Fine Aggregate As A Partial Replacement With Waste Glass In Concrete

Sudhir Kumar[1], Suleman Ali[2], Manish Chaudhary[3],
Rajneesh k Gautam[4], Islamuddin[5]
[1, 2,3,4,5] Dept of Civil Engineering
[1, 4, 5]UIET, Babasaheb Bhimrao Ambedkar University, Lucknow-India
[2]Himgiri Zee University, Dehradun – India
[3]Sam Higginbottom Institute of Agriculture Technology and Science, Allahabad- India

Abstract- *Concrete is most widely used man made construction material and its demand is increasing day by day. Due to Construction and demolition activity has led to increased support up of waste in the landfills. The interest of the construction community in using waste or recycled materials in concrete is increasing because of the more stress is given on sustainable construction. The waste glass is among the generated waste as well. On other hand, the demand of cement, an important construction material has been increasing every year which led to increase in production of cement. Cement production is a significant source of global carbon dioxide (CO_2) emissions. In the present experimental study it was intended to explore the possibility of utilization of waste glass in concrete using Portland Pozzolana Cement (PPC). Fine aggregate was replaced with waste glass in the range of 10% to 80% at an interval of 10%. M25 (1:1.58:3 at 0.45 water/cement ratio) concrete specimens at different replacement level of Portland Pozzolana Cement (PPC) were cast for compressive strength after 7days and 28 days curing. The experimental result showed that fine aggregate can be replaced up to 50% by fly ash without considerable change in compressive strength.*

Keywords- Waste Glass, Compressive strength, fine aggregate, PPC Concrete

I. INTRODUCTION

In recent living, there is an escalating significance for using waste glass in concrete. This significance has been motivated by the large amount of waste glass available from empty bottles, waste windows glass and containers. If such glass could be consumed in concrete, it would considerably decrease the disposal of waste glass and solve some of environmental troubles. The use of waste glass as aggregate in concrete has been attempted recently. Using such glass as a construction material is among the most exactingly choice because of the potentially plummeting the cost of glass disposal and concrete production. It is projected that observable differences occur in the structure between glass concrete and conventionally concrete. In present time, the huge consumption of concrete in construction activities, the available sources of natural sand are getting exhausted. Hence conservational consumption of natural river sand is very high due to its extensive use in concrete. In particular, the demand for natural river sand is quite high in developed countries owing to infrastructural growth. The non-availability of sufficient quantity of natural river sand for making cement concrete is affecting the growth of construction industry in many parts of the country. Consequently, it is a requirement for effective utilization of waste glass. Waste glass as alternative and supplementary material which can be used as partial replacement of conventional material. *G. D. Perkins (2007)* is investigated that Crushed glass is a suitable material for use as 100% replacement for fine aggregate. Glass powder exhibits pozzolanic properties but is dependent upon fineness of the powder. Concrete containing glass as fine aggregate can achieve comparable strengths to that of natural sand aggregates. *Haider K et al. (2009)* is investigated that the possibility of using waste glass of size up to 5mm as a fine aggregate in concrete and mortar. The waste glass was used as a partial weight replacement of sand with percentages of 10, 20, 30 and 40 %. The results have indicated that increasing the fractions of sand replacement by waste glass leads to reduce the compressive and tensile strength for both mortar and concrete. *Shivacharan et al. (2015)* 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.

II. METHOD AND METHODOLOGY

1) ***Cement***- In this study, Portland Pozzolana Cement (fly ash based) of single batch was used conforming to IS 1489(part I):1991 specification. Properties of PPC are as listed below.

Initial setting time (145 minutes), Final setting time (315 minutes), Standard consistency % (31.6%)

Fineness (% retained on 90µ in sieve) (3.7%), Specific gravity (2.73), Soundness (Le-chatelier expansion) (0.5 mm), 7 Days compressive strength (33MPa), 28 Days compressive strength (44 MPa).

2) ***Fine Aggregate-*** Fine aggregate (FA) used in this investigation was locally available the natural river sand passing completely through 4.75 mm aperture size sieve and conforming to zone II as per IS:383-1970 specification. Its fineness modulus and specific gravity were 2.74 and 2.35 respectively.

3) ***Coarse Aggregate-*** A Combined grading of the two individual 20 mm and 10 mm Nominal size coarse aggregate (20mm CA & 10mm CA) gradings was used with the ratio of these coarse aggregates as 60:40 respectively. Particle size distribution curve of the Achieved Combined coarse aggregate with these two (20 mm and 10 mm) coarse aggregate by the Recorded sieve analysis test result with permissible limits (UPL & LPL), Properties of the Achieved Combined coarse Aggregate (CCA) of 20 mm Nominal size are shown in Table -1.

Table-1, Properties of Coarse Aggregate (CA)

Properties		Result value
Fineness Modulus	10 mm Aggregate(10mm CA)	5.854
	20 mm Aggregate(20mm CA)	7. 104
	Combined Coarse Aggregate(CCA)	6.479
Water absorption (%)		0.84
Specific gravity		2.60

4) ***Waste Glass-*** Waste glass locally available at Batra shops, has been collected and made into glass powder. Glass waste is very hard material. Before adding glass powder in the concrete it has to be powdered to desired size. In this studies glass powder was made manually by using impact container and then passing through 90 micron IS sieve in table the physical and chemical properties are presented.

Table-2 Properties of Waste Glass

Properties		Result Value
Physical Properties	Specific Gravity	2.65
	Fineness Passing 90µ	97%
	Fineness Passing 150µ	100%
Chemical Properties	pH	10.25
	Colour	White

5) ***Super Plasticizer*** – Sulphonated naphthalene formaldehyde (SNF) based Super plasticizer (KEM SUPLAST 101 S) of Chembond chemicals was used which conforms to IS:9103-1999 specifications. It was in liquid form compatible with the used Cement, brown in colour having specific gravity 1.2 and it showed good deflocculation and dispersion with cement particles to enhance the workability of concrete mix.

6) ***Mix Design of the Referral Concrete*** - M-25 grade of concrete conforming to IS:10262-2009 guidelines was designed as the referral concrete with the mix proportion of (1:1.58:3)and water-cement ratio(W/C) of 0.45 by weight taking with 0.6% super plasticizer dose by weight of cement.

7) ***Water*** – Potable water was used for mixing the concrete mix in entire investigation and for curing the concrete in the determination of the optimal percentage of stone dust as fine aggregate replacement.

Experimental design

The cubes were cast in steel moulds of inner dimensions of cube, 150 x 150 x 150 mm. All the materials are weighted as per mix proportion of 1:1.58:3 with a W/C ratio of 0.45 which correspond to M25 grade of concrete. Fine aggregate is replaced by Waste glass powder. Each mix comprises of various percentages of fine aggregate replacement material in increasing order i.e. 10%, 20%, 30%, 40%, 50%, 60%, 70% and 80% respectively in replacement. The specimens were cured for a period of 7days and 28 days.

III. RESULT 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 fine aggregate replacement are shown in Table -3. The same results are given in figure -1, for visual observation and having the idea about variation pattern. It was observed that at constant dose of Super plasticizer (0.6%) workability of concrete made using waste glass as fine aggregate 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.

Table 3 – Variation of Slump at different replacement levels (%) of Fine aggregate

S.No.	Replacement level (%) Waste glass	Slump (mm) with 0.6 % with Super plasticizer
1	0	65
2	10	60
3	20	73
4	30	70
5	40	63
6	50	55
7	60	47
8	70	38
9	80	35

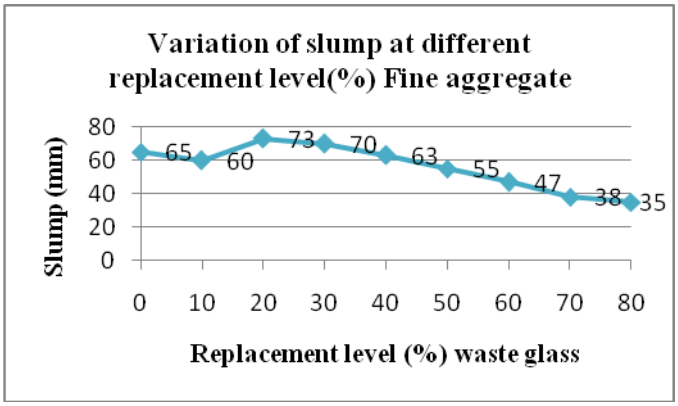

Figure-1 Variation of slump at different replacement level (%) Fine aggregate

B) Compressive Strength:- Compressive strength of the concrete cube specimen was calculated by dividing the maximum load applied to the specimen during the test by the cross sectional area. The average of three values of compressive strength was taken as the representative compressive strength. In test, cube specimen was placed in the CTM machine in such manner that the load was applied to the opposite sides of the concrete cube as cast, that is, not to the top and bottom as per IS: 516-2004 specification. Result of compressive strength of specimens cast for different replacement levels of fine aggregate with stone dust in Portland Pozzolana Cement (PPC) concrete, and a constant dose of super plasticizer are discussed here in after. The average compressive strength of concrete for 7 days and 28 days were tested as per IS 516 – 2004 guidelines and results are tabulated in table-4 and its graphical representation on figure-2 (line chart). It was observed that the compressive strength of specimen at 50% replacement level of fine aggregate with waste glass powder was more than designed value of conventional concrete which shows suitability of waste glass in concrete as partial replacement of fine aggregate from compressive strength point of view. The 7 days compressive strength variations within 44.28% maximum strength and attains on 40% replacement of Fine aggregate with waste glass. The 28 days compressive strength gradually increased with the increase of all replacement level of waste glass. At 50% replacement of waste glass concrete attains maximum value and then compressive strength decreases with increases replacement level of waste glass. The results of compressive strength of concrete made using waste glass as Fine aggregate replacement are shown in Table-4. The same results are given in figure-2 for visual observation and having the idea about variation pattern. It is obvious from Table-4 compressive strength of concrete made using waste glass as Fine aggregate replacement was more than conventional concrete at all the replacement level of 28 days, however strength is maximum at 50% replacement level.

Table-4 Compressive strength results with replacement level of fine aggregate

S.No.	Cube Designation	Replacement Level of Waste Glass (%)	Compressive Strength(N/mm²)	
			7 Days	28 Days
1	A0	0	18.56	31.74
2	A1	10	22.35	30.64
3	A2	20	24.55	33.78
4	A3	30	23.15	34.86
5	A4	40	26.78	37.75
6	A5	50	25.80	38.90
7	A6	60	24.96	34.10
8	A7	70	24.25	32.98
9	A8	80	23.37	32.12

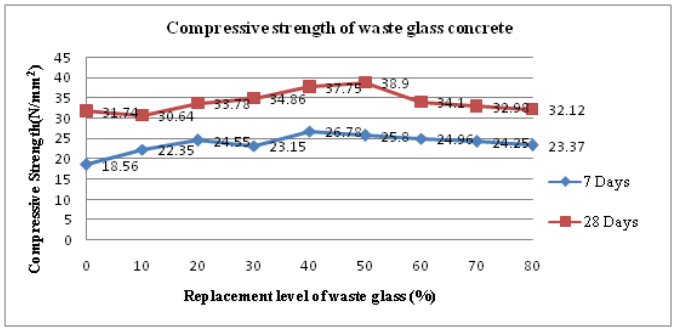

Figure-2 Variation of compressive strength with replacement level (%) of fine aggregate

IV. CONCLUSION

On the basis of above investigation it can be concluded that –

1. Waste glass is to be used as fine aggregate replacement in Portland Pozzolana cement (PPC) concrete as partially.
2. While using waste glass as partial replacement with fine aggregate in concrete increased the workability

with increased in replacement level up to 30%, and then decreases at all replacement levels.

3. Compressive strength of concrete made using waste glass used as partial replacement of Fine aggregate. The optimum replacement level of waste glass with Fine aggregate in concrete is 50%.
4. Use of waste glass powder as Fine aggregate in concrete is advantageous in different manners such as environmental aspects and strength criteria also.

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