Use of Glass Powder as Partial Replacement of Cement in Cement Concrete

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***Abstract*: We did the project work for the determination of the effect of the use of „Glass Powder' as a partial replacement of cement to assess the pozzolanic nature of fine glass powder when mixed in concrete and compare the performance when other pozzolanic materials are mixed.**

The present study shows that waste glass, if ground finer than 600µm shows a pozzolanic behavior. It reacts with lime at early stage of hydration forming extra CSH gel thereby forming denser cement matrix. Thus, early consumption of alkalis by glass particles helps in the reduction of alkali-silica reaction hence enhancing the durability of concrete. Number of tests were conducted to study the effect of 0%,10%,20%,30% and 40% replacement of cement by glass powder on workability and compressive strength. The results showed that the maximum increase in strength of concrete occurred when 20% replacement was done with glass powder.

INTRODUCTION:

Concrete is the 2nd largest of the most widely used materials; but there are environmental issues associated with its use which are needed to be taken under consideration and cannot be ignored. Concrete production uses large quantities of natural resources as aggregates and contributes to the release of carbon dioxide during the production of cement. One ton of carbon dioxide is released into the atmosphere for the production of one ton of cement, which is approximately 7% of the world's total yearly production of CO2 (Meyer, 2004). Concrete is a common construction material in India and its production causes the same environmental concerns as that of regular concrete.

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In recent years, there has been an increasing incentive to minimize the environmental effect of the construction industry through programs such as the Leadership in Energy and Environmental Design (LEED) Green Building Rating System, which rewards points for sustainable construction practices (CaGBC, 2009). Greater sustainability of the construction industry can be achieved if a portion of the virgin aggregate or cement is replaced with waste materials. Significant experimental work was performed on the use of recycled concrete aggregate to replace virgin aggregate and on the use of pozzolanic materials to be used as partial replacement of cement in concrete, such as fly ash, silica fume and ground granulated blast furnace slag. Due to the successful implementation of these waste materials into regular concrete there is increased desire to find new post-consumer materials which can be used as a partial replacement for cement. The experimental work presented in this research looks at

the use of glass, as an eco-friendly material to replace cement in the production of concrete masonry blocks.

Objective

The objective of the research is to study the effect of the use of "Glass Powder" as a partial replacement of cement to assess the pozzolanic nature of fine glass powder when mixed in concrete and to know the changes occur in concrete properties and strength.

MATERIALS:

- **Cement:**

The cement used for this experiment is Ultratech Ordinary Portland Cement of Grade53 with a specific gravity of 3.15 and its other properties in accordance with the requirements of IS 12269-1987.

- **Fine Aggregate:**

CFA from local market at Madan Pura having a specific gravity of 2.65 and confirming to the requirements of IS 383-1970.

- **Coarse Aggregate:**

Angular aggregates of maximum size 20 mm with a specific gravity of 2.65 confirming to the requirements of IS 383-1970.

- **Water**:

Potable water was used.

- **Glass Powder:**

Waste glass from Bharat Bazar was brought and crushed finer than IS 300-micron sieve.

Experimental investigations:

Grade of concrete: M15 (Nominal mix) with a W/C of 0.65
Number of cubes cast: 30 of 150 mm size (6 cubes with conventional concrete,6 each with glass powder as partial replacement to cement to an extent of 10%,20%,30%,40%).
Batching of materials:
The materials were batched as under for the cubes as shown in table below.

Description	Cement in Kg	FA in SSD in Kg	CA in SSD in Kg	Water in Kg	Glass powder in Kg
Mix 1 with 0% Glass	7	14	28	4.55	0
Mix 2 with 10% Glass	6.3	14	28	4.55	0.7
Mix 3 with 20% Glass	5.7	14	28	4.55	1.4
Mix 4 with 30% Glass	4.9	14	28	4.55	2.1
Mix 5 with 40% Glass	4.2	14	28	4.55	2.8

Weigh batching was adopted for all the materials.

Mixing of materials:

Proper mixing of concrete was carried out manually in a good way. Initially, the ingredients were mixed well in dry state. Then water was added little by little and mixed well to give a concrete of uniform colour and consistency.

The concrete so mixed was tested for its workability in terms of slump. The results are shown in table 1.

Placing and Compacting:

Concrete was then placed in the cube moulds in three layers of approximately 5cm deep,and each layer was compacted manually with 16 mm diameter compacting rod to ensure 100% compaction.

Curing:

The cubes were then maintained at a temperature of 27˚C and at a relative humidity of 90% for 24 hours from the time of addition of water. After 24 hours the specimens were marked and removed from the moulds and immediately kept submerged in clean water and kept there and taken out just prior to testing.

Procedure of testing:

Specimens stored in water were tested immediately on removal while in wet state. Surface water and grit were however wiped with a cloth and the testing was done in accordance with IS 516, the rate of loading was kept at 140 kg/sq.cm/min and the load at which the specimen failed was noted. Three cubes were tested and the average of the three was taken as the compressive strength. The results of all the cubes is presented.

RESULT:

Description	Slump value	Effect noticed
Mix with 0% glass powder	75 mm	

Mix with 10% glass powder	65 mm	-10
Mix with 20% glass powder	60mm	-15
Mix with 30% glass powder	52mm	-23
Mix with 40% glass powder	50mm	-25

We observed that the slump value decreased with the addition of glass powder using the same source material and proportion of ingredients

CONCLUSION:

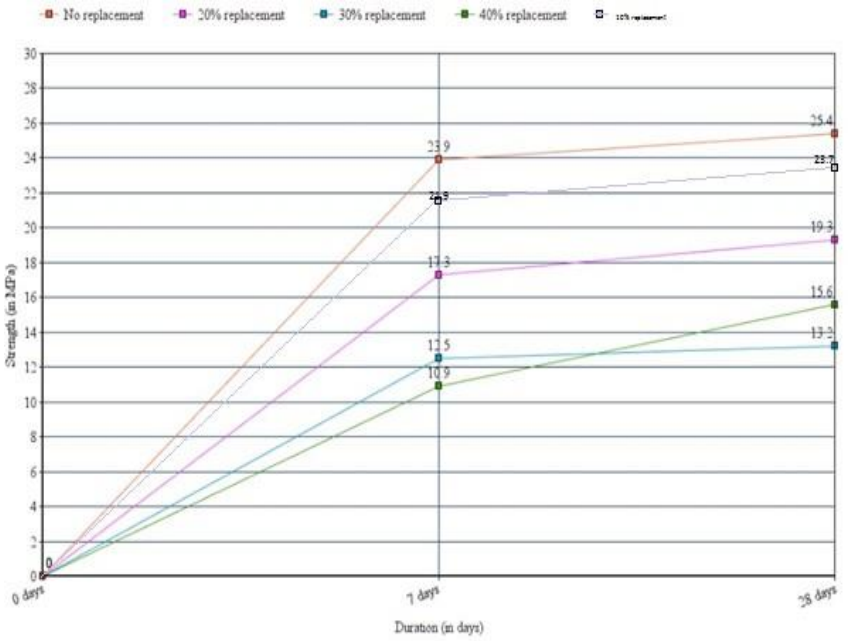
Approximately, 3 million tonnes of glass waste is produced every year.

While in 2018, India was the second largest producer of cement in the world. The country had about eight percent of the global installed capacity that year. Consumption of cement at this time stood at around 270 million tons. The market has been dominated by the private sector, having about 98 percent of the total production capacity. Demand for cement was estimated to increase in the coming years. This meant an increase in the installed production capacity as well. Housing and real estate were the major consumers of the material in 2019, accounting for over 60 percent of the domestic demand.

Table for compressive strength:

Days	No replacement			10% replacement			20% replacement			30% replacement			40% replacement		
After 7 days	23.5	25.4	22.8	20.4	21.2	24.1	18.3	16.4	17.1	12.5	12.7	12.4	12.3	9.2	11.7
Avg. Strength (MPa)		23.9			21.9			17.3			12.5			10.9	
28 days	25.7	24.5	25.2	22.9	22.1	26.1	18.7	19.8	19.6	14.8	12.8	11.8	16.1	14.5	16.4
Avg. Strength (MPa)		25.1			23.7			19.3			13.2			15.6	

Graph:



Project Conclusion:

By using the glass powder in concrete will reduce the greenhouse effect produced by the cement manufacturing industry. Glass powder concrete increases the compressive, tensile and flexural strength effectively, when compared with conventional concrete. Beyond 25% there is a decrease in compressive strength and Split tensile strength for 28 and 7days curing period. There is a decrease in workability as the replacement level increases, and hence water consumption will be more for higher replacements. The maximum replacement level of Glass powder is 25% for M20 grade of concret

BIBLIOGRAPHY

[1] Bang R.S, Pateriya I.K, and Chitalange M.R, Useof pond ash as fine aggregate-Experimental Study, New Construction Materials, 2009, 48- 51.
[2] Baxer Jin W, and Meyer C, Glasscrete-Concrete with glass aggregate, ACI Materials journal, 2000, 208-213.
[3] Byars E.A, Morales B, and Zhu H.Y, Waste glass as concrete aggregate and pozzolana-laboratory and industrial projects, Concrete, 38, 2004, 41-
[4] 44.
[5] Chen C.H, Huang R, Wu J.K and Yang C.C, Waste E-glass particles used in cementitious mixtures, Cement and concrete Research, 36,2006, 449-456.
[6] Federico L.M, and Chidiac S.E, Waste glass as Supplementary Cementitious material in concrete-Critical review of treatment methods, Cement and Concrete Composites, 31, 2009,
[7] 606-610.
[8] Her-Yung Wang, A Study of the effects of LCD glass sand on the properties of concrete, Waste Management, 29, 2009, 335-341.
[9] Jitendra A Jain and Narayanan Neithalath, Chloride transport in fly ash and glass powder modified concretsInfludence of test methods on microstructure, Cement and Concrete Composites, 32, 2010, 148-156.
[10] Nathan Schwarz and Narayanan Neithalath, Influence of a fine glass powder on cement hydration: comparison to fly ash and modeling the degree of hydration, Cement and Concrete Research, 38, 2008, 429-436.
[11] Nathan Schwarz, Hieu cam and Narayanan Neithallath, Influence of a fine glass powder on the durability characteristics of concrete and its comparison to fly ash, Cement and ConcreteComposites, 30, 2008, 486-496.
[12] Omer Ozkand and Isa Yuksel, Studies on mortars containing waste bottle glass and industrialby- products, Construction and Building Materials, 22, 2008, 1288-1298.
[13] Seung Bum Park, Bong chum Lee and Jeong Hwan Kim., Studies on mechanical properties of
[14] concrete containing waste glass aggregate, Cement and concrete Research, 34, 2004, 2181-
[15] 2189.
[16] Suryvanshi C.S, Use of industrial and domestic waste in concrete, Civil Engineering and Construction Review, 26, 1999, 26-31.
[17] Tang Albert, Dhir Ravindra, Dyer, Tom and Yongjun, Towards maximizing the value and sustainable use of glass, Concrete Journal, 38,2004, 38-40.
[18] Yixin Shao, ThibautLefort, ShyleshMoras and Damian Rodriguez, Studies on concrete containing ground waste glass, Cement and Concrete Research, 30, 2000,91-100.