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Experimental Investigation on Strength of Glass Powder Replacement by Cement in Concrete with Different Dosages

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Abstract

Storage and safe disposal of waste & crushed glass is a huge problem for our urban & rural areas in India. Everywhere reuse of waste glass eliminates or consumption this problem. In this experimental work, the effect of partially replacing of glass powder in concrete is studied. The cement in concrete is replaced by waste glass powder in steps of 10% 20%, 30%& 40% respectively by volume of cement and its effects on compressive strength, split tensile strength, workability and flexural strength are determined. It is found that the compressive, flexural and split tensile strengths of concrete increase initially as the replacement percentage of cement by glass powder increases become maximum at about 20% and later decrease. The workability of concrete reduces monotonically as the replacement percentage of cement by glass powder increases. The replacement of cement up to about 20% by glass powder can be done without sacrificing the compressive strength.
Keywords: ASR, pulverized fuel ash (PFA), silica fume(SF)

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. 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. 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 have been made in using crushed glass as fine aggregate in the replacement of river sand. 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. Glass is amorphous material with high silica content, thus making it potentially pozzolanic when particle size is less than 75µm. 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 greenhouse management. A major concern regarding the use of glass in concrete is the chemical reaction that take space 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 met kaolin (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. 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; optimal dosage range of this glass powder is chosen based on cement paste studies selected properties of the glass powder modified mixtures are compared with the properties of conventional concrete. 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. GLASS POWDER REINFORCED CONCRETE

High-performance concrete is defined as a concrete meeting special combination of performance and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing, and curing practices. High-performance concrete (HPC) exceeds the properties and constructability of normal concrete. Normal and special materials are used to make these specially designed concretes that must meet a combination of performance requirements. Special mixing, placing, and curing practices may be needed to produce and handle high-performance concrete. High-performance concrete almost always has a higher strength than normal concrete. However, strength is not always the primary required property. For example, a normal strength concrete with very high durability and very low permeability is considered to have high performance properties. By using by-products such as silica fume with super plasticizer we can achieve high performance concrete, which possess high workability, high strength, and high modulus of elasticity, high density, high dimensional stability, low permeability and resistance to chemical attack. HPC is often called “durable” concrete because its strength and permeability to chloride penetration makes it last much longer than conventional concrete.

III. COMPOSITION GLASS & CEMENT POWDER REINFORCED CONCRETE

Table - 1
Chemical composition of cementing materials

Composition (% by mass)/ property	*Cement*	*Glass powder*
Silica (SiO2)	*20.2*	*72.5*
Alumina (Al2O3)	*4.7*	*0.4*
Iron oxide (Fe2O3)	*3.0*	*0.2*
Calcium oxide (CaO)	*61.9*	*9.7*
Magnesium oxide (MgO)	*2.6*	*3.3*
Sodium oxide (Na2O)	*0.19*	*13.7*
Potassium oxide (K2O)	*0.82*	*0.1*
Sulphur trioxide (SO3)	*3.9*	*-*
Loss of ignition	*1.9*	*0.36*
Fineness % passing (sieve size)	*97.4(45 μm)*	*80 (45 μm)*
Unit weight, Kg/m3	*3150*	*2579*
Specific gravity	*3.15*	*2.58*

IV. GLASS POWDER

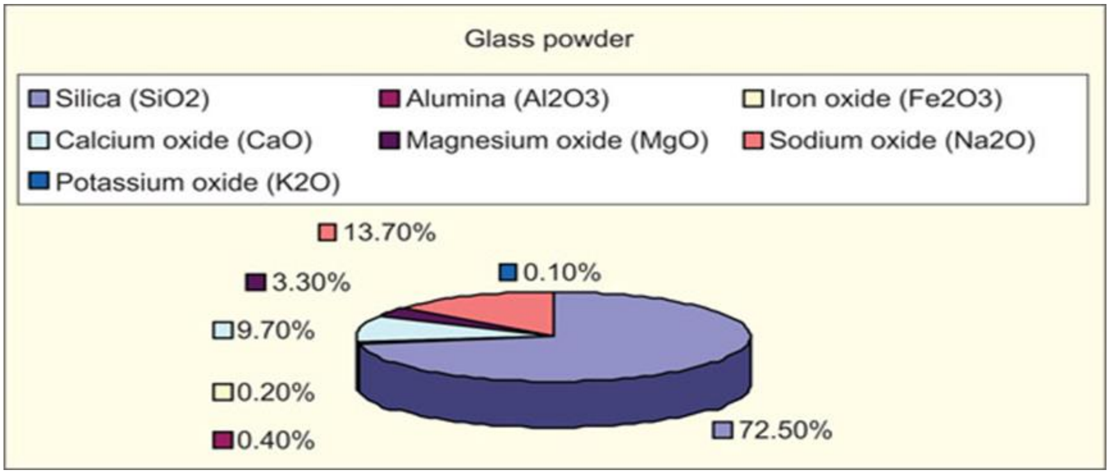

Fig. 1: Glass Powder

V. BEHAVIOUR OF GLASS POWDER REINFORCED CONCRETE UNDER CONVENTIONAL LOADING

Flexural behavior of glass powder concrete & compressive and split tensile strength.

Previous studied of glass fiber shows with addition of glass fiber (E-glass powder composites 2 wt% and 6 wt % of e-glass powder were fabricated by liquid metallurgy (stir cast) method. The casted composite specimens were machined as per test standards. The specimens were tested to know the common casting defects using ultra-sonic flaw detector testing system. Some of the mechanical properties have been evaluated and compared with E-Glass powder. Significant improvement in tensile properties, compressive strength and hardness are noticeable as the wt % of the glass powder increases. The microstructures of the composites were studied to know the dispersion of the E-glass fiber in matrix. It has been observed that addition of E-glass powder significantly improves ultimate tensile strength along with compressive strength and hardness properties as compared with that of unreinforced matrix. The test specimens were prepared by machining from the cylindrical, cube & beam castings.

VI. Review of Literature

A. Recycled Glass as a Partial Replacement For Fine Aggregate In Self Compacting Concrete:

1) Esraa Emam Ali, Sherif H. Al-Tersawy 2012

Glass has been indispensable to man's life due to its properties, including pliability to take any shape with ease, bright surface, resistance to abrasion, reasonable safety and durability. Waste glass creates serious environmental problems, mainly due to the inconsistency of waste glass streams. With increasing environmental pressure to reduce solid waste and to recycle as much as possible, the concrete industry has adopted a number of methods to achieve this goal. Self-Compacting Concrete (SCC) may lead to evolution of a more quality controlled concrete, assuring a better workability and avoiding human errors with regard to mixing and workability issues. On the other hand, it resolves the problem of noise and vibration during installation.

2) High-volume natural volcanic pozzolan and limestone powder as partial replacements for portland cement in self-compacting and sustainable concrete.K. Celik , , M.D. Jackson, 2014

A laboratory study demonstrates that high volume, 45% by mass replacement of portland cement (OPC) with 30% finely-ground basaltic ash from Saudi Arabia (NP) and 15% limestone powder (LS) produces concrete with good workability, high 28-day compressive strength (39 MPa), excellent one year strength (57 MPa), and very high resistance to chloride penetration. Conventional OPC is produced by intergrading 95% portland clinker and 5% gypsum, and its clinker factor (CF) thus equals 0.95. With 30% NP and 15% LS portland clinker replacement, the CF of the blended ternary PC equals 0.52 so that 48% CO2 emissions could be avoided, while enhancing strength development and durability in the resulting self-compacting concrete (SCC).

3) Performance of dry cast concrete blocks containing waste glass powder or polyethylene aggregates S.E. Chidiac, , S.N. Mihaljevic 2011

Dry-cast concrete blocks are a popular building material; however, to improve the economic and environmental sustainability of this industry, its dependence on natural aggregate and Portland cement needs to be reduced. To further this goal, blocks with up to 25% of the cement replaced with waste glass powder (WGP) or up to 15% of the sand replaced with high density polyethylene (HDPE) or low density polyethylene (LDPE) polymer pellets were produced in an industrial plant. The physical, mechanical and durability properties of the individual blocks and the mechanical properties of the block assemblages were tested. Based on statistical analyses, the blocks with 10% WGP as cement replacement performed similarly to the control blocks.

B. Recycled Glass Concrete K. Zheng 2013:

The chapter begins by introducing sources of waste glass and ways of recycling waste glass in concrete. It then summarizes fresh properties and mechanical properties of recycled glass concrete and discusses how recycled waste glass affects these properties. The chapter elaborates on durability of recycled glass concrete, especially on alkali-silica reactivity since this is the main concern for recycled glass concrete. Finally, the chapter presents suggestions for further studies on recycled glass concrete, and proposes future trends of using recycled glass in concrete in more economic and eco-efficient ways

C. Durability of Mortar Using Waste Glass Powder As Cement Replacement:

1) Ana Mafalda Matos, , Joana Sousa-Coutinho2012 .

It is well known that Portland cement production is an energy-intensive industry, being responsible for about 5% of the global anthropogenic carbon dioxide emissions worldwide. An important contribution to sustainability of concrete and cement industries consists of using pozzolanic additions, especially if obtained from waste such as waste glass.Crushed waste glass was ground (WGP) and used in mortar as a partial cement replacement (0%, 10% and 20%) material to ascertain applicability in concrete.An extensive experimental program was carried out including pozzolanic activity, setting time, soundness, specific gravity, chemical analyses, laser particle size distribution, X-ray diffraction and scanning electron microscopy (SEM) on WGP and resistance to alkali silica reaction (ASR), chloride ion penetration resistance, absorption by capillarity, accelerated carbonation and external sulphate resistance on mortar containing WGP.Glass particles well encapsulated into dense and mature gel observed by SEM, may help explaining enhanced durability results and thus confirming that waste glass powder can further contribute to sustainability in construction

D. Properties of Concrete Contains Mixed Colour Waste Recycled Glass As Sand And Cement Replacement

1) Bashar Taha, , Ghassan Nounu2013

Mixed colour waste recycled glass is waste material that cannot be reused in glass industry. Concrete can be considered as an outlet for the surplus quantities of the mixed colour waste recycled glass. This research work studies the feasibility of recycled glass sand (RGS) and pozzolanic glass powder (PGP) in concrete as sand and cement replacement, respectively. Ground granulated blast furnace slag (GGBS) and metakaolin (MK) were used in this study to replace Portland cement and investigate the effect of RGS on the behavior and properties of concrete contains blend of different cementations materials.

2) Recycled waste glass as fine aggregate replacement in cementations materials based on Portland cement.

Alaa M. Rashad 2014 Disposal of waste glass derived from container or packaging glass, flat glass, domestic or tableware glass and continuous filament glass fibers is one of the major environmental challenges. This challenge continues to increase with increasing the amount of waste glass and decreasing the capacity of landfill space.

3) Development of lightweight aggregate from sewage sludge and waste glass powder for concrete

Bui Le Anh Tuan, , Chao-Lung Hwang 2013.

Waste glass in the production of cement and concrete –and glass industries are facing a lot of challenges due to the high greenhouse gases emissions, the intensive use of energy and the intensive use of the earth’s natural resources.

4) Effect of partial replacement of cement with waste glass powder on the properties of concrete

Prema Kumar W P1*, Ananthayya M B2 and Vijay K 2014

Storage and safe disposal of waste glass is a huge problem for municipalities everywhere. Reuse of waste glass eliminates/reduces this problem. In this experimental work, the effect of partially replacing cement in concrete by glass powder is studied. The cement in concrete is replaced by waste glass powder in steps of 5% from 0% to 40% by volume and its effects on compressive strength, split tensile strength, workability and weight density are determined.

5) Experimental Investigation on Self Compacting Concrete Using Glass Powder Mayur B. Vanjare, Shriram H. Mahure*(2012)*

Self-compacting concrete is a type of concrete that gets under its self-weight. It is commonly abbreviated as the concrete. Which can have placed and compacted in to every corner of formwork; purely means of its self-weight by eliminating the need of either external energy input from vibrators or any type of compacting effort. There is a current trend in all over the world to utilize the treated and untreated industrial by- products, domestic wastes etc. as raw materials in concrete. These not only help in the reuse o f the waste materials but also create a cleaner and greener environment. This study aims to focus on the possibility of using waste material in a preparation of innovative concrete. One kind of waste was identified: Glass Powder (GP). The use of this (GP) was proposed in different percentage as an instead of cement for production of self-compacting concrete. The paper deals with the ingredient of these mixtures (Glass powder, fly ash, super plasticizer, cement) by examining their specific role in self compacting concrete Usually, SCC mixtures have high contents of fines in order to obtain the required rheological properties to achieve self-compact ability, which usually results in mixtures with high content of Portland cement, and consequently, high values of initial and final strength, much higher than those strictly required by the project.

6) A Review Of Pervious Concrete By Using Various Talsania Jayeshkumar Pitroda** Prof.Chetna M.Vyas*(2015)*

Being at the core of construction pervious concrete has gravitated curiosity of many passionate researchers towards itself. They studied and experimented with different composition to evaluate efficiency of pervious concrete. Such explorations lead to conquering many hurdles and lead ultimately to sustainable development, a very important aspect of research in the 21st century. The main objective of this investigation is to increase the strength and permeability of pervious concrete and decrease the cost of pervious concrete by replacing cement with various industrial waste materials such as waste glass powder, hypo sludge, ceramic waste and rice husk ash. This paper describes the literature which is based on previous concrete in which fly ash, silica fume and ground granulated blast furnace slag is partially replaced by cement in pervious concrete and various industrial such as waste glass powder, hypo sludge, ceramic waste, rice husk ash partially replaced by cement in concrete. This paper provides a review of research era in the area of pervious concrete it is clear that by using waste material by partially replacement of cement in pervious concrete, overall cost of making of concrete can reduce.

*7) * DR. (SMT.) B. K. Shah** Prof. P.J.Patel Ceramic Powder In Concrete By Partial Replacement Of Cement- A Literature Analysis Jay Patel *** (2015)*

Ceramic products made up with different raw materials like china clay, ball clay, potash feldspar, dolomite, talc and different chemicals for a glazing and finishing. Ceramic production conduct s on temperature 200°C to 2000°C, So the possibility of pozzolonic reactivity in such products, Which is responsible for long term strength and good durability. Here some literature paper analysis done, which are base on ceramic material partially replaced by cement in concrete. In such paper authors conducted mechanical properties tests and durability tests. They tried to replace ceramic material with cement up to 50 % with M- 20 to M-40 grade of concrete. The Ceramic industries are dumping the waste in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping. This leads to serious environmental and dust pollution and occupation of a vast area of land, especially after the powder dries up so it is necessary to dispose the Ceramic waste quickly and use in the construction industry.

8) Influence of Glass Powder on the Properties Of Concrete Veena V. Bhat 1 , N. Bhavanishankar Rao(2014)

Glass is commonly used in building / construction industries and large amount of glass is powdered daily. The disposal of waste glass is an environmental issue as waste glass causes disposal problem. Today the construction industry is in need of finding cost effective materials for increasing the strength of concrete structures. Glass powder finer than 600 µ is reported to have pozzolanic behavior. An attempt is made to investigate the possibility of using the waste glass powder as the partial replacement of ordinary Portland cement in concrete.

9) Effects of Waste Glass Powder as Pozzolanic Material in Saw Dust Cement Brick Omoniyi, Akinyemi (2014)

This work examines the possibility of using Waste Glass Powder (WGP) as a partial replacement of cement in saw dust composite brick to assess its pozzolanic activity and its effect on the properties of the composite. WGP was used to partially replace cement at 0%, 5%, 10%, 15%, 20%, 25%, and 30% in the production of test samples of 100x100x100mm at binder sand mixing ratio of 1:6. After casting the cubes, they were tested for compressive strength, water absorption, and capillary water absorption and volume porosity. The results indicated that WGP can be used as cement replacement material up to 30% at particle size less than 100µm to prevent alkali silica reaction and this can be utilized in the manufacture of non-load bearing sand concrete block without any unfavorable effect.

E. Previous Prepartion, Properties and Mix Design of Glass Powder Reinforced Concrete:

Many works have been done to explore the benefits of using pozzolanic materials in making and enhancing the properties of concrete. M.D.A. Thomas, M.H. Shehata et al. have studied the ternary cementations blends of Portland cement, silica fume, and fly ash offer significant advantages over binary blends and even greater enhancements over plain Portland cement. Sandor Popo vics have studied the Portland cement-fly ash - silica fume systems in concrete and concluded several beneficial effects of addition of silica fume to the fly ash cement mortar in terms of strength, workability and ultra-sonic velocity test results. Jan Bijen has studied the benefits of slag and fly ash added to concrete made with OPC in terms of alkali-silica reaction, sulphate attack. L. Lam, Y.L. Wong, and C.S. Poon in their studied entitled Effect of fly ash and silica fume on compressive and fracture behaviors of concrete had concluded enhancement in strength properties of concrete by adding different percentage of fly ash and silica fume. Tahir Gonen and Salih Yazicioglu studied the influence of binary and ternary blend of mineral admixtures on the short and long term performances of concrete and concluded many improved concrete properties in fresh and hardened states. Mateusz Radlinski, Jan Olek and Tommy Nantung in their experimental work entitled Effect of mixture composition and Initial curing conditions on the scaling resistance of ternary concrete have find out effect of different proportions of ingredients of ternary blend of binder mix on scaling resistance of concrete in low temperatures.

VII. EXPERIMENTAL SETUP

A. Experimental Program:

In order to achieve the stated objectives, this study was carried out in few stages. On the initial stage, all the materials and equipment's needed must be gathered or checked for availability. Then, the concrete mixes according to the predefined proportions. Concrete samples were tested through concrete tests such as cube test. Finally, the results obtained were analyzed to draw out conclusion

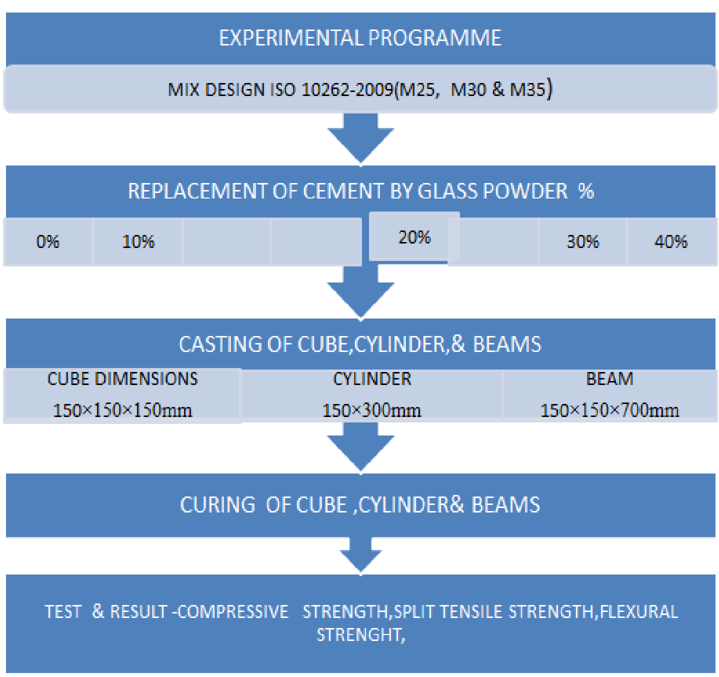

Fig. 2: Experimental Program

B. *Experimental Program:*

In order to study effect of replacement of cement in various ratio of industrial waste glass powder compression, flexure, split tension on 117 cubes, 13 beams and 13 cylinders were casted respectively. The experimental program was divided into four groups.

Each group consists of 3 cubes, 1 cylinder and 1 beam, of 15x15x15cm, 15(dia) x30cm and 15x15x70cm respectively.

- The first group is the control (Plain) concrete with 0% glass powder (PPC)
- The second group consisted of 10% glass powder, with aspect ratio by replacement of cement.
- The third group consisted of 20% glass powder, with aspect ratio by replacement of cement.
- The fourth group consisted of 30% glass powder, with aspect ratio by replacement of cement.
- The fifth group consisted of 40%glass powder, with aspect ratio by replacement of cement.

C. *Materials And Tests:*

1) Cement

Cement acts as a binding agent for materials. Cement as applied in Civil Engineering Industry is produced by claiming at high temperature. It is admixture of calcareous, siliceous, aluminous substances and crushing the clinkers to a fine powder. Cement is the most expensive materials in concrete and it is available in different forms. When cement is mixed with water, a chemical reaction takes place as a result of which the cement paste sets and hardens to a stone mass. Depending upon the chemical compositions, setting and hardening properties, cement can be broadly divided into following categories.

- Portland pozzlana Cement
- Special Cement

The cement used in this experimental investigation is ordinary Portland cement 53 grade. Storage of cement requires extra special care to preserve its quality and fitness for use. To prevent its deterioration, wind, rain etc.

D. *Tests On Cement*

1) Standard Consistency and Initial Setting Time

Standard consistency of cement is defined as that water content at which the needle of the apparatus fails to penetrate the specimen by 5mm from bottom of the mould.

Standard Consistency of the cement paste = 30%.

Initial Setting Time of Cement = 45min.

Weight of cement taken in the mould = 300 grams

2) Specific Gravity Test for Cement

Table - 2

Specific gravity test	*Weight(kg)*	*cement(weight in kg)*
Weight of pycnometer	*W1=0.644kg*	*0.644*
Weight of pycnometer + cement	*W2=0.844kg*	*0.844*
Weight of pycnometer + cement+ kerosene	*W3=1.321kg*	*1.321*
Weight of pycnometer + kerosene	*W4=1.144kg*	*1.141*
Specific gravity W2-W1/(W2-W1)-(W3-W4)0.79		*3.21*

E. *Working Mechanisms:*

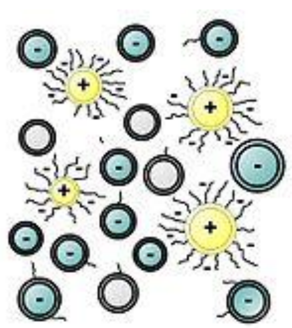

Fig. 3: Polycarboxylate displacement on a multi-phase suspension

PCE's backbone, which is negatively charged, permits the adsorption on the positively charged colloidal particles. As a consequence of PCE adsorption, the zeta potential of the suspended particles changes, due to the adsorptions of the COO- groups on the colloid surface. This displacement of the polymer on the particle surface ensures to the side chains the possibility to exert repulsion forces, which disperse the particles of the suspension and avoid friction. These forces can be directly detected by the use of the atomic force microscopy (AFM), working with model substances in liquid environment.

Fig.4:

F. Glass Powder:

Table - 3

Physical properties of Glass powder		
1	*Specific gravity*	*2.6*
2	*Fineness passing 150µm*	*99.5*
3	*Fineness passing 90 µm*	*98*
Chemical Properties		
1	*Ph*	*10.25*
2	*Color*	*Grayish white*
Chemical composition		*% by mass*
1	SiO_2	*67.33*
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	K_2O	*0.638*
9	ZrO_2	*0.019*
10	ZnO_2	*0.008*
11	*SrO*	*0.016*
12	P_2O_5	*0.051*
13	*NiO*	*0.014*
14	*CuO*	*0.009*
15	Cr_2O_3	*0.022*

G. Curing:

Curing is the process of preventing the loss of moisture from concrete while maintaining a satisfactory temperature. More elaborately curing is defined as process of maintaining satisfactory moisture content and favorable temperature in concrete during the period immediately following placement, so that hydration of cement may continue until the desired properties are developed to sufficient degree to meet the requirement at service. After casting the molded specimens are stored in the laboratory and at a room temperature for 24 hours from the time at addition of water to dry ingredients. After this period the specimens are removed from the moulds immediately submerged in clean and fresh water. The specimens are cured for 28days in the present work.

Fig. 5: Curing

H. Flexural Test:

SFRC beams of size 150x150x700mm are tested using a flexure testing machine. The specimen is simply supported on the two rollers of the machine which are 600mm apart, with a bearing of 50mm from each support. The load shall be applied on the beam from two rollers which are placed above the beam with a spacing of 200mm. The load is applied at a uniform rate such that the extreme fibers stress increases at 0.7N/mm2/min i.e., the rate of loading shall be4 KN/min. The load is increased till the specimen fails. The maximum value of the load applied is noted down. The appearance of the fracture faces of concrete and any unique features are noted.

Fig. 7: Flexure test

The modulus of rupture is calculated using the formula.
$\sigma s = Pl/bd^2$, where,
P = load in N applied to the specimen
l = length in mm of the span on which the specimen is supported (600)
b = measured width in mm of the specimen
d = measured depth in mm of the specimen at point of failure.

I. Split Tensile Test:

SFRC cylinders of size 15cm (dia) x 30cm (height) are casted. The test is carried out by placing a cylindrical specimen horizontally between the loading surface of a compression testing machine and the load is applied until the failure of the cylinder, along the vertical diameter. When the load is applied along the generatrix, an element on the vertical diameter of the cylinder is subjected to a horizontal stress of $2P/\pi ld$.
Where, P is the compressive load on the cylinder
l is the length of the cylinder
d is diameter of the cylinder.

Fig. 8: Split Tensile Test

VIII. RESULT

Table - 4.1
Result Of Cube (Grade M-25) Compressive Strength In N/Mm^2

% of glass powder	*Compressive strength in N/mm^2*			*Average compressive strength in N/mm^2*		
	After 7 days	*After 14 days*	*After 28 days*	*7 days*	*14 days*	*28 days*
0%	*18.72*	*25.90*	*28.90*	*18.44*	*25.55*	*28.37*
	18.82	*26.0*	*28.80*			
	18.92	*25.80*	*28.70*			
10 %	*19.32*	*26.40*	*29.40*	*20.60*	*28.53*	*31.70*
	19.12	*26.60*	*29.20*			
	19.22	*26.20*	*29.30*			
20 %	*19.72*	*26.9*	*29.80*	*22.30*	*30.87*	*34.30*
	19.82	*26.9*	*29.90*			
	19.92	*26.9*	*29.70*			
30 %	*20.22*	*27.4*	*30.10*	*19.734*	*27.324*	*30.36*
	20.32	*27.5*	*30.20*			
	20.12	*27.3*	*30.00*			
40 %	*19.8*	*26.95*	*29.90*	*17.628*	*24.408*	*27.12*
	19.7	*26.85*	*29.80*			
	19.9	*27.05*	*30.00*			

Result of compressive strength for M-25 grade of concrete on cube specimen with 0%,10 %, 20%, 30 %, 40% glass powder mixes are shown in table & graph below. Table-4.1 shows the compressive strength values of M-25 grade concrete and glass powder mixes and their values are observed to be varied from 18.44 to 28.37 N/mm2 with 0% glass powder, 20.60 to 31.70 N/mm2 with 10% 22.30 to 34.30 N/mm2 with 20%; 19.734 to 30.36 N/mm2 with 30 %, & 17.628 to 27.12 N/mm2 with 40% of glass powder. the 7 days,14 days and 28 days compressive strength of concrete increases initially as the replacement percentage of cement with glass powder increases, and become maximum at about 20% and later decreases.

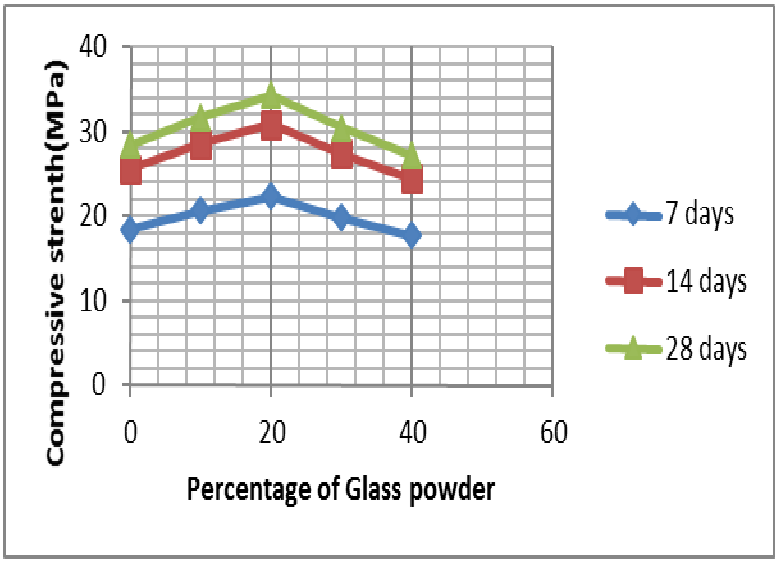

Fig. 4.1: variation in compressive strength according to % of glass powder (Grade M-25)

Table - 4.2
Result of Cube (Grade M-30) Compressive Strength In N/Mm2

% of glass powder	*Compressive strength in N/mm²*			*Average compressive strength in N/mm²*		
	After 7 days	*After 14 days*	*After 28 days*	*7 days*	*14 days*	*28 days*
0 %	*22.87*	*31.67*	*35.13*	*22.85*	*31.63*	*35.15*
	22.83	*31.66*	*35.14*			
	22.86	*31.62*	*35.17*			
10 %	*25.14*	*34.77*	*38.63*	*25.12*	*34.78*	*38.65*
	25.11	*34.76*	*38.66*			
	25.12	*34.79*	*38.70*			
20 %	*28.43*	*39.39*	*43.77*	*28.45*	*39.42*	*43.80*
	28.49	*39.47*	*43.79*			
	28.44	*39.44*	*43.82*			
30 %	*25.33*	*35.07*	*38.91*	*25.30*	*35.05*	*38.95*
	25.28	*35.01*	*38.97*			
	25.29	*35.03*	*38.96*			
40 %	*22.19*	*39.68*	*34.10*	*22.17*	*39.70*	*34.12*
	22.16	*39.72*	*34.13*			
	22.15	*39.69*	*34.14*			

Result of compressive strength for M-30 grade of concrete on cube specimen with 0%, 10 %, 20%, 30 %, 40% glass powder mixes are shown in table & graph below. Table-4.2 shows the compressive strength values of M-30 grade concrete and glass powder mixes and their values are observed to be varied from 22.85 to 35.15 N/mm2 with 0% glass powder, 25.125 to 38.65 N/mm2 with 10% 28.45 to 43.80 N/mm2 with 20%; 25.30 to 38.95 N/mm2 with 30 %, & 22.175 to 34.12 N/mm2 with 40% of glass powder. The 7 days, 14 days and 28 days compressive strength of concrete increases initially as the replacement percentage of cement with glass powder increases, and become maximum at about 20% and later decreases.

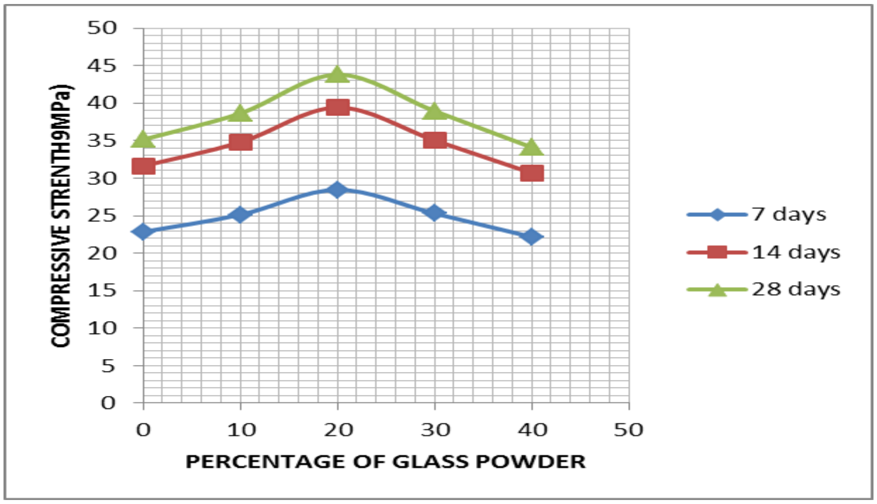

Fig. 9: variation in compressive strength according to % of glass powder (Grade M-30)

IX. Conclusion

The following conclusions are made based on the above study:

- The 7 days, 14 days and 28 days compressive strengths of concrete increase initially as the replacement percentage of cement with glass powder increases, and become maximum at about 20% and later decreases.
- The flexural strength of concrete increases initially as the replacement percentage of cement with glass powder increases, and becomes maximum at about20% and later decrease.
- The split tensile strength of concrete increases initially as the replacement percentage of cement with glass powder increases, and becomes maximum at about20% and later decrease.
- The slump of concrete decrease monotonically as the replacement
- Percentage of cement with glass powder increases. The workability decreases when cement is replaced partially with glass powder.
- The present study shows that there is a great potential for the utilization of glass powdering concrete as partial replacement of cement. About 20% of cement may be replaced with glass powder without any sacrifice on the compressive strength.
- Using of waste glass powder in local construction Bhopal area its reducing cost significantly in casting of one m3 for grade concrete M-25, M-30& M-35 save in Rs 348, 425 & 560 approximately.

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