World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:11, No:02, 2017

A Parametric Investigation into the Free Vibration and Flutter Characteristics of High Aspect Ratio Aircraft Wings Using Polynomial Distributions of Stiffness and Mass Properties

Authors : Ranjan Banerjee, W. D. Gunawardana

Abstract : The free vibration and flutter analysis plays a major part in aircraft design which is indeed, a mandatory requirement. In particular, high aspect ratio transport airliner wings are prone to free vibration and flutter problems that must be addressed during the design process as demanded by the airworthiness authorities. The purpose of this paper is to carry out a detailed free vibration and flutter analysis for a wide range of high aspect ratio aircraft wings and generate design curves to provide useful visions and understandings of aircraft design from an aeroelastic perspective. In the initial stage of the investigation, the bending and torsional stiffnesses of a number of transport aircraft wings are looked at and critically examined to see whether it is possible to express the stiffness distributions in polynomial form, but in a sufficiently accurate manner. A similar attempt is made for mass and mass moment of inertia distributions of the wing. Once the choice of stiffness and mass distributions in polynomial form is made, the high aspect ratio wing is idealised by a series of bending-torsion coupled beams from a structural standpoint. Then the dynamic stiffness method is applied to compute the natural frequencies and mode shape of the wing. Next the wing is idealised aerodynamically and to this end, unsteady aerodynamic of Theodorsen type is employed to represent the harmonically oscillating wing. Following this step, a normal mode method through the use of generalised coordinates is applied to formulate the flutter problem. In essence, the generalised mass, stiffness and aerodynamic matrices are combined to obtain the flutter matrix which is subsequently solved in the complex domain to determine the flutter speed and flutter frequency. In the final stage of the investigation, an exhaustive parametric study is carried out by varying significant wing parameters to generate design curves which help to predict the free vibration and flutter behaviour of high aspect ratio transport aircraft wings in a generic manner. It is in the aeroelastic context of aircraft design where the results are expected to be most useful.

Keywords : high-aspect ratio wing, flutter, dynamic stiffness method, free vibration, aeroelasticity
Conference Title : ICAS 2017 : International Conference on Aeronautical Sciences
Conference Location : Melbourne, Australia
Conference Dates : February 02-03, 2017