

A Study on the Utilization of Ferrous Slag as Partial Replacement to Fine Aggregate in Cement Concrete

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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. The increase in demand for the ingredients of concrete is met by partial replacement of materials by the waste materials which is obtained by means of various industries. Slag is a by-product of iron smelting and hundreds of tons are produced every year all over the world in the process of refining metals and making alloys. In appearance, slag looks like a loose collection of aggregate, with lumps of varying sizes. It is also sometimes referred to as cinder, in a reference to its sometimes dark and crumbly appearance. This substance is produced during the smelting process in several ways. In appearance, slag looks like a loose collection of aggregate, with lumps of varying sizes. This substance is produced during the smelting process in several ways. Industrial waste could be used efficiently & effectively to obtain greater strength than conventional concrete mixes. Thus the use of ferrous slag in concrete could enhance the strength in concrete and also reduces environmental pollution.

KEYWORDS: reducing of sand, ferrous slag, environmental waste, strength.

I. INTRODUCTION

Concrete's versatility durability and economy have made it the world's most used construction material. The India uses about 7.3 million cubic meter of concrete each year. Due to this the cost of construction increases and causes environment pollution. As the demand for concrete as a construction material increase, so the demand for fine aggregate increases. Global warming and environmental destruction have become manifest problems in recent years, heightening concern about global environmental issues, and a changeover from the mass-production, mass-consumption, mass-waste society of the past to a zero-emission society is now viewed as important. Due to the increase of rate of population, the rate of waste materials increases due to growth of consumerism, development of industry and technology. The disposal of these waste materials poses a very big problem to the society and hence convention of these solid wastes into useful materials is the need of the present day. The iron and steel industry produces extremely large amounts of slag as by product of the iron making and steel making processes, And hence it is necessary to develop slag production and recycling technologies and intermediate treatment technologies. The ferrous slag is a suitable industrial waste material for replacing fine aggregate in concrete. By using this we can increase strength of concrete and reduce environment pollution.

II. LITERATURE REVIEW

Ayano and Sakata critically reviewed the characteristics of Ferrous Slag and its effects on the engineering properties of cement, mortars and concrete. They reported that the shrinkage of specimens containing FS fine aggregate is similar or even less than that of specimens without FS One province in China published technical guidelines for the use of FS as sand for mortars and concrete.

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Khalifaet al reported that the use of FS as sand substitution improves strength and durability characteristics of high strength concrete at same workability and produces concrete that meets strength and durability design requirements.

Hwang and Laiw reported that the amount of bleeding of mortar made with FS is comparatively less than that using natural sand. However, the heavy specific weight and the glass-like smooth surface properties of irregular grain shape of FS aggregates are effective for characteristics of bleeding.

Studies by Alnuaimi indicated that replacement of fine aggregate (sand) by Ferrous slag does not have an adverse effect on the load carrying capacity of the concrete columns.

Chen Meizhu, Zhou Mingkai, Wu Shaopeng, 2007, worked on mortar made up of ferrous slag, ground granulated blast furnace, gypsum, clinker and steel slag sand. The experimental results show the application of steel slag sand may reduce the dosage of cement clinker and increase the content of industrial waste product using steel slag sand.

Juan M. Manso, et al., 2004 carried out work in laboratory to produce concrete with good properties using oxidizing ferrous slag as fine aggregate. The concrete was tested for durability characteristics like soundness, leaching test, accelerated ageing test etc. The durability of the Ferrous slag concrete was found to be acceptable, especially in the geographical region for which its use was proposed, where the winter temperature hardly ever falls below 32°F (0°C).

Keun Hyeok Yang, Jin Kyu Song, Jae-Sam Lee, 2010 studied alkali activated mortars and concrete using light weight aggregates. Test results showed that the compressive strength of alkali activated mortar decreased linearly with the increase of replacement level of light weight fine aggregate regardless of the water binder ratio.

III. RELATED WORK

Ferrous slag is a by-product of the iron and steel making process. Steel cannot be prepared in the Basic Oxygen Furnace (BOF) or in an Electric Arc Furnace (EAF) without making its by-product, steel slag.

1. The use of ferrous slag aggregate in concrete by replacing fine aggregate is a most promising concept.
2. The ferrous slag present in concrete Satisfy all physical, chemical and mechanical properties which slow down the hydration of blended cement due to morphology and low calcium silicate content.
3. Thus ferrous slag can be used in conventional concrete to improve its mechanical, chemical and physical properties. The only potential problem with ferrous slag aggregate is its expansive characteristics and undesirable reactions between slag and components of concrete. The only potential problem with ferrous slag aggregate is its expansive characteristics and undesirable reactions between slag and components of concrete. Studies and tests are being conducted on ways to use this ferrous slag as a fine aggregate in concrete.

The slag has a number of desirable characteristics for this type of construction, including:

- (a) Particle shape and texture that provides exceptionally high Stability
- (b) Non-plastic fines
- (c) Volume stability under all weathering conditions
- (d) Lower weight per unit volume
- (e) Hydraulic property
- (f) No alkali-aggregate reaction
- (g) Low Na_2O and k_2O
- (h) Thermal insulation and sound absorption effects when made into a fiber.

IV. PRESENTATION OF THE MAIN CONTRIBUTION OF THE PAPER

The main contribution for the experiment is replacement of fine aggregate with ferrous slag, as replaced with some percentages, when the strength will reach high and sudden decrease when the increase in percentage of ferrous slag .Percentage of slag replaced with fine aggregate is 0%, 10%, 20%, 30%, 40%, 50%.

V. METHODOGY AND DISCUSSION

Investigate the effect of iron slag on compressive strength, split tensile strength, flexural strength and impact resistance test. The replacement of fine aggregate with ferrous slag of 0%, 10%, 20%, 30%, 40%, 50%.the procedure as we adopt the Indian Standard Recommended Method of Concrete Mix Design (IS 10262 – 1982). In present work various materials is used with their respective properties namely: OPC 43 Grade cement, ferrous slag, Fine aggregates: Natural River sand, Coarse aggregate and Water

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Materials:

PORTLAND CEMENT: The function of cement is first of all to bind the sand and stone together and second to fill up the voids in between sand and stone particles to form a compact mass. It constitutes only about 20 percent of the total volume of concrete mix; it is the active portion of binding medium and is the only scientifically controlled ingredient of concrete. Any variation in its quantity affects the compressive strength of the concrete mix. Portland cement referred as (Ordinary Portland Cement) is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. The OPC is classified into three grades, namely 33 Grade, 43 Grade, 53 Grade depending upon the strength of 28 days. It has been possible to upgrade the qualities of cement by using high quality limestone, modern equipments, maintaining better particle size distribution, finer grinding and better packing. Generally use of high grade cement offers many advantages for making stronger concrete. Although they are little costlier than low grade cement, The specific gravity of cement was tested as per IS: 8112 and was found to be 3.15. In this research cement used OPC 43 grade confirming to IS: 8112. The physical Properties of the cement obtained on conducting, appropriate are IS: 10262-2009. A cementations material is one that has the adhesive and cohesive properties necessary to proper bond inert aggregates into a solid mass adequate strength and durability.

FINE AGGREGATES: The aggregates most of which pass through 4.75 mm IS sieve are termed as fine aggregates. Natural sand

COARSE AGGREGATES: The aggregate which is retained over IS Sieve 4.75 mm is termed as coarse aggregate. Crushed graves or stone obtained by crushing of gravel or hard stone. Clean potable water is used for Mixing and Curing operation for the work. The Water supplied in the campus is of the potable standard of PH value 7 is used. Pure water is not good use with ordinary Portland cement. This can be used with high alumina cement. If impurities in the water may affect the setting time of cement, strength of concrete, and may cause corrosion of the reinforcement.

VI. EXPERIMENTAL RESULTS

The experiments done on cement, fine aggregate, coarse aggregate, ferrous slag.

Properties	Results
Fineness	3.67
Specific Gravity	3.04
Standard Consistency	32%
Initial setting time	35 min
Final setting time	600 min

Cement

Properties	Results
Fineness	2.95
Specific Gravity	2.6
Bulk Density	10%
Moisture Content	8%
Grading	Zone -1

fine aggregate

PROPERTIES	RESULTS
Impact test	8.06%
Aggregate crushing test	15.97%
Water absorption	1%
Specific gravity	2.64
Size	20 mm

coarse aggregate

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PROPERTIES	Results
Type	Industrial waste
Specific gravity	2.81
Water absorption	4%
Fineness modulus	3.04
Grading	Zone-I

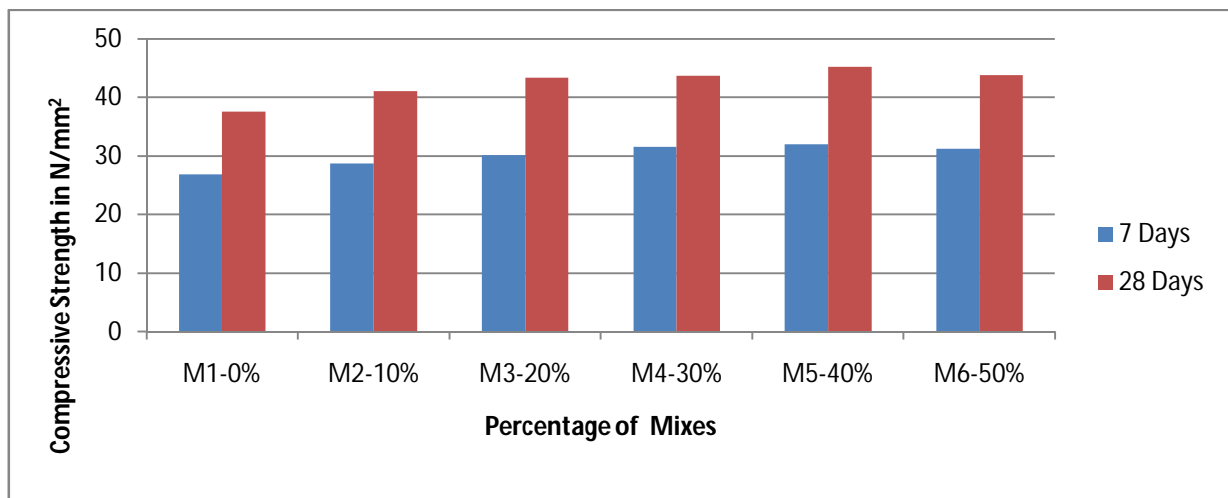
Physical properties of ferrous slag

Particulars	RESULT
CaO	36.35
Mgo	9.59
Al ₂ O ₃	16.21
SO ₂	1.78
SiO ₂	35.20
Fe ₂ O ₃	0.56

chemical properties of ferrous slag

Test results:

Compressive strength in N/mm ²		
Mix	7 days	28 days
M ₁ -0% Slag	26.81	41.02
M ₂ -10% Slag	28.67	42.08
M ₃ -20% Slag	30.41	43.37
M ₄ -30% Slag	31.15	43.68
M ₅ -40% Slag	32	45.15
M ₆ -50% Slag	31.25	44



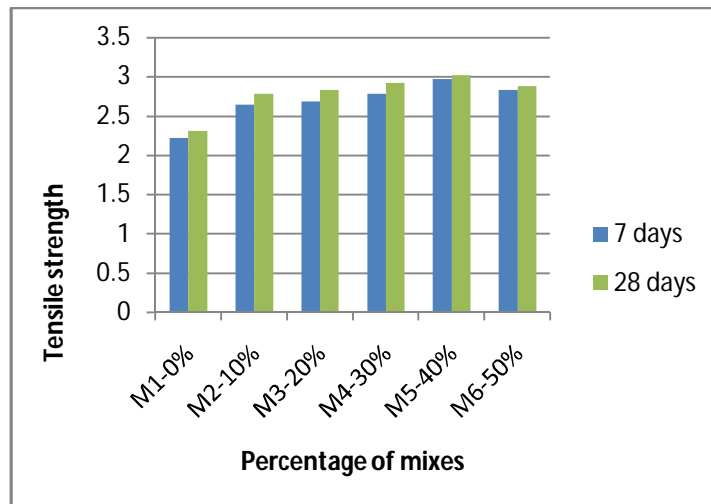
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Split tensile strength

Split tensile strength N/mm ²		
MIX	7 days	28 days
M ₁ -0% Slag	2.221	2.310
M ₂ -10% Slag	2.640	2.782
M ₃ -20% Slag	2.687	2.830
M ₄ -30% Slag	2.782	2.923
M ₅ -40% Slag	2.971	3.018
M ₆ -50% Slag	2.830	2.876



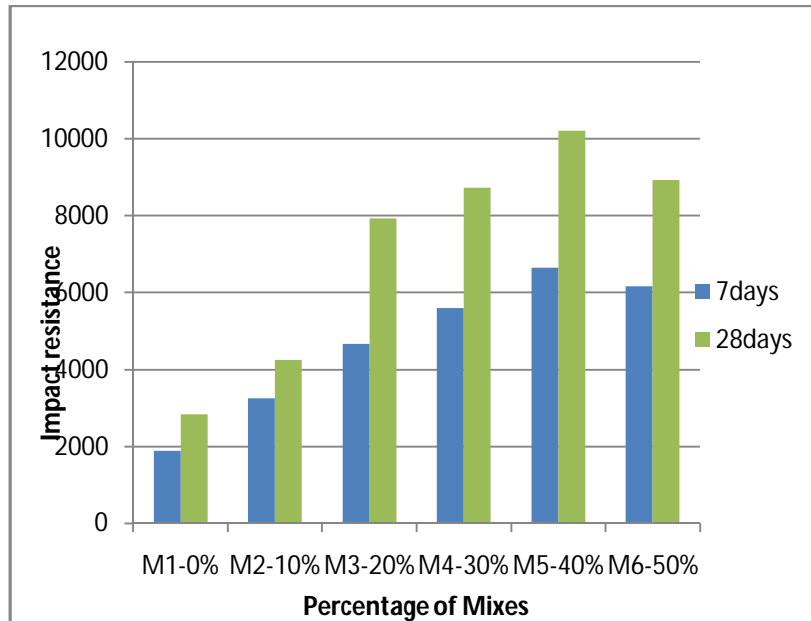
Impact resistance: Impact resistance strength

Impact Energy (EI =N*M*G*H) Nm		
Mix	7days	28days
M ₁ -0% Slag	1895.20	2853.00
M ₂ -10% Slag	3258.14	4298.01
M ₃ -20% Slag	4684.91	7943.05
M ₄ -30% Slag	5600.60	8730.97
M ₅ -40% Slag	6665.35	10221.62
M ₆ -50% Slag	6175.56	8943.92

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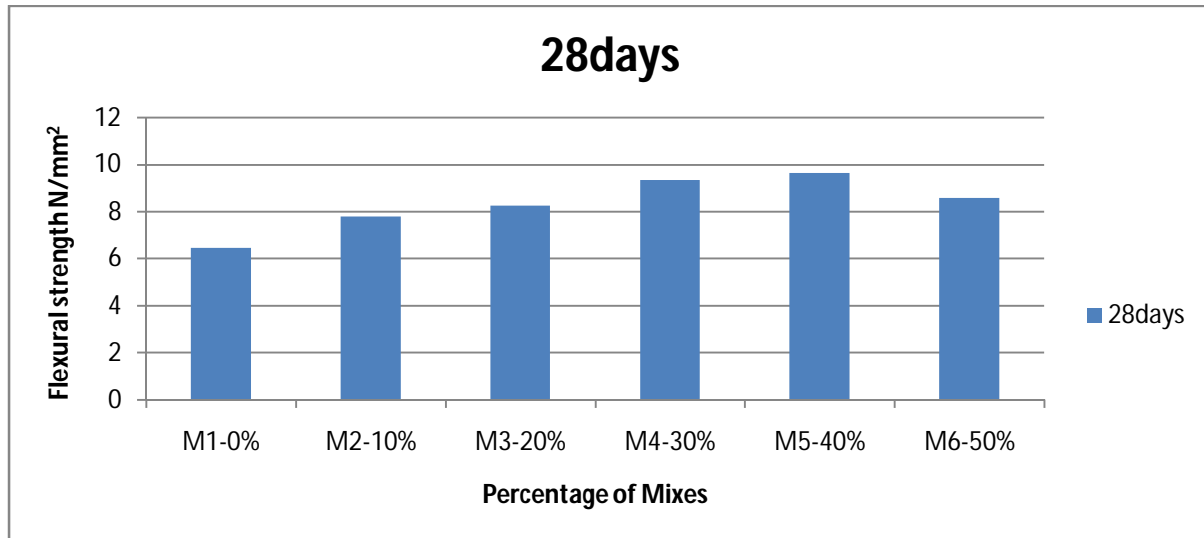
: Flexural strength:

Flexural strength N/mm ²	
Mix	28 days
M ₁ -0% Slag	6.44
M ₂ -10% Slag	7.77
M ₃ -20% Slag	8.24
M ₄ -30% Slag	9.33
M ₅ -40% Slag	9.64
M ₆ -50% Slag	8.58

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VII. CONCLUSION

The behaviour of ferrous slag seems to be similar to river sand for its use as fine aggregate in concrete mixes. The strength and durability characteristics of concrete mixtures have been computed in the present work by replacing 10%, 20%, 30%, 40% and 50% iron slag with the sand. On the basis of present study, following conclusions are drawn. The replacement of fine aggregate with ferrous slag in concrete improves the environmental condition and economy too. The ferrous slag replacements in all mixes indicated higher strength gain properties considering the various strengths arrived in this investigation. The Compressive strength tends to increase with increase percentages of iron slag in the mix. At 40% slag replacement a maximum strength gain of 20% was seen for 7 days & 11% was increased for 28 days. The early age strength gain is higher as compared to later ages if 40% of fine aggregate is replaced by iron slag. The compressive strength is increased when it is replaced up to 40% and further it will reduce. Split tensile property of concrete has been constantly increased, and slag not affected the tensile property. At 40% slag replacement a maximum strength gain of 34% was seen for 7 Days, 30% for 28 days. At early age presence of more amount of iron slag as sand replacement in concrete is beneficial for improving the strength characteristics. The experimental ultimate moment of the test beams are greater than the theoretical ultimate moment, the flexural results show that there is increase in cracking moment by increasing percentage of ferrous slag in the mix. At 40% slag replacement a maximum strength gain of 45% was seen for 28 days.

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