Technische Universität Braunschweig

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Modelle für die Beschreibung der Zustandsänderung bei Alterung von Baustoffen

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Solution methods for failure analysis of massive structural elements

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Various methods are used for computation of mechanical response of a loaded structure. Well established path-follow- ing methods, such as arc-length method, are usually used for tracing equilibrium paths of geometrically and/ or materi- ally nonlinear structures. When analysing the nonlinear problems with the localized material failures (softening), stan- dard path-following methods can fail. For this reason we derived new versions of the path-following method more suited for problems that take into account localized material failures. One version is based on adaptive one-degree-of- freedom constraint equation, which proved to be relatively successful in analysing problems with the material softening that are modelled by the embedded-discontinuity finite elements. The other versions are based on controlling incre- mental plastic dissipation in an inelastic structure. The advantages and disadvantages of the presented path-following methods with different constraint equations are discussed and illustrated on a set of numerical examples. As for the modelling material failures in quasi brittle 2d solids, several embedded strong discontinuity finite element formulations are presented. The considered formulations are based either on: (a) classical displacement-based isoparametric quadrilateral finite element or (b) on quadrilateral finite element enhanced with incompatible displacements. In order to describe a crack formation and opening, the element kinematics is enhanced by four basic separation modes and rela- ted kinematic parameters. The interpolation functions that describe enhanced kinematics have a jump in displace- ments along the crack. Two possibilities are shown for deriving the operators in the local equilibrium equations that are responsible for relating the bulk stresses with the tractions in the crack. For the crack embedment, the major-principle- stress criterion was used, which is suitable for the quasi brittle materials. The normal and tangential cohesion tractions in the crack are described by two uncoupled, non-associative damage-softening constitutive relations. A new crack tracing algorithm is proposed for computation of crack propagation through the mesh. It allows for crack formation in several elements in a single solution increment. Results of a set of numerical examples are presented in order to show the performance of the derived embedded strong discontinuity quadrilateral finite element formulations and the crack tracing algorithm.

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