**Temperature Effect on the Modal Properties of Laminated Composite Structures**

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**ABSTRACT**

The composite materials and structures currently have a wide range of engineering applications, especially in aeronautical, ship and marine structures. The increasing use of composite materials in engineering structures has brought many new problems for structural maintenance, inspection and vibration control. Vibration damping becomes increasingly important for improvement of vibration and noise control, and fatigue and impact resistance in advanced engineering systems. The examination of environmental factors on structural vibration properties is important in order to reliably apply the vibration-based structural condition monitoring and vibration control techniques to engineering structures. Environmental conditions affect structural vibration properties in a complicated manner, so in this paper the variations of frequencies, mode shapes and damping with respect to temperature changes from -15 to 45 Celsius degree are investigated. The modal properties are identified from vibration tests of cantilever beams using Subspace-based System Identification (SSI) method.

**KEY WORDS:** Vibration; Composite materials; Composite structures; Modal parameter identification; Finite element analysis; Damping; Viscoelastic layers

1. INTRODUCTION

Composite materials and structures currently have a wide range of engineering applications, especially in the aeronautical, ship and marine structures fields, because of their excellent stiffness, low density and ease of shaping. Composite materials possess specific strengths and Young’s moduli many times greater than those of the most widely used metallic materials, such as steel, aluminum and titanium. However, those composites have some disadvantages. Compared with conventional materials, it is more possible to produce damage in their fabrication and operation phases. So the increasing use of composite materials in engineering structures has brought many new problems for structural maintenance, inspection and vibration control. Vibration-based structural health monitoring and vibration control techniques of composite structures have been developed in the last years. The feasibility of developing a visco-elastic damping material of structures for vibration damping has received extensive interest. Surface treatment uses high damping materials firmly attached to the surface of structural elements. Understanding the damping characteristics of visco-elastically damped structures is strongly necessary. Vibration damping becomes increasingly important for improved vibration and noise control, fatigue and impact resistance in advanced engineering systems. Jonhnson (1995) reviewed the techniques employed for integral passive damping for vibration control. And in another way, composite materials have received special attention in vibration-based damage detection techniques. An excellent review of the literature on the damage characterization problem up to 2006 can be found in Montalvao et al.,(2006), Sohn et.al, (2003)and Doebling et al.,(1996). Many works have demonstrated the feasibility of the vibration-based method (Steenackers et.al, (2005), Yang et.al (2003), Li and Yang (2006)). The examination of the effect of environmental conditions on structural vibration properties is important in order to reliably apply the vibration-based structural condition monitoring methods and vibration techniques to engineering structures. Modal testing has the potential to provide the basis for rapid, inexpensive vibration characterization of composites structures. Firstly, vibration testing can be used to estimate for composite structures damage detection; Secondly, the same kinds of tests should be very useful in assessing the effectiveness of such kinds of maintenance; thirdly, vibration testing can be used for estimate the vibration characteristic of composite structures. Changes in environmental conditions such as temperature affect structural vibration properties. Many researchers studied the effect of changing environmental conditions on structural vibration properties. (Askegaard et al.,(1998), Ionan et al.(1999), Cioara et al.,(2000), Maecck et al.,(2000), Rohmann et al.,(2000), Peeters et al.,(2001)). But none of the above studies, however, investigated the changing environmental conditions on structural damping, although temperature was reported as the single most important environmental factor affecting the structural damping. None of the above studies investigated the environmental effect on mode shapes. Environmental conditions

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