Secondary Rupture at a Distance from the Primary One without Further External Loading

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In this series of experimental investigation into deeper understanding of the relation between the local and global behavior of multiple cracks - here, equivalent to potential rupture nucleation areas - that are broadly distributed in a brittle solid medium, we are tracing each individual mechanical interaction of cracks while measuring collective stress-strain curves and physical properties like tensile strength of the medium. For this purpose, we are using a high-speed digital video camera and a tensile testing machine with two-dimensional, initially linear elastic rectangular polycarbonate specimens. So far, we have experimentally confirmed parts of the theoretical predictions such as the change in the stress-strain relation with the prescribed constant strain rate externally applied to the specimen, including the increase of the overall tensile strength with the given strain rate, at least in a relatively smaller strain rate range (*SSJ Fall Meeting*, 2017, 2018; *JpGU*, 2019). Here, our attention is paid more to the secondary rupture that is initiated due to the expansion of the primary rupture and its possible effect on the global nature of the medium considered. By varying the initial distribution pattern and density of cracks, together with the experimental technique of dynamic photoelasticity, we investigate how actually the main rupture elongates and propagates, and how the primary rupture-induced waves can generate secondary ruptures, which will probably not be recognized simply by the examination of the global stress-strain relation. Although some researchers do insist that rupture can develop only when external load (e.g. gas generated by ignition of explosives) is directly applied to the solid specimen, we have found that after a total split of the specimen into two, the initiation and propagation of the secondary rupture can occur at a distant position from the primary rupture, i.e. rupture may jump even without presence of further external load. Surprisingly, in our observations, the direction of propagation of the secondary rupture is opposite to that of the primary one. Thus, the start of the secondary rupture propagation is apparently not driven by additionally applied external energy, but it is owing to dynamic waves induced by the primary rupture. Because the primary rupture completely divides the specimen, the external remote load quasi-statically applied to the specimen until the total split becomes zero when the secondary rupture is initiated. In other words, the expansion or influence of the secondary rupture really cannot be traced by the global stress-strain relation collected by the tensile testing machine. The results indicate the importance of observing not only the global or collective behavior but also the local individual interaction or dynamic stress change / wave motion if the specimen is of finite size.

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