Investigation on Partial Replacement of Cement with Glass Powder in Concrete

R. Mahalakshmi[1], K. Manoj[2], U. Venkata Suneel[3], Ch. Sriram[4]
[1,2,3,4]*Student, PACE Institute of Technology & Sciences*

***Abstract*—Glass powder is incredibly fine powder shows pozzolanic properties, which might be used as partial replacement of cement in concrete. Glass may be a common material employed in day-to-day life in constructions. Its lifetime is proscribed. After use, it is recycled or sent to landfills. Since glass is not biodegradable. So, land filling is not eco-friendly. Mix design M20 was casted by replacement of cement with Glass powder by weight at 0%, 10%, 20%. Cubes (Cube - 150*150*150mm) were prepared for testing after seven-, and twenty-eight-days natural process in water served as the control. The main objective is to compare the compressive strength for the designed mix specimen (M20) with conventional and replaced concretes.**

***Keywords*— Waste glass, Recycling, Cement, pozzolanic properties.**

I. INTRODUCTION

Concrete is a widely used construction material due to its durability and economy. However, its manufacturing process emits CO2 gas, contributing to 65% of global warming. To reduce environmental impact, alternative binders are used in concrete production. Reusing bulky waste is considered the best environmental solution for disposal problems. Glass, a high silica content material, is being explored as a replacement for conventional cement in concrete production for greenhouse management. However, concerns arise from the Alkali-Silicate reaction, which can cause expansion and cracking. This study compares finely powdered waste glasses as a partial replacement for cement in concrete, comparing concrete mixtures with different glass powder proportions and testing compressive strength after 7 and 28 days of curing.

‘’Pollution is nothing but the resources we are not harvesting. We allow them to disperse because we’ve been ignorant of their value.’’

Economic growth, urbanization, and industrialization increase waste volumes, with globalization worsening issues. Ineffective waste management leads to health risks, pollution, and resource loss. An integrated approach is crucial for sustainable development strategies, prioritizing waste prevention and minimization.

K. Zheng (2013) et al, have studied the text discusses the use of recycled glass concrete, its properties, durability, and future trends for economic and eco-efficient concrete production.

Seung- Bum Park and Bong Chun Lee (2004) et al, discussed the park suggests recycling colored waste glasses as concrete aggregate, reducing environment impact. However, over 20% glass content in concrete decreases compressive and flexural strength.

Vasudevan Gunalaan and Kanapathy pillay Seri Ganis (2013) et al, the research found that using waste glass powder in concrete improves slump property and workability. After curing specimens for 7, 14, and 28 days, 20% glass powder mix showed a positive compressive strength at 28 days, compared to 10% and 15%.

R. Vandhiyan et al (2013) et al, the study found that workability decreased with increasing replacement of cement with waste glass powder, primarily due to increased surface area and angular shape of glass particles. However, early strength gain increased by 29% at 7 days.

II. MATERIALS AND METHODOLOGY

Experiments were conducted on concrete prepared by partial replacement of cement by waste glass powder of particle size 75µm. The waste glass powder was replaced by 10%, 20%, 30% and 35% with 15% fly ash of the binder and the mix design was prepared.

Cement is replaced with fine glass aggregate up to 35%. The physical and chemical characteristic was studied, and the chemical components of the glass powder used in the concrete were also determined.

A. Cement

The cement used in this study was 53 grade Ordinary Portland Cement (OPC) confirming to IS 12269-1987. Cement is a binding material, which is the combination of two called calcareous and argillaceous materials. DECCAN -53 grade ordinary Portland cement conforming to IS: 12269 were used in concrete.

B. Fine Aggregate

Locally available sand confirming zone II with specific gravity 2.62 was used. The testing of sand was done as per Indian Standard Specification IS: 383-1970.

C. Coarse Aggregate

Coarse aggregate used was 20mm downsize and specific gravity 2.93. Testing was done as per Indian Standard Specification IS: 383-1970.

D. Glass Powder

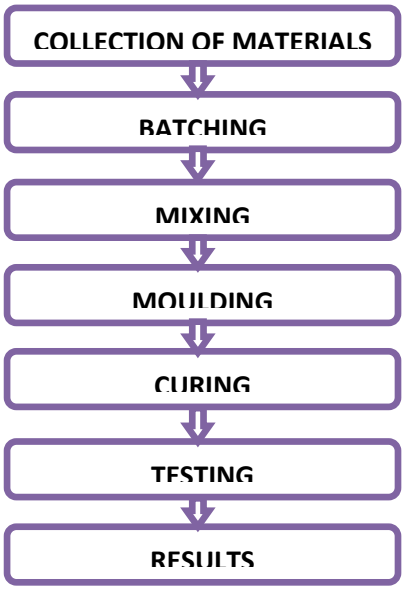
Waste glass available locally was collected and made into glass powder. Glass waste is very hard material. Before adding glass powder in the concrete, it has to be powdered to desired size.

Glass is an amorphous, transparent, super-cooled liquid produced by melting silica, CaCO3, and soda ash. It is used as aggregates in road construction, masonry, and building materials. Glass powder, obtained from crushing glass pieces, can be used as a cement replacement material up to particle size less than 90µm.

S.no	Physical properties of glass powder	
1	Specific gravity	2.6
2	Fineness passing 150 µm	99.5
3	Fineness passing 90 µm	98
	Chemical properties of glass powder	
4	PH	10.25
5	Color	Grayish white

E. Water

The locally available potable water, which is free from concentration of acid and organic substances, is used for mixing the concrete.



F. Procedure of Making Concrete Cubes

For knowing compressive-strength of concrete, we generally test concrete-cube at laboratory. These cubes are made on construction site. In this article I'll discuss the procedures of making concrete cube.

Cube Mould (150x150x150 mm or 100x100x100mm)

Tamping bar (16 mm diameter and bull-nosed)

Steel Float/Trowel

Clean the cube-mould properly and apply oil on inner surface of mould. But no oil should be visible on surface. fix the cube mould with base plate tightly. No gap should be left in joints so that cement-slurry doesn't penetrate. place the mould on levelled surface. Take concrete from three or four random mixes. Place concrete into mould in three layers. Compact each layer by giving 35 blows of tamping bar. Remove excess concrete from the top of mould and finish concrete surface with trowel. Make the top surface of concrete cube even and smooth. Left the mould completely undisturbed for first four hours after casting. after ending undisturbed period, put down casting date and item name on the top of concrete specimen with permanent marker.

After 8 to 10 hours of casting, wrap the cube mould with wetted hessian cloth. Cover the mould's top portion with a polythene sheet so that water doesn't fall on concrete surface. uncover and remove the cube specimens from mould after 24±½ hours of casting. For removing specimen from mould, first loosen all nut-bolts and carefully remove specimen because concrete is still weak and can be broken. Immediately after removing, put the specimen into a tank of clean water for curing. Make sure cube specimen is fully submerged in water. After 28 days of curing take out specimens from water tank and send to laboratory for testing. generally three cube specimens are tested separately at laboratory and the average result is counted as concrete compressive-strength. so we make three specimens on site at a time.

G. Compression Test

For this purpose, either concrete cubes are tested in the laboratory. 3 concrete cubes are generally made and cured for 7 and 28 days at site and then sent to laboratory for testing.

Concrete's compressive-strength mostly depends on the mix design. But it is affected by several other factors. Such as mixing of concrete, placing of concrete, curing of concrete as well as quality of concrete ingredients. So we can't be assured that if we produce concrete as per mix design we will get desired compressive strength. However, we should know the concrete compressive strength for every part of concrete-structure.

The following procedure may be adopted for finding the compressive strength of concrete

Calculate the volume of the concrete required for casting the specimens. Take the mix proportions based on the grade of concrete. The volume of the coarse aggregate can be taken as volume of the required concrete. Then using bulk density of coarse aggregate. The other materials weights can be determined. Pour the required quantity of cement over the weighed sand and mix in dry condition. Add water at 0.5 of water cement ratio and mix thoroughly to get concrete of uniform color. Place the green concrete in mould in three equal layers and compact with vibrator help the specimen in the moulds at 90% relative humidity. Remove the specimens from moulds after 24 hours of casting and keep in curing tank. Take out the specimens on the day of casting and take the dimensions of the concrete cubes correct to 1mm and find the weight of the each specimen. Keep the cubes on the compression plate of the compression testing machine such that the load is applied on the sides as cast. The capacity of machine is 2000 KN or 20 T. Apply the load at a uniform rate of 40 kg/sq. minute. Note the loads at first crack and at crushing make a note of the type of fracture.

III. RESULT AND DISCUSSION

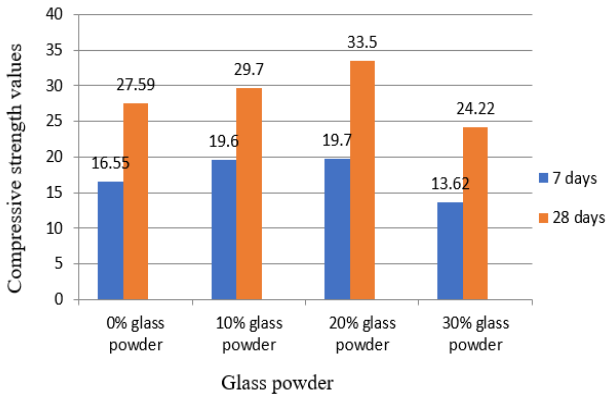
Results for the compressive strength test measurements are presented in tables and graphical forms.

A. Compression Strength Test:

Size 150 x 150 x 150mm were casted and tested for 7 days and 28 days testing of the specimens for each percentage after conducting the workability tests. The results are tabulated below.

The compression strength of concrete cubes for various percentage of glass powder at 7 days & 28 days

S.No	% Replacement of Cement by Glass Powder in Concrete	Compressive e strength, 7 days (N/mm2)	Compressive strength, 28 days (N/mm2)
1	0%	16.55	27.59
2	10%	19.6	29.7
3	20%	19.7	33.5
4	30%	13.62	24.22



Compressive strength of 0% glass powder is 16.55 N/mm^2 at 7 days and 27.59N/mm^2 at 28 days and compressive strength of 10% glass powder 19.6 N/mm^2 at 7 days and 29.7 N/mm^2 at 28 days and compressive strength of 20% glass powder 19.7 N/mm^2 at 7 days and 33.5 N/mm^2 at 28 days and compressive strength of 30% glass powder 13.62 N/mm^2 at 7 days and 24.22 N/mm^2 at 28 days.

IV. CONCLUSION

1) Addition of GLP increases the strength of concrete.
2) At the level of 20% replacement of cement by glass powder meets maximum strength as compare to that of normal concrete and other percentage of replacement of cement.
3) As the concentration of GLP particle decreases in concrete the strength of concrete increases.
4) From results it is conclude that particle size less than 90 micron get higher strength than that of particle size ranges from 90 to 150 micron.
5) The cost of construction involved in the project will reduce and it becomes economical.
6) Workability is found to be decreases in all types of concrete with increase in glass powder
7) By using waste glass powder Some amount of environmental disturbances is reduced.

REFERENCE

[1] Khatib JM, Negim EM, Sohl HS, ChilesheN;Glass powder utilisation in concrete production. European Journal of Applied Sciences, 2012; 4 (4):173-176.

[2] Khmiri A, Samet B, Chaabouni M; Assessment of the waste glass powder pozzolanic activity by different methods. IJRRAS, 2012; 10(2): 322-328.

[3] NurhayatDegirmenci,Arin&Ozge, “Utilization of waste glass as sand replacement in cement mortar”, indan journal of engineering & materials science vol.18,aug 2011.pp.303-308.

[4] MEYER, C., Development of Glass Concrete Products, Final Report to Office of Recycling Market Development, New York State Department of Economic Development, Albany, NY, March 1998.

[5] MEYER, C. and BAXTER, S., Use of Recycled Glass and Fly Ash for Precast Concrete, Final Report 98-18, New York State Energy Research and Development Authority, Albany, NY, October 1999.

[6] C. Meyer, N. Egosi, and C. Andela, “Concrete with Waste Glass as Aggregate” in “Recycling and Re-use of Glass Cullet”, Dhir, Dyer and Limbachiya, editors, Proceedings of the International Symposium Concrete Technology Unit of ASCE and University of Dundee, March 19-20, 2001.

[7] Shilpa raju and DrP.R.kumar “Effect of using glass powder in concrete”, International journal of innovative research in science, Engineering and Technology.[IC – IASET 2014].

[8] M. S. Shetty “concrete technology” (2012).

[9] A.R. Santhakumar “Concrete technology”15th impression 2014.

[10] Mohamed A. Aldieb, and Hesham G. Ibrahim, Member, IAENG Proceedings of the World Congress on Engineering and Computer Science 2010 Vol II WCECS 2010, October 20-22, 2010, San Francisco, USA

[11] Amin A. Hanhan (2004) "Influence of the SO3 Content of Cement on the Durability and Strength of Concrete Exposed to Sodium Sulfate Environment" A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering Department of Civil and Environmental Engineering College of Engineering University of South Florida.

[12] Thusharapriyadarshana "Variation in cemet properties and its effect on quality of concrete" University of Peradeniya, 20400, Sri lanka.