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STUDY ON MECHANICAL PROPERTIES OF M30 GRADE CONCRETE BY PARTIALLY REPLACING CEMENT WITH MICRO SILICA AND FINE AGGREGATE WITH COPPER SLAG

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ABSTRACT

Cement, sand, and aggregate are essential for every construction sector to function properly. Sand is a primary ingredient in the manufacturing of mortar and concrete, and it plays an important role in the design of concrete mixes. Because of the deterioration of rivers nowadays, as well as environmental concerns, river sand is becomingincreasingly scarce. The lack of availability or scarcity of river sand will have an impact on the building sector; as a result, it is necessary to develop innovative alternative materials to substitute river sand in order to prevent excessive river erosion and environmental damage. Many academics are working on developing alternative materials to sand, with copper slag being one of the most promising candidates. Cobalt slag and micro silica are industrial by-product minerals that are created as a by-product of the copper and ferro-silicon metal manufacturing processes, respectively. The use of copper slag and micro silica in building not only serves to lower the cost of construction, but it also helps to reduce the impact on the environment by utilizing materials that would otherwisebe deemed waste. In this study, an attempt has been made to review all of the material that is currently available and to determine the outcomes of numerous researchers in order to offer a strategy that will be appropriate for subsequent research. According to the findings of the study, waste materials or byproducts of industry such as copper slag and micro silica can be advantageously utilized in the preparation of concrete, which not only lowersthe cost of concrete but also solves the problem of obtaining river sand, which is also beneficial to the environment.

INTRODUCTION

The use of industrial waste or secondary materials in the production of cement and concrete has boosted the industry's ability to meet demand in the building industry. By-products and waste materials are being generated in increasing numbers by numerous sectors. The dumping or disposal of waste items results in environmental andhealth hazards, as we are all well aware. As a result, recycling of waste materials has a significant potential in theconcrete manufacturing business. Many years have passed since by-products such as fly ash, silica fume, and slagwere regarded as unusable waste materials. It has been employed in the construction of power plants, chemical facilities, and under-water structures since the concrete created with these components demonstrated improved workability and durability when compared to conventional concrete. Intensive research investigations have been carried out during the last few decades to investigate all feasible strategies of reusing waste. Several alternative aggregates have been accepted in various locations as alternatives to crushed stone in embankment, road, pavement, foundation, and building construction. As Teikthyeluin et al. point out in their paper, blast furnace ash,steel slag, coal fly ash, and bottom ash have all been accepted as raw materials in the manufacture of ordinary Portland cement (2006).

Copper slag is a type of industrial by-product material that is created during the process of producing copper metal. Copper slag is produced at a rate of around 2.2 tons for every tons of copper produced. It has been calculated that the world copper industry generates around 24.6 million tons of slag annually (Gorai et al 2003). Despite the fact that copper slag is frequently employed in the sand blasting business and the manufacture of abrasive tools, the remainder is disposed of without any further usage or reclamation being possible. Copper slag contains mechanical and chemical properties that allow it to be utilized in concrete as a partial replacement for Portland cement or as a substitute for aggregates, depending on the application. Copper slag, for example, offers a variety of advantageous mechanical features for usage as an aggregate, including outstanding soundness characteristics, strong abrasion resistance, and good stability, as described by the American Concrete Institute (Gorai et al 2003). Copper slag also exhibits pozzolanic qualities due to the low concentration of CaO in it. It can exhibit cementitiousproperties when activated with NaOH, and it can be utilized as a partial or complete replacement for Portland cement in some applications. It is advantageous to use copper slag in applications such as concrete replacement (instead of Portland cement) or as a raw material since it has the dual advantage that it reduces the cost of concretewhile also decreasing the cost of disposal. The use of copper slag

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as a replacement for cement in the concrete industry can have the benefit of lowering disposal costs while also aiding in the preservation and protection of theenvironment. Despite the fact that various studies have been conducted on the effects of copper, there has been little progress. The use of copper slag as a replacement for cement in the concrete industry can have the benefit of lowering disposal costs while also aiding in the preservation and protection of the environment. Despite the fact that various studies have been conducted on the effects of copper, there has been little progress. Further research into the effects of copper slag replacement on the characteristics of concrete is required in order to gain a comprehensive understanding that would serve as the foundation for allowing the use of copper slag in concreteon an engineering basis.

LITERATURE REVIEW

Al-jabri et al (2009) It was discovered in 2009 that the performance of high strength concrete (HSC) made withcopper slag as a fine aggregate at constant workability could be improved by the addition of a superplasticizer. The researchers also investigated the effect of superplasticizer addition on the properties of HSC made with copper slag in their research. Copper slag was used in two separate series of concrete compositions, each with a different amount of copper slag. The first series consisted of six concrete mixtures made with varying quantities of copperslag and maintained at a consistent workability throughout the process. The water content of each combination was modified in order to attain the same workability as that of the control mixture, which was the goal. The secondseries included the preparation of twelve different concrete mixtures. Only the first combination was created withsuper plasticizer, whereas the remaining eleven mixtures were prepared without the use of super plasticizer and with varying quantities of copper slag used as sand replacement, as shown in Table 1. It was discovered that whencopper slag replacement was carried out at 100 percent, it reduced water use by over 22 percent when compared to the control combination. The strength and durability of HSC were found to be significantly improved when the amount of copper slag in the concrete mixture was increased. While the strength and durability properties of HSCwere improved as the copper content of the concrete paste increased, the lack of the super plasticizer from the concrete paste had a negative impact on these qualities.

Al-jabri et al. (2011) studied the effects of employing copper slag as a fine aggregate in cement mortars and concrete on the characteristics of the materials used. The copper slag was added to a variety of mortar and concrete mixes in varying quantities, ranging from 0 percent (for the control mixture) to 100 percent (for the high copper slag combination) as fine aggregate replacement. Compressive strength of cement mortar mixtures was tested, as well as porosity. whereas the workability, density, compressive strength, tensile strength, flexural strength, and durability of concrete mixtures were all examined durability. The results obtained for cement mortars demonstrated that all mixes including varying amounts of copper slag produced the same results.The compressivestrength of the test mixture should be comparable to or greater than that of the control mixture. There was an increase of more than 70% in the overall score. In comparison to the control mixture, the compressive strength ofmortars with 50% copper slag substitution was significantly higher. The results obtained for concrete revealed that the density of the concrete increases by approximately 5% as the copper slag percentage increases rises. In contrast, as the percentage of copper slag in the mix grew, the workability increased dramatically when comparedwith the initial mix. Mixture management is important. The use of up to 40–50 percent copper slag as a sand replacement resulted in concrete with equivalent strength to that of the original. Mixture management is important. More copper slag was added, however the strength of the concrete was reduced as a result of the rise in free water content. There is content in the mix. Using these findings, it was discovered that surface water absorption reduced as copper slag percentage increased up to 50%. replacement. Above and beyond this point, the absorption rate increased rapidly, and the percentage volume of permeable voids grew dramatically a mixture that is comparableto the control mixture As a result, it was advised that copper slag can be used up to 40–50 percent (by weight of sand) of the time. Used as a substitute for fine aggregates in order to produce concrete that meets the required strength and durability specifications.

Bipragorai et al. (2003) examined the features of copper slag, in addition to different processing methods such as pyro, hydrothermal, and electrolytic. Copper slag is processed using a mixture of pyro-hydrometallurgical processes for metal recovery and the creation of value-added products. Copper slag, which is created during the pyrometallurgical manufacture of copper from copper ores, comprises a variety of elements such as iron, zinc, and aluminum. Alumina, calcium oxide, silica, and other similar materials are used. This research examines the advantageous physico-mechanical features of copper slag that can be used in many applications be used in the production of products such as cement, fill, ballast, abrasive, aggregate, roofing granules, glass, and tiles, amongothers. Aside from that,obtaining the rich metals by various extractive metallurgical routes while taking advantageof the advantageous physico-mechanical and chemical properties Because of the qualities of copper slag, it is usedto make a variety of value-added products such as cement, fill, ballast, abrasive, and other materials. Cutting tools, aggregate, roofing granules, glass, and tiles, to name a few examples. The usage of copper slag in this manner may result in a reduction in the cost of copper disposal. This may also result in a reduction in environmental problems.

Caijun Shi and colleagues (2008) examined the features of copper slag and the influence of copper slag on the mechanical properties of cement. Mortars and concrete were tested, and it was discovered that the use of copper slag in cement and concrete provides additional strength. Environmental as well as technical advantages for all associated businesses, particularly in places where a significant amount of copper is present It is necessary to make slag. Cement, mortar, and concrete are all produced when it is utilized as a cement replacement or as an aggregate replacement. When compared to typical Portland cement containing normal amounts of copper slag, copper slag-containing cements perform significantly better and even more physical strength.

kay wille, (2015). Dealt with SF and immoderate fine silicon oxide powder in order to improve the ultra high performance pervious concrete matrix's pervious properties. achieve the goal of a moderately high-performance cement with compressive strength in excess of 150 Mpa, rather than the current standard.

Zain (2015) demonstrated that the STS/CS ratio drops as the strength class of concrete is improved, and as a result, high strength PCCs are more susceptible to brittle failure than regular strength PCCs, according to Zain. PCC has a low energy absorption capacity (also known as toughness) when subjected to tensile and compressiveloads, respectively.

Copper slag-containing concrete in a sulphate solution was explored by Najimi and colleagues (Najimi and colleagues, 2011). In this perspective, an example would be there was an experimental investigation that included expansion measurements, compressive strength deterioration, and micro structural analyses conducted in sulphatesolution on concretes. This was achieved by substituting copper slag for cement in proportions of 0 percent, 5 percent, 10 percent, and 15 percent waste. The results of this investigation emphasized the efficiency of copper slag substitution in enhancing the concrete resistance against the onslaught of sulphates

Washington Almeida Moura et al (2007) presented the findings of a study on the usage of copper slag as pozzolanic to be used as a supplementary cementing substance in concrete. Initially, the copper slag's chemical and mineralogical features were investigated. They had been decided. Following this, concrete batches were constructed with copper slag additions of 20 percent (related to the cement weight) and with copper slag additionsof 10 percent (relative to the cement weight). The specific gravity, compressive strength, splitting-tensile strength,absorption, and absorption rate of a set were all evaluated by using a microscope. The capillary suction method and carbonation are both used. In conclusion, the findings indicated that copper slag has the potential to be used as an additive in steel production.

MATERIALS AND METHODS

Cement In the course of this research, Birla Super 53 grade ordinary Portland cement was utilised. This is the type that is utilised the majority of the time cement used in the building sector of the construction industry in India.

Fine Aggregates

Fine aggregate is defined as having a particle size that is less than 4.75 millimetres in diameter.

Coarse Aggregates

We chose coarse rocks with sizes ranging from 10mm to 20mm in size. These were acquired at a location near the Shiroli MIDC Kolhapur. The Krishna River in Maharashtra was mined for its natural river sand, which was purchased from the river.

Copper slag

Suyog Suppliers (zone-II), a business located in Pune, provided the copper slag that was utilised for the completion of this project utilised for sand blasting, with the supplier bringing the slag all the way from Baruch in Gujarat.

Plastizers

To increase the fresh meat's workability, Pherma Plastex Plastizers were utilized in accordance with the manufacturer's instructions Concrete mix.

Water

During the casting and curing processes of the concrete blocks, drinking water was utilized .Micro Silica is a substance that is incredibly fine, with an average diameter that is one hundred times finer than cement. Micro Ceraflux India in Kolhapur is the source of the silica that was used in this paper, and Cabot India was the manufacturer Mumbai.

Mortar

Mortar is made by combining cement and sand in a ratio of 1:3, adding 0.47 parts water to the mix, and replacing some of the sand with crushed stone copper slag zeroes (controlled mortar), 10percent , 20percent , 30 percent , 40 percent , 50 percent , 60 percent 70 percent , 80 percent , 90 percent ,100 percent.

The physical and chemical properties of Micro silica are tabulated below

Properties	Ordinary PortlandCement	Micro silica
Specific gravity	3.1	2.2
Mean grain size	22.5	0.15
Specific area (cm^2/gm)	3250	150000
Colour	Dark grey	Light to dark grey

The physical and chemical properties of copper slag are tabulated below

PHYSICAL PROPERTIES	
Appearance	Black glassy granules
Colour	Black
Grain shape	Granular
pH	6.6 - 7.2
Specific gravity	3.5 - 3.8
Bulk density	1.9 g/cc
Hardness	6 - 7 MOH scale

FINENESS MODULUS

A sieve analysis was carried out on coarse aggregates (20 mm & 10 mm), sand, and copper slag in order to figure out the fineness modulus of each of these materials. By using sieving, it was possible to ensure that the grain size distribution of both aggregates fell within the range of 4.75–13.20 mm and so eliminate any effect that aggregate size might have had. According to the International Standard 383–1970, the grading does not fall inside the boundaries of any specific grading zone of sieves other than the 600-micron IS Sieve by a if the entire quantity is less than five percent, then it is to be regarded to fall within that grading zone. This acknowledgement is not applied to the percentage that passed the IS sieve with a pore size of 600 microns or to the percentage that passed any other sieve size at the upper boundary of Grading Zone I or the lower limit of Grading Zone IV, depending on how fine or coarse it is. The Sand, in this particular work, was
from the first grading zone, and the copper slag came from the second zone.

SPECIFIC GRAVITY

For the purpose of determining the aggregates' specific gravity in 20 mm and 10 mm sizes, a weighing bucket was utilised. (2.67 and 2.75 correspondingly, as demonstrated in Table 1). Using a pycnometer and basing their findings on IS 2386-1963 (BIS, 1963), the researchers found that sand has a specific gravity of 2.65, while copper slag has a specific gravity of 3.30. It was noticed that there was a When compared to sand, the specific gravity of copper slag was significantly higher.

EFFECT OF COPPER SLAG ON COMPRESSIVE STRENGTH

At 28 after mixing, a cube of concrete measuring 150 mm x 150 mm x 150 mm was used to assess the compressive strength of concrete prepared with or without copper slag.in this the microsilic apercent is fixed to 12.5%. Because of this, the 0 to 100% CS percent replacement copper slag this replacement had a higher compressive strength than the controlled concrete. The compressive strength was higher than that of controlled concrete for 25% replacement 28 days. The compressive strength was lower for concrete with 100 percent replacement compared to controlled concrete.

Table: Compressive strength of the cube after 28 days curing

% replacementof cement with Micro Silica	% replacementof fine aggregate with Copper Slag	Compressive load taken by the cube after 28 days curing (in KN)			Avg.load (in KN)	Compressive strength (in N/mm^2)
		Specimen1	Specimen2	Specimen3		
0%	0%	875	900	860	878.33	39.04
12.5%	0%	905	890	945	913.33	40.59
12.5%	25%	1080	1240	1150	1156.67	51.41
12.5%	50%	855	810	895	853.33	37.92
12.5%	75%	480	545	605	543.33	24.15
12.5%	100%	365	300	325	330	14.67

EFFECT OF COPPER SLAG ON SPLIT TENSILE STRENGTH

Maximum split tensile strength of the cylinder after 28 days curing is achieved at 25%replacement of Copper slag and 12.5% of cement replaced with Micro silica and the value is 3.16 N/mm^2.Based on this work it was observed that 25% Copper slag as replacement of fine aggregate and 12.5% of cement replaced with Micro silica was found to be optimum amount for a significant enhancement of split tensile strength.

Table : Split tensile strength of the cylinder after 28 days curing

% replacementof cement with Micro Silica	% replacementof fine aggregate with CopperSlag	nsile load taken by the cylinderafter 28 days curing (in KN)			Avg.load (in KN)	Split tensile strength (in N/mm^2)
		Specimen1	Specimen2	Specimen3		
0%	0%	155	175	160	163.33	2.31
12.5%	0%	170	165	170	168.33	2.38
12.5%	25%	220	250	200	223.33	3.16
12.5%	50%	185	130	180	165	2.33
12.5%	75%	115	130	150	131.67	1.86
12.5%	100%	100	95	125	106.67	1.51

CONCLUSIONS

The following conclusions were drawn from this study

1) It is concluded that the optimum mixture of concrete is obtained at 25% of fine aggregate replaced with Copper Slag and partially replacing 12.5% of cement with Micro Silica.
2) It is also understood that the compressive strength and tensile strength of 7days and 28days concrete specimens progresses until optimum mixture and then continuously decreases.
3) The copper slag can be effectively used to increase the strength of concrete.

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