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# Experimental Investigation on Fully Replacement of Steel Slag as Course Aggregate in $M_{30}$ Grade Concrete

J. Vengadesh Marshall Raman (M.Tech)[1], M. Sriram (M.E)[2]
*Assistant Professor Mailam Engineering College*

***Abstract:*** ***Slag is co-product of the iron and steel making process. The use of steel slag reduces the need of natural rock as constructional material, hence preserving our natural rock resources, maximum utilization and recycling of by-products and recovered waste materials for economic and environmental reasons has led to rapid development of slag utilization. The use of steel aggregate in concrete by replacing natural aggregates is a most promising concept.***
***An attempt was made to replace coarse aggregate with the steel slag. When it was cut to a required size of 20 mm and less. This steel slag with different percentage of 25%, 50%, 75%, 100%, was tested for partial replacement of coarse aggregate for M30 grade concrete. The compressive strength of steel slag with 25% replacement was found to have 40.4 N/mm$^2$ at the end of 28 days Which is marginal to the conventional concrete. The split tensile strength of fuel dispenser hose pipe with 10% replacement was 5N/mm$^2$ at the end of 28 days which is more than conventional concrete. The flexural strength of fuel dispenser hose pipe with 10% replacement was 5N/mm$^2$ at the end of 28 days which is more than conventional concrete. Hence 10% of fuel dispenser can be replaced for coarse aggregate in cement concrete.***
***Key words: Steel slag, Compressive strength, Split tensile strength, Flexural strength, M30 grade concrete***

## I. INTRODUCTION

Steel slag aggregates generally exhibit the potential to expand due to the presence of un-hydrated free lime and magnesium oxides which hydrate in humid environments. If such a product is used in the concrete, it influences both the mechanical and physical properties of concrete along with its durability. The purpose of this research is to explore the feasibility of utilizing the steel slag produced by steel industries as a replacement for natural coarse aggregate in the concrete. *Khalid Raza et al.* The workability of concrete decreased with 100% replacement of normal crushed coarse aggregate with slag aggregate by amount 8% in M40 grade of concrete compared to control mix of concrete. The workability improved by 20% by replacing fine aggregate with granular slag up to 50% replacement level. *Joseph O. Akinmusuruet al.* Use of steel slag as and aggregate for concrete mixes, and in powder form as a concrete, has been investigated. (Determine the water-absorption capacities)Mix ratios used were 1:1½:3 and1:2: 4 with water/cement ratios varying from 0.52 to 0.55.The workability from 90 to 100 mm and 0.89 to 0.96, respectively. *RamziTahaet al.* The compressive strength of concrete containing steel slag aggregates increased with an increase in percentage of slag aggregates in the mix. The 28-day compressive strength reached a maximum value of 43.88 mpa with 100% steel slag aggregate (S20-100) and a minimum value of 38.62 mpa for the mix with 25% steel slag aggregate (S20-25). *Abdullah A. Almusallam et al* The influence of aggregate quality on the compressive strength of plain and 10% and 15% silica fume cement concretes is summarized. The highest compressive strength was measured in the concrete specimens prepared with steel-slag aggregates. While the lowest compressive strength was noted in the concrete specimens prepared with calcareous limestone aggregates. *Marco Pasetto et al.* Slag aggregate having acceptable properties such as crushing value, impact strength and water absorption shall be used in concrete. Incorporating slag in coarse aggregate reduces compressive strength by 2% in 20% replacement, 16% for 40%replacement, 17% for 60% replacement and 19% for 100% replacement. Ahmed Ebrahim et al Increasing the steel slag percentage (SSP) to the limestone in the blended mix increases the mechanical properties such as maximum dry density, California Bearing Ratio and resilient modulus. The best density and strength for the layer with the least construction costs obtained at a blended mix of 70% steel slag percentage to 30% limestone. Adding steel slag to the limestone aggregates increases the resistance to deflection and vertical strain

## II. MATERIALS

*A. Cement*


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Ordinary Portland cement, 43 grade conforming to IS: 12269 – 1987. Some of the properties are tested and listed below.

Table1 physical properties of cement

| Sl. No | Property | Value |
|---|---|---|
| 1 | Specific gravity | 3.15 |
| 2 | Standard consistency | 29 % |
| 3 | Initial setting time | 110 min |
| 4 | Final setting time | 400 n |

*B. Fine Aggregate*

Locally available sand passing through 4.75 mm has to be used in this experimental work. The following properties of fine aggregates are determined as per IS:2386-1963.

Table 2 physical properties of sand

| Sl. No | Property | Value |
|---|---|---|
| 1 | Specific gravity of sand | 2.57 |
| 2 | Fineness modulus of sand | 2.80 |
| 3 | Water absorption | 1.57% |
| 4 | Bulk density of sand | 1710kg/$m^3$ |

*C. Coarse Aggregate*

The coarse aggregate passing through 20 mm and retaining 4.75 mm has to be used for experimental work. The following properties of coarse aggregate are determined as per IS:2386-1963.

Table 3 physical properties of coarse aggregate

| Sl. No | Property | Value |
|---|---|---|
| 1 | Specific gravity of coarse aggregate | 2.75 |
| 2 | Fineness modulus of coarse aggregate | 7.16 |
| 3 | Water absorption | 1 % |
| 4 | Bulk density of coarse aggregate | 1472kg/$m^3$ |
| 5 | Impact value | 19 |

*D. Steel Slag*

Steel slag is residue of steel industry; it's produced during the separation of molten steel from impurities in steel making furnaces. Steel slag is produced in general two types (1) basic oxygen furnace, (2) electric arc furnace as a byproduct of the production of steel. For this study the steel slag has collected from PULLKIT steel industry at Aeripakkam. The collected steel slag is in the standard size range of 20mm – 30mm. crushing has performed for the steel slag to obtain the standard coarse aggregate zone.


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Table 4 physical properties of steel slag

| Si. No | Property | Value |
|---|---|---|
| 1 | Specific gravity of steel slag | 3.9 |
| 2 | Water absorption | 3.0 |
| 3 | Bulk density of steel slag | 1520kg/m$^3$ |
| 4 | Zone | II |
| 5 | Los Angeles Abrasion | 28 % |
| 6 | Impact value | 29 % |
| 7 | Crushing strength | 26 % |

Fig 1 Steel slag

*E. Water*

Clean potable water is used for Mixing and Curing operation for the work. The Water supplied in the campus is of the potable standard of PH value 7 is used.

*F. Chemical Admixture*

To improve the workability of the fresh concrete, super plasticizers are used. This is a crucial component in SCC .VARAPLAST 123 from Akarsh Chemicals (INDIA) Ltd was used. It is a non-toxic brown liquid based on naphthalene polymer. The properties of the super plasticizers (SP) as given in the literature of the manufacturer are in the Table 3.6

Table 5 Properties of Admixture as Given By Its Manufacturer

| SI.NO | Physical State | Brown Liquid |
|---|---|---|
| 1 | Dry Matter Content | 35% |
| 2 | Specific Gravity | 1.21 |
| 3 | Chloride Content | Nil |
| 4 | pH | 7 To 8 |
| 5 | Air Entertainment | Less Than 1% |


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Table 6 mix proportions per $m^3$ for m30 of concrete

| SI.No | Ingredients | Quantity $kg/m^3$ |
|---|---|---|
| 1 | Cement | 350 |
| 2 | Fine Aggregate | 750 |
| 3 | Coarse Aggregate | 1205 |
| 4 | Water | 158 |
| 5 | SP | 2.45 |

## III. METHODOLOGY

Compression strength test, split tensile strength and flexural strength test will be carried out by Indian standards. Concrete specimens will be prepared with natural coarse aggregate and steel slag coarse aggregate. The mixture will be prepared with the cement of $350kg/m^3$ and water to cement ratio of 0.45. The mix proportion of materials 1: 2.14: 3.44 as per IS 10262-2009. To cast concrete cubes specimen of size 100× 100 ×100 and to test the harden cube on 28 days under compression. To cast concrete cylinder specimen of size 100× 200 and to test the harden cylinder on 28 days under split tensile. To cast concrete prism specimen of size 100× 100 ×500 and to test the harden prism on 28 days under flexural. Strength studies like compressive strength, flexural strength and split tensile strength are to be conducted. M30 grade Concrete mix with w/c ratio of 0.45 was prepared. The mixes were designated in accordance with IS: 10262-2009. Steel slag is used as a replacement to coarse aggregate by varying the percentage from 25 to 100. A chemical admixture of 0.6% was used to make the concrete workable. A total of 45 concrete cubes were casted for different percentages of replacement of coarse aggregate. The specimens were remolded after 24 hours and curing was done for different age of testing, i.e., 7, and 28 day. Beam of 15 numbers was casted for determining the flexural strength of the concrete.

## IV. RESULTS AND DISCUSSION

### *A. Compressive Strength Test*

The compressive strength of concrete on 28th day was 42.5 MPa for 0%, 40.4 MPa for 25%, 38.1 MPa for 50%, 34.2 MPa for 75% and 32.4 MPa for 100% replacement of steel slag with coarse aggregate. From the results it was found that there is a decrease in compressive strength with the increase in the percntage replacement of steel slag with coarse aggregate.

Table 7 compressive strength of concrete for various ages of curing

| S.NO | Steel slag coarse aggregate % | Compressive strength $N/mm^2$ | |
|---|---|---|---|
| | | 7 day | 28 day |
| 1 | 0 | 23 | 42.5 |
| 2 | 25 | 21.7 | 40.4 |
| 3 | 50 | 20.4 | 38.1 |
| 4 | 75 | 19.2 | 34.2 |
| 5 | 100 | 18.7 | 32.4 |


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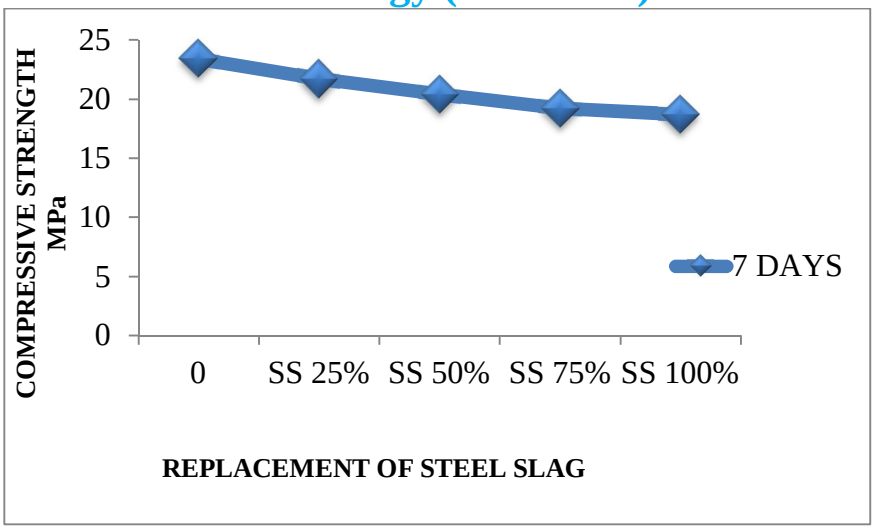


Fig 2 Compressive Strength Vs % of Steel Slag Coarse Aggregate

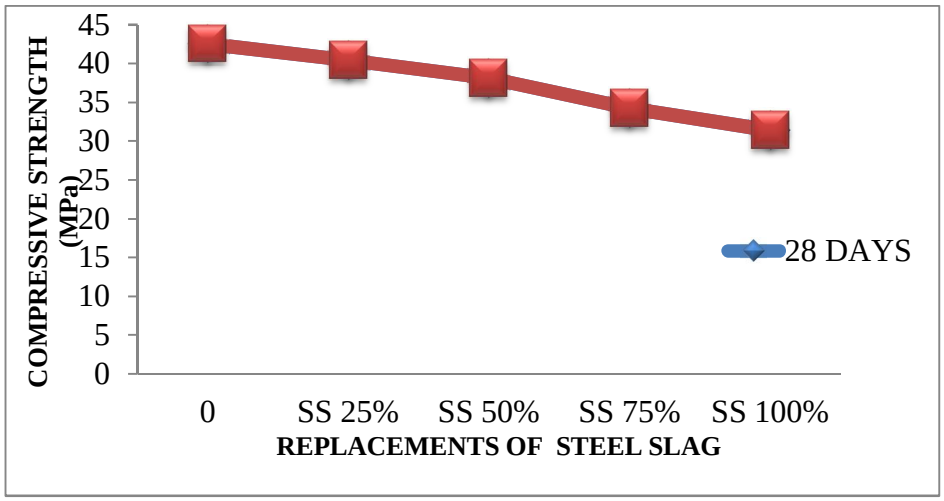


Fig 3 Compressive Strength Vs % of Steel Slag Coarse Aggregate

*B. Flexural Strength of Concrete*

Flexural strength of the concrete at various replacement of natural coarse (i.e. 0%, 25%, 50%,and 100%) with steel slag coarse aggregate at 28 days of normal curing are given in table8. based on the results following inferences are drawn.

Table 8 Flexural Strength of Concrete With And Without Slag Coarse Aggregate

| SI.NO | Steel Slag Coarse Aggregate % | Flexural Strength N/mm² |
|---|---|---|
| 1 | 0 | 5.87 |
| 2 | 25 | 5.72 |
| 3 | 50 | 5.65 |
| 4 | 75 | 5.35 |
| 5 | 100 | 4.76 |


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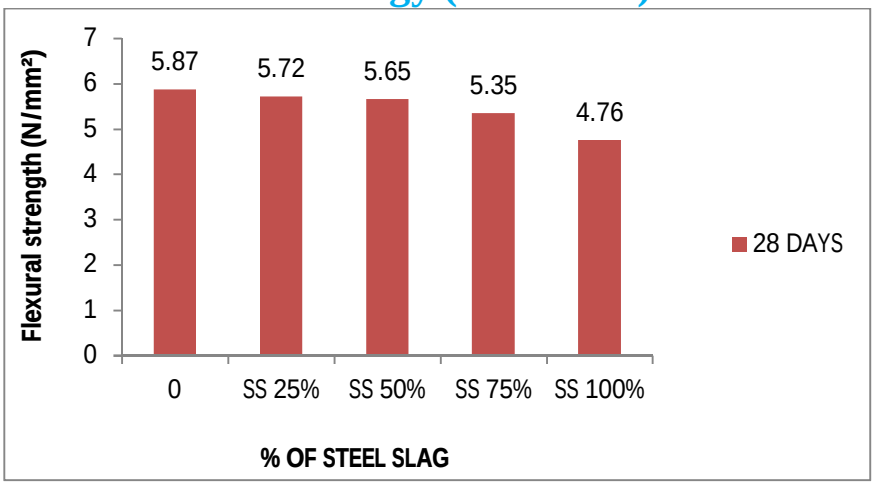


Fig 4 flexural strength Vs % of Steel Slag Coarse Aggregate

*C. Split tensile Strength Of Concrete*

Split strength of the concrete at various replacement of natural coarse (i.e. 0%, 25%, 50%,and 100%) with steel slag coarse aggregate at 28 days of normal curing are given in table

Table 9 split tensile strength of concrete

| S.NO | Steel Slag Coarse Aggregate % | Split tensile strength N/mm² |
|---|---|---|
| 1 | 0 | 4.2 |
| 2 | 25 | 4.08 |
| 3 | 50 | 3.85 |
| 4 | 75 | 3.70 |
| 5 | 100 | 3.41 |

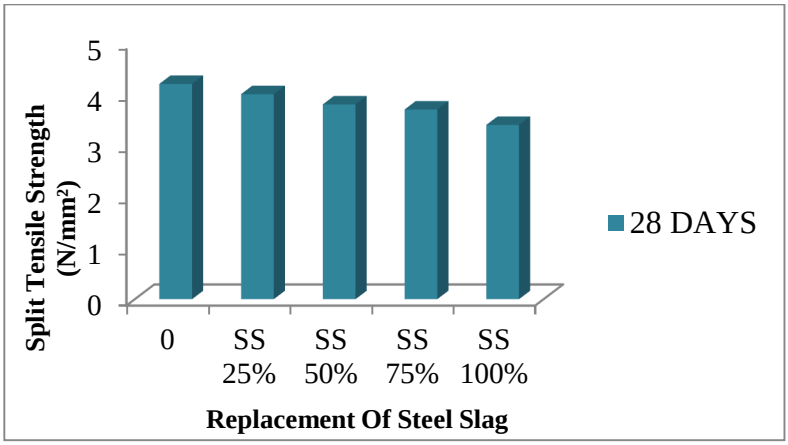


Fig 5 Split tensile Strength Vs % of Steel Slag Coarse Aggregate

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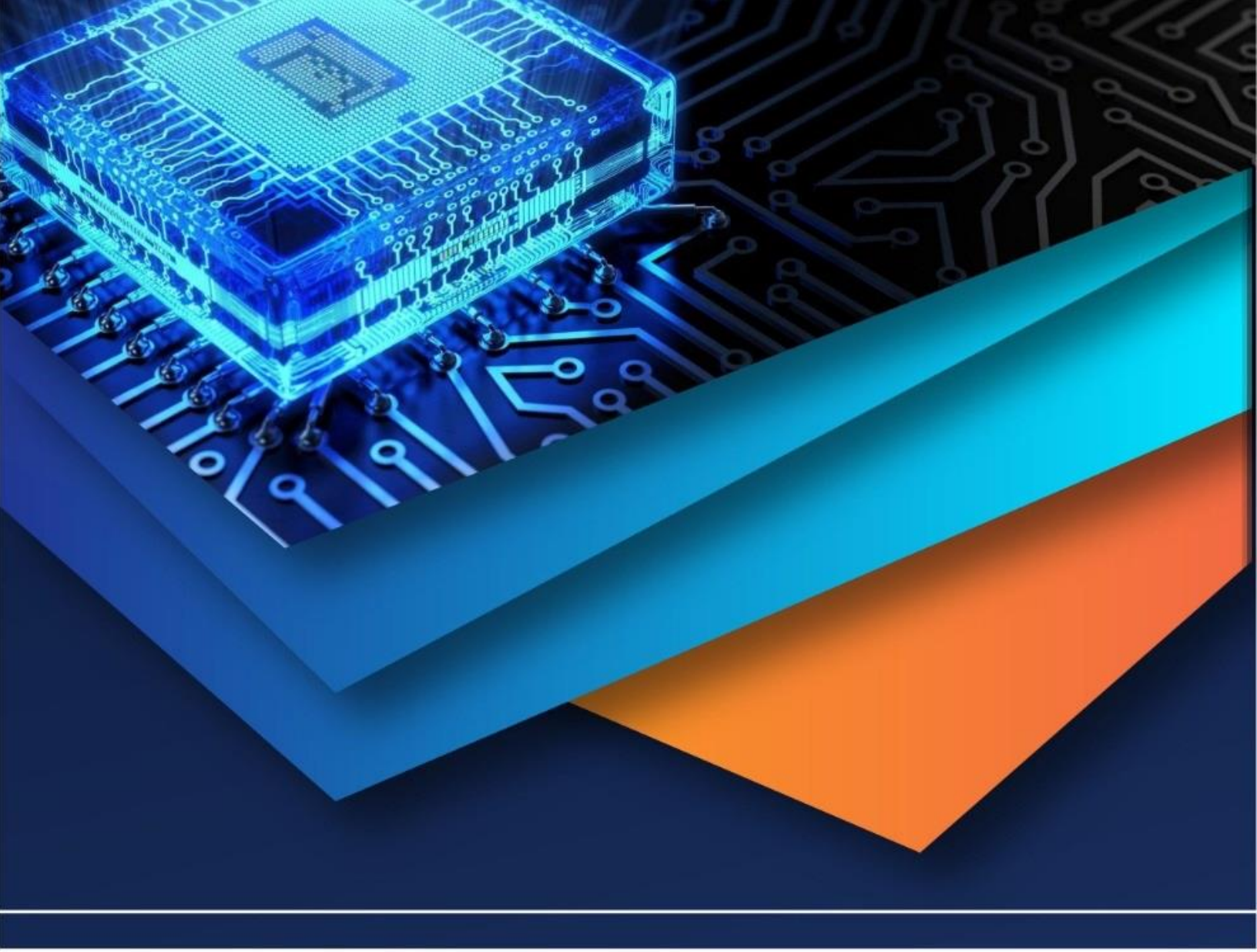

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