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Experimental study on waste foundry sand and steel slag concrete

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ABSTRACT

Generation of waste foundry sand as by- the product of metal casting industries causes environmental problems because of its improper disposal. Thus, its usage in building material, construction and in other fields is essential for reduction of environmental problems. Similarly, in foundries (where the ferrous and non-ferrous metals are melted.), the slag is produced after the completion of the melting process it can also be used as a building material, construction and in another field. This research is carried out to produce low-cost and eco-friendly concrete. This paper demonstrates the use of waste foundry sand as a partial replacement by fine aggregate and slag is as coarse aggregate in concrete. An experimental investigation is carried out on concrete containing waste foundry sand in the range of 0%, 20 %, 40% by weight and slag is fully replaced (100%) for M-25 grade concrete (OPC). The material was produced, tested and compared with conventional concrete in terms of workability and strength. These tests were carried on a standard cube of size 150mm×150mm×150mm for 7, 14 and 28 days to determine the mechanical properties of concrete.

Keywords— *Waste foundry sand, Steel slag, Cement (OPC), Low-cost concrete, Eco-friendly, Compressive strength, Split tensile strength*

1. INTRODUCTION

Concrete is an artificial material which is widely used in all the construction sectors. All the constructions around the world are constructed with the help of concrete such as Buildings, Roadways, Bridges, and Dams etc. The concrete is a costly material and due to which the cost of the construction increases with the increase in the quantity of the concrete. To overcome this problem we have used industrial waste materials as a fine aggregate and coarse aggregate. Waste foundry sand is used as a fine aggregate and Steel slag is used as a coarse aggregate

1.1 Waste Foundry Sand (WFS)

Metal industries use sand casting in which moulds are made of uniform sized, clean, high silica sand. After the casting, process foundries recycle and reuse the sand several times but after some time, it is discarded from the foundries known as waste foundry sand. Its harmful effect on environment and disposal problem can be minimized if used in engineering structures. Indian foundries produce approximately 1.71 million tons of waste foundry sand each year (metal world, 2006).

Fig. 1: Waste Foundry Sand

Waste foundry sand is made up of mostly natural sand material. Its properties are similar to the properties of natural or manufactured sand, the fineness modulus of waste foundry sand is 2.62 thus it can normally we used as a replacement of sand.

1.2 Steel Slag

Steel slag a by-product of steel making is produced during the separation of the molten steel from impurities in steel-making furnaces. The slag occurs as a molten liquid melt and is a complex solution of silicates and oxides that solidifies upon cooling. Steel slag was used as fine or coarse aggregate in concrete mixtures.

It is estimated that between 7.0 and 7.5 million metric tons (7.7 to 8.3 million tons) of steel slag is used each year in the United States. 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. While most of the furnace slag is recycled for use as an aggregate, excess steel slag from other operations (raker, ladle, clean out, or pit slag) is usually sent to landfills for disposal. The use of steel slag as an aggregate is considered standard practice in many construction sectors, with applications that include its use in granular base, embankments, engineered fill, highway shoulders, and hot mix asphalt pavement.

Fig. 2: Steel Slag

1.3 Cement (OPC)

Cement is defined as the product of manufactured by burning and crushing to powder an intimate and well proportion mixture of calcareous and argillaceous material is known as cement. The various types of cement are available in the market and in our project, we have used an ordinary Portland cement. Ordinary Portland cement (OPC) has a compressive strength of 43 $N/mm^{2.}$

2. OBJECTIVES

To check the behaviour of concrete after adding foundry sand and slag.
To check the difference in the cost of conventional concrete and foundry sand and slag concrete.
To create the best from the waste.
To make an Eco-friendly concrete.

3. EXPERIMENTAL PROCEDURE

3.1 Mould preparation

The steel moulds are used for casting concrete cubes. We have used a mould of size 15×15×15 cm for the casting of concrete cubes. The greasing process is to be followed before the casting of concrete into the mould. After that, it is ready for the casting process.

3.2 Mix proportion

Mix proportion is nothing but it is a quantitative ratio of the materials (i.e. cement: Fine aggregate: Coarse Aggregate).

Table 1: Mix Proportion for a Conventional Concrete (M-25) for a Volume of 1 Cube (15×15×15 cm)

S. no.	Cement (gm)	Natural Fine Agg. (gm)	Natural Coarse Agg. (gm)	Water (lit.)
1.	1898	2126	3950	950

Table 2: Mix Proportion for a conventional concrete (M-25 grade) with the replacement of waste Foundry sand for a Volume of 1 Cube (15×15×15 cm)

Replacement material (%)	Cement (gm)	WFS (Fine Agg.) (gm)	Natural Fine Agg. (gm)	Natural Coarse Agg. (gm)	Water (lit.)
WFS (20)	1898	455	1700	3950	950
WFS (40)	1898	911	1276	3950	950

Table 3: Mix Proportion for a waste Foundry Sand and Steel Slag Concrete (M-25 grade) for a Volume of 1 Cube (15×15×15 cm)

Replacement material (%)	Cement (gm)	WFS (Fine Agg.) (gm)	Natural Fine Agg. (gm)	Steel Slag (gm)	Water (lit.)
WFS (20)	1898	455	1700	2025	950
WFS (40)	1898	911	1276	2025	950

3.3 Mixing process
Tilting type of concrete mixer was used for the mixing of the concrete. First of all the dry mixing of all the ingredients in concrete were done with the help of mixing drum. Then the water is added into the dry mix as per the water-cement ratio and it is mixed well with all other the ingredient.

3.4 Workability
Workability of concrete is the property of freshly mixed concrete which determines the ease and homogeneity with which it can be mixed, placed, consolidated and finished. The workability of concrete depends on many factors Such as water-cement ratio, mix proportion, size and shape of aggregate etc.

3.5 Casting process
After the completion of mixing process the greased moulds are taken and placed on a level surface and then the concrete is cast into the mould in three layers and each layer of the concrete is tamped 25 times with the help of tamping rod and the top surface of the concrete is roughly levelled with the help of trowel.

3.6 Curing process
Curing is necessary for the continuation of hydration reaction which gives concrete its strength. It is necessary to avoid drying of concrete till full strength is achieved. It prevents water loss by evaporation and help in maintaining the process of hydration.

4. RESULT ANALYSIS AND COMPARATIVE STUDY (After 7 days of curing)
The objective of this study was to determine the strength of concrete containing waste foundry sand as a partial replacement of fine aggregate and steel slag as a partial replacement of coarse aggregate. For this purpose different test on hardening, concrete was conducted at the age of 7 days like compressive strength test and splitting tensile strength test on 150×150×150 mm size cube.

4.1 Compressive strength
Compressive strength test was performed on a cube sample of size 150×150×150 mm using a universal testing machine (UTM). Three samples per batch were tested with the average strength value reported in the table given below.

Fig. 3: Compressive strength test

Table 4: Compressive strength of conventional concrete (M-25) after 7 days of curing

S. no.	Sample 1 (N/mm^2)	Sample 2 (N/mm^2)	Sample 3 (N/mm^2)	Avg. compressive strength (after 7 days) (N/mm^2)
1.	17.77	16.44	18.44	17.55

Table 5: Compressive strength of conventional concrete (M-25) with the replacement of waste foundry sand after 7 days of curing

S. no.	Replacement (%)	Sample 1 (N/mm^2)	Sample 2 (N/mm^2)	Sample 3 (N/mm^2)	Avg. compressive strength (after 7 days) (N/mm^2)
	WFS				
1	20%	19.55	18.89	21.33	19.92
2	40%	18.67	17.55	17.33	17.85

Table 6: Compressive strength of a waste Foundry Sand and Steel Slag Concrete (M-25 grade) after 7 days of curing

S. no.	Replacement (%)		Sample 1 (N/mm^2)	Sample 2 (N/mm^2)	Sample 3 (N/mm^2)	Avg. compressive strength (after 7 days) (N/mm^2)
	WFS	Steel Slag				
1.	20%	100%	22.67	22.22	21.11	22
2.	40%	100%	18.58	19.24	18.22	18.63

4.2 Splitting tensile strength test

Splitting tensile strength tests were performing on a Universal testing machine using cylindrical or cubical samples. A cubical sample of 15×15×15 cm was tested while performing a splitting tensile strength test during this testing a sample was placed in an inclined position on a UTM and then the load was applied on a placed cube. The three samples per batch were tested with the average strength values reported in the table given below:

Fig. 4: Split tensile strength test

Table 7: Tensile strength of conventional concrete (M-25) after 7 days of curing

S. no.	Sample 1 (N/mm^2)	Sample 2 (N/mm^2)	Sample 3 (N/mm^2)	Avg. tensile strength (after 7 days) (N/mm^2)
1.	2.02	2.14	2.12	2.09

Table 8: Tensile strength of conventional concrete (M-25) with the replacement of waste foundry sand after 7 days of curing

S. no.	Replacement (%) WFS	Sample 1 (N/mm^2)	Sample 2 (N/mm^2)	Sample 3 (N/mm^2)	Avg. tensile strength (after 7 days) (N/mm^2)
1	20%	2.2	2.18	2.12	2.17
2	40%	1.96	2.04	2.14	2.04

Table 9: Tensile strength of a waste Foundry Sand and Steel Slag Concrete (M-25 grade) after 7 days of curing

S. no.	Replacement (%) WFS	Sample 1 (N/mm^2)	Sample 2 (N/mm^2)	Sample 3 (N/mm^2)	Avg. tensile strength (after 7 days) (N/mm^2)
1	20%	100%	2.25	2.32	2.28
2	40%	100%	2.1	2.03	2.14

5. CONCLUSION

- From the above tables, we can say that the waste foundry sand and steel slag is increased the strength of concrete.
- After the 7 days of curing of concrete cubes, tested cubes has given satisfactory results regarding their compressive strength and workability.
- According to these results, the foundry sand and slag concrete can easily be used for all types of concreting works.
- The use of waste foundry sand and slag concrete will help to achieve the required strength at a low cost.

6. REFERENCES

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