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EXPERIMENTAL INVESTIGATION ON LIGHT WEIGHT CONCRETE WITH STEEL SLAG AND M-SAND

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Abstract— This study presents an evaluation of steel slag aggregate, m-sand in concrete comparison with the conventional natural coarse, fine aggregate in concrete. Hardened concrete consist of more than 70% coarse aggregate 50% of fine aggregate due to the high demand in building materials and the increase of the amount of disposed waste material, suppliers and researchers are exploring the use of alternative materials which could preserve natural sources and save the environment. Steel slag was used as an coarse aggregate replacement and m-sand was used an fine aggregate replacement in conventional concrete mixes. Steel slag which is mainly consists of calcium carbonate is produced as a by-product during the oxidation process in steel industry and m-sand was collected from the quarries . Steel slag and m-sand was selected due to its characteristics, which are almost similar to conventional aggregates and the fact that it is easily obtainable as a by-product of the steel industry and quarries. As a result, utilization of steel slag and m-sand will save natural resources and provide clean environment. We have replaced fine aggregate completely by m-sand and coarse aggregate is replaced by 25%,50%,75% of steel slag. By utilising steel slag as coarse aggregate which also reduce the weight of the concrete there by we can reduce the cost of construction.

Keywords: Steel Slag, M-sand, Light weight concrete.

INTRODUCTION

LIGHT WEIGHT CONCRETE:

Lightweight concretes can either be lightweight aggregate concrete, foamed concrete or autoclaved aerated concrete (AAC). Lightweight concrete blocks are often used in house construction. Lightweight aggregate concrete can be produced using a variety of lightweight aggregates. Lightweight aggregates originate from either:

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- Natural materials, like volcanic pumice.
- The thermal treatment of natural raw materials like clay, slate or shale i.e. Leca.
- Manufacture from industrial by-products such as fly ash, i.e. Lytag.
- Processing of industrial by-products such as pelletised expanded slab, i.e. Pellite.

The required properties of the lightweight concrete will have a bearing on the best type of lightweight aggregate to use. If little structural requirement, but high thermal insulation properties, are needed then a light, weak aggregate can be used. This will result in relatively low strength concrete.

The elastic modulus of lightweight concretes is lower than the equivalent strength normal weight concrete, but when considering the deflection of a slab or beam, this is counteracted by the reduced self-weight.

The basic design for lightweight concrete is covered in Eurocode 2 Part 1-1, with section 11 having particular rules required for lightweight aggregate concretes. Concrete is considered to be lightweight is the density is not more than 2200kg/m^3 (the density of normal weight concrete is assumed to be between 2300kg/m^3 and 2400kg/m^3) and a proportion of the aggregate should have a density of less than 2000kg/m^3. Lightweight concrete can be specified using the notation LC for the strength class, e.g LC30/33, which denotes a lightweight concrete with a cylinder strength of 30MPa and a cube strength of 33MPa.

The lighter the concrete, the greater are the differences to be accounted for in the properties of the concrete. The tensile strength, ultimate strains and shear strengths are all lower than a normal weight concrete with the same cylinder strength. Lightweight concretes are also less stiff than the equivalent normal strength concrete. However, this is mitigated by the reduction in self-weight to be carried, so the overall effect tends to be a slight reduction in the depth of a beam or slab.

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Creep and shrinkage for lightweight concretes are higher than that for the equivalent normal weight concrete, and this should be taken into account when designing the structure.

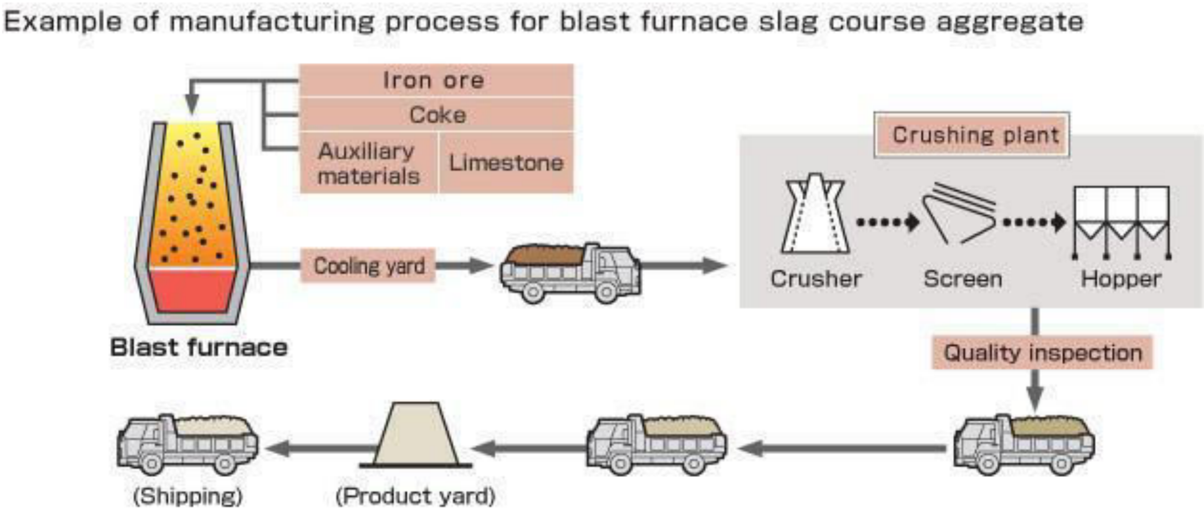

Fig.1. Extraction process of Steel Slag Aggregate.

MATERIALS USED AND THEIR SPECIFICATIONS

Materials play an important role in Concrete. The materials used for preparing self curing concrete are Cement, Fine Aggregate, Coarse Aggregate, Water Steel Slag Aggregate and Super plasticizers which are confirming to the requirements of the Indian Standard (IS) specifications are given in table 1.

Table 1 Materials used and their specifications

SL.NO	MATERIAL	TYPE	IS SPECIFICATION
1	CEMENT	Ordinary Portland Cement (OPC) 53 Grade	IS 12269-2013
2	COARSE AGGREGATE	Crushed Angular Aggregate (size = 20 mm)	IS 2386(Part I & III)-1963
3	FINE AGGREGATE	Natural Sand (size ≤ 4.75 mm)	IS 2386(Part I & III)-1963
4	WATER	Clean potable water (pH value=7.0)	IS 456 – 2000
5	STEEL SLAG	Air Cool Blast Furnace Slag (Size = 20 mm)	IS 2386 (Part I & III)-1963

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EXPERIMENTAL INVESTIGATION

The materials used for this study were initially investigated and tested. The test was carried out for different materials such as Cement, Fine aggregate, Coarse aggregates, Steel Slag Aggregates and their results were listed in tables.

Cement

Natural sand and Quarry Dust with fraction passing through 4.75mm and retained on 600 micron sieve is used and will be tested as per IS 2386(Part I& III)-1963. The properties of the fine aggregate and quarry dust are shown in Table 2.

Table 2 Testing of Cement

SL.NO	TYPE OF TEST	VALUES OBTAINED FOR CEMENT
1	Fineness Test by Sieving	3.89%
2	Standard Consistency Test	22%
3	Initial Setting Time	30 Minutes
4	Final Setting Time	10 Hours
5	Specific Gravity Test	2.7

Fine aggregate and Quarry Dust Natural

Natural Sand and Quarry Dust confirming to IS 2386 (Part I and Part III) was used. Sand and Quarry Dust are passed through 4.75mm before retaining on 600 micron sieve. The properties of the fine aggregate and quarry dust are shown in Table 3.

Table 3 Testing of Fine Aggregate

SL.NO	TYPE OF TEST	VALUES OBTAINED	
		FOR SAND	FOR QUARRY DUST
1	Fineness Modulus Test	2.541	2.529
2	Bulkiness Of Sand	6.66%	5.26
3	Specific Gravity Test	2.59	2.57
4	Water Absorption Test	0.53%	0.91

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Coarse aggregate

The 20mm size of Coarse aggregate is used and will be tested as per IS 2386(Part I and III). The properties of the coarse aggregate are shown in Table 4.

Table 4 Testing of Coarse Aggregate

SL.NO	TYPE OF TEST	VALUES OBTAINED
1	Fineness Modulus Test	2.28
2	Specific Gravity Test	2.27
3	Water Absorption Test	0.4%
4	Aggregate Crushing Value	12.85%
5	Aggregate Impact Value	12.18%
6	Aggregate Abrasion Value	36.55%
7	Flakiness Index	36.30%
8	Elongation Index	45.55%

MIX DESIGN

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible.

One of the ultimate aims of studying the various properties of the materials of concrete, plastic concrete and hardened concrete is to enable a concrete technologist to design a concrete mix for a particular strength and durability.

Mix design for each set having different combinations are carried out by using ACI 211.4R-93 method. The mix proportion obtained for normal M40 grade concrete is 1: 0.67: 1.84 with a water-cement ratio of 0.3.

FRESH CONCRETE

The fresh concrete is made with the mix ratio as per design standards for M40 grade concrete and the workability of the concrete was tested. The properties of fresh concrete are given in table 5.

Table 5 properties of Fresh concrete

S.NO.	TEST	RESULT
1	Slump Value	50mm
2	Compaction Factor	94.70%
3	Flow value	50%
4	Vee-bee consistency	8 seconds

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EXPERIMENTAL PROCEDURE

STRENGTH TEST

The specimen of standard cube of size 15cmx15cmx15cm, standard cylinder of size 30cm height and 15cm diameter and prism of size 10cmx10cmx50cm were used to determine the compressive strength, split tensile strength and flexural strength of the concrete. These specimens were tested on 7th, 14th & 28th day‘s strength.

Experiments Conducted

The following experiments were conducted on the specimens casted.

- Compression test
- Split tensile test
- Flexural test

Compression Test

Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The cube specimen is of the size 15 x 15 x 15 cm were tested for compressive strength as per IS 516-1959 using a calibrated compression testing machine.

Split Tensile test

Split tensile strength of concrete is usually found by testing concrete cylinder of size 30cm height and 15cm diameter. The specimens were tested for its tensile strength as per IS: 516-1959 using a calibrated compression testing machine.

Flexural Strength Test

Flexural strength is the one of the measure of tensile strength of concrete. It is the ability of a prism to resist failure in bending. It is measured by loading un-reinforced slab or prism of size 10cm x 10cm x 50cm. The specimens were tested for its flexural strength as per IS: 516-1959 using a calibrated flexural testing machine.

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EXPERIMENTAL RESULTS

STRENGTH TEST

Compressive Strength Test

The compressive strength test is one of the most important properties of concrete and it is used to find the overall quality of concrete. The cubes were casted and cured for the testing as shown in figure. The concrete cubes are tested at the end of 7, 14 and 28 days. The test result shows that the strength of the Steel Slag Aggregate concrete is slightly higher than the conventional concrete. The tables and graphs listed below shows the relationship between the number of days and mean compressive strength of cube.

Fig.2 curing of test specimens of standard. concrete

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Table .6 Comparison of compressive strength of concrete cubes

% of Steel Slag Aggregate with M - sand	7days (N/mm^2)	14days (N/mm^2)	28 days (N/mm^2)S
0	14.33	23.99	45.01
25	17.29	24.88	48.23
50	18.54	26.22	48.59
75	16.36	25.99	46.12

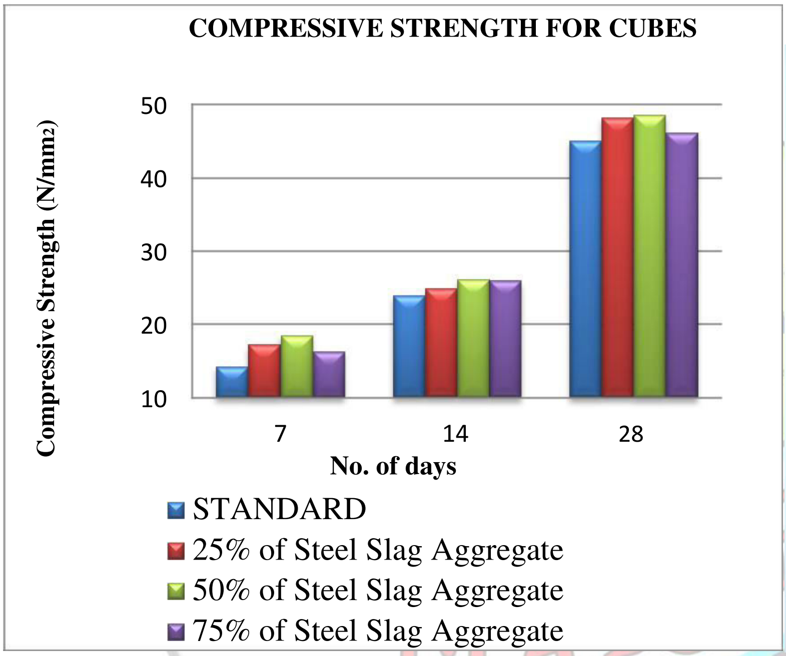

Chart. 1. compressive strength of Standard and Steel Slag Aggregate of concrete cubes

Fig.3 compression strength Test

Split Tensile Strength:

The cylindrical shaped concretes were tested to find the split tensile strength at the end of 7, 14 and 28 days. From the test results, it is learnt that the split tensile strength of the Steel Slag aggregate concrete is considerably higher than the conventional concrete. Chart.2 shows the relation between no. of days and its mean split tensile strength of cylinders.

Table.7 Split Tensile strength of standard and Steel Slag Aggregate of cylinders

% of Steel Slag Aggregate with M – sand	7days (N/mm^2)	14days (N/mm^2)	28 days (N/mm^2)
0	7.07	13.01	20.81
25	9.54	14.85	21.12
50	9.98	15.26	21.89
75	8.12	14.23	20.99

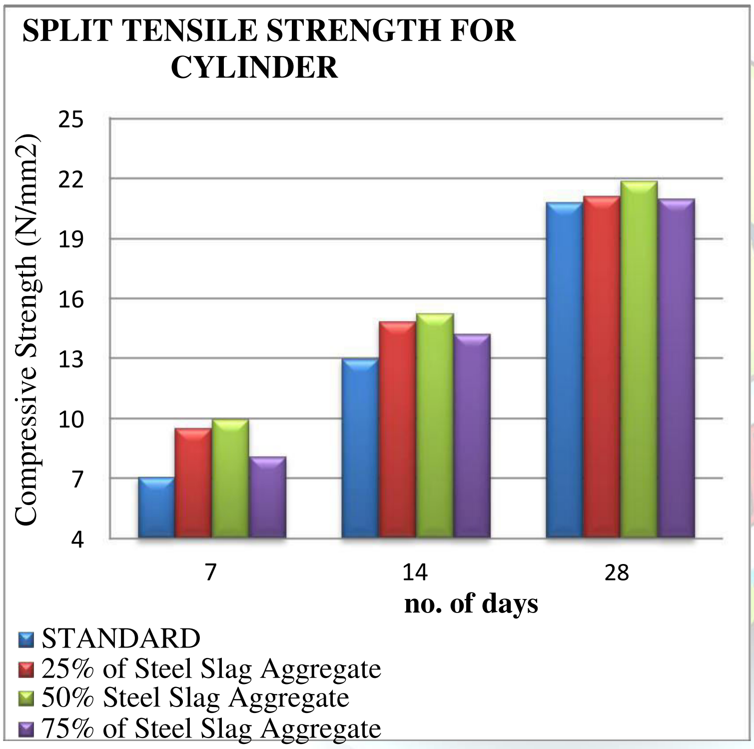

Chart 2. Split Tensile strength of Standard and Steel Slag Aggregate concrete cylinders

Fig.4. Split Tensile Test

Flexural Strength Test

The Prisms were tested to find the flexural strength at the end of 7, 14 and 28 days. From the test results, it is learnt that the flexural strength of the Steel Slag aggregate concrete is slightly higher than the conventional concrete. Chart 3 shows the relation between no. of days and its mean flexural strength of concrete prisms.

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Table 8 Flexural strength of standard and Steel Slag Aggregate of cylinders

% of Steel Slag Aggregate with M - sand	7days (N/mm^2)	14days (N/mm^2)	28days (N/mm^2)
0	2.59	5.5	9.3
25	7.42	9.22	10.87
50	8.65	9.87	11.04
75	6.32	8.23	9.88

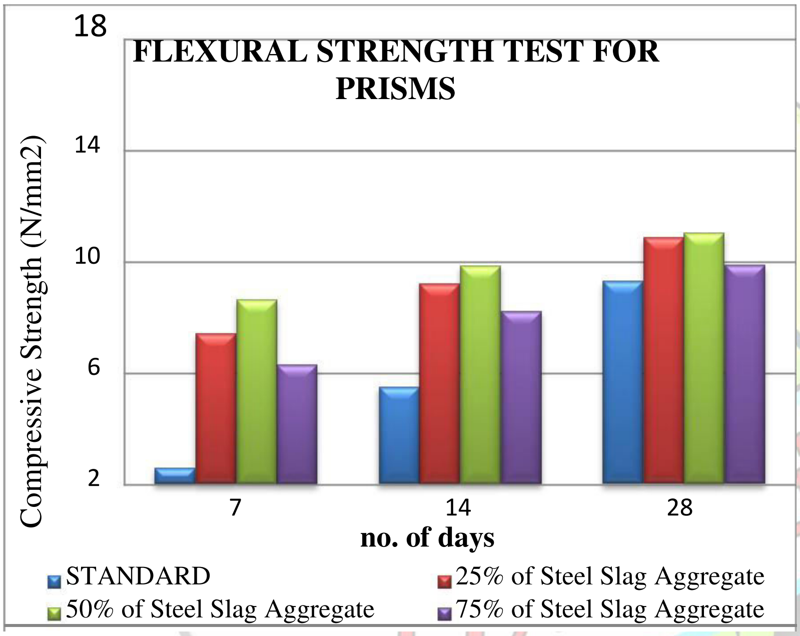

Chart.3 Flexural Strength of Standard and Steel Slag Aggregate concrete prism

Fig.5 Flexural Strength test

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CONCLUSION

This project work is based on the usage of light weight concrete with Quarry dust a cheap material used as complete replacement for sand and addition to that steel slag aggregate are used in the concrete mixtures. It is concluded that the strength and durability of the concrete performs better with steel slag aggregate.

1. The experimental investigation was conducted to improve the strength of concrete with quarry dust as fine aggregate with addition of steel slag aggregate as a light weight concrete.
2. To improve the workability of the concrete mix super plasticizer also used. Properties of materials used in concrete were listed out. Workability and strength characteristics of the steel slag concrete were compared with conventional concrete.
3. Quarry dust has lots of finer dust particle than sand which reduce the workability of concrete. To compensate this problem super plasticizer was used. When quarry dust was used with super plasticizer it will show better workability and flow ability.
4. From this we can conclude that 100% replacement of sand with quarry dust shows good strength and it was conclude quarry dust is the better alternative for natural sand.
5. Compressive strength, split tension strength and flexural strength of light weight concrete with quarry dust and steel slag is higher than the conventional concrete.

Thus, from the above results, it is concluded that the Quarry dust as complete replacement for sand and addition to that 50% of steel slag aggregate are used in the concrete mixtures in concrete is found to be good ,economic and improves the strength of concrete.

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