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Experimental Study of Workability and Mechanical Properties of Concrete Containing Powder Glass and Mineral Waste Glass with Separate and Simultaneous Applications

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ABSTRACT: The large volume of unrecoverable waste glass has recently been considered as an alternative to some concrete components. In the previous studies, the replacement of sand with crumb glass at high ratios resulted in a significant reduction in the mechanical properties of concrete. In this research, the sand was replaced with waste fractures with ratios of 5%, 8% and 12%, and 3 mixing designs were cast. Three mixes were also made by replacing glass powder with cement at 4%, 8% and 12%. Combined designs with a constant replacement of 8% glass crumbs with sand and cement with glass powder in ratios of 4%, 8% and 12% were also prepared. A total of 230 sampling was done. The compressive strength of samples at the age of 7, 28, 56 and 91 days, and tensile strength at 28 days were also measured. Static modulus test was performed on cylindrical specimens. Experiments results in fresh and hardened concretes compounds decreased compared to mixed glass containing glass powder, which is indicative of the undesirable use of glass as a crumbly and increased alkali-silica activity. The undesirable performance of glass jar on the mechanical properties of concrete through the replacement of cement with glass powder has been greatly improved. The results showed that simultaneous replacement of cement with glass powder in low proportions in designs containing 8% permanent sand replacement with glass jar, resulted in a significant reduction in the workability and improvement of mechanical properties of concrete compared to the reference design.

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1- Introduction

In recent years, the use of glass waste in concrete has greatly increased the necessity of investigating the effects of these lesions on the behavioral and mechanical properties of concrete [1]. Glass is one of the oldest blacksmith materials produced in various forms, hence the need for recycling is important to prevent environmental problems. Theoretically, glass is a 100% recycled material that can be recycled unlimitedly and without any loss of quality. There are many examples of successful recycling of waste glass that can be used as substitutes for aggregates or pozzolanic admixtures in concretes [2]. The reason for the use of concrete with waste glasses is to prevent further environmental degradation as well as to improve some concrete specifications. Thus, with the proper replacement of waste glass with aggregates used in concrete, it can be economical to avoid the cost of disposing such waste [3]. However, today, global development has caused a huge amount of waste and casualties on the environment, and construction and demolition activities have had the largest contribution to environmental damage. Therefore, the use of recycled waste will not only reduce production, but also reduce waste disposal and environmental protection [4].

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Nasser and Sourkhish's research showed that when the size of the crushed glass is measured to the micro-scale, a pozzolanic reaction occurs with hydrate of the cement, resulting in the formation of secondary hydrated calcium silicate. These reactions apply to optimal changes in the hydrated structure of cement paste and surface transfer areas in recycled concrete. The results showed that the glass powder replaced with part of the cement provided significant gains in the strength and durability of recycled concrete and limited alkaline-silica reactions [5]. Previous studies have shown that the glass can be used in three ways, including coarse-grained, fine-grained and glass powder in concrete. Coarse and fine grained materials can cause alkaline-silica reactions in concrete, but glass powder can reduce the effect of alkaline-silica reaction. It is, however, commercially economical to use glass powder instead of cement, so that the glass is used as aggregate in concrete [6, 7].

Generally, the glass silica section in the concrete can cause problems caused by alkaline-silica reaction. This feature can be considered as an advantage of glass powder and its use as a pozzolanic material in concrete. This reaction can be very dangerous for the stability of the concrete, therefore an appropriate prevention should be made to minimize the effect of this reaction [8]. According to the research data, due to the fact that the mechanical properties of concrete in high glass replacement ratios fall, therefore, the maximum replacement ratio in this study was limited to 12%. The purpose of the study is to investigate the effects of powder and aggregate application of glass on the performance and mechanical properties of concrete.

2- Research methodology

In this study, a total of 12 mixing designs were made. In 3 mixing designs, the waste glass was replaced by 4%, 8% and 12% cement; In 3 other mixing schemes, the scraps were replaced by 5%, 8% and 12% sand; The design of 8% Sand Glass Replacement Glass was selected as Optimum Design; In 3 other mixing schemes containing sand substitute with a constant value of 8%, the waste glass was replaced by 4%, 8% and 12% cement. It should be noted that the percentages selected were based on the experience of the authors of the article and the research-related records. The naming method of the designs is such as follows: SH, GP and GS represent the reference design, the designs containing the powdered glass and glass. The number after the Latin name of the name indicates the percentage of the use of this material as an alternative. For example GS5 means that in this mixing plan, 5% of the mixing design sand with the glass jar was replaced. In Table 1, details of the final mixing designs for a concrete cubic meter are presented.

3- Results and discussion

3- 1- Compressive strength of mixing designs with separate and simultaneous replacement

The compressive strength growth pattern in all mixing designs is shown in Figure 1.

Table 1: Details of the concrete mixing designs used in the research

Layout code	Glass powder (%)	Glass jar (%)	Cement content (kg/m^3)	Super -plasticizer (kg/m^3)	Water (kg/m^3)	Gravel 3/4” (kg/m^3)	Gravel 3/8” (kg/m^3)	Sand (kg/m^3)	Glass powder (kg/m^3)	Glass jar (kg/m^3)	w/c
SH	0	0	422.2	5.6	185	438.1	438.6	872.9	0	0	0.44
GS5	0	5	422.2	5.6	185	438.1	438.6	872.9	0	43.6	0.44
GS8	0	8	422.2	5.6	185	438.1	438.6	872.9	0	69.8	0.44
GS12	0	12	422.2	5.6	185	438.1	438.6	872.9	0	104.7	0.44
GP4	4	0	405.3	5.6	185	438.1	438.6	872.9	16.9	0	0.44
GP8	8	0	388.4	5.6	185	438.1	438.6	872.9	33.8	0	0.44
GP12	12	0	371.6	5.6	185	438.1	438.6	872.9	50.7	0	0.44
GS8GP4	4	8	405.3	5.6	185	438.1	438.6	838.0	16.9	69.8	0.44
GS8GP8	8	8	388.4	5.6	185	438.1	438.6	803.1	33.8	69.8	0.44
GS8GP12	12	8	371.6	5.6	185	438.1	438.6	768.2	55.7	69.8	0.44

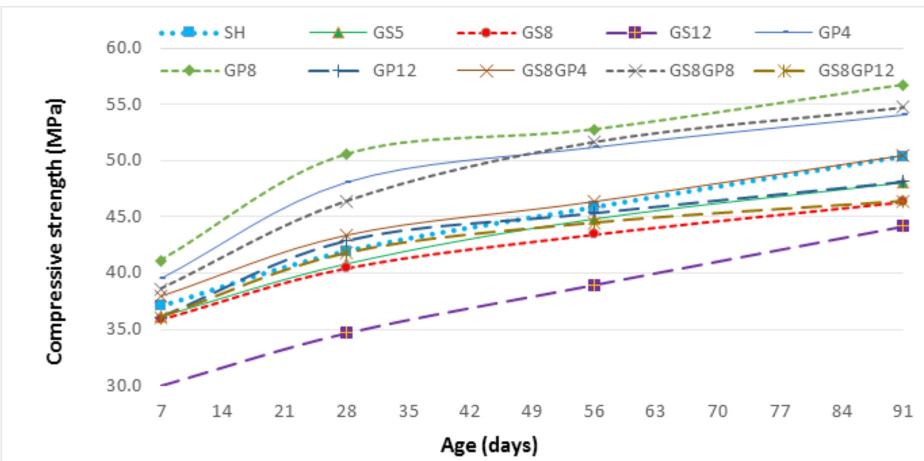

Figure 1. Growth of compressive strength with age of samples in different research designs

4- Conclusions

The compressive strength, tensile strength, static elasticity, slump and specific gravity of fresh and hardened composite designs showed a decrease compared to those containing pure glass powder. This indicates the undesirable use of glass in the form of granular particles (glass jar) in the concrete structure and increased alkali-silica activity. The undesirable performance of the crumbly application on mechanical properties of concrete has improved to a great extent through the replacement of cement with glass powder.

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