JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Compressive Strength of Concrete by Replacing Cement with Silica Fume for M30 Grade

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Abstract:

In this research paper, the effect of replacing cement with silica fume on the compressive strength of M30 grade concrete was investigated. Silica fume, a highly pozzolanic material obtained as a byproduct of silicon and ferrosilicon alloy production, was used as a partial replacement of cement at different levels ranging from 5% to 20 by weight. Concrete cubes were cast and tested for compressive strength at curing ages of 7 and 14 days. The results showed that the addition of silica fume improved the compressive strength of M30 grade concrete, with the highest increase observed at the 15% replacement level. The improvement was most significant at early curing ages, attributed to the pozzolanic reaction of silica fume that enhances hydration and results in denser and stronger concrete. The research also evaluated the effect of silica fume on other properties such as workability, water absorption, and porosity, and found slight reductions in workability but improved durability and resistance to permeability in silica fume-blended concrete. The results suggest that silica fume can be effectively used as a partial replacement of cement in M30 grade concrete to enhance its compressive strength and durability, with the optimum replacement level depending on local factors and conditions

Keywords: Compressive strength, Concrete, Silica fume, Partial replacement, M30 grade

Introduction:

Concrete is one of the most widely used construction materials due to its versatility, durability,and relatively low cost. The compressive strength of concrete is a key parameter that determines its ability to withstand loads and perform in structural applications. In recent years, there has been increasing interest in the use of supplementary cementitious materials to improve the properties of concrete, including its strength and durability.

Silica fume, also known as micro silica, is a byproduct of the production of silicon and ferrosilicon alloys. It is an ultrafine powder with high pozzolanic activity, which makes it a suitable candidate for use as an SCM in concrete. Silica fume reacts with calcium hydroxide, a byproduct of cement hydration, to form additional calcium silicate hydrate (CSH) gel, which contributes to the strength and densification of the concrete matrix.

The M30 grade of concrete is commonly used in various structural applications, such as in the construction of buildings, bridges, and highways. It is important to investigate the effect of replacing cement with silica fume on the compressive strength of concrete in the M30 grade range, as it can have significant implications for the performance and durability of suchstructures.

Experimental Procedure:

The experimental program involved casting a total of 24 concrete cubes of size 150 mm x 150 mm x 150 mm. Six different concrete mixtures were prepared with varying proportions of silica fume as a partial replacement for cement. The replacement levels of silica fume wereselected as 0%, 5%, 10%, 15%, and 20% of the total cementitious content. The control mixture without silica fume was also prepared for comparison. The materials used in the experimental program included ordinary Portland cement (OPC), fine aggregate, coarse aggregate, water, and silica fume.

Materials: The required strength or target strength of concrete can be obtained by careful selection of ingredients, correct grading of ingredients, accurate water measurements and adopting a good workmanship in mixing, transporting, placing, compacting, finishing and curing of concrete in the construction work. The properties of material used for making the concrete mix are determined in laboratory as per relevant codes of practice. Different materials used in present study were cement, coarse aggregates, fine aggregates, water and silica fume. The aim of studying of various properties of materials is used to check the appearance with codal requirements and to enable an engineer to design a concrete mix for a particular strength.

Cement: Ordinary Portland Cement of Ultratech brand of 43 grade confirming to IS 4031-1988 was used in the present study.

Standard consistency test of cement 30%

Initial and final setting time of cement 45min&180minFineness of cement 87%

Test for soundness of cement 10%

Fine Aggregate :

TEST OF FINE AGGREGATE RESULT

Bulking of fine aggregate was found max. height 375 mm and bulking 25% and sieve analysis of fine aggregate fineness modulus 2.508

COMPRESSIVE STRENGTH TEST

Compressive strength is the ability of material to carry the load on its surface without any crack or deflection. A material under compression tends to reduce size, while in tension size elongates.

The compressive strength of concrete cube test provides an idea about all characteristics of concrete. By this test we can judge that whether concreting have done properly or not.

Compressive strength of concrete depends on many factors such as water-cement ratio, cement, strength, quality of concrete material, quality control during the production of concrete etc. Test for compressive strength is carried out either on a cube or a cylinder.

Procedure for compressive strength test of concrete cubes

For cube test two types of specimens either cubes of 15 cm × 15 cm × 15 cm or 10 cm × 10 cm × 10 cm depending upon size of aggregate are used. For most of works cubical mold of 15 cm × 15 cm × 15 cm are commonly used.

This concrete is poured in the mold and appropriately tempered so as not to have any voids. After 24 hours, molds are removed, and test specimens are put in the water for curing. The top surface of the specimen should be made even and smooth. This is done by cement paste and spreading smoothly on the whole area of the specimen.

These specimens are tested by Universal Testing Machine after 7 days curing, 14 days curing or 28 days curing. Loads should be applied gradually at the rate of 140 kg/cm^2 per minute till the specimens fails. Load at the failure divided by cross-sectional area of specimen gives the compressive strength of concrete.

Mixing of concrete for cube test

Mixing of concrete has done by hand in laboratory and following steps are taken:

Mix the cement and fine aggregate on a watertight none-absorbent platform until the mixture is thoroughly blended and is of uniform color.

Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch.

Add water and mix it until the concrete appears to be homogeneous and of the desiredconsistency.

Sampling of Cubes for Test

Clean the moulds and apply oil.

Fill the concrete in the molds in layers approximately 5 cm thick.

Compact each layer with not less than 35 strokes per layer using a tamping rod(steel bar 16 mm diameter and 60 cm long, bullet-pointed at lower end).

Level the top surface and smoothen it with a trowel.

Curing of Cubes

The test specimens are stored in moist air for 24 hours after this period the specimens are marked and removed from the molds and kept submerged in clear freshwater until taken out prior to the test.

Precautions for Tests

The water for curing should be tested every 7 days and the temperature of the water must beat 27 ± 2 ℃.

Procedures for Concrete Cube Test

Remove the specimen from the water after specified curing time and wipe out excess waterfrom the surface.

Take the dimension of the specimen to the nearest 0.2mClean the bearing surface of the testing machine

Place the specimen in the machine in such a manner that the load shall be applied to theopposite sides of the cube cast.

Align the specimen centrally on the base plate of the machine.

Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
Apply the load gradually without shock and continuously at the rate of 140 kg/cm^2/minutetill the specimen fails

Record the maximum load and note any unusual features in the type of failure.

Results and Discussion

Replacement of cement by silica fume (%)

Replacement of cement with silica fume (%)	Compressive Strength in Days (N/mm^2)		
	7	14	28
0	28.22	35.28	39.20
5	28.60	36.36	40.86
10	28.93	36.48	41.94
15	28.66	35.52	40.37
20	27.49	32.77	37.68

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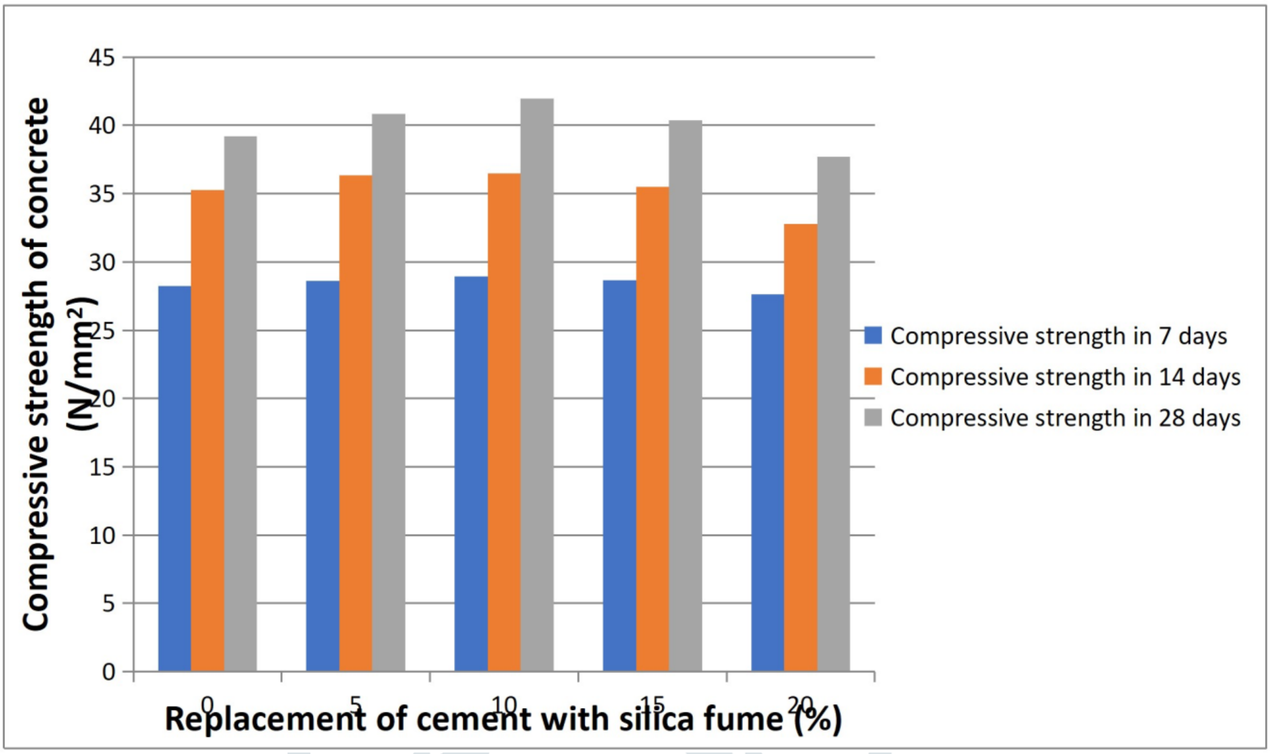

Compressive strength of M30 grade of concrete increased for 5%, 10%, replacement of cement with silica fume. As we increased further replacement of cement 15%, 20%, compressive strength of M30 grade concrete starts decreasing.

Based on the findings of this project, it can be concluded that the replacement of cement with silica fume in concrete mixtures can result in improved performance in terms of strength, durability, and workability. However, the optimal replacement level of silica fume may vary depending on the specific requirements of the concrete mix and project specifications. Further research and experimentation may be needed to optimize the use of silica fume in different types of concrete applications. Overall, the use of silica fume as a supplementary cementitious material has the potential to enhance the performance of concrete and contribute to sustainable construction practices.

Conclusion:

From the above study conclusion can be drawn

1. Compressive strength of M30 grade of concrete increased on replacement of cement with silica fume.
2. The addition of silica fume to concrete mixtures is a commonly used strategy to enhance performance in terms of strength, durability, and sometimes even workability, depending on the specific application and mix design.
3. The use of silica fume as a supplementary cementitious material not only enhances the performance of concrete but also promotes sustainable construction practices by reducing waste, lowering carbon emissions, and improving the longevity of structures.

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