Modelling of the damage process in brittle materials under dynamic tensile loading

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Dynamic fragmentation processes are observed in brittle materials such as ceramics, concrete, glass or rocks submitted to impact loading or blasting. Under such loadings, tensile stresses at high stress-rate develop in the structure. This phenomenon generates a multiple fragmentation characterised by a high density of oriented cracks. The damage properties (namely, characteristic time, cracking density, activated flaws) as well as the dynamic strength of the material are important points to be understood.

In the present work, a micro-mechanical anisotropic damage model is developed based on the fragmentation phenomenology assuming unstable micro-cracks initiated from point defects. This model shows how the brittle probabilistic behaviour under quasi-static loading is changed into a determistic stress-rate-dependent behaviour with the increase of the loading rate. It also underlines the influence on the one hand of material parameters and on the other hand of the loading rate and volume size on the fragmentation regime (i.e., single/multiple) and properties (time to damage, cracking density, mean failure stress and scatter). This model is applied to simulate the damage process observed during edge-on impact tests performed with an infiltrated SiC ceramic and an ultra-high strength concrete.