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

MODELING AND UPSCALING UNSATURATED FLOW THROUGH RANDOMLY HETEROGENEOUS SOILS

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Summary. Unsaturated steady flow through randomly heterogeneous soils is simulated numerically, analyzed and upscaled. Spatially distributed sets of unsaturated soil parameters are generated using a turning band random field generator. Numerical simulations are conducted for each single realization of random parameters set. The main focus is on analyzing global hydraulic behaviour at sample scale, and in particular, the upscaled 'effective' conductivity Kii(<h>) versus mean pressure <h> along horizontal and vertical directions. The results obtained along these lines in *Veena S. Soraganvi 2005* (Chapter 6: Ph.D. thesis, IISci. Bangalore, India) are here synthesized and re-interpreted.

At local scale, we use mostly the exponential conductivity curve of Gardner, with two cross-correlated and spatially correlated random fields: scale factor β (m^{-1}), and saturated conductivity K_S (m/s). The numerical flow fields are analysed to explore the global effects of local variability and spatial structure (layering, imperfect layers, isotropic heterogeneity).

The β parameter is a pore size distribution parameter, whose inverse represents a capillary length scale ($1/\beta = \lambda_{CAP}$). This scale is compared to layer thickness or correlation length (λ_Z). Cases $\beta\lambda_Z \sim 1$, $\beta\lambda_Z < 1$, $\beta\lambda_Z > 1$ are explored.

It is found that perfectly stratified unsaturated soils can behave like saturated media, with arithmetically averaged K(h) in parallel flow, and harmonically averaged K(h) in perpendicular flow; however in some cases, depending on flow regime and layer thickness, this 'classical' behaviour does not hold. This is analyzed and explained in relation to linearized spectral perturbation results in the literature (*T.C.-J. Yeh et al.*). Furthermore, it is shown that the behavior of effective unsaturated conductivity can be captured parametrically via a probabilistic '*power average model*', where the product $\beta\lambda_Z$ plays a direct role (*R. Ababou et al.*). The latter model is also compared to linearized spectral perturbation theory. Finally, extension to *Van Genuchten* local conductivity curves is also discussed and implemented.