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PII: S0263-8223(16)00078-7
DOI: http://dx.doi.org/10.1016/j.compstruct.2016.01.065
Reference: COST 7170

To appear in: *Composite Structures*

Uniaxial and biaxial post-buckling behaviors of longitudinally graded rectangular plates on elastic foundations according to the 3D theory of elasticity

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Abstract

Longitudinally varying the material properties may be an adequate optimization solution when there are restrictions in varying cross sections of the load carrying elements but leads to distorted and variable length buckling and post-buckling deformation waves. In the present paper, uniaxial and biaxial post-buckling behaviors of the longitudinally graded plates are investigated. Neither post-buckling nor even buckling of the longitudinally graded plates have been studied so far. Moreover, effects of the elastic foundation that significantly alter the post-buckling deformations and strength of the plate, are studied. Due to occurrence of large deformations in the post-buckling region, the exact 3D elasticity theory is employed here instead of the approximate plate theories. Furthermore, the full form of Green's strain tensor is adopted. To establish a stress field that is continuous at the mutual nodes of the adjacent elements, a C^1-continuous 3D Hermitian element in employed to discretize the plate. The nonlinear post-buckling equilibrium equations are solved by Crisfield-Ramm arc-length method in conjunction with the modified Newton–Raphson technique. Results show that heterogeneity of the material properties may lead to abrupt deflection decreases or even reversals and the elastic foundation leads to increases in both the buckling strength and number of the deformation waves.

Keywords: Post-buckling analyses; Longitudinally graded rectangular plates; Elastic foundation; 3D Hermitian element; Arc-length method.

1 Introduction

Tapered beams, plates, discs, and cylindrical or conical shells have commonly been used in many mechanical applications to establish identical maximum stresses in the longitudinal sections of the components. Variations in the height of section may not be necessary linear, e.g., in the leaf springs. This optimization technique may not be available for some designs with spatial and manufacturing restrictions. As an alternate optimization choice, components with fixed thicknesses but with a rigidity (elastic modulus) that varies along a characteristic length of the component, may be used. Therefore, longitudinally graded beams, plates or shells may be used as optimized designs. Present research is concerned with the longitudinally graded plate-type structures. These structures may be subjected to buckling or even post-buckling under compressive loads.

Uniaxial buckling of the rectangular functionally graded plates [1-3] has been studied by numerous researchers. Alipour and Shariyat studied buckling behaviors of viscoelastic [4] and bidirectional [5] FGM plates with or without elastic foundations. Very limited papers have been published on biaxial buckling of the FGM plates. Samsam Shariat et al. [6] studied buckling of thick rectangular FGM plates under biaxial loads, using the third-order shear deformation theory (TSDT). Uymaz and Aydogdu [7]

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