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Effects on Compressive Strength of Concrete by using Glass Powder as Replacement of Cement

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***Abstract*— Significant amount of research is being carried out around the world to find a full or partial replacement for cement. Better and environment friendly materials are being considered because the production of cement contributes a significant amount in greenhouse gas generation. Significant amount of research is going on regarding replacing cement in concrete with waste material. Glass powder can be used a partial replacement for cement in concrete. It has been found that glass shows pozzollonic properties when in powder form (less than 150µm).**

In this paper, an attempt has been made to replace cement with glass powder in concrete partially. The concrete with partial replacement of cement in the range of 10% to 50% is considered for the study of effects on the compressive strength of concrete.

Keywords—Glass; Glass Powder; Compressive strength; cement; concrete;

I. INTRODUCTION

Concrete is a very important part of the construction industry and cement is the main component of the concrete. Production of cement is not very environmental friendly as it releases green house gasses. Although, it is yet to find out full replacement for cement in concrete, replacement of cement with other cementous material in some proportions are carried out for various purposes such as increase compressive strength, increase density, decrease crack formation etc. some of the popular materials used are fly ash, furnace slag and silica fumes. One such material that has been in research for the partial replacement purpose is waste glass.

Glass is an integral part of our day-to-day life. It has versatile properties and multiple uses in various industries. It has been used to improve the aesthetic values of many buildings since centuries. It has been tested for its other properties as well. One of which is pozzolonic property. However disposal of glass is a problem as it is being packed and disposed off as landfill. Glass, being non-biodegradable will always have a problem to be disposed off.

Glass can be used as a replacement for cement in concrete. Using glass as fine aggregate and course aggregate in not advisable as it undergoes Alkali-Silica Reaction (ASR) when comes in contact with Portland cement. This causes cracks in concrete and degradation of its strength. However, research has proven that with decrease in the size of the glass aggregate the ASR also decreases. When glass is powdered down to less than 500µm size, it shows pozzolonic properties when used in concrete as a partial replacement for cement. Research show that finely powdered glass will expand very less when under going pozzolonic reaction in concrete and can be used as a potential material to replace cement. Following table show the constituents of glass powder and cement.

Table 1: chemical composition of glass and cement.

Sr. No.	Chemical composition	Glass powder (%)	Cement (%)
1	SiO2	70.22	23.71
2	CaO	11.13	57.27
3	MgO	-	3.85
4	Al2O3	1.64	4.51
5	Fe2O3	0.52	4.83
6	So3	-	2.73
7	Na2O	15.29	-
8	K2O	-	0.37
9	Cl	-	0.0068

II. EXPERIMENTS

A. *Objective of the investigation*

Experiments were conducted to form concrete using finely grounded glass powder as a partial replacement of cement. The glass particles are less than 500µm. The following is considered while conducting the experiments and casting.

- Comparing the results with the standard values of compressive strengths that are obtained by testing of concrete with no glass content at 14th day.

III. MATERIALS AND EXPERIMENT

A. *material used*

1. Glass powder- finely grounded glass powder.
2. Ordinary Portland cement- 53 grade cement was used for the experiment
3. Coarse aggregate- standard crushed stones available for regular construction works were used.
4. Fine aggregate- conventional sand was used which passed through 4.75mm sieve.
5. No chemical admixtures or plasticizers were added.

B. *Procedure*

- Initially 3 cubes and 3 beams of standard sizes were cast for M20 grade of concrete for reference, defined as RF.

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- 5 sets of cubes and beams were cast for different proportion of replacement of cement in concrete for the same mix design, defined as M1 to M5.
- The proportion of the glass in designated grade are as follows:

Table 2: Glass proportion in respective concrete mix.

Name	% Of Glass
RF	0
M1	10
M2	20
M3	30
M4	40
M5	50

- Cube specimens of size 150mm X 150mm X 150mm were prepared for every concrete mix with different proportion of glass and were tested on 14th day.

C. *Mix Design*

The mix design was prepared for M20 grade concrete. For the calculation of the quantities and mix design IS 456:2000 and IS 10262:2009 were used.

The quantities required for M20 grade are given in the table below. This concrete mix will be referred as "RF".

Table 3: Mix design for RF

Name	Quantity
Cement	394.32 kg
Water	197.16 kg
Fine aggregate	705.5 kg
Course aggregate	1151.10 kg

The quantities for other mix that contains glass powder content are given in the table below.

Table 3: Mix design for M1 to M5

Mix name	Glass content (kg)	Cement (kg)	Fine aggregate (kg)	Course aggregate (kg)
M1	39.4	354.8	705.5	1151.1
M2	78.8	315.4	705.5	1151.1
M3	118.2	276.0	705.5	1151.1
M4	157.7	236.5	705.5	1151.1
M5	197.1	197.1	705.5	1151.1

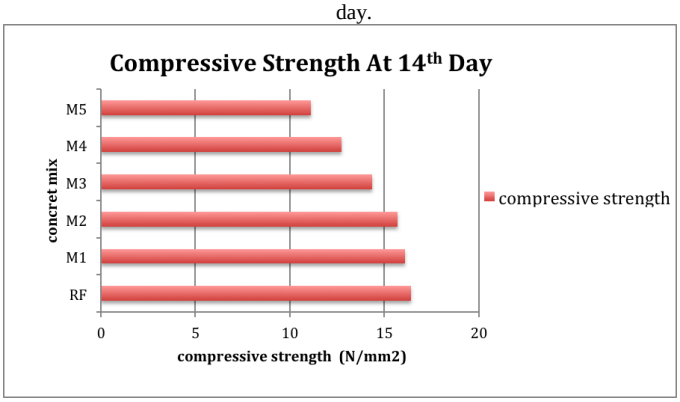
D. *Tests*

Compression test- 3 cubes of each type of concrete mix were tested for compressive strength. The table below shows the value of average compressive strength of various type of mix. All the tests were performed according to IS 516-1959.

Table 4: Compressive strength of various mix at 14th day

Name Of Mix	Compressive Strength
RF	16.4
M1	16.1
M2	15.7
M3	14.4
M4	12.7
M5	11.1

Graph 1: Comparison between compressive strengths of various mix at 14th day.



IV. RESULTS AND DISCUSSIONS

- It is evident that waste glass can be used as a partial replacement for in cement.
- Ideally only 30% of replacement of cement should be done as it is observed in the tests that compressive strength decreases after that value of replacement.
- It is also observed that while performing the casting of the concrete, with increase in the glass content there is an increase in the need of water content or else the workability of the mix decreases.

V. CONCLUSIONS

Glass has been used as a partial replacement of cement in concrete for M20 grade mix in different proportions and the compressive strengths of the specimens were tested. The following conclusions have been drawn on the basis of the results obtained from the tests.

- The replacement of cement with glass powder can be done upto 30% by mass. Though, The results shows no significant increase in the compressive strength at initial stage when glass is being used but it is approximately equal to the normal concrete value when the proportion of glass is below 30%.
- It can be concluded that waste glass can be used as a partial replacement for cement. In this way we can use waste glass for constructive use, reduce glass landfill problems and be environment friendly.

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