An Experimental Study on Partial Replacement of Fine Aggregate using Steel Slag

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Abstract

Modification of concrete properties by the addition of appropriate materials is a popular field of concrete research. In this study we are focusing on the use of selected waste of steel industry (steel slag) as a partial replacement for fine aggregate in the production of concrete. In this research study, concretes were made with steel slag as substitution for raw fine aggregate. Fine aggregate was replaced by these wastes in different proportions (20%, 40%, & 60 %,) by weight of fine aggregate. The aim of this study is to investigate the compressive strength, split tensile strength and Material properties of concrete with steel chips as a partial replacement for fine aggregate. The experimental results indicates that, the concrete mixed with steel chips have better strength than conventional concrete, while in the case of concrete mixed with the scale of 40%, it attains the maximum strength.
Keyword- Fine Aggregates, Steel Slag, Compressive Strength, Split Tensile Strength

I. INTRODUCTION

Steel slag exist as by-product during melting of steel scrap from the impurities and fluxing agents, which form the liquid slag floating over the liquid steel in are or induction furnaces, or other melting units. The ferroalloys industry has generated historically substantial solid waste. Great amount of wasted materials is generated by industries and has caused tremendous harm to both the environment and ecology. The waste removed from the furnace separately in a rate of about (10- 15%) of the produced steel. Reuse of waste material has become very important during the past decade because of the reinforcement of environmental regulations that require minimizing waste disposal In India, there is a great demand of aggregates mainly from civil engineering industry for road and concrete constructions. The construction of highways and development of several expressways for high-speed corridors exert tremendous pressure on natural resources. Mainly highway agencies, private organization individuals are in the process of completing a wide variety of studies and research projects concerning the feasibility, environmental suitability, and performance of using waste industrial products in highway construction. These studies to match society's need for safe and economic disposal of waste materials with the highway industries need for better and more cost-effective construction materials.

A. Utilization of Steel Slag

In the past 20"century, steel slag was found to be excellent aggregate for road paving. Chemical composition of typical waste material, which would have a promising future in the steel slag consist mainly $Si0_2$, Al_2O_3, CaO, MnO, MgO, TiO_2, P205 and fe203. The steel slag is considered as the material for various types of structures due to its durability in construction field. Concrete is a widely used construction. For a long time it was considered as the durable material requiring a little or no maintenance. In recent times it was too harsh environments, deterioration of concrete will occur found that, when reinforced concrete structures are exposed due to many reasons like chloride and sulphate attack, acid attack, corrosion failure etc. On the contrary the aggregates used for the concrete are facing the greater demand. Utilization of industrial soil waste or secondary materials has been encouraged in the construction field for the production of cement and concretes. There are very less investigators on the use of Steel slag in cement concrete. Not much research has been carried out in India and other countries concerning the incorporation of Steel slag in concrete. Therefore, to generate specific experimental data on strength and other characteristics of Steel slag as aggregate, this work is performed.

B. Scope

The scope of this research was to investigate the properties of concrete with steel slag aggregates. The fresh and hardened properties of concrete were tested with steel slag aggregates. In addition to this research several tests were also included such as compressive strength, split tensile strength and the flexural strength of concrete with steel slag aggregates.

C. Purpose

The purpose of this research was to explore the feasibility of utilizing the steel slag as a replacement for natural aggregate in the concrete. 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 Researchers in the past have successfully incorporated this industrial by- product as aggregates for hydraulically bound mixtures for road bases. The use of this material as a construction aggregate is being studied, and further research is ongoing in the United State.

II. LITERATURE REVIEW

1) Experimental study of blast furnace slag concrete - Authors : Gurjeet singh, sanja sangwan, Mohd.usman
Ultra-fine aggregate. Various strength parameters like compressive strength, flexural strength, split tensile strength etc. are evaluated and showed that by incorporating slag partially or fully in concrete, the mechanical properties of concrete can be improve. However, the use of blast furnace slag as a fine aggregate has not been studied yet. Hence, in the present study, blast furnace slag is used as fine aggregate in different proportion i.e. 0%, 20%, 40%, 60%, 80% and 100%. The compressive strength, split tensile strength and flexural behaviour of reinforced beams are evaluated and compared with that the strength of control mix.
2) Utilization of steel slag in concrete as a partial replacement material for fine aggregate - Authors: P.S kothai, Dr.R.Malathy
A comprehensive study of the potential health risks Associated with the environmental application (eg. Fill, road base, landscaping) of iron and steel making was performed using characterization data for 73 samples of slag collected from blast furnaces, basic oxygen furnaces and electric arc furnace. Characterization data were compared to regulatory health based "screening" bench marks to determine constituent of interest anatomy, Beryllium, Cadmium, Trivalent and hexavalent chromium, manganese, thallium and vanadium were measured above screening levels and were assessed. This research was intended to study the effectiveness of using steel slag aggregate (SSA) in improving the engineering properties of locally produced asphalt concrete (AC) mixes. The research started by evaluating the toxicity and chemical and physical properties of the steel slag. Then structures are exposed due to many reasons like chloride and sulphate attack, acid attack, corrosion failure etc. On the contrary the aggregates used for the concrete are facing the greater demand. Utilization of industrial soil waste or secondary materials has been encouraged in the construction field for the production of cement and concretes. There are very less investigators on the use of Steel slag in cement concrete. Not much research has been carried out in India and other countries concerning the incorporation of Steel slag in concrete. The replacing up to 75% of the lime stone coarse aggregate by SSA improved the mechanical properties of the AC mixes. The results also showed that the 25% replacement was the optimal replacement level.

III. MATERIALS AND METHOD

A. Cement
Ordinary Portland cement of grade 53 was used. The initial setting time of cement is 30 minutes and the specific gravity of cement is 3.15.

B. Fine Aggregate
Fine aggregate used was clear sand passing through 4.75 mm sieve with a specific gravity of 2.6. The grading zone of aggregate was zone II.

C. Coarse Aggregate
Coarse aggregate used was angular crushed aggregate with a specific gravity of 2.67.

D. Water
Portable drinking water having pH value of 7 and conforming to IS 456 – 2000 used for concreting.

E. Steel Slag
Steel slag is 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).

Fig. 1: steel slag

S.No.	Designation	Properties
1	Colour	Light to dark Brown
2	Shape	Highly angular
3	Bulk density	1911.11 Kg/m^3
4	pH (in water)	8
5	Combustibility	Non-combustible
6	Surface Texture	Rough
7	Specific Gravity	2.93

Table 1: Physical Properties of steel slag

S.No.	Constituent	Composition (%)
1	Calcium Oxide (Cao)	40 - 52
2	Silica (SiO2)	10 - 19
3	Iron Oxide (FeO)	10 - 40
4	Manganese Oxide (MnO)	5 - 8
5	Magnesium Oxide (MgO)	5 – 10
6	Aluminium Oxide (Al2O3)	1 - 3
7	Phosphorous Oxide (P2O5)	0.5 – 1

Table 2: Chemical Properties of steel slag

S.No	Mix	F.A %	S.S %
1	CC	100	-
2	CSS1	80	20
3	CSS2	60	40
4	CSS3	40	60

Table 3: Mix Proportions

IV. COMPRESSIVE STRENGTH

The specimens are placed in the machine in such a manner that the load is applied to opposite sides of the cubes as cast. The axis of the specimen is carefully aligned with the centre of thrust of the spherically seated plate. A spherically seated block is brought to bear on the specimen; the movable portion is rotated gently by hand so that uniform seating may be obtained. The compressive strength machine of 1000kN capacity is used, to apply the axial force of compression results shown in Graph.

Fig. 2: Compressive strength

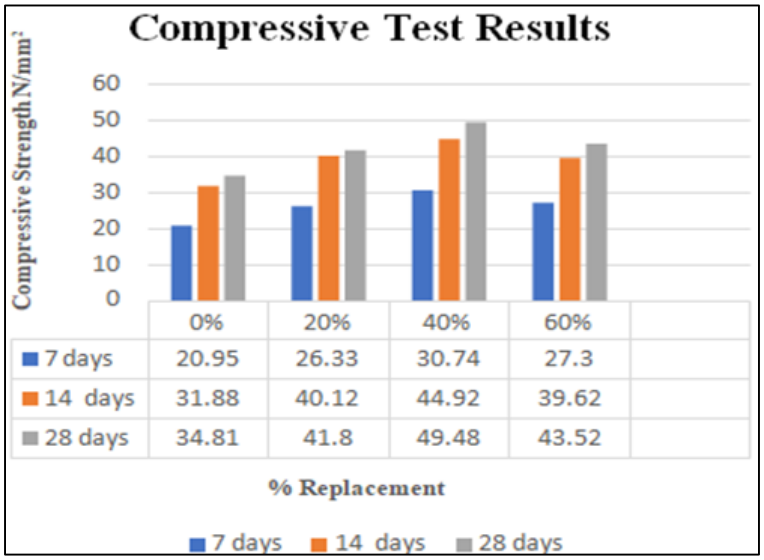

Fig. 3: Compressive strength

A. Split Tensile Strength Test

Align the specimen so that the lines marked on the ends of vertical and centre over the bottom plate. Place the other plywood strip above the specimen. Bring down the upper plate to touch the plywood strip. Apply the load continuously without shock at a rate of approximately 14.1kg/cm^2/minute and the split tensile strength results shown in Graph.

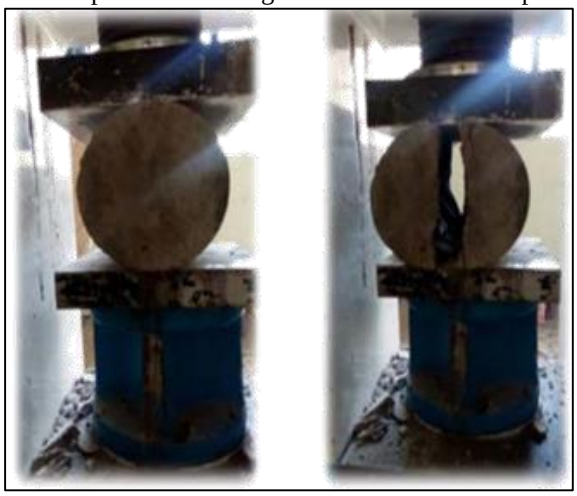

Fig. 4: Split Tensile Test

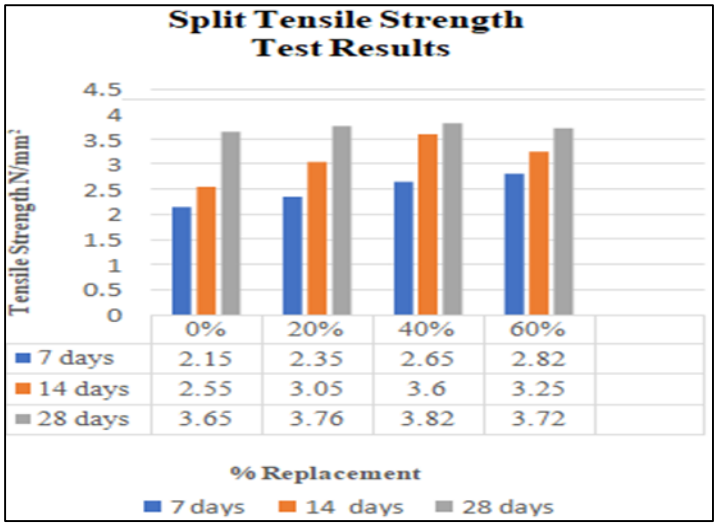

Fig. 5: Split Tensile Strength Test Results

V. CONCLUSION

The compressive strength decreases after 40 %replacement of steel slag. The split tensile strength increases with increase in percentage of steel slag by 40 % by weight of fine aggregate. From the results of compressive strength, split tensile strength of 7 days, 14 days, 28 days curing, 40 % replacement of fine aggregate by steel slag is the optimum percentage of replacement of M30 grade concrete and decreases considerably in further replacement of slag in concrete.

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