FREE-VIBRATION ANALYSIS OF DELAMINATED SHELLS VIA UNIFIED FORMULATION

M. Cinefra[1], E. Carrera[1], S. Valvano[1]

(1) Department of Mechanical and Aerospace Engineering, Politecnico di Torino
Corso Duca degli Abbruzzi 24, 10129, Turin, Italy
maria.cinefra, erasmo.carrera, stefano.valvano {@polito.it} www.mul2.com

Keywords: Delamination, Composite, Shell, Unified Formulation, Mixed Interpolated Tensorial Components.

Abstract

The present work deals with the free-vibration analysis of multilayered composite shells affected by localised delamintions. The delamination in composite structures may occur either during the manufacturing process or during service period of the structure. Delaminations can be distinguished into two types, one delamination at the free edges caused by high free edge stresses, and the other embedded within the body of the structure which may be due to manufacturing defects or voids, or due to impact loads. To facilitate the understanding of the effect of the delamination on the structures, and to analyze possible algorithms for structural health monitoring of delaminated structures, delamination models are required. Several authors have studied delaminated shells, like Nanda and Sahu have carried out free vibration analysis of delaminated composite shells [1] using different shell theories. Dynamic instability of delaminated skew plates subjected to static and dynamic loads based on higher order shear deformation theory was studied out by Noh and Lee [2]. These works used a single theory or couple of theories to carry out their studies. The proposed investigation tries to comprehensively carry out free vibration analysis of delaminated composite shells using refined and advanced shell models, contained in the *Carrera's* Unified Formulation (CUF). One of the most interesting features of the CUF consists in the possibility to keep the order of the expansion of the state variables along the thickness of the plate as a parameter of the model. Finite elements with layer-wise capabilities are employed to ensure an accurate description of the mechanical fields in the layers. It is essential to take into account the discontinuity of the mechanical properties at the layer interfaces. For these reasons, the use of classical plate theories based on Kirchhoff and Reissner-Mindlin hypotheses can lead to inaccurate results. The Mixed Interpolated Tensorial Components (MITC) method is employed to contrast the membrane-shear locking phenomenon that usually affects shell finite elements. This formulation has already shown all its potentiality as a base for finite elements in the mechanical analysis of multilayered shells [3]. Some results from the free-vibration analysis of shells will be provided, in order to show the efficiency of models presented.

References

[1] Namita Nanda and S.K. Sahu, "Free vibration analysis of delaminated composite shells using different shell theories," *International Journal of Pressure Vessels and Piping*, Vol. 98, 111-118, 2012

[2] Myung-Hyun Noh and Sang-Youl Lee, "Dynamic instability of delaminated composite skew plates subjected to combined static and dynamic loads based on HSDT," *Composites Part B: Engineering*, Vol. 58, 113-121, 2014

[3] M. Cinefra and E. Carrera., "Shell finite elements with different though-the-thickness kinematics for the linear analysis of cylindrical multilayered structures," *International Journal for Numerical Methods in Engineering*, 93, 160 182, (2013).