Two-dimensional cross-sectional analysis of composite beams using Rayleigh-Ritz-based dimensional reduction method

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PII: S0263-8223(17)32450-9
DOI: https://doi.org/10.1016/j.compstruct.2017.10.049
Reference: COST 9024

To appear in: *Composite Structures*

Received Date: 6 August 2017
Revised Date: 2 October 2017
Accepted Date: 16 October 2017

Please cite this article as: Ghafari, E., Rezaeepazhand, J., Two-dimensional cross-sectional analysis of composite beams using Rayleigh-Ritz-based dimensional reduction method, *Composite Structures* (2017), doi: https://doi.org/10.1016/j.compstruct.2017.10.049

Two-dimensional cross-sectional analysis of composite beams using Rayleigh-Ritz-based dimensional reduction method

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Abstract

In this paper, cross-sectional analysis of composite beams using a Rayleigh-Ritz-based dimensional reduction method is presented. In dimensional reduction method, the three-dimensional (3D) elasticity problem is reduced to a two-dimensional (2D) cross-sectional analysis which yields cross-sectional stiffness constants. Then a one-dimensional (1D) beam problem, with fidelity to 3D deformation effects, is attained. Using Rayleigh-Ritz method, the cumbersome procedure of mesh generation on beam section is eliminated in contrast to finite element-based cross-sectional analysis. Shear deformation effects and B-spline basis functions in Rayleigh-Ritz-based cross-sectional analysis are considered in this study. Different isotropic and composite beams are examined. Moreover, the effects of considering transverse shear deformation, coupling stiffness constants and honeycomb core for composite thin-walled beams are investigated. Using the present method, a fast and precise tool for analysis of composite beams with arbitrary cross-section geometry and material anisotropy is available for design of composite beam-like structures.

Keywords

Composite beam, Dimensional reduction method, Beam cross-sectional analysis, Rayleigh-Ritz method, Shear deformation effects

1. Introduction

By growing use of composite beam-like structures, such as wind turbine blades, helicopter rotor blades and aircraft propellers, advanced composite beam theories appeared from the beginning of 1980's decay to deal with composite beams with arbitrary cross-section geometry and material anisotropy. Giavotto et al. [1] in 1983 computed the 6×6 beam cross-sectional stiffness matrix and stresses via the virtual work principle. The solution is divided to extremity and central regions, although just the central solution seems to be the practical one. As finding the exact solution of shear refined model is not possible, the central solution is obtained by considering warping parameters and 1D strain resultants to be linear polynomials of axial coordinate. For an analysis