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Generation of Tensile Cracks during a 3D Dynamic Shear Rupture Propagation

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Dynamic simulation of rupture processes during earthquakes is usually performed under the assumption that only shear slip (Mode II and/or III) occurs. This is widely accepted in the study of earthquakes because this phenomenon may be considered to be a dynamically running shear crack. However, it is well known that the rupture process of an earthquake involves the superposition of the three basic modes (Mode I, II and III) recognized in dynamic fracture mechanics. In this context, a 3D shear dynamic rupture process is simulated assuming that the shear slip takes place only in a pre-existing fault and we open the possibility of introducing internal new cracks that propagates under tensile stress as a consequence of the dynamic process of the shear slip propagation. The Discrete Element Method (DEM) is used to solve this problem because it has the feasibility of introducing internal tensile. The numerical solution is developed for near-field elastodynamic motion coupled to frictional sliding on a pre-existing fault. For the spontaneous shear rupture propagation the simple slip weakening model is used as a friction law on the pre-existing fault, and for the new tensile cracks, the fracture will occur, following the classical Griffith theory, when the critical value of tensile fracture surface energy has been reached. The purpose of this paper is to investigate numerically the formation of new cracks in the surrounding areas around the source fault during an earthquake. For the simulation we assumed a theoretical vertical strike slip fault (19km x 19km) with an asperity (7km x 7km). The fault is embedded at a depth of 3km from the free-surface. The results suggest that the new cracks generated by the shear slipping extend mainly from the borders of the pre-existing fault and asperity forming a flower structure. The variation of the asperity location with depth strongly affects the cracks generated from the top of the fault and the free-surface rupture. When the asperity is located less than a certain depth, the flower structure originated from the top of the fault reaches the free-surface. It was also found that the generation of tensile cracks strongly affects the rupture process of the fault and the near source ground motion. The pattern of the ground motion suffers a drastic change.