MULTISCALE CONTINUUM MECHANICS OF CEMENTITIOUS MATERIALS: CREEP AND STRENGTH

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ABSTRACT

Cementitious materials are hierarchically organized, microheterogeneous media, i.e. characteristic heterogeneities are found at different microscopic scales of observation. Because of hydration, the microstructure of cementitious materials undergoes a continuous transformation, and this renders the mechanical behavior of cement pastes, mortars, and concretes strongly dependent on their initial composition and on their maturity, i.e. on the initial water-to-cement mass ratio and the initial aggregate-to-cement mass ratio, as well as on the degree of hydration which is equal to zero at the time of mixing, and which attains the value one once all available clinker has been consumed by the hydration reaction. This provides the motivation for employing continuum micromechanics approaches, aiming at estimation of the macroscopic behavior of representative volumes of cementitious materials. This estimation is based on the knowledge of microscopic properties including (i) the intrinsic mechanical behavior of quasi-homogeneous material phases such as unhydrated clinker, water, hydration products, air, and aggregates, (ii) their dosages (volume fractions), (iii) their characteristic phase shapes, and (iv) their mutual interaction. Herein, we recall multiscale continuum mechanics models for aging creep [1] and strength [2] of cementitious materials. The creep model makes use of the fact that hydrates are the only creeping constituent of concrete [3] and that they exhibit deviatoric (volume preserving) creep only [4]. The strength model envisions that the microstructure of cementitious materials remains essentially intact as long as deviatoric higher-order stress averages of hydrates ("hydrate stress peaks") remain below a deviatoric hydrate strength value, and that reaching the microscopic strength of hydrates refers to the ultimate load bearable by the overall material. Comparing model predictions with experimental data from classical macroscopic material testing allows for quantitative model validation.

Keywords
Continuum micromechanics, hypothesis testing, deviatoric creep of hydrates, elasto-brittle strength of hydrates.

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