

Water Flow Problem in Discrete Fracture Network – Algebraic Multigrid vs. Simplification of the Fracture Network

P. Rálek, J. Březina, J. Kopal, M. Hokr

This contribution deals with potential groundwater flow modelling in fractured rock. As the test problem, we used 2D stochastically generated discrete fracture network, which consists of 7797 fractures divided to 60052 segments, with large variation between largest and smallest segments. For the numerical solution, the mixed-hybrid finite element method implemented in code FLOW123D (developed at the Technical University of Liberec) was used. The discretized problem is large and numerically instable.

The first approach to improve the numerical stability of the discretized problem was the simplification of the fracture network. The fact, that the hydraulic conductivity of the fractures strongly depends on their lengths, guides to the idea of changing insignificant fractures so that it simplifies the whole fracture network. The algorithm combines deleting of small fractures, union of near intersection nodes and union of those fractures, which became (partly) identical. The originated fracture network, according optional reduction parameters, can more or less be geometrically similar to the original one, but still preserves the hydraulic behavior of the original fracture network and has better properties (e.g. disposes the small segments lying between very near intersections).

The other approach for the decrease of the computational size of the problem was algebraic multigrid preconditioning used to the discretization of the original fracture network. For the multigrid preconditioning, we used its implementation in PETSc package, which is nowadays a part of FLOW123D code.

These two approaches were used at several cases with different levels of fracture simplification or preconditioning. The contribution presents the influence of both approaches to the solution of the flow problem.