



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: PFA, ASR, HPC, SCC, HDPE, LDPE, WGP

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 75 μ m. 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 take place between the silica – 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

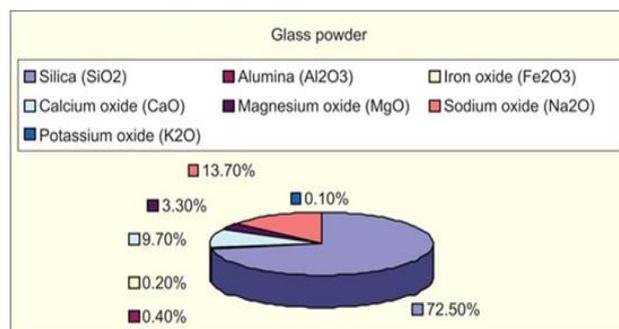
High-performance concrete is defined as a concrete meeting special combination of performance and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing, and curing practices. High-performance concrete (HPC) exceeds the properties and 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 impermeability to chloride penetration makes it last much longer than conventional concrete.

2.1 Composition Glass & Cement Powder Reinforced Concrete

Table 1: Chemical composition of cementing materials		
Composition (% by mass)/ property	Cement	Glass powder
Silica (SiO ₂)	20.2	72.5
Alumina (Al ₂ O ₃)	4.7	0.4
Iron oxide (Fe ₂ O ₃)	3.0	0.2
Calcium oxide (CaO)	61.9	9.7
Magnesium oxide (MgO)	2.6	3.3
Sodium oxide (Na ₂ O)	0.19	13.7
Potassium oxide (K ₂ O)	0.82	0.1
Sulphur trioxide (SO ₃)	3.9	-
Loss of ignition	1.9	0.36
Fineness % passing (sieve size)	97.4(45 μm)	80 (45 μm)
Unit weight, Kg/m ³	3150	2579
Specific gravity	3.15	2.58

2.2 Glass Powder



2.3 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.

III. REVIEW OF LITERATURE

Recycled glass as a partial replacement for fine aggregate in self compacting concrete

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.

High-volume natural volcanic pozzolan and limestone powder as partial replacements for portland cement in self-compacting and sustainable concrete. K. Celik¹, M.D. Jackson² 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).

Performance of dry cast concrete blocks containing waste glass powder or polyethylene aggregates S.E. Chidiac¹, 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.

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

Durability of mortar using waste glass powder as cement replacement

Ana Mafalda Matos¹, Joana Sousa-Coutinho 2012 .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

Properties of concrete contains mixed colour waste recycled glass as sand and cement replacement

Bashar Taha¹, Ghassan Nounu 2013 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.

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.

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

Bui Le Anh Tuan¹, 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.

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

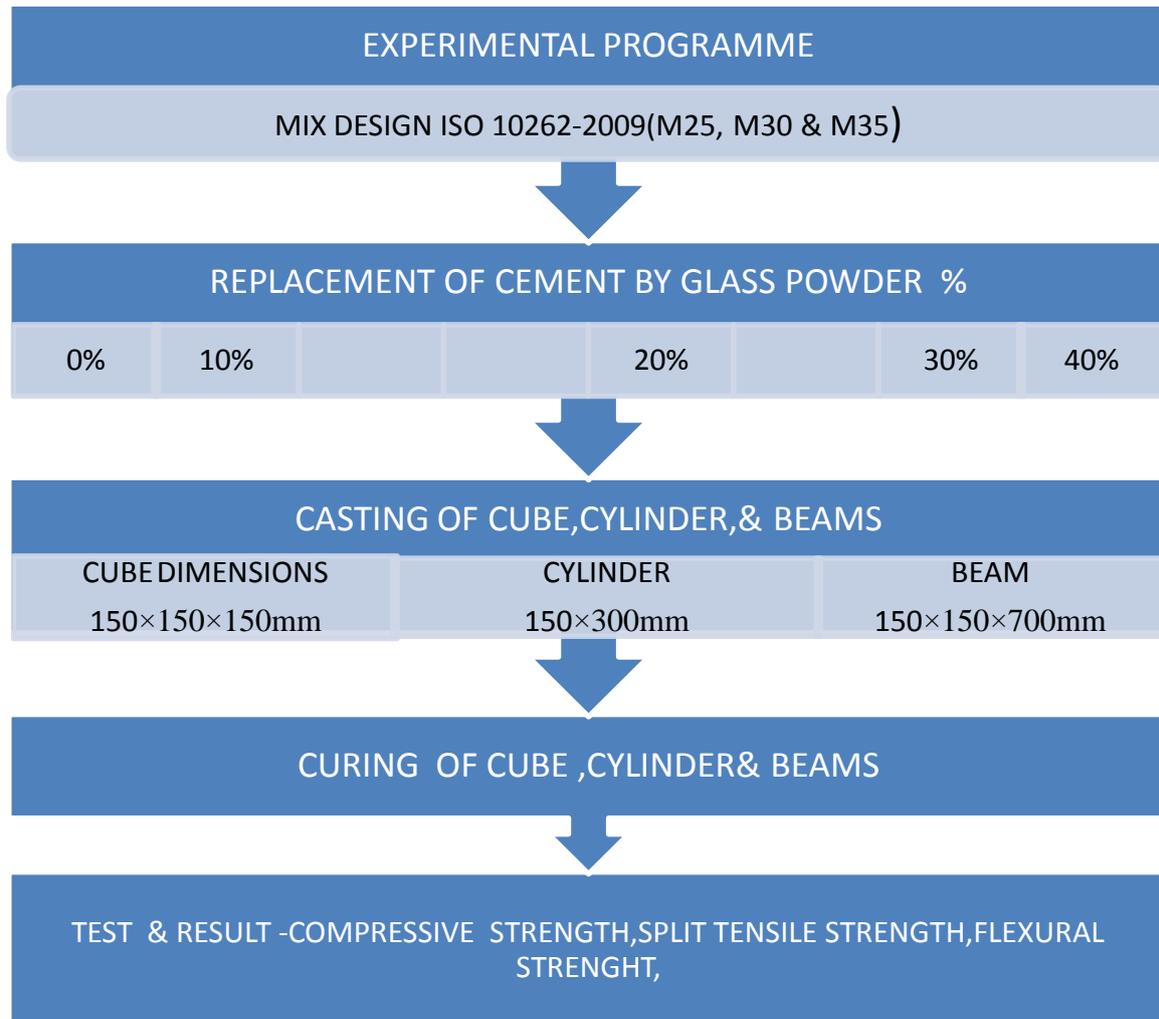
Prema Kumar W P1*, Ananthayya M B2 and Vijay K 2014

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.

IV. EXPERIMENTAL SETUP

4.1 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 equipments 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



4.2 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.

4.3 Materials and Tests:

4.3.1 Cement:

Cement acts as a binding agent for materials. Cement as applied in Civil Engineering Industry is produced by claming 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.

Tests on Cement

4.3.2. Standard Consistency And Initial Settig 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

4.3.3 Specific Gravity Test For Cement

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

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