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SOUND TRANSMISSION THROUGH LIGHTWEIGHT GYPSUM BOARD PANELS

Mahavir Singh*, Omkar Sharma, and V. Mohanan

Acoustics Section, National Physical Laboratory
Dr. K.S. Krishnan Road, New Delhi 110 012, India
mahavir@nplindia.ernet.in

Abstract

Various factors influence the sound transmission through gypsum board panels. Some of them are well known e.g. the thickness, density, number of sheets, and type of frame or sound absorbing material inserted into cavity. The paper presents an analyze of results of measurements carried out by Acoustics Section of NPL on different samples of gypsum board panels during last five years. Over hundreds panels were tested on the same facility under similar conditions. Various technical solutions were considered. Comparison of values obtained confirm the influence of such factors as screw span, rigidity condition, channel connection, distance between studs and cavity absorption and sound bridges in this paper.

INTRODUCTION

Various factors influence the sound transmission loss in lightweight gypsum board wall panels. Some of them are well known e.g. the thickness and number of boards on each side of the frame, sound absorbing material inserted into cavity or type and structure of frame. These elements are taken into consideration while designing partitions of required sound transmission loss. Field measurements often reveal substantial differences between results obtained in the laboratory and in real building which are not associated with flanking transmission. Even the laboratory tests conducted on semi-identical samples of wall panels on different test facilities can reveal essential differences in sound transmission loss [1-4]. The analyses of collected results indicate possible reasons of such discrepancies.

INFLUENCE OF SCREW SPAN

Several partition panels were tested with typical (200 mm) span of screw joining panels to steel channels of frame and then with enlarged distance between screws (600-1000 mm). The results obtained in case of a typical single wall panel are compared in Figure 1. The increase of distance between screws caused the increase of *TL* in the medium and high frequency range. The same effect was found in other samples of different single wall panels regardless of stud section, type of absorbing material inserted into the cavity and number of boards on both sides of the frame. There are probably two main reasons causing such behaviour; different ratio of energy transmitted *via* studs connecting both leafs of gypsum board in each case and different rigidity of edges of gypsum boards.

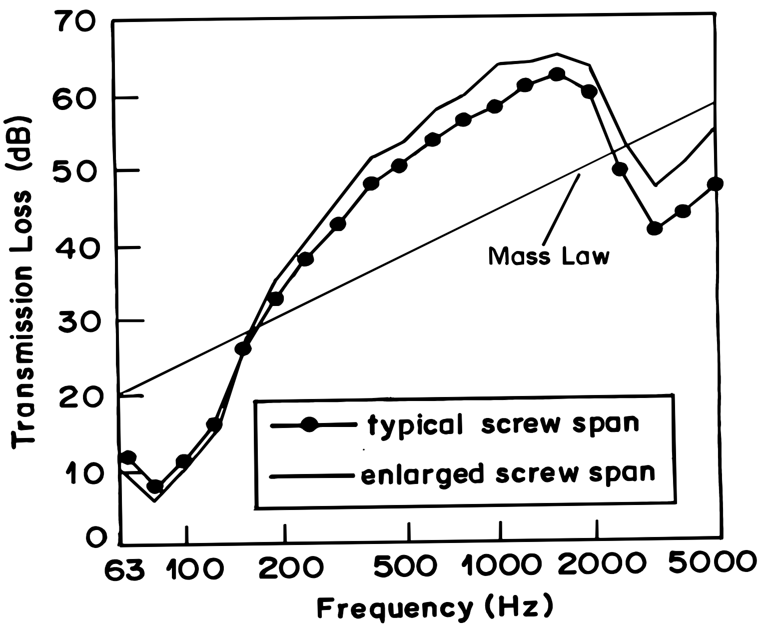

Figure 1 - The *influence of screw span on the airborne sound transmission loss of single gypsum board wall pane*

Result of enlarged distance between screws was also studied in case of double wall panels. The increase of screw span resulted in reduction of *TL* in low frequency region. In case of double wall panels, steel studs are separated and do not connect the panels fixed on both sides of the frame. Hence, the screw distance does not influence this path of transmission (*via* studs). Reduced screw span restricted modal behaviour across the surface of panels in low frequency bands and resulted in increasing *TL* in this range.

INFLUENCE OF RIGIDITY OF GYPSUM BOARD EDGES

The influence of rigidity of gypsum board edges themselves on *TL* of lightweight wall panel can be observed when comparing results of measurements carried out immediately after plastering the edges of boards screwed to the frame (fresh soft gypsum plaster) and after a period of curing time when the connecting mortar is rigid and firm. It forms a sort of continuous rib on the perimeter of gypsum board. Figure 2 shows the comparison of two curves; first obtained just after plastering joints and the second one hour later. The drop in *TL* after the period of curing time in the range of high frequency is conspicuous. Such tendency was observed in the case of other samples regardless of their frame type or structure. Similar effect was found when testing a single leaf of gypsum board with completely free edges and after forming a small rib around the perimeter.

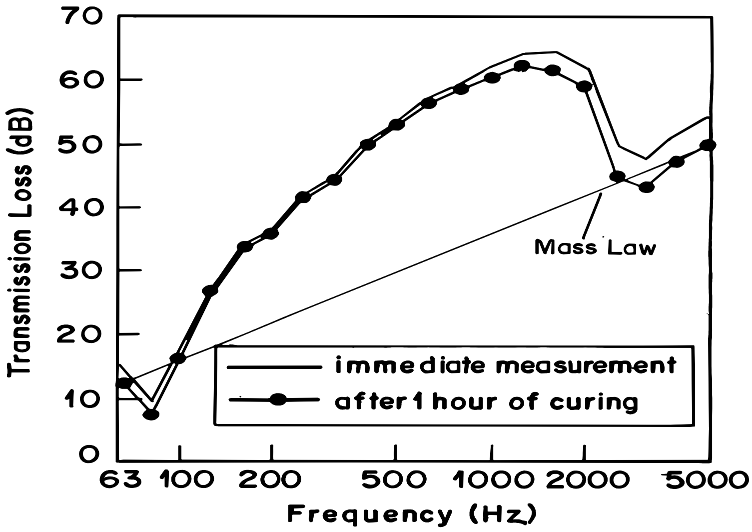

Figure 2 - Change of sound transmission loss of lightweight gypsum board wall panel after period of curing time

INFLUENCE OF CONNECTION OF STEEL CHANNELS

Another factor that can influence the *TL* of lightweight gypsum board wall panel is the connection of steel channels to the partitions surrounding the considered wall panel. This path of transmission is of rising importance in case of double wall panel where both leaves of gypsum boards are connected to each other only on perimeter by surrounding structures.

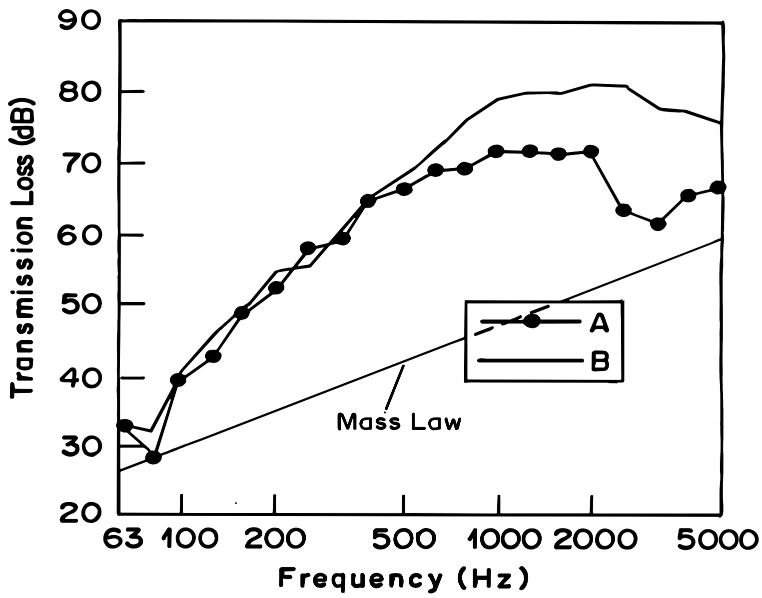

Figure 3 - Sound transmission loss of wall panels with different connection of steel channels to surrounding structure

Figure 3 shows the *TL* curves of two double wall panels whose frames were constructed with 100 mm channels, 200 mm of glass fibre batt was inserted into cavity and two layers of 12.5 mm gypsum board were fixed on each side. In the case of partition a both parts of the frame are joined to a concrete boundary of test facility opening on the same side of vibration brake (which is between totally separated reverberant chambers of the laboratory). The frame of partition B is probably caused by the shortage of power in the source room in the high frequency range.

INFLUENCE OF DISTANCE BETWEEN STUDS

The distance between studs, which determine the dimensions of sub boards, also influence the acoustical performance of the wall panel. Larger distance usually results in better *TL*. An example is given in Figure 4 where the characteristics of two different single wall panels are compared. In both cases, two layers of 12.5 mm thick gypsum boards were used and the distance between studs was 300 mm and 600 mm. The second wall panel has significantly better *TL* in medium and high frequency bands. A similar effect was noticed when comparing *TL* of wall panels with 12.5 mm boards connected to each one (600 mm), and each second (800 mm). The difference in *STC* was up to 5 dB.

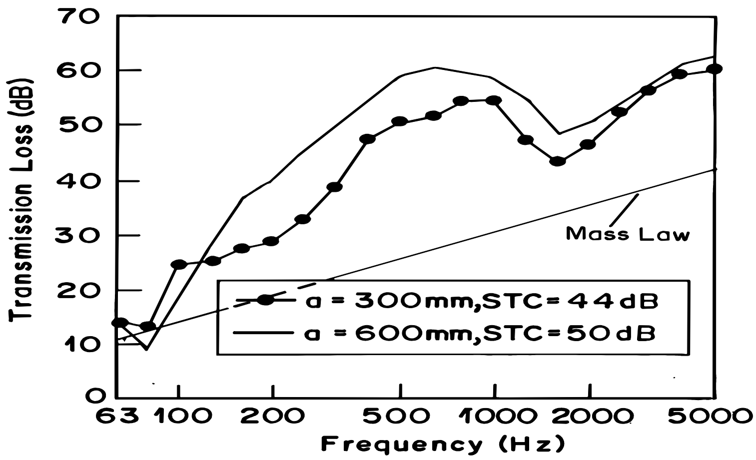

Figure 4 - Sound *transmission loss of lightweight wall panels with different distance between studs*

INFLUENCE OF CAVITY ABSORPTION

To eliminate the effects of coincidence from the study, the panels used were 3 mm and 6 mm hardboards. Results of the experiments are shown in Figure 5.

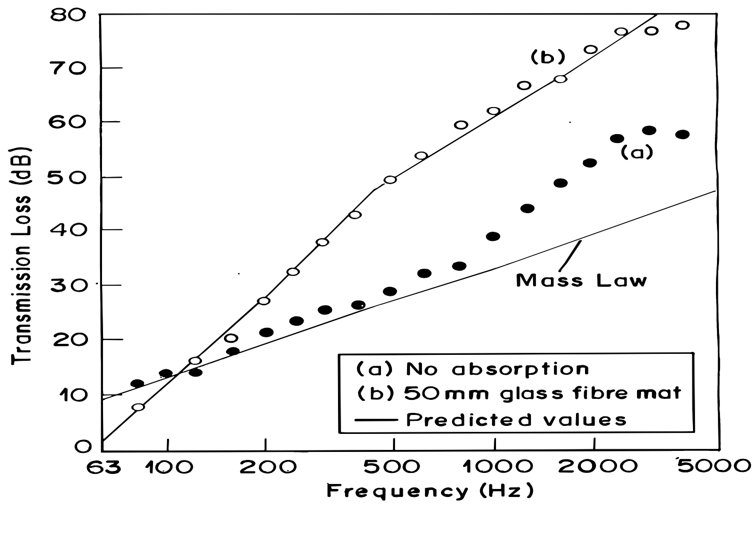

Figure 5 - Effect *of cavity absorption on sound transmission loss of double panel*

In the absence of absorption, curve (a) of Figure 5 shows that strong acoustic coupling between the panels results in a single panel performance at frequencies less than the first cavity resonance perpendicular to the plane of the panels. At higher frequencies, the phase of the sound pressure varies over the thickness of the cavity and the acoustic coupling is weaker. In this frequency range, sound transmission loss is seen to increase and behave more like a double panel, although the predicted values are not attained. The introduction of a 50 mm layer of glass fibre mat (48 kg/m^3) across the entire cavity width (curve (b) of Figure 5) produces a remarkable improvement in sound transmission loss. The agreement between theory and experiment in this case is good.

INFLUENCE OF SOUND BRIDGES

Another assumption in the theory is that the two panels in a double panel construction are completely isolated from one another and that the only path of energy transfer between the two is an airborne path. In practice, it is normal to have some form of connection between the panels in order to provide added stiffness and to withstand lateral loads. These connections take the form of wooden or metal studs in building structures and metal ribs and stringers in aerospace structures. Their effect is to provide a transmission path parallel to the airborne path with the result that more acoustic power is radiated by the structure and the sound transmission loss is reduced. It is not always possible to eliminate these inter-panel connections or *sound bridges* as they are called. Therefore, it is necessary to predetermine reduction in sound transmission loss, while designing such multiple structures.

There are basically three types of inter-panel connections; namely, no structural connection, point connection and line connection (each form of connection can be idealized as either a point or line connection (or no connection), referring to the area over which the bridge acts. The latter type is by far the most commonly encountered in practice since it provides a means of greatly increasing the lateral stiffness of a panel. The method used to determine the reduction in sound transmission loss through a double panel due to the insertion of a number of sound bridges is to sum the acoustic power radiated by the action of the bridges and that radiated by the ideal, isolated panel. This is performed [5] with the result as shown in Figure 6.

It can be seen that the sound bridges dominate the sound transmission loss behaviour above a certain frequency. The increase in sound transmission loss above the calculated mass low for the complete structure (ΔTL in the Figure 6) depends on whether the bridges are point or line connections. It also depends on the number of such bridges and the critical frequency of the panels. Higher values are obtained with few bridges and flexible panels.

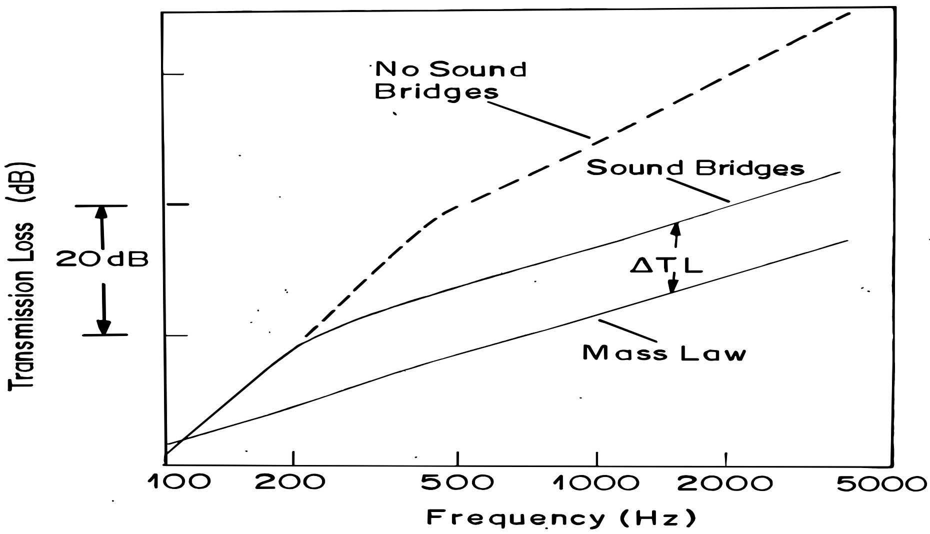

Figure 6 - Effect *of sound bridges on the sound transmission loss of a general double panel*

A practical example of the bridging effect is shown in Figure 7 for the case of a single wood stud wall (studs 600 mm o.c.) with 15 mm and 9.5 mm gypsum board panels. The improvement of point over the line connections is of the order of 5 to 8 dB in the mid-frequency region. It is to be noted that there is a good agreement between theory and experiment.

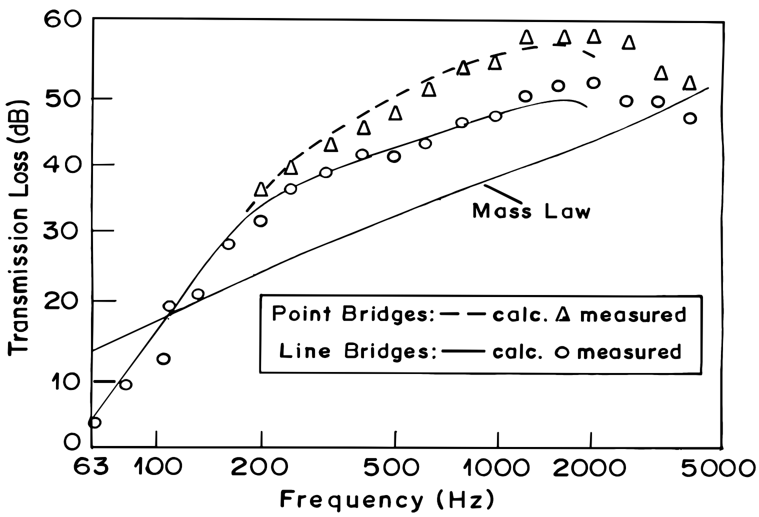

Figure 7 - Sound transmission loss of double panel with sound bridges

CONCLUSIONS

These factors impacting the sound transmission loss have to be included along with properties of cavity absorption, amount and location of absorption material, spacing and type of framing and attachment of gypsum board to framing while designing new type of panels.

REFERENCES

[1] Farina A., Fausti P., Pompoli R., Scamoni F., “Intercomparison of laboratory measurements of airborne sound insulation of partition”, Inter-noise 96,881-886 (1996).

[2] Pompoli R., “Intercomparison of laboratory measurements of airborne sound insulation of walls”, Final report, University of Ferrara, Italy, (1997).

[3] Pompoli R., Smith R.S., “Possible reasons for the discrepancy in the reproducibility results of the inter-comparison of laboratory measurements of airborne sound insulation of walls”, 18th Meeting of CEN/TC126/WG, Zurich (1998).

[4] Schmitz A., Meier A., Rabbe G., “Inter-comparison test of sound insulation measurement in test facilities. I”, J. Acoust. Soc. Am., **105**(2), Pt., Joint Meeting: ASE/EAA/DEGA (1999).

[5] Fahy F., Walker J., *Fundamentals of noise and vibration.* (E &FN Spon, An imprint of Routledge, London and New York, 1998).