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Is glass powder a waste or boon for concrete : A thought provoking study

■ **Bhupinderjeet Singh and Ritesh Jain**

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See end of the Paper for authors' affiliation

Correspondence to :

Bhupinderjeet Singh
Department of Agricultural Engineering, Punjab Agricultural University, **Ludhiana (Punjab) India**
Email : singhbhupinderjeet096@gmail.com

■ **ABSTRACT :** The utilization of glass powder in the present days as a substitute for cement is to enhance the strength of concrete. The glass powder was supplanted by 0 per cent, 5 per cent, 10 per cent, 15per cent and 20 per cent for 7 and 28 days for cubes for compressive strength. The utilization of concrete and generation of cement makes considerably more ecological issues and costlier. To maintain a strategic distance from such conditions, the substance of cement is decreased and replaced by glass powder which lessens cost and builds quality and durability of cement. Concrete is the most broadly utilized and adaptable structure material which is commonly used to resist compressive powers. By the addition of some pozzolanic materials, the different properties of cement *viz.*, workability, durability and quality can be improved (Singh and Jain, 2018). Glass may be added in crushed form or in powder form along with the addition of admixtures/plasticizers or without addition of any of the alternate materials in the nominal concrete (Singh and Jain, 2018). Accordingly, a study about usage of glass powder has been made in this paper to include it in concrete as an ingredient so that the best possible usage may be used in the concrete with a partial replacement. From the test the glass powder concrete gives more strength as compared to conventional concrete and can be used for normal construction process.

■ **KEY WORDS :** Wastes reduction, Glass powder, Concrete, Compressive strength

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Concrete is widely used construction material in the present industry. The concrete consists of cement, fine aggregates and coarse aggregates. Concrete is strong in compression and weak in tension. Also the cement manufacturing industry on an average emits 7 per cent of greenhouse gases to earth's atmosphere which leads to global warming (Dabiri *et al.*, 2018). The use of river sand as fine aggregate tends to exploitation of natural resources which cause lowering of water table. In order to address these environmental affects extensive research is ongoing into the use of cement replacements, using many waste materials [like waste glass, plastics, flyash, etc.] and industry's byproducts. Waste glass is a non- biodegradable material and disposal of waste glass into the land results in the soil pollution (Jangid and Saoji, 2014). So to avoid these disposable problems waste glass is used as partial replacements of coarse and fine aggregates. In cement manufacturing a replacing aggregate with glass waste will reduce unit weight of the concrete, under laboratory studies glass has high silica content on its feasibility condition. Use of waste glass in concrete makes the structure denser, this results in reduction of water absorption and improves durability of concrete (Jangid

and Saoji, 2014). The addition of glass powder in concrete shows improvement in the compressive strength, flexural strength and tensile strength.

METHODOLOGY

Cement:

Cement is a powdery substance made by calcining lime and clay, mixed with water to form mortar or mixed with sand, gravel, and water to make concrete. Common materials used to manufacture cement include limestone, shells, and chalk or marl combined with shale, clay, slate, blast furnace slag, silica sand and iron ore (Shetty, 2005). Cement is primarily consists of silicates and aluminates of lime obtained from limestone and clay. OPC is the basic Portland cement and is best suited for use in general concrete construction. OPC 43 grade was used in this study as shown in Fig. A. The specific gravity was found to be 3150 kg/mm^3.

Fig. A : Cement

Coarse aggregates:

Aggregates most of which retained on 4.75-mm BIS Sieve are known as coarse aggregates as shown in Fig.

Fig. B : Coarse aggregate

Fig. C : Sand

B. The specific gravity was found to be 2600 kg/mm^3. The characteristics of different types of aggregates, crushed aggregates tend to improve the strength because of interlocking of angular particles (Vijayakumar *et al.*, 2013), while rounded aggregates improved the flow because of lower internal friction. Crushed stone aggregates of nominal size 20 mm and 10 mm in the proportion of 50:50 were used throughout the experimental study.

Fine aggregates:

Aggregates most of which passes 4.75-mm BIS Sieve known as fine aggregates as shown in Fig. C. The specific gravity was found to be 2600 kg/mm^3. Depending upon the particle size distribution, the fine aggregates are divided into four grading zones as per BIS: 383-1970 that are zone I, zone II, zone III and zone IV (Junior *et al.*, 2014). The grading zones become finer from grading zone I to grading zone IV. The sand confirming to zone II was used in this study.

Water:

Fresh and clean tap water was used for casting the specimens in the present study. The water was relatively free from organic matter, silt, oil, sugar, chloride and acidic material as per BIS: 456-2000.

Glass powder:

Glass powder from Akshar chem glass powder was used which was approx. 99 per cent pure as shown in Fig. D. This material replaces the cement in mix proportion. The fineness per cent passing was 80 and sieve size for passage was 45µm. The specific gravity

of glass powder was found to be 2580 kg/mm^3 which is quite comparable to that of cement (Vasudevan and Pillay, 2013) and aids in its partial replacement without compromising its strength.

(a) (b)

Fig. D : Glass powder

Mix proportion and testing of specimen:

Mix design:

The concrete mix design was obtained by using Indian Standard Code IS 10262-2009. The concrete was designed for M20 grade concrete (most commonly used these days in construction). Based on the calculation from lab test, water cement ratio was found to be 0.45. Design proportions are 1:2.83:1.66 for cement, coarse and fine was made as per standard design procedure calculations (Shetty, 2005). Further 5, 10, 15 and 20 per cent of glass powder was added to concrete replacing with cement in concrete to find the effect of glass powder on its compressive strength. The tests were conducted in a set of three samples for each of the mix and average values from the test was taken for the result and discussion part. Any other type of admixtures was not used in this study.

The experimental investigation of work was done in step by step as follows:

Weighing:

All the materials *i.e.* cement, sand, glass powder and water was weighed using weighing machine available in the laboratory according to the mix design ratio calculated and mentioned above.

Mixing:

The mixing of all the materials was done manually using hand mixing process as shown in Fig. E. The equipments used for mixing was trowel and spade.

Fig. E : Mixing

Preparation of moulds:

The cubes of dimension 150mm each was used for filling as shown in Fig. F. The cylindrical moulds were properly cleaned, tightened and oiled before the filling of the concrete mixture.

Fig. F : Moulds

Compaction:

The compaction of the cubes was done by using vibratory testing machine available in the laboratory as shown in Fig. G. The striking by trowel was also done for final finishing and proper compaction.

Fig. G : Compaction

Curing:

The cubes were kept for 24 hrs and after that demoulding of cube was done and marked for future identification while testing. The cubes were kept in water tank as shown in Fig. H for 7 and 28 days of curing respectively for different specimens.

Fig. H : Curing tank

Testing:

The cubes were taken out of water tank after 7 and 28 days for performing the compression strength test as shown in Fig. I and J. For each specimen three samples were casted and the mean value was noted up for final results.

Fig. I : Compression testing machine

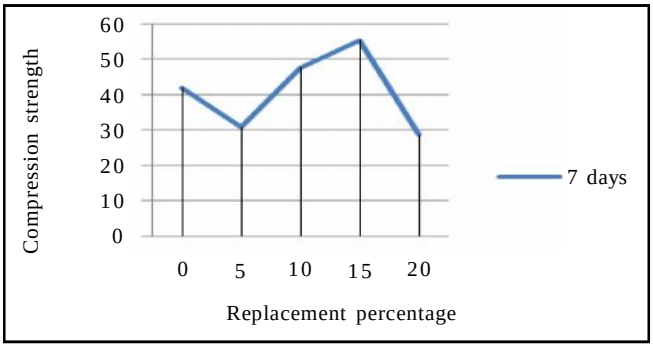
Fig. J : Broken cubes

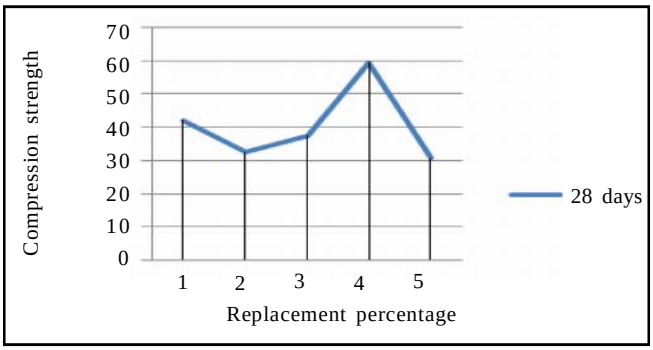
■ RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Compressive strength:

The cubes were tested for compressive strength after 7 and 28 days of curing. The results of the cubes were noted and shown graphically in this section. The average value of three samples for each replacement was plotted on the graph.





From the data above, we find that there is considerable increase in strength upto 15 per cent usage of glass powder (40% high as compared to nominal concrete). Further beyond this the value decreases and reaches to same value as obtained by nominal mix. As such it's found that the concrete may be used with glass powder upto 15 per cent partially replacing cement if we are concerned about compressive strength only. Further if we have to make disposal of glass powder waste for the saving environmental hazards made by it then we can replace cement partially in the concrete upto 20 per cent without hampering its compressive

strength (Ramana and Samdani, 2013).

Conclusion:

From the study we find the following conclusions:

There is considerable increase in strength upto 15 per cent usage of glass powder (40% high as compared to nominal concrete).

Beyond this value *i.e.* at 20 per cent partial replacement compressive strength of concrete decreases and reaches to same value as obtained by nominal mix.

Further if we have to make disposal of glass powder waste for the saving environmental hazards made by it then we can replace cement partially in the concrete upto 20 per cent without hampering its compressive strength.

As such it's found that the concrete may be used with glass powder upto 15 per cent partially replacing cement in M20 grade concrete if we are concerned about compressive strength only.

Future scope:

Further studies can be conducted for different grades of concrete with partial replacement by glass powder so that those grades may also be stabilised.

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Authors' affiliations:

Ritesh Jain, Department of Civil Engineering, Punjab Agricultural University, **Ludhiana (Punjab) India** (Email:ritesh5@pau.edu**)**

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