EVALUATION OF STRENGTH PROPERTIES OF CONCRETE CONTAINING GLASS POWDER WASTE

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Abstract: **In today's boom of urbanization, construction of civil infrastructure is very important for any developing country. Cement isone of the main material used in construction. As the requirement of cement is increasing, Cement production is also increasingand consequently CO_2 content in environment. So efforts are being done to develop some alternativematerialfor concrete productionusing Waste material. Waste glass powder is one such alternative. As glass is non biodegradable so it will also help in solving glass related environmental problems.**

In the present work cement is partially replaced by waste glass powder in different proportions (2%, 6%, 10%, 14%, 18%, 22%, 26% and 30%) by weight. The compressive strength of various concretes are compared and based on that comparison it is concluded that glass powder of size less than 90 micron can be used as partial replacement of cement. Result shows that compressive strength as well as the flexural strength is maximum when 18% cement is partially replaced by waste glass powder by weight.

Index terms-Concrete, Waste glass powder, Compressive strength, Flexural strength.

1. INTRODUCTION

Concrete is the combination of cement, water, coarse aggregate and fine aggregate. With the advancement of technologies and rapid increase of industries, environmental problems are also increasing day by day, global warming being the major problem among all environmental problems. As the production of cement releases CO2 which is the main source of global warming, efforts are being made to reduce the production of CO2 by using other sustainable methods.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. Using waste glass powder as partial replacement of cement is one of the solution to this problem. Land filling is the most common method for disposing waste glass. It is harmful to environment as it degrades the quality of soil and also reduces its fertility. If the waste glass is used in concrete it would not only reduce the quantity of waste to be landfilled but would also increase the strength of concrete. Glass is a common house hold product and can be found in the form of bottles, jars, windows, bulbs etc.

Various types of glass are there which can be used such as borosilicate and soda lime silicate glass.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.Bashar Tahaet al.(2009); Mohammadreza Mirzahosseini et al.(2014) stated that fine glass powder exhibits pozzolanic properties and is effective in suppressing ASR. It is reported (Omoniyi, T.E. et al. 2014) that If glass powder is less than 100 μm it shows pozzolanic behavior. Dr. G. Vijaykumar et al.(2013) stated that if the glass particle size is less than 75μm, it will prevent alkali silica reaction. Various researches are done in this field. 30% replacement of cement with waste glass powder gives approximately equal strength to normal concrete. Omoniyi TE et al. (2014); Mohd.Rahman et al. (2015)

Use of waste glass powder in concrete increases its compressive strength and flexural strength. Dr. G. Vijaykumar et al. (2013). Also it is economical and durable in longer run.

2. MATERIALS

Concrete consists of cement, fine aggregate, coarse aggregate and water. In this paper waste glass powder 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 is used which conforms to IndianSpecification IS8112.

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 departmentis used in this work. Specific gravity of coarse aggregate is 2.87 and waterabsorption is 0.13%.

D. Waste Glass Powder

The commonly used glass of doors, windows, containers and decorative items is collected and converted intopowderof desired size. The size of glass powder is less than 90 micron..

E.Water

Fresh water available in the institute laboratory is used in this work.

3. EXPERIMENT AND RESULT

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

A.STANDARD CONSISTENCY

Standard consistency of cement is calculated using the vicat apparatus. In this test sample of cement is taken and weighed percentage of water is added to it.A paste is prepared andvicat plunger is released upon it. This procedure is followed till the plunger penetration is 33-35 mm from the top.

The table below shows the result of standard consistency of cement

Table 1:- standard consistency test result

Percentage of cement replaced by waste glass powder	Standard consistency (in %)
0%	30.25
2%	30.25
6%	30.75
10%	31.50
14%	31.75
18%	32.50
22%	34.00
26%	35.50
30%	36.75

Graphical representation of standard consistency result is shown

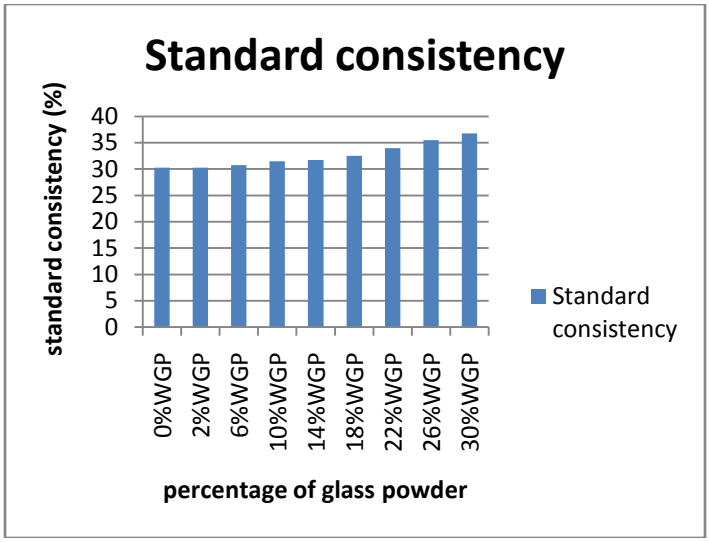

Figure 1:- standard consistency test result

B. INITIAL AND FINAL SETTING TIME

Initial and final setting time of cement is also conducted using vicat apparatus. In this test 0.85% of water required for standard consistency is taken and a paste is made. Then a needle is released upon it. When the needle fails to pierce the paste that time is recorded, it is initial setting time of cement. *The initial setting time of cement used is 42 minutes*.
For the final setting time needle is replaced by annular attachment. When the attachment fails to makean

impression on paste and only needle makes an impression that time is final setting time and *the value comes out to be 385 minutes.*

The result for initial and final testing 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)
0%	42	385
2%	43	385
6%	44	391
10%	46	401
14%	50	408
18%	53	417
22%	60	429
26%	63	439
30%	67	444

C.MIX DESIGN

M 30 grade mix is designed according to the specifications of IS 10262: 2009. The quantities of ingredients are shown in table below

Quantity of water includes the water absorbed by ingredients.

Table 3:- mix design proportions

WATER(l/m³)	CEMENT(kg/m³)	C.A. (kg/m³)	F.A. (kg/m³)
197	419.15	1152.14	694.22
0.47	1	2.748	1.656

The slump value taken is 100 mm.

In this study total of 81 cubical standard specimen of dimension 150X150X150mm and 18 cuboidal specimen of dimension 500X100X100mm is casted and compressive and flexural strength is tested.
The cement is replaced by glass powder from 2% to 30% at 4%interval by weight. Compressive strength of cubical specimen is tested at 3 days, 7 days, 28 days using compressive testing machine (CTM) and the flexural strength of cuboidal specimen is tested at 28 days
Table 4:- workability test result

Percentage replacement of cement by glass powder	Slump value (mm)	Percentage change from control mix (%)
OPC	89	0
2%	87	2.24
6%	84	5.61
10%	80	10.11
14%	76	14.60
18%	72	19.10
22%	69	22.47
26%	64	28.08
30%	58	34.83

Workability is also tested at each proportion to determine the ease with which glass powder can be used in concrete. Initial and final setting time of cement with glass powder at different proportions is also calculated.
The results are as follows.

D.WORKABILITY TEST

The graphical representation of workability test result is shown
In figure 1

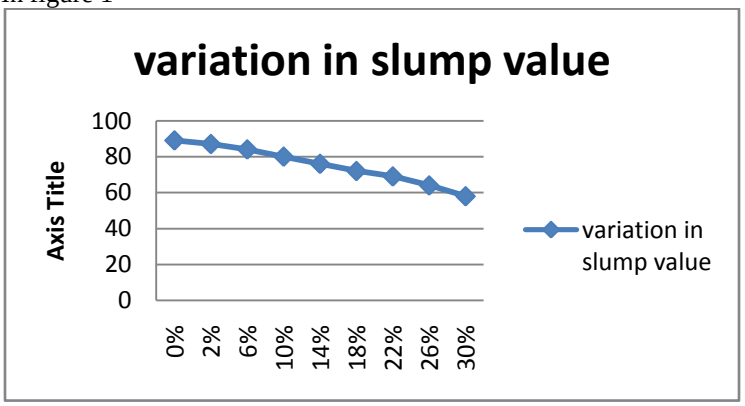

Figure 2:- workability of concretes

Cement replaced	3days average compressive strength (N/mm²)	7 days average compressive strength (N/mm²)	28 days average compressive strength (N/mm²)
0%	**15.40**	**21.62**	**34.22**
2%	15.26	21.33	34.07
6%	14.81	20.59	33.18
10%	14.07	20.74	32.88
14%	14.37	21.18	33.03
18%	15.40	21.62	34.38
22%	13.93	20.0	33.62
26%	13.33	18.96	30.81
30	12.59	17.18	27.11

Table 5:- compressive strength test result

E. COMPRESSIVE STRENGTH TEST

The compressive strength of cubical specimen at 3 days, 7 days and 28 days is calculated.

The compressive strength calculated is the average of strength of three cubical specimens that are casted for each proportion.

Graphical representation of compressive strength result

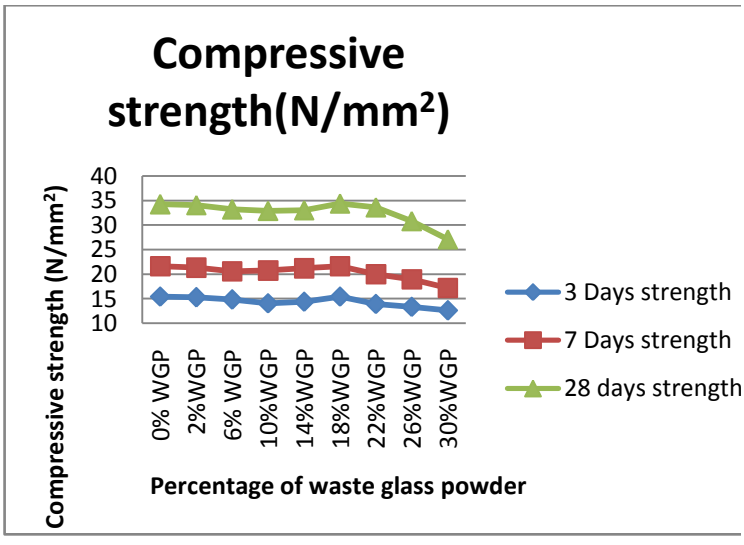

Figure 3:-Variation in compressive strength

F. FLEXURAL STRENGTH TEST RESULT

The flexural strength of beam specimens is calculated for different percentage of glass powder in cement. Following formula is used.

$M/I=\sigma/Y$

$\sigma = M*Y/I$

The flexural strength results are as follows

Table 6:- flexural strength result

Cement replaced	Strength (N/mm²)
0%	3.9
2%	3.74
6%	3.55
10%	3.25
14%	3.45
18%	3.86
22%	3.42
26%	3.0
30%	2.7

Graphical representation of flexural strength result

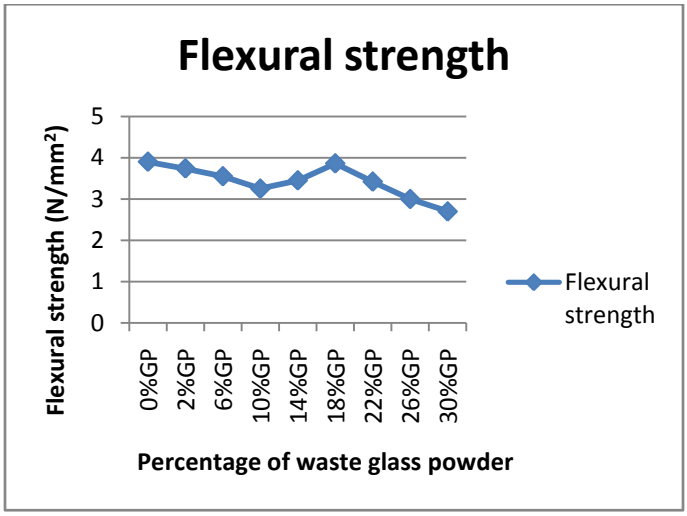

Figure 4:- Variation in Flexural strength

4. CONCLUSION

- The workability gradually reduces from 0 to 34% aspartial replacement of cement with waste glass powder is done
- 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 90 micron, it can be used as supplementary cementious material (SCM) in concrete.
- Addition of glass powder in concrete gives satisfactory results.
- As glass is non biodegradable and its decomposition is an environmental problem, utilization of WGP will help in solving environmental problems related to waste glass.

5. REFERENCES

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