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Optimal design of thin-walled functionally graded beams for buckling problems

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Abstract

This paper presents a modeling as well as a numerical approach for geometric and material optimization of thin-walled functionally graded I-shaped cross-section beam focusing on lateral and flexural-torsional buckling problems. Material properties are assumed to be varied through the shell thickness by a non-monotonic function in which volume fractions of constituent phases have been estimated according to a piecewise cubic interpolation. Governing buckling equations, also a finite element method based on Vlasov's thin-walled theory are developed. Genetic algorithm (GA) is utilized as an optimal tool that preserving the computational efficiency of the overall analysis. N-point volume fraction through-the-thickness direction, as well as width-to-thickness, span-to-height ratios are simultaneously considered as design variables. The obtained critical buckling parameters are verified via several benchmark problems. Optimum results are found to be beneficial for a specific design of thin-walled functionally graded beams.

Keywords: Buckling; Optimization; Mechanical properties; Computational modeling; Thin-walled FG beam.

1. Introduction

1.1. Literature review

For a last few decades, Functionally Graded Materials (FGMs) with superior advantages have been applied in a variety of structures and many fields, such as aerospace, civil and mechanical engineering. Whilst the operating conditions are severe, FGMs utilize the smoothing material composition gradation and avoid the abrupt transition across the interface between distinct materials in conventional multi-layer systems which usually causes inter-laminar stresses and de-lamination or cracking [1, 2]. Furthermore, the undesired effects from both high temperature environment and loading impact have been tackled better in FG structures where higher tensile strength and corrosive characteristics are well organized at the right

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