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IMPROVEMENT OF SOUND INSULATION OF TIMBER FLOORS: A STUDY OF THE RELATIVE SIGNIFICANCE OF MASS, RESONANCE AND RESILIENCE IN THE SYSTEM.

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INTRODUCTION

In this, the first of two papers relating to combined laboratory and field measurements of timber floors, the subject of impact noise is referred to, leaving airborne noise transmission as the subject of the second part.

The timber floor is a very complex system to study theoretically, involving the resonant and non-resonant behaviour of the floor and ceiling panels, the resonances within the various cavities, the dynamic behaviour of the floating floor or resiliently suspended ceiling and finally the mass reactance of the deafening material together with its related air flow resistance and absorptive properties.
Any attempt at correlation between theoretical prediction and field measurement results is immediately frustrated by the variability of the latter due to a number of recurring problems.

(1) The mass added in the form of deafening, is frequently found to vary even in the same dwelling.

(2) For a given weight of deafening the insulation would appear to vary from one material to another.

(3) The thickness and density of the resilient quilt is often found to vary.

(4) Nails are often passed through resilient quilts either by accident or deliberately in order to provide greater stability to the floating floor.

(5) Adjustments to the floor design to accommodate service pipes or conduit often introduces resonant cavities which reduce the sound insulation. The installation of services beneath the floor boards frequently results in the floating floor being short circuited.

In view of the difficulty of achieving controlled experimental conditions in the field, a set of tests were carried out in the laboratory. The tests were devised mainly to provide answers to some commonly recurring problems encountered during field measurements.

PROGRAMME OF TESTS

The following programme of tests was carried out to study the effects upon impact sound reduction of the variations given below.

(a) Variation of the type of deafening material.

(b) Variation of the type of resilient quilt in ribbed constructions.

(c) Variation of the type of resilient quilt in platform constructions.

(d) Variation of the type of resilient fixing in ceiling construction.

(e) Variation of the type of cavity infill.

EXPERIMENTAL CONDITIONS

A timber floor with dimensions 4m x 3m was erected in the Acoustics Laboratory. The basic design of the floor which was supported on dense concrete block walls is shown in Figure 1.

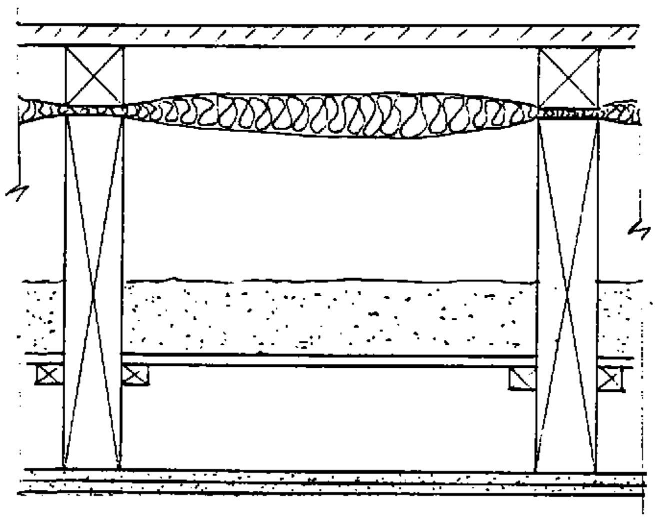

FIGURE 1

The source used for the measurements was a Bruel and Kjaer Tapping Machine with measurements taken at five positions over the floor area.

The sound pressure level was recorded in the room below using a B&K Condenser Microphone located on a rotating boom.

Measurements of surface vibration were made using a B&K Accelerometer at five ceiling positions and seven wall positions.

VARIATION IN THE TYPE OF DEAFENING MATERIAL

It has been noticed during field tests that a higher incidence of failures are recorded in the case of timber floors incorporating dry sand as the deafening material. Hamilton (1) reported that research into the sound insulation of floors which had undergone rehabilitation had shown sand to give an inferior result to other deafening materials.

Three materials, solid fuel ashes, 9mm granite aggregate and dry sand were inserted into the test floor so as to add 80 kg/m^2 in each case. The results in Figure 2 show sand to give an inferior insulation at most frequencies, but particularly below 500 Hz.

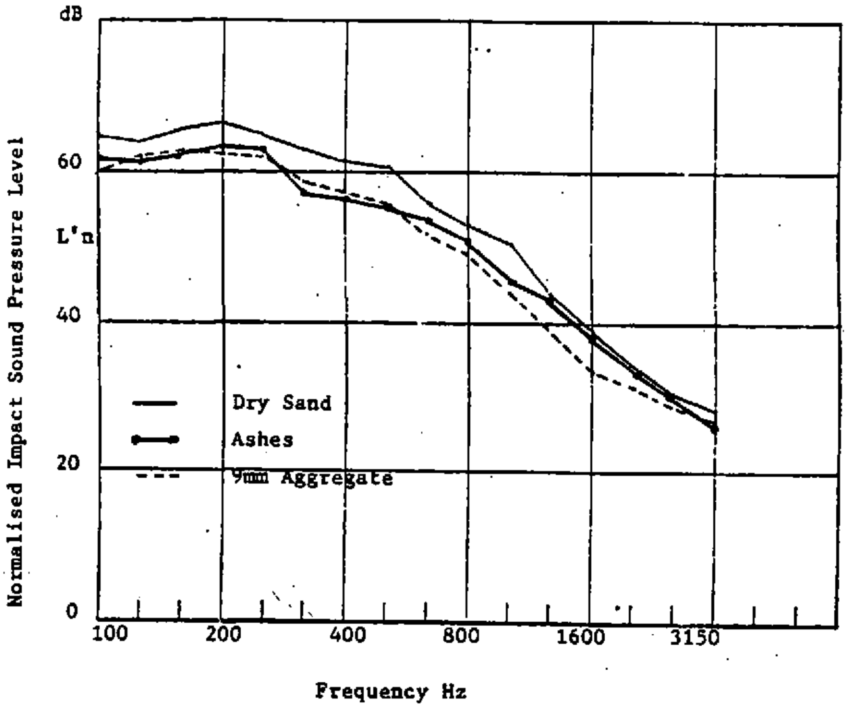

Figure 2 - Effect of Different Deafening Material

The results of acceleration on the ceiling have shown little agreement with the sound pressure level results. Whilst the reason for the difference has not yet been explained, it is hoped that measurements of air flow resistance through the different materials will give some explanation of the reason for the variation found.

VARIATION OF THE TYPE OF RESILIENT QUILT IN RIBBED CONSTRUCTIONS

The provisions laid down under Section 3 of Approved Document E, the Building Regulations 1985, for resilient strips under ribbed flooring state that mineral fibre of at least 25mm thickness with a density 70-140 kg/m^3 should be used. Whilst this density of mineral wool gives a satisfactory performance, an equally suitable result may be obtained in respect of impact noise, by different variations of thickness and density.

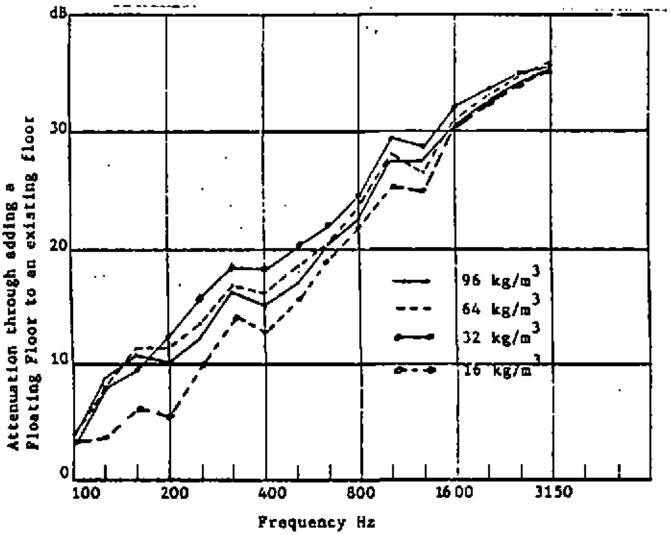

Figure 3 - Ribbed Construction - Effect of Different Density of 25mm Resilient Quilt

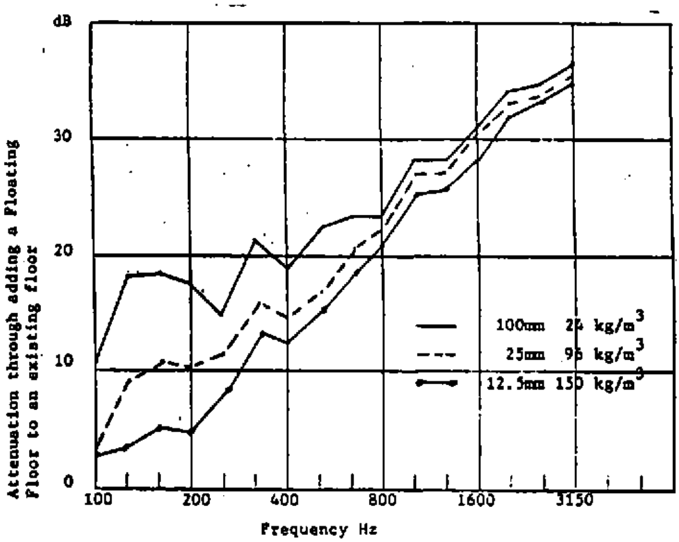

Figure 4 - Ribbed Construction - Effect of Different Thickness of Resilient Quilt with similar surface density.

The results in Figure 3 show the attenuation which may be achieved by adding a floating ribbed construction on top of an existing floor. The results tend to indicate that the insulation is less sensitive to a change in density than reported elsewhere (2).

The results in Figure 4 would indicate that the thickness of quilt is a more significant parameter than the density, although it is acknowledged that the stability of the walking surface is not unimportant in this respect.

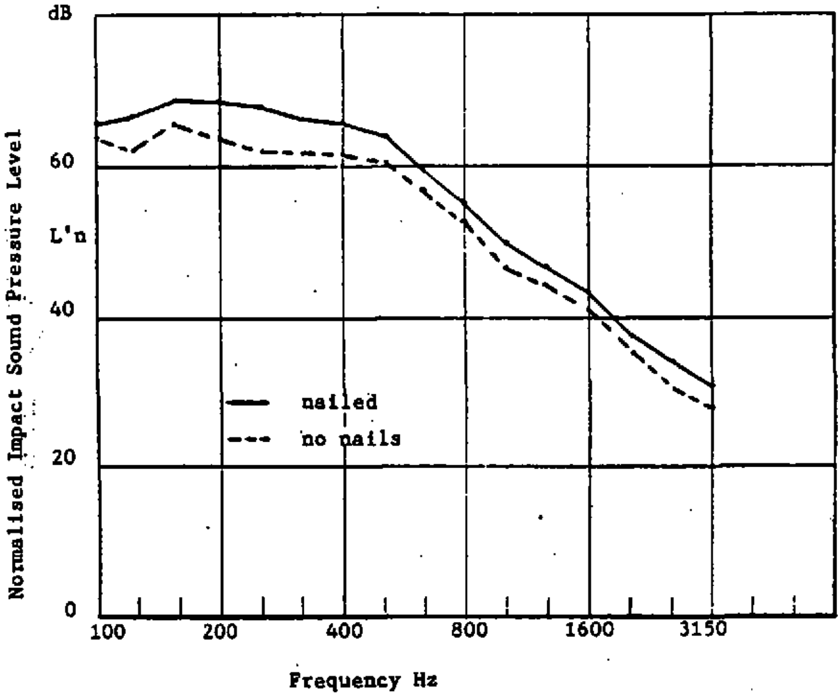

Figure 5 - Ribbed Construction - Effect of Nailing through a floating ribbed floor

Because of the problem of stability or simply to reduce the likelihood of gaps opening up at the skirting after the placing of furniture, it is a common occurrence to find a floating floor nailed through the resilient layer into the joist. The results in Figure 5 indicate the average of test results in three different types of dwellings. The floors were more or less identical in design with all three using 50mm thick mineral wool 36 kg/m^3 for the resilient layer.

The results indicate a mean 3.0 dB reduction in impact sound insulation due to nailing which is considerably less than the 10 dB reduction reported by Utley et al (2) during a test on a simple floor with 25mm thick quilt. This would suggest that there was still significant resilience left in the 50mm quilt after nailing, but virtually none in the thinner quilt.

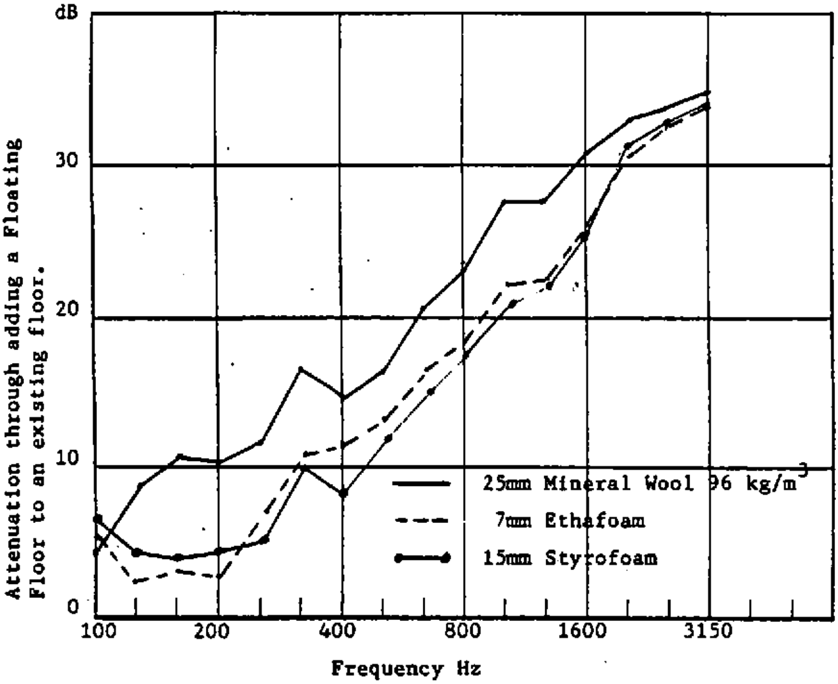

Figure 6 - Ribbed Construction - Effect of Different Types of Resilient Material

The results shown in Figure 6 indicate that alternative resilient materials do not provide the same degree of attenuation in ribbed constructions as mineral wool. However they do offer easier handling and are always likely to be considered as an alternative to mineral wool.

VARIATION OF THE TYPE OF QUILT IN PLATFORM CONSTRUCTIONS

In a similar comparison to that given above different densities of quilt have been measured.

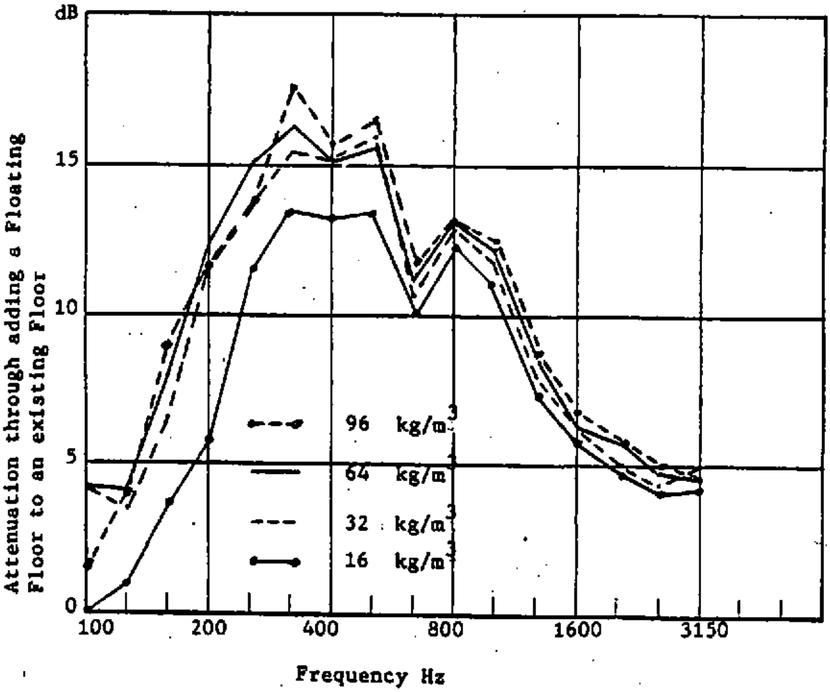

Figure 7 - Platform Construction - Effect of Different Density of 25mm Resilient Quilt

The conclusions are more or less similar to those found with the ribbed construction except that the optimum density, especially when one considers low frequency performance, is around 64 kg/m^3. This is in broad agreement with Utley (2) who suggested that the optimum density should be around 70 kg/m^3.

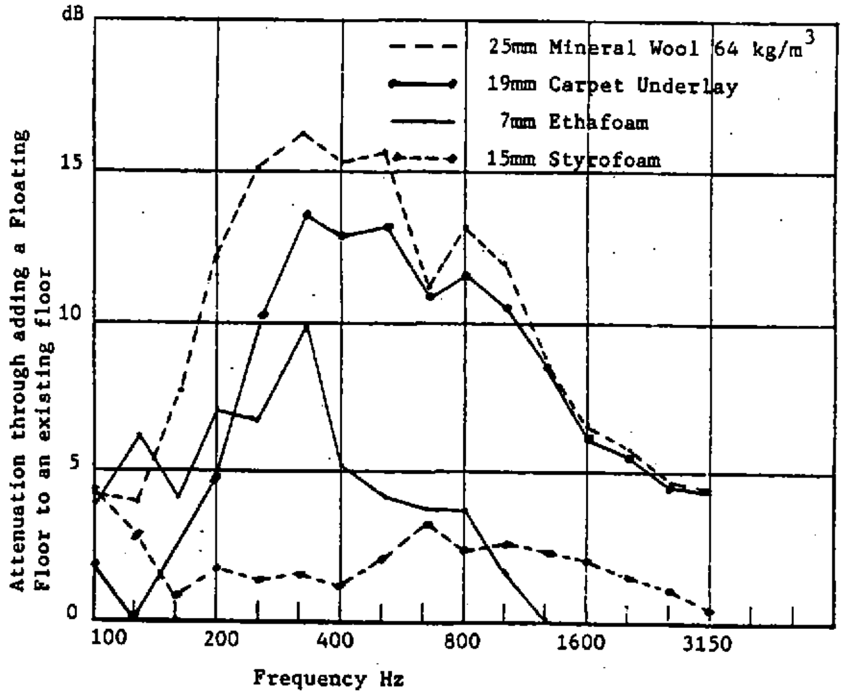

Figure 8 - Platform Construction - Effect of Different Types of Resilient Material.

The use of alternative resilient materials has indicated that none of those considered has produced a satisfactory performance.

VARIATION OF THE TYPE OF RESILIENT FIXING IN CEILING CONSTRUCTION

During remedial work it is not always possible to apply the treatment to the floor surface. Two types of resilient fixing are compared, one involving the resilient fixing of plasterboard sheet without an increase in ceiling depth and the other involving a proprietary metal channel suspended ceiling with a 150mm cavity. The attenuation produced by a single extra sheet of plasterboard is shown simply to provide a basis for assessing the effect of the resilience alone. Similarly the result of a completely independent ceiling is shown, again to show the limitation provided by the metal, albeit resilient, connection.

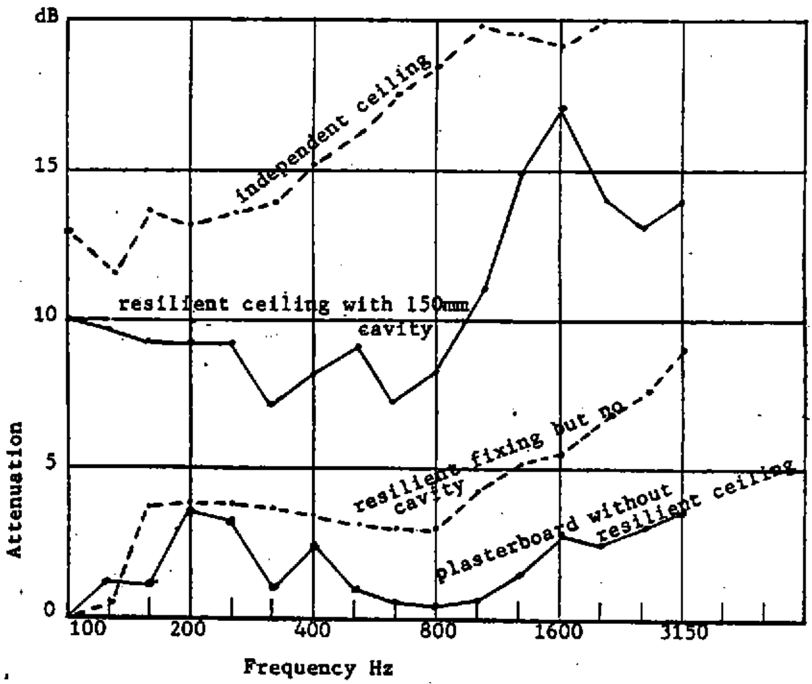

Figure 9 - Effect of adding a resilient ceiling of 12mm plasterboard

The results are rather predictable and mainly serve to illustrate the influence of a cavity upon the attenuation.

VARIATION OF THE TYPE OF CAVITY INFILL

Introducing blown fibre into the cavity of a timber floor is not generally considered to provide any useful attenuation. However, the resonant behaviour of the cavity will always contribute to the overall transmission even although it may be a minor component as in cases of impact transmission through timber floors.

Two types of blown fibre viz mineral wool 55 kg/m^3 and cellulose fibre 60 kg/m^3 were blown into the cavities of identical floors during a field measurement.

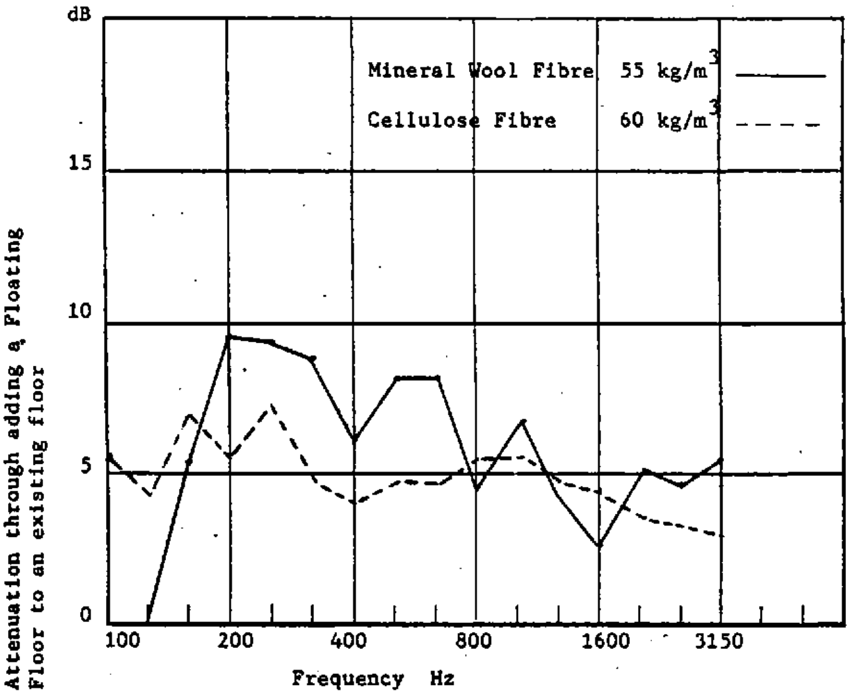

Figure 10 - Effect of adding cavity infill

The mineral wool gave a slightly better performance over the full frequency range with a mean improvement of 5.5 dB compared to 4.8 dB for cellulose. However the low frequency performance, which is invariably critical with timber floors, was superior with the cellulose blown fibre.

CONCLUSIONS

The measurements on deafening material have indicated that dry sand would appear to have an inferior performance to other forms of pugging. Additional research is required to fully evaluate the relative properties of these materials, particularly the air flow resistance.

The density of mineral wool quilts used as resilient layers has been found to be less significant than hitherto reported and provided that the density exeeds 32 kg/m^3, adequate isolation may be obtained. Impact transmission is more sensitive to variations in the thickness of the quilt. Results from field measurements, not reported in this text, would suggest that satisfactory isolation could be provided by either 50mm thick mineral wool of 32 kg/m^3 density or the use of resilient battens, that is, with 7mm polyethylene foam plus 25mm thick mineral wool of 32 kg/m^3 density.

The effects of nailing thicker or denser quilts have been found to be less detrimental than hitherto suggested.
Mineral wool has been found to be the most suitable material for the resilient layer in platform constructions and the optimum density found to be around 64 kg/m^3 which agrees with B.R.E. findings.

A substantial increase in insulation is possible by use of a resilient ceiling, but the degree of attenuation, particularly of low frequency, will be dependent upon the depth of the cavity.

The significance of damping cavity resonance by the insertion of blown fibre has been demonstrated.

ACKNOWLEDGEMENT

I should like to acknowledge the significant contribution made in this work by Ms. Bernadette McKell.

REFERENCES

(1) Hamilton, W. and Blair, J. - "Field Measurement in Glasgow" - Proceedings of Seminar on Sound Insulation of Timber Joisted Floors, Glasgow, June 1984

(2) Utley, W., and Cappelen, P. - "The Sound Insulation of Wood-Joisted Floors in Timber Frame Constructions" Current Paper 46/78 Building Research Establishment, D.O.E.