Analysis of Strength And Durability Parameters of Concrete By Replacement of Cement With Silica Fume

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Abstract- *The construction activities in last few decades have increased many folds in almost all the developing countries of the world. Cement is becoming a scarce commodity globally because of its growing demand day by day. It is the need of time to search such alternatives materials that would partially or fully replace cement used in concrete and mortars without affecting its quality, strength and other characteristics. The use of supplementary cementitious materials (SCMs) or non-conventional material is vital in developing low cost construction by addition of some pozzolanic materials, the various properties of concrete viz., workability, durability, strength. Silica fume is by product resulting from the reduction carbothermic of high-purity quartz with coal or coke and wood chips in an furnace during the production of silicon metal or silicon alloys. silica fume is known to improve both the mechanical properties and durability of concrete.*

This paper presents a detailed experimental study on compressive , split tensile and flexural strength at age of 7,14,28 days. Durability study on acid attack was also studied and % of weight loss is compared with normal concrete. Test results indicate that use of silica fume in concrete has improved the performance of concrete in strength as well as durability aspect.

Keywords- silica fume compressive strength split tensile strength flexural strength durability

I. INTRODUCTION

The increasing scarcity of raw materials and an urgent need to protect the environment against pollution has accentuated the significance of developing new building materials based on industrial wastes. Silica fume is one such waste generated from Ferrosilicon industries and is creating unmanageable disposal and utilization problems due to its potential to pollute the environment. Silica fume has a good potential to be used in the preparation of inexpensive building materials. This is available at minimum cost in many places and is suitable as replacement for expensive cement, it can be utilized intensively in concrete to achieve economy in building construction.

The production of Ordinary Portland Cement (OPC), the main ingredient in normal concrete unfortunately, emits vast amounts of carbon-dioxide gas into the atmosphere which has major contributions to greenhouse effect and thereby causing global warming; hence it is obvious to use either alternate or other materials as part replacement. Some alternate or supplementary pozzozlanic materials like Fly ash, silica fume, Rice husk ash, Ground Granulated Blast furnace Slag, and High Reactive Metakaolin can be used for cement as partial replacement in concrete and should lead to global sustainable development and lowest possible environmental impact and energy saving. The use of pozzolonas in concrete and mortar was started with the view to reduce the cost, overcome the adverse effect of OPC and utilize waste materials and by products of industrial activities which were providing harmful to environments, natural resources etc. Also, the use of pozzolonas improve several properties of mortar and concrete viz. workability, strength, resistance to cracks, permeability and durability. Further the use of pozzolonas has resulted in the production of high performance concrete.

II. EXPERIMENTAL INVESTIGATION

1. MATERIALS

a) Cement –

Ordinary Portland cement of Birla Super Cement of 53 grade confirming to IS:12269-1987 was used in the present study. Properties of cement are –

1) Specific Gravity = 3.15
2) Initial Setting Time = 37 mins

b) Fine Aggregate-

Natural sand as per IS 383-1987 was used. Locally available river sand was used. The properties of fine aggregate are shown in table

Table 1.

Sr.No	Property	Result
1	Specific gravity	2.63
2	Fineness modulus	3.686
3	Greading zone	1

c) Coarse Aggregate –

Crushed aggregate confirming to IS 383-1987 was used. Aggregates of size 20mm and 12.5mm of specific gravity 2.49 used.

d) Silica Fume –

Silica fume used was confirming to ASTM- C(1240-2000) and was supplied by OSWAL INDUSTRIES. The silica fume is used as a partial replacement of cement. The properties of silica fume are shown in table below.

Table2.

Specific gravity	1.94
Size	0.1 Micron
Surface area	20000 m^2/kg
SiO_2	(90-96) %
Al_2O_3	(0.5-0.8) %

*As per manufacturers manual

2. Mix Proportioning

All the specimens were prepared using design mix M30 grade of concrete As per Indian Standard Recommended Method Of Concrete Mix Design (IS 10262-1982) .the following quantities shows quantities for 1 M3.

CEMENT = 450 kg
WATER = 191.58 lit.
FINE AGGREGATE = 665.1007 kg
COARSE AGGREGATE = 1027.3989 kg
WATER CEMENT RATIO = 0.40

III. EXPERIMENTAL PROCEDURE

All the specimens were casted using appropriate materials in quantities and water-cement ratio as per mix design calcultions .The materials were mixed by hand mixing and filled in moulds which were then compacted using vibrators. after 24 hrs the specimens were demoulded and placed in curing tank for curing up to 28 days.

After 7, 14 and 28 days respective testings were done and results were calculated.

For durability test the cubes were weighed again cured for 31 days with 5 % dilute hydrochloric acid solution. after 31 days the cubes were agained weighed and tested for compression.

1. FOR COMPRESSIVR STRENGTH – 24 CUBES OF (150 X150 X150) mm
2. FOR SPLIT TENSILE STRENGTH – 24 CYLINDERS OF (D=150 mm & H= 300 mm)
3. FOR FLEXURAL STRENGTH - 4 BEAMS OF (150 x 150 x 700) mm
4. FOR DURABILITY – ACID RESISTANCE TEST – 4 CUBES OF (105 X 150 x 150)

IV. TEST RESULTS AND DISSCUSSIONS

1. COMPRESSIVE STERNGTH

Table 3.

% REPLACEMENT OF CEMENT WITH SILICA FUME	**COMPRESSIVE STRENGTH OF CONCRETE (N/mm^2)**		
	7 DAYS	**14 DAYS**	**28 DAYS**
0 %	**19.775**	**32.885**	**33.995**
10%	**23.244**	**36.22**	**44.22**
20%	**24.64**	**25.995**	**35.33**
30%	**13.33**	**19.775**	**31.775**

Compressive strength variation

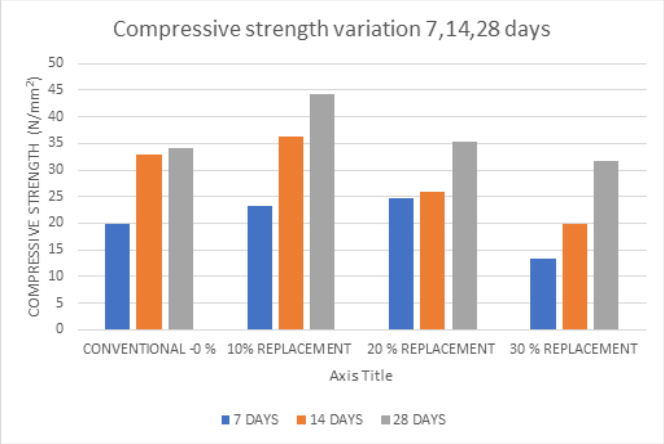

Figure 1.

Compressive strength

As we have casted cubes using M30 mix design the compressive strength of cubes without any replacement of cement i.e. conventional concrete is 33.995 MPa and by replacing cement with silica fume with percentage variation 10%, 20% and 30% respectively we get 28 days strength as 44.22,35.33 and 31.775 Mpa.

It shows that 10% replacement gives much more strength than normal concrete and upto 20% replacement we get strength more than conventional but as we replace 30% cement the strength gets reduced, which is much less than even conventional concrete also.

In case of 20% replacement 7 days strength is higher than normal and 10 % but at end of 14 & 28 days strength does not increase that much it becomes less than 10% and normal concrete.

Therefore optimum range for replacement of cement with silica fume is 10-20 %

SPLIT TENSILE STRENGTH –

Table 5.

% REPLACEMENT OF CEMENT WITH SILICA FUME	SPLIT TENSILE STRENGTH OF CONCRETE (N/mm^2)		
	7 DAYS	14 DAYS	28 DAYS
0 %	2.192	2.458	2.678
10 %	2.510	2.330	2.759
20 %	2.793	1.981	2.110
30 %	1.378	1.346	1.769

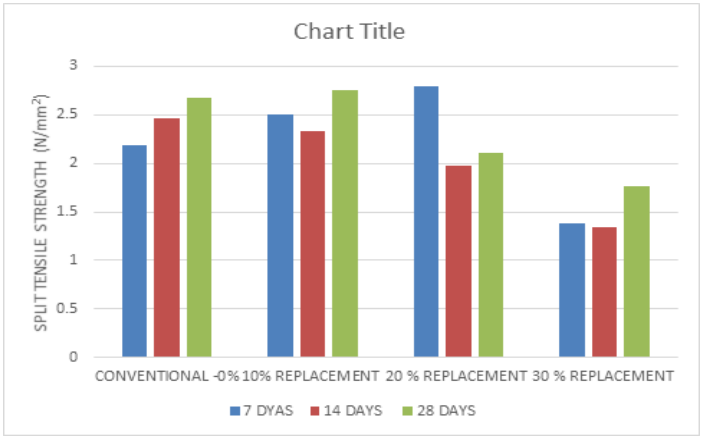

Figure 2.

Split tensile strength –

As we have casted cylinders using M30 mix design the split tensile strength of cylinders without any replacement of cement i.e. conventional concrete is 2.678 MPa and by replacing cement with silica fume with percentage variation 10%, 20% and 30% respectively we get 28 days strengths as 2.759 , 2.110 and 1.769 MPa.

In case of split tensile strength for 10% replacement strength is more than normal concrete but in case of 20 % and 30 % strength get reduced.

Same as in case of compressive strength the results for 20 % replacement at
7 days testing are more than normal and 10 % but at end of 14 & 28 days strength get reduced.

Split tensile strength results aslo shows that optimum replacement range of cement with silica fume is 10-20 %.

2. DURABILITY TEST -ACID RESISTANCE

The action of acids on concrete is the conversion of calcium compounds into calcium salts of the attacking acid. This reactions destroy the concrete structure. The % of loss in compressive strength was 16.33,11.25,12.56,13.56 respectively. Thus replacement of silica fume is found to have increased the durability against acid attack. This is due to the

silica present in silica fume which combines with calcium hydroxide and reduces the amount susceptible to acid attack.

Table 6.

SR.NO.	SILICA FUME %	LOSS IN WEIGHT (%) AT 30 DAYS	LOSS IN COMPRESSIVE STRENGTH (%) AT 30 DAYS
1.	0	1.528	16.33
2.	10	1.142	11.25
3.	20	2.093	12.56
4.	30	1.628	13.56

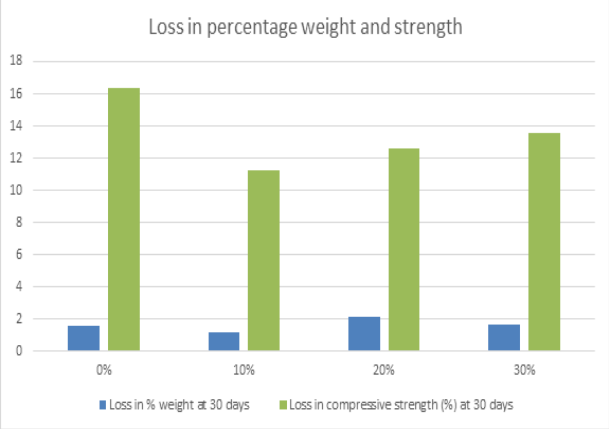

Figure 7 the batching of the products of size 17 response of the system

This variation of % loss in weights and strength of concrete at end of 31 days shows that % loss in strength and weight of 10 % replacement is less than conventional concrete out of 10 % ,20 % and 30% replacement.

And hence it shows that in case of durability of concrete the opimum range for replacement of cement with silica is 10-20 %.

V. CONCLUSION

The optimum 7 , 14 and 28 days compressive strength and flexural strength have been obtained in the range of 10 -20% silica fume replacement level. In case of split tensile strength for 10% replacement strength is more than normal concrete but in case of 20 % and 30 % strength get reduced. When compared to other mix the loss weight and compressive strength % was found to be reduced by 1.142 & 11.25 when the cement was replaced by 10 % of silica fume.

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