inter•noise 96
25th Anniversary Congress – Liverpool

INCE: 33

SOUND INSULATION IMPROVEMENT USING HONEYCOMB SANDWICH PANELS

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1. Introduction

Research results on acoustic treatment technology of honeycomb material to improve noise transmission loss characteristics of light-weight panels were presented in this paper. A prediction model has been presented to describe the transmission loss of the honeycomb panels based on the knowledge of their structural modal parameters. A series of test specimen with aluminum sheets and fiber reinforced concrete sheets as added on panels have been used to investigate the effect of stiffness and damping on noise transmission loss of the honeycomb sandwich panels. The experimental results of noise transmission loss for both aircraft sidewall aluminum panels and fiber reinforced concrete panels are obtained. Comparison of the experimental results shows that the techniques using acoustic treatment of added-on honeycomb stiffened structure and damping material to reduce the noise transmission are effective. Some practical honeycomb panel design approach has been developed for achieving transmission loss greater than mass law in the frequency band of interest.

It is very difficult to increase the noise transmission loss of light-weight panels at low and middle frequencies due to the light weight, less damping. Some work has been carried out to improve the acoustic performance of light-weight panels by increasing the thickness of panels and number of stiffeners[1, 2], but very few applications can be available. The effect of absorption treatment such as by using fiber glass was found to be small at low frequencies[3].

High TL design of honeycomb sandwich panels

Existing approaches to the design of high TL panels include the " shear wall " , the " coincidence wall " and the " mode canceling panel[4] ". The first two approaches are conventional by which the coincidence resonance is kept at high frequencies above the band of interest by employing a core with a large stiffness through the thickness of the panel. For the former the shear stiffness is carefully controlled so that the wave speed in the mid-frequency region does not exceed the sound speed to avoid coincidence in the frequency band of interest. For the latter the panel damping is utilized to increase the TL in the region where antisymmetric panel motions are coincidentally excited. The third approach is improved by which the double wall resonance frequency is moved to lower frequencies below the frequency band of interest. Those approaches are based on an understanding of coincidence effects in the interaction of the incident sound field with the vibration response of the panel. They can be used to design panels with high TL in mid-frequency region and above, specially near the critical frequency.

2. Experimental Specimen and Results.

To upgrade noise transmission loss performance of the basic honeycomb sandwich panel as an alternative partition panels of housing, two test panels (Test No.C_1 ,C_2) were fabricated with 2.5-mm GRC or GRSC face sheets and a 25-mm resin impregnated paper honeycomb core, and another test panel (Test No.C_3) were fabricated with 2.5-mm GRSC face sheets and 12.5-mm resin impregnated paper honeycomb cores with damping layer sandwiched in.

The resonance frequencies are calculated for the three honeycomb panels and tabulated in Table 1. To verify the reasonable agreement with experimental values, transfer functions between acoustic input (microphone in source room) and vibrational output (accelerometer on panel) were obtained for the three panels. The experimental results of damping loss factor are also tabulated in Table 1.

Table 1 Resonance frequencies and damping loss factor of the honeycomb sandwich panels

Test No.	Resonance frequencies Theory	Test	Damping loss factor
C_1	150	164	0.025
C_2	145	162	0.015
C_3	--	145	0.15

Noise transmission loss performance of the three panels were measured in the Noise Laboratory of the Department of Civil & Structural Engineering of The Hong Kong Polytechnic University. Prediction results and measured TL results are compared in Fig.1~3 for those panels separately. Mass law TL was calculated using the measured mass of the testing panels. Predicted TL was calculated from Eqs.(26) and (27) using the measured resonance frequencies and damping loss factor which was tabulated in Table 1. The results show that the honeycomb sandwich panels have greater measured TL in low frequencies, but only the double-layer honeycomb sandwich panel gives greater measured TL than the mass law TL in entire low-and mid-frequency region.

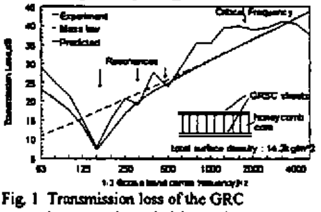

Fig. 1 Transmission loss of the GRC honeycomb sandwich panel

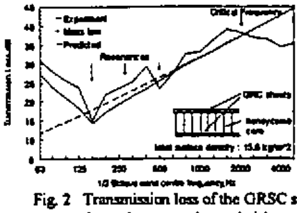

Fig. 2 Transmission loss of the GRSC single-layer honeycomb sandwich panel

Experimental result comparison in Fig.4~6 indicate that the honeycomb panel with GRC face sheets has a little greater TL than the honeycomb panel with GRSC face sheets in low frequency region, and the double-layer honeycomb panel gives much greater TL than the single-layer honeycomb panel in low frequency region.

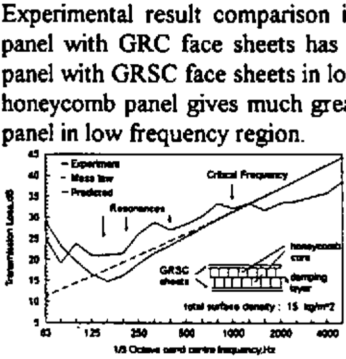

Fig. 3 Transmission loss of the GRSC double-layer honeycomb sandwich panel

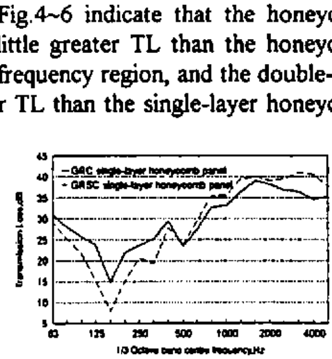

Fig. 4 Experimental result comparison of transmission loss for the GRC and GRSC single-layer honeycomb panels

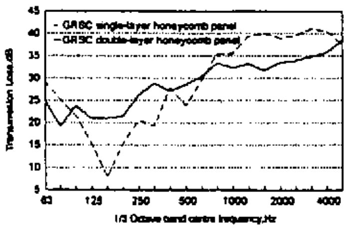

Fig. 5 Experimental result comparison of transmission loss for the GRSC single and double layer honeycomb panels

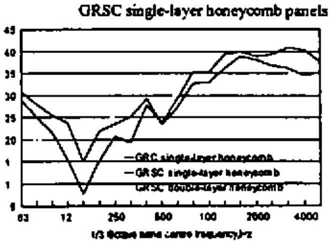

Fig. 6 Experimental result comparison of transmission loss for the GRC and GRSC honeycomb sandwich panels

3. Conclusions

The add-on treatment has been implemented by attaching the honeycomb sandwich panels and the damping tapes to the interior side of the skin subpanels. The test results show that attaching the honeycomb sandwich panels directly to the interior side of the skin subpanels by high strength epoxy is more effective for improving the noise transmission loss in low frequency range. This result can be used in various actual applications, especially when considering the transmission of sound into or out of small existing confined spaces, through light-weight panels, such as motor cars, aircraft fuselages, or electronic component enclosures.

The partition panels were fabricated using GRC or GRSC face sheets and resin-impregnated paper honeycomb core .Relatively good agreement has been reached between theoretical predictions and experimental measurements of noise transmission loss through the partition panels in low frequency region. The test results show that the honeycomb sandwich panel with GRC face sheets has a little greater TL than which with GRSC face sheets in low frequency region, and the honeycomb sandwich panel with double-layer core gives much greater TL than which with single-layer core. A practical approach developed here for the design of high TL in low frequency region is that a damping layer sheet is sandwiched in honeycomb sandwich cores.

4. References

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