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Quasi-brittle cracking, coupled processes and hydraulic fractures

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Quasibrittle materials such as concrete or rock, when subject to mechanical action (either direct or indirectly induced by environmental effects), exhibit a transition from (visco) elastic response, to distributed micro-cracking, and coalescence to localized macro-cracking. In the approximately 4 decades since the term quasi-brittle was coined, a variety of models have been proposed. Models based on the continuum approach such as elasto-plasticity, continuum damage mechanics have been extensively developed. The process of localization into macro-cracks has been tackled either via "discrete cracking" (Fictitious crack model) or "smeared cracking" and associated regularization procedures with subsequent and size effect laws. A number of numerical techniques have emerged that try to reconcile all aspects of quasi-brittle material behavior, although no magic recipe seems to have been proposed as yet. Techniques such as zero-thickness interface elements or XFEM allow to integrate discrete cracks into background continuum meshes. Each one has its advantages and disadvantages, requiring in some cases, costly algorithms for re-meshing, crack tracking, etc.

Besides direct mechanical actions, cracking of concrete and geo-materials is often caused by environmental processes or flow/diffusion/transport-induced actions. All those problems have in common the need to solve coupled problems including mechanical and flow/diffusion/transport equations, although the degree of coupling may vary substantially from one case to another. This includes for instance (but not exclusively):

(i) Cracking of concrete-like materials due to differential volume changes due to durability-related phenomena such as drying shrinkage, sulfate attack, carbonation, alkali-silica-reaction, high temperatures.

(ii) Cracking (or opening of existing fractures) in rock masses due to fluid injections such as hydraulic fracture.

Quasi-brittle materials are heterogeneous in nature, and micro- or meso-mechanical models in which the heterogeneities are described explicitly are able to simplify considerably the constitutive description, and yet offer a much more powerful tool to represent the material behavior in simple and complex scenarios including not only complex mechanical scenarios but also combination of mechanical and diffusion-driven or coupled environmental actions.

This mini-symposium intends to gather contributions on all those and related topics, with a specific view to applications on concrete and rock.