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SOUND TRANSMISSION THROUGH BUILDINGS USING STATISTICAL ENERGY ANALYSIS

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Introduction

The idea of using statistical energy analysis (SEA) to analyse sound transmission through buildings is not new and has been carried out since the introduction of SEA almost 20 years ago. These studies have been very successful for both direct and indirect sound transmission paths but unfortunately they have tended, for practical reasons, to be limited to laboratory situations where conditions can be well controlled. In order to determine how well those theories could be applied in practice a series of tests were carried out on an actual building.

Coupling Loss Factors

Since the material properties, including damping, can be easily found for a building structure (see "The measurement of material properties" a paper presented at this conference) the question as to whether SEA can be applied to buildings depends almost entirely on whether or not the coupling loss factors (CLFs) that are measured agree with those that are predicted. A coupling loss factor is simply a measure of how much sound energy passes from one element of the building, either a room or a wall (or a floor) to another part of the building in which it is in contact. There are therefore CLFs between rooms and walls, walls and rooms and walls and walls. Over 150 of the coupling loss factors were measured in the building and for comparison with predicted results similar CLFs have been averaged.

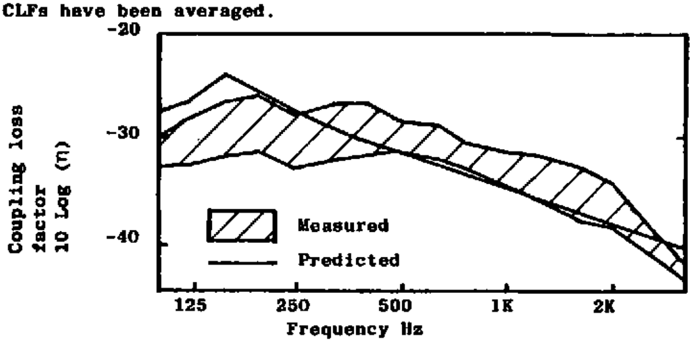

Fig. 1 Measured and predicted coupling loss factor from a wall to a room.

Fig. 1 shows the measured and predicted (1) sound radiation from a wall and is the average of 8 results. Except at the low frequencies around the critical frequency the agreement is quite good and this is important if accurate predictions are to be made of the transmission loss of walls. Similar agreement is found for the CLF between the room and wall and the two CLFs can be combined to give the noise reduction of the direct path between the two rooms.

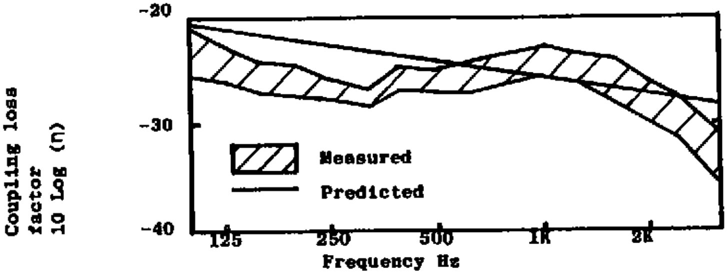

Fig. 2 Measured and predicted coupling loss factor round a cross joint from a wall to a floor.

Figure 2 shows the measured and predicted (2) coupling loss factor round a cross joint from a wall to the floor above,or below, and is one of the commonest joints found in buildings with 20 different measurements being averaged for this figure. Only the simplest theory has been shown as the agreement with this theory is no worse than with more complex theories and has the advantage of being sufficiently simple that it can be computed on a programmable hand calculator. The downward turn of the measured results at the high frequencies is due to poor bonding between the wall and the floor and changes as the quality of the bonding changes. The bonding between the floor and the wall above is better than the bonding between the floor and the wall below and so there is less drop in the measured curve. Similarly there is a better bond between loadbearing and non-loadbearing walls and the floor with a corresponding smaller drop at the high frequencies.

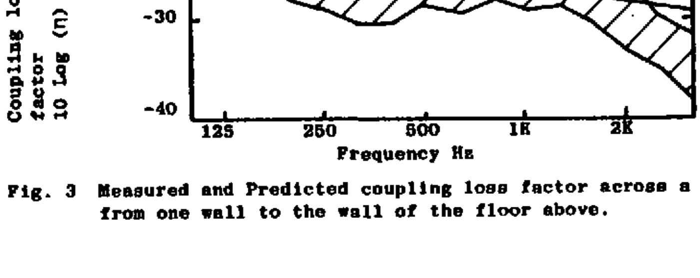

Fig. 3 Measured and Predicted coupling loss factor across a tee joint from one wall to the wall of the floor above.

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Figure 3 shows the measured and predicted sound transmission across a tee joint from one outside wall to the outside wall of the floor above or below. Again the agreement is quite good between the predicted result and the measured result, which is the average of 9 different tests on different walls. In this case the agreement can be improved slightly if more complex theories are used (3,4) but these are not shown.

Overall the results have shown that the agreement between the measured and predicted results is reasonable and can often be improved if more complex theories are used. However the bonding between walls becomes important at high frequencies changing the actual boundary conditions quite significantly from those expected. As it is virtually impossible to predict these changes, this brings into question the usefulness of detailed and complex theories that are usually more accurate at high frequencies, for the analysis of sound in real buildings. Fortunately the poor bonding tends to decrease the sound transmission and give improved insulation but this is not always the case.

Predicting Sound Transmission in a Building

Comparison of measured and predicted CLFs is a useful exercise to check on individual theories but the true test of whether SEA can be applied to buildings depends not on whether a given CLF can be predicted but whether all the CLFs can be combined to predict accurately the resultant SPL in the rooms of a building. For a large building this is a difficult problem which is still being studied. The indications are that very accurate results will not be obtained but that reasonable estimates should be possible.

References

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