Optimization of the Fundamental Frequencies of Axially Compressed Laminated Curved Panels

Hsuan-Teh Hu and Jun-Ming Chen
Department of Civil Engineering, National Cheng Kung University

ABSTRACT

Free vibration analyses of laminated curved panels subjected to axial compressive forces are carried out by employing the Abaqus finite element program. The fundamental frequencies of these composite laminated curved panels with a given material system are then maximized with respect to fiber orientations by using the golden section method. Through a parametric study, the significant influences of the end conditions, the panel aspect ratio, the panel curvature and the compressive force on the maximum fundamental frequencies and the associated optimal fiber orientations are demonstrated and discussed.

Keywords: Maximization, fundamental frequencies, axially compressed laminated curved panels.

1. INTRODUCTION

The applications of fiber-composite laminate materials to aerospace industrial such as spacecraft, high-speed aircraft and satellite have increased rapidly in recent years. The most major components of the aerospace structures are frequently made of curved panels and subjected to various kinds of compressive forces. Therefore, knowledge of the dynamic characteristics of composite laminated curved panels in compression, such as their fundamental natural frequency, is essential.

The fundamental natural frequency of composite laminated curved panels highly depends on the ply orientations (Crawley, 1979; Chandrashekhara, 1989; Qatu and Leissa, 1991; Raouf, 1994; Chun and Lam, 1995; Hu and Juang, 1997; Hu and Tsai, 1999; Hu and Ou, 2001; Hu and Tsai, 2009), end conditions (Sharma and Darvizeh, 1987; Chandrashekhara, 1989; Chun and Lam, 1995; Hu and Juang, 1997; Hu and Tsai, 1999), geometries (Chandrashekhara, 1989; Qatu and Leissa, 1991; Hu and Juang, 1997; Hu and Tsai, 1999; Hu and Ou, 2001; Hu and Tsai, 2009), and compressive forces (Dhanaraj and Palanininathan, 1990; Chen, Cheng, Chien and Doong, 2002; Nayak, Moy and Shenoi, 2005; Hu and Tsai, 2009). Therefore, proper selection of appropriate lamination to maximize the fundamental frequency of composite laminated curved panels in compression becomes a crucial problem (Bert, 1991; Abrate, 1994; Raouf, 1994; Topal and Uzman, 2006).

Research on the subject of structural optimization has been reported by many investigators (Schmit, 1981) and has been widely employed to study the dynamic behavior of composite structures (Abrate, 1994; Hu, and Ho, 1996; Hu and Juang, 1997; Hu and Tsai, 1999; Hu and Ou, 2001; Narita, 2003; Topal and Uzman, 2006; Hu and Wang, 2007; Hu and Tsai, 2009). Among various optimization schemes, the golden section method is a simple technique and can be easily programmed for solution on the computer (Vanderplaats, 1984; Haftka, Gürdal and Kamat, 1990). In this investigation, maximization of the fundamental natural frequency of composite laminated curved panels in compression with respect to fiber orientations is performed by using the golden section method. The fundamental frequencies of composite laminated curved panels are calculated by using the Abaqus finite element program (Abaqus, Inc., 2010). In the paper, the constitutive equations for fiber-composite lamina, vibration analysis and golden section method are briefly reviewed. The influences of the end conditions, the panel aspect ratio, the panel curvature and the compressive force on the maximum fundamental natural frequency and the associated optimal fiber orientations of the laminated curved panels are presented and important conclusions obtained from the study