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Performing Various Tests on Concrete by Adding Glass Powder

Prem Chand Gautam
Maharishi University of Information Technology Lucknow (Uttar Pradesh) India.

Abstract *- Cement manufacturing industry is one of the carbon dioxide emitting sources besides deforestation and burning of fossil fuels. The global warming is caused by the emission of green house gases, such as CO_2, to the atmosphere. Among the greenhouse gases,CO_2 contributes about 65% of global warming. The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. In order to address environmental effects associated with cement manufacturing, there is a need to develop alternative binders to make concrete. Consequently extensive research is on going into the use of cement replacements, using many waste materials and industrial by products. Efforts have been made in the concrete industry to use waste glass as partial replacement of coarse or fine aggregates and cement. In this study, finely powdered waste glasses are used as a partial replacement of cement in concrete and compared it with conventional concrete. This work examines the possibility of using Glass powder as a partial replacement of cement for new concrete. Glass powder was partially replaced as 10%, 20%, 30% and 40% and tested for its compressive, Tensile and flexural strength up to 60 days of age and were compared with those of conventional concrete; from the results obtained , it is found that glass powder can be used as cement replacement material upto particle size less than 75µm to prevent alkali silica reaction.*

Keywords **–powdered waste glass,, workability, Alkalinity, split tensile, pozzolanic**

I. INTRODUCTION

The interest of the construction community in using waste or recycled materials in concrete is increasing because of the emphasis placed on sustainable construction, the waste glass from in and around the small shops is packed as a waste and disposed as landfill. Glass is an inert material which could be recycled and used many times without changing its chemical property(Aimin Xu and Ahmad shayam,2004).Besides using waste glass as cullet in glass manufacturing ,waste glass is crushed into specified sizes for use as aggregate in various applications such as water filtration, grit plastering, sand cover for sport turf and sand replacement in concrete(Carpenter,A.J. and Cramer,C.M,1999).

Since the demand in the concrete manufacturing is increasing day by day, the utilization of river sand as fine aggregate leads to exploitation of natural resources, lowering of water table, sinking of the bridge piers, etc as a common treat. Attempts has been made in using crushed glass as fine aggregate in the replacement of river sand (Chi sing lam, chi sun poon and Dixon chan,2007).The crushed glass was also used as coarse aggregate in concrete production but due to its flat and elongated nature which enhances the decrease in the workability and attributed the drop in compressive strength (Christoper cheeseman,2011)

Glass is amorphous material with high silica content, thus making it potentially pozzolanic when particle size is less than 75µm(Federio.L.M and Chidiac S.E,2001, Jin.W, Meyer.C, and Baxter.S,2000). Studies have shown that finely ground glass does not contribute to alkali – silica reaction. In the recent, various attempts and research have been made to use ground glass as a replacement in conventional ingredients in concrete production as a part of green house management. A major concern regarding the use of glass in concrete is the chemical reaction that takes place between the silca – rich glass particle and the alkali in pore solution of concrete, which is called Alkali – Silicate reaction can be very detrimental to the stability of concrete, unless appropriate precautions are taken to minimize its effects. ASR can be prevented or reduced by adding mineral admixtures in the concrete mixture, common mineral admixtures used to minimize ASR are pulverized fuel ash (PFA), silica fume(SF) and metkaolin (MK).A number of studies have proven the suppressing ability of these materials on ASR. A high amount of waste glass as aggregate is known to decrease the concrete unit weight (Christopher cheeseman, 2011, Mageswari.L.M and B.Vidivelli,2010). The fact that glass has a high silica content has led to laboratory studies on its feasibility as a raw material in cement manufacture. The use of finely divided glass powder as a cement replacement material has yielded positive results (Malek Batayneh, Iqbal Marie, Ibrahim Asi,2007),Optimal dosage range of this glass powder is chosen based on cement paste studies.

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Selected properties of the glass powder modified mixtures are compared with the properties of conventional concrete (C.Meyer, S.Baxter and W.Jin,1996, Narayanan Neithalath and Nathan Schwarz,2009). The ultimate aim of this work is to ascertain the performance of concretes containing glass powder and compare it with the performance of conventional concretes.

II. Significance Of The Work

The use of recycled glass as aggregate greatly enhances the aesthetic appeal of the concrete. Recent research findings have shown that concrete made with recycled glass aggregate have shown better long term strength and better thermal insulation due to its better thermal properties of the glass aggregates(Samtur.H.R,1974, Seung Bum Park and Bong-Chum Lee,2004). When tested for the compressive strength values at the 10 %, 40%, and 60 % aggregate replacement by waste glass with 0 – 10mm particle size were 3%, 8% and 5% above the value of conventional concrete. It has been concluded that 30% glass powder could be incorporated as cement replacement in concrete without any long-term detrimental effects. Upto 50% of both fine and coarse aggregate could also be replaced in concrete of 32 MPa strength grade with acceptable strength development properties. Better results are achieved when the waste glass powder replaced either 30 % or 70% of the sand with particles sizes ranging between 50 µm and 100 µm (Federio.L.M and Chidiac S.E,2001). Used glass waste, which is cylindrical in shape prevents crack propagation in concrete structures. From the research carried out on glass powder by the authors, it was found that glass of particle size 1.18 to 2.36 mm produced the highest expansion where as low expansion was observed at smaller particle sizes(Idir.R,Cyr.M and Tagnit – Hamou.A,2009). It was observed that with a 30% replacement of cement by amber waste glass content of particle size 75µm along with flyash, the compressive strength of concrete increase 25% at 7 days and 35% when tested for 28 days strength (Pereira de Oliveira. L.A, J.P. castro – Gomes, P. Santos, 2008). This effect provide ample evidence that both flyash and waste glass sand can be used together to produce concretes with relative high strength without any adverse reaction. Particle sizes under that threshold had no effect on length variations. Glass was ground to a particle size of 300 or smaller, the alkali reaction (ASR) induced expansion could be reduced.

In fact, data reported in the literature show that if the waste glass is finely ground, under 75 µm. this effect does not occur and mortar durability is increased (Mageswari.L.M and B.Vidivelli,2010).

The tensile and flexural strength are adversely affected by the addition on waste to replace the virgin aggregate, at a replacement level of 30 % for the fine aggregate, the tensile strength decreased by 3%, in comparison to the control conventional concrete(Seung Bum Park and Bong-Chum Lee,2004).

III. Experimental Investigation

Experiment were conducted on concrete prepared by partial replacement of cement by waste glass powder of particle size 75µm.The the waste glass powder was replaced by 10%, 20%, 30% and 40% of the binder and the mix design was prepared. The physical and chemical characteristic was studied and the chemical components of the glass powder used in the concrete were also determined by XRF (IIker bekir topcu and mehmet canbaz,2004).

A. Materials used

I. Cement, water and Aggregates: Concrete is prepared by mixing various constituents like cement, aggregates, water etc. which are economically available. Ordinary Portland cement of 43 grade conforming to IS 8112 was used throughout the work. The fine aggregate used in this investigation was clean river sand, whose maximum size is 4.75 mm, conforming to grading zone II. Machine crushed blue granite stone angular in shape was used as coarse aggregate. Two size of coarse is used; one 16 mm passing through 12.5 mm retained and other 25 mm passing through 20mm retained. As per IS: 2386 – 1963 recommendations the following properties of coarse aggregates were determined.

II. Glass powder: Waste glass available locally in Pondicherry shops is 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 ground in ball/ pulverizer for a period of 30 to 6o minutes resulted in particle sizes less than size 150 µm and sieved in 75 µm Fig.1. The physical, chemical properties and chemical composition are presented in the table 1, 2 & 3.

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Figure 1 Glass powder

TABLE I
Physical properties of glass powder

S.No	Physical Properties of Glass Powder	
1	Specific gravity	2.6
2	Fineness Passing 150µm	99.5
3	Fineness Passing 90µm	98

TABLE II
Chemical properties of glass powder

S.No	Chemical Properties of Glass Powder	
1	pH	10.25
2	Colour	Grayish white

TABLE III
Chemical Composition of glass powder

S.No	Chemical Properties of Glass Powder	% by mass
1	SiO_2	67.330
2	Al_2O_3	2.620
3	Fe_2O_3	1.420
4	TiO_2	0.157
5	CaO	12.450
6	MgO	2.738
7	Na_2O	12.050
8	K2O	0.638
9	ZrO2	0.019
10	ZnO	0.008
11	SrO	0.016
12	P2O5	0.051
13	NiO	0.014
14	CuO	0.009
15	Cr2O3	0.022

B. Mix proportion and of testing specimens

I. Mix Design: The concrete mix design was proposed by using Indian Standard for control concrete. The grade was M20. The mixture will be prepared with the cement content of 330kg/m3 and water to cement ratio of 0.53. The mix proportion of materials is 1:2.33:3.6 as per IS 10262-2009. Then natural fine aggregate was used. The replacement levels of cement, glass powder were used in terms of 10%, 20%, 30% and 40% in concrete. Chemical admixture is not used here.

II. Durability Test: The concrete prepared with various percentage replacement of the cement such as 10%,20%,30% and 40% was cured under normal condition as per IS recommendation and were tested at 28 days and 60 days for determining the compressive , tensile and flexural strength and also compared with the test results of conventional concrete Fig.2,3,&4.

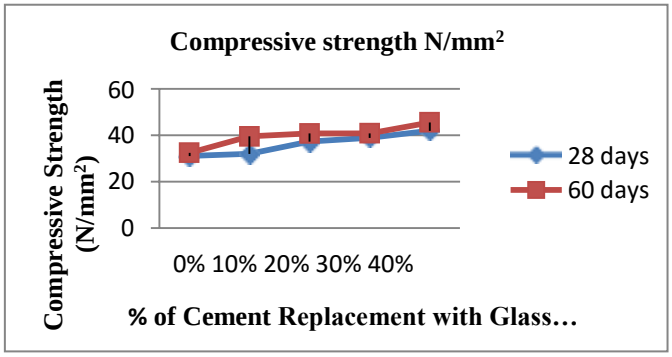

Figure 2 Comparative compressive strength of various percentage replacement of Glass powder with cement.

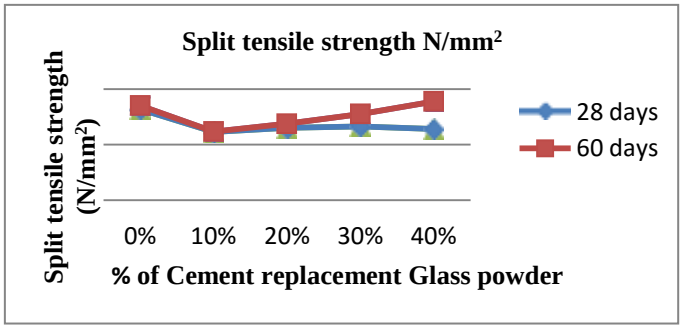

Figure 3 Comparative tensile strength of various percentage replacement of Glass powder with cement.

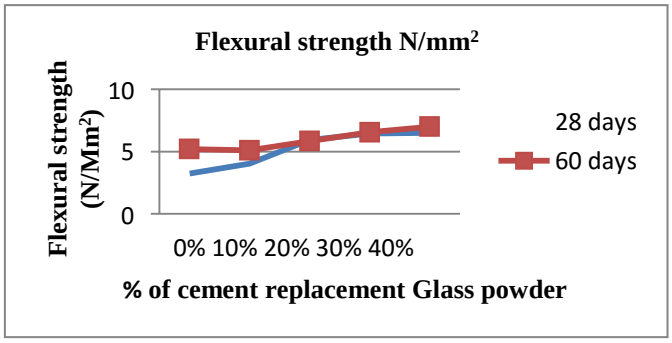

Figure 4 Comparative Flexural strength of various percentage replacement of Glass powder with cement.

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III. Workability Test: Workability is the property of freshly mixed concrete that determines the ease with which it can be properly mixed , placed ,consolidated and finished without segregation. The workability of fresh concrete was measured by means of the conventional slump test as per IS; 1199(1989). Before the fresh concrete was cast into moulds, the slump value of the fresh concrete was measured using slump cone. In this project work, the slump value of fresh concrete was maintained in the range of 80mm to 100mm.

IV. Alkalinity test: After 28 days curing the specimen are taken out from curing tank. Specimens are dried in oven at 105°C for 24 hours.the dry specimens are cooled to room temperature. Dry specimens are broken and separated the mortar from the concrete. Then the mortar is grinded into powder form. The powdered mortar is sieved in 150µ. 10 gm of mortar is taken and it is diluted in 50ml distilled water and completely stirred it. Then the pH meter immerse into the solution and pH value of the solution is noted Fig.5. The general pH value of the solution and the level of inducing corrosion in the concrete was noted and the results are shown in table 4.

Figure 5 Alkalinity test on Glass powder added concrete

TABLE 4
The Alkalinity test values for glass powder added concrete

% Replacement of Glass powder in concrete	pH Value
0	12.6
10	12.7
20	12.46
30	12.67
40	12.98

IV. Result And Discussion

The compressive strength test on both conventional and glass added concrete was performed on standard compression testing machine of 3000kN capacity, as per IS: 516-1959.

Totally 30 numbers of cubical specimens of size 100mm X100mmX100mm, and 30 number of cylinder was casted and tested for the compressive strength at the age of 28 days and 60 days. Each of the compressive strength test data corresponds to the mean value of the compressive strength of three cubes. At 28 days the glass powder shows a strength of 41.96N/mm^2, strength at 30% cement replacement, at 28 days but mean while in 60 days it shows strength at 40% 0f 3.55N/mm2. The flexural strength of glass powder added concrete at the age of 28 days and 60 days. At 28 days, in 10% replacement the strength has been increased to 6.5N/mm2, which is gained at 30% at 60 days itself and goes higher to 7.01N/mm2 in 40 %.The pH value observed from the alkalinity test showed that the specimen tested found to be more alkaline and hence more resistant towards corrosion.

V. Conclusion

Conventional concrete shows at 28 days compressive strength as 31.1 N/mm2, split tensile strength of 2.27N/mm^2 and flexural strength of 3.25N/mm^2

1. Replacement of glass powder in cement by 20%, 30% and 40% increases the compressive strength by 19.6%, 25.3% and 33.7% respectively.
2. Replacement of glass powder in cement by 40% increases the split tensile strength by 4.4% respectively
3. Replacement of glass powder in cement by 20%, 30% and 40% increases the flexural strength by 83.07%, 99.07% and 100% respectively.
4. Glass powder concrete increases the compressive, tensile and flexural strength effectively, when compared with conventional concrete.
5. Very finely ground glass has been shown to be excellent filler and may have sufficient pozzolonic properties to serve as partial cement replacement, the effect of ASR appear to be reduced with finer glass particles, with replacement level.

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