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Dynamic analysis of sandwich panels and topological design of cores considering the size effect

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ABSTRACT

A typical sandwich panel is composed of the upper and lower skins separated by a lightweight core, for instance, foams, truss， honeycombs and corrugated cores [1-4]. And each kind of cores has various structural forms. For example, the foam cores have polymer and metallic ones with open-cell and close-cell ones; the truss cores have tetrahedral, pyramidal, 3D Kagome and diamond ones; the honeycomb cores have hexagonal, square and triangle ones; the corrugated cores have V-core, X-core, circle-core, and so on. Moreover they have attractive properties for use as sandwich cores, including high specific stiffness and strength, high impact energy absorption, good sound damping, electromagnetic wave absorption, thermal insulation and non combustibility [5-7]. Just owing to their excellent characteristics and various structural forms, sandwich panels are extensively used in the aerospace, building, automobile, package, and shipbuilding industries.

Qatu[8] reviewed recent research advances in the dynamic behaviour of shells from the following four aspects: the theory being applied, the analysis method, complicating effects and the various shell geometries. Yuan [9] developed a B-spline finite strip method for predicting the natural frequencies of vibration and the buckling stresses of rectangular sandwich panels. Nayak [10] used two new C^0 assumed strain finite element formulations of Reddy's higher-order theory to determine the natural frequencies of various composite and sandwich plates. Rao [11] presented a semi-analytical method to evaluate the natural frequencies for simply supported, cross-ply laminated and sandwich plates by using higher order mixed theory.

In this work, firstly the natural frequencies for simply supported sandwich panels with the periodic honeycomb cores are calculated numerically with the different core size and the same volume faction. The computing results show that the dynamic responses of sandwich panels depend upon the scale of the core unit cell. With the decreasing of the size of the core unit cell, the natural frequencies trend to the numerical and analytical solutions when sandwich panels are considered as three-layered plates with the effective core estimated by the homogenization method. Secondly, with the upper

and lower skins as non-designable domains, three dimensional configurations of scale-related sandwich cores with the different size are designed for the natural frequency maximization of the sandwich panel. The topology optimization problem is solved by the dual optimization scheme. And the quadratic perimeter constraint is employed to eliminate checkerboards occurring in the design process. Numerical results show that the optimal topology of the core unit cell is influenced by the scale of involved unit cell.

REFERENCES

[1] L.J. Gibson, M.F. Ashby, *Cellular solids structure and properties*, Oxford: Pergamon Press; 1998.

[2] N. Wicks, J.W. Hutchinson, Performance of sandwich plates with truss cores, *Mechanics of Materials*, 36 (2004): 739-751.

[3] A. Petras, M.P.F. Sutcliffe, Failure mode maps for honeycomb sandwich panels, *Composite Structures*, 44 (1999): 237-252.

[4] L. Valdevit, Z. Wei, C. Mercer, F.W. Zok b, A.G. Evans, Structural performance of near-optimal sandwich panels with corrugated cores, *International Journal of Solids and Structures*, 43 (2006): 4888-4905.

[5] D. Lukkassen, A. Meidell, *Advanced Materials and Structures and their Fabrication Processes*, Third edition, Narvik University College, HiN, October 13, 2003.

[6] H. Zhu, B.V. Sankar, Analysis of sandwich TPS panel with functionally graded foam core by Galerkin method, *Composite Structures*, 77 (2007): 280-287.

[7] M. Styles, P. Compston, S. Kalyanasundaram, The effect of core thickness on the flexural behaviour of aluminium foam sandwich structures, *Composite Structures*, 80 (2007): 532-538.

[8] M. S Qatu, Recent research advances in the dynamic behavior of shells: 1989-2000, Part 1: Laminated composite shells, *Appl Mech Rev*, vol 55: 325-350, (2002).

[9] W.X. Yuan, D.J. Dawe, Free vibration and stability analysis of stiffened sandwich plates, *Composite Structures*, 63: 123-137, (2004).

[10] A.K. Nayak, S.S.J. Moy, R.A. Shenoi, Free vibration analysis of composite sandwich plates based on Reddy's higher-order theory, *Composites: Part B*, 33: 505–519,(2002).

[11] M.K. Rao, Y.M. Desai, Analytical solutions for vibrations of laminated and sandwich plates using mixed theory, *Composite Structures*, 63: 361-373,(2004).