THE CALIBRATION OF A NONLOCAL COUPLED DAMAGE-PLASTICITY MODEL FOR DUCTILE METAL ALLOYS

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ABSTRACT

Continuum Damage Mechanics (CDM) can be used to describe material softening, crack initiation, propagation and failure in a consistent fashion. In the present study we use nonlocal averaging of the plastic strain to render finite element-based CDM models mesh-independent and to overcome the numerical instabilities associated with damage localisation. We address the key question of parameter calibration by interpreting the data from a single tensile test that makes use of multiple gauge length extensometry. We illustrate the approach using the examples of aerospace alloys of aluminium (AA6082-T0), nickel-base super-alloy IN 718, and titanium alloy Ti-6Al-4V.

Keywords: coupled local-nonlocal damage-plasticity, parameter calibration, size effects.

INTRODUCTION

Nonlocal damage mechanics approaches possess the versatility and numerical stability that hold the prospect of modelling all aspects of the fracture process, from initiation to propagation to final failure. However, before any model can be applied to the task of modelling real structures, model parameters must be calibrated to reflect the mechanical behaviour of a particular material. Although a significant number of nonlocal models for predicting failure have been proposed (e.g. Borino, 2003; Belnoue, 2007), parameter calibration for these nonlocal models remains an open area of research. A particular challenge remains establishing an appropriate procedure for identifying the characteristic length.

As a means of calibrating the nonlocal radius, Bazant (1989) suggested performing tension tests on two similar concrete specimens of different size, but with one sample being artificially reinforced by attaching steel reinforcement, whilst the other was weakened by introducing a notch. As a consequence, in one sample tensile softening damage remained distributed, while in the other it became localised. More generally, it can be observed that usually nonlocal models require extensive test programs (multiple specimens) and inverse problem approaches to determine parameters.

RESULTS AND CONCLUSIONS

We present an approach to the problem that is termed the adaptive damage calibration method. It uses a simple piecewise linear approximation for the damage function. It is shown that the results of a single tensile test furnish sufficient data to carry out parameter calibration.

Fig. 1 provides a graphical illustration of the adaptive parameter calibration method. Model parameters that describe damage increment as a function of plastic strain and strain increment are adjusted at each incremental step of running the model to ensure agreement with the experimental curve. We report the successful application of the approach to three different aerospace alloys.

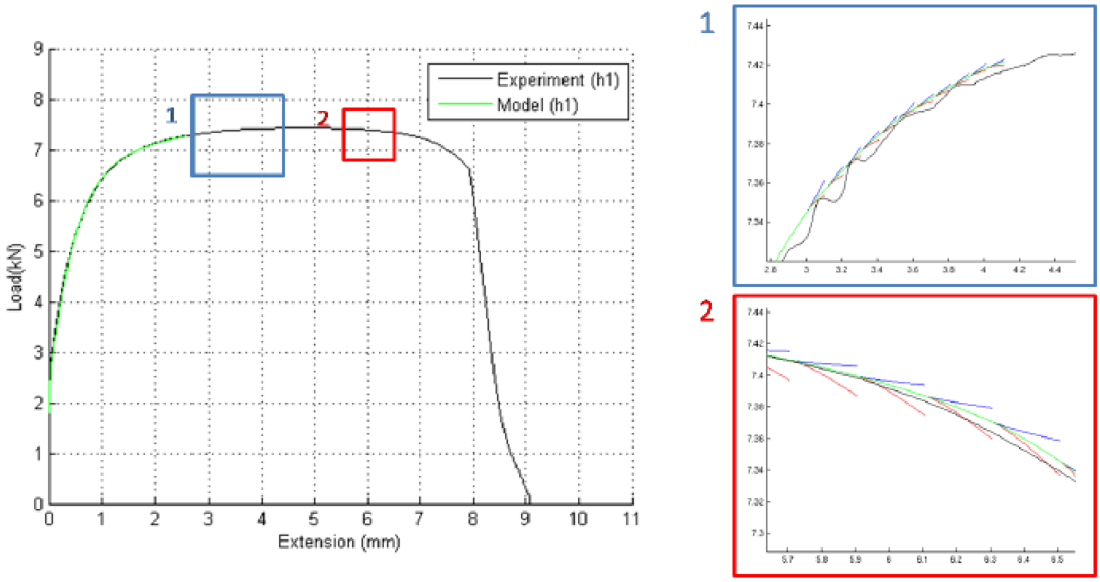

Fig.1 Illustration of the application of the calibration approach.

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