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Mechanical and Aerospace Engineering Department
University of Texas at Arlington

ANALYSIS OF LAMINATED CURVED BEAM WITH AND WITHOUT DEFECTS AND IMPERFECTIONS

By

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Abstract

Several studies have focused on the modeling and response characterization of composite structural members, with particular emphasis on composite curved beams. The class of curved beam is explored to determine mechanical response in primary aerospace structural applications. The present work focuses on developing analytical closed-form solutions for investigating composite curved beams with and without fiber waviness and delamination. The present work can efficiently characterize the structural behavior of composite curved beams under bending.

This work shows the development of a novel mathematical approach to predict structural performance by investigating axial stiffness, bending stiffness with consideration of shear deformation in composite curved beam. A modified Classical Lamination Theory (CLT) is proposed by considering cross-section effect of a beam. Finite Element (FE) analysis is employed to compare against the analytical results. Parametric study is conducted to investigate effects of radius of composite curved beam versus axial and bending stiffness. Ply stress variations are also studied for a composite curved beam under bending. The stress results obtained from numerical analysis show excellent agreement in comparison with present approach.

The present work also studied fiber waviness effect in composite curved beam. Fiber waviness has an adverse influence on the mechanical properties. The tensile, compressive strength, and
fatigue life degrade significantly due to fiber waviness. The proposed method takes into account the degraded stiffness properties by considering the various amplitude-length ratio of fiber waviness presented in a curved beam. It can be concluded that for a composite curved beam with fiber waviness, the effect of stiffness reduction significantly increases if the amplitude-length ratio is between 0.6 and 1.0. Moreover, the present work provides an analytical solution to predict the interlaminar radial stress $\sigma_r$ if fiber waviness is present. The analytical results show excellent agreement with results obtained from numerical analysis.

Delamination is considered as one of the dominant failure factors in composite and leads to substantial stiffness loses. The present work provides an analytical method for calculation of the strain energy release rate (ERR) of a delamination in a composite curved beam. In the present approach, we allow for a delamination which is not symmetric with respect to the middle span of the composite curved beam and can be located at any arbitrary interface.