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Influence of Polymer and Marble Waste on the Calorimetric and Physico-Mechanical Properties of Mortar

Alya Harichane
Institute of Science, University Center of Tipaza, 42000, Algeria
*harichane.alya@cu-tipaza.dz

ABSTRACT

The use of polycarboxylate ether superplasticizer PCE in the preparation of mortars and concretes containing marble waste influences the hydration kinetics and the amount of total heat released. This leads to a modification of certain properties of the mortar, namely workability, calorimetry and mechanical resistance. In this study two ether polycarboxylate superplasticizers with different chemical structures were used; they were incorporated at different dosages into a standardized marble waste based cement . The objective of this work is to study the effectiveness of these superplasticizers and to select the most compatible product with cement and the most suitable for use according to the climates of the country. The impact of superplasticizers on fresh cement containing marble waste was studied by measuring the Marsh cone flow time and calorimetric measurement. In the hardened state, the mechanical properties were provided by measuring the compressive strength. The results show that low dosages of ether polycarboxylate superplasticizer promote grain hydration and produce more heato; n the other hand, high dosages delay the contact of the cement grains with the mixing water and cause a reduction in the final heat released and a delay in setting. The ether polycarboxylate superplasticizer whith high carboxylic density gives the best mechanical resistance compressive at 7 and 28 days.

Keywords: Keywords: marble waste, calorimeter, hydration, resistance, polymer

1. Introduction

According to the World Cement Association (WCA), the cement industry is responsible for 5–6% of global carbon dioxide emissions [1]. This association requires a significant reduction in the carbon footprint of the cement industry. One approach to this is to partially move away from cement in favor of “mineral additions”, which can often be waste products from other industries. However, substituting cement with mineral additions such as marble waste strongly modifies the rheological and mechanical properties of concrete [2, 3]. Therefore, in some cases, the composition of concrete mixes has to be adjusted with regard to these additives in order to maintain the quality and parameters of the concrete. The use of polycarboxylate ether superplasticizers (PCEs) is absolutely necessary for concretes thatcontain mineral additives, e.g., marble waste, in order to make these additives “work”. Among the most important superplasticizers currently used in the preparation of concrete, we find polycarboxylates [4], preferred for their ability to improve the properties of concrete [5;6], and to give it better mechanical behavior due to the reduction in the necessary W/C ratio. The type of polycarboxylate used and its molecular structure influence the rheological behavior of the pastes [7-9]. These polymers influence the heat of hydration as well as the quantity of hydration products formed. Their dispersion effect is linked to adsorption which depends on the compatibility between superplasticizer and cement. The dispersion of grains promotes direct contact with the mixing water, which increases the quantity of hydrates formed and improves the mechanical properties of mortars or concretes. The aim of our study is to compensate for the lack of information by analyzing the effect of two polycarboxylates of different chemical structure on the physico-mechanical and calorific properties of cement pastes containing marble waste.

2. Experimental

2.1. Materials

The cement used in this work is a composite portland cement (CEM II/ A-L 42.5 N) containing 17% clay and 80% limestone and 2% sand and 1% iron ore, produced by the company Mitidja Cements; Algeria. As

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the partial Portland cement replacement, waste marble from the aggregate production of marble stone in the CHATT/FilFila quarry of the Skikda region was used. Before use, it was ground to the proper size in order to obtain a WMD fineness in the ordinary Portland cement fineness range (between 3000 to 4000 cm2/g). Two types of polymers produced in Sica Algeria were used; they are new-generation, non-chlorinated, and they are based on modified polycarboxylic ether.

3. Results and discussion

3.1. Hydration heat

The figure 1 and 2 illustrates the evolution of the total exothermic heat provided by different dosages of each superplasticizer. By adding superplasticizer to the mortar, the final heat decreases with increasing superplasticizer dosage; due to the dispersion of grains and the availability of water released by their deflocculation. The superplasticizers delay the contact of the cement grains with the mixing water and cause a reduction in the final heat. Polycarboxylate molecules prefer to attach to C3A and C4AF and their hydration products, and delay the hydration of C3S and the formation of CSH and CH [9]; after the addition of 0.5% of a polycarboxylate, the formation of portlandite began after 18 hours of hydration, on the other hand for an ordinary cement without superplasticizer it began after 4 hours. Polycarboxylates delay initial hydration for a long time, since the thickness of the superplasticizer absorption layer interferes with ion diffusion, on the other hand when Ca+2 ions saturate the surface, the growth of CH eliminates the layer doubles and diffuses the silicates to the surface of the solution [9].

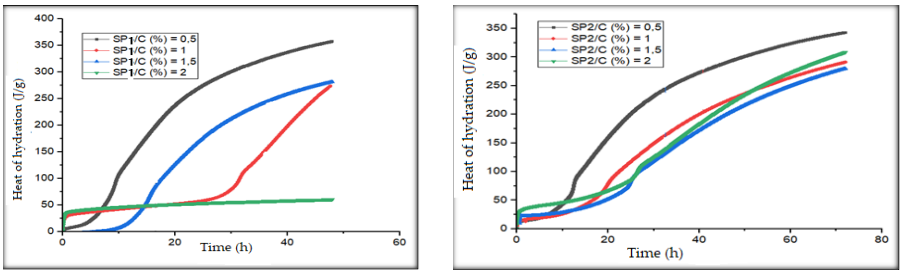

Figure 1: Influence of the SP1 and SP2 dosage on the heat of hydration of a cement mortar.

4. Conclusions

Superplasticizers are used to improve the mechanical and calorimetric properties of cementitious systems. These anionic polymers adsorb on the surface of the cement grains and cause dispersion of the particles. Fluidity is thus obtained by the deflocculation of the cement grains and the release of the water retained in the fl occulates. A consecutive reduction in the heat of hydration as a function of the superplasticizer dosage is then mentioned.

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