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Assessment of Influence on Compressive Strength of M20 Concrete by Replacing Copper Slag and Waste Glass Powder against Fine Aggregates

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Abstract: Sand is one of the most important constituent for preparation of concrete. Recently for conventional construction huge demand for sand is the major problem. Rapid extraction of sand from river bed creates many problems as decreasing water table, loss of vegetation, erosion of river bed and disturbance to aquatic life. We required a best alternative construction material to fulfill the demand of sand. Some of the waste products as copper slag, waste glass etc have been used as fine aggregate for production of concrete in the construction industries. This paper presents the effect of replacement of copper slag and waste glass powder as fine aggregate in place of sand on the properties of concrete and to find alternative ways conserving the environment and recycling of waste materials. Sand was replaced in M20 grade of concrete with percentages 0%, 10%, 20%, 30%, 40%, 60% and 80% by weight. The tests were conducted for properties of fresh as well as hard concrete. The test results indicated that copper slag and waste glass powder can be effectively used as fine aggregate in structural concrete up to replacement of 40%. The highest compressive strength obtained was 46.18N/mm² for 20% replacement (copper slag 10% & Waste glass powder 10%) after 28 days of curing. The workability of concrete increase as the percentage of copper slag and waste glass increases in the concrete mix.

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

I. INTRODUCTION

Natural resources are depleting worldwide. Large amount of industrial waste and by products accumulated every year in the developing countries. Sustainability and resource efficiency are becoming increasing by most important issues in today's construction industries. Therefore utilization of secondary waste material is being encouraged in construction field. Harmful effect of waste can be reduced by producing good and durable concrete by using waste and by product as copper slag, waste glass etc. recycling is one of the major concern today's modern waste management system. There are three main component of waste management Reduced, Reuse and Recycling. With the help of recycling of materials we reduced the use of fresh raw material and also convert the waste material to useful material. Cement, coarse aggregate and fine aggregate (Sand) are the basic raw material used for preparation of concrete mix. River sand is one of the prime materials used as fine aggregate for preparation of mortar and concrete. The demand of river sand is very high due this shortage of river sand is being felt in many parts of country. Copper slag and waste glass are considered as waste material which could have a promising future in construction industries as partial or full replacement of fine aggregate. The use of waste material in construction field for production of concrete contributes to reducing the consumption of natural resources.

II. MATERIALS USED

A. Waste Materials

(a) Copper Slag

Copper Slag is a by-product produced from the process of manufacturing copper as the copper slag settles

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down in the smelter. Table 1 shows the properties of copper slag and Fig.1 represent copper slag.

TABLE 1
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

Fig.1. Copper Slag

(b) Waste Glass Powder

Glass powder is prepared by crushing the collected waste glass using Los Angeles abrasion testing machine. Table 2 shows the properties of waste glass powder and Fig. 2 represent glass powder.

TABLE 2
PROPERTIES OF WASTE GLASS POWDER

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

Fig.2. Waste Glass Powder

B. Conventional Materials

(a) Cement

Ordinary Portland cement 53 grade of Ultra Tech cement brand conforming to IS: 8112-1989 and IS: 12269-1987 is used in this experimental work. Table 3 shows the properties of cement.

TABLE 3
PROPERTIES OF CEMENT OPC 53

S. No.	Specification	Values
1-	Standard Consistency	32%
2-	Specific Gravity	3.15
3-	Initial Setting Time	48min
4-	Final Setting Time	310min

(b) Fine Aggregate

The aggregate size is lesser than 4.75mm is considered as fine aggregate. Generally locally available clean natural river sand was used. The sand should be free from clay or inorganic materials. Table 4 shows the properties of fine aggregate.

TABLE 4
PROPERTIES OF FINE AGGREGATES

S. No.	Specification	Values
1-	Specific gravity	2.63
2-	Fines modulus	2.93
3-	Bulk density	1645
4-	Water absorption (%)	0.94

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(c) Coarse aggregate

The aggregate size is bigger than 4.75mm is considered as coarse aggregate. Coarse aggregate of 20mm maximum size and 10mm minimum size was used for experimental work. Table 5 shows the properties of coarse aggregate.

TABLE 5
PROPERTIES OF COARSE AGGREGATES

S. No.	Specification	Values
1-	Specific Gravity	2.66
2-	Fineness Modulus	2.55
3-	Bulk Density	1585
4-	Water absorption (%)	0.64

III. EXPERIMENTAL INVESTIGATION

A. Sieve Analysis

The experimental work starts with the sieve analysis of material. IS sieve of varying size are used. The details of sieve analysis are given in Table 6.

TABLE 6
SIEVE ANALYSIS OF SAND, COPPER SLAG & GLASS POWDER

S. No.	Sieve Size (mm)	Cumulative Percentage Passing (%)		
		Sand	Copper Slag	Glass Powder
1	4.75	99.20	100	100
2	2.36	94.40	94.96	100
3	1.18	71.42	57.20	68.17
4	600µm	35.94	17.43	42.39
5	300µm	4.70	3.73	24.63
6	150µm	0.64	1.17	9.63

B. Mix Design and Sample Preparation

The mix proportion for M20 grade concrete used in this experiment are carried out according to IS: 10262-1982. The detailed mix design is presented in the in the appendix. The mix proportion obtained and the quantity of materials required for one cubic meter of concrete is given in Table 7. Concrete mixtures were prepared with different proportion of copper slag and waste glass powder. The proportion (by weight) of copper slag and waste glass powder added to the concrete mixture were as follows- 0%, 10%, 20%, 30%, 40%, 60% and 80%. The control mix design to have a target 28 days compressive strength of 20N/mm² (M20) using a water to cement ratio of 0.5.

TABLE 7
MIX PROPORTION FOR M20 CONCRETE

Mix	PROPORTION BY WEIGHT (kg/m³)					
	W/C Ratio	Cement	Sand	Aggregate	Copper slag	Glass Powder
H1	0.5	386	648	1273	00	00
H2	0.5	386	583	1273	33	33
H3	0.5	386	519	1273	65	65
H4	0.5	386	454	1273	97	97
H5	0.5	386	389	1273	130	130
H6	0.5	386	260	1273	195	195
H7	0.5	386	130	1273	260	260

C. Workability Test

Workability is an important property of fresh concrete which decide easy or difficulty of handling concrete. The workability of concrete depends on many factors as properties of ingredient, temperature, mixing method, admixture etc. Workability of concrete was determined by conducting slump cone test as per IS: 1199-1959 for different percentage variation as 0%, 10%, 20%, 30%, 40% 60% and 80%. (Fig. 3)

D. Compressive Strength Test

Compressive strength is one of most important property of concrete. It is expressed as load per unit area. Method for determining the compressive strength of concrete is to apply load at a constant rate on a concrete cube of standard size 150x150x150 mm until the specimen fails. In this work the compression tests performed accordance with IS: 516-1959 “Methods of tests for compressive strength for concrete” the apparatus used to determine the compressive strength of concrete is Universal

Fig.3. Slump Test

Fig.4. Compression Test

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Testing Machine (UTM). In this research work prepared samples were tested for compressive strength at 7, 14, and 28 days of curing. (Fig. 4)

IV. Results And Discussion

A. Workability

The slump cone test carried out on various samples of concrete of M20 grade and results are given in Table 8 and graphically represented in Fig. 5. During the whole research work water to cement ratio was kept 0.5, no extra amount of water is added to get slump. From the results, it can be seen that as the percentage of copper slag and waste glass powder increases as 10%, 20%, 30%, 40%, 60%, and 80% in the concrete of M20 grade slump value may also increased.

B. Compressive Strength

Compressive strength test were conducted on samples made during at various curing ages. 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. Table 9 shows the compressive strength of the concrete tested and Fig. 6 graphically represents the compressive strength of concrete tested. From the test results it can be observed that the compressive strength of copper slag and waste glass powder concrete mix with 10%, 20%, 30%, and 40% fine aggregate replacement 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 copper slag and waste glass powder gave the lowest compressive strength 36.97 N/mm² compared with 38.13 N/mm² for control mix.

TABLE 8
SLUMP CONE TEST RESULTS

Samples	Replacement of sand (%)	Copper Slag (%)	Glass Powder (%)	Slump Value (mm)
H1	0	0	0	30
H2	10	5	5	40
H3	20	10	10	45
H4	30	15	15	50
H5	40	20	20	60
H6	60	30	30	65
H7	80	40	40	75

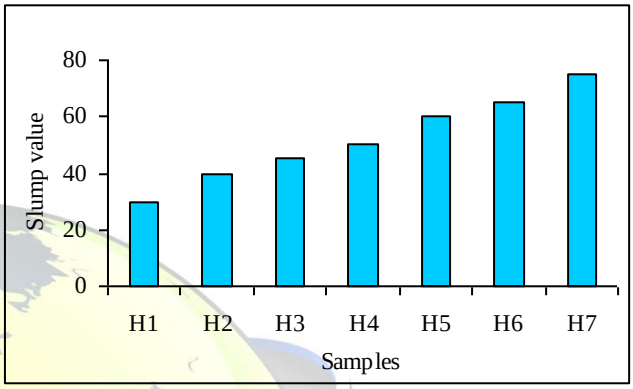

Fig.5. Slump Values

TABLE 9
COMPRESSIVE STENGTH TEST RESULTS

Samples	Replacement of sand (%)	Compressive Strength (N/mm²)		
		7 days	14 days	28 days
H1	0	28.42	33.76	38.13
H2	10	32.80	38.53	42.53
H3	20	33.71	42.18	46.18
H4	30	31.43	41.13	44.43
H5	40	28.44	38.69	41.54
H6	60	28.36	32.98	37.88
H7	80	24.50	31.54	36.97

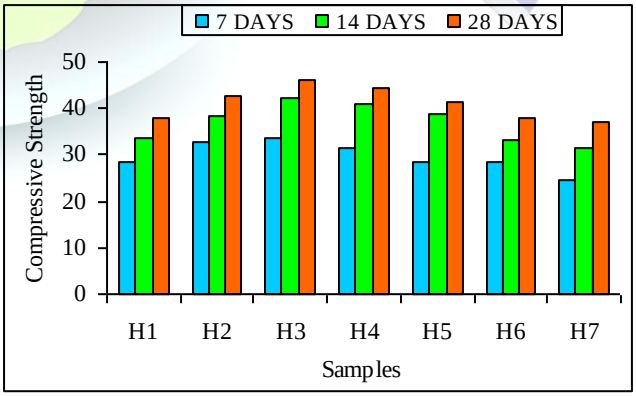

Fig.6. Compressive Strength of concrete

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V. CONCLUSION

1. The workability of concrete increases as the percentage of copper slag and waste glass powder increases in concrete mix, this is because copper slag and waste glass powder do not absorb the water in large proportion.
2. The use of waste glass powder and copper slag as a partial replacement for fine aggregate (sand) increasing up to 40% replacement.
3. Concrete achieved highest compressive strength at 20% replacement of fine aggregate with waste glass powder and copper slag.
4. The use of copper slag and waste glass powder as fine aggregate reduces the consumption of natural river sand as well as cost of construction.

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