

Glass Waste in Concrete: Effect on Workability and Compressive Strength

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ABSTRACT: Major challengers due to growing construction are unbearable burden on environment and rapid depletion of respective natural resources. Any construction activities require more or less natural material like aggregates which cause rapid depletion of the same due to high consumption. On the other hand production of one ton cement is responsible for emission of 0.9 ton CO₂. For sustainable development use of waste material in construction may be a key point. In the present investigation an attempted is made to explore the possibility of using waste glass as partial replacement of cement and fine aggregate in concrete. Waste sheet glass kept in abundance was crushed and sieve. The fraction passing through 150 micron IS sieve was used as partial replacement of cement (5% - 25%). Whereas fraction passed through IS 4.75 mm sieve was used as partial replacement of natural fine aggregate (10% - 70%). Result showed that glass waste can be used as partial replacement of cement and fine aggregate individually. It is also revealed that compressive strength of concrete made with glass waste was more than the referral conventional concrete at all the replacement levels of cement and natural fine aggregate.

KEYWORDS: Waste Glass, Replacement, Concrete, Cement, Construction, Fine aggregate.

I. INTRODUCTION

Concrete is versatile building material and is used in almost all the construction works. Consumption of concrete is increasing day by day due to reason one or another which in terms put enormous pressure on environment for the want of component of concrete which are mostly available in natural form. It is our duty to relieve the pressure from the environment for ecological balance and to conserve the natural resources for generation to come. In the country like India sustainable and cheap construction is need of the time to strengthen the economy. This can be achieve by using waste material like waste sheet glass in construction which will not only reduce the cast of construction but also relieve the pressure from the environment.

Bajad *et al.*, (2011) observed with increasing replacement of cement with glass powder up to 20%. The highest percentage increase in the compressive strength was about 30% and flexural strength was about 22% at 20% replacement level. When the cement replacement level was increased beyond 20%, the compressive strength decreased. Gautam., (2012) indicated that Waste glass can effectively be used as coarse aggregate replacement (upto 50%) without substantial change in strength. Nassar and Soroushian.,(2012) studied about Strength and durability of recycled aggregate concrete containing milled glass as partial replacement for cement on the compressive strength of concrete. Milled waste glass was used as secondary cementitious material towards production of recycled aggregate concrete with improved strength and durability attributes. Gautam *et al.*, (2012) indicated that waste glass can effectively be used as fine aggregate replacement (up to 40%) without substantial change in strength. Lisa m., (2013), determined the waste glass - a supplementary cementitious material. (Shayan & Xu, 2004; Meyer, *et al*, 2001; Carles *et al*, 2008),

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determined the Use of glass powder in the presence of reactive aggregates can actually mitigate ASR. Improved workability and durability were reported for concrete containing glass as a SCM. The compressive strength of concrete containing glass powder is lower than OPC at early ages, but continues to develop, approaching the control strength over time at addition up to 30%, and can surpass that of OPC in some cases. Diego F. Romero (2013), studied about Concrete Durability and Environmental Performance of Mixtures Containing Recycled Hazardous Waste Aggregates. For waste glass aggregates, several researchers concluded that the shape and texture of crushed, angular sand and glass particles reduce concrete workability, while spherical shaped aggregates increase the workability. This paper presents results of an experimental program carried out to observe the suitability of using waste sheet glass as partial replacement of cement and fine aggregate individually in concrete. Result obtain are discussed in detail here in after.

II. MATERIALS AND METHODOLOGY

A) Cement

In this work, Portland pozzolana cement conforming to IS: 1489-1991(Part 1) obtained from a single batch was used throughout the investigation. The physical properties of PPC as determinate are given in table 1.

Table 1- Properties of Cement and Waste Glass Powder

Properties	Result Value
Standard consistency %	31 %
Initial setting time	250 minutes
Final setting time	325 minutes
Soundness (Lech atelier expansion)	0.5 mm
Fineness (% retained on 90µm IS sieve)	3.5 %
7 days Compressive strength	33 MPa
28 days Compressive strength	44 MPa
Specific gravity for Cement	2.70
Specific gravity for Waste Glass Powder	2.5

B) Fine Aggregate

The fine aggregate was used in this investigation locally available river sand, which was passed through 4.75 mm size and conforming to the gradation zone II as per IS:383-1970 specification. Specific gravity of fine aggregate and waste glass was 2.3 and 2.5 respectively. Fineness modulus for same was 2.75 and 2.94 respectively. Particle size distribution curve of the noted sieve analysis test results for used fine aggregate and waste glass are shown as figure 1 and figure 2.

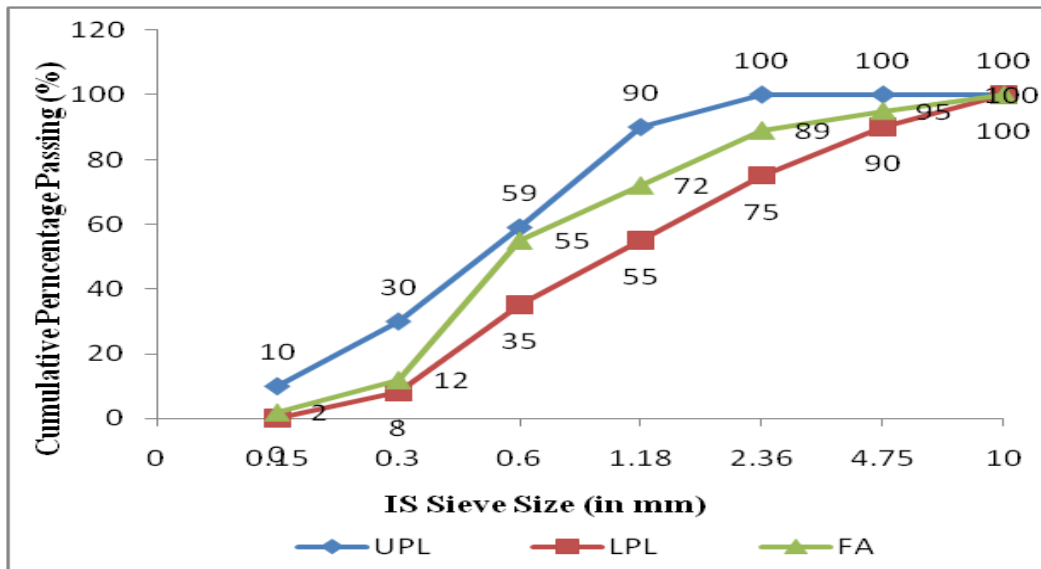


Figure 1- Grading curve of the Fine Aggregate

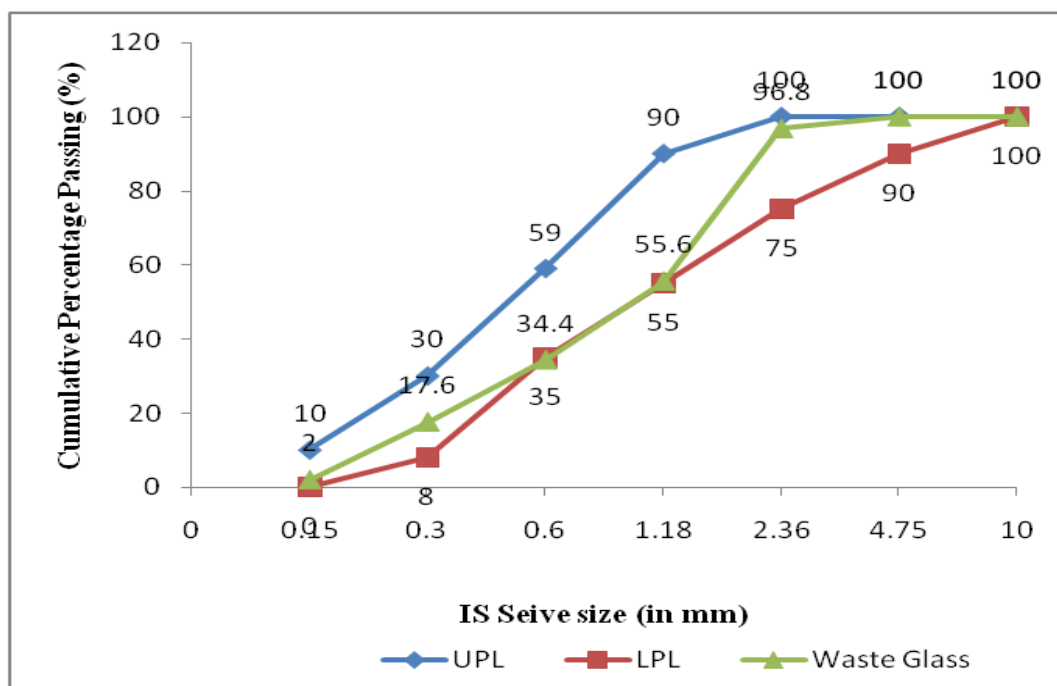


Figure 2- Grading curve of the Waste Glass

C) Coarse Aggregate

A Combined grading of the two individual 20 mm and 10 mm nominal size coarse aggregate (20mm & 10mm) grading was used with the ratio of 60:40 respectively conforms to IS:383-1970. Particle size distribution curve of the achieved combined coarse aggregate with these two (20 mm and 10 mm) coarse aggregate by the noted sieve analysis test result

with permissible limits (UPL & LPL) is shown in figure 3. Properties of the Achieved Combined coarse Aggregate (CCA) of 20 mm Nominal size are shown in Table 2.

Table 2- Properties of Coarse Aggregate –

Properties		Result value
Fineness Modulus	Aggregate (10mm)	5.956
	Aggregate (20mm)	7.012
	Combined Coarse Aggregate (10mm &20mm)	6.548
Water absorption (%)		0.80
Specific Gravity		2.60

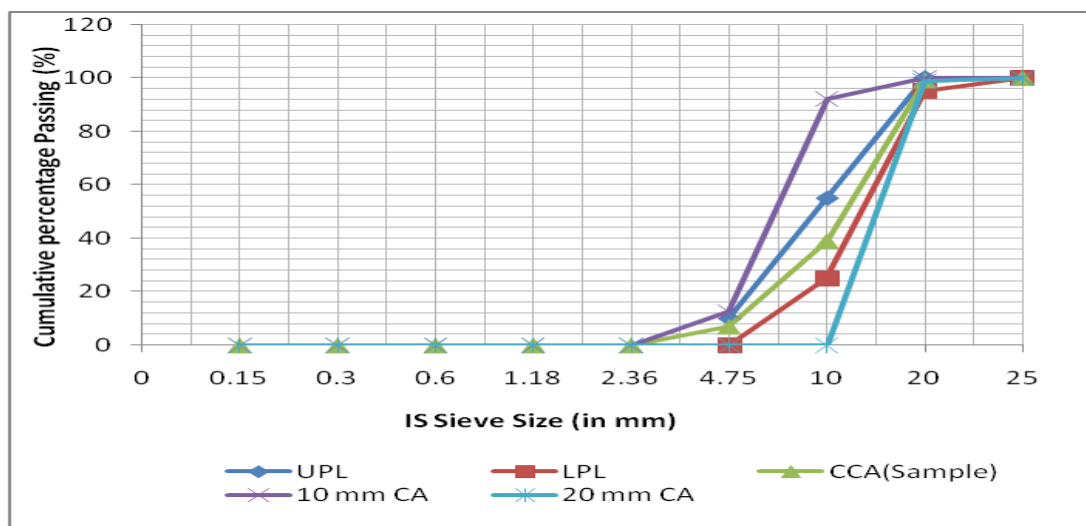


Figure 3 – Grading Curve of the Combined Coarse Aggregate

D) Superplasticizer

Sulphonated naphthalene based Superplasticizer (KEM SUPLAST 101 S) of Chembond chemicals was used which conforms to IS: 9103-1999 specifications. Its specific gravity was 1.2 and showed good enhancement in workability of concrete mix.

E) Water

Fresh water was used for mixing the concrete mix in entire investigation and for curing the concrete in finding maximum possible utilization of waste glass as cement and fine aggregate replacement.

F) Concrete

The concrete mix design is done in accordance with IS 10262(2009). The cement content used in the mix design is taken as 380 kg/m³ which satisfies minimum requirement of 300 kg/m³ in order to avoid the balling affect. Good stone aggregate and Natural River sand of Zone-II were used as coarse and fine aggregate respectively. Nominal size of coarse aggregate was 20mm. A sieve analysis conforming to IS 383-1970 was carried out for both the fine and coarse aggregates.

III. RESULTS AND DISCUSSION

A) Workability

Workability is property of concrete which determine ease in mixing, placing and compaction of concrete. The results of workability in terms of slump for concrete made using waste glass as cement and fine aggregate replacement are shown in table 3 and 4. The same results are given in figure 4 and 5 for visual observation and having the idea about variation pattern. It was observed that at constant dose of Superplasticizer (0.6%) workability of concrete made using waste glass as cement replacement was increased with replacement level. This increase was due to the increasing content of waste glass with is hydrophobic in nature. Resulting is more availability of water as compare to conventional concrete.

It was also observed that workability of concrete made using waste glass as fine aggregate replacement was increased with replacement level up to 40% and there after reduction in slump was observed. Increase in workability may be due to the non water absorbent nature of waste glass as compare to natural sand. However decrease in slump may be due to the loss of effective water from specimen through rapid transportation caused by more voids produced by equivalent waste glass component in lieu of natural sand being heavier than the later.

Table 3 – Variation of Slump at different replacement levels of cement

S. No.	Replacement level (%)	Slump (mm) with 0.6 % with Superplasticizer
1	0	50
2	5	55
3	10	70
4	15	75
5	20	83
6	25	90

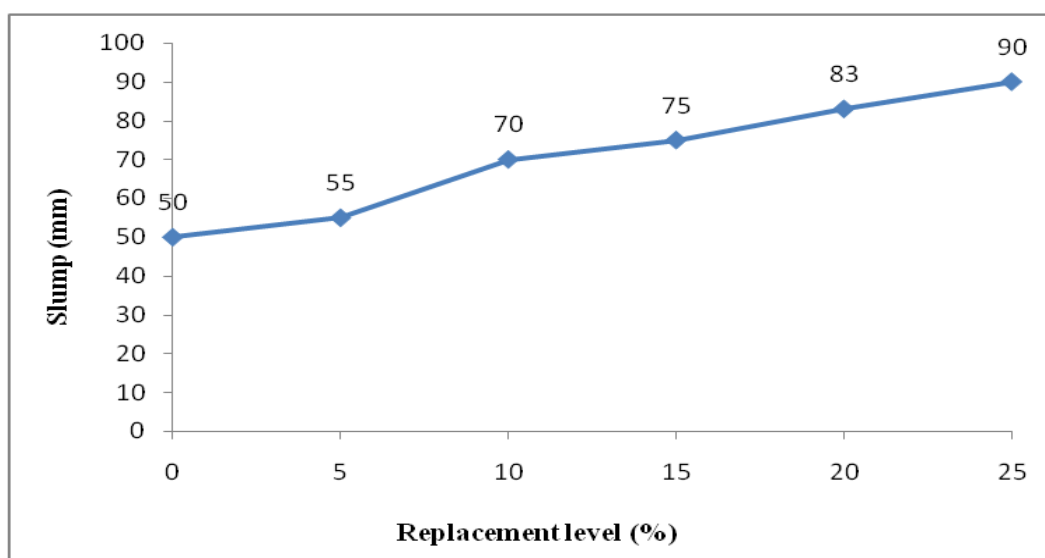


Figure 4 – Variation of Slump at different replacement levels of cement

Table 4- Variation of Slump at different replacement levels of fine aggregate

S. No.	Replacement level (%)	Slump (mm) with 0.6 % with Superplasticizer
1	0	50
2	10	65
3	20	70
4	30	65
5	40	60
6	50	50
7	60	42
8	70	37

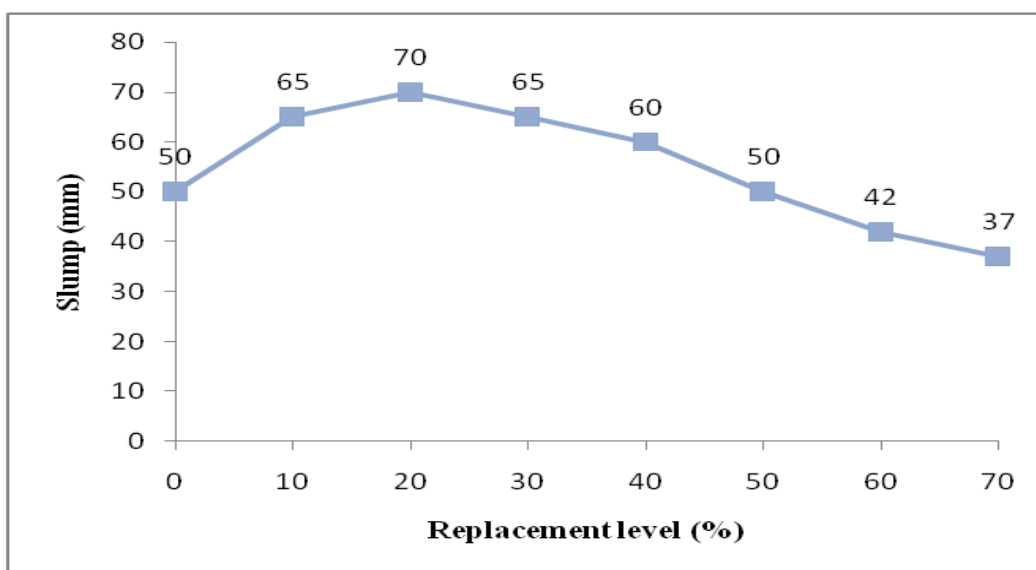


Figure 5 – Variation of Slump at different replacement levels of fine aggregate

B) Compressive strength

The results of compressive strength of concrete made using waste glass as cement and fine aggregate replacement are shown in table 5 and 6. The same results are given in figure 6 and 7 for visual observation and having the idea about variation pattern. It is evident from table 5 compressive strength of concrete made using waste glass as cement replacement was more than conventional concrete at all the replacement level of 28 days, however strength is maximum at 15% replacement level.

It was also observed that compressive strength using waste glass as fine aggregate replacement was decreased at 10% replacement level as compare to conventional concrete. Decreased in strength may be due to the lesser volume of equivalent waste glass as compare to natural sand since former is heavier the later. However compressive strength was increased at all the replacement level beyond the 10% then that of conventional concrete. This may be attributed to the batter bonding between glass partial, aggregate and cement as compare to conventional concrete.

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Table 5- Variation of compressive strength with replacement level of cement

Specimen Designation	Replacement level (%)	Compressive strength (MPa)	
		7 days	28 days
B1	0	24.59	31.72
B2	5	26.10	33.45
B3	10	26.07	35.19
B4	15	24.56	38.00
B5	20	22.15	36.93
B6	25	21.12	36.15

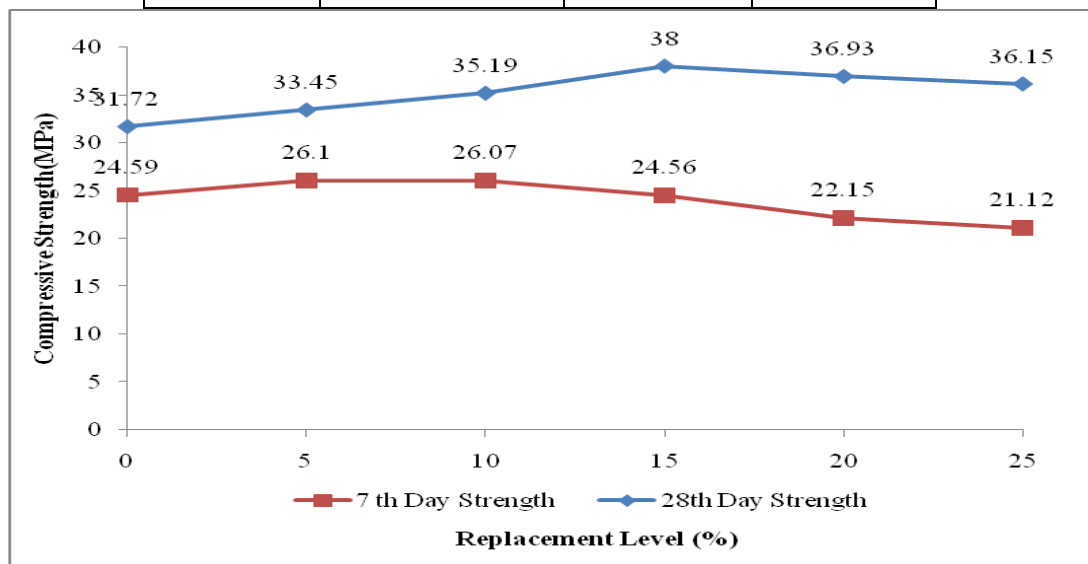


Figure 6 – Variation of compressive strength with replacement level of cement

Table 6- Variation of compressive strength with replacement level of fine aggregate

Specimen Designation	Replacement level (%)	Compressive strength (MPa)	
		7 days	28 days
A1	0	24.59	31.72
A2	10	22.25	30.60
A3	20	24.30	33.71
A4	30	22.38	34.60
A5	40	26.52	37.50
A6	50	25.26	38.45
A7	60	25.87	34.00
A8	70	25.54	33.39

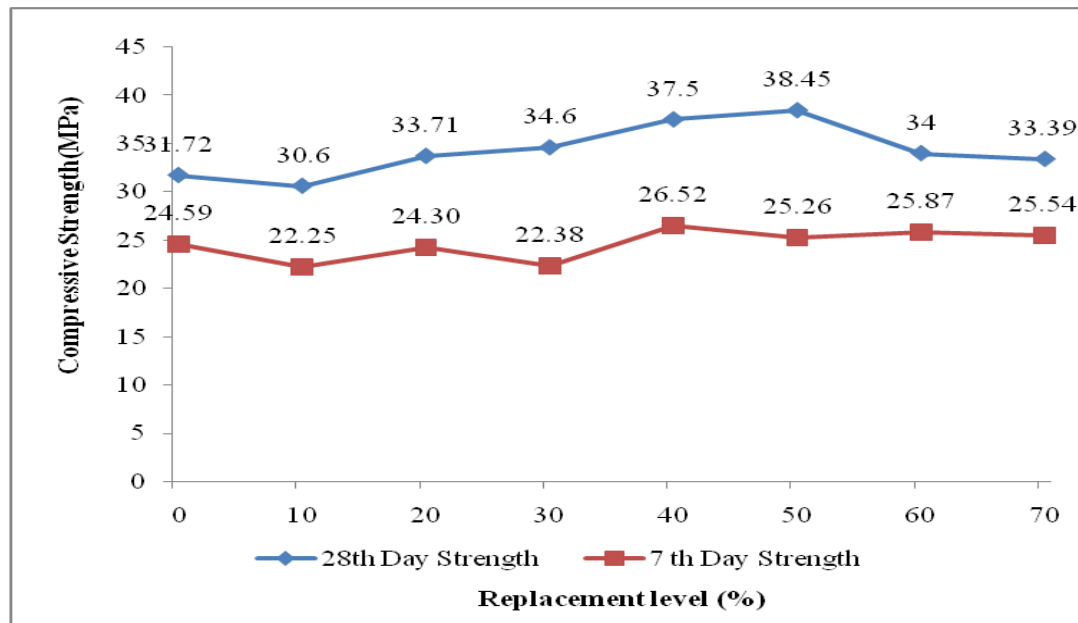


Figure 7 – Variation of compressive strength with replacement level of fine aggregate

IV. CONCLUSION

Based on above study following conclusion are drawn -

1. While using waste glass as partial replacement of PPC in concrete increased the workability with increased in replacement level.
2. In general, workability of concrete made using as fine aggregate tended to be increased.
3. Compressive strength of concrete made using waste glass used as partial replacement of cement.

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