Technical Assessment on Performance of Partial Replacement of Coarse Aggregate by Steel Slag in Concrete

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Abstract:

Road Construction is an activity in which natural resources are used the most in comparison with else branches of Civil Engineering. Prominent quantities of natural materials, stone, rocks and sand are built into kilometres of roads or in reconstruction of frail roads. This paper presents the basic characteristics of slag, describes several of established investigate studies carried out so far, and analyses domestic experience and the possibilities of application of slag in road constructions.

To solve the problem of greenhouse gas emission from industries we can reuse the wastes from industries and help environment. The effective manner is to use slag in concrete by replacing natural coarse aggregate. In this study, the replacement was done with coarse aggregate by steel slag for different proportions of 0%, 25%, 50%, 75% and 100% for a M30 grade of concrete is used for a water cement ratio of 0.48. Tests for compressive strength at 7 days, 14days and 28 days are conducted on specimens. Split tensile strength and flexural strength are carried for 28 days. The optimum strength is obtained on 75% replacement of coarse aggregate by steel slag.

Keywords: *Cement, Compressive Strength, Flexural Strength, Natural Coarse Aggregates, Split Tensile Strength, Steel Slag.*

I.INTRODUCTION:

Concrete is one of the widely using prime materials for structures in various applications all over the world. Aggregates and cement plays an important role in concrete. In India limited resources of natural aggregates are available, after some days Government will impose restrictions on removal of sand from the river beds due to its threatening effects on environment. Cement production industries liberates large amount of carbon dioxide which causes ozone depletion (Kanmalai, 2008). This burden creates a topic on the sustainability of concrete. In magnitude to attain factual a sustainable relevant, suitable discipline approaches can be done. In arrangement to defeat this problem, industrialized slags can be used as alternate construction material.

It is a non-metallic instrumentation material formed from the reaction of flux such as CaO pollutant with the inorganic non-metallic components from the steel scrap (Chinnaraju,2013) Steel slag are beingness victimized as aggregates in asphalt paving road mixes due to their mechanical strength, stiffness, consistency, wear resistance and water absorption. Steel slag generally exhibits the passableness to change due to the presence of un-hydrated remove hydroxide and magnesium oxides which hydrate in humid environments. The steel slag which obtained from ISMT Jejuri steel plant, Maharashtra.

II.LITERATURE REVIEW:

1. Ivana Barišić, Sanja Dimter, Ivanka Netinger (April 2010):

Accordingly slag is used the most in asphalt mixtures, although its good properties are also used for application in other layers of pavement structure, primarily unbound base courses and embankment. An area of application that has not been studied extensively so far is the application of slag in stabilized mixtures for construction of base courses, which could be great interest for domestic road construction. Cement-bound base courses were designed to increase the bearing capacity. Domestic slag has a significant quantity of calcium oxide, CaO (25-30 %, whilst free CaO accounts for 0,22 -0,28 %), which is the basic indicator of pozzolanic behaviour of the material. The quantity of CaO indicates primarily the existence of the possibility of utilization of steel slag as portion of binder or as binder, but also as aggregate in stabilized base courses, which creates a possibility of new research in this area.

2. George Wang and Russell Thompson (March 2011) :

Quantified usability criteria are imperative for utilization of various slags in a full scale. The criteria developed for slag use as a crystalline material in confined matrices are reliable and practical in use. To utilize slags in road construction and to make sure the use is technically sound and durable, the following steps have to be followed: (i) select the right criterion for a specific use; (ii) conduct relevant laboratory testing to quantify the given sample; (iii) determine the usability based on relevant criterion; (iv) field quality control is must; also (v) long term performance is monitor, which are the same as the use of normal natural materials

3. Mohd. Rosli Hainin (Jan. 2015):

Slags is been successfully used for the construction of roads in wearing course, base and sub base as well. Specially in Canada, Europe, Australia and USA have not treated it as an industrial waste but a good construction material by successful use of steel slag as aggregate in surfacing and base of flexible pavements. Steel slag is produced in United States of America by 17 companies. Special specification and sufficient record of its uses and performance on major projects around the world indicate that both steel (BOF or EAF) slag is a material of choice.

4. P. Vasanthi (Sept 2014):

Slag is a by-product of the manufacture of steel is one of the useful industrial by- products. It can be used in the recent construction industries as a partial substitute of either fine aggregate or coarse aggregates. This slag is currently being used in road construction work and also used in making pavements and path ways. Only about 15 to 20 percent of the steel slag generated is utilized for these applications and the remaining slag is dumped as a waste, which needs large areas of land. The utilization of steel slag as partial replacement of coarse aggregate in concrete is economical for the better strength and workability it imparts up to 75% replacement level. It is found that increase in replacement level of steel slag above 75% decreases the strength and workability of concrete. This experimental study has proved the better method or pathway in producing strong and durable concrete.

TABLE 1: PHYSICAL PROPERTIES OF MATERIALS

	Fine aggregate	Coarse aggregate	Steel slag
Material Specific gravity	2.665	2.673	2.61
Water absorption (%)	0.9	1.29	2.8
Bulk density (kg/m3)	1632.42	1548	1475
Moisture content (%)	2.89	0.28	0.4
Fineness modulus	3.18	4.32	3.10

III. METHODOLOGY

Number of basic tests are conducted on Ordinary Portland Cement 53 grade, fine aggregate, coarse aggregate and steel slag for checking their suitabilities for making concrete. Mix proportions of concrete are modified for using EAF steel slag with partial replacement of coarse aggregate replaced with 0%, 25%, 50%, 75% and 100% of steel slag casted in cubes. Specimens are cast as per design mix and the tests are conducted after proper curing, the tests are compressive strength of cubes (150mm x 150mm x 150mm), split tensile strength of cylinders (150mm x 300mm) and flexural strength of cubes (100mm x 100mm x 500mm). From the studies, optimum results are found out and compared with the control concrete.

IV. MIX PROPORTION

Concrete mix design is a process in which the proportions of the various raw materials of concrete are determined to achieve a certain minimum strength, as economically as possible. Based on the simplified mix design procedure as per IS 10262:2009, a concrete mix proportions with characteristic compressive strength (fck) of 30Mpa was designed without any admixtures for water cement ratio 0.48. The mix adopted for the study is given in Table 2.

TABLE 2: MIX PROPORTION CEMENT

	Cement	Water	Fine Aggregate	Coarse Aggregate
kg/m3	387.5	186ltr	680	1110
Ratio	1	0.48	1.75	2.86

V.TEST RESULTS AND DISCUSSION

The test results of slump cone, compressive strength, flexural strength and split tensile strength obtained from the experimental study are given in the form of graph along with discussion.

A. Slump test

Slump test is conducted on fresh concrete of different design mix proportions. The obtained slump value for control concrete is 50 mm. This indicates medium workability.

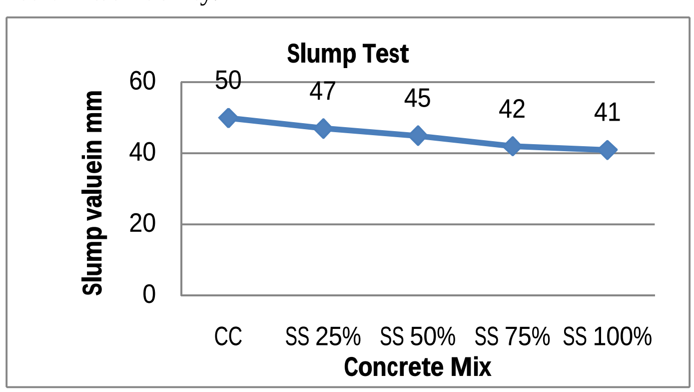

Fig 1: slump value of concrete.

Fig.1 above is shows the variation of slump value of concrete using steel slag. From the graph it is concluded that in concrete as percentage of steel slag increases it decreases the workability.

B. Compressive strength

Specimen are casted in concrete cubes of sizes 150 mm X 150 mm X 150 mm and are cured, it is tested for compressive strength under compression testing machine (CTM). The maximum load at failure reading was taken. Fig.2 shows the compressive strength of concrete using steel slag at 7th, 14 th and 28th day.

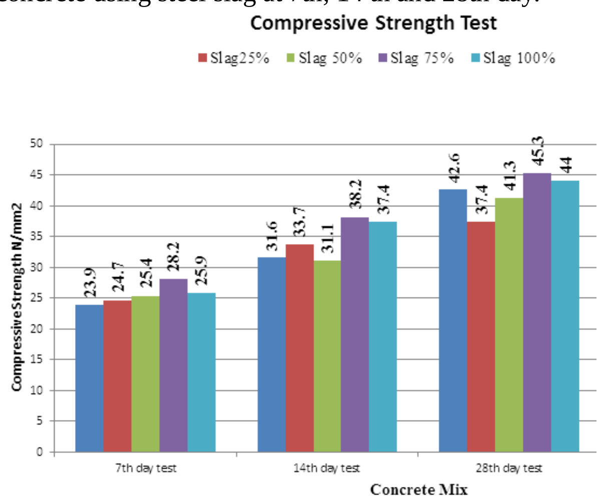

Fig.2 compressive strength of concrete

It was observed that the strength of concrete increases with the increase in the quantity of steel slag as replacement to natural aggregates. Up to 75% replacement of coarse aggregates by steel slag.

The compressive strength of concrete of all concrete mix increases up to 75% but decrease after 75% .The compressive strength of concrete increases 14 % if 75% of coarse aggregate is replaced by steel slag. The improvement in strength may be due to shape, size and surface texture of steel slag aggregates, which provide better bonding between the particles and cement paste.

C. Split tensile strength

Concrete cylinders having diameter 150 mm and height 300mm were casted and the specimens are cured, specimens are tested for split tensile on 28th day.

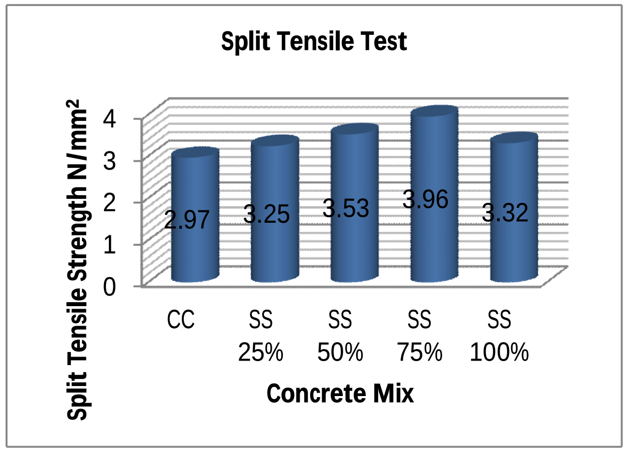

Fig 3: split tensile strength of concrete

D. Flexural strength test

The flexural strength test for beam specimen having the size of 100 x 100 x 500 mm was casted and cured for 28 days. It was kept horizontally between the supports of a universal testing machine (UTM) and the load is applied until failure of the beam. The failure load is noted and shorter length from crack to support strength measured. Fig.4 shows the flexural strength of concrete using steel slag at 28th day. It is observed that flexural strength of concrete increases with the increase in the quantity of steel slag as replacement of coarse aggregate. Up to 75% of replacement by steel slag, the flexural strength of concrete increases but beyond 75% decrease in the strength was observed. The maximum increase in the flexural strength obtained at 75% replacement and the flexural strength of concrete increases 15.43 % compared with control concrete.

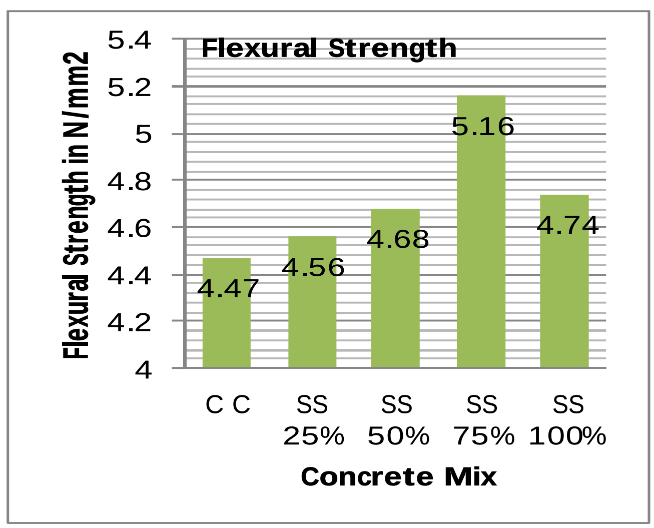

Fig:4 Flexural strength of concrete using steel slag.

VI. DURABILITY TEST RESULTS

A. Sulphate attack test

The 150mm of cubes were immersed in the 5% of MgSO4 solution for 28 days and found that the percentage loss in weight and compressive strength of concrete cubes. The result of the test showed that concrete containing steel slag has good resistance to sulphate attack. The loss in weight and compressive strength of concrete with 75% of steel slag was lower than control concrete. The percentage of loss of compressive strength of conventional concrete is 2.87% and percentage of loss in weight by 4.86% when compared with the concrete containing steel slag. The concrete cube containing steel slag resists the sulphate attack when compared to the control concrete. Table 3 shows the percentage of weight loss and strength loss in sulphate attack test.

TABLE 3:STRENGTH AND WEIGHT LOSS IN CONCRETE

Specimen	Loss in weight %	Loss in compressive strength %
Conventional cube	4.78 4.86	2.87
Cube contain 75% of Steel Slag	2.76	3.95

B. Acid Resistance test

The acid resistance test was conducted over 150 mm cubes by immersing them in 5 % of Hydrochloric acid solution for 28 days. Then the weight and compressive strength loss were determined for the cubes. From the results, it was concluded that the concrete having steel slag has good acid resistance when compared with control concrete. It could be in concrete; the use of steel slag prevents a growth of calcium hydroxide around the fine particles and prevents the formation of ettringite (sulfate calcium sulfoaluminate). Thus, these mechanisms improves the resistance of concrete to acid attack. The obtained weight loss of control concrete is 3.44% and higher than the concrete with steel slag. The percentage of loss of compressive strength of control concrete is 1.98% and higher than the concrete containing steel slag. The concrete cube containing steel slag resist the acid attack when compared to the control concrete. Table 4 shows the percentage of weight loss and strength loss in acid resistance test.

TABLE 4 PERCENTAGE OF LOSS IN WEIGHT AND COMPRESSIVE STRENGTH DUE TO ACID ATTACK

Specimen	Loss in weight (%)	Loss in compressive strength (%)
Conventional cube	6.83	9.85
Cube contain 75% of Steel Slag	4.15	7.89

VII. CONCLUSION

From the experimental works carried out, the following conclusions are made. After this experimental study, it has proved to be better way to for disposal of steel slag. The replacement of coarse aggregate with EAF steel slag has increased the compressive strength, flexural strength and split tensile strength of concrete. The optimum percentage of steel slag was found to be 75%. As we increase the percentage of steel slag in concrete it shows higher resistance to acid and sulphate attack. When this optimized value will be used, it will give more durable concrete and good strength when compared to conventional concrete and saves material cost up to 10%.

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