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A COMPARITIVE STUDY OF STRENGTHS OF CEMENT REPLACED WITH FLYASH & FINE AGREEGATE REPLACED WITH COPPER SLAG

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Abstract—Concrete is being widely used for the construction of most of buildings, bridges etc. Hence it has been properly labelled as the backbone to the infrastructure development of a nation. Cement, fine aggregate and coarse aggregate are the main ingredients of concrete. Investigations are carried out to explore the possibility of using fly ash and copper slag as a partial replacement of cement and sand in concrete mixtures. The effects of replacing cement and fine aggregate by flash and copper slag on the compressive strength of cubes, spilt tensile strength of cylinders and flexural behaviour of beams are evaluated in this work. Six test groups are constituted with the replacement percentages of 0% (Control) 10%, 20%, 30%, 40% and 50% copper slag with sand in each series and 15% of cement replaced by fly ash except control specimen. The results showed the effect of fly ash and copper slag on concrete cubes, cylinders and RCC beams has a considerable amount of increase in the compressive, spilt tensile strength and flexural behaviour characteristics.

Keywords— Copper slag, fly ash , fine aggregates, coarse aggregates, cement, compressive strength, spilt tensile strength, flexural strength.

I INTRODUCTION

The consumption of aggregate of all types has been increasing in recent years. In most countries at a rate far exceeding that suggested by the growth of their economy of construction. 85% of the total solid waste is under the category of building construction waste, of which 90% is being dumped. 7% of Co_2 released to atmosphere is appeared during cement production. Harmful effects of concrete on environmental can be reduced by producing good and durable concrete. When fly ash is substituted for cement, the additional volume of fly ash replaces part of the fine aggregate and fills aggregate voids with paste, providing more cohesion and plasticity.

Binaya et al. (2014) reviewed that the behaviour of copper slag is similar to that of river sand used as fine aggregate in concrete. He also noted that the compressive strength of concrete increases with the addition of copper slag up to 40%, after that it starts decreasing on further addition of it. Arivalagan et al. (2013) reviewed that the flexural strength of the beam increased by 21% to 51% while replacement of copper slag. Another conclusion was that by using copper slag as a partial replacement for sand, strength increased up to 40% replacement level. Higher level replacement led to segregation and bleeding due to less water absorption capacity of copper slag. It was also observed that the sand replaced copper slag beams showed an increase in energy absorption capacity.

Copper slag is considered as a waste material which is used in the construction industry as a partial or full substitute of either cement or aggregates. Copper slag is produced in the extraction process of copper metal in refinery plants.

Sterlite industries (India) ltd, Tuticorin, India produces 4 lakh tons of copper per year. For every ton of copper production, about 2.2 tons of copper slag is generated. Therefore in India 8 lakh tons of copper slag is generated every year. Copper slag have been widely used for abrasive tools, roofing granules, cutting tools, abrasive, tiles, glass, road base construction, rail road ballast and cement and concrete industries.

Khalifa .S Al-Jabri (2008) reported that the effect of copper slag substitution as a fine aggregate on the strength and durability of HSC. The results indicated that the workability increased rapidly with increases in copper slag content in the concrete mixture due to the low water absorption and glassy surface of copper slag. Addition of up to 50% of copper slag as sand replacement yielded comparable strength with that of the control mix.

Although there are many studies that have been reported by investigators on the use of copper slag or fly ash in cement concrete, not much research has been carried out in India concerning the incorporation of fly ash and copper slag in concrete. Therefore this thesis work presented the effect of fly ash and copper slag as a substitution of cement and fine aggregate in RCC beams.

II OBJECTIVES

1. To investigate the mechanical properties of concrete incorporating Fly ash and Copper slag as a partial replacement of cement and fine aggregate.
2. To investigate the flexural behaviour of RCC beams incorporating Fly ash and Copper slag as a partial replacement of cement and fine aggregate.
3. To study the workability of replaced mix with conventional materials.

4. To study the comparison of strengths obtained by using crushed stone aggregate and river sand with replaced materials.

III MATERIALS USED

Coarse aggregates: The Coarse aggregate exclusively passing through 40mm sieve size and retained on 20mm sieve is selected.

Fine aggregates: The sand which was locally available and passing through 4.75mm IS sieve is used. Sand passing through IS 4.75mm Sieve will be used for casting all the specimens.

Cement: OPC (Ordinary Portland Cement) 53 grade is used.

Water: Portable water is used which should be free from organic matter and curing is done as per IS 456:2000.

The main raw materials used in preparation of concrete blocks by partially replacing fine aggregate with copper slag and cement with fly ash.

A.PHYSICAL AND CHEMICAL PROPERTIES OF FLY ASH

Sl.No	Constituent	Fly ash (%)
1	SiO_2	58.82
2	Al_2O_3	19.65
3	Fe_2O_3	10.67
4	CaO	02.18
5	MgO	03.92
6	SO_3	00.48
7	Loss of Ignition	00.91
8	Specific gravity	02.24
9	Specific surface area (cm^2/g)	3812

B.PHYSICAL PROPERTIES OF COPPER SLAG

Sl.No	Property	Value
1	Appearance	Black Glassy Granules
2	Colour	Black
3	Grain shape	Granular
4	% of voids	35%
5	Water absorption%	0.16
6	Bulk density g/cc	2.18 g/cc
7	Specific gravity	3.74

IV METHODOLOGY

In our study M20 grade concrete was used for casting all kind of concrete specimens. This study was concerned with the replacement of fine aggregate and cement in concrete. The cubes and cylinders were used for compressive strength and splitting tensile strength respectively. Beams were used to find the flexural behaviour respectively. The following tests were to be conducted for various proportions of copper slag and 15% fly ash. Compressive strength test on cubes Split tensile strength test on cylinders Flexural behaviour of RCC beams

Fig 1: Copper slag

Fig 2: Casting of Cubes

Fig 3: Casting of Cylinders

Fig 4 : Casting of Beams

Fig 5: Curing of Cubes, Cylinders and Beams

Fig 6: Experimental Setup of RCC beam

V MIX DESIGN AND TEST RESULTS

15% of Cement replaced by Fly ash except control concrete (CC) and fly ash concrete (FA)
CC -Control Concrete (0%)
FA - 15% fly ash replacement for cement
CS1 -10% copper slag replacement for sand
CS2 -20% copper slag replacement for sand
CS3 -30% copper slag replacement for sand
CS4 -40% copper slag replacement for sand
CS5 -50% copper slag replacement for sand

TABLE 1
MIX PROPORTIONS BASED ON WEIGHT OF MATERIALS

Sl.No	% of slag added	% of fly ash added	Cement kg/m^3	Fly ash kg/m^3	Copper slag kg/m^3	Sand kg/m^3	Coarse Aggregate kg/m^3	Water litres/m^3	Mix ratio
1	-	-	360	-	-	697	1192	192	1: 1.93: 3.31
2	10	15	306	54	72	648	1183	192	1: 1.99: 3.29
3	20	15	306	54	149	596	1183	192	1: 2.08: 3.29
4	30	15	306	54	233.1	543.9	1183	192	1: 2.16: 3.29
5	40	15	306	54	322	483	1183	192	1: 2.24: 3.29
6	50	15	306	54	416.5	416.5	1183	192	1: 2.31: 3.29

TABLE 2
COMPRESSIVE STRENGTH RESULTS ON CONCRETE CUBES
For compressive strength of concrete cubes are casted of size 150mm*150mm*150mm. These are water cured for 7,14 and 28 days.

S.No	Mix dentity	Average Compressive Strength at 7 days (N/mm^2)	Average Compressive Strength at 14 days (N/mm^2)	Average Compressive Strength at 28 days (N/mm^2)	Increase in compressive strength (%)
1	CC	17.59	24.74	28.60	-------
2	FA	18.83	25.45	30.51	6.67
3	CS1	20.00	26.99	31.11	8.77
4	CS2	22.30	31.26	35.85	25.35
5	CS3	25.38	35.53	40.59	41.92
6	CS4	27.11	37.92	43.25	51.22
7	CS5	20.24	29.7	34.22	19.64

TABLE 3
SPILT TENSILE STRENGTH TEST ON CYLINDERS
For split tensile test cylinders are casted of size 30 cms length and 15 cms diameter. These are water cured for 28 days.

S.No	Mix identity	Ultimate load (kN)	Average ultimate loads (kN)	Split tensile strength at 28 days (N/mm^2)	Percentage increase in strength
1.	CC	220	225.00	3.20	---
		220			
		240			
2.	FA	230	240.00	3.40	6.17
		250			
		240			
3.	CS1	260	260.00	3.68	15.00
		240			
		280			
4.	CS2	280	290.00	4.11	28.44
		300			
		290			
5.	CS3	280	300.00	4.26	33.13
		310			
		310			
6.	CS4	310	305.00	4.35	35.94
		310			
		300			
7.	CS5	290	275.00	3.90	21.88
		260			
		280			

TABLE 4
FLEXURE BEHAVIOUR OF RCC BEAMS FOR VARIOUS PROPORTIONS OF COPPER SLAG REPLACED WITH SAND AND 15% FLYASH WITH CEMENT

For this test the beams are casted and the dimensions are 1500 x 150 x 150 mm. These beams are water cured for 28 days.

S.No	Parameter	CC	CS1	CS2	CS3	CS4	CS5
1	Initial crack load in kN	21.00	23.00	24.50	26.50	30.50	26.50
2	Ultimate load in kN	42.00	44.50	47.00	49.50	52.50	46.50
3	Ultimate deflection in mm	20.72	22.18	22.50	22.96	23.50	21.78
4	Yield load in kN	32	33	35	36	38	35
5	Yield Deflection in mm	5.43	5.19	4.71	4.09	3.81	4.86
6	Deflection Ductility	3.81	4.29	4.77	5.61	6.07	4.48
7	Stiffness at yield load kN/mm	5.89	6.35	7.43	8.80	9.81	7.20
8	Stiffness at ultimate load kN/mm	2.02	2.04	2.08	2.16	2.23	2.13
9	Percentage increase in Ultimate load %	--	5.95	11.90	17.865	25.00	10.70

Graphs are drawn between compressive strength and percentage of copper slag added. On X-axis percentage of copper slag and on Y- axis compressive Strength values are added

Case:1 Copper slag added to Concrete cubes

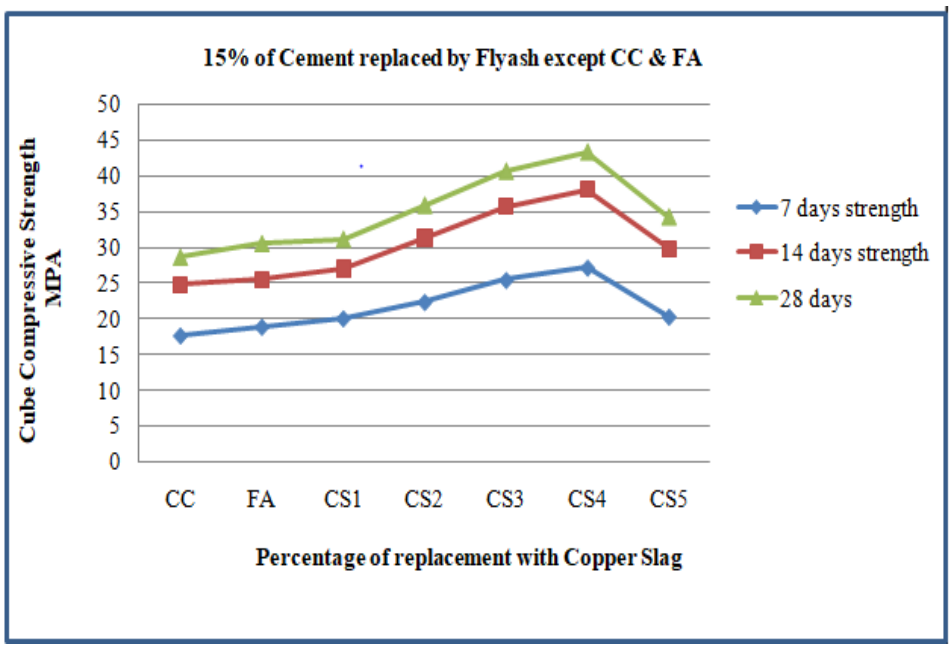

Fig 7: Variation of Cube Compressive Strength

In the above graph the compression strength test, we observe that at 40% we get the maximum value , later on increasing the replacement of copper slag at 50%, the strength was reduced but the values strength attained for 40% was greater than the nominal mix design value.

Case:2 Copper slag added to Cylinders

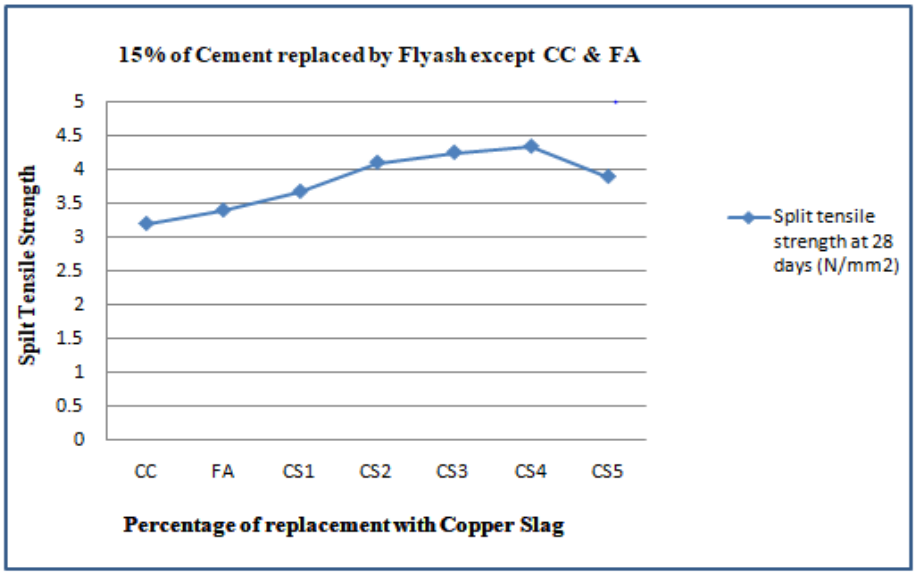

Fig 8: Variation of Compressive Strength for Spilt Tensile Strength

The Split tensile strength test the cylinders are placed for 28 days water curing and after that it was tested on UTM machine. The results observed that at 40% it has highest strength and later on increasing the percentage the split tensile strength was reduced.

Case:3 Copper slag added to Beams

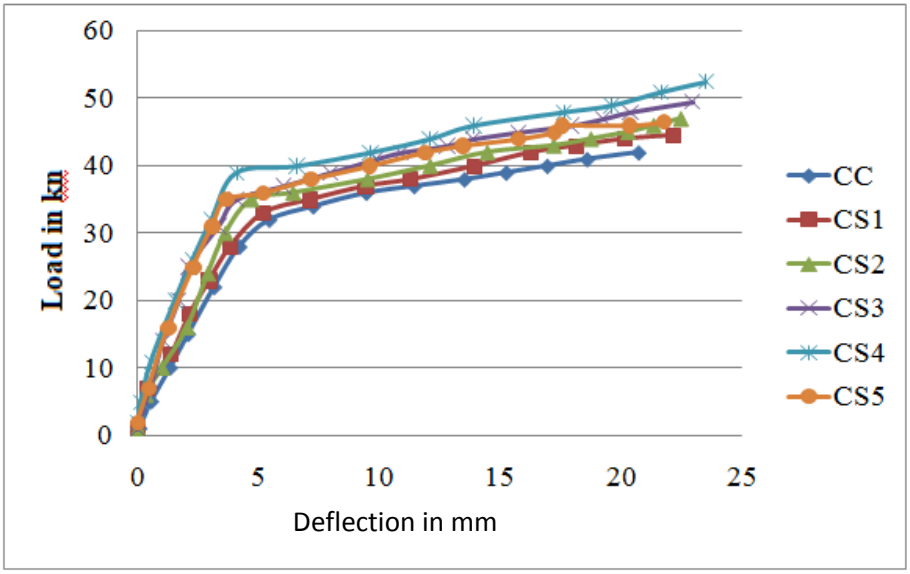

Fig. 9 variation of compressive strength for Flexural strength test

Flexural test , the beams are casted of 1500mm * 150mm * 150mm size and that are also placed for 28 days water curing, after that it was tested in UTM which has one point load at the centre. In the graph we can see that at 40% the height value observed and later on increasing the percentage of ceramic waste the flexural strength was reduced.

VI CONCLUSIONS

- The partial substitution of fly ash and copper slag in cement and fine aggregate reduced the cost of making concrete.
- The addition of fly ash and copper slag has improved the compressive strength, split tensile strength and flexural behaviour of concrete.
- The compressive strength and split tensile strength for 40% and 15% replacement of copper slag and fly ash by sand and cement increases 51.22% and 35.94% compared to the control mix.

- The compressive strength and split tensile strength for 15% of cement replaced by fly ash increases 6% compared to the control mix.
- The flexural behaviour of RCC beams results showed that the ultimate load carrying capacity of the beam increases by 25% for 40% and 15% replacement of copper slag and fly ash.
- Addition of up to 40% of copper slag as sand replacement yielded comparable
- strength with that of the control mix. However, further addition of copper slag caused reduction in the strength due to an increase of the free water content in the mix.
- Fly ash helps to fill voids between aggregates and improve the bond strength.
- The stiffness value and deflection ductility value showed an increase of 23.50% and 52.50% for 40% and 15% replacement of copper slag and fly ash.
- It was observed that the fly ash, copper slag admixed RCC beams showed an increase in energy absorption values.

VII REFERENCES

[1] Khalifa S. Al-Jabri, Abdullah H. Al-Saidy, Ramzi Taha (2010) "Effect of copper slag as a fine aggregate on the properties of cement mortars and concrete", Journals of Construction and Building Materials, Vol.25 pp.933–938.

[2] Al-Jabri.K.S, Taha.R.A, Al-Hashmi.A, Al-Harthy .A.S (2005). " Effect of copper slag and cement by-pass dust addition on mechanical properties of concrete", Journals of Construction and Building Materials, Vol. 20, pp.322–331.

[3] Hossain .K, Lachemi.M, "Strength, durability and micro structural aspects of high performance volcanic ash concretre", Vol 37, pp 759-766, 2007M

[4] Ibrahim Turkmen ,Mehmet Gavgali, Rustem Gul(2002) " Influence of mineral admixtures on the mechanical roperties and corrosion of steel embedded in high strength concrete, Materials letters, Vol 57, pp 2037-2043, 2002.

[5] Jayasankar.R, Mahindran.N, Ilangovan.R . "Studies on concrete using fly ash, rice husk ash and egg shell powder" International journal of Civil and Structural Engineering Volume 1, No 3, 2010.

[6] Kayali.O , Zhu.B "Chloride induced reinforcement corrosion in light weight aggregate high strength fly ash concrete", Vol 19, pp 327-336, 2005.

[7] Khalifa S. Al-Jabri, Abdullah H. Al-Saidy, Ramzi Taha (2010) "Effect of copper slag as a fine aggregate on the properties of cement mortars and concrete", Journals of Construction and Building Materials, Vol.25 pp.933–938.

[8] Khalifa S. Al-Jabri, Makoto Hisada, Abdullah H. Al-Saidy , S.K. Al-Oraimi (2009) "Performance of high strength concrete made with copper slag as a fine aggregate",Journals of Construction and Building Materials, Vol.23 , pp.2132–2140.

[9] Malek Batayneh, Iqbal Marie, Ibrahim Asi (2006). "Use of selected waste materials in concrete mixes" Waste Management, Vol. 27, pp.1870–1876.

[10] Mobasher.B, Devaguptapu. R, Arino.A.M (2001) " Effect of Copper slag on the hydration of Blended Cementitious mixtures" ASCE, Materials Engineering Conference, Materials for the New Millenium, ed. K. Chong, pp. 1677-86, 1996.

[11] Mostafa Khanzadi, Ali Behnood. (2009). "Mechanical properties of high-strength concrete incorporating copper slag as coarse aggregate". Construction and Building Materials 23 (2009) 2183–2188.

[12] Najimi.M, Sobhani,J, Pourkhorshidi.A.J (2010). "Durability of copper slag contained concrete exposed to sulfate attack", Journals of Construction and Building Materials, Vol.25,pp.1895–1905.