Impact of Copper Slag and Waste Glass Powder Replacement for Fine Aggregate in Normal Mix Concrete

Hemant Kumar[1], Dr. J. P. Tegar[2], Nitin Verma[3]

[1]P.G. Scholar, [2]Proffesor, [3]P.G. Scholar,

Department of Civil and Environmental Engineering, NITTTR, Bhopal (M.P.) India

Abstract – In order to make concrete industries sustainable, the use of waste materials in place of natural resources is one of the best alternatives. The environmental and economic concern is the biggest challenge construction industries facing. The research work investigation was conducted to study the viability of using copper slag and waste glass powder as an alternative material for partial replacement of fine aggregate in preparation of concrete mix. Fine aggregate were replaced by copper slag and waste glass powder as 10%, 20%, 30%, 40%, 60% and 80% by weight for concrete mix of M20 grade with water cement ratio 0.5. The fresh concrete were tested for workability and concrete specimen were tested for compressive strength at 7, 14 and 28 days of age and the results obtained were compared with control concrete mix. The results concluded that the workability of fresh concrete increase as the percentage of copper slag and waste glass powder increases. The compressive strength of concrete specimen increases up to 40% replacement level and highest compressive strength achieved at 20% replacement of fine aggregate with copper slag and waste glass powder. The density of concrete cubes also increases up to 40% replacement beyond that it starts decreasing.

Keywords - Concrete, Copper slag, Compressive strength, Fine aggregate, Waste glass powder.

I. INTRODUCTION

Initiatives are developing worldwide to control and manage the supervision of byproducts, residuals and industrial waste in order to preserve the environment from contamination. Utilization of industrial waste or secondary materials has encouraged in construction industries for the production of concrete because it contribute to reducing the consumption of natural resources and also minimize the adverse environmental effects with disposal of these wastes. Harmful effect of concrete can be minimizing by producing good and durable concrete by using industrial byproduct. The sustainable for construction involve the use of nonconventional and innovative materials, and recycling of waste materials in order to compensate the scarcity of natural resources and to find alternative ways of conserving the environment (Jaypal Naganur et al 2014). Copper slag is one of the materials that are considered as a waste material which could have a promising future in construction industries as partial or full substitute of either cement or aggregate (Arivanlagan S. 2013). Suresh T. et al (2015) reported that concrete containing copper slag as fine aggregate displayed similar mechanical properties as conventional concrete containing sand. Madhavi et al (2015) have studied the mechanical properties of concrete containing copper slag as replacement for fine aggregates. They observed that addition of copper slag improved the mechanical strength of concrete. In India 0.7% of total urban waste enervated comprises of glass (D. Elavarasan et al 2016). Glass is an inert material which could be recycled and used many times without changing its chemical properties (R. Ramasubramani 2016). The quantities of waste glass have been on the rise in recent years due to an increase in the standard of living. Unfortunately the majority of waste glass is not being recycled but rather abandoned and is therefore the cause of certain serious problems such as waste of natural resources and environmental problem (Bhandari P. S. 2014). Chirag V. et al (2015) studied the properties of concrete containing crushed waste glass particles as fine aggregates. They have observed that the inclusion of waste glass powder improved the strength and workability of concrete. M. S. Kuttimarks (2014) investigated the properties of concrete containing waste crushed glass as replacement of sand and fly ash as replacement of cement. The compressive strength of the waste glass and fly ash concrete mix of M40 grade of concrete after 7 & 14 days shows an increment. This paper presents the study of the effect of copper slag and waste glass powder as partial or full replacement of fine aggregate in concrete. In this research work workability and compressive strength of concrete was investigated for the various proportion of copper slag and waste glass powder as a sand substitute in concrete.

II. SELECTION OF MATERIALS

1. Cement-

Ordinary Portland cement (ultra tech) of 53 grade having specific gravity of 3.15 has been used. The initial setting time and final setting time of cement were found to be 48min and 310min respectively.

2. Aggregates-

Gravels of 20mm maximum size and 10mm minimum size were used as a coarse aggregate. Mostly natural river sand passing through 4.75 mm I.S. Sieve was used as fine aggregates.

Table-1 Properties of Aggregates

S. No.	Properties	Coarse Aggregate	Fine Aggregate
1-	Specific Gravity	2.66	2.63
2-	Fineness Modulus	2.55	2.93
3-	Bulk Density	1585	1645
4-	Water absorption (%)	0.64	0.94

3. Copper Slag-

Copper Slag is a by-product produced during the matte smelting and refining of copper. It has been estimated that about 2.2-3 tons of slag are generated for every ton of copper production. The physical properties of copper slag are tabulated below. (Fig. 1)

Table-2 Properties of Copper Slag

S. No.	Specification	Values
1-	Specific Gravity	3.62
2-	Fineness Modulus	3.26
3-	Bulk Density	1886
4-	Water absorption (%)	0.3

4. Waste Glass Powder-

Glass is a common product that can be found in different forms: jars, bottles, bulbs, windows and windshields, sheets etc. Glass powder is prepared by crushing the collected waste glass using Los Angeles abrasion testing machine. (Fig. 2)

Table-3 Properties of Waste Glass Powder

S. No.	Properties	Values
1-	Specific Gravity	2.7
2-	Fineness Modulus	2.55
3-	Bulk Density	1310
4-	Water absorption (%)	0.4

5. Water-

Potable fresh water available from local sources free from deleterious materials was used for mixing as well as for curing of all the mixes tried in this investigation.

Fig-1 Copper Slag

Fig-2 Waste Glass Powder

III. SIEVE ANALYSIS OF MATERIALS

The details of sieve analysis of Sand, Copper slag and Waste Glass Powder are given in Table-4.

Table-4 Sieve Analysis of Sand, Copper Slag & Glass Powder

S. No.	Sieve Size (mm)	Cumulative Percentage Passing (%)		
		Sand	Copper Slag	Glass Powder
1	4.75	99.2	100	100
2	2.36	94.4	94.96	100
3	1.18	71.42	57.2	68.17
4	600µm	35.94	17.43	42.39
5	300µm	4.7	3.73	24.63
6	150µm	0.64	1.17	9.63

IV. MIX PROPORTION

The mix proportion for M20 grade concrete used in this experiment are carried out according to IS: 10262-1982. The mix proportion obtained and the quantity of materials required for one cubic meter of concrete is given in Table-5.

Table-5 Mix Proportion for M20 Concrete

Mixes	Raw Materials (kg/m³)					
	W/C Ratio	Cement	Sand	Aggregate	Copper slag	Glass Powder
0%	0.5	386	648	1273	0	0
10%	0.5	386	583	1273	33	33
20%	0.5	386	519	1273	65	65
30%	0.5	386	454	1273	97	97
40%	0.5	386	389	1273	130	130
60%	0.5	386	260	1273	195	195
80%	0.5	386	130	1273	260	260

V. RESULTS AND DISCUSSION

Workability-

The slump test conducted as per IS: 1199-1959 to determined the workability of fresh concrete mix having different percentage of copper slag and waste glass powder as 0%, 10%, 20%, 30%, 40%, 60% and 80%. During the whole research work water to cement ratio was kept 0.5 and no extra amount of water is added to get slump. From the results, it was concluded that as the percentage of copper slag and waste glass powder increases in the concrete mix of M20 grade slump value may also increased. The results are tabulated below in Table 6 and represented graphically in Figure 3.

Compressive Strength-

Total 63 cubes were prepared for the 7th, 14th, & 28th day testing with 0%, 10%, 20%, 30%, 40%, 60% and 80% constant replacement of fine aggregate by copper slag and waste glass powder. Compressive strength test were carried out as per IS: 516-1959. The cube samples of size 150x150x150 mm were prepared and tested at 7, 14 and 28 days of curing in water. Three samples were tested at each curing ages. The Test results obtained after different curing age are shown in Table 7 and graphical represented in Figure 4. From the test results, it can be concluded that the compressive strength of concrete with 10%, 20%, 30%, and 40% replacement of fine aggregate with copper slag and waste glass powder were higher than the control mix. Highest compressive strength was achieved by 20% replacement of copper slag and waste glass powder, which was found about 46.18 N/mm2 compared with 38.13 N/mm2 for the control mix after 28 days of curing. This means that there is an increase in the strength of almost 21% compared to the control mix at 28days. Mixture with 80% replacement of fine aggregate gave the lowest compressive strength 36.97 N/mm2 compared with 38.13 N/mm2 for control mix.

Density-

The density of concrete cubes is significantly higher in all percentage replacement of fine aggregate with copper slag and waste glass powder compared to conventional concrete. The maximum density of concrete cubes achieved at the percentage level of 40 %. The density of concrete cubes are given in Table 8 and graphically represented in Figure 5.

Table-6 Slump Cone Test Results

Samples	Replacement of sand with copper slag and waste glass powder (%)	Slump Value (mm)
H1	0	30
H2	10	40
H3	20	45
H4	30	50
H5	40	60
H6	60	65
H7	80	75

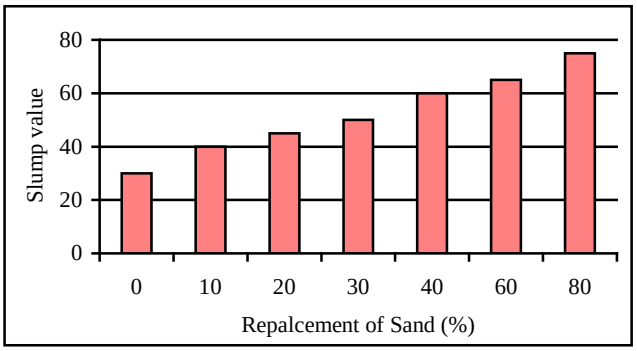

Fig-3 Slump Values

Table-7 Compressive Strength Test Results

Replacement of Sand (%)	Compressive Strength (N/mm2)		
	7 days	14 days	28 days
0	28.42	33.76	38.13
10	32.80	38.53	42.53
20	33.71	42.18	46.18
30	31.43	41.13	44.43
40	28.44	38.69	41.54
60	28.36	32.98	37.88
80	24.50	31.54	36.97

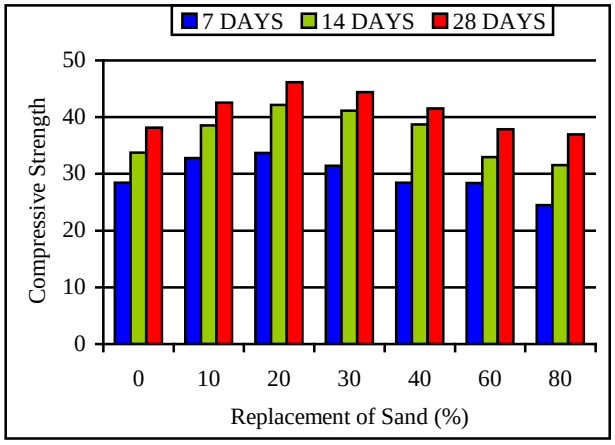

Fig-4 Compressive Strength of Concrete

Table-8 Density of Concrete Cubes

S. No.	Replacement of sand (%)	Density (Kg/m³)
1	0	2232.47
2	10	2252.27
3	20	2323.20
4	30	2325.27
5	40	2336.33
6	60	2332.47
7	80	2278.53

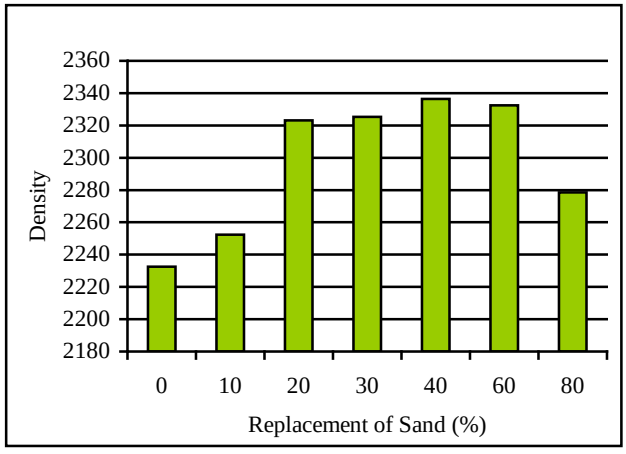

Fig-5 Density of Concrete Cubes

VI. CONCLUSION

The results shows that the copper slag and waste glass powder as fine aggregate in concrete have significantly higher compressive strength compare to conventional concrete. It was found that fine aggregate can be replaced with composition of copper slag and waste glass powder with maximum limit of 40%. But result shows that maximum compressive strength of concrete was achieved with 20% replacement of fine aggregate with composition of copper slag and waste glass powder. Slump loss of concrete goes on increasing with increase of quantity of copper slag and waste glass powder. The density of concrete cube is significantly higher in all percentage replacement of fine aggregate with copper slag and waste glass powder compared to conventional concrete. The maximum density obtained at 40% replacement of fine aggregate.

VII. FUTURE WORK

From this experimental study it is clear indicated that using waste glass and copper slag in concrete increases strength. Following parameter will be study in future work-

- ✓ To find out optimum percentage of copper slag and waste glass that can be used in concrete mix for partial or full replacement of fine aggregates without significant loss of strength.
- ✓ To assess the various properties of concrete with different percentage content of copper slag and waste glass.

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