

# Reuse of glass in concrete analysis with minimizing impact of solid waste on environment

## Abstract

This research was conducted to utilize waste glass as a fine aggregate at par ASTM standard for fine aggregates. Waste glass fine aggregates of different sizes rang (1.71 to 1.19mm) were used to partially replace hill sand (fine aggregates). Hill sand was partially replaced with waste glass fine aggregate as 4%, 8%, 12%, 16%, 20%, 24%, 28%, 32%, 36% and 40% by weight in concrete mix with ratio of 1:1.5:3. The concrete cubes were cast and tested for compressive strength, density and water absorption at twenty-eight (standard) days age and these results were compared with same parameters of virgin 1:1.5:3 concrete. It was observed that replacement of fine aggregates at 12% with waste glass achieved strength about 46.162N/mm<sup>2</sup> which is better result by using waste glass aggregates. The density of glass concrete also increased about 3.67% at 12% replacement of hill sand as compared to virgin concrete. The water absorption of glass concrete decreased about 1.05 % at 40% replacement of hill sand. The test results show that it is possible to use waste glass as a fine aggregate with same characteristics to those of natural sand aggregate concrete provided.

**Keywords:** waste glass, fine aggregates, ASTM standard, concrete, compressive strength, density and water absorption.

Volume 4 Issue 3 - 2018

**Rabnawaz juj,<sup>1</sup> Farhan Hussain Wagan,<sup>2</sup>Abdullah Sand,<sup>3</sup> Ghulam Hussain Wagan<sup>4</sup>**

<sup>1</sup>Sindh Building Control Authority, Government of Sindh, Pakistan

<sup>2</sup>Civil Engineering Department, Quaid-e-Awam University of Engineering, Science & Technology, Pakistan

<sup>3</sup>Chairman Civil Engineering Department, Quaid-e-Awam University of Engineering, Science & Technology, Pakistan

<sup>4</sup>Head of Civil Engineering Department, Swedish College of Engineering and Technology, Pakistan

**Correspondence:** Farhan Hussain Wagan, Civil Engineering Department, Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Sindh, Pakistan,  
Email farhan\_hussain\_4u@yahoo.com

**Received:** February 21, 2018 | **Published:** May 21, 2018

## Materials

The Concrete is a mixture of cement, sand, coarse aggregate and water. It is a main building construction material which is the world's most devouring man-made material.

## Glass

It is a hard and fragile material prepared by melting sand with soda (sodium carbonate) and lime (CaCO<sub>3</sub>) and cooling rapidly. Glass was 1st prepared in 3500 BC in Mesopotamia presently Iraq. Glass is broadly used in our daily life in the shape of bottle, utensils, glass sheets, etc.

## Waste glass

Like other countries in Pakistan, the main element of solid waste is waste glass. It can be found in many forms including, bulb glass, sheet glass, glass bottles, windows glass and glass containers. It is 100% recyclable material with high performance, and unique aesthetic properties, which makes it suitable for wide appeared uses. The huge volume of yearly disposed waste glass is available in the country.<sup>1</sup> The landfill of waste glass is undesirable because it is not biodegradable and not friendly to the environment. The use of waste glass was first reported 50 years ago and with the passage of time research is being carried out to investigate its properties when used for replacement of cement, fine aggregate and coarse aggregate in the concrete mix.

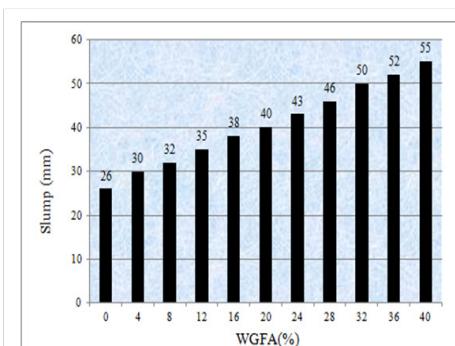
## Glass concrete (Glasscrete)

It is a type of concrete which is prepared by addition of waste glass as partial or complete replacement of cement or fine aggregate or coarse aggregate. The use of glass as aggregates in cement has great potential for future high-quality concrete development. When waste glasses are reused in making concrete products, the production cost of

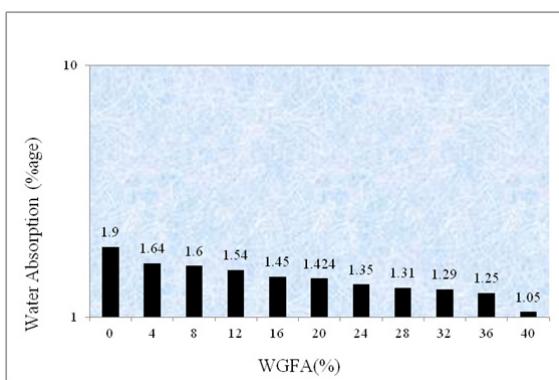
concrete will go down, crushed glass if properly sized and processed it can exhibit characteristic applications to that of gravel and sand (Figure 1-4).



**Figure 1** Grinded waste glass.



**Figure 2** A graph of slump test of Glass Concrete for WGFA size passing from 1.71 mm & retained on 1.19 mm sieve.



**Figure 3** A Graph of Water absorption test of Glass Concrete for WGFA size passing from 1.71 mm sieve & retained on 1.19 mm sieve.



**Figure 4** A graph of Density test of Glass Concrete for WGFA size passing from 1.71 mm & retained on 1.19 mm sieve.

## Literature review

Waste material fly ash has been used with glass aggregate to enhance the green environment and durability of concrete and that can be utilized for different transportation function.

From laboratory tests, it can be concluded that the fly ash is helpful against ASR by

- Decrease the alkalinity of pore solution.
- Decrease the mass transport in concrete.
- Improve the tensile strength of concrete.

By the addition of fly ash, it also decreases the ASR. The Glasscrete has been good for workability, reducing the coefficient of thermal expansion, reducing chloride permeability and absorption of water.<sup>2</sup> The hollow blocks which are prepared from clear flat window glass for non-load bearing walls which reduce the water–cement ratio, which depending on the quantity of flat glass present in the mixture. By using flat glass the value of modulus of elasticity decreases, as the unit weight of concrete reduces. The flat window glass has a quality in producing pozzolanic property and its small moisture content property so by this advantage it can be used with the ratio of 1:2:4 for load bearing blocks.<sup>3</sup> The utilization of fiberglass, this waste achieved from industries and fulfills the requirement fine aggregate as an alternative material. It can

be determined that it not only enhances the quality of concrete but also easy and effective disposal of this waste, also decreases the cost of concrete. From the laboratory results, the slump value of glass fiber concrete decreases with the enhance of waste glass fiber percentage.<sup>4</sup> Cement can partially be replaced with glass powder in new concrete and to monitor the creep of this concrete. From the laboratory results, it can be found that the waste (Lamp) glass effectively utilizes in a preparation of concrete, thus the reduction of the amount of this waste in and reduce the usage of cement which leads to decrease the amount of carbon dioxide discharge into the air.<sup>5</sup> Mixed–Colored waste glass has sufficient chemical composition and reactivity to increase the chemical stability, toughness, and moisture resistance. It is necessary to grind at microscale particle size for enhancing the helpful chemical reaction in concrete. In this research concrete prepared by partial replacement of cement with waste glass. From results it can be found that the waste glass is used as a partial replacement of cement helps in better strength and durability while comparing with standard concrete. Waste glass also has also pozzolanic reaction with cement hydrates to develop the chemical composition and microstructure of concrete. It also plays an important role in development of saving energy, economical and sustainable concrete–base infrastructure system.<sup>6</sup> The huge volume of waste glass has been augmenting in few years due to enhancing the development of industrialization and living standard. Unfortunately, as the waste glass present in huge volume, it is not recycled in quantity as desire, hence the cause of definite issues such as waste of natural resources and environmental pollution. This research provides short information and concrete containing waste glass powder which undergoes sulfate attacks.

- The concrete which consists of 20% waste glass powder as cement replacement achieved high strength.
- When glass concrete undergoes sulfate attack, the decrease in strength of concrete was observed.
- When waste glass powder utilizes in appropriate proportions could be minimized by sulfate attack.
- The glass powder is feasible for concrete by considering strength criteria.
- It is possible to use waste glass powder partially instead of cement.<sup>7</sup>

The utilization of sheet glass powder in concrete which enhances the green environment and decrease s the wastes. The concrete which contains Sheet Glass Powder (SGP) can economize waste disposal, sites and saving natural sand. This paper determined the possibility of utilizing the waste glass powder as partial replacement of fine aggregate in concrete. The test results show the water requirement decreases with the increase of sheet glass powder, The concrete which contain s 100% SGP as replacement of fine aggregate proved good outcome as compared with controlled concrete at 28 days curing and 45 days curing after that the reduction in strength had been observed due to Alkali–Silica Reactions. The density of waste glass concrete was more than controlled concrete. This waste present in huge volume and can be used in concrete to decrease the volume of waste in the environment, 10% utilization of waste glass powder as partial replacement in concrete was at an optimum level.<sup>8</sup> Disposal of solid waste to the landfills of used Solid waste which can be used in concrete is a serious issue to be solved for Pakistan EPA. Currently, this industry is facing many challenges, concrete with different

proportions to produce concrete more strong than ordinary concrete (especially as a member like Beam) economic and cost effective.<sup>9</sup>

## Aims and objectives of research

This research aims to investigate possible utilization of waste glass as fine aggregate in concrete keeping essential properties intact.

The Specific Objectives are:

1. To study the compressive strength of concrete by replacing hill sand with different proportion & sizes of waste glass fine aggregate.
2. To study workability, density & water absorption of concrete made by replacing hill sand with different proportion & sizes of waste glass fine aggregate (Table 1-4).

**Table 1** Results of slump test of Glass Concrete for WGFA size passing from 1.71 mm & retained on 1.19 mm sieve

Batch no.	WGFA (%)	slump (mm)	increase %age
1	0	26	—
2	4	30	15
3	8	32	23
4	12	35	34.61
5	16	38	46.16
6	20	40	53.84
7	24	43	65.38
8	28	46	76.92
9	32	50	92.3
10	36	52	100
11	40	55	111.5

**Table 2** Results of Water absorption test of Glass Concrete for WGFA size passing from 1.71 mm sieve & retained on 1.19 mm sieve

Batch no.	WGFA (%)	water absorption (%age)	Decrease %age
1	0	1.9	—
2	4	1.64	13.68
3	8	1.6	15.78
4	12	1.54	18.94
5	16	1.45	23.68
6	20	1.424	25.05
7	24	1.35	28.94
8	28	1.31	31.05
9	32	1.29	32.1
10	36	1.25	34.21
11	40	1.05	44.73

**Table 3** Results of Density test of Glass Concrete for WGFA size passing from 1.71mm& retained on 1.19mm sieve

Batch no.	WGFA (%)	density (kg/m <sup>3</sup> )	increase (%age)
1	0	2558	—
2	4	2605	1.83
3	8	2610	2.03
4	12	2652	3.67
5	16	2580	0.8
6	20	2571	0.5
7	24	2572	0.54
8	28	2570	0.46
9	32	2568	0.39
10	36	2560	0.078
11	40	2511	-1.83

**Table 4** Results of Compressive Strength test of Glass Concrete for WGFA size passing from 1.71mm& retained on 1.19mm sieve

Batch no.	WGFA (%)	compressive strength (n/mm <sup>2</sup> )	increase %age
1	0	31.518	—
2	4	38.844	20.7
3	8	41.954	33.11
4	12	45.142	43.22
5	16	43.526	38
6	20	37.023	17.46
7	24	35.963	14.08
8	28	33.346	5.8
9	32	32.06	1.6
10	36	31.675	0.48
11	40	29.275	-7.11

## Conclusion

Based on the obtained results in this study, it can be concluded that:

- I. In general, it is found with the replacement of hill sand with WGFA strength increases with a maximum at 12% replacement. However, workability increases continuously, and water absorption decreases with virgin concrete.
- II. By increasing dosages of WGFA in concrete, the workability increases significantly with maximum 120% and 111.5% as compared with ordinary concrete.
- III. By increasing dosages of WGFA 01 and WGFA 02 in concrete, the water absorption of concrete decreased, maximum decrease 44.73% & 46.84% as compared with ordinary concrete, at the addition of 40% WGFA.

## Discussion

By increasing the dosage of WGFA, the density of concrete increased, maximum 3.67% and 3.32% increased as compared to ordinary concrete, at the addition of 12% of WGFA respectively, whereas on further increment of WGFA, the density of concrete decreased.

## Acknowledgements

None.

## Conflict of interest

The author declares there is no conflict of interest.

## References

1. EPMC Estimates. *Brief on Solid Waste Management in Pakistan*, Pakistan; 1996.
2. Rajabipour F. *Utilizing coal fly ash and Recycled glass in Developing Green Concrete Materials*. The Pennsylvania state university USA; 2012.
3. Tomas Ucol-Ganiron. Recycled Window Glass for Non-Load Bearing Wall. *International Journal of Innovation Management Technology*. 2012;3(6).
4. Yogeshlyer Murthy. Performance Glass Fiber Reinforced Concrete. *International Journal of Engineering and Innovative Technology (IJEIT)*. 2012;1(6).
5. Andina Sprince. Creep Behaviour of Concrete with Glass Waste Microfiller. 8th International Scientific and Practical Conference. *Environment Technology Resources*. 2011;II.
6. Roz-Ud- Din Nassar. Field investigation of concrete incorporating milled waste glass. *Journal of solid waste technology and management*. 2011;37(4).
7. Bajad MN. Effect of Glass on Strength of Concrete Subjected to Sulphate Attach. *International Journal of Civil Engineering Research and Development*. 2011;1(2).
8. Mages Wari M. The use of Sheet Glass Powder as Fine Aggregate Replacement Concrete. *The Open Civil Engineering Journal*. 2010;65–71.
9. Rizwan Hussain Wagan, Farhan Hussain Wagan, Imran Hussain Wagan, et al. The Effect of Waste Tyre Steel Fibers distribution Characteristics on the Flexural Strength of Concrete with Improving Environmental Impact in Pakistan. *American Journal of Applied Scientific Research*. 2017;3(5):49–55.