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A GUIDE TO FLANKING TRANSMISSION

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INTRODUCTION

Over the years there have been many studies of flanking transmission ranging from practical guides based on measurements to extensive theoretical studies. However, these have not been widely used and few designers have any 'feel' for flanking transmission.

For the direct sound path most acousticians know that; the noise reduction, D, between two rooms decreases by 3dB if the area of the common wall is doubled; the noise reduction increases by 6dB when the surface density doubles; the absorption in the room will affect the noise reduction and; the noise reduction will increase with frequency at a rate of 6-9dB/octave.

Flanking transmission on the other hand tends to be a mystery. Questions such as:-

What are the flanking paths that are important ?

How does flanking transmission vary with frequency ?

What effect does the area of the flanking wall have on transmission ?

How will transmission change if the flanking wall is made thicker or thinner or heavier or lighter ?

These are very important questions which are of great importance for anyone concerned with sound transmission and yet these are questions which never seem to be answered directly.

This paper sets out to answer these questions and gives simple equations which can be used to predict the magnitude of the noise reduction due to flanking transmission.

THEORY OF FLANKING TRANSMISSION

The situation that will be considered in this paper is shown in Figure 1. This shows two rooms separated by a common wall. The source room is room 1, the receiving room is room 3 and the common wall is wall 2. The direct path for sound transmission is therefore path 1-2-3. If flanking transmission is being considered then sound that passes along path 1-2-5-3, path

1-4-5-3 and path 1-4-2-3 may also be taken into account. These are the three flanking paths that involve sound transmission across one structural joint. Similar flanking paths will exist past all of the edges of the common wall. Longer paths will also exist but these are less important.

It is assumed that walls 4 and 5 are made of the same material and have the same thickness and that if wall 6 is present then it will be the made of the same material and have the same thickness as wall 2. It is assumed that the critical frequency of all the walls is less than the frequency range of interest so that only resonant transmission need be considered and that "mass law" or non-resonant transmission can be ignored.

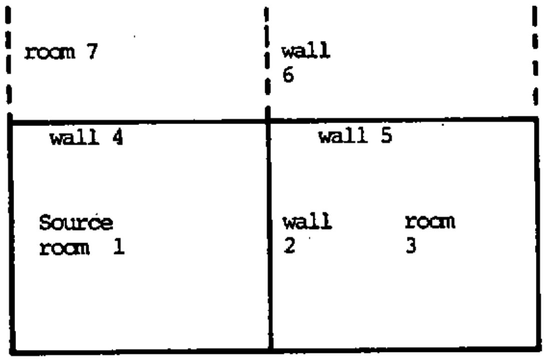

Figure 1. Typical plan of a building.

Direct Path

For the direct path 1-2-3 the noise reduction will be

$$D_{1-2-3} = SRI_2 - 10Log[S_2] + 10Log\left[\frac{0.161\ V_3}{T_3}\right] \qquad (1)$$

where V is the volume of the receiving room, S is the area of the common wall and T is the reverberation time of the receiving room. SRI is the sound reduction index of the common wall and can be given by

$$SRI_2 = 10Log\left[\frac{\rho_s^2\ f^{2\cdot5}}{26224\ f_{c2}}\right] \qquad (2)$$

where ρ_s is the surface density of the wall and f_c is the critical frequency. It has been assumed that the radiation efficiency of the wall is 1 and that the structural damping of the wall can be approximated to $f^{-\frac{1}{2}}$ [1]. These assumptions are also made when calculating the noise reduction of the flanking paths.

From these equations all the properties of the direct path described in the second paragraph can be deduced.

Flanking path 1-4-5-3

The flanking path 1-4-5-3 consists of the excitation of wall 4, transmission to wall 5 and radiation into room 3. Radiation from wall 5 to room 3 is the same as radiation from wall 4 to room 7 since the walls are assumed to have the same properties. The excitation and radiation of the wall are very closely related to the SRI of the flanking wall. The structure to structure transmission part can be written in terms of the structure to structure transmission loss, R, and the material properties of the walls involved. An expression can then be derived for the noise reduction of the flanking path 1-4-5-3 [2].

The most useful method of describing this flanking path is to give the difference between the noise reduction of the flanking path and the noise reduction of the direct path. The difference in the noise reduction of the two paths is [2]

$$\text{Path difference}_{(1-4-5-3)-(1-2-3)} = R_{45} + 10\text{Log}\left[\frac{\rho_{s_4}^{\,2}\, f_{c_2}}{\rho_{s_2}^{\,2}\, f_{c_4}}\right] + 10\text{Log}\left[\frac{S_2}{L_{45}}\right] + 5\text{Log}[f_{c_4}] - 15.4 \qquad (3)$$

where R is the structure to structure transmission loss and can be found in reference [1], f_c is the critical frequency and L_{45} is the common boundary length of walls 4 and 5. The second term is the difference between the the SRI of the common wall and the SRI of the flanking wall.

Flanking path 1-2-5-3 and Path 1-4-2-3

In a similar manner the noise reduction of the flanking paths 1-2-4-3 and 1-4-2-3 can be determined. The magnitude of these two paths are the same and therefore the calculation only has to be carried out once. Again the result is best expressed as the difference between the noise reduction of the direct and the flanking paths. The difference in the noise reduction of the two paths is [2]

$$\text{Path difference}_{(1-2-5-3)-(1-2-3)} = R_{25} + 10\text{Log}\left[\frac{\rho_{s_5}}{\rho_{s_2}}\right] + 10\text{Log}\left[\frac{S_2}{L_{25}}\right] + 5\text{Log}[f_{c_2}] - 15.4 \qquad (4)$$

and is very similar to equation (3).

The difference between the airborne paths 1-2-5-3 and 1-2-3 is the same the difference between paths 2-5-3 and 2-3 when the wall (or more usually a floor) is excited by an impact source. Equation (4) can therefore also be used to give the difference between the direct and flanking paths for impact sound insulation.

DISCUSSION

Equations (3) and (4) are relatively simple expressions which can be used to give the noise reduction of the flanking paths relative to that of the direct path. From these equations some of the basic properties of the flanking paths can be determined.

1) None of the terms are dependant on frequency and therefore the difference between the direct and flanking paths does not vary with frequency. A more detailed analysis would show that some of the terms are frequency dependant but this is of minor importance in a general analysis.

2) Flanking transmission is independent of the area of the flanking walls and the only dimension that is important is the length of the boundary between the two walls across which sound is transmitted.

3) Increasing the surface density of the walls will increase the noise reduction of the flanking paths unless the critical frequency or the structural transmission loss are also considerably changed. This would be unusual.

It is clear that if the basic material properties of the walls (surface density and critical frequency) and the basic geometry of the system are known then the noise reduction of flanking paths can be computed.

REFERENCES

[1] R.J.M. Craik, Damping of building structures, Applied Acoustics, 14, (1981), p347-361.

[2] R.J.M. Craik, The noise reduction of flanking paths. Submitted for publication to Applied Acoustics.