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Development of extended BIEM and its application to earthquake dynamic rupture analysis in inhomogeneous media

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The boundary integral equation method (BIEM) has been applied to the analysis of rupture propagation of non-planar faults in an unbounded homogeneous elastic medium. We have proposed an extended BIEM (XBIEM) that is applicable in an inhomogeneous bounded medium consisting of homogeneous sub-regions (Kame and Kusakabe, 2012). We have developed a preliminary code for mode III dynamic rupture propagation interacting with medium interfaces. The validation tests have been carried out by comparing the XBIEM results with the BIEM solution for simple problems of the wave propagation and the dynamic rupture in a homogeneous full-space with a planar interface. It was found out that the discretized interfaces worked well for both problems.

In the present paper, we additionally validated our numerical code for two specific cases: 1) wave propagation in a homogeneous media with a non-planar interface and 2) wave propagation in a bimaterial with a planar interface. For the first case, it was found out that non-planar interface worked quite well. For the second case, our numerical result showed a good agreement with Hirano's analytic solution (Hirano, private communication). In both cases, our numerical code worked well enough and we proceed to apply our code to a new type of problem: dynamic rupture propagation interacting with a medium interface.

Here we considered dynamic rupture propagation on a planar fault embedded normal to the planar interface of a bimaterial. Spontaneous rupture is allowed not only on the planar main fault but also on the interfacial fault and it is controlled by slip-weakening laws on them: their peak strength are separately chosen and its ratio zeta=tau^peak_main/tau^peak_interface is chosen as one of controlling parameters. Another parameter is eta chosen as a ratio of the shear wave velocities, eta=beta_+/beta_-. Simulations were conducted for hundreds of parameter sets of (eta, zeta). Our results showed two distinct rupture processes: a) one is to propagate rupture just on the prescribed fault, and b) another is to activate the subsidiary interfacial rupture, which finally results in arresting rupture on the main planar fault.

Two processes were found to be clearly divided by a line in the parameter plane (eta, zeta). With increasing zeta, rupture tends to stay on the main fault with less significant activation of subsidiary interfacial rupture and it agrees with our physical anticipation. With increasing eta from 0.7 to 1.3 (one means homogeneous), rupture process shifts from (a) to (b). This eta dependency is not easily understandable at this moment but it clearly showed a significant effect of inhomogeneous medium on arresting dynamic rupture.

Keywords: dynamic rupture, BIEM, bimaterial interface, simulation