21st International Conference **ENGINEERING MECHANICS 2015**
Svratka, Czech Republic, May 11 –14, 2015
Paper **#092**, **pp. 148–149**

Modelling of Moisture Transport Influenced by Damage in Concrete Structures

Tomáš Koudelka[a], Jaroslav Kruis[b]

Faculty of Civil Engineering of Czech Technical University in Prague,
Thákurova 7, Praha 6, 16629, Czech Republic

[a]koudelka@cml.fsv.cvut.cz, [b]jk@cml.fsv.cvut.cz

Keywords: damage, moisture transport, coupled problems, concrete

Abstract: The paper describes model of the moisture transport in concrete material where the permeability is influenced by the crack opening which is determined by the scalar isotropic damage model. These models are used for the simluation fourpoint shear test coupled with moisture transport and simulation of storage tank.

Extended abstract

The paper deals with the fully coupled heat and moisture transport in heterogeneous quasi-brittle materials such as concrete. Generally, the mechanical behaviour of concrete material is nonlinear and it is different in tension and compression. Due to applied load, void nucleation and crack growing appear in the original solid skeleton which lead to changes in porosity and reduction of Young's modulus. There are two main approaches for the description of the crack growing - damage or fracture mechanics. In this contribution, the damage mechanics [1] is used for the description of mechanical behaviour because we assume materials and structures in serviceability states rather than the limit state. Therefore, the concept of smeared cracks is more suitable and it can be relatively easily connected with transport processes. The scalar isotropic damage model was used in this paper due to its simplicity and because the initial transport properties are assumed to be also isotropic.

The heat and moisture transfer is modelled by the Kunzel's model [2]. Two unknowns are introduced in the model, relative humidity and temperature. The model divides overhygroscopic region into two subranges - capillary water region and supersaturated region, where different conditions for water and water vapor transport are considered. For the description of simultaneous water and water vapor transport, the relative humidity is chosen as the only moisture potential for both hygroscopic and overhygroscopic range. This model uses certain simplifications but nevertheless, the model describes all substantial phenomena and the predicted results comply well with experimentally obtained data, which is the main advantage of the model. Also determination of the material properties can be obtained quickly from the common laboratory tests. Contrary to that advantages, the model suffers by numerical difficulties in the case the relative humidity approaches the fully saturated state. The sorption isotherm is nearly vertical and its derivatives are extremely high.

It is usually assumed that the mechanical behaviour is influenced by the heat and moisture transport (temperature and water content are used for determinantion of strains) while the description of transport processes is usually not affected by the mechanical models. In the case of damage evolution, the damage growth increases the porosity which results in faster moisture transport and therefore this phenomena should be taken into account. If the damage parameter is relatively small (smaller than 0.1), the transport process is affected moderately and it can be described by explicit formula for the permeability. If the damage parameter is close to one, material is severely damaged and transport resembles convection described by the Hagen-Poiseuille law [3]. For the intermediate cases of the damage state, the permeability can be obtained by interpolation. This numerical approach is tested on examples of four-point shear test and numerical simulation of a storage tank that were computed by SIFEL [4] with help of the above implemented models.

The following figures Fig. 1 and Fig. 2 depict the distribution of damage parameter ω and volumetric moisture content w in the case of four-point shear test of concrete specimen saturated from the bottom surface by water.

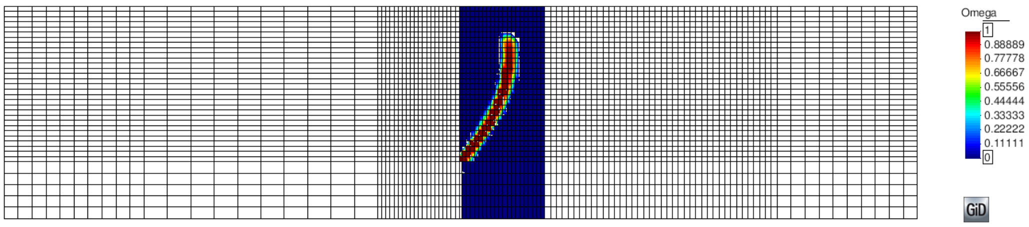

Fig. 1: Four-point-shear problem: distribution of the damage parameter ω.

As the evolved damage parameter (as seen in Fig 1) influences the permeability, distribution of the volumetric moisture content differs from an undamaged state and a strip with higher moisture content can be seen in Fig. 2.

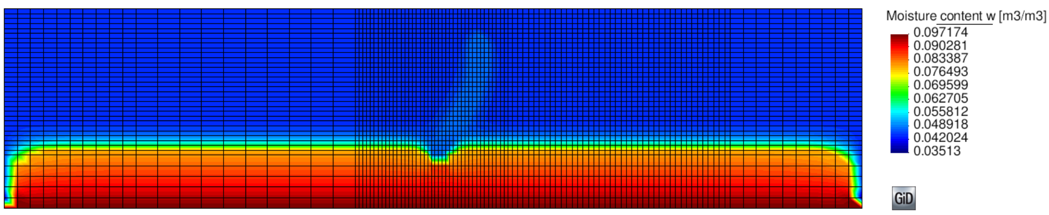

Fig. 2: Four-point-shear problem: distribution of the volumetric moisture content w.

Acknowledgement: This paper was supported by project No. 13-18652S of Grant Agency of Czech Republic which is highly appreciated.

References

[1] J. Lemaitre, J.L. Chaboche, Mechanics of solid materials(Cambridge University Press, Cambridge, UK 1994).

[2] H.M. Kunzel, Simultaneous Heat and Moisture Transport in Building Components (Fraunhofer Institute of Building Physics, Fraunhofer IRB Verlag Stuttgart 1995).

[3] G. Pijaudier-Cabot, F. Dufour, M. Choinska, Multiscale Modeling of Heterogenous Materials: From Microstructure to Macro-scale Properties, Wiley, (2010) p. 277-292

[4] Open source software package SIFEL http://mech.fsv.cvut.cz/šifel/