SOUND TRANSMISSION LOSS IMPROVEMENT BY A VISCOELASTIC MATERIAL USED IN A CONSTRAINED LAYER DAMPING SYSTEM

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1. INTRODUCTION

At NRC-IRC, a double leaf wall assembly has been tested with and without a constrained layer damper (CLD) to determine the improvement on the sound transmission loss (TL). In parallel, a Statistical Energy Analysis (SEA) model was derived to estimate the effect of the loss factor on the airborne TL. The theoretical and measured improvements will be compared in this paper.

The total loss factors (η) estimated from measurements [1] for the undamped and damped leaves of the wall assemblies were used as input data in the derived SEA model to estimate the relationship between total loss factor of the leaves and transmission loss. The SEA model could also be applied to other processes that change the total loss factor of the separating leafs.

A constrained layer damper is a viscoelastic material that is embedded between two parallel plates. The vibration energy in the first leaf creates shear strain in the viscoelastic material which dissipates kinetic energy into heat. A CLD is an effective way to maximize transmission loss through a partition by increasing its damping.

2. SETUP

The wall specimens described below were installed in the reverberant wall sound transmission facility of IRC and the airborne TL measurements were measured according to ASTM E90.

Specimen description (3.6 m x 2.4 m)

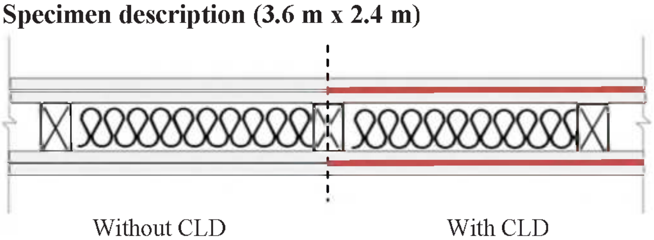

Figure 2 – Wall assemblies viewed from above

-2 x 4 wood studs spaced 610 mm o.c.
-2 layers of 16 mm (5/8 in.) gypsum board on each side
-Gypsum board screw spacing: *Base layer*: 41 mm screws spaced 610 mm o.c. along the edge and in the field
Face layer: 50 mm screws spaced 305 mm o.c. along the edge and in the field
-90 mm glass fibre insulation batts in cavity

The CLD wall assembly contains viscoelastic material embedded between the two gypsum panels on each side.

2.1 SEA model

SEA is a method for estimating the acoustic power flow through a system [2]. The method subdivides the system into smaller elements, the so-called subsystems (plates, beams, rooms, cavities), that support a group of resonant modes and have a sufficient modal density and modal overlap. Thus, in subsystems only resonant energy is considered that is stored by the modes and is governed by the damping. Further, coupling loss factors describe the power flow between coupled subsystems (e.g. between the room and the leaf of the wall) whereas total loss factors describe the sum of all energy losses within the subsystems. In case of the leaf of the wall the total loss factor includes internal losses due to vibration damping in the gypsum board and CLD as well as coupling losses due to radiation of sound into the room and into the cavity and vibration transmission through the frame to other subsystems.
For airborne sound transmission, a simplified SEA model system of two rooms separated by a simple double leaf wall is shown in Figure 1. The model includes only transmission paths with the leaves as resonant subsystems and hence sound transmission in the model depends on the total loss factor of the leaves. The model is only a first order approximation since non-resonant sound transmission through the leaves below the coincidence frequency that is not affected by the total loss factor of the leaves is assumed to be small and neglected.

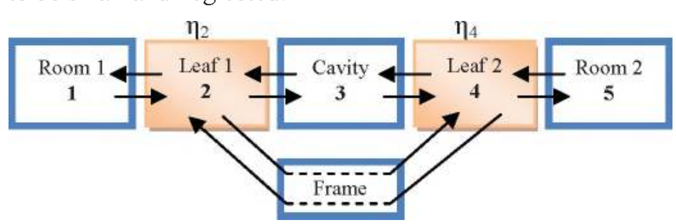

Figure 1 – Simplified SEA model of two rooms separated by a double leaf wall

The change in transmission loss (ΔTL) for the resonant transmission between the undamped and damped system can be calculated using the following equation:

$$\Delta TL = TL_{1-5,dampped} - TL_{1-5,undampped}$$

Using the simple SEA model and assuming the only difference in the system between the two cases is the damping of leaves 2 and 4, the change in transmission loss can be expressed in terms of the total loss factors of the leaves:

$$\Delta TL = 10\log\left(\frac{\eta_{2,damped} \cdot \eta_{4,damped}}{\eta_{2,undamped} \cdot \eta_{4,undamped}}\right)$$

2.2 Measurement of the damping loss factors

The measurement of the loss factors on the wall specimens with and without the viscoelastic material was done as part of a parallel paper by J.G. Richter [1]. The reverberation method was used to measure the total loss factors on one side of the installed wall. The TL improvement was calculated for each 1/3 octave band by using the loss factors as input data in equation 1.

3. RESULTS AND DISCUSSION

Figure 2 contains the airborne TL curves for both wall assemblies with and without a CLD system.

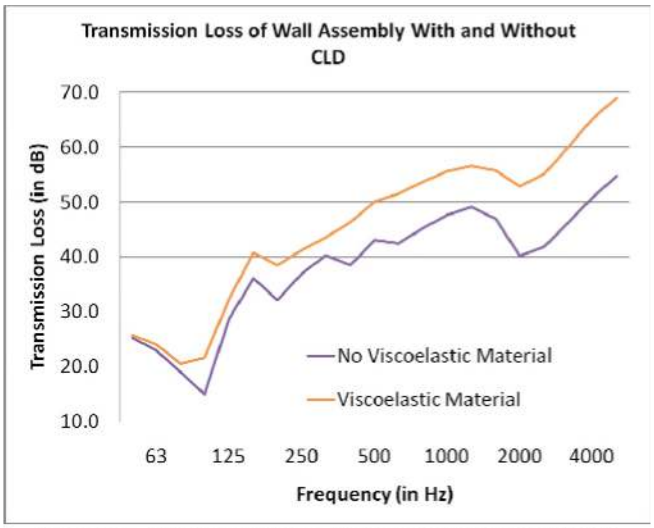

Figure 2 – Measured transmission loss with and without constraint layer damper (CLD).

The addition of a viscoelastic material between the leaves improves the TL significantly by more than 10 dB in the mid- and high frequency range increasing the STC rating by 8 points from 44 to 52. The critical frequency, 2000 Hz, is the same for both wall assemblies, which indicates that the stiffness properties of the leaves are not affected by the viscoelastic damping compound.

Figure 3 shows the difference in TL with and without the CLD (Figure 2) and the estimated ΔTL calculated from the SEA equation 1.

Although the curves crisscross each other, there is very good agreement between the measured and estimated ΔTL. Below the coincidence frequency the agreement is better than above, although it was expected that the estimate might be compromised by non-resonantly transmitted sound that is not considered in this simple SEA model.

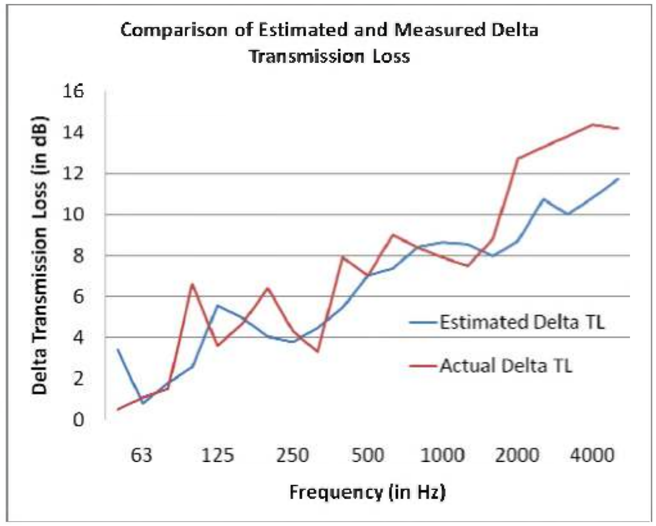

Figure 3 – Comparison of estimated and measured change in transmission loss.

Thus, the results support the assumption that most sound is transmitted resonantly by the frame and the cavity. The divergence above coincidence frequency can be attributed to uncertainties in the measured total loss factors, e.g. small decay range or back-coupling of radiated sound from the room.

4. CONCLUSION

The SEA model seems to be good enough to calculate the change of transmission loss due to added damping for a double leaf assembly and constraint layer damping is an effective way to increase the transmission loss. Knowing the relation between the damping loss factor of the leaf and the transmission loss of the partition is essential in designing better leaves and materials needed for higher performing assemblies. This paper presented a link between the material properties of the leaf and the improvement of the transmission loss.

Further work could include verification of the method with other viscoelastic materials used in a CLD application.

REFERENCES

[1] Ritcher, Jan-Gerrit (**2011**) ,*Comparison of Different Methods to Calculate Structural Damping*, 2011 CAA Conference Proceedings

[2] Craik, Robert JM (**1996**), *Sound Transmission through Buildings using Statistical Energy Analysis*, Gower Publishing Ltd.

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