INTERNATIONAL JOURNAL OF COMPUTATIONAL AND MATHEMATICAL IDEAS [IJCMI] ISSN: 0974-8652

Effect on using Steel Slag as Replacement in High Strength Concrete

Volume 12, Issue 1 July-Aug: 2016

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***Abstract**: Construction industry has a wide range of work globally. In today's world, the construction rate is progressing very faster which results in the faster consumption of naturally occurring construction materials. The consumption rate of natural sand is increased very rapidly from last few years. In the recent era, global warming affects the environment very badly whose adverse effects can be seen as dry rivers and streams. We get natural sand from these rivers and streams but extraction in a large amount affects the environment. In this dissertation, the work is executed to study the optimum percentage replacement of steel slag with natural sand by which the excessive usage of fine aggregate can be minimized.*

Keywords: Steel Slag, Fine Aggregate, Compressive Strength, Flexural Strength, Tensile Strength.

I. INTRODUCTION

In general, concrete is a made up of basically three components namely water, aggregate (rock, sand or gravel) and cement, all have their own distinct properties comprise poured and harden into the durable material. Here the discussion is based on depletion of natural fine aggregate by extracting it in an in-ecological way. Due to this ecological imbalance, in India, the government has banned the illegal extraction of natural sands in maximum areas. To overcome from this scarce and costly fine aggregate a well deserved alternate material should be introduced to lessen the use of natural sand.

As an alternate option, steel slag, a well known by-product of steel obtained while cutting and shaping from various steel furnaces or industries can be taken into consideration. As we know where there is production there is wastage too therefore responsible waste disposal is of great concern. Instead of irresponsible disposition reuse of steel slag would be eco-friend, cost effective and can be used as an alternate building material which will lower the cost of construction too. So, in this study steel slag is used for the making of concrete in place of natural sand (fine aggregate) to understand the variations in properties.

II. LITERATURE REVIEW

A. *Bashar Taha (2009)* [1] in their work "Utilization waste recycled glass as sand/cement (RSG) and pozzolanic glass powder (PGP) was examined in their study. There is no major difference found in compressive strength while replacing RSG while compressive strength reduced by 16% whereas 10.6% decrement noted at 28 and 364 days when 20% of Portland cement was replaced by PGP. British Standard BS 812 Part 123:1999 was followed while monitoring the potential expansion of concrete due to alkali-silica reaction (ASR).Their work failed to show good results with that of sand/cement both.

B. *Girish Sharma(2015)*[6] studied in his work "Beneficial effects of steel slag on concrete" with the aim of replacing steel slag of M35 grade with aggregates(fine & coarse), the percentage from 0% to 55% and tested on its 7th and 28th day after curing. Their deep analysis concludes that there is constant increment when replaced with that of steel slag and can be used practically. Decrement is mentioned after 55% in case of coarse aggregate.

C. *P. Jyotsna Devi et.al.(2014)*[8] in their work "A Study on the Flexural and Split Tensile Strengths of Steel Fibre Reinforced Concrete at High Temperatures "mixing with 1% volume of steel fibers to evaluate its performance at normal (M30) and at

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INTERNATIONAL JOURNAL OF COMPUTATIONAL AND MATHEMATICAL IDEAS [IJCMI] ISSN: 0974-8652

high strength concrete (M60).They introduced good results with that of steel fibres.By adding steel fibres flexural resistance can be increased. The test is carried out for 7, 28 and 91 days.

MATERIAL USED

3.1 Cement: After conforming IS: 4031-1967, Portland pozzolona cement is used in this experiment. Cement of53Grade is used, properties having specific gravity value 3.15(IS8112).

3.2 Fine Aggregate: By IS: 383-1970, fine aggregate is classified into for different zones from zone-1 to zone-4 according to their practical size distribution. Narmada river sand which passed through 4.75 mm sieve is used in this experiment.

3.3 Course Aggregate: After sieve analysis, the retained aggregate of size 4.75mm left are the coarse aggregates used in this experiment.

3.4 Steel Slag: Fine loose steel granular materials collected from steel furnaces stored as waste in a bulk for further replacement levels in this experiment.

3.5. Water: Clean tap water is used in this experiment.

IV. METHODOLOGY

The proportion of concrete mix materials are calculated by mix design calculation and justified by conforming the specifications mentioned in IS: 516-1959.A sample of concrete mix is prepared by conventional hand mixing method on the non-water absorbent platform with the help of a shovel. Workability of fresh concrete is obtained by slump cone test. Concrete cube mould of specimen size 150mm x 150mm x 150 mm generally compacted by 6 round of tamping(each round consist of 25tamps) to ensure proper compaction. After leaving for 24 hours for proper settening specimens were Demoulded and allowed for curing for gaining its optimum strength till the date of testing.

V.EXPERIMENTAL TESTS AND RESULTS

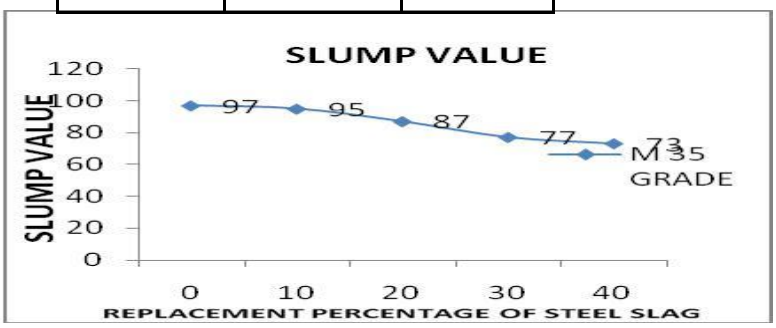
5.1 SLUMP CONE TEST

Slump cone test is conducted to quantify the behaviour of compacted inverted cone under the influence of gravity according to IS: 1199.Basically, consistency is measured by slump cone test.

Table 1.Slump test results for M35 grade of concrete

Sr. No.	% Replacement of Steel Slag	Slump Value In MM for M 35
1.	0%	97
2.	10%	93
3..	20%	85
4.	30%	77
5.	40%	73

1: Slump Values of M 35 grade of concrete



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1. The result of slump cone test indicates a smoothen curve in decreasing manner from that of 0% to 30% and afterwards a small increment noticed at 40%, conducted by trial and error method of mixing.

COMPACTION FACTOR

After conforming IS: 1199, compacting factor apparatus is used in the experiment conducted. Determination of workability is conducted by this test.

Table 2.Compaction factor test results for M35 grade of concrete

Sr. No.	% Replacement of Fine Aggregate by Steel Slag	Compaction factor Value in MM forM 30
1.	0%	0.933
2.	10%	0.936
3.	20%	0.941
4.	30%	0.948
5.	40%	0.957

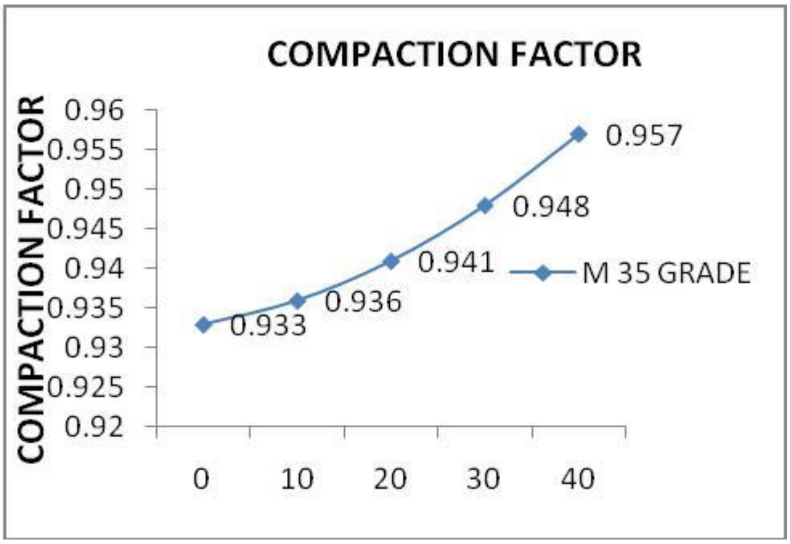

Figure2: Compaction Values of M35 grade of concrete

5.2. COMPRESSIVE STRENGTH TEST

Compressive strength is defined as the ratio of ultimate load (N) to that of the area of cross section (mm^2).The compressive testing machine is used to find compressive strength.

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Compressive strength is defined as the ratio of ultimate load (N) to that of the area of cross section (mm^2).The compressive testing machine is used to find compressive strength. Concrete cubes casted and tested to study the load at which it fails at a replacement level of 10%, 20%, 30% and 40%, after 7, 14, 28 and 28 days of curing for M35 grade of concrete.

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Table 3.Avg.Compressive strength test results for M35 grade of concrete

Sr. No.	Percentage Replacement of Fine Aggregate by Steel Slag	Average Com-pressive Strength (N/mm^2)	Average Com-pressive Strength (N/mm^2)	Average Com-pressive Strength (N/mm^2)	Average Com-pressive Strength (N/mm^2)
		7 DAYS	14 DAYS	28 DAYS	50 DAYS
1.	0%	24.57	32.16	43.42	47.21
2.	10%	25.12	33.81	44.76	48.69
3.	20%	27.39	35.4	46.3	49.31
4.	30%	29.11	37.03	48.8	52.25
5.	40%	28.07	36.13	47.62	50.37

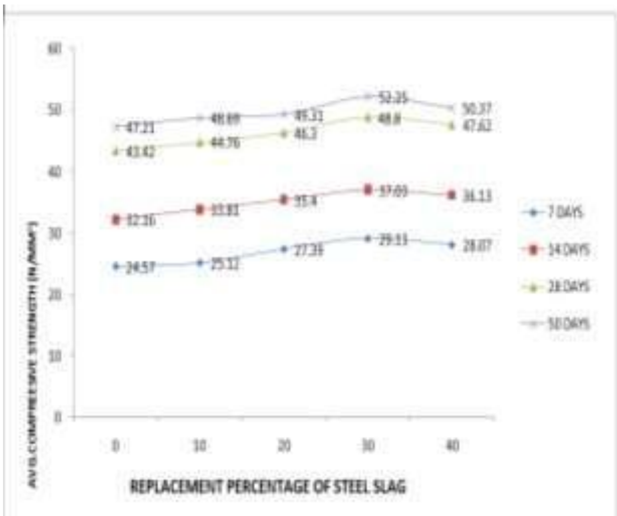

Figure 3: Compressive Strength Graph of Steel Slag by Fine Aggregates for M35

1. The resultant graph of compressive strength of M35 grade of concrete concludes good strength results up to 30% of replacement afterwards at 40% it decreases. The strength increases gradually. The test readings are tabulated and plotted above.

5.3. SPLIT TENSILE STRENGTH

Tensile strength is defined as the topmost stress that a material can sustain while pulled or stretched. This test is conducted by replacing steel slag at a level of 10%, 20%, 30% and 40% after 7, 14, 28 and 50 days of curing for an M35 grade of concrete.

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Table 4.Avg. Tensile strength test results for M35 grade of concrete

Sr. No	Percentage Replacement of Fine Aggregate by Steel Slag	Average Tensile Strength of M 35 (N/mm^2)
		28 DAYS
1.	0%	4.073
2.	10%	4.28
3.	20%	4.456
4.	30%	4.66
5.	40%	4.573

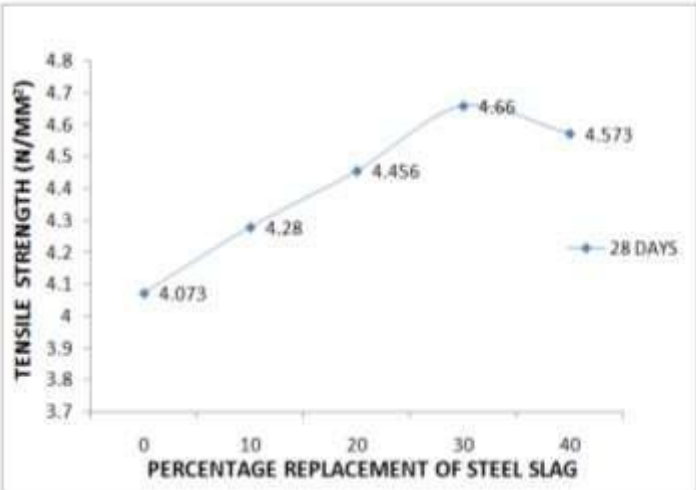

Fig.4: Tensile Strength Graph of Steel Slag by Fine Aggregates for M35 at 28 Days.

1. The resultant graph of split tensile strength strength of M35 grade of concrete concludes good strength results up to 30% of replacement afterwards at 40% it decreases. The strength increases gradually. The test readings are tabulated and plotted above.

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5.4. FLEXURAL STRENGTH TEST

Flexural strength is defined as the materials ability to resist deformation under load. This test is conducted by replacing steel slag at a level of 10%, 20%, 30% and 40% after 7, 14, 28 and 50 days of curing for an M35 grade of concrete.

Table 5.Avg.Tensile strength test results for M35 grade of concrete

Sr. No	Percentage Replacement of Fine Aggregate by Steel Slag	Average Flexural Strength for M35. (N/mm^2)
		28 DAYS
1.	0%	4.073
2.	10%	4.28
3.	20%	4.456
4.	30%	4.66
5.	40%	4.573

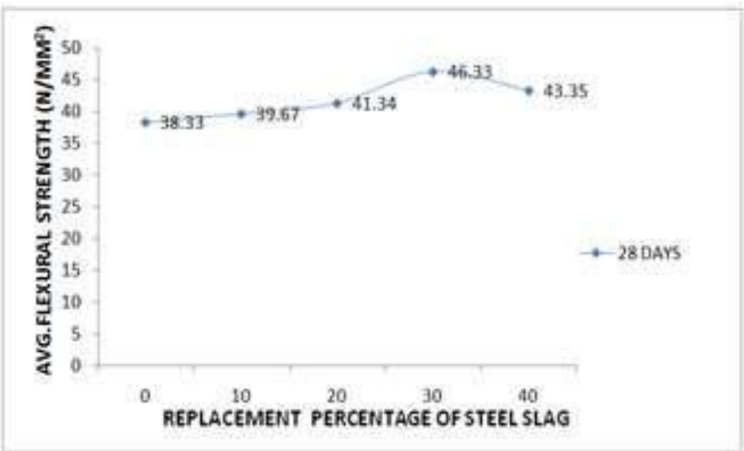

Fig.4: Flexural Strength Graph of Steel Slag by Fine Aggregates for M35 at 28 Days.

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The resultant graph of flexural strength strength of M35 grade of concrete concludes good strength results up to 30% of replacement afterwards at 40% it decreases. The strength increases gradually. The test readings are tabulated and plotted above.

CONCLUSIONS

From the above experimental study and deep analysis, following conclusions are made:

1. With the increased percentage of steel slag, workability (slump) is also increased, whereas compaction factor decreases.

2. During compressive strength test, at optimum replacement level, i.e.at 30% replacement 15.88% strength is noted for 7 days of curing while 15.14% for 14days, 12.39% for 28 days and10.67% for that of 50 days of curing on compared with the conventional concrete mix.

3. During split tensile strength test, at optimum replacement level, i.e.at 30% replacement noted as 14.40% strength for 28 days of curing compared with that of the conventional concrete mix which shows an increment in strength on a replacement.

4. During flexural strength test, at optimum replacement level, i.e.at 30% replacement noted as 20.87% strength for 28 days of curing compared with that of the conventional concrete mix which shows an increment in strength on a replacement.

5. From the above experimented results in compressive strength, split tensile strength and flexural strength, the concrete of M35 grade shows comprehensively good results from the conventional concrete mix. Hence it is concluded that the use of steel slag up to 30% does not show any harm to the concrete mix and can be taken as an alternate of fine aggregate.

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Volume 12, Issue 1 July - Aug: 2016

INTERNATIONAL JOURNAL OF COMPUTATIONAL AND MATHEMATICAL IDEAS [IJCMI] ISSN: 0974-8652