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SCOPE OF REPLACING FINE AGGREGATE WITH COPPER SLAG IN CONCRETE- A REVIEW

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ABSTRACT- In the present scenario carbon emission and sand mining are major concern due to its hazardous effect to environment and making serious imbalance to the ecosystem. Various studies have been conducted to reduce severe effect on environment, using byproducts like copper slag as partial replacement of fine aggregate. Different researchers have also revealed numerous uses of copper slag as a replacing agent in determining the strength of concrete. A comprehensive review of studies has been presented in this paper for scope of replacement of fine aggregate from copper slag in concrete.

Key Words: Copper slag, Fine aggregate, Review, Replacement, Concrete, Strength.

I. PREAMBLE

Copper slag is one of the materials that can be considered as a waste material which could have a promising future in construction industry as partial or full substitute of any two either cement or aggregates. It is an industrial by-product material produced during the copper smelting and refining process of manufacturing of copper which can be used for a surprising number of applications in the building and industrial fields. This material represents a popular alternative to sand as a blasting medium in industrial cleaning. Using blasting or high-pressure spraying techniques, companies are using copper slag to clean large smelting equipment or furnaces .Material like copper slag can be used as one which can reduce the cost of construction. Here an attempt has been made to compile the various studies done on the replacement of copper slag in fine aggregate to judge the strength of concrete.

The by-product discharged from the copper manufacturing industry is called as slag. About 2.2 tones of copper slag result in every ton of copper production (Chockalingam *et al*., 2013). Approximately 24.6 million tons of slags are generated from the world copper industry (Gorai *et al*, 2003). Nataraja *et al*., 2014 revealed the various regions of copper slag generation depicted in Table 1.

Table 1. Copper slag generation in various regions

Regions	Copper slag generation/annum in million ton
Asia Europe 5.56	7.26
North America	5.90
Europe	5.56
South America	4.18
Africa	1.23
Oceania	0.45

II. PRODUCTION OF COPPER SLAG

Copper slag is a by-product obtained during the matte smelting and refining of copper. 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/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 depicted the physical and chemical properties of copper slag given in Table 2 and Table 3, respectively.

Figure 1: Flow chart of the pyrometallurgical copper process by Zander and Friedrich

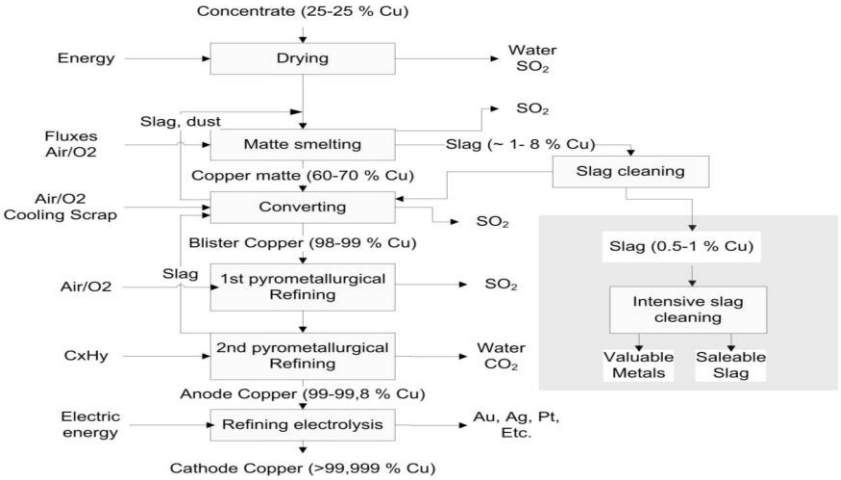

Table 2. Physical properties of copper slag (Chockalingam *et al*., 2013))

Physical Properties	**Brinda *et al*, (2010), Brinda and Nagan,(2010) Brinda and Nagan(2011)**
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 properties of copper slag

Chemical Component	**Chemical Component (%)**
SiO_2	25.85
Fe_2O_3	68.29
Al_2O_3	0.22
CaO	0.15
Na_2O	0.58
K_2O	0.23
LoI	6.59
Mn_2O_3	0.22
TiO_2	0.41

III. USES OF COPPER SLAG

The proper disposal as well as management of the copper slag, is been required to make the environment pollution free. Therefore, reusing it helps in the protection of surrounding as well as in a stable management. There are various uses of copper slag such as: it is used in blended cement, in replacement of concrete and sand both, in production of cement clinker. Its acts as resistant for corrosion and also reduce seismic force as well as earth pressure.

The figure 1 depicted the pictorial representation of copper slag which can be used up in different field. It is been used in abrasive tools, in roofing granules in tiles and glass manufacturing copper slag is also used in cutting the tools and in pavement.

Figure 1. Pictorial representation of copper slag used in relevant field (Nataraja *et al*., 2014)

Relevant studies have been carried out on the possibilities of replacing the copper slag and reusing it. The findings of the earlier workers with their conclusions are been summarized in the tabular form for quick understanding of the reviewer (Table 4).

Table 4. The various research findings with their conclusions done by different experts

S.No.	Authors	Experiment	Conclusion
1.	Srinivas and Muranal (2015)	Study of the properties of concrete containing copper slag as a fine aggregate.	The researchers concluded that the workability was increase up to 31.57 for 100% replacement of copper slag as a fine aggregate. The maximum compressive strength of concrete increases up to 8.63% for 20% replacement of fine aggregate. They also revealed that 40% of the copper slag can be replaced which is greater than the target strength.
2.	I. J. Karthick & S. Suriya Prakash (2014)	Experimental Study on strength characteristics on M_2O Concrete with Partial Replacement of Cement With Fly ASH and Replacement of Fine Aggregate with Copper Slag	Various proportions of copper slag replacement with sand (0%, 10%, 20%, 30%, 40% & 50%) and partial replacement of fly ash with cement 30% in concrete revealed that the compressive strength of concrete cubes with 40% replacement of fine aggregate with copper slag shows an increase of 15% when compared to the normal concrete cube. Similarly, there was increased in the split tensile strength of concrete with 40% replacement of fine aggregate with copper slag shows an increase of 34% when compared to conventional concrete.
3.	T. Ch. Madhavi (2014)	Copper Slag In Concrete As Replacement.	The researchers found in his experiment that the copper slag is an industrial waste which can be used as a replacement for cement and sand and helps in increasing the mechanical properties of concrete. The use of copper slag can be done up to 30% exceeding it's used beyond 50% decrease the strength.
4.	Arivalagan. S (2013)	Experimental Study on the Flexural Behavior of Reinforced Concrete Beams as Replacement of Copper Slag as Fine Aggregate	In this investigation replacement of fine aggregate with copper slag was done to depict the compressive strength of cubes, flexural strength of beams and split tensile strength of cylinders. The copper slag was added with sand to find out the results of concrete proportion ranging from 5, 20%, 40%, 60%, 80% and 100%. The maximum (35.11 Mpa) compressive strength was obtained in 40% replacement. The results also revealed the effect of copper slag on RCC concrete elements which shows increment in all compressive strength, split tensile, flexural strength and energy absorption characters. The results also depicts the value of slump which lies between 90 to 120 mm and the flexural strength of beam and also get increased by (21% to 51%) due to the replacement of copper slag.
5.	Kharade *et al*., 2013	An experimental investigation of properties of concrete with partial or full replacement of fine aggregate through copper slag.	They investigated that the copper slag does not have tendency of absorbing the water in large proportion and hence the percentage of copper slag in concrete mix increases, the workability of concrete too increase. The result of their paper revealed that when fine aggregate was replaced by 20% copper slag, compressive strength of concrete increased by 29% at 28 days. When replacement of copper slag was done up to 80% the strength increases, but if this replacement of copper slag was done up to 80% the strength increases beyond 80%, the strength directly gets decreased. It was also observed that the strength at 100% replacement was reduced by 7% at 28 days. At last, the workers observed that the flexural as well as compressive strength was increased due to the high toughness property of copper slag.

6.	R. R. Chavan & D.B. Kulkarni (2013)	Performance of copper slag on strength properties as partial replace of fine aggregate in concrete mix design.	In the experiment work M25 grade concrete was used and tests were conducted for various proportions of copper slag replacement with sand of 0 to 100% in concrete. The obtained results were compared with those of control concrete made with ordinary Portland cement and sand shows that the Maximum Compressive strength of concrete increased by 55% at 40% replacement of fine aggregate by copper slag, and up to 75%replacement, concrete gain more strength than control mix concrete strength. It is observed that, the flexural strength of concrete at 28 days is higher than design mix (Without replacement) for 20% replacement of fine aggregate by Copper slag, the flexural strength of concrete is increased by 14%. Compressive strength and flexural Strength is increased due to high toughness of Copper slag.
7.	Brindha and Nagan (2011)	Durability of copper slag admixed concrete.	The strength of concrete increases with respect to the percentage of slag added by weight of fine aggregate up to 40% of additions and 15% of cement.
8.	Najimi *et al* (2011)	The performance of copper slag contained concrete in sulphate solution.	The study of Najimi *et al* in 2011 year depicted that when replacement of copper slag was done then there was improve in concrete resistance against sulphate attack.
9.	Mosafa Khanzadi and Ali Behnood (2009)	"Mechanical properties of high-strength concrete incorporating copper slag as coarse aggregate"	The investigation revealed the effects of replacing limestone coarse aggregate by copper slag coarse aggregate on the compressive strength, splitting tensile strength and rebound hammer values of high-strength concretes are evaluated in this work. Use of copper slag aggregate showed an increase of about 10–15% compressive strength and an increase of 10–18% splitting tensile strength when compared to limestone aggregate indicating that using copper slag as coarse aggregate in high-strength concrete is suitable.
10.	Byung Sik Chun *et al* (2005)	Evaluated the applicability of copper slag as a substitute for sand of sand compaction pile method	The strength of composite ground was compared and analyzed by monitoring the stress and ground settlement of clay, sand compaction pile and copper slag compaction pile
11.	Ke Ru Wu *et al* (2001)	The effect of copper slag in coarse aggregate type on mechanical properties of high-performance concrete.	They revealed that if we select high strength aggregate with low brittleness then manufacturing of high strength concrete with lower brittleness can be made.
12.	Ayano *et al* (2000)	The effects of using several types of slag on mortar and concrete reactions, reinforcing steel corrosion, abrasion, workability and slump, shrinkage, and freezing and thawing characteristics	The researcher depicted that the strength, durability and setting time of the concrete mixtures get increased when it was made up with the use of copper slag.

IV. CONCLUSION

In the present scenario, the use of copper slag is increasing day by day both in research as well as in the construction companies. Since, the physical and mechanical properties of copper slag have maximum advantages. Therefore, replacement or reuse of it can be done in several manners. Keeping in mind about the rapid urbanization in the country, the safe disposal and judicial resource management is the important issue which can be balanced by the reuse of slag. The well defined scope in the future studies of copper slag is that it can also be replaced by cement and fine aggregate very easily and has an application in concrete as a admixture. Maximum compressive, tensile and flexural strength is obtained when copper slag is replaced with fine aggregate up to 40%. With such important properties of copper slag, further research is advised to analyze the scope of replacement extensively.

REFERENCES

[1]. Ayano Toshiki, Kuramoto Osamu, and Sakata Kenji. 2000. "Concrete with copper slag fine aggregate", Society of Materials Science, Vol. 49, pp. 1097-1102.

[2]. Arivalagan. S (2013):"Experimental Study on the Flexural Behaviour of Reinforced Concrete Beams as Replacement of Copper Slag as Fine Aggregate" Journal of Civil Engineering and Urbanism Volume 3, Issue 4(176-182).

[3]. Brindha, D and Nagan, S. "Utilization of copper slag as a partial replacement of fine aggregate".2010. International Journal of Earth Sciences and Engineering, Vol.3, No.4, pp: 579-585.

[4]. Brindha, D and Nagan, S. 2011. "Durability studies on copper slag admixed concrete", Asian Journal of Civil Engineering (Building and housing), Vol.12, No.5, pp: 563-578.

[5]. Byung Sik Chun, Du Hee Park, and Hun Chul Jung. 2005 "A Study on the Application of Copper Slag as a Sand Substitute of Sand Compaction Pile", proceedings of 15th international off shore and polar Engineering conference.

[6]. Chockalingam, M., Jayagnesh, D., Vijayaraghavan, J. and Jegan, J. 2013. Scope for resue of copper salg in concrete. A Review. 2013. International Journal of Civil Engineering and Technology (IJCIET). Vol.4, Issue 6.pp.89-100.

[7]. Gorai, B. and Jana, R.K.2002. "Premchand. Characteristics and utilization of copper slag",Resources Conservation and Recycling, Vol. 39, pp. 299-313.

[8]. I. J. Karthick (2014): "Experimental Study on Strength Characteristics on M2O Concrete with Partial Replacement of Cement with Fly ASH and Replacement of Fine Aggregate with Copper Slag**"** Vol. 1, Issue 1(26-29).

[9]. Khanzadi, M and Behnood, A. 2009 "Mechanical properties of high-strength concrete incorporating copper slag as coarse aggregate", "Construction and Building Materials, Vol. 23, 2183–2188.

[10]. M. Najimi, J. Sobhani and A. R. Pourkhorshidi (2011) "Durability of copper slag contained concrete exposed to sulphate attack". Construction and Building Materials 25(2011)1895-1905.

[11]. Madhavi, T.Ch. 2014. Copper slag in concrete as replacement material. International Journal of Civil engineering and technology (IJCIET). Vol.5, Issue, 3, pp.327-332.

[12]. Naganur, J. and B. A. Chethan. 2014. Effect of copper slag as a partial replacement of fine aggregate on the properties of cement concrete. International Journal of Research (IJR). Vol-1, Issue-8.

[13]. Nataraja, M.C., Chandan, G.N. and Rajeeth, T. J. 2014. Concrete mix design using copper slag as fine aggregate. International Journal of Civil Engineering and Technology (IJCIET). Vol 5, Issue 9, pp.90-99.

[14]. R R Chavan& D B Kulkarni (2013) : "Performance of Copper Slag on Strength properties as Partial Replace of Fine Aggregate in Concrete Mix Design" International Journal of Advanced Engineering Research and Studies.

[15]. Zander, M. and Friedrich, B. 2011. Improving copper recovery from production slags by advanced stirring methods. Proceeding of EMC.