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Analysis of Compressive Strength of Hardened Concrete: Replacing Natural Sand by Steel Slag

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ABSTRACT
The natural resources are getting depleted day by day. The need to preserve natural resources has become necessary. This problem can be overcome by finding an alternative for natural aggregates. The huge amount of waste generated during steel production and its disposal is a serious environmental issue. The steel manufacturing industries in India produces 12MT/year by-product called steel slag. When this steel slag is directly dumped to ground it cause acquisition of huge land and also degrading the soil quality. In this research work , steel slag is used as a replacement for fine aggregates in concrete. Hence solving the problem of depletion of natural aggregates and dumping of steel slag, also reducing the cost of concrete up to some extent. The use of steel slag in concrete has enhanced the compressive strength of concrete.
Keywords :— Aggregates, Compressive Strength, Concrete, Natural Sand, Steel Slag

I. INTRODUCTION

In construction material, concrete plays an important role. Concrete is prepared by mixing various materials like cement, aggregates, water etc. which locally available. Availability of natural aggregates is getting depleted and also is becoming costly. To meet the scarcity, it is necessary to find suitable alternative to natural aggregates for preparing concrete. Therefore replacement is becoming necessary, and in this research work an attempt has been made to replace natural aggregates by steel slag. As compared to other countries utilization of steel slag is very less in India.

Steel slag is a by-product which is obtained from steel industry. It is generated as a residue during production of steel. It is obtained either from conversion of iron to steel in Basic Oxygen Furnace(BOF), or by the melting of scrap to make steel in the Electric Arc Furnace . Slag consists of calcium, magnesium, manganese and aluminium silicates in various combinations.The slag material is non-hazardous in nature as per chemical analysis report of CPCB. Slag actually has many uses and it can rarely go to waste. Slag is a by-product of the iron and steel manufacturing process. The first step in production of steel is to manufacture iron. Iron ore, a mixture of oxides of iron, silica and alumina, together with a fuel consisting of coke, oxygen and pulverized coal and also limestone as a fluxing agent, are fed together into a blast furnace consisting of a large vertical chamber through which large volumes of hot air are blasted. The chemical reaction further results into two products . They are molten iron metal and molten slag. Slag, which has a relatively lower specific gravity, does not mix with the molten metal and it leaves the furnace which is commonly called Blast Furnace slag. Generally a blast furnace operates on a continuous basis and produces approximately 250-300 kg of slag per tones of iron produced.

The Liquid blast furnace slag flows into pits where is air cooled and sprayed with a small quantity of water .The cooled slag is then transported to a crushing and screening plant where it is further processed into various products.

Alternatively, liquid slag can be rapidly quenched using large volumes of high-pressure water to produce a sandy like material called Granulated Blast Furnace Slag(GBPS). It can be used as an aggregate, as ballast and also as component of phosphate fertilizer.

II. PROBLEM STATEMENT

Waste management is one of the most common and challenging problem in the world. According to Indian Mineral Year Book 56th edition in the year 2017, 12 MT per annum of steel slag is generated and disposed off. As a result large area of land is being sacrificed for the disposal of this waste. As natural aggregates are getting deployed day by day and its increasing cost making the construction activities non-economical. Depletion of natural aggregates is creating serious impact on economy of construction. Hence an alternative is found out to replace natural aggregate in construction by using steel slag aggregate. The awareness of steel slag as a useful material is very limited in India .However many other countries especially economically developed countries have been used steel slag in variety of application.

III. SCOPE

Scope of the project is limited to test physical and chemical properties of steel slag and use it as replacement material for

fine aggregate .Further work consist of testing the sample and distinguish the cost and hardened properties with and without steel slag.

IV. MATERIALS

CEMENT

Ordinary Portland cement of grade 45 was used. The specific gravity of cement is 3.15.

FINE AGGREGATE

Crush sand passing through 4.75mm sieve with a specific gravity of 2.85. The grading zone of aggregate was zone 3.

COARSE AGGREGATE

Angular crushed aggregate of 20mm size were used. The specific gravity of coarse aggregate was 2.9.

STEEL SLAG

Steel slag has been sourced from JSW steel industries ,dolvi. The specific gravity of steel slag was 2.54

CONCRETE MIX DESIGN

Design concrete mix of 1:2.566:4.12 is adopted to attain 38.25 N/mm2 . The water-cement ratio of 0.45is used.

V. METHODOLOGY

The basic tests were conducted on OPC43 grade cement, fine aggregate , coarse aggregate and steel slag to check the suitability for making concrete. The experimental investigation has been carried out on the test specimens of cubes to study the strength properties as a result of partially replacing fine aggregate by steel slag in various percentages such as 0%,15%, 25%, 30%, 35%. Compressive strength test was conducted on hardened concrete after 7days, 14days, and 28 days of curing. And slump test was conducted on fresh concrete.

VI. RESULT

a) Slump Test

Slump Test was done on fresh concrete for various replacement of steel slag.

	For 0 %	For 15%	For 25%	For 30%	For 35%
Slump Value	80mm	70mm	65mm	60mm	60mm

b) Compressive Strength

12 cubes of M30 grade concrete were casted for each replacement . Among them 3 cubes were tested on 7th day , 3 on 14th day and 3 on 28th day, Total 60 cubes were casted and out of that 45 cubes were tested. Specimens were casted as per mix design and its size was 150mm*150mm*150mm.

Compressive strength on	For 0%	For 15%	For 25%	For 30%	For 35%
7 days	28.63	30.51	32.97	30.12	29.37
14 days	32.29	33.706	35.74	33.7	34.21
28 days	39.61	42.1	44.04	43.07	41.89

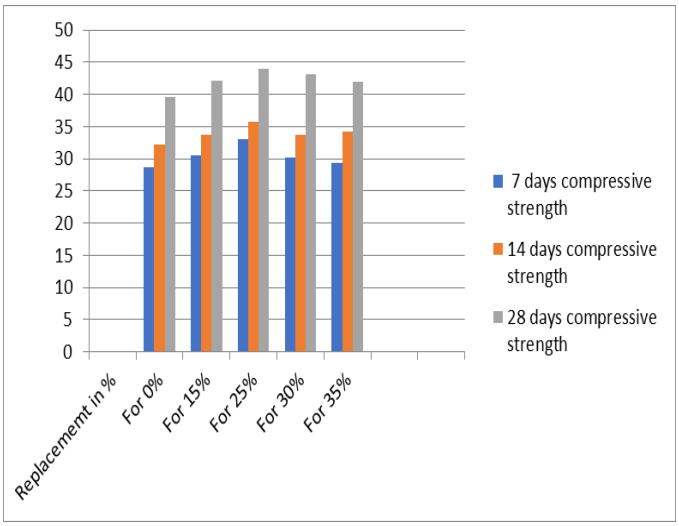

Fig. 1 Graph of average Compressive Strength in MPa

Fig. 2 Testing of Cubes

VII. CONCLUSIONS

Compressive strength increases with increase in % of steel slag upto 25% replacement .

Compressive strength starts decreasing after 25% replacement of steel slag.

From the results of compressive strength of 7days , 14 days and 28 days of curing , 25% replacement of fine aggregate by steel slag is the optimum % of replacement for M30 grade of concrete.

The replacement of steel slag as fine aggregate in concrete has positive impact on compressive strength , hence use of steel slag in concrete will eliminate one of the environmental problem created by steel industry and preserve natural sand.

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