A Study Focus on Concrete Replacing LD Slag as Fine Aggregate

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Abstract— *Concrete is a composite material composed of fine and coarse granular aggregate (which acts as a filler material) embedded in a hard matrix of cement (which acts as binder) that fills the space among the aggregate particles and glue them together.*

The main constituents being cement, fine aggregate (river sand), coarse aggregate and water. The increase in cement production and its usage and also its impact on the environment is addressed widely throughout the world in recent years, which gave light to researches to use alternative materials to cement such as fly ash, silica fume, ggbs etc. But now the focus is also on the increase in demand of the other constituent materials of concrete such as fine and coarse aggregate. Following the same lines of research and in a verge to find a new alternative material for river sand which is available in sufficient quantity in India and other countries also as a potential to be use as sand in concrete as resulted in using LD slag (granulated blast furnace slag) as a fine aggregate in concrete.

Keywords—LD Slag, Granulated blast furnace slag, Alternative sand, Slag.

I. INTRODUCTION

The fine and coarse aggregates form the skeleton of the concrete and generally occupy 60-75% of its volume and are one of the main constituent's materials in concrete production. The aggregate properties directly affect the physical and mechanical properties of the concrete along with its economy.

The rapid rate of growth in population in India and other developed countries as forced the construction industry to use the building ingredient at rapid rate and resulting in depletion of natural resources and also has a severe impact on the environment causing many risks either directly or indirectly such as depletion of river due to sand mining being done at alarming rate etc. On the other hand industrialization, rapid growth of industries in India gave birth to waste products. The steady increase in demands due to population growth as also resulted in increase in production and as the production rate increases to match the consumption rate the waste generated by the process during production also increases proportionality. But the waste products generated by these industries are causing environmental hazards as their disposal being a major issue, due to over the period. Of time waste management has become one of the most complex and challenging problems in India. Thus a review of the recent research showed that it is possible to utilize industrial by-products and also other waste materials in production of normal and high strength concrete when used as partial or full replacement of cement or aggregate or both. The research as also showed that many of the concrete produced made with wastes and industrial resources possess superior properties compared with the conventional concrete in terms of strength, performance and durability. Thus in order to find an alternative to reduce the use of river sand or natural sand many research is being carried out and fly ash is been widely accepted and also approved by the government as an alternative to river sand. Following the same lines of research and in a verge to find a new alternative material for river sand which is available in sufficient quantity in India and also as a potential to be use as sand in concrete as resulted in using *LD slag* (granulated blast furnace slag) as a fine aggregate in concrete. The main objective of this study is the possible usage of LD slag from iron and steel industry as a constituent material in concrete replacing natural sand. Thus in order to minimize the usage of natural sand in concrete an alternative material which is similar to natural sand in function is to be used in concrete. The alternative material used in this thesis report is LD SLAG and its suitability as fine aggregate is been checked and also its effect on mechanical properties of concrete is studied and the feasibility of LD slag as a potential replacement of river sand is checked along with its possible replacement levels.

Objective

The main objective of this experimental investigation is to minimize the usage of natural sand in concrete by using an alternative material which is similar to natural sand in function when used in concrete.

- To study the suitability of using LD slag as replacement of fine aggregate in concrete.
- To study the behavior of concrete replacing sand by LD slag in different replacement percentages to get optimum results.
- To conduct basic tests such as gradation, water absorption, specific gravity and bulking of LD slag and comparing the results with natural sand to check its suitability as fine aggregate in concrete.
- Commenting on the effect on the overall behavior of sand slag replaced concrete with respect to workability, compression strength, split tensile strength and flexural strength test on concrete for a fixed grade of concrete M40.

II. EXPERIMENTAL INVESTIGATION

Experimental Program

Materials Used

The basic materials used for this Concrete such as

- Cement,
- LD Slag
- Aggregates
- Super plasticizer(conplast SP:430)

LD Slag

Steel slag, a by-product of steel making, is produced during the separation of the molten steel from impurities in steel-making furnaces (1). The slag occurs as a molten liquid melt and is a complex solution of silicates and oxides that solidifies upon cooling. There are many grades of steel that can be produced, and the properties of each steel slag can change significantly with each grade. Grades of steel can be divided into high, medium, and low, depending on the carbon content of the steel. High-grade steels have high carbon content. To reduce the amount of carbon in the steel, greater oxygen levels are required in the steel-making process. This requires the addition of increased levels of lime and do lime for the removal of impurities from the steel and increased slag formation. There are different types of steel slag generated during the steel-making process. These different types are referred to as furnace or tap slag, raker slag, synthetic or ladle slag, a study on mechanical properties of concrete by replacing LD slag as fine aggregate and pit or cleanout slag.

River sand and LD slag used as fine aggregate in concrete

Physical Properties of river sand

Physical properties of sand	
Specific gravity	2.62
Water absorption	1.68%
Dry loose bulk density	1468 Kg/cum
Soundness	0.90%
Fineness Modulus	2.72
Zone	II
Silt (volume)	2.0%

Super Plasticizer: Conplast SP 430 Conplast SP 430 complies with IS 9103 – 1999(2) and BS 5075 part 3. Conplast SP 430 confirms to ASTM-C-494 Type 'F' and Type 'A' depending on the dosages used. Conplast SP 430 is based on Sulphonated Napthalene Polymers and supplied as a brown liquid which is instantly dispersible in water. Conplast SP 430 has been specially formulated to give high water reductions up to 25% without loss of workability or to produce high quality concrete of reduced permeability.

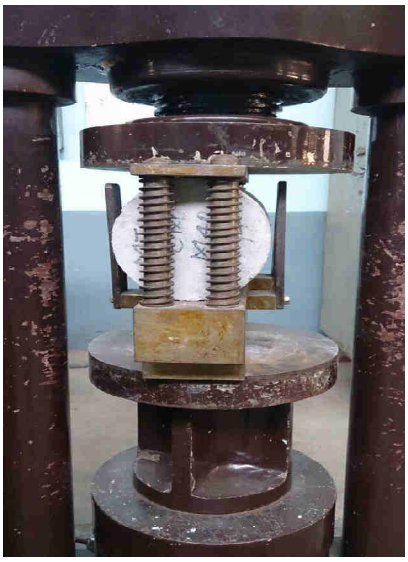
General properties of conplast SP 430

S No.	**Details**	**Results**
1	Specific Gravity	1.22 to 1.225 at 30℃
2	Chloride content	NIL to IS 456 – 2000
3	Air Entrained	Approximately 1% additional air

Detailed description of concrete mixes

M-40 grade of concrete CM	**0%**
LD-15	15%
LD-30	30%
LD-45	45%
LD-60	60%
LD-80	80%

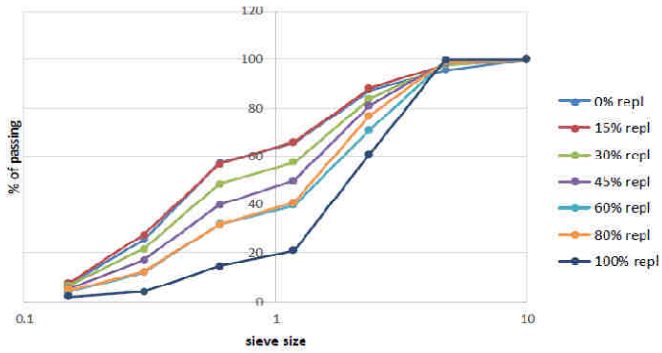
Slump property



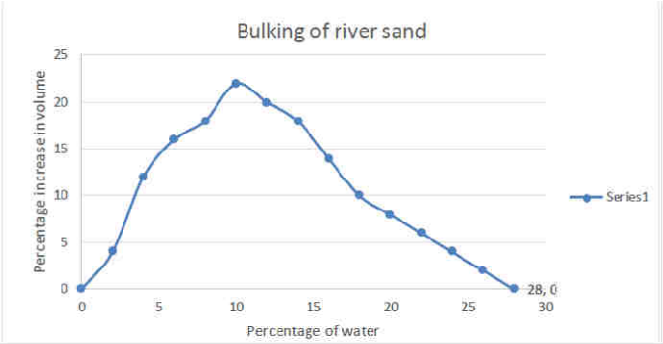
Testing of cubes & cylinder for compression and split tensile strength

Testing of prisms for modulus of rupture (flexure test):
28 days of curing the prisms were taken out from the curing tank, weighed and tested for modulus of rupture under two point loading in a flexure testing machine according to IS: 516 – 1959(3). The maximum load 'P' and the distance of the crack from the nearer support 'a' measured on the center line of the tensile face of the specimen are recorded. The modulus of rupture was calculated according to the clause 8.4 of IS: 516 – 1959 as given below.
Case (i) If 'a' is less than 133mm but greater than 110mm for 100mm specimens, σr = P X l/bd2
Case (ii) If 'a' is less than 133mm but greater than 110mm for 100mm specimens, σr = 3P X a/bd2
Where σr = Modulus of rupture
a = Distance of the crack from the near support, measured along the centre line on the tensile face of the specimen
L = length of the span = 400mm for 100mm specimens
b = width of the cross section = 100mm
d = height of the cross section = 100mm
Case (iii) if 'a' is less than 110mm for 100mm specimens the results of the test are discarded.

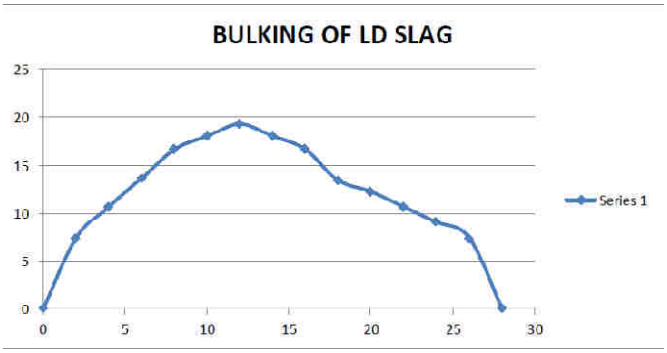
III. RESULTS AND DISCUSSION



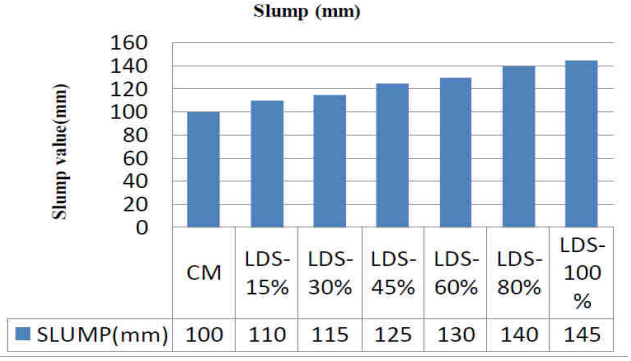
Sieve analysis of fine aggregates with different replacements.



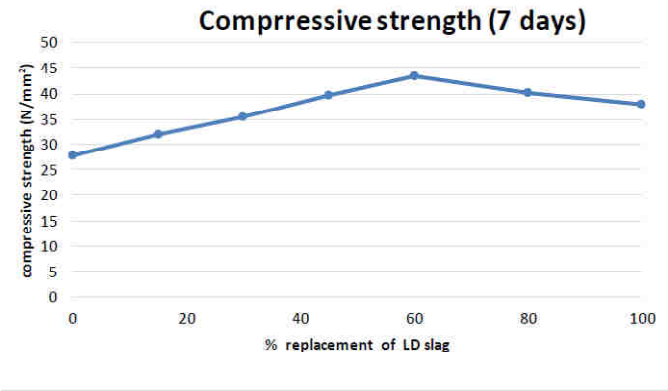
Bulking of river sand



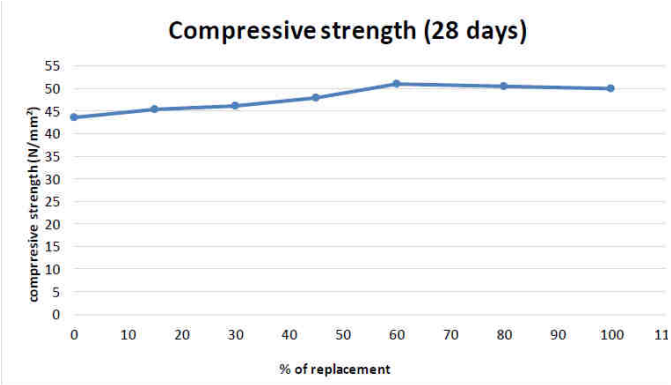
Bulking of LD slag



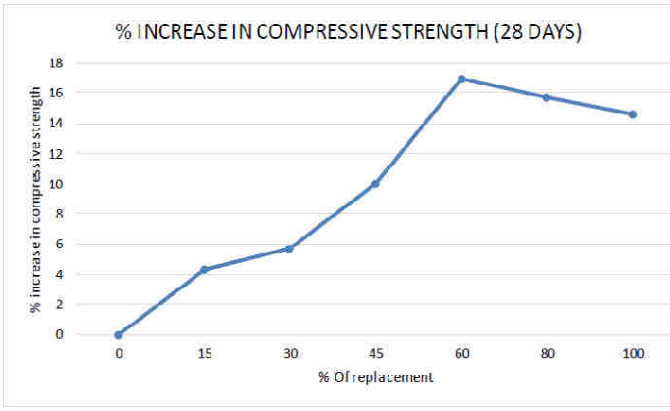
Slump for different replacements



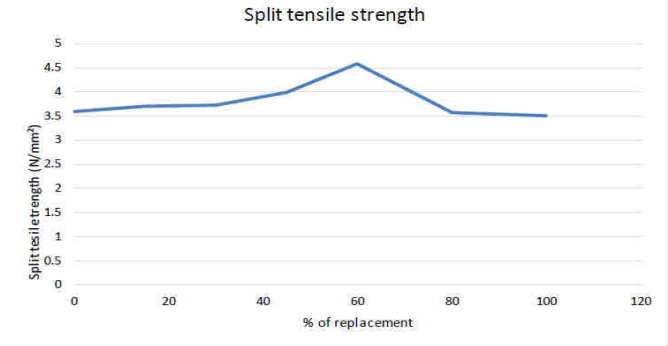
Compressive strength for 7 days



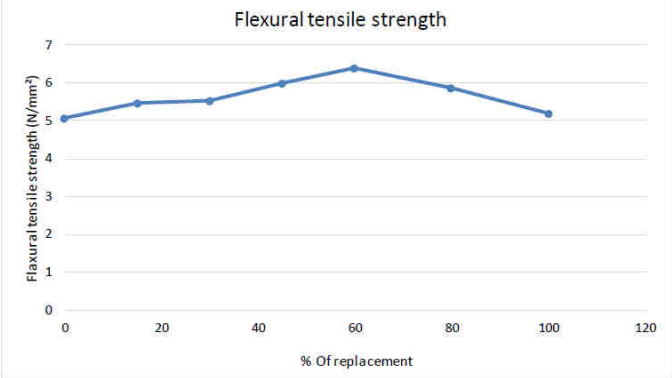
Compressive strength for 28 days



% increase in compressive strength after 28 days



Split tensile strength of concrete after 28 days



Flexural tensile strength of cylinder after 28 days

IV. DISCUSSION

The use of LD slag in concrete and its effect on various properties of concrete is studied in this experimental work. The basic test done for the materials used in concrete as were in comply with IS code recommendations. The gradation of river sand showed that it belongs to Zone II. And the fineness modulus of fine aggregates varied from 2.72-3.11. The gradation of coarse aggregate showed that the fineness modules being 7.29. The specific gravity of river sand obtained was 2.62, LD slag 2.45 and coarse aggregate 2.65. The basic results give a clear indication that LD slag can be used as fine aggregate in concrete. The extents of its usage in concrete either partial or full replacement is judge by its influence on mechanical properties of concrete. The concrete containing LD slag showed no major difficulty in handling the concrete which incorporated LD slag aggregates was encountered except at 75% or higher replacement percentages. There were no major changes in the fresh or hardened properties of concrete with LD slag. The size and grading of LD slag aggregates were similar to natural sand aggregates. Using different ranges of sizes of aggregates enable the smaller particles to pack between larger particles and thereby reducing the void spaces and lowering the cement paste requirements. Most properties of concrete are directly related to its compressive strength. The concrete cubes containing LD slag showed a gradual increase in compression strength and when compared with the control mix the varying of strength was very small and acceptable considering cost reduction provided by LD slag.

The results of compressive test, split tensile test and flexural test all indicated 45% replacement of LD slag was optimum and showed no negative effects on concrete but only workability of concrete showed be check carefully and super-plasticizer dosage show be regulated to avoid segregation problem and to get a uniform and cohesive mix.

V. CONCLUSION

In the present study, experimental analysis has been conducted to observe the variation of workability and compressive strength of concrete when the FA is partially

replaced with LD slag (Linz and Donawitz). The inferences and conclusions are listed below:

- The compressive strength of concrete after 7 days of curing increases with the increase in percentage of replacement of fine aggregate with LD slag.
- The compressive strength of concrete after 28 days of curing increases with increase in replacement of fine aggregate by LD slag up to 60% replacement and decreases at 80% and 100% of replacement.
- The split tensile strength and flexural tensile strength of concrete after 28 days of curing increases up to 60% replacements and decreases at 80% and 100% replacements.
- The results of compression test split tensile tests and flexural strength provides optimum strength at 60% replacements but density of concrete at 60% replacement is more than 26 KN/m³ which is considered as high density concrete. But at 45% replacement it provides density 25KN/m³ which is considered as normal density concrete. Hence we considered 45% replacement as optimum.

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