The Attenuation of Aircraft Noise by Wood Stud Walls

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Introduction

This paper presents measurements of the effects of: the mass of surface layers, stud size and spacing, structural breaks, and cavity insulation, on the sound transmission loss of exterior wood stud walls. Modern Canadian constructions tend to be more air-tight and to have thicker walls with greater thermal insulation than previously. This investigation of the acoustical properties of such modern wall constructions is part of a larger project to measure exterior building façade components [1] and to develop a computer based procedure for the design of the sound insulation of buildings exposed to aircraft noise.

Measurements were made according to the ASTM E90 procedure but with the frequency range of measurements extended from 50 to 5k Hz. The overall performance of the walls was rated using the ASTM Outdoor-Indoor Transmission Class (OITC).

Key Features of Acoustical Characteristics

Figure 1 illustrates the measured sound transmission loss (TL) versus frequency for two walls that illustrate the important characteristics that are key to understanding the parameters that most influence their overall sound insulation. One wall was the base wall from which many of the comparisons in this study were based. It consisted of a single 13 mm layer of directly attached gypsum board on the interior of 140 mm wood studs at a 406 mm spacing and with glass fibre thermal insulation filling the stud cavities. The exterior surface was vinyl siding on Oriented Strand Board (OSB) sheathing. The other wall was similar except that the interior surface was a double layer of gypsum board mounted on resilient channels. These results show the obvious improvements due to the addition of the structural break created by the use of the resilient channels.

For the results of both walls shown in Figure 1, the dip in the 2.5k to 3.1k Hz region is the well-known coincidence dip, due to the coincidence between the velocity of the incident sound and the bending waves in the gypsum board and OSB panels. However, the low frequency dips more strongly influence overall indoor sound levels for these walls and are therefore more important. For the base wall, without resilient channels, the dip at 125 Hz is the primary structural resonance of the ribbed panel system formed by the surface layers rigidly attached to the stud system [2]. When resilient channels are added to create a structural break, this primary structural resonance no longer exists. However, the two surface layers are then effectively coupled by the stiffness of the air cavity and a mass-air-mass resonance occurs in the 63 Hz band for this wall. The frequency of this resonance is determined by the masses of the surface layers and the stiffness of the contained air and is further modified by the additional stiffness of the resilient channels. Both of these resonances limit the overall performance of the respective walls and have the most important influence on the A-weighted indoor aircraft noise levels.

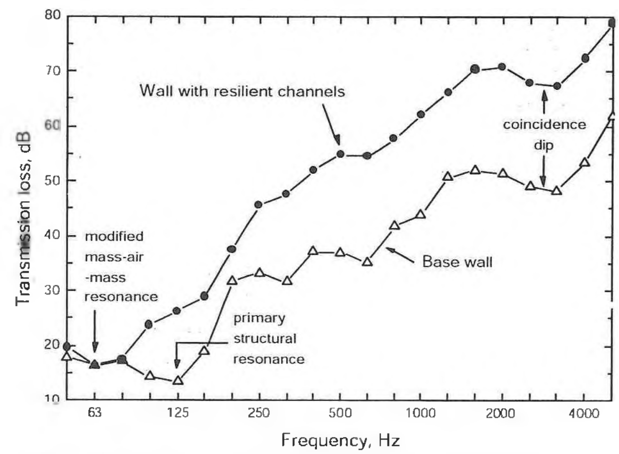

Figure 1. Key characteristics influencing the sound insulation of wood stud walls

Mass of the surface layers

Figure 2 illustrates examples of the effects of varied surface mass for walls without structural breaks. For most changes the increase in OITC rating is approximately 10 times the logarithm of the ratio of the surface masses. Adding brick cladding resulted in a larger increase than this because there was also a 16 mm air gap (with occasional ties) between the exterior sheathing and the brick. All results are limited by the primary structural resonance of the wood stud wall.

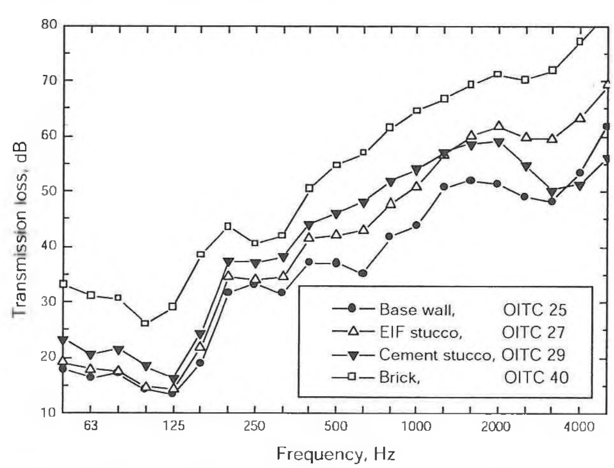

Figure 2. Adding heavier surface layers to the base wall.

Stud Size and Spacing

Increasing the stud spacing and/or the stud size lowers the frequency of the primary structural resonance and hence improves the overall sound insulation of the walls. Figure 3 shows that the effect of stud size is most significant for larger stud spacings. Increasing the stud spacing from 305 to 406 and to 610 mm decreased the frequency of the resonance dip from 200 to 125 and to 80 Hz and would also decrease A-weighted indoor sound levels (not shown).

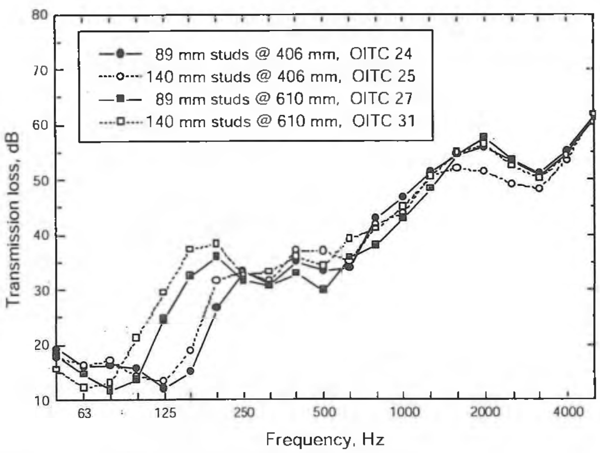

Figure 3. Varied stud size and spacing.

Structural Breaks

Structural breaks were achieved by either attaching the gypsum board using resilient channels or by using staggered stud constructions. Figure 4 illustrates that adding resilient channels eliminates the primary structural resonance at about 125 Hz, but introduces a modified mass-air-mass resonance that limits the low frequency sound insulation. Adding mass to the surfaces of the walls with resilient channels further improves the TL values.

The results in Figure 5 for staggered stud walls show that these walls can be more effective at the important lower frequencies. Adding mass to the surface layers systematically lowers the mass-air-mass resonance and improves the overall OITC rating for these walls. When resilient channels were added to staggered stud walls, the TL values improved above 400 Hz. Stud spacing was not important in walls where there was a structural break.

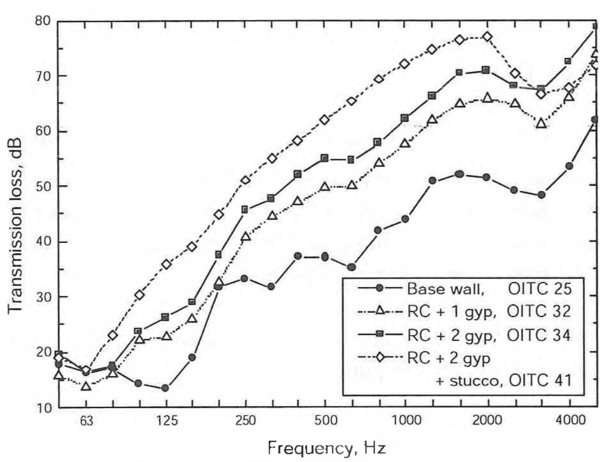

Figure 4. Effects of adding resilient channels (RC).

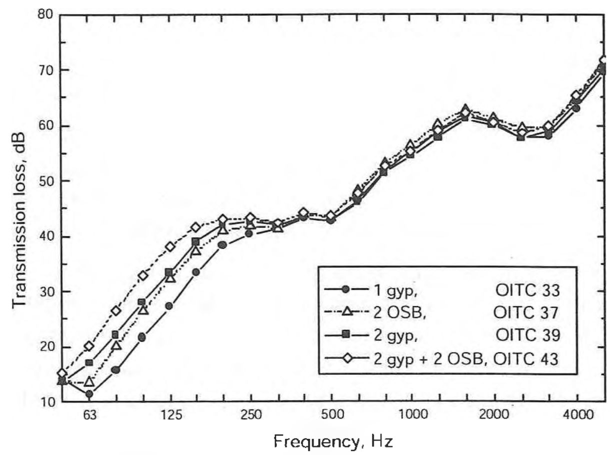

Figure 5. Staggered stud walls.

Cavity Thermal Insulation

The effects of three types of thermal insulation in the stud space were compared in a wall having vinyl siding and OSB sheathing on the exterior and with two layers of gypsum board attached with resilient channels as the interior surface. Varied insulation led to changes in OITC values of 1 or 2 points but these were partially due to the rounding up of the values to integers in the OITC procedure and to the particular wall construction used.

Conclusions

The overall sound insulation of wood stud exterior walls is limited by poor performance at the low frequencies due to one of 2 types of low frequency resonance. It is therefore very important to concentrate on improving the low frequency sound transmission loss to achieve better overall sound insulation.

Acknowledgements

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References

1. Bradley, J.S. and Birta, J.A., "Laboratory Measurements of the Sound Insulation of Building Façade Elements", Institute for Research in Construction Internal Report IR-818, October 2000.

2. Lin, G-F and Garrelick, J.M., "Sound Transmission Through Periodically Framed Parallel Plates", J. Acoust. Soc. Am., Vol. 61, No. 4, pp. 1014-1018, (1977).