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EXTENDED ABSTRACT

Experimental Study on Properties and Resistance of Local Mineral Pozzolanic Concrete against Fire and Evaluation of Its Ability to Reduce CO_2 Emissions

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1. Introduction

Global warming is mainly due to pollution from greenhouse gas emissions and often carbon dioxide (CO_2). Reducing greenhouse gases and analyzing and monitoring the environment is one of the human concerns today. Cement factories are major producers of greenhouse gases. Finding a cementitious material (pozzolan) that can be replaced in a part of concrete cement will play an important role in reducing cement consumption and CO_2 emission pollution. The local mineral pozzolans studied have similar properties to world famous pozzolans and have relevant standards.

2. Methodology

In order to investigate the effect of local mineral pozzolan on engineering properties and fire resistance of concrete, according to previous studies and optimizations, 15% by weight of local mineral pozzolan replaced part of the cement in concrete and tests were performed according to Table 1.

Table 1. Test and specimens' properties

Test	Shape	Dimension (mm)	Days of Cured	Standards
Compressive Strength	Cubic	100×100×100	7,14,28,56,90	BS EN12390-3:2009 (BS, EN 12390-3:2009)
Flexural Strength	prism	400×100×100	7,14,28,56,90	ASTM C1609 (ASTM, 2019)
Fire Resistance	Cubic	100×100×100	28,90	ASTM E119 (E119, 2012)

Also, in order to evaluate the effect of local mineral pozzolan on reducing CO_2 emissions, related studies were performed and compared with similar pozzolans.

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3. Results and discussion

3.1. Compressive Strength

Local mineral pozzolans showed 28.25 and 1.44% higher compressive strength than plain cement concrete (PCC) at 28 and 90 days of curing. The compressive strength of the 7-day sample containing polypropylene fibers has increased by about 16% compared to the typical cement concrete sample. This compressive strength increased by 50% in 28 days and by 15% in 90 days. also; The environmental processing of 28-day samples decreased by 13% compared to the processing of the same water-immersed sample. In samples containing hybrid steel and polypropylene compared to conventional cement concrete, the compressive strength of the 7-day sample containing hybrid fibers increased by about 27%, this resistance increased by 27% in 28 days and by 33% in 90 days. Found. The environmental processing of 28-day-old samples decreased by 11% compared to the processing of the same sample immersed in water during the same period.

3.2. Flexural Strength

Local mineral pozzolans showed 28.59 and 4.26 percent higher tensile strength than ordinary cement concrete in 28 and 90 days, respectively. Experimental results have shown that the flexural strength of a combination of steel fiber and polypropylene samples gives better results. In the 28-day immersion treatment, the flexural strength of the hybrid sample was about 78, 39 and 5%, respectively, higher than that of the conventional cement concrete sample and the sample containing polypropylene fibers and the sample with steel fibers. also; In 90-day processing, the hybrid sample had higher flexural strength of about 81, 41 and 3.5%, respectively, than the sample of ordinary cement concrete and the sample with polypropylene fibers and the sample with steel fibers. Water-immersed treated specimens had a higher flexural strength at 28 days of age than ambient-treated specimens. This increase in strength is 5.5% for a sample of ordinary cement concrete, 7.25% for a sample containing mineral pozzolans, 3.2% for a sample containing steel fibers, 6% for a sample containing polypropylene fibers and 3.4% for a sample containing hybrid fibers.

Low flexural strength has been observed in fiber-free concrete samples. However, the presence of fibers in concrete increases its ductility and flexural strength by distributing force and delaying the failure of the sample. These observations are consistent with previous research findings that mill pozzolanic activity in the formation of cement hydrates increases with decreasing porosity and increasing the cohesion of the hydrated cement matrix, leading to a significant increase in strength of up to 90 days.

3.3. Fire Resistance

Initially, three general samples (for the average) of each age were weighed from the destination test and then subjected to compressive strength tests. Then, to test the fire resistance, the remaining samples at the desired ages (28 and 90 days) are placed in an electric oven at 600°C with a heating rate of 10°C/min, and for one hour at 600°C. Remained at a constant temperature. The samples are then taken out of the electric oven and stored at room temperature to cool to ambient temperature. Temperature and time curves were calculated and plotted for the samples. After cooling the samples, their weight was controlled and then their weight loss was calculated. Mass reduction was observed in samples containing local mineral pozzolans. The cause can be related to its very small size and its location between the aggregates. We find that ordinary cement concrete samples have the highest mass reduction. Concrete containing steel fibers and steel-polypropylene composite fibers had the lowest mass loss, respectively, and concrete containing polypropylene had less mass loss than conventional cement concrete, but lost more weight than samples containing steel and hybrids.

3.4. Evaluating the effect of concrete mixture parameters on the environment

By applying pre-studied coefficients of greenhouse gas emission capacity from each of the concrete components and comparing it with similar studies in three silica foam (SF) fly ash (FA) pozzoons, the smelting furnace slag (GGBS) is consistent (Yang K-H et al., 2015). Asyabar local mineral pozzolan is a desirable and effective pozzolan with the characteristics of the most widely used pozzolans in the world and is used to prevent the further spread of CO_2 pollution from the cement industry and the production of environmentally friendly concrete.

4. Conclusions

Steel fibers improve compressive strength better than other fibers. Steel fibers and polypropylene increase the axial compressive strength to some extent, but the volume fraction of the fibers must be within the optimal range. Uniaxial compressive strength did not increase significantly compared to the compressive strength of both types of fibers (hybrids). The combination of the two types of fibers in hybrid specimens did not significantly increase its uniaxial compressive strength and its greater effect was to improve crack propagation in hybrid specimens. In prismatic samples with composite steel and polypropylene fibers, it was observed that polypropylene fibers to some extent prevent the growth of fine cracks, but with increasing pressure, the effect of steel fibers after the initial cracking and the appearance of the first point is the maximum load. Increasing. Smaller fibers bridged between small cracks control the growth of fine cracks and prevent them from joining, and larger fibers prevent large cracks from forming and spreading, and significantly improve fracture toughness. Concretes containing steel fibers had better strength than other samples due to their ability to transfer capillary water vapor out of the samples after being exposed to a temperature of 600°C. Samples containing hybrid fibers had the same strength as polypropylene fibers. Evaluation of the effect of reducing CO_2 pollution in all concrete samples made with local mineral pozzolans and comparing it with plain cement concrete showed that replacing 15% by weight of these local mineral pozzolans with cement can reduce CO_2 pollution emissions by 15.20%. The chemical reaction of pozzolan in the concrete binder reduced the content of portlandite and calcite. This pozzolan also decreased the number of pores and enhanced the integrity of the interfacial transition zone (ITZ) in the concrete compared to ordinary (Portland) cement concrete.

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