An Experimental Investigation on Concrete by Partial Replacement of Copper Slag with Fine Aggregate

M. Mohammad Rayan[1], Dr. P.Ragunathapandian[2], Ms. R. Haripraba[3]
[1]*M.E., Structural Engineer (Student), Arulmigu Meenakshi Amman College of Engineering, Vadamavandal – 604 410, Thiruvannamalai Dt.*
[2]*M.E., Ph.D, Professor and Head of the Dept., Arulmigu Meenakshi Amman College of Engineering, Vadamavandal – 604 410, Thiruvannamalai Dt.*
[3]*M.E., (Ph.D) Assistant Professor, Arulmigu Meenakshi Amman College of Engineering, Vadamavandal – 604 410, Thiruvannamalai Dt.*

Abstract-This Experimental Investigation on concrete by partial replacement of fine aggregate with copper slag to improve the quality strength parameters, for example compressive strength, split tensile strength, and flexural strength of the M-30 grade of concrete. Here the fine aggregate partially replaced with copper slag in concrete with 5%, 10%, 15% & 20% by weight of fine aggregates and cement Mix design was prepared for M-30 grade of concrete by replacement of copper slag as fine aggregate and cement. We can reduce the digging of river sand which effects the hydraulic structure stability and as well as we can reduce the open land fill and environmental pollution with copper slag usage it in concrete.

Test outcomes shows that the strength performances of concrete has enhanced having copper slag as a partial substitution of Sand and cement (0-20%) in concrete however in conditions of stability the concrete establish to be low resistant to acid attack and high resistance against sulphate attack. At that point investigate variation between values of results with conventional concrete. Graphs are drawn strength vs. replacement with fine aggregate results are compared with normal concrete.

Key Words – Copper Slag

I. INTRODUCTION

Concrete is most widely used construction material in the world due to its ability to get cast in any form and shape it also replaces old construction materials such as brick and stone masonry etc. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cementations material, aggregate and water and by adding some special ingredients. Hence concrete is very well suitable for a wide range of applications. Concrete is normally used in the frame structure. But there is limitation like self-compaction, surface finishes maintains strength at congested area. Construction of high performance structures such as high rice reinforced and pre stressed concrete buildings, long span concrete bridges, etc. aggregates and cement are considered one of the main constituents of concrete. The utilization of copper slag for applications such as Portland cement replacement in concrete, or as raw material has the dual benefit of eliminating the cost of disposal and lowering the cost of the concrete. The use of copper slag in the concrete industry as a replacement for cement can have the benefit of reducing the costs of disposal and help in protecting the environment.

Copper slag is an industrial by-product material produced from the process of manufacturing copper. For every ton of copper production, about 2.2 tons of copper slag is generated in world. It has been estimated that approximately 24.6 million tons of slag are generated from the world copper industry. Copper slag possesses mechanical and chemical characteristics that qualify the material to be used in concrete as a partial replacement for Portland cement or as a substitute for aggregates. The utilization of copper slag for applications such as Portland cement replacement in concrete, or as raw material has the dual benefit of eliminating the cost of disposal and lowering the cost of the concrete. The use of copper slag in the concrete industry as a replacement for cement can have the benefit of reducing the costs of disposal and help in protecting the environment. Despite the fact that several studies have been reported on the effect of

S.No.	Particulars	River Sand
1	Source	Vellore
2	Zone	Zone II (IS : 383-1970)
3	Specific Gravity	2.60
4	Finess Modulus	2.89
5	Density	1752 Kg/m3

copper slag replacement 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. LITERATURE REVIEW

Though number of significant results have been reported on the use of copper slag in concrete, but there is not much literature available on the use of copper slag as partial replacement of fine aggregates

Chavan abd Kulkarni (2013): Investigation on the effect of using copper slag as a replacement of fine aggregate on the strength properties - 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.

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.

Madhavi et al (2007): Stabilize the slope in retaining walls against seismic forces using copper slag as backfill material - The wall constructed with copper slag backfill showed lesser faces deformations compared with sand.

Hwang: examined the effects of fine aggregate replacement on the rheology, compressive strength, and carbonation properties of copper slag and mortar. Rheological properties, compressive strength, and rate of carbonation of mortars of water to Portland cement ratio of 0.3, 0.4, and 0.5, in which the fine aggregate was replaced with copper slag at 25% and 50% levels. Test results showed that rheological constants increased with higher replacement level of copper slag and that, when water to Portland cement ratio was maintained, the strength development and carbonation properties were improved.

Mobasher et al 1996) and Tixier et al (1997): Effect of copper slag on

the hydration of cement-based materials - A significant increase in the compressive strength

for up to 90 days of hydration. Also, a decrease in capillary porosity and an increase in gel porosity.

III. MATERIAL USED

1.CEMENT

Ordinary Portland cement (53 Grade) was used for casting all the specimens, the type of cement affects the rate of hydration, so that the strengths at 21 early ages can be considerably influenced by the particular cement used. It is also important to ensure compatibility of the chemical and mineral admixtures with cement. Properties of cement physical properties of the cement in the present experimental work are given below.

1.1Physical Properties of Cement

S. No	Physical Properties Of Opc 53 Grade Cement	Results	Requirements As Per Is:8112-1989
1	Specific Gravity	3.13	3.10-3.15
2	Standard Consistency (%)	36	30-35
3	Initial Setting Time (Min)	40	30 Minimum
4	Final Setting Time (Min)	480	600 Maximum
5	Soundness test	0.5 cm (expansion)	Does not exceed 10mm

2.FINE AGGREGATE: -

River sand from local sources was used as the fine aggregate. The specific gravity of sand is 2.60. Properties of Fine Aggregate Physical properties of the fine aggregate used in the present work are given below.

2.1 Physical Properties of Fine Aggregate

3.WATER: -

Potable fresh water, which is free from concentration of acid and organic substances was used for mixing the concrete.

4.COARSE AGGREGATE: -

Crushed granite aggregate with specific gravity of 2.8

and passing through 20 mm sieve and retainedon 10 mm was 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.

4.1 Physical Properties of Coarse Aggregate

Sl.No	Particulars	Natural Aggregate
1	Source	Vellore
2	Max Aggregate Size	20mm
3	Specific Gravity	2.81
4	Finess Modulus	5.4
5	Bulk Density	1805kg/m^3
6	Flakiness Index	14.21 %
7	Elongation Index	12.00 %
8	Impact Copper Slagtor Test	14.92 %
9	Crushing test	7.80 %

5. Copper slag

Copper slag is a heterogeneous by-product material produced in the combustion process of coal used in power stations. It is a fine grey coloured powder having spherical glassy particles that rise with the flue gases. As copper slag contains pozzolanic materials components which reach with lime to form cementatious materials. Thus Copper slag is used in concrete, mines, landfills and dams

Table - General Properties Copper Slag

FINESS	2.5
SPECIFIC GRAVITY	1.90 – SUB BITUMINOUS 2.90 - IRON BITUMINOUS
SIZE	10 – 100 MICRON
SHAPE	SPHERICAL
COLOUR	LIGHT COLOUR – PRESENT IN LIME CONTENT BROWN COLOUR – PRESENT IN IRON CONTENT DARK BLACK COLOUR – BURNT CONTENT

Physical Properties of Copper slag

Table 3.13 : Properties of Copper slag

Sl.No	Test On Copper slag	Results
1	Specific Gravity	3.4
2	Standard Consistency (%)	39%
3	Initial Setting Time(Min)	1hr 40 mins
4	Final Setting Time(Min)	10 hrs

IV-MIX DESIGN

Grade designation : M30
Type of cement : OPC 53 grade
Max nominal size of aggregate : 20mm
Min cement content : 320 kg/m3
Max water cement ratio : 0.45
Workability : 120mm
Exposure condition : extreme (plain)
Method of concrete placing : manual

- Degree of supervision :good
- Type of aggregate :crushed angular
- Max cement content :410 kg/m3
- Chemical admixture :Nil

Test data for material

- Cement used :O.P.C 53 grade
- Specific gravity of cement :3.15
- Chemical admixture : Master Glenium

Specific gravity of:
1.fine aggregate :2.60
2.coarse aggregate :2.81
Water absorption:
1.fine aggregate : 1.69 %
2. coarse aggregate : 0.33 %
free (surface) moisture:
1.fine aggregate :Nil
2.coarse aggregate :Nil
sieve analysis:
1.fine aggregate :conforming to grading zone I
2.coarse aggregate : -

V. RESULT AND ANALYSIS

1. Compressive Strength Test

Concrete is weak in tension and strong in compression so the concrete should be strong to attain high compression. In this study for each mix 3-samples were tested and the average strength is compared with nominal mix of M-30 grade. Compressive strength test finds out the high amount of compressive load a material can bear below facture limit. The results of compressive strength at the age of 7, 14, and 28 days.

Compressive strength test results for different proportion with Partially Replacement of Copper Slag with Fine Aggregate

SI.NO	Percentage	Compressive Strength (N/MM2)		
		7days	14days	28days
1.	0%	19.94	27.42	32.43
2.	5%	18.5	26.75	30.5
3.	10%	16.5	24	28
4.	15%	20	27.8	34
5.	20%	13.5	22.5	25.99

2. Split Tensile Strength Test

The split tensile strength of concrete is tested by casting cylinder of size 150mm x 300mm and is continuously cured for 28 days testing. Cylinders were casted for normal M30 grade and for 5%, 10%, 15% and 20% by weight partial replacement of copper slag for sand & cement. Three samples are tested and the average values are taken as tensile strength of concrete.

SI.NO	Partially Replacement of Copper Slag	Split Tensile Strength (N/MM2)
		M30
1.	0%	3.088
2.	5%	2.944
3.	10%	2.89
4.	15%	3.25
5.	20%	2.458

Flexural strength results for different proportions with Partially Replacement of Copper Slag with Fine Aggregate

SI.NO	% OF COPPER SLAG WITH FINE AGGREGATE	FLEXURAL STRENGTH (MPa)		
		7days	14days	28days
1.	0%	3.8	3.55	5.1
2.	5%	5.5	5.85	6.85
3.	10%	4.75	5.7	6.40
4.	15%	4.21	5.23	5.73
5.	20%	3.75	4.23	4.45

VI. CONCLUSION

From above experimental test, following conclusions are drawn:

1) Compressive strength of concrete increases after Replacement of Cement by Copper Slag in it.

2) Compressive strength increases as increase in Copper Slag content up to 15% replacement, further increase in Copper Slag content shows decrease in compressive strength of concrete.

3) For M40 grade concrete, optimum mix is B2 and C2 with 15% replacement of Copper Slag

4) The results showed that the workability of Concrete increased substantially with increase of Copper Slag content in the concrete mixture due to the low water absorption, coarser (in nature than sand) and glassy surface of Copper slag, thereby the Strength properties also improved

VII. REFERENCE

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