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High-order ADE solution for the fluid diffusion equation and application in coupled hydro-mechanical simulation

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To improve the stability and efficiency of explicit techniques, one proposed method is to use an unconditionally stable alternating direction explicit (ADE) scheme. However, the standard ADE scheme is only moderately accurate and restricted to uniform grids. This paper develops a novel high-order ADE scheme capable of solving the fluid diffusion equation applicable for non-uniform grids. The new scheme is derived by performing a fourth-order finite difference approximation to the spatial derivatives of the diffusion equation in non-uniform grid. The implicit Crank-Nicolson technique is then applied to the resulting approximation, and the subsequent equation is split into two alternating direction sweeps, giving rise to a new high-order ADE scheme. Because the new scheme can be potentially applied in coupled hydro-mechanical (H-M) simulation, the pore pressure solutions from the new scheme are then sequentially coupled with an existing geomechanical simulator in the computer program FLAC. This coupling procedure is called the sequentially-explicit coupling technique based on the fourth-order ADE scheme (SEA-4). Verifications of well-known consolidation problems showed that the new ADE scheme and SEA-4 can reduce computer runtime by 46–75% to that of FLAC's basic scheme. At the same time, the techniques still maintained average percentage error of 1.6–3.5% for pore pressure and 0.2–1.5% for displacement solutions and were still accurate under typical grid non-uniformities. This result suggests that the new high-order ADE scheme can provide an efficient explicit technique for solving the flow equation of a coupled H-M problem, which will be beneficial for large-scale and long-term H-M problems in geoengineering.

Time Block Preference

Time Block C (18:00-21:00 CET)

References

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