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# EXPERIMENTAL STUDY ON REPLACEMENT OF FINE AGGREGATE WITH COPPER SLAG AND STONE DUST IN CONCRETE

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## ABSTRACT

In present arena, speedy urban development has created an immense demand for river sand that makes it much expensive. Different suitable materials were introduced in all forms of construction to lower the pressure on natural materials, which will stabilize the financial purpose of the project and also balance the surrounding environment.

The over-exploitation of the natural resources for the construction has a negative impact on the environment. Thereof making construction unsustainable. Utilization of industrial waste in construction is gaining force, not only due to availability of the good quality natural raw material but also due to the great potential of various industrial by-products to be a valuable resource. The present experimental study is conducted to explore the feasibility of copper slag as river sand in mortar mixes.

Copper Slag is a by-product of copper which is produced during smelting of copper used as a substitute to river sand. Which is also recommended by IS: 383-2016. The specific gravity of copper slag is high. The present experiment is carried out for M40 design mix by replacing river sand with copper slag partially in proportion of 50% replacement. Compressive strength, split tensile strength and flexural strength at the ages for 7,28 days for various combinations of Copper Slag and Stone Dust were investigated.

**KEYWORDS:** Copper Slag, Stone Dust, Compressive strength, spilt tensile strength, Flexural strength

## INTRODUCTION

Concrete is a mixer of cement, fine aggregate, coarse aggregate and water. Concrete in large scale used for construction purpose. In concrete as a fine aggregate mostly river sand this makes the scarcity of natural sand. After various doing research to replace river sand some materials were introduced, which are basically cheaply available mainly industrial by products and industrial wastes are utilizing as fine aggregate in concrete.

In our country there is huge demand for aggregates but there is low availability for fine aggregates. So, researches developed waste management strategies to apply for replacement of fine aggregates for specific need. Natural resources are depleting world-wide at the same time the generated waste from the industry are increasing substantially. The sustainable development for construction involves the use of nonconventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways conserving the environment.

### Significance of concrete

Concrete is the most commonly used man-made material on earth. It is an important construction material used extensively in buildings, bridges, roads and dams. Its uses range from structural applications, to paviours, kerbs, pipes and drains.

Concrete is a composite material, consisting mainly of Portland cement, water and aggregate (gravel, sand or rock). When these materials are mixed together, they form a workable paste which then gradually hardens over time.

Concrete strength is determined by the force required to crush it and is measured in pounds per square inch or kilogram per square centimeter. Strength can be affected by many variables including moisture and temperature. The tensile strength of concrete can be improved with the addition of metal rods, wires, cables or mesh.

## COPPER SLAG

Copper slag is the by-product of the manufacture of copper. Large amount of copper slag is generated as waste worldwide during the copper smelting process. To produce every ton of copper, approximately 2.2-3.0 tons copper slag is generated as a by-product material. Utilization of copper slag in applications such as Portland cement substitution and aggregates has threefold advantages of eliminating the costs of dumping, reducing the cost of concrete, and minimizing air pollution problems. Many researchers have investigated the use of copper slag

in the production of cement, mortar and concrete as raw materials for clinker, cement replacement, fine and coarse aggregate. The use of copper slag in cement and concrete provides potential environmental as well as economic benefits for all related industrieFig1: copper slag

Fig1: copper slag

## AIM AND OBJECTIVES

The main objective of replacement of fine aggregate is to increase the strength of concrete by partial replacement of sand by copper slag.
Specific objectives are

- To experimentally investigate the strength of concrete with partial replacement of sand with copper slag to compare conventional concrete by conducting.

a) compressive test.
b) split tensile strength.

- For the proper usage of waste materials.
- Reduce disposal problem by using industrial waste as a concrete ingredient.
- To reduce the cost of construction.
- To increase the strength of concrete.

**Materials Used:**

**Cement:**
The cement which is used in our project is UltraTech cement of 53 grade without any lumps.

**Fine aggregate:**

**Stone dust**
Stone dust is a by-product or crushed stone, which is sometimes called crusher run. Stone dust is also known as rock dust is collected using a screen that keeps the larger pieces of crushed stone above the screen while allowing the rock dust to fall through. This process is the reason why the stone dust is often called quarry screenings. Crushed stones are graded by number according to the size of the crushed stone. As stone dust is the smallest form of crushed stone.

All materials have properties that make them suitable for different purposes. Stone dust has many properties that make it a useful by-product to use for many hardscaping jobs. Understanding the properties of stone dust can help you to decide which jobs it is most suitable.

**Fig 2:** Stone dust

**Coarse Aggregate**
The size of aggregate between 20mm and 4.75mm is considered as coarse aggregate. Almost all-natural aggregate materials originate from bed rocks. There are three kinds of rocks, namely, igneous, sedimentary and metamorphic. These classifications are based on the mode of formation of rocks. It may be recalled that igneous rocks are formed by the cooling of molten lava or magma at the surface of the crest or deep beneath the crest. The sedimentary rocks are formed below the sea bed and subsequently lifted up. Metamorphic rocks are originally either igneous or sedimentary rocks which are subsequently metamorphosed due to extreme heat and pressure.

**Water:**
The water which is used naturally available tap water or portable water without containing any chemicals or salt. The water is normally used in mixing the concrete as well as for curing the concrete moulds or specimens as per code IS 456:2000.

**Methodology:**
The mix design adopted is M40(design mix) which is estimated according to the code IS:10262-2009. The proportion for this mix is (1:0.25:0.5) and the adopted water cementratio as 0.5.
The proportions of copper slag and stone dust which are replaced in place of the fine aggregate are 50% stone dust and 50% copper slag. The mixing which is adopted is hand mixing. The concrete is mixed and are casted in the form of cubes, cylinders and prisms. Curing is done after the hardening process completed for a period of 28 days. The curing which

is generally adopted is pond curing. After a specified period of curing the tests for the specimens are conducted.

Table 1: Mix proportions

| Mix Design | Proportions |
|---|---|
| Nominal | 1:0.25:0.5 |
| Replacement of fine aggregate with copper slag and stone dust | 1:1.35+0.9:2.94 |

Table 2: Compositions for various proportions

| Description | Cement | Coarse Aggregate | Fine Aggregate | Water |
|---|---|---|---|---|
| Nominal Concrete | 3.9kg | 11.6kg | 7.14kg | 1.97lit |
| Replacement of fine aggregate with Copper Slag and Stone Dust | 3.9kg | 11.6kg | 8.90kg | 1.97lit |

## RESULTS AND DISCUSSIONS:

**Results of Compressive Strength Test of Cubes:**

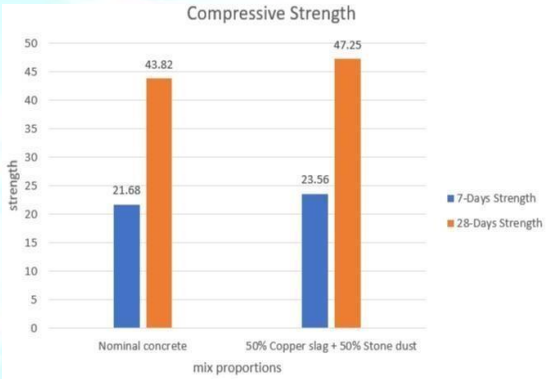
In order to study compressive strength of stone dust and copper slag replaced concretes, different proportion of copper slag and stone dust were prepared. Totally 12 cubes were casted. Curing is done for 7 days and 28 days in normal water for compressive strength test.

From the results listed in table below, it is obtained that 7 days and 28 days strength of all the mixes is varied from all the ages.

**Table No 3:** Results of Compressive Strength Test of Cubes.

| Description | 7-Days | 28-Days |
|---|---|---|
| Nominal concrete | 21.68 N/mm$^2$ | 43.82 N/mm$^2$ |
| 50% Copper slag + 50% Stone dust | 23.56 N/mm$^2$ | 47.25 N/mm$^2$ |

The average compressive strength for cube at 50% of copper slag and 50% of stone dust at age 7 and 28 days are given in table 4.7, it can be noted that, concrete strength compare with nominal concrete. The fig shows the ductile failure of cube specimens. The graphical representation shows the compressive strength of copper slag




Bar Chart Showing Compressive Strength of Cubes Between Normal Concrete Vs Combination of Copper Slag and Stone Dust.

## Splitting Tensile Strength:

For the determination of splitting tensile strength of concrete, cylinder specimens of diameter to length ratio 1:2 was selected, with diameter as 150 mm and the length as 300 mm specimens were dried in open air after 7 and 28 days of curing and subjected to splitting tensile test under compressive testing machine.

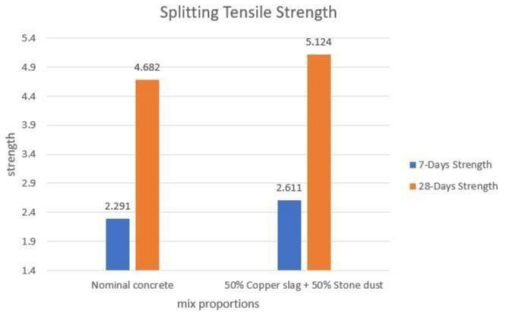
The splitting tensile strength (f) was obtained using the formula,

**F =2P/3.14dl (N/mm$^2$)**.

Where F = load at failure /cross sectional area (N/mm2) P = load at failure(N) d = diameter ofspecimen (mm) l = length of specimen(mm)

**Results of Splitting Tensile Strength Test of Cylinder:**

In order to study splitting tensile strength of copper slag and stone dust replaced concretes, different proportions of copper slag and stone dust were prepared. Totally 12 cylinders were casted. Curing is




done for 7 days and 28 days in normal water to test for splitting tensile strength. From the results listed in Table below, it is obtained that 7 days and 28 days strength of all the mixes is varied from all the ages.

**Table No 4**: Results of Splitting Tensile Strength Test of Cylinders.

| Description | 7-Days | 28-Days |
|---|---|---|
| Nominal concrete | 2.291 N/mm$^2$ | 4.682N/mm$^2$ |
| 50% Copper slag + 50% Stone dust | 2.611 N/mm$^2$ | 5.124N/mm$^2$ |

Bar Chart Showing Splitting Tensile Strength of Cylinders Between Normal Concrete Vs Combination of Copper Slag and Stone Dust.

## Flexural Strength:

For the determination of flexural strength of concrete, beam specimens of dimension 500mmx100mmx100mm specimens were dried in open air after 7 and 28 days of curing and subjected to flexural test under flexural testing machine.

The flexural strength (f) was obtained using the formula, **F =PL/bd$^2$ (N/mm$^2$)**. Where, F = load at failure /cross sectional area(N/mm2)

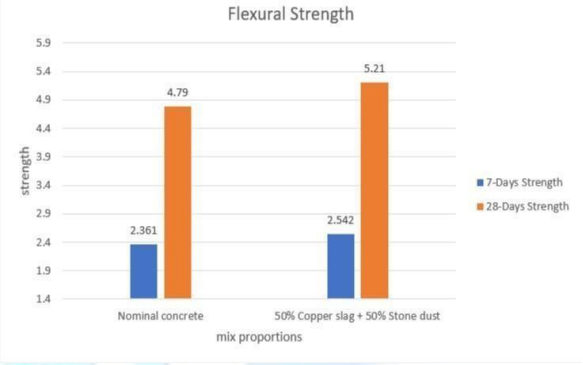
P = load atfailure (N) d = diameter of specimen (mm) L = length of specimen (mm)

## Results of Flexural Strength Test of Prisms:

In order to study flexural strength of copper slag and stone dust replaced concretes, different proportions of copper slag and stone dust were prepared. Totally 12 prisms were casted. Curing is done for 7 days and 28 days in normal water to test for flexural strength. From the results listed in Table below, it is obtained that 7 days and 28 days strength of all the mixes is varied from all theages.

**Table No 5**: Results of Flexural Strength Test of Prisms:

| Description | 7-Days | 28-Days |
|---|---|---|
| Nominal concrete | 2.361 N/mm$^2$ | 4.792 N/mm$^2$ |
| 50% Copper slag + 50% Stone dust | 2.542 N/mm$^2$ | 5.216 N/mm$^2$ |




Bar Chart Showing Flexural Strength of Prisms Between Normal Concrete Vs Combination of Copper Slag and Stone Dust.

## CONCLUSION

From the experimental investigations conducted, the following are the conclusions drawn.

A. Copper Slag is a suitable material for replacement of fine aggregate in concrete.

B. Copper Slag concrete showed considerable increase in strength when used in permissible quantities.

C. The maximum strength was achieved for replacement of fine aggregate with 50% of Stone Dust and 50% of Copper Slag.

D. Compressive Strength was increased by 8.67% for 7 days and 7.83% for 28 days when compared to Normal mix for replacement of fine aggregate with 50% of Stone Dust and 50% of Copper Slag.

E. Split tensile Strength was increased by 13.96% for 7 days and 9.44% for 28 days when compared to Normal mix for replacement of fine aggregate with 50% of Stone Dust and 50% of Copper Slag.

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