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# Analyze of 3D fluid driven crack in saturated porous media under P- and S-waves by hybrid hypersingular integral method

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Strong earthquakes can have catastrophic effects on society, and therefore the precise prediction of large earthquakes is crucial for seismic hazard reduction. The genesis and occurrence of earthquakes and their subsequent effects involve complex physical processes. Studying these processes helps us understand the mechanics of earthquakes and the future physical state of the earth. Earthquake studies focus on the nucleation of rupture, thermo- and hydro-mechanical weakening of fault zones during seismic slip, fracture propagation through branched and offset fault systems, and relations between stress, seismicity, and deformation in or near continental and subduction fault systems.

Fluid driven fracture is a fundamental geophysical phenomenon operating in planetary interiors on many scales; it plays a major role in chemical differentiation of the upper mantle and dynamic delayed triggering of earthquakes process. Because our ability to make direct observation of the dynamics and styles of fluid driven fracture is quite limited, our understanding of this phenomenon relies on theoretical models that use fundamental physical principles and available field data to constrain the behavior of fluid driven cracks at depth.

However, relatively little work has been done on 3D extended fluid driven crack propagation. This seems to be due mainly to the present limitations on practical methods (such as CPU time and storage requirements) and on theoretical aspects (strongly singular domain integrals). This requires general and accurate theoretical method.

This work reports a new and accurate way of theoretical and numerical description of the extended 3D fluid (electromagnetic and flow) driven crack progression in saturated porous media for P- and S-waves under fully coupled electromagnetothermoelastic field. First, based on the viscous fluid flow reciprocal work theorem, the hybrid hypersingular integral equation (HIE) method proposed by the author was defined by combined with the coupled extended wave time-domain HIE, the lattice Boltzmann method and the interface phase field method. The general extended 3D fluid flow velocity wave solutions are obtained by the extended wave time-domains Green's function method. The 3D extended dynamic fluid driven crack modeling under fully coupled electromagnetothermoelastic P- and S-wave and flow field was established. Then, the problem is reduced to solving a set of extended hybrid HIEs coupled with nonlinear boundary domain integral equations, in which the unknown functions are the general extended flow velocity discontinuity waves. The behavior of the general extended singular stress indices around the crack front terminating is analyzed by hybrid time-domain main-part analysis. The general extended singular pore stress waves (SPSWs) and the extended dynamic stress intensity factors (DSIFs) on the fluid driven crack surface are obtained from closed-form solutions. In addition, a numerical method for the problem is proposed, in which the extended velocity discontinuity waves are approximated by the product of time-domain density functions and polynomials. The extended DSIFs and general extended SPSWs are calculated, and the results are presented toward demonstrating the applicability of the proposed method.

Key words 3D fluid driven crack propagation mechanism; P- and S-waves; Fully coupled electromagnetothermoelastic field; Hypersingular integral method, Lattice Boltzmann method; Interface phase field method; Extended dynamic stress intensity factor; General extended singular pore stress waves.