Feasibility Studies on Waste Glass Powder

Sudharsan N, Saravanaganesh S

Abstract*: The focus of this investigation to evaluate the possibility of using waste glass powders in concrete. Concrete is an artificial stone-like material used for various structural purposes made by mixing cement, water, sand and gravel that hardens into a super strong building material. Cement is the major component of the concrete than the others due to its pozzolanic and binding property. During the manufacturing of cement, it emits many greenhouse gases due to the burning of fossil fuels, and it causes environmental pollution. Cement production is growing by 2.5% annually, and it is expected to rise in the forthcoming years. The emission of greenhouse gases causes global warming. In order to overcome such effects, there is an alternative need to make concrete. Glass is one of the materials which are obtained as waste and it is disposed of at landfills. The exploitation of throw away glass materials in the concrete useful to lessen the environmental pollution and also strengthen the concrete. The waste glass components are usually made up of bottles, broken glassware, light bulbs, and it is disposed of as a waste due to its weight and density. It helps to provide a greener environment and concrete. The results and strength of this paper show that the glass powder has a pozzolanic property and used in the place of cement.

Keywords: Glass powder, Compressive strength, Sorptivity, Carbonation

I. INTRODUCTION

In today's scenario, concrete is indispensible material in construction. Creating a good concrete is an art, and if not give proper attention it will end up making a bad concrete. Hence as a civil engineer, one should be thorough with the entire factor of concrete from which he can produce good concrete. Sometimes improvements in concrete properties can be made by altering the ingredients in proportions. Most of today's high-performance concrete mixtures one or more alternative cementitious materials are used to enhance workability, strength, durability, service life, and other performance characteristics. Alternative cementitious materials are finely divided materials that replace or supplement the use of Portland cement. These materials include the wastes such as fly ash, rice husk ash, silica fume, copper slag, steel slag, waste tires, glass, ground granulated blast furnace slag, etc. can be used as a replacement of cement in concrete. These materials are generally obtained as byproducts from other processes or natural materials. They can be used for improving the concrete performance in its fresh and hardened state. Utilization of cementitious products in cement offers greater advantages and name a few includes, reduction in cement plant volume capacity, reduction in fuel, Lower Co_2 emission and reduced alkali-silica reactivity, and reduces permeability. Their use reduces the cost and improves one or more technical properties of concrete. Among the alternative cementitious materials, the glass is one of the waste materials which have a great futuristic part could have a promising future in the construction industry as a partial substitute of cement.

Facts of waste glass

As the usage of the glass increases, the amount of waste gets also increases. In 2004 approximately 12.5 million tons or 77% of the waste glass generated in the United States. In America generated 11.6 million tons of glass in the municipal solid waste (MSW) stream in the year 2012. The sources of wastages of glass are from food, soft drink, beer, food, wine, and liquor which is disposed of in landfills and dumped as waste material and this causes environmental pollution. To prevent this, it can be recycled and reused for various purposes. The glass is one of the waste materials which could have a promising future in the construction industry as a partial substitute of cement. Glass has a significant potential of getting developed as a suitable alternative material to these resources. Many industrial by-products have been successfully used in the construction industry for the production of cement and concrete. Use of waste glass in concrete makes key contributions towards the development of a green concrete based infrastructure.

The strength of the recycled glass sand mixes was decreased by increasing the recycled glass content. Mixtures containing glass powder reduces the chloride ion permeability. The slower strength gain in early days and it exceeded about 15 Mpa at the later ages when compared to conventional. The glass powder having a particle size finer than 38 mm did exhibit a pozzolanic behavior and leads to a higher reactivity with lime, a higher compressive strength in concrete, and a lower expansion. The recycled glass powder can reduce the permeability of the concrete mix, and it enhances durability and restricts the migration of the water and ions inside the concrete mix. The use of glass powder in concrete reduces the expansion due to alkali-silica reaction and improving durability characteristics. Higher the glass powder content can improve the performance of workability and drying shrinkage. Glass powder shows that there is improve in the strength of mortars more than the conventional.

It is possible to re-softening and re-melting the glass numerous times, and hence it is ideal for glass recycling. Soda-lime glass is fairly cheap, quite hard material, and enormously workable. It has a lower melting point and a higher coefficient of expansion and contraction. Most of the colored and clear glass types the

Revised Manuscript Received on June 11, 2019

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primary material is Soda-lime glass. Soda lime glass is prepared by melting the raw materials such as sodium carbonate, lime, dolomite, silicon dioxide, aluminium oxide and small quantities of sodium sulphate and sodium chloride. It is placed in a glass furnace and heating at a temperature of about 1675°C. The temperature is restricted to the quality of the furnace material and the glass composition. Instead of using pure chemicals in this process fairly low-priced materials such as sand, feldspar, trona be used.

I. MATERIALS

Cement

In this study, the Ordinary Portland cement (OPC) of grade 53 was used as per IS 4031-1988. It offers an advantage of greater speed in strength achievement. The physical and chemical properties of the cement as tabulated as follows.

Table 1 Physical Properties of Cement

S.No	Properties	Relevant IS code	Observed values
1	Standard consistency	IS 4031(PART IV):1988	28 %
2	Initial setting time	IS 4031(PART IV):1988	44 minutes
3	Final setting time	IS 4031(PART IV):1988	693 minutes
4	Fineness	IS 4031(PART IV):1988	0 %
5	Specific gravity	IS 4031(PART II):1988	3.12

Table 2 Chemical Properties of Cement

S.No	Component	Percentage
1	CaO	63.41
2	SiO_2	21.22
3	Al_2O_3	6.27
4	Fe_2O_3	3.08
5	MgO	1.85
7	$Na_2O + K_2O$	2.02

Glass

Two types of glass powders were used in this study were Soda lime glass powder and Boron glass powder. Both powders are obtained by crushing and grinding the glasses. The powders were sieved under the 75µ sieve. These powders are having different in physical and chemical properties. The chemical composition of the two types of glass powders and the cement are tabulated in table 3.

Table 3 Properties of soda lime and boron glass powder

S.no	Constituents	Glass powder	
		Soda lime	Boron
1	Silica (SiO_2)	76.39	81.30
2	Alumina (Al_2O_3)	2.19	2.22
3	Calcium oxide (CaO)	6.05	0.01
4	Iron oxide (Fe_2O_3)	1.08	0.94
5	Magnesium oxide(MgO)	1.18	---
6	Sodium oxide and potassium oxide (Na_2O+K_2O)	11.70	3.55

Fine aggregate

Locally available river sand is used for this study. The sand is washed thoroughly and sieved in the 600µ sieve. The properties of fine aggregate are monitored as per IS 2386-1963 (PART I, II, IV) / IS 383-1970 and the obtained results are represented in table 4.

Table 4 Properties of fine aggregate

S.no	Properties	Relevant IS code	Observed values
1	Fineness modulus	IS 383-1970	2.27
2	Specific gravity	IS 2386(PARTI):1963	2.65
3	Water absorption	IS 2386(PART I):1963	0.7
4	Bulk density	IS 2386(PART II):1963	1736 kg/m^3

Water

Water is to be used for mixing and curing should be free from impurities and harmful materials. Portable water is generally preferable for producing excellent concrete. The pH value of the water to be used should be greater than 6. In the present study, the water is collected from the campus, and it is used for both mixing and curing.

II. EXPERIMENTAL STUDY

Experiments were conducted on mortar cubes by replacing the waste glass powder of particle size 75µm in the place of
Cement.

Sample preparation

The fresh mortar mix samples were prepared by replacing the waste glass powder in the place of cement by 0%, 2%, 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, and 20% .The prepared mortar mix were cast and then put into the moulds of size 7.06 cm x 7.06 cm x 7.06 cm and 100 mm dia and 50mm high for compressive strength and sorptivity respectively. After casting mortar, the specimen was kept under water curing for 7 & 28 days for compressive strength and 28 days for sorptivity.

Compressive Strength Test

Totally 132 mortar cubes were cast. For every ratio, 3 cubes were cast and keep it for 7 and 28 days for curing. The cubes were undergone for Compression Testing Machine (CTM) after drying to compute the final load. For this study, the water-cement ratio of 0.45 is sustained for

both soda lime and boron glass powders.

III. RESULT AND DISCUSSIONS

Compressive Strength

The following graph fig.1 represents the Compressive strength for soda lime powder for 7 days and 28 days respectively.

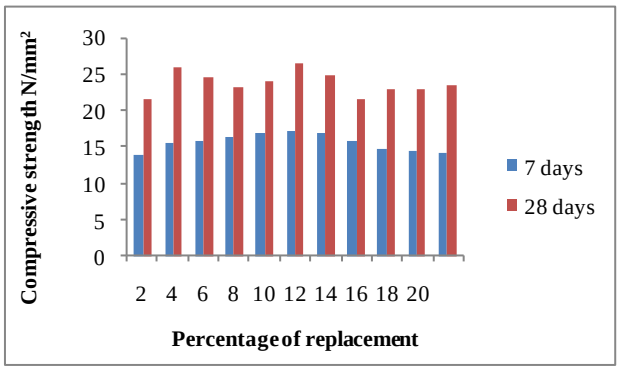

Fig. 1 Compressive strength of soda glass powder added cubes

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The fig.2 represents the Compressive strength for Boron glass powder for 7 days and 28 days respectively.

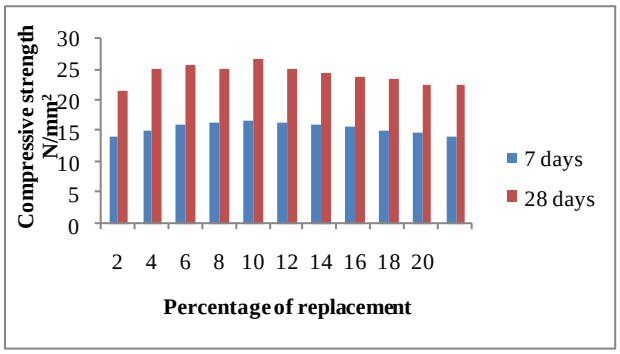

Fig. 1 Compressive strength of Boron glass powder added cubes

From the above graphs, it clearly is shown that the strength is improved when compared to conventional mix and it showed the optimum percentage of 10% and 8% of replacing soda lime and boron glass powder respectively in the place of cement

Sorptivity test

This test is conducted to quantify the rate of ingress of water through the mortar under capillary action. The specimen is cast by using the mould of size 100 mm dia and 50 mm high. After casting the specimen, which was oven dried at 110 C for 24 hours. Then it is placed under the water not more than 5 mm above the base of the specimen and the remaining portion of the specimen is sealed or coated. Then the specimen is weighed after 30 minutes to measure the quantity of water observed by the specimen. It is determined by using the relation,

$$S = I/t^{1/2}$$

$$I = \Delta_w / Ad$$

Δ_w= Weight deviation = W_2-W_1

W_1 = specimen dry weight (gm)

W_2 = Weight of specimen after capillary suction formed (gm).

A = specimen surface area

D = water density

The sorptivity results are obtained and shown in the graph for soda lime and boron glass powders for 28 days.

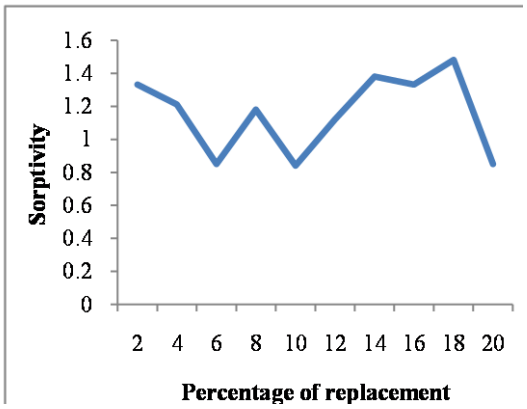

Fig. 3 Sorptivity of soda glass powder added cubes for 28 days

Fig. 4 Sorptivity of boron glass powder added cubes for 28 days

Carbonation

Carbonation is caused by atmosphere's CO_2, has the effect of reducing the pH. This test is carried out to evaluate the portion of affected concrete because of the Co_2 from atmosphere and moisture and thereby depletion of concrete alkalinity level.

It was used 0.2% phenolphthalein as pH indication of concrete. The change of pink color indicates the concrete is not affected by carbonation and the no changes in color take place; it is suggestive of carbonation-affected concrete.

Fig. 4 Carbonation of Glass powder added cubes

IV. CONCLUSION

Published By:
Blue Eyes Intelligence Engineering
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The proposed approach explained the utilization of glass powdered produced from the industrial wastes as a fractional substitute for cement in cement sand mortar paste. A 10% and 8% of cement substituted by soda lime and boron glass powder respectively were established to be best onel. Sorptivity test also proves that water absorption is less up to 10% and it gradually increased in both Soda lime and Boron glass powders. Carbonation test also proves that the mortar prepared by using soda lime and boron glass partially in the place of cement free from carbonation effect. The result from this study, the utilization of waste glass powder as a fractional substitute in cement material shows good cementitious property and also gives high strength and durability.

REFERENCES

1. Bashar Taha & Ghassan Nounu, 'Properties of concrete contains mixed colour waste recycled glass replacement as sand and cement replacement', *Construction and building materials*, vol.22, 2008, pp.713-720.
2. Yixin Shao, Thibaut Lefort, Shylesh Moras & Damian Rodriguez. "Studies on concrete containing ground waste glass." *Cement and Concrete Research*, 30, 2000, pp. 91-100.
3. Sudharsan N, Palanisamy T. and Subhash C. Yaragal, "Environmental Sustainability of Waste Glass As A Valuable Construction Material – A Critical Review", *Ecology, Environment and Conservation*, Vol 24, Feb. Suppl. Issue 2018, pp. 335-S342.
4. Nathan Schwarz, Hieu Cam & Narayanan Neithalath. "Influence of a fine glass powder on the durability characteristics of concrete and its comparison to fly ash." *Cement & Concrete Composites*, 30, 2008, pp. 486-496.
5. Maddalena Carsana, Massimiliano Frassoni & Luca Bertolini. "Comparison of ground waste glass with other supplementary cementitious materials." *Cement and Concrete Composites*, 45, 2014, pp.39-45.
6. Sudharsan N, Palanisamy T., "A Comprehensive Study on Potential Use of Waste Materials in Brick for Sus-tainable Development", *Ecology, Environment and Conservation*, Vol 24, Feb. Suppl. Issue 2018, pp. 343-S347.

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