

Experimental Study on Partial Replacement of Fine Aggregate by Steel Slag

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ABSTRACT: It is estimated that between 7.0 and 7.5 million metric tons (7.7 to 8.3 million tons) of steel slag is obtained each year in India. The primary applications for steel slag in the United States are its use as a granular base or as an aggregate material in construction applications. The cost of concrete can be reduced by the usage of this waste product's partial replacement for fine aggregate. The main objective of this investigation is to study experimentally the effect of partial replacement of fine aggregate by steel slag on the various strength properties of concrete by using the mix design of M20 grade. Test specimen with 0, 10, 20, 30, 40&50% of partial replacement of fine aggregate by steel slag were cast and tested for compressive strength after curing period of 7 days & 28 days. Based on these experimental investigations, it is concluded that the effective utilization of waste materials obtained from the steel manufacturing industries, as aggregate gave good results for concrete when compared to the natural aggregate concrete.

INTRODUCTION

As a construction material, concrete is the largest production of all other materials. The present consumption is nearly 400 million tons per year and the demand is expected to reach one billion tons within the next decade. Aggregate are the important constituents in concrete. They give body to the concrete; reduce shrinkage and effect economy. One most important factor for producing workable concrete is good gradation of aggregates.

Good grading implies that sample fractions of aggregates in required proportion such that sample contain minimum voids. A sample of well graded aggregate containing minimum voids will require minimum paste to fill up the voids in the aggregates. Minimum paste will means less quantity of cement and less water. This will further mean increased economy, higher strength, lower shrinkage and greater durability.

The requirement of aggregate is also increased proportionally but the materials required for producing cement and concrete are obtained from the earth's crust only. Hence, we are exploiting the natural resources in an extremely high manner and results in depletion of the same and creating environmental strain.

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.

In this experimental investigation an attempt is made to study the effect of partial replacement of fine aggregate by the waste materials (slag) obtained from AGNI steel industry, Ingur on properties of concrete.

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II. STUDY OF TEST

In this project, we have planned to use the alternate aggregate which is a natural step towards solving part of the depletion of natural aggregate. Steel slag is obtained from Agni steel pvt ltd. Ingur and it is available in both coarse aggregate and fine aggregate form. Various tests are to be conducted on steel slag fine aggregate.

1. Specific gravity.
2. Water absorption.
3. Finess test

Concrete mix is designed as per I.S codal provision for M20 grade. Slump & Workability tests are to be done. Fine aggregate is replaced by steel slag form 0% to 30% in steps of 10% .After casting, compressive strength test at 28days curing are to be conducted & compared with conventional concrete.

Effective percentage of replacement is to be determined.

III. SELECTION OF INGREDIENTS

List of materials used

- Cement
- Fine Aggregate
- Coarse Aggregate
- Steel Slag
- water

Cement is grade of 53 confirming to IS 269-1976 and is: 4031-1998 is used to make HPC. Factors like heat of hydration, initial setting time etc was considered in selecting the type of cement. Fine aggregate (sand) used for HPC is properly graded to give minimum void ratio. River sand fineness 2.73 conforming to zone II of IS: 383. Sand is washed to remove deleterious materials and tested as per IS: 2386 For making concrete max size of aggregate is 20mm because bigger size particles cause concentration of stresses around particles due to difference the elastic modulus of the paste and aggregate hence lower strength of concrete. The aggregate used is sound free from deleterious materials and having a crushing strength at least 1.5 times that of concrete.

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. Slag appears in concrete, aggregate road materials, as ballast, and is sometimes used as a component of phosphate fertilizer. In appearance, slag looks like a loose collection of aggregate, with lumps of varying sizes. Slag is also sometimes referred to as cinder, in a reference to its sometimes dark and crumbly appearance.

Slag is produced during the smelting process in several ways. Firstly, slag represents undesired impurities in the metals being smelted, 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 slag 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.

Common components of slag include the oxides of silicon, aluminum, and magnesium, as well as sulfur, which is always present. Slag also contains phosphorous, calcium, ash, remnants of flux materials such as limestone, and remainders of chemical reactions between the metal and the furnace lining. Other compounds found in slag depend on the type of

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smelting. Non-ferrous slag, as iron is an undesired element. Ferrous smelting, such as that used to produce steel, creates non ferrous slag, as all the iron in the smelting process

After slag is allowed to age, it can be sold for use in other industrial processes. One of the most common is as a constituent of concrete and cement. Slag works very well as a loose aggregate and can be ground to produce a more even grain. Slag is also mixed with materials for making roadways, used as ballast on trains and large trucks, and is also applied as phosphate fertilizer. When used as fertilizer, the slag is ground very fine before being spread and it slowly time releases nutrients because it takes a long time to break down. Potable water conforming to requirements of IS: 456 is used for making of concrete.

MIXES FOR 0% OF STEEL SLAG WITH SAND

Sl.no	Name of the mould	Quantity of the material			
		Cement 'kg'	Fine Aggregate with steel slag	Coarse Aggregate	Water
1	Cube	1.5	1.98	4.92	0.75

MIXES FOR 10% OF STEEL SLAG WITH SAND

Sl.no	Name of the mould	Quantity of the material				
		Cement 'kg'	Fine Aggregate with steel slag	Coarse Aggregate	Water	
1	Cube	1.5	1.782	0.198	4.92	0.75

MIXES FOR 20% OF STEEL SLAG WITH SAND

Sl.no	Name of the mould	Quantity of the material				
		Cement 'kg'	Fine Aggregate with steel slag	Coarse Aggregate	water	
1	Cube	1.5	1.584	0.396	4.92	0.75

MIXES FOR 30% OF STEEL SLAG WITH SAND

Sl.no	Name of the mould	Quantity of the material				
		Cement 'kg'	Fine Aggregate with steel slag	Coarse Aggregate	water	
1	Cube	1.5	1.386	0.594	4.92	0.75

IV.METHODOLOGY

Concrete mix for M20 grade is designed as per Indian standards method. Quantity of materials required is derived for various percentage of replacement. Then concrete is caste in the mould of size100mm X 100mm X100mm and then cured and then finally tested after 7 days and 28 days. For each percentage of replacement 6 cubes are made. From this the effective percentage of replacement of fine aggregate by steel slag is then found forM20 grade concrete.

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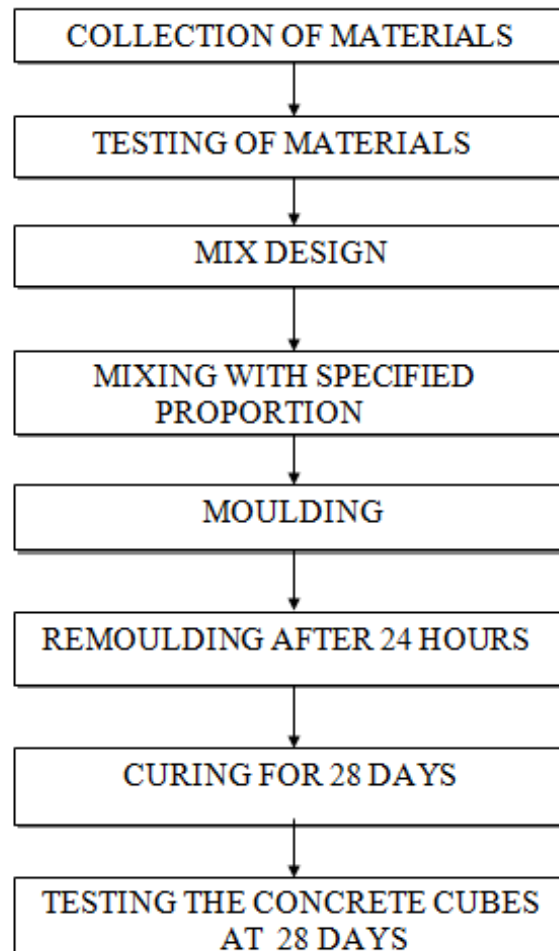
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Various percentages of replacements:

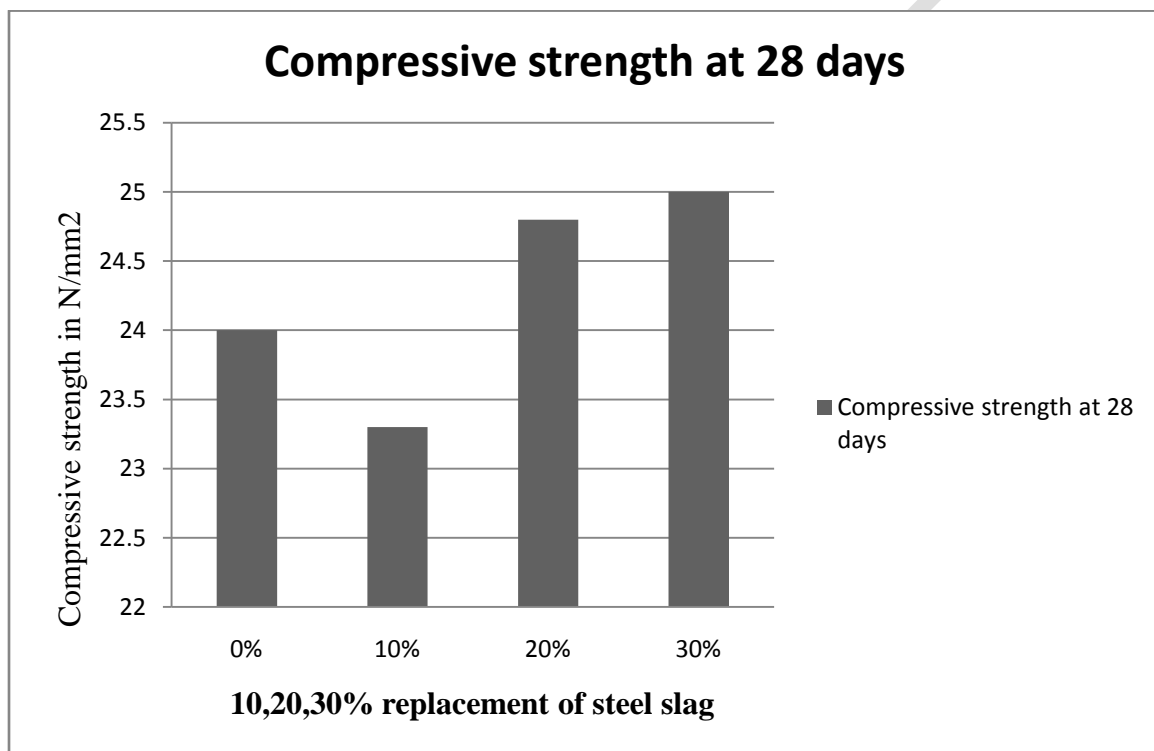
- 0% of fine aggregate replaced by steel slag
- 10% of fine aggregate replaced by steel slag
- 20% of fine aggregate replaced by steel slag
- 30% of fine aggregate replaced by steel slag

VARIOUS PROCESSES FOR MANUFACTURING CONCRETE CUBES

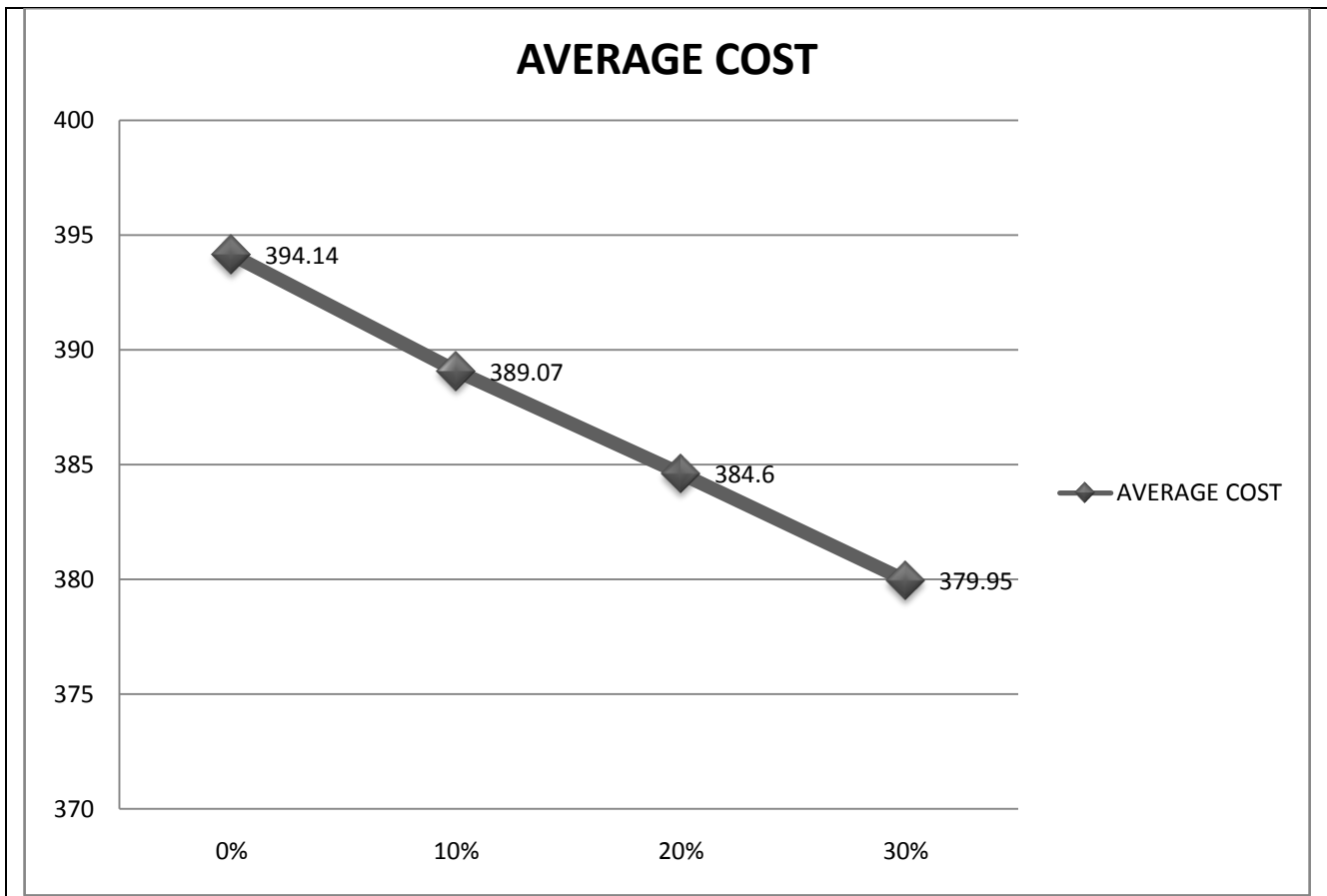


V.RESULTS AND DISCUSSION

Compressive strength at 28 days in N/mm²



Cost estimation of the conventional concrete and slagcrete.



% of Replacement

Average cost of the conventional concrete and slagcrete.

VI.CONCLUSION

After conducting all the test on the specimen, the has been observed that 30% replacement of fine aggregate with steel slag proved to be good in compression strength, where as the concrete Properties with equal proportion of steel slag and conventional Fine aggregate confirmed to be inefficient. The compressive strength of the concrete increase as the

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percentage of replacement increases up to 30%. Above that percentage of replacement, the average compressive strength decreases. Therefore, the optimum percentage of replacement suggested is 30% in which the strength obtained is 27Mpa for M20 grade of concrete. The cost of construction varies depending on the cost of materials. Since steel slag is available at free of cost, the cost of concrete decreases, as the percentage of replacement increases. So, more the percentage of replacement, higher will be the reduction in cost.

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