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主　論　文　の　要　旨

論文題目 Creep mechanism of calcium-silicate-hydrate and physical property change of hardened cement paste under drying conditions

(乾燥下におけるカルシウムシリケート水和物のクリープメカニズムとセメントペーストの物性変化)

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論 文 内 容 の 要 旨

Concrete structure is a social symbol that shows the growth of civilization of humanity for responding to the basic needs in residence, industry, public health until fine art. Since it expressed materially both stability and strength. In fact, concrete has an invisible change and deteriorates according to the service life, usage condition, and environment. For these reasons, the main interest of the thesis is the microstructural alteration of cement paste under different drying conditions. The presence of calcium-silicate-hydrate (C-S-H), which is the main binding phase in cement paste, primarily induces the microstructural change due to the expression of colloidal features. The sophistication of the mechanism behind the alteration at nanoscale links to the physical properties and creep behavior at a macroscopic scale. The results presented in this thesis show the effect of varying relative humidity, water-to-cement ratios, and cement type on the creep properties of hardened cement paste as determined by microindentation and the physical properties evaluated by bending test. XRD/Rietveld analysis and sorption measurements were used to characterize the tested cement paste samples.

For creep behavior of C-S-H, multi-scale analysis was applied to downscale the creep properties of the cement paste to that of the C-S-H gel. When the drying relative humidity decreases, the specific surface area decreases whereas the bulk modulus of the C-S-H gel increases. This increase of creep modulus may be explained by the sliding of C-S-H sheets as lubricated by water molecules. Drying reduces the specific surface area, resulting in increased difficulty in the sliding of C-S-H sheets; hence, the creep modulus increases. The C-S-H sheets slide easily over the critical thickness of the water molecules (1 nm) where a change of thickness of adsorbed water does not affect the creep modulus. For water thicknesses below 1 nm, the sliding becomes difficult. Our results are supported by the results from a local microscopic relaxation model and the atomistic simulation taken from literature.

For physical property change, the re-organization of C-S-H induces the agglomeration under drying condition. When the water evaporates from cement paste, the small pores below 15 nm gradually disappear and concurrently generate the large pores. The bending strength decreases due to stress concentration around the large capillary pores. At 40% relative humidity, the maximum volume of large capillary pores affects the minimum bending strength for the higher water-to-cement ratio samples. The increase of solid gel space ratio and surface energy enhance the bending strength especially at strong drying state. Moreover, this mechanism can extent to all type of cement paste for assessment the bending strength change.