Numerical Simulation of the Development of Thermally Induced Stresses in Young Concrete

Universität Karlsruhe (TH)

BAUSTATIK

Diplomarbeit von Erika Schaumann an der UPC, Barcelona

Motivation

Cervera *et al.* (1999) from the International Center for Numerical Methods in Engineering (CIMNE) in Barcelona have developed a numerical model for coupled thermo-chemo-mechanical process, considering many of the relevant features of the hydration and aging of concrete. This model is able to accurately predict the evolution in the hydration heat production and the main mechanical properties of concrete. Until now the prediction of stresses by the model could not be verified precisely enough due to the difficulties of measuring the stresses in young concrete.

Mangold (1994) simulated experimentally the stress development during the first week in different parts of a wall. A numerical simulation of this experiments gives now the possibility to verify the stress prediction by the constitutive model.

Thermo-Chemo-Mechanical Model

The rheological model which is used to represent the mechanical behaviour of concrete consists of a viscoelastic chain, with the elastic moduli, E^i, and the relaxation times of the dashpots, defined as $\tau^i = \eta^i / E^i$, of the $i = 1, ..., N$ Maxwell elements as material parameters.

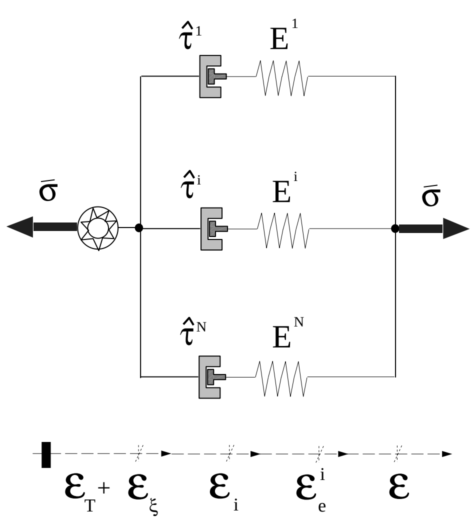

Fig. 1: Rheological model for long term behaviour.

Note that the thermal, $\varepsilon_T = \alpha_T \left(T - T_{ref}\right) \mathbf{1}$, and the chemical, $\varepsilon_\xi = \alpha_\xi \xi \mathbf{1}$, volumetric strains affect all the elements in the same way, but the viscous strain tensor, ε_i, is different for each Maxwell element.

Numerical Simulation

Figure 2 shows the temperature development due to the hydration heat in different sections of an one meter thick wall.

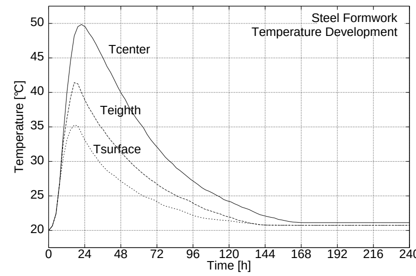

Fig. 2: Development of Temperature in the Wall.

Figure 3 represents the development of stresses during the first seven days in the center and at the surface of the wall (+: experimental results by Mangold; line: numerical simulation). Note that the higher the temperature the higher the viscous behaviour of concrete, which is defined by the retardation time of the dashpot RETA and the Young modulus constant ELAS.

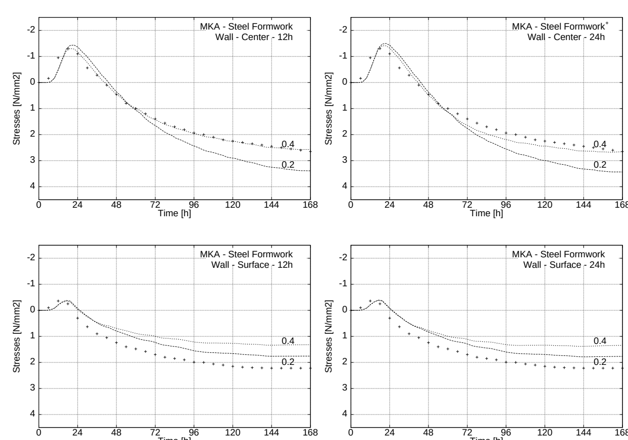

Fig. 3: Numerical Simulation of the Stress Development in the center and at the surface of the wall with RETA:12h and RETA:24h.

Conclusion

In order to achieve an exact prediction of the stress development after the first day an additional viscous effect to the aging effect (which is essential and occurs as long as the elastic modulus varies) is introduced. It is defined by the dashpot viscosity of the Maxwell chain in the model. It is found that the smaller the temperature development due to the hydration heat the less the viscous behaviour of concrete.