Compatibility of cement and native and modified starches through hydration heat study

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Abstract— This work has been done in order to valorize starch in industrial mortars. Its effect on cement hydration has been studied to propose the mechanism of interaction. After the characterization of raw materials, the study in concentrated environment (low ratio W/C) is closer to real conditions of use. It doesn't reveal apparent effects of natural starch which is entirely compatible with cement up to 10% of content. The evolution curves of hydration show not only that the heated starch and dextrose are set-retarding agent to a degree but also that the setting time increases with the polysaccharide content. At high content, there is a total incompatibility with cement. The study of heat of hydration also points out the influence of polysaccharides introduction time and gives more information about their action.

Index Terms— Starch, polysaccharides, Cement hydrations, organic admixture, setting time, compatibility.

1 Introduction

Research on the interactions between polysaccharides including starch (modified or not) and the cement is still incomplete. Studies on the hydration of cement in diluted environment in the presence of starch show that dextrose could be used as a retarder; but diluted environment is a bit far from the actual conditions of use of cement; so we are interested in conducting investigations under conditions that are closer to the real ones.

Our study aims at helping to elucidate chemicals mechanisms between polysaccharides and cement; so we will be able to study their compatibility and the effects of polysaccharides as set retarding through the hydration heat study.

2 Materials And Methods

2.1 Materials

Three polysaccharides were used:
- A native starch extracted from sweet cassava noted AN.
- The dextrose noted D.
- A modified starch prepared from the native starch noted AM
- The cement used for the studies is Portland of type CPJ35 noted C.

We measure the heat of hydration of cement with a device including: one calorimeter (adiabatic enclosure) made of three compartments of 25 x 45 x 35 cm; each of them has a small thermally insulated (thermos), three thermocouples (type K) connected to a central data acquisition which is in turn connected to a computer that records the data (see Fig. 1).

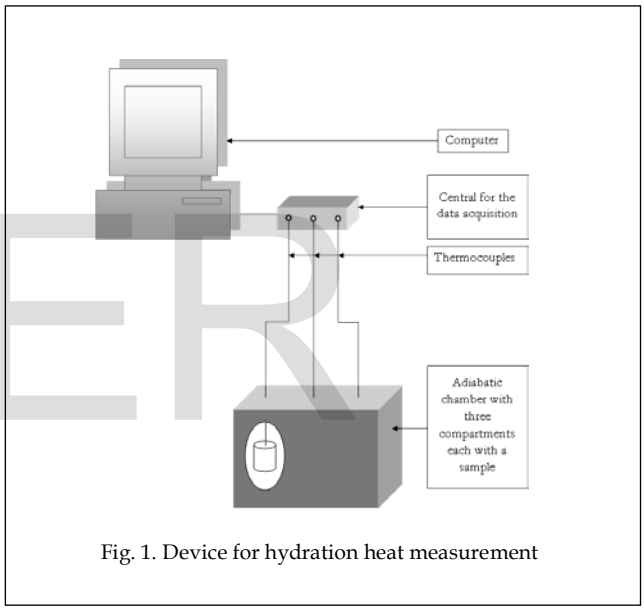

Fig. 1. Device for hydration heat measurement

2.2 Methods

The studies were undertaken in a concentrated environment with a ratio W/C=0,5. Before starting the essay, the ambient temperature was raised. We weigh the study's materials and we make the mixture.

The thermocouple is immersed at the heart of the mixture closed in appropriate thermos which in turn is sealed in one of the three compartments of an adiabatic large enclosure.

The data logger is immediately started and programmed to record temperatures throughout the test period. This will enables, after data processing and calculation of some explicit features, to assess the extent of hydration's heat of the mixtures.

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3 RESULTS

3.1 Influence of the starches on the heat of hydration

For polysaccharide content relative to the mass of cement is equal to 2%, we studied the evolution of the heat of hydration of cement in the presence of three types of polysaccharides (AN, AM and D). The curves look as follows:

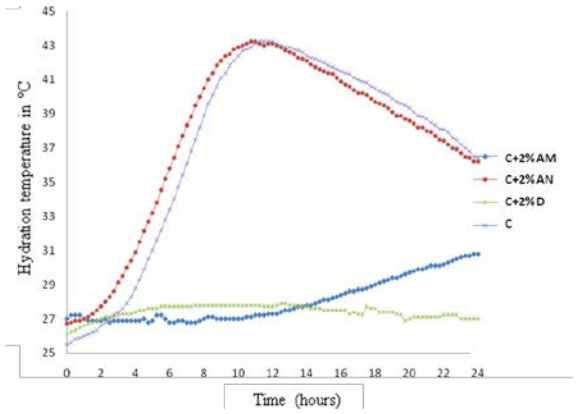

Fig. 2. Hydration of cement in the presence of the various starches

The analysis of these results shows that the impact on the hydration heat is not the same from one polysaccharide to another.

Indeed, native starch has virtually no effect on the hydration heat. The dextrose and AM have shown an aspect of set-retarding for the 24 hours of study. For these modified starches, the dormant period overrides the other periods that are absent during the 24 hours of study.

3.2 Influence of the content in starch

3.2.1 Native stach (AN)

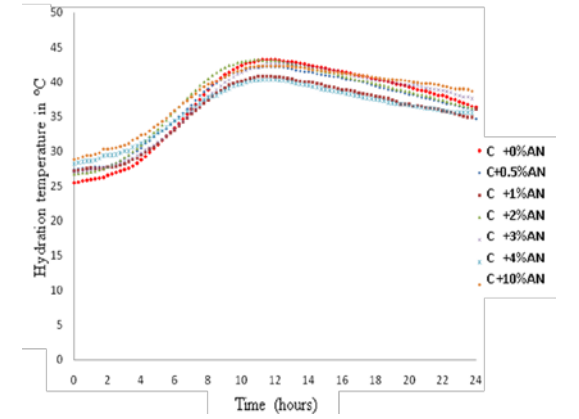

Fig. 3. Hydration of cement according to the content of native starch

We notice that up to 10% of content, the native starch doesn't have any effect on the hydration heat of Cement.

3.2.2 Modified staches (AM and D)

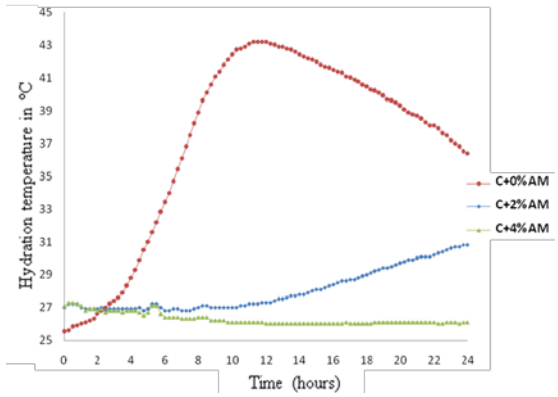

Fig. 4(a). Hydration of cement according to the AM content

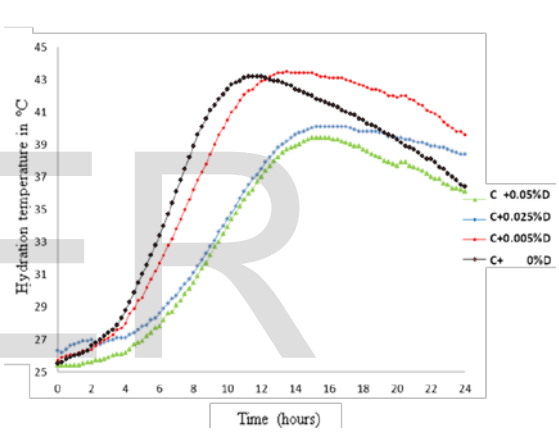

Fig. 4(b). Hydration of cement according to the dextrose content

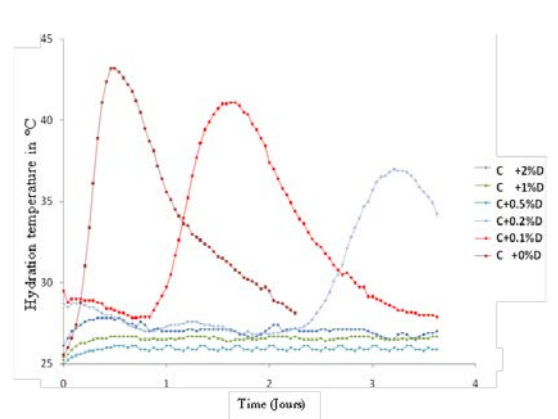

Fig. 4(c). Hydration of cement according to the dextrose content

Figures 5a, 5b and 5c show that the effect of dextrose varies according to its content. Dextrose and AM are retarders and better, the delay is controlled by the quantity added. It can vary from a few minutes to several hours and for some proportions, this delay can last for days.

Nevertheless dextrose proportions > 0.5% completely inhibited the cement hydration.

3.3 Influence of the moment of introduction of starches

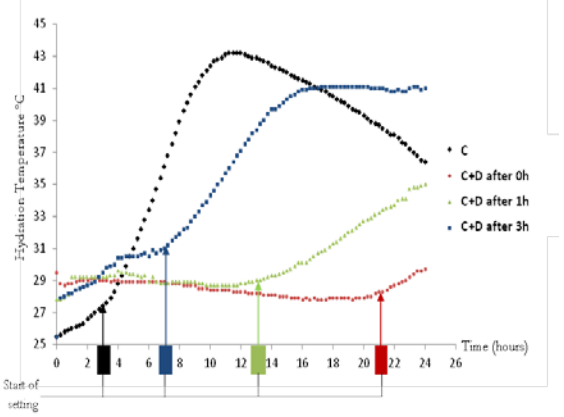

Fig. 5. Influence of the moment of introduction of the starches

The longer is the period between the mixing and the addition of polysaccharide, the lower is the effect on the heat of hydration.

The action of the starches on cement is thus related to the starter or not of the crystalline growth.

4 Conclusion

In sum, the effect on the cement hydration heat is not the same from a polysaccharide to another; the native starch does not have an effect whereas dextrose and AM show their function of retarder; the delay is controlled by the proportioning. From 0,5%, dextrose inhibits completely the cement setting.

Lastly, the hydration heat evolution and the time of the beginning of cement setting depend on the moment of introduction of polysaccharide; earlier it is injected into the cement admixture, better it delays the setting time

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