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The application of first-order second-moment method to quantify the uncertainty of poroelastic problems

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Poroelastic theory is a conscientious theory that it considers the coupled relationship between deformation and excess pore water pressure in soil body under stress. Although the theory has applied widely in different fields such as geomechanics, biomechanics, the scarcity of field data and strong variation of material property limit the usage of the theory. We developed stochastic poroelastic model using displacements and excess pore water pressure as the variables to investigate the coupled behavior between soil and water in heterogeneous media. First-order-second-moment (FOSM) method was applied and the log normal hydraulic conductivity is treated as the only random variable in this study. Mean and perturbation equations are derived, respectively, to investigate the statistical moments of variables. The results of FOSM are validated by those of Monte Carlo (MC) simulation. A one-dimensional column was used as an example to illustrate the results. Hydraulic conductivity and excess pore pressure are found to be proportional in the upper part of the column and inversely proportional in the lower part at early time when drained condition was set at upper boundary. The results of covariance functions between the two stochastic approaches show similar patterns in spite of the magnitudes are not exact the same. While the MC approach is suffered by the accumulated numerical error and uncertainty of statistical model, the FOSM approach takes much less cumbrous calculation and computer resources. The FOSM approach performs efficiently to explore the statistical moments of a coupled soil-water system.