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An Experimental Study on Partial Replacement of Cement in Concrete by Using Silica Fume

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Abstract: *The use of silica fume in the present days is to increase the strength of cement concrete. The silica fume was replaced by 0%, 2.5%, 5%, 7.5%, 10%, 12.5%, 15%, 20%, 25% and 30% for 7, 14 & 28 days for M20, M25 and M30 grade of concrete. Casted 150 mm X 150 mm X 150 mm cubes for Compressive strength, 100 mm X 100 mm X 500 mm beams for Flexural Strength, and Cylinder size 150 mm diameter and 300 mm height are casting for Split Tensile Strength and Slump cone for workability of concrete and other properties like compacting factor and slump were also determined for three mixes of concrete. The use of cement and production of cement creates much more environmental issues & costlier. To avoid such circumstances, the content of cement is reduced in concrete and replaced by silica fume which reduces cost & addition silica fume also increases strength. Concrete is the most commonly used and versatile building material which is generally used to resist compressive forces. By addition of some pozzolanic materials, the various properties of concrete viz, workability, Strength, Resistance to cracks and permeability can be improved. Many modern concrete mixes are modified with addition of admixtures, which improve the micro structure as well as decrease the calcium hydroxide concentration by consuming it through a pozzolanic reaction. The subsequent modification of the micro structure of cement composites improves the mechanical properties, durability and increases the service-life properties.*

KEYWORDS: Compressive Strength, Flexural Strength, Split Tensile Strength, Workability of Concrete, and Silica Fume.

I. INTRODUCTION

Concrete is a most frequently 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 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. The use of micro silica as a pozzolana 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

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.

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.

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.

4. Silica Fume: Silica fume is a byproduct in the reduce of high-purity quartz with coke in electric arc furnaces in the manufacture of silicon and ferrosilicon alloys. Micro silica consist of fine element with a surface area on the order of 215,280 ft^2/lb (20,000 m^2/kg) when particular 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 its compressive strength, bond strength, and abrasion resistance. These improvement stems from both the mechanical improvements resulting from addition of a 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. It has been reported that the pozzolanic reaction of silica fume is very important 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	20000m^2/kg
Bulk Modulus	240kg/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%

III. METHODOLOGY:-

The methodology adopted to accomplish the objective of the experimental investigation and execution of work was done in step by step as follow:

1) Weighing- The quantity of all ingredients of the concrete i.e. cement, silica fume, fine aggregate, coarse aggregate and water for each batch was determined as per the mix design ratio and weighed using weighing machine available in laboratory.

2) Mixing- Process of mixing of various ingredients adopted was as per IS: 516-1959 and hand mixing process was adopted for mixing the concrete.

3) Preparation of moulds- Before casting the specimens, all cube, beam and cylinder moulds were cleaned, screwed tightly and oil was applied to all surfaces to prevent adhesion of concrete during casting.

4) Compaction- Placing of concrete in oiled moulds was done in three layers and each layer tamped 25 times with the tamping rod. After tamping the moulds, they were compacted using vibratory machine.

5) Curing- After 24 hours, all the casted specimens were DE moulded from the moulds and marked (to identify the casting batch) and immediately put into the curing tank for a period of 7, 14 and 28 days for different specimens. The specimens were not allowed to become dry during the curing period.

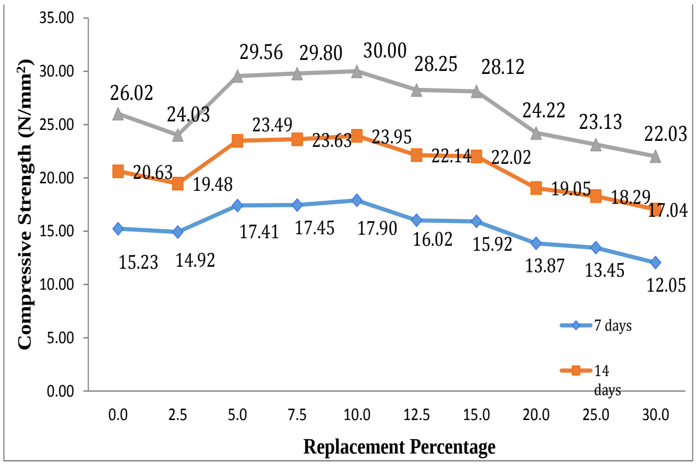
6) Testing- Specimens were taken out from the curing tank after 7, 14 and 28 days to perform various tests. Three numbers of specimens in each sample were tested and the average value was calculated. Fresh concrete property like workability was examined during casting by slump cone test. Hardened properties were found out by carrying out the investigational work on cubes, beams and cylinders which were casted in laboratory and their behaviour under test were observed at 7, 14 & 28 days for compressive strength, flexural strength and split tensile strength.

IV. RESULS AND DISCUSSION:-

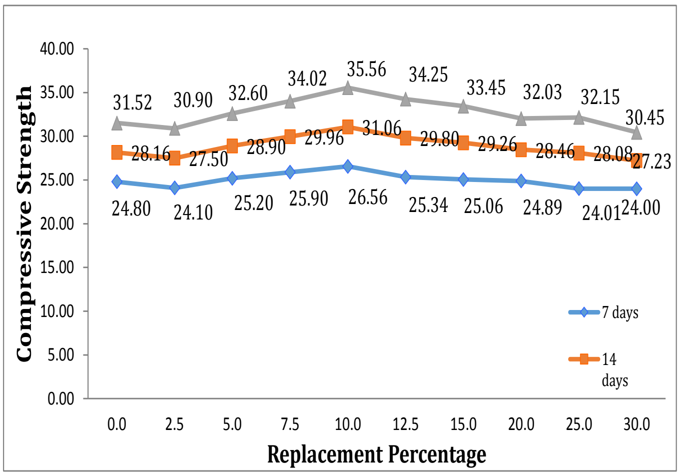
All work is carried out in single stages, result of all stage is presented in graphical form. Tests are performed on cubes, beams & cylinders and their 7 days, 14 days & 28 days strengths have been determined. A comparison of strengths for 7 days, 14 days and 28 days are also formulated.

1. Compressive Strength:-

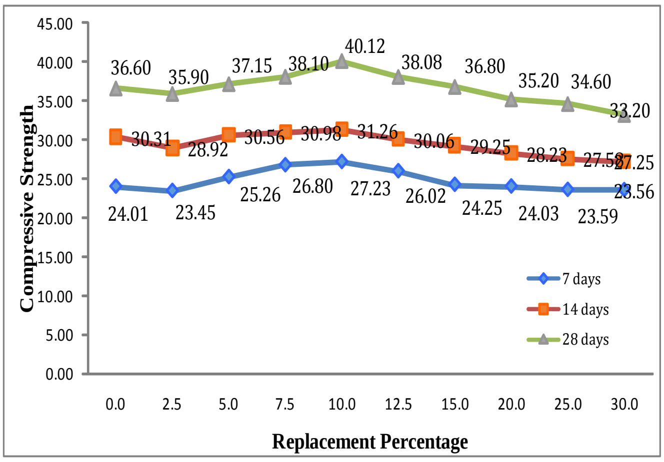
The results of the compressive strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The compressive strength test were conducted at curing ages of 7, 14, and 28, days. Variation of compressive strength of all the mixes cured at 7, 14, and 28, days are also shown in Graphswhich shows the variation of compressive strength of concrete mixes w.r.t control mix (100% OPC + 0% SF) after 7, 14, and 28, days respectively.



Graph: 1 Compressive Strength in N/mm² at various ages for M20



Graph: 2 Compressive Strength in N/mm² at various ages for M25

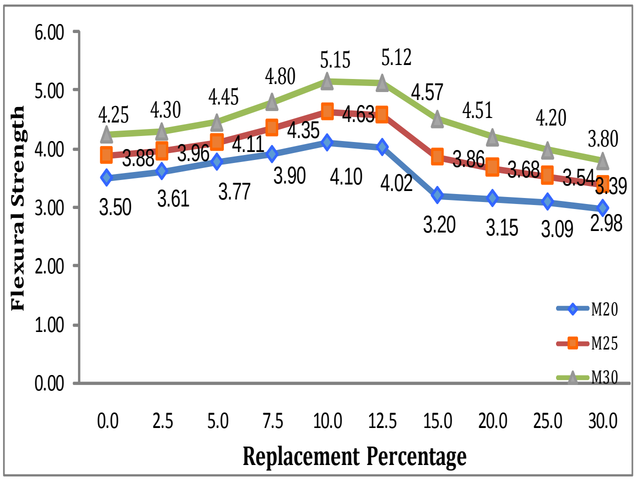


Graph: 3 Compressive Strength in N/mm² at various ages for M30

Graph 1, 2 and 3 are shows that there is an increase in compressive strength with the increase in silica fume percentages upto 10%, thereafter there is a decrease in compressive strength with further increase in silica fume in all the curing ages of concrete. The results of compressive strength for M25 concrete and M30 are given in graph. The variation of compressive strength with percentages silica fume is shows in Graph 2 and Graph 3 for M25 and M30 concretes.

2. Split Tensile Strength:-

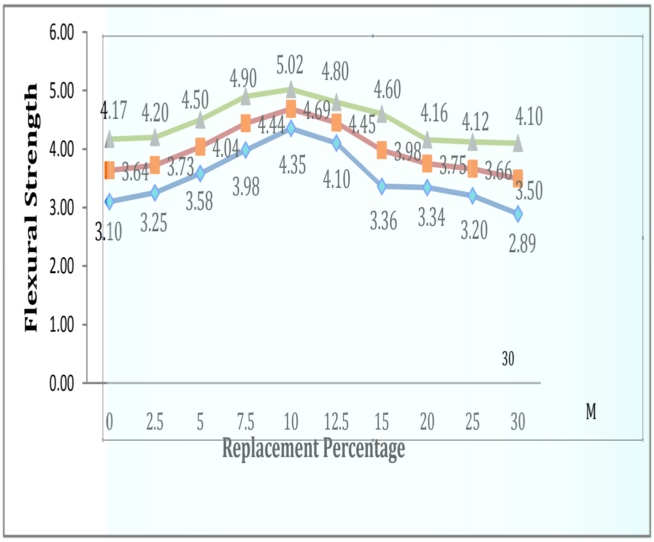
The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 28 days..Variation of splitting tensile strength of all the mixes cured at 28 days is also shown in graph.



Graph: 4 Split Tensile Strength in N/mm² at 28 days

3. Flexural Strength:-

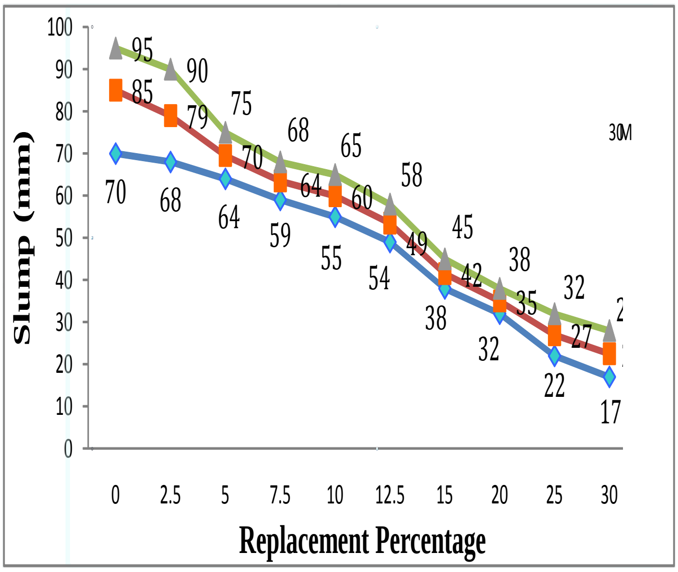
The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 28 days. The splitting tensile strength test results of all the mixes at different curing ages are shown in graph. Variation of splitting tensile strength of all the mixes cured at 28 days is also shown in graph 5, it shows the variation of splitting tensile strength of concrete mixes with respect to control mix (90% OPC + 0% SF) after 28 days respectively.



Graph:- 5 Flexural Strength in N/mm² at 28 Days

4. Workability of Concrete Mixes:-

The workability of concrete mixes was found out by slump test as per procedure given in chapter 3. Water cement ratio (W/C) was kept constant 0.5 for all the concrete mixes. The workability results of different concrete mixes were shown in Graph 6.



Graph 6 Slump (mm) at 28 days

V. CONCLUSION

The following conclusion is made from the detailed experimental investigations conducted on the behaviour of normal grade concrete.

Compressive strength, Flexural strength, Split tensile strength and Durability test of concrete

Mixes made with and without silica fume has been determined at 7, 14, & 28 days of curing. The strength gained has been determined of silica fume added concrete with addition of 2.50%, 5%, 7.5%, 10%, 12.5% 15%, 20%, 25% & 30% for M20, M25 and M30 grade as a partial replacement of cement in conventional concrete. From the results it is conclude that the silica fume is a superior replacement of cement. The rate of strength increase in silica fume concrete is high. After performing all the tests and analysing their result, the following conclusions have been derived:

1. The results achieved from the existing study shows that silica fume is great potential for the utilization in concrete as replacement of cement.

2. Workability of concrete decreases as proportion of silica fumes increases.

3. Maximum compressive strength was observed when silica fume replacement is about 10%.

4. Maximum split tensile strength was observed when silica fume replacement is about 10%.

5. Maximum flexural strength was observed when silica fume replacement is about 10%.

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