Replacement of Coarse Aggregate using Steel Slag in Concrete

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***Abstract*—Natural aggregates are becoming scarce and their production and shipments is also becoming more difficult. The main objective of this study is to identify alternative source of good quality aggregates which is depleting very fast rate due to the fast pace of construction activities in India and to improve the workability and durability of concrete . Use of steel slag as a waste industrial which is the by-Product of iron and steel production provides great opportunity to utilize it as an alternate to normally available coarse aggregates. In this study concrete of M25 grade for a w/c ratio of 0.45 respectively for the replacement of 60%,70% and 80% of coarse aggregates by steel slag which is produced as a waste material in steel industry and has a negative impact on environment when disposed. The investigation reveals that the steel slag could be utilized as coarse aggregate in all the concrete applications and shows a considerable improvement in the compressive strength of concrete over the control mixes by 7 to 8%. Results show that the concrete incorporating steel slag has higher compressive strength and an increase in density and stability was clearly observed in the specimens replaced with steel slag as coarse aggregate.**

Keywords—Industrial by-product, Steel Slag , coarse aggregate, Compressive strength, Water Absorption.

I. INTRODUCTION

The aggregates typically account about 75% of the concrete volume and play a substantial role in different concrete properties such as workability, strength, dimensional stability and durability. Conventional concrete consists of sand as fine aggregate and gravel, limestone or granite in various sizes and shapes as coarse aggregate. There is a growing interest in using waste materials as alternative aggregate materials and significant research is made on the use of many different materials as aggregate substitutes such as coal ash, blast furnace slag and steel slag. This type of waste material can solve problems for lack of aggregate in various construction sites and reduce environmental problems related to aggregate mining and waste disposal .Steel 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. The consumption of Slag in concrete not only helps in reducing greenhouse gases but also helps in making a eco friendly material. Steel slag can be reduces the need of natural rock as constructional material, hence preserving our natural rock resources, maximum utilization and recycling of by-product sand recovered waste materials for economic and environmental reasons has led to rapid development of slag utilization.

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). [6] 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.

Figure 1 Sample steel slag

METHODOLOGY:-

Use of Steel slag as a waste industrial materials in cement concrete and determine its compressive strength by cube test on 7days, 28days. The main objective of this research is to study the effect of using the Steel slag added

different ratios on improving the strength of the concrete. The various percentage of replacement is 60%,70%,80%.

MATERIALS PROPERTIES;

The basic materials required for the concrete are cement, fine aggregate and coarse aggregate. The steel slag used as a replacement material is also tested for its basic properties. The properties are given in table 1.

Table-1 PROPERTIES OF MATERIALS

	Cement	fine aggregate	Coarse aggregate	Steel slag
Specific gravity	3.15	2.6	2.67	3.9
Water absorption%	-	1%	0.65%	0.54%
Fineness modulus	-	2.64	2.9	3.1
Impact value	-	-	13.5%	17.3%

Mix proportion

M25 grade of concrete is design based on IS 10262-1982 and IS 383-1970 codal provisions. The mix proportion arrived for control concrete & for various percentage of replacements are given as table-2

Table -2 mix proportion for various percentage replacement

Replacement Percentage%	cement	Fine aggregate	Coarse aggregate	Steel slag
0	1	1.18	2.62	0
60	1	1.18	1.05	1.57
70	1	1.18	0.79	1.83
80	1	1.18	0.53	2.09

Experimental Investigation

Size of the specimen -150x150x150mm

Figure 2 casting on cubes

Figure 3 compressive strength test

RESULTS AND DISCUSSION

The steel slag has been used as the replacement material for coarse aggregate and the cubes are tested for compressive strength. The values are present in table 3 & the variation is shown in figure 4

Table -3 compressive strength for 7 days curing

Percentage of steel slag(%)	Compressive strength on 7th day N/mm^2	Average compressive strength N/mm^2
60	24.36 25.78 25.53	25.22
70	32.22 29.86 33.25	31.78
80	26.71 30.71 31.42	29.61

CONCLUSION

The main aim of this research was to study the behavior of concrete and changes in the properties of concrete with steel slag replacing the use of natural aggregates.Steel slag is a by product and using it as aggregates in concrete will might prove an economical and environmentally friendly solution. The demand for aggregates is increasing rapidly and so as the demand of concrete. Thus, it is becoming more important to find suitable alternatives for aggregates in the future.

A through literature review was conducted to study and investigate the properties of steel slag aggregates. The results showed that it has properties similar to natural aggregates and it would not cause any harm if incorporated in to concrete. A comparison was made between concrete having natural coarse aggregates and fine aggregate with various percentage so steel slag replaced by volume.

Compressive strength, splitting tensile strength for steel slag was similar to conventional concrete. The strength may be affected with time and so long term effects on hardened properties of concrete require further investigation.

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