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Experimental Study on Use of Silica Fume in Concrete

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Abstract*—Ordinary Portland cement is use for making the civil structures. Portland cement can partially replaced by silica fume. Silica fume is non-metallic , non-hazardous waste of industries. It is suitable for concrete mix and improves properties of concrete which is compressive strength , flexural strength etc. The main objective of this work is to determine the optimum replacement of silica fume percentages which can be suitably used under the Indian conditions. To achieve the objective various properties of concrete using silica fume have been estimated. Further to define the optimum replacement percentage comparison between the regular concrete and concrete containing silica fume is done .It has been seen that when cement is replaced by silica fume compressive strength increases up to certain percentage 15% replacement of cement by silica fume).But higher replacement of cement by silica fume gives lower strength.*

Keywords—Cementitious materials, Compressive strength silica fume, partial cement replacements, pozzolana

I. INTRODUCTION

Silica fume can be used either as a densified or undenified powder, a slurry, as a combination at the concrete mixer, or part of a factory-blended cement. The Report provides detailed information and references for further reading, on the effect of the materials on the fresh and hardened properties of concrete. Generally, the comparisons are made against a concrete made with 100% CEM I (Portland cement).The following terms are used with specific
meanings:
• blending: mixing together cementitious components at the concrete mixer or in the
cement
• factory (including inter-grinding):
• composite cement: the binder where the cementitious components are blended in a cement
• factory (including inter-grinding)
• combination: the binder where the cementitious components are blended at the concrete mixer
• strength class: the characteristic compressive strength of test cubes at 28-days
• w/c: water/cementitious ratio

The paper provide detailed information and references for further reading, on the effect of silica fume (SF) on the fresh and harden properties of concrete. Generally, a comparisons are made against a concrete made with 100% ordinary Portland cement.

II. MATERIAL AND METHOD

2.1. Materials

2.1.1. Cement:

A cement is defined as a binding material having cohesive as well as adhesive properties.

2.1.2. Sand: The black type is a bit unusual. The components of the black-sand can be different from those of the white-sand. It is normally found in 2 forms. One type consists of small pieces of lava and other as a combination of minerals formed by sedimentation. This specific black-sand consist of basalt which is the material produced by a volcanic eruption. The basalts grains get their form by the effect of the wind and wave. These minerals are regularly transported to the beach by the rivers.

2.1.3. Silica Fume: Silica fume, also known as micro silica, It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of round particles with the average particle diameter of 150 mm. The main field of application is as pozzolanic material for HPC. The mix proportion of silica fume concrete used 3 different percentages of silica fume of 15%, 20% and 25%. Silica fume use in concrete can be found in wet and dry form, dry form was selected as a compound in this study

2.1.4. Aggregate: Aggregate which is used in this block of silica fume concrete is coarse aggregate and fine aggregate, Natural and washed recycled aggregates were used in the concrete mixes. In this study, two size fractions of crushed limestone and coarse aggregates were used. One with nominal sizes of 4/12 mm and the other with nominal size of 8/22 mm as the natural coarse aggregate. Size fraction of silica based on natural aggregate (river sand) with nominal sizes of 0/4 mm was used as a natural fine aggregate (sand) in the concrete mixes. The recycled aggregate contain almost totally of crushed concrete rubbles found from building demolition projects. By using laboratory jaw crusher. Demolition waste aggregates were crushed to obtain cumulative grain size distribution curve similar to that prepared with the natural coarse aggregates.

2.2.Testing On Aggregate

Aggregates are very important component of concrete.Various test on aggregates are listed below

2.2.1 Aggregate Impact Value

Test is done to determine the aggregate impact value of coarse aggregates as per IS: 2386 (Part IV) – 1963.The apparatus use for determining aggregate impact value of coarse aggregates is 1) Impact testing machine2) IS Sieves of sizes – 12.5mm, 10mm and 2.36mm 3) A cylindrical metal measure of 75mm diameter and 50mm depth 4) A tamping rod of 10mm circular cross section and 230mm length, rounded at one end and Oven.

Preparation of Sample:

i) The test sample must conform to the following grading:

– Passing through 12.5mm IS Sieve – 100%

– Retention on 10mm IS Sieve – 100%

ii) The sample must be oven-dried for 4hrs.at a temperature of 100-110^{0}c and cooled.

iii) The measure must be about one-third full with the prepared aggregates and tamped with 25 strokes of the tamping rod.

A further similar quantity of aggregatemust be add and further tamping of 25 strokes given. The measure should be filled to overflow then tamped 25 times and the surplus aggregates struck off using a tamping rod as a straight edge. The net weight of the aggregates in the measure should be determine to nearest gram (Weight 'A').

Procedure to determine Aggregate Impact Value

1. i) The cup of the impact testing machine must be fixed firmly in position on the base of the machine and the whole of the test sample placed in and compacted by 25 strokes of a tamping rod.
2. ii) The hammer should be raised to 380mm above the upper surface of aggregates cup and allowed to fall freely onto the aggregates. The test sample must be subjected to a total of 15 such blows, each being delivered at an interval of not less than one second.

Reporting of Results

2. i) The sample must be removed and sieved through a 2.36mm IS Sieve. The fraction passing through must be weighed (Weight 'B'). The fraction retained on the sieve must also be weighed (Weight 'C') and if the total weight (B+C) is less than the initial weight (A) by more than one gram, the result must be discarded and a fresh test done.
3. ii) The ratio of the weight of the fines formed to the total sample weight must be expressed as a percentage.

Aggregate impact value = (B/A) x 100%

2.2.2 Aggregate Crushing Value

Test helps to determine - Aggregate crushing value of coarse aggregates as per IS: 2386 (Part IV) – 1963. The apparatus are1) Cylindrical measure and plunger 2) Compression testing machine 3) IS Sieves of sizes – 12.5mm, 10mm and 2.36mm.

Procedure to determine Aggregate Crushing Value:

i) The aggregates passing through 12.5 millimeter and retained on 10millimeterIS Sieve are oven-dried at a temperature of 100 to 110^{0}C for 3 - 4hrs.

ii) A cylinder of the apparatus is full in 3 layers, each layer packed with 25 strokes of a tamping rod.

iii) The weight of aggregate is measured (Weight 'A').

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iv) The surface of aggregates is then flattened and the plunger injected. The apparatus then placed in a compression testing machine and then loaded at a uniform rate as to achieve 40t load in 10 minutes. After this the load is released.

v) The sample then sieved through 2.36 millimeter IS Sieve and the fraction passing through the sieve is weighed (Weight 'B').

vi) Two tests must be conducted.

Aggregate crushing value = (B/A) x 100%

2.2.3. Water Absorption :

Test helps to determine the water absorption of coarse aggregates as per IS:2386 (Part 3) – 1963. For this test a sample not less than 2000gramshould be used. The apparatus are 1) Wire basket – perforated 2) electroplated or plastic coated with wire hangers for suspending it from the balance 3) Water-tight container for overhanging the basket 4) Dry soft absorbent cloth – 75cm x 45cm (2 numbers) 5) Shallow tray of minimum 650 sq.cm area 6) Air-tight container of a capacity similar to the basket and Oven.

Procedure to determine the water absorption of Aggregates:

i) The sample must be thoroughly washed to remove finer particles and dust, drained and then placed in the wire basket and absorbed in distilled water at a temperature between 22 and 32^{0}C.

ii) After absorption, the entrapped air must be remove by lifting the basket and allowing it to drop 25 times in 25 seconds. The basket and sample must remain immersed for a period of 24 + 1⁄2 hrs afterwards.

iii) The basket and aggregates must then be removed from the water, allowed to drain for a few minutes, after which the aggregates must be gently let down from the basket on to one of the dry clothes and softly surface-dried with the cloth , transferring it to a second dry cloth when the first would remove no further moisture. The aggregates must be spread on the second cloth and exposed to the atmosphere away from direct sunlight till it appears to be completely surface-dry. The aggregates must be weighed (Weight 'A').

iv) The aggregates must then be placed in an oven at a temperature of 100 to 110oC for 24hrs. It must then be removed from the oven, cooled and weighed (Weight 'B').

Formula for Water absorption = [(A – B)/B] x 100%

2.3. Mix Design

Table1
Mix Design

Sr. No.	Replacement of silica fume with cement	Cement Content (kg/m^3)	Silica Fume Content (kg/m^3)	10 mm Aggregate (kg/m^3)	20 mm Aggregate (kg/m^3)	Crushed Sand (kg/m^3)	Water (kg/m^3)	Admixture (kg/m^3)
1	0%	380	00	359	924	711	160	3.8
2	15%	323	57	359	924	711	160	3.8
3	20%	304	76	359	924	711	160	3.8
4	25%	285	95	359	924	711	160	3.8

2.4. Results And Discussion

2.4.1 Tests onaggregate:

Aggregate Impact Value was recorded as 15.14%.

Aggregate Crushing Value was recorded as23.64%

Aggregate water absorption was recorded as 0.206%

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2.4.2 Compressive Strength ofconcrete

Sr No	ID Mark of Specimen	Ageof Specimen (Days)	Weight, (Kg)	Maximum Load , (KN)	Crushing Strength, (N/mm^2)	Crushing Strength, (Kg/cm^2)
1	15% Silica Fume	7	8.452	581.2	25.83	263.3
2		7	8.426	577.8	25.68	261.8
3		7	8.330	589.1	26.18	266.9
				Average Value =	**25.90**	**264.0**

Sr No	ID Mark of Specimen	Ageof Specimen (Days)	Weight, (Kg)	Maximum Load , (KN)	Crushing Strength, (N/mm^2)	Crushing Strength, (Kg/cm^2)
1	20% Silica Fume	7	8.378	488.3	21.70	221.2
2		7	8.420	487.5	21.67	220.9
3		7	8.354	491.2	21.83	222.5
				Average Value =	**21.73**	**221.5**

Sr No	ID Mark of Specimen	Ageof Specimen (Days)	Weight, (Kg)	Maximum Load , (KN)	Crushing Strength, (N/mm^2)	Crushing Strength, (Kg/cm^2)
1	25% Silica Fume	7	8.432	433.8	19.28	196.5
2		7	8.364	427.9	19.02	193.9
3		7	8.448	425.1	18.89	192.6
				Average Value =	**19.06**	**194.3**

Table 3
COMPARISON BETWEEN MAIN METHOD

`	PAPER	ADVANTAGES	DISADVANTAGES
1	Concrete mix proportioning using micro silica	Silica fume in concrete increase the compressive strength of concrete.	Too much silica fume cause the concrete to become gluey and thus reduce the workability.
2	Study of Silica fume as Partial Replacement of Cement in Concrete	Silica fume in concrete increases the tensile strength of concrete and hence there is increase in flexural strength.	Silica fume concrete shrinkage rate is large especially when early dry shrinkage and easy to make crack in the use of silica fume concrete disturb/effect the overall strength.
3	Investigating effects of silica fume into cement concrete	silica fume in concrete has increased the strength and durability at all ages when compared to normal concrete . Silica fume reduces segregation and bleeding.	Silica fume requires a high amount of water and needs to be used with a superplasticizer.
4	Experimental study of Silica fume as Partial Replacement of Cement in Concrete	Silica fume is a good replacement of cement. The rate of strength gain in silica fume concrete (SFC) is very high.	Silica fume concrete (SFC) workability is poor and is not easy to make the concrete vibrating close grained as well as not easy to plaster.

III. CONCLUSION

The use of silica-fume give rise to increase in fresh and hardened properties of concrete, with less cement and concrete having better resistance for freezing and thawing than ordinary concrete, durability is enhanced through significant improvement in resistance to chemical attack. Aggregate influence, to a great extent, the load transfer capability of structure. Not only that aggregates must and strong and durable, they must also possess proper shape and size to make the structure act monolithically. Aggregates are tested for impact, crushing and water absorption.

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