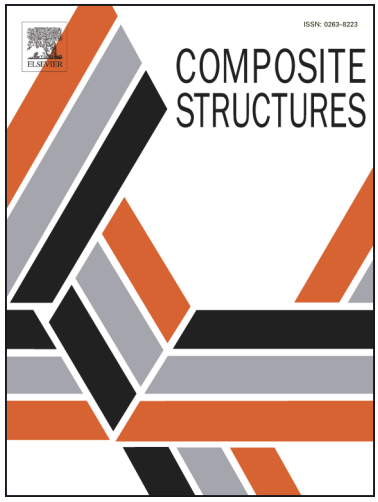

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Elastic-plastic analysis of functionally graded bars under torsional loading

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Abstract. In this paper a new integral equation solution to the elastic-plastic problem of functionally graded bars under torsional loading is presented. The formulation is general in the sense that it can be applied to an arbitrary cross-section made of any type of elastoplastic material. In material science the Functionally Graded Material (FGM) is a non-homogeneous composite which performs as a single-phase material, by unifying the best properties of its constituent phase material. The nonlinear elastic-plastic behavior is treated by employing the deformation theory of plasticity. According to this theory, the material constants are assumed variable within the cross section, and are updated through an iterative process so as the equivalent stress and strain at each point coincide with the uniaxial material curve. In this investigation a new straightforward nonlinear procedure is introduced in the deformation theory of plasticity which simplifies the solution method. At each iteration step, the warping function is obtained by solving the torsion problem of a non-homogeneous isotropic bar using the Boundary Element Method (BEM) in conjunction with the Analog Equation Method (AEM). Without restricting the generality, the FGM material is comprised of a ceramic phase and a metal phase. The ceramic is assumed to behave linearly elastic, whereas the metal is modeled as an elastic – linear hardening material. Furthermore, the TTO homogenization scheme for estimating the effective properties of the two-phase FGM was adopted. Several bars with various cross-sections and material types are analyzed, in order to validate the proposed model and exemplify its salient features. Moreover, useful conclusion are drawn from the elastic-plastic behavior of functionally graded bars under torsional loading.

1. Introduction

In this paper a new integral equation solution to the elastic-plastic problem of functionally