Damage Mechanics Analysis with Arc-length Solver

Jaroslav Kruis

Department of Mechanics, Faculty of Civil Engineering, Czech Technical University
Thákurova 7, 166 29 Prague, Czech Republic
tel: +420 224 354 580, e-mail: jk@cml.fsv.cvut.cz

Analysis of quasi-brittle materials like concrete or rock based on the damage mechanics is discussed. Brief overview of the isotropic damage model with one damage parameter and generalized damage model with two parameters will be given. It is well known that the damage models are mesh dependent and localization of the damage can be observed. Method of variable softening modulus is used to remedy this drawback.

The softening branch in the stress-strain diagram leads to difficulties with the solution of nonlinear algebraic equations obtained after discretization of the problem by the finite element method. The classical Newton-Raphson method cannot pass the eventual peak on the force-displacement diagram of structure. Therefore, the arc-length method is used for this purposes.

The original arc-length method results in a non-symmetric matrix of the system of equations and special solvers have to be applied. The spherical and cylindrical variants of the arc-length methods lead to symmetric matrices but an auxiliary quadratic equation containing the load-level parameter has to be solved. The selection of appropriate root can sometimes fail. The linearized arc-length method leads to an auxiliary linear equation for the load-level parameter. The selection of suitable variant of the arc-length method will be also discussed.

Damage analyses of specimen and geotechnical structures will be described. The results are compared with the response of specimen in laboratory and with measured values in real structures. Suitable damage models and variants of the arc-length method are compared.