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GEOTECHNICAL ENGINEERING STUDENT ORGANIZATION AT UIUC

CEE 595F – Geotechnical Engineering Seminar

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Modeling Earthquake Ruptures With High Resolution Fault Zone Physics

Ahmed Ettaf Elbanna

Assistant Professor of Civil Engineering
University of Illinois Urbana Champaign

Abstract

Earthquakes are among the costliest natural hazards on earth. The dynamical instabilities responsible for the onset and ensuing propagation of these events are linked to fundamental physics of fluid filled granular materials and rocks in the subsurface subjected to extreme geophysical conditions and coupled with long range static and dynamic stress transfer. Over the past few years, advances in computational earthquake dynamics are opening new opportunities in addressing the conundrum of scales in this extreme mechanics and societally relevant problem. In this presentation, I will focus on a new computational algorithm for modeling earthquake ruptures with high resolution fault zone physics. I will present a hybrid method that combines Finite element method (FEM) and Spectral boundary integral (SBI) equation through the consistent exchange of displacement and traction boundary conditions, thereby benefiting from the flexibility of FEM in handling problems with nonlinearities or small-scale heterogeneities and from the superior performance and accuracy of SBI. We validate the hybrid method using a benchmark problem from the Southern California Earthquake Center's dynamic rupture simulation validation exercises and show that the method enables exact near field truncation of the elastodynamic solution. We further demonstrate the capability and computational efficiency of the hybrid scheme for resolving off-fault complexities using a unique model of a fault zone with explicit representation of small scale secondary faults and branches enabling new insights into earthquake rupture dynamics that may not be realizable in homogenized isotropic plasticity or damage models. Specifically, we show that secondary faults may not only act as energy sinks but they could also be energy sources promoting transient accelerations of rupture propagation speed and slip rate on the main fault. We also show that these secondary features significantly affect the stress state on the main fault and contribute to the enhanced generation of high frequency radiation. I will close by discussing some possible future applications of this modeling framework.

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