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Replacing of Energy Optimizing Furnace Slag as a Fine Aggregate in Concrete

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ABSTRACT

Concrete is largest produced material in the construction industry and as per WHO concrete is the largest consumed material by human beings after food and water. About 75% of the concrete is composed of aggregates and because of huge demand of concrete all over the world, availability of natural aggregates is becoming scarce. Civil engineers have always been looking for an alternative for the use of more ecofriendly and easily available materials as a replacement to conventional constituents in concrete. Concrete industry has always welcomed the use of various industrial waste materials as a replacement to these constituents since, otherwise such industrial waste need to be disposed in the form of landfills causing enormous amount of land pollution. This project presents the experimental investigation carried out to evaluate the effect of partial replacement of fine aggregate in concrete by steel slag which is waste product generated during the production of steel. The use of steel slag reduces the need of natural rock as constructional material, hence preserving our natural rock resources besides provides an environmental friendly option of concrete production. Steel slag mainly consists of calcium carbonate and is produced as a by-product of oxidation process in steel industry.

Keywords: Concrete, Steel slag, Fine aggregate, Coarse aggregate, Portland cement

1.INTRODUCTION

In construction industry concrete is the largest produced material. In India alone, every year hundreds of million cubic meters of concrete is consumed. Concrete is made up of coarse and fine aggregates gluedtogether by binding material. The usual concrete practice in construction industry is unsustainable because each year it consumes enormous quantities of natural resources like sand, stone and millions of tons of cement which is not eco-friendly. An aggregate constitute about 70-80 percent volume of concrete and considerably impacts its various properties. Due to rapid growth in the demand of concrete throughout the world, even some developed countries have undergone some shortage in the supply of aggregates. Therefore, there is a need for research to find an eco friendly and easily available alternative to the use of constituent materials in concrete. Slag, by-product obtained from the steel manufacturing industry formed in smelting, welding, and other metallurgical and combustion processes from impurities in the metals or ores being treated. Slag consists mostly of mixed oxides of elements such as silicon, sulfur, phosphorus and aluminum ash and products formed in their reactions with furnace linings and fluxing substances such as limestone. It has been estimated that in India alone, approximately one thousand million tons of slag is generated as a solid waste and thus there is a need of research to

utilize this major by product of steel industry, being not recyclable, as one of the constituents in the concrete production. The use of steel slag in construction industry preserves our natural aggregates, utilizes slag waste from steel industries thereby, reducing the environmental pollution to a greater extent. In this study it is proposed to use steel slag as a partial replacement to fine aggregate in different mixes of concrete, where different percentages of cement has been replaced by fly ash and metakoalin. Tests on compressive strength, tensile strength, sorptivity and water absorption were performed and the effect of increasing the percentage of steel slag on various parameters were studied and compared.

2.MATERIAL

2.1 Cement and Aggregates

The OPC is classified into three grades, namely 33 Grade, 43 Grade, 53 Grade depending upon the strength of 28 days. Ordinary Portland Cement (OPC) of 53 Grade (RAMCO cement) from a single lot was used throughout the course of the investigation. The physical properties of the cement as determined from various tests conforming to Indian Standard IS: 8112:1989

Physical Properties of Fine and Coarse Aggregate

Description	Fine Aggregate	Coarse Aggregate
Specific gravity	2.6	2.75
Water absorption	1.57%	2.3%
Fineness modulus	3.1(zone II)	6.4
Surface moisture	Nil	Nil
Bulk density	1450 kg/m^3	1765kg/m^3

Table 1.1

Physical Properties of EOF Steel Slag

Properties	Result
Specific gravity	2.8
Bulk density	1455kg/m^3
Fineness modulus	2.9(zone I)
Water absorption	1.87%

Table 1.2

Chemical Properties of EOF Steel Slag

Parameter	Steel Slag (%)
CaO	35.28
MgO	9.27
SiO_2	16.69
Al_2O_3	6.20
MnO	1.88
FeO	26.91
P_2O_5	1.43
Na_2O	0.16
K_2O	0.03
SO_3	0.56

Table 1.3

3. SPECIMEN PREPARATION

Then weighed quantity of fine aggregates and coarse aggregate was added and mixed indry state until homogenous mixture was obtained. Measured quantity of water was added and ingredients were mixed in the mixer. All the moulds were oiled before casting the specimens. Cube specimens of size150 mm x 150 mm x 150 mm of each concrete mixture were cast to determine the compressive strength, splitting tensile strength, cylindrical specimens of size 150 mm x 300 mm were cast to measure the modulus of elasticity of concrete. Cylindrical specimens of size 100 mm x 200 mm were cast to determine thesorptivity, chloride ion penetration and water loss through air drying. Cube specimens of size 100 mm x 100mm x 100 mm were cast to determine the resistance of concrete to external acid attack. Prism specimen of size 100 mm x 100 mm x 500 mm were cast to measure the length change when the specimens were exposed to airdrying and Concrete tile specimens of size 150 mm x 300 mm were cast to determine the resistance toabrasion. The

specimens were de-moulded after 24 ±1 hr of adding water to concrete mixture. Aftermoulding the specimens were cured in water at room temperature.

4. RESULT AND DISCUSSION

4.1 COMPRESSIVE STRENGTH TEST RESULTS

Test specimens of size 150 x 150 x 150 mm were prepared for testing the compressive strength concrete. The concrete mixes with varying percentages of energy optimizing furnace steel slag replacing to sand were casted into cubes and cylinders for subsequent testing.

Compression strength

mix	7 days	21 days	28 days
Mix -0	26.93	27.83	31.2
Mix -1	27.7	28.2	28.4
Mix -2	27.83	28.4	31.6

Table 1.4

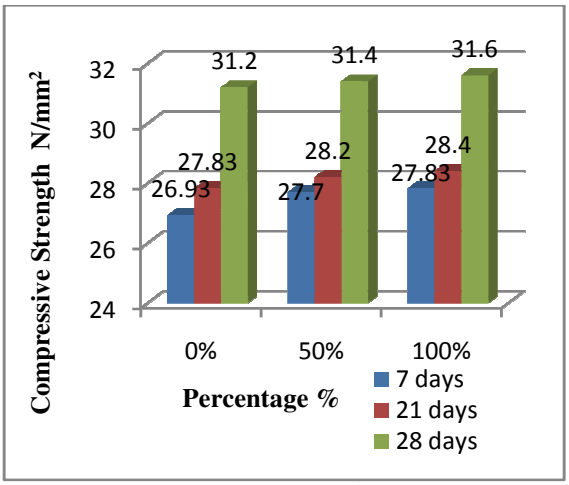

CHART 1.1

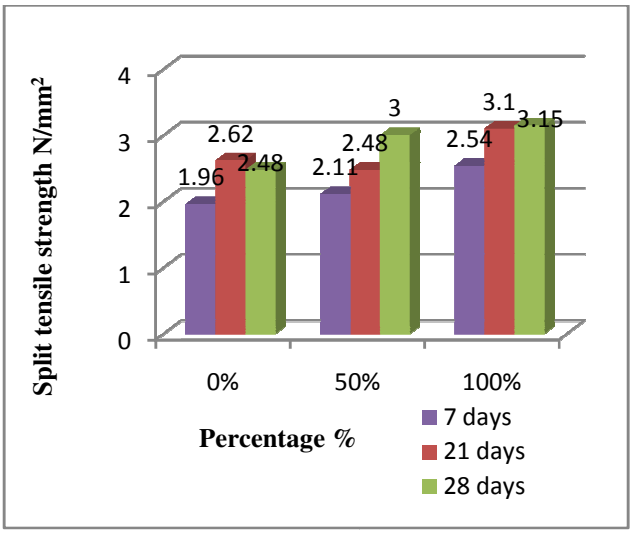

CHART 1.2

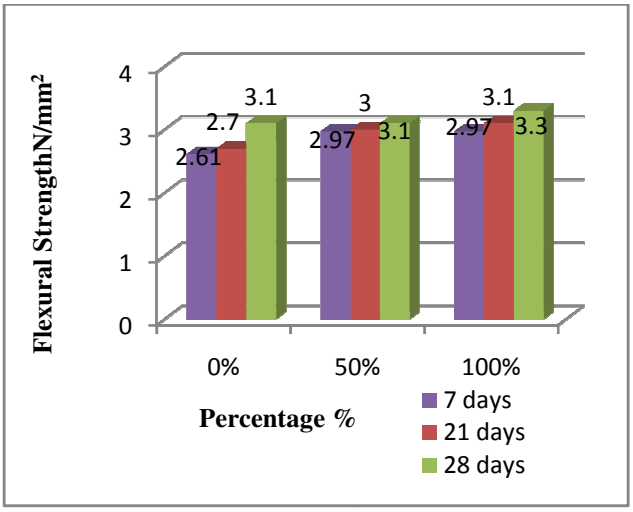

CHART 1.3

From the test results, EOF Slag found to be better performance in workability and strength properties.

5. CONCLUSION

5.1 COMPRESSIVE STRENGTH ANALYSIS

From the compression test results it is found that the concrete mix with 100% replacement of fine aggregate with EOF slag shows the higher compressive strength than the Reference concrete mix for both 7 days, 21 days and 28 days curing.

From the analysis, it is concluded that EOF Slag mix, which is 100% replacement of EOF Slag, is found to be the most preferable one when compared with other mixes by analyzing its Compressive strength, Workability and Cost. It is recommended as favorable mix for Structural applications.

5.2 SPLIT TENSILE STRENGTH ANALYSIS

From the split tensile test results it is found that the concrete mix with 100% replacement of fine aggregate with EOF Slag shows the higher compressive strength than the Reference concrete mix for both 7 days, 21days and 28 days curing.

From the analysis, it is concluded that EOF Slag mix, which is 100% replacement of fine aggregate , is found to be the most preferable one when compared with other mixes by analyzing its split tensile strength,

Workability and Cost. It is recommended as favorable mix for Structural applications.

5.3 FLEXURAL STRENGTH ANALYSIS

From the flexural test results it is found that the concrete mix with 100% replacement of EOF Slag shows the higher compressive strength than the Reference concrete mix for both7 days, 21days and 28 days curing.

From the analysis, it is concluded that EOF slag mix, which is 100% replacement of EOF slag, is found to be the most preferable one when compared with other mixes by analyzing its flexural strength, Workability and Cost. It is recommended as favorable mix for Structural applications.

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