Comparative Strength Analysis of Concrete by Using Steel Slag as an Alternative to Normal Aggregates (Coarse) in Concrete

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Abstract—The basic objective of this study was to identify alternative source of good quality aggregates which is depleting very fast due to the fast pace of construction activities in India. Use of steel slag a waste industrial by-Product of iron and steel production provides great opportunity to utilize it as an alternative to normally available aggregates (coarse). In this study concrete of M40 grade for a W/C ratio of 0.40 respectively for the replacement of 0, 10, 20, 30, 40, and 50% of aggregates (coarse) by steel slag Among those is steel sag which is produced as a waste material in steel industry and has a negative impact on environment when disposed. Whole study was done in single phase, i.e. normal crushed coarse aggregate with granular steel slag. The investigation revealed improvement in compressive strength, split tensile, and flexural strength over control mixes by 4 to 8%. The replacement of 50% slag aggregate (coarse) increased concrete density by about 50 to 7% Compared to control mix.

Keywords-- Steel Slag aggregate, coarse aggregate, alternative material for concrete, Compressive strength, Flexural Strength.

I. INTRODUCTION
Blast furnace slag is produced as a by-product during the manufacture of iron and steel. Significant quantities of steel slag are generated as the major by-product from the conversion of iron to steel in the basic steel making processes (Cement Australia Group). The steel slag generated from the

Conversion of iron to steel is poured into beds and slowly cooled under ambient conditions. Steel slag can be used in the construction industry as aggregates in concrete by replacing natural aggregates [1].

The consumption of Slag in concrete not only helps in reducing greenhouse gases but also helps in making environmentally friendly material. During the production of iron and steel, fluxes (limestone and/or dolomite) are charged into blast furnace along with coke for fuel.[2]

Cement Concrete: Cement concrete is defined as the mixture of cement, aggregates, sand with water which hardens into super strong building materials and

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will be used in construction of buildings, foundations, highway, sidewalks etc. Here, cement act as a binding material. Concrete is a composite material which is composed of coarse granular materials called aggregates or filler embedded together in the form of a matrix with the help of the cement or binding material that fills the space between the aggregates particles and glues them together.

**Steel Slag**: Steel slag is a by-product obtained either from conversion of iron to steel in a Basic Oxygen Furnace (BOF) or by the melting of scrap to make steel in the Electric Arc Furnace (EAF). Steel slag is defined by the American Society for Testing and Materials (ASTM) as a non-metallic product, consisting essentially of calcium silicates and ferrites combined with fused oxides of iron, aluminum, manganese, calcium and magnesium that are developed simultaneously with steel in basic oxygen, electric arc, or open hearth furnaces (Kalyoncu, 2001). Unlike the Basic Oxygen Furnace (BOF) process, the Electric Arc Furnace (EAF) does not use hot metal, but uses cold steel scraps. The main constituents of iron and steel slags are silica, alumina, calcium, and magnesia, which together make about 95% of the total composition. Physical characteristics such as porosity, density, particle gradation, are affected by the cooling rate of the slag and its chemical composition.

**CURRENT USES OF STEEL SLAG**

- Steel slag is used as an ideal aggregate in hot mix asphalt (HMA) surface mixture application due to its high frictional resistance and skid resistance characteristics. The cubical nature of steel slag and its rough texture provides more resistance than round, smooth and elongated aggregates.
- It is also used for manufacture of Portland cement.
- It is also used in agriculture because it has minerals like iron, manganese, magnesium, zinc and molybdenum which are valuable plant nutrients.
- It is environment friendly. During the production of cement, the CO2 emissions are reduced as slag has previously undergone the calcination process.
- Steel slag aggregates are used for soil stabilization or soil improvement material and for remediation of industrial waste water run-off.

> **Aggregates**: Aggregates provide dimensional stability and wear resistance for concrete. Not only do they provide strength and durability to concrete, but they also influence the mechanical and physical properties of concrete. Aggregates act as a filler material and lower the cost of concrete. Aggregates should be hard, strong, free from undesirable impurities and chemically stable.

They should not interfere with the cement or any of the materials incorporated into concrete. They should be free from impurities and organic matters which may affect the hydration process of cement. The workability, strength, durability and moisture susceptibility of concrete are greatly influenced by the characteristics of aggregates. The size and
grading of aggregates are important parameters in the design of a mix for a particular project because they can influence the workability of fresh concrete and its hardened strength.

II. OBJECTIVE

- Use of Steel slag as a waste industrial materials in cement concrete and determine its compressive strength by cube test on 7 days, 14 days and 28 days.
- To know the proportion of Steel slag with super plasticizer (PC based) Design Mix.
- Also check the Flexural Strength by prism test on 7 days, 14 days and 28 days.
- The original scope of this research was to investigate the properties of concrete with steel slag aggregates.
- The main objective of this research is to study the effect of using the Steel slag that combined with super plasticizer by different ratios on improving the strength of the concrete.

III. LITERATURE REVIEW

This chapter discusses concrete in general as well as the effects of incorporating steel slag aggregates into the concrete mixture. Topics addressed include steel slag, how it is manufactured, its properties, comparison of steel slag aggregates with natural aggregates, and its feasibility for use as a replacement for natural aggregates in concrete.

Concrete is a composite material which is composed of coarse granular materials called aggregates or filler embedded together in the form of a matrix with the help of the cement or binding material that fills the space between the aggregates particles and glues them together.

Aggregates are usually obtained from natural rocks, either crushed stones or natural gravels.

A. Steel Rolling Mills

There Are Four Working Factories

- Jordan Steel
- The Global steel industry area
- General company for the manufacture of iron specialist
- Petra iron industry

IV. EXPERIMENTAL INVESTIGATION ON CONCRETE

A. Materials: The materials involved in this project are cement, fine aggregate, coarse aggregate and admixtures such as Blast furnace Slag and super plasticizer. The properties of the materials are tested and tabulated.

Table 1: Physical Properties of Material

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity of CA</td>
<td>2.79</td>
</tr>
<tr>
<td>Specific gravity of FA</td>
<td>2.65</td>
</tr>
<tr>
<td>Specific gravity of steel slag</td>
<td>3.9</td>
</tr>
<tr>
<td>Water absorption of steel slag</td>
<td>2.3%</td>
</tr>
<tr>
<td>Fineness modulus of steel slag</td>
<td>2.94</td>
</tr>
<tr>
<td>Specific gravity of cement</td>
<td>3.15</td>
</tr>
<tr>
<td>Fineness modulus of CA</td>
<td>6.98</td>
</tr>
<tr>
<td>Water absorption of CA</td>
<td>0.6%</td>
</tr>
</tbody>
</table>
B. Mix Design: Mix has been designed for M40 grade concrete by Indian standard recommended method of concrete mix design as per design code IRC 44 and IS: 10262-1982.

The experimental investigation carried out in soil to determine their properties and the test procedure for finding out the compressive strength of concrete and flexural strength of concrete as per IS 516-1959. Slump test is used to determine the workability of fresh concrete. Slump test as per IS: 1199 – 1959 is followed. The apparatus used for doing slump test are Slump cone and tamping rod. The cube specimen of the size 150mm X 150mmX150mm is made and tested in compression testing machine to determine the compressive strength of concrete.

Table 2: Mix Proportion for Concrete

<table>
<thead>
<tr>
<th>Replacement level of steel slag</th>
<th>Mix proportion for M40 concrete</th>
</tr>
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<tbody>
<tr>
<td>A 0%</td>
<td>1:1.65:2.92</td>
</tr>
<tr>
<td>B 10%</td>
<td>1:1.65:2.62</td>
</tr>
<tr>
<td>C 20%</td>
<td>1:1.65:2.33</td>
</tr>
<tr>
<td>D 30%</td>
<td>1:1.65:2.03</td>
</tr>
<tr>
<td>E 40%</td>
<td>1:1.65:1.75</td>
</tr>
<tr>
<td>F 50%</td>
<td>1:1.65:1.45</td>
</tr>
</tbody>
</table>

Table No-2 represents the different ratio of replacement level of Steel slag on M40 Mix design.

V. CONCLUSION:

- The study concluded that compressive strength of concrete improved by 5% to 8% at all the replacement of crushed coarse aggregate with slag.
- 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.
- It could be said that 100% replacement of crushed coarse aggregate with slag enhanced concrete density by 6to 8% in all the concrete mixes and reduce concrete density by 2% in case of replacing fine aggregate with granular slag.
- Super plasticizer is used as a admixture in concrete and it could be save 20-30% water but setting time will be increases.

VI. REFERENCES:


