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THE SOUND INSULATION OF ACCESS FLOORS

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INTRODUCTION

Access (computer type) floors are now commonly used in offices, as an alternative to suspended ceilings, to provide horizontal services distribution space. Modern offices are now frequently built with large open floor areas which may subsequently be divided up with partitions. The flexibility demanded for partition positions, and the requirement for continuous services ducts and trunking, usually preclude the use of floor void divisions. The common problem with sound transmission over partitions via a suspended ceiling void becomes inverted.

The investigations described in this paper were undertaken as part of the acoustic design for the new office building for Lloyd's of London.

No satisfactory information on the performance of access floors was available. Most information available related to the sound insulation of access floors with no floor covering, and it was felt that this was likely to significantly affect the results.

The performance to be obtained had to be specified before it was known how well the floors might perform. As a result, the technical department of one manufacturer complained that no access floor system could possibly achieve the specified sound insulation. Happily, not only were they proved wrong, but their own floor exceeded the requirements with a healthy margin.

Three series of tests were carried out. In the first, ten different types of floor overlaid with carpet tiles were tested under similar conditions. The construction of the floor panels can be put into three groups: Steel tray with chipboard/timber infill, stiffened steel & aluminium, and reinforced cement/anhydrite/calcium sulphate

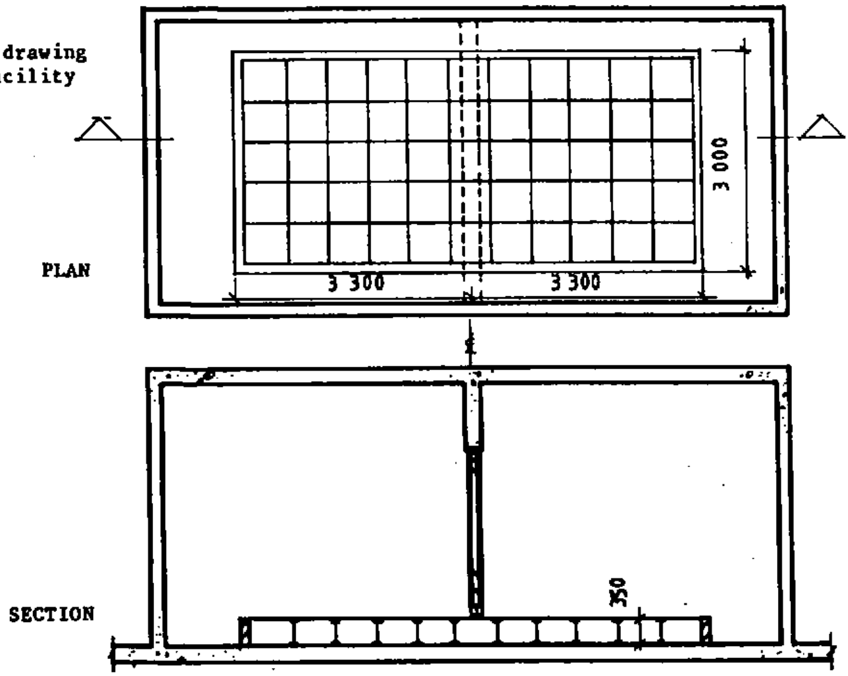
The second series was carried out on two versions of a steel panel (hollow and concrete filled) with and without carpet, and with and without a rolled rockwool firebreak filling the floor void along the partition line.

The third set of tests was carried out on one floor type to determine the effect of floor grilles and under-floor services. In the Lloyd's building, the air distribution system utilises the floor void as a plenum. Small recirculation fans move air from the void and expel it via flexible ducts into the office space above. Return air is drawn into the void via floor grilles, and fresh air is fed into the void from the main ducts. The extract is taken from a separate duct system under the ceiling. The effect of many penetrations of the floor, some with thin metal ducts connected and others covered with only a grille, was clearly of some concern.

TEST PROCEDURE

In the absence of any relevant standard, the test procedure for suspended ceilings laid down in ISO/DIS 140/9 [1] was adapted. The test chamber was divided by a 215 mm brick wall plastered on both sides, and supported on a steel beam with a 350 mm space beneath. The steel beam was clad with plasterboard and rockwool. Dwarf brick walls were used to provide the void boundaries. One side and both end walls were lined with sound absorbent rockwool. The first test demonstrated an unexpectedly high sound insulation from the access floor, and the sound insulation of the partition wall was then upgraded by adding two sheets of 10 mm plasterboard over 50 mm rockwool to both sides. Unfortunately, the sound insulation of the upgraded partition wall could not be measured. It should therefore recognised that the results given here may include significant transmission through this wall.

Figure 1. Schematic drawing of test facility



The floors were tested as laid by the manufacturers' workmen, and no attempt was made to lay the floor to an abnormally high standard. Sealing between the floor and the bottom of the steel beam, and around the periphery of the floor was undertaken by the laboratory staff. All floor panels were 600 mm square, and were supported by pedestals at each corner without stringers.

SOUND INSULATION OF VARIOUS TYPES OF ACCESS FLOORS

Ten different floors, overlaid with 600 mm square carpet tiles, were tested under similar conditions. A description of the floors and the normalised level differences measured are given in Table 1, and in Figures 2,3,& 4.

Table 1 Details and sound insulation of access floors

Ref	Construction	Mass (kg/m^2)	Thick (mm)	D_{nw} (dB)
A1	Cementitious chipboard	49	37	53
A2	Reinforced concrete with metal edge	50	30	53
A3	Anhydrite filled steel tray	30	33	52
A4	Calcium sulphate with steel sheet on bottom	49	37	51
B1	Diecast Aluminium (flat top, ribbed bottom)	23	38	50
(B2	Pressed steel, concrete filled	37	32	49)
B3	Pressed steel (flat top, egg-crate bottom)	18	32	49
C1	Chipboard core in 18g steel tray + 24g steel top	36	30	47
C2	Timber core encased in 28g steel	27	32	47
C3	Chipboard faced top & bottom with steel	37	32	46

The sound insulation at low frequencies (mean of 100,125,& 160 Hz) has been plotted against the floor mass in Figure 5. This indicates a logarithmic relationship with about 4 dB increase in sound insulation per doubling of mass for most of the floors, but there are three significant variations (A1,A3 & B2) from this.

The sound insulation of groups A & B rises fairly steadily with frequency at a rate of 6 to 7 dB/octave up to about 1 kHz, above which there is a plateau.

The sound insulation of the group C panels exhibits what seems to be a classic coincidence phenomenon. One would expect a simple plywood panel to have a coincidence frequency of about 700 Hz. Facing with steel sheet almost doubles the mass and also must considerably increase the bending stiffness, probably resulting in a reduction of the coincidence frequency. The frequency region of the plateau thus seems compatible with a coincidence effect.

The panels in group A, with the exception of A4 also show what may be a coincidence dip above 1 kHz. The material used for these panels seems likely to have properties comparable with concrete. Panel A2 is a fairly simple reinforced cement panel, and as such would be expected to have a coincidence frequency of about 1,200 Hz.

SOUND INSULATION OF ACCESS FLOORS

Figure 2. Insulation of group A floors

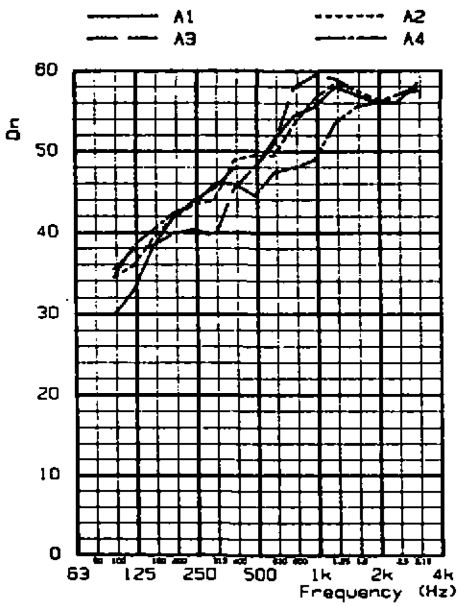
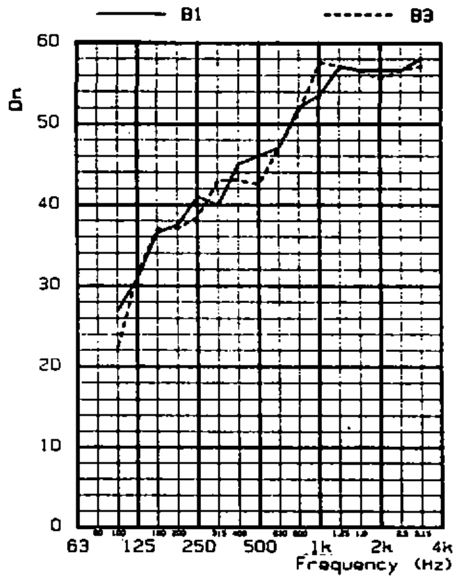


Figure 3. Insulation of group B floors



Group B panels are constructed from steel or aluminium. B2 has the hollow parts filled with concrete and is of a form completely different from any other panel; it is therefore not considered further here. B1 and B3 have a flat top surface and ribbed bottom. The ribbing will increase the bending stiffness to mass ratio, and hence should lower the coincidence frequency below that of a flat plate of the same material. A flat plate of steel of the same mass would have a coincidence frequency of about 5,400 Hz, and aluminium about 1,500 Hz. It seems possible that the dips above 1,000 Hz are also due to coincidence.

The levelling off above 1kHz, which is common to most of the floors, may in part be due to the difficulties of sealing between the floor and partition, or to flanking transmission.

THE EFFECT OF CARPET AND FIREBREAK

Two versions of the same panel (B2 & B3), were tested to determine the effect of the carpet and a firebreak. The firebreak comprised rolled up rockwool blanket filling the gap directly beneath the partition. The sound insulation measured are given in Table 2, and in Figures 6 and 7.

Table 2 Comparison of sound insulation of hollow and filled panels with and without carpet and firebreaks.

Hollow panel (B3)	D_{nw}	Filled panel (B2)	D_{nw}
Panel only	38	Panel only	38
With carpet	49	With carpet	49
With firebreak	44	With firebreak	47
With carpet & firebreak	51	With carpet & firebreak	52

Figure 6. Insulation of hollow panels

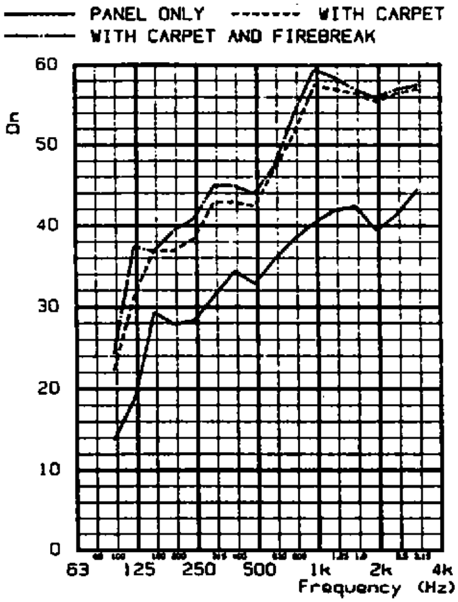
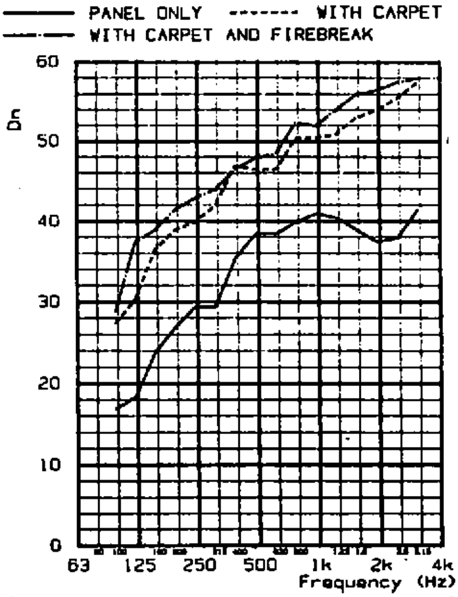


Figure 7. Insulation of filled panels



SOUND INSULATION OF ACCESS FLOORS

Figure 4. Insulation of group C floors

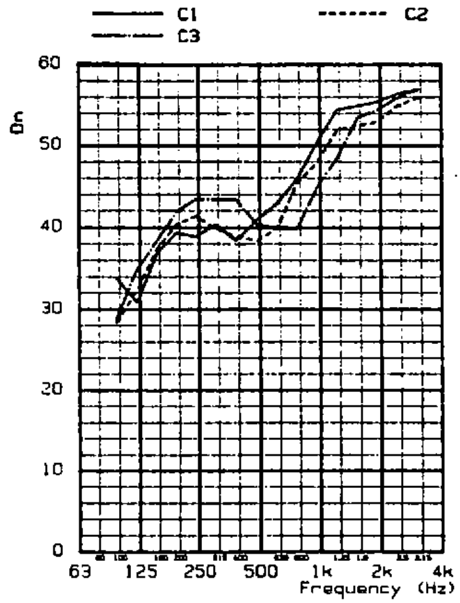
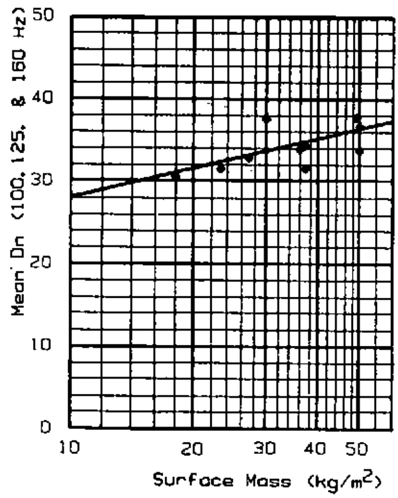


Figure 5. Low frequency insulation versus mass



The group A panels - based on a core material comparable with concrete - performed best overall, and particularly well at low frequencies.

Group B panels performed almost as well as group A but with slightly less low frequency insulation. On the basis of D_{nw} set against weight, a factor which is increasingly important in modern office buildings, the B1 and B3 panels far outshine the rest.

The timber/chipboard based panels in Group C had the worst performance, mainly as a result of the mid-frequency plateau. Nevertheless, these panels still achieved a D_{nw} of 46 - 47 dB which is quite adequate for many office applications.

The effect of overlaying the floor with carpet is quite substantial for both panel types, and improves the sound insulation by about 8 - 10 dB below 1 kHz and up to 17 dB above 1 kHz. With both the hollow and filled panels, the D_{nw} is increased by 11 dB. It is likely that the carpet has two main effects: It acts as a damping layer and also covers the small gaps between floor panels.

The effect of the fire break upon the bare panel is also substantial but, as might be expected, the improvement to the carpeted floor is just 2 - 3 dB.

The effect of filling the voids of the hollow panels with concrete was a little surprising. A significant improvement had been expected since the mass had been doubled. In the event, the sound insulation of the filled panel was better at some frequencies and worse at others, with little or no increase in the D_{nw}.

THE EFFECT OF PENETRATIONS

Since speech privacy was of prime concern in this case, and because of time-table and budget limitations, the effect upon sound insulation of penetrations and services was measured in the third octave bands from only 400 Hz to 2 kHz.

Tests were carried out to determine the effect of return air grilles (direct air paths through the floor panels), circulating fans (which again provide direct air paths through the panels), and heat-pumps (which provided no direct air path through the panels). Each heat pump was in effect, a pair of large grilles on the same side of the partition connected by a metal duct.

A description of most of these tests is beyond the scope of this paper, but among the tests carried out were those to determine the effect of return air grilles. The return air grilles comprised holes about 200 mm diameter in the floor panel, filled by a plastic grille with some 0.011 m^2 open area, and with an air flow controlling plastic 'pot' beneath. Single grilles on both sides of the partition were tested at two distances from the partition, with metal elbows fitted to the bottom, and then with a 1 m length of flexible duct connected to the elbow and running away from the partition line under the floor. The results are shown in Table 3.

Table 3 Sound insulation of floor with penetrations

Condition	Mean D_n (400-2000 Hz)
No grilles	51.8
Grilles at 600 mm from partition	50.0
Grilles at 1200 mm from partition	49.4
Grilles at 600 mm from partition + elbow	50.6
Grilles at 1200 mm from partition + elbow	50.4
Grilles at 600 mm from partition + elbow + duct	50.1

It appears from this that there is no significant difference between the results with the presence of return air grilles. This may be an indication that the direct sound travelling between the penetrations on opposite sides of the partition is not significant.

In the worst case measured - with one heat-pump and two return air grilles on each side of the partition - the mean D_n (400 - 2000 Hz) was 48.8 dB.

GENERAL OBSERVATIONS

It is worth recording several subjective observations, some of which were to be expected. The area of floor within one metre or so of the wall (on the receiving side) appeared to radiate far more sound than the rest. It became clear that the sealing of the floor to the underside of the partition, and to the void walls near to the partition, was most critical. There appeared to be no significant radiation of sound from the panel joints, which were simple butt joints. However, since the panel joints rarely coincided with the carpet joints, they were normally covered with carpet.

CONCLUDING REMARKS

The sound insulation of access floors was found to be greater than expected by their manufacturers. It was, however, similar to or greater than that predicted by comparison with suspended ceilings [2]. The sound insulation of the stiffened steel (unfilled) and aluminium floors exceeded that expected, and was exceptionally good for the weight. Those floors with a timber or chipboard core suffered from what appeared to be a severe coincidence plateau.

Tests on the steel floor showed that its sound insulation owed much to the effect of overlaying carpet. Filling the voids with concrete did not produce a much better overall performance, even though this doubled the weight. A rolled rockwool firebreak beneath the partition produced a substantial improvement only on the uncarpeted floor.

The investigations were funded partly by Lloyd's and partly by manufacturers who were tendering for the project.

REFERENCES

[1] ISO/DIS 140/9 'Acoustics - Measurements of sound insulation in buildings and of building elements - Part 9. Laboratory measurement of the room-to-room airborne sound insulation of a suspended ceiling with a plenum above it',(1981).

[2] A. J. Jones, 'Interoffice privacy and the suspended ceiling', Noise Control and Vibration Isolation 9 (2),41-45, (1978).