SOUND TRANSMISSION LOSS OF LATTICE SANDWICH PLATE WITH PYRAMIDAL TRUSS CORES

Dongwei Wang[1], Li Ma[2*]

Center for Composite Materials, Harbin Institute of Technology,

Harbin 150001, PR China

* Corresponding author (**mali@hit.edu.cn**)

Keywords: Sound transmission loss, Pyramidal truss cores, Wave propagation

ABSTRACT

The abstract should be entitled with the word **ABSTRACT** centred, in 11 pt boldface Times New Roman. Leave one 11pt space after this title. The **ABSTRACT** should not exceed 300 words of text.

1 INTRODUCTION

Sandwich structure commonly consisting of two thin but stiff face sheets separated by the lightweight core material has broad application prospects [1-2]. It has superior properties of low density, high strength, high modulus and potential application in heat transfer, impact resistance, energy absorbing, etc. Lattice sandwich structure as a kind of potential sandwich structure has attracted more attentions about stastic [3] and vibration properties [4] for its periodicity, multifunction and designability. It possesses superior mechanical characteristics and potential of multi-functional applications. Our aiming is to gain a multi-functional structure combining with load capacity and sound insulation.

To reach that purpose, we established the model and investgated the acoustic performance of the lattice sandwich structure.

2 Model

The infinite two-dimensional sandwich structure with pyramidal truss cores is investigated, as shown in Figure 1. *x*- and *y*-directions are alone the panel and *z*-direction is perpendicular to it. The structure is surrounded by acoustic fluid.

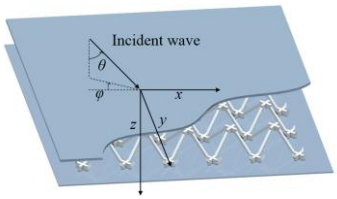

Figure 1: Lattice structure with pyramidal truss cores.

The displacements $w(x,y)$ of the face panel at corresponding points in different periodic elements should have the relationship of transfer constant e^{μ}. The wavenumber and length of cell L should satisfy $kL=\mu$. The motion of panel is expressed as [5]：

$$w_1=\sum_{n=-\infty}^{\infty}\sum_{m=-\infty}^{\infty}W_1^{n,m}e^{-j\left[\left(\mu_x+2n\pi/L\right)x+\left(\mu_y+2n\pi/L\right)y-wt\right]}, \tag{1}$$

$$w_2=\sum_{n=-\infty}^{\infty}\sum_{m=-\infty}^{\infty}W_2^{n,m}e^{-j\left[\left(\mu_x+2n\pi/L\right)\left(x-L/2\right)+\left(\mu_y+2n\pi/L\right)\left(y-L/2\right)-wt\right]}. \tag{2}$$

The truss is regarded as Euler-Bernoulli beam and the stiffness of force K_z and moments K_{rx}, K_{ry} caused by compression and bend are obtained easily. The governing equations of two face sheet are represented as follows:

$$\mathrm{D}\nabla^4 w_1 + \left(m_1 + \frac{4M_l}{L^2}\right)\frac{\partial^2 w_1}{\partial t^2} - j\omega\rho\left(\Phi_1 - \Phi_2\right) = -2\left(K_z + K_{rx}\frac{\partial^2}{\partial x^2} + K_{ry}\frac{\partial^2}{\partial y^2}\right), \tag{3}$$
$$\times\left(w_1 - w_2\right)\sum_{n=-\infty}^{+\infty}\sum_{m=-\infty}^{+\infty}\left[\delta\left(x+nL\right)\delta\left(y+mL\right) + \delta\left(x+nL\right)\delta\left(y-L+mL\right)\right]$$

$$\mathrm{D}\nabla^4 w_2 + \left(m_2 + \frac{4M_l}{L^2}\right)\frac{\partial^2 w_2}{\partial t^2} + 4\left(K_z + K_{rx}\frac{\partial^2}{\partial x^2} + K_{ry}\frac{\partial^2}{\partial y^2}\right)\left(w_2 - w_1\right). \tag{4}$$
$$\times\sum_{n=-\infty}^{+\infty}\sum_{m=-\infty}^{+\infty}\left[\delta\left(x+nL-\frac{L}{2}\right)\delta\left(y+mL-\frac{L}{2}\right)\right] - j\omega\rho\left(\Phi_2 - \Phi_3\right) = 0.$$

The acoustic properties of structure could be calculated once the sheet displacements w_i obtained.

3 CONCLUSIONS

The convergence was checked out and the result was truncated in limited terms. The STL curves show the trend, properties of sound insulation and different kinds of resonance. The incident wave and the effects of parameters are discussed for thorough understanding and system design, such as the material, size and layout. Some of results are shown below.

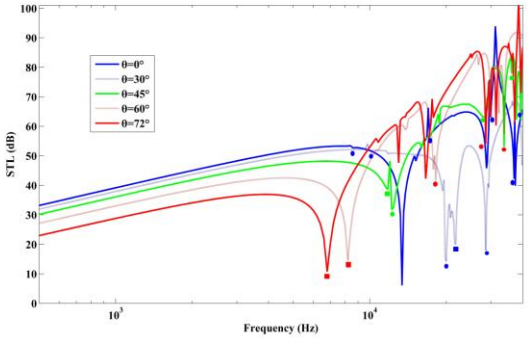

Figure 2: STL curves with respect to varies elevation angle θ of incident wave.

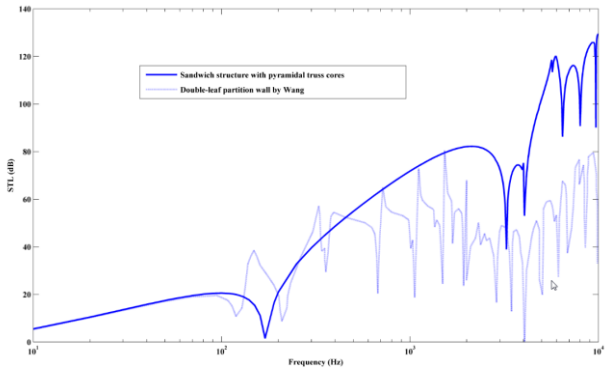

Figure 3: Comparison of structure with pyramidal truss cores and double-leaf partition wall.

Vertical incident meets the best sound isolation in brief. While the azimuth angle φ exerts little influence on the result. Curves coincide in the front half and seem like small oblique translation in some degree in latter half. On the other hand, the increase of modulus of elasticity of truss causes the promotion of the previous resonance frequencies but less effect in high frequency range. But enhancing modulus of elasticity of panel could increase the transmission loss as a whole. The area and shape of cross-section of truss have little impact overall and altering the support angle influences the result which has the similar trend in affecting equivalent density.

Besides, the theoretical results were compared with those of another lightweight structure, the periodic double-leaf partition wall as Fig.3. The comparison shows the advantage of the lattice structure, especially in high frequency range.

4 REFERENCES

The references should be placed at the end of the paper and entitled with the word **REFERENCES** centred, in 11 pt boldface Times New Roman. References should be quoted in the text by numbers ([1], [2, 3] or [1-3]) and grouped together in the list of references in numerical order. For the style, please consult the references shown hereafter in a list of references including a journal paper [1], a book [2] and a conference proceeding [3].

9 CONCLUSIONS

The paper should be written following the format of this template. The file has to be translated into Portable Document Format (PDF) before submission.

Presenting authors should upload the full paper in pdf format using the special web-link they will receive upon registration and payment of registration fee via the ICCM21 online submission system www.iccm21.org no later than ***15 February 2017***.

For more information about the instructions for the layout of the paper, please contact the Conference Secretariat via sending email to iccm21@csfcm.org.cn.

ACKNOWLEDGEMENTS

This present work was supported by National Science Foundation of China under Grant Nos. 11672085.

REFERENCES

[1] S. Georgiadis, A.J. Gunnion, R.S. Thomson, B.K. Gartwright. Bird-strike simulation for certification of the boeing 787 composite moveable trailing edge. *Composite Structures*, **86**, 2008, pp. 258-268.

[2] G. Bella, L. Calabrese, C. Borsellino. Mechanical characterisation of a glass/polyester sandwich structure for marine applications. *Materials and Design*, **42**, 2012, pp. 486-494.

[3] M. Li, L.Z. Wu, L. Ma, and et al. Mechanical response of all composite pyramidal lattice truss core sandwich panels. *Journal of Materials Science and Technology*, **27**, 2011, pp. 570-576.

[4] J.S. Yang, J. Xiong, L. Ma, and et al. Vibration and damping characteristics of hybrid carbon fiber composite pyramidal truss sandwich panels with viscoelastic layers. *Composite Structure*, **106**, 2013, pp. 570-580

[5] J.H. Lee, J. Kim. Analysis of sound transmission through periodically stiffened panels by space harmonic expansion method. *Journal of Sound and Vibration*, **251**, 2002, pp. 349-366.

[6] J.S. Bolton, N.M. Shiau, Y.J. Kang. Sound transmission through multi-panel structures lined with elastic porous materials. *Journal of Sound and Vibration*, **191**, 1996, pp. 317-347