STOCHASTIC ANALYSIS OF LOCALISED FAILURE

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Failure can be associated with a decrease of the load carrying capacity as the deformation of a body increases. This behaviour is known as softening in a context of continuum mechanics. When a solid experiences softening, this is often accompanied by the emergence of narrow zones where large strains are developed, while the rest of the material unloads elastically. When softening is introduced in the stress-strain relation, classical continuum models are meaningless because the strains become infinite within a band of zero width and collapse takes place without energy dissipation. This can be remedied by using a regularisation technique. Regularisation is successfully achieved by considering non-locality, which can be introduced through weighting integrals or spatial gradient dependence of the strain. Strain rate dependence has also been proved to provide regularisation. These descriptions result in a mathematically well-posed problem and enable one to perform meaningful finite element simulations. However, this is not sufficient to simulate all the phenomena that can take place during failure. Fracture can happen suddenly in states of homogeneous deformation. As the failure mechanism is often initiated by heterogeneity in the material, computer simulations cannot reproduce the localisation behaviour unless an imperfection is supplied manually. From this point of view, an objective simulation can only be carried out if the imperfections are incorporated in the mathematical model. This can be done by describing them as random quantities.

Research in this subject has been carried out by the authors [1] utilising the finite element reliability method. For this purpose a limit state function is defined for a relevant indicator of the structural performance such as the peak load or the dissipated energy. The corresponding design points are calculated through a gradient based optimisation algorithm. The reliability index of each design point provides information on the significance of the resulting localisation pattern. It is observed that the nature of the most significant localisation patterns is related to the ductility of the material.

The approach described above essentially consists of a deterministic model extended with a random input for the material properties. Current research is directed towards a full stochastic description of the solid response by means of stochastic finite elements. In this fashion, localisation phenomena can be analysed from a probabilistic point of view by studying the autocorrelation of internal quantities such as the hardening parameter or the damage indicator.

References

[1] M.A. Gutiérrez, R. de Borst, “Stochastic aspects of localised failure: material and boundary imperfections”, *International Journal of Solids and Structures,* v. 37, p. 7145–7159, 2000.