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Variable stiffness laminated composite shells - free vibration characteristics based on higher-order structural theory

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Abstract

In this study, the free vibration characteristics of variable stiffness laminated composite shells is numerically studied using a higher-order accurate theory. The unique feature of the variable stiffness composites is that the fiber orientation within the lamina changes continuously leading to spatial variation of stiffness of the resulting laminate. A systematic parametric study is conducted to bring out the influence of fiber orientation within and across the laminae, shell geometry and the structural theory on the fundamental frequency. The influence of environmental factors such as the temperature and the presence of moisture is also considered. It is inferred that the spatial variation of stiffness due to curvilinear fibres introduces additional flexibility in designing structures made of such materials.

Keywords: Variable stiffness composites, Curvilinear fiber, Higher order accurate theory, shear flexible element, cylindrical shell, spherical shell

1. Introduction

Fiber reinforced composite laminates are preferred over isotropic material due to its excellent strength-to and stiffness-to weight ratio. Typically a few layers are joined together to provide desirable properties. Each layer consists of high-modulus, high-strength fibers embedded in a matrix material. Typically these fibers are straight within a lamina. Recently, the concept of variable stiffness laminated composites (VSCL) has emerged to further enhance the structural response of constant stiffness composite laminate (CSCL). Earlier studies focused on understanding the response of CSCL based on first order and higher theories [1, 2]. The spatial discretization were based on either Lagrange shape functions [3, 4, 5], meshfree shape functions [6] or non-uniform rational B-splines [7, 8] within the Galerkin framework.

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