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EFFECT OF COPPER SLAG AND FLY ASH ON MECHANICAL PROPERTIES OF CONCRETE

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ABSTRACT

The tentative examination was operated to study the impact of using fly ash with cement and copper slag with fine aggregate on the character of concrete. Different concrete samples prefabricated with various quantities of copper slag vary up to 0% to 60% as fine aggregates substitution and 20% as fly ash replacement with cement. Concrete samples were determined for various strengths that is compressive, tensile and flexural strength and also. Evaluated for Ultrasonic pulse velocity. The outcomes acquired for concrete declared that all samples with various copper slag quantities and constant fly ash proportion that is higher compressive strength as compare to the control specimen. The outcomes acquired for concrete show that the percentage (%) of copper slag increased then also increased the workability of concrete as compared with control specimens. If, copper slag more than 30% replacement with fine aggregate then the outcomes show the reduction of strengths because the water absorption of copper slag is very less. And these results shows that is 20% as fly ash substitution with cement and up to 30% as copper slag substitution with fine aggregate to acquire a good mechanical properties of concrete

Key words: Fly Ash, Fine Aggregate, Copper Slag, Cement, Concrete.

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1. INTRODUCTION

Sustainability and resource capacity are becoming elongate vital purport within nowadays construction industry. Huge countries are evidencing a fast enlargement in the construction factory, which include the use of inartificial modality for the evolution of infrastructure. Therefore finders evolve worthless conduct technique to apply for substitution of fine aggregate for exclusive requirement [22].The worthless material(fly ash and copper slag) is used in only secure region of construction industry, which reduce the problems of environmental, problems of space and construction cost. Copper slag were produced as a by-product of copper procedure ,that is chiefly finished up as ground dispose although few quantity of copper slag are applied in the usage of abrasives in the process of iron mould deflected[21].Its include huge quantity of Iron oxide and Silicate. The physical character of copper slag is similar of natural sand. The compositve marks that is sulphate, copper and alumina existing that it's not detrimental. It is the worthless material of matte dissolving and rectification of copper that is every ton of copper produced almost 2.5 tons of copper slag [1].

Electricity is the important for evolution of someone country. Coal is a main origin of fuel for manufacture of electricity in huge countries in the world. In the procedure of electricity generation huge amounts of fly ash get generate. Newsday's about 60% power is production by using coal as fuel, which outcomes in the generated of about 225 million tons of Ash yearly. Fly ash use decrease permeability, alkali aggregate reaction and heat of hydration and improvement the workability, enhanced the obstruction to corrosion and sulphate attack thus making concrete mass much stable and durable and thus decrease cost of concrete [9]. In huge of the evolved countries, fly ash is used as one of the necessary in gradient of durable concrete. Erection of cement is high energy profound industry. In the erection of one ton of cement, about one ton of Co_2 (Carbon dioxide) is emitted and goes to atmosphere. Short needs of cement mean less emission of Co_2 outcome in scarcity in greenhouse gas emission. The more cement quantity that mean more strength but durability has not proved in real imagination for the structure without covering to different climate condition. To make cement concrete stable and durable at less cost use of cementitious material that is fly ash begin in exercises and is presently a proved technology world over [14].

Copper slag is a material that are contemplate as a worthless which could have a liberal of promising incoming in construction factory as partial replacement of fine aggregates[18]. Occupier can also use this worthless material in place of fine aggregate during construction work. It can also be applied as a different construction fields that is construction material, built up into blocks. It is large area applied in the sand explosion factory. Huge quantities of worthless materials are being produced by many industries and fill of worthless materials is causing health and environmental hazards. For several years, Industrial by-products that is slag, fly ash and silica fume were contemplate as worthless materials. Usage of these materials as substitution for sand and cement in concrete define reclamation in mechanical characters compared to normal concrete and has found their usage in the different structures [13].

In the recent past, profound investigation studies have been perform to find out all possible recycling and reuse methods. Construction worthless, blast furnace Slag, coal fly ash ,steel slag and bottom ash have been admitted in different places as aggregates in pavements foundation, embankment, roads, and building construction, raw product in the erection of ordinary Portland cement(OPC) [6].

The use of this slag in the concrete as a substitution for fine aggregate, reduces the costs of disposal, lowers the cost of the concrete and also helps in conservancy the environment nevertheless the matter of fact that many studies have been in directed on the impact of copper slag on the characters of concrete.

2. MATERIALS PROPERTIES

2.1. Cement

In this study, It is used in ordinary Portland cement (OPC) and its 43 grade from Ambuja cement industry. In various construction companies used in this cement.

Table 1 Cement (Physical Properties).

Sr. no.	Tests	Results	Specified by IS 8112:2013 Code
I	Cement Consistency	32	30
II	Initial setting time (mint.)	65	30
III	Final setting time (mint.)	250	600
IV	Specific gravity	3.15	2.5-3.5
V	Compressive strength (MPa)	46.7	58
VI	Soundness of cement(mm)	4	10

2.2. Fine Aggregate

It is obtained after sieve of fine aggregate which passed through 4.75mm. The fineness modulus of sand is 3.05% and specific gravity is 2.69.

2.3. Coarse Aggregate

It is acquired from a local source. This coarse aggregate used size between 10mm to 20mm with fineness modulus is 7.92% and with specific gravity is 2.74.

2.4. Fly Ash

In this work fly ash of class f type was used. The colour of fly ash was grey and the partical size of fly ash was used less than 35µm and Its specific gravity was 2.35 and was taken from (Guru Gobind Singh Super Thermal Power Plant Rupnagar Punjab).

Figure 1 Fly ash

Table 2 Fly ash (Physical Properties)

Sr.no.	Physical Properties	Fly Ash
1	Bulk Density	0.9-1.4
2	Specific Gravity	1.7-2.7
3	Plasticity	Less or Non-Plastic
4	Shrinkage Limit	Supreme
5	Clay	Negligible
6	Free Swell Index	Very Less
7	Classification of Texture	Sandy Silt or Silty Loam
8	Capacity of Water Holding	41%-60%
9	Porosity	31%-65%

2.5. Copper Slag

The colour of copper slag was black and the copper slag in irregular form and specific gravity is 3.65 and its fineness modulus is 4.36 and was taken from Synco Industries Ltd. (Jodhpur, India).

Figure 2 Copper slag

2.6. Physical & Chemical Properties of Copper slag

The physical and chemical characters of copper slag given below in the table no. 3 and table no.4, respectively.

Table 3 Copper slag (Physical properties)

Physical properties	Physical component
Shape of Particle	Irregular Shape
Plausibility	glassy& Black
Type	Air cooled type
Specific gravity	3.92,3.69
Voids%	43.21%
Bulk Density	2.09 g/cc, 1.71 to 1.91 g/cc
Fineness modulus	3.47
Angle of internal friction	51° 20’
Size of Particle	0.077 to 4.75 mm
Hardness	Lies between 6and 7.1

Table 4 Copper slag (Chemical Properties)

Chemical Properties	Copper slag (%)
Silica(sio_2)	33.05
Alumina(Al_2so_3)	2.79
Iron oxide(Fe_2o_3)	53.46
Calcium oxide(Cao)	6.07
Calcium oxide(Cao)	1.58
Sulphuric trioxide(So_3)	1.89

3. EXPERIMENTAL INVESTIGATION

3.1. Concrete samples

Different concrete samples with various quantities of waste copper slag used as a partial replacement for fine aggregate were prefabricated in sequence to evaluate the impact of and fly ash and copper slag replacements on the mechanical properties of ordinary concrete. Six concrete specimens were prefabricated with various quantities of copper slag that is vary from

0% to 60% as fine aggregates substitution and 20% as fly ash replacement with cement. Mix design for M-40 is shown in Table 5.

3.2. Mix Design

Table 5 Mix design for M-40

Sr No.	Mix detail	Cement (kg/m^3)	Fly ash(kg/m^3)	Fine aggregate (kg/m^3)	Copper slag (kg/m^3)	Coarse aggregate (kg/m^3)	Admixture (Super plasticizer)	Water (kg/m^3)
1	C1	407.07	0	851.15	0	1083	8.14	162.82
2	C2	325.65	81.42	851.15	0	1083	8.14	162.82
3	C3	325.65	81.42	723.47	127.68	1083	8.14	162.82
4	C4	325.65	81.42	595.80	255.35	1083	8.14	162.82
5	C5	325.65	81.42	467.97	383.18	1083	8.14	162.82
6	C6	325.65	81.42	340.46	510.69	1083	8.14	162.82

4. METHODOLOGY

This research work, M40 grade concrete is used and the total no. of specimen is 60 for cube, 60 for beam and 60 for cylinder. for the testing of strength tests that is compressive, Split tensile and Flexural strength test with include the average of two specimen after 7,14,28 and 56 days. for tests are conducting for various substitution of the cement using constant percentage of fly ash that is 20% and substitution of the sand using copper slag that are 0%, 15%, 30%, 45% & 60% with strengthened sample and the various replacement that is (0% to 60%) shows the C1 TO C6.and also testing of ultrasonic pulse velocity test and rebound hammer test was to be done for each sample.

Table 6 Dimensions and date of testing of various samples

Strength test (MPa)	Compression test (MPa)	Split tensile strength (MPa)	Flexural strength (MPa)
Sample Types	Cubes	Cylinders	Beams
Sample Sizes(mm)	(150)*(150)*(150)	(150)*(300)	(100)*(100)*(500)
Number of sample	60	60	60
Days of Testing	7,14,28& 56	7,14,28&56	7,14,28 & 56

Table 7 Substitutions of Fly ash and Copper slag

Sr. no.	Mix detail	Cement (Percentage)	Fly Ash (Percentage)	Fine aggregate (Percentage)	Copper slag (Percentage)
1	C1	100	0	100	0
2	C2	80	20	100	0
3	C3	80	20	85	15
4	C4	80	20	70	30
5	C5	80	20	55	45
6	C6	80	20	40	60

5. RESULTS AND DISCUSSION

The mechanical characters of concrete that is show in below tables & Figures

5.1. Compression Test

In this test, to find the compressive strength and its size of sample is 150*150*150 mm. The casted samples of various % of copper slag up to 0% to 60%and constant 20% fly ash and using tamping rod to correctly compacted the concrete. Than the cube samples are put curing for 7days, 14days, 28 days and 56 days. This test was done with the help of IS 516:1976. The cube compressive test results of various mixes considered in comparisons is given in Table 8& fig 3.

Table 8 Results of compressive strength test

Specimens	Compressive Strength (MPa)			
	After7th day	After14thday	After28thday	After56th day
C1	17.70	25.20	37.35	41.15
C2	21.66	29.84	38.40	42.77
C3	22.66	30.04	39.90	44.20
C4	25.90	32.40	43.94	50.39
C5	22.04	29.90	39.79	45.84
C6	18.13	26.83	35.14	42.65

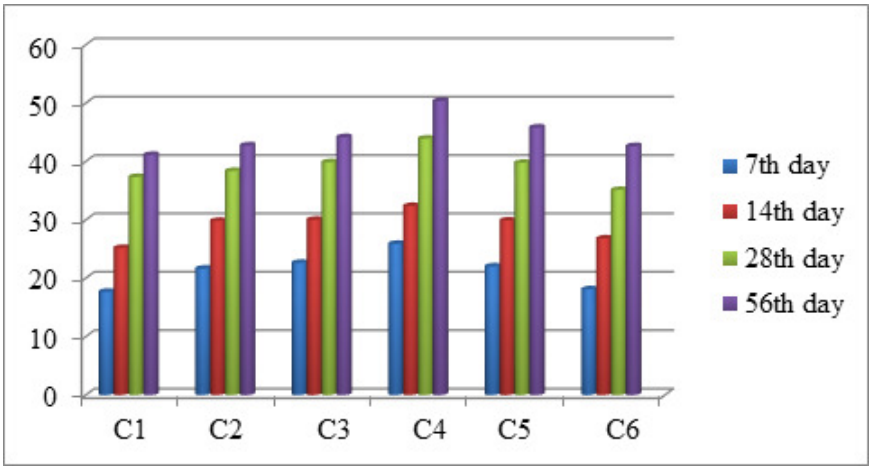

Figure 3 Compressive strength

5.2. Split Tensile Strength

In this test, to determine the split tensile strength and its size of sample is (150×300) mm. The casted samples of various % of copper slag up to 0% to 60% and constant 20% fly ash. Than the cylinder samples are put curing for 7days, 14day, 28days and 56 days. The Split tensile strength test results of different mixes considered in comparisons is given in Table 9& fig 4.

Table 9 Results of Split tensile strength test

Specimens	Split Tensile Strength (MPa)			
	After 7th day	After 14th day	After28th day	After56th day
C1	4.02	5.20	6.91	8.54
C2	4.21	5.55	7.79	9.04
C3	4.39	5.69	7.90	9.14
C4	5.21	7.14	9.57	11.77
C5	4.38	6.64	8.13	10.09
C6	4.20	5.77	7.91	9.86

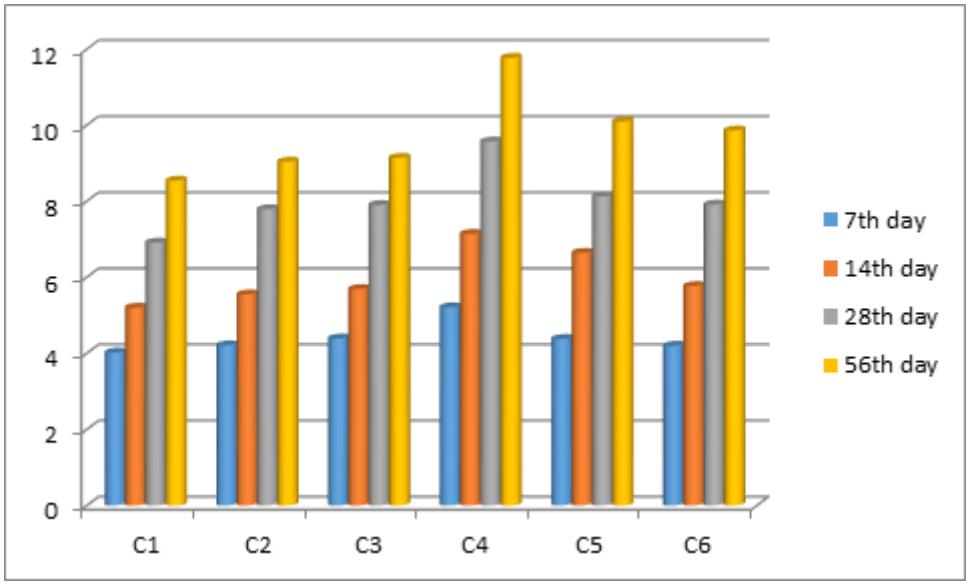

Figure 4 Split tensile strength

5.3. Flexural Strength

To find the flexural strength of concrete, beam specimens of standard dimension 500x100x100mm were cast with 15%, 30%, 45% and 60% substitution of sand with copper slag and20% replacement of cement with fly ash for control concrete. The flexural strength results of various mixes considered in comparisons is given in Table 10& fig. 5.

Table 10 Flexural tensile strength test results

Specimens	Flexural Strength(MPa)			
	After 7th day	After 14thday	After28thday	After 56thday
C1	2.42	3.04	5.41	7.15
C2	2.52	3.22	5.60	7.65
C3	2.70	3.30	5.87	7.78
C4	3.12	3.80	6.16	8.77
C5	2.44	3.26	5.77	7.30
C6	2.30	3.12	5.19	7.14

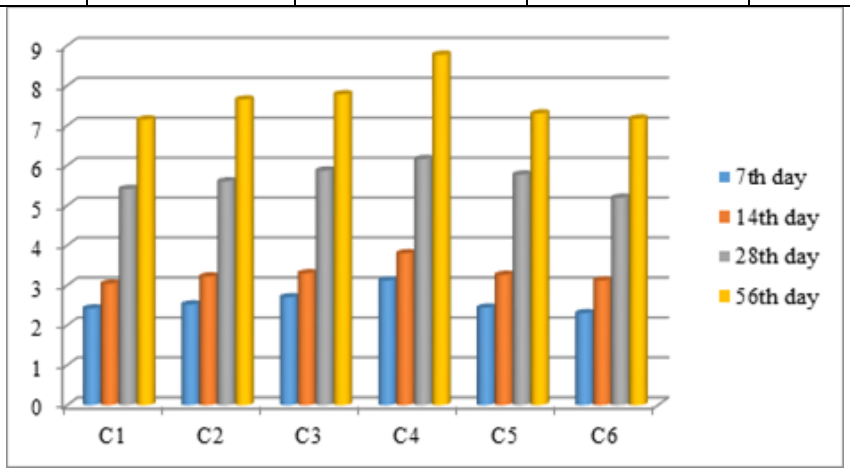

Figure 5 Flexural strength

5.4. Rebound hammer test

This test is also known as non-destructive test. Its determine the compressive strength of the concrete without damage or broken the part of structure (any part of concrete). And the results shows given below the table no.11

Table 11 Rebound hammer test results

Specimens	Compressive strength (MPa)	
	28th day	56th day
C1	33.50	38.6
C2	37.40	40.55
C3	38.65	42.30
C4	40.75	47.88
C5	37.36	42.77
C6	32.18	40.15

5.5. Ultrasonic pulse velocity test

This test is also a part of non-destructive test. Its determine the quality of concrete with the help of pulse velocity machine, and the results of these tests shows the given below table no. 12

Table 12 Ultrasonic pulse velocity test results

Mix Proportions	28th Day		56th Day	
	Velocity (m/s)	Concrete quality	Velocity (m/s)	Concrete quality
C1	3125	Medium	3544	Good
C2	3571	Good	3867	Good
C3	3614	Good	4044	Good
C4	4054	Good	4656	Excellent
C5	3570	Good	4011	Good
C6	3488	Good	3954	Good

6. CONCLUSION

- Copper Slag has a potential to provide as an alternative for 20% substitution of cement as a fly ash and 30% substitution of fine aggregate as a copper slag and helps in maintaining the environmental as well as economical balance.
- The maximum Compressive strength was achieved for20% substitution of cement as a fly ash30% substitution of fine aggregate as a copper slag. Further addition of copper slag reduces the strength.
- The maximum Split tensile strength was achieved for 20% substitution of cement as a fly ash and 30% substitution of fine aggregate as a copper slag . Further addition of copper slag reduces the strength.
- The maximum Flexural strength was achieved for 20% substitution of cement as a fly ash and 30% substitution of fine aggregate as a copper slag. Further addition of copper slag reduces the strength.
- The pulse velocity is about 4500m/sec for 20% substitution of cement as a fly ash .and 30% copper slag substitution as a fine aggregate.
- It increased the slump value of concrete with the increase in copper slag material with substitution of fine aggregate as a same water-cement ratio.
- The waste materials(copper slag & fly ash) is used in only secure area for construction industry , which remove the problems of environmental , problems of space and construction cost.

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