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Refined Multi-scale Damage Model for Cement Paste

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This paper focuses on development of multi-scale micromechanical damage model for the prediction of early-age strength of cement pastes. The model is based in four-level hierarchical model originally introduced in [1], which starts at nano-scale focusing on Calcium-Silicate-Hydrate (C-S-H) gel and, gradually introducing capillar porosity and clinker grains, goes up with the scale to cement paste with entrapped air.

Refined three-scale version of the model supplied with more realistic data on strength of C-S-H globules, based on atomistic simulations, predicted tensile strength of C-S-H gel to be approximately 250 MPa for the low-density packing and 500 MPa for the high-density packing. These results are in very good agreement with recently performed micro-bending tests on cantilevers using nanoindentation [3], where authors reported tensile strength of C-S-H gel in the range $264 - 700$ MPa. However, further upscaling overestimates the tensile strength at the cement paste level, which indicates absence of some fundamental mechanism or lack of description of some crucial phenomena in the model. Qualified guess based on [4] would suggest presence of additional defects, such as micro-cracks, in the micro-structure at a cement paste level (Althogh the physical origin of microcracks is still unclear and can rise from different phenomena, for instance hydration, autogeneous shrinkage or from the heterogenity of microstructure). Incorporation of such cracks is next logical step in order to refine the multi-scale model predicting abilities and the obtained results will be presented in front of the audience.

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