Strength Analysis of Concrete in which Cement Partially replaced by Glass Powder

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Abstract

The main aim of this study is to estimate the strength of concrete in which a part of cement is replaced by waste glass powder. For this work concrete mix ofM20 grade was used. Water cement ratio of 0.5 and the glass powder is replaced in cement as 10%, 20%, 30% and 40% increment by the weight of cement. The glass powder used in this work is having the particle size less than 90 microns. The compressive, flexural, and split tensile strengths are determined at different days of curing i.e. at 7 and 28 days for all the mixes. Test was conducted to study the properties of concrete in hardened state like compressive, split tensile, flexural strength and in green state like compaction factor test. From the data it is observed that the glass powder incorporation showed a significant improvement in the hardened state properties of concrete up to 20% of replacement.

Key words: Cement, Glass powder, Concrete, Split tensile strength, Flexural strength, compressive strength

I. Introduction

Cement is the back bone for global infrastructural development. In 2010 it is estimated that global production of cement is about 3.3 billion tons. It is observed that 0.87 ton of CO2 is emitted for every ton production of cement, such that 7% of the world`s CO2 emission is attributable to Portland cement industry. Because of the significant contribution to the environmental pollution and to the high consumption of natural resources like limestone etc,hence we cannot produce cement in more quantity there is a need to economize the use of cement. The practical available solutions to economize cement is to replace cement with supplementary cementitious material like glass powder.

Enormous quantity of waste glass is generated throughout world. Glass comprises 0.7% of India's total urban waste.In UK yearly two to three million tons of waste glass is produce. Much of the glass produced in the World is discarded, stockpiled or land filled. This pattern has influenced environmental organizations to pressure the professional community to lower the amount of glass being discarded as well as find a way to use the non-recycled glass in new applications. The waste glass is one of the issues of environmental problem. The usage of glass has increased considerably in every industry, which has in essence, contributed to the increase of waste disposal. In addition, glass waste is considered as non-decaying material that should be dumped at the site.

The concrete industry has made an effort to partially replace cement by waste glass powder. The grounded waste glass shows pozzolanic properties as it contains SiO2 and therefore it can replace cement in concrete up to some extent and contribute in development of strength. The silica content is very high in the glass and also it is amorphous in nature, thus making it pozzolanic when it is finer than 600µm.

By using glass powder partially in place of cement we can achieve the economy because of low cost of this material as compared to cement. By using this material we can reduce the demand for cement we can also reduce the wastage of post consumer glass saving in abundant open space for storage or dumping.

II. Materials used

a. Cement (53 Grade OPC)
b. Fine aggregate (F.A)
c. Coarse aggregate (C.A)
d. Glass powder (G.P)
e. Water

III. Experimental methodology

a. Mix design (M20)

Indian standard institute has brought out mix design procedure mainly work done in national laboratories i.e. covered in IS 10262-2009.This method can be applied to both medium strength and high strength concrete. M20 grade of concrete was designed by using IS method of mix design.

The quantities of ingredients in kg/m^3 are shown in below table.

Table-1

Water	Cement	FA	CA (20mm)
191.6	383.20	678.391	1187.424
0.5	1	1.77	3.1

b. Tests on fresh concrete

- Compaction factor test

c. Casting and curing

Moulds of standard size 150 mm X150 mm X 150 mm were used for casting the cubes, standard moulds of size 150 mm X 300 mm were used for casing cylinders, standard moulds of size 100 mm X 100 mm X 500 mm were used for casing prisms and standard moulds of size 150 mm X 150 mm X 700 mm were used for casing the RCC beams. The number of specimens casted for M20 grade concrete is shown in below table.

Table-2 representation of test specimens casted

S. No.	Percentage replacement of glass powder	Curing period and types of specimen for 7 days and 28 days			Number of specimens
		Cubes	Cylinders	Prisms	
1	0%	6	6	6	18
2	10%	6	6	6	18
3	20%	6	6	6	18
4	30%	6	6	6	18
5	40%	6	6	6	18

d. Tests on hardened concrete

- Compression test on cubes
- Split tensile test on cylinders
- Flexural strength on prisms

IV. Results and discussions

a. Compaction factor test on fresh concrete

The values of compaction factor test for M20 grade of concrete are shown in the below table-3.

Table-3 results of compaction factor test

S. No.	Percentage replacement of glass powder	Compaction factor values for M20 grade concrete
1	0%	0.863
2	10%	0.85
3	20%	0.842
4	30%	0.832
5	40%	0.828

It was observed from the Compaction factor test which is a test conducted to measure the workability of the concrete, the workability of concrete was decreased by the increase in the percentage replacement of cement with glass powder by weight.

b. Compression test on cubes

The results of compressive strengths of M20 grade for different percentage dosage of glass powder are shown in table-4.

S. No.	Percentage replacement of glass powder	Compressive strength values	
		Average 7 days strength (N/mm^2)	Average 28 days strength (N/mm^2)
1	0%	18.38	27.90
2	10%	19.18	30.30
3	20%	20.93	33.65
4	30%	18.82	28.78
5	40%	16.06	24.20

From the test results of compressive strength for M20 grade concrete, it is found that the compressive strength has increased with the increase in glass powder content up to 20% then the strength decreased. It is found that the optimum percentage dosage of glass powder which gives the max compressive strength for M20 grade concrete is 20%.

c. Split tensile test on cylinders

The results of split tensile strengths of M20 grade for different percentage dosage of glass powder are shown in table-5.

S. No.	Percentage replacement of glass powder	Split tensile strength values	
		Average 7 days strength (N/mm^2)	Average 28 days strength (N/mm^2)
1	0%	1.11	2.19
2	10%	1.21	2.37
3	20%	1.29	2.74
4	30%	1.15	2.25
5	40%	0.9	1.73

From the test results of cylinder split tensile strength for M20 grade, it is found that the split tensile strength has increased with the increase in glass powder content up to 20% then the strength decreased. It is found that the optimum percentage dosage of glass powder which gives the maximum split tensile strength for M20 grade concrete is 20%.

d. Flexural strength on prisms

The results of flexural strength on prisms of M20 grade for different percentage dosage of glass powder are shown in table-6.

S. No.	Percentage replacement of glass powder	Flexural strength values	
		Average 7 days strength (N/mm^2)	Average 28 days strength (N/mm^2)
1	0%	2.35	3.27
2	10%	2.49	3.40
3	20%	2.62	3.79
4	30%	2.42	3.33
5	40%	2.16	3.10

From the test results of M20 concrete, it is found that the flexural strength has increased with the increase in glass powder content upto 20% then the strength decreased. It is found that the optimum percentage dosage of glass powder which gives the maximum flexural strength for M20 grade concrete is 20%.

V. Conclusions:

1. For replacing cement by glass powder the optimum value is 20%.
2. The workability of concrete reduced with the increase in replacement of cement by glass powder.
3. It is found that there was 14 % increment in compressive strength for M20 grade concrete at 7 days of curing.
4. It is found that there was 21 % increment in compressive strength for M20 grade concrete at 28 days of curing.
5. It is found that there was 16 % increment in split tensile strength for M20 grade concrete at 7 days of curing.
6. It is found that there was 25 % increment in split tensile strength for M20 grade concrete at 28 days of curing.
7. It is found that there was 11 % increment in flexural strength for M20 grade concrete at 7 days of curing.
8. It is found that there was 16 % increment in flexural strength for M20 grade concrete at 28 days of curing.
9. Cost reduction of 13% is achieved for optimum glass powder replacement for M20 concrete.
10. The first crack appeared for CVC members at early stage, where as for RGP members the first crack has appeared lately.
11. It is noted that the load carrying capacity of RGP20% member is more compared to CVC member.
12. It is observed that the deflection of RGP20% member is less compared to CVC member.
13. It is observed that the deflection of RGP20% member is less compared to CVC member.
14. Additionally, use of RGP prevents Ca $(OH)_2$ leaching.

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