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A Study on Non Destructive Tests of Concrete with Different Grades Copper Slag as Replacement of Fine Aggregate

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Abstract: **- Concrete plays the key role towards this development and a large quantum of concrete is being utilized in every construction practice. River sand, which is one of the major constituents used in the production of concrete, has become very expensive and also becoming scarce due to the depletion of river beds. Copper slag is an industrial by-product material produced from the process of manufacturing copper. It has been estimated that approximately 24.6 million tons of slag are generated from the world copper industry.**

Copper slag is considered as one of the waste materials which can have a promising future in construction industry as partial or full substitute of either cement or aggregates. For each ton of copper production, about 2.2 tonnes of copper slag is generated. This slag is currently used for many purposes like land filling, construction of abrasive tools, roofing granules, cutting tools and rail road ballast material, which are not very high value added application.

These applications utilize only about 15% to 20% of copper slag generated and remaining material is dumped as a waste. In order to reduce the accumulation of copper slag and also to provide an alternative material for an approach has been done to investigate the use of copper slag in concrete for the partial replacement of sand.

Hence, in this paper consists the results of an experimental investigation was done to find out the The various strengths (non-destructive tests) of concrete like ultrasonic pulse velocity test, rebound hammer test were studied for various replacements of fine aggregate using copper slag that are 0% (for the control mixture), 20%, 40%, 60%, 80%, and 100% of Copper Slag by weight. Test results indicate significant improvement in the strength properties of plain concrete by the inclusion of up to 80% Copper slag as replacement of fine aggregate (sand), and can be effectively used in structural concrete.

The rebound hammer test showed higher rebound strength at 20% fine aggregate replacement, this is due to uniformity of concrete. The pulse wave velocity is higher for the 20% fine aggregate replacement, it is understood that the density of the mix is high and free from pores. Also as percentage of Copper Slag increased the density of concrete increased. The workability of concrete increased with increase in percentage of copper slag.

Keywords: Copper Slag, Concrete, ultrasonic pulse velocity test, rebound hammer test, non-destructive tests etc.

INTRODUCTION

The use of industrial waste or secondary materials to encourage the production of cement and concrete at the construction site. The industry is producing new by-products and scrap. Disposal or disposal of waste can cause environmental and health problems. Therefore, the recycling of waste materials in the concrete industry has great potential. Over the years, by-products such as fly ash, silica fume and slag are considered waste. Compared with ordinary concrete, concrete made of this material has improved operability and durability, and has been used in the construction of electric power, chemical plants and underwater structures.

Polymers are considered to be one of the main components of concrete because they account for more than 70% of the concrete matrix. In many countries, suitable for the construction of natural aggregate scarcity, while in other countries, due to increased demand for construction industry, total consumption has increased. In order to reduce the dependence on natural aggregates, as the main source of aggregate in concrete, manure aggregates and artificial aggregates produced by industrial waste provide an alternative to the construction industry. Therefore, the use of aggregate from industrial waste can be replaced to natural and artificial aggregate.

The basic strategy to reduce the problem of solid waste treatment has been committed to minimizing the waste production and waste as a raw material for waste recycling and waste as raw materials. The useful use of the product in concrete technology has been well known and has been published for many years, such as coal fly ash, fly ash, blast furnace slag and silica fume, as part of Portland's alternative cement. Compared with Portland cement, these materials are widely used in industrial and chemical plant construction.

Copper slag is widely used as an abrasive media to remove rust, old coating and other impurities in dry abrasive blasting due to its high hardness (6-7 Mohs), high density (2.8-3.8 g/cm^3) and low free silica content. At present, across the world around 33 tonnes of slag is generated while in India three copper producers Sterlite, Birla Copper and Hindustan Copper produce around 6-6.5 tones of slag at different sites. Used copper slag is the largest source of waste from shipyards and refineries. The primary advantage to copper slag is the low risk it poses to health and the environment. Copper slag also has a high strength-to-weight ratio, making it an effective option in concrete, or as a fill material under the roadway.

2. MATERIALS USED

Cement: Generally Portland cement, Ordinary Portland Cement (OPC) is by far the most important type of cement and other cementitious materials such as fly ash and slag cement, serve as a binder for the aggregate. The cement used in this study is of OPC 53 grade conforming to IS 12269.

Water: Water is then mixed with this dry composite, which produces a semi-liquid that workers can shape (typically by pouring it into a form). The concrete solidifies and hardens to rock-hard strength through a chemical process called hydration. The water reacts with the cement, which bonds the other components together, creating a robust stone-like material. The good quality water is used in this study.

Coarse Aggregate: The aggregate size bigger than 4.75 mm, is considered as coarse aggregate. It can be found from original bed rocks. Coarse aggregate are available in different shape like rounded, Irregular or partly rounded, Angular, Flaky etc. It should be free from any organic impurities and the dirt content was negligible.

Fine Aggregate:

The aggregate size is lesser than 4.75 mm is considered as fine aggregate. The sand particles should be free from any clay or inorganic materials and found to be hard and durable.

Copper slag:

Copper slag is an irregular, black, glassy and granular in nature and its properties are similar to the river sand. In this project, Copper slag used is brought from Sterile Industries India Ltd, Hyderabad. The chemical traces such as copper, sulphate and alumina present in the slag are not harmful.

Objective of this study

The objective was to investigate the effect of partial and full replacement of fine aggregate with copper slag on the strength and behavior. In this experimental study, M20, M30, M40 grade concrete was used and the tests were conducted for different replacement of fine aggregate using copper slag as 0%, 20%, 40%, 60%, 80%, and 100% in concrete. The obtained results are compared with the control concrete made with fine aggregate.

Methodology and Experimental work:

The workability parameters such as slump value and compaction factor were studied. In hardened state: - non-destructive tests such as rebound hammer test and ultrasonic pulse velocity test were conducted for every mix. The obtained results are tabulated.

The details of specimen used in the work is given below

Strength test	Ultrasonic pulse velocity test	Rebound hammer test
Sample type	cube	Cube
Sample size (mm)	150×150 × 150	150×150×150
Days of testing	28	28
Total no. of samples for one series	6	6

Table1: Details of specimen

Preparation of samples:

Ultrasonic pulse velocity test:

Several samples were prepared and cured as per IS 516. For Ultrasonic pulse velocity test concrete cubes of size 150mm X 150mm X150mm were cast with & without copper slag. Six cubes from each mix were tested and their average values were used in the analysis using pundit ultrasonic pulse velocity testing machine. The quality & the void ratio of the concrete was determined at the ages of 28days. From the study of test results it can be seen that the fine aggregate replacement by copper slag concrete mixes were shows the better results than the nominal mixes at all stages.

Fig1. Conducting ultrasonic pulse velocity test

Rebound Hammer Test:

Rebound hammer test is done to find out the compressive strength of concrete by using rebound hammer as per IS: 13311 (Part 2) – 1992. The rebound of an elastic mass depends on the hardness of the surface against which its mass strikes. When the plunger of the rebound hammer is pressed against the surface of the concrete, the spring-controlled mass rebounds and the extent of such a rebound depends upon the surface hardness of the concrete. The surface hardness and therefore the rebound is taken to be related to the compressive strength of the concrete. The rebound value is read from a graduated scale and is designated as the rebound number or rebound index. The compressive strength can be read directly from the graph provided on the body of the hammer.

Before commencement of a test, the rebound hammer should be tested against the test anvil, to get reliable results, for which the manufacturer of the rebound hammer indicates the range of readings on the anvil suitable for different types of rebound hammer. Apply light pressure on the plunger – it will release it from the locked position and allow it to extend to the ready position for the test. Press the plunger against the surface of the concrete, keeping the instrument perpendicular to the test surface. Apply a gradual increase in pressure until the hammer impacts. (Do not touch the button while depressing the plunger. Press the button after impact, in case it is not convenient to note the rebound reading in that position). Take the average of about 10 readings.

Fig2: Conducting Rebound hammer test

Copper slag added in %	Rebound strength		Rebound value	
0	49.5	35	30.25	40.2
20	55.8	53.5	40.5	45.7
40	54	90	34.5	60.3
60	57.65	63	44	54.7
80	55.3	43	39.75	48.7
100	54.2	56.5	38.35	53

Table2: Rebound hammer test values for M20 grade concrete

Copper slag added in %	Rebound strength		Rebound value	
0	59	34	53.7	45.2
20	41.5	73.5	48.2	57.2
40	38	90	46.8	60.3
60	65.5	63	55.4	54.7
80	31	43	43.7	48.7
100	44.5	56.5	49.4	53

Table3: Rebound hammer test values for M30 grade concrete

Copper slag added in %	Rebound strength		Rebound value	
0	76.5	70.5	57.8	56.5
20	89.5	71	60.2	56.6
40	56.5	61.5	53.1	54.4
60	56.5	61	53	54.3
80	51	53	53.7	58.7
100	54.0	58.5	50.4	56

Table4: Rebound hammer test values for M40 grade concrete

Copper slag added in %	Distance	Time (µSec)	UPV	Average pulse Velocity	Quality of concrete
0	150	29.90	5.017	4.695	Excellent
	150	34.30	4.373		
20	150	34.10	4.637	4.808	Excellent
	150	37.50	4.979		
40	150	39.30	4.537	4.691	Excellent
	150	39.00	4.846		
60	150	37.60	4.989	4.865	Excellent
	150	40.10	4.741		
80	150	38.5	4.827	4.826	Excellent
	150	39.1	4.826		
100	150	34.88	4.510	4.581	Excellent
	150	34.60	4.653		

Table5: UPV values for M20 grade concrete

Copper slag added in %	Distance	Time (µSec)	UPV	Average pulse Velocity	Quality of concrete
0	150	30.9	4.854	4.894	Excellent
	150	30.4	4.934		
20	150	31.6	4.747	4.840	Excellent
	150	30.4	4.934		
40	150	29.9	5.017	4.935	Excellent
	150	30.9	4.854		
60	150	31.9	4.702	4.739	Excellent
	150	31.4	4.777		
80	150	33.2	4.518	4.588	Excellent
	150	32.2	4.658		
100	150	29.9	5.017	4.845	Excellent
	150	32.1	4.673		

Table6: UPV values for M30 grade concrete

Copper slag added in %	Distance	Time (µSec)	UPV	Average pulse Velocity	Quality of concrete
0	150	29.2	5.137	5.094	Excellent
	150	29.7	5.051		
20	150	29.4	5.102	4.978	Excellent
	150	30.9	4.854		
40	150	29.4	5.102	4.962	Excellent
	150	31.1	4.823		
60	150	30.4	4.934	4.918	Excellent
	150	30.6	4.902		
80	150	32.5	4.652	4.562	Excellent
	150	31.2	4.472		
100	150	28.5	4.856	4.749	Excellent
	150	30.7	4.642		

Table7: UPV values for M40 grade concrete

CONCLUSIONS

From the results and discussions, the following conclusions were made.

• The replacement of fine aggregate using copper slag in concrete increases the density of concrete thereby increases the self-weight of the concrete.

• The workability of concrete increased with the increase in copper slag content of fine aggregate replacements at same water-cement ratio.

The rebound hammer test revealed the uniformity of concrete and their compressive strength.

• The ultrasonic pulse velocity test indicated the excellent quality of concrete at 20% replacement level.

Replacement of copper slag in fine aggregate reduces the cost of making concrete

• The construction industry is the only area for safe use of waste materials, which reduces the environmental problems, space problems and cost of construction.

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