Summary: A coupled model for the prediction of damage under hygro-mechanical loading is developed. The model combines a mechanical and a moisture transport model within a poromechanical framework. Damage is incorporated by embedded displacement discontinuities, allowing an accurate prediction of the crack path within a coarse finite element mesh. To simulate the preferential wetting around a crack, a discrete front tracking method to predict the fluid transport through cracks is incorporated in a continuous moisture transport model. The computational features and capabilities of the coupled model and the effects of moisture on dimensional stability, crack opening evolution and cracking behaviour are illustrated with different examples of combined mechanical and moisture loading during three point bending tests on a fictitious sandstone.

MSC:

76S05 Flows in porous media; filtration; seepage

Cited in **4** Documents

Keywords:

poromechanical; moisture transport; partition-of-unity; discrete model; fracture flow

Full Text: DOI

References:

[1] Baggio, P.; Majorana, C.E.; Schrefler, B.A., Thermo-hygro-mechanical analysis of concrete, J. engng. mech. (ASCE), 126, 223-242, (2000)

[2] Bazant, Z.P.; Prat, P.C., Effect of temperature and humidity on fracture energy of concrete, ACI mater. J., 85, 262-271, (1988)

[3] Bear, J.; Bachmat, Y., Introduction to modelling of transport phenomena in porous media, (1975), Kluwer Academic Publishers Dordrecht

[4] Bear, J.; Tsang, C.-F.; de Marsily, G., Flow and contaminant transport phenomena in porous media, (1993), Academic Press Inc.

[5] Belytschko, T.; Black, T., Elastic crack growth in finite elements with minimal remeshing, Int. J. numer. meth. engng., 45, 601-620, (1999) · Zbl 0943.74061

[6] Carmeliet, J.; Delerue, J.F.; Vandersteen, K.; Roels, S., Three-dimensional liquid transport in concrete cracks, Int. J. numer. anal. meth. geomech., 28, 671-687, (2004) · Zbl 1112.74486

[7] Carmeliet, J.; Van Den Abeele, K.E.A., Poromechanical approach describing the moisture influence on the non-linear quasi-static and dynamic behaviour of porous building materials, Mater. struct., 37, 271-280, (2004)

[8] Coussy, O., Mechanics of porous continua, (1995), John Wiley \& Sons Chichester

[9] Coussy, O.; Eymard, R.; Lassabatère, T., Constitutive modelling of unsaturated drying deformable materials, J. engng. mech., 658-667, (1998)

[10] K. De Proft, A combined experimental computational study to discrete fracture of brittle materials, Ph.D. dissertation, Vrije Universiteit Brussel, 2003.

[11] Durner, W., Hydraulic conductivity estimations for soils with heterogeneous pore structure, Water resour. res., 30, 211-223, (1994)

[12] Dverstorp, B.; Andersson, J.; Nordqvist, W., Discrete fracture network interpretation of field tracer migration in sparsely fractured rock, Water resour. res., 28, 9, 2327-2343, (1992)

[13] S. Grasberger, G. Meschke, Numerical simulation of coupled thermo-hygro-mechanical processes within concrete, in: 6th International Conference on Creep, Shrinkage and Durability of Concrete and Other Quasi-Brittle Materials (Concreep 6), Cambridge, USA, 2001. · Zbl 0980.74507

[14] Hvistendahl Karlsen, K.; Lie, K.A.; Risebro, N.H.; Froyen, J., A front-tracking approach to a two-phase fluid flow model with capillary forces, In situ, 22, 1, 59-89, (1998)

[15] Lewis, R.W.; Schrefler, B.A., The finite element method in the static and dynamic deformation and consolidation of porous

media, (1998), John Wiley \& Sons Chichester · Zbl 0935.74004

[16] Moës, N.; Dolbow, J.; Belytschko, T., A finite element method for crack growth without remeshing, Int. J. numer. meth. engng., 46, 131-150, (1999) · Zbl 0955.74066

[17] Murphy, J.R.; Thomson, N.R., Two-phase flow in a variable aperture fracture, Water resour. res., 29, 10, 3453-3476, (1993)

[18] Nordqvist, A.W.; Tsang, Y.W.; Tsang, C.F.; Dverstorp, B.; Andersson, J., A variable aperture fracture network model for flow and transport in fractured rocks, Water resour. res., 28, 6, 1703-1713, (1992)

[19] Roels, S.; Carmeliet, J.; Hens, H., Mesh adaptive finite element formulation for moisture transfer in materials with a critical moisture content, Int. J. numer. meth. engng., 46, 1001-1016, (1999) · Zbl 0968.76046

[20] Roels, S.; Elsen, J.; Carmeliet, J.; Hens, H., Characterisation of pore structure by combining Mercury porosimetry and micrography, Mater. struct., 34, 76-82, (2001)

[21] Roels, S.; Vandersteen, K.; Carmeliet, J., Measuring and simulating moisture uptake in a fractured porous medium, Adv. water resour., 26, 237-246, (2003)

[22] Therrien, R.; Sudicky, E.A., Three-dimensional analysis of variably-saturated flow and solute transport in discretely-fractured porous media, J. contam. hydrol., 23, 1-44, (1996)

[23] Ulm, F.-J.; Torrenti, J.-M.; Adenot, F., Chemo-poroplasticity of calcium leaching in concrete, J. engng. mech. (ASCE), 125, 1200-1211, (1999)

[24] Wells, G.N.; Sluys, L.J., A new method for modelling cohesive cracks using finite elements, Int. J. numer. meth. engng., 50, 2667-2682, (2001) · Zbl 1013.74074

[25] Whitaker, S., Simultaneous heat, mass and momentum transfer in porous media: a theory of drying porous media, Adv. heat transfer, 119-203, (1977)