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THE RESPONSE OF A LARGE PLATE TO POINT EXCITATION AND THE MEASUREMENT OF ITS ENERGY LEVELS

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INTRODUCTION

In the measurement of energy levels of a point excited plate, the spatial distribution of energy is frequently assumed to be random. This enables the energy levels of a plate to be measured simply by sampling randomly from a finite number of points depending on the accuracy desired.

It has been found that the assumption that energy is randomly distributed spatially (for a point excited plate) may not be valid even for plates of normal sizes tested in the laboratory, within the standard frequency range of interest. This means that the measurement of energy levels of such a plate can be a very laborious task. Readings have to be taken from a grid drawn all over the plate, and the finer the grid the more accurate the results would be. The accuracy of such a measurement is difficult to assess.

A more efficient approach in the measurement of the energy levels is required, for which an understanding of the actual response of a large plate to point excitation is essential.

THE RESPONSE OF POINT EXCITED PLATES

The acceleration level (of a point excited plate) due to the direct field energy at any point r away from the source, in relation to that at the source position, is given as

$$A_D = -(1.96 + 10\log kr + 2.17kr\eta), \quad \text{dB} \qquad (1)$$

where k is the flexural wave number of the plate; η is the total loss factor.

The acceleration level due to the reverberant field energy, in relation to that at the source is given as

$$A_R = 9.03 - 1.09k\eta d - 10\log k^2S\eta , \quad \text{dB} \qquad (2)$$

where d is the mean free path of the plate and S is the plate's area.

For a point excited plate where the energy distribution is spatially non-random, the direct field energy dominates its total energy. Figs. 1 and 2 show the typical results of the walls studied. The measured values are the total acceleration levels whereas the predicted curves are computed using Eq.(1) only. The results show that for plates of normal sizes (the areas of all the walls tested are approximately $9m^2$) and of materials often used in the laboratory (plywood and concrete blockwalls), the assumption of random distribution of energy over the wall is not valid for frequencies above 1.6kHz. In those situations the direct field energy dominates the total energy of the wall. The agreement between the measured and the theoretical values is good.

MEASUREMENT OF ENERGY LEVELS

Using Eq.(1) and (2), the energy density of the plate at any point r away from the source is found to be

$$E_D = \pi_{in} \left\{ \frac{EXP(-kr\eta/2)}{2\pi r C_g} + \frac{EXP(-k\eta d/4)}{S\omega\eta} \right\} \qquad (3)$$

where π_{in} is the power input into the plate; C_g is the group velocity of the flexural waves; ω is the angular frequency.

Neglecting the contribution from the reverberant field energy, the cumulative energy from the area bounded by the radius r (centred at the point of excitation) due to the direct field energy can be determined by integrating Eq.(3) over the area concerned. This is found to be,

$$E_{TOT,0\to r} = \frac{\pi_{in}}{\omega\eta} (1 - EXP(-kr\eta/2)) \qquad (4)$$

The predicted values of Eq.(4) are compared to the measured total energy. Fig.3 shows a typical set of results. The agreement between the measured and the predicted results is good.

From Eq.(4), a value of r can be determined so that the aggregate contribution from the part of the wall outside the radius r is negligible, depending on the accuracy desired. For a radius R within wich 90% of the total energy of the whole wall lies, the value of R is given by

$$R = 4.61/k\eta \qquad (5)$$

Hence it has been shown that for a large plate, there is little meaning in measuring beyond the radius R from the source. By concentrating the measurements in a much smaller area of the wall one can afford to use a finer grid. This will lead to more efficient measurements and accurate results.

Using Eq.(5), guides may be drawn for plates of any materials so that the area within which one needs only to measure can be determined quickly. An example of such a guide is as shown in Fig.4.

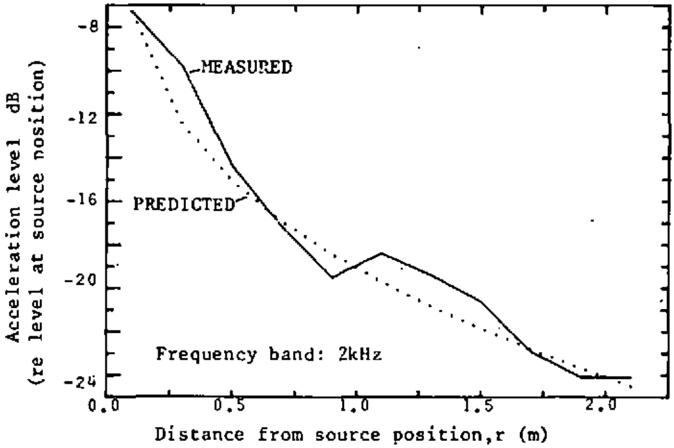

Fig. 1. Spatial distribution of acceleration levels for a point excited simple plywood panel

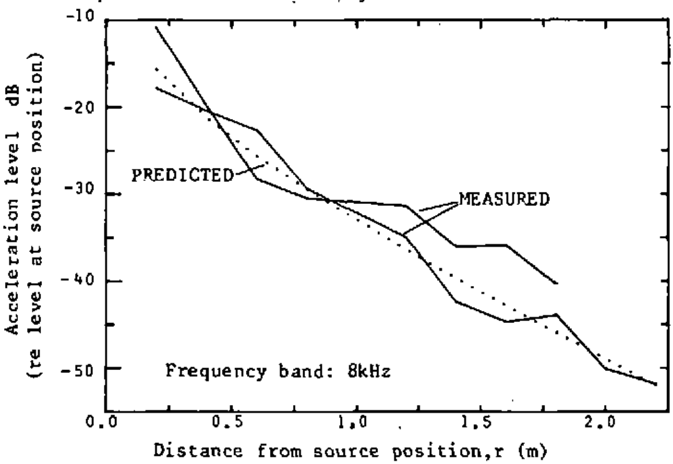

Fig. 2. Spatial distribution of acceleration levels for a point excited studded plywood panel

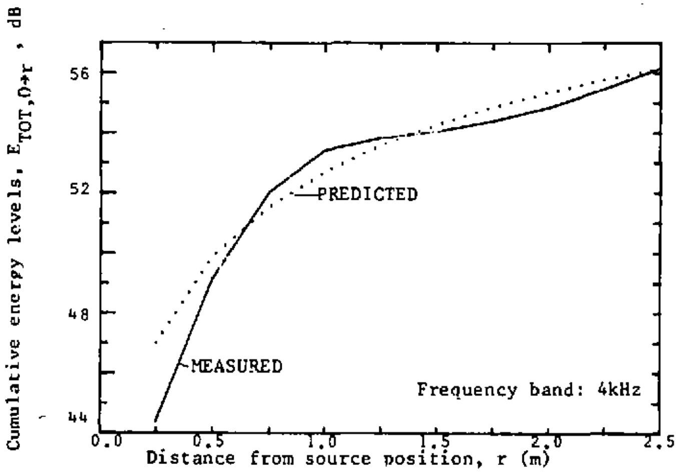

Fig.3. Cumulative energy levels of concrete block wall of 150mm thick

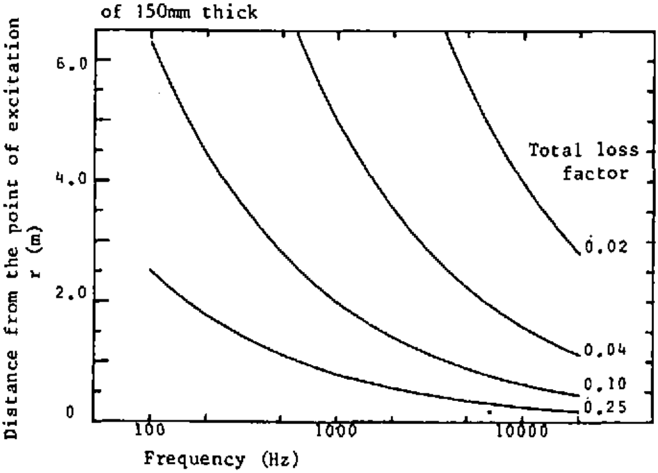

Fig.4. An example of a measurement guide drawn for plywood