HDM
HRVATSKO DRUŠTVO ZA MEHANIKU
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Predavanje HDM-a:

Characterisation and Modelling of Fracture Resistance for Quasi-Brittle and Ductile Interfaces

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SAŽETAK

This talk will focus on structural interfaces where a crack can initiate and/or propagate with quasi-brittle or even significantly ductile behavior. Typical examples include delamination in composite laminates and debonding of adhesive joints. The three main theories available to engineers to address such problems are linear elastic fracture mechanics (LEFM), non-linear fracture mechanics (NLFM) and cohesive-zone models (CZMs). The first two have been extensively used in applications and underpin a number of industrial standards and codes of practice. CZMs have been initially proposed nearly 60 years ago and have then become extremely popular in the fracture-mechanics research community over the recent 20 years. They introduce a nonlinear 'traction-separation law' between two faces of a potential crack. In such a way, the singularity found in LEFM is replaced with a finite-size cohesive zone, where cohesive stresses are directly modelled. On the other hand, the richer description of the fracture process offered by CZMs also entails a significantly increased computational cost.

The first part of this talk will describe a part of recent work [1] in which, for cases of mode-I (opening) cracks, LEFM, NLFM and CZMs are compared in terms of their main 'energy parameters'. These are the critical energy release rate, $\boldsymbol{G_c}$, introduced in LEFM, the critical value of the J integral, $\boldsymbol{J_c}$, used in NLFM, and the area, $\boldsymbol{\Omega}$, under the traction-separation law defined in a CZM, which can be interpreted as the 'work of separation'. Contrary to what is often found in the literature, $\boldsymbol{\Omega}$ is not equal to $\boldsymbol{G_c}$ except for special cases, and it is not necessarily equal to $\boldsymbol{J_c}$ either.

The second part of the talk will discuss some advantages offered by CZMs, namely that they can be formulated in a way to separately account for different dissipation mechanisms that contribute to the work of separation, $\boldsymbol{\Omega}$. The talk will here mainly focus on mode-I rate-dependent crack growth [2]. The thermodynamics of this modelling approach will be revisited as it provides a very general framework, in which different visco-elastic or visco-plastic laws can be introduced, as well as different damage evolution laws. Validation of these models for cases of rubber and epoxy interfaces will be presented and discussed.

[1] L. Škec, G. Alfano, G. Jelenić (2018). On G_c, J_c and the characterisation of the mode-I fracture resistance in delamination or adhesive debonding. *International Journal of Solids and Structures* 144-145:100-122.

[2] G. Alfano, M. Musto (2017). Thermodynamic derivation and damage evolution for a fractional cohesive-zone model, *Journal of Engineering Mechanics* 143(7):D4017001.