ECTP 2002
The Sixteenth European Conference on Thermophysical Properties

Pierre MOUNANGA, PhD student in Civil Engineering

IUT de Saint-Nazaire
Département Génie Civil

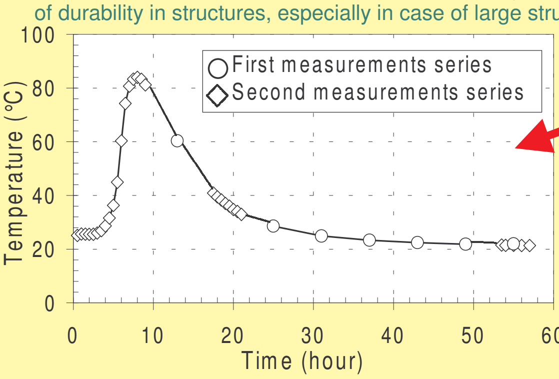
Laboratoire de Génie Civil de Nantes – Saint-Nazaire

Interest and objectives of the study

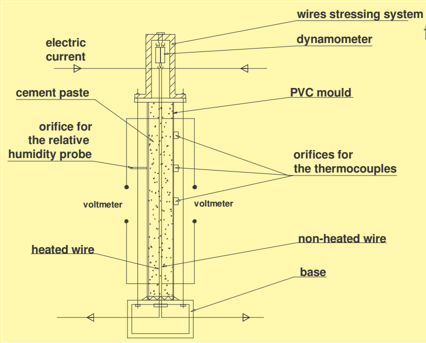
The aim of the present work is to study the evolution of the apparent thermal properties of Ordinary Portland Cement paste.

The hydration process of cement that leads to these mechanical properties occurs with **important heat liberation**. Both this exothermic character and the thermo-activated character of the hydration reactions can lead to cracks at early ages of the material and to a loss of durability in structures, especially in case of large structures.

In order to prevent these cracks, it is important to understand precisely the thermal behaviour of the material during its hydration.

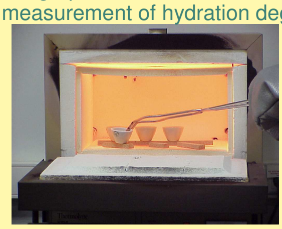


Experimental methods

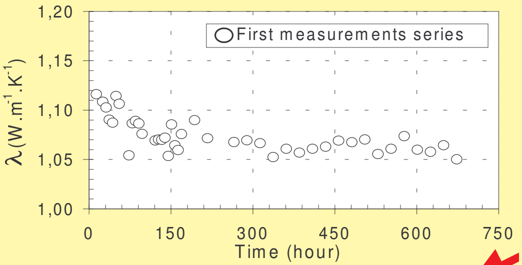


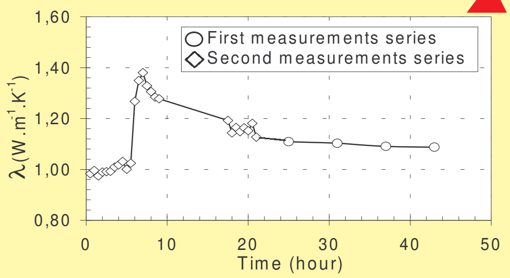
Schematic of the test device used for the measurement of fresh cement paste thermal conductivity.

Photograph of the furnace used for the measurement of hydration degree.



Experimental results

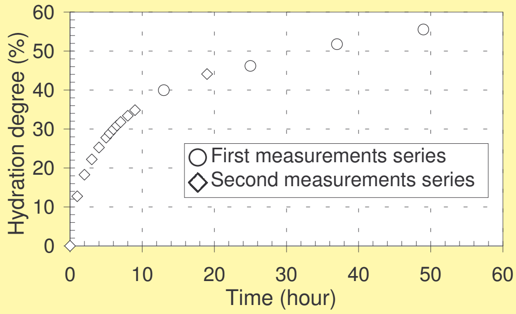




Evolution of apparent thermal conductivity λ^* at very early ages.

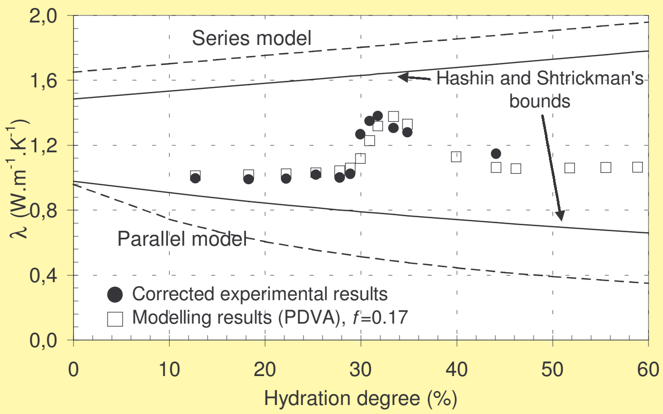
Measurement of thermophysical properties performed using the "hot wire" method.

Two series of tests were achieved in order to clarify apparent thermal conductivity variations at very early ages. Tests were conducted on ordinary cement paste (water/cement ratio=0.348).



Measurement of hydration degree α based on the determination of chemically bound water in cement paste (non-evaporable water).

Modelling approaches



Bracketing of measured apparent thermal conductivity (corrected results) with different multiphase models (series/parallel model and Hashin and Shtrikman's model) and comparison with apparent thermal conductivity computed using PDVA (f=0.17).

Two modelling approaches have been used to explain the presence of a peak in the evolution of apparent thermal conductivity of ordinary cement paste:

- ***Classical Maxwell's problem:*** Considering cement paste as a multiphase material and assigning to each phase (V_i) the values of its own thermal properties (λ_i), the apparent thermal conductivity evolution of the material (λ^*) was expressed as a function of the progression of chemical reactions (α: hydration degree, T: temperature).

$$\lambda^* = g\left(\lambda_i(T), V_i(\alpha)\right)$$

- ***Philip and De Vries' analysis:*** A second approach consists in taking account of the micro-structuration of the material (creation of non-saturated internal porosity) and in assuming evaporation-condensation mechanisms.

$$\lambda^* = \lambda_0 + f\lambda_{diff}$$

where λ^* is the apparent thermal conductivity, λ_0 is the "pure" thermal conductivity, f is a resistance factor to vapour diffusion and λ_{diff} is the apparent contribution of water vapour diffusion to heat transfer.