XVIII International Conference on Water Resources
CMWR 2010
J. Carrera (Ed)
CIMNE, Barcelona 2010

A MODIFIED MASS LUMPING PROCEDURE FOR THE MIXED HYBRID FINITE ELEMENT METHOD APPLIED TO UNSATURATED WATER FLOW MODELLING

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Summary. Mixed Hybrid Finite Elements (MHFE) are a numerical method becoming more and more popular in Geosciences. The method allows a simultaneous approximation of both pressure head and velocity and can handle general irregular grids with highly heterogeneous permeability. However, the MHFE solution may exhibit solution with unphysical oscillations because of the non respect of the discrete maximum principle. Consequently, when dealing with unsaturated water flow and because of the nonlinearity of the problem, the calculations are strongly exposed to convergence problems, especially in the case of infiltration of sharp wetting fronts in dry soils. A technique commonly used in finite element methods is the so-called mass lumping.

A recent mass lumping procedure, suitable for various shapes of 2D elements, was developed by Belfort et al. [2009] without resorting to any numerical integration. The basic idea of this procedure is 1- to calculate steady-state fluxes by using the classical MHFE method, 2- to add the accumulation and sink/source terms directly on the edges. In this procedure, the MHFE method is seen as a nonconforming finite element method.

This procedure allows to reduce the unphysical oscillations in many cases. However, when applied for distorted elements and/or anisotropic domains, the obtained solution is still exposed to strong unphysical oscillations and to convergence difficulties. To avoid this problem, we propose in this work a new procedure that takes into account the anisotropy and the shape of the element during the mass distribution of the accumulation and sink/source terms at edges.

Several 2D numerical experiments in homogeneous and heterogeneous porous media are provided to illustrate the benefits of this procedure.