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Experimental Investigation of Silica Fume based Concrete of M25 Grade

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Abstract: ***To ordinary Portland cement concrete many binder materials are used to increase the properties. Here I am using Silica fume as a binder to ordinary Portland cement concrete as it the strength properties, physical and chemical properties, bond strength, etc.***
The research describes the importance of silica fume based concrete and its effects on the concrete properties.
Since, concrete is used everywhere for construction we need to look a way to reduce the cost of building materials and increase the life span of a structure.
Silica fume is replaced in 0, 3, 6, 9, 12 and 15% with weight of cement and casted cubes, cylinders and beams to find the compressive strength, tensile strength and flexural strength respectively. Proper introduction of silica fume in concrete improves both the mechanical and durability characteristics of the concrete and on fresh concrete too.
Keywords: silica fume, cement, compressive strength, split tensile strength, flexural strength.

I. INTRODUCTION

Since we know that silica fume, fly ash, copper slag, etc are waste materials that cause environmental problems. So reuse of this materials from industries have been increased, this materials can be used to produce new products or can be used as admixtures so that natural resources are used more effectively and can protect environment from this waste materials.
Silica fume is produced by a byproduct of silicon metal or ferrosilicon alloy. Silica fume is mostly used in replacement of cement as a binder.
Because of its chemical and physical properties, it is very reactive pozzolan. Concrete containing silica fume contain high strength when it is mixed in concrete and is durable too. The physical composition of silica fume diameter is about 0.1 micron to 0.2 micron and surface area is about 30,000 m^2/kg.
Silica fume improves the long term corrosion resistance and alkali silica increases expansion but also increases the carbonation of depth and reduces heat of hydration.

II. LITERATURE REVIEW

Abhinav shyam, et. al. (2017) study reveals that there is a significant change in strength properties of concrete. This experiment was carried out in various grade concrete to find out the results. From 5% to 15% replacement of silica fume there is improvement in strength of concrete.
Amudhavalli & Mathew (2012) observed that the strength and durability characteristics of silica fume based concrete. The main parameter investigated in this study id M35 grade concrete with partial replacement of 0, 5, 10, 15 and 20%. A detailed experimental study in compressive strength, split tensile strength and flexural strength at age of 7 days and 28 days was carried out. Results show that silica fume in concrete has improved the performance of concrete in strength as well as in durability aspect.
Dilip Kumar Singha Roy, et. al. (2012) observed that silica fume concrete is more compact and thereby more durable in nature and hence with some degree of quality, it may be used in places constructed where there is chance of a chemical attack, frost action, etc.
Faseyemi victor ajileye (2012) studied that when cement is replaced with silica fume the strength of concrete has been increased from 16.15% to 29.24%. both the physical and chemical properties of concrete are increased.
V. Bhikshma, et. al. (2009) observed that there is an increase in Young's modulus of concrete as silica fume content increases. This increase is up to a replacement level of 12%. Workability decreases as the replacement of silica fume increases and the water consumption will be more for higher replacements.

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III. METHODOLOGY

The methodology used for this experiment comprised of both preliminary and experimental investigation. These are presented as follow:

A. Preliminary Investigation

For the preliminary investigation, silica fume, cement, fine aggregate and coarse aggregate were subjected to physical and chemical analysis to determine whether they are useful for the experiment standards.

The experiment program was designed to investigate silica fume as partial replacement of cement in concrete. The replacement levels are selected as 3, 6, 9, 12, and 15% for the standard size of cubes, cylinders and beams.

The experimental investigation is done on materials used in this experiment. The other materials used in this experiment are:

1) *Cement:* Ordinary Portland cement of 53 grade is used. The specific gravity of cement is 3.04. The cement is conformed to the requirement of BIS 12 (1996).

Table 3.1: Properties of cement.

Properties	Observed values
Specific gravity	3.04
Initial setting time	29.8 min
Final setting time	540 min
Consistency of cement	28%

2) *Aggregates:* There is the insert filler in the concrete mixture which constitute between 70 – 75% by volume of the whole mixture. Natural river sand with specific gravity of 2.65 and 20mm and lesser size aggregates having specific gravity of 2.75 is used.

Table 3.2: Properties of Aggregates.

Properties	Observed values
Specific gravity of fine aggregate	2.65
Fineness modulus	2.28
Water absorption of fine aggregate	1%
Specific gravity of coarse aggregate	2.75
Bulk density	1650 Kg/m^3
Fineness	7.54
Water absorption	1.25%
Partial shape	Angular

3) *Water:* The water used for the experiment was free of acids, organic matter, suspended solids, alkalis and impurities. P^H results of water used in experiment are 6.5.

4) *Super Plasticizer:* Conplast SP430 is used where a high degree of workability and its retention is required, where delays in transportation or placing are likely in transportation or placing are likely. It facilitates the production of high quality concrete.

Table 3.3: Properties of Super plasticizer.

Properties	Observed Values
Specific gravity	1.220 to 1.225
Chloride content	Nil as per IS 456
Appearance	Brown liquid

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B. Experimental Investigation

For compressive strength of concrete, cube moulds of size 150mm x 150mm x 150mm are used. For split tensile strength of concrete, cylinder moulds of size 150mm diameter x 300mm height are used. For flexural strength of concrete, beam moulds of size 100mm x 100mm x 500 mm are used. These moulds were casted with silica fume based concrete are rested the concrete in moulds for 24 hours and later de molded it and cured them in water. The test for cubes, cylinders and beams were carried out on 7^{th} day and 28^{th} day.

1) Mix Proportion: Mix proportion used to cast the moulds is 1:1.43:2.53:0.36. The super plasticizer used as 2% in water replacement.

Table 3.4: Mix proportion for M25 grade concrete

Water cement ratio	0.36
Water content	157728 Kg/m^3
Cement content	438.13 Kg/m^3
Silica fume-15%	65.719 Kg/m^3
Coarse Aggregate	1108 Kg/m^3
Fine Aggregate	627 Kg/m^3
Chemical Admixture	3.50 Kg/m^3

IV. TEST RESULTS AND DISCUSSION

Initial tests were conducted on both fresh concrete and hardened concrete.

A. Fresh Concrete

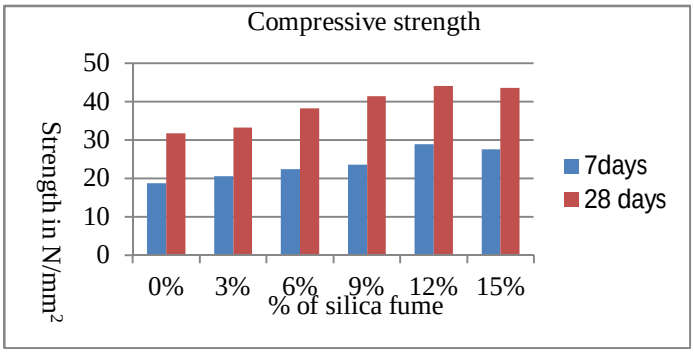
Tests were conducted on fresh concrete and find out that silica fume particles affect the mobility of water within concrete, segregation and bleeding of concrete. Silica fume is more cohesive and less prone to segregation than concrete than normal concrete. It produces very large reduction in water permeability.

B. Hardened Concrete

The tests were carried out conforming to IS 516 – 1959 to obtain compressive strength, split tensile strength and flexural strength:

Table 4.1: Result of Compressive strength.

Mix	% of SF	Compressive strength in MPa	
		7 days	28 days
S_0	0%	18.81	31.70
S_3	3%	20.59	33.20
S_6	6%	22.37	38.28
S_9	9%	23.56	41.47
S_{12}	12%	28.89	44.18
S_{15}	15%	28.44	43.56



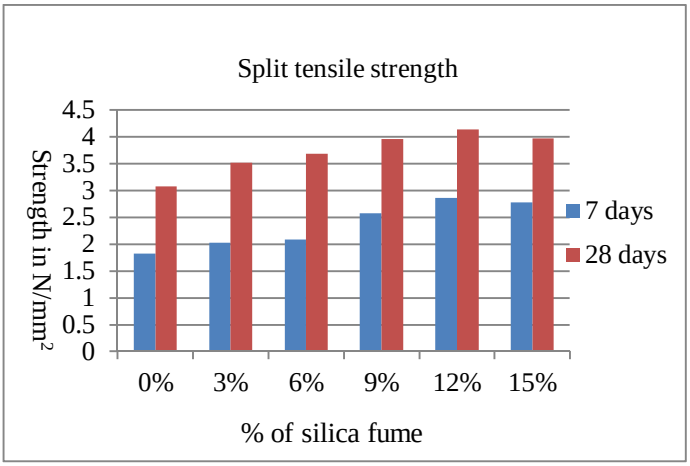
Graph 1: Effect of Silica fume on compressive strength of concrete.

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The above table 4.1 and graph 1 represents the results of compressive strength of cubes for 7 days and 28 days. The result says that there is increase in strength of concrete till 12% replacement of silica fume and decrease in strength at 15%. The test is done in universal testing machine.

Table 4.2: Result of Split tensile strength.

Mix	% of SF	Split tensile strength in MPa	
		7 days	28 days
S_0	0%	1.82	3.08
S_3	3%	2.02	3.52
S_6	6%	2.09	3.68
S_9	9%	2.57	3.96
S_{12}	12%	2.86	4.14
S_{15}	15%	2.78	3.97



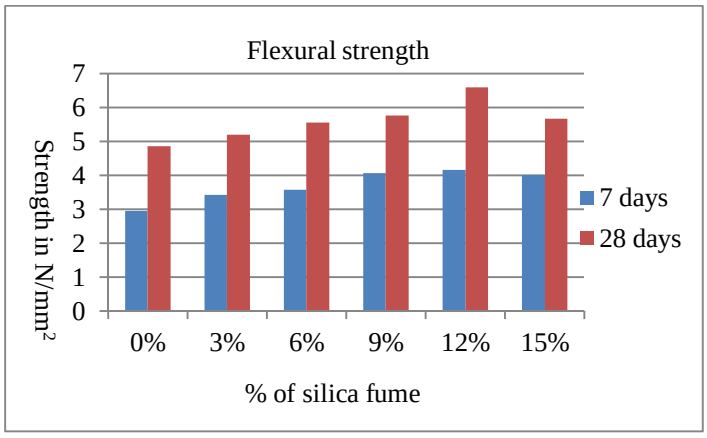
Graph 2: Effect of Silica fume on Split tensile strength of concrete.

The above table 4.2 and graph 2 represents the results of split tensile strength of cylinder for 7 days and 28 days. The result says that there is increase in flexural strength of concrete till 12% and then there is a decrease in strength of concrete at 15%. The test is done in universal testing machine.

Table 4.3: Results of Flexural strength.

Mix	% of SF	Flexural strength in MPa	
		7 days	28 days
S_0	0%	2.96	4.86
S_3	3%	3.43	5.20
S_6	6%	3.58	5.55
S_9	9%	4.07	5.75
S_{12}	12%	4.15	6.58
S_{15}	15%	4.00	5.67

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Graph 3: Effect of Silica fume on Flexural strength of concrete.

The above table 4.3 and graph 3 represents the affect of silica fume on flexural strength of concrete. The result says that there is growth in strength till 12% of silica fume replacement and then decrease in the strength at 15%. The test is done on flexural test machine.

V. CONCLUSION

A. It is concluded that partial replacement of silica fume in concrete increases the properties of concrete not only in fresh state but also in hardened state.

B. The compressive strength increased up to 28.89 MPa and 44.18 MPa at 7 days and 28 days respectively, later the strength decreased.

C. The split tensile strength increased up to 2.86 MPa and 4.14 MPa at 7 days and 28 days respectively, later decreased in strength.

D. The flexural strength also increased up to 4.15 MPa and 6.58 MPa at 7 days and 28 days respectively, later there is decrease in strength.

E. In fresh concrete it decreased segregation and bleeding, and also decreased the permeability.

F. The optimum percentage of silica fume replacement is found to be at 12%.

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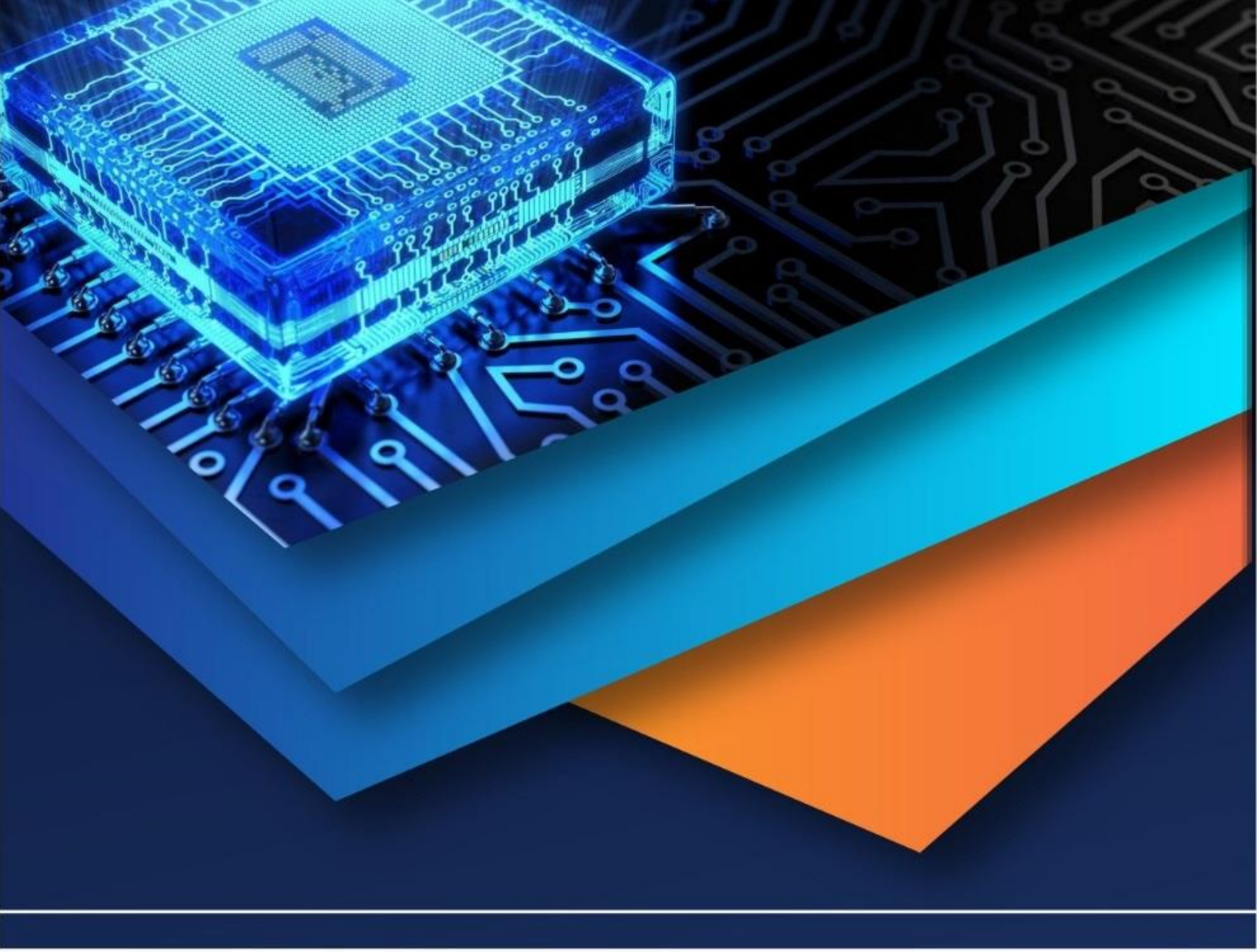
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