A Micromechanical Model for the Effective Elastic Properties of Hardened Cement Paste

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The elastic properties of hardened cement paste are very important for many applications. Usually they are obtained by considering cement paste as continuum. However, fundamentally cement paste is a composite medium. And considering its constituent macro and micro pores, it can also be regarded as a porous medium. A micromechanical model based on the theories of micromechanics and poromechanics [1] is proposed.

The components of hardened cement paste, depending on the availability of water during its hardening history (water cement ratio), may include hydrated product (formed mainly by C-S-H and CH), pores of different sizes, pore water, and anhydrous cement particles. In the proposed model, all the possible constituents of hardened cement paste are considered. Anhydrous cement is considered to exist, and is assumed to be surrounded by hydrated products, i.e., the anhydrous cement serves as the core of the cement paste skeleton and the hydrated products form the shell around it.

Using different length scales, four levels of composite media can be identified for cement paste. Starting from the largest scale, these four levels are cement paste (Level III), cement skeleton (Level II), hydrated product (Level I) and C-S-H matrix (Level 0). In the proposed model, C-S-H matrix is treated similar to CH or clinkers as one medium, but with drained or undrained elastic moduli. Therefore, only three levels of composite media exist in the proposed model. The effective moduli of elasticity of lower level are used as the input of the next level, treating the lower level composite as one effective medium. Mori-Tanaka scheme [2] is used both in Level I and Level III, and the self-consistent model [3] is used to describe the effective elastic properties of Level II. The intrinsic elastic properties of the constituent components that reported in literatures are used as input for the proposed model.

The proposed model was verified using available experimental results on cement pastes.

References

[1] O. Coussy, *Poromechanics*, John Wiley & Sons, New York, 2004.

[2] T. Mori and K. Tanaka, " Average stress in matrix and average elastic energy of materials with misfitting inclusions," *Acta Metall.* **21**, 571–574, 1973.

[3] R.M. Christensen, *Mechanics of Composite Materials*, John Wiley & Sons, New York, 1979.

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