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EFFECT OF SILICA FUME ON STEEL SLAG CONCRETE

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ABSTRACT: Concrete is the most versatile construction material because it can be designed to withstand the harshest environments while taking on the most inspirational forms. Engineers are continually pushing the limits to improve its performance with the help of innovative chemical admixtures and supplementary cementitious materials. Nowadays, most concrete mixture contains supplementary cementitious material which forms part of the cementitious component. These materials are majority byproducts from other processes. The main benefits of SCMs are their ability to replace certain amount of cement and still able to display cementitious property, thus reducing the cost of using Portland cement.

The fast growth in instralisation has resulted in tons and tons of byproduct or waste materials, which can be used as SCMs such as fly ash, silica fume, ground granulated blast furnace slag, steel slag etc. The use of these byproducts not only helps to utilize these waste materials but also enhances the properties of concrete in fresh and hydrated states. Slag cement and fly ash are the two most common SCMs used in concrete. Most concrete produced today includes one or both of these materials. For this reason their properties are frequently compared to each other by mix designers seeking to optimize concrete mixtures. Perhaps the most successful SCM is silica fume because it improves both strength and durability of concrete to such extent that modern design rules call for the addition of silica fume for design of high strength concrete. To design high strength concrete good quality aggregates is also required. Steel slag is an industrial byproduct obtained from the steel manufacturing industry. This can be used as aggregate in concrete.It is currently used as aggregate in hot mix asphalt surface applications, but there is a need for some additional work to determine the feasibility of utilizing this industrial byproduct more wisely as a replacement for both fine and coarse aggregates in a conventional concrete mixture. Replacing all or some portion of natural aggregates with steel slag would lead to considerable environmental benefits. Steel slag aggregate generally exhibit a propensity to expand because of the presence of free lime and magnesium oxides hence steel slag aggregates are not used in concrete making. Proper weathering treatment and use of pozzolanic materials like silica fume with steel slag is reported to reduce the expansion of the concrete. However, all these materials have certain shortfalls but a proper combination of them can compensate each other's drawbacks which may result in a good matrix product with enhance overall quality.

I. INTRODUCTION:

Concrete is a mixture of cement, sand, coarse aggregate and water. Its success lies in its versatility as can be designed to withstand harshest environments while taking on the most inspirational forms. Engineers and scientists are further trying to increase its limits with the help of innovative chemical admixtures and various supplementary cementitious materials SCMs. Early SCMs consisted of natural, readily available materials like volcanic ash or diatomaceous earth. The engineering marvels like Roman aqueducts, the Coliseum are examples of this technique used by Greeks and Romans. Nowadays, most concrete mixture contains SCMs which are mainly byproducts or waste materials from other industrial processes

1.2. SUPPLEMENTARY CEMENTITIOUS MATERIAL:

More recently, strict environmental – pollution controls and regulations have produced an increase in the industrial wastes and sub graded byproducts which can be used as SCMs such as fly ash, silica fume, ground granulated blast furnace slag etc. The use of SCMs in concrete constructions not only prevent these materials to check the pollution but also to enhance the properties of concrete in fresh and hydrated states.

II.LITERATURE SURVEY:

Many works have been done to explore the benefits of using pozzolanic materials in making and enhancing the properties of concrete. M.D.A. Thomas, M.H.Shehata[1] et al. have studied the ternary cementitious blends of Portland cement, silica fume, and fly ash offer significant advantages over binary blends and even greater enhancements over plain Portland cement. Sandor Popovics[2] have studied the Portland cement-fly ash – silica fume systems in concrete and concluded several beneficial effects of addition of silica fume to the fly ash cement mortar in terms of strength, workability and ultra sonic velocity test results.

III.MATERIALS AND METHODOLOGY:

3.1. MATERIALS:

3.1.1 Silica Fume:

Silica fume is a byproduct in the reduction of high-purity quartz with coke in electric arc furnaces in the production of silicon and ferrosilicon alloys. Silica fume consists of fine particles with a surface area on the order of 215,280 ft²/lb (20,000 m²/kg) when measured by nitrogen adsorption techniques, with particles approximately one hundredth the size of the average cement Because of its extreme fineness and high silica content, silica fume is a very effective pozzolanic material particle.

3.2 METHODOLOGY:

TEST PROCEDURE:

The Experimental programme was carried out in two stages.

Stage 1: Experimental work were conducted on mortarmixes by using different binder mix modified with different percentages of silica fume.

Stage2: Experimental works were conducted on steelslag concrete mixes by using different binder mix modified with different percentages of silica fume.

3.3 LABORATORY TEST CONDUCTED: 3.3.1 Compressive Strength Test:

For each set six standard cubes were cast to determine 7-days,28 day and 56 days compressive strength after curing. Also nine no. of cube was casted to know the compressive strength of concrete. The size of the cube is as per the IS 10086 – 1982.

3.3.2 Capillary absorption Test:

Two cube specimens were cast for both (Mortar and concrete cube) to determine capillary absorption coefficients after 7days, 28 days and 56 days curing. This test is conducted to check the capillary absorption of different binder mix mortar matrices which indirectly measure the durability of the different mortar matrices [8].

Procedure:

1.The specimen was dried in oven at about 105^{0}C until constant mass was obtained.

2.Specimen was cool down to room temperature for 6hr.

3.The sides of the specimen was coated with paraffin to achieve unidirectional flow.

4.The specimen was exposed to water on one face by placing it on slightly raised seat (about 5 mm) on a pan filled with water.

5.The water on the pan was maintained about 5mm above the base of the specimen during the experiment as shown in the figure below.

6.The weight of the specimen was measured at 15 min and 30 min. intervals.

7.The capillary absorption coefficient (k) was calculated by using formula:

k=Q/A* sqrt (t) where Q is amount of water absorbed A is cross sectional area in contact with water t is time

3.3.3 Porosity Test:

Two cylindrical specimen of size 65 mm dia and 100 mm height for each mix were cast for porosity test after 7 days and 28 day of cuing. This indirectly measures the durability of the mortar matrices

Procedure:

1) The specimen was dried in oven at about 100^{0}C until constant mass W_{dry} was obtained.
2) The specimens were placed in a desiccators filled with distilled water under vacuum for 3 hrs.
3) Weight of the saturated specimen W_{sat} in distilled water is taken.
4) The specimens are taken out and its weight is taken in air i.e. W_{wat}
5) The vacuum saturated porosity is calculated by the formula

IV. RESULTS AND DISCUSSIONS:

4.1 EXPERIMENTAL STUDY ON MORTAR:

Here we prepared mortar with ratio 1:3 from different types of cement + silica fume replacement as binder mix and sand as fine aggregate. Then its physical properties like capillary absorption consistency, compressive strength and porosity was predicted. These test results both in tabular form and graphical presentation are given below.

4.1.1 Normal Consistency for Mortar:

Normal consistency of different binder mixes was determined using the following procedure referring to IS 4031: part 4 (1988):

[1]300 gm of sample coarser than 150 micron sieve is taken.

[2]Approximate percentage of water was added to the sample and was mixed thoroughly for 2-3 minutes.

[3]Paste was placed in the vicat‟smould and was kept under the needle of vicat‟s apparatus.

[4]Needle was released quickly after making it touch the surface of the sample.

[5]Check was made whether the reading was coming in between 5-7 mm or not and same process was repeated if not

[6]The percentage of water with which the above condition is satisfied is called normal consistency.

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FIG.1.SCANNING ELECTRON MICROSCOPE

This is the instrument in which we done the SEM analysis of concrete specimen. Since our strength is decrease with increase in silica fume replacement. By this analysis we can know that there is a good bond formation between cement paste and steel slag or not.

4.2.5 Flexural Test:

The flexural strength of steel slag concrete at 28 days and 56 days is given below.

Table 4.10

Type of cement	% of SF replaced	28 days(N/mm^2)	56 days (N/mm^2)
Fly ash cement (FC)	0	6.875	4
	10	7	4.25
	20	6.875	4.5
Slag cement (SC)	0	7	5
	10	6.5	3.55
	20	6.125	3.975
Slag and fly ash cement blend (1:1) (SFC)	0	7	4.5
	10	6.725	3.23
	20	4.75	2.975

From above table we see that flexural strength of steel slag concrete is decreased from 28 days to

V.CONCLUSION:

From the present study the following conclusions are drawn:

1.Inclusion of silica fume improves the strength of different types of binder mix by making them more denser.

2.Addition of silica fume improves the early strength gain of fly ash cement whereas it increases the later age strength of slag cement.

3.The equal blend of slag and fly ash cements improves overall strength development at any stage.

4.Addition of silica fume to any binder mix reduces capillary absorption and porosity because fine particles of silica fume reacts with lime present in cement and form hydrates dancer and crystalline in composition.

5.The capillary absorption and porosity decreases with increase dose up to 20% replacement of silica fume for mortar.

6.Addition of silica fume to the concrete containing steel slag as coarse aggregate reduces the strength of concrete at any age.

7.This is due to the formation of voids during mixing and compacting the concrete mix in vibration table because silica fume make the mixture sticky or more cohesive which do not allow the entrapped air to escape. The use of needle vibrator may help to minimize this problem.

8.The most important reason of reduction in strength is due to alkali aggregate reaction between binder matrix and the steel slag used as coarse aggregate. By nature cement paste is alkaline. The presence of alkalis Na_2O, K_2O in the steel slag make the concrete more alkaline.

9.When silica fume is added to the concrete, silica present in the silica fume react with the alkalis and lime and form a gel which harm the bond between aggregate and the binder matrix. This decrease is more prominent with higher dose of silica fume.

10.Combination of fly ash cement and silica fume makes the concrete more cohesive or sticky than the concrete containing slag cement and silica fume causing formation of more voids with fly ash cement. The total replacement of natural coarse aggregate by steel slag is not recommended in concrete. A partial replacement with fly ash cement may help to produce high strength concrete with properly treated steel slag.

11.The steel slag should be properly treated by stock piling it in open for at least one year to allow the free CaO&MgO to hydrate and thereby to reduce the expansion in later age.

12.A thorough chemical analysis of the steel slag is recommended to find out the presence of alkalis which may adversely affect to the bond between binder matrix an the aggregate.

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