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Effects of Waste Copper Slag on Replacement of Fine Aggregates in M40.

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ABSTRACT—

The findings of an experimental investigation on various durability tests on concrete that contains copper slag as a partial replacement for sand are presented in this paper. In this study, experiments were carried out using varying percentages of copper slag as fine aggregate in M40 grade concrete. Some of the industrial by-products have been used in the construction industry for the production of concrete. Copper slag is one of the materials that is considered as a waste material which could have been used in construction industry as partial replacement of either cement or aggregates. For this thesis work, M40 grade concrete was used and the tests were conducted for various proportions of copper slag replacement with sand from 0% to 50 % in concrete and copper slag replacement with cement from 0% to 15%.

Keywords— durability tests, fine aggregate, copper slag, cement, aggregate,

I. Introduction

Cements are adhesive materials which have the ability of bonding particles of solid matter into a compact whole. This broad definition encompasses a wide variety of adhesive materials. However, for engineering purposes it is restricted to calcareous cements that contain compounds of lime as their main principal constituent. The main raw materials used in producing Portland cement are the oxides: lime (CaO), produced by heating calcium carbonate; silica (SiO_2), found in natural rocks and minerals; alumina (Al_2O_3), found in clay minerals; and ferric oxide (Fe_2O_3), found in clays. Cement as a binder is a vital element in concrete and the quality of concrete depends on the cement or binder, the aggregate, the mix design and the handling involved in making, placing and subsequent curing. The performance of cement used in concrete is influenced by its chemical composition.

Table 1- % Chemical composition of cement and copper slag

Components	PC%	CS%
SiO_2	19.85	38.31
Al2O3	4.78	7.28
Fe2O3	2.38	25.91
CaO	63.06	12.31
MgO	2.32	6.41
K2O	0.94	1.08
Na2O	0.22	0.91
TiO2	0.25	0.61
Mn2O3	0.05	0.14
P2O5	0.26	0.20
SrO	0.3	0.02
ZnO	-	0.36
SO3	2.48	0.42
Loss on Ignition (LOI)	2.83	2.38
SiO2 + Al2O3 + Fe2O3	27.01	71.5
$(CaO + MgO)/SiO_2$	3.29	0.49

Table 2 Chemical composition of cement and copper slag

Chemical composition of cement and copper slag		
Compound/property	Cement	Copper slag
Chemical analysis (%)		

Calcium oxide (CaO)	62.89	22.25
Silica (SiO_2)	20.19	9.57
Alumina (Al_2O_3)	3.84	4.43
Iron oxide (Fe_2O_3)	3.99	57.42
Manganese oxide (MnO)	0.2	–
Magnesium oxide (MgO)	3.56	1.56
Sodium oxide (Na_2O)	0.2	1.47
Potassium oxide (K_2O)	0.72	–
Titanium dioxide (TiO_2)	0.26	–
Sulfur trioxide (SO_3)	1.87	–
Cu as CuO	–	1.24
Zn as ZnO	–	0.94
Pb as PbO	–	0.51
Ba as BaO	–	0.23
Ni as NiO	–	0.06

II. LITERATURE REVIEW

Madheswaran et al. (2014) In this study, the use of copper slag as a substitute for sand in cement concrete and building construction is the main topic. For usage as masonry mortars and plastering, cement mortar mixtures with fine aggregate composed of various ratios of copper slag and sand were investigated. Three 1-by-1-meter brick wall panels were plastered. The studies revealed that while plastering may be done with copper slag-based mortar, the amount of material wasted owing to material bouncing off plastered surfaces increases as copper slag percentage increases. As a result, it is recommended that copper slag be utilised up to 25% for vertical surfaces like brick/block walls and up to 50% by mass of fine aggregate when plastering horizontal surfaces like floors. In this investigation, two water-to-cement ratios and various amounts of copper slag—from 0% (for the control mix) to 100% of fine aggregate—were used to create concrete mixtures. The workability, density, and compressive strength of the concrete mixtures were assessed.

Poovizhi et al. (2015) - In this study, the optimization of copper slag replacement for cement and natural sand is shown. Compressive strength, flexural strength, and split tensile strength of concrete mixtures of M25 grade were assessed. Five percentages of natural sand were substituted with copper slag (i.e. 10%, 20%, 30%, 40%, 50%), and four percentages of cement with copper slag (i.e. 5%, 10%, 15%, 20%). Copper slag up to 40% added as sand and 15% added as cement produced a mix with equivalent strength to the control mix.

Patnaik et al. (2015) - A test was done to see how well concrete held up when copper slag was used in place of some of the sand (fine aggregate) in the mix. With varying percentages of copper slag replacement (0 to 50%), two different types of concrete grade (M20 & M30) were used. For both concrete mixtures, strength and durability characteristics including compressive strength and flexural strength were assessed. According to test results, adding up to 40% of copper slag to concrete has enhanced its strength properties. Nevertheless, when it comes to durability, the concrete was shown to have low resistance to acid assault and higher resistance to sulphate attack.

Singh et al. (2015) - This study examined the impact of partial cement replacement with copper slag on the compressive strength of concrete. After 10% of CS, there is a considerable drop in compressive strength because of the rise in free water content in mixtures. The reduction in compressive strength is small up to 10% of CS. 10% is suggested as the ideal amount of copper slag in place of cement.

Leema Rose et al. (2015) - This study's major objective is to determine the strength and durability characteristics of M30 concrete that has fine aggregate substituted with 10%, 20%, 30%, or 40%. According to the results of the compressive test, up to 30% of replacement copper slag boosts the concrete's strength by weight of fine aggregate. Hence, a 30% replacement of fine aggregate with copper slag is advised.

Patil (2015) - In this study, M30 grade concrete was employed, and experiments were run for different percentages of copper slag substitution with sand ranging from 0% to 100%. At a 20% replacement of fine aggregate, the maximum compressive strength of concrete improved by 34%; at an 80% replacement, the strength of the concrete exceeded that of typical concrete. The flexural strength of concrete is seen to rise by 14% when copper slag replaces natural sand up to 30%. The flexural strength of concrete is higher than usual mix due to the full % replacement of fine particles by copper slag.

Singh and Singh Bath (2015) - The current study promoted using copper slag made from industrial waste in place of natural particles in M30 concrete. According to the findings, adding copper slag to concrete boosts flexural strength by roughly 17% compared to control mixture. It is advised that copper slag can substitute fine aggregates to the extent of up to 40%.

Raza et al. (2015) they analyses the concrete performance by using iron slag as a partial replacement of coarse aggregates in concrete. In this study the coarse aggregate (CA) were partially replaced with iron slag aggregate at different proportions of 0%, 10%, 20%, 30% 40% and 50%. Compressive strength and Flexural strength on M40 grade of concrete with 0.45 water/cement ratio were investigated. In which to determine and check out the compressive strength, Flexural strength, and split tensile strength of concrete with various percentages of iron Slag Aggregate. The result has been found from the various tests which were compared with conventional concrete. Thus the use of iron slag in concrete could enhance the strength in concrete.

Chauhan and Bondre (2015) has clarified about the incomplete replacement of sand by copper slag in concrete. This paper reports the exploratory examination which researched the halfway replacement of sand with quarry dust. At first cement concrete block was contemplated with different extents of cement concrete + copper slag(M 20 and M25). The test comes about demonstrated that the expansion of copper slagfine aggregate proportion of 30%, 40% and half was found to upgrade the compressive properties.

III. EXPERIMENT AND METHODOLOGY

Table 3. - Compressive strength in N/mm^2 at 28 days

Mix	Compressive strength in N/mm^2 at 28 days			Avg. Compressive strength in N/mm^2 at 28 days
M40	38	35	34	36.33
C10	40.12	41.02	40.2	40.44
C20	42.2	43	42.5	42.4
C30	44.5	45	43.9	44.4
C40	46.9	47.7	47.1	47.2
C50	43.2	44	44.2	43.8

IV Conclusions

- Optimum content of copper slag is 8% by weight replacement of copper slag with cement in M40 mix.
- As the percentage of Copper slag in concrete mix increases, the workability of concrete increases. This is because copper slag is unable to absorb the water in large proportion.
- Addition of slag in concrete increases the density thereby the self-weight of the concrete.
- Compaction factor value also increases as the rate of percentage by weight of copper slag increases.
- Copper slag has good resistant from chloride and sulphate attack , because of its low permeability.
- Compressive strength is increased when it is partially replaced with fine aggregates due to high toughness of Copper slag.
- Use of copper slag helps in waste management and dumping industrial wastes.

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