Effect of Silica Fume on Strength Parameters of Concrete As A Partial Substitution of Cement

Prabhulal Chouhan[1], Sagar Jamle[2], M.P. Verma[3]
[1] M. Tech. Scholar, Department Of Civil Engineering, Oriental University, Indore, Madhya Pradesh, India.
[2] Assistant. Professor, Department of Civil Engineering, Oriental University, Indore, M.P., India.
[3] Prof. & Head, Department of Civil Engineering, Oriental University, Indore, M.P., India.

Abstract*-The waste materials which can be used as additional cementitious material like fly ash, silica fume, blast furnace, steel slag etc. From all these waste material the most successful cementitious material is silica fume because it improves the strength of concrete to such level that recent design rules identify for the addition of silica fume for design of high strength concrete. Silica fume is also known as micro silica; it is used as an artificial pozzolanic super plasticizer. Now days the high strength and high performance concrete is extensively used in much civil engineering structure. To reduce the amount of cement in concrete supplementary material are used. Silica fume is most popular material used in the concrete to improve its flexural, split tensile strength. For this purpose silica fume is replaced by 0%, 5%, 7.5%, 12.5%, 15%, 20% & 25% by the weight of cement. Water binder ratio is taken 0.42 for M-25 grade of concrete. Various tests were conducted in the research which showed the results of the same percentage at the different of 0% 5%, 7.5%, 12.5%, 15%, 20% & 25% for the time period of 7, 14, and 28 days curing as a substitution of cement by micro silica on Split Tensile Strength, flexural strength.*

Keywords- Silica Fume, Flexural Strength, Split Tensile test, W/C ratio.

I. INTRODUCTION

Concrete is a most commonly used building material which is a mixture of cement, sand, coarse aggregate and water. It is used for construction of multi-storey buildings, dams, road pavement, tanks, offshore structures, canal lining. The method of selecting appropriate ingredients of concrete and determining their relative amount with the intention of producing a concrete of the necessary strength durability and workability as efficiently as possible is termed the concrete mix design. The compressive strength of harden concrete is commonly considered to be an index of its extra properties depends upon a lot of factors e.g. worth and amount of cement water and aggregates batching and mixing placing compaction and curing. The cost of concrete prepared by the cost of materials plant and labour the variation in the cost of material begin from the information that the cement is numerous times costly than the aggregates thus the intent is to produce a mix as feasible from the practical point of view the rich mixes may lead to high shrinkage and crack in the structural concrete and to development of high heat of hydration is mass concrete which may cause cracking. The genuine cost of concrete is related to cost of materials essential for produce a minimum mean strength called characteristic strength that is specific by designer of the structures. This depends on the quality control measures but there is no doubt that quality control add to the cost of concrete. The level of quality control is often an inexpensive cooperation and depends on the size and type of job nowadays engineers and scientists are trying to enhance the strength of concrete by adding the several other economical and waste material as a partial substitute of cement or as a admixture fly ash, silica fume, steel slag etc. are the few examples of these types of materials. These materials are generally by-product from further industries for example fly ash is a waste product from power plants and silica fume is a by-product resulting from decrease of high purity quartz by coal or coke and wood chips in an electric arc furnace during production of silicon metal or ferrosilicon alloys. But nowadays silica fume is used in large amount because it enhances the property of concrete. The use of micro silica as a pozzolanic material has enhanced in recent years because when mixed in definite proportions it improves the properties of both fresh and hard concrete like durability, strength, permeability and compressive strength, flexural strength and tensile strength.

II. MATERIALS & METHODOLOGY

1. MATERIALS USED

1.1 CEMENT: Ordinary Portland cement (OPC) Of 53 grades satisfying the requirements of IS: 8112- 1939 is used. The specific gravity of cement was found to be 3.0.

1.2 FINE AGGREGATES: Sand is the main component grading zone-II of IS: 383-1978 was used with specific gravity of 2.62 and water absorption of 1.8% at 24 hours.

1.3 COARSE AGGREGATES: Mechanically crushed stone of 20mm maximum size, satisfying to IS: 383-1978 was used. The specific gravity was found to be 2.62 and 2.64 and water absorption is 0.16% and 0.18% at 24 hours of 20mm aggregates respectively.

1.4 SILICA FUME: Silica fume is a byproduct in the decrease of high-purity quartz with coke in electric arc furnaces in the manufacture of silicon and ferrosilicon alloys. Micro silica consist of fine particle with a surface area on the order of 215,280 ft²/lb (20,000 m²/kg) when precise by nitrogen adsorption techniques, with particle just about one hundredth the size of the average cement Because of its excessive fineness and high silica content, micro silica is a very efficient pozzolanic material particle. Micro silica is added to Portland cement concrete to enhance its properties, in particular it's compressive strength, bond strength, and abrasion resistance. These improvement stems from both the mechanical improvements resulting from addition of an extremely fine particle to the cement paste mix as well as from the pozzolanic reactions between the micro silica and liberated calcium hydroxide in the paste. Addition of silica fume also decrease the permeability of concrete to chloride ions, which protect the reinforcing steel of concrete from corrosion, especially in chloride-rich environment such as coastal region. While silica fume is incorporated, the rate of cement hydration increases at the early hours due to liberation of OH ÿ ions and alkalis into the pore fluid. It has been reported that the pozzolanic reaction of silica fume is very significant and the no evaporable water content decreases between 90 and 550 days at low water /binder ratios with the addition of silica fume.

Table 1 - Physical Properties Of Silica Fume

Properties	**Observed Values**
colour	Dark grey
Specific gravity	2.2
Fineness modulus	$20000 m^2/kg$
Bulk Modulus	$240 kg/m^3$

Table 2- Chemical Properties Of Silica Fume

Properties	**Observed value**
Sio2	90-96%
Al2o3	0.6 -3.0%
Fe2o3	0.3-0.8%
Mgo	0.4-1.5%
Cao	0.1-0.6%
Na2o	0.3-0.7%
K2o	0.04-1.0%
C	0.5-1.4%
S	0.1-2.5%
Loss of ignition (C+S)	0.7-2.5%

2. FLEXURAL STRENGTH: Beams of size 10cm*10cm*50cm are casted for determining flexural strength. Test on beams are performed at the age of 7, 14, 28 days of the specimen. Placement of specimen in machine is done as per IS: 516-1959 in the clause no 8.3.1 page no 17. Load is applied at increasing rate of 108KN/min. Load is applied until specimen fails and load at which specimen fails is recorded. As specified in the IS code flexural strength is calculated.

Fig. 1 Tested beam analysis

3. SPLIT TENSILE STRENGTH

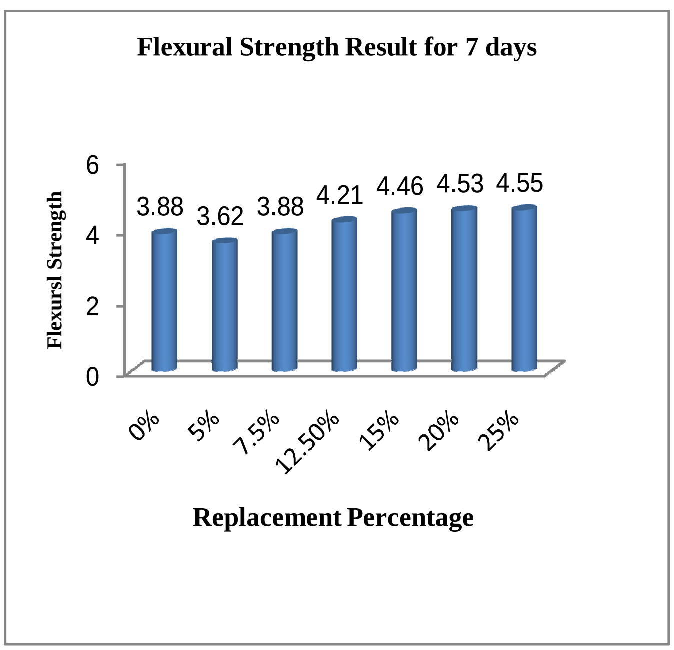
Cylinders of size 15 cm diameter and 30 cm height are casted for determining Split Tensile Strength. Test on cylinders are performed at the age of 7, 14& 28 days of the specimen. Placement of specimen in machine is done as per IS: 516-1959. Load is applied until specimen fails and load at which specimen fails is recorded. As specified in the IS code Split Tensile Strength is calculated.

Fig. 2 Tested Cylinders Analysis

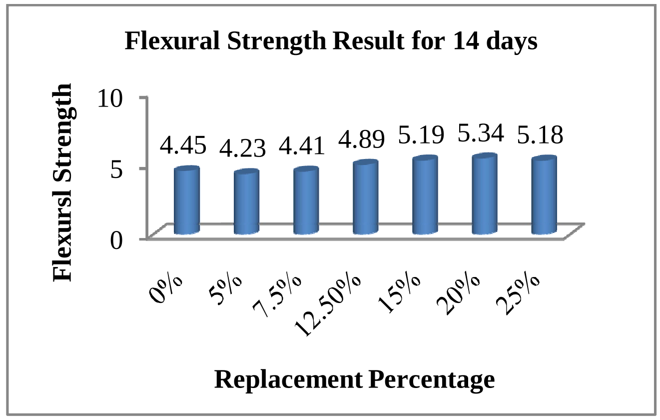
III. RESULT & DISCUSSION

Table 3 Flexural Strength Test

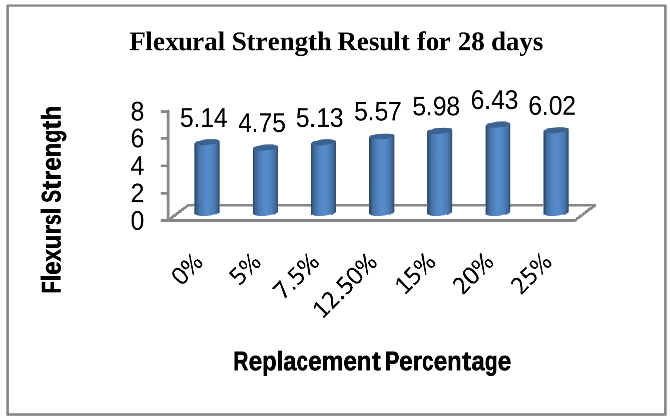
Mix	% Replacement	Compressive Strength (N/mm^2)		
		7 days	14 days	28 days
M-1	0	3.88	4.45	5.14
M-2	5	3.62	4.23	4.75
M-3	7.5	3.88	4.41	5.13
M-4	12.5	4.21	4.89	5.57
M-5	15	4.46	5.19	5.98
M-6	20	4.53	5.34	6.43
M-7	25	4.35	5.18	6.02



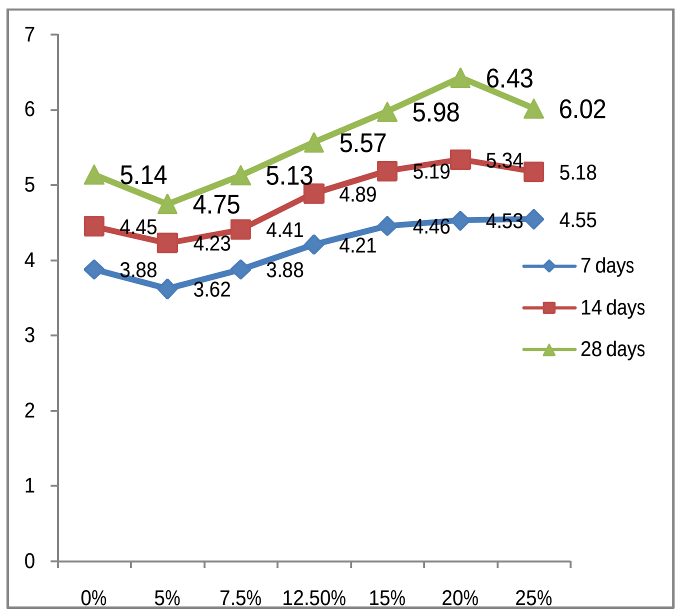
Graph: 1 Flexural Strength at 7 days



Graph: 2 Flexural Strength at 14 days



Graph: 3 Flexural Strength at 28 days



Graph: 4 Flexural Strength in N/mm2 at various age (Days)

As shown in the graph: (7 days strength), when cement is partially replaced 20% by SF i.e. Mix-06, flexural strength is increased by 20%. Afterwards when % of SF is increased the strength starts decreasing.

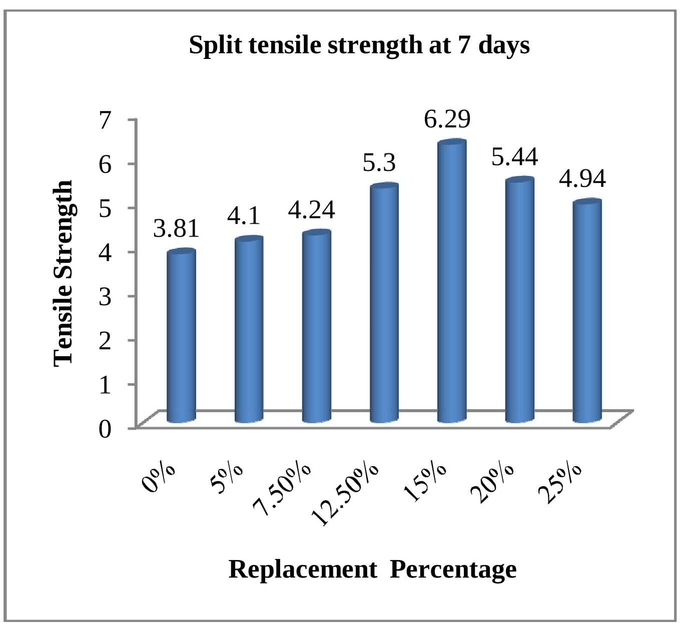
When (14 days strength) is analyzed, 20% replacement of silica gives 25.39% more flexural strength when compared with normal concrete. Here also, when % of SF is increased, strength starts decreasing.

28 days strength in graph: 7 shows an increment of 22.10% of strength of 20% replacement of silica fume as compared with conventional concrete. Again strength is decreased when % of silica fume is increased.

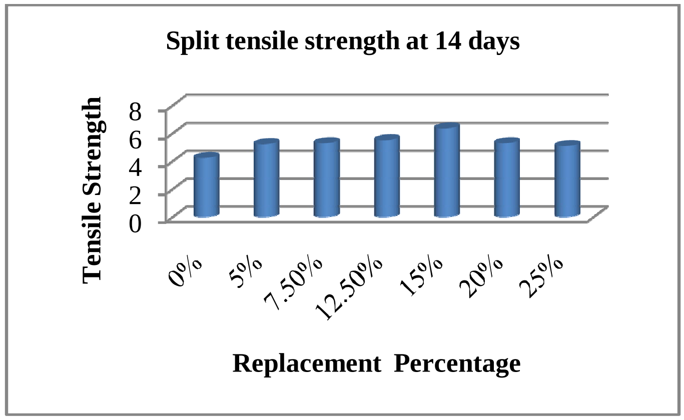
As discussed here, it can be said that an increment in compressive strength of 20% replacement of silica fume nearly 25% is achieved as compared with conventional concrete mix.

Table 4 Split Tensile Strength Test

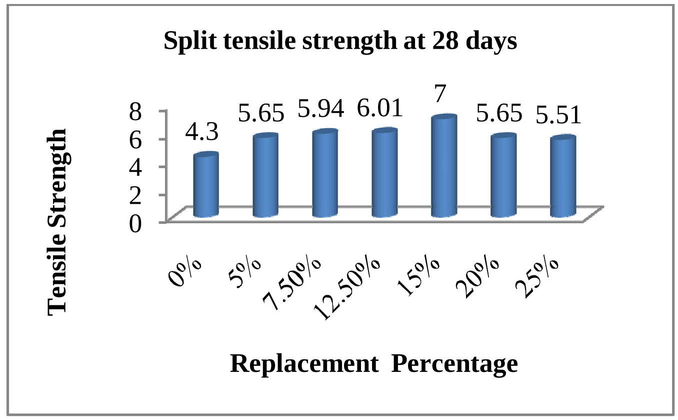
Mix	% Replacement	Compressive Strength (N/mm^2)		
		7 days	14 days	28 days
M-1	0	3.81	4.24	4.31
M-2	5	4.1	5.23	5.65
M-3	7.5	4.24	5.3	5.94
M-4	12.5	5.30	5.51	6.01
M-5	15	6.29	6.36	7.00
M-6	20	5.44	5.30	5.65
M-7	25	4.94	5.09	5.51



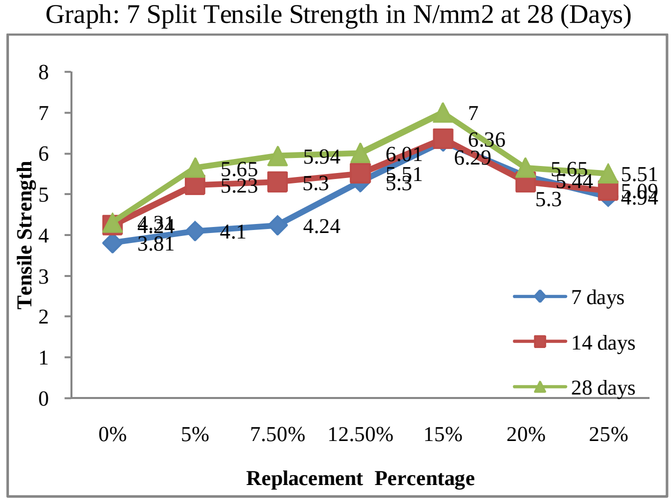
Graph: 5 Split Tensile Strength in N/mm^2 at 7 (Days)



Graph: 6 Split Tensile Strength in N/mm2 at 14 (Days)



Graph: 7 Split Tensile Strength in N/mm2 at 28 (Days)



Graph: 8 Split Tensile Strength in N/mm2 at various age (Days)

As shown in the graph: 9 (7 days strength), when cement is partially replaced 15% by SF i.e., Split Tensile strength is increased by 38%. Afterwards when % of SF is increased the strength starts decreasing

When graph: 10 (14 days strength) is analyzed, 15% replacement of silica gives 42.39% more Split Tensile strength when compared with normal concrete. Here also, when % of SF is increased, strength starts decreasing.

28 days strength in graph: 11 shows and increment of 45.58% of strength of 15% replacement of silica fume as compared with conventional concrete. Again strength is decreased when % of silica fume is increased.

As discussed here, it can be said that an increment in compressive strength of 15% replacement of silica fume nearly 45% is achieved as compared with conventional concrete mix

IV. CONCLUSION

After performing all the tests and analyzing their result, the following conclusions have been derived:

1. The results achieved from the existing study shows that silica fumesare great potential for the utilization in concrete as replacement of cement.
2. Maximum split tensile strength was observed when silica fume replacement is about 20%.
3. Workability of concrete decreases as proportion of silica fumes increases.
4. Maximum flexural strength was observed when silica fume replacement is about 15%.

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