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AN EXPERIMENTAL INVESTIGATION OF PARTIALLY REPLACEMENT OF CEMENT WITH GLASS POWDER AND FINE AGGREGATE WITH COPPER SLAG

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Abstract*— Conventional concrete made by some ingredients like water, cement and aggregates. Day to day we need to improvement the property of concrete like strength, workability... For this improvement, we need to find some new alternative materials or find some chemical admixture or partial or full replacement of conventional material. In this experimental investigation, to study the effect of using glass powder and copper slag on the property of concrete. OPC53 cement replaced by waste glass powder and fine aggregate replaced by the copper slag. The range of replacement of glass powder with cement is 5% to 15% with an increment of every 2.5% and the range of replacement of copper slag with fine aggregate is 30% to 50% with an increment of every 5%. These all the mixes will be cast for M30 grade of concrete and tested for workability, compressive strength, tensile strength and flexural strength.

***Keywords*— Cement, Fine aggregate, Waste material, Glass powder, Copper slag, Compressive Strength, Tensile strength, Flexural strength**

I. Introduction

Concrete is one of the most commonly used a construction material composed of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time. Concrete technology deals with the study of properties of concrete and its practical applications. As a result of many developments and improvements in the concrete technology, we need to replace existing sources with a new alternative. The use of waste materials in construction industry has significantly increase in the past few years, due to the fact that they do not have any adverse effects on the properties of concrete and thus provide an effective platform for the disposal of waste material in permanent concrete structures. We have many waste items which are non-usable and used in landfills. We can use these waste materials as an alternative of primary ingredients of concrete without compromise the quality of concrete.

Cement industry has been always among the largest CO_2 emission sources. Almost 5-7% of global CO_2 emissions are caused by cement plants, while 900 kg CO_2 is emitted to the atmosphere for producing one ton of cement. As far as alternative materials are the case, utilizing industrial by-products instead of conventional materials result in the significant emission mitigation. Industrial wastes which can be used as raw material simultaneously mitigate emissions in cement plants and landfills. Hence in this research work the cement will be replaced by the waste glass powder, to reduce the amount of cement will be used and counter the hazardous effects produced by the cement manufacturing by replacement of optimum amount of glass powder. Glass contains high amount of silica content, which has in turn lead to the laboratory studies on the practicality of using waste glass as a raw material in concrete batching to making it a good pozzolanic material.

Now a days consumptions of natural non-renewable ingredients like sand and aggregate is increase day by day because of increasing the demand of concrete. Hence this research work is carried out for optimum replacement of sand by copper slag. Copper slag is an industrial by-product material produced during the process of manufacturing and refining of copper. To produce 1 ton of copper, approximately 2.2 to 3.0 tons copper slag is generated as a by-product material. Worldwide about 33 million tons of copper slag is generating annually. Copper slag is widely used in the sand blasting industry and land reclamation. Copper slag is one of the materials that is considered as a waste material which could have a promising future in the construction industry as partial substitute of either aggregates. Because of the raw Copper slag also has a particle sizes ranging from micrometers to larger than 1 cm in diameter and high strength-to-weight ratio, making it an effective option in concrete.

One of the primary advantages of copper slag is the low risk it poses to health and the environment.

II. Material and Method

A. Material

1) Cement: The Ordinary Portland (OPC) 53 Grade conforming IS 269:2015.

2) Glass Powder : Glass powder was produced by squashing waste glass pieces in crusher factory. Particle size of Waste Glass Powder is < 75 µm.

Table 1 Chemical composition of waste glass powder

Sr. No.	Chemical Properties	Result Obtained
1	Silica as SiO_2	69.38 %
2	Calcium Oxides as CaO	8.23 %
3	Magnesium as MgO	2.94 %
4	Iron as Fe_2O_3	1.22 %
5	Alumina as Al_2O_3	1.94 %
6	Sodium Oxide as Na_2O	9.73 %
7	Potassium Oxide as K_2O	0.41 %
8	Sulphur Trioxide as SO_3	2.12 %

3) COARSE AND FINE AGGREGATE: Coarse aggregate (CA) and Fine aggregate (FA) was used to work conforming IS 383:2016 from Natural source. FA fraction size was 4.75 mm to 150µ, Specific gravity and water absorption was 2.69 and 1% respectively and CA fraction size was 20 mm to 4.75 mm, Specific gravity and water absorption was 2.87 and 0.5% respectively.

4) COPPER SLAG : Copper slag has granular particle with fraction size of 4.75mm to 150 µm and specific gravity is 3.78.

Table 2 Chemical composition of copper slag

Sr. No.	Chemical Properties	Result Obtained
1	Silica as SiO_2	27.94 %
2	Calcium Oxides as CaO	2.71 %
3	Magnesium as MgO	1.68 %
4	Iron as Fe_2O_3	40.96 %
5	Alumina as Al_2O_3	18.87 %
6	Sodium Oxide as Na_2O	0.45 %
7	Potassium Oxide as K_2O	0.37 %
8	Sulphur Trioxide as SO_3	0.83 %
9	Chromium oxide as Cr_2O_3	0.21 %
10	Titanium dioxide as TiO_2	0.19 %

5) WATER AND CHEMICAL ADMIXTURE: The portable water used which pH value not less than 6 as per IS 456: 2000 and High range water reducer (HRWR) chemical admixture also used in this study.

III. METHODOLOGY

In this experimental investigation an attempt has been made to find out the strength of concrete produced by replacing the cement with Glass powder in various percentages ranging from 5% to 15% in increments of 2.5% [0%, 5%, 7.5%, 10%, 12.5%, and 15%] and the range of replacement of copper slag with fine aggregate is 30% to 50% with increment of every 5% [0%, 30%, 35%, 40%, 45%, 50%] compression with Normal concrete. Mix design carried out for M30 grade of concrete as per IS 10262:2009 yielded a mix proportion of 1:1.9:3.3 with water cement ratio of 0.44. Specimens were prepared according to the mix proportion and by replacing cement with glass powder and send with copper slag in different proportion. An increasing trend in compressive strength and flexural strength was observed with increasing replacement of cement and sand. To find out compressive strength, split tensile strength and flexural strength specimens of dimensions 150x150x150 mm, 150mm (d) x300mm and 100x100x500 mm were cast and tested as per IS 516: 2018. Details of mix content with various percentage replacement of cement and sand, is shown in Table 2.

Table 3 Various Mix proportions

Sr. No.	Mix No.	Replacement Percentage			
		Cement	Glass Powder	Sand	Copper Slag
1	Mix 1	100%	0%	100%	0%
2	Mix 2	95.0%	5.0%	100%	0%

3	Mix 3	92.5%	7.5%	100%	0%
4	Mix 4	90.0%	10.0%	100%	0%
5	Mix 5	87.5%	12.5%	100%	0%
6	Mix 6	85.0%	15.0%	100%	0%
7	Mix 7	87.5%	12.5%	70%	30%
8	Mix 8	87.5%	12.5%	65%	35%
9	Mix 9	87.5%	12.5%	60%	40%
10	Mix 10	87.5%	12.5%	55%	45%
11	Mix 11	87.5%	12.5%	50%	50%

IV. Results and Discussion

The All work is carried out in single stages, result of all stage is presented in graphical form. Tests are performed on cubes, beams & cylinders and their 7 days, 14 days & 28 days strengths have been determined. A comparison of strengths for 7 days, 14 days and 28 days are also formulated.

A. **Workability of Concrete Mixes:** The workability of concrete mixes was found out by slump test and compacting factor test Water cement ratio (W/C) was kept constant 0.41 for all the concrete mixes. The workability results of different concrete mixes were shown in Figure 1 & 2.

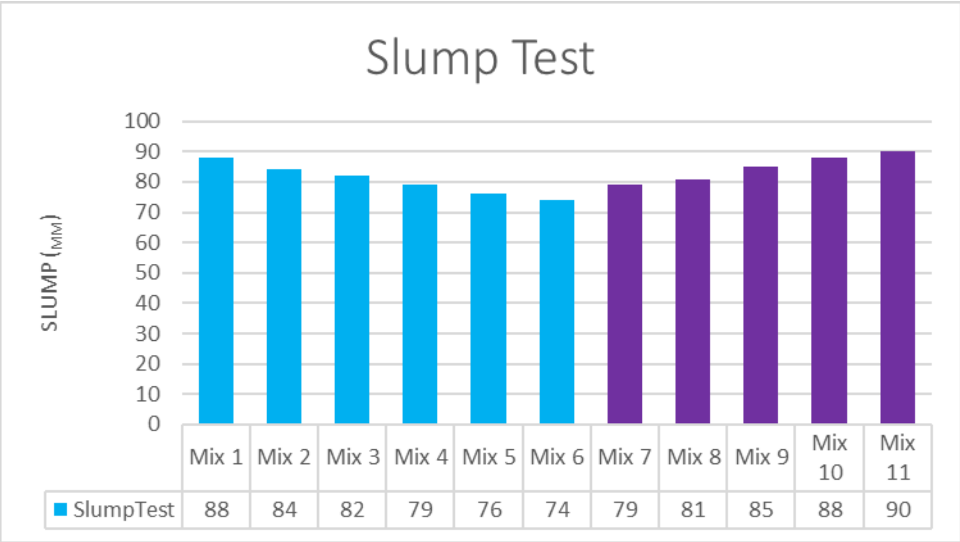

Figure 1. Slump test result of M30 grade of concrete

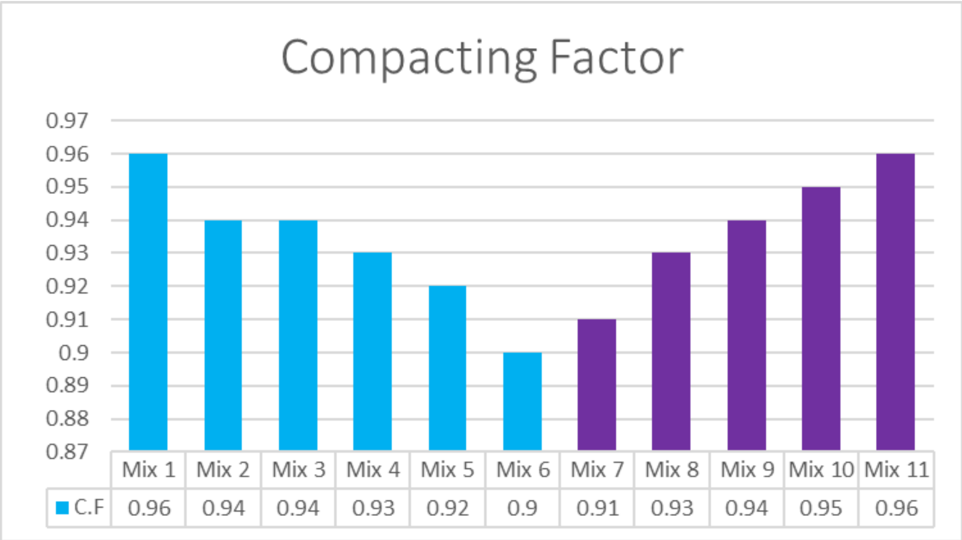

Figure 2. Compacting factor test result of M30 grade of concrete

B. **Compressive Strength**: The results of the compressive strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The compressive strength test were conducted at curing ages of 7 and 28 days. Variation of compressive strength of all the mixes are also shown in Graphs which shows the variation of compressive strength of concrete mixes w.r.t control mix (100% OPC + 0% SF) after 7 and 28 days respectively shown in Figure 3 &4.

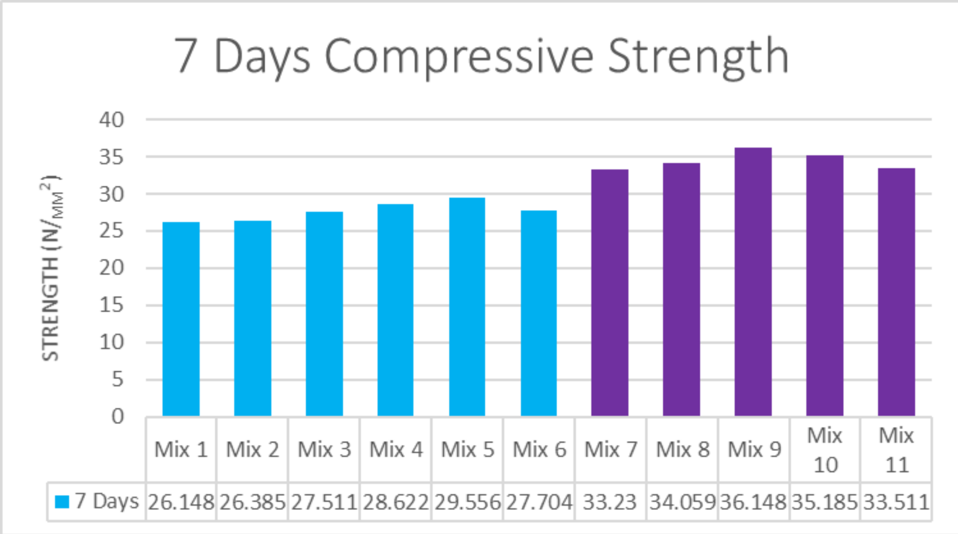

Figure 3. 7Days Compressive strength test result of M30 grade of concrete

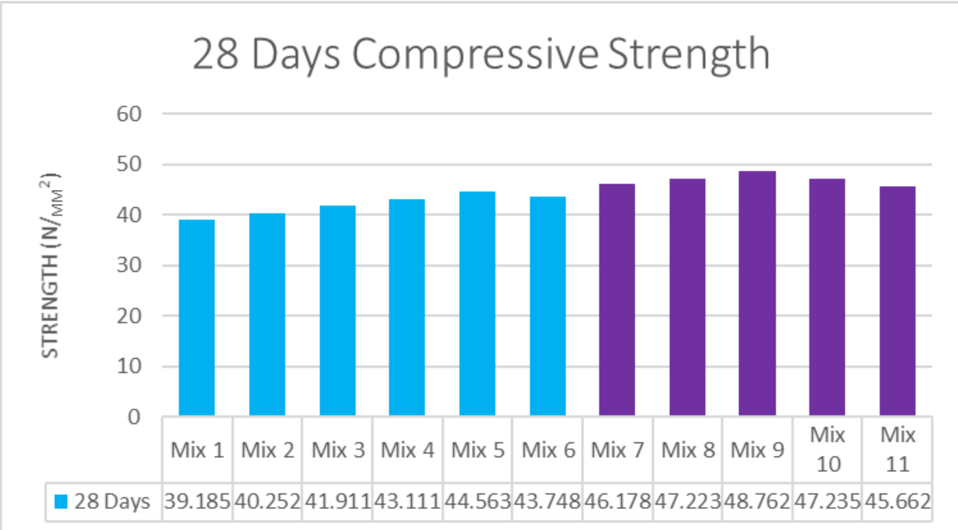

Figure 4. 28Days Compressive strength test result of M30 grade of concrete

C. **Split Tensile Strength Test:** The results of the splitting tensile strength tests conducted on concrete specimens of different mixes. The splitting tensile strength test was conducted at curing ages of 28 days. Variation of splitting tensile strength of all the mixes shown in Figure 5.

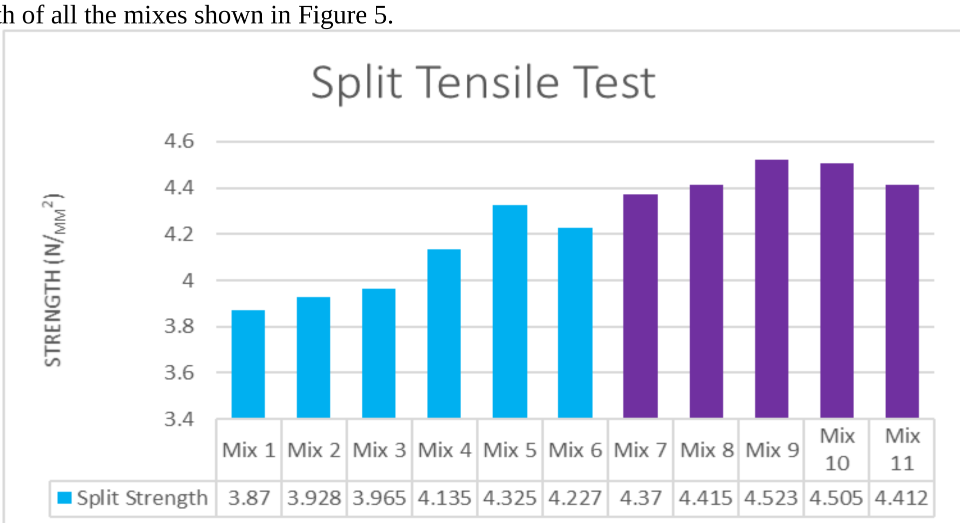

Figure 5. Split tensile test result of M30 grade of concrete

D. **Flexural Strength Test:** The results of the flexural strength tests conducted on concrete specimens of different mixes. The flexural strength test results of all the mixes at 28 days curing ages shown in Figure 6.

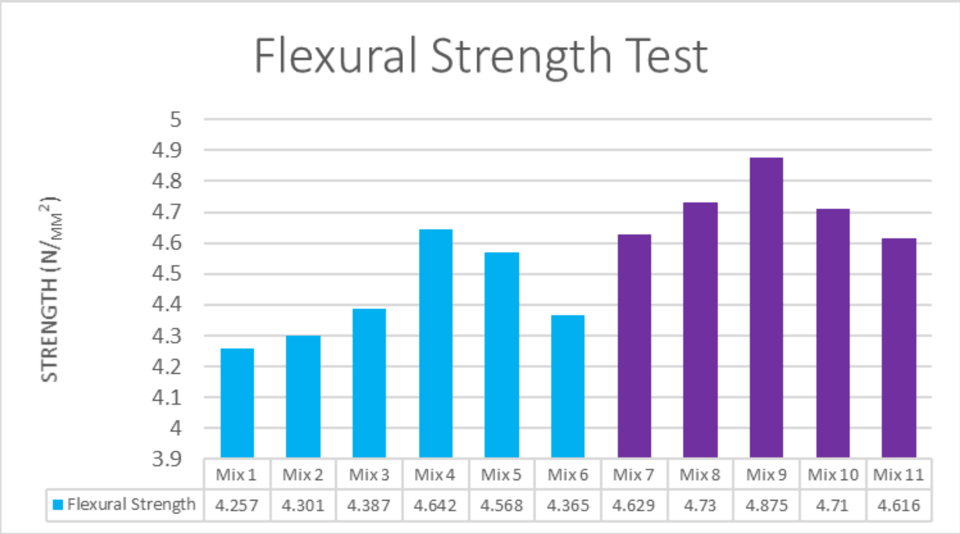

Figure 6. Flexural strength test result of M30 grade of concrete

V. CONCLUSIONS

The percentage replacement of cement with waste glass powder was increases, workability of concrete was decrease. Use of super plasticizer was found to be necessary to maintain workability with restricted water cement ratio.

Workability and density of concrete was increased by increasing the percentage of replacement of Fine aggregate with copper slag.

Replacement 12.5% of cement with glass powder the compressive strength was increased by 13.04% at 7 days, 13.73%at 28 days And Split tensile strength increased by 11.76%. Flexural strength was increased by 9.04% at a 10% replacement of cement as compared with normal concrete. Beyond the 12.5% replacement of cement decrease the compressive strength and split tensile strength, flexural strength decrease after 10% replacement of cement.

Replacement 12.5% of cement with glass powder and 40% of fine aggregate with copper slag the compressive strength was increased by 38.24% at 7 days, 24.44%at 28 days. Split tensile strength increased by 16.87% and Flexural strength was increased by 14.56% as compared with normal concrete. Beyond the 40% replacement of fine aggregate also decrease the compressive strength, split tensile strength and flexural strength.

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