Performance of Concrete When Cement is partially replaced with Sisal Fiber and Silica Fume

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Abstract : ***The incorporation of admixtures in concrete is generally to achieve economy, durability, strength and impermeability etc. Now a day's different research have suggested that silica fume is very effective in the design and development of high performance concrete. Because of the pozzolanic nature and filling property of silica fume, the interest in adding silica fume in concrete has increased considerably. Research is also done to improve the performance of concrete by introduction of natural fibers. Here the natural fiber i.e. sisal fiber is utilized in this experiment for evaluation of compressive, tensile and flexural strength of concrete by simultaneously adding silica fume and sisal fiber as partial replacement of cement in the of grade M20 and M50. Cement is replaced by silica fume in a proportion of 10% and 15% respectively, however sisal fibers is added in proportion of 0.3%, 1%, 1.5% and 2% respectively. According to IS 516 and IS 5816 the specimens of cubes, cylinders and beams were casted and tested at the age of 7 day and 28 days to evaluate the effect of performance. Optimum results with increase in strength were found at silica fume being added at 15% and sisal fiber at a proportion of 1.5% for both M20 and M50 grade. The results obtained are in accordance with the IS codes.***

IndexTerms - Cement replacement, Sisal Fiber, Silica Fume, High performance concrete, Sustainable.

I. INTRODUCTION

In the last two decades High Performance Concrete has been developed and used for concrete mixture which possess high strength, high workability and stability, resistance to chemical attack etc. The High Performance Concrete is produced by using supplementary cementitious materials (SCMs) such as silica fume, fly ash and ground granulated blast furnace slag etc. to enhance the performance of concrete, workability, resistance to cracks and permeability etc. Most commonly used supplementary material is silica fume which is used in the development of High Performance Concrete. It is a byproduct of the smelting process in the silicon and ferrosilicon industry. Silica fume is also known as condensed micro silica or silica dust. It is of grey colour or white colour consisting of very fine particles. The particles of silica fumes are 100 times smaller than the average cement particle which makes it highly effective pozzolanic material. By the use of silica fume several properties such as compressive strength, abrasion resistance etc. are increased and hence helps in protecting reinforcing steel from corrosion.

With the introduction of silica fume in concrete may increase the compressive strength of concrete but the tensile properties remain unchanged. To improve the tensile properties natural fibers i.e. sisal fibers are now considered as a suitable reinforcing material in concrete because of their several advantages such as low cost, high strength and recyclability. Addition of sisal fibers will reduce the shrinkage crack problems and improves its static and dynamic properties. The inherent deficiencies of concrete can be overcome by introduction of sisal fiber. The advantages of higher strength, better durability, cost and environmental compatibility makes it more convenient to use.

II. Aim and Scope

- To study the variation in characteristic behaviour of concrete when cement is simultaneously replaced by silica fume and sisal fiber with various proportions in grade M20 & M50.
- To determine the optimum percentage of silica fume & sisal fiber used as simultaneous replacement of cement in varying proportion, which enhances the workability of concrete.
- To determine the percentage increase in compressive strength of concrete due to blending with sisal fiber and silica fume.

III. MATERIALS AND METHODOLOGY

In this experimental project concept of using sisal fiber in concrete was conceived. An idea about the natural fiber known as the sisal fiber being used in concrete was obtained by referring various literature available. The addition of silica fumes was conceived earlier to enhance the properties of concrete but the combination of sisal fiber and silica fumes introduced simultaneously is being executed in this project. The knowledge on fiber reinforced concrete was also obtained by referring various journals. Review of literature was done and the concept was finalized and various tests on Cement, fine aggregate and coarse aggregates were carried out to determine the material properties and prepare the mix design accordingly. In order to do find the merit or demerit of any special concrete, it has to be compared with conventional concrete. Therefore, a set of conventional concrete specimen is also required. In order to cast a set of conventional concrete, initially the mix design for M20 grade and M50 of concrete was made. Tests on fresh concrete were carried out. Workability was checked by carrying out slump test. The water cement was also determined based on three different designs of trail mix. The mix with optimum results were considered for casting conventional concrete.

The same mix ratio which was used to cast conventional concrete specimen, was also used to cast special concrete specimens which included addition of silica fume and sisal fiber. Special concrete specimens consist of cubes, cylinders and beams. OPC grade 53 cement was

used in casting. The coarse aggregate added to the mix was divided into two portions. 60% of 20mm aggregate and 40% of 10mm aggregate was used. 9 mixes of special concrete specimens were casted and cured. Testing were carried out to find the compressive strength, split tensile strength and flexural strength for the special concrete at the age of 7 days and 28 days respectively. With the results obtained, the optimum percentage of sisal fiber and silica fume to be added is found out. With the results, the percentage which gives us the optimum result is found.
Following proportions were used in the concrete mix samples:
Table 1 & 2: The dry mixes composition of blended cement (wt. %)

For M20:

Concrete Mixes	Sisal Fiber (SS)	Silica Fume (SF)
M20	0%	0%
M20	0.3%	10%
M20	1%	10%
M20	1.5%	10%
M20	2%	10%
M20	0.3%	15%
M20	1%	15%
M20	1.5%	15%
M20	2%	15%

For M50:

Concrete Mixes	Silica Fumes (SF)	Sisal Fiber (NF)
M50	0%	0%
M50	0.3%	10%
M50	1%	10%
M50	1.5%	10%
M50	2%	10%
M50	0.3%	15%
M50	1%	15%
M50	1.5%	15%
M50	2%	15%

IV. RESULTS AND DISCUSSIONS

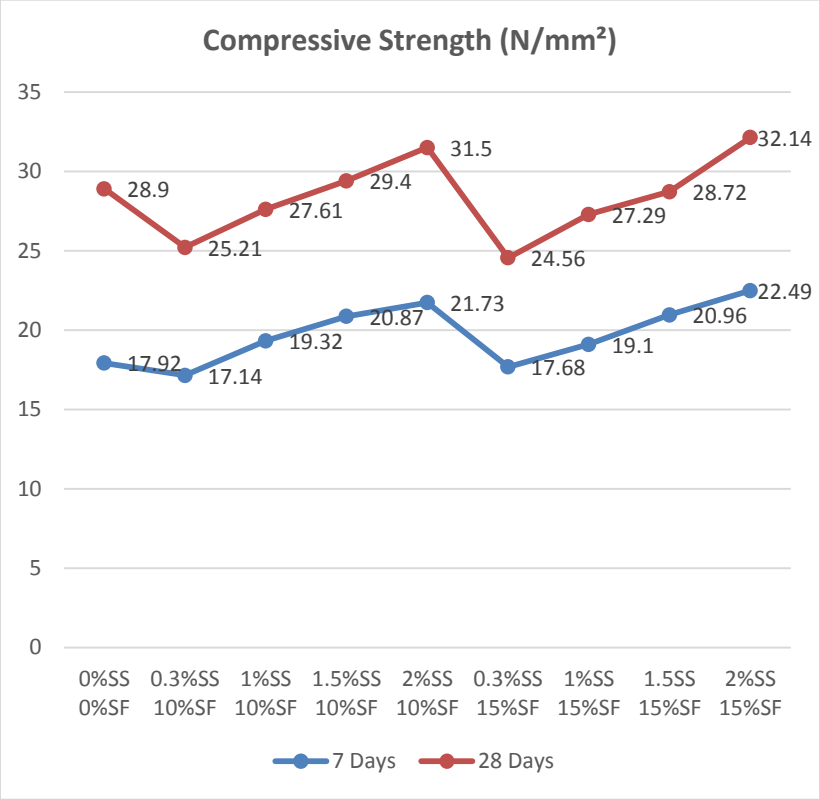
Compressive Strength:

The test was conducted as per IS 516-1959 codal provision. The tests were carried out at a uniform stress after the specimen has been centered in the testing machine. For all mixes compressive strengths were determined at 7 days & 28 days. Compressive strength results which are obtained in M20 and M50 grades of concrete is represented as below:

For M20:

Compressive Strength		
Mix	**7 Days**	**28 Days**
0%SS 0%SF	17.92	28.9
0.3%SS 10%SF	17.14	25.21
1%SS 10%SF	19.32	27.61
1.5%SS 10%SF	20.87	29.4
2%SS 10%SF	21.73	31.5
0.3%SS 15%SF	17.68	24.56

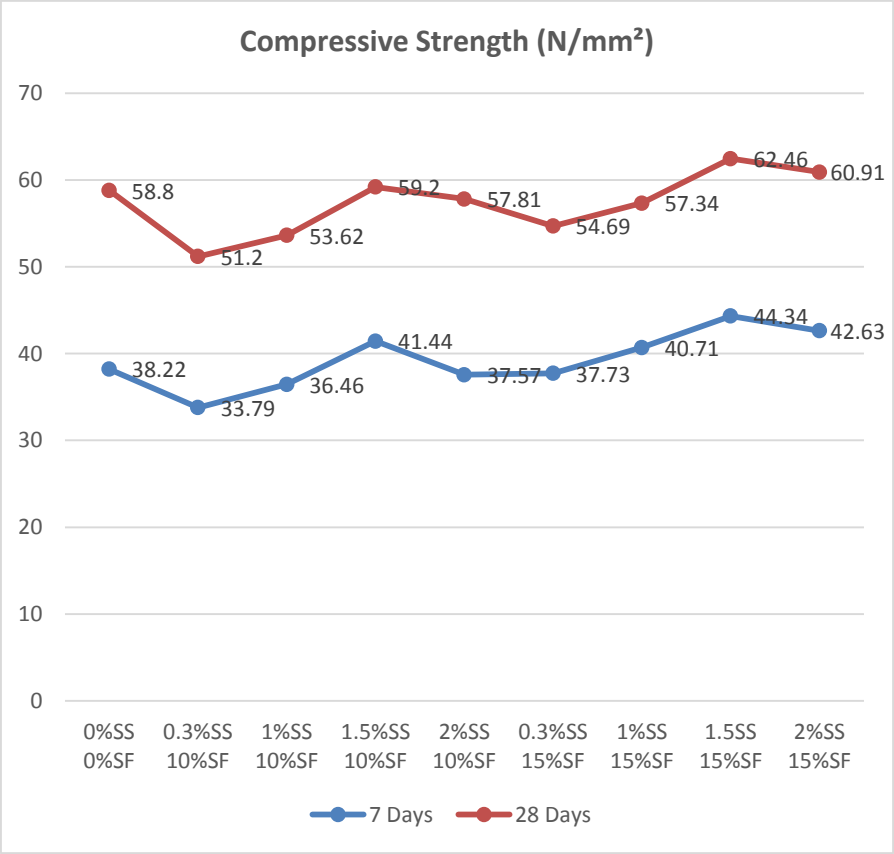
1%SS 15%SF	19.1	27.29
1.5%SS 15%SF	20.96	28.72
2%SS 15%SF	22.49	32.14



It is seen that optimum addition of 2% of sisal fiber and 15% silica fume gave a compressive strength of 32.14 MPa at 28 days which is highest amongst the other trial mixes. The results are below average at 0.3% of sisal fiber.

For M50:

Compressive Strength		
Mix	**7 Days**	**28 Days**
0%SS 0%SF	38.22	58.8
0.3%SS 10%SF	33.79	51.2
1%SS 10%SF	36.46	53.62
1.5%SS 10%SF	41.44	59.2
2%SS 10%SF	37.57	57.81
0.3%SS 15%SF	37.73	54.69
1%SS 15%SF	40.71	57.34
1.5%SS 15%SF	44.34	62.46
2%SS 15%SF	42.63	60.91



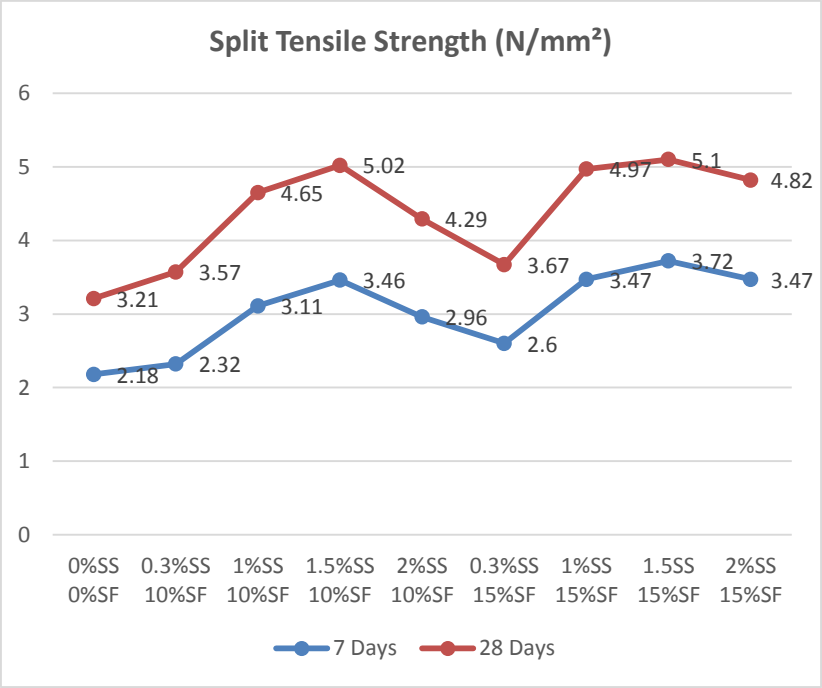
Compressive strength of 62.46 MPa was obtained with the addition of 1.5% sisal fiber and 15% silica fume. However lowest results were found when sisal was 0.3% and 10% silica fume.

Split Tensile Strength:

The test was conducted as per IS: 5816-1999 codal provisions. For split tensile strength, the cylinder of 150mm diameter and 300mm height were used. In replacement of micro silica, the splitting tensile strength of silica concrete showed to be higher than that of the control concrete. This is due to the very fine particle of micro silica and its reaction with concrete. The split tensile strength which are obtained in M20 and M50 grades of concrete is represented as below:

For M20:

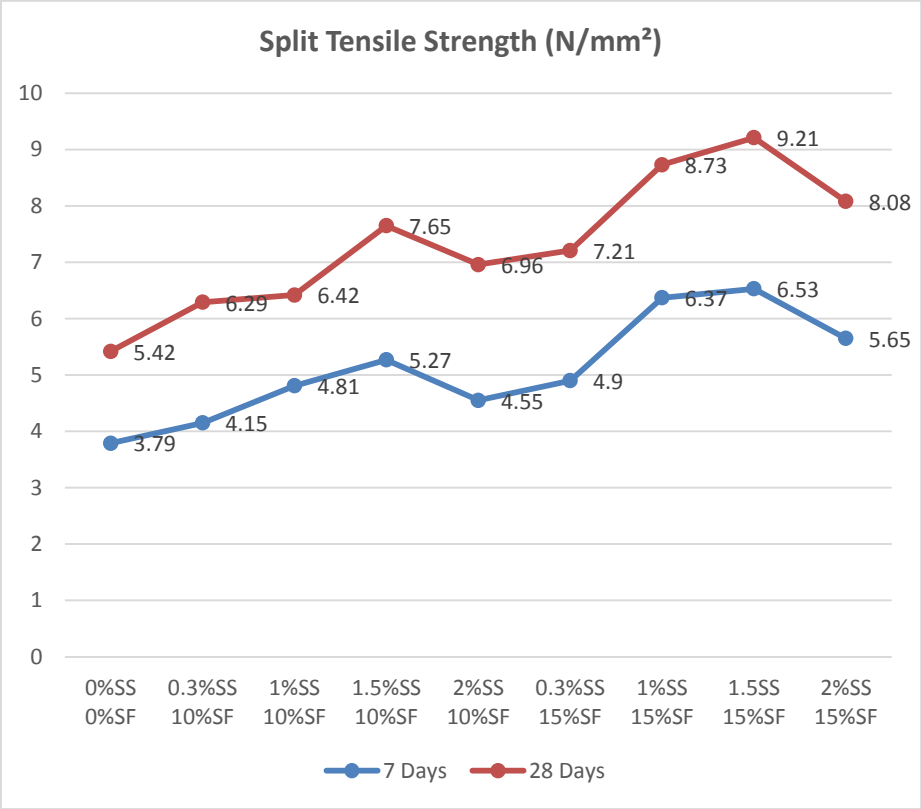
Split Tensile Strength		
Mix	**7 Days**	**28 Days**
0%SS 0%SF	2.18	3.21
0.3%SS 10%SF	2.32	3.57
1%SS 10%SF	3.11	4.65
1.5%SS 10%SF	3.46	5.02
2%SS 10%SF	2.96	4.29
0.3%SS 15%SF	2.6	3.67
1%SS 15%SF	3.47	4.97
1.5%SS 15%SF	3.72	5.1
2%SS 15%SF	3.47	4.82



The optimum percentage of sisal fiber and silica fume was found to be 1.5% and 15% respectively. The tensile strength achieved is 5.1 MPa at 28 days.

For M50:

Split Tensile Strength		
Mix	**7 Days**	**28 Days**
0%SS 0%SF	3.79	5.42
0.3%SS 10%SF	4.15	6.29
1%SS 10%SF	4.81	6.42
1.5%SS 10%SF	5.27	7.65
2%SS 10%SF	4.55	6.96
0.3%SS 15%SF	4.9	7.21
1%SS 15%SF	6.37	8.73
1.5%SS 15%SF	6.53	9.21
2%SS 15%SF	5.65	8.08



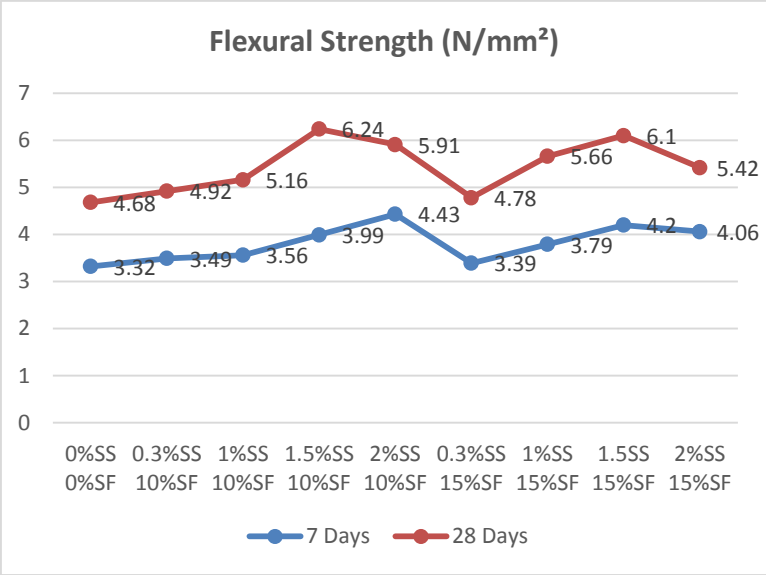
Here for the M50 grade concrete also the optimum percentage of sisal is found to be 1.5% and that of silica fume if 15%. The tensile strength obtained is 9.21 MPa.

Flexural Strength:

The test was conducted as per IS: 516-1959 codal provisions. Flexure strength was measured by loading 150mm x150 mm x 700 mm concrete beams with a span at least three times the depth. The flexural strength which are obtained in M20 and M50 grades of concrete is represented as below:

For M20:

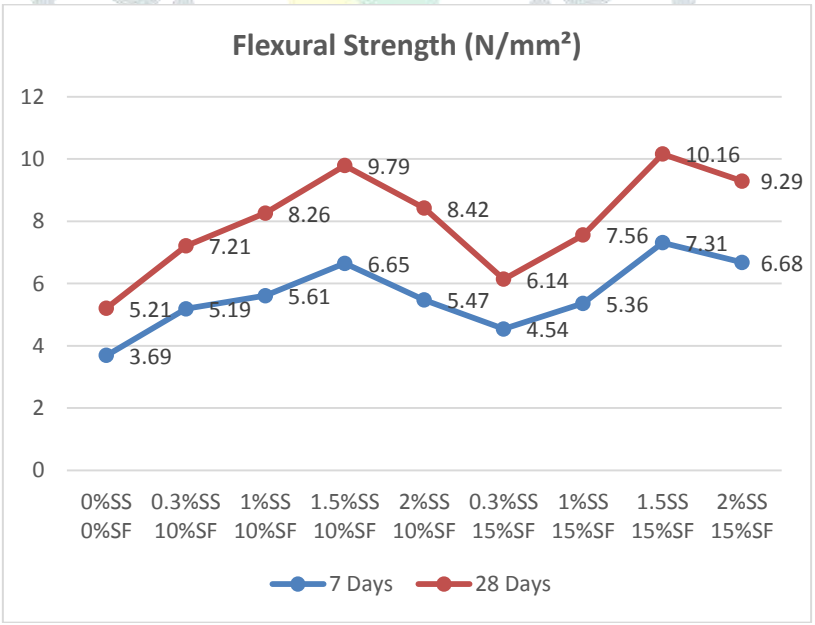
Flexural Strength		
Mix	**7 Days**	**28 Days**
0%SS 0%SF	3.32	4.68
0.3%SS 10%SF	3.49	4.92
1%SS 10%SF	3.56	5.16
1.5%SS 10%SF	3.99	6.24
2%SS 10%SF	4.43	5.91
0.3%SS 15%SF	3.39	4.78
1%SS 15%SF	3.79	5.66
1.5%SS 15%SF	4.2	6.1
2%SS 15%SF	4.06	5.42



For M20 grade concrete the optimum results were found at 28 days with sisal fiber 1.5% and that of silica fume is 10%. Also trial with 1.5% sisal fiber and 15% silica fume gave good results.

For M50:

Flexural Strength		
Mix	**7 Days**	**28 Days**
0%SS 0%SF	3.69	5.21
0.3%SS 10%SF	5.19	7.21
1%SS 10%SF	5.61	8.26
1.5%SS 10%SF	6.65	9.79
2%SS 10%SF	5.47	8.42
0.3%SS 15%SF	4.54	6.14
1%SS 15%SF	5.36	7.56
1.5%SS 15%SF	7.31	10.16
2%SS 15%SF	6.68	9.29



It is seen that addition of 1.5% sisal fiber gave best results of flexural strength for M50 grade along with 10% and 15% silica fume.

V. CONCLUSION

From the above investigational work and test results, it was concluded that the optimum percentage of sisal fiber and silica fume for maximum strengths (compressive) was found to be 2% & 15% respectively for M20 concrete mix. However for M50 grade concrete mix the optimum percentage of sisal fiber was 1.5% and that of silica fume was 15% for compressive strength. The optimum percentage for split tensile strength was found to be 1.5% of sisal fiber and 15% silica fumes for both M20 and M50 grade of concrete. With respect to flexural strength 1.5% sisal fiber and 15% silica fumes addition gave optimum results for M20 and M50 grade. It was also concluded that the

workability decreases with increase in percentage of sisal fiber as well as silica fume. It is concluded that 15% replacement of Micro silica induces higher strength properties and good workability properties, this may be due to the filling effect of micro silica. The strength of sisal fiber & silica added concrete is higher when compared to conventional concrete.

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