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A study on development of concrete using copper slag with silica fume

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ABSTRACT

The present study will provide a better understanding of mechanical and durability properties of concrete in which fine aggregate is partially replaced with copper slag. In the present experimental study the various strength properties like compressive strength, the tensile strength of concrete and also durability properties like capillary suction absorption test on both ordinary concrete and copper slag Concrete, best copper slag concrete mix is carried out and compared with an ordinary concrete mix for economic and ecological study. In this study different percentage of copper, slag is used. Copper slag as a replacement of fine aggregate in concrete and replaced in the range of 0%, 10%, 20 %, 30%, 40% and 50% by weight of fine aggregate in concrete. It was found that with an increase in the amount of copper slag in concrete up to 30% with increased mechanical properties of concrete. It was also found that durability like acid resistance and capillary suction absorption test conducted for long durability show that addition of copper slag up to 30% certain limit replacement to fine aggregate with less water absorption compare with control mix and less affected with acid attack.

Keywords— *Copper slag, Silica fume, Admixture, Workability, Compressive strength, Split tensile strength, Durability*

1. INTRODUCTION

Nowadays the concrete industry is consuming a lot of natural resources. This causes a lot of damage to the environment and mother earth. So, the less cement and natural aggregates that are used in concrete production, the lower the impact on the environment. The increase in the cost of landfill, scarcity of natural resources for aggregate, encourages the use of construction waste as a source of aggregate a sustainable construction has become a great concern over construction practice at the expense of the future of our planet. This is due to the fact that the construction industry is a massive consumer of natural resources and a huge waste producer as well. The high value of raw material consumption in the construction industry becomes one of the main factors that cause environmental damage and pollution to our mother earth and the depletion of natural and mineral resources.

2. MATERIALS USED

2.1 Cement

Ordinary Portland cement (OPC) from a solitary parcel was utilized over the span of the examination. The physical properties of the concrete are resolved from different tests, fitting in with Indian Standard IS: 1489-1991(Part-1) are recorded in Table 3.1. Every one of the tests was done according to the suggestions of Maybe: 4031-1988. Bond was precisely put away to anticipate weakening in its properties because of contact with the dampness.

2.2 Course aggregate

Crushed angular granite metal from a local source was used as coarse aggregate. The specific gravity was 2.63; the coarse aggregate is defined as that retained on 4.75 mm IS sieve. To increase the density of the resulting concrete mix, the coarse aggregate is frequently used in 20mm sizes.

2.3 Fine Aggregate

IS 383-1970 characterizes the fine total, as the one passing 4.75 mm IS sifter. The fine total is frequently named as a sand measure total. Locally accessible riverbed sand was utilized in the present examination. The sand complies with reviewing Zone – III according to Seems to be: 383– 1970 respectively. The specific gravity was 1.70.

2.4 Copper Slag

Copper slag is a waste product obtained from different copper industry and copper factories. The specific gravity was 2.50. The steel slag conforms to grading Zone – III as per IS 383 – 1970 respectively.

3. RESULT AND DISCUSSION ON EXPERIMENTAL TESTS

3.1 Workability of Concrete Mixes

The workability of concrete mixes was found out by slump test as per procedure is given in chapter 3. w/c ratio was kept constant 0.45 for all the concrete mixes. The workability results of different concrete mixes were shown in Table 1.

Table 1: Workability values for different concrete mixes

Mix no	Description	Slump (mm)
1	100%FA+0% CS+10%SF	116
2	90%FA+10% CS+10%SF	113
3	80%FA+20% CS+10%SF	108
4	70%FA+30% CS+10%SF	103
5	80%FA+40% CS+10%SF	95
6	50%FA+50% CS+10%SF	90

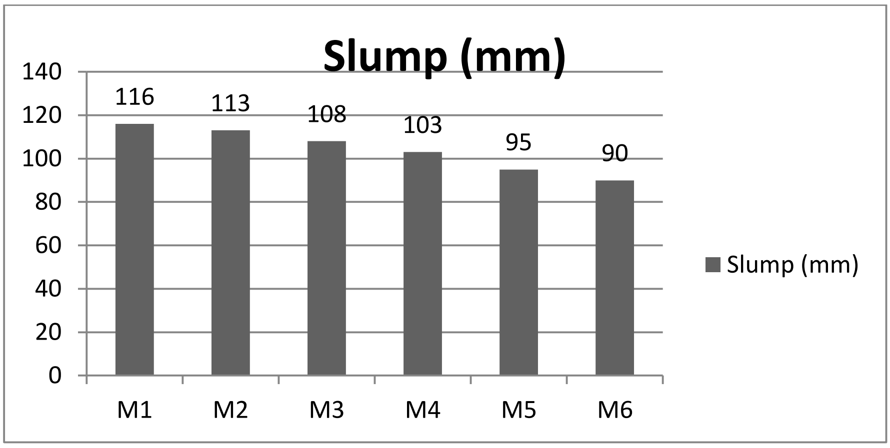

Fig. 1: Slump test results

Table 1 shows that as the addition of copper slag to concrete mix increases, the workability of the concrete mix was found to decreasing as compared to the control mix. The lowest value of slump was obtained with mix 50%FA+50% CS+10%SF and the highest value was obtained with 100%FA+0% CS+10%SF.

3.2 Compressive Strength

The consequences of the compressive quality tests led on solid examples of various blends restored at various ages are introduced and talked about in this area. The compressive quality test was led at relieving ages of 7, 14, 28, 56 and 90 days. The compressive quality test consequences of all the blends at various restoring ages appear in table 2. Variation of compressive strength of all the mixes cured at 7,14,28,56 and 90 days are also shown in figure 1.

Table 2: Compressive strength (MPa) results of all mixes of concrete at different curing ages

Mix no.	Description	7 days	14 days	28 days	56 days	90 days
1	100%FA+0%CS+10%SF	16.00	20.00	32.27	37.00	40.32
2	90%FA+10%CS+10%SF	17.65	22.15	34.60	39.41	42.12
3	80%FA+20%CS+10%SF	18.82	23.20	35.70	41.40	43.80
4	70%FA+30%CS+10%SF	20.50	25.80	37.23	44.30	46.30
5	60%FA+40%CS+10%SF	19.9	24.5	36.10	43.12	44.56
6	50%FA+50%CS+10%SF	18.20	23.10	34.50	42.28	42.50

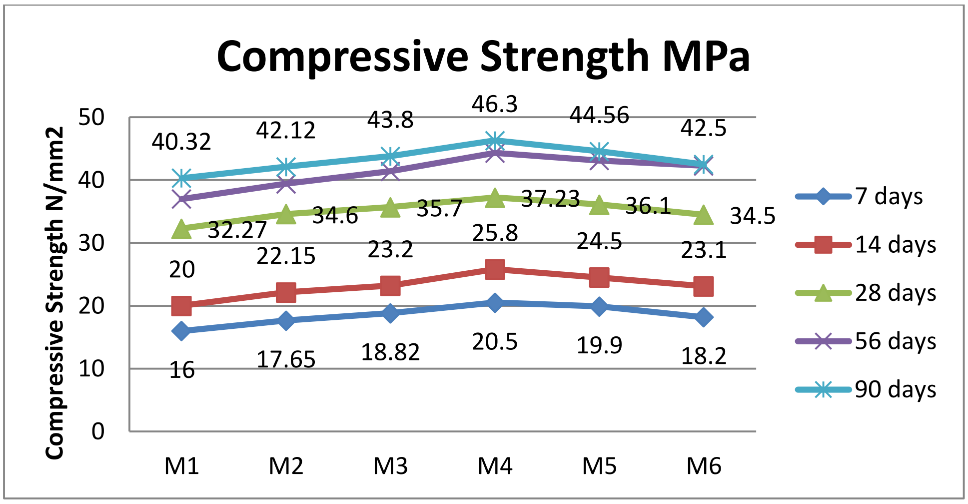

Fig. 2: Compressive strength test results

Table 2 shows that the addition of copper slag 50% replacement by weight of fine aggregate shows a decrease in compressive strength at 28 days concrete compared with control mix of concrete. It can also be observed from Fig 4.1 that the maximum compressive strength at 28 days of curing was obtained for a mix containing 70%FA+30%CS+10%SF. The maximum compressive strength obtained at mix M4 value is 37.23 MPa it is increasing 13.32 % compared with normal mix concrete M1. Finally, the addition of copper slag in concrete compressive strength increasing up to a certain limit after increasing amount of copper slag more than decreasing compressive strength respectively.

3.3 Split Tensile Strength Test Results

The consequences of the part elasticity tests led on solid examples of various blends restored at various ages are exhibited and talked about in this segment. The part rigidity test was led at restoring ages of 7, 14, 28, 56 and 90 days. The splitting tensile strength test results of all the mixes at different curing ages are shown in table 3.Variation of splitting tensile strength of all the mixes cured at 7, 14, 28, 56 and 90 days.

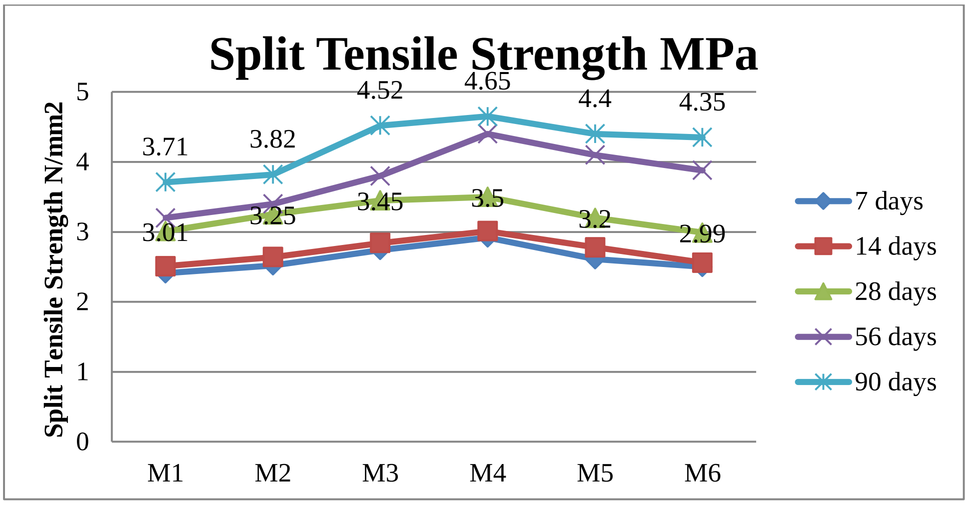

Fig. 3: Split test results

Figure 3 shows that the splitting tensile strength test results of copper slag concrete show The maximum value of splitting tensile strength obtained for content 70%FA+30% SS+5%SF mix was 3.50 MPa and 4.65 MPa at 28 and 90 days respectively. The lowest split tensile strength was obtained by 50%, copper slag mix which is 2.99 and 4.35MPa at 28 and 90 days respectively.

4. CAPILLARY SUCTION ABSORPTION TEST RESULTS

Sorptivity is defined as the rate of movement of a waterfront through a porous material under capillary action. Sorptivity test differs from the ISAT as the former measures the rate of capillary suction as opposed to the bulk effect of capillary suction in the latter at a specified time.

Table 3: Average IRA (mm/Sec$^{1/2}$) at 56 and 90 days of curing

Mix no.	Description	Average IRA (mm/Sec$^{1/2}$)	
		56 days	90 days
1	100%FA+0%CS+10%SF	0.0189	0.0171
2	90%FA+10%CS+10%SF	0.0172	0.0152
3	80%FA+20%CS+10%SF	0.0155	0.0147
4	70%FA+30%CS+10%SF	0.0140	0.0130
5	60%FA+40%CS+10%SF	0.0162	0.0151
6	50%FA+50%CS+10%SF	0.0201	0.0195

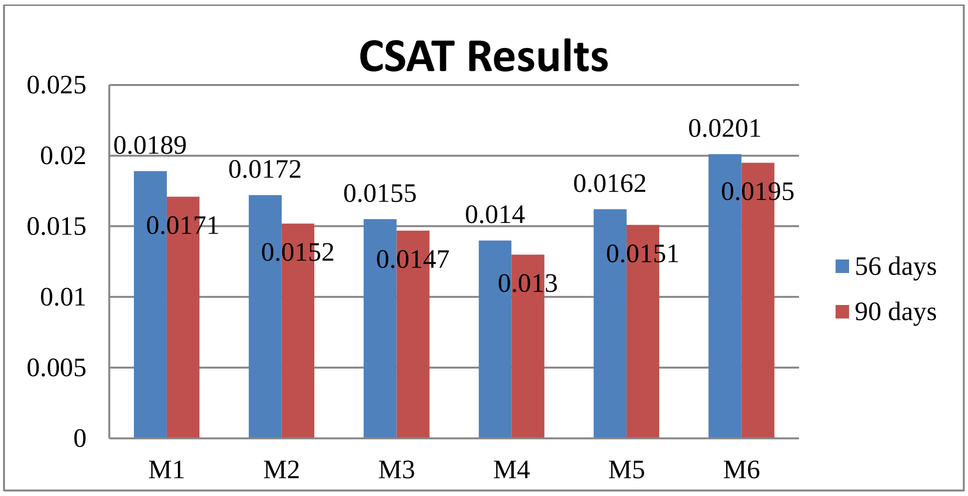

Fig. 4: CSAT Results

The table shows the variation in the IRA value of concrete mixes at different curing ages. The lowest IRA value was obtained with a mix containing 70%FA+30%CS+10%SF for all curing ages, whereas mix containing 50%FA+50%CS+10%SF give the maximum value at all curing ages. Mix with 70%FA+30%CS+10%SF show less absorption value 0.0140 and 0131 Average IRA (mm/Sec$^{1/2}$) at 56 days and 90 days out of all the mixes and mix with 50%FA+50%CS+10%SF show high absorption value at both 56 and 90 days.

5. CONCLUSIONS

- It was observed that as the addition of copper slag to concrete mix increases, the workability of the concrete mix was found to decreasing as compared to the control mix. The lowest value of slump was obtained with mix 50%FA+50%
- CS+10%SF and the highest value was obtained with 100%FA+0% CS+10%SF
- It was observed that the addition of copper slag in concrete with increasing compressive strength as well as tensile strength as compared to control. Further copper slag replacement with fine aggregate up to 30% at obtained better results compare to another mix. The percentage of copper slag increasing with decreasing compressive strength as well as tensile strength.
- It was observed that in concrete containing more copper slag was found to absorption more water compare to ordinary concrete. It was observed that at optimum dosage i.e at 10-30% replacement of copper slag with fine aggregate concrete is minimum water absorption capacity of concrete compare to control mix finally increasing percentage copper slag in concrete water capacity is more compared to control mix.
- The durability of concrete from the aspect of resistance to acid attack on concrete increases by adding copper slag in concrete. The optimum value of copper slag for resistance to acid attack was 10-30% by weight of the fine aggregate.
- The concrete containing 30% copper slag by weight of fine aggregate shows a less capillary rise in concrete.

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