Mechanics of Nano, Micro and Macro Composite Structures
Politecnico di Torino, 18-20 June 2012

A. J. M. Ferreira, E. Carrera (Editors)
http://paginas.fe.up.pt/~icnmmcs/

FLUTTER ANALYSIS OF COMPOSITE WINGS BY 1D CUF MODELS

Marco Petrolo and Erasmo Carrera

Politecnico di Torino
Department of Aeronautics and Space Engineering
Corso Duca degli Abruzzi, 24
10129, Torino, Italy

e-mail: marco.petrolo@polito.it, web page: http://www.mul2.com

Key words: Flutter, 1D Refined Models, Doublet Lattice Method, Unified Formulation

ABSTRACT

Flutter analyses of composite wings are presented in this paper. Wing structures are modeled by means of the 1D Carrera Unified Formulation (CUF) for refined finite elements. CUF 1D models have recently been developed for isotropic [1, 2] and composite structures [3]. CUF models exploit arbitrary order expansions of the generalized variables above the cross-section of the structure. Different expansion functions can be adopted such as polynomial or sinusoidal. In this paper, the TE 1D CUF class is exploited where Taylor-like polynomial expansions are adopted. The order (N) of the expansion is a free-parameter of the formulation; in other words, N is one of the inputs of the analysis. Any-order models can be obtained with no need of ad hoc formulations by exploiting the so-called fundamental nuclei formulation which allows one to obtain finite element matrices in a form that is independent of the order of the model. 1D CUF models allow us to detect highly accurate shell-like static deformations and modal shapes of thin-walled structures with a significant reduction of computational costs.

1D CUF structural models were herein coupled to a refined version of the Doublet-Lattice Method, DLM, based on a quartic approximation of the oscillatory kernel [4]. Flutter analyses were performed by means of the g-method [5].
Table 1 shows a typical result from the present formulation. A straight composite wing made of an eight-layer laminate was considered. Natural frequencies and flutter velocities were obtained and compared with those by Kameyama and Fukunaga [6] . A fourth-order TE model was used, $N = 4$. Results from 1D CUF models accurately match those from 2D CLT models with small computational costs.

Model	f_1	f_2	f_3	f_4	f_5	V_F
$N = 4$	7.2	45.1	58.9*	126.5	181.9*	38.2
Kameyama and Fukunaga (2007) (CLT)	7.3	45.4	59.1*	127.7	182.3*	38.8

(*)torsional mode

Table 1: Vibration frequencies [Hz] and flutter velocities [m/s] of an eight-layer straight laminated wing

REFERENCES

[1] E. Carrera and M. Petrolo, "On the effectiveness of higher-order terms in refined beam theories", *Journal of Applied Mechanics*, 78(2), (2011).

[2] E. Carrera, G. Giunta and M. Petrolo, *Beam Structures: Classical and Advanced Theories*, John Wiley & Sons, Ltd (2011).

[3] E. Carrera and M. Petrolo, "Refined One-Dimensional Formulations for Laminated Structure Analysis", *AIAA Journal*, DOI: 10.2514/1.J051219, (In Press).

[4] W. P. Rodden, P. F. Taylor and S. C. McIntosh Jr, "Further Refinement of the Subsonic Doublet-Lattice Method", *Journal of Aircraft*, 35(5), 720–726, (1998).

[5] P. C. Chen, "Damping Perturbation Method for Flutter Solution: The g-Method", *AIAA Journal,* 38(9), 1519–1524, (2000)

[6] M. Kameyama and H. Fukunaga, "Optimum design of composite plate wings for aeroelastic characteristics using lamination parameters", *Computers and Structures*, 85, (2007).