MULTIPLE FLOW OF WATER, WATER VAPOR, NAPL, NAPL VAPOUR, AIR AND HEAT IN A SOIL PROFILE

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Summary, keywords

The paper presents a new software module called POLLUT_TRANSPORT for multiphase flow analysis in unsaturated and saturated soils. The analysed system may include: water and water vapour flow, Non-Aqueous Phase Liquid (NAPL) and NAPL vapour flow, (NAPL stands for fluid akin toluene, petrol etc.), dry air flow and heat flow. The last flow is considered because some properties of fluid are highly dependent on temperature. It applies particularly to volatile NAPLs.

Multiphase flow, airflow, heat flow, NAPL, numerical solutions, software

Souhrn, klíčová slova

Práce prezentuje nový softwarový modul, nazvaný POLLUT_TRANSPORT pro vícefázové proudění v nasycené a nenasycené půdě. Řešený systém může zahrnovat vodu, její páry,NAPL a jeho páry (NAPL jsou látky nerozpustné ve vodě a nemísitelné s vodou, např. toluen, petrolej a další), dále transport vzduchu a tepla. Transport tepla je zahrnut proto, že některé vlastnosti tekutin jsou silně závislé na teplotě. To je zvláště důležité pro těkavé NAPL látky.

Vícefázové proudění, proudění vzduchu, proudění tepla, NAPL, numerické řešení, software

Introduction

The process of development of such a software module involves the three main steps (Jendele et al. 2002): 1. Development of a theoretical model,

2. Development of a procedure for its numerical solution and,

3. Development of a tool for its practical application

Although the paper briefly presents governing equations, its main interest is focussed towards numerical solution procedure and its computer implementation. Some of these topics bring novel techniques:

The software module uses so-called Primary Variable Switching Scheme (PVSS), which is extended to multiphase flow conditions. The method is built on the Mixed formulation (Celia et al. 1990, Celia, Binning, 1992). Although the problem state variables volumetric fluid contents θ, hydraulic capillary pressure heads ψ, temperature T and gas pressure p are not mutually independent, for corrector phase of the solution they are used directly. It supports numerical stability and accuracy of the solution. On the other hand, for the predictor phase either ψ or θ has to be eliminated using constitutive equations. The choice of which of them retain and which are eliminated depends on current total saturation at the particular location. For low level of saturation, θ is retained and ψ eliminated, whilst for saturated soil clearly it must be the other way around. The paper presents most details of the PVSS, including solution of some peculiarities inherent to the dynamic switching between θ and ψ primary variables.

From programmer's point of view, the software module POLLUT_TRANSPORT is also interesting. It is built within ATENA ("Advanced Tool for Non-Linear Engineering Analysis" system recently developed by Cervenka Consulting, Prague, Cervenka et al. (2000)). The novelty of the adopted architecture is that the ATENA Kernel serves as a generic Final Element Module (FEM), or in words of programmers as a set of hierarchically created dynamically linked libraries that provide most services needed for any FEM analysis akin equation solver, database for FEM topology etc. It includes also support for pre and post-processing. On the other hand, an analysis's specific features are coded in a specific engineering module. Good example of such a module is the present module POLLUT_TRANSPORT. This architecture clearly saves a lot of programmer's development effort. The result is higher quality and effectiveness of the resulting FE software. Also, as all engineering modules in ATENA use the same pre- and post-processors, i.e. the same graphic user interface, their mastering is significantly simpler.

References

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