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Effect of Silica Fume on Steel Slag Concrete

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ABSRTACT- In India, the production of steel slag is about 12 million tons in the steel industries and we can use in our concrete as a waste material. Concrete is most commonly and widely used building material used in all around the world. Concrete is the mixture of cement, sand, aggregates (fine and coarse), and water. The utilization of concrete is continuously increasing due to which there is a great effect on natural resources. There are many numbers of by-products (like, steel slag, silica fume, fly ash, etc.) that are produced during the production or the manufacturing of material like steel, silicon metal, etc. In the present study effect of silica fume on steel slag concrete has been carried out on M25 grade of concrete by varying percentage of steel slag i.e. 45%, 50% and 55% and constant value of silica fume i.e. 10%. From the study it has been observed that the compressive strength decreases while increases the percentages of steel slag. Therefore, up to 45% replacement of steel slag with the fine aggregates and 10% replacement of silica fume with cement give best result and after that the strength will decreases.

KEYWORDS- Steel Slag, Silica Fume, Concrete, Compressive Strength, w/c ratio

I. INTRODUCTION

As we know that there are many numbers of by- products (like, steel slag, silica fume, fly ash, etc.) that are produced during the production or the manufacturing of material like steel, silicon metal, etc. as a waste material. The utilization of concrete is continuously increasing due to which there is a great effect on natural resources. For reducing this major problem, we should take the materials that can substitute the natural resources. So, we are going to use Steel slag and silica fume which are an industrial by product obtained after the production of steel and silicon metal respectively.

The production of steel is associated with the generation of solid waste materials like slag. Infact, many by products and solid wastes can be used in concrete mixes as aggregates, sand and cement replacement, depending on their chemical and physical characterization, if adequately treated. In steel industry, steel slag having desirable qualities and can be used as coarse aggregates as well as fine aggregates in concrete construction. Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys and it is also known as Micro silica. One of the most beneficial uses for silica fume is in concrete because of its chemical and physical properties; it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable. This type of supplementary materials not only reduces the environmental pollution but also enhance the properties of the material like concrete in fresh and hydrated state. The properties of concrete like strength, durability, etc. mainly depend upon the quality of the material used in our project. Therefore, in our work different percentages of steel slag with constant percentage of silica fume as a supplementary material with fine aggregates and cement respectively has been used.

II. RELATED STUDIES

Sumeet Thakur, in 2015, in his research on "Strength Modification of Steel Slag Concrete due to Silica Fume" concluded that the silica fumes can be used as substituent on cement without affecting the properties of the cement along with enhancement in properties of concrete. He also concluded that the addition of steel slag as aggregate alone causes the contraction in the concrete and hence in contradiction silica fumes and fly ash cement can be used [1]. P.Harish and J.Supriya, did "Strength and Durability Studies on Silica Fume in Slag Concrete" and concluded that Silica fume added mixes shows higher strength values compared to their high volume fly ash counterparts at later stages (after 28 days) [2]. Ashfi Rahman, and Harjinder Singh, studied "Effect of mineral admixtures on characteristics of high strength concrete" and concluded that the replacement materials i.e. fly ash, blast furnace slag and silica fume are suitable for making high strength concrete. They also observed that addition of silica fume to concrete leads to improvement in compressive strength and split tensile strength of concrete at all stages [3].

S. Tanveer Hussain, and K.V.S.Gopala Krishna Sastry, performed "Study of strength properties of concrete by using micro silica and nano silica" and concluded that cement replacement up to 7.5% with Silica fume and up to 2% with nano silica, leads to increasing compressive strength, split tensile strength and flexural strength for both M40 and M50 grade. Beyond 7.5% of SF and 2% of NS there is decreasing in compressive strength, split tensile strength and flexural strength for both M40 and M50 mixes. They also observed

that maximum replacement level of silica fume is 7.5% and nano silica is 2% for both M40 and M50 grade concrete and the percentage increase in compressive strength, split tensile strength and flexural strength of concrete with combination of SF at 7.5% and NS at 2% is (25.807%, 25.766% and 18.9%).for M40 grade and (25.357%, 25.035% and 16.067%) for M50 grade concrete which is More when compared to normal concrete of M40 and M50 grades [4].

Verma Ajay, Chandak Rajeev and Yadav R.K. did research work on "Effect of Micro Silica on The Strength of Concrete with Ordinary Portland Cement" and concluded that Silica fume increases the strength of concrete more 25%. Silica fume is much cheaper then cement therefore it very important form economical point of view. Silica fume is a material which may be a reason of Air Pollution this is a byproduct of some Industries use of micro silica with concrete decrease the air pollution. Silica fume also decrease the voids in concrete. Addition of silica fume reduces capillary absorption and porosity because fine particles of silica fume reacts with lime present in cement [5].

Devaraj P Kumbar and V D Gundakalle, (2013) did research on "A study on effect of silica fume on the mechanical properties of steel slag aggregate concrete" and they conclude that the replacement of cement by 15% of silica fume and natural aggregate by upto 50% steel slag shows improved compressive strength, tensile strength, flexural strength and shear strength than the normal concrete [6].

Apoorv Singh, Prof. R.D. Patel and Khalid Raza, did research on "A comparative study on compressive and Flexural strength of concrete containing different admixtures as partial replacement of cement" and conclude that silica fume gives highest value of flexural and compressive strength as compared to the rice husk ash and iron slag [7].

D. Karthik, J. Doraikkannan, did "Experimental Investigation of Silica Fume and Steel Slag in Concrete" and found that 15% replacement of cement by silica fume and 50% of sand by steel slag the performance of concrete get improved and also it will help to reduce the construction cost and the environmental pollution caused by industrial by products[8].

P.S Kothai and Dr. R. Malathy, did study on "Utilization of steel slag in concrete as a partial replacement material for fine aggregates" and conclude that the partial substitution of natural aggregates with steel slag aggregates permits a gain of compressive, tensile and flexural strength and modulus of elasticity of concrete up to an optimum value of replacement [9].

Sanjay Kumar Athya and Miss Ragini Mishra, studied "Effect of silica fume on different strength parameter of steel slag concrete" and concluded that the optimum 7 and 28-day compressive strength and flexural strength have been obtained in the range of 10-15% silica fume replacement level. Increase in split tensile strength beyond 10% silica fume replacement is almost insignificant whereas gain in flexural tensile strength have occurred even up to 15 % replacements [10].

III. OBJECTIVES & METHODOLOY

A. Objectives of Study

- The objectives of proposed research work are as follows: -
- To find out the strength characteristics of steel slag aggregates (used as partial replacement offline aggregates) matrix along with replacement with silica fumes and its feasibility against conventional concrete.
- To reduce economic footprint of cement industry. (Replacement with silica fumes)
- To reduce economic footprint of aggregates industries. (Replacement with aggregates)
- To reduce our various waste materials from environment by using them in our project work so that these materials will not cause any pollution in our environment while they are dumping in an open area.

B. Materials & Methods

Various tests have been performed on the fine and coarse aggregates and cement that have been used in the research.

C. Specific gravity and water absorption

Specific gravity and water absorption obtained for coarse aggregates as per Indian Standard 2386 (Part III) – 1963 is as under:

Sp. gr. of coarse aggregates on dry basis: 3.19

Sp. gr. of coarse aggregates on saturated surface dry basis: 3.19

The water absorption of coarse aggregates: 0.12%

D. Crushing value & Impact Value

The crushing value obtained for aggregates used in our project is as per IS: 2386 (Part IV) – 1963 is 17.51 % and The impact value obtained for coarse aggregates used in our project work as confirming to IS: 2386 (Part IV) – 1963 is 13.02 %

E. Fineness Modulus

The fineness modulus obtained for coarse aggregates used in our research work as per IS: 10067 – 1962 and for fine aggregates is as per IS: 10067 – 1962 calculated as under:

The fineness modulus of coarse aggregate: 7.94

The fineness modulus of fine aggregate: 3.27

F. Mix design M25

In mix design the existing method as per IS: 10262(1982) and SP23 (1983) has been used for selecting the reference mix (25), however, new information given in IS: 456 (2000) was incorporated; procedure is modified to that extent. In order to get the final mix proportions for the reference mix design, the trial mix design had been prepared earlier for grade and tested at 28 days. The adjustments were made in

value of water and sand for the concrete mix design and the trial mixes adopted for M25. The test result of compressive strength after 28 days of all trial mixes is listed.

G. Actual quantity required for the mix per bag

Cement- 370.60
Sand- 559.34

Coarse aggregate

Fraction 1 60% of 20mm coarse aggregate- 729.96 kg
Fraction 2 40% of 10 mm coarse aggregate Extra water- 48.64 kg
For water cement ratio of 0.517 the water required liters- 191.60
Extra water to be added for absorption for coarse aggregate- 6.08 liters
Water to be added for fine aggregate- 5.90 liters
Water to be deducted for free moisture present in coarse aggregate- 0.00 liters
Water to be deducted for free moisture present in fie aggregate liters- 11.19
Actual quantity of water to be required for adjustment liters- 192.39
Actual quantity of sand required after allowance for free moisture- 570.53

Actual quantity of course aggregates to be required

Fraction I 60% of 20 mm coarse aggregates- 726.31 kg
Fraction II 40% of 10 mm coarse aggregates- 484.20 kg
The estimated actual mix proportion for one bag of cement (table 1).

Table 1: Estimated actual mix proportion for one bag of cement

Water in liters	Cement in kg	Fine Aggregate in kg	Coarse Aggregate in kg
192.39	370.60	570.53	1210.52
0.52	1	1.15	3.26

d. Materials & Equipment's used in research work

Figure-1 shows various materials used in the research work and Figure-2 shows various equipements used for material testing i.e.

Figure-3 depicts the equipments/moulds used for preparing and testing compressive strength of concrete.

43 Grade OPC | **Fine aggregates** | **Coarse aggregates** | **Silica fume** | **Steel slag**

Figure 1: Materials used Cement, Sand, Aggregates, Silic Fume & Steel Slag

Impact testing machine | **Different sizes of sieves for course aggregates** | **Platform Balance (100kg)** | **Different sizes of sieves for fine aggregates**

Figure 2; Various equipements used for material testing

Cube mould & Beam mould

Cylindrical mould

Compression Testing Machine

Flexural testing machine

Figure 3: Equipments/moulds used for preparing and testing of concrete

IV. RESULTS & DISCUSSIONS

Compressive strength of concrete was tested for 7, 14 and 28 days by varying percentages of the steel slag and silica fume according to the Mix design. Results are tabulated in table-2 and represented graphically in Figure-4, 5, 6 &7. Whereas the combined effect on the compressive strength is represented in Figure 8.

Table 2: Compressive Strength of Standard Concrete Cubes:

Sr. no.	Days of Curing	Compressive Strength (N/mm^2)			
		Standard Concrete Cube (OPC)	45% and 10% replacement of steel slag and silica fume	50% and 10% replacement of steel slag and silica fume respectively	55% and 10% replacement of steel slag and silica fume
1.	7-Days	17.15	19.64	17.50	16.71
2.	14- Days	20.48	22.55	20.14	17.97
3.	28- Days	24.79	27.51	25.16	19.76

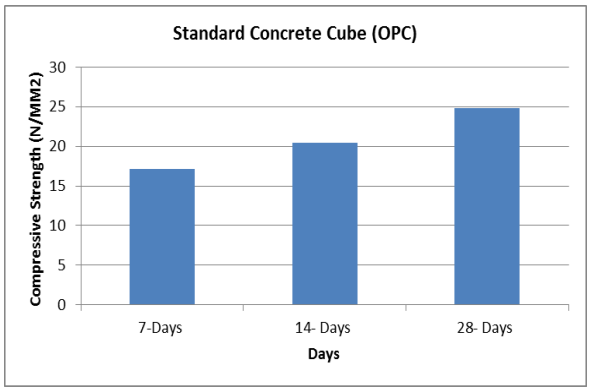

Figure 4: Compressive Strength of standard Concrete Cube (OPC)

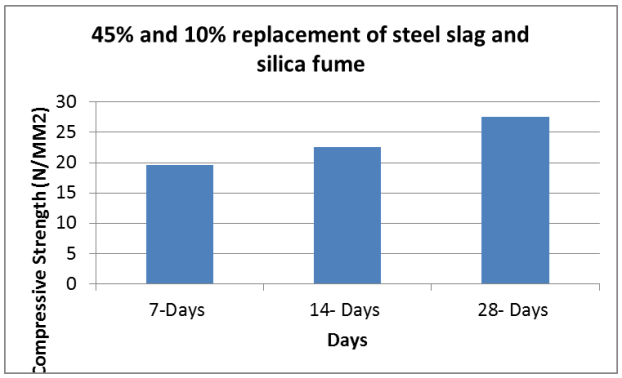

Figure 5: Compressive Strength with 45% and 10% replacement of steel slag and silica fume respectively

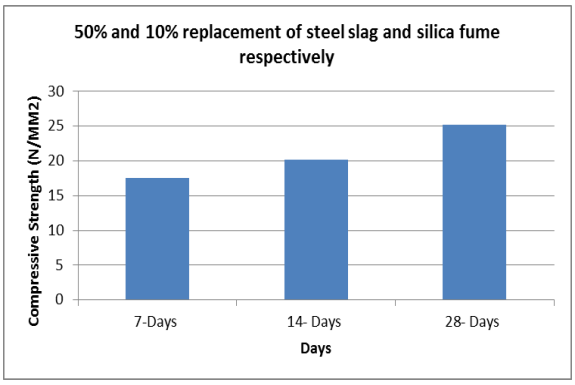

Figure 6: Compressive Strength with 50% and 10% replacement of steel slag and silica fume respectively

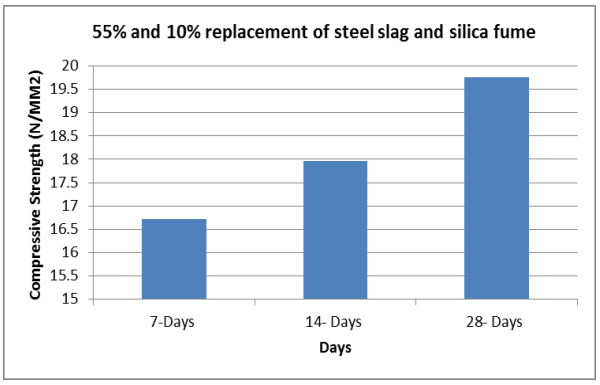

Figure 7: Compressive Strength with 55% and 10% replacement of steel slag and silica fume respectively

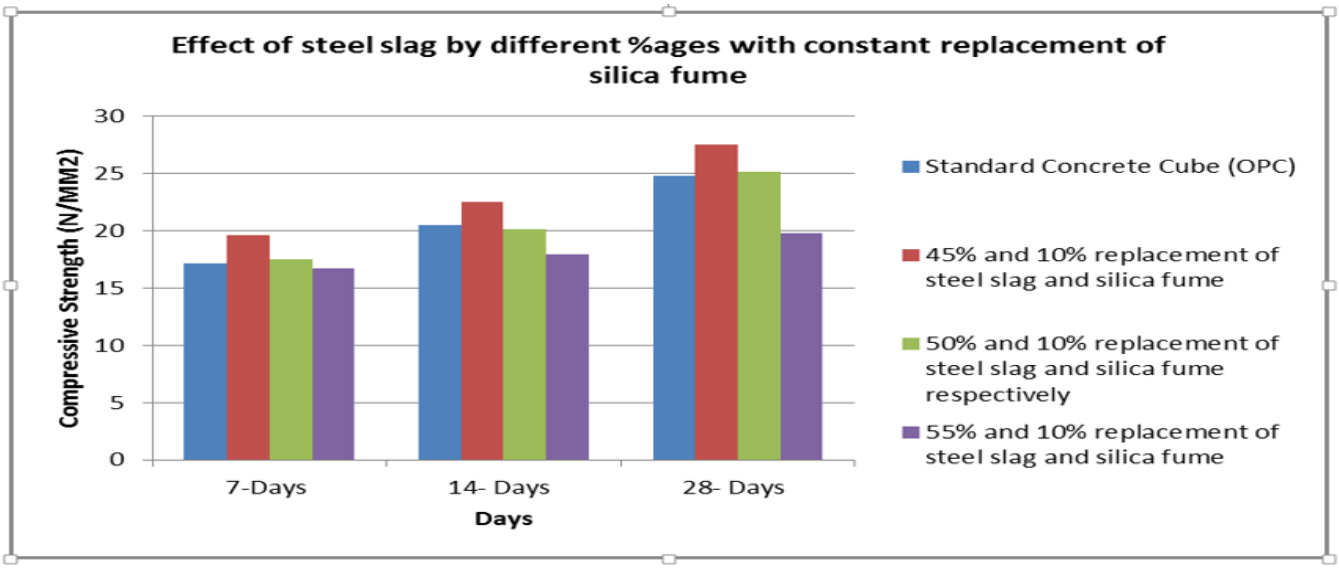

Figure 8: Combined effect on the compressive strength is represented

V. CONCLUSIONS

Every effort has been made to get the results within precise limits. The study gave us a vast idea about the properties of steel slag and silica fume in the concrete and how it affects its properties by using different percentages of steel slag i.e. 45%, 50% and 55% and constant value of silica fume i.e.

10%. We conclude that the compressive strength decreases while increases the percentages of steel slag. Therefore, upto 45% replacement of steel slag with the fine aggregates and 10% replacement of silica fume with cement give best result and after that the strength will decreases.

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