Investigation of Properties of Fresh and Hardened Concrete Containing Waste Glass Powder as Partial Replacement of Cement

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ABSTARCT -***Waste glass when grounded to very fine powdered form particle size finer than 100 micron, shows some pozzolanic activities as it contains high percentage of silica (SiO_2) and therefore this waste material can replace cement partially, In this work, an attempt has been made to find out the strength of concrete containing waste glass powder as pozzolanic material .Cement replacement by waste glass powder in the range 4% to 28 % with increment of 4% have been studied. Replacement of 16 % cement by waste glass powder was found to produce almost same strength as that of control mix.***

KEYWORDS: *Waste Glass Powder (WGP), Pozzolana, Compressive strength, Flexural strength,Workability*

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1. INTRODUCTION

Concrete due to its versatility and mouldability is one of the most widely used men made construction material in the world. This is the only substance on our planet which is utilized second to water. Concrete plays an important role in infrastructure development of fast growing countries like India. Concrete for the twenty first century can be made much stronger, more durable and at the same time and cost efficient. Concrete require cement as a binding material which is much costly than the other ingredients of concrete. Cement is used as a binding material in concrete. But there are some drawbacks of this material like it produce considerable amount of carbon dioxide which is a green house gas hazardous to environment and a source of pollution. Hence to reduce the consumption of cement in construction attempts has to be made to replace this material either fully or partially. From previous research till date there is no material which fully replaces the cement at reasonable cost. In this research work cement is partially replaced by waste glass powder partially. Glass powder is rich in silica (SiO_2) and also shows some pozolanic activity. Waste glass when grounded to very fine powdered form prevents alkali silica reaction. Jangid Jitendra B. and Saoji A.C. [2012] reported that the workability goes on decreasing as the percentage glass powder in the mix increases, Kumarappan N. [2013] reported that up to 10% replacement of glass powde is feasible as it showed higher compressive strength than the control mix, Bajad M.N. et al [2011] found that the maximum compressive strength is achieved at 20% replacement of cement by waste glass powder in both the cases that is when concrete is subjected to sulphate attack

and when concrete not subjected to sulphate attack beyond 25% replacement compressive strength decreases. Jangid Jitendra B. and Saoji A.C. [2012] reported that compressive strength increase up to 20%, cement replacement with waste glass powder beyond this **co**mpressive strength decreases. R. Vandhiyan et al [2013] concluded that there is considerable improvement in the flexural strength of concrete at 10% replacement of cement, beyond 10% replacement flexure strength decreases.

2. OBJECTIVE OF STUDY

Recycling of waste glass possesses major problems and at the same time it is quite costly also. This problem can be greatly eliminated by utilizing waste glass in concrete in powdered form to replace cement partially. Incorporation of waste material will results in economical mix. In this experimental work main objective is to determine the effect of glass powder on workability, consistency, setting time, compressive strength and flexural strength of different mix prepared by partial replacement of cement by waste glass powder.

3. MATERIALS

The ingredients of concrete consist of Cement, fine aggregate, coarse aggregates and water with or without admixtures In this research we used waste glass powder as a partial replacement of cement is replaced by waste glass powder in the range 4% to 28 % with increment of 4%.

3.1 Cement –In this research work Ordinary Portland Cement of grade 43 is used.

Lime	62%
Silica	22%
Alumina	05%
Calcium Sulphate	04%
Iron Oxide	03%
Magnesia	02%
Alkalis	01%

Source- M.S. Shetty, "Concrete Technology"

Table 1:- chief constituents of cement

3.2 Aggregates- well graded fine aggregate (zone-I) from Indus river near Gwalior city of used, coarse aggregate of nominal maximum size 20 mm are used in this research work.

3.3 Glass powder – Finely grounded waste glass powder passing 99% from 100 micron sieve is used.

SiO_2	72.42%
Al_2O_3	1.44%
TiO_2	0.035%
Cr_2O_3	0.002%
Fe_2O_3	0.07%
Na_2O	13.64%
MgO	0.32%
Alkali's (K_2O, Na_2O)	11.3%

Table 2:- chief constituents of glass

4. MIX PROPORTIONING

In this experimental work M30 grade of concrete mix have been designed as per IS: 10262-2009. Cement is replaced in range of 0%, 4%, 8%, 12%, 16%, 20% 24% and 28%, admixtures are not used in this work. Total 72 cubes of size 150 mm x 150mm x 150 mm casted for determining compressive strength cubes are tested in the compression testing machine at age of 3, 7and 28 days of curing respectively and total 16 beams of size 500 mm x 100 mm x 100 mm casted and tested for flexure strength.

Quantities of ingredients per cubic meter of control concrete are given in following table.

Cement (kg/m^3)	**Coarse aggregate (kg/m^3)**	**Fine aggregate (kg/m^3)**	**Water (kg/m^3)**	**W/C ratio**
419.15	1152.1	694.22	197	0.47

5. RESULTS AND DISCUSSION

5.1 Standard consistency

Sample	Standard consistency (%)
OPC cement	30.25
4% replacement of cement by GP	30.50
8% replacement of cement by GP	31.25
12% replacement of cement by GP	31.75
16% replacement of cement by GP	32.00
20% replacement of cement by GP	33.25
24% replacement of cement by GP	34.75
28 % replacement of cement by GP	36.25

Table 3:- Standard Consistency test result

From above results we conclude that the standard consistency increase with increase in the proportion of waste glass powder. Standard consistency increased from 30.25% for normal OPC cement to 36.25% for mix with 28% replacement of cement with waste glass powder. This shows that requirement of water increases as the percentage of glass powder increases

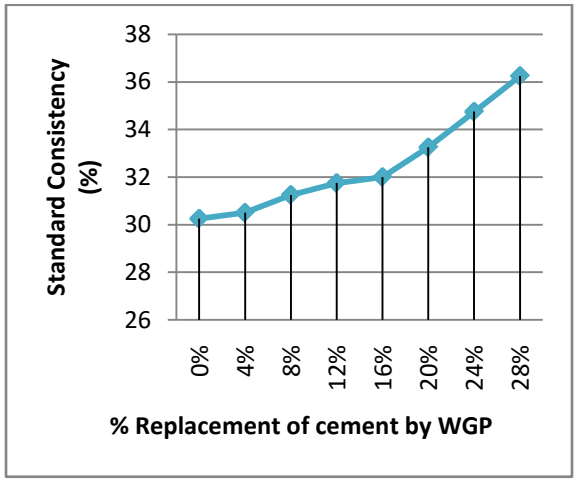
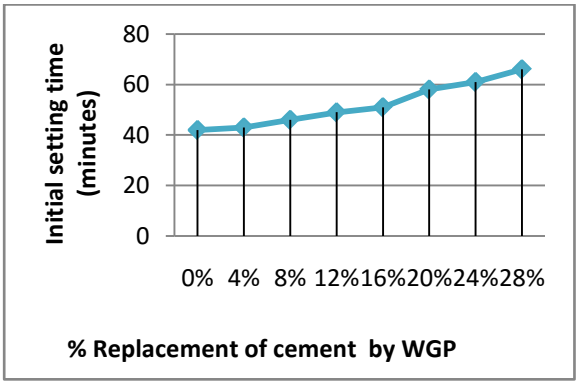


Figure 1:- Variation of standard consistency of various samples containing WGP.

5.2 Initial and Final setting time (minutes)

Sample	Initial setting time (minutes)	Final setting time (minutes)
OPC cement	42	385
4% replacement of cement by GP	43	390
8% replacement of cement by GP	46	394
12% replacement of cement by GP	49	408
16% replacement of cement by GP	51	410
20% replacement of cement by GP	58	424
24% replacement of cement by GP	61	432
28 % replacement of cement by GP	66	440

Table 4:- Initial and Final setting time



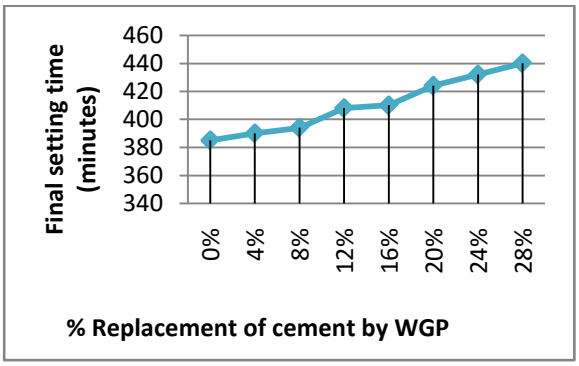


Figure 2:- Variation of Initial and final setting time of various samples containing WGP

From the results it is concluded that the Initial and Final setting time increase with increase in the

percentage of waste glass powder used as partially replacement of cement.

5.3 Workability (Slump Cone Test):

Sample	Slump value(mm)
OPC cement	89
4% replacement of cement by GP	84
8% replacement of cement by GP	82
12% replacement of cement by GP	80
16% replacement of cement by GP	73
20% replacement of cement by GP	71
24% replacement of cement by GP	66
28 % replacement of cement by GP	61

Figure 5:- Workability of concretes

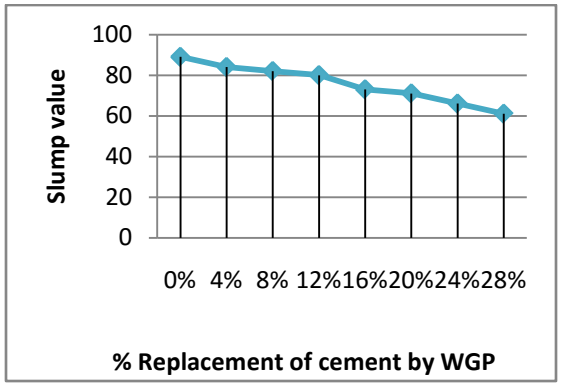


Figure 3:- Variation of slump value of various samples containing WGP

From above results it is concluded that the workability decrease with increase in the percentage of waste glass powder used as partially replacement of cement. Slump value decreased from 89 mm for normal OPC cement to 61 mm for mix with 28% replacement of cement with waste glass powder

5.4 Compressive Strength and Flexure Strength:

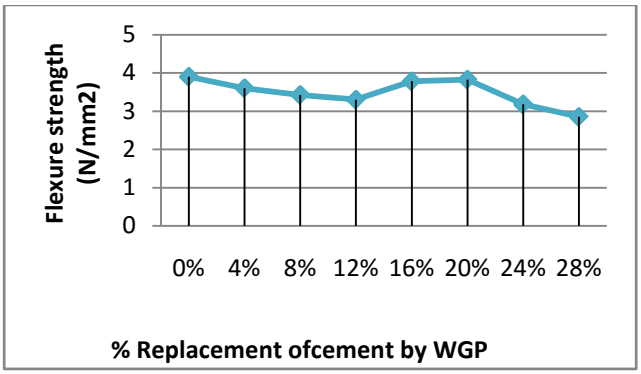


Figure 4:- Variation of flexure strength of various samples containing WGP

Flexure strength obtained maximum at 20% replacement of cement with waste glass powder in the mix which is 98% of the strength obtained from control mix sample.

Table 6:-Compressive and Flexure strength test result

Sample	compressive strength (N/mm^2)			Flexure strength (N/mm^2)
	3 days	7 days	28 days	
OPC cement	15.41	21.62	34.22	3.9
4% replacement of cement by GP	15.11	21.04	33.63	3.6
8% replacement of cement by GP	14.37	20.73	32.59	3.425
12% replacement of cement by GP	14.22	20.89	33.03	3.3
16% replacement of cement by GP	14.52	21.18	33.92	3.78
20% replacement of cement by GP	14.81	20.15	33.78	3.825
24% replacement of cement by GP	13.62	19.11	32.15	3.18
28 % replacement of cement by GP	12.74	17.63	28.44	2.85

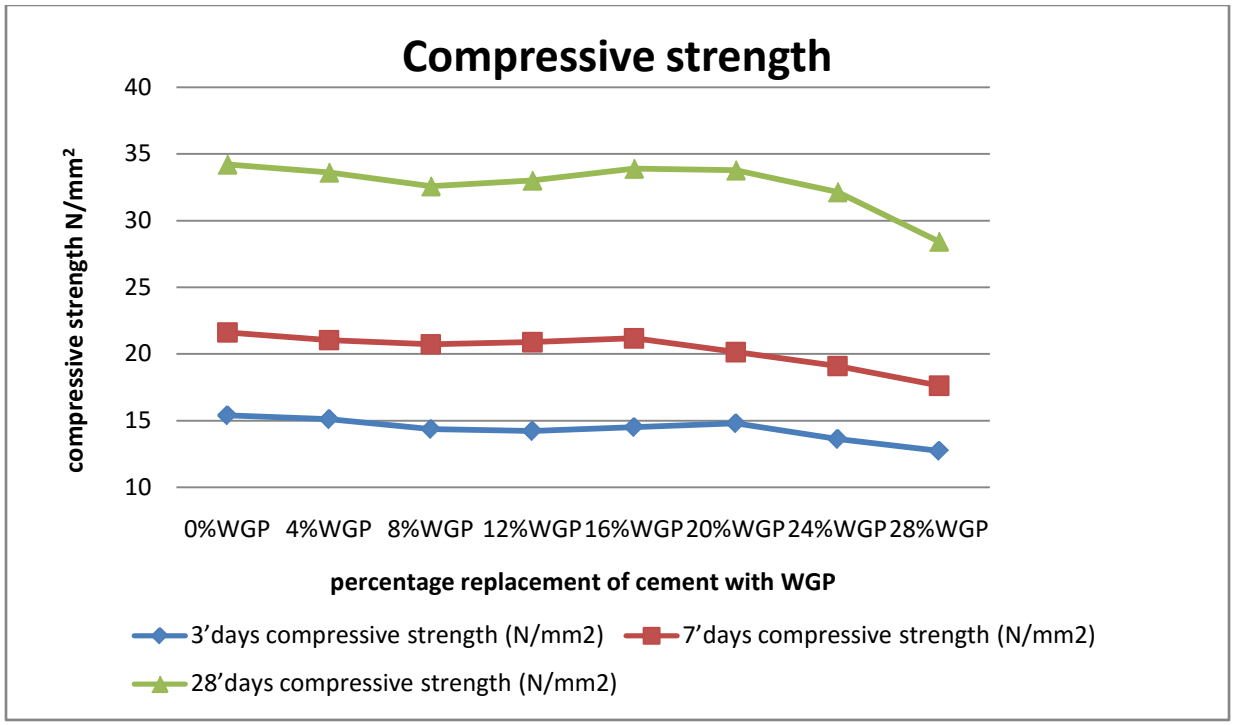


Figure 5:- Variation of Compressive strength of various samples at 3 days, 7days and 28 days respectively

6. CONCLUSION

Following conclusions can be drawn from the present work

Water requirement for standard consistency, initial and final setting time increases with the increase in percentage of waste glass powder in cement

Almost same compressive strength as that of control mix is achieved at all ages in concrete in which 16% cement is replaced by WGP.

Flexural strength of concrete with 20% replacement of cement by WGP shows best results with flexural strength 98% of that of control mix.

Thus 20% cement can be replaced by WGP without any significant decrease in compressive and flexural strength of concrete.

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