DUAL VARIABLE APPROACH FOR MIXED-HYBRID FINITE ELEMENT APPROXIMATION OF THE POTENTIAL FLUID FLOW PROBLEM

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Mixed-hybrid finite element discretization of the Darcy's law and the continuity equation that describe the potential fluid flow problem in porous media leads to symmetric but indefinite linear systems for the velocity and pressure vector components. It is known that due to this particular block structure of our application the primal approach based on a partial elimination of the velocity and certain pressure unknowns leading to sparse Schur complement systems is a very efficient technique. The second efficient alternative is an approach based on the explicit construction of a null-space basis of a part of the off diagonal block and on the subsequent iterative solution of a system projected onto this null-space. We will show that such approach corresponds actually to an algebraic reconstruction of the system matrix which comes from an entire mixed approximation without explicit formulation of underlying mixed finite element setting. Moreover, the analysis indicates that the null-space basis corresponding to a block of Lagrange multipliers can be constructed orthogonal and very sparse. In this contribution we compare the computational efficiency of elimination of either primal or dual variables and subsequent iterative solution of resulting Schur complement or projected systems. Since the asymptotic convergence factor of both primal and dual approaches depends linearly on the mesh size parameter, we performed computational experiments on real-world problems and report a comparison of numerical results which includes not only the cost of iterative part but also the overhead of initial transformation and back substitution processes. This comparison indicates that dual variable approach can be superior to primal approach for problems with ill-conditioned hydraulic permeability tensor. This work was supported by the project 1ET400300415 within the National Program of Research Information Society.

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