Buckling performance of variable stiffness composites considering material uncertainties via multiscale stochastic fibre volumes

A.R. Sanchez-Majano, A. Pagani

Politecnico di Torino, Corso Duca degli Abruzzi 24, Torino. alberto.racionero@polito.it

Politecnico di Torino, Corso Duca degli Abruzzi 24, Torino. alfonso.pagani@polito.it

Keywords: Variable stiffness composites, defect modelling, micromechanics, Unified Formulation

The novel manufacturing techniques of composite laminates are leading to a reduction in the amount of defects present at the mesoscale level of variable stiffness plates (VSP), see for instance the Continuous Tow Shearing [1] method that permits to avoid the misalingments and skip the presence of gaps and/or overlaps among tows. Nevertheless, the inner constituents of the composite material might not be flaw-exempt, e.g: void content, variation in the fibre volume, presence of different phases, etc. This fact leads to the need of a multiscale analysis of the whole VSP, which have been demonstrated to be computationally expensive for classic composite structures. In the recent years, the Carrera Unified Formulation (CUF) [2] has been extended to the micromechanical [3] and multiscale [4] analysis of material composites, providing solutions that required fewer number of degrees of freedom and, thus, a reduction in terms of CPU time. By using the CUF framework, extended to both VSP [5] and micromechanics, this work aims to show how variations in the fibre volume content of the material affect the buckling performance of VSPs. For doing so, stochastic fibre volume fields are generated by means of the Covariance Matrix Decomposition (CMD) [6]. Each component of the random field is assigned to a micromechanical model in order to homogenise the material elastic properties, thus leading to a spatially varying distribution of such properties.

References

[1] B.C. Kim, P.M. Weaver, K. Potter. *Manufacturing characteristics of the continuous tow shearing method for manufacturing variable angle tow composites*. Composites: Part A 61, 2014. Pages 141-151.

[2] E. Carrera, M. Cinefra, M. Petrolo, E. Zappino. Finite Element Analysis of Structures through Unified Formulation. Wiley & Sons. 2014. ISBN: 978-1-119-94121-7.

[3] A.G. de Miguel, A. Pagani, W. Yu, E. Carrera. *Micromechanics of periodically heterogeneous materials using higher-order beam theories and the mechanics of structure genome.* Composite Structures 180, 2017. Pages 484-496.

[4] I. Kaleel, M. Petrolo, E. Carrera, A.M. Waas. *Computationally Efficient Concurrent Multiscale Framework for the Linear Analysis of Composite Structures.* AIAA Journal 2019, Pages 1–10.

[5] A. Pagani, A.R. Sanchez-Majano. *Influence of fibre misalingments on buckling performance of variable stiffness composites using layerwise models and random fields.* Mechanics of Advanced Materials and Structures 2020. DOI: https://doi.org/10.1080/15376494.2020.1771485

[6] P. Spanos, B. Zelding. *Monte Carlo treatment of random fields: a broad perspective.* Applied Mechanics Review 51(3), 1998. Pages: 219-237