

Experimental Investigation on Strength Properties of Concrete by Partial Replacement of Coarse Aggregate with Steel Slag

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ABSTRACT: As a construction material, concrete is the largest production of all other materials. Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. Slag is a byproduct of metal smelting and hundreds of tons of it are produced every year all over the world in the process of refining metals and making alloys. Like other industrial byproducts, slag actually has many uses and rarely goes to waste. It appears in concrete, aggregate road materials, as ballast and is sometimes used as a component of phosphate fertilizer. This substance is produced during the smelting process in several ways. Firstly, slag represents undesired impurities in the metals, which float to the top during the smelting process. Secondly, metals start to oxidize as they are smelted, and slag forms a protective crust of oxides on the top of the metal being smelted, protecting the liquid metal underneath. When the metal is smelted to satisfaction, the slag is skimmed from the top and disposed of in a slag heap to age. Aging material is an important part of the process, as it needs to be exposed to the weather and allowed to break down slightly before it can be used. In this experimental investigation an attempt is made to study the effect of partial replacement of Coarse aggregate by steel slag in the mechanical properties of M₂₀ grade concrete.

KEYWORDS: Steel Slag, Coarse aggregate, Compressive strength, Split tensile strength

I. INTRODUCTION

It is generally known that, the fundamental requirement for making concrete structure is to produce good quality concrete. Good quality concrete is produced by carefully mixing cement, water, and fine and coarse aggregate and combining admixtures as needed to obtain the optimum product in quality and economy for any use. Since aggregates occupy 70-80 percent of the volume of concrete, their impact on various characteristics and properties of concrete is undoubtedly considerable. All along in India, we have been using natural sand and gravel in concrete manufacturing. Availability of natural aggregates is getting depleted and also it becoming costly. Hence, there has to be an emphasis on the use of wastes and by-products in all areas including construction industry. As 75% of concrete is composed of aggregates it is imperative that we look to maximize the use of waste as aggregate input in concrete making. This research work determines the effect of partial substitution of coarse aggregates by steel slag on the mechanical properties of concrete.

II. LITERATURE REVIEW

K.G.Hiraskar and Chetan patil, May 2013, "Use of Steel slag aggregate in concrete". In the present investigation steel slag from local industries has been utilized to find its suitability as a coarse aggregate in concrete making. Replacing all or some portion of natural aggregates with slag would lead to considerable environmental benefits. The result indicates that the unit weight of steel slag aggregate concrete is lower than that of conventional concrete. The compressive strength of steel slag aggregate concrete is found to be higher than that of conventional concrete. It has also reduced water absorption and porosity beyond 28 days in comparison to that of conventional concrete.

P.S.Kothai and R.Malathy, October 2013, "Enhancement of Concrete properties by Steel slag as a Partial Replacement Material for Coarse Aggregate". From this experimental investigation the workability of concrete does

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not have any major change because of addition of steel slag. Also the compressive strength, split tensile strength, flexural strength of concrete are improved due to the chemical content of steel slag.

Mohammed Nadeem and Arun D Pofale, June 2012, “Utilization of industrial waste slags as aggregate in concrete applications by adopting Taguchi’s approach for optimization”. This investigation proves that slag due to its chemical composition and its chemical inertness soundness of aggregate and concrete could be effectively utilized as aggregates in all concrete constructions like plain concrete and reinforced cement concrete.

Tarun R Naik, Shiv S Singh, October 1996, “Use of Steel slag aggregate in concrete” investigated application of foundry by-product materials in manufacture of concrete and masonry products. Compressive strength of concrete increased slightly due to the replacement of regular coarse aggregate with foundry slag however strengths were appropriate for structural concrete.

III. MATERIALS PROPERTIES

Ordinary Portland cement of 53 grade with standard consistency of 32.5%, Initial setting time 32 minutes, Final setting time 362 minutes and specific gravity of 3.15. Fine aggregate conforming to IS: 383-1970 with 2.59 specific gravity, 2% water absorption and specific gravity of coarse aggregate 2.83, 1.5% water absorption used for preparation of concrete specimens.

Steel slag

Steel slag is obtained from **Agni Steels Private Limited, Ingur, TamilNadu, India**. Its specific gravity was found to be 2.0 and water absorption 1.2%. The chemical composition of slag is usually expressed in terms of simple oxides calculated from elemental analysis determined by x-ray fluorescence.

IV. EXPERIMENTAL INVESTIGATION

Specimen Casting

Three numbers of specimens with and without proofing admixture were casted. The specimens are de-moulded after one day. 12 hours prior to the testing, the specimens are allowed to air dry in the laboratory.

1. Compression Test

The compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compression test is carried out on the 7 and 28 days cured moulds. Totally 27 were caste and tested using the Universal testing machine.

Compressive strength = [Failure load (P) / Cross sectional area (mm²)]

2. Split Tensile Strength Test

Control and partially confined concrete specimens of cylindrical shapes of dimension 150 mm dia. and 300 mm height was used for determining the tensile strength. This test was carried out by placing the cylindrical specimen horizontally between the loading surfaces of the compression testing machine and the load was applied until the failure of the cylinder along a vertical diameter happens.

Split Tensile Strength = $2P / \pi DL$; where, P-applied load, D-diameter of the specimen, L-length of the specimen.

Results of Concrete

Table1. Compression Test Result on Concrete

Curing	Compressive Strength(N/mm ²)			
	Nominal Mix	10% Replacement	20% Replacement	30% Replacement
	0:100 (Steel Slag: C.A)	10:90 (Steel Slag: C.A)	20:80 (Steel Slag: C.A)	30:70 (Steel Slag: C.A)
7 Days	16.15	16.75	17.59	17.34
14 Days	18.62	19.1	20.14	19.06
28 Days	21.25	21.29	22.63	20.81

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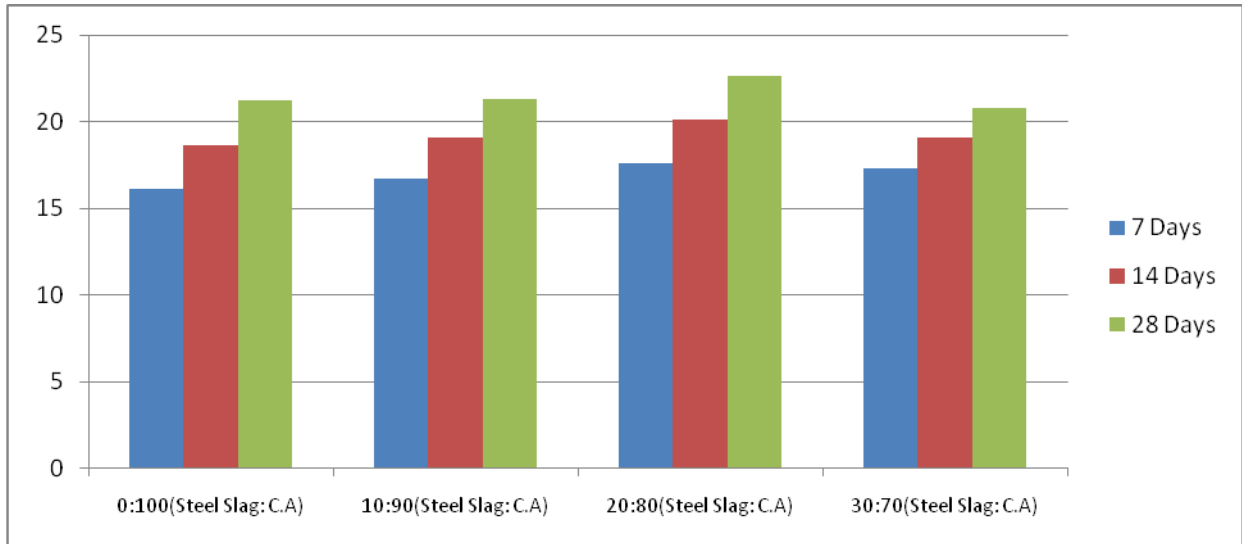


Figure1. Compression Strength Test Result

Table2. Split Tensile Strength Test Result on Concrete

Curing	Split Tensile Strength (N/mm ²)			
	Nominal Mix	10% Replacement	20% Replacement	30% Replacement
	0:100 (Steel Slag: C.A)	10:90 (Steel Slag: C.A)	20:80 (Steel Slag: C.A)	30:70 (Steel Slag: C.A)
7 Days	0.57	0.76	1.82	2.76
14 Days	1.05	1.14	1.94	2.66
28 Days	1.49	1.48	2.05	2.58

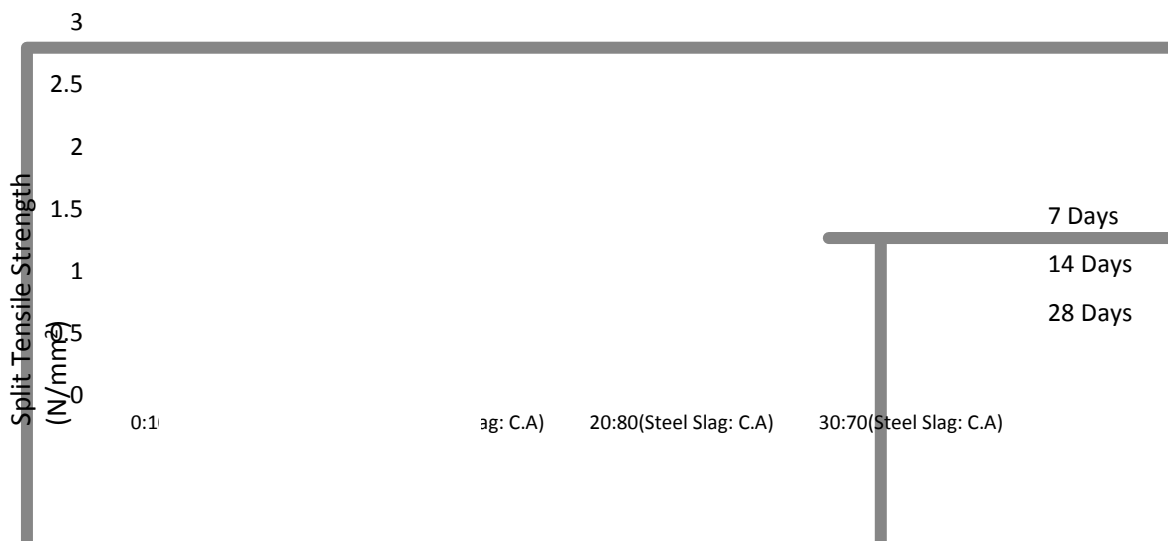


Figure 2. Split Tensile Strength Result

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Figure3. Compression Test



Figure4. Split Tensile Strength Test

V. RESULT AND DISCUSSION

Compressive strength is gradually increased upto 20% replacement of steel slag in concrete. After that it reduced slightly from our research. But Split tensile strength is gradually increased upto 30% replacement of steel slag in concrete.

VI. CONCLUSION

30% of replacement not produced optimum compressive strength. We suggest 20 to 25% of replacement may produce optimum compressive strength. Split tensile strength is gradually increased upto 30%, so we suggest 30 to 35% of replacement may produce optimum strength. Finally we suggest steel slag replacement is suitable for tension member.

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