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Comparative Study Of Normal Concrete With Partial Replacement Of Cement With Silica Fume For The Grade Of M50

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ABSTRACT

Concrete is the most important engineering material and the addition of some other materials may change the properties of concrete. With increase in trend towards the wider use of concrete for prestressed concrete and high rise buildings there is a growing demand of concrete with higher compressive strength. Mineral additions which are also known as mineral admixtures have been used with cements for many years. Silica fume or micro silica was initially vied as cement replacement material and in some area it is usually used as replaced by much smaller quantity of silica fume micro silica may be used as Pozzolanic admixtures. Admixture is defined as a material other than cement water and aggregate that is used as ingredient of concrete and is added to the batch immediately before or during mixing. Pozzolanic admixtures are siliceous or aluminous material which is themselves posses little or no cementitious value but will in finely divided form and in the presence of water chemically react with calcium hydroxide liberated on hydration at ordinary temperature to form compounds possessing cementitious properties. ***In our experiment using micro silica an artificial pozzolans and partially replacing cement with silica fume by adding 0%, 5%, 7.5%, 10%, 12.5% by weight of cement in concrete and comparing the compressive strength of normal concrete with silica fume replaced concrete.***

KEYWORDS:, Silica Fume (SF), Compressive strength (CS), Cemcrete SP25 and Universal Testing Machine (UTM), Compressive testing machine (SICCCTM-01).

1. INTRODUCTION

Concrete is the most widely used construction material in the world. In recent years, researchers have focused on the improvement of concrete quality regarding its mechanical and durability properties. These can be achieved by the application of the supplementary cementitious materials.

Out of these supplementary cementitious materials, silica fume is the one of the waste materials that is being produced in tones of industrial waste per year in our country. The first testing of silica fume in Portland-cement-based concretes was carried out in 1952. The biggest drawback to exploring the properties of silica fume was a lack of material to experiment with. Early research used an expensive additive called fumed silica, an amorphous form of silica made by combustion of silicon tetrachloride in a hydrogen-oxygen flame. Silica fume on the other hand, is a very fine pozzolanic material. It is a by-product of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses of silica fume is in concrete. Because of its chemical and physical properties; it is a very reactive pozzolanic material. Concrete containing silica fume has very high strength and is very durable.

Recently Nano Technology has been introduced in Civil Engineering applications. One of the most used nano material is Nano Silica (NS). This is the first Nano product that has replaced the micro silica. The advancement made

silica is much better than silica fume used in conventional concrete. Nano silica possess more pozzolanic nature, it has the capability to react with the free lime during the cement hydration and forms additional C-S-H gel which gives strength, impermeability and durability to concrete.

Balendran, et al(2001) demonstrated the effect of quick and slow cooling on residual compressive strengths of various high strength concrete grades (60, 90, 110, 130 MPa) cured for 28 days with an optimum dosage of micro silica as 10% of cementations material, 10 mm maximum size of coarse aggregate and water binder ratio ranging from 0.5 to 0.24.

Belaoura Mebarek, et al (2013) explained the use of super plasticizers, and ultrafine particles such as silica fume, has significantly minimized the amount of mixing water in concrete while improving workability. Owning to this water reduction (and thus the w/c ratio), the mechanical strength of such concretes has considerably increased. The compressive strength may exceed 80 MPa. Therefore, their use is very promising from an economic point of view and quality of civil engineering an hydraulics works.

Borys and Patrick (2004) completed a study on several ultra-fines used to produce very high performance concrete and ultra-high performance concrete. The ultrafine powders used were metakaolin (MK), pulverized fly ash (PFA), limestone micro filler (LM), siliceous micro filer (SM) and micronized phonolith (PF). Despite a significant higher dosage of super plasticizer in comparison of those with silica fume, the UHPC with metkaolin shows poor workability with a slump of 17 cm. the fluidity of metkaolin blended cement become poorer than that of Portland cement at the same dosage of super plasticizer and the same w/c ratio. The UHPC with pulverized fly ash required significant higher water content. All the compressive strength of UHPC was above 150 MPa at the age of 28 days except for those with pulverized fly ash.

Dilip Kumar Singha Roy (2012) has investigated on the strength parameters of concrete made with partial replacement of cement by SF.

Duval and Kadri (2000) results show that partial cement replacement up to 10% silica fume does not reduce the concrete workability. Moreover, the super plasticizer dosage depends on the cement characteristics. At low water-cementitious materials ratios, slump loss with time is observed and increased with high replacement levels. Silica fume at replacement contents up to 20% produce higher compressive strength than control concretes; nevertheless, the strength gain is less than 15%. Models to evaluate the compressive strength .

Mohammad Reza ZamaniAbyaneh, et al (2013) have found that the concrete produced with Micro-SiO2 and Nano-SiO2 show higher degrees of quality in their compressive strength than the concrete which only have Micro-SiO2 in their mixtures. Specimens with 2% Nano-SiO2 and 10% Micro-SiO2 had less water absorption and more electricace.

2. MATERIALS USED AND THEIR PROPERTIES

In this present investigation materials used are Cement, Fine aggregate, Coarse aggregate, Silica Fume, Super plasticizer.

CEMENT:

Ultra tech cement of ordinary Portland cement (OPC) of 53 Grade was used which satisfies the requirements of IS: 12269-1987.

Table No.1: Properties of Cement

S.N.O	PROPERTIES	RESULTS
1	Normal Consistency	29.50%
2	Specific Gravity	3.0
3	Initial setting time	33 min

FINE AGGREGATE:

locally available sand was used. The sand was conforming to zone IV as per IS: 383-1987. Aggregate passing the 9.5-mm sieve and almost entirely passing the No.4 (4.75-mm) sieve and predominantly retained on the No. 200 (75 µm) sieve.

The volume of fine aggregate depends largely upon its moisture content. When the fine aggregate is moist each particle gets coated with a film of water due to surface tension. The particles are kept separated and hence the volume apparently increases. The increase in volume is known as "Bulking" The amount of Bulking increases initially with increase in water content but decrease to zero with further increase in water content over to bulking, Fine aggregate shows completely unrealistic volume.

Table No.2: Table Showing Properties of Fine Aggregate

S.N.O	PROPERTIES	RESULTS
1	Bulk density (kg/m^3)	1650
2	Specific gravity	2.60
3.	Fineness modulus	2.81
4.	Free surface moisture (%)	2.0

COARSE AGGREGATE:

The crushed aggregate was used from the local quarry. In this experiment the aggregate was used of 20mm down and tested as per IS: 2386-1963(I, II, III) specification.

Fineness modulus. of an aggregate is approximate proportional of the average size of particles in the aggregate. In another words coarse particles of the aggregate having of Fineness modulus is determined by adding the cumulative percentage of material retained on each sieve and dividing the sum of cumulative percentage of material retained on each sieve by100

The properties of coarse aggregate are shown in Table

Table No.3: Showing Properties Of Coarse Aggregate:

S.N.O	PROPERTIES	RESULTS
1	Maximum Nominal size	20mm
2	Bulk density (kg/m^3)	1800
3	Specific gravity	2.67
4	Fineness modulus	4.6

SILICA FUME:

Silica fume, also referred to as micro silica or condensed silica fume, is a by-product material that is used as a pozzolan. This by-product is a result of the reduction of high-purity quartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy. Silica fume rises as an oxidized vapour from the 2000°C (3630°F) furnaces. When it cools it condenses and is collected in huge cloth bags. The condensed silica fume is then processed to remove impurities and to control particle size.

Condensed silica fume is essentially silicon dioxide (usually more than 85%) in noncrystalline (amorphorous) form. Since it is an airborne material like fly ash, it has a spherical shape. It is extremely fine with particles less than 1 µm in diameter and with an average diameter of about 0.1 µm, about 100 times smaller than average cement particles.

Condensed silica fume has a surface area of about 20,000 m^2 /kg (nitrogen adsorption method). For comparison, tobacco smoke's surface area is about 10,000 m2/ kg. Type I and Type III cements have surface areas of about 300 to 400 m2 /kg and 500 to 600 m2/kg (Blaine), respectively.

The relative density of silica fume is generally in the range of 2.20 to 2.5. Portland cement has a relative density of about 3.15. The bulk density (uncompacted unit weight) of silica fume varies from 130 to 430 kg/m3.

Silica fume is sold in powder form but is more commonly available in a liquid. Silica fume is used in amounts between 5% and 15% by mass of the total cementitious material. It is used in applications where a high degree of impermeability is needed and in high- strength concrete.

The silica fume was used in these experiments conforms to ASTM C1240 and IS 15388:2003. The silica fume is extremely fine particle, which exists in white color powder form.

Table No.4:Showing The Properties Of Silica Fume

S.N.O	PROPERTIES	RESULTS
1	Form	Ultrafine amorphous powder
2	Color	White
3	Specific gravity	2.39
4	Pack density	0.76 gm/cc
5	Specific surface	20m^2 /g
6	Particle size	15µm
7	Sio2	99.89%

SUPER PLASTICIZERS:

CEMCRETE SP25 was used for M50 Grade of concrete. The properties of super plasticizer is shown in table

Table No.5: Properties of Super Plasticizer

Color	Brown
Specific gravity	1.20+0.035
Chloride content	Nil to BS 5075 to I.S:456-78
Nitrate content	Nil
Freezing point	0°C
Air entrainment	Maximum 0.5%

3. EXPERIMENTAL PROGRAMME

The experimental program was designed to compare the mechanical properties i.e. compressive strength, split tensile strength, and flexural strength of high strength concrete M_{50} grade of concrete and with different

replacement levels of ordinary Portland cement (ultra tech cement 53 grade) with silica fume (5%, 7.5%, 10% and 12.5%) and results are compared.

3.1 Mix Proportions:

concrete mixes were designed to a compressive strength of M50 **grades** with water cement ratio of 0.38 respectively as per IS code 10262-2009. In these case, the cement was replaced with SF by (5%, 7.5%, 10% and 12.5%)

the proportions of constituent materials for Mixes are presented in table 6

Table no.6: Mix proportion of concrete

S.NO	Materials	Quantities in Kg/m^3
		M_{50} Grade
1	Cement	428.4Kg/m3
2	Water	148 Kg/m3
3	Fine aggregate	673.4 Kg/m3
4	Coarse aggregate	1177.5 Kg/m3
5	Water cement ratio	0.38

The specimens of standard cubes (150mmx150mmx150mm) , standard cylinders of (150mm Dia x300mm height) and standard beams of (100mmx100mmx500mm) were cast with various percentage replacements of SF . Compression testing machine (CTM) was used to test 28 days compressive strength and split tensile strength of specimens. Universal Testing Machine (UTM) was used to test 28 days flexural strength of specimens.

4. RESULTS AND DISCUSSIONS

4.1 Mechanical Properties:

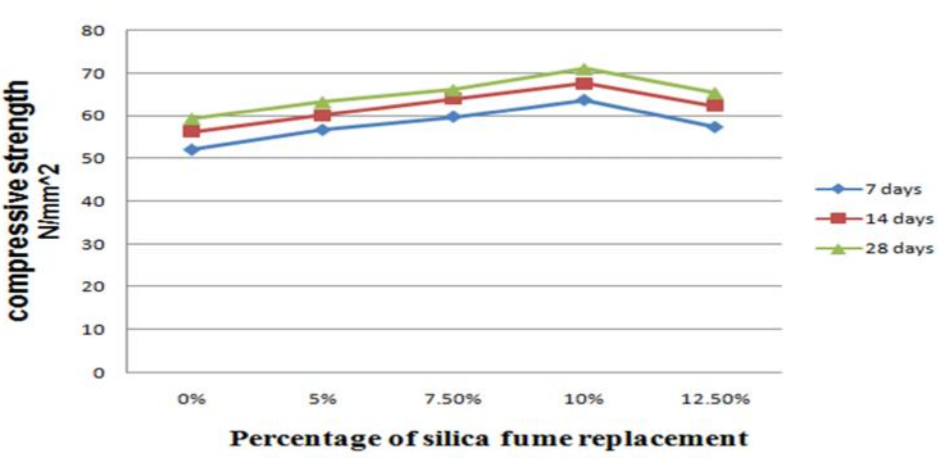
4.1.1 Compressive Strength:

The compressive strength M_{50} grade concrete at the age of 28 days is presented in graph.

There is a significance improvement in the strength of concrete because of high pozzolanic nature of silica fume and their filling ability. Compressive strength of mixes of M50 at 28 days age, with replacement of SF was increased gradually up to an optimum replacement level of 10% and then decreased. The maximum 28 days cube strength of M_{50} grade with 10 % of silica fume was 71.29N/mm^2.

Compressive strength of M_{50} at 28 days age with replacement of silica fume was increased gradually up to an optimum replacement level of 10% and then decreased.

Comparative graph of various replacements of cement with silica fume



5. CONCLUSIONS

Based on experimental results the following conclusions are drawn

1. Its shows that at 10% of silica replaced concrete has given more strength when compare to the normal concrete.
2. Silica fume also decrease the voids in concrete.
3. The incorporation of silica fume in concrete has a marginal influence on the density of concrete.
4. The results indicate that for the concrete mix and silica fume used in this study, the optimum replacement level of silica fume is about 10%.
5. The results of the present investigation indicate that other mix design parameters remaining constant, silica fume incorporation in concrete results in significant improvements in compressive strengths.
6. The super plasticizer demand of concrete containing Silica Fume increases with increasing amount of silica fume. The increase is primarily due to the fineness of the silica fume.
7. So this study can be used to encourage industries to use silica fume as replacement for cementitious materials by 10%-30% of their weight. It has also been found that at the same w/c ratio the strength of silica fume concrete is more than the normal concrete.
8. The cost of concrete also decreases by 20%-30% by using silica fume. Good quality control and high early strength can be achieved in silica fume concrete which may be useful in various structural constructions such as high-rise buildings, bridges, chimneys, machine foundations, run ways etc., .

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