A two-scale constitutive parameters identification procedure for elastoplastic fracture

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ABSTRACT

The identification of the constitutive parameters of the bulk and of the cohesive traction-separation law for cracks is a key issue for the reliability of numerical simulations of elastoplastic fracture. Attempts to identify the cohesive zone model (CZM) parameters have been made in [1] by considering genetic algorithms and minimizing an objective function involving the global macroscopic response. As an alternative route, a method based on the J-integral has been proposed in [2] to identify the shape of the CZM by monitoring the crack propagation in single-edge notched specimens tested inside a scanning electron microscope (SEM) chamber.

The aim of the present study is to provide a robust identification procedure of the elastoplastic constitutive parameters of the continuum and the shape of the CZM traction-separation relation through the gradient descent method. The case considered is the elastoplastic fracture of specimens tested with a tensile stage inside a SEM. The objective function Φ, which has to be minimized, is defined as the sum of two norms that measure the distance between the results of numerical simulations and of the experiments. The former involves parameters related to the microscopic response (crack opening, crack length, etc.), whereas the latter regards macroscopic data (force-displacement relation). Under these assumptions the objective function reads:

$$\Phi = \alpha \left\| P_{micro}^{(num)} - P_{micro}^{(exp)} \right\| + \beta \left\| P_{macro}^{(num)} - P_{macro}^{(exp)} \right\|$$

where $0 \leq \alpha \leq 1$ and $0 \leq \beta \leq 1$ ($\alpha+\beta=1$) are two weights used to give different priority to the micro or to the macro scale responses during the identification process.

The material parameters p_i to be identified are the Young's modulus of the material, the yield strength, and the polynomial expression of the CZM that, for the sake of generality, is defined by a spline passing through set of characteristic points in the cohesive traction-separation plane. The objective function Φ is suitably linearized with respect to the parameters p_i to be identified. Then, in order to minimize Φ, is used an iterative procedure which is based on the computation of the partial derivative of the objective function with respect to the constitutive parameters, i.e., the so-called sensitivity matrix. Numerical examples are provided in relation to experimental fracture mechanics tests inside a SEM carried out by the present authors on ductile busbars used to electrically connect solar cells in photovoltaic modules.

REFERENCES

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