inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 3.3

SOUND TRANSMISSION THROUGH MULTI-LAYER LIGHTWEIGHT PARTITIONS

R. Craik

Heriot-Watt University, Department of Building Engineering and Surveying, EH14 4AS, Edinburgh, United Kingdom

Tel.: ++44 (0) 131 449 5111 x4624 / Fax: ++44 (0) 131 451 3161 / Email: r.j.m.craik@hw.ac.uk

Keywords:
SOUND TRANSMISSION, TRIPLE WALLS

ABSTRACT
The sound reduction indexes (SRI) of a series of triple walls, constructed from plasterboard attached to timber frames, are presented. These results are compared with a double wall. It is found that, unlike the double wall, structural coupling is relatively unimportant compared with the acoustic path. This could simplify the construction of manufactured partitions.

1 - INTRODUCTION

Double leaf lightweight partitions are widely used in buildings and other structures. They can provide adequate sound insulation whilst retaining low mass. For higher levels of sound insulation walls with three or more layers may offer advantages.

Acoustically the best triple walls will consist of three independent layers that are not physically connected as was studied by Brekke [1]. However, if the wall is to be manufactured then the wall needs to be constructed as a single unit with all three layers connected together. One method of construction is shown in Figure 1 where the staggered frames helps reduce structural coupling. There are other advantages in having all the layers connected including protection against fire and smoke propagation and static stiffness.

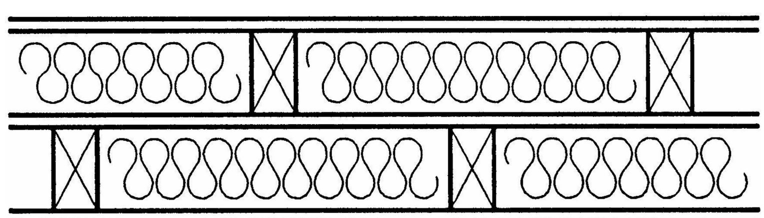

Figure 1: Plan section through a triple wall with staggered studs.

In multilayer walls of this type, both double and triple, there are two types of transmission path. There are those that involve the cavity, or cavities, and those that involve the structure. Acoustic transmission through the cavities is usually non-resonant (mass law) transmission from the source room into the cavity, into the second cavity in a triple wall, and then into the receiving room. Only at very high frequencies is resonant transmission important. The amount of sound transmitted by this path is directly proportional to the damping of the cavity and hence to the amount of absorption in the cavity.

The structural path involves acoustic excitation of the plasterboard in the source room followed by transmission through the structure and radiation into the receiving room. For double walls where the plasterboard is attached to a frame at widely spaced points then the coupling can be considered to be at discrete points. The frame is then best modeled as a beam and the coupling between the plasterboard on either side and the frame can be computed from the mobility of the plasterboard and frame [2, 3].

These values of coupling can then be inserted into a statistical energy analysis (SEA) model to compute the overall transmission [4].
If the nails or screws are closely spaced then the coupling is better modeled as a continuous line and the frame is then a mechanism of transmission between the two layers of plasterboard [2, 3]. Again the transmission coefficients can be inserted into an SEA model to compute the overall transmission.
If there is a line connection on one side and a point connection on the other then the coupling can be found by using a point coupling model and including the frame with the plate on the line side and using the mobility of the beam/plate combination [5].
Similar models can be used for the coupling in triple walls.

2 - DOUBLE WALLS

In a double wall, if there is no acoustic absorption in the cavity, then the acoustic path will normally be the most important path unless there is very strong line connection, which is unusual. If there is absorption in the cavity then the acoustic path tends to be much weaker and the structural path will dominate unless the coupling is very weak due to few point connections.
Figure 2 shows a comparison of the measured and predicted SRI for a double wall constructed from 12.5 mm plasterboard on either side of a 100 × 50 timber frame. The cavity was filled with 100 mm absorption which completely filled the cavity and touched the plasterboard increasing the structural damping. Results are shown for the case where the plasterboard is point connected, line connected and point connected on one side and line connected on the other. It can be seen that there is good agreement between the measured and predicted results. The highest SRI is for a wall with few point connections and the lowest SRI for a wall with many screws so that the coupling can be modeled as a line connection. The measured curve that lies between these results is for the case where there is a line connection on one side and discrete points on the other.

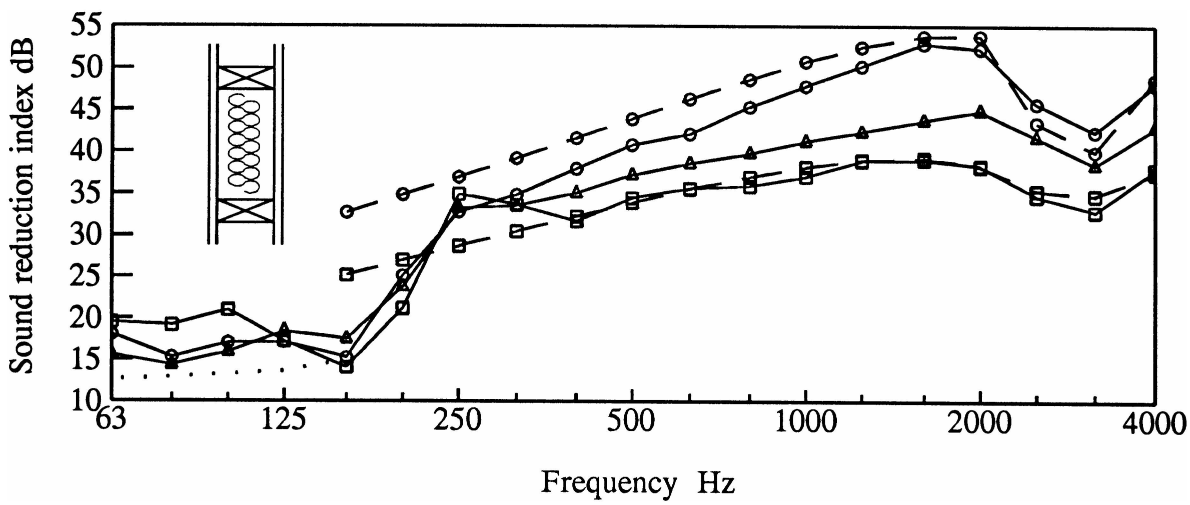

Figure 2: Sound reduction index of a double wall with added absorption; −−−, measured; − − − −, predicted ;......., low frequency model; □, line connection; ○, point connection; △, line/point.

3 - TRIPLE WALLS

Figures 3, 4 show in the SRI through a series of triple walls. Each wall consisted of three single layers of 12.5 mm plasterboard screwed to two frames of 90 x 40 mm timber. The frames were offset, as shown in Figure 1, so that there was no direct transmission between the outer layers of plasterboard. The results in Figure 3 are for the case where there was no absorption in the cavity and the results in Figure 4 are for the case where there was 50 mm absorption in the cavity positioned so as not to touch the plasterboard. Four different structural connection methods were measured. The weakest coupling occurs when the plasterboard is attached at a few discrete points so that the coupling is point connected at all 4 interfaces (labelled PPPP). The strongest coupling will occur if there are many screws so that the coupling can be considered to be a continuous line connection at each junction (labelled LLLL). There are two intermediate conditions where there is a line connection on the outside and point connection in the inside (LPPL) or else a point connection on the outside and a line connection on the inside (PLLP).

The results in both figures 3, 4 show that (apart from inevitable experimental variation) the four types of structural coupling give the same measured values of SRI at least up to 2 kHz. This shows that for a triple wall, unlike a double wall, the nature of the structural coupling is not important and that the acoustic path is dominant even where there is absorption present.
At low frequencies there is a very pronounced dip at 80 Hz which is the mass-spring-mass-spring-mass resonance. This resonance frequency is lower than for the double wall shown in Figure 2 as the overall thickness of the wall is greater. Below this frequency both figures 3, 4 give similar results as would be expected since the wall effectively acts as a single leaf partition. Above 80 Hz there is a sharp rise in SRI as the wall behavior changes from acting as a single leaf partition to a triple leaf partition.
Above 2 kHz the results are different suggesting that structural coupling may be important and in each figure the lowest SRI is for the line connected case where the coupling is strongest.
A comparison of the results in figures 3, 4 show that there is a considerable increase in SRI above 80 Hz as a result of including absorption in the cavity. This is consistent with the acoustic path being the dominant path. The improvement is smaller at high frequencies where structural paths are likely to become important.

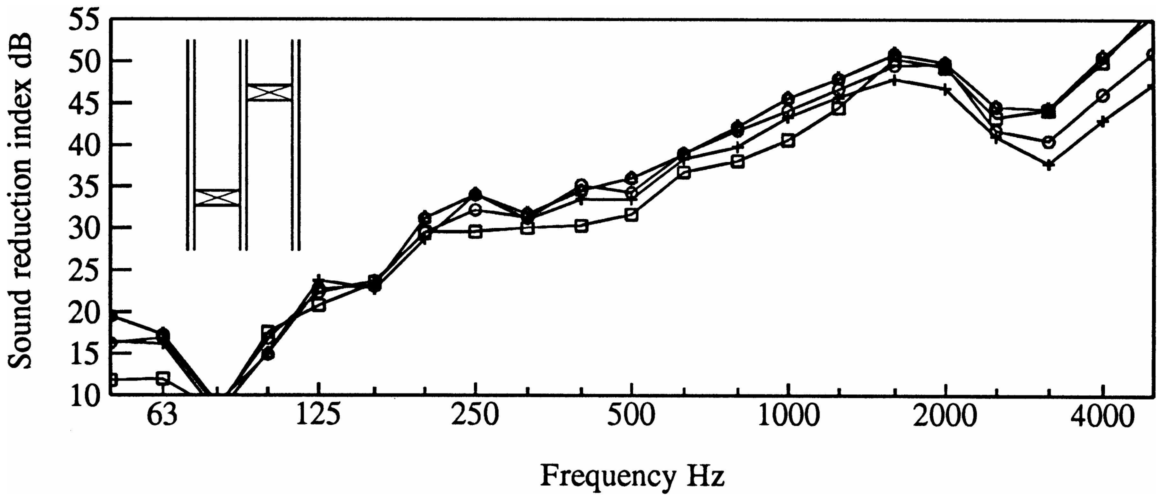

Figure 3: Sound reduction index for a triple wall with no absorption; □, PPPP; ○, PLLP; △, LPPL; +, LLLL.

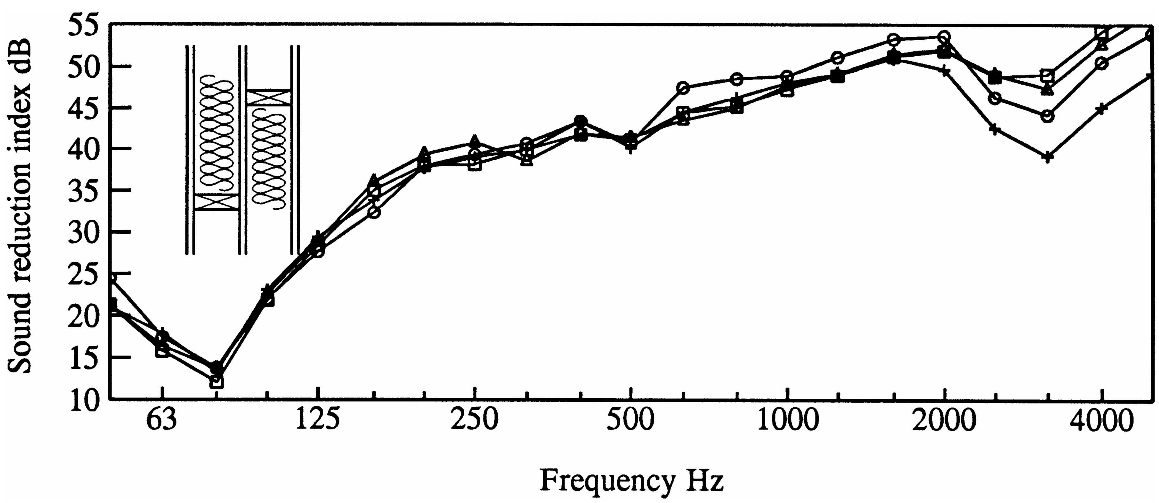

Figure 4: Sound reduction index a triple wall with absorption; □, PPPP; ○, PLLP; △, LPPL; +, LLLL.

4 - DISCUSSION

The results of this paper have shown that triple walls can achieve high levels of sound insulation. Structural coupling is far less important than for double walls and for most practical walls the transmission is likely to be dominated by acoustic coupling through the cavities. This has implications for manufacturers of wall panels since way in which layers are attached to a frame can then be determined by reasons other than acoustic ones such as ease of manufacturing or structural stability. The ability to manufacture robust simple units with high sound insulation is likely to have a wide range of applications producing good acoustics at lower cost and with less variability in performance due to smaller tolerances during manufacture.

ACKNOWLEDGEMENTS

Part of this work was funded by the Engineering and Physical Science Research Council and the Defence Evaluation Research Agency of the United Kingdom.

REFERENCES

1. **A. Brekke**, Calculation methods for the transmission loss of single, double and triple partitions, *Applied Acoustics*, Vol. 14, pp. 225-240, 1981
2. **R.J.M. Craik and R.S. Smith**, Sound transmission through double leaf lightweight partitions, Part 1 - Airborne sound, *Applied acoustics*, Vol. 61, pp. 223-245, 2000
3. **R.J.M. Craik and R.S. Smith**, Sound transmission through double leaf lightweight partitions, Part 2 - Structure-borne sound, *Applied acoustics*, Vol. 61, pp. 247-269,, 2000
4. **R.J.M. Craik**, *Sound transmission through buildings using statistical energy analysis*, 1996
5. **G. Lamb**, Input impedance of a beam coupled to a plate, *Journal of the Acoustical Society of America*, Vol. 33, pp. 628-633, 1961