Indian Journal of Science and Technology, *Vol 11(31), DOI: 10.17485/ijst/2018/v11i31/130501,* August 2018
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Partial Replacement of Fine Aggregates with Waste Glass in Concrete With Respect To Conventional Concrete with Alccofine

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Abstract

Objective: To find out compressive strength, flexural strength and tensile strength of concrete by using waste glass as a fine aggregate and to check internal structure of concrete by SEM test and XRD test. **Method:** Waste glass is the better idea to use in concrete as fine aggregate as India produce 22 million metric ton of waste glass per year and recycles only 45% of it. Fine aggregates replaced by glass with 3%, 6%, 9%, 12%, 15% in M40 mix. In this research also alccofine 1203 used to provide additional strength to concrete. Tests performed on these examples were: compressive strength, split tensile strength, flexural strength test, SEM and XRD test. **Findings:** Strength increases with the addition of glass particles to the concrete by partially replacing fine aggregates. Alccofine addition to glass as additive helps to improve the strength properties of glass concrete due to its micro size. Strength increases as replacement of 5%, 7% to 9 % due to angular shape of glass molecules. **Improvement:** Size of the waste glass can be finer and more Alccofine may be added.

Keywords: Alccofine, Compressive Strength, SEM (Scanning Electrons Microscope), XRD (X-Ray Diffraction), Waste Glass

1. Introduction

In the construction industry mostly materials we used is taken from natural resources. Due to use of these material at high rate they getting depleted at high stage[1–3]. Due to use of Sand River as a fine aggregate the water table has been reduced and also erosion of river bed takes place. India produce 22 million glass waste in a year and to recycling the glass requires high energy and more is expensive so used in concrete is a good idea[4–7].

The glass is delivered by softening a blend of materials, for example, silica, soda ash and $CaCO_3$ at high temperature took after by cooling[8]. Glass, being non-biodegradable, reusing openings should be researched[9]. Because of the high material utilization of the development business, the usage of waste glass as an incomplete substitution for fine aggregate in structural concrete is especially alluring idea and can be implement at higher scale level[10–12].

2. Material Used

a) Cement - Ordinary Portland Cement (OPC) was utilized as the primary binder in this study. No any lumps in the cement and prepared freshly.

b) Coarse Aggregate - The crushed stone aggregates were used of 20mm and 10 mm size and can be of elongated, irregular and angular shape as mix proportion.

c) Fine Aggregate - Normal fine aggregate fundamentally utilized is mining sand which acquired sieve analysis result all particles under 1.18 mm in diameter.

d) Fine Glass Aggregates - Reused waste glass was utilized as a partial substitution for characteristic fine aggregate. The glass rates of (3%, 6%, 9%, 12% and 15%) by weight were utilized as a part of this investigation. The glass has been washed, pulverized and screened to evacu-

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ate essentially all particles fewer than 1.18 mm in diameter. The measure of waste glass utilized was in go 75 micron to 4.75 mm.

e) Additive - Additive to be used is alccofine 1203 to enhance the strength of concrete with fine glass powder.

f) Water - Clean municipal water free from organic compound to be used throughout this study.

g) Preparation of fine glass powder - Glass powder was prepared by crushing waste glass bottles by using rammer and then sieved.

3. Material Properties

a) Properties of Cement - Cement is utilised as a binder in concrete mix. Cement used in this is OPC cement. The properties of cement are given in Table 1.

Table 1. Properties of cement

Sr. no	Property	Value obtained
1	Initial setting time	55 min
2	Final setting time	265 min
3	Compressive strength	54MPa
4	Specific gravity	3.13

b) Properties of Aggregate - The concrete mix utilized river sand and the properties are given in Tables 2,3.

Table 2. Properties of fine aggregate

Sr. no	Property	Values obtained
1	Particle size	4.75mm
2	Fineness modulus	2.7
3	Specific gravity	2.65

Table 3. Properties of coarse aggregate

Sr. no	Property	Value obtained
1	Particle size	20mm
2	Specific gravity	2.73
3	Fineness modulus	4.6

c) Properties of Fine Glass Aggregate - It has same properties as that of fine aggregates but the shape of fine glass aggregate is irregular and of hydrophobic nature. Properties of fine glass aggregates are given in Table 4.

Table 4. Properties of fine glass aggregate

Sr. no	Property	Value obtained
1	Colour	Colour less
2	Particle size	More than 4.73
3	specific gravity	2.63
4	Physical state	Small in size

d) Properties of Alccofine 1203 - It is a nano material made by Ambuja Cement Pvt. Ltd. It is basically used in shotcrete and used to fill cracks. The properties of Alccofine 1203 are shown in Table 5.

Table 5. Properties of Alccofine 1203

Sr. no.	Property	Value obtained
1	Colour	gray
2	Specific gravity	2.9
3	Physical state	Powder form
4	density	650-700

4. Test Results

4.1 Compressive Strength Test

The Compressive Strength of concrete cubes is given by load per unit area which denoted as P/A N/mm^2. The Compressive Strength results for 7, 28 and 56 days respectively are given in the following Figure 1–3.

The Figure 1 shows that the increase in compressive strength occurs till 9% addition of glass particles with 2% alccofine addition due to angular shape of glass particles and addition of Alccofine leads to fill the microscopic voids beyond 9% it goes on decreasing the strength step by step due to bleeding when vibrator is used.

4.2 Split Tensile Strength Test

Split Tensile strength is the tensile strength of concrete which is necessary to calculate as it gives the point where concrete cracks when tensile forces acts on it that is splitting the concrete cylinder into two parts. It is given as 2P/πdl where P is the load acting, d is the diameter of cylinder and l is the supported length of cylinder. The Figure 2 shows the split tensile strength for the glass concrete at 7,28 and 56 days of testing.

The split tensile strength of concrete increases with the glass replacement with fine aggregates as up to 9 % due to angular shape of glass molecule and decreasing by further replacement bleeding due to use of vibrator.

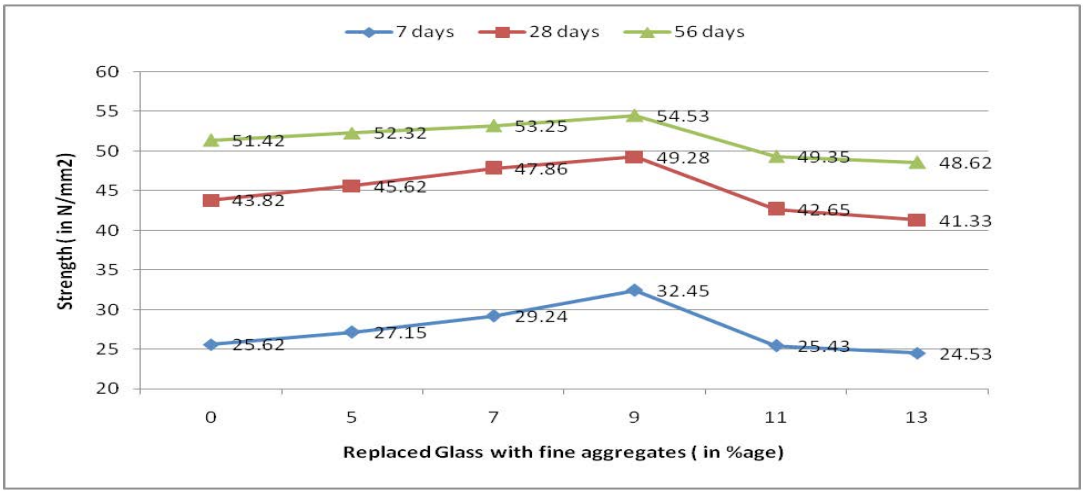

Figure 1. Compressive strength for M40 grade glass concrete.

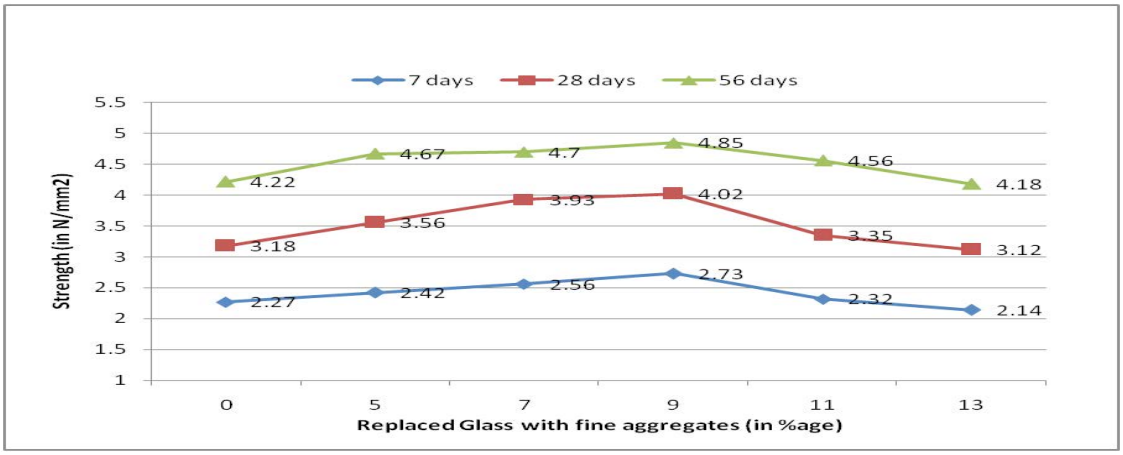

Figure 2. Split tensile strength of M40 grade glass concrete.

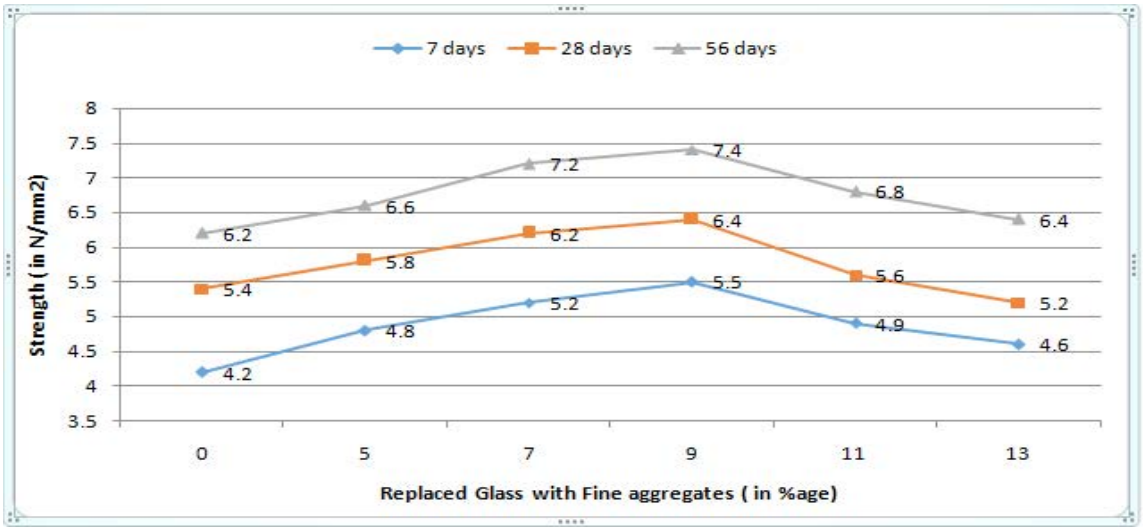

Figure 3. Flexural strength of M40 grade glass concrete.

4.3 Flexural Strength Test

Flexural Strength is given for 10cm specimen as pl/bd^2 when a >13.3cm and when a < 13.3cm it is given as $3pa/bd^2$, where p is load, l is supported length, b is width, d is the depth and a is the distance between nearer support and fracture. The Figure 3 shows the flexural strength of Glass concrete at 7, 28 and 56 days testing.

Flexural strength of glass concrete also increases up to 9 % addition of glass to the concrete as a replacement with fine aggregates due to microscopic voids fill by Alccofine and after 9% it starts decreasing due to bleeding and brittle nature of glass.

4.4 SEM and XRD Test

SEM Test - The Figures 4–5 show the glass particles present in the concrete and the magnifying image of glass in concrete and the shape of concrete. In SEM test show the packing of Alccofine particles in concrete.

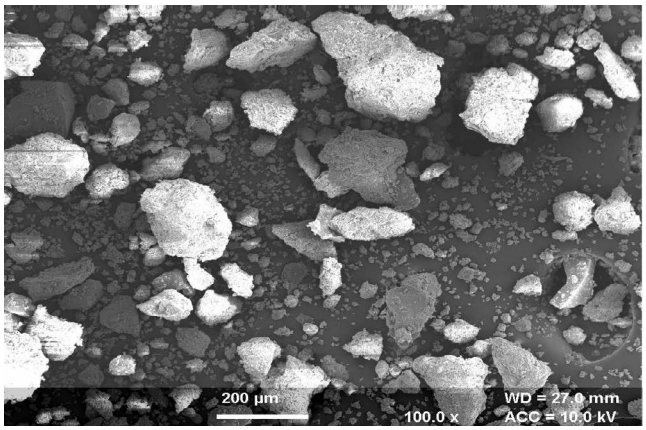

Figure 4. SEM image for glass concrete.

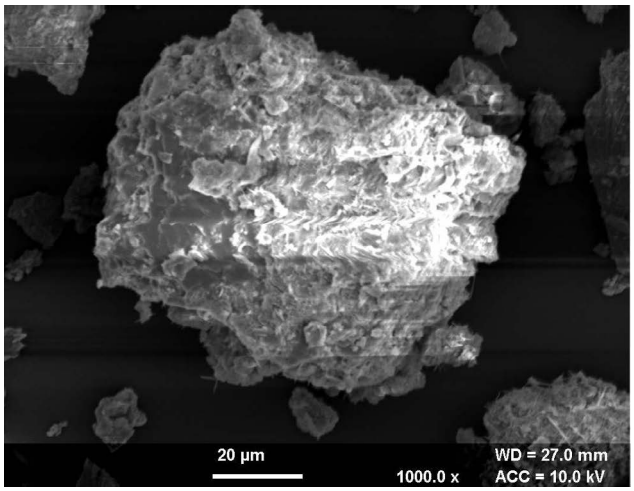

Figure 5. SEM image of glass in concrete.

XRD Test- It shows spacing between diameter to diameter of atoms at different angles. Table 6 shows the d-spacing between the atoms at different positions and angles.

Table 6. XRD details for glass with 2% alccofine

Pos. [°2θ]	FWHM Total [°2θ]	d-spacing [Å]	Rel. Int. [%]	Area [cts*°2θ]
15.8628	0.1291	5.58238	0.00	0.01
18.0976	0.0993	4.89776	5.03	27.43
19.0034	0.0340	4.66630	0.00	0.01
20.9196	0.0786	4.24301	6.63	32.84
23.0374	0.2341	3.85751	0.82	16.32
26.7094	0.0537	3.33493	100.00	422.67
27.6927	1.0381	3.21871	0.67	58.60
29.5155	0.4407	3.02395	2.08	100.46
32.0820	0.9063	2.78765	0.99	98.56
32.6220	0.2792	2.74273	1.18	35.15
34.1613	0.2738	2.62259	3.44	98.99
36.5950	0.0993	2.45356	3.86	39.03
39.5295	0.0725	2.27792	4.50	29.18
40.3542	0.0935	2.23325	1.32	6.78
41.1903	0.8184	2.18983	0.55	47.91
42.5005	0.0907	2.12530	1.54	8.14
43.0880	0.3656	2.09768	0.53	16.07
45.8461	0.1388	1.97769	1.23	17.18
47.1847	0.2455	1.92466	1.32	30.89
50.1883	0.1114	1.81628	3.30	35.15
50.8399	0.1380	1.79452	1.38	13.28
54.3769	0.1780	1.68586	0.65	6.45
54.9422	0.0716	1.66984	2.94	17.88
60.0064	0.1132	1.54045	2.19	16.79
62.4677	0.0340	1.48554	1.75	3.28
64.1123	0.0452	1.45134	0.93	4.62
68.3664	0.1496	1.37103	9.05	103.13
75.7042	0.1516	1.25532	0.86	7.16
77.6129	0.0340	1.22915	0.52	0.97
80.0210	0.2864	1.19811	0.54	8.57
81.3456	0.4549	1.18191	0.52	14.64

5. Conclusion

1. Compressive strength, flexural strength and split tensile strength increases with the addition of glass as

replacement with fine aggregates with Alccofine as additive up to 9% addition to concrete.
2. Glass usage is possible as partial replacement of fine aggregate.
3. Reduction in strength may be due to the decrease in workability after 9%
4. XRD test shows that intermolecular attraction between glass molecules increase due to addition of alccofine1203.
5. It is possible and better to reuse waste glass in concrete to a greater extend because it saves energy.

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