ESTIMATION OF HONEYCOMB SANDWICH PROPERTIES THROUGH NUMERICAL HOMOGENIZATION

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ABSTRACT

Honeycomb sandwich panels are widely used in aeronautic industry, and more particularly in the construction of airplane and helicopter trim panels. The current study is motivated by aircraft cabin noise reduction applications, where Active Structural Acoustic Control of the trim panels through piezoelectric patches is considered. As an initial step to such control, predictive models of the panel dynamics are needed for design.

Honeycomb models currently used in industry are either two dimensional (2D) shell models or layered shell-solid-shell models. The later being more accurate for thick layer configurations will be preferred here.

This paper describes a numerical homogenization approach, illustrated on Figure 1, to get a Shell-Volume-Shell (SVS) finite element honeycomb sandwich model from a detailed three dimensional (3D) Shell one. The finite element modeling and the modal computations are supported by the Structural Dynamics Toolbox (SDT [1]) of Matlab software.

In order to obtain numerically an accurate Shell-Volume-Shell model, in a first step, it is generated from a very detailed model (3D FEM, Figure 1 - left) much closer to the physical honeycomb structure. In a second step, the two models are correlated with the dynamical criterions of the modes and the in-plane and out-plane displacement fields of the laminates.

The 3D detailed model is considered as reference, it takes into account the geometry of the honeycomb with a high accuracy and each element of the FEM possesses shell properties. However, the high number of degrees of freedom (DOF) makes difficult the implementation of this model for a whole structure.
The SVS homogenized model is a simplified FEM with shell elements for laminates and solid elements for the honeycomb core. The geometry of SVS FEM is generated from the 3D detailed FEM. About the material properties of homogenized honeycomb core, different theories of prediction exist in the literature [2]. Here, the Gibson and Ashby formulation of honeycomb material properties, calculated from the constitutive material of the cell, is taken as reference for the correlation loop.

The procedure of numerical homogenization is based on a comparison of the eigenfrequencies, and the in-plane and out-plane displacement fields of the laminates for a same mode calculated for the two FEM with the Structural Dynamics Toolbox. For a given structure of composite material, the homogenization is carried out on a sample test in both directions of orthotropic honeycomb (x, y) with periodic conditions. The influent parameters E_{Cz}, G_{Cxz}, G_{Cxz}, among the nine orthotropic properties of honeycomb, are optimized numerically to assume the same dynamical behavior quoted above for the both FEM for different lengths of periodicity. The good Shell-Volume-Shell modeling is obtained, when the correlation is correct for all lengths of periodicity.

The procedure of homogenization and correlation of the two FEM is described and results of comparison on a reference Aluminum/honeycomb Nomex sandwich are presented.

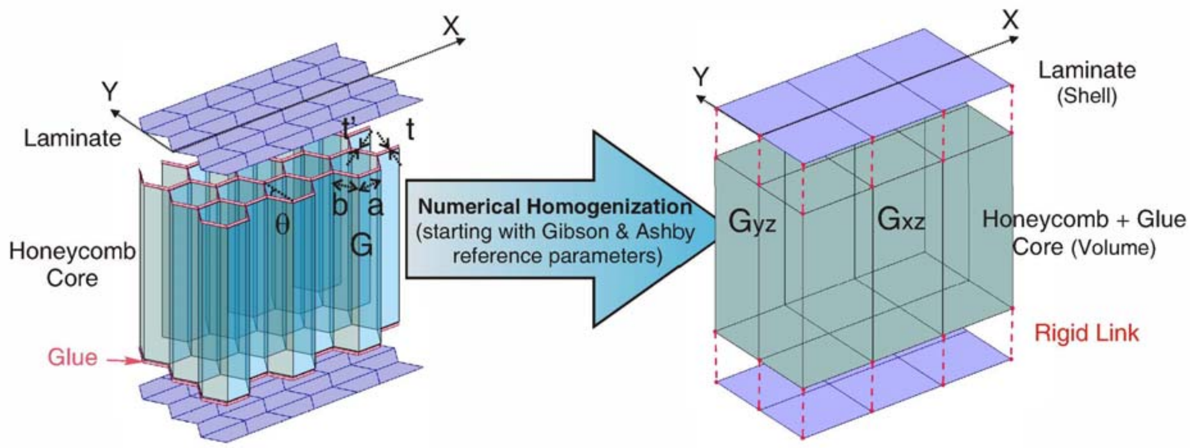

Figure 1- Homogenization from the detailed 3D model to the SVS model.

REFERENCES

[1] E. Balmès and J.-M. Leclère, "Structural Dynamics Toolbox – FEMLink", User's Guide Version 5.2, May 2005.

[2] C. W. Schwingshackl, P. R. Cunningham, and G. S. Aglietti, "Honeycomb elastic material properties: A review of existing theories and a new dynamic approach", in International Conference on Noise and Vibration Engineering, ISMA, 2004.