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An experimental investigation of steel slag by using partial replacement of fine aggregate

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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 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. 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. 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.**

1. INTRODUCTION

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 fine aggregates by steel slag on the mechanical properties of concrete. also to impact loads.It is a part of both the average household and is in commercial and industrial application. One of the benefits of using this type of plastic is that it can be useful in numerous applications including as a structural plastic or as a fibers type plastic. Steel slag (alternatively low volume fractions are used for secondary temperature shrinkage reinforcement, overlays and pavements, slabs, flooring systems, crash barriers, precast pile shells and shotcrete for tunnel linings, canals and reservoirs. According to the researches, the increase of formability and bending strength are the extra advantages of adding the fibers to the concrete.Adding fibers to concrete greatly increases the toughness of the material. The use of fibers also alters the behavior of the fibers matrix composite after it has cracked, thereby improving its toughness.Fiber volumes greater than 2.0 percent normally involve the use of continuous fibers, which are not usually considered for paving applications due to constructability problems. Fiber volumes up to 0.5 percent can be used without major adjustments to the mixture proportions. As volume levels approach 0.5 percent, air-entraining and water-reducing admixtures are required.

II .LITERATURE REVIEW

Comprehensive study of the potential health risks associated with the environmental applications (e.g. fill, road base , landscaping) of iron and steel making slag was performed using characterization data for 73 samples of slag collected from blast furnaces, basic oxygen furnaces and electric arc furnaces. Characterization data were compared to regulatory health based “screening” bench marks to determine constituents of interest. Antimony, Beryllium, Cadmium, Trivalent & Hexavalent chromium, Manganese, Thallium and Vanadium were measured above screening levels and were assessed in an application–specific exposure assessment using standard U.S. Environmental Protection Agency risk assessment methods. A stochastic analysis was conducted to evaluate the variability and uncertainty in the inhalation exposure and risk estimates, and the oral bio accessibility of certain metals in the slag was quantified. The risk assessment found no significant hazards toaggregates in construction products requires the consideration of certain issues. Firstly, as steel slag is an industrial by product until recently disposed in landfills, the question is whether it is suitable for use in construction. Then the technical characteristics of the material are examined because due to its physicochemical properties steel slag requires special care, but can also provide maximum value if used for specific applications. The utilization of a by-product in suitable applications mainly where it is advantageous compared to traditional materials, but also where it is most economical can give a higher added value to the product. Finally, there are a number of economyrelated parameters that allow for a new product to enter the construction market like the situation of the local aggregate market or the need to communicate the efficiency of a new product through demonstration projects. Through all the above considerations and knowledge through practice we look at the way steel slag aggregates enter the construction market in Greece.2.

In this project slag from steel industry is used to replace for fine aggregate. Steel slag is a byproduct 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). Like other industrial by products, 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.The original 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. For this research the percentage of the volume of natural aggregates normally used in concrete was replaced by steel slag. This replacement was done in10%, 20%, 30% increments until all natural aggregates were replaced by the steel slag. Thus replacing the natural aggregates in concrete applications with steel slag would lead to considerable environmental benefits and would be economical.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 byproduct 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 on going in the United State.Human health as a result of the environmental applications of steel-industry slag.

III. MATERIALS

The basic tests are conducted on various materials like OPC53 grade Cement, fine aggregate, coarse aggregate and steel slag to check their suitability for making concrete. The experimental investigation has been carried out on the test 3 specimens of Cubes, Cylinders, and Beams each to study the strength properties as a result of replacing fine aggregate by Steel slag in various percentages namely 10%, 20% and 30% of steel slag.

IV. EXPERIMENTAL INVESTIGATION

MaterialsCement:

Ordinary Portland cement of 53
Grade conforming to IS 12269-1987, and the
cement should be clean, dry and free from impurities

Table 1 Physicalproperties of cement

S.No	Properties	Obtained values
1	Consistency test	34%
2	Initial setting time	35 Minutes
3	Final setting time	370 Minutes
4	Fineness test	6%
5	Specific gravity	3.116

Fine aggregate

Manufactured Sand: Locally available river sand conforming to grading zone III of IS: 383-1970 is completely washed.

Coarse Aggregate: Crushed angular aggregate with maximum grain size of 20 mmand downgraded was used and having bulk density 1.38 kg/m3. The specific gravity is 2.82.

Water: According to IS 3025, Water to be used for mixing and curing should be free from injurious or deleterious materials. Potable water is generally considered satisfactory.

In the present investigation, available water within the campus is used for mixing and curing purposes.

Steel slag: Sprayed sealing and asphalt applications. Skid resistant sealing aggregate. Base and sub base pavement construction. Hard stand areas. Construction fills Subsurface drainage filter materials.

V. CONCRETE MIX PROPORTIONS

The mixes were designed in accordance with IS 10262-2009 mix design method. Based on the result, the mix proportions M25 was designed. Concrete mix with the W/C ratio of 0.45 was prepared. The details of mix proportion and materials required for 1m³ of concrete.

Mix proportion

Grade	**Cement(kg)**	**FA (kg)**	**CA (kg)**	**Water**
M25	437.7	620	1080.2	197
Mix ratio	1	1.4	2.46	0.45

Compressive Strength

Compressive strength of concrete is tested on cube at different percentage of steel slag content in concrete. The strength of concrete has been tested on cube at 7 days.

Compression testing machine is used for testing the compressive strength test on concrete. At the time of testing the cube is taken out of water and driedand then tested keeping the smooth faces in upper and lower part. The strength of concrete is very much dependant up on the hydration reaction. In this experiment, in all cases, some percentage adding of sand by steel slag test results, as shown in Table and show that seven days compressive. The reduction of the strength increased with increasing percentage of steel slag after some specific limit.

Compressive strength of concrete at 7 days and 28 days

Steel slag	**Results of Compressive strength test N/mm^2**
10%	12.4
20%	15.8
30%	17
Steel slag	**Results of Compressive strength test N/mm^2**
10%	16.13
20%	21.21
30%	24.11

Split tensile strength

Split Tensile strength of concrete is tested on cylinders at different percentage of polypropylene fiber Content in concrete. The strength of concrete has been tested on cylinder at 7 days. Compression testing machine is used for testing the Split Tensile strength test on concrete along with two wooden boards. At the time of testing the cylinder taken out of water and dried and then tested.

Spilt tensile strength of concrete

Steel slag	**Results of split tensile strength test N/mm^2**
10%	1.88
20%	2.68
30%	2.92
Steel slag	**Results of Split tensile strength test N/mm^2**
10%	3.41
20%	3.72
30%	3.89

VI. CONCLUSION

1)To take a optimum value of 10% adding of concrete with steel slag there is optimum percentage to increase in all mechanicalproperties.

2) Compressive strength of material increases with increasing steel slag content.

3) Strength enhancement in splitting tensile strength due to steel slag addition up to 30%.

4) The durability of concrete improves and addition of steel slag greatly improves the fracture parameters of concrete.

5) The compressive strength, split tensile strength increase with the addition of steel slag content as compared with conventional concrete.

6) The workability of steel slag concrete has been found to decrease with increase in steel slag content replacement.

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