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THE ACOUSTICS OF VILLAGE HALLS

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INTRODUCTION

If the experience in the Bristol area is any guide there could be a general problem with the acoustic performance of medium sized general purpose halls. Both the Bristol Polytechnic and Bristol University receive a steady stream of enquiries for urgent remedial treatment for buildings with severe acoustic problems. These general purpose halls are considered to be virtually unusable by their owners. Figure 1 illustrates the problem by showing the measured reverberation times for a few of these buildings, generally these reverberation times are at least twice the recommended value (1). This paper briefly reviews the methods of prediction of reverberation time and compares these with the measured values for one hall at Pucklechurch where remedial treatment was undertaken. Quoting from the letter received from the chairman of the Pucklechurch Community Association, "the results have been most impressive and the acoustics have improved beyond recognition".

REVIEW

In the nineteen twenties Professor Sabine (2) investigated the poor acoustic performance of lecture rooms at Harvard University and suggested the use of the reverberation time, defined as the time required for a sound to become inaudible, as an indicator of acoustic acceptability.

Sabine's original equation, when standardised to an intensity fall to one millionth of its initial value, becomes

$$\text{Reverberation Time, } T = \frac{0.16\ V}{A}$$

where V is room volume, m^3
A is room absorption, m^2

The room absorption was originally known as 'open window units' but is now named after Professor Sabine.

Embleton (3) details the development of reverberation time formulae and raises doubts regarding the validity of absorption coefficients obtained using a reverberation chamber and cites a long list of references spanning the period 1930 to 1970. Embleton specifies three absorption coefficients, the coefficient at a given angle of incidence, a statistical coefficient for a perfectly diffuse sound field and a reverberation chamber coefficient. For purely resistive surfaces the coefficient for a particular angle may have any value beween 0 and 1, the statistical coefficient lies between 0 and 0.96 (4) but the value obtained using reverberation can exceed unity by as much as 30%.

Most of the published values of absorption coefficient eg (1), (5), (6) were determined from reverberation time measurements using an approved chamber and procedure aimed at achieving a diffuse sound field. Kuttruf (7) reported that a material which by the standard procedure had a coefficient of 0.94 exhibited a coefficient of 0.18 when the material entirely covered one wall of the test room, Northwood (8) extended the theory of surface absorption of diffuse sound fields (4) to a finite area of absorbing material and to

reactive surfaces. Quoting from Northwood: 'The most important application of the foregoing calculations is to provide an independent check on the reverberation room method for measuring sound absorption coefficients. The reverberation room method purports to measure the random-incidence absorption coefficient of a sample of material, but the intricacies of the method, based more on empirical attempts to obtain repeatable results then on theoretical considerations, leave some doubt regarding the quantity that finally emerges. For a special category of materials, it is now possible to calculate from impedance-measurements the absorption coefficients that should be obtained in the reverberent room .....'. It was shown in the 1960's (9) (10) using round robin tests that the then current recommended practice for reverberation chambers did not ensure that any two laboratories would obtain the same results for identical samples. It is clear that the published values for absorption should be used with caution, however, there currently exists acoustic problems which require solutions. This paper demonstrates that for medium sized general purpose halls the use of published absorption coefficients and the basic Sabine equation does predict the measured reverberation time with acceptable accuracy in the mid and high frequencies. Figure 2.

MEASUREMENTS

Many of Bristol's buildings have been investigated by the Polytechnic or the University over a number of years. Some of these had complex problems requiring sophisticated experimental techniques but the majority could be dramatically improved by reducing the reverberation time by about 50%. The Pucklechurch Hall was investigated (11) and treatment specified to reduce the mid-frequency reverberation times to 1 second, this required three quarters of the suspended ceiling to be replaced by acoustic tiles. Figure 2 compares the measured and predicted values before and after the addition of acoustic ceiling tiles. These are in good agreement in the mid and high frequencies. The values plotted for the predicted reverberation times after treatment were obtained by adjusting the original prediction calculation, obviously closer agreement would be obtained if the measured reverberation time were used.

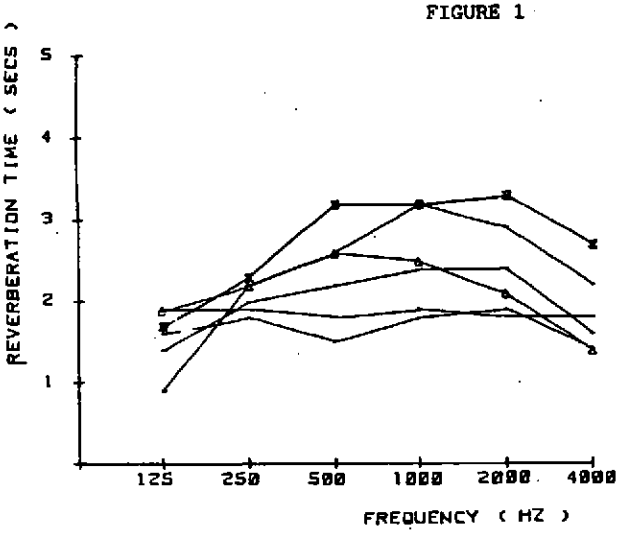
The design value of 1 second at 1 KHz was not achieved and subsequent investigation using an impedance tube indicated that the acoustic tiles installed did not meet the specified value of absorption.

CONCLUSION

Although the reverberation time is only a broad indicator of acoustic performance it is possible to use published absorption coefficient values and Sabine's equation to achieve a reasonable acoustic design for a medium sized general purpose hall. The cost of remedial work at Pucklechurch was less than £2000, split equally between materials and labour, this expenditure producing a dramatic improvement in acoustic comfort and it is estimated that the cost at design stage would have been less than £500.

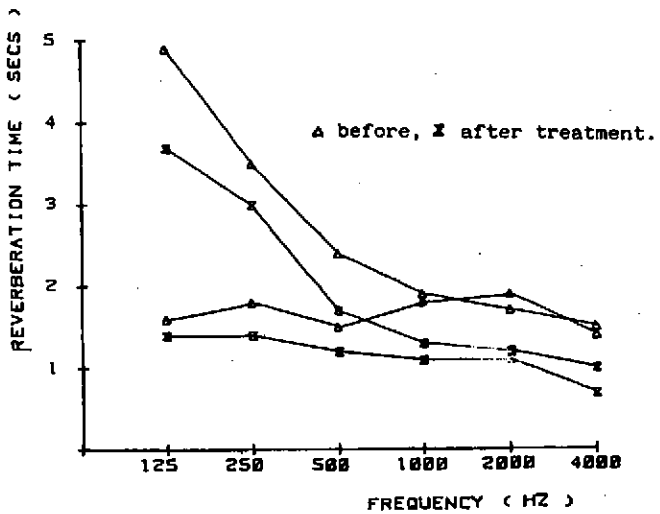
Surely our Institute must pursue this matter with the utmost vigour, for it cannot be too much to expect the building designers to undertake such an elementary performance prediction when its omission can be so disastrous.

FIGURE 1



Reverberation times for six general purpose halls in the Bristol Area.

FIGURE 2



Measured and predicted reverberation times for Pucklechurch Hall.