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USE OF COPPER SLAG AS PARTIAL REPLACEMENT MATERIAL FOR RIVER SAND IN CONCRETE (SPLIT TENSILE STRENGTH)

Varun bhati
Environmental Engineer, Guest faculty, MBM University

ABSTRACT- Owing to the restrictions imposed by Ministry of Environment and non-availability or shortage of river sand, there is a need to find the new alternative material to replace the river sand such that excess river erosion and harm to environment is prevented. Utilization of industrial waste materials in concrete compensates the lack of natural resources, solving the disposal problem of waste and to find alternative technique to safeguard the nature. This research aims to study the effect of copper slag as partial replacement of fine aggregate with 0%, 10%, 20%, 30%, 35%, 40%, 45% and 50% by weight of copper slag in concrete. Split tensile strength of concrete cylinders for various replacement proportions with copper slag were find out and from that optimum replacement proportion was determined separately.

INTRODUCTION- One of the fast depleting resources is the natural river sand, the cost of which made the construction costlier in the recent times. The continuous quarrying lowers the ground water table which directly checks the greenery of the land. In order to reduce dependence on natural aggregates as main source of aggregates in concrete, the artificial aggregate generated from industrial wastes provide an alternative for the construction industry. Out of various available alternative materials, the use of copper slag in concrete provides potential environmental as well as economic benefits for all related industries, particularly in places where copper slag is produced.

Slag is the glass like by-product left over after a desired metal has been separated from its raw ore. It can be also defined as "Waste content of metal ores that floats on the surface during the process of extracting or refining metal". Presently worldwide around 33MT of copper slag is generated yearly amongst that India contributes 6.0–6.5 million tons per year. For every ton of copper produced, roughly 3 tons of copper slag gets generated (Goraietal. 2002). Copper slag is a by-product obtained during the matte smelting and refining of copper.

METHODOLOGY AND MATERIAL USED- The concrete mix of M20, M25, M30 grade were made as per the guidelines given in the Indian standards IS: 456 (2000). The slag was added to the mix by the weight of fine aggregate. Mix Proportion of M20 grade 1:1.5:3 (w/c 0.5), Mix Proportion of M25 grade 1:1:2 (w/c 0.5), Mix Proportion of M30 grade 1:1.53:2.53 (w/c 0.45),**.** The three numbers of specimens in each sample were tested and the average value was calculated.

All the dry mixing material like cement, fine aggregate, copper slag, coarse aggregate were put down in the container before the water was added. Manual hand mixing was done. The environment which is provided for the proper hydration of cement paste in cement concrete called as curing of concrete. This process improve strength and impermeable nature of concrete. After 24 hours, all the prepared specimens were immediately put into the curing tank for a period of 7, 28 days. Room temperature maintained throughout the curing.

Cement- The ordinary Portland cement (OPC) of 43 grade was used for casting the specimens of all the concrete mixes. Cement was free from the moisture and also free from any hard lumps. The cement was of uniform grey colour.

Fine Aggregates- Fineness modulus for fine aggregate generally ranges from 2.2 to 3.2.

The results of sieve analysis test were compared with the IS: 383-2016 code and it belongs to the zone II.

Table 1: Sieve analysis of fine aggregate

Sieve Size (mm)	Weight Retained (gm)	Percentage Retained	Cumulative % Retained	% Passing	% Passing as per IS 383
4.75	21	2.1	2.1	97.9	90-100
2.36	39	3.9	6	94	75-100
1.18	172	17.2	23.2	76.8	55-100
.600	353	35.3	58.5	41.5	35-59
.300	261	26.1	84.6	15.4	8-30
.150	133	13.3	97.9	2.1	0-10
PAN	19	0.0	0.0	0.0	
Total	1000		FM = 2.72		

Figure 1: Particle size distribution curve -fine aggregate

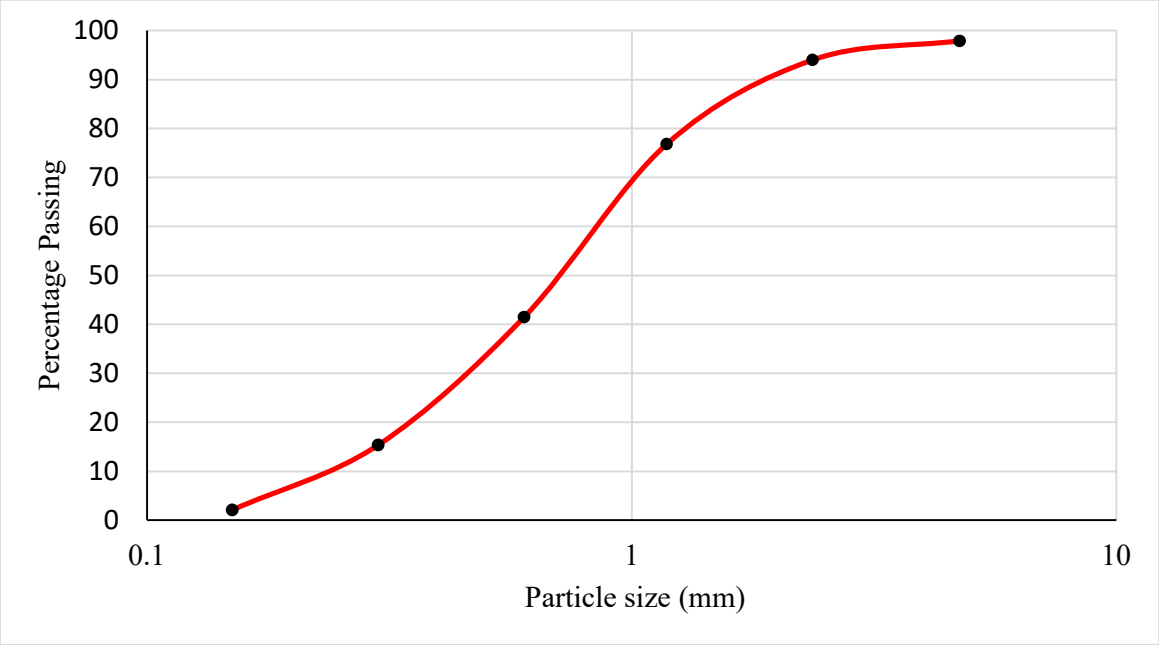


Table 2: Physical properties of fine aggregate

Test particulars	Results
Specific gravity	2.61
Fineness modulus	2.72
Bulk density (kg/litre)(Rodded)	1.58
Water absorption (%)	1.2

Coarse Aggregate-

The 20 mm size of coarse aggregate were used in this study. It should be angular in shape which shows good inter locking properties. Fineness modulus for coarse aggregate generally ranges from 6 to 8.

Table 3: Sieve analysis of Coarse aggregate

Sieve Size (mm)	Weight Retained (gm)	Percentage Retained	Cumulative % Retained	% Passing	% Passing per IS 383
40	0	0	0	100	100
20	90	3	3	97	85-100
10	2885	96.16	99.16	0.84	0-20
4.75	25	0.833	99.99	0.007	0-5
PAN	0	0.0	0.0	0.0	
Total	3000		FM=6.73		

Table 4: Physical properties of Coarse aggregate

Test particulars	Results
Specific gravity	2.72
Fineness modulus	6.73
Water absorption (%)	0.60
Bulk density(kg/litre)(Rodded)	1.56

Copper slag- Copper slag is obtained from SYNCO INDUSTRIES LIMITED (Heavy industrial area) Jodhpur, Rajasthan. Copper slag is crushed into pieces and used as fine aggregates. The results of sieve analysis test were compared with the IS: 383-2016 code and it belongs to the zone II.

Table 5: Sieve analysis of copper slag

Sieve Size (mm)	Weight Retained (gm)	Percentage Retained	Cumulative % Retained	% Passing	% Passing per IS 383
4.75	0	0	0	100	90-100
2.36	71.2	7.12	7.12	92.88	75-100
1.18	343	34.3	41.42	58.58	55-100
.600	176.2	17.62	59.04	40.96	35-59
.300	214.4	21.44	80.48	19.52	8-30
.150	120	12	92.48	7.52	0-10
PAN	5.2	0.0	0.0	0.0	
Total	1000		FM = 2.80		

Figure 2: Particle size distribution curve – copper slag

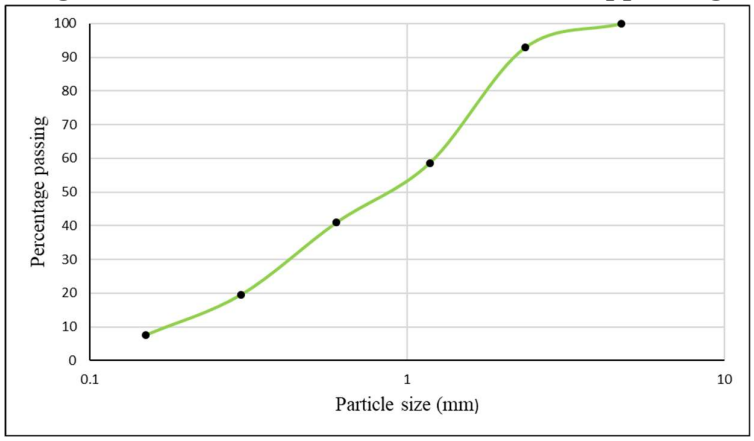
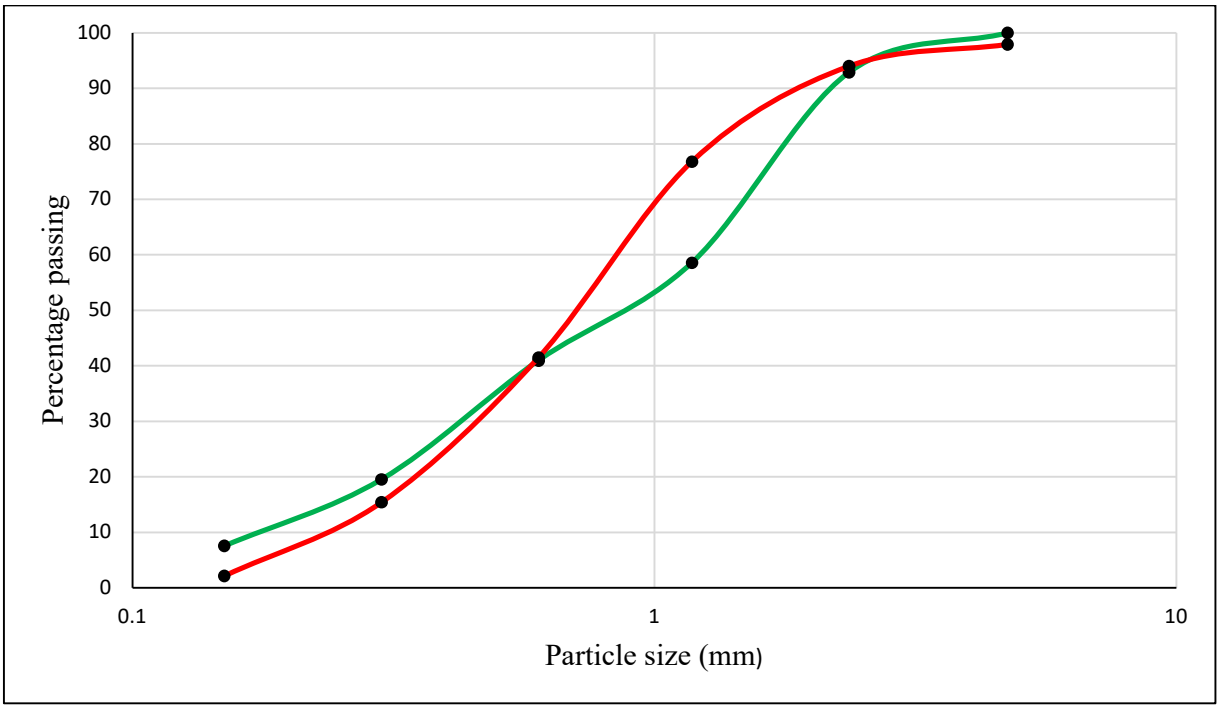


Table 6: Physical properties of copper slag

Test particulars	Results
Specific gravity	2.95
Fineness modulus	2.80
Bulk density (kg/litre) (Rodded)	1.65
Water absorption (%)	0.8

Comparison of River Sand and Copper Slag properties The figure below shows the curve between river sand and copper slag.

Figure 3: Particle size distribution curve - River sand v/s copper slag



Water-

Water was taken from the same source throughout the investigation. It was free from impurities, salt and other toxic substances. It was used for mixing, casting and curing the concrete specimen as per IS: 456-2000.

ANALYSIS AND RESULTS-

In this investigation, specimens of size 300mm × 150 mm concrete cylinder were cast for Split tensile strength.The compression testing machine (CTM) was used for testing specimens. All

the specimens were subjected to the compressive axial load without shock and increased continuously until the failure of specimen and no greater load can be sustained.

Table 7: Split tensile strength of concrete cylinders for 7 and 28 days of curing (N/mm^2)

River sand(%)	Copper slag(%)	M20		M25		M30	
		7days	28days	7days	28days	7days	28days
100%	0%	1.45	2.21	1.69	2.63	1.88	2.92
90%	10%	1.5	2.3	1.74	2.73	1.97	3.01
80%	20%	1.64	2.54	1.93	3.01	2.16	3.34
70%	30%	1.69	2.58	2.02	3.1	2.21	3.39
65%	35%	1.74	2.68	2.07	3.2	2.3	3.57
60%	40%	1.78	2.73	2.11	3.29	2.4	3.71
55%	45%	1.73	2.63	1.97	3.11	2.26	3.53
50%	50%	1.59	2.49	1.93	3.06	2.21	3.43

Figure 4: Graph comparing Split tensile strength of concrete cylinder for 7 and 28 days (M20)

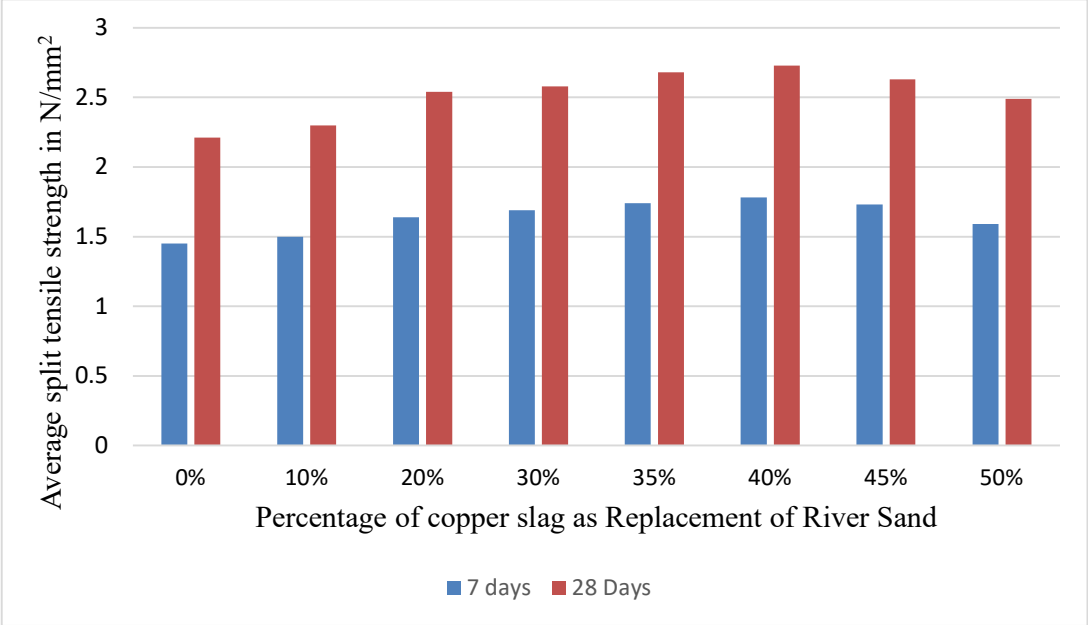


Figure 5 : Graph comparing Split tensile strength of concrete cylinder for 7 and 28 days (M25)

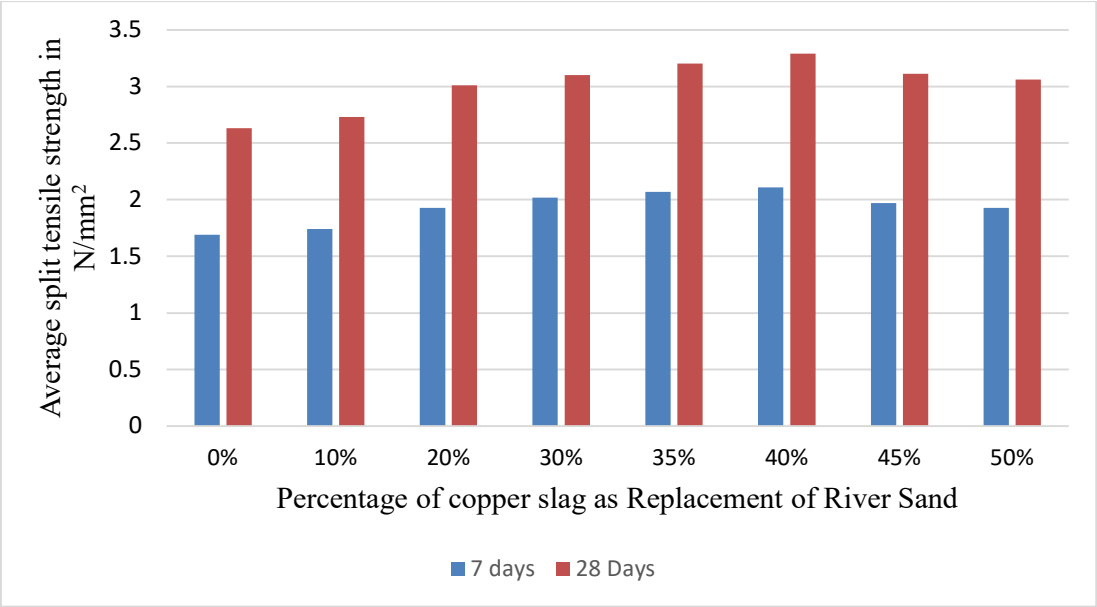
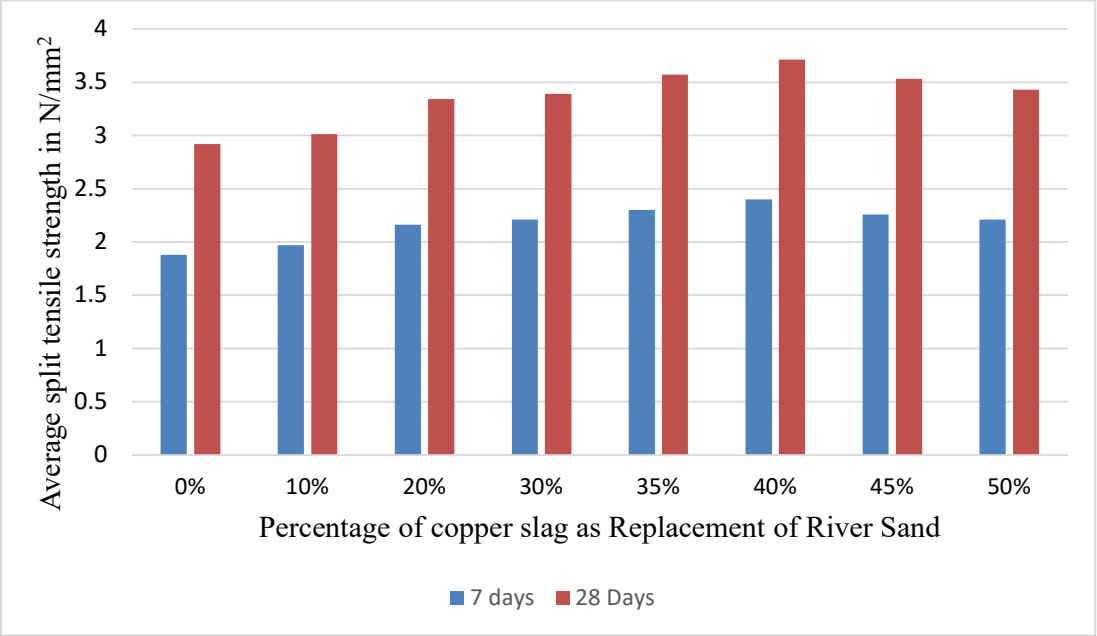


Figure 6 : Graph comparing Split tensile strength of concrete cylinder for 7 and 28 days (M30)



RESULTS-

M20- The increment in Split tensile strength for 7 days curing is 3.44% for 10% copper slag replacement, 13.10% for 20% copper slag replacement, 16.55% for 30% copper slag replacement, 20% for 35% copper slag replacement, 22.75% for 40% copper slag replacement, 19.31% for 45% copper slag replacement and 9.65 % for 50% copper slag replacement.The increment in Split tensile strength for 28 days curing is 4.07% for 10% copper slag replacement, 14.41% for 20% copper slag replacement, 16.74% for 30% copper slag replacement, 21.26% for 35% copper slag

replacement, 23.52% for 40% copper slag replacement, 18.46% for 45% copper slag replacement and 12.82% for 50% copper slag replacement.

M25- The increment in Split tensile strength for 7 days curing is 2.95% for 10% copper slag replacement, 14.20% for 20% copper slag replacement, 19.52% for 30% copper slag replacement, 22.48% for 35% copper slag replacement, 24.85% for 40% copper slag replacement, 16.56% for 45% copper slag replacement and 14.20 % for 50% copper slag replacement.The increment in Split tensile strength for 28 days curing is 3.80% for 10% copper slag replacement, 14.44% for 20% copper slag replacement, 17.87% for 30% copper slag replacement,21.67% for 35% copper slag replacement, 25.09% for 40% copper slag replacement, 18.25% for 45% copper slag replacement and 16.34% for 50% copper slag replacement.

M30- The increment in Split tensile strength for 7 days curing is 4.78% for 10% copper slag replacement, 14.89% for 20% copper slag replacement, 17.55% for 30% copper slag replacement, 22.34% for 35% copper slag replacement, 27.65% for 40% copper slag replacement, 20.21% for 45% copper slag replacement and 17.55% for 50% copper slag replacement.The increment in Split tensile strength for 28 days curing is 3.08% for 10% copper slag replacement, 14.38% for 20% copper slag replacement, 16.09% for 30% copper slag replacement, 22.48% for 35% copper slag replacement, 27.05% for 40% copper slag replacement, 20.89% for 45% copper slag replacement and 17.69% for 50% copper slag replacement.

CONCLUSION-

1. Fineness modulus for river sand generally ranges from 2.2 to 3.2. When the experiment was performed fineness modulus for river sand was 2.72 and for copper slag was 2.80.The specific gravity of river sand generally ranges from 2.5 to 3. When the experiment was performed specific gravity of river sand was 2.61 and for copper slag was 2.95. Water absorption for river sand generally ranges from 0.3% to 2.5%. When the experiment was performed water absorption for river sand was 1.2% and for copper slag was 0.80%. Bulk density (rodded) for river sand generally ranges from 1.45- 1.65kg/m^3. When the experiment was performed bulk density (rodded) for river sand was 1.58 kg/lt and for copper slag was 1.65 kg/lt. Therefore the physical properties such as fineness modulus, specific gravity, water absorption and bulk density of copper slag were almost similar to the properties of natural river sand.
2. Copper slag particles are angular in shape having sharp edges and rough texture. This property makes in better interlocking between particles.
3. Split tensile strength of concrete cylinders increases with increase in percentage of copper slag up to 40% by weight of river sand.

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