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Replacement of Cement with Silica Fume,Wheat Straw Ash and Steel Fibers in Concrete

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ABSTRACT

Concrete is the most widely used construction material for various civil construction purposes. A lot various tests are carried out on concrete every day to improve or change its properties. To change the properties of different types of cement materials used in the concrete mix. Primary the advantage of using cementing materials for construction is to reduce and change the consumption of cement concrete properties. This article is a combination of different types of steel fibers, Silica Fume and Wheat Straw Ash is studied on the strength side of concrete. The percentage of Silica Fume in this test is 5%, 7.5% and 10% were used. The percentage of wheat straw ash is 5 percent and steel fiber is taken 1 percent by weight of cement. This paper presents the most comprehensive study to date of mechanical, physical, and durability properties concrete. A total of 54 mixes (test mix, control mix and different mix) were prepared with M30 grade of concrete and result was studied. Cube size of 150mmX150mmX150mm and 150mm diameter 300mm height cylinder was used for casting. The cube and cylinder were tested for compressive strength and split tensile strength at 7 days to 28 days of age. Based on the results, Silica Fume, Wheat Straw Ash and Steel Fiber concrete have all increased strength and Resistance to deformation of concrete at any age compared to normal concrete. Used for good for productivity as well as environmental sustainability.

Keywords: Silica fume, Wheat Straw Ash, Steel Fibers, properties of concrete.

INTRODUCTION

Now a day, concrete is most commonly used construction material. It traditionally consists of coarse aggregate, fine aggregate, cement and water. Along with these ingredients, minerals and admixtures also being used. Concrete can be defined as ordinary concrete, standard concrete and High strength concrete based on its characteristic compressive strength.

Now a day the concrete is modified with the help of different materials whose main work is to provide more durability and strength to the concrete, in which such materials are wheat straw ash, silica fume and steel fibers. This is the materials which allow the concrete to perform in higher order. To make concrete more strong in all aspect it is very necessary to modify the concrete in different and in advanced way. Steel fibers are one the ingredients which provide more strength and durability to the concrete.

High strength concrete can be produced by adding silica fume as some replacement of cement. The combine use of wheat straw ash, silica fume and steel fibers improves the mechanical properties of concrete. Traditionally, it has been treated as a waste material. In India and many other countries, farmers burn it, contributing to air pollution and creating a public health hazard. Wheat straw waste is a major agricultural by-product obtained from cereal production, which causes environmental pollution because the farmers burn it directly in open fields. When wheat straw waste is properly burnt under controlled situation it gives cementing properties that can be used as supplementary cementing material. The resulting ash contains higher percentage of silica, the particles of ash are also finer as compared to cement, and therefore it is considered as supplementary cementing material. The advantage of using wheat straw ash in concrete as cement replacement material revealed that increase in compressive strength when it was replaced by 5% cement.

Silica Fume is the by product from an electric arc furnace used in manufacturing of silicon metal or silicon alloy. Silica fumes help to improve both the mechanical characteristics as well as durability of concrete. In this time economic and environmental consideration is very important in construction. Studies shows that up to 20 % replacement of wheat straw ash in OPC are valuable in term of strength and durability. The addition of fibers in concrete results in dense and uniform material, it also helps in improving micro structure and to control the micro cracks in concrete. In general, the addition of fibers along with Silica Fume and wheat straw ash in concrete has been proven to improve the mechanical property of concrete, particularly the tensile strength and ductility performance.

OBJECTIVE

The use of waste material like silica fume, wheat straw ash, GGBS etc. in concrete is common now a day. This research aims to use agricultural waste such as wheat straw ash in concrete to make concrete economical and reduce the environmental problems. In this experimental study we are have designed high strength concrete using agricultural waste and by product of electric arc furnace.

1. To achieve M30 grade of concrete mix design.
2. To determine and study the characteristics of concrete using Silica Fume, Steel Fibers and Wheat straw ash in concrete.
3. To determine the effect of Silica Fume when it is replaced with cement.
4. To determine the workability of plan concrete and silica fume mix concrete.
5. To determine the compressive and split tensile (7 & 28 days) of concrete using the optimum dose of wheat straw ash and steel fiber with various percentage replacement of Silica Fume (5%, 7.5% & 10%).
6. To determine the mechanical properties of concrete for getting the optimum dose of silica fume and steel fiber to be used in high strength concrete.

MATERIAL USED

Cement-

Grade 43 OPC cement is used for these experiments. 33 minutes and 185 minutes were determined as the initial setting time and final setting time of the cement. A cement specific gravity of 3.14 was found. The cement used for this work is free of lumps and in good condition. It was obtained from a fresh stock stored at room temperature.

Fine Aggregate -

Locally available artificial sand passed through a 4.75mm sieve was used for the casting of cubes and cylinders. Its properties are tested for specific gravity, sieve analysis and fineness coefficient according to IS: 2386-1970. The specific gravity of fine aggregate is 2.75.Fine aggregate water absorption of 1.21% was measured.

Coarse Aggregate -

Locally available coarse aggregate will be used for this operation. 12mm and 20mm aggregate with angular dimensions were used. Its properties have been tested by specific gravity, sieve analysis and other tests according to IS: 383-1970. A coarse aggregate specific gravity of 2.86 was found. Coarse aggregate water absorption of 0.50% was measured.

Silica Fume-

Silica Fume is a by-product formed from high-purity quartz containing carbon in electric arc furnaces in the manufacture of ferrosilicon and silicon metal. The main component of silica fume is silicon dioxide, which is very fine and spherical. It is an industrial waste mainly generated as a by-product of the ferrosilicon industry. Like fly ash, it reacts with Ca(OH)2 produced during the water-cement reaction process. Silica fume is a very fine mineral mixture. Almost 100 times finer than average cement granules. This very fine grain improves the pore structure of the concrete, increasing its strength and making it a denser concrete. Silica fume is the most reactive pozzolanic due to its high surface area and low abundance compared to other pozzolanic materials. The specific gravity of silica fume was found to be 2.25.

Steel Fiber -

Hook end, long straight fiber with aspect ratio of 50 is used. The steel fibers have a diameter and length of 1 mm, and 50 mm were used in this experiment. The reason for choosing this aspect ratio is that many researchers consider an aspect ratio of 50 to be optimum.

For preparation of fibers, bundles of wires purchased from the market. These bundles were manually cut to the required size. An aspect ratio of 50 was maintained throughout the study.

Wheat Straw Ash-

Straw Ash is collected directly from farms and burned directly in an open environment. It is the waste that farmer's burn after harvesting their crops. Straw ash is a dark gray colour. The small particles play an important role in filling the voids in the concrete, creating

a dense and durable concrete. Straw ash has pozzolanic properties and reacts with lime to form cement-like compounds. The specific gravity of straw ash was found to be 1.51.

Admixtures-

Admixtures are materials other than cement, aggregates, and water added to concrete before or during mixing to modify properties such as workability, cure temperature range, cure time, colour, etc. Today, concrete mixtures without admixtures were exception. Admixtures are chemical products added to concrete mixes in amounts not exceeding 5% of the weight of cement. The effectiveness of each admixture depends on the amount added to the concrete and the composition of the mixture.

Water-

Potable water is used for both mixing and curing in this piece. The water used for these experiments is free of all contaminants.

METHODOLOGY

In this study, the amounts of cement, sand, aggregate, water, silica fume fly ash, steel fiber, superplasticizer were first calculated and weighted according to the design mix ratio of 1:6.9:3.13. Water cement ratio of 0.37 was adopted for this experiment.

Various steps adopted for this experiments-

i. Collected all information and studies related to silica fume, wheat straw ash and steel fibers.
ii. Visited to the market to buy all ingredients such as silica fume, and steel fibers experiments.
iii. Test performed on silica fume and wheat straw ash.
iv. Silica Fume, wheat straw ash and Steel Fibers were replaced with cement with required quantity.
v. After mixing is completed, concrete is placed in mould i.e. cubes (150mm X 150mm X 150mm) and cylinders (150 mm diameter and 300mm length) then compacted by using table vibrator for compaction.
vi. Putting concrete in mould, after 24 hours the mould were removed and cubes and cylinders were kept for curing for 7 days and 28 days. After completion of curing period cubes and cylinders were taken out from water before 24 hours of testing.
vii. The following test were conducted:
    - Compressive strength test
    - Split tensile test

EXPERIMENTAL DATA

Compressive Strength Test

Compressive strength was performed using 150 mm X 150mm X 150mm Cubes consolidated by vibration. Cubes were remolded after 24 hours and cured in the curing pond. The results of Compressive strength test have been shown in table simultaneously different percentages of mix proportions have been determined by replacing cement with silica fume, wheat straw ash and steel fibers.

A) Compressive Strength test for 7 Days: -

Table shows 7 Days Compressive Strength Test Results

S. No.	Steel Fibers	Silica Fume	Wheat straw ash	Load (KN)	Compressive Strength (N/mm^2)	Average Result ($N/mm^{2)}$
1	0%	0%	0%	419.8	21.32	19.94
	0%	0%	0%	410.4	18.24	
	0%	0%	0%	456.4	20.28	
2	1%	0%	5%	595.9	26.48	25.27
	1%	0%	5%	542.4	24.10	
	1%	0%	5%	567.1	25.25	
3	1%	5%	5%	637.70	28.34	26.03
	1%	5%	5%	550.60	24.47	

	1%	5%	5%	568.9	25.28	
4	1%	7.5%	5%	820.4	36.46	38.47
	1%	7.5%	5%	910.5	40.46	
	1%	7.5%	5%	866.4	38.50	
5	1%	10%	5%	794.9	35.32	33.98
	1%	10%	5%	750.6	33.36	
	1%	10%	5%	749.0	33.28	

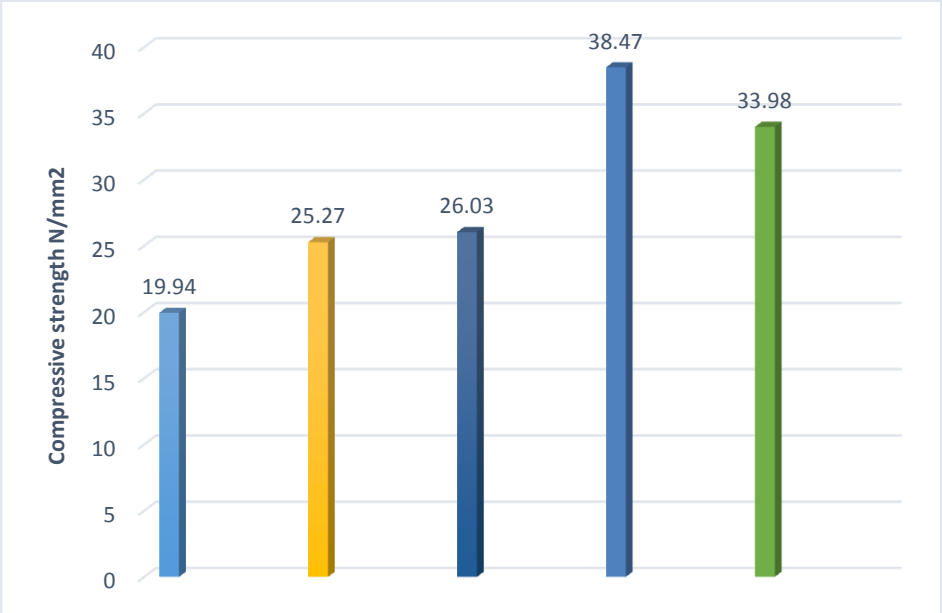

Figure shows Average Compressive Strength for 7 Days

Compressive Strength Test for 28 Days: -

Table shows 28 Days Compressive Strength Test Results

S. No.	Steel Fibers	Silica Fume	Wheat straw ash	Load (KN)	Compressive Strength (N/mm^2)	Average Result (N/mm$^{2)}$
1	0%	0%	0%	910.9	40.48	40.27
	0%	0%	0%	950.1	42.22	
	0%	0%	0%	857.81	38.12	
2	1%	0%	5%	1002.5	44.56	43.53
	1%	0%	5%	966.9	42.97	
	1%	0%	5%	969.2	43.07	
3	1%	5%	5%	918.2	40.8	37.75
	1%	5%	5%	780.2	34.67	
	1%	5%	5%	850.2	37.79	

4	1%	7.5%	5%	1080.2	48.00	46.90
	1%	7.5%	5%	995.4	44.24	
	1%	7.5%	5%	1090.9	48.48	
5	1%	10%	5%	1050.2	46.68	45.89
	1%	10%	5%	1071.7	47.63	
	1%	10%	5%	975.1	43.37	

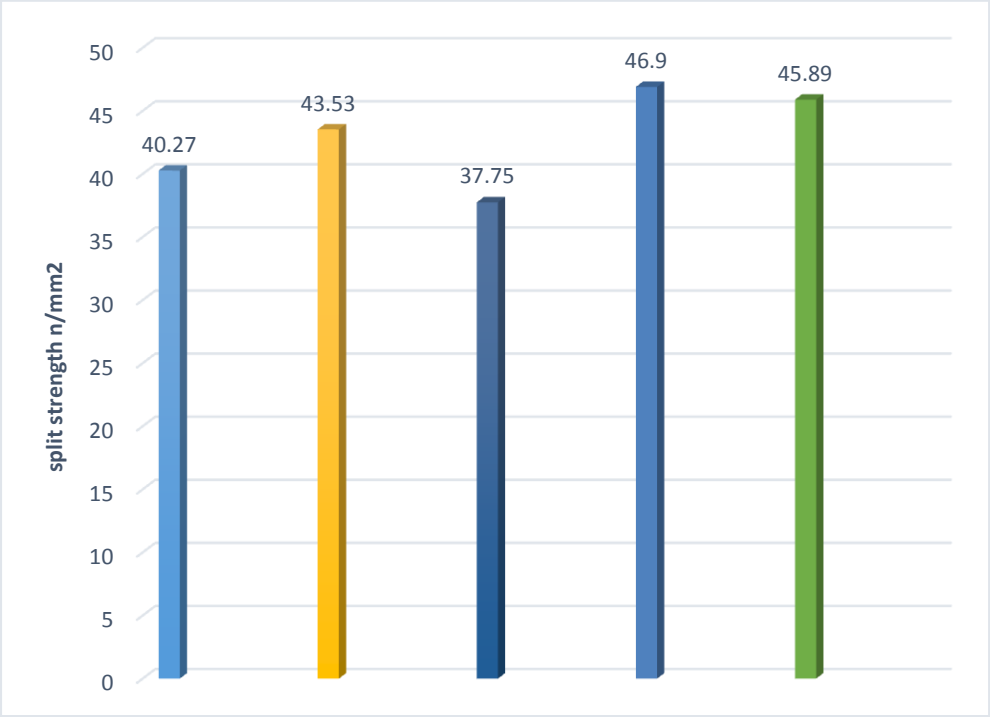

Figure shows Average Compressive Strength for 28 Days

B) Split Tensile Strength Test

In this standard test, determine the tensile strength of concrete in indirect way. Cylinders of 150mm diameter and 300mm height were cast and tested for 7 days and 28 days for split tensile strength.

Split Tensile Test for 7 days: -

Table shows 7 Days Split Tensile Strength Test Result

S. No.	Steel Fibers	Silica Fume	Wheat straw ash	Load (KN)	Split Tensile Strength (N/mm^2)	Average Result ($N/mm^{2)}$
1	0%	0%	0%	150.00	2.12	2.2
	0%	0%	0%	160.30	2.26	
	0%	0%	0%	158.30	2.22	
	1%	5%	5%	193.1	2.73	

2	1%	5%	5%	180.42	2.55	2.75
	1%	5%	5%	210.4	2.97	
3	1%	7.5%	5%	250.3	3.54	3.18
	1%	7.5%	5%	209.9	2.9	
	1%	7.5%	5%	219.2	3.10	
4	1%	10%	5%	247.4	3.5	2.86
	1%	10%	5%	209.0	2.9	
	1%	10%	5%	157.0	2.2	

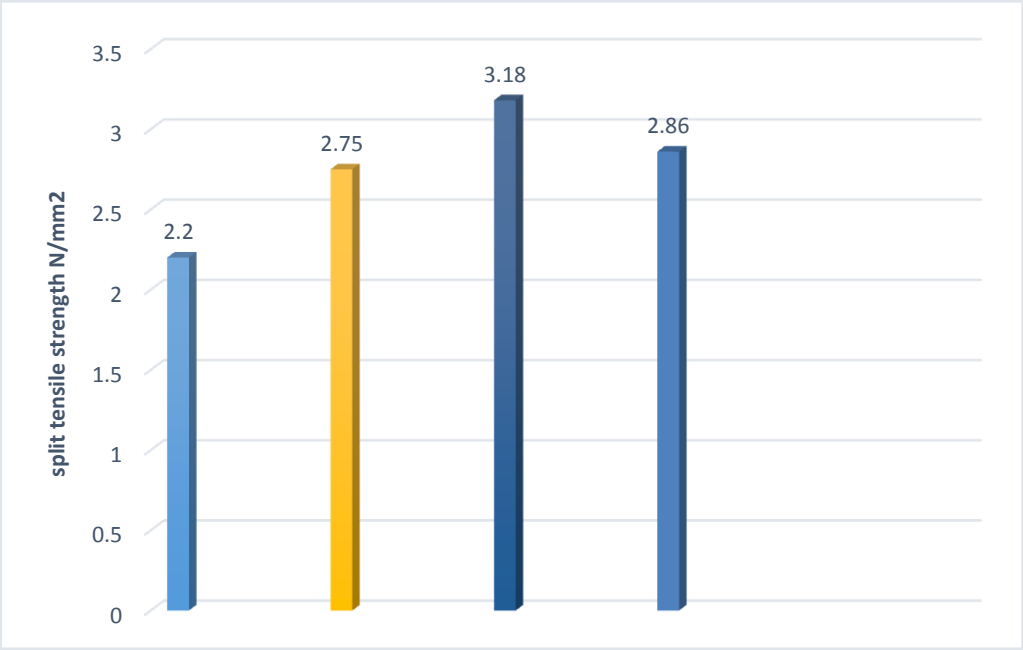

Figure shows Average Split Tensile for 7 Days

Split Tensile Test for 28 days: -

Table shows 28 Days Split Tensile Strength Test Result

S. No.	Steel Fibers	Silica Fume	Wheat straw ash	Load (KN)	Split Tensile Strength (N/mm^2)	Average Result ($N/mm^{2)}$
1	0%	0%	0%	237.9	3.36	3..36
	0%	0%	0%	220.00	3.11	
	0%	0%	0%	256.0	3.61	

2	1%	5%	5%	250.10	3.53	3.19
	1%	5%	5%	217.5	3.07	
	1%	5%	5%	210.2	2.97	
3	1%	7.5%	5%	276.6	3.90	3.86
	1%	7.5%	5%	250.1	3.53	
	1%	7.5%	5%	295.3	4.17	
4	1%	10%	5%	255.00	3.61	3.70
	1%	10%	5%	250.20	3.54	
	1%	10%	5%	280.4	3.96	

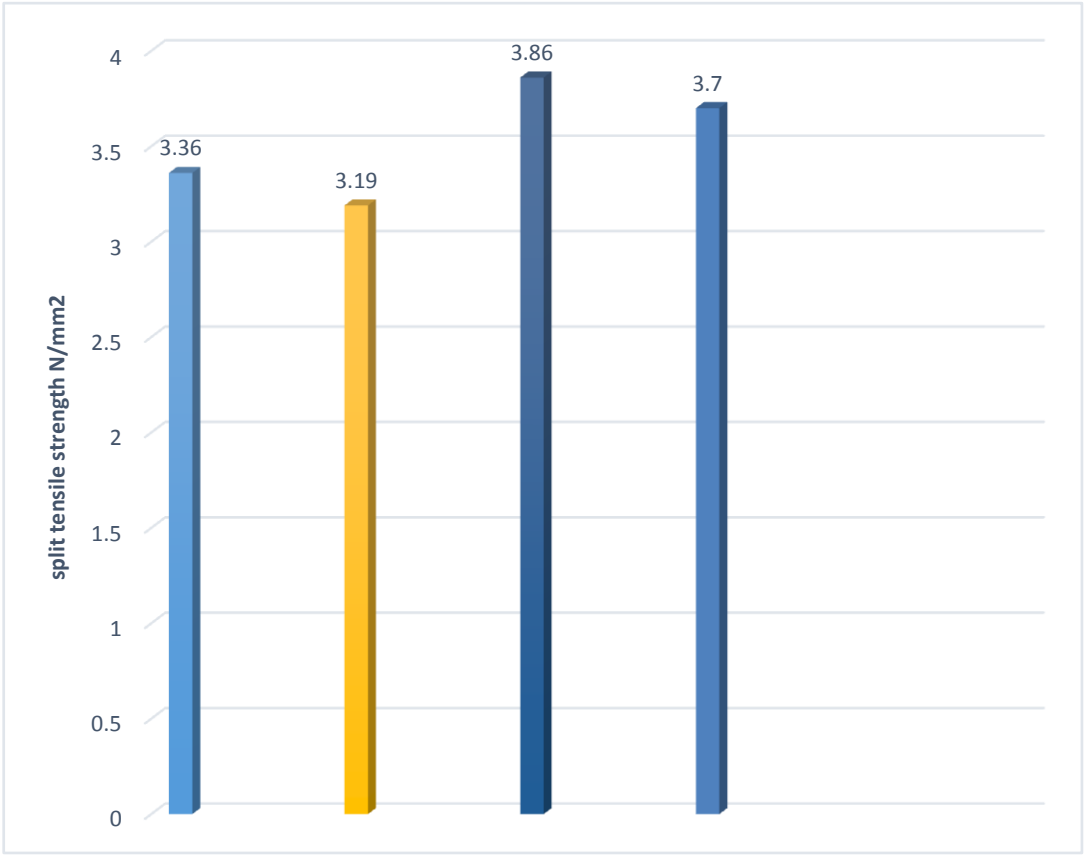

Figure shows Average Split Tensile for 28 Days

CONCLUSION

On the basis of experiments, it concludes that replacement of cement with Silica Fume, Wheat Straw Ash and Steel Fibers the Compressive strength as well as tensile strength of concrete increases. The following are the conclusions are found from this study as below.

1. In this research it is found that, the optimum percentage of Silica Fume, Wheat Straw Ash and Steel Fibers is found to be 7.5%, 5% and 1%.
2. Addition of silica fume in concrete reduces workability and increases bond strength of concrete.
3. Silica fume increases Compressive strength of concrete significantly, but the increment depends upon amount of silica fume which is replaced by cement.
4. Addition of silica fume, steel fibers in concrete it increases the density of concrete which helps in improvement of strength.
5. Addition of Wheat straw ash in concrete further reduces workability.
6. The optimum level of wheat straw ash is 5%, in order to obtain maximum strength of concrete.
7. Apart from economical point of view, it is observed that, replacement of cement with wheat straw ash, silica fume and steel fibers can be economical & environmental friendly for mass concrete work. It will not only reduce the consumption of cement, which will be ecofriendly but will also solve the problems of disposal of wheat straw ash.

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