

Modeling natural convection in random porous media¹

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In this work, we consider natural convection in flow saturated heterogeneous porous media with random porosity. We treat the porosity as a random field and solve this problem using the stochastic finite element method. A stabilized stochastic finite element second-order projection method, which is based on a pressure gradient projection, is developed to solve the stochastic Navier-Stokes equations. This method is an improvement on the previously developed first-order projection method to reflect the porosity dependence of the pressure gradient term in the governing equation and eliminate the pressure instability when using the finite element method. The random porosity is modeled as a Gaussian random field using the Karhunen-Loeve expansion, whose correlation function is extracted from the image of a realistic random porous medium. The nonlinear function of the random porosity is projected onto the polynomial chaos basis using a non-intrusive approach. The numerical results are compared with those obtained from a sparse grid collocation approach and the Monte-Carlo method. Excellent agreement between these results indicates the effectiveness of the proposed methodology.

¹ Presented at the 9th National Congress on Computational Mechanics, San Francisco, CA, July 22-26, 2007 ("Computational aspects of the Stochastic Finite Element Method ", Organizers: Manolis Papadrakakis, Vissarion Papadopoulos and Dimos C. Charmpis).