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THE EFFECT OF LABORATORY DESIGN ON MEASURED WALL PERFORMANCE

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INTRODUCTION

Sound transmission laboratories are used throughout the world in order to measure the performance of walls and partitions. When different laboratories measure the same wall (say concrete block) then different answers will be obtained. Sometimes these differences can be attributed to differences in equipment or measurement procedures. Alternatively there could be differences due to variations between the batch of blocks used for the wall or the method of construction. Finally there are differences in performance due to the design of the laboratory itself. It is the differences due to the laboratory that are examined in this paper.

The laboratory design can affect the performance of the system in two ways. The way in which the test wall is connected to the rest of the structure determines the damping of the test wall. The second effect of the laboratory is in the provision of flanking paths. These are also affected by the way in which the test wall is connected to the laboratory and so the two effects are not independent.

There are of course steps that can be taken to reduce the effects of flanking. Structural breaks between the chambers can eliminate some flanking paths but may increase others. Lining panels may be placed over some or all of the surfaces. However, it is more difficult to control the conditions at the boundary of the wall and hence to control the damping.

The work in this paper is restricted to a theoretical analysis of the performance of laboratories carried out using statistical energy analysis in which the test wall is of solid masonry. This represents the simplest case as cavity walls are more complicated.

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BASIC LABORATORY

The basic laboratory that was used in the calculations consists to two rooms each with dimensions 3 x 4 x 5 m and a test wall with dimensions 3 x 4 m. The test wall was taken as 100 mm thick and the chamber walls as 200 mm thick and each has a density of 2000 kg/m^3 and a critical frequency of 325 Hz. The ceiling and floor of the laboratories were taken as 200 mm thick with a density of 2300 kg/m^3 and a critical frequency of 96 Hz. The internal loss factor of all of the materials was taken as 0.015.

The test wall was modelled as being either free standing between the test chambers, built into one side or built into both sides, shown in Fig. 1 as A, B and C respectively.

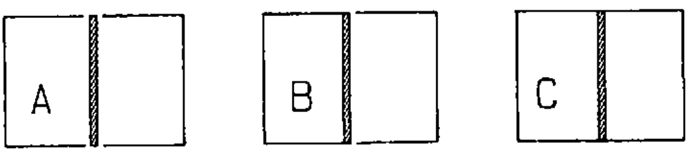

Fig.1 Plan (or section) of the basic laboratory design considered.
A - Free standing wall
B - Wall connected to one chamber
C - Wall connected to both chambers

LEVEL DIFFERENCE OR SOUND REDUCTION INDEX

When determining the performance of the system the results can either be expressed as a sound reduction index or as a normalised level difference. The SRI is defined as the ratio of the power incident on the wall divided by the power radiated by it. This measure, though in some cases more common, is less appropriate for the complete analysis of a system. Usually part of the sound transmitted to the receiving room was not incident on the test wall and some was not radiated by it (and some is neither incident on the wall nor radiated by it). Therefore in this paper the simpler normalised level difference (normalised to a reverberation time of 0.5 seconds) has been used.

DAMPING

The first effect to be considered is the effect of the laboratory on the damping of the wall and its effect on the overall transmission of the system. The normalised level difference due to sound transmission through the direct resonant path can be given as

$$D_{nT} = 10\log\left(\frac{\rho_s^2 f^3 V\eta}{81700\, S f_c \sigma^2}\right) \qquad (1)$$

where ρ_s is the surface density, η is the total loss factor, f_c is the critical frequency, S the area and σ is the radiation efficiency of the test wall and V is the volume of the receiving room. It can be seen that the level difference is directly proportional to the damping so that a 1 dB change in damping has a 1 dB change in transmission by the direct path. This path usually dominates above the critical frequency. Non-resonant transmission, which is usually dominant below the critical frequency, is not affected by damping.

The damping of the test wall can be seen in Fig. 2 for four different conditions. The first three correspond to the three different laboratory designs given in Fig. 1 where the test wall is free standing, connected to one chamber and connected to two chambers. The fourth line (top) is the total loss factor of a wall built into a typical structure with absorption at the boundaries of 0.3 which is typical of real walls.

It can be seen that there are considerable differences in damping between the four walls which would result in different values of level difference. The lowest damping and hence the lowest level difference is for the free standing wall which has damping that is independent of frequency except for the peak in the 315 Hz band which is where the critical frequency occurs. In the two laboratories where the test wall is connected to the structure the damping is almost the same whether the wall is connected to one chamber or two.

The three laboratory results are lower than the damping for a typical wall with a boundary absorption of 0.3. Thus the laboratories do not accurately reproduce field conditions.

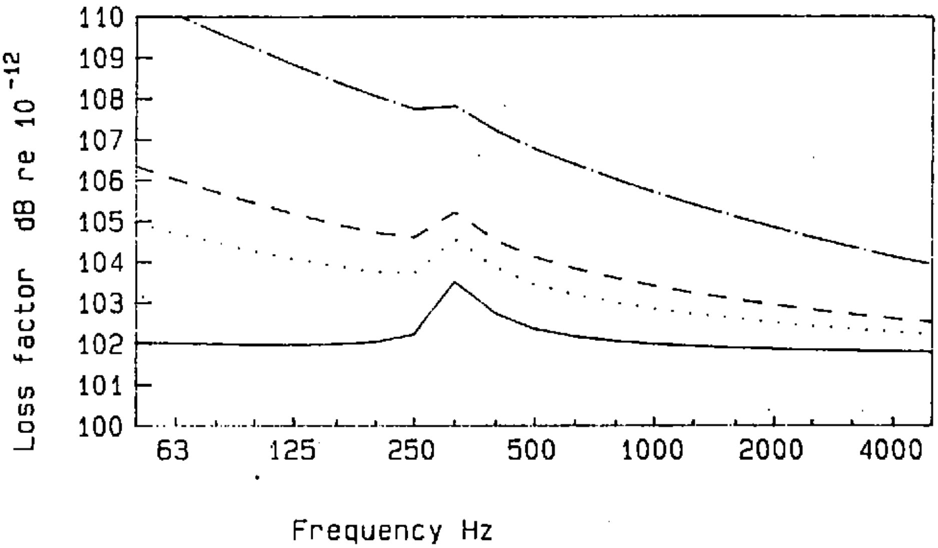

Fig 2. Damping of the test wall for different lab designs. ———, free standing wall; -------, wall connected to one chamber; ·······, wall connected to both chambers; -·-·-·-, boundary absorption of 0.3.

EFFECT OF FLANKING PATHS

When flanking paths are introduced into the model then the performance changes. When the wall is free standing, there are no flanking paths and the overall level difference is the same as the direct path. However when the wall is connected to a chamber then there will a reduction in the level difference due to the additional flanking paths.

The effect of introducing these paths can be seen in Fig. 3 which shows the difference between the level difference of a laboratory with a free standing wall and one where the test wall is connected to one or both chambers. It can be seen that above 315 Hz, which is above the critical frequency of all structural elements, the difference between the different laboratories is small with the free standing wall having the lowest level difference. However, at the lower frequencies the performance of the system where the wall is connected to the laboratory is worse particularly where the wall is connected to both chambers. In most cases the single figure rating is determined by the lower frequencies and so the poorer performance at lower frequencies can be important. At all frequencies the level difference is lower when the test wall is connected to both chambers.

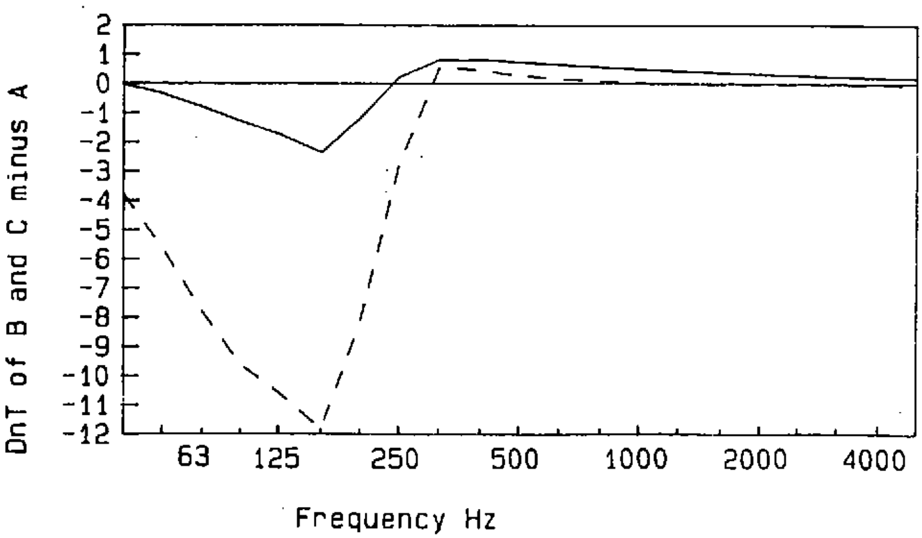

Fig 3. The level difference of the same wall for different laboratory designs minus the level difference for the free standing wall. ———, wall connected to one chamber; ------, wall connected to both chambers.

LINING PANELS

If lining panels are fitted to the walls, ceiling and floors the flanking paths can be eliminated and this will help to reduce some of the differences between different laboratories. However the laboratory will still affect the performance by affecting the damping of the test wall. This can be seen in Fig. 4 which shows the difference between the level difference of a free standing wall (which has no flanking paths) and laboratories where the wall is connected to one or two chambers but where all chamber walls, ceilings and floors are covered by lining panels to completely eliminate excitation of the structure by airborne sound and also to eliminate completely radiation from the structure. It can be seen that the increased damping of the test wall has resulted in higher level difference of up to 2 dB so that different laboratories will still give different results. Again the level difference is higher if the test wall is connected to only one chamber.

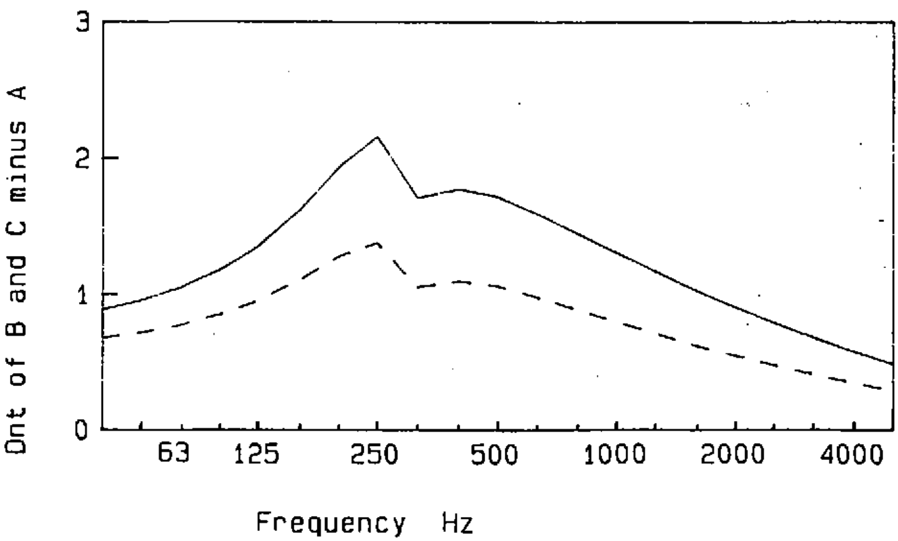

Fig 4. The difference in performance of the same wall in laboratories with linings on the wall minus the level difference for the free standing wall. ———, wall connected to one chamber; ------, wall connected to both chambers.

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DISCUSSION

These results have shown that the laboratory will affect the measured level difference which will in turn will affect the perceived performance of the test wall. The damping of the test wall will be affected by the way in which it is connected to the laboratory structure and it is difficult to control this in a sensible manner. The test wall could always be built on an independent foundation so that there was never a structural connection to the laboratory chambers. However this would lead to results that cannot be readily related to field measurements because the damping of real walls would be higher. In any case there would probably still be differences between laboratories due to differences in the foundation of the free standing wall.

If the laboratory is built directly onto the ground then there will be power flow from the laboratory floors into the ground whereas if the chambers are isolated on spring mounts then there will be less power flow. This will also affect the performance with the highest level difference being obtained when there are losses to the ground. Changes in the size of the test wall will affect the performance with all designs tending to the performance of the free standing wall as the wall becomes large (and hence edge conditions become less important).

The performance will also be affected by such factors as whether the wall is built in a niche in or is not built full width and full height but this has not been investigated.