# An Experimental Analysis on Effect of Silica Flume on Steel Slag Cement

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## Abstract

*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. In the present work a series of tests were carried out to make comparative studies of various mechanical properties of concrete mixes prepared by using ACC brand Slag cement , Fly ash cement and their blend (in 1:1 proportion ). These binder mixes are modified by 10% and 20% of silica fume in replacement. The fine aggregate used is natural sand comply to zone II as per IS 383-1982.The coarse aggregate used is steel making slag of 20 mm down size. The ingredients are mixed in 1: 1.5: 3 proportions. The properties studied are 7days, 28days and 56 days compressive strengths, flexural strength, porosity, capillary absorption.*

**Keywords—** *Steel slag, Silica Flume, Concrete.*

## 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. 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. The SCMs can be divided in two categories based on their type of reaction : hydraulic and pozzolanic. Hydraulic materials react directly with water to form cementitious compound like GGBS. Pozzolanic materials do not have any cementitious property but when used with cement or lime react with calcium hydroxide to form products possessing cementitious prosperities.

## II. METHODOLOGY

Physical *properties of Steel slag.*
The different physical properties of steel slag are given below in Table No 3.4.

Table No.3.4

| Material | Specific gravity | Water absorption in % |
|---|---|---|
| Steel slag | 3.35 | 1.1% |

*3.1.2.3 XRD Analysis of Steel slag.*

From XRD Analysis of steel slag we can find what type Alkalis present. These are tabulated in Table No 3.5.

Table No.3.5

| Chemical Compound | Visible | Ref-Code | Score |
|---|---|---|---|
| $Na_2O$ | Yes | 03-1074 | 10 |
| $K_2O$ | Yes | 77-2176 | 10 |

From above table we can conclude that some amount of Alkalis present in steel slag.

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‟s mould 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.

Normal consistency of different binder mixes were tabulated below in Table No. 4.1.

Table No 4.8

| Mix | Description | Cement (grams) | Silica fume (grams) | Consistency (%) |
|---|---|---|---|---|
| SC0 | SC | 300 | 0 | 31.5 |
| SC10 | SC with 10% SF | 270 | 30 | 35 |
| SC20 | SC with 20% SF | 240 | 60 | 40.5 |
| FC0 | FC | 300 | 0 | 37.5 |
| FC10 | FC with 10% SF | 270 | 30 | 47 |
| FC20 | FC with 20% SF | 240 | 60 | 55.5 |
| SFC0 | SC:FC (1:1) | 150 each | 0 | 36.5 |
| SFC10 | SC:FC (1:1) with 10% SF | 135 each | 30 | 41.5 |

| | | | | |
|---|---|---|---|---|
| SFC20 | SC:FC (1:1) with 20% SF | 120 each | 60 | 47.5 |

Water /Cement Ratio and Slump.
The water cement ratio and slump of steel slag concrete with different binder mix with silica fume replacement is given below

Table No 4.8

| Type of cement | % of SF replaced | W/C Ratio | Slump in (mm) |
|---|---|---|---|
| Fly ash cement | 0 | 0.51 | 52 |
| | 10 | 0.58 | 52 |
| | 20 | 0.591 | 58 |
| Slag cement | 0 | 0.47 | 63 |
| | 10 | 0.518 | 50 |
| | 20 | 0.581 | 55 |
| Slag and fly ash cement blend ( 1:1) | 0 | 0.489 | 60 |
| | 10 | 0.543 | 53 |
| | 20 | 0.544 | 52 |

Compressive Strength of different mortars after 7days ,28days and 56 days were tabulated in Table No. 4.8.

Table No 4.8

| Type of cement | % of SF replaced | 7days | 28days | 56 days |
|---|---|---|---|---|
| Fly ash cement | 0 | 23.33 | 37.1 | 45.1 |
| | 10 | 21.61 | 27.77 | 30.44 |
| | 20 | 20.66 | 23.1 | 28 |
| Slag cement | 0 | 16.6 | 26.21 | 28.44 |
| | 10 | 18.44 | 25.33 | 25.55 |
| | 20 | 19.2 | 24.89 | 21.1 |
| Slag and fly ash cement blend (1:1) | 0 | 27.05 | 27.55 | 33.11 |
| | 10 | 22 | 23.77 | 29.77 |
| | 20 | 20 | 22.88 | 28.88 |

Wet and Dry Test.
Table No.4.9 shows 28 days and 56 days wet and dry test of concrete cube.

Table No. 4.9

| Type of cement | % of SF replaced | 28 days (N/mm2) | 56 days (N/mm2) |
|---|---|---|---|
| Fly ash cement ( FC ) | 0 | 36.5 | 36 |
| | 10 | 30.7 | 30.66 |
| | 20 | 26.8 | 28.44 |
| Slag cement ( SC ) | 0 | 23.8 | 27.55 |
| | 10 | 26.8 | 24.88 |
| | 20 | 25.3 | 20.88 |
| Slag and fly ash cement blend (1:1) ( SFC ) | 0 | 20.7 | 38.22 |
| | 10 | 36.5 | 24 |
| | 20 | 30.1 | 30.66 |

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/mm2) | 56 days ( N/mm2) |
|---|---|---|---|
| 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 |

## III CONCLUSION

1. Addition of silica fume to the concrete containing steel slag as coarse aggregate reduces the strength of concrete at any age.
2. 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.

3. 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. 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.

4. 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. Therefore the concrete mixes containing fly ash and silica fume show higher capillary absorption and porosity than concrete mixes containing slag cement and silica fume.

5. 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.

6. 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.

7. 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 and the aggregate.would not be much change in the durability of concrete.

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