The effect of Waste Glass as Partial Replacement of cement on Properties of Concrete

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Abstract: The utilization of solid waste materials or industrial waste as partial substitution of cement is growing in construction industry all around world to reduce the consumption of cement consequently reduction in CO_2 emission into the atmosphere and reduction in energy consumption. The aim of this study is to improve the strength of concrete made by replacing the cement with waste glass. In this study the cement was replaced with waste glass as 5, 10, 15, 20 and 25% by weight of cement with constant water to binder ratio of 0.5. One mixture of control concrete and five modified concrete mixtures prepared with replacement of cement with waste glass were prepared. Workability, density of hardened concrete, Compressive and tensile strength of control and modified concrete were tested. The experimental test results revealed that, significant improvement was observed at 10% replacement of cement with waste glass on the investigated properties of concrete.

Keywords: *Waste Glass, Concrete, cement replacement, Workability, Tensile strength, Compressive Strength*

1. Introduction

The utilization of solid waste materials or industrial waste as partial substitution of cement in concrete is a feasible approach for decreasing the utilization of Portland cement and consequently decreasing the environmental and energy impact of concrete production [1]. Different types of industrial bi-products are presently utilized in the production of environmental friendly materials which replace the traditional construction materials. Amongst the various types of industrial bi-products, waste glass is considered as the most appropriate replacement of aggregate due to its physical characteristics and chemical composition [2]. Glass is very hard, durable and if finely ground, it can serve as a pozzolanic material thus making it suitable for use as partial substitution of cement and fine aggregate. Partial replacement also improves the flow properties of concrete, so it can be used to make high strength concrete without using other super plasticizers [3]. Due to availability in different attractive colors, glass also provides aesthetic view.

Furthermore, recycling glass makes incineration cheap, save a lot of landfill space and reduce greenhouse gases produced from manufacturing of cement. Recycling of glass in construction has been studied for a half decade now. In 1963, glass was used for the first time in the construction industry for "architectural exposed concrete", since then it has been used in roadway construction and as asphalt [4-6]. Glass was found to be pozzolanic if ground to particle size less than 75um [7]. Several researches were investigated the waste glass applications in concrete as partial substitution of cement and fine aggregate [8-15].

The objective of this study is to use the waste glass as a cement replacement material to solve the problem of solid waste generated due to waste glass and to reduce the CO_2 emission and energy consumption due to production of cement.

2. Experimental Programme

2.1 Materials

Materials used during this research activity consist of cement, fine aggregate, coarse aggregate, waste glass and water. Ordinary Portland cements obtained from the local market was used. Locally available clean hill sand passing from 4.75 mm sieve free from inorganic materials was used. Coarse aggregate having maximum size of 19 mm clean and free from clay and other ingredients was used in preparing concrete mix. Waste Glass was washed, grinded and passed from sieve no 325 before using as cement replacement material.

2.2 Mix Proportions

Total 60 specimens were cast keeping cement, fine aggregate and coarse aggregate in ratio of 1:1.5:3. Water binder ratio was maintained as 0.5 for all the batches. Dimensions of specimens were 150x150 x150mm for cubes and cylinder specimen of 150mm diameter and height equal to 300mm. One mixture of plain concrete and five mixture of modified concrete prepared with 5%, 10%, 15%, 20% and 25% replacement of cement by waste glass. Detail of mix design is shown in Table 1.

2.3 Testing Methodology

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Workability and density of hardened concrete of all mixtures were determined as per ASTM C143 and BS.EN 12390-7 respectively. Compressive and tensile strength was conducted on the specimen of plain concrete and concrete prepared with substitution of cement by different proportions of waste glass at the age of 28 days as per BS 1881-116 and BS.EN 12390-6 respectively.

3. Results and Discussion

3.1 *Workability*

The results of all 6 mixtures of Workability of control concrete and modified concrete prepared with partial replacement of cement with waste glass is presented in Fig.1.

Table1. Mix Proportions

S.No	Cement (g)	WGFA (%)	Fine aggregate (g)	Coarse Aggregate (g)	W/C Ratio
01	2670	0	4005	8010	0.5
02	2536.5	5	4005	8010	0.5
03	2403	10	4005	8010	0.5
04	2269.5	15	4005	8010	0.5
05	2136	20	4005	8010	0.5
06	2002.5	25	4005	8010	0.5

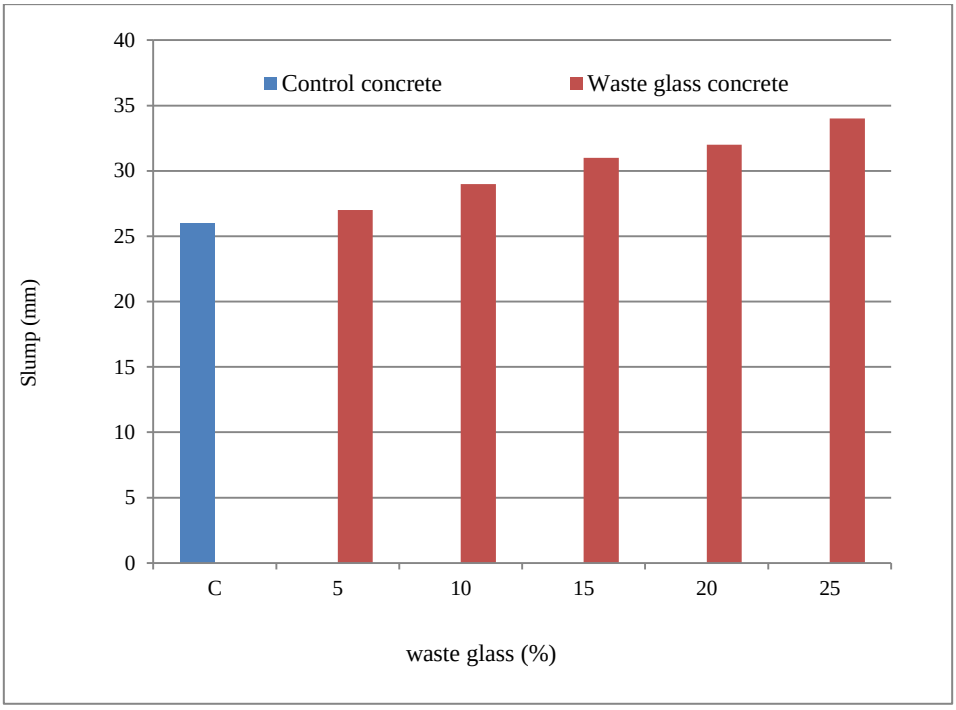

Figure 1. comparision of the results of control and waste glass concrete

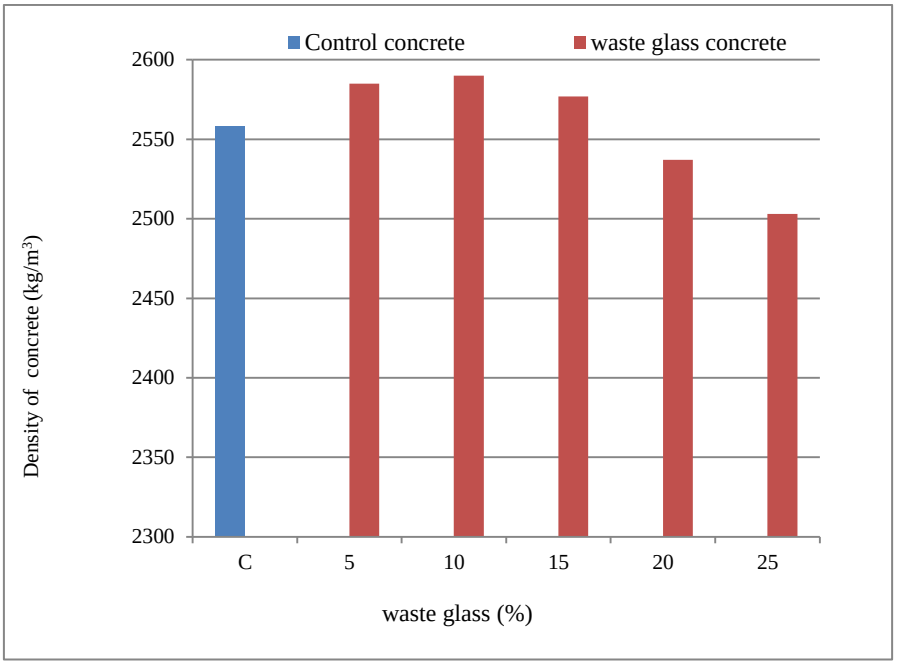

Figure 2. comparision of density of control and waste glass concrete.

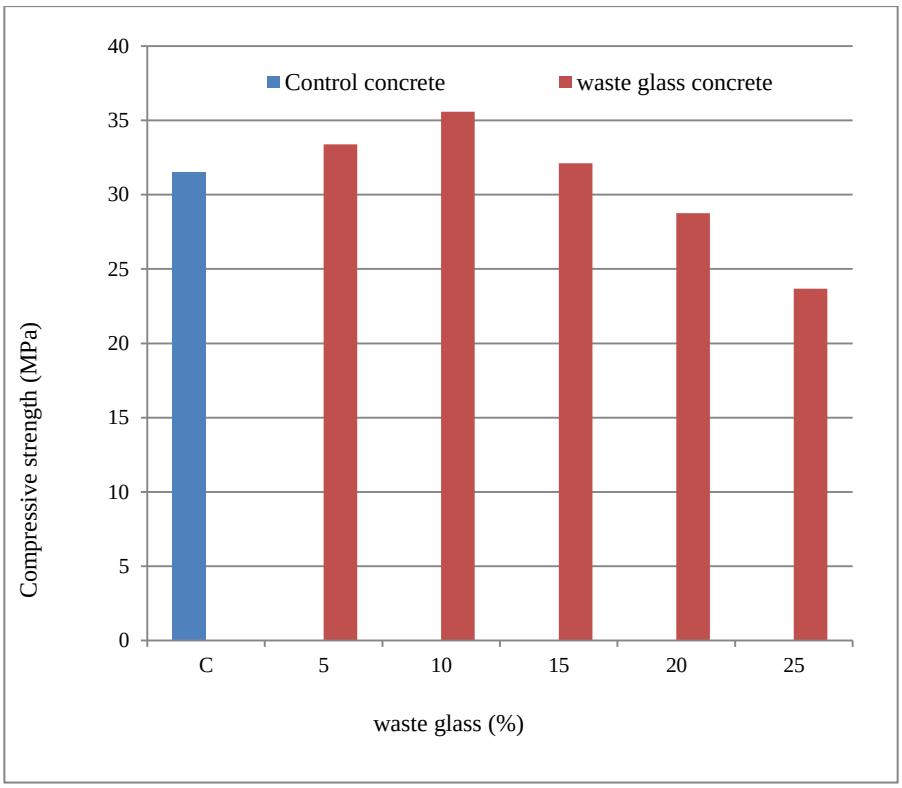

Figure 3. Comparision of compressive strength of control and waste glass concrete

It is oblivious from Fig.1 that the workability of concrete is increases as the dosage of waste glass is increasing. The maximum increase in workability was observed at 25% replacement of cement with waste glass.

3.2 Density of Hardened concrete

The results of all 6 mixtures of density of control concrete and modified concrete prepared with partial substitution of cement with waste glass is presented in Fig. 2.

It is oblivious from Fig.2 that the density of hardened concrete is increases with substitution of cement by waste glass from (5-10%). The maximum increase i.e., 1.25% more density than that of control concrete was observed at 10% substitution of cement with waste glass. On further substitution of cement more than 10% with waste glass, the density of hardened concrete decreased.

3.3 Compressive strength

The results of compressive strength of control concrete and concrete prepared with partial replacement of cement with waste glass of all 6 mixtures are shown in Fig.3.

It is oblivious from Fig.3 that the compressive strength of concrete is increases with substitution of cement by waste glass from (5-10%).The maximum compressive strength of concrete i.e., 12.95% more than that of control concrete was observed at 10% substitution of cement with waste glass. On further replacement of cement more than 10% with waste glass, the compressive strength of concrete decreased.

3.4 Tensile strength

The results of tensile strength of control concrete and concrete prepared with partial substitution of cement with waste glass of all 6 mixtures are presented in Fig.4.

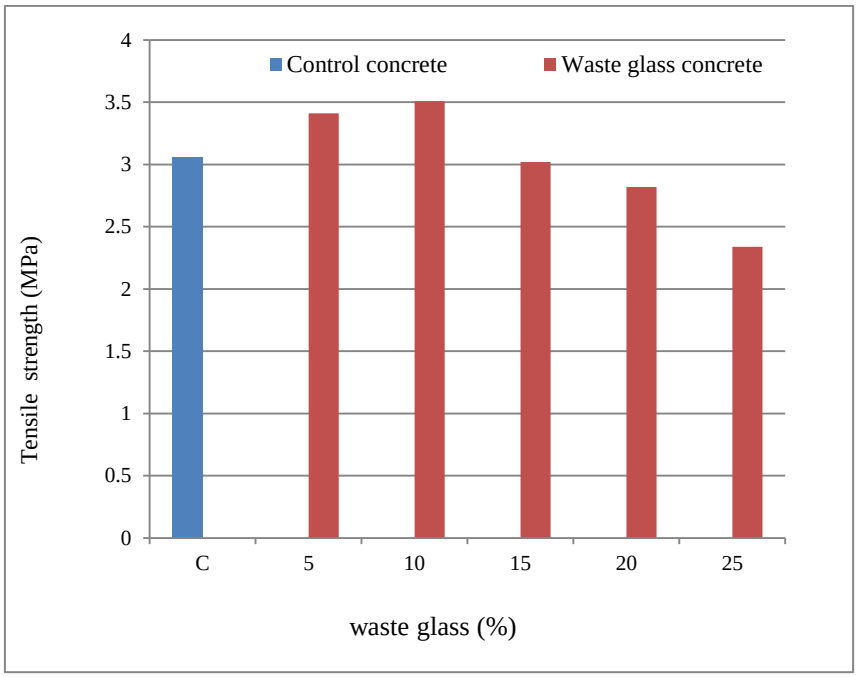

Figure 4. Comparision of tensile strength of control and waste glass concretes

It is oblivious from Fig.4 that the tensile strength of concrete is increases with substitution of cement by waste glass from (5-10%).The maximum tensile strength of concrete i.e., 14.71% more than that of control concrete was observed at 10% substitution of cement with waste glass. On further substitution of cement more than 10% with waste glass, the tensile strength of concrete decreased.

4. Conclusion

On the basis of conducted research it can be concluded that: Workability of concrete is increases as the dosage of waste glass is increasing. The maximum increase in workability was observed at 25% substitution of cement with waste glass.

Density of hardened concrete is increases with substitution of cement by waste glass from (5-10%). The maximum increase in density of hardened concrete was observed at 10% substitution of cement with waste glass.

Compressive strength of concrete is increases with substitution of cement by waste glass from (5-10%). The maximum compressive strength of concrete was observed at 10% substitution of cement with waste glass.

Tensile strength of concrete is increases with substitution of cement by waste glass from (5-10%). The maximum tensile strength of concrete was observed at 10% substitution of cement with waste glass.

Hence, on the bases of the results, 10% substitution of cement with waste glass is optimum.

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