STUDY ON COPPER SLAG AND MICRO SILICA EFFECTS IN DURABILITY PROPERTIES OF CONCRETE

Md Arshad Hussain[1], M.Muzaffar Ahmed[2]
[1]PG Student, Siddharth Institute of Engineering & Technology, Puttur, A.P, India
[2]Assistant Professor of Civil Engineering Department, Siddharth Institute of Engineering & Technology, Puttur, A.P, India

Abstract

The purpose of this research is to find the suitability of copper slag as an alternative material for the river sand. This experimental study was divided into four phases, where in the first phase physical properties of cement, aggregates, Silica Fume and copper slag were examined. In the second phase, M30 grade of concrete is chosen to perform the effective replacement of copper slag with fine aggregate by replacement levels of 0%, 25%, 50% and 75% and the behavior of fresh and hardened properties of concrete was carried out. Cement is replaced by Silica Fume for 5%, 10% and 15% were used in the concrete by weight of cement. This project will present the results of an experimental study on various Compressive strength, Split tensile strength, Workability test and Durability on concrete containing copper slag and micro silica as partial replacement of sand and Cement respectively.

From the test results, it was concluded that cube compressive strength, split tensile strength and Flexural Strength of concrete had higher strength for 25% replacement of copper slag with 10% Silica Fume. Copper slag replacement at 50% & 75% with Silica Fume showed a marginal variation in cube compressive strength, Split tensile strength and Flexural Strength.

Keywords: Durability Properties, Acid attack test, copper slag, silica fume.

I. INTRODUCTION

Conventional concrete, a versatile material can be prepared by mixing the ingredients cement, river sand and coarse aggregate with required water cement ratio. Cementing medium is a product of reaction chemically, between water and hydraulic cement. Concrete is made with several types of cement and also containing pozzolana, blast furnace slag, sulphur, a regulated set additive, polymers, admixtures, fibers etc. Workability is an amount of useful internal work which is necessary to produce full compaction which is a physical property of concrete and the work or energy required to over come the internal friction between the individual particles, formwork surface or reinforcement provided in the concrete.

Concrete has become inevitable material in human life due to its extensive usage in modern construction activities and its properties like strength and durability. India has taken a sound decision on infrastructural development in 21st century, such as express highways, airports, ports, power projects and tourism projects. In every construction activity involves with concrete, hence concrete plays a vital role in present scenario of construction industry. Wide range usage of concrete is in infrastructural development because of its characteristics. The usage of available natural resources and the consequent requirement of energy for the processing has become a serious economic impact.

By different ingredients of concrete, depending upon the purpose and use, the properties of concrete can also be changed or varied. Since the shielding ability and attenuation capacity are not influenced by the type of material and it depends on density of concrete, it is essential to increase the mass of concrete per unit. Concrete has relatively higher compressive strength but very lower tensile strength. For this cause, it is usually reinforced with materials to make it sound in tension (often steel). Concrete can be damaged by many actions, such as freezing of trapped water, permeability in concrete composition. To overcome the damage of concrete, proper quality of ingredients shall be used in the concrete composition. Due to the vast usage of concrete in this century, concrete ingredients are depleting stage. Hence, production of quality concrete is quite difficult with low quantity of quality ingredients. So, recycling, reuse and substitution of ingredients are one solution to overcome shortage of quality aggregates.

II. OBJECTIVE

The purpose of this research is to find the suitability of copper slag as an alternative material for the river sand. This project will present the results of an experimental study on various Compressive strength, Split tensile strength, Workability test and Durability on concrete containing copper slag and micro silica as partial replacement of sand and Cement respectively.

III. EXPERIMENTAL INVESTIGATION

3.10 PROPERTIES OF MATERIALS

3.11 CEMENT

In this study, Zuari Cement of 53 grade Ordinary Portland Cement conforming to IS: 12269–1987 was used for the entire work. The cement was purchased from single source and was used for casting of all specimens. The physical properties of cement are furnished in Table 1.

Table 1 --Properties of cement

S. No	Characteristics	Test results	Requirements as per IS 12269 – 1987
1	Fineness (retained on 90-µm sieve)	6%	<10%
2	Normal Consistency	32%	--
3	Initial setting time of cement	70 min's	30 minutes (minimum)
4	Final setting time of cement	350 min's	600 minutes (maximum)
5	Expansion in Le-chatelier's method	3 mm	10 mm (maximum)
6	Specific gravity	3.12	3.10 – 3.25

3.12 FINE AGGREGATE

Locally available river sand confirming to IS specifications was used as the fine aggregate in the concrete preparation. The properties of fine aggregate are shown in Table.2.

Table 2 -- Properties of Fine Aggregate

S. No	Test conducted	Results obtained		Permissible Limits as per IS 383 – 1970
1	Specific gravity	2.6		2.5 to 3.0
2	Fineness modulus	2.77		--
3	Bulk density	Loose State	1450 kg/m3	1400 to 1750 kg/m3
		Compacted State	1520 kg/m3	
4	Water absorption (%)	1.09		Max 3%
5	Sieve Analysis	Zone – II		--

3.13 COARSE AGGREGATE

Crushed granite metal of nominal size 20 mm and 10 mm obtained from the local quarry and confirming to IS specifications were used. The properties of coarse aggregate are shown in Table.3. The coarse aggregate used for the preparation of concrete is a combination of 20 mm and 10 mm size aggregates in ratio 1.5: 1.0.

Table3 -- Properties of Coarse Aggregate

S. No	Test conducted	Results obtained		Permissible Limits as per IS 383 – 1970
1	Specific gravity	2.6		2.5 to 3.0
2	Fineness modulus	2.77		--
3	Bulk density	Loose State	1450 kg/m3	1400 to 1750 kg/m3
		Compacted State	1520 kg/m3	
4	Water absorption (%)	1.09		Max 3%
5	Sieve Analysis	Zone – II		--

3.14 SILICA FUME

Table 4 -- Properties of Silica-Fume

S.NO.	Characteristics	ASTM-C-1240	Analysis Results
1	SiO2(Min)	85%	90.20%
2	LOI (Max)	6%	2.80%
3	Moisture (Max)	3%	0.20%
4	Pozzolanic Activity Index (Min)	105%	127%
5	Specific surface Area (m2/gm)	> 15	> 21
6	Bulk density (Kg/m3)	550 to 700	604
7	> 45 Microns (Max)	10%	0.20%

3.15 COPPER SLAG

Table 5 – Physical Properties of Copper Slag

Physical Properties	Copper slag
Particle shape	Irregular
Appearance	Black and glassy
Type	Air cooled
Specific gravity	3.91
Percentage of voids %	35
Bulk density g/cc	2.08
Fineness modulus	3.47
Angle of internal friction	51° 20’
Ultimate shear stress kg/cm	0.4106
Water absorption %	0.16
Moisture content %	0.1

3.15 WATER

Water used for casting and curing of concrete test specimens is free from impurities which when present can adversely influence the various properties of concrete.

3.16 CONCRETE MIX PROPORTION

In the present experimental investigation, the influence of combined application of various types of steel fibres on M30 grade concrete is studied.

M40 grade of concrete were designed as per the Indian Standard code of practice. The various ingredients for one cubic meter of M40 grade concrete are shown in Table 5.

Table. 6 Quantities of Ingredients per cum of M30 Grade Concrete

S. No	Mix Identification	Cement (kg's)	Fine Aggregate		Coarse Aggregate (kg's)	Water (lit)	Silica Fume (kg's)
			Sand (kg's)	Copper Slag(kg's)			
1	C.C	360	688	0	1225	177	0
2	25% C.S	360	517	262	1225	183	0
3	50% C.S	360	344	524	1225	181	0
4	75% C.S	360	172	786	1225	179	0
5	25% C.S + 5% S.F	342	517	262	1225	183	15
6	25% C.S + 10% S.F	324	517	262	1225	183	30
7	25% C.S + 15% S.F	306	517	262	1225	183	45
8	50% C.S + 5% S.F	342	344	524	1225	181	15
9	50% C.S + 10% S.F	324	344	524	1225	181	30
10	50% C.S + 15% S.F	306	344	524	1225	181	45
11	75% C.S + 5% S.F	342	172	786	1225	179	15
12	75% C.S + 10% S.F	324	172	786	1225	179	30
13	75% C.S + 15% S.F	306	172	786	1225	179	45

4 EXPERIMENTAL INVESTIGATION

4.1 CONCRETE MIX PREPARATION

Design of concrete mix requires complete knowledge of various properties of the constituent materials. Initially the ingredients such as cement and fine aggregate were mixed, to which the coarse aggregate are added followed by addition of water and thoroughly mixed. Prior to casting of specimens, workability is measured in accordance with the code IS 1199-1959 by slump cone test.

4.2 DURABILITY OF CONCRETE

The concrete cubes of size 150 mm × 150 mm × 150mm were prepared and it is tested for its durability at the age of 28 days. The percentage loss of weight of the concrete specimen and percentage loss in compressive strength were calculated.

5 RESULTS AND DISCUSSIONS

5.1 Durability of concrete

a) Acid attack test:

The action of acids on hardened concrete is the conversion of ferrous compounds into the ferrous salts of the attacking acid. Copper slag contains nearly 60% of Fe_2O_3, as a result of this, the copper slag admixed concrete when immersed in 5% H_2So_4 acid solution, it is subjected to more loss of weight and loss in compressive strength when compared with controlled concrete.

The test results of acid attack test with 5% Sulphuric acid (H_2SO_4) of M30 grade concrete with various proportions of copper slag and Silica Fume is shown in Table 6.6. The variation of loss of weight and decrease in compressive strength of M30 grade concrete with different percentages of copper slag and Silica Fume is shown in Figure

Table7 – Effect of acid attack on compressive strength at 28 days

S. No	Mix Designation	Weight of cubes (Kg)		% Loss in wt.	Comp strength N/mm2		% Loss of Comp Strength
		Before	After 28 Days		Before acid attack	After acid attack 28 days	
1	C.C	8.64	8.49	1.73	34.31	31.71	7.56
2	25% CS	9.46	8.80	6.97	31.02	23.88	23.03
3	50% CS	9.05	8.38	7.4	28.05	19.11	31.86
4	75% CS	9.31	8.57	7.94	27.18	16.38	39.75
5	25% CS + 5% SF	9	8.34	7.33	43.30	34.09	21.27
6	25% CS + 10% SF	9.15	8.43	7.87	45.36	32.50	28.34
7	25% CS + 15% SF	9.38	8.63	8.01	41.16	26.22	36.3
8	50% CS + 5% SF	8.8	8.15	7.42	41.50	33.22	19.96
9	50% CS + 10% SF	9.12	8.42	7.68	42.90	31.63	26.27
10	50% CS + 15% SF	9.11	8.40	7.8	39.68	25.85	34.84
11	75% CS + 5% SF	8.37	7.76	7.25	37.54	25.88	31.06
12	75% CS + 10% SF	8.35	7.83	6.21	40.26	28.07	30.27
13	75% CS + 15% SF	8.55	8.03	6.04	34.40	25.08	27.1

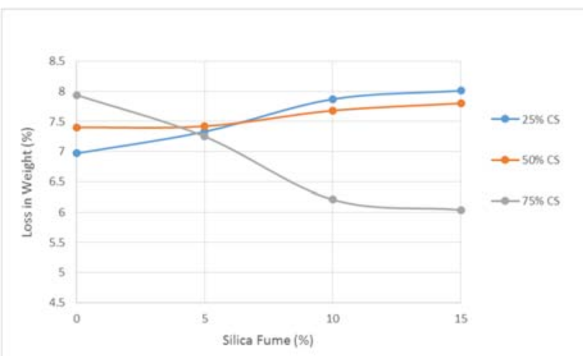

Figure 1- Percentage Loss of Weight with various percentages of Copper Slag and Silica Fume

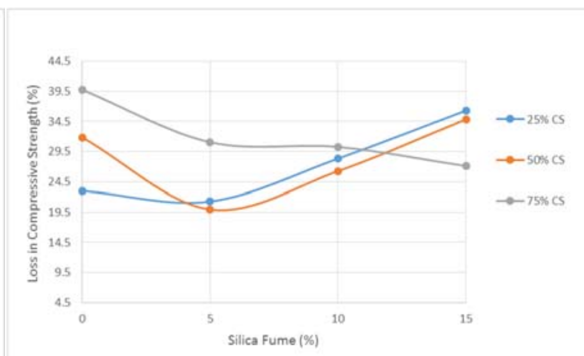

Figure 2- Percentage Loss in compressive strength with various percentages of Copper Slag and Silica Fume

V. CONCLUSIONS

Based on the experimental investigations, the following conclusions were drawn.

1. From acid resistance test, it was observed that the concrete containing copper slag was found to be low resistant to the H_2SO_4 solution than the control concrete.
2. The maximum percentage loss in weight is found for 75% replacement of copper slag without Silica Fume.
3. The maximum percentage loss in weight is found for 25% replacement of copper slag and 15% replacement of silica fume with sand and cement respectively.
4. The maximum percentage loss in compressive strength was found for 75% replacement of copper slag.

REFERENCES

1)Abdullah A. Almusallam, HamoudBeshr, Mohammed Maslehuddin and Omar S.B. Al-Amoudi, Effect of silica fume on the mechanical properties of low quality coarse aggregate concrete, Cement and Concrete Composites, 26, 891–900 (2004)

2)Binaya Patnaik, Seshadri Sekhar T and Srinivasa Rao. An Experimental Investigation on Optimum Usage of Copper Slag as Fine Aggregate in Copper Slag admixed Concrete. International Journal of Current Engineering and Technology, Vol.4, No.5, 2014

3) B. S. HamadZ. S. Seferian “Role of casting position on bond strength of confined tension lap splices in silica fume concrete” Materials and Structures November 2000, Volume 33, Issue 9, pp 584–593

4)Carl RedonJean-Louis Chermant“Compactness of the Cement Microstructure Versus Crack Bridging in Mortars Reinforced with Amorphous Cast Iron Fibers and Silica Fumes”Applied Composite MaterialsMay 2001, Volume 8, Issue 3, pp 149–161

5) Chavan, R.R. and Kulkarni, D.B. “Performance of copper slag on strength properties as partial replacement of fine aggregate in concrete mix design”, International Journal of Advanced Research and Studies, Vol.2, No.4, pp.95-98, 2013

6)Erhan G and Mehmet G (2007) Strength development andchloride penetration in rubberized concretes with andwithout silica fume. Materials and Structures 40: 953–964

7) Fidjestol P, Lewis R (2003) Microsilica as an addition. In: Hewlett, P.C. (ed.) Lea's Chemistry of Cement and Concrete, 4th ed., (Arnold Publishers, London), pp. 675–702

8)Gorai, B. and Jana, R.K. Premchand. “Characteristics and utilization of copper slag”, Resources Conservation and Recycling, Vol. 39, pp. 299-313, 2002.

9) Hooton RD. Influence of silica fume replacement ofcement on physical properties and resistance toSulphate attack, Freezing and Thawing, and alkali-silica reactivity, ACIMaterial Journal, No. 2, 90(1993) 143-519