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Book review

Sideris K, Sideris KK, Xanthi, Greece. Ten years of cement hydration equation and the application to chemistry and physics of cement paste, mortar and concrete. Thessaloniki, Greece: Publishing House Kyriakidis Brothers S.A. 2003 ISBN: 960-343-722-0

Recently a Monograph dedicated to the cement chemists H.L. Le Chatelier, G. Parissakis, F.W. Locher and U. Ludwig has been published regarding the applicability of the cement hydration equation to describe the time dependency of a number of properties of hydrating cement paste, mortar and concrete. The cement hydration equation was introduced in 1993 by K. Sideris and can simply be written

$$K = K_\infty \pm b \cdot t^{-p}$$

where K is an investigated property taken as "hydration criterion" at time t ($t \gg 0$) and K_∞ is the same property at infinite time (or rather final hydration at about 15 years with available excess water). Both b and p are variables, but p is named the "the hydration number". The equation relies on equal fractional rate of hydration of all major Portland cement phases (i.e. C_3S, β-C_2S, C_3A and C_4AF) at any given time and expresses then the hydration kinetics of Portland cement. This assumption has been shown to be correct by the validity of the cement hydration equation applied to 61 commonly established hydration criteria (usually when $t \geqslant 3$ or 7 days) and is explained by a catalytic effect in cement.

The 61 hydration criteria are listed for *negative* sign in the equation (properties *increasing* with time);

- heat of hydration of Portland cement, C_3S or β-C_2S (3)
- non-evaporable water of pastes of Portland cement and individual phases or mixes thereof (9)
- liberation of calcium hydroxide by hydrating Portland cement or C_3S (2)
- binding of lime in lime-pozzolanic material-water mixes (3)
- surface area of pastes of Portland cement, C_3S or β-C_2S (3)
- compressive strength of pastes of Portland cement, individual cement phases or mixes thereof, and lime-Santorin earth (10)
- compressive strength of mortar based on pure or blended Portland cements (6)
- flexural strength of Portland cement mortar (1)
- compressive strength of concrete based on pure or blended Portland cements (4)
- flexural strength of concrete based on pure or blended Portland cement (2)
- splitting strength of Portland cement concrete (1)
- static modulus of elasticity of concrete (1)
- Poisson ratio of concrete (1)
- dynamic modulus of elasticity of concrete (1)
- resonance frequency of concrete (1)
- pulse velocity in concrete (1)
- rebound hammer units for concrete (1)
- acoustic-ultrasonic test for concrete (1)

and for *positive* sign in the equation (properties *decreasing* with time);

- unhydrated residue in pastes of Portland cement or individual cement phases as determined by quantitative X-ray diffraction (5)
- water sorption of paste (1)
- total porosity or porosity with pore opening >75 Å of paste (2)
- density (1)
- gas permeability (1)

The reason why all these properties can be used as criteria in the cement hydration equation, is that they are all directly or indirectly a result of the hydration of cement or the pozzolanic reaction. However, sometimes the validity of the equation has to be divided into two periods for long term (e.g. 10 years) measurements, usually with a parameter shift around 14–28 days. The monograph is a collection of papers dealing with some of the listed properties in detail.

The monograph describes in detail how values for the variables in the equation can be obtained either through an elaborate iteration process ("method of different values of p") or by a special computer program. However, commercially available programs (e.g. Σ-plot) are capable of fitting the cement hydration equation to experimental data finding suitable values for the unknowns K_∞, b and p.

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The monograph is recommended reading for anyone interested in the kinetics of cement hydration and how a number of long term properties for cement paste, mortar or concrete can be forecast once 3 unknowns in a rather simple equation have been determined by relatively few measurements in time.

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