An Elaborate Research Foray on the Strength Parameters of Concrete using Glass Powder, Waste Foundry Sand and Copper Slag

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Abstract*: This research paper presents the design of concrete mix prepaid with Glass powder as fractional substitution of cement, Waste Foundry Sand (WFS) and Copper Slag as a fractional substitution of fine aggregates. Glass powder is a waste material obtained during polishing of glass. Generally glass is mainly composed of silica and when it is finely grounded into particle size less than 75 microns it exhibits pozzolanic reaction with cement and helps in formation of good secondary Calcium Silicate Hydrate (C-S-H) gel. Waste Foundry Sand (WFS) and Copper slag are obtained from foundry and copper industry. In this research work glass powder is partially replaced at five different substitution rates (5%, 10%, 15%, 20% and 25%) with cement , On the other hand waste foundry sand is replaced at (50%, 40%, 30%, 20% and 10%) and copper slag is replaced at constant percentage of 30% with fine aggregates.

It was obtained that the strength parameter values of concrete having glass powder, waste foundry sand and copper slag is obtained maximum at concrete mixture of S4 containing 20% Glass Powder +20% Waste Foundry Sand and 30% Copper slag gives satisfactory results.

***Index Terms*: Glass powder, waste foundry sand, copper slag.**

I. INTRODUCTION

Concrete is one of the most extensively used building materials in the world. However, Portland cement is used in concrete, during the production of cement it release large amount of CO2, a greenhouse gas. The increase in number of cement and concrete industries leads to environment pollution. There is a need to replace a part of cement by some supplementary cementations material to decrease the use of cement and the environmental pollution to some extent. Some of supplementary cementations materials like silica fume (SF), ground granulated blast furnace slag (GGBS), fly ash can be used as partial substitution of cement in concrete.

The primary components of concrete mixture are OPC, natural aggregates, water and admixture. In the present research paper cement is partially replaced by glass powder. When glass powder is finely ground in micro size particles it undergoes pozzolanic reaction and it leads to creation of secondary calcium silicate hydrate (C-S-H) gel.

Thiruvenkitam Manoharan (2018) has done an experimental study on used foundry sand as a part substitution of fine aggregate. Experimental works were carried out to study the mechanical properties of the M30 grade concrete. The natural fine aggregate was partially substituted by foundry sand at several proportion of 5%, 10%, 15%, 20% and 25 wt% respectively. From the test results it was concluded that the maximum results obtained at 20% replacement offine aggregates with used foundry sand.

G. M. Sadiqul Islam (2017) studied an experimental research on mechanical properties of concrete with partial substitution of cement by Glass powder. Experimental works were carried out to study mechanical possessions of the M25 grade concrete with Glass powder. The cement was partially substituted by glass powder at different proportion of 0%, 5%, 10%, 15%, 20%, and 25%. The mechanical possessions (flexural and compressive strength) and durability properties (water absorption) were studied in this paper. From tests results it was concluded that the maximum results obtained at 20% replacement of cement with glass powder.

Jung Hwan Hyun (2016) studied the mechanical (split tensile strength, flexural strength and compressive strength tests) and durability properties (water absorption) of M30 concrete. In this paper fine aggregate is partially substituted with Waste Foundry Sand at different proportion (10%, 20%, 30%, 40% and 50%). From test results it was concluded that the mechanical and durability possessions of the concrete mixes is maximum at 20% replacement of WFS and this results were approximately near to the value of conventional concrete mix, and the mean strength values decreased was 2.1%. The reduction in the strength parameters of concrete was due to very fine quality of the foundry sand and the existence of waste materials like mud, dust plus timber floor in the foundry sand. From the test results it was concluded that at 20% replacement of WFS is used in concrete construction without disturbing the principles of concrete, and a replacement of WFS further than 20% not worthy for concrete production.

Weide Zhang (2015) studied the mechanical properties (split tensile strength, flexural strength and compressive strength tests) of material using copper slag as a partial substitution of fine aggregate at six dissimilar proportions (0%, 20%, 40%, 60%, 80% and 100%). The results shows that the fine aggregates is partially replaced with 40% copper slag exhibit higher strength than control specimen and also increase the workability of concrete. In SEM test, we find there is small difference between material and control material less than 40 % replacement of copper slag.

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II. MATERIALS

A. Cement

OPC of 43 Grade was used in the experiment. Fresh cement without any lumps was used in the experiment. The physical and chemical properties of cement fulfill the necessities of IS: 8112-1989.

Table 1: Chemical composition of Portland cement and glass powder

Components	SiO2	Al2O3	Fe2O3	CaO	MgO	SO3	K2O	Na2O
Cement	21.73	3.60	1.50	63.20	2.50	0.27	0.96	0.03
Glass powder	71.40	2.54	1.50	63.20	0.16	0.36	12.25	0.04

B. Aggregates

The normal river sand passing over 4.75mm was used as a fine aggregates and 20mm size of crushed blue metal from local grinder industry is used as a coarse aggregates. Natural aggregates used in concrete should be free from impurities like soil and mud particles..

Table 2: The physical possessions of Natural Aggregates

S. No	Parameters	Fine Aggregates	Coarse Aggregates
1	Water absorption	1%	0.5%
2	Specific gravity	2.62	2.76
3	Fineness modulus	2.60	7.12

C. Waste Foundry Sand

Foundry sand contain of fresh, consistently sized and high superiority silica sand with unvarying physical appearance. It is a by-product from foundry industry. Foundry industries effectively reutilize and reprocess the fresh silica sand many times in a foundry. When the fresh silica sand cannot be reprocessed in the foundry, it is detached from the foundry and is designated as waste foundry sand.

Table 3: Physical Properties of Waste Foundry Sand

S.NO.	Parameters	WFS
1	Water absorption	0.92
2	Specific gravity	2.35
3	Fineness modulus	2.37

D. Copper slag

Now a day the consumption of natural aggregate in concrete manufacture is very high and demand for river sand is escalating day by day. In order to reduce the demand for river sand, some researcher identified other materials like copper slag as a partial substitution of normal river sand in concrete production

Copper slag is a by-artifact formed during the process of excavating of copper metal in processing plant. Copper slag can be used as a partial substitution for fine aggregate in concrete production because its physical properties and application are approximately similar to the fine aggregates and its cost is very less as compared to fine aggregates. By using the copper slag in concrete production we can solve the dumping problem of copper slag.

Table 4: Physical Properties of Copper Slag

S.NO.	Properties	Copper slag
1	Particle shape	uneven
2	exterior	Black
3	kind	Air cooled
4	Specific gravity	3.36
5	Fineness modules	3.43
6	Water absorption	0.3-0.4%

E. Admixture

The water reducing admixture of SIKAPLAST® 4202NS from SIKA INDIA was used in this present research work

III. MIX PROPORTIONING

The M30 mix was considered as per IS: 10262-2009. Glass powder as a fractional substitution of OPC, Waste foundry sand and copper slag is partially replaced with Fine Aggregates.

Table 5: Mix Proportion

Mix Design	Cement	Glass Powder	Fine Aggregates	Waste Foundry Sand	Copper Slag
Control mix	100%	0%	100%	0%	0%
S1	95%	5%	20%	50%	30%
S2	90%	10%	30%	40%	30%
S3	85%	15%	40%	30%	30%
S4	80%	20%	50%	20%	30%
S5	75%	25%	60%	10%	30%

IV. STRENGTH EVALUATION

A. Compressive Strength test

Mix design of M30 grade concrete was prepared and the specimens are tested conferring to IS: 516-1959. Where OPC 43 grade cement, aggregate of 20mm size and sand of zone –III is used. The test was performed on casted concrete specimens of dimensions 1.50 cm x 1.50cm x 1.50cm. To improve the quality of concrete, cement is partially replaced with Glass powder, fine aggregate is partly substituted with Waste Foundry sand and Copper Slag will be incorporated in concrete. The casted concrete specimens are to be tested successively 7 days and 28 days of curing.

Table 6: Results of Compressive strength

S. No.	Glass Powder	Waste Foundry Sand	Copper Slag	Compressive Strength	
				7 Days	28 days
Control Mix	0%	0%	0%	22.35	33.37
S1	5%	50%	30%	22.29	33.27
S2	10%	40%	30%	23.99	35.72
S3	15%	30%	30%	25.38	37.89
S4	**20%**	**20%**	**30%**	**26.55**	**39.64**
S5	25%	10%	30%	2.41	36.44

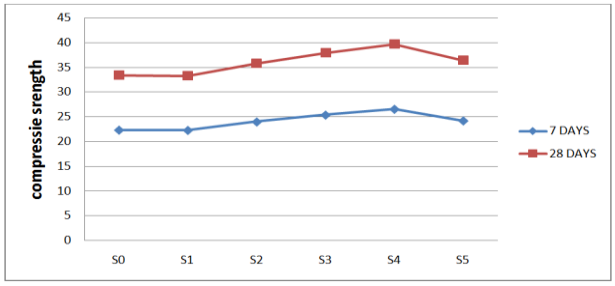

Figure 1: Results of compressive strength test for different percentage replacement in concrete mix

B. Split Tensile Strength test

Mix design of M30 grade concrete was prepared and the specimens were tested conferring to IS: 5816-1999. The test was performed on concrete cylinder of 1.50cm diameter and 3.00cm height. The casted concrete cylinder specimens are to be tested after 7 days and 28 days.

Table 7: Results of Split tensile strength

S. No.	Glass Powder	Waste Foundry Sand	Copper Slag	Compressive Strength	
				7 Days	28 days
Control Mix	0%	0%	0%	2.70	4.04
S1	5%	50%	30%	2.72	4.03
S2	10%	40%	30%	2.8	4.18
S3	15%	30%	30%	2.88	4.30
S4	**20%**	**20%**	**30%**	2.95	4.40
S5	25%	10%	30%	2.82	4.22

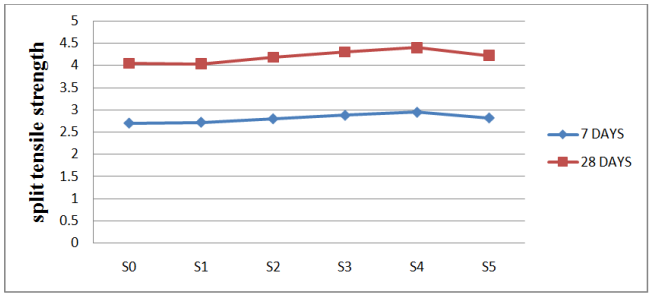

Figure 2: Results of split tensile strength test for different percentage replacement in concrete mix

C. Bond Strength

150mm x 150mm x 150mm cubical specimens are to be prepared. A reinforcement bar of 18mm diameter is too casted along with concrete. The specimens are to be tested past 7 days and 28 days of curing by means of Universal Testing Machine. The reinforcement bar is gripped in the machine and allowed for tensile load. At failure of specimen the reinforcement bar will undergo slip. Results of different batches are to be compared on the basis of slip determined.

Table 8

S. No.	Glass powder	Waste Foundry sand	Copper slag	Diameter of steel bar (mm)	Pull out force(P) (KN)	Bond strength(t_{bd}) (Mpa)	Slip (mm)
Control mix	0%	0%	0%	18	43.18	4.89	0.46
S1	5%	50%	30%	18	49.38	5.82	0.69
S2	10%	40%	30%	18	60.81	7.17	0.98
S3	15%	30%	30%	18	68.0	8.02	1.25
S4	**20%**	**20%**	**30%**	**18**	**74.22**	**8.75**	**1.54**
S5	25%	10%	30%	18	72.35	8.53	1.69

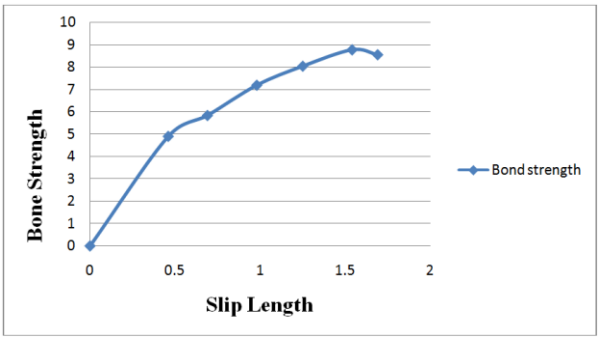

Figure 3: Results of Bond Strength test for different percentage replacement in concrete mix

V. CONCLUSION

1) Maximum compressive strength value is obtained at S4 mix of 20% Glass Powder +20% Waste Foundry Sand and 30% Copper slag.
2) Maximum split tensile strength value is obtained at S4 mix of 20% Glass Powder +20% Waste Foundry Sand and 30% Copper slag.
3) Maximum bond strength value is obtained at S4 mix of 20% Glass Powder +20% Waste Foundry Sand and 30% Copper slag.
4) Mean compressive strength values of concrete mix for 28days is 6.06%,18.44%,28%,50%,7.88% higher than the values of control concrete and the values are obtained from mix S1,S2,S3,S4 and S5.
5) Mean split tensile strength values of concrete mix for 28days is 11.85%,15.19%,15.8%,12.15%,9.11% higher than the values of control concrete and the values are obtained from mix S1,S2,S3,S4 and S5.

Hence we can conclude from test results that as substitution rate of Waste Foundry Sand increases beyond 20% replacement the strength decreases due to fineness of Waste Foundry Sand.

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