STUDY OF WASTE GLASS POWDER AS POZZOLANIC MATERIAL IN CONCRETE

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Abstract - *Glass is utilized in numerous structures in everyday life. It has restricted life expectancy and after use it is either accumulated or shipped off landfills. Since glass is non-biodegradable, landfills don't give a climate agreeable arrangement. Thus, there is solid need to use squander glasses. Numerous endeavors have been made to utilize waste glass in solid industry as a substitution of coarse aggregate, fine aggregate and concrete. Its exhibition as a coarse aggregate substitution has been discovered to be non-good as a result of solidarity relapse and development because of soluble base silica response. The examination shows that there is strength misfortune because of fine total replacement moreover. The point of the current work was to utilize glass powder as a substitution of concrete to survey the pozzolanic action of fine glass powder in cement and contrast its presentation and other pozzolanic materials like silica smoke and fly debris. A progression of tests were directed to examine the impact of 15% and 30% substitution of concrete by silica fume, fly ash and glass powder on compressive strength and toughness as capillary absorption ingestion. The molecule size impact was assessed by utilizing glass powder of size 150μm-100μm and glass powder of size under 100μm.The present examination shows that waste glass, if ground better than 100μm shows a pozzolanic conduct. The early utilization of salts by glass particles restrained alkali silica response henceforth increment solidness of cement.*

Key Words: waste glass, concrete, compressive strength, fly ash, silica fume

1. INTRODUCTION

Concrete is a mixture of cement, sand, coarse aggregate and water. The key factor that increases the value of cement is that it very well may be intended to withstand harshest conditions critical job. Global warming and climate change have become adverse effect about ecological issues, and a changeover from the mass-waste, mass-utilization, and large scale manufacturing society of the past to a zero-spread society is presently seen as huge. Ordinarily glass doesn't hurt the climate in any capacity since it doesn't radiate poisons, however it can hurt people just as creatures, if not managed cautiously and it is less well disposed to climate since it is non-biodegradable. Along these lines, the advancement of new advances has been required. The term glass contains a few compound varieties including soft drink lime silicate glass, salt silicate glass and boro-silicate glass. Until this point in time, these kinds of glasses glass powder have been broadly utilized in concrete and total combination as pozzolana for common works. The presentation of waste glass in concrete will build the antacid substance in the concrete. It likewise help in blocks and clay production and it jelly crude materials, diminishes energy utilization and volume of waste shipped off landfill. As valuable reused materials, glasses and glass powder are basically utilized in fields identified with structural designing, for instance, in concrete, as pozzolana also act as beneficial cementitious materials, and coarse aggregate. Their reusing proportion is near 100%, and it is additionally utilized in concrete without unfavourable impacts in solid solidness. In this way, it is viewed as ideal for reusing. Recently, Glasses and its powder have been utilized as a development material to diminish natural issues. The coarse and fine glass aggregates could cause ASR (alkali silica response) in concrete, yet the glass powder could stifle their ASR propensity, an impact like strengthening cementations materials (SCMs). Accordingly, glass is utilized as a substitution of beneficial cementitious materials.

2. MATERIAL AND METHOD

The materials used in this present work are glass powder, Ordinary Portland cement (43 grade), fly ash, silica fumes, coarse aggregates and fine aggregates.

2.1 Glass Powder

The glass powder used in the present study is brought from local market. This material replaces the cement in mix proportion. Particle size distribution graph shown in fig.1

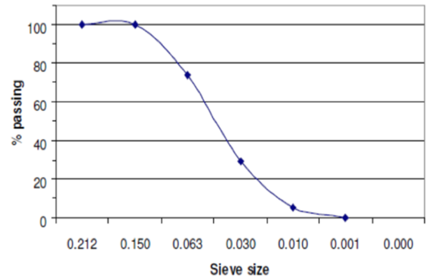

Fig-1: Particle size distribution

2.2 Silica Fumes

Silica fume is profoundly responsive pozzolanic material and is a side-effect from the creation of silicon or Ferro-silicon metal. It is formed from the flue gases from electric furnace. Silica fume is fine powder, with particles about 100th times minor than normal concrete grain. It is accessible in a water slurry structure. It is utilized at 5% to 12% by mass of valuable cementitious materials for solid designs that requires high strength. Substance Properties of silica seethe as provided by the provider.

Table 1 Chemical Properties of silica fume

Silica fume	ASTM-C-1240	Actual Analysis
SiO_2	85% min	86.7% min
LOI	6% max	2.5%
Moisture	3%	0.7%
Pozz Activity Index	105% min	129%
sp surface area	>15 m^2/gm.	>22m^2/gm.
Bulk density	550 -700	600

2.3 Fly Ash

Fly ash is largely made up of calcium oxide and silicon dioxide can be used as a substitute or as a supplant for Portland cement. The sieve analysis is given in Fig. 2.

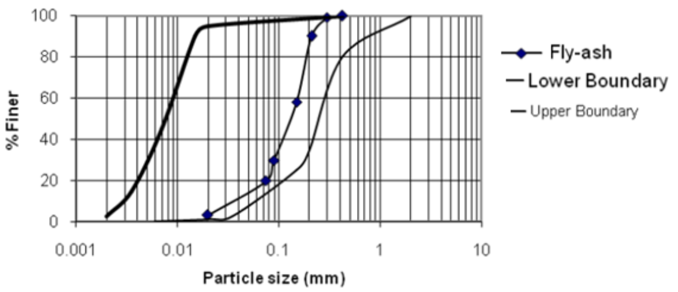

Fig-2: grain size distribution by fly ash

2.4 Ordinary Portland cement (OPC)

The OPC (43 grade) used in the present work. This is used as main binder in the mixes.

2.5 Fine Aggregate

Naturally available sand is used as fine aggregate in the present work. The most common constituent of sand is silica, usually in the form of quartz, which is chemical inert and hard. Hence used as a fine aggregate in concrete. The sieve analysis of sand is shown in table 2. As per IS383 the sand falls under zone 4.

Table 2 sieve analysis of sand

Sieve size(mm)	Aggregate wt. retained(Kg)	% wt. retained	Cumulative % wt. retained	100-cumulative % passing
4.25	0.39	3.9	3.9	96.1
2.36	0.27	2.7	6.6	93.4
1.18	0.88	8.8	15.4	84.6
0.6	0.176	17.6	33	67
0.3	0.416	41.6	74.6	25.4
0.15	0.234	23.4	98	2
Pan	0.014	1.4	99.4	0.6

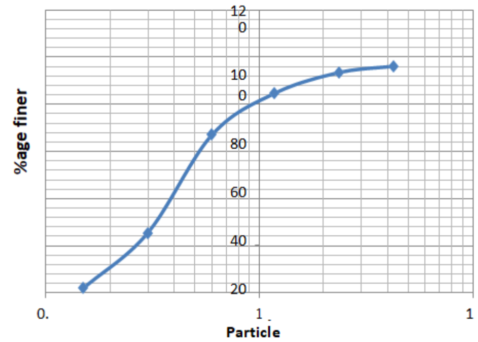

Fig-3: Sieve analysis of fine aggregate

2.6 Coarse Aggregate

The coarse aggregate available in structural engineering lab of civil engineering department. The sieve analysis of 20mm and 10mm down size is shown in table 3 & 4 and sieve analysis in Fig.4 respectively.

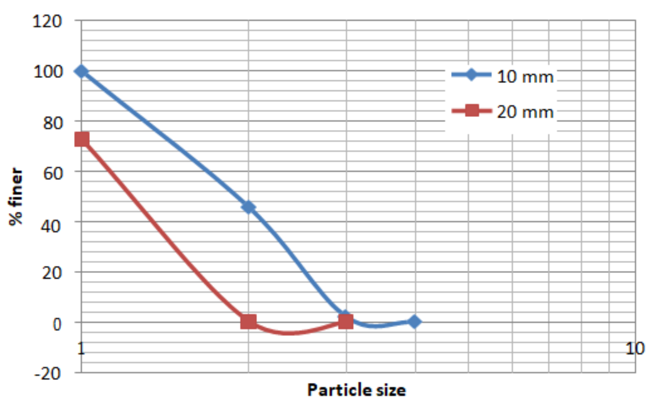

Fig-4: Sieve analysis of coarse aggregate

Table 3 the sieve analysis of 20 mm size

Sieve size(mm)	Aggregate wt. retained (Kg)	% wt. retained	Cumulative % wt. retained	100–cumulative% passing
20	1.374	27.48	27.48	72.52
10	3.604	72.08	99.56	0.44
4.75	0.022	0.44	100	0

Table 4 the sieve analysis of 10 mm size

Sieve size(mm)	Aggregate wt. retained(Kg)	% wt. retained	Cumulative % wt. retained	100 – cumulative % passing
20	0.016	0.32	0.32	99.68
10	2.696	53.92	54.24	45.76
4.75	2.178	43.56	97.8	2.2
Pan	0.108	2.16	99.96	0.04

Table 5 Physical characteristics of materials

Description	Specific gravity
Cement (OPC)	3.09
Silica fume	2.28
Fly ash	2.96
Glass powder	3.01
Coarse aggregate	2.9
Fine aggregate	2.62
Water	1

3. METHODOLOGY

A nominal mix of concrete of proportion 1:2:4 was adopted for the present study. The first mix MC1 is control mix having only cement as binder. The MCF series had fly ash as replacement of cement. The MCS & MCG series had silica fume and glass powder as replacement of cement. The compressive strength tests were conducted to monitor the strength development of concrete containing 15% & 30% of this pozzolana as cement replacement. The particle size effect of glass powder studied by using glass powder of size (150-100) µ and (50-100) µ.

Capillary absorption test is conducted to study the effect of alkali aggregate reaction. The tests were conducted in two series.

•In first Series 30 % of pozzolana were used as partial replacement of cement.

•In second series 15% of pozzolana was used as partial replacement of cement.

11 numbers of standard cubes (150x150x150 mm) were cast to measure the compressive strength after 28 days and 52 days. Two cubes were retained to measure capillary absorption after 28 days and 52 days respectively.

To study the characteristics following tests were conducted

3.1 Normal consistency

Normal consistency of different binder mixes determined by using the procedure referring to IS 4031: part 4 (1988):

• 300 gram of sample coarser than 150µ sieve is taken.

• Approximate percentage of water added to sample and mixed methodically for 2-3 minutes.

• After applying oil to the surface of mould, paste was filled in the Vicat's mould and was placed under the needle of Vicat's apparatus.

• Release quickly the needle allowing it to sink in the paste and note down the penetration reading when the needle becomes stable.

• If the penetration reading is less than 5 to 7 mm, prepare the paste again with more water and repeat the above procedure until the needle penetrate to a depth of 5 to 7 mm.

• The percentage of the water with which the above situation is satisfied is called normal consistency.

3.2 Compressive Strength Test

For each series five set were cast to determine compressive strength. Each set comprises of eleven standard cubes out of which nine cubes were cast to measure the compressive strength after 28days and 52 days. The size of the cube is as per the IS code 10086 – 1982.

3.3 Capillary absorption Test

Out of eleven standard cubes two cubes were retained to measure capillary absorption coefficients after 28 days and 52 days curing respectively. This test is conducted to measure the capillary absorption which indirectly measures the durability.

Procedure:

I. The sample was dried in oven at 105ºC until constant mass was obtained.

II. Sample was cool down to room temperature for 6hr.

III. The side of the sample was coated with paraffin to attain unidirectional flow.

IV. The sample was exposed to water on one side by placing it on a pan filled with the water.

V. The water in the pan was kept about 5mm above the base of the specimen as shown in the figure below.

VI. The weight of the sample was measured at 15 and 30 minutes intervals.

VII. The capillary absorption coefficient (k) was calculated by using formula: k= Q/A* sqrt (t)

Where, Q= amount of water absorbed

A = cross sectional area in contact with water t = time

4 RESULTS AND DISCUSSIONS

Normal consistency of binder mixes were tabulated below

Table 6 Normal consistency of binder mixes

Mix	Description	Cement(g)	Silica fume (g)	Fly ash(g)	Glass powder(g)	Consistency (%)
MC	CEMENT	300	0	0	0	31.2
MCS	MC with 15% SF	255	45	0	0	36.67
MCF	MC with 15% FA	255	0	45	0	38.3
MCG1	MC with 15% GP	255	0	0	45	37.2
MCG2	MC with 30% GP	210	0	0	90	38.5

Where, MC= pure cement, SF= silica fume, FA= fly ash, GP= glass powder

4.1 Compressive Strength

The results of compressive strength testing of laboratory-cured cubes are presented in table 7& table 8 for First series with 30% cement replacement and Second series with 15% cement replacement respectively. The strength values reported are the average of three test results. Fig.5 and Fig. 6 are graphical representation of strength development of concrete cubes of various mixes for the First series and second series respectively.

Compressive Strength of series after 28 days and 52 days were tabulated below:

Table 7 First Series with 30% cement replacement

DESIGN MIX	28 days (N/mm^2)	52 days (N/mm^2)
MC1	21.13	25.43
MCS1	21.38	23.51
MCF1	14.86	17.38
MCG11	12.78	14.47
MCG12	14.32	17.15

Where, Where,

Mix MC1= Only OPC cement

Mix MCS1= cement + 30% silica fume Mix MCF1= cement + 30% fly ash

Mix MCG11= cement+ 30% glass powder (150-100) micron

Mix MCG12= cement + 30% glass powder (<100) micron

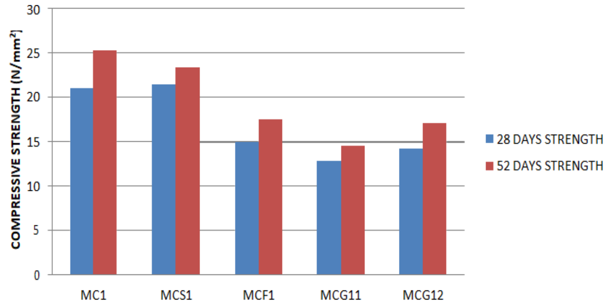

Fig-5: Compressive Strength of mixes with 30% replacement of cement

Table 8 Second Series with 15% cement replacement

DESIGN MIX	28 days (N/mm^2)	52 days (N/mm^2)
MC2	21.03	25.33
MCS2	22.88	24.88
MCF2	15.55	18.81
MCG21	13.77	14.67
MCG22	15.11	19.57

Where, Mix MC2= Only PPC cement

Mix MCS2= cement + 15% silica fume

Mix MCF2= cement + 15% fly ash

MixMCG21= cement+ 15% glass powder (150-100) micron

Mix MCG22= cement + 15% glass powder (100-50) micron

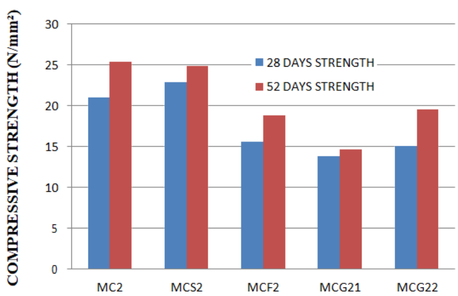

Fig-6: Compressive Strength of mixes with 15% replacement of cement

The results indicate that silica fume replacement produces higher strength than the glass powder and fly ash replacement. The strength development of concrete mix with glass powder of size <100µ is almost or more than the concrete mix with fly ash as cement replacement. This is confirmed from the results of both the series. The graphical representation of this result is shown in Fig.7& Fig 8.

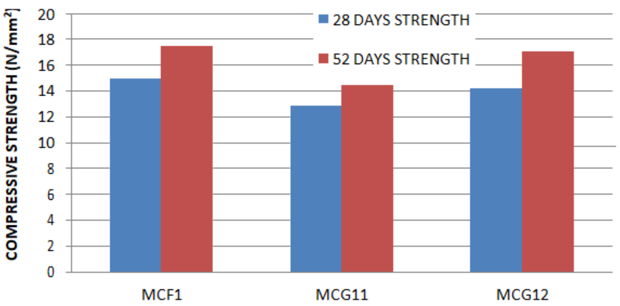

Fig-7: Series 1 Glass Powder replacement Vs. Fly ash replacement

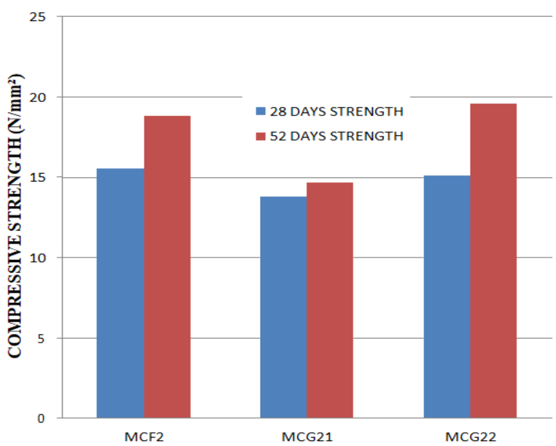

Fig-8: Series 2 Glass Powder replacement Vs. Fly ash replacement

Table 9 Coefficients of capillary absorption of series after 28 days and 52 days Series 1

DESIGN MIX	28 days(k*10-^{3} cm/s)	52 days(k*10-^{3} cm/s)
MC1	3.02	2.98
MCS1	1.65	1.57
MCF1	1.52	1.82
MCG11	2.85	3.14
MCG12	1.73	1.59

5. CONCLUSIONS

The glass powder concrete MCG12 likewise has lower k worth, showing denser lattice arrangement. The blend MCG11 has most noteworthy k value likely because of bond disappointment in light of salt silica response. The fly ash solid shows preferred execution over the control blend MC1. Waste glass, if ground better than 100µm shows a pozzolanic conduct. The more modest molecule size of the glass powder has higher action with lime bringing about higher compressive strength in the solid mix compared to fly ash solid, fiber glass powder concrete had somewhat higher early strength just as late strength. Miniature underlying assessment shows that glass powder creates a denser grid which improves the sturdiness property of cement. The coefficient of capillary absorption test additionally demonstrates that joining of better glass powder improves toughness. Glass powder of size 150µm - 100µm show commencement of soluble base total response. The information introduced in this examination shows that silica fume is best SCM. It invigorates most noteworthy compressive on account of its more modest grain size and round shapes. The outcomes acquired from the current examination shows that there is incredible potential for the use of best glass powder in concrete as substitution of concrete. The fine glass powder can be utilized as a substitution for costly materials like silica fume and fly ash. It very well may be presumed that 30% of glass powder of size under 100µm could be incorporated as concrete substitution in concrete with no negative impact.

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