# COUPLING OF SGBEM AND FEM FOR MODELING STEADY-STATE FLOW IN ANISOTROPIC POROUS MEDIA CONTAINING IMPERMEABLE SURFACES

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Modeling of physical phenomena associated with fluid flow within reservoirs is a subject of interest and has been computationally challenging for several decades. Understanding these complex situations is important for optimum design, control and management of reservoir production. As a result of the complexity involved (e.g. nonlinearity, inhomogeneity, and anisotropy of data associated with the problem), a mathematical model corresponding to this boundary value problem is complicated and a numerical procedures which has a capability to perform comprehensive analysis is then required. In this study, attention is restricted to steady-state, single phase flow in a porous medium which contains impermeable surfaces. Results from this study may provide understanding and insight into certain real problems, e.g. flow in a porous reservoir containing seals.

In this paper we present a computational technique for modeling steady-state, Darcy's flow in a generally anisotropic porous medium containing impermeable surfaces. The technique employs a weakly-singular, symmetric Galerkin boundary element method (SGBEM) to model flow within a (local and homogeneous) region containing the impermeable surface while employs the standard Galerkin finite element method (FEM) to treat flow in the remaining (possibly complex and non-homogenous) region. The SGBEM is based on a pair of weakly-singular, weak-form fluid pressure and fluid flux integral equations which contain only weakly-singular kernels of order $1/r$ and are applicable to isotropic and generally anisotropic permeability [1,2]. The two methods are then properly coupled to obtain a final formulation which is in a symmetric form.

In the numerical implementation, both conforming and nonconforming discretization of the interface of the two regions are treated; the latter feature significantly reduces effort in mesh construction. Other important features of the technique are: 1) standard $C^o$ elements can be employed everywhere to discretize the SGBEM region since the method is based on the weakly-singular formulation; 2) special tip elements are used along the boundary of the impermeable surface to accurately capture asymptotic behavior of the jump of fluid pressure; and 3) the formulation produces a symmetric system of algebraic equations for both conforming and nonconforming cases. To demonstrate the accuracy and capability of the method, several numerical examples are solved.

**References**

[1] J. Rungamornrat and M.F. Wheeler, "Weakly-singular integral equations for steady-state flow in isotropic porous media," Technical report: ICES report 05-30, The University of Texas at Austin, June 2005.
[2] J. Rungamornrat and M.F. Wheeler, "Weakly-singular integral equations for Darcy's flow in anisotropic porous media," Submitted to *Engineering Analysis with Boundary Elements*, August 2005.

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