11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

THEORETICAL, COMPUTATIONAL AND EXPERIMENTAL STUDIES OF THE BEHAVIOR OF STRUCTURAL MATERIALS UNDER MULTIAXIAL LOADING CONDITIONS

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Key words: *Constitutive Equations, Limit Design, Stress State Dependence, Ratio of Triaxiality, FEM.*

The most widely used conventional isotropic elastic-plastic models are based on the hypothesis of “single” curve. This assumption states that dependence of the equivalent von Mises stress on the equivalent strain remains unchanged for all combinations of components of the stress tensor. This single curve is usually based on the stress-strain curve obtained in the experiments under uniaxial tension or compression and can be reliably used for isotropic materials with no structural discontinuities. This approach usually can not be used in cases of multiaxial stress state requiring high accuracy that is typical e.g. for aerospace industry even for materials that are generally considered to be isotropic. There is a large number of theories tending to cover this flaws of the classical theories for specific cases.

The authors propose a generalized approach to the description of stress state dependent elastic-plastic behavior of materials. The main idea of this approach is the including of dependence on the stress state type into classical constitutive equations of solid media. The ratio $\xi = \sigma/\sigma_0$ of the mean stress and von Mises equivalent stress (ratio of triaxaility) is proposed to be used as the parameter of stress state. This parameter characterizes the average ratio between normal and shear stresses and can be used to distinguish different types of stress states (e.g. $\xi = 0$ for pure shear and $\xi = \pm 1/3$ for uniaxial tension/compression). Generalized versions of the yield criteria can be obtained from classical criteria by assuming the dependence on the stress state parameter. The yield criterion for isotropic material can be expressed as

$$f(\xi)\sigma_0 = k, \tag{1}$$

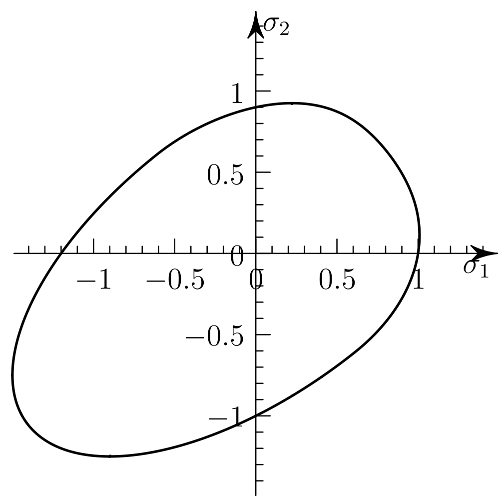

Figure 1: Example of anisotropic stress state dependent yield surface in principal stresses

where k is material constant, σ_0 is equivalent stress and $f(\xi)$ is a function of stress state paramater that can be found in a series of experiments with different stress states.

The yield criterion for anisotropic materials can be derived as corresponding generalization of the Hill's criterion:

$$A_{ijmn}(\xi)S_{ij}S_{mn} = k^2, \tag{2}$$

where S_{ij} are the components of the deviator of the stress tensor. The example of the anisotropic yield surface is shown on the figure .

In this work, the theoretical studies of constitutive equations based on the proposed approach are summarized. The usage of the derived relations is illustrated on a number of theoretical examples, computations and analyses of the actual experiments.

Acknowledgements. This work was carried out in the Perm National Research Polytechnic University with support of the Government of Russian Federation (the Decree No. 220 on April 9, 2010) under the Contract No. 14.B25.310006, on June 24, 2013.

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