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Symmetrization of the effective stress tensor for anisotropic damaged continua

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A uniform formulation of the effective stress tensor symmetrization procedure has been proposed. This form contains the classical additive and multiplicative symmetrization schemes as particular cases. Different options of symmetrization of the effective stress tensor for the unidirectionally damaged material with parallel microcracks and for the bidirectionally damaged material with a system of orthogonal microcracks were compared. The differences in any forms of the effective stress tensor were second-order infinitesimals for low damage levels.
The differences in predictions from considered symmetrization schemes increased with the growth of the damage level and with that of the differences between the eigenvalues of damage.
An identification procedure for anisotropic damage was proposed on the basis of acoustic emission methods and then it was discussed.
Key words: continuum damage mechanics; damage tensor; effective stress tensor; anisotropy; simulation; identification

Introduction

The effective stress tensor (EST) is one of the central concepts in continuous damage mechanics (CDM). It was introduced for the one-dimensional case in the first papers on the mechanics of a damaged continuum by Kachanov [1] and Rabotnov [2]. The emergence and evolution of microdefects (microcracks and micropores) leads to a reduction in the effective area of the bearing elements of the quasicontinuum, which in turn leads to an increase in internal stresses (called effective), which at the macrolevel can be regarded as averaging of the real stresses acting in the material at the microlevel. Therefore, the formulations of the phenomenological constitutive equations used within the CDM are, as a rule, related to substituting the traditional Cauchy tensor by the effective stress tensor.

Noteworthy Russian and foreign reviews carried out using the CDM include Refs. [3–7], reflecting the current state of the problem and offering a comprehensive review of all the key issues. The potential of CDM was illustrated with the analysis of creep [5–10], plasticity [6, 11, 12], fatigue [13–17, 6], combination of fatigue and creep [6, 18], thermal fatigue [18] and brittle fracture [19, 20, 6, 7] processes.