www.ijemr.net ISSN (ONLINE): 2250-0758, ISSN (PRINT): 2394-6962

Volume-7, Issue-2, March-April 2017

International Journal of Engineering and Management Research

Page Number: 242-245

Experimental Investigation on Concrete by Replacement of Natural Sand using Steel Slag

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ABSTRACT

Now a day's concrete plays a major role in construction industry. Availability of construction material is less day by day. So we can introduce a new kind of material in construction industry to reduce the cost as well as user friendly material. In the last few decades there has been rapid increase in the waste materials and by-products. Some of the industrial by-products like GGBS, fly ash, copper slag, steel slag, silica fume have been successfully replaced for cement and concrete in the construction industry. It reduces the consumption of natural resources.

Steel slag is one of the materials that is considered as a by-product (waste material) obtained during the matte smelting and refining of copper. It has the physical properties similar to that of the fine aggregate, hence it can be used as a replacement for fine aggregate in concrete. By the replacement of 0% to 100% of steel slag (by weight) as a replacement for fine aggregate will produce a concrete with durability requirements.

This works shows the results of an experimental study on strength and durability tests on concrete containing slag as a replacement of fine aggregate such as compressive strength test and rapid chloride permeability test. For this research work M40 grade was used and the tests are conducted for various proportions of slag with fine aggregate 25%,50%,75%,100%.The obtained results were compared with those of conventional concrete.

Keywords— eco-sand, steel sag, replacement of aggregate, strength comparison

I. INTRODUCTION

Concrete, a construction material is the largest production of all other materials. Aggregates are the important constituents in concrete. They give body to the concrete; reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is good gradation of aggregates. The increase in demand for the ingredients of concrete is met by partial replacement of materials by the waste materials obtained via various industries.

In this work steel slag has been partially replaced for sand and used as fine aggregate. The main objective of this work is to study the compressive strength of steel slag replaced concrete and to find the chloride permeability of steel slag based concrete.

Mohammed nadeem and Arun D. Pofale**;** analysed that concrete of M20, M30 and M40 grades were considered for replacing 0, 30, 50, 70 and 100% of coarse and fine aggregates by slag. The entire study was done in two phases, i.e. Replacement of normal crushed coarse aggregate with crystallized slag and replacement of natural fine aggregate with granular slag. The replacement of 100 % slag aggregate (coarse) increased concrete density by about 5 to 7 % compared to control mix. Based on the overall observations, it recommended that the slag could be effectively utilized as coarse and fine aggregates in all the concrete applications. It could also be said that full substitution of slag aggregate with normal crushed coarse aggregate improved the flexibility and split tensile strength by 6% to 8% at all replacements and in case of replacing fine aggregate & both the aggregates(Fine & coarse) with slag, the strength improvement was at 30% to 50% replacements.

Mahmoud Ameri et al evaluated the effect of utilizing air-cooled steel slag from Zob-Ahan steel production factory in concrete. General observations are done according to ASTM D 5106 in order to consider suitability of steel slag replaced with natural aggregates of concrete. Compressive strength tests were performed on samples containing slag ratios of 0, 25, 50, 75 and 100 % and cement contents of concrete 200, 300 and 350 kg/m^3. According to the results, Compressive strength improves with the increase in steel slag ratio up to 25% but increasing the steel slag ratio above 25% decreases compressive strength.

II. MATERIAL PROPERTIES

Steel Slag:

Slag a byproduct of metal smelting is produced hundreds of tons every year all over the world in the process of refining metals and making alloys. Steel slag with specific gravity 3.6 was used in this research

Cement:

53 grade of cement confirming to IS Standard with specific gravity 3.15 was used in this research

Fine aggregate: Fine aggregate confirming to IS: 383-1970 was used. Specific Gravity was found to be 2.68

Coarse Aggregate:

Specific Gravity of Coarse aggregate was found to be 2.78

Water:

Potable water without deleterious material was used for concrete mixing

III. MIX PROPORTIONING

Mix design as per IS 10262:2009 was done for M40 Grade of concrete with mix proportion ratio 1:2.56:3.60 and with water cement ratio 0.4 was used to make concrete

Compression Test:

The cube specimen is of the size 15 x 15 x 15 cm as per IS:516-1959 were cast and tested and results were tabulated in table 1. Slump was found to be 60mm

TABLE 1 COMPRESSIVE STRENGTH FOR M_{40} GRADE OF CONCRETE

S.No	Composition Of Steel Slag	7 Days Strength N/mm^2	14 Days Strength N/mm^2	28 Days Strength N/mm^2
1	0%	29.12	37.46	44.87
2	25%	31.11	38.33	46.11
3	50%	33.16	41.28	48.98
4	75%	28.93	35.4	44.39
5	100%	26.14	31.72	38.50

IV. RAPID CHLORIDE PERMEABILITY TEST

The test method involves obtaining a 100 mm (4 in.) diameter core or cylinder sample from the concrete being tested. A 50 mm (2 in.) specimen is cut from the sample. The side of the Cylindrical specimen is coated with epoxy, and once the epoxy is dried, it is put in a vacuum Chamber for 3 hours. The specimen is vacuum saturated for 1 hour and is soaked for 18 hours. It is then placed in the test device (see test method for schematic of device). The left-hand side (–) of the test cell is filled with a 3% NaCl solution. The right side (+) of the test cell is filled with 0.3N NaOH solution. The system is then connected and a 60-volt potential is applied for 6 hours. Readings are taken every 30 minutes. At the end of 6 hours the sample is removed from the cell and the amount of coulombs passed through the Specimen is calculated. RCPT Values are tabulated in table2 and 3.Fig 1 shows the details about charges passed in coulombs for control concrete and replaced concrete

Table 2 RCPT Values

Time	0%	25%	50%	75%	100%
Minutes	Ampere	Ampere	Ampere	Ampere	Ampere
0	0.09	0.07	0.02	0.03	0.06
30	0.15	0.10	0.09	0.05	0.07
60	0.12	0.11	0.06	0.05	0.07
90	0.13	0.11	0.07	0.06	0.08

120	0.14	0.13	0.08	0.07	0.1
150	0.15	0.14	0.09	0.09	0.11
180	0.17	0.15	0.09	0.11	0.13
210	0.18	0.17	0.11	0.11	0.16
240	0.2	0.18	0.12	0.13	0.16
270	0.22	0.18	0.14	0.13	0.16
300	0.22	0.18	0.14	0.13	0.16
330	0.22	0.18	0.14	0.13	0.16
360	0.22	0.18	0.14	0.13	0.16

Table 3 RCPT Values for Control Concrete and Replacement Based Concrete

COMPOSITION OF STEEL SLAG IN CONCRETE	CHARGES PASSED IN COULOMBS
0%	3699
25%	3159
50%	2025
75%	2052
100%	2646

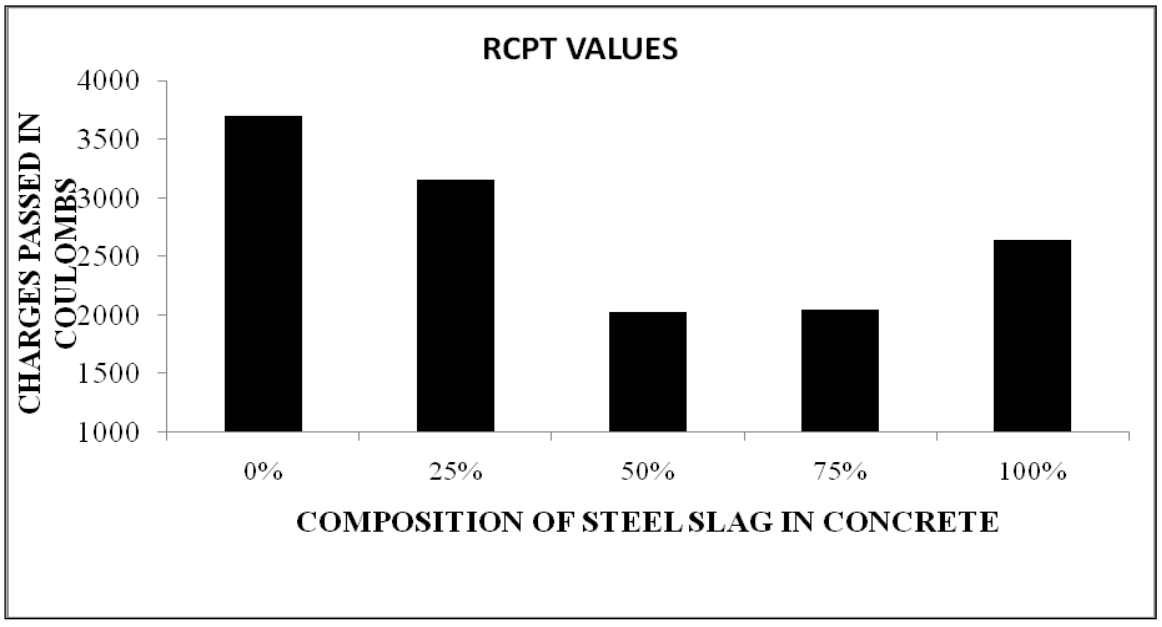

Fig 1 CHARGES PASSED IN COULOMBS FOR CONTROL AND REPLACED CONCRETE

V. CONCLUSION

The following conclusions are drawn based on the findings of the tests reported here:

Compared to the control mix, the steel slag based concrete showed an increase in the density up to 20%, whereas the workability was found to be often better. Steel slag has lower absorption and higher strength properties than fine aggregate. The highest strength obtained was 48.98 MPa (50% replacement) and the corresponding strength for control concrete was 44.87 MPa.

With higher level of replacements (100%) there was a slight bleeding tendency and it is recommended that up to 50% of steel slag can be used as replacement of sand. The utilization of steel slag in concrete provides additional environmental as well as technical benefits for all related industries. Replacement of steel slag increases the self weight of concrete specimens to the maximum of 15 to 20 %.For higher replacement of steel slag in sand (greater than 50%) the compressive decreases due to an increase of free water content in the mix.

Rapid chloride permeability test for 50% replacement chloride permeability was found to be good

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