Spatiotemporal Complexity of Rupture Evolution in a Fault Damage Zone with Multiple Small-Scale Cracks

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By using a high-speed digital video camera and a tensile testing machine, in this series of experimental study (*SSJ Fall Meeting*, 2017, 2018, 2019; *JpGU Meeting*, 2019), we have been trying to comprehend more deeply the relation between the local and global mechanical characteristics of sets of small-scale cracks that are densely distributed in a certain area of a brittle solid medium. These cracks, subjected to quasi-static loading, are preset in order to model a geological fault damage zone. Contrary to the rupture of (one single or a few) large-scale geological fault planes that can generate low-frequency waves and has been extensively investigated, the interaction of multiply extending small-scale cracks may radiate higher-frequency waves and its mechanical details have not been fully clarified yet.

So far, through dynamic photoelastic observations, we have found spatiotemporally complex but ordered rupture development in two-dimensional brittle polycarbonate specimens. Every rectangular specimen is under external tensile loading that is acting parallel to the free surfaces at a constant strain rate. Small-scale cracks, parallel to each other and having some dip angle, are prepared with a digitally controlled laser cutter. In the case if the parallel cracks dip vertically, for instance, as preliminarily reported earlier (*SSJ Fall Meeting*, 2019), upon surfacing of an upward-moving primary rupture, the rupture jumps on the top free surface to remote positions and the secondary ruptures start traveling downward into the opposite direction. It is noteworthy that the secondary and significantly delayed further ruptures, that is, a cluster of ruptures, are generated and propagated even without applying additional external loading. Seemingly, they are due to dynamic waves associated with the primary rupture, especially Rayleigh surface waves produced upon rupture surfacing. The experimental findings and a crucial role of Rayleigh surface waves in inducing the secondary and further ruptures can be confirmed with numerical simulations based on a spatiotemporally second-order finite difference technique.

For other different experimentally-set dip angles, it seems that the rupture evolution can become either fully dynamic (for larger dip angles; behavior similar to the vertically dipping one) or quasi-static (for smaller angles; ruptures tend to bridge the gaps between the preexisting cracks in a step-by-step manner).

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