Micro-structure of Portland Cement Paste and Time Evolution of Dynamic Properties of Its Hydration Water during the Curing Process

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Abstract

The major hydration product of commercial Portland cement paste, a construction material of the largest production and use in modern society, is the Calcium-Silicate-Hydrate (C-S-H) gel. Thus the detail knowledge of characteristic mico-structure of the C-S-H gel as a function of its hydration level is essential to the understanding of its ultimate mechanical strength when the cement paste eventually sets and becomes a concrete. The basic building block of the C-S-H is called a "globule" in Jennings' Colloidal Model-II developed in 2006 [1]. The detailed nano-structure of the globule is so far not given quantitatively. We recently determined the structural parameters of the globule with good accuracy by an Extended-Q Small-Angle Neutron Scattering (EQ-SANS) technique probing a large interval of the scattering vector Q, from 0.015 $Å^{-1}$ to 1.0 $Å^{-1}$. In this Q-range an inter-lamellar peak at 0.65 $Å^{-1}$-0.80 $Å^{-1}$ is present, shifting as a function of the water content present in the C-S-H gel. This additional feature enables us to confirm the presence of a lamellar structure and determine the thicknesses of both the water and the hydrated calcium silicate layers respectively proper of the C-S-H globules as a function of its hydration level [2].

The hydration kinetics of the four pure phases (C_3S, C_2S, C_3A, and C_4AF) present in the commercial Portland cement have been investigated by the incoherent Quasi-Elastic Neutron Scattering (QENS) technique, using Relaxing Cage Model (RCM), a method of analysis developed by Chen [3-12]. This model allows us to extract first the immobile fraction p of water, which gives the fraction, $1-p$, of the unreacted water during initial stage of hydration reaction in the cement paste. Furthermore, RCM gives also the average relaxation time $\langle\tau\rangle$, the self-diffusion constant D and the stretch exponent β of the relaxation function of hydration water. These parameters allow us to assess the average pore size and the pore size distribution inside a cement paste and their variations during the kinetic evolution of the hydration reaction.

References

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