THE PREDICTION OF NOISE ATTENUATION BY FINITE BARRIERS

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INTRODUCTION

This paper describes a theoretical method of predicting the noise reduction of a plane acoustic barrier of finite dimensions. The equation developed are based on the Fresnel-Kirchhoff theory. Previous work [1] has shown a method of barrier sub-division and this paper extends this work to show how the number of elements chosen for the sub-division is compared to the accuracy of prediction for the attenuation.

THEORY

The Fresnel-Kirchhoff diffraction integral states that the disturbance $U_B(p)$ at $p$ due to the opening $B$ in the finite screen is given by:

$$U_B(p) = -\left(\frac{A_1}{2\lambda}\right) \int_B \frac{e^{ik(\ell + m)}}{2m} \left[\cos(n,\ell) - \cos(n,m)\right] ds - (1)$$

Where $\ell$ and $m$ are the variable distances from $s$ and $p$ respectively to the point of integration (see Figure 1).

It should be noted that this integral cannot be applied in the form given because it is applicable only for a region whose linear dimensions are small compared with the distances from source and monitoring position. A method of barrier sub-division [2] has been achieved by dividing the barrier surface into smaller elemental regions $R_1, R_2, ... R_n$. Thus the integral in the equation above will be modified to

$$U_{R_j}(p) = -\left(\frac{A_1}{2\lambda}\right) \int_{R_j} \frac{e^{ik(\ell + m)}}{2m} \left[\cos(n,\ell) - \cos(n,m)\right] ds$$
However, no work has yet been published of element quantification for a given barrier relevant to this paper.

From the above equation the insertion loss of the barrier is given by:

\[ IL(p) = 10 \log \frac{1}{A^2 + B^2} \]

Where

\[ A = \cos kd - \frac{2d/\lambda (1 - \alpha)}{j=1} \sum \text{Im}(F_j) \]
\[ B = \sin kd + \frac{2d/\lambda (1 - \alpha)}{j=1} \sum \text{Re}(F_j) \]

where \( F_j \) is a function of the shadow angle and the wave number of the source.

The above equation for the insertion loss was the basis of a computer program used in the present work and for this paper the effect of the insertion loss due to the barrier was studied.

Figure 2 shows the model used for this study where the distance from the barrier to the receiver has been varied and the attenuation due to the barrier studied for different element numbers.

Figure 3 shows a study for convergence to number of elements. It is shown that convergence of elements is satisfied above element number of five. Figure 4 indicates that for an increase in frequency a higher number of elements is required for convergence, in this case for example above 15 elements.

The reason for the oscillation in this figure is due to the exponential term in equation (1') where at high frequencies more oscillation is exhibited.

CONCLUSION

The attenuation of the finite barrier has been calculated by rigorous theory. This theory based on the Fresnel-Kirchhoff integral is only suitable for small element size and this paper has shown that when the barrier is sub-divided into elements a minimum number of elements has to be computed for each condition and thereafter the convergence of the curve optimises the element number for that particular configuration.

REFERENCES

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Location of source & receiver from barrier in the theoretical study of the element number.