Theoretical Study on Rheological Properties of Fresh Concrete

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In this fundamental study for realizing numerical flow simulation-based workability design of concrete, the award winner firstly proposed a micrometric approach to rheological performances of fresh concrete. This approach treats fresh concrete as a particle assembly containing water, and deduces its shear deformation from the particle movements.

Next, the relationship between particle assembly's shear deformation and particle movements was formulated by geometric analysis, the formulation of the amount of active cement particles, of which inter-particle forces are greater than the inter-particle resistances except viscous resistance, was obtained by probability analyses, the occurring rate of moving cement particles from the active particles was clarified by applying the Eyring rate process theory in consideration of frictional and fabric resistances, and the granular characteristics of fresh concrete, such as contact angles and moving distances of the particles under different stress levels, were investigated by X-ray Imaging and Laser-Aided Tomography.

Then this micrometric approach was used to formulate the constitutive laws (stress-strain/ strain rate-time-temperature relationships) and shear failure limit stress of fresh concrete in static state by accumulating the micrometric behaviors of the particles, which can describe the shear deformation characteristics: non-linear, vertical pressure -dependent, and thixotropic, etc. And a rheometer was further developed for the measurement of the parameters in the constitutive laws.

The award winner also proposed a prediction model of shear resistance growth caused by boundary restraint and a bleeding model for fresh concrete through theoretical analyses, and developed a test method of aggregate particle geometry in this study.