To Study Mechanical Properties of Concrete Using Waste Glass Powder And Fly Ash

Prashant M. Jagtap[1], Prof. Sonal T. Pawar[2]
[1, 2] Dept of Civil Engineering
[1, 2] KJ College of Engineering Management and Research,Pune, Maharashtra, India

Abstract*- Glass is used in many forms in day-to-day life. It has limited life span and after use it is either stock piled or sent to landfills. Since glass is non-biodegradable, landfills do not provide an environment friendly solution. Hence, there is strong need to utilize waste glasses. Many efforts have been made to use waste glass in concrete industry as a replacement of coarse aggregate, fine aggregate and cement.*

Now in the present study we are replacing the cement by waste glass powder partially, main constituent of all type glass is silica (SiO_2) as large size particle of glass used as the coarse and fine aggregates in concrete but in coarse aggregate replacement has been found to be non-satisfactory because of alkali-silica reaction (ASR). To minimize the ASR which is hazardous to concrete, we used very fine glass powder less than 100µm.

So, In present study we are going to focus on use of glass powder (90 µm) as a partial replacement for cement in concrete.

Keywords- waste glass powder, alkali-silica reaction, cement concrete etc.

I. INTRODUCTION

Concrete is a blend of cement, sand, coarse aggregate and water. The key factor that adds value to concrete is that it can be designed to withstand harshest environments significant role. Today global warming and environmental devastation have become manifest harms in recent years, concern about environmental issues, and a changeover from the mass-waste, mass-consumption, mass-production society of the past to a zero-emanation society is now viewed as significant. Normally glass does not harm the environment in any way because it does not give off pollutants, but it can harm humans as well as animals, if not dealt carefully and it is less friendly to environment because it is non-biodegradable. Thus, the development of new technologies has been required. The term glass contains several chemical diversities including soda-lime silicate glass, alkali-silicate glass and boro-silicate glass. To date, these types of glasses glass powder have been widely used in cement and aggregate mixture as pozzolana for civil works. The introduction of waste glass in cement will increase the alkali content in the cement. It also help in bricks and ceramic manufacture and it preserves raw materials, decreases energy consumption and volume of waste sent to landfill. As useful recycled materials, glasses and glass powder are mainly used in fields related to civil engineering, for example, in cement, as pozzolana (supplementary cementitious materials), and coarse aggregate. Their recycling ratio is close to 100%, and it is also used in concrete without adverse effects in concrete durability. Therefore, it is considered ideal for recycling.

Recently, Glasses and its powder has been used as a construction material to decrease environmental problems. The coarse and fine glass aggregates could cause ASR (alkali-silica reaction) in concrete , but the glass powder could suppress their ASR tendency, an effect similar to supplementary cementations materials (SCMs). Therefore, glass is used as a replacement of supplementary cementitious materials.

In 2005, approximately12.8 million tons of waste glass were disposed in the United States, while only 2.75 million tons were recycled. The remaining waste glass was land-filled at tremendous cost to individual corporations and municipalities. With the number of land-fills in the United States decreasing nearly 80% since 1988, the need to recycle and reuse waste materials like glass is imperative. The efforts to use such non-conventional materials which are typically of local or regional origin in concrete will get a boost if there are systematic and comprehensive studies to quantify the performance of concretes containing such materials.

A number of previous studies have examined the use of waste glass in concrete. The use of waste glass as an aggregate replacement, inert filler, or partial cement replacement has been investigated. Increasing amounts of waste glass as coarse aggregates in concrete shave been reported to decrease the mechanical properties, primarily because of a weak interface. Also, larger particle sizes of glass (greater than 1.2–1.5 mm) are found to facilitate alkali–silica reaction (ASR) in concretes. Thus, when using ground glass or glass powder in cementitious systems, the particle size is not conducive for ASR to occur, but the potential of high alkali content of glass powder to cause deleterious expansions need to be accounted for. The pozzolanic properties of glass powders also have been explored in some studies. Glass is amorphous material with high silica content, thus making it potentially pozzolanic when particle size is less than 75µm. In the recent, various attempts and research have been made to use ground glass as a replacement to 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 silica – rich glass particle and the alkali in pore solution of concrete, which is called Alkali – Silica reaction (ASR) 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 met kaolin (MK). The fact that glass has 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.

II. EXPERIMENTAL DETAILS

Materials

A. Cement:

Among the chemical constituents of cement, the most important ones are C_3A, C_3S and C_2S. The C_3A portion of cement hydrates more rapidly, thereby reducing the workability of fresh concrete. It also adsorbs the chemical admixtures quickly which leads to reduction in availability of those admixtures for comparatively slower setting components of cement viz., C_2S and C_3S. This further affects the workability of fresh concrete and also its rate of retention of workability. Concrete is mixture of cement, aggregate, water etc. which are economically available. Ordinary Portland cement of 53 grade confirming IS: 12269-1987 was used throughout the work.

Cement used and tested in laboratory and its results are as follows;

Brand Name : Ultra tech Cement 53 Grade O.P.C.

Conforming IS Codes : IS: 12269-1987

Table 3.1 - Physical properties of Cement

Sr. No.	Description of Test	Results	As per IS: 12269-1987
01	Specific gravity	3.15	3.15
02	Standard consistency of cement	31 %	30-35 mm
03	Setting time of cement a) Initial setting time b) Final setting time	 112 min 238 min	> 30 min < 600 min

B. Fine Aggregate (Sand):

River sand is used as a fine aggregate. Among various characteristics the most important one for FAC is its grading. Coarser sand may be preferred as finer sand increases the water demand of concrete and very fine sand may not be essential in FAC as it usually has larger content of fine particles in the form of cement and mineral admixtures such as fly ash, silica fume etc.

After reviewing all above requirements, locally available sand, from Bhima river, is used as fine aggregate, it confirms to zone II of IS 383-1983 and, other necessary properties

Table 2.1: Specific gravity of fine aggregate (Sand)

Sr. No.	Particulars	Sample
1	Wt. of surface dry agg. (W_1)	0.500
2	Wt. of pyc. + agg. + Water (W_2)	3.036
3	Wt. of pyc. + Water (W_3)	2.772
4	Wt. of oven dried sample (W_4)	0.484
5	Sp. Gravity = G = W_4 / [W_1 - (W_2 . W_3)	2.62

C. Coarse Aggregate:

The properties such as moisture content, water absorption, etc., would help in adjusting the quantity of mixing water for the FAC mix. The strength properties of CA such as Aggregate Abrasion value, Aggregate Impact value, Compressive strength, Aggregate Crushing value (10% fine value) etc. would determine the limits of strength of FAC which can be achieved with a given aggregate and these limits need to be investigated for creating database for rational design of FAC.

Locally available crushed stone aggregates with size 5mm to 12.5 mm and of maximum size 12.5 mm are used. The test results are as follows¬:

Table 2.2: Specific gravity of coarse aggregate

Sr. No.	Particulars	Sample
1	Wt. of surface dry agg. (W_1)	0.502
2	Wt. of pyc. + agg. + Water (W_2)	3.054
3	Wt. of pyc. + Water (W_3)	2.722
4	Wt. of oven dried sample (W_4)	0.497
5	Sp. Gravity = $G = W_4 / [W_1 - (W_2 . W_3)$	2.67

D. Glass powder:

Waste glass available locally in area 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 for a period of 30 to 60 minutes resulted in particle sizes less than size 90µm and sieved in 75µm. The physical, chemical properties and chemical composition are presented in the table

Table 2.3: Physical Properties of Glass Powder

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

Table 2.4: Chemical Properties of Glass Powder

Sr. No.	Chemical Properties of Glass Powder	
1	Ph	10.25
2	Colour	Grayish White

E. Fly Ash :

Fly ash are used as partial replacement to cement. The physical and chemical properties are mentioned below in table

Table 2.5: Table Physical And Chemical properties of Fly Ash.

Test No.	Test	Unit	I.S. Specification
1	Fineness by Blaine's air permeability	M^2/Kg	320
2	25 Micron Residue	%	Not Specified
3	45 Micron Residue	%	34
4	Lime Reactivity	N^2/mm^2	4.5
5	Moisture Content	%	2.0
6	Autoclave Expansion	%	0.8
7	Compressive strength at 28 days % of plain cement mortar	%	80
8	Loss on Ignition	%	5

F. Water:

Water plays an important role in concrete as the addition of water in cement paste the hydration reaction start. The water used in the concrete should be portable. When water mix with cement paste forms and cement paste bound the other ingredients of concrete. The C-S-H gel binds the other ingredients of concrete.

As per IS 456-2000 water used for the mixing and curing shall be clean and free from injuries amounts of oils, alkalis, salts, sugars, organic materials or other substances that may deleterious to concrete or steel. In this work, available tap water is used for concreting.

III. MIXTURE PROPORTIONING (CONCRETE MIX DESIGN)

Grade of Concrete : M30
Characteristic Strength (Fck) : 30Mpa
Standard Deviation : 1.91Mpa*
Target Mean Strength : T.M.S.= Fck +1.65 x S.D.
(from I.S 456-2000) = 30 + 1.65×1.91= 38.15Mpa

Table 2.6: Contents in $1m^3(kg/m^3)$

Cement	W/C	Water	Sand	20mm	10mm
400	0.43	172	635	619	564
1		0.43	1.6	1.547	1.36

Cement: Sand: Coarse Aggregates = 1 : 1.6 : 2.907

Table 4.2: Concrete Mixtures With Different Proportions Of GP And Fly Ash

CONCRETE MIX.	MATERIAL %		
	CEMENT	GLASS POWDER	FLY ASH
A	100	0	0
B	85	5	10
C	80	10	10
D	75	15	10
E	70	20	10
F	65	25	10
G	60	30	10

IV. RESULT AND DISCUSSION

A. Compression strength test

The variation of Compressive strength with respect to replacement of cement with% Glass Powder is shown in the table and graph. The samples were cured for respective test time and then tested for 7 days, 28 days.

Table 5.3 – Compressive strength test results

Concrete Mix No.	% Glass Powder	Compressive Strength N/mm^2			
		7 Days	28 Days	56 Days	90 Days
A	0	31.77	37.71	38.36	38.77
B	5	32.14	38.18	38.42	38.91
C	10	33.17	38.67	38.89	39.27
D	15	33.72	39.11	39.67	40.07
E	20	30.18	33.12	33.78	34.16
F	25	28.92	32.44	32.61	32.97
G	30	27.26	31.23	31.53	31.95

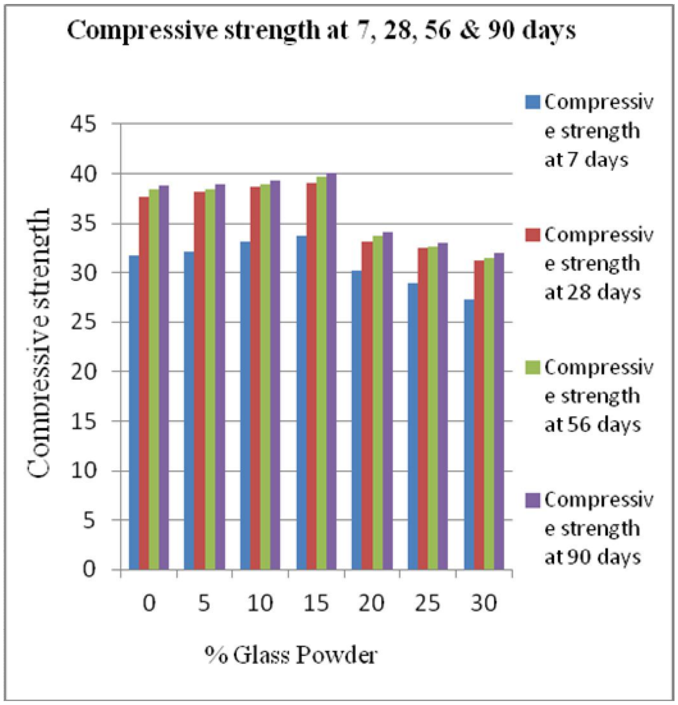

Figure 5.7: Compressive Strength (7,28,56 & 90 days) Vs. % Replacement of cement with glass powder

B. Split tensile test

The variation of split tensile strength with respect to replacement of cement with glass powder is shown in table and graph.

Table 5.5: Split tensile test results

Mix No.	% Glass powder	Split tensile strength at 28 days (N/mm^2)	Split tensile strength at 56 days (N/mm^2)	Split tensile strength at 90 days (N/mm^2)
A	0	3.97	4.22	4.67
B	5	4.01	4.36	4.78
C	10	4.07	4.4	4.85
D	15	4.12	4.43	4.89
E	20	3.91	4.16	4.61
F	25	3.67	3.97	4.43
G	30	3.35	3.71	4.34

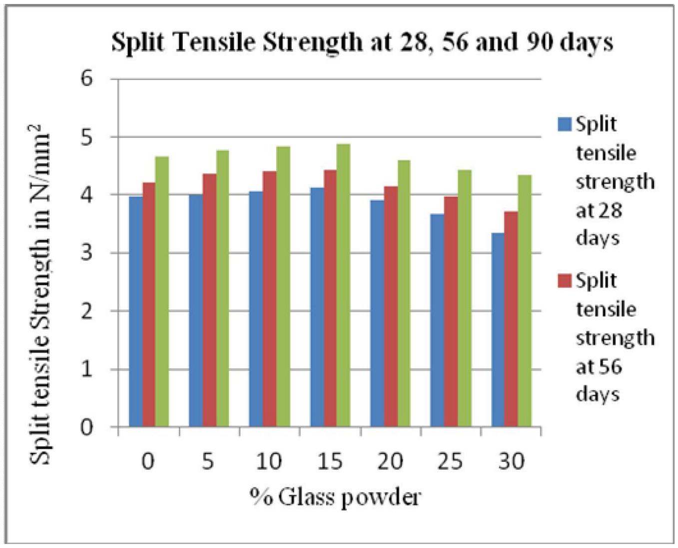

Figure 5.11: Split tensile strength (28, 56 & 90 days) Vs. % Replacement of cement with glass powder

C. Flexural strength test

The variation of flexural strength with respect to replacement of cement with glass powder is shown in table and graph.

Table 5.6: Flexural strength test results

Mix No.	% Glass powder	Flexural strength at 28 days (N/mm^2)	Flexural strength at 56 days (N/mm^2)	Flexural strength at 90 days (N/mm^2)
A	0	4.36	4.45	4.60
B	5	4.2	4.27	4.4
C	10	4.03	4.11	4.2
D	15	3.91	4.04	4.09
E	20	3.82	3.9	4.02
F	25	3.75	3.81	3.95
G	30	3.51	3.67	3.79

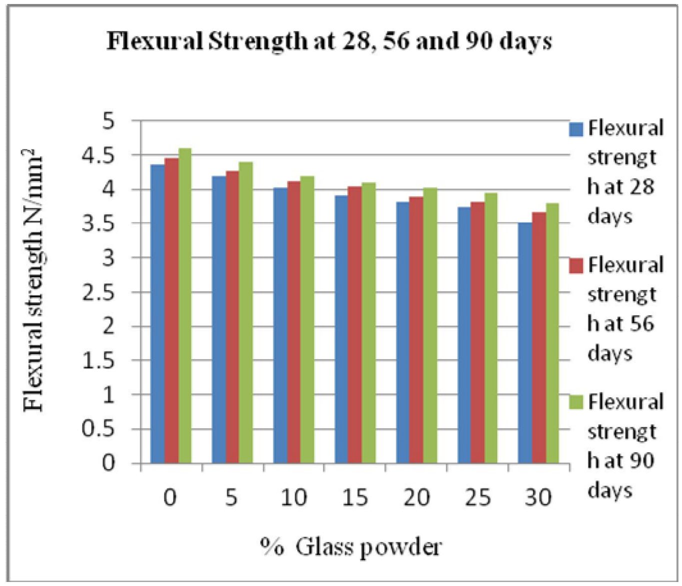

Figure 5.15: Flexural strength (28, 56 & 90 days) Vs. % Replacement of cement with glass powder

V. CONCLUSIONS

1. Workability of concrete goes on decreasing as the percentage of Glass powder increases.
2. Compaction Factor of concrete goes on decreasing as the percentage of Glass powder increases.
3. Average compressive strength is increased up to 8.96% at 7 days for mix D, up to 5.05% at 28 days for mix D, up to 4.62% at 56 days for mix D and up to 4.52 at 90 days for mix D. It is also observed that the average compressive strength is highest for 15 % of replacement at 7, 28, 56 & 90 days.
4. Split tensile strength goes on increasing up to 5.05% for 28 days, up to 6.52% for 56 days & up to 6.00% for 90 days. It is also observed that there is decrease in the strength beyond mix D for 28 days, 56 days and 90 days.
5. It is observed that there is decrease in flexural strength in initial replacement of 5% and 10%. The strength is increased at replacement of 15 % and 20% glass powder for 28 days and 56 days beyond which strength is decreased again. For 90 days it is observed that only 15 % glass powder has increased the flexural strength test of the replacements show a fall in strength compared to reference mix.

REFERENCES

[1] Dr. G. Vijayak kumar and Ms H. Vishaliny, "Studies on Glass Powder as Partial Replacement of Cement in Concrete Production", vol. 3, Issue 2, February 2013.

[2] Sunny O. Nwaubani and Konstantinos I. Poutos, "The Influence of Waste Glass Powder Fineness on the

Properties of Cement Mortars", vol. 2, Issue 2, February 2013.

[3] Nathan Schwarz and Hieu Cam, "Influence of a fine glass powder on the durability characteristics of concrete and it comparison to fly ash", 5 February 2008.

[4] Ana Mafalda Matos and Joana Sousa-Coutinho, "Durability of mortar using waste glass powder as cement replacement", 25 April 2012.

[5] Ahmad Shayan and Aimin Xu, "Performance of glass powder as a pozzolanic material in concrete: A field trial on concrete slabs", ARRB Group 500 Burwood Highway, Australia, December 2005.

[6] Rahmat Madandoust and Reza Ghavidel, "Mechanical properties of concrete containing waste glass powder and rice husk ash", August 2013.

[7] Alaa M. Rashad,, "Recycled waste glass as fine aggregate replacement in cementitious materials based on Portland cement", August 2014.