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Fully Coupled Porous Media Model

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Abstract : This work focuses on the development and implementation of a fully implicit-implicit, coupled mechanical deformation and porous flow, finite element software tool. The fully implicit software accurately predicts classical fundamental analytical solutions such as the Terzaghi consolidation problem. Furthermore, it can capture other analytical solutions less well known in the literature, such as Gibson's sedimentation rate problem and Coussy's problems investigating wellbore stability for poroelastic rocks. The mechanical volume strains are transferred to the porous flow governing equation in an implicit framework. This will overcome some of the many current industrial issues, which use explicit solvers for the mechanical governing equations and only implicit solvers on the porous flow side. This can potentially lead to instability and non-convergence issues in the coupled system, plus giving results with an accountable degree of error. The specification of a fully monolithic implicit-implicit coupled porous media code sees the solution of both seepage-mechanical equations in one matrix system, under a unified time-stepping scheme, which makes the problem definition much easier. When using an explicit solver, additional input such as the damping coefficient and mass scaling factor is required, which are circumvented with a fully implicit solution. Further, improved accuracy is achieved as the solution is not dependent on predictor-corrector methods for the pore fluid pressure solution, but at the potential cost of reduced stability. In testing of this fully monolithic porous media code, there is the comparison of the fully implicit coupled scheme against an existing staggered explicit-implicit coupled scheme solution across a range of geotechnical problems. These cases include 1) Biot coefficient calculation, 2) consolidation theory with Terzaghi analytical solution, 3) sedimentation theory with Gibson analytical solution, and 4) Coussy well-bore poroelastic analytical solutions.

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