COMPRESSIVE STRENGTH AND DURABILITY STUDIES ON CONCRETE WITH SPONGE IRON SCRAP MATERIAL AS COARSE AGGREGATE

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Abstract

Aggregate is one of the main ingredients in producing concrete. It is 75% of the concrete. The strength of the concrete produced is dependent on the properties of aggregates used. There is huge demand for this material. Hence need for an alternative coarse aggregate arises. The scope of project was to investigate the possibility of using sponge iron scrap material as an alternative material to coarse aggregate in structural concrete. Experimental investigation was carried out on compressive strength and durability related tests such as acid resistance test and Permeability. Tests were conducted by replacing the coarse aggregates in concrete mixes by sponge iron scrap material. From the experimental investigation it was found that sponge iron scrap material can be used as an alternative for coarse aggregate in concrete. However further investigations have to be made to study long term effects.

Keywords: *Sponge iron scrap material, Compressive strength, Acid resistance test and Permeability tests*

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1. INTRODUCTION

Cement concrete is the most extensively used construction material in the world and is the second to water as the most heavily consumed substance with about six billion tonnes produced every year. It has emerged as the dominant construction material for the infrastructure needs of the 21stcentury. Large quantities of waste materials are produced from the manufacturing industry, service industry and municipal solid waste incinerators. The waste materials are gaining attention to use those materials as a substitute to natural aggregate in concrete and other construction materials. It helps in reducing the cost of concrete manufacturing and also has numerous indirect benefits such as reduction in land-fill cost, energy saving, and protecting the environment from possible pollution effects. A variety of new materials in the field of concrete technology have been developed during the recent past with the ongoing demand of construction industries to meet the functional, strength, economical and durability requirements.

2. SPONGE IRON SCRAP MATERIAL

During the manufacturing process of reinforcement steel from iron ore, while processing raw ore to sponge iron, some scrap material will be produced which is also known as dolochar. The principal raw materials required for sponge iron production are iron ore, non-coking coal, and dolomite. For the production of 100 tonnes of sponge iron, there are 154 tonnes of iron ore and 120 tonnes (B grade) of coal required. The solid waste generated during this process is around 45 tonnes and out of which 25 tonnes is dolochar. The generation of this scrap material is high due to the use of inferior quality of coal in the sponge iron manufacturing industry. This scrap material until now is used for land-filling. The recovery of carbon values present in dolochar through flotation and could not achieve any significant recovery due to poor liberation of the carbon particle present in the scrap material.

This Sponge Iron Scrap material is in the shape of coarse aggregate. In this regard we are testing the material so that it can be used as replacement of coarse aggregate in making cement concrete.

Table 1: Physical Properties of Sponge Iron material

S No.	Property	Test Result
1	Fineness Modulus	6.87
2	Specific Gravity	2.64
3	Bulk Density (loose) Bulk Density (Compacted)	1358 kg/m^3 1471 kg/m^3
4	Aggregate Crushing Value	30.23
5	Aggregate Impact Value	29.91
6	Water Absorption	6.14 %

Concrete Mix Design

Using the properties of cement aggregate, concrete mix of M20 grade was designed as per code[1]. The following proportions by weight were obtained.

Table 2: Mix proportion for M20 grade concrete

Cement	Fine Aggregate	Coarse Aggregate	Water
320 kg/m^3	694 kg/m^3	1156 kg/m^3	192 kg/m^3

3. COMPRESSIVE STRENGTH AND DURABILITY STUDIES

Compressive strength of M20 grade concrete using sponge iron scrap material as coarse aggregate is 28.66 N/mm^2. Whereas that of conventional crushed granite stone concrete is 28.24 N/mm^2.

3.1 Studies on Acid Attack Resistance

1. To study the effect of aggressive chemical environment on compressive strength loss and weight loss of sponge iron scrap material concrete exposed to different concentrations of various acids as shown below:
   i. 5% and 10% HCL
   ii. 5% and 10% H_2SO_4
2. Evaluation of Acid Durability Factors (ADFs) and Acid Attack Factors (AAFs) of sponge iron scrap material concretes exposed to different concentrations of various acids investigated.

Table 3: Percentage Weight Loss of M20 grade concrete in HCL 5 % solution

S No.	Days of Exposure	% Weight Loss
1	7	2.12
2	14	2.49
3	21	2.71
4	28	2.89

Table 4: Percentage Weight Loss of M20 grade concrete in H_2SO_4 5% solution

S No.	Days of Exposure	% Weight Loss
1	7	2.94
2	14	4.03
3	21	7.12
4	28	9.65

The loss of weight of concrete cubes increases with the increasing values of acid concentration. Sulphuric acid caused higher deterioration compared to hydrochloric acid during testing period. HCL 10% and H_2SO_4 10% follows similar pattern

Table 5: Percentage Compressive Strength Loss of M20 grade concrete in HCL 5% solution

S No.	Days of Exposure	% Strength Loss
1	7	2.62
2	14	4.87
3	21	7.32
4	28	10.62

Table 6: Percentage Compressive Strength Loss of M20 grade concrete in H_2SO_4 5% solution

S No.	Days of Exposure	% Strength Loss
1	7	23.42
2	14	44.24
3	21	63.04
4	28	78.6

Sulphuric acid caused higher deterioration compared to hydrochloric acid during testing period. HCL 10% and H_2SO_4 10% follows similar pattern

3.2 Acid Durability Factors (ADF)

Table 7: Acid Durability Factors of M20 grade concrete in HCL 5% solution

S No.	Days of Exposure	ADF
1	7	24.34
2	14	47.56
3	21	69.51
4	28	89.38

Table 8: Acid Durability Factors of M20 grade concrete in H_2SO_4 5% solution

S No.	Days of Exposure	ADF
1	7	22.58
2	14	43.09
3	21	61.93
4	28	75.87

Acid durability factors are higher in hydrochloric acid compared to sulphuric acid solutions. HCL 10% and H_2SO_4 10% follows similar pattern.

3.3 Acid Attack Factors (AAF)

The extent of deterioration at each corner of the struck face and the opposite face is measured in terms of the solid diagonals (in mm) for each of the two cubes

Table 9: Acid Attack Factors of M20 grade concrete in HCL 5% solution

S No.	Days of Exposure	AAF
1	7	0.975
2	14	1.041
3	21	1.067
4	28	1.083

Table 10: Acid Attack Factors of M20 grade concrete in H_2SO_4 5% solution

S No.	Days of Exposure	AAF
1	7	1.483
2	14	1.844
3	21	2.164
4	28	2.387

Acid Attack Factors are higher in sulphuric acid solution compared to hydrochloric acid solution during testing period. Acid attack factors of sponge iron scrap material concrete cubes is similar to that of conventional crushed granite stone aggregate concrete cubes. HCL 10% and H_2SO_4 10% follows similar pattern.

3.4 Rapid Chloride Permeability Test

The test should be performed according to Code [2]. The test determines the electrical conductance of the specimen, expressed as total charge passed through the specimen.

Table 11: Rapid Chloride Ion Penetration Test for M20 grade concrete

Time	Cell 1	Cell 2
30 min	109	97
1 hr	108	99
1 hr 30 min	106	103
2 hr	74	95
2 hr 30 min	69	89
3 hr	50	85
3 hr 30 min	109	102
4 hr	113	104
4 hr 30 min	113	103
5 hr	114	104
5 hr 30 min	117	105
6 hr	114	103
Total	1196	1189

Chloride Ion Permeability = 1192.5 coulombs

As per ASTM C1202 RCPT ratings, Chloride ion permeability in concrete using sponge iron scrap material as coarse aggregate has low permeability.

4. CONCLUSION

From the experimental investigation on sponge iron scrap material as a full replacement of coarse aggregate in concrete the following conclusions are drawn.

1. Water absorption of Sponge iron scrap material is found to be higher than conventional crushed granite stone aggregate. Hence necessary corrections have to be carried out in mix design.
2. Sponge iron scrap material is innocuous in nature, which indicates no alkali aggregate reaction.
3. Compressive strength of Design mix of M20 grade concrete using sponge iron scrap material as coarse aggregate is 1.5% higher than that of conventional crushed granite stone concrete.
4. Percentage weight loss, Percentage strength loss, Acid durability factors and Acid attack factors of sponge iron scrap material concrete cubes is similar to that of conventional crushed granite stone aggregate concrete cubes
5. Chloride ion permeability in concrete using sponge ion scrap material as aggregate has low permeability as per ASTM C1202 RCPT ratings.

From the experimental investigation it was found that sponge iron scrap material can be used as an alternative for coarse aggregate in concrete. However further investigations have to be made to study long term effects.

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