A CASE STUDY ON COPPER SLAG AS PARTIAL REPLACEMENT OF FINE AGRREGATE

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Abstract - *The objective of this project is to study the strength properties of copper slag as a partial replacement of sand at different levels (0%, 20% and 40%). Copper slag is a by-product obtained during the matte smelting and refining of copper. In the present investigation it is proposed to study the engineering properties of Copper slag viz. Slump test, compressive strength , split tensile strength after 7, 14 and 28 days at ambient room temperature curing. From the results, it is concluded that the increased replacement level of Copper slag) increased the compressive strength, splitting tensile strength values of mixes. Results recommended using Copper slag as Partial replacement sand are economical.*

Key Words: **Copper slag, Slump test, Compressive Strength, Split Tensile Strength**

1.INTRODUCTION

It is widely known India is a developing country due to rapid urbanization and industrialization it is necessary to construct so many infrastructure projects to meet the needs for that purpose concrete is required .We know that concrete is mixture of cement, fine aggregate and coarse aggregate with designed w/c ratio. Generally fine aggregate used as sand, and coarse aggregate used as crushed stone etc. Coming to the sand it is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e., a soil containing more than 85% sand-sized particles (by mass). The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide or SiO2), usually in the form of quartz. The second most common type of sand is calcium carbonate, for example aragonite, which has mostly been created, over the past half billion years, by various forms of life, like coral and shellfish. It is for example, the primary form of sand apparent in areas where reefs have dominated the ecosystem for millions of years like the Caribbean.In terms of particle size as used by geologists, sand particles range in diameter from 0.0625 mm (or 1/16 mm) to 2 mm. An individual particle in this range size is termed a sand grain. Sand grains are between gravel (with particles ranging from 2 mm up to 64 mm) and silt (particles smaller than 0.0625 mm down to 0.004 mm). The size specification between sand and gravel has remained constant for more than a century, but particle diameters as small as 0.02 mm were considered sand under the Albert Atterberg standard in use during the early 20th century. A 1953 engineering standard published by the American Association of State Highway and Transportation Officials set the minimum sand size at 0.074 mm. A 1938 specification of the United States Department of Agriculture was 0.05 mm. Sand feels gritty when rubbed between the fingers (silt, by comparison, feels like flour).The most common constituent of sand, in inland continental settings and non-tropical coastal settings, is silica (silicon dioxide, or SiO2), usually in the form of quartz, which, because of its chemical inertness and considerable hardness, is the most common mineral resistant to weathering.The composition of mineral sand is highly variable, depending on the local rock sources and conditions gemstones. Only some sands are suitable for the construction industry, for example for making concrete. Because of the growth of population and of cities and the consequent construction activity there is a huge demand for these special kinds of sand, and natural sources are running low. In 2012 French director Denis Delestrac made a documentary called "Sand Wars" about the impact of the lack of construction sand. It shows the ecological and economic effects of both legal and illegal trade in construction sand. Sand's many uses require a significant dredging industry, raising environmental concerns over fish depletion, landslides, and flooding. Countries such as China, Indonesia, Malaysia and Cambodia ban sand exports, citing these issues as a major factor. India also ban export of sand and supply, monitoring of sand is controlled by Government. In regard of this, the research reported in this thesis was dedicated to investigate the strength properties of copper slag as a partial replacement of sand .

2. EXPERIMENTAL STUDY

The objective of this project is to study the copper slag as replacement of fine aggregate for 0%, 20%, 40%. Compressive strength test was conducted on the cubical specimens for all the mixes after 7, 14 and 28 days of curing as per IS 516 [7]. Three cubical specimens of size 150 mm x 150 mm x 150 mm were cast and tested for each age and each mix. Splitting tensile strength (STS) test was conducted on the specimens for all the mixes after 7 , 14 and 28 days of curing as per IS 5816 [8]. Three cylindrical specimens of size 150 mm x 300 mm were cast and tested for each age and each mix.

3. MIX DESIGN

Indian Standard Recommended Method of Concrete Mix Design (IS 10262 – 1982)[21]

The Bureau of Indian Standards recommended a set of procedure for design of concrete mix mainly based on the work done in national laboratories. The mix design procedures are covered in IS 10262–82[21]. The methods given can be applied for both medium strength and high strength concrete. Before we proceed with describing this method step by step, the following short comings in this method are pointed out. Some of them have arisen in view of the revision of IS 456–2000[20]. The procedures of concrete mix design needs revision and at this point of time (2000 AD) a committee has been formed to look into the matter of Mix Design.

i)Target mean strength for Mix Design:

Concrete mix should be designed for certain higher strength than characteristic strength so that the field strength or site strength of concrete will not be falling below the characteristic strength by certain percent of the result. Assuming 5 percent of the site results are allowed to fall below the characteristic strength, the target mean strength is given by the following relation:

$$f'ck = fck + t \times S$$

$$f' = fck + 1.65\ S$$

S = Standard deviation

t = Tolerance factor

Enough number of trails were not conducted prior to the mix design, standard deviation can be assumed from table 11.21 which is taken from IS 456 : 2000[20]

ii)Water cement ratio:

The water content of concrete is influenced by a number of factors such as aggregate size, shape, texture, workability, cement and other supplementary cementitious material type and content and chemical admixture.The quantity of maximum mixing water per unit volume of concrete is given in table 11.23 in IS 10262 -1982[21]. The quantity of water given in table is for angular coarse aggregate and for 25 to 50 mm slump range.

iii)Cementitious material content:

Cement plus supplementary cementitious material content per unit volume of concrete may be calculated from the free water-cement ratio and the quantity of water per unit volume of concrete. The cementitious material content so calculated shall be checked against the minimum cementitious content for the durability requirement and greater of the two values adopted. The minimum cement content is given in table 9.23 and table 9.12 in IS10262-1982[21].

iv) coarse aggregate proportions:

Aggregates of the same nominal maximum, size type and grading will produce concrete of satisfactory workability, when a given volume of coarse aggregate is used. Approximate aggregate volume in given table 11.24 (IS 456:2000)[20] for a w/c ratio of 0.5. This aggregate volume may be adjusted for other w/c ratio in the following way. For every decrease of w/c ratio by 0.05, the coarse aggregate volume may be increased by 1.0 per cent to reduce the sand content for every increase of w/c ratio by 0.05 the coarse aggregate volume may be decreased by 1.0 percent to increase the sand content.

v) fine aggregate proportion:

From all the above steps, we have estimated the proportions of all the ingredients except coarse and fine aggregates. As a next step, find out the absolute volume of all the so far known ingredients. Deduct the sum of all the known absolute volume from unit volume (1 m3), the result will be the absolute volume of coarse and fine aggregates put together. We know the volume of coarse aggregate and hence volume of fine aggregate can be calculated.

vi)Trail Mix

With the last step the weight of all the ingredients in kg/m3 can be found out. Observe the workability bleeding and segregation characteristics and cohesiveness of concrete etc. The measured workability in terms of slump or flow value is different from stipulated value, the water and /or admixture content may be adjusted suitably. With this adjustment, the mix proportions will be recalculated, keeping the w/c ratio at the preselected value, which will comprise trail mix no 2. In addition, two more trail mixes no 3 & 4 shall be made with water content same as trail mix no 2 and varying the w/c ratio by +/- 10 percent of the preselected value.

4. MECHANICAL PROPERITIES OF COPPER SLAG MIXED CONCRETE

Table 2 shows the compressive strength and splitting tensile strength of Copper slag mixes (0% ,20%, 40%) at different curing periods.

Table 2: Compressive strength and Split Tensile Strength of Concrete

Mechanical property	Age (days)	CS0%	CS20%	CS40%
Compressive strength, f'_c (MPa)	7	29.33	25.33	28.89
	14	30.67	30.22	34.00
	28	34.67	34.51	34.89
Splitting tensile strength, f_{ct} (MPa)	28	2.2	2.21	2.23

From the results it is concluded that CS acts as filling material which fills the voids of the concrete and hence makes the concrete dense. Hence from the Figure 1 and Figure 2, it is concluded that the increased replacement level of CS increased the strength of concrete mixes at ambient room temperature curing. Keeping in view of sustainability, CS can be used as partial replacement of sand .

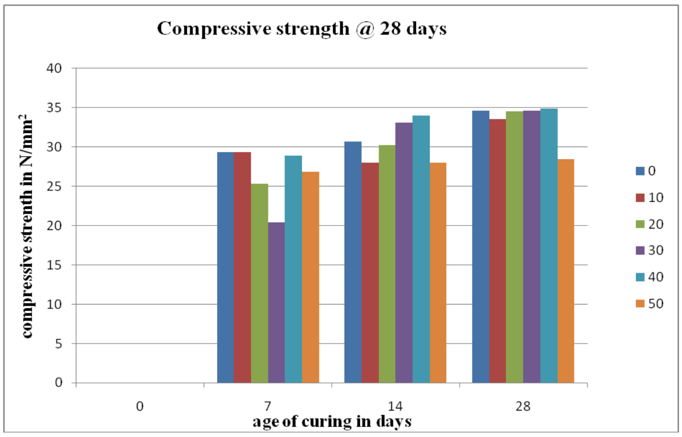

Figure 1. Compressive strength versus age

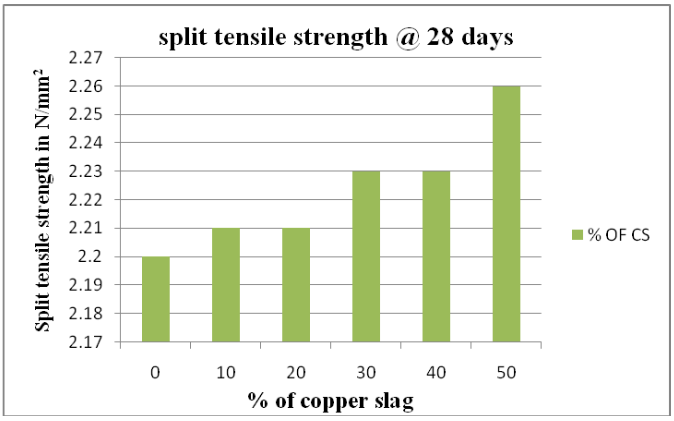

Figure 2. Split Tensile Strength versus % of Copper slag

5. CONCLUSIONS

Based on the test results, the following conclusions are drawn:

1. By adding different dosages of copper slag in conventional concrete we observed that compressive strength at 7 days gain early strength for lower percentage dosages of copper slag. This is attributed high percent of silica, high toughness of copper slag and better heat of hydration

2. But at 28 days gain later compressive strength for higher percentage of dosages of copper slag i.e., 40%. It is almost equal to conventional concrete mix. This is attributed that copper slag has high density than sand, so self weight of concrete is increases.

3. The split tensile strength of concrete increased with increased copper slag content in concrete and the results were more than empirical design values and capable resisting diagonal failure in RC elements and better than made of natural sand.

4. Keeping in view of savings in natural resources, sustainability, environment, production cost, maintenance cost and all other CS properties, it can be recommended as an innovative construction material for the use of constructions.

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