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WORKMANSHIP AND ITS EFFECT ON SOUND TRANSMISSION

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INTRODUCTION

Although buildings are very complex structures they are not always built with the care and precision of other engineering structures. As a result it is sometimes found that two buildings or parts of buildings which appear to be identical do not perform acoustically in the same way. If this difference in performance cannot be attributed to differences in design, construction or material properties then it must be somehow related to workmanship.

For any particular construction the measured performance of one example will not be exactly the same as the performance of another. If many different examples are measured than the mean performance can be computed. The standard deviation of the individual performances can also be calculated as a measure of the spread of results about the mean. If care has been taken in the selection of the different examples so that the design, the construction methods and the materials used are the same then the variation in performance must be due to a variation in the standard of workmanship. (Assuming that there is no measurement error.)

Variation in workmanship therefore leads to a spread in measured performance and therefore the standard deviation of the individual results can be taken as a measure of the (variation in) workmanship.

EXPERIMENT

In order to determine whether any significant variation in performance occurs detailed measurements were made of structure-borne sound transmission in a building. Structure-borne measurements were chosen because they are much easier to predict and flanking paths are usually less important.

Two walls or floors which were connected along a line were selected. One of the walls was then excited by hitting the wall with a plastic headed hammer for a period of 15 seconds. Each hit was at a different position and therefore the measurement was averaged over many (about 50) source positions. The acceleration level of each wall was measured and the difference was determined. The accelerometers were then moved to new positions on the walls and the measurement was repeated. This was continued until the the

accuracy of the level difference (95% confidence interval) was less than ±2dB at 125Hz.

The mean level difference is a measure of the performance of the joint. The standard deviation of the individual level differences is a measure of the variation between pairs of positions from which the measurement error can be computed. There are of course other errors in the measurement apart from the error due to incomplete spacial averaging. These other errors are much less important and are discussed in the next section.

RESULTS

As a check on the measurement procedure the same joint was measured a number of times using the same procedure. Since the joint must have the same performance any difference in the results is a measure of the total measurement error. An Analysis of Variance (ANOVA) was carried out to find whether or not the known measurement error described above (arising from incomplete spacial averaging) would explain the difference in measured performance. It was found that the measurement error did not account for all of the measured difference in performance. At some frequencies there was still some residual error. The residual variation is given in Figure 1. The average standard deviation is about 0.5dB which corresponds to a variance (standard deviation squared) of 0.25dB. This is sufficiently small not to affect the main results.

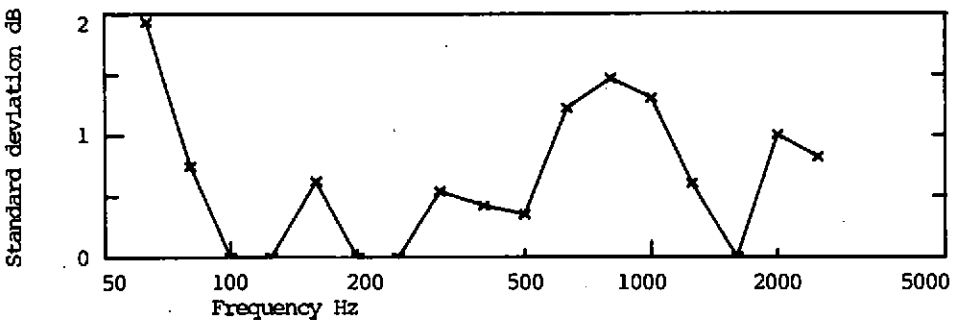

Figure 1. Residual measurement error for sound transmission from a wall to a floor.

For each of the five types of joint that were studied the variation in performance between 10 examples (standard deviation) was computed for each frequency. This variation was due to

a) measurement error due to incomplete spacial averaging,
b) other measurement error,
c) predictable variations in performance and
d) unpredictable variations in performance ie. workmanship.

As part of the Analysis of Variance the main measurement error arising from incomplete spacial averaging (a) was deducted. Corrections for the other measurement errors (b) were estimated but made little difference. Corrections were made to take into account small measured changes in damping, length and width which could give rise to predictable difference in performances (c). These corrections also did not significantly reduce the variation that was measured (because the joints were chosen to be as similar as possible). The remaining variation is therefore due to unexplainable variations in performance ie workmanship.

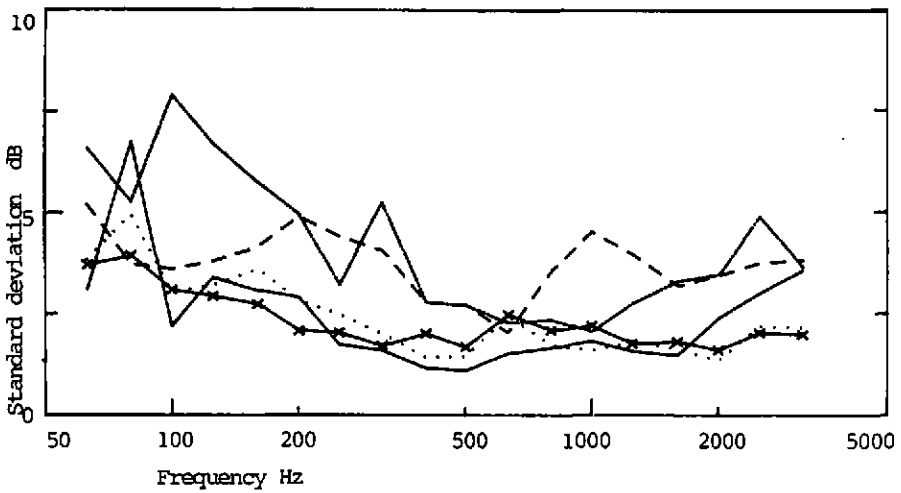

Figure 2. Estimated variation in performance due to workmanship.

—*—*— Transmission from a big wall to a big floor at a cross joint
- - - Transmission from a big wall to a small wall at a tee joint
····· Transmission from a big floor to a small wall at a cross joint
——— Transmission from a small wall to a big wall at a corner joint
—·— Transmission from a small wall to a small wall at a tee joint

The resulting estimate of variation due to workmanship can be see in Figure 2. This shows the standard deviation after correcting for the principal measurement error and for small changes in predicted performance but not the residual error shown in Figure 1.

It can be seen that at the higher frequencies where statistical predictions are most reliable the variation is about 2-3dB. At lower frequencies the variation is higher due the the importance of individual modes which do not all have exactly the same frequencies. This would be expected as the sizes of the panels are not exactly the same.

The results that have been obtained relate only to structure-borne sound transmission on one type of structure. Different types of structure or airborne tests may give different results. However, similar variations might be obtained in other situations.

A standard deviation of 2dB is quite high and means that a single test on a construction will have a 95% probability of lying in a band of about ±4dB (assuming a normal distribution). It is therefore clear that a single example of a construction will often not be sufficient to determine the performance no matter how accurately the measurement is carried out. For example if a comparison is to be made of two different constructions which are expected to be only marginally different, by say 1 or 2dB at a few frequencies, then a single example of each construction would not be sufficient to be sure that they really are different.

CONCLUSIONS

It was found that for sound transmission between walls or floors which were nominally identical there was a difference in performance. After making allowance for measurement error the variation was approximately 2dB (standard deviation) and was similar for each of the five different types of joint construction that were tested. At low frequencies the variation is higher due to the small numbers of resonant modes which do not always have the same frequencies in different walls.

It is therefore concluded that there is a significant variation in performance between nominally identical structures and that this variation is about 2dB for the structure type that was studied.

ACKNOWLEDGEMENTS

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