Off fault stress distribution around dynamic slip pulse on a bimaterial interface

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Seismologically observed slip duration is generally shorter than expected from classical crack theory. To explain this gap, Heaton [1990] proposed slip pulse model, in which slip velocity is localized near the propgating fault tip. Such slip pulse can be predicted by a model studied by Weertman [1980], who assumed dynamic propagation of shear rupture with constant rupture velocity along an interface of welded two dissimilar materials. He derived the expression for the 1-D stress distribution on the interface in a form of integral. Weertman showed that the rupture becomes pulse-like because of the interaction between slip and normal stress on the interface. Following his study, dynamic shear rupture on bimaterial interface has been studied by many researchers mainly numeriaclly (e.g., Andrews and Ben-Zion [1997], Ben-Zion and Andrews [1998] etc.).

On the other hand, the generation of co-seismic damage zone has been examined on the basis of dynamic stress change caused by the slip in a homogeneous isotropic medium (e.g., Poliakov et al. [2002], Rice et al. [2005]). Damage distribution is highly controversial issue and analytic solution of stress distribution around fault can contribute to understanding of damage generation.

In this study, we derive analytic solution of the 2-D stress distribution around the dynamic slip pulse on a bimaterial interface with closed form and examine the possibility of damage generation near the fault. We assume some models concerning the frictional property on the interface: 1) zero friction with constant stress drop, 2) Coulomb's friction law with constant coefficient of friction, and 3) distance-weakening friction law. We find that higher stress state appears in more compliant material in the cases (1) and (3). This means that much broader damage zone might appears in more compliant material. Meanwhile, the case (2) shows quite interesting stress distribution. According to Adda-Bedia and Ben Amar [2003], the stress singularity at the fault tips strongly depends on the propagation direction of the pulse in the case (2). We find the generation of broader high-stress zone near the tip of pulse when the pulse propagates in the direction of slip of more compliant material. Some numerical studies have showed that dynamic slip pulse tends to propagate in the direction of slip of more compliant material and this direction is generally referred to as "prefered direction" (Dalguer and Day [2009]). Our present study suggests that dynamic slip pulse propagating in the prefered direction can generate much broader damage zone when Coulomb's friction law is fulfilled.