



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 11, November 2022

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.118

9940 572 462

6381 907 438

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# Experimental Investigation on Strength Property of Concrete due to Partial Replacement of Fine Aggregate by Copper Slag

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**ABSTRACT:** Concrete is the most used construction material in civil engineering. Concrete is the World's most consumed material product next to water. The Copper Slag has been used as a partial replacement for fine aggregate in the concrete. The Copper slag is obtained as a by-product in the manufacturing of copper by smelting. During smelting, impurities become slag streams on the liquid metal. By utilizing this product as partial replacement in concrete, the concrete can be made more eco-friendly.

In the present work, an attempt has been made to study the behaviour of concrete by replacing Natural river sand as well as M-sand by Copper slag. The main aim of this work is to study the fresh and hardened properties of M-30 grade control concrete and concrete made with partial replacement of fine aggregate with copper slag. To study fresh property Slump test is conducted. To study the hardened properties of concrete, compressive and split-tensile strength are conducted and comparative studies are carried out.

## I. INTRODUCTION

Concrete is a properly mixed substance made of cementitious elements, water, and aggregate (and occasionally admixtures). When the mixture is placed in forms and given time to cure, it hardens into a mass that resembles rock. Careful management of both the raw materials and production components is the secret to making high-quality concrete. Which are

- **Cement:** The most popular cementitious material is OPC.
- **Aggregate:** These consist mostly of inert, naturally occurring granular substances like sand, gravel, or crushed stone. However, technology is expanding to incorporate the usage of synthetic and recycled goods.
- **Water:** Water should be pure.
- **Chemical Admixtures:** These concrete additives, in addition to Portland cement, water, and aggregates, are added to the mixture right before or during mixing in order to decrease the amount of water needed, fast or delay setting, or enhance durability

### COPPER SLAG

In the process of extracting copper by smelting, copper slag is produced. Impurities turn as slag streams on the liquid metal during the smelting process. About 2.5 tonnes of copper slag are produced for every metric tonne of copper.

Most commonly, copper slag is used for surface impact cleaning. Metal, stone, concrete, and other materials' outer layers can be cleaned and shaped by grating impacts. During this cycle, a shower of grit—rough grains—is pushed in the direction of the work piece. The speed at which grit is used, the amount of residue created, and the quality of the finished surface are only a few of the factors that are impacted by the grit material selected.

## II. LITERATURE REVIEW

- **Pranshu Saxena, Ashish Simalti**(2015), "Scope of replacing fine aggregate with copper slag in concrete – A review", concluded that at 40% replacement results increase in compressive, tensile and flexural strength
- **J. Anna Mary** (2016), "An experimental investigation on copper slag as a replacement of fine aggregate in concrete", Concluded that at 40% replacement gave highest strength.
- **Naveed A Shaikh, Pradeep P Tapkire**(2016) "A partial replacement of fine aggregate by copper slag in concrete", concluded that 40% gave highest strength.



- N.Srinivasulu , A. Roopa, M. Venkateswarlu , P. Pavani (2016). “A case study of copper slag as partial replacement of fine aggregate”, 40% replacement gave highest strength.
- JayapalNaganur, Chethan B.A (2014) “Effect of copper slag as a partial replacement of fine aggregate on the properties of cement concrete”, 40% replacement gave highest strength.
- Tamil Selvi P, Lakshmi Narayani P and Ramya G (2014), “Experimental study on concrete using copper slag as replacement material of fine aggregate”, 40% replacement gave highest strength.
- Ambrish E, Dhavamani Doss, ShanmugaNathan N, Ganapathi Raj S (2017) “partial replacement of copper slag as fine aggregate”, M25 grade concrete with 0%-20% at 5% interval, concluded that strength goes on increasing with replacement.
- C.K. Madheswaran, P.S. Ambily, J.K.Dattatreya, N.P.Rajamane (2014)”Studies on use of copper slag as replacement material for river sand in building construction”, concrete with 0%-75% at 25% interval, concluded that copper slag behave similar to river sand and clay bricks made using copper slag is stronger.
- M.Baby, A.Gowshik, J.Jayaprakash, A.V.KarthickRajeshwar (2015) “Use of copper slag as a replacement for fine aggregate in concrete”, M40 grade concrete with 0%-50%, concluded that 40% replacement gave highest strength.
- AlindaDey, Deepjyoti Dev and PurnachandraSaha (2014)“Use of copper slag as sustainable aggregate”, 50% replacement gave highest strength.

### III. OBJECTIVES

- To find the workability nature of fresh concrete
- To determine the strength of concrete due to partial replacement of Fine aggregate by copper slag at 10%, 20%, 30%, 40%, 50% to natural river sand and M-sand and compare the results

### IV. MATERIALS USED

**Cement:** OPC 43grade with Specific gravity 3.01.

**Fine aggregate:** M-sand, River sand and copper slag confining to zone2 and Specific gravity-2.65, 2.65 & 4.03 respectively

**Coarse aggregate:** Locally available coarse aggregate with max particle size 20mm and Specific gravity 2.64

**Super plasticizer:**Conplast WL is used by 0.4% by weight of cement.

### V. MIX PROPORTION AND MIX DETAILS

The mix proportions were calculated for M30 grade of concrete for w/c ratio of 0.45 respectively by using IS-10262-2019 method of mix design. Keeping w/c ratio as constant for control mix and by 0, 10, 20, 30, 40 and 50 % replacements given in table.

| Sample designation | Description                               | W/C  | Water (kg/m <sup>3</sup> ) | Cement (kg/m <sup>3</sup> ) | Natural sand (kg/m <sup>3</sup> ) | Copperslag (kg/m <sup>3</sup> ) | C.A (kg/m <sup>3</sup> ) |
|--------------------|---|------|----------------------------|-----------------------------|-----------------------------------|---------------------------------|--------------------------|
| S0                 | CONTROL CONCRETE OF GRADE M <sub>30</sub> | 0.45 | 168                        | 374                         | 680                               | -                               | 1163                     |
| S1                 | 10% SAND REPLACED WITH COPPER SLAG.       | 0.45 | 168                        | 374                         | 612                               | 68                              | 1163                     |
| S2                 | 20% SAND REPLACED WITH COPPER SLAG.       | 0.45 | 168                        | 374                         | 544                               | 136                             | 1163                     |
| S3                 | 30% SAND REPLACED WITH COPPER SLAG.       | 0.45 | 168                        | 374                         | 476                               | 204                             | 1163                     |



|     |                                       |      |     |     |     |     |      |
|-----|---------------------------------------|------|-----|-----|-----|-----|------|
| S4  | 40% SAND REPLACED WITH COPPER SLAG.   | 0.45 | 168 | 374 | 408 | 272 | 1163 |
| S5  | 50% SAND REPLACED WITH COPPER SLAG.   | 0.45 | 168 | 374 | 340 | 340 | 1163 |
| S6  | CONTROL CONCRETE OF GRADE M30         | 0.45 | 168 | 374 | 680 | -   | 1163 |
| S7  | 10% M-SAND REPLACED WITH COPPER SLAG. | 0.45 | 168 | 374 | 612 | 68  | 1163 |
| S8  | 20% M-SAND REPLACED WITH COPPER SLAG. | 0.45 | 168 | 374 | 544 | 136 | 1163 |
| S9  | 30% M-SAND REPLACED WITH COPPER SLAG. | 0.45 | 168 | 374 | 476 | 204 | 1163 |
| S10 | 40% M-SAND REPLACED WITH COPPER SLAG. | 0.45 | 168 | 374 | 408 | 272 | 1163 |
| S11 | 50% M-SAND REPLACED WITH COPPER SLAG. | 0.45 | 168 | 374 | 340 | 340 | 1163 |

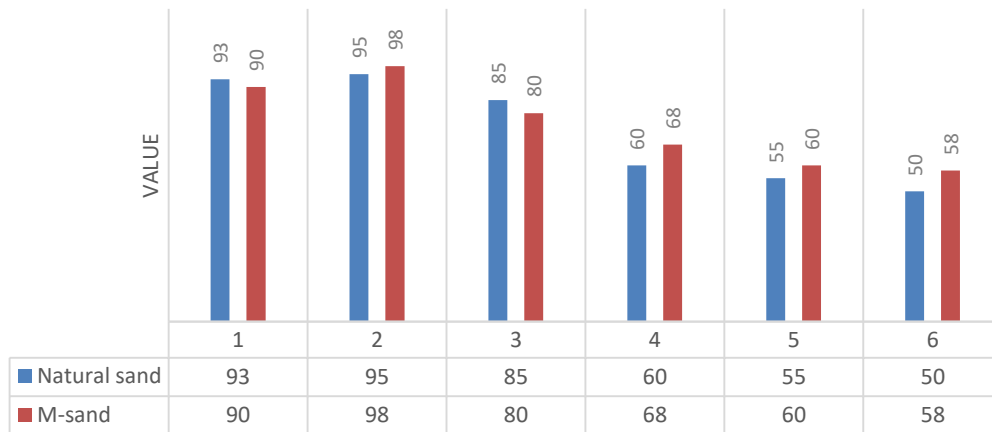
VI. EXPERIMENTAL RESULTS

Fresh Properties: Slump

| SLNO | MIX DESIGNATION | SLUMP(mm) |
|------|-----------------|-----------|
| 1    | S0              | 93        |
| 2    | S1              | 95        |
| 3    | S2              | 85        |
| 4    | S3              | 60        |
| 5    | S4              | 55        |
| 6    | S5              | 50        |
| 7    | S6              | 90        |
| 8    | S7              | 98        |
| 9    | S8              | 80        |
| 10   | S9              | 68        |
| 11   | S10             | 60        |
| 12   | S11             | 58        |



### SLUMP



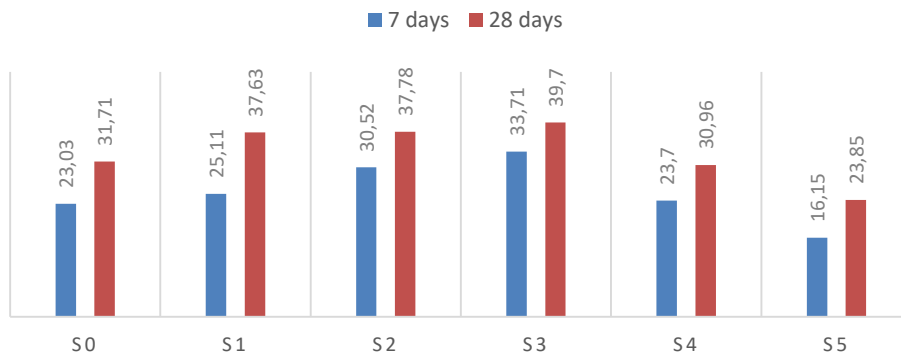
**Hardened Properties:**

**1) Compressive strength**

- Compressive strength of control concrete and concrete made by replacing Natural sand with copper slag at various percentages

| MIX DESIGNATION | 7days | 28days |
|-----------------|-------|--------|
| S0              | 23.03 | 31.71  |
| S1              | 25.11 | 37.63  |
| S2              | 30.52 | 37.78  |
| S3              | 33.71 | 39.70  |
| S4              | 23.70 | 30.96  |
| S5              | 16.15 | 23.85  |

### COMPRESSIVE STRENGTH

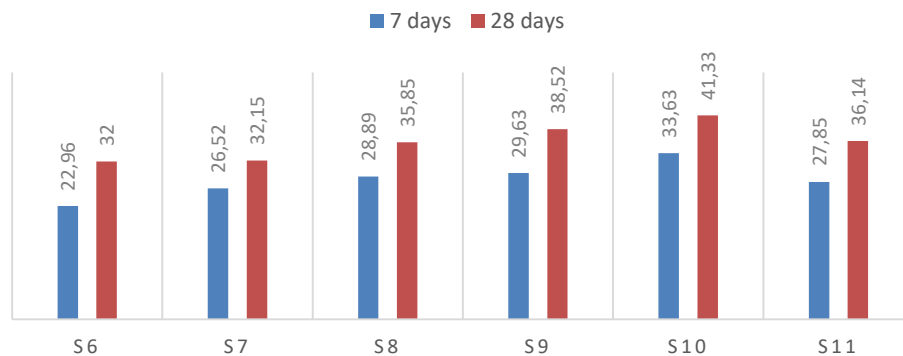


- Compressive strength of control concrete and concrete made by replacing M-sand with copper slag at various percentages



| MIX DESIGNATION | 7days | 28days |
|-----------------|-------|--------|
| S6              | 22.96 | 32     |
| S7              | 26.52 | 32.15  |
| S8              | 28.89 | 35.85  |
| S9              | 29.63 | 38.52  |
| S10             | 33.63 | 41.33  |
| S11             | 27.85 | 36.14  |

### COMPRESSIVE STRENGTH



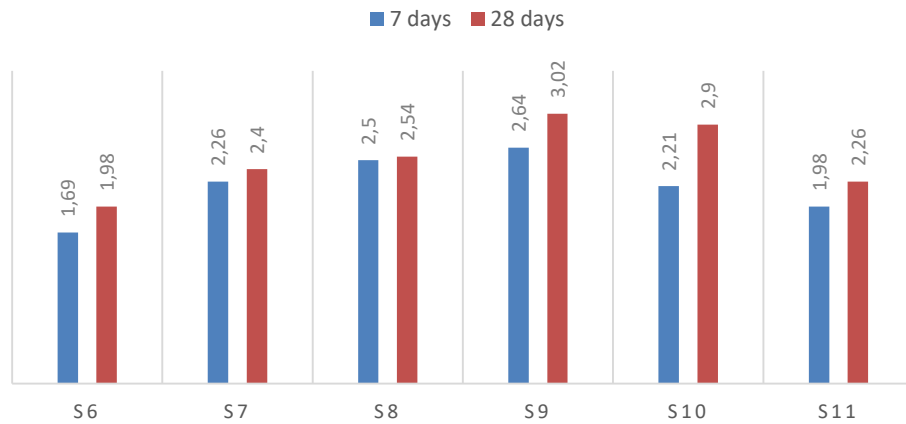
#### 2) Split tensile strength

- Split tensile strength of control concrete and concrete made by replacing Natural sand with copper slag at various percentages

| MIX DESIGNATION | 7days | 28days |
|-----------------|-------|--------|
| S0              | 1.69  | 1.98   |
| S1              | 2.26  | 2.4    |
| S2              | 2.5   | 2.54   |
| S3              | 2.64  | 3.02   |
| S4              | 2.21  | 2.9    |
| S5              | 1.98  | 2.26   |



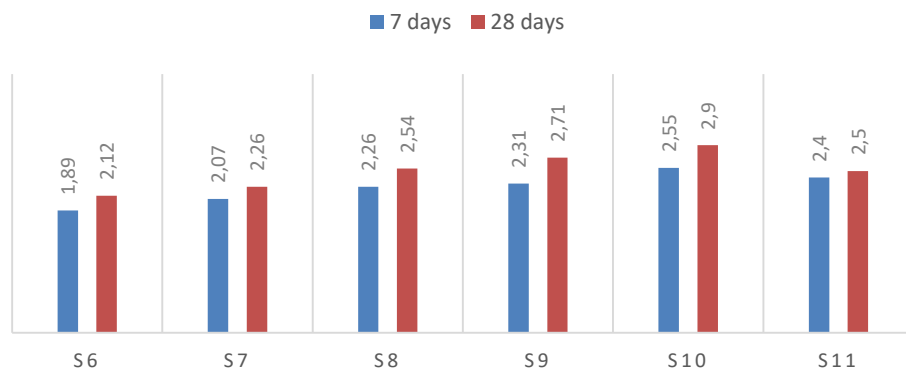
### TENSILE STRENGTH



- Split tensile strength of control concrete and concrete made by replacing M-sand with copper slag at various percentages

| MIX DESIGNATION | 7days | 28days |
|-----------------|-------|--------|
| S0              | 1.89  | 2.12   |
| S1              | 2.07  | 2.26   |
| S2              | 2.26  | 2.54   |
| S3              | 2.31  | 2.71   |
| S4              | 2.55  | 2.90   |
| S5              | 2.40  | 2.50   |

### TENSILE STRENGTH





## VII. CONCLUSION

- Addition of copper slag to Plain cement concrete will not improve the workability property. It is observed that the slump value goes on decreasing with the increase in amount of copper slag addition in both the case of Natural sand and M-sand concrete
- There is a remarkable increase in both compressive and split tensile strength due to addition of copper slag. In case of concrete with natural sand, there is an increase of 25.19% in 28 days compressive strength and 52.53% in split-tensile strength as compared with reference mix. For 30% replacement of river sand by copper slag.
- Similarly there is a remarkable increase in both compressive and split-tensile strength due to addition of copper slag. In case of concrete with M-sand, there is an increase of 24.15% in 28 days compressive strength and 36.79% in split-tensile strength as compared with reference mix. For 40% replacement of M-sand with copper slag.

With above observation, it can be concluded that, even though there is a reduction in workability property, since there is an appreciable increase in the strength of concrete, copper slag can be effectively used as a replacing material for both River sand as well as M-sand.

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