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RESEARCH ARTICLE

PARTIAL REPLACEMENT OF FINE AGGREGATE WITH COPPER SLAG – A REVIEW.

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Abstract

Urbanization has been increasing rapidly thereby the usage of concrete has been increasing tremendously. Because of increase in construction enterprise, natural sand and M sand are depleting at an alarming rate cause numerous environmental troubles. At this degree copper slag , an industrial byproduct generated at some point of smelting and refining of Copper may be a partial alternative for fine aggregate where its international annual technology is about 33 million tonnes. The current scenario, where the carbon emission and sand mining are major subject because of its hazardous impact to surroundings and making severe imbalance to the surroundings. Various studies have been conducted to reduce effect on environment, using byproducts like copper slag as partial replacement of fine aggregate is one of the best method in reducing the impacts. Different researchers 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.

Introduction:-

Copper slag is a by-product produced during smelting of copper. During smelting, impurities become slag which floats on the molten metal. Slag that is quenched in water produces angular granules which are disposed of as waste or utilized. Slag from ores that are mechanically concentrated before smelting contain mostly iron oxides and silicon oxides. Copper slag can be used in concrete production as a partial replacement for sand. Copper slag is used as a building material, formed into blocks. Material like copper slag can be used as one which can reduce the cost of construction. In this work, an extensive study using copper slag has been carried out to investigate strength, workability and durability. The attempt is made to prove in all aspect like the serviceability, durability and economy in experimental study is structurally satisfactory.

At present about 33 million tons of copper slag is generating annually worldwide among that India contributing 6 to 6.5 million tones. 50 % copper slag can be used as replacement of natural sand in to obtain mortar and concrete with required performance, strength and durability. (Khalifa S. Al-Jabri et al 2011).

This report investigated the mechanical properties of high strength concrete incorporating copper slag as fine aggregates. The rising need for alternative fine aggregates substitution of sand is essential due to its high materials cost and the emphasis on sustainable concrete

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Literature Review:-

Copper slag is a by-product obtained during matte smelting and refining of copper. One of the greatest potential applications for reusing copper slag is in concrete production. Many researchers have studied the effect of replacement of fine aggregate by copper slag on the mechanical and durability properties of ordinary portland cement concrete. The literature being reviewed as below

Sreelakshmi S,Sruthi KP ,Mohammed Munavvir P, Mashad V (2016) investigated in the proportioning the concrete mix for type of job in hand is an essential part of any quality assurance plan. This can be done effectively with proper understanding of properties of constituent material of concrete. In this project river sand is replaced with M sand as fine aggregate material in concrete. And also in the selected mix, copper slag is partially replaced adorably from 10% up to 40% resulting a greater compressive strength than the nominal mix strength. And that the optimum percentage replacement of copper slag in fine aggregate is inferred as 40%. The comparative study result empowers the conclusion that all M sand mixes have higher compressive strength than mixes produced by using river sand. Being an industrial waste copper slag causes bad effects on environment and using it as a fine aggregate material in concrete this effects can be reduced and also can reduce the scarcity of good quality natural river sand due to depletion of resources and restriction due to environmental consideration has made.

Tamil Selvi P, Lakshmi Narayani P and Ramya G (2014) studied the replacement of fine aggregate using copper slag in concrete increases the density of concrete thereby increases the self weight of the concrete. The workability of concrete increased with the increase in copper slag content of fine aggregate replacements at same water-cement ratio. Form the results of compressive strength, split tensile strength and flexural strength, the 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 rebound hammer test revealed the uniformity of concrete and their compressive strength. The ultrasonic pulse velocity test indicated the excellent quality of concrete at 40% replacement level. The construction industry is the only area for safe use of waste materials, which reduces the environmental problems, space problems and cost of construction.

R R Chavan and D B Kulkarni(2013) has investigated the performance of high strength concrete (HSC) made with copper slag as a fine aggregate at constant workability and studied the effect conducted experimental investigations to study the effect of using copper slag as a replacement of fine aggregate on the strength properties and concluded that Maximum Compressive strength of concrete increased by 55% at 40% replacement of fine aggregate by copper slag and flexural strength increased by 14 % for 40 % replacement. Many researchers have investigated worldwide on the possible use of copper slag as a concrete aggregate

T. Ch. Madhavi (2014) reported the 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

Jayapal Naganur and Chetan B.A.(2014) studied the compressive strength increased with increase in copper slag content up to a replacement level of 50%. The maximum increase in compressive strength was observed at a replacement level of 40%. Beyond the replacement level of 50% of sand with copper slag in concrete, a decrease in strength was observed. Hence, the properties of concrete were evaluated up to a replacement level of 60%The density of concrete increased with increase in percentage of copper slag.

Material Properties:-

A. Cement:-

Cement is a binder, a substance used in construction that sets, hardens and adheres to other materials, binding them together. The properties of cement are given in Table.1. cement and an aggregate to form a strong building material. Fig.2 show the cement. Ordinary Portland cement (53 Grade) was used for casting all the Specimens. To produce high performance concrete, the utilization of high strength cements is necessary. Different types of cement have different water requirements to produce pastes of standard consistence. Different types of cement also will produce concrete have a different rates of strength development

Fig 1:- Cement

Table 1:- Properties of cement

S.NO	PROPERTIES	VALUES
1	Fineness	7.5%
2	Initial setting time	28 min
3	Final setting time	600 min
4	Grade of cement	53

B. Fine aggregate:-

Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve. Fig.3 shows the fine aggregate and the properties of sand in Table.2

Fig. 2:- Fine aggregate

Table 2:- Properties of fine aggregate

S.NO	PROPERTIES	VALUES
1	Specific Gravity	2.65
2	Fineness Modulus	2.25
3	Water Absorption	1.5%

C. Copper slag:

Copper slag is a by-product of copper extracting by smelting. During smelting, impurities become slag which floats on the molten metal.

Fig.3:- Copper

Table 3:- Chemical Properties of Copper Slag.

S.NO.	CHEMICAL COMPONENT	% OF CHEMICAL COMPONENT
1	SiO2	37.26
2	Fe2O3	47.45
3	Al2O3	3.95
4	CaO	2.38
5	Na2O	0.65
6	K2O	2.62
7	Mn2O3	0.086
8	TiO2	0.33
9	SO3	2.75
10	CuO	1.12

D.Coarse Aggregate:-

Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

Fig. 3:- Coarse Aggregate

Table 4:- Physical Properties of coarse aggregate

S.N0.	PHYSICAL PROPERTIES	DESCRIPTION
1.	Particle shape	Irregular
2.	Appearance	Black & glassy
3.	Type	Air cooled
4.	Specific gravity	3.91,3.68
5.	of voids	43.20%
6.	Bulk density	2.08 g/cc, 1.70 to 1.90 g/cc
7.	Fineness modulus of copper slag	3.47
8.	Angle of internal friction	51° 20’
9.	Particle size	0.075 mm to 4.75 mm
10.	Hardness	Between 6and 7

Table 5:- Mechanical Properties of Coarse aggregate

S.NO.	PROPERTIES	VALUES
1	SPECIFIC GRAVITY	2.65
2	Size of aggregate	12.5 mm
3	Water absorption	2.0%
4	Impact test	15.2%

Result and Discussion:-

Copper slag is one of the materials that is considered as a waste material which could have a promising future in construction industry as partial or full substitute of either cement or aggregates. Copper slag increases the workability. Being an industrial waste copper slag causes bad effects on environment and using it as a fine aggregate material in concrete this effects can be reduced and also can reduce the scarcity of good quality natural river sand

due to depletion of resources and restriction due to environmental consideration has made. If we are able to use the copper slag in place of natural sand then we can successively obtain a material to replace the sand, which is ecofriendly and cost effective. The presence of copper in copper slag is about

Table 6:- Compressive strength of concrete at the age of 7days and 28 days.

S.NO.	% of Replacement	7 DAYS	28 DAYS	AUTHORS
1	0	16.52	32.5	Sreelakshmi et al.,
	10	20.5	38.56	
	20	22.2	41.1	
	30	3.4	41.93	
	40	24.04	42.5	
	50	22	41.5	
	60	19.5	34.6	
2	0	29.50	38.80	Tami Selvi et al.,
	20	33.72	40.70	
	40	38.37	42.95	
	60	30.88	34.44	
	80	29.65	31.39	
	100	26.87	27.66	
3	0	18.29	30.36	R R Chavan et al.,
	10	24.12	35.17	
	20	25.43	38.22	
	30	27.75	42.29	D B Kulkarni
	40	28.48	43.01	
	50	23.25	39.53	
	60	22.37	35.89	
	75	21.21	26.88	
	100	18.31	25.14	
4.	0	27.2	32	T. Ch. Madhavi et al.,
	10	27.7	34.4	
	20	29.3	34.9	
	30	29.9	35.4	
	40	31.7	56.9	
	50	27.2	53.3	
	60	21.3	36.4	
	100	17.3	35.6	
5	0	17.03	29.25	Jayapal Naganur
	10	18.74	29.85	Chetan B.A
	20	20.22	32.07	
	30	23.11	37.55	
	40	2466	39.48	
	50	20.96	33.03	
	60	16.48	28.66	

0.2% which is not harmful. From the above discussions I had concluded that the water absorption rate of copper slag is much less than that of the fine aggregate. The specific gravity of the copper slag is found to be higher than that of the fine aggregate which increases the density of concrete. Fineness modulus results shows that both copper slag and fine aggregate exhibits similar granular properties.

Conclusion:-

1) Compared to the control mix, there was a slight increase in the concrete density of nearly 5% with the increase of copper slag content.
2) Whereas the workability increased rapidly with increases in copper slag percentage
3) It is recommended that 35 wt. % of copper slag can be used as replacement of sand in order to obtain High strength with good properties

4) The physical and mechanical properties of copper slag have maximum advantages. Therefore, replacement or reuse of it can be done in several manners
5) Maximum compressive, tensile and flexural strength is obtained when copper slag is replaced with fine aggregate up to 40%.
6) It is observed that when increasing percentage replacement of fine aggregate by Copper slag the unit weight of concrete is gradually incases.

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