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Study on Strength of High Performance Concrete by Partial Replacement of Fine Aggregate by Copper Slag

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ABSTRACT

The present experimental work investigated the effect of using copper slag as a replacement of sand. The M50 grade concrete used was designed by using modified ACI method. There are 5 concrete were prepared with different proportions of copper slag as a replacement of sand ranging from 45% to 60%. This mixes were evaluated for compressive strength, split tensile strength and flexural strength. The results indicate that the water requirement was reduced when copper slag is used as replacement of sand also there is a slight increase in strength with the increase of copper slag content. Up to 50% replacement of sand with copper slag shows increase in strength with that of the control mix. But further addition of copper slag caused reduction in strength due to free water content in the mix. Therefore it can be concluded that the use of copper slag as sand substitution upto 50% improves strength.

Keywords:- Copper Slag, Compressive Strength, Split Tensile Strength, Flexural Strength,

I. LITERATURE REVIEW

Khalifa et al.(2009), The results indicates that there is a slight increase in the HPC density of nearly 5% with the increase in copper slag content, whereas the workability increased rapidly with increase in copper slag percentage. Addition of up to 50% of copper slag as sand replacement yielded comparable strength with that of the control mix. However, further additions of copper slag caused reduction in the strength due to an increase of the free water content in the mix.

Ramzitaha et al.(2011),In this, Various mortar and concrete mixture were prepared with different proportion of copper slag ranging from 0% to 100% as fine aggregates replacement. The results obtained for cement mortars revealed that all mixtures with different copper slag proportions yielded comparable or higher compressive strength than that of the control mixture. A substitution of up to 40-50% copper slag as a sand replacement yielded comparable strength to that of control mixture. Addition of more copper slag resulted in strength reduction due to the increase in free water content in mix.

Wei wu et al.(2010) ,This study investigated the mechanical properties of high strength concrete incorporating copper slag as a fine aggregate and concluded that less than 40% copper slag as sand substitution can achieve a high strength concrete. The results indicated that the strength of the concrete with less than 40% copper slag replacement was higher than or equal to that of control specimen and the workability even had a dramatic growth.

S.K.Al-Oraimi et al.(2009), This research study was conducted to investigate the performance of high strength concrete made with copper slag as a fine aggregate at constant workability and to study the effect of super plasticizer addition on the properties of HSC made with copper slag. The water content was adjusted in each mixture in order to achieve the same workability as that for the control mix. The results indicate that the water demand reduced by almost 22% at 100% copper slag replacement compared to the control mixture. While superplasticers is very important ingredient in HSC made with copper slag in order to provide good workability and better consistency for the concrete mix.

BipraGorai et al.(2003), The favorable physic-mechanical characteristics of copper slag can be utilized to make the product like cement, fill, ballast, abrasive, aggregate, roofing granules, glass, tiles, etc. This paper gives a review of characterstics of copper slag as well as various processes such as pyro,hydro and combination of pyro-hydrometallurgical methods for metal recovery and preparation of value added products from copper slag

From the above literature, addition of up to 50% of copper slag as sand replacement yielded comparable strength with that of the control mix .further addition of copper slag caused reduction in the strength due to an increase of the free water content in mix.

The surface water absorption of concrete was reduced up to 40% copper slag replacement for sand. Mixtures with 80% and 100% copper slag replacement gave the lowest compressive strength value of approximately 80Mpa,which was almost 16% lower than the strength of the control mix.

II. NEED FOR THE RESEARCH

The search for newer material and newer technology, especially in the construction industry is on in view of growing awareness on protection of environment and the conservation of natural resources. However, due to the high cost of natural sand used as a fine aggregate and the rising emphasis on sustainable construction, there is a need for the construction industry to search for alternative materials as fine aggregates in concrete production. Together with this, the problem of waste disposal as becomes a major concern for planners and engineers in developing countries. With the enormous increase in the quantity of waste materials from the industries the continuing the shortage of dumping sites, increasing the transport and disposal cost. From the above literature the maximum strength was achieved at copper slag 50%, the strength decreased while increasing the further % of copper slag, due to more water content. To reduce water content by using superplactizers.

III. MATERIAL INVESTIGATION

3.1 Cement

Ordinary Portland cement (OPC) – 53 grade of cement is used for the entire experimental investigation. The physical properties were tested according to standard procedure confirming to IS: 269-1976. The physical properties of the cement are given in table 3.1.

Table 3.1 Physical properties of cement

S.No	Properties	Results
1	Standard consistency	31 %
2	Initial setting time	22 min
3	Final setting time	190 min
4	Specific gravity	3.12

3.2 Fine aggregate

The sand is used as fine aggregate as per IS 2386 (Part V) 1963 and it is collected from nearby area. The sand has been sieved in 4.75 mm sieve IS 383 - 1970. The properties of which are presented in the Table 3.2.

Table 3.2 physical properties of fine aggregate

S.No	Description	Result
1	Specific gravity	2.53
2	Water absorption (%)	1.25
3	Bulk density(g/cm^3)	1.560
4	Fineness modulus	2.99
5	Zone	I

3.3 Coarse aggregate

Machine crushed blue granite broken stone angular in shape is used as coarse aggragate. The coarse aggregate is choosen by shape as per IS 2386 (Part I) 1963, surface texture characteritics of aggregate is classified as in IS 383 - 1970. The following properties of coarse aggragates were determined and tabulated in Table3.3

Table 3.3 Physical properties of coarse aggregate

Sl.No	Description	Result
1	Specific gravity	2.7
2	Water absorption (%)	1.05
3	Bulk density(g/cm^3)	1.560
4	Fineness modulus	2.99
5	Zone	I

3.4 Copper slag

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, which is the waste material produced in the extraction process of copper metal in refinery plants, has low cost and its application as a fine aggregate in concrete production reaps many environmental benefits such as waste recycling and solves disposal problems. Copper slag possesses mechanical and chemical characteristics that qualify the material to be used in concrete as a partial replacement as fine aggregate. The properties of copper slag listed in Table 3.4

Table 3.4 Properties of copper slag

Sl.No	Description	Result
1	Specific gravity	3.63
2	Water absorption (%)	3.4%

Fig. 3.1 Copper slag

3.5Water

Ordinary clean portable water free from suspended particles was used both for mixing and curing the concrete specimens.

IV. MIX PROPORTIONS

Table 4.1 Designation of concrete&Percentage of replacement of CS

MIX	Designation of concrete	Percentage of Copper slag
CC	M1	-
CS 45	M2	45%
CS 50	M3	50%
CS 55	M4	55%
CS 60	M5	60%

CC- Conventional concrete, **CS**- copper slag

Table 4.2 Cement, fine aggregate, coarse aggregate & copper slag content in mix

MIX	Cement (kg/m^3)	Water (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Copper slag (kg/m^3)
M1	519.12	148.39	616.12	1009.16	-
M2	519.12	148.39	338.87	1009.16	277.25
M3	519.12	148.39	308.06	1009.16	308.06
M4	519.12	148.39	277.26	1009.16	338.86
M5	519.12	148.39	246.45	1009.16	369.67

V. EXPERIMENTAL INVESTIGATIONS

5.1 Compression Test

Table 5.1 Compressive Strength at 7 & 28 days

Concrete Type	Compressive strength at 7 days (N/mm^2)	Compressive strength at 28 days (N/mm^2)
M1	31.2	50.8
M2	39.5	54.2
M3	45.8	59.54
M4	48.4	61.04
M5	45.3	59.4

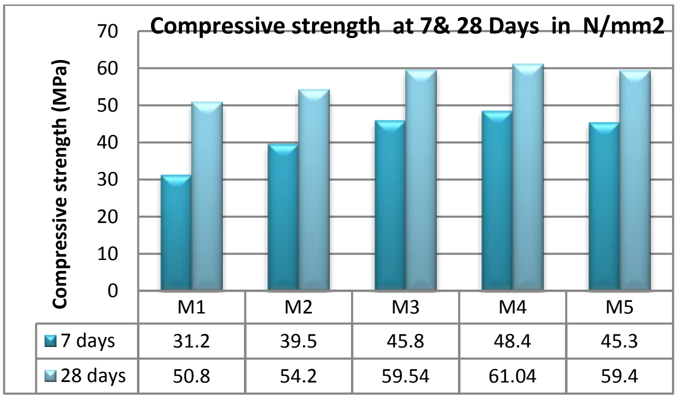

Fig 5.1 Compressive Strength at 7 & 28 days

5.2 Split Tensile Test

Table 5.2 Split Tensile Test at 7 & 28 days

Concrete Type	Split tensile strength at 7 days (N/mm^2)	Split tensile strength at 28 days (N/mm^2)
M1	3.82	5.56
M2	4.45	6.83
M3	4.26	6.79
M4	3.92	6.14
M5	3.21	4.97

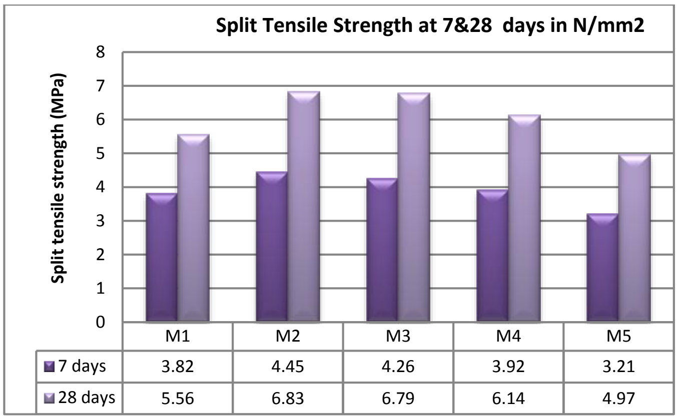

Fig 5.2 Split Tensile Test at 7 & 28 days

5.3 Flexural Strength

Table 5.3 Flexural Strength Test for 7 &28 days

Concrete Type	7 days Flexural strength (N/mm^2)	28 days Flexural strength (N/mm^2)
M1	4.12	7.04
M2	4.96	8.18
M3	5.22	9.14
M4	5.20	9.08
M5	5.08	8.96

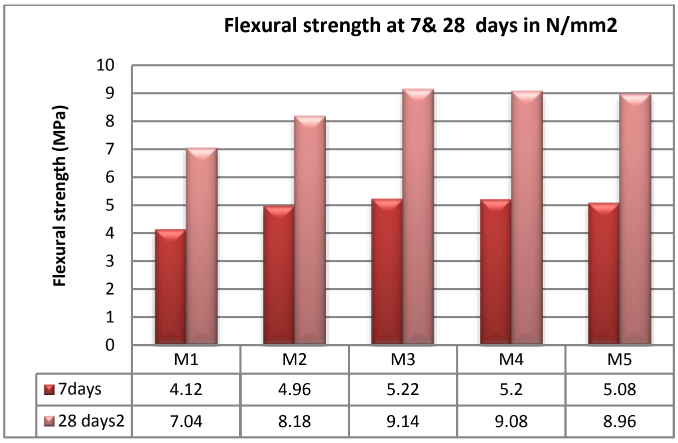

Fig 5.3 Flexural Strength Test for 7 &28 days

VI. RESULTS AND DISCUSSIONS

Table 6.1 Percentage increase/decrease in compressive strength after 28 days

Nominal Mix	Other mixes	Increase/decrease in strength (%)
Conventional Concrete mix M1	M2	+6.8
	M3	+17.20
	M4	+20.15
	M5	+16.92

Table 6.2 Percentage increase/decrease in split tensile strength after 28 days

Nominal Mix	Other mixes	Increase/decrease in strength (%)
Conventional Concrete mix M1	M2	+22.84
	M3	+22.12
	M4	+10.43
	M5	-10.61

Table 6.3 Percentage increase/decrease in flexural strength after 28 days

Nominal Mix	Other mixes	Increase/decrease in strength (%)
Conventional Concrete mix M1	M2	+16.19
	M3	+29.82
	M4	+28.97
	M5	+27.27

VII. CONCLUSION

- ✓ Replacement of copper slag by 45% - 60% shows increase in strength than conventional concrete.
- ✓ Fine aggregate replaced by 55% have increase in strength up to 20.15% to the conventional concrete. Further replacement of copper slag have slight decrease in strength, this is due to increase in free water content in the mix.
- ✓ Replacement of fine aggregate by 45% shows increase in split tensile strength by 22%. Further replacement up to 60%, there is decrease in split tensile strength by 10% to the conventional concrete.
- ✓ Replacement of fine aggregate by 55% of copper slag shows increase in flexural strength by 29% to the conventional concrete.
- ✓ Replacement of fine aggregate by copper slag up to 55% shows good result in strength characteristics of concrete, hence replacement of copper slag up to 55% is an opt for a high performance concrete.

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