Toward a micromechanical identification of cohesive parameters

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In continuum damage mechanics as well as in surface fracture approaches, the mesh dependency is a crucial problem that is still an open issue of concern. In this paper, we focus on the case of surface damage mechanics, more precisely on the cohesive-volumetric method: cohesive zone models (CZMs) are embedded between each volumetric finite elements. For such approaches, the aforementioned mesh sensitivity is noteworthy observed for: 1/ the spatial crack path depending on the mesh morphology, and 2/ the material convergence of the global quantities (maximal stress, dissipation energy, etc) obtained from numerical simulations. An interesting solution to deal with the spatial dependence on the mesh morphology is to use isotropic meshes (or pinwheel-based mesh [1]). On the other hand, the mesh sensitivity of the global quantities can be avoided with an ad hoc calibration of the cohesive parameters as proposed by [2] for brittle materials.

In this study, we extend this calibration approach to the case of damageable elasto-plastic materials. In order to derive direct relationships between the local cohesive parameters and the overall material properties, an equivalent non-linear 'matrix- inclusions' composite is introduced as a representation of the cohesive-volumetric discretization: the matrix has the same behavior as the bulk elements of the finite element discretization whereas the inclusions has a cohesive behavior so that the traction-separation CZM law derives from. The overall behavior of the studied composite is then obtained by extending the non-linear P. P. Castañeda homogenization scheme [3] to the case of cohesive-volumetric media. Unlike to what is proposed in the literature, the obtained micromechanical model is able to be applied whatever: i) shape of the cohesive law ii) the material hardening behavior and iii) the (triaxiality of the) applied loading. It allows exhibiting the effect of the macroscopic strain triaxiality as the primary local cohesive parameters on the overall response (figurename 1-left).

As result of the model, a set of explicit relationships between the local cohesive and material global properties is obtained. Hence, knowing the material overall properties (given by experimental measurement, e.g. digital image correlation (DIC)), the applied triaxiality loading rate (imposed loading) and the underlying mesh for numerical stimulations (mesh size and morphology), the CZMs parameters can be calibrated through an inverse

analysis of the obtained local-to-global relationships of the proposed model. More interestingly, practical criteria are obtained for the calibration of : the cohesive strength, the initiation softening opening, and the cohesive energy. The proposed criteria depend on: 1/ the mesh size and morphology through the key parameter: the mesh density, 2/ the applied loading triaxiality rate (Figure 1-right) and 3/ the global material properties (maximal stress, energy, etc).

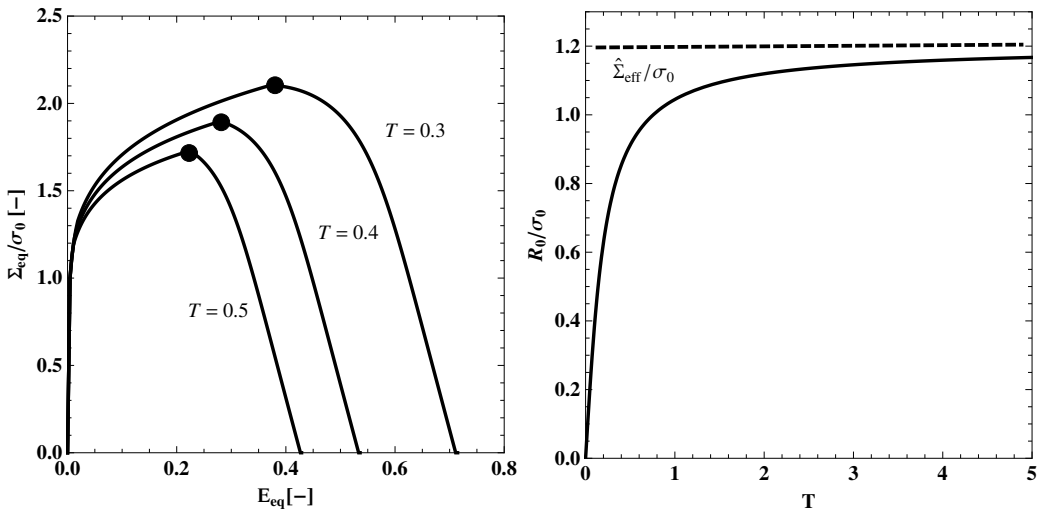

Figure 1: Illustration of the effect of the applied loading triaxiality on: (left) the overall elasto-plasto-damageable behavior, and (right) the calibration of the cohesive peak stress.

References

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