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Use of Copper Slag as Fine Aggregate in Concrete: A review

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***Abstract:** In India, there is large demand of aggregates mainly from civil engineering industry for the construction of road and concrete. But now a days, it is very difficult problem for available for fine aggregate. The construction industry is the only area where the safe use of waste material (Copper Slag) is possible. Various studies have been conducted to reduce effect on environment, reduce cost of concrete, using by products like copper slag as partial replacement of fine aggregate is one of the best method in reducing the impacts. The many authors have also revealed numerous uses of copper slag as a replacing agent in determining the strength of concrete. A thorough review of copper slag and its properties is been carried out in this paper. The purpose of the investigation is to analyse the behaviour of concrete while replacing the copper slag with different proportions of fine aggregate in concrete. 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.*
***Keywords:** Copper slag, fine aggregate, cement, concrete*

I. INTRODUCTION

Many countries are witnessing a rapid growth in the construction industry, which involves the use of natural resources for the development of infrastructure. The authors developed waste management strategies to apply for replacement of fine aggregate for specific need. The construction industry is the only area where the safe use of waste material (Copper Slag) is possible, Copper Slag reduces environment pollution, space problem and also reduces the cost of concrete. Copper Slag were generated as a by-product of Copper processing ,in which mostly ended up as land fill though some amount of Copper Slag are used in the application of abrasives in the process of rust removal. It contains large amount of Iron Oxide and Silicate. Its physical properties are similar of natural sand. The chemical traces such as Copper, Sulphate & Alumina present in the Slag are not harmful. Copper slag is the waste material of refining of copper and matte smelting such that each ton of copper generates approximately 2.5 tons of copper slag.

Copper slag is one of the materials that are considered as a waste which could have a promising future in construction Industry as partial or full substitute of aggregates. Copper Slag is used to increase the strength of concrete and reduces the environmental pollution, space problem and also reduces the cost of concrete. Copper slag has also gained popularity in the building industry for use as a fill material. Contractors may also use copper slag in place of sand during concrete construction. Copper slag can also be used as a building material, formed into blocks. Copper slag is widely used in the sand blasting industry and also in the manufacture of abrasive tools .Large quantities of waste materials are being generated by various industries and disposal of waste materials is causing environmental and health hazards. For many years, Industrial by-products such as fly ash, silica fume and slag were considered as waste materials. Application of these materials as replacement for cement and sand in Concrete showed improvement in workability and durability compared to normal concrete and has found their application in the many structures.

In the recent past, intensive research studies have been carried out to explore all possible recycling and reuse methods. Construction waste, blast furnace Slag, steel slag, coal fly ash and bottom ash have been accepted in many places as alternative aggregates in embankment, roads, pavements foundation and building construction, raw material in the manufacture of ordinary Portland cement as pointed out by Teikthyeluin et al (2004).The world copper production is currently about 14.98 million tonnes (International Copper Study Group, 2005) and it is estimated that for every tonne of copper produced, about 2.2 tonnes of copper slag is generated as a waste .Around 24.6 million tons of Copper slag is generated from the world copper industry (Gorai et al 2003). Though some portion of copper slag is widely used in the sand blasting and in the manufacturing of abrasive tools, the remainder is disposed of without any further reuse or reclamation. The use of copper slag in the concrete as a replacement for fine aggregate, reduces the costs of disposal, lowers the cost of the concrete and also helps in protecting the environment. Despite the fact that several studies have been reported on the effect of copper slag on the properties of Concrete, further investigations are necessary in order to obtain a comprehensive understanding that would provide an engineering base to allow the use of copper slag in concrete.

II. MATERIAL PROPERTIES

A. *Cement*

Ordinary Portland cement of 43 grades confirming to IS 8112:1989 is used. The Properties of Cement are shown in Table 1.

Table 1: Physical properties of cement

Sr. No.	Test	Results	Specified by IS 8112:2013
1	Fineness of cement (kg/m2)	245	225
2	Consistency of cement	36	30
3	Initial setting time (minutes)	75	30
4	Final setting time (minutes)	260	600
5	Specific gravity	3.12	2.5-3.5
6	Compressive strength (N/mm2)	48.3	58
7	Soundness (mm)	3	10

B. *Fine Aggregate*

Fine aggregates are obtained after sieve of sand which passed through 4.75mm. The fineness modulus of sand is 3.30% and specific gravity is 2.74

C. *Coarse Aggregate*

The Coarse aggregate are obtained from a local quarry. The coarse aggregate is used with size between 10mm to 20mm having a specific gravity 2.74 and fineness modulus of 5.9%.

D. *Copper Slag*

Copper slag is a by-product of copper obtained during the matte smelting and refining of copper. Copper slag is an irregular, granular in nature, glassy and black and its properties are similar to the river sand. In this project, Copper slag used is brought from Sterile Industries India Ltd, Tuticorin. Every ton of copper will generate approximately 2.5 tons of copper slag. (Sterlite Industries India Ltd produces 400,000t/year of copper and during the process, around 800,000t of copper slag is generated in a year (Al-Jabri, et al 2009).

Figure 1. Copper slag

E. *Production of Copper Slag*

Exploitage of copper slag in uses such as Portland cement substitution and/or as aggregates has threefold advantages of eliminating the costs of dumping, reducing the cost of concrete, and minimizing air pollution problems (Kharade et al., 2013). The researchers related the physical and chemical properties of copper slag given in Table 2 and Table 3, respectively.

Table 2. Physical properties of copper slag (Chockalingam et al., 2013)

Physical properties	Physical component
Particle shape	Irregular
Appearance	Black & glassy
Type	Air cooled
Specific gravity	3.91,3.68
Percentage of voids	43.20%
Bulk density	2.08 g/cc, 1.70 to 1.90 g/cc
Fineness modulus of copper slag	3.47
Angle of internal friction	51° 20’
Particle size	0.075 mm to 4.75 mm
Hardness	Between 6and 7

Table 3: Chemical composition of copper slag

Component	Copper slag (%)
Silica (sio_2)	33.05
Alumina (Al_2so_3)	2.79
Iron oxide (Fe_2o_3)	53.45
Calcium oxide (Cao)	6.06
Calcium oxide (Cao)	1.56
Sulphuric trioxide (so_3)	1.89

F. Use of Copper Slag In Concrete

1) Cost of Concrete production is reduced when Copper Slag is used as a fine aggregate in concrete.

2) High toughness of Copper Slag contributes to Increased Compressive strength.

3) Due to low water absorption and due to glassy surface of Copper slag the workability of concrete is increased with increase of Copper Slag content in the concrete mixture.

4) Use of copper slag has helped in waste management and dumping of industrial wastes.

5) Copper Slag has similar properties as river sand as it contains silica (SiO_2) similar to sand.

6) Addition of Copper slag increases then the density of concrete there by enlargement the self-weight. \

III. LITERATURE REVIEW

Sr. No.	Authors	Title	Conclusion
1	Al-Jabri et al (2009)	Copper slag as sand replacement for high performance concrete	The results indicate that there is a slight increase in the HPC density of nearly 5% with the increase of copper slag content, whereas the workability increased rapidly with increases in copper slag percentage. Addition of up to 50% of copper slag as sand replacement yielded comparable strength with that of the control mix. However, further additions of copper slag caused reduction in the strength due to an increase of the free water content in the mix[1].
2	Caijun Shi et al (2008)	Utilization of copper slag in cement and concrete	The authors concluded that the utilization of copper slag in cement mortar and concrete is very effective and beneficial for all related industries, particularly in areas where a considerable amount of copper slag is produced. It proved both environmental as well as technical benefits. They observed that there was

			more than 70% improvement in the compressive strength of mortars with 50% copper slag substitution[2].
3	Chavan et al (2013)	Performance of Copper Slag on strength properties as partial replace of Fine Aggregate in concrete mix design	In this research paper, M25 grade of concrete was used and tests were conducted for various proportions of copper slag replacement with sand of 0 to 100% in concrete and observed that the maximum compressive strength of concrete increased by 55% at 40% after replacement of fine aggregate by copper slag, and up to 75% replacement, the concrete gain more strength than control mix concrete strength[3].
4	Harsha et al (2015)	Performance of Concrete by Copper Slag as Partial Replacement of Fine Aggregates	The percentage replacement of sand by granulated copper slag were 0%,10%,20%,30%,40%,50%,60% and 70%. Required numbers of cubes, cylinders, beams were cast for grades of M30. Curing should be done for a period of 7, 28 days of hydration with partial replacement of sand by Copper slag. The experimental investigation showed that percentage replacement of sand by copper slag shall be up to 60%[4].
5	Kayathri et al (2014)	Effect of Copper Slag, Fly Ash and Granite Power as a Partial Replacement in Fine Aggregate	In this paper fine aggregate (sand) was replaced with four different percentages (0%, 25%, 50% and 75%) of fly ash, copper slag and granite powder by weight. Tests were performed for properties of fresh concrete. Compressive strength, split tensile strength were determined at 7, 14 and 28days. It is concluded that the strength of concrete is determined by the properties of Copper slag, Granite powder. The compressive strength of various mixes of Copper slag, Granite powder, and Fly ash fiber in concrete at 28days will be 51.8 N/mm^2 [5].
6	Khanzadi et al (2009)	Mechanical properties of high strength concrete incorporating copper slag as coarse aggregate	The percentages of the cement replacements by silica fume were 0%, 6%, and 10%. The use of copper slag aggregate compared to limestone aggregate resulted in a 28-day compressive strength increase of about 10–15%, and a splitting tensile strength increase of 10–18%. It can be concluded from the results of this study that using copper slag as coarse aggregate in high-strength concrete is technically possible and useful[6].
7	Kumar & Ramana (2015)	Use of Copper Slag and Fly Ash in High Strength Concrete	In this paper, five mixes containing different proportions of copper slag ranging from 0% (for the control mix) to 75%. Five mixes containing fly ash as partial replacement of cement ranging from 6% to 30% (all 5 mixes contains 50% copper slag as sand replacements). Concrete mixes were tested for workability, density, compressive strength, tensile

			strength, flexural strength. The results indicate that it is recommended that 50% of copper slag can be used as replacement of sand and 18% fly ash can be used as replacement of cement in order to obtain high strength concrete[7].
8	Ahmad et al(2017)	Experimental study on the behaviour of copper slag as partial replacement of fine aggregate in concrete.	The present investigation is carried out for M-40 grade of concrete mixes with Partial replacement of Fine Aggregate (Sand) by Copper Slag in proportions of 0%, 10%,20%,30%,40% and 50%.The result indicates the maximum strength was achieved for 40 % replacement of fine aggregate with copper slag. Further addition of copper slag reduces the strength[8].
9	Madhavi (2014)	Copper slag in concrete as replacement material	This paper studies the effect of replacement of Fine aggregate with copper slag on mechanical properties of concrete. Copper slag which is an industrial waste product can be used as replacement for cement and sand and contributes to the increase in various mechanical properties of concrete. Copper slag can be used upto 30% but when used beyond 50% results in decrease in strengths[9].
10	Madheswaran et al (2014)	Studies on use of Copper Slag as Replacement Material for River Sand in Building Constructions	It is suggested that the copper slag can be used for plastering of floorings and horizontal up to 50 % by mass of the fine aggregate, and for vertical surfaces, such as, brick/block walls it can be used up to 25 %. In this study on concrete mixtures were prepared with two water cement ratios and different proportions of copper slag ranging from 0 % (for the control mix) to 100 % of fine aggregate. The Concrete mixes were evaluated for workability, density, and compressive strength[10].
11	Janakiramaiah et al. (2016)	A study of concrete using copper slag as a partial replacement of fine aggregate.	The results showed that the dynamic compressive strength of copper slag reinforced concrete generally improved with the increase in amounts of copper slag used as a sand replacement up to 20%, compared with the control concrete, beyond which the strength was reduced. Also investigated the mechanical properties of high strength concrete incorporating copper slag as a fine aggregate. The results indicated that the strength of concrete, with less than40% copper slag replacement, was higher than or equal to that of the control Specimen[11].
12	Purna (2014)	Use of Copper Slag as Sustainable Aggregate	It is observed that there is 70% improvement in compressive strength with 50% replacement of copper slag. The flexural and tensile strength were similar to the control mix(100% sand) spending up to 50 % copper slag replacement of sand, but decreased with an additional surge in copper slag

			contents. In the concrete mixture, workability increases with the increase of copper slag. It is suggested that 40-50% substitution of copper slag as aggregate (fine) produces good quality of concrete having good quality requirement[12].
13	Selvi P et al (2014)	Experimental Study on Concrete Using Copper Slag as Replacement Material of Fine Aggregate	The results concluded that the compressive strength, split tensile strength and flexural strength of concrete shown higher value at 40% replacement of fine aggregate using copper slag. So it is recommended that 40% of fine aggregate can be replaced by copper slag. The ultrasonic pulse velocity test indicated the excellent quality of concrete at 40% replacement level[13].
14	Singh et al (2014)	Utilization of Copper Slag as Fine Aggregates in Cement Concrete Pavements	In this study, M30 grade concrete was considered to study the strength parameters, compressive and flexural strength development for concrete curing periods of 3, 7 and 28 days. It is concluded that the compressive and flexural strength increases with respect to the percentage replacement of copper slag by the weight of fine aggregate up to 40% replacement[14].
15	Taha et al (2011)	Effect of copper slag as a fine aggregate on the properties of cement mortar and concrete	A substitution of up to 40–50% copper slag as a sand replacement yielded comparable strength to that of the control mixture. However, addition of more copper slag resulted in strength reduction due to the increase in the free water content in the mix. Also, the results demonstrated that surface water absorption decreased as copper slag content increases up to 50% replacement[15].
16	Velumani & kumar (2014)	Durability And Characteristics of Copper Slag As Fine Aggregate and Fly Ash as Cement in Concrete	The author observed that the compressive strength on concrete increased by surrogating fine aggregate by 40% of copper slag.From the test results it has been founded that the average pulse velocity is above 5 km/sec for 40% copper slag replacement with fine aggregate and 30% replacement with cement[16].
17	Vijaya raghavan et al (2017)	Effect of copper slag, iron slag and recycled concrete aggregate on the mechanical properties of concrete	From this study, it is observed that 40% of copper slag, 40% of iron slag and 25% of RCA is the optimized replacement mix of fine and course aggregate respectively, which highly enhances the mechanical properties of concrete when compared with conventional concrete[17].

IV. CONCLUSION

The following conclusions may be drawn from the present study

A. Copper slag which is an industrial waste product can be used as replacement for cement and sand and contributes to the increase in various mechanical properties of concrete. Copper slag can be used upto 30% but when used beyond 50% results in decrease in strengths

B. Copper slag is a suitable material for replacement of fine aggregate in concrete.

C. Copper slag concrete showed considerable increase in strength when used with in permissible quantities.

D. The maximum strength was achieved for 30% to 40 % replacement of fine aggregate with copper slag. Further addition of copper slag reduces the strength.

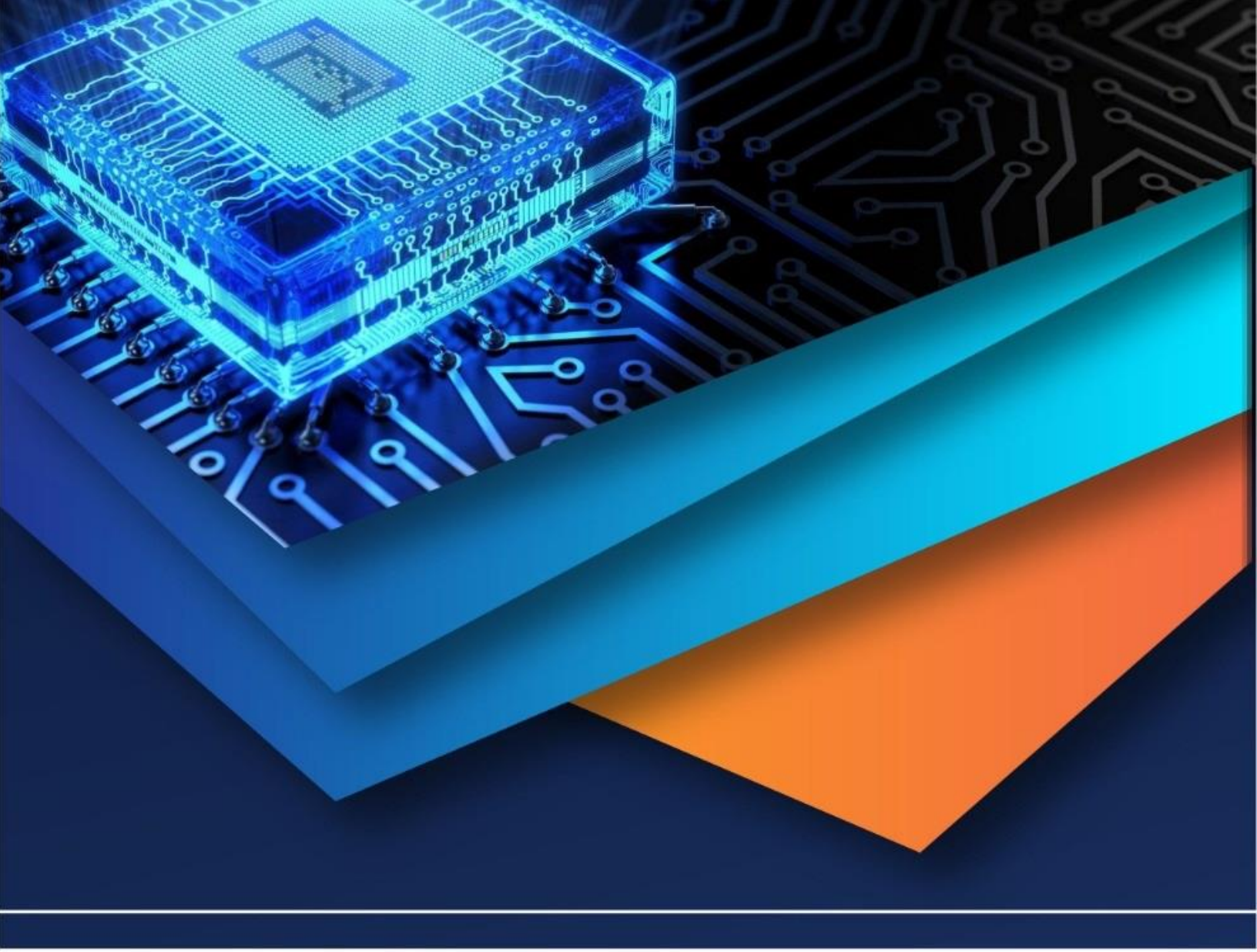
E. The replacement of fine aggregate using copper slag in concrete increases the density of concrete thereby increases the self-weight of the concrete.

F. The construction industry is the only area for safe use of waste materials, which reduces the environmental problems, space problems and cost of construction.

G. Copper Slag has a potential to provide as an alternative to fine aggregate up to30% to 40% and helps in maintaining the environmental as well as economical balance.

REFERENCES

[1] Al-Jabri, et al (2009): Copper slag as sand replacement for high performance concrete
[2] Shi & Meyer, &Behnood, (2008): Utilization of copper slag in cement and concrete. J. Resources, Conservation & Recycling. Vol. 52(10): 1115-1120.
[3] Chavan &Kulkarni (2013): Performance of copper slag on strength properties as partial replace of Fine Aggregate in concrete mix design
[4] Harsha & Teja&Ramesh (2015): Performance of Concrete by Copper Slag as Partial Replacement of Fine Aggregates
[5] Kayathri & Kumar & Karthik (2014): Effect of copper slag , fly ash & granite powder as a partial replacement of fine aggregates
[6] Mostafa Khanzadi(2009): Mechanical properties of high strength concrete incorporating copper slag as coarse aggregate
[7] Kumar & Romana (2015): Use of copper slag and fly ash in high strength concret
[8] Abhinav Shyam& Abdullah Anwar &Syed Aqeel Ahmad (2017): Experimental study on the behavior of copper slag as partial replacement of fine aggregate in concrete
[9] Madhavi (2014): Copper slag in concrete as replacement material
[10] Madheswaran & Ambily & Dattatreya &Raja mane(2014):Studies on use of Copper Slag as Replacement Material for River Sand in Building Construction
[11] B. Janakiramaiah & Dr. B. Ramesh Babu & G. Raghu Yadav(2016): A study of concrete using copper slag as a partial replacement of fine aggregate
[12] Alinda Deys & Purnachandra Saha(2014): Use of copper slag as sustainable aggregate
[13] Selvi & Narayani&Ramya (2014): Experimental Study on Concrete Using Copper Slag as Replacement Material of FiAggregate. J Civil Environ Eng 4: 156. doi:10.4172/2165-784X.1000156
[14] Thongam Prantis Singh & Dr. Rajeshekhara & Suhas(2014): Utilization of copper slag as fine aggregate in cement concrete pavement
[15] Ramzi Taha,Khalifa's & Abdula (2011): Effect of copper slag as a fine aggregate on the properties of cement mortar and concrete
[16] Velumani&kumar (2014): Durability and Characteristics of Copper Slag as Fine Aggregate and Fly Ash as Cement in Concrete
[17] Vijaya raghavan&, Judeb&Thivyac (2017):Effect of copper slag, iron slag and recycled concrete aggregate on the mechanical properties of concrete
[18] Wang & Zhang & Zhou (2016): Investigation on electromagnetic and microwave absorption properties of copper slag filled cement mortar
[19] Wu, W., Zhang, W. & Ma, G. (2010): Optimum content of copper slag as a fine aggregate in high strength concrete. J. Material & Design. Vol. 31(6): 2878-2883
[20] Chockalingam, Jayagnesh ,Jegan (2013): Scope for reuse of copper slag in concrete
[21] Bipro Gorai&Jana & Premchand (2003): Characteristics and utilization of copper slag.



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