Utilization of Waste Glass as Partial Replacement of Fine Aggregate in Concrete

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Abstract: The aim of this study is to improve the strength of concrete made by partial replacement of fine aggregate with waste glass. The fine aggregate was replaced by waste glass as (0-40%) with dosage of 4% using constant water-binder ratio as 0.45. Two sizes of waste glass fine aggregate (WGFA1) passing from 1.71 mm sieve and retained from 1.19 mm sieve and WGFA2 size passing from 1.19 mm sieve and retained from 0.5 mm sieve were used as partial replacement of hill sand. One mixture of control concrete and twenty mixtures of modified concrete prepared with partial replacement of fine aggregate with two different sizes of waste glass were prepared. The workability, water absorption, density and compressive strength of control and modified concretes were tested. The experimental test results revealed that maximum improvement was observed at 12% replacement of hill sand with waste glass on all investigated properties of concrete. Moreover, better improvement was observed with replacement of hill sand with waste glass fine aggregate WGFA1 than that of WGFA2.

Keywords: *Waste Glass, Fine aggregate replacement, Water absorption, Density of concrete, Compressive Strength*

1. Introduction

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 [1]. Glass is very hard, durable and if finely ground, it can serve as a pozzolanic material thus making it suitable for use as partial replacement 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 [2]. 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 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 [3-5]. Glass was found to be pozzolanic if ground to particle size less than 75um [6]. Several researches were carried out to test glass applications in concrete as partial replacement of cement and fine aggregate [7-14]. The objective of this study is to use the waste glass as a partial replacement of fine aggregate to solve the problem of solid waste generated due to waste glass and to reduce the consumption of natural hill sand and to improve the properties of concrete.

2. Experimental Programme

2.1 Materials

Materials used during this research activity consist of cement, fine aggregate, coarse aggregate, waste glass of two different sizes and water. Ordinary Portland cements obtained from the local market was used. 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 collected from local trash shops used as partial replacement of fine aggregate (hill sand). Waste glass fine aggregate WGFA1 passing from 1.71 mm sieve and retained from 1.19 mm sieve and WGFA2 size passing from 1.19 mm sieve and retained from 0.5 mm sieve were used as partial replacement of fine aggregate (hill sand).

2.2 Mix Proportions

Total 110 specimens were caste keeping cement, fine aggregate and coarse aggregate in ratio of 1:1.5:3. Water binder ratio was maintained as 0.45 for all the batches. Dimensions of specimens were 150x150x150mm of cubes was cast. One mixture of plain concrete and twenty mixtures of modified concrete prepared by the 4, 8, 12, 16, 20, 24, 28, 32, 36 and 40% substitution of fine aggregate (hill sand) with waste glass were prepared. Detail of mix design is shown in Table 1.

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Table.1. Mix Design of concrete

Batch No.	Cement (grams)	WGFA1 (%)	WGFA2 (%)	WGFA (grams)	Fine aggregate (grams)	Coarse aggregate (grams)	Water Cement Ratio
01	2670	0	0	0	4005	8010	0.45
02	2670	4	0	160	3845	8010	0.45
03	2670	8	0	320	3685	8010	0.45
04	2670	12	0	480	3525	8010	0.45
05	2670	16	0	640	3365	8010	0.45
06	2670	20	0	800	3205	8010	0.45
07	2670	24	0	960	3045	8010	0.45
08	2670	28	0	1120	2885	8010	0.45
09	2670	32	0	1280	2725	8010	0.45
10	2670	36	0	1440	2565	8010	0.45
11	2670	40	0	1600	2405	8010	0.45
12	2670	0	4	160	3845	8010	0.45
13	2670	0	8	320	3685	8010	0.45
14	2670	0	12	480	3525	8010	0.45
15	2670	0	16	640	3365	8010	0.45
16	2670	0	20	800	3205	8010	0.45
17	2670	0	24	960	3045	8010	0.45
18	2670	0	28	1120	2885	8010	0.45
19	2670	0	32	1280	2725	8010	0.45
20	2670	0	36	1440	2565	8010	0.45
21	2670	0	40	1600	2405	8010	0.45

2.3 Testing Methodology

Workability, water absorption and density of hardened concrete of all mixtures were determined as per ASTM C143, ASTM D570 and BS.EN 12390-7 respectively. Compressive and strength was conducted on the specimen of plain concrete and concrete prepared with substitution of fine aggregate by different proportions of waste glass at the age of 28 days as per BS 1881-116.

3. Results and Discussions

3.1 Workability

The results of all 21 mixtures of Workability of control concrete and modified concrete prepared with partial replacement of fine aggregate with waste glass is presented in Fig.1. 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 40% replacement of hill sand with waste glass. More improvement in WGFA1 modified concretes was observed as compared to control and WGFA2 modified concretes.

3.2 Water absorption

The results of all 21 mixtures of water absorption of control concrete and modified concrete prepared with partial replacement of fine aggregate with waste glass is presented in Fig.2

It is clear from Fig.2 that the water absorption of concrete is decreases as the dosage of waste glass is increasing. The maximum decrease in water absorption of concrete was observed at 40% replacement of hill sand with waste glass. More decrease in water absorption in WGFA1 modified concretes was observed as compared to control and WGFA2 modified concretes.

3.3 Density of Hardened concrete

The results of all 21 mixtures of density of control concrete and modified concrete prepared with partial replacement of fine aggregate with waste glass is presented in Fig.3.

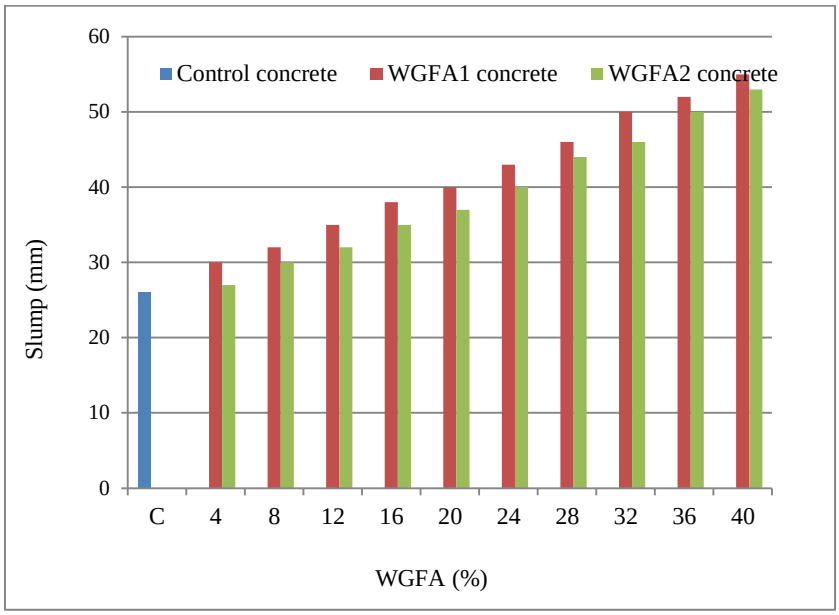

Figure. 1. comparision of the results of control and waste glass fine aggregate concrete

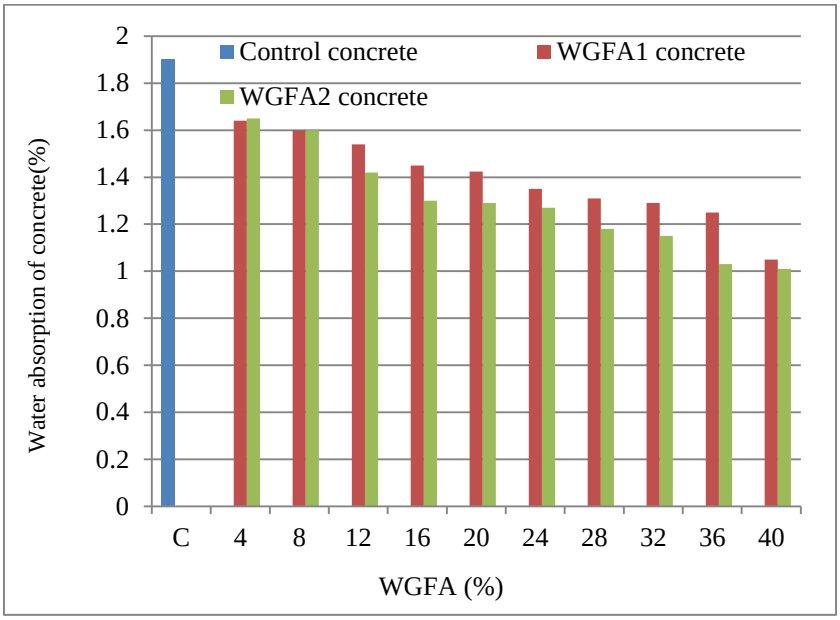

Figure. 2. comparision of waterabsorption of control and waste glass fine aggregate concrete

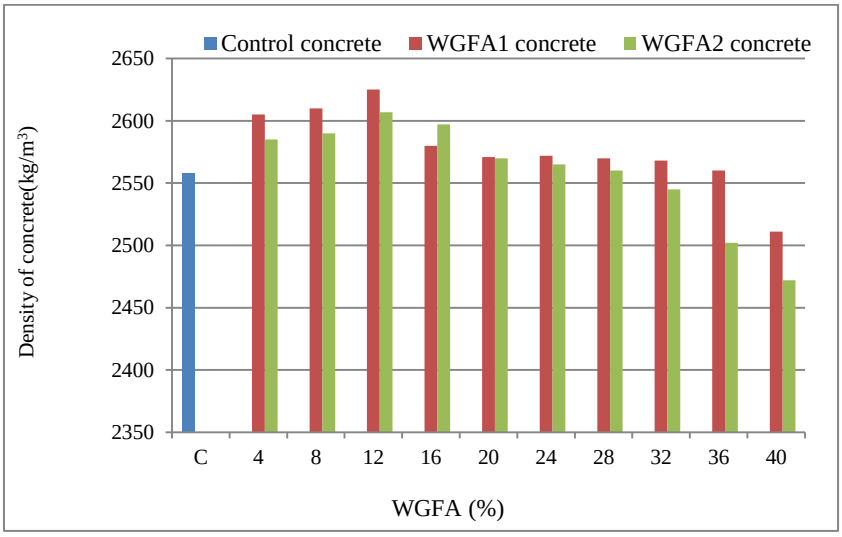

Figure. 3. comparision of density of control and waste glass fine aggregate concretes

It is oblivious from

Fig.3 that the density of concrete is increases with replacement of fine aggregate by waste glass from (4-12%). The maximum increase i.e., 1.92% more density than that of control concrete was observed at 12% replacement of hill sand with WGFA1. On further replacement of hill sand more than 12% with waste glass density of hardened concrete decreased. More improvement in density of hardened WGFA1 modified concretes were observed as compared to control and WGFA2 modified concretes.

3.3 Compressive strength

The results of compressive strength of control concrete and concrete prepared with partial replacement of hill sand with waste glass of all 21 mixtures is presented in Fig.4.

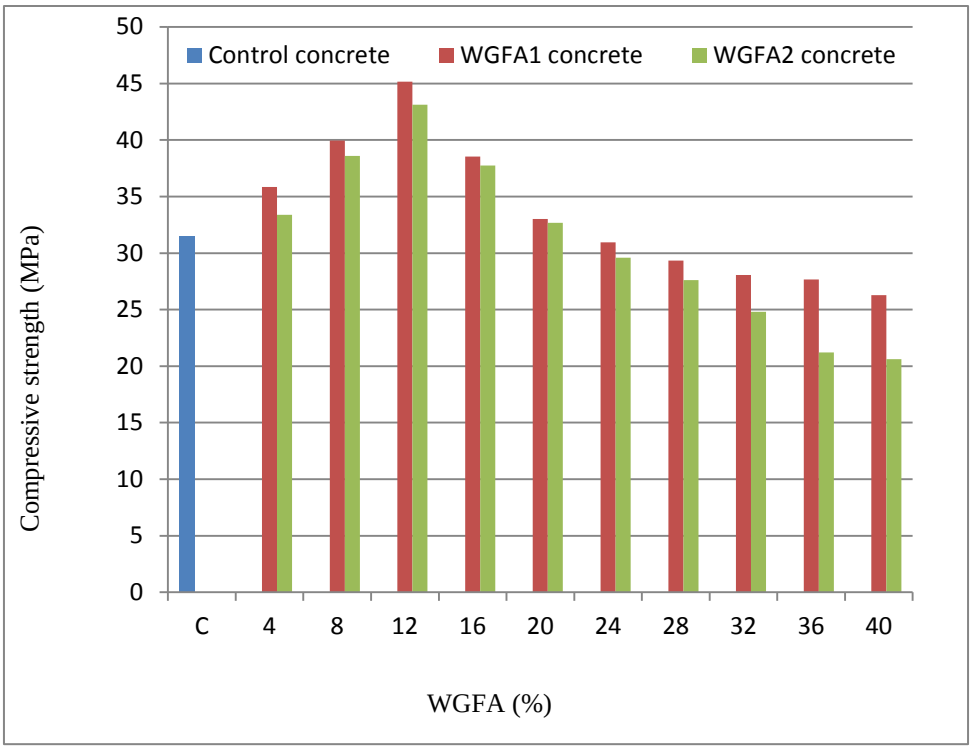

Figure. 4. Comparision of compressive strength of control and waste glass fine aggregate concretes

It is oblivious from Fig.4 that the compressive strength of concrete is increases with replacement of fine aggregate by WGFA1 from (4-12%).The maximum compressive strength i.e., 36.85% more than that of control concrete was observed at 12% replacement of hill sand with waste glass. On further replacement of hill sand more than 12% with waste glass compressive strength of concrete decreased. More improvement in compressive strength WGFA1 modified concretes were observed as compared to control and WGFA2 modified concretes.

4. Conclusions

On the basis of conducted research it can be concluded that;

- Workability of concrete is increases as the dosage of waste glass is increasing. More improvement in WGFA1 modified concretes are observed as compared to control WGFA2 modified concretes.
- Water absorption of concrete is decreases as the dosage of waste glass is increasing. More decrease in water absorption in WGFA1 modified concretes are observed as compared to control and WGFA2 modified concretes.
- Density of hardened concrete is increases with replacement of fine aggregate by waste glass from (4-12%). The maximum increase in density of hardened concrete was observed at 12% replacement of hill sand with waste glass. More improvement in density of hardened WGFA1 modified concretes are observed as compared to control and WGFA2 modified concretes.
- Compressive strength of concrete is increases with replacement of fine aggregate by waste glass from (4-12%). The maximum compressive strength of concrete was observed at 12% replacement of hill sand with WGFA1. On further replacement of hill sand more than 12% with waste glass compressive strength of concrete decreased. More improvement in compressive strength WGFA1 modified concretes are observed as compared to control and WGFA2 modified concretes.
- Hence, on the bases of the results, 12% substitution of fine aggregate with waste glass fine aggregate (WGFA1) passing from 1.71 mm sieve and retained from 1.19 mm sieve is optimum.

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