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Experimental Investigation on Partial Replacement of Cement by Waste Glass Powder

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Abstract: ***All over the world million tons of waste glass is being generated. There are many forms of glass including container glass and flat glass. In day to day life glass is used in many form. It has a limited life span and after use it is either stock piled or sent to landfills. Normally waste glass does not create any harm to the environment due to its non-degradable nature but if it is improperly disposed then it may harm both human and animal. Hence, there is strong need to utilize waste glass powder. Towards the development of the sustainable (energy –efficient, environmentally friendly and economical) infrastructure system, using waste glass powder as partial replacement of cement in concrete could be one of the most important step. When waste glass is converted into micro size particle it undergo pozzolanic reaction with cement hydrates, forming calcium silicate hydrate. This research work investigate the mechanical properties; compressive strength and flexure strength of concrete using waste glass powder as partial replacement of cement. To calculate the strength and other properties some number of cubes were cast using glass powder as replacement of cement at various proportions like 5%, 10% and 15%.later the casted specimen are tested for its strength. Basically cement is a factory made product and their quality and standard can be easily controlled and maintained, water used is usually a tap water. Fine aggregate are natural sand.***

Keywords: waste glass powder, Cement, Compressive, flexural

1. Introduction

As we know that now a day, most of the developing country facing shortage of post consumers disposal waste site and it's become very serious problems. For this reason, regenerating and using waste manufactured goods as resources and prevent environmental pollutions. Protecting environment is a major task for the researcher, use of cement in concrete increases the quality of the construction to the larger extent but on the other hand, the production of cement increases the pollution as well. Therefore in research considering the post consumers waste glass, there is an effort to recover and use waste glass or otherwise it's up at disposal landfill. Currently most of recovered waste glasses is used by many manufactured company in the production of new glasses such as bottle and etc. But only a limited amount from the waste glass collected is that can be used towards the production of new glasses. The main reason of this study is to create a better environment that free from polluted space and also to find a better solution for concrete mixture that can provide higher strength to concrete from the waste glass product. Even it may give low cost of using this kind of admixture rather than buying costly admixture to get great and higher strength in concrete as now days it's the admixture that in market are very costly and often increase the cost of the construction.

1.1 Why glass powder

The finely ground glass powder having high silica (SiO_2) content, high surface area and amorphous nature suggest that glass powder glass powder could perform as alternative supplementary cementitious material. Glass is inorganic in nature, were introduced in the concrete mix. The original reason for this material is that, it is cheap and it is a byproduct or waste from the industrial process. Being non-biodegradable in nature, glass disposal as landfill has the environmental impact and could be expensive. Glass can be recycled many times without the change in its chemical properties. Although due to the high level of impurity or colored waste glass has low recycling rate. The glass is mainly silica-based material in non-crystalline amorphous form and can be used in cement based application. The glass powder has low specific gravity than the cement therefore the number of glass particles becomes more hence it improves microstructures make concrete less porous also the weight of concrete gets reduces in a small amount. As the replacement level of glass powder increases the pH value of concrete also get an increase so that it becomes more alkaline and gives protection to the corrosion of reinforcement, The glass powder does not absorb water hence it ultimately increase the workability of the concrete.

2. Literature Review

Canbaz, (2004) [1] have used the waste glass (WG) as a partial replacement of an aggregate in concrete having the range of size 4-16 mm in a proportion of 0-60%. He studied the effects of waste glass on workability and strength of concrete. He concluded that there is a significant reduction in the compressive strength of concrete up to 49% at 60% addition of WG, there is no effect of WG on the workability of concrete, waste glass addition decreases the slump and WG cannot be used as an aggregate because of alkali-silica reaction.

J.M.Khatib, (2012) [2] have studied the tests on glass powder containing concrete in which cement is replaced partially with glass powder in the varying percentage 0-40%. The test included ultrasonic pulse velocity (UPV), compressive strength and absorption. Testing of UPV was determined at 1 day, 7, 14, 21 and 28 days whereas the compressive strength was determined at 28 days only. He concluded that maximum strength of concrete occurs at around 10% glass powder. Beyond 10% there is a reduction in strength of concrete.

Chikhalikar S.M. and Tande S.N (2012) [3] There is a need to replace a part of fine aggregate by waste glass powder to reduce the consumption of fine aggregate and the environmental pollution can be checked to some extent. Recently the research has presented that the waste glass can be effectively used in concrete as fine aggregate. Waste glass when grounded to very fine powder shows some

cementitious properties because of silica content. Therefore the glass powder to some point can replace the cement and fine aggregate, contributes for the strength development and also enhances durability of the concrete.

Idir R (2009) [4] Demand for recycled glass has considerably decreasing in recent years. Glass is cheaper to store than to recycle, as it is expensive for the recycling process. There are several alternatives for the reuse of waste glass. According to previous studies, all the applications, which require pre-conditioning and crushing of waste glass, are more or less limited and unable to absorb all the quantities of waste glass available. In order to provide a sustainable solution to glass storage, a prospective and incentive way would be to reuse this type of glass in concrete.

3. Experimental Investigation

3.1 Material

3.1.1 Cement

For this research work ultratech ordinary Portland cement of Grade 53 is used. The specifications of ordinary Portland cement are as per IS 12269:1987. The properties of cement are given in Table no. 1

Table 1: Properties of cement

S. No.	*Properties*	*Result*
1	Specific gravity	3.15
2	Standard consistency	33%
3	Initial setting time	80min.
4	Final setting time	250min.
5	Fineness	330m^2/kg

3.1.2 Fine aggregate

In present experimental work, Godavari River Sand is used as a fine aggregate. The sand is sieved and size fractions are combined in equal proportion to maintain grading complying with standard sand as per IS 650:1991. The sieve analysis of sand is done by IS 383 and the results are given in Table no.2

Table 2: Properties of fine aggregate

S. No.	Properties	Result
1	Specific gravity	2.58
2	Apparent specific gravity	3.19
3	Water absorption	3.497%
4	Grading Zone	II

3.1.3 Coarse Aggregate

Aggregates are one of the important components of concrete and they parts about 75 to 80% of total volume of concrete. They help in a decrease of shrinkage and control economy asit were. Following are some of the properties of aggregates, which the impact of concrete. Coarse aggregate is the most grounded and scarcest penetrable part of the concrete. It is allaround that crushed stone aggregate lead to higher abilities than adjusted ones. In the present examination, provincially accessible smashed rock of size 20 mm was used exclusively by volume. The aggregates are used as per the specifications are given inIS2386 (part1).

Table 3: Properties of coarse Aggregate

S. No.	*Properties*	*Result*
1	Specific gravity	2.89
2	Apparent specific gravity	2.97
3	Water absorption	1.21%
4	Abrasion value	8.34%
5	Crushing value	29.9%

3.1.4 Glass powder

The glass is an amorphous non-crystalline substance commonly made from silica (SiO_2) heated with chemicals and minerals. It is made by melting various minerals such as $CaCO_3$, dolomite ($CaMg(CO_3)_2$) silicon dioxide, soda ash melted at a very high temperature up to 1700˚C goes along with cooling during which it gets solidified. And this solidificationoccurs without crystallization because of its non-liquid and non-solid state. Glass powder having a fineness of glass is 52µm used in this research.

Table 4: Properties of glass powder

S. No.	Properties	Result
1	Specific gravity	2.6
2	Glass powder size	52µm
3	pH	10.25
4	Color	Grayish white

3.1.5 Water

Water is a fundamental component of concrete as it is viably included in chemical responses with cement, particularly hydration. In the present inspection expendable water is used according to IS 456: 2000 was used for preparation of cement, the water concrete proportion chooses the quality of cement. It is an adequately taking an interest constituent material in the synthetic response with the bond. The workability of the concrete is controlled by various components, for instance, the beginning measure of water, the reactivity of cement.

Table 5: Properties of water

S. No.	*Properties*	*Result*
1	pH	8.1
2	Suspended solids (mg/l)	NIL
3	Dissolved Solids (mg/l)	288

3.2 Mix proportion

Mix design of concrete designed in this experiment as per the Indian standard 10262:2009 and 456:2000. Sample was prepared for mix design of M25 grade of concrete. Mix proportions of concrete (Kg/m^3) shown in below table.

Table 6: Mix Proportion

S. No.	Material	Quantity(Kg/m3)
1	Cement	360
2	Water	180
3	Coarse aggregate	1150
4	Fine aggregate	745
5	20mm (60%)	690
6	10mm (40%)	460
7	Water-cement ratio	0.5

3.2 Experimental procedure

Concrete cubes were casted for compressive test and beams were casted for flexural test. The cubes were casted in a steel molds of size 150×150×150 $mm^3$and beams were casted in a steel molds of size 100×100×150 mm^3. The molds were properly tightened with bolts and properly cleaned and greeced with oil for easy removal of concrete cubes. After that molds were placed on plate vibrator and the concrete were placed in the mold in three layers and compacted uniformly with the help of tamping rod along with the vibration for proper compaction and removal of voids. After casting of concrete cubes in three layers, the top surface is levelled by using a trowel. After casting, all cubes were demold after 24 hour and placed in water for curing. The curing process was done for 7 days, 14 days and 28 days.12 cubes were casted for compressive strength and 12 beams were casted for flexural strength.

4. Result and Discussion

The result of slump test and strength of hardened concrete to partial replacement of Glass powder are discussed below:

4.1 Workability Test

4.1.1 Slump test

Workability of the concrete was found out by slump cone test confirming to IS 1199-1959. The slump cone apparatus was used as per specification is given in IS 7320-1974. Having bottom diameter 20cm, top diameter 10cm and height 30cm. The mold was placed on a smooth, horizontal, rigid and non-absorbent surface, such as a carefully levelled metal plate, the mold being firmly held in place while it is being filled. The mold was filled in four layers, each approximately one-quarter of the height of the mold. Each layer shall be tamped with twenty-five strokes of the rounded end of the tamping rod. The mold was removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside and the slump shall be measured immediately by determining the difference between the height of the mold and that of the highest point of the specimen being tested.

Table 7: Slump test result

S. No.	*Glass powder (%)*	*Result*
1	0	73
2	5	63
3	10	47
4	15	30

4.2 Strength test

Table 8: Result of compressive and Flexural strength

Replacement Percentage (%)	Compressive strength (N/mm^2)			Flexural strength (N/mm^2)		
	7 days	14 days	28 days	7 days	14 days	28 days
0	18.07	22.07	28.87	2.08	4.05	6.20
5	18.61	22.91	34.18	2.12	4.63	7.08
10	18.33	22.55	29.51	3.93	5.49	7.99
15	18.19	15.35	25.13	5.27	6.07	9.04

4.2.1 Compressive strength

Result of compressive strength of concrete given in table 8. Glass powder replaced with cement. Test was carried out to obtain compressive strength of concrete at the age of 7, 14 and 28 days. Cubes were tested using Compressive Strength Testing machine (CTM) capacity of 1000 KN. From the fig.1 maximum increase in compressive strength obtained as 18.61, 22.91 and 34.18 N/mm^2 at 7, 14 and 28 days when glass powder was replaced by 5% of cement.

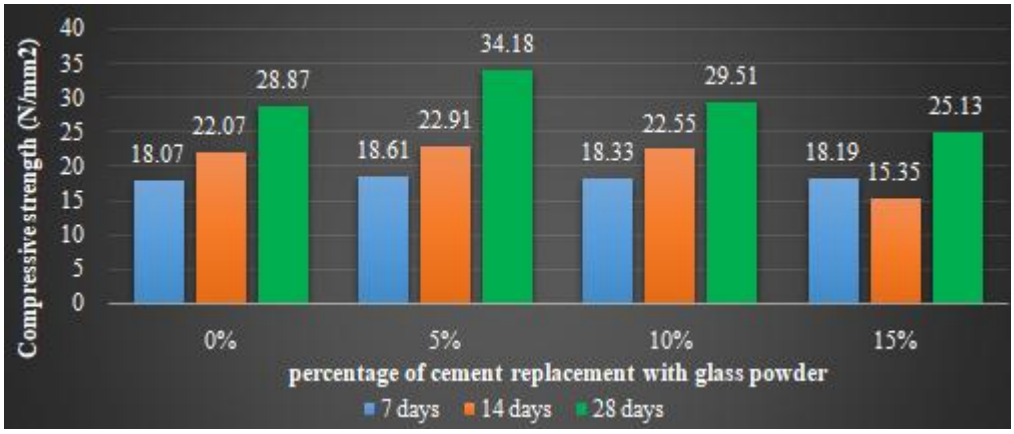

Figure 1: Comparative compressive strength of various percentage replacement of glass powder with cement

4.2.2 Flexural strength

Result of flexural strength of concrete. Glass powder replaced presented in above table 8. Test was carried out to obtain flexural strength of concrete at the age of 7, 14 and 28 days. Beams were tested using Flexural Strength Testing machine (FTM) capacity 1000 KN. From the fig.2 maximum increase in flexural strength is obtain as 7.08 N/mm^2, 7.99 N/mm^2 and 9.04 N/mm^2 at 7, 14 and 28 days when glass powder was replaced by 15% of cement.

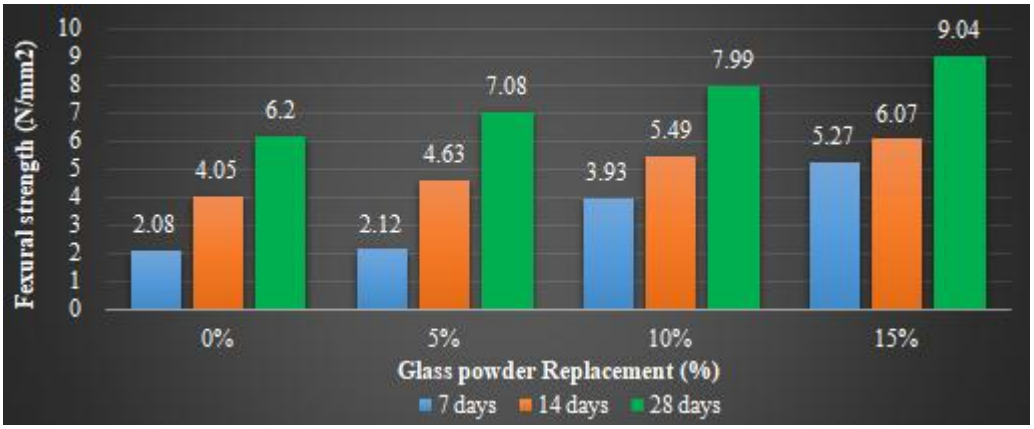

Figure 2: Comparative flexural strength of various percentage replacement of glass powder with cement

5. Conclusion

Based on scope of material, techniques, procedure and another parameter associated this work following conclusions are recommended can be stated. The conclusions drawn are

- Glass powder can be used as a cementitious material when it is ground fine. Using ground glass powder can reduce the use of cement and the associated energy demand and impact on air pollution and CO_2 emission.
- The particle size of glass powder has an influence on the strength as well as durability properties of concrete. Finer the particle size better will be the results.
- Observe the initial and final setting time of cement.
- As 5% replacement of cement with glass powder gives maximum compressive strength at 28 days than the control concrete and above 5% the strength substantially decreases. It was observed that a 5% replacement of cement with the glass powder used in this study is feasible in cementitious systems at later curing ages.
- As 15% replacement of cement with glass powder gives maximum flexural strength at 28 days than the control concrete and below 15% the strength substantially decreases. It was observed that a 15% replacement of cement with the glass powder used in this study is feasible in cementitious systems at later curing ages.
- The use of glass powder has an effect on the workability of the concrete. The slump of concrete seems to decrease with the increase in glass powder in the concrete mix.
- Glass powder concrete increases the compressive strength when used in limited quantity(upto 5%). It also enhances flexural strength of concrete when used in quantity (upto 15%)

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References

[1] Y. Jani and W. Hogland, "Journal of Environmental Chemical Engineering Waste glass in the production of cement and concrete – A review," *Biochem. Pharmacol.*, vol. 2, no. 3, pp. 1767–1775, 2014.
[2] J. S. Dali and S. N. Tande, "ADMIXTURES SUBJECTED TO HIGH TEMPERATURE PERFORMANCE OF CONCRETE CONTAINING MINERAL," 2012.
[3] M. Canbaz, "Properties of concrete containing waste glass," vol. 34, pp. 267–274, 2004.
[4] J. M. Khatib, E. M. Negim, H. S. Sohl, and N. Chileshe, "Glass Powder Utilisation in Concrete Production," *Eur. J. Appl. Sci.*, vol. 4, no. 4, pp. 173–176, 2012.
[5] P. A. Patel, "Comparative Study of Waste Glass Powder as Pozzolanic Material in Concrete A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE 61 Department of Civil Engineering National Institute of Technology National Institute of Technology," 2012.
[6] S. O. Nwaubani and K. I. Poutos, "The Influence of Waste Glass Powder Fineness on the Properties of Cement Mortars," vol. 2, no. 2, pp. 110–116, 2013.
[7] G. Vijayakumar, M. H. Vishaliny, and D. Govindarajulu, "Studies on Glass Powder as Partial Replacement of Cement in Concrete Production," vol. 3, no. 2, pp. 153– 157, 2013.
[8] G. Vasudevan and S. Ganis, "Performance of Using Waste Glass Powder In Concrete As Replacement Of Cement," no. 12, pp. 175–181, 2013.
[9] E. Šerelis and H. Hilbig, "The effect of glass powder on the microstructure of ultra high performance concrete," vol. 68, pp. 102–109, 2014.
[10] H. Du and K. H. Tan, "Properties of high volume glass powder concrete," *Cem. Concr. Compos.*, 2016.
[11] IS 456:2000, Plain and Reinforced concrete code of practice, Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Marg, New Delhi -110002
[12] IS 10262:2009 , " Indian Standard Specification for concrete mix design", Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Marg, New Delhi-110002
[13] IS 1199:1959, "Method of sampling and Analysis of concrete" , Bureau ofIndian Standard, New Delhi, 1959
[14] IS 516:1959, "Method of test for Strength of concrete" , Bureau of Indian Standard, New Delhi,1959