

Effect of Waste Glass as Partial Replacement for Coarse Aggregates in Concrete

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ABSTRACT

This study investigated the effects of using waste glass as partial replacement of coarse aggregates in concrete of 20 mm coarse aggregates sizes. The crushed glass was introduced into a concrete mix as partial replacement of coarse aggregates at 0, 15, 20, 25 and 30% replacement. Concrete cubes measuring 150 x 150 x 150 mm were casted. Workability tests for the fresh concretes were performed for each batch and their results recorded. The cubes compressive strength were evaluated at 7, 14 and 28 days curing. Compressive strengths of 19.7, 16.29, 20.44, 16.0 and 19.7 N/mm² for the 0%, 15%, 20%, 25% and 30% replacement levels were obtained at the 28th day curing respectively. The compressive strength reduced with increase in the volume of glass. The workability of the concrete reduced with increase in replacement of glass as the slump values were recorded as 10, 10, 8, 5 and 5 mm respectively which make them true slump. The density of the concrete follows the trend of the compressive strength as it decrease with increase in replacement at the 28th day curing. The values of the densities were 2562.9, 2637.0, 2696.3, 2601.5, and 2472.1 kg/m³.

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Introduction

Glass is a transparent material produced by melting a mixture of materials such as silica, soda ash, and CaCO₃ at high temperature followed by cooling where solidification occurs without crystallization. Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing. Glass is an ideal material for recycling. The use of recycle glass saves lot of energy and the increasing awareness of glass recycling speeds up focus on the use of waste glass in different forms in various fields. One of its significant contributions is the construction field where the waste glass was re - used for concrete production [1]. Using of waste glass in the concrete construction sector is advantageous, as the production costs of concrete will go down [2]. Recycling of this waste glass by converting it to aggregate components could save landfill space and reduce the demand for extraction of natural raw materials for construction activities [3].

Reference [2] observed from his study that the workability of waste glass in concrete has insignificant effect on it as only its strength is slightly reduced. Reference [5] investigated the incorporation of waste bottle glass into concrete mixes as a supplementary cementing material and concluded that the pozzolanic properties of waste glass as an Alkali Silica Reaction (ASR) are related to particle size and percent. Reference [6] stated that due to low demand of recycled glass, expense of recycling is high; a sustainable solution is to reuse the glass in concrete. Reference [7] investigated the effects of adding waste glass as

coarse aggregate in concrete mixture and finds out that the percentage to be replace at optimum level is 10%. To this effect, this research was carried out to find a higher percentage replacement.

Materials and Methods

All materials used in this study were locally sourced which include Portland cement, water, fine aggregates, coarse aggregates and waste glass. The cement used in this study was ordinary Portland cement (OPC) of Dangote (42 grade) brand obtained in a local store. The fine aggregate used was that of river origin as natural sand accumulated from the disintegration of rocks which was sorted out by currents of water and in this case, the one used had 4.75 mm maximum size. The coarse aggregates utilized was obtained from Paladan quarry site along Zaria-Sokoto highway, having maximum size of 25.4 mm. Generally, water for drinking such as tap water, well water and pipe borne water are good in making cement mortar and concrete. For the purpose of this research pipe borne water obtained from the Department of Civil Engineering, Ahmadu Bello University Zaria was used. At w/c of 0.60. The waste glass used in this study was obtained from various shops along Kwangila-Sabon Gari route Zaria, Kaduna State-Nigeria. The whole quantity was crushed using a crushing machine provided by the Department of Glass and Silicates Technology in Ahmadu Bello University, Zaria.

The methods employed in this research was preliminary tests of cement, aggregates and concrete which were all observed in

accordance to BS Codes of practice and the results obtained are summarized in Tables 1a and b.

Table 1a: Properties of cement

S/N	Properties	Experimental value	(BS codes)
1	Normal consistency	6.0mm	BS EN196-3: 1995
2	Initial setting time	125(mins)	BS EN197- 1(2000)
3	Final setting time	205(mins)	BS EN197- 1(2000)
4	Soundness of cement	1mm	BS EN 196 part 3:1995
5	Specific gravity	3.2	BS 812: part 2: 1995

Table 1b: Properties of aggregates

Property	Fine aggregate	Coarse aggregate		(BS codes)
		Gravel	Waste glass	
Specific gravity	2.8	2.6	2.6	BS 812: part 2: 1995
Aggregate impact value		27.06	20.4	BS 812: part 112: 1990
Aggregate crushing value		24.3	46.03	BS 812: part 110:1990

Results and Discussion

Results of the workability tests for the fresh concretes are displayed in Figure 1, which shows that the workability value of slump decreases with increase in percentage of replacement this may be as results of the glass content which unlike conventional coarse aggregates that absorbs water thereby rendering the concrete less workable, the waste glass does not absorb moisture hence, having a good workability. Results of compressive strengths of concrete for 7, 14 and 28 days curing are indicated in Figure 2. The results show that when a coarse aggregate is replaced by 20% waste glass, the compressive strength reaches 20.44 N/mm² at its 28 days curing which shows similar trend to the control replacement being 0%. However, the graphs do not have a steady increase pattern but undulating one, reason being that the waste glass surface area is uniform and smooth hence, as the percentage of replacement becomes higher, the bonding between the waste glass and the mortar becomes less adhesive due to slippage at the surface of the glass. Results of hardened density for 7 and 14 days are represented in Table 2. Which shows that the density of the hardened concrete increases with the percentage of replacement and days of curing. However, it was noticed that the increase in density with increase in curing days and percentage of replacement does not follow similar trend in the 7 days curing of 20%, reason being that the mold used might have expanded hence, more mass was weighed for that particular sample. In addition, the 28 days curing values of hardened density is captured in Figure 3. The result shows that the density of the concrete increases with increase in glass replacement of 20% and then starts falling with increase in replacement higher than 20%. The falling is due to the specific gravity of the glass content; as the content increases the strength decreases.

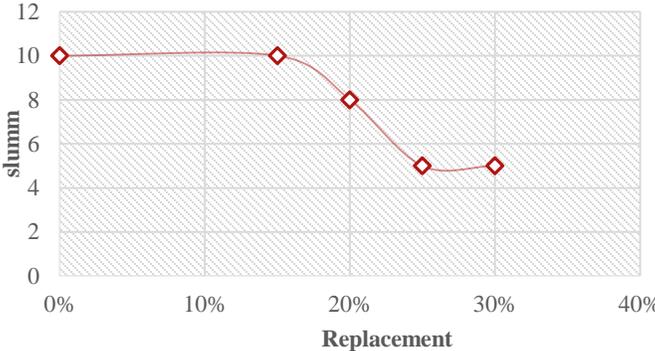


Figure 1: Slump value graph

Table 2: Results of density

Replacement	Densities (kg/m ³)	
	7 days	14 days
0%	2501.5	2518.5
15%	2266.7	2311.1
20%	2616.3	2586.7
25%	2660.7	2607.4
30%	2450.4	2601.5

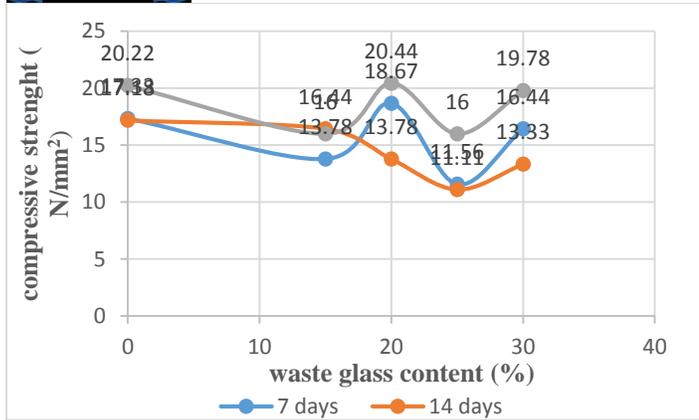


Figure 2: Compressive strength graph

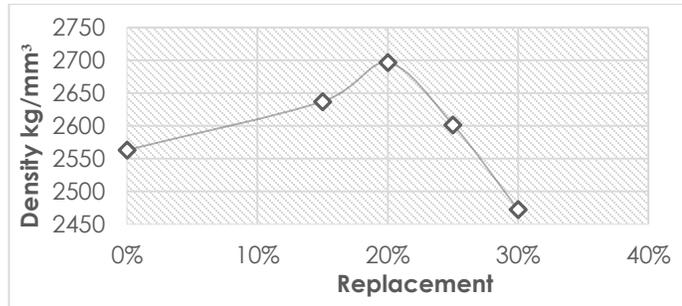


Figure 3: Hardened density graph

Conclusion

From the results obtained, the following conclusions can be drawn;

1. A maximum compressive strength of 20.44 N/mm² at 28 days was recorded with the 20% replacement, which

gave rise to the highest density and compressive strength.

2. The optimum percent of partial replacement of coarse aggregate with waste glass was found to be 20% which is higher than 10% replacement as gotten by Thomas (2014).
3. The workability of the replacement mix reduces with increase in percentage replacement of the coarse aggregate with waste glass.
4. Use of waste glass in concrete will eradicate the disposal problem of waste glass and improve environment friendliness.

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