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On the Free Vibration of Honeycomb Sandwich Plates

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Summary

The aim of this paper is to improve the dynamic effects of geometric design variables on a honeycomb sandwich plate. The variables of the honeycomb core were radius and thickness of the hexagonal cell while the mass of the honeycomb sandwich plate was kept constant. In addition, an attempt has been made to investigate the effect of material alteration relative to the upper and lower facings.

Keywords: Free vibration; sandwich plate; laminated facings; honeycomb core dimensions; finite element analysis.

1. Introduction

The increase or decrease in the natural frequency will depend on several design variables. Besides the material properties, the designer must consider the ratio *r/L* (honeycomb cell radius/plate length) and the ratio *H/e* (core thickness/facing thickness). All of these design variables will affect the sandwich plate natural frequencies. It is, therefore, required to undertake parameter studies which provide the means of selection and design of lightweight sandwich plates. However, difficulties inherent to transverse shear deformation, anisotropy of material and boundary conditions constitute a complex and tedious analysis and this make the solution of the equation system impossible. Finite element technique was, therefore, suggested to overcome these difficulties.

2. Numerical results and discussion

2.1 Vibration modes of homogeneous and sandwich plates

Two plate constructions having the same material (aluminium), same mass and same boundary conditions (fully clamped) were investigated. The former plate construction was thin and homogeneous; whereas the latter construction was a honeycomb sandwich plate. It was noted that the natural frequencies of a sandwich plate are greater than those of a homogeneous one. This gain in frequency is directly related to *H*, which rise the natural frequencies of the sandwich plate without materially increasing its mass. The first four mode shapes for both plates were seen to be identical.

2.2 Influence of honeycomb cell radius on the sandwich plate natural frequencies

According to *Fig.*1, it can be noted that the frequency ratio Δ_i $(i=1,2,3,4)$ decreases in hyperbolic form. Seen that Δ_i is high for small values of *r/L*; it is, therefore, recommended to choose the smallest practical value of *r/L*.

2.3 Effect of core thickness on the sandwich plate natural frequencies

According to *Fig.* 2, the ratio Δ_i increases with *H/e* in logarithmic form. For small values of *H/e* (less than 25), the natural frequencies converge to the same value. Whereas, for high values of *H/e*, the condition of divergence is clearly observed.

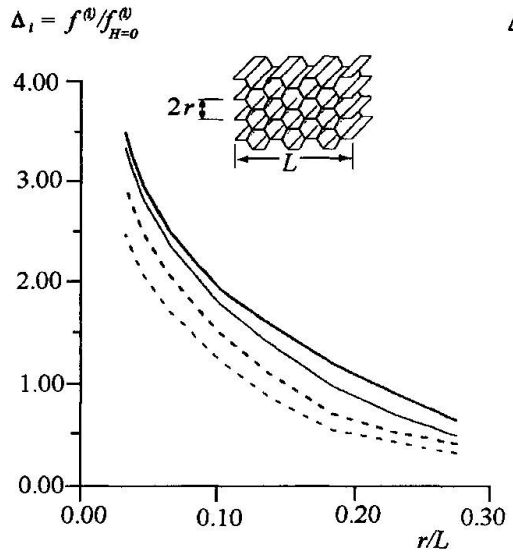

Fig.1 Frequency ratio Δ_i versus hexagonal cell ratio r/L for aluminium honeycomb plate. Frequency mode: (——)1st; (——)2nd; (– – –)3rd; (------)4th.

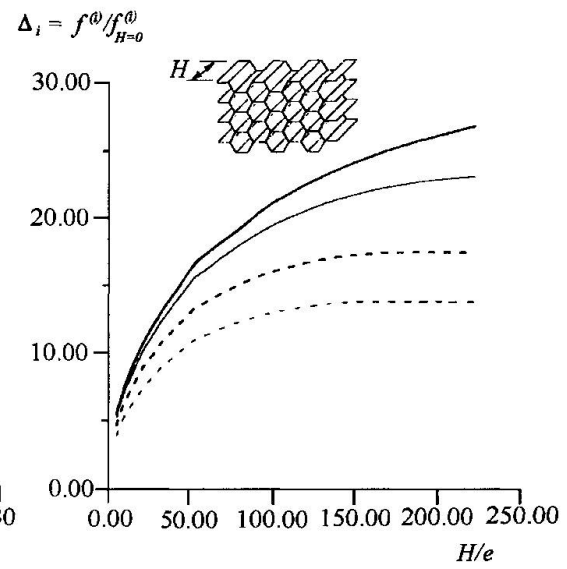

Fig.2 Frequency ratio Δ_i versus sandwich thickeness ratio H/e for all aluminium sandwich plate Frequency mode: as Fig.1.

2.4 Effect of facing material on the sandwich plate natural frequencies

A honeycombed sandwich plate with laminated composite facings was fully investigated. The source for increasing frequency and reducing vibration amplitude levels without introducing weight penalty is believed to be related to the fibre reinforcements which must be tailored in the plane where they will be most effective.

3. Conclusion

The present analysis reinforces the fact that vibration behaviour of complex systems must not be dependent upon one analysis procedure only. Comprehensive modelling of a finite element solution from an experimental procedure should be undertaken before parameter studies are made.