A phase-field and interface damage model for mixed-mode fracture in materials with inclusions

R. Vodička[1*]

[1] Technical University of Košice, Faculty of Civil Engineering, Vysokoškolská 4, 042 00 Košice, Slovakia, roman.vodicka@tuke.sk

The presented approach provides a tool for analysing fracture in materials and along material interfaces of general multi-domain structures under quasi-static conditions. It is intended for materials appearing in engineering structures made of multiple components: including grains or fibres which may be spaced inside the matrix material. Description of the fracture processes are based on considering internal parameters in sense of damage.

Two independent parameters are introduced to make a difference between interface and material cracks. The state of interface faults is defined considering it as a thin adhesive layer and pertinent internal variable renders relation between stress and strain quantities in the form known in cohesive zone models. Such treatment results from problems of delamination [1] or adhesive contact [2] which introduced requested internal variable for interface damage. The other parameter is defined in bulk domains and controls the degradation state in a sense of phase-field fracture guaranteeing the damaged zones in form of smeared cracks. Though originally considered as a regularisation of variational Griffith-like models of fracture [3], the phase-field appriach developed to a powerful computational tool, which my modify damaging behaviour by adjusting material degradation, fault initiation [4], or even be combined with flaws related to material interfaces [5]. Another important feature of modelling both interface and phase-field rupture is the capability of making difference between fracture modes which is useful when the structure is exposed to combined loading causing both tensional and shear effects. It is usually related to additional dissipation in other than opening fracture modes. The crack mode sensitivity was in this sense described by the model in [1] and an appropriate phase field model can be found in [6]. The present contribution intends to integrate both concepts as it was sketched by the author in [7].

The computational techniques used in the approach utilise possibility of defining the solved problem variationally which allows implementation of (sequential) quadratic programming methods into a finite element discretisation and appropriate time stepping methods. The MATLAB simulations with an inhouse computer code validate developed formulation for analysis of fracture problems in multi-domain elements of structures.

References

[1] R. Vodička, A quasi-static interface damage model with cohesive cracks: SQP–SGBEM implementation, Eng Anal Bound Elem 62 (2016) 123–140.

[2] M. Raous, L. Cangemi, M. Cocu, A consistent model coupling adhesion, friction and unilateral contact, Comput Method Appl M 177 (1999) 383–399.

[3] B. Bourdin, G. A. Francfort, J. J. Marigo, The variational approach to fracture, J Elasticity 91 (2008) 5–148.

[4] E. Tanné, T. Li, B. Bourdin, J.-J. Marigo, C. Maurini, Crack nucleation in variational phase-field models of brittle fracture, J Mech Phys Solids 110 (2018) 80–99.

[5] M. Paggi, J. Reinoso, Revisiting the problem of a crack impinging on an interface: A modeling framework for the interaction between the phase field approach for brittle fracture and the interface cohesive zone model, Comput Method Appl M 321 (2017) 145–172.

[6] Y. Feng, J. Li, Phase-field cohesive fracture theory: A unified framework for dissipative systems based on variational inequality of virtual works, J Mech Phys Solids 159 (2022) 104737.

[7] R. Vodička, A quasi-static computational model for interface and phase-field fracture in domains with inclusions, Procedia Structural Integrity 42 (2022) 927–934. 23 European Conference on Fracture.