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An Experimental Study on Strength of Concrete with partial Replacement of Sand by Stone quarry dust & Copper slag

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Abstract - *This work reports an experimental study to investigate use of Copper Slag and Quarry Dust as partial replacement of sand i. e. fine aggregate. The Copper Slag and Stone Quarry dust in concrete provides economic benefits as well as for all environmental related problems in industries. Due to the scarcity of fine aggregate for the preparation of mortar and concrete, partial replacement of Copper Slag and Stone quarry Dust with Fine aggregate have been attempted. Copper Slag is the by-product obtained during matte smelting and refining of Copper Slag at industrial level. The strength characteristics of conventional concrete and slag replaced concrete such as compressive strength, split tensile strength and flexural strength has to be determined. In this experimental study concrete were tested by adding Copper Slag and Quarry Dust to Fine aggregate in various percentages ranging from 0%, 15%, 30%, 45%, 40. M-25 & M-30 Grade concrete specimens were cured for 7 to 28 days and to be tested for compression strength, split tensile strength and flexural strength.*

Key Words*: *Copper slag, Quarry dust, concrete, compressive strength, split tensile strength, flexural strength.

1. INTRODUCTION

Concrete is the most popular building material in the world. However, the production of cement has diminished the limestone reserves in the world and requires a great consumption of energy. River sand has been the most popular choice for the fine aggregate component of concrete in the past, but over use of the material has led to environmental concerns, the depleting of securable river sand deposits and a concomitant price increase in the material. Therefore, it is desirable to obtain cheap, environmentally friendly substitutes for cement and river sand that are preferably by products. Quarry dust has been proposed as an alternative to river sand that gives additional benefit to concrete. Quarry dust is known to increase the strength of concrete over concrete made with equal quantities of river sand, but it causes a reduction in the workability of concrete.

Granulated copper slag (or) copper slag which is a by-product of metallurgical operations in Sterile industries (India) Ltd., Tuticorin was used for the experimental investigation. For every tone of metal production, about 2.2 ton of waste slag is generated. Dumping or disposal of such huge quantities of slag cause environmental and space problems. During the past two decades, attempts have been made by several investigators and copper producing units all over the world to explore the possible utilization of copper slag. The physical and mechanical properties of granulated copper slag shows that it can be used to make products like coarse and fine aggregates, cement, fill, ballast, roofing granules, glass, tiles etc.

2. NEED FOR REPLACEMENT OF FINE AGGREGATE

Large scale efforts are required for reducing the usage of the raw material that are present, so that large replacement is done using the various by-product materials that are available in the present day. The other material that can be used is quarry dust which is made while in the processing of the Granite stone into aggregates, this is formed as a fine dust in the crushers that process the coarse aggregates, which is used a earthwork filling material in the road formations majorly. Many studies are made with several other materials which gave the concrete to be a material made of recycled material but the parameters that are primary for the material was not satisfied. The properties of concrete in fresh and hardened state are studied in the various papers that are used as a reference for this. Some of the properties are workability, compressive strength are the major one that are considered.

3. SCOPES AND OBJECTIVES

1. To investigate the effect of Copper Slag & Stone dust waste materials in concrete on its strength.

2. By utilizing the knowledge about the different parameter working out on the better result and safe concrete production with M-25 & M-30 grades of concrete.

3. To save the natural resource and cost optimization.

4. Better consumption of resources and providing maximum serviceability to concrete.

4. MATERIALS & METHODOLOGY

4.1 Cement

Ordinary Portland Cement (53 Grade) with 28% normal consistency with specific surface 3300 cm2/g conforming to IS 8112-1989 is used.

Table -1: Properties of Cement

Properties	Value
Fineness of cement	6%
Grade of Cement	OPC(43 grade)
Specific gravity of cement	2.90
Initial setting time	112
Final setting time	320
Normal Consistency	34%

4.2 Fine Aggregate

The natural fine aggregates are river sand is used. Medium size sand of passing through IS sieve of size 4.75 mm.

Table -2: Properties of Fine Aggregate (River Sand)

Properties	Value
Specific Gravity	2.44
Fineness Modulus	2.25
Water absorption	1.5%

4.3 Coarse Aggregates:

Crushed granite conforming to IS 383 – 1987 was used. Coarse aggregate passing through 20mm and retained on 16mm sieve was used.

Table -3: Properties of Coarse Aggregate

Properties	Values
Specific Gravity	3.125
Size of Aggregates	20mm
Fineness Modulus	5.96
Water absorption	2.0%
Impact Test	15.2%
Crushing Test	22.5%

4.4 Copper Slag

Copper slag is a by-product during copper smelting and refining process. As refineries draw metal out of copper ore, they produce a large volume of non-metallic dust, soot, and rock. Copper slag which is an industrial waste obtained from smelting and refining process of copper from Strelite Industry Ltd., Tuticorin, and Tamilnadu. Nearly 4 tons of copper is obtained as waste is disposed to lands cause's environmental impacts. So it can be reused as concreting materials.

Table -4: Properties of Copper slag

Chemical Component	Percentage of chemical Component
SiO_2	37.26
Fe_2O_3	47.45
Al_2O_3	3.95
CaO	2.38
Na_2O	0.65
K_2O	2.62
Mn_2O_3	0.086
TiO_2	0.33
SO_3	2.75
CuO	1.12

4.5 Quarry Dust

Stone dust produced from stone crushing zones appears as a problem for effective disposal. Hence in this work stone dust is used in the concrete as partial replacement of the sand. The main purpose of this work is to waste minimization. The study focuses to determine the relative performance of concrete by using stone dust. Stone dust was collected from local stone crushing units of Hoshangabad, District, M. P. It was initially dry in condition when collected from plant.

4.6 WATER

Water is an important ingredient of concrete. As general guidance, if the water is fit for drinking and it is fit for making concrete. Water containing a small sum of salt is not suitable for concrete. pH is between 6 and 8 the water is accepted to be suitable. The best way to use the water from a particular sources and concrete is made. Concrete is suitable for 7 and 28 days strength.

5. EXPERIMENTAL PROGRAM

The basic mix proportions were modified for using Copper Slag and Quarry Dust as partial replacement for fine aggregates. Six Concrete mixes with different of CS and QD ranging from 0% to 45% were considered.

5.1 Fresh Concrete Tests:

5.1.1Workability (Slump test)

A slump of 25mm is generally provides good workability of concrete. Throughout the project, no more extra amount of water needed to get slump. Moisture content and absorption of ingredients were taken into account for calculating the amount of water needed. Table shows the measured slump and the amount of water needed to obtain the slump during the project.

Table -5: Workability of Concrete (M-25)

S. No.	Percentage of Variation	Slump in (mm) Contain Copper slag	Slump in (mm) Contain stone dust
1	0	65	65
2	15	68	85
3	30	85	115
4	45	105	135

5.1.2 STRENGTH TESTING PROCEDURE

The standard size of concrete cube is 150mm X 150mm X 150mm and concrete beam of size 700mm X 150mm X 150mm and cylinder specimen of 150mm diameter and 300mm height were cast to determine the compressive strength and flexural strength and split tensile test of the concrete at 7 days and 28 days. The specimens were de-mould after casting and they are cured for 7 days and 28 days.

Table7: Compressive Strength of M-25 concrete Mix contain copper slag at Different curing stages

Percentage replacement	7 Days	14 Days	28 Days	50 Days
0%	17.53	22.70	29.10	39.68
15%	19.18	24.63	33.56	41.65
30%	16.43	21.10	28.75	37.65
45%	14.75	19.51	26.05	31.25

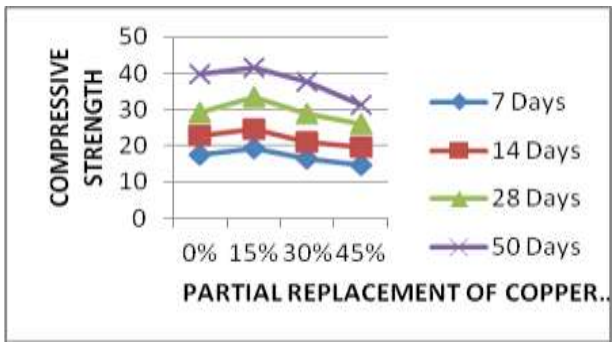
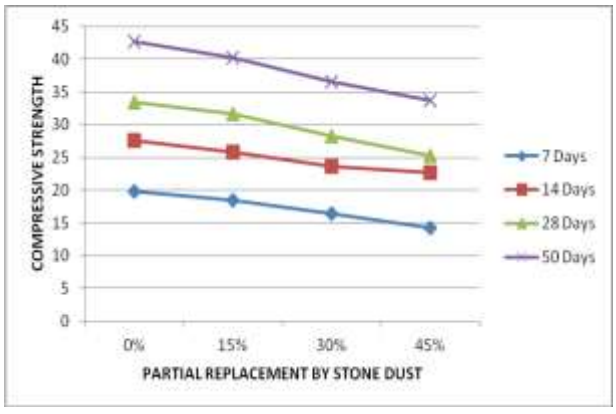


Chart -1: Compressive Strength of M-25 concrete Mix contain copper slag at Different curing stages



6. CONCLUSIONS

From the study of partial replacement of copper slag and quarry dust the following results are obtained.

1. The highest compressive strength was obtained 41.87 Mpa for a replacement of Fine Aggregate by 40%.
2. It is observed that the Split Tensile Strength of concrete 7 to 28 Days is higher for 15% of replacement fine aggregate by C.S and Q.D. Also split tensile strength is more than control mix in all % replacement.
3. More over target strength has been obtained from [30-40%] replacement ratio and a only gradually decrease is seen in full replacement of FA.
4. Hence, both C.S and Q.D can be partially replace. The use of natural sand without sacrificing strength.

7. SCOPE OF FUTURE WORK

1. This research was intended to discover the influence of copper slag additions in concrete elements for M25, and M30 mixes.
2. Copper slag & stonedust can be effectively replaced in concrete applications such as making bricks, hollow blocks and pavement blocks.
3. While copper slag has higher shear strength value it can be used for soil stabilization.
4. Copper slag can be substituted along with fly ash, silica fume and granulated blast oven slag in concrete and RCC members which can be tested for mechanical actions.

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