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An analytical solution to the stain energy release rate of a crack in functionally graded nonlinear elastic beams

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Abstract

An analytical approach was developed for studying the delamination fracture behaviour of functionally graded beam configurations with considering the material non-linearity. It was assumed that the mechanical response of functionally graded beams can be described by a non-linear stress-strain curve that is not symmetric for tension and compression (different stress-strain relations were used for tension and compression). The material is functionally graded along the beam height. Fracture behaviour was analyzed in terms of the strain energy release rate. A delamination crack located arbitrarily along the beam height was considered. The strain energy release rate was expressed in a function of the bending moments and axial forces in the cross-sections ahead and behind the crack front. The approach developed was applied to analyze the strain energy release rate in the functionally graded Double Cantilever Beam (DCB) configuration with material non-linearity. The strain energy release rate derived was compared with fracture analysis by the *J*-integral for verification. The effects of material properties and crack location on the fracture in the DCB were evaluated. It was shown that the approach developed is very useful for studying the fracture in functionally graded beam structures that exhibit material non-linearity.

Key words: Functionally graded beams, Fracture, Material non-linearity, Analytical solution