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Influence of Waste Glass Powder on Properties of Concrete

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Abstract – In today's world, civil infrastructure plays a very important role in development of any country. Cement is the main constituent used in construction industry. As the cement production is increasing, consequently CO_2 content is also increasing in environment. So efforts are being done to develop some alternative ways for concrete production using Waste material. Waste glass powder (WGP) is one such alternative. The non-biodegradability of waste glass powder makes it a harmful pollutant of environment, so its use as supplementary compendious material (SCM) will also help in solving glass related environmental problems.

The present work consists of using WGP in different proportions (2%, 6%, 10%, 14%, 18%, 22%, 26% and 30%) by weight. The concrete samples were tested for compressive and flexural strength and it was concluded that waste glass powder of size less than 100 micron can be used as partial replacement of cement. The compressive strength as well as the flexural strength was maximum at 18% partial replacement of cement with waste glass powder by weight.

Index terms- Cement, Waste glass powder, Compressive strength, Flexural strength, Supplementary Cementious Material.

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I. INTRODUCTION

Concrete is the blend of cement, water, coarse aggregate and fine aggregate. With the rapid urbanization, environmental problems are also increasing day by day. The production of cement indirectly contributes to global warming as it releases CO_2 which is the main source of global warming. It is reported (P.S. Mane Deshmukh et al. 2012) that every year almost 1 M^3 of cement is produced for every person in this world and the carbon dioxide released in atmosphere by cement production is approximately 5-10% of overall carbon dioxide production in the world. So efforts are being made to reduce the emission of carbon dioxide by using waste glass powder as partial replacement of cement which otherwise would be emitted if no replacement was done. The non-recyclable waste glass is landfilled and due to this landfilling the environment is polluted as it degrades the quality of soil and also reduces its fertility. The use of waste glass as supplementary cementious material would not only reduce the quantity of waste to be landfilled but would also increase the strength of concrete.

As the main constituent of glass is silica sand the main problem that arises when glass pieces is used in concrete is the alkali silica reaction (ASR).Many studies suggest that glass in powder form can be used as supplementary cementious material. Dr. G. Vijaykumar et al. (2013) stated that if the glass particle size is less than 75µm, it will prevent alkali silica reaction. . 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 of glass powder in the mix increases. Various researches are done in this field. 30% replacement of cement with waste glass powder gives approximately equal strength to normal concrete Mohd. Rahman et al. (2015)

Compressive and flexural strength increases when WGP is used as partial replacement of cement. Also it is economical and durable in longer run. R. Vandhiyan et al [2013] stated that at 10% partial replacement of cement there is considerable improvement in fleaxural strength of concrete. Beyond 10% flexural strength decreases.

II. MATERIALS

In this work WGP is used as a partial replacement of cement. The cement is replaced at 2%, 6%, 10%, 14%, 18%, 22%, 26% and 30%.

Description of materials is as follows

A. Cement

Ordinary Portland cement of grade 43(Mycem cement) was used which conforms to Indian Specification IS 8112 (1989).

B. Fine Aggregate

Naturally available sand which passes through 4.75 mm IS sieve is used.

Specific gravity of sand is 2.66 and water absorption is 1.7%.

The sand used is of zone 1conforming to IS 383.

C. Coarse Aggregate

The coarse aggregate available in concrete laboratory of civil engineering department is used in this work. Specific gravity of coarse aggregate is 2.87 and water absorption is 0.13%.

D. Waste Glass Powder

Finely grounded waste glass powder passing 99% from 100 micron sieve was purchased from Goldy minerals Dealer company form New Delhi market.

E. Water

Fresh water available in the institute laboratory was used.

III. EXPERIMENT AND RESULT

The experimental program consists of following tests which were performed in this study.

A. STANDARD CONSISTENCY

Vicat apparatus was used to calculate the standard consistency of cement. Cement paste with weighed percentage of water was prepared and vicat plunger is released upon it. This procedure is followed till the plunger penetration is 33-35 mm from the top.

The result of standard consistency of cement is as follows.

Table 1:- standard consistency test result

Percentage of cement replaced by waste glass powder	Standard consistency (in %)
OPC cement	30.25%
2% replacement of cement by WGP	30.25%
6% replacement of cement by WGP	30.75%
10% replacement of cement by WGP	31.50%
14% replacement of cement by WGP	31.75%
18% replacement of cement by WGP	32.50%
22% replacement of cement by WGP	34.00%
26 % replacement of cement by WGP	35.50%
30 % replacement of cement by WGP	36.75%

Graphical representation of standard consistency result is shown

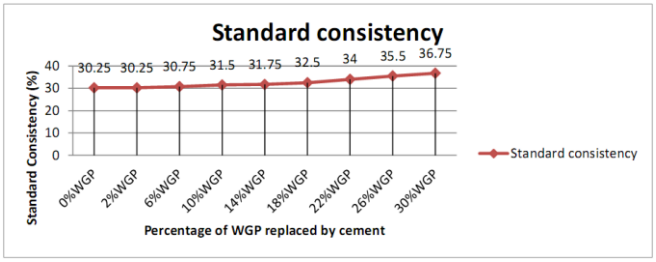

Figure 1:- standard consistency test result

B. INITIAL AND FINAL SETTING TIME

The Initial and final setting time of cement when different proportions of glass powder are added to it

Table 2:- Initial and Final setting time

Percentage Cement replaced by glass powder	Initial setting time (in min)	Final setting time (in min)
OPC cement	42 min	385 min
2% replacement of cement by WGP	43 min	385 min
6% replacement of cement by WGP	44 min	391 min
10% replacement of cement by WGP	46 min	401 min
14% replacement of cement by WGP	50 min	408 min
18% replacement of cement by WGP	53 min	417 min
22% replacement of cement by WGP	60 min	429 min
26 % replacement of cement by WGP	63 min	439 min
30 % replacement of cement by WGP	67 min	444 min

C. MIX DESIGN

Mix design of M30 grade of concrete as per IS 10262 (2009) was designed. Final quantities are as follows

Table 3 :- mix design proportions

WATER (l/m^3)	CEMENT (kg/m^3)	C.A. (kg/m^3)	F.A. (kg/m^3)
197	419.15	1152.14	694.22
0.47	1	2.748	1.656

80 - 100 mm slump value was taken.

For the determination of compressive strength 81 cubical standard specimen of dimension 150X150X150mm were casted and 18 cuboidal specimen of dimension 500X100X100mm were casted to determine the flexural strength.

The cement was replaced by glass powder at 4% interval from 2% to 30% by weight. Compressive strength was tested at 3 days, 7 days, 28 days using compressive testing machine (CTM) and the flexural strength of cuboidal specimen was tested at 28 days using capacity testing universal machine.

Workability and Initial and final setting time of cement with glass powder at different proportions was also calculated.

D. WORKABILITY TEST

Table 4:- workability test result

Percentage replacement of cement by glass powder	Slump value(mm)
OPC cement	89
2% replacement of cement by WGP	87
6% replacement of cement by WGP	84
10% replacement of cement by WGP	80
14% replacement of cement by WGP	76
18% replacement of cement by WGP	72
22% replacement of cement by WGP	69
26 % replacement of cement by WGP	64
30 % replacement of cement by WGP	58

The graphical representation of workability test result is shown in figure 2

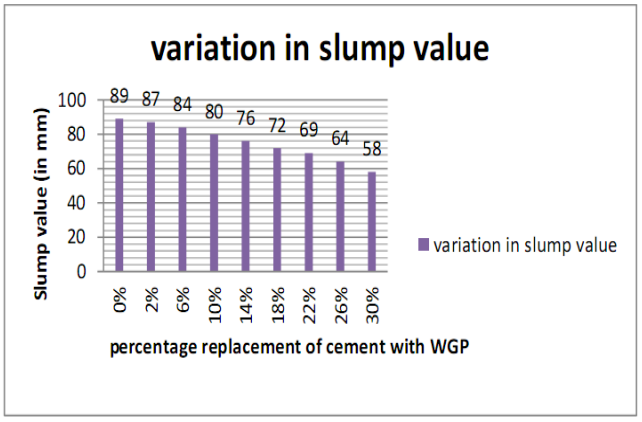

Figure 2:- workability of concretes

E. COMPRESSIVE STRENGTH TEST

$$\text{Compressive strength} = \frac{\text{LOAD (N)}}{\text{CROSS SECTIONAL AREA (mm2)}}$$

The compressive strength was calculated using following formula

Table 5:- compressive strength test result

Concrete Sample	3days average compressive strength (N/mm^2)	7 days average compressive strength (N/mm^2)	28 days average compressive strength (N/mm^2)
Control Concrete	**15.40** N/mm^2	**21.62** N/mm^2	**34.22** N/mm^2
2% replacement of cement by WGP	15.26 N/mm^2	21.33 N/mm^2	34.07 N/mm^2
6% replacement of cement by WGP	14.81 N/mm^2	20.59 N/mm^2	33.18 N/mm^2
10% replacement of cement by WGP	14.07 N/mm^2	20.74 N/mm^2	32.88 N/mm^2
14% replacement of cement by WGP	14.37 N/mm^2	21.18 N/mm^2	33.03 N/mm^2
18% replacement of cement by WGP	**15.40** N/mm^2	**21.62** N/mm^2	**34.38** N/mm^2
22% replacement of cement by WGP	13.93 N/mm^2	20.0 N/mm^2	33.62 N/mm^2
26 % replacement of cement by WGP	13.33 N/mm^2	18.96 N/mm^2	30.81 N/mm^2
30 % replacement of cement by WGP	12.59 N/mm^2	17.18 N/mm^2	27.11 N/mm^2

Graphical representation of compressive strength result

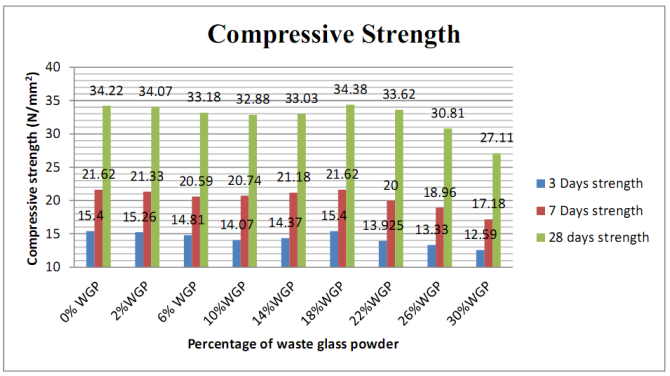

Figure 3:-Variation in compressive strength

F. FLEXURAL STRENGTH TEST

The flexural strength results are as follows

Table 6:- flexural strength result

Concrete Sample	Flexural Strength (N/mm^2)
Control Concrete	3.9 N/mm^2
2% replacement of cement by WGP	3.74 N/mm^2
6% replacement of cement by WGP	3.55 N/mm^2
10% replacement of cement by WGP	3.25 N/mm^2
14% replacement of cement by WGP	3.45 N/mm^2
18% replacement of cement by WGP	3.86 N/mm^2
22% replacement of cement by WGP	3.42 N/mm^2
26 % replacement of cement by WGP	3.0 N/mm^2
30 % replacement of cement by WGP	2.7 N/mm^2

Graphical representation of flexural strength result

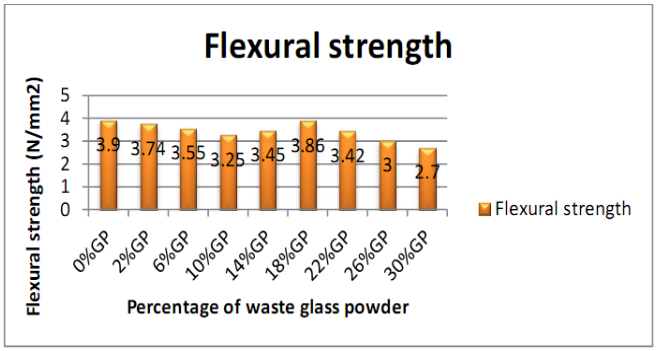

Figure 4:- Variation in Flexural strength

IV. CONCLUSION

- The workability reduces as the percentage of WGP is increased in concrete.
- The standard consistency of cement increases as waste glass powder is added to it.
- The initial and final setting time of cement increases as waste glass powder percentage increases.
- At 18% partial replacement of cement by waste glass powder the compressive strength of concrete is same as that of control concrete at 3 days and 7 days. At this replacement 28 days compressive strength is slightly more than control concrete.
- The flexural strength of concrete is maximum (i.e. 3.86 N/mm^2) when 18% partial replacement is done.
- If the size of waste glass powder is less than 100 micron, it shows pozzolanic behavior.
- Utilization of WGP as partial replacement of cement will help in solving environmental problems related to waste glass.

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