PARTIAL REPLACEMENT OF RIVER SAND AND CEMENT BY COPPER SLAG AND GROUND GRANULATED BLAST-FURNACE SLAG (GGBS)

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Abstract –

The construction industry's increasing demand for materials like sand and cement has led to the exploration of alternative ingredients to reduce the negative impact on the environment. This study focuses on the utilization of waste materials, specifically copper slag and ground granulated blast furnace slag (GGBS), in the production of concrete. Copper slag, a by-product of copper manufacturing, is often disposed of unsafely, causing environmental pollution. By replacing natural sand with copper slag in concrete, not only can pollution and space problems be reduced, but the cost of concrete can also be decreased. GGBS, obtained from iron and steel production, is a fine powder that, when combined with common Portland cement, enhances the strength and durability of concrete structures. The aim of this research is to determine the optimum percentage of GGBS replacement in cement and copper slag replacement in sand to achieve higher strength in concrete. Various tests, including workability, compressive strength, and split tensile strength, are conducted to compare the performance of the concrete mixes with different proportions of GGBS and copper slag. The results indicate that the replacement of natural sand and cement with copper slag sand and GGBS improves the compressive and split tensile strengths of the concrete. This study supports the use of copper slag and GGBS as cost-effective and eco-friendly alternative materials in concrete production, contributing to sustainable construction practices and the efficient utilization of waste materials from the industrial sector.

Index Terms - River Sand, Cement, Copper Slag, Ground Granulated Blast-Furnace Slag (GGBS), Compressive Strength and Tensile Strength.

I.INTRODUCTION :-

Developments in science and technology in the last decades have expanded various industries. As a result, there is an increased need for materials, such as iron, steel, copper, and concrete.Concrete has become an essential construction material that cannot be avoided. According to current trends, concrete has avoided the phase of system of four components, namely, cement, water, coarse aggregate and fine aggregate. It can be a combination of various other factors. In recent times, apart from the four ingredients of fly ash, ground granulated blast furnace slag, silica fume, rice husk ash, metakaolin and super plasticizer, there are six more materials used in the manufacture of concrete. The situation demands. The main aim of sustainable construction is reducing the negative impact on the environment caused by the construction industry which is the largest consumer of natural resources. Over the years, managing waste has become one of the most difficult and challenging issues in the world affecting the environment to a great deal. Many kinds of by products have been generated due to the fast growth of industrialization kinds of waste which have proved hazardous to the environment and has also given rise to storage problems. The construction industry has constantly been at the forefront in the consumption of these waste products in huge quantities. The use of slag in concrete not only helps in decreasing greenhouse gases but also helps in producing materials which are environmental friendly.

Copper slag is utilized as an alternative material in the manufacture of concrete. During the smelting process, while manufacturing copper products, copper slag is the waste material that is generally generated from the industrial sector. It is very expensive to dispose this waste safely and leads to polluting the environment. The only area where the waste material (copper slag) can be safely disposed is the construction industry. When it is used to replace natural sand in making concrete, it reduces pollution of the environment, space problem and also decreases the cost of concrete. Due to the higher density of copper liquid it settles down in the smelter and the smears of copper slag remaining on the surface (also in liquid form) are removed and cooled. A hard and crystalline product is created due to slow cooling of air amorphous, glassy granulates are produced due to fast cooling in water. In the production of concrete, copper slag can be used as a part of concrete production in the place of natural sand.

When iron slag is doused, Ground granulated blast furnace slag (GGBS) is obtained (a by-product of iron and steel production) from a blast furnace in water or steam, producing a smooth, granular product. By drying and grinding this to a fine powder, GGBS, is used to make concrete structures when mixed with common Portland cement along with other pozzolanic materials. Presently, about 33 million tons of copper slag is being created yearly globally; India contributes 6-6.5 million tons among them. The cost of development is reduced along with GBBS when copper slag is used thereby decreasing the harmful effects on the environment. Hereafter, in the present scenario an attempt will be made to restrain the cost of cement and sand with concrete blend of grade M25. The cement will be partially replace with GGBS at 10%, 20% and 30% by dry weight of cement and sand is replaced with copper slag at a constant proportion of 40% by dry weight of sand for M25 mix. Concrete mixes will prepare, tested

and analyze regarding compressive, flexural and split tensile strength. The obtained test results will compared with that of conventional concrete and the proportion of GGBS and copper slag replaced which will give higher strength is selected to be optimum proportion for construction works.

II. LITERATURE SURVEY :-

- **Kumar Gedela Santhosh, Sk M. Subhani, A Bahurudeenb (14 March, 2021),** have been found out influence of characteristics of alternative fine aggregates on properties of concrete such as workability, compressive strength, water absorption, carbonation, abrasion resistance, chloride permeability, septicity, ultra sonic pulse velocity, and drying shrinkage are critically reviewed and compared. From the detailed review, the optimum replacement level of 20 % is witnessed for copper slag.

- **Ruijun wang, Qi shi, Yang li, Ziliang cao, Zheng si, (12 April, 2021),** This paper mainly reviews the relevant literature published in the past decade. It mainly discusses the properties of Copper Slag and the influence of partial replacement of Copper Slag on performance of concrete. This paper has consulted more than 90 related studies. The fresh performance, mechanical property and durability of CS concrete are discussed from three aspects such as particle size, replacement rate and replacement method. Using CS as a partial substitute can improve the environmental impact

- **Yasser Sharifi, Iman afshoon, Saman asad-abadi, Farhad aslani, (23 June, 2020),** This research aims to utilize Waste Copper Slag (WCS) as an alternative to natural coarse aggregate in self-compacting concrete (SCC). Replacing 100% Waste Copper Slag as coarse aggregates in Self Compacting Concrete showed 27%, 29%, and 26% growth in compressive, split, and flexural strengths in 28 days, respectively. A cost analysis of the Self Compacting Concrete showed that incorporating Waste Copper Slag for all coarse aggregates reduced production costs by 19%. Utilizing the Waste Copper Slag in green Self Compacting Concrete was feasible.

- **Madhura Sridharan, T. Ch. Madhavi, (7 November, 2020),** The current study is aimed at assessing the mechanical strength of concrete with copper slag as alternative filler instead of river sand. Based on observations it was concluded that the substitution of sand with copper slag up to 40% exhibited better results than the control concrete. Test results on workability indicated an increasing trend with increase in the content of copper slag in concrete. When 40% copper slag was used in concrete, the compression strength, split tensile strength and flexural strength showed the highest values when compared to the other mixes.

- **M.A.G. dos Anjos, A.T.C. Sales, N. Andrade, (12 March, 2017),** This work focuses on assessing the viability of applying blasted copper slag, produced during abrasive blasting, as fine aggregate for Portland cement concrete manufacturing, resulting in an alternative and safe disposal method. Leaching assays showed no toxicity for this material. Concrete mixtures were produced, with high aggregate replacement ratios, varying from 0% to 100%. Axial compressive strength, diametrical compressive strength, elastic

modulus, physical indexes and durability were evaluated.

- **J. Vijayaraghavan, A. Belin Judeb , J. Thivyac., (14 June, 2017),** Generally, the existing studies focused on alternatives for these construction aggregates, but still there is enough room to explore further. Hence, this study considers as an opportunity to investigate the effect of using alternatives for both fine and course aggregates with copper slag (30%, 40% and 50%) with various proportions of mix by the partial replacement of sand. From the study, it has been concluded that 40% of copper slag possess more strength than conventional concrete mix.

- **V.R. Prasath Kumar, K.Gunasekaran, T. Shyamala, (10 June, 2019),** This study is conducted by completely replacing coarse aggregate with coconut shell (CS) an agricultural waste. Though it achieves the target strength the decrease in quality of coconut shell concrete (CSC) is enhanced by utilizing a pozzolanic material Ground Granulated Blast-furnace Slag (GGBS) and its optimum percentage of replacement with cement is found as 10% by conducting compressive strength for varying percentage of replacement say 0%, 5%, 10%, 15%, and 20%.

- **Rabih Ghostine, Nicolas Bur, Françoise Feugeas, Ibrahim Hoteit, (21 June, 2022),** In this paper, supplementary cementitious materials are used as a substitute for cement to decrease carbon dioxide emissions. A by-product of the iron manufacturing industry, ground granulated blast-furnace slag (GGBS), known to improve some performance characteristics of concrete, is used as an effective cement replacement to manufacture mortar samples. Here, the influence of curing conditions on the durability of samples including various amounts of GGBS is investigated experimentally and numerically. Twelve high-strength Portland cement CEM I 52.5 N samples were prepared, in which 0%, 45%, 60%, and 80% of cement were substituted by GGBS

III.`OBJECTIVE

- To utilize wastes and by-products generated from industries as an alternative material for cement and fine aggregates.
- To find the optimum percentage of replacement of alternative material i.e. GGBS.

IV. METHADOLOGY

- **COPPER SLAG SAND**

In nature, iron, copper, lead, nickel and other metals are found in impure states called ores, often oxidized and mixed in with silicates of other metals. During smelting,when the ore is exposed to high temperatures, these impurities are separated from the molten metal and can be removed, that impurities crushed with help of crusher with appropriate size that's matches to the natural sand

Fig. No.1: Copper Slag Sand

So we use the waste copper slag in concrete to become the construction economical as well as eco-friendly. The iron slag sand used in the present study is brought from bhagvati Steel industry, Sinner. This material replaces the natural sand inmix proportion.

Table No.4: Physical Properties of Copper Slag Sand

Sr. No.	Property	Result
1.	Particle shape and size	Flaky and cubical ,below 4.75mm
2.	Grading Zone	Zone II
3.	Fineness modulus	3.11
4.	Specific gravity	3.4
5.	Bulk Density	1.96
6.	Silt content	Nil
7.	Surface moisture	Nil

- **GROUND GRANULATED BLAST-FURNACE SLAG (GGBS)**

Ground-granulated blast-furnace slag (GGBS) is obtained by quenching moltenіron slag from a blast furnace in water, to produce a glassy, granular product that is thendried and ground into a fine powder. Ground-granulated blast furnace slag is a latent hydraulic binder forming calcium silicate hydrates (C-S-H) after contact with water. It is a strength-enhancing compound improving the durability of concrete. It is acomponent of metallurgic cement. Its main advantage is its slow release of hydration heat allowing to limit the temperature increase in massive concrete components and structures during cement setting and concrete curing, or to cast concrete during hot summer.

The main components of blast furnace slag are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1-18%). In general increasing the CaO content of the slag results in raised slag basicity and an increase in compressive strength. The MgO and Al_2O_3 content show the same trend up to respectively 10-12% and 14%, beyond which no further improvement can be obtained. Several compositional ratios or so-called hydraulic indices have been used to correlate slag composition with hydraulic activity; the latter being mostly expressed as the binder compressive strength.

Fig. No.2 Ground Granulated Blast-Furnace Slag

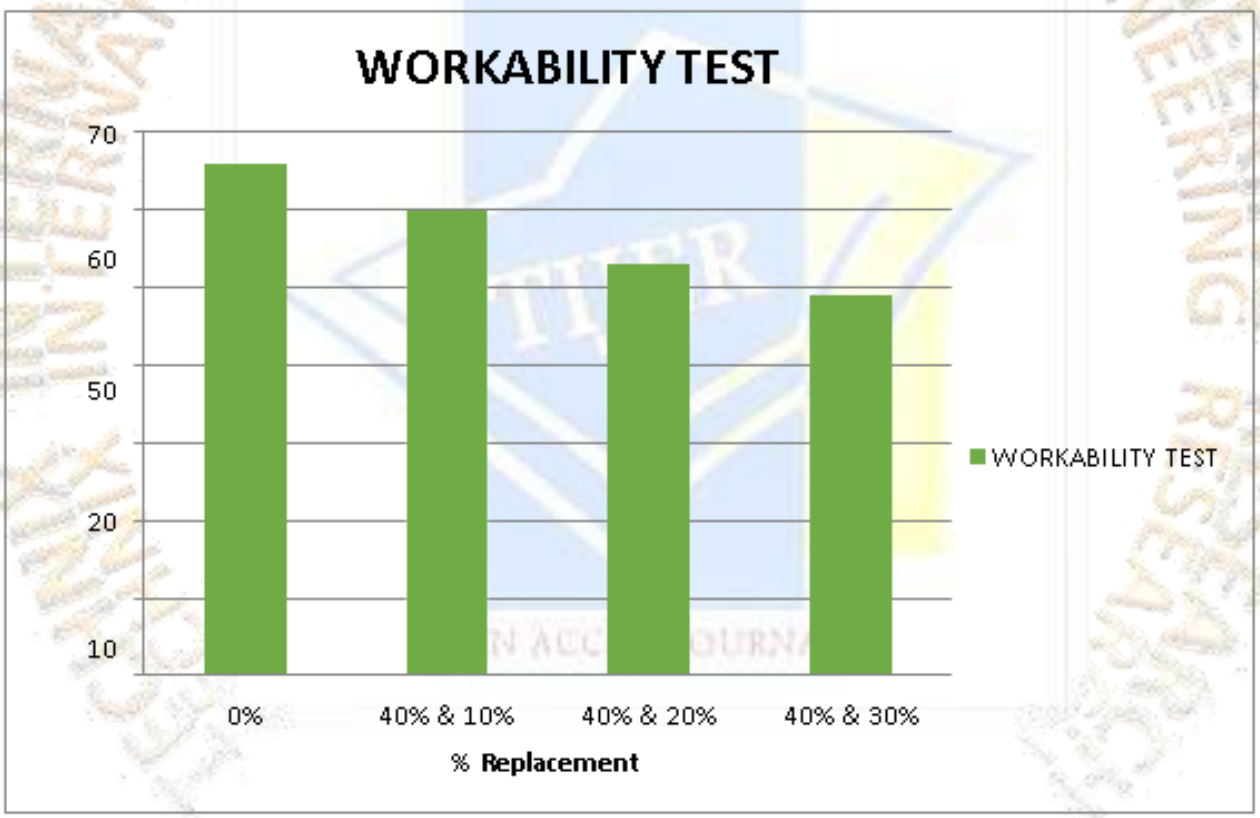
V. TESTS & RESULTS

- **WORKABILITY TEST**

For checking workability of concrete slump cone method is used. Table 4.1 andgraph 4.1 shows the results of workability of concrete with natural sand replacement bycopper slag sand and cement by GGBS in various percentages ranging from 0% to 20%in increments of 10% (0%, 10%, 20%).

Sr.No	% Replacement of Natural sand by Artificial sand (Copper slag sand)	Slump (mm).
1	0%	66
2	40% & 10 %	60
3	40% & 20 %	53
4	40% & 30 %	49

Table 4.1 Slump Value for All Proportions

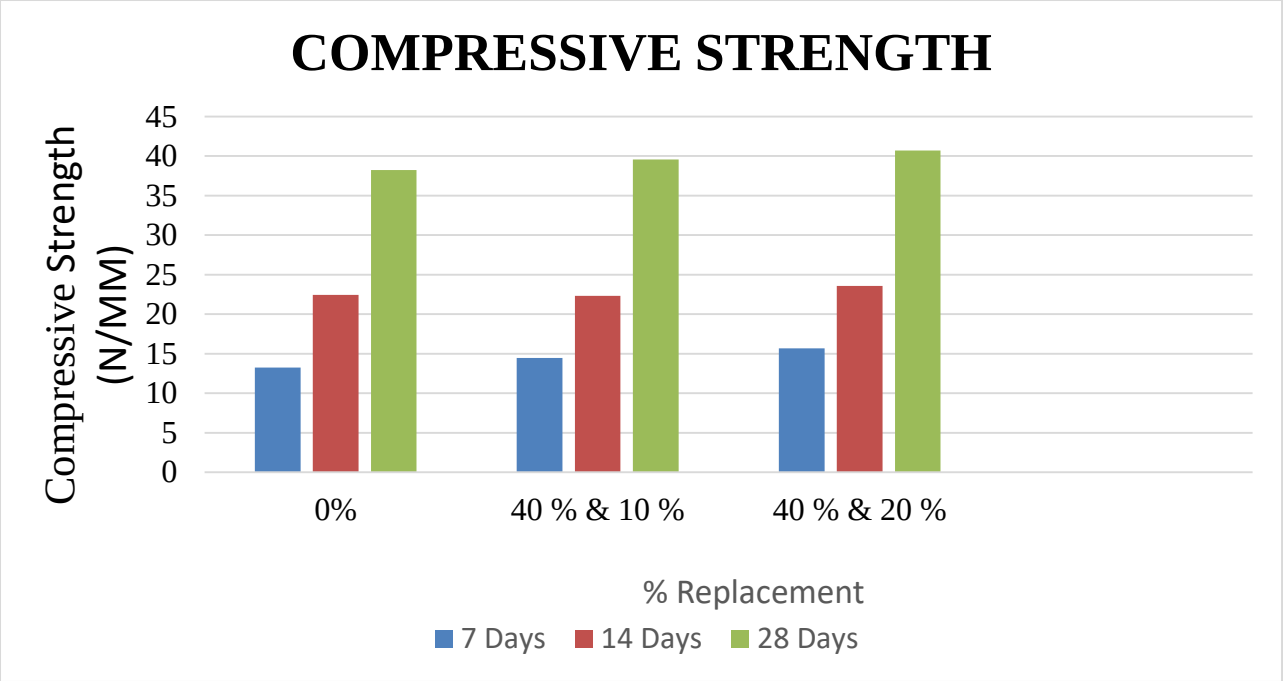


- **COMPRESSIVE STRENGTH TEST**

Compressive Strength The compressive strength of three cubes 150mm x 150mm x 150mm were tested for 7 & 28 days. 2000 KN capacity compression testing machine (CTM) was used to measure the compressive strength of concrete. As per IS: 516-1959, loading rate of 2.5 kn/s was applied. Compressive strength was measured for 7 & 28 days. The table below shows the compression strength for control mix trail. Table 5 - Compression Strength of 7 & 28 days

Sr. no.	% Replacement of cement & natural sand by GGBS & copper slag sand	Compressive Strength (MPa)			Remark
		3 Days	7 Days	28 Days	
1	0%	13.24	22.05	38.23	As per of IS: 456: 2000. Target mean compressive strengthat 28 days for M_{25} concrete is 25 Mpa
2	40% & 10 %	14.45	22.30	39.56	
3	40% & 20 %	15.69	23.55	40.68	
4	40% & 30%	15.86	23.69	41.11	

Table: 4.2 Experimental Test Results for Compressive Strength

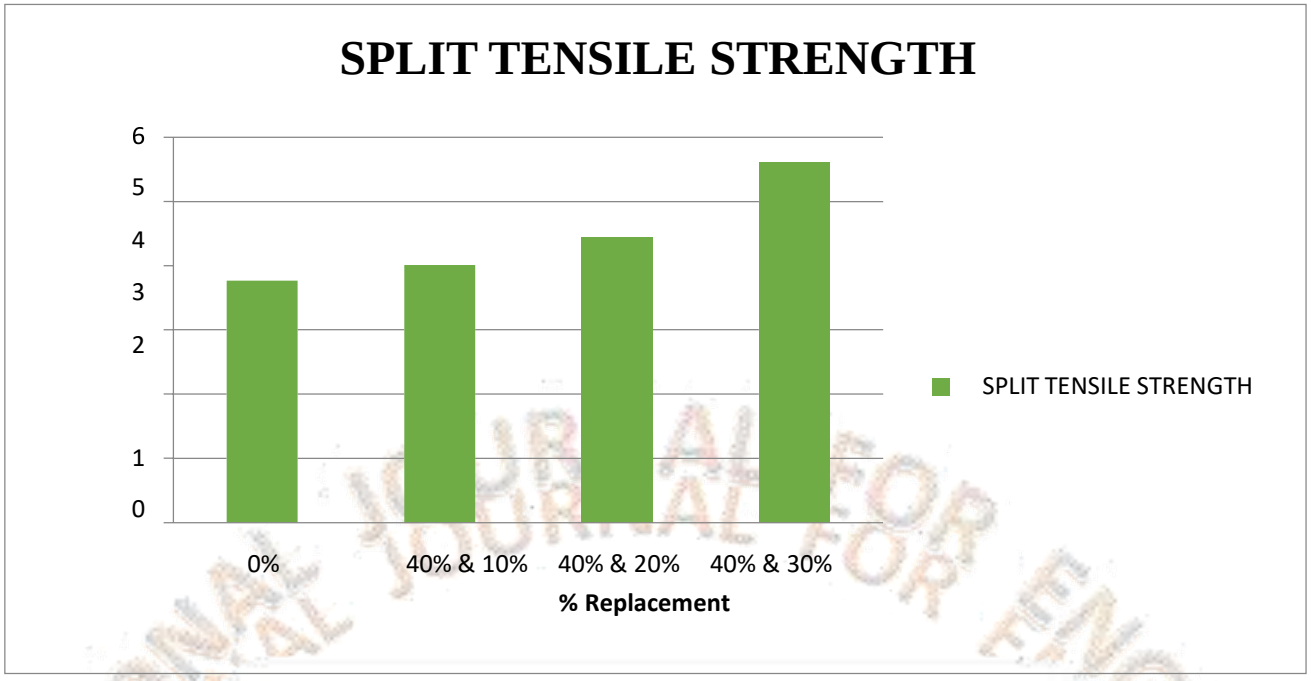


- **SPILT TENSILE STRENGTH TEST**

This test was carried out on a universal testing machine (UTM) of capacity 1000KN. As per IS: 516-1959 loading rate of 2.5kn/s was applied. Cylinder specimens (size 150 mm dia X 300 mm long) were used for this testing. Tensile strength was measured at 7 & 28 days.

Sr. No.	% Replacement of Cement And Natural Sand by GGBS and Copper Slag Sand	Split Tensile Strength (MPa)	Remark
1	0%	3.77	Split Tensile Strength of M25grade concrete is 4.28Mpa
2	40% & 10 %	4.01	
3	40% & 20 %	4.44	
4	40% & 30%	5.61	

Table 4.3 Experimental Test Results for Split Tensile Strengt



V. CONCLUSIONS

- As the Percentage of cooper slag sand And GGBS in concrete increases, workability of concrete decreases. A decrease of 9.09% ,19.69% and 25.75% workability was observed for constant 40% copper slag and 10%, 20% and 30% GGBS replacement respectively as compare with conventional concrete.
- The replacement of natural sand and Cement by copper slag sand and GGBS cement in concrete increases the compressive strength of concrete. For 28 days increase of 2.61 %, 6.40 % and 7.53% strength can be achieved when 40% natural sand and 10%, 20% and 30% cement was replaced by copper slag sand and GGBS Cement in concrete.
- The replacement of natural sand and cement by copper slag sand and GGBS in concrete also increases the split tensile strength of concrete. Increase of 6.36 %, 17.77 % and 48.80% strength can be achieved when 40% natural sand and 10%, 20% and 30% cement was replaced by copper slag sand and GGBS cement in concrete.
- This work related to the use of copper slag sand and GGBS cement as waste cheap material used as fine aggregate and cement in M25 grade of concrete and recommend as the approval of the material for use in concrete as a partial replacement material for the aggregate and cement. The partial replacement of natural sand and cement show good results about structural point of view.
- The partial replacement of a natural sand and cement with copper slag sand and GGBS acts as a cost benefit material as a replacement point of view and there is mass utilization of waste material generates during the manufacturing of copper and steel.

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