Shrinkage Behavior and Viscoelastic Properties of Cement Pastes, Mortar And Concrete

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I. INTRODUCTION

The experimental work is meant to identify and quantify how the properties of cement based materials in sealed conditions since very early age evolve. As the early age properties evolution occurs very fast, the characterization of these properties must be automatic. For that purpose, new testing methods aim at monitoring the early age properties of cement based materials are needed. Since experimental testing of several properties such as creep at early ages is very complicated and time consuming, the necessary number of tests to find parameters related to the model has to be limited. The first part of the experimental work focuses on the development of new testing methods. For the understanding of the physical mechanisms which occur during the hydration process, several parameters should be tested. In that frame, the following parameters are studied: the water-cement ratio, the nature of the binder (with eco-concrete for which 75% of the cement is substituted by slag and limestone filler) and the scale effect.

II. MATERIALS AND METHODS

MATERIALS AND MIXTURE COMPOSITION

The tests presented here were performed on the four concretes C0.4, C0.5, C0.6 and CSCM for which the compositions are given in chapter 3. For each composition, the aggregate content is the same.Only the water and cement content varies or the nature of the binder. The effective water-to-cement ratio are 0.35 – 0.44 and 0.53. 75% of the cement is substituted by ground granulated blast-furnace slag (GGBFS) and limestone filler (LMF) (25%) for the composition CSCM.

TIME-SCALE

For consideration of the ageing and the main temperature effect, concrete properties are expressed in function of the equivalent time teqor the advancement degree of reaction α. The apparent activation energy was determined in [2] with the compressive strength results obtained at 3 different temperatures (38 kJ/mol for compositions with CEM I and 48 kJ/mol for CSCM composition).

SETTING TIME

Setting time of the concretes was determined by monitoring of the transmission of the ultrasound P- and S-wave through concrete according to the method developed by Carette, *et al.*[3,4]. Values of the initial and final setting time

Are given in Chapter3.The value obtained was compared to ASTM C403[5] and very equivalent results were obtained for several compositions including composition C0.4and CSCM [3].

ASSESSMENT OF THE AUTOGENOUSS TRAIN AND THECTE

The free deformation of the studied concrete is measured from casting using the BTJADE [6] and the test protocole

Results

COEFFICIENT OF THERMALE XPANSION

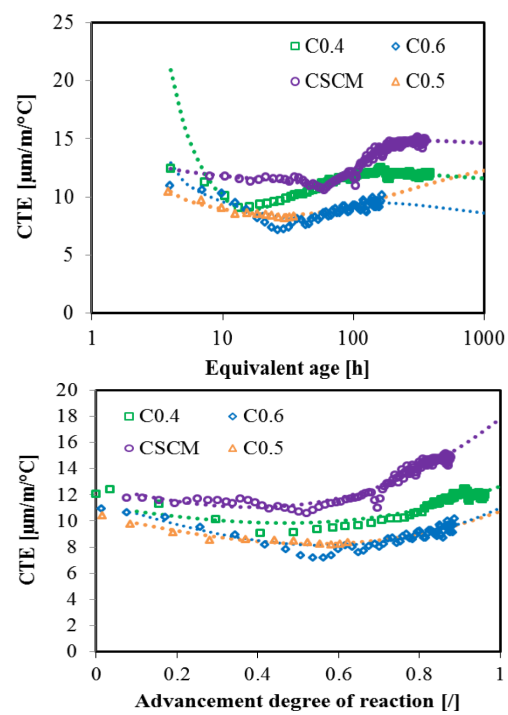

Figure1- Evolution of the coefficient to thermal expansion according to the equivalent age.

Dash lines correspond to model presented in Equation AND Evolution of the coefficient to f thermal expansion according to the advancement degree of hydration. Dashlines correspond to model presented in Equation 3.

AUTO GENOUSDE FORMATION

Results of the autogenous strain are given in Figure 3 according to the equivalent time and in Figure 4 according to the advancement degree of reaction. Autogenous strains are set to zero at the final setting time. Values obtained before the final setting are not associated to the autogenous strain. Two stages are observed in the results. Just after the final setting time, the swelling of the concrete takes place till a maximum value. Swelling can be induced by re-absorption of water (no bleeding was observed here during the casting and at the end of the test) or crystallization pressures generated due to solid phase formation [7,8]. Then a shrinkage period (due to self-desiccation of the cement paste) occurs. As expected, for composition with high water-cement ratio the swelling is significant (40 µm/m for the composition C0.6) and close to zero for low water-cement ratio. Effect of substitution of cement by slag and limestone filler is strongly highlighted on the swelling. The age of concrete when the maximum of the autogenous strain occurs depends on the concrete composition. For composition with low water-cement ratio, the maximum value takes place just after setting and for high water-cement ratio the maximum value of the autogenous deformation occurs later. For CSCM mixture, the maximum of the autogenous strain occurs at an equivalent age of 60 hours. This is explained by the very low rate of the hydration process during this period. When regarding the results according to the advancement degree of reaction, the maximum value of the autogenous strain occurs during a very close interval (between 0.4 and 0.5) for each composition. Also the evolution of the autogenous strain is very similar for the different water-cement ratio between an advancement degree of reaction between 0.4 and 0.65.

EFFECT OF WATER-CEMENT RATIO ON THE VISCOELASTICBEHAVIOUROFCEMENTBASEDMATERIAL SINCE SETTING TIME

The tests presented here were fully performed in the laboratory of civil Engineering at ULB on three concretes with different water cement ratio C0.4, C05 and C06 for which mix proportions are given in Chapter 3. For each composition, the aggregate content is the same. Only the water and cement content are not the same.

Preliminary results

A certain number of fundamentals properties were determined before the study of the viscoelastic behaviour of the three concrete mixes. The setting is determined on basis of the monitoring of the transmission of the ultrasound p- and s-wave through concrete according to the method developed by Carette, *et al.* [3,4]. Values of the initial and final setting time are given in Table 1.

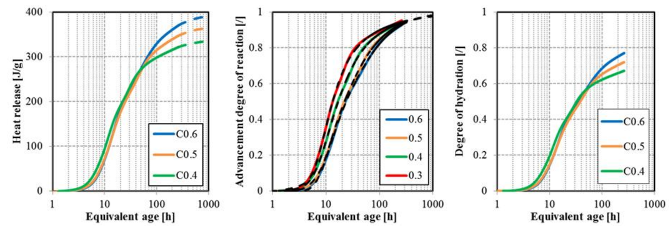

Figure : Heat release for several water-cement ratio. Continuous lines correspond to the experimental results and dashlines correspond to interpolated value used to define the ultime heat release.

SUMMARY AND CONCLUSIONS

Thestudyofthedevelopmentofthepropertiesofcementbasedmaterialssincesettingtimewas performed in main phases: The extension of this new approach to the study of relevant parameters which are the water- cement ratio, the restrained effect of aggregate on the cement paste in the development of concrete properties at early age, the substitution of cement by mineral addition and the difference of behavior in tension and in compression.

Development of a new testing and modeling approach

A new test protocol is defined for the monitoring of the autogenous strain and the coefficient of thermal expansion. Every 130 minutes, thermal variations of 3°C are applied on a concrete sample with the device so-called BTJADE. Thermal and autogenous strains are distinguished by creating a fictive thermal cure at 20°C from the experimental results. A similar strategy is developed for the monitoring of the autogenous deformation and the coefficient of thermal expansion for cement paste and mortar by using the Auto shrink device.

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