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**Hengguang Li, Anna Mazzucato and Victor Nistor\***, Mathematics Department, McAllister Bldg., University Park, PA 16802. *Analysis of transmission and mixed boundary value problems with applications to the Finite Element Method.*

We study theoretical and practical issues in the Finite Element Method for a strongly elliptic second order equation with jump discontinuities in its coefficients on a polygonal domain  $\Omega$  with cracks. More precisely, we consider the equation  $-\operatorname{div}(A\nabla u) = f \in H^{m-1}(\Omega)$  with mixed boundary conditions, where the matrix  $A$  has variable, piecewise smooth coefficients. We establish regularity and Fredholm results. When the interface is smooth and no two adjacent edges have natural boundary conditions, we also establish well-posedness in weighted Sobolev spaces. In general, we obtain well-posedness in an augmented space Sobolev space. The theoretical analysis yields interpolation estimates that are then used to construct improved graded meshes recovering the (quasi-)optimal rate of convergence for piecewise polynomials of degree  $m \geq 1$ . We present several numerical tests. (Received February 15, 2010)