Effect of using Recycled glass as supplementary cementitious material on cement mortar

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INTRODUCTION

The cement industry has a large environmental footprint, it is considering all the greenhouse gases emitted by cement manufacture, this production is responsible for 3% of green- house gases emission in the world. The effects of using industrial and domestic waste as alternative fuels and raw materials in cement production have received considerable attention in recent years [1–3].

Million tons of waste glass are generated annually all over the world. In 2005, the total global waste glass production estimate was 130 Mt [4]. Waste glass has become a significant environmental problem. Since those wastes are not biodegradable and due to their low rate of recycling this waste are disposed as landfills. The physical, chemical composition and the pozzolanic properties of waste glass are encouraging for the use of this waste in the cement and concrete industries and to provide an environmental friendly solution for the glass industries. [5]. The utilization of waste glass as aggregates in concrete production has been widely investigated [6-8]. However, the highly amorphous silica structure and a considerable amount of sodium, alkali-silica reaction expansion becomes a serious problem for this application [9].

The effects of cement partial replacement by waste glass on mechanical physical and durability of cement mortar was investigated by several authors[4, 10, 11]. It was demonstrated that glass at particle below 100 µm can have a pozzolanic reactivity greater than that of fly ash[11].

This study investigates the performance of cement mortars incorporating recycled waste glass as replacement of cement. The current situation of discarding waste glass to landfills creates serious environmental problems due to non-biodegradable form of waste glass. Two types of waste glass were used in this study, windshield glass and bottle glass in proportions of 0%, 5%, 10%, 20% and 30% by weight.

Materials and methods

Windshield glass and bottes glass were collected cleaned and crushed separately at under 100 µm. The cement was replaced by windshield glass or bottes glass from 0%, 5%, 10%, 20% and 30% by weight. Cement used in this study is the Algerian Portland cement CEM I 52.5 N. The mortars are prepared by mixing cement, demineralized water and sand NF EN 196-1 [4]. A constant water to binder ratio (0.5) was maintained for preparing mortar samples with a sand to cement weight ratio of 3. For the sulphate attack tests, the mortar specimens were cured in water at 23 ± 2 °C for 28 days before being immersed in 8% sodium sulphate.

The chemical and mineralogical composition were determined by X-ray fluorescence (PANalytical Perl'X 3) and X-ray diffraction (BrukerD8; CuKα,2- 99◦2 θ, 0.017◦2 θ step).

The Setting time, mortar flow and a the compressive strength were determined using French standards.

The chemical composition of the glass waste and cement used in this study are presented in Table 1. The XRD patterns of the glass waste are summarized in Fig 1.

Results and Discussion

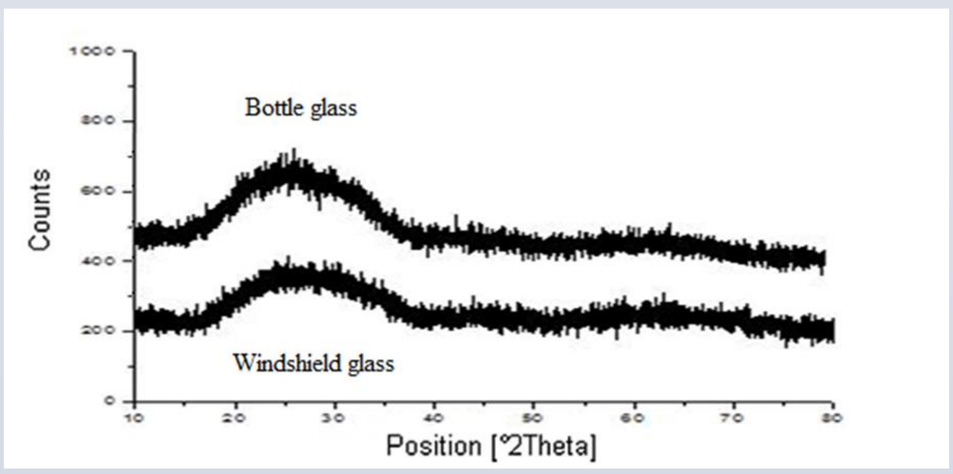

Fig. 1. X-ray spectrum of waste glasses.

Table 2 Chemical composition of cement and recycled waste glass.

	Chemical composition (wt%) CaO										
Material	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	Na_2O	TiO2	Cl	LOI
Bottle glass	72.45	2.49	0.58	10.86	0.88	0.04	0.37	11.35	0.019	0.001	0.7
Windshield glass	72.47	1.99	0.73	8.71	3.45	0.07	0.48	12.09	0.007	0.003	0
Cement	20.62	4.9	3.7	64.47	1.71	2.23	0.65	0.19	/	0.03	1.5

According to ASTM C618 (ASTM, 2015a), (SiO_2 +Al_2O_3 +$Fe2O_3$)'s minimum requirement for a standard pozzolana is 70% which is comparable with the results obtained for the waste glass samples[4].

Setting time

The initial setting and final setting of samples incorporating different amounts of waste glass are shown in Fig. 2. the addition of waste glass prolongs both the initial setting and the final setting time of the samples. An increase in the flowability is observed in mortar with the incorporation of waste glass.

Increasing the waste glass amount (Fig.3) decreases the compressive strength at all curing period.

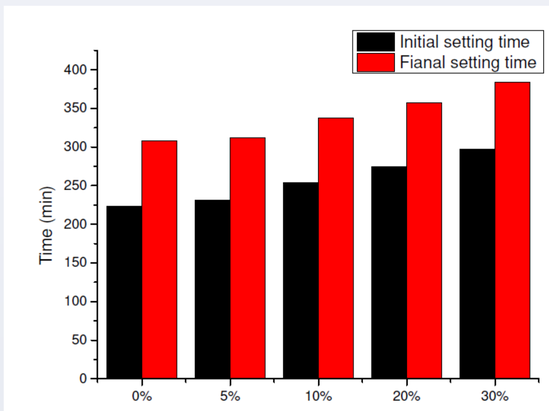

Fig. 2. Setting time of cement mortar samples.

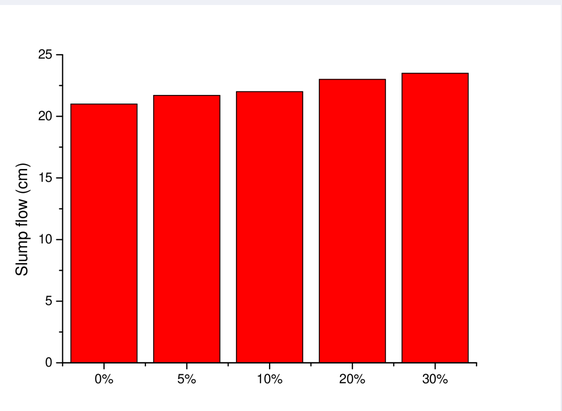

Fig. 3. Slump flow of cement mortar samples.

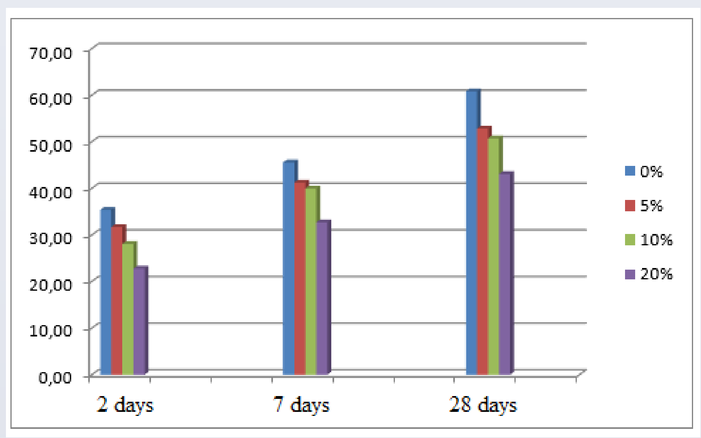

Fig. 3. Compressive strength of cement mortars samples

Conclusion

The utilization of waste glass as cement replacement for cement mortar preparation is suitable since in terms of physical and chemical characteristics, glass can be considered a pozzolanic-cementitious material.

The compressive strength of cement mortar decreases with the increase of recycled glass content. Incorporating waste glass in cement mortar increase the flowability and initial and final setting times.

The utilization of bottle glass shows better performances in both flowability and compressive strength than using windshield glass, but no significant difference in setting times.

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