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# THE EFFECT OF LINING REVEALS WITH SOUND ABSORBENT MATERIAL

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## ABSTRACT

The sill and reveal of a panel or window system are known to influence the acoustic transmission of the system and it is known that lining the reveal with sound absorbent material can increase the sound reduction index. This work examines the influence of a window to sill or reveal ratio upon the known effects, by testing two window sizes whilst maintaining sill or reveal depths. The potential for marked increase in sound reduction index by reveal absorbent lining is also examined and deductions concerning its use are made.

## SOMMAIRE

Les appuis (intérieur et extérieur) d'une fenêtre (ou d'un panneau en laboratoire) peuvent affecter la transmission acoustique d'un système de fenêtre. Il est aussi connu que fait de recouvrir ces appuis d'un matériau acoustiquement absorbant augmente l'indice de réduction du son. Ce projet étudie l'influence des appuis en considérant deux fenêtres de dimensions différentes tout en gardant constante la largeur des appuis. Il est également question de l'usage de recouvrements absorbants pour les appuis de manière à obtenir un accroissement sensible de l'indice de réduction du son.

## 1. INTRODUCTION

The transmission of sound through window and wall systems is known to be influenced by many physical features such as room size, panel size, mounting conditions and so on; amongst these influencing factors, it has been shown [1], [2], that the sill or reveal of a panel system or a combination of both, will also influence the transmission of sound, and that these particular features may be engineered to increase the sound reduction index of the system [3] - particularly by lining the reveal with sound absorbent material.

As in Reference [3] both sills and reveals are considered here to consist of equal depth projections from the four sides of a rectangular panel or window. That projection towards the source room will be referred to as a 'sill', whilst the projection towards the reception room will be referred to as a 'reveal'.

Two questions arise from these earlier works; "What is the effect of panel to sill or reveal dimensions"?, and "What limits of use in frequency or extent of lining might apply"? This paper presents the results of recent measurements undertaken at the Centre for Building Studies which contribute towards answering these question.

## 2. THE EXPERIMENTAL FACILITY AND TEST ARRANGEMENTS

The transmission loss suite of the Centre for Building Studies at Concordia University consists of two isolated rectangular rooms of differing dimensions. The larger room has a volume of 95 $m^3$ and the smaller room of volume 34 $m^3$. The Schroder cut off frequency for the larger room is 250 Hz. In the present tests the smaller room was employed as the receiving room and was lined on three adjacent surfaces with a proprietary 10cm thick sound absorbent material to facilitate the measurement of transmitted energy by a sound intensity measurement system. The test facility is described more fully in reference [4].

A heavy filler wall was constructed in the test aperture between the two rooms on either side of steel frames which marked the boundary between them; the wall Sound Transmission Class (STC) was determined to be 60.

The test panel was mounted flush to the source room surface in order to accurately assess the surface incidence intensity as inferred from the reverberant source room sound pressure level measurements, however, the flush mounted condition was necessarily disturbed by the mounting of sill projections into the source room for some of the measurements.

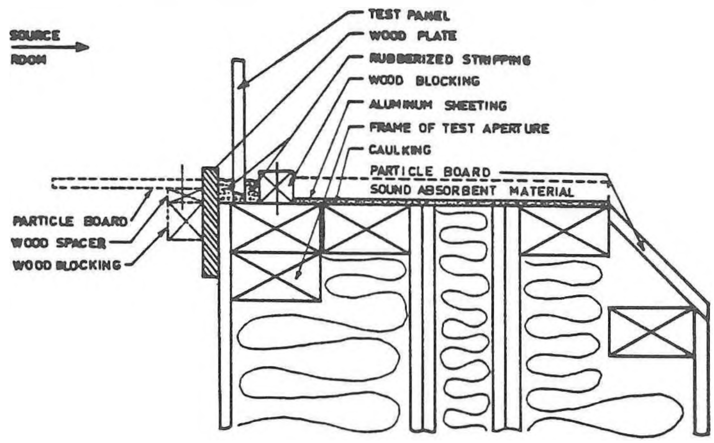



FIGURE 1. MOUNTING OF TEST PANEL ON FILLER WALL WITH SILL OR ABSORBENT MATERIAL

The mounting, shown in Figure 1, resulted in a 39.4 cm (15.5") deep reveal with the option of adding sill projections or lining the reveal with absorbent material.

Two panel sizes were tested 1.14 m x 1.14 m x 0.64 cm (1/4") thick glass and 1.52 m x 1.52 x .64 cm (1/4"), and the filler wall was designed for successive demolition in order to accomodate these sizes.

## 3. TEST PROCEDURE

White noise was generated in the source room by two loudspeakers placed in the corners of the room opposite the test aperture and the mean sound pressure levels in the source room were measured using a rotating microphone boom (B & K 3923P). The microphone described a plane circular path at 70° from the horizontal and the length of the arm was 1.6 m, this configuration was chosen so that the microphone cleared the walls and stationary diffusers by at least 0.8 m. The minimum distance from the microphone to speaker was

1 m. and the period of a complete revolution of the microphone was 32 seconds.

All measurements were computer controlled and fed to a third octave analyser. In this case, the Sound Intensity Analyser type 2134/3360 from Brüel and Kjaer.

The incident intensity was calculated from the mean sound pressure level as measured in the reverberant source room.

The transmitted sound intensity was measured directly using a B & K Sound Intensity Microphone Probe type 3519 with a face-to-face microphone configuration. The 1/2" microphones with 12 mm spacer were chosen; this gave a useful frequency range of 125 Hz to 5 k Hz with an accuracy of $\pm$ 1dB assuming a monople source. An averaging time of 8 seconds was selected.

The intensity radiated by the panel was measured at 81 evenly distributed points over the measured plane and the microphone probe was mounted on a mechanical traverse system that enabled it to be fixed during each measurement interval. The probe was then moved by hand from point to point, although later developments will include the automation of this traverse. A point array measurement system was chosen to allow the construction of surface intensity profiles; surface profiles for the present panels are presented and discussed in reference [5]. Selection of array point numbers, averaging times and pressure to intensity ratios are also discussed in reference [5].

## 4. TESTS AND RESULTS

Two sets of tests with two sizes of 6 mm glass panel were undertaken.

The first series of tests involved measuring the sound intensity on the reception side at a distance of 5.08 cm. (2"), from the panel for a no sill condition, then with a 19 cm. sill, and then with a 38 cm. sill; each sill was constructed of 16 mm (5/8") wood particle board. For these tests the permanent 39 cm. reveal was in the bare condition and the reception measurement was chosen close to the panel (5 cm.) to avoid extraneous reveal effects.

Figure 2 displays the sound transmission loss of the 1.14 m x 1.14 m ($1.3m^2$) panel with no sill, 19 cm. sill, and 38 cm. sill, whilst Figure 3 displays the sound transmission loss of the 1.52 x 1.52 m ($2.3m^2$) panel with no sill, 19 cm. sill, and 38 cm. sill.

Figure 4 displays the difference in transmission loss between the no sill and 38 cm. sill condition for both sizes of panel.

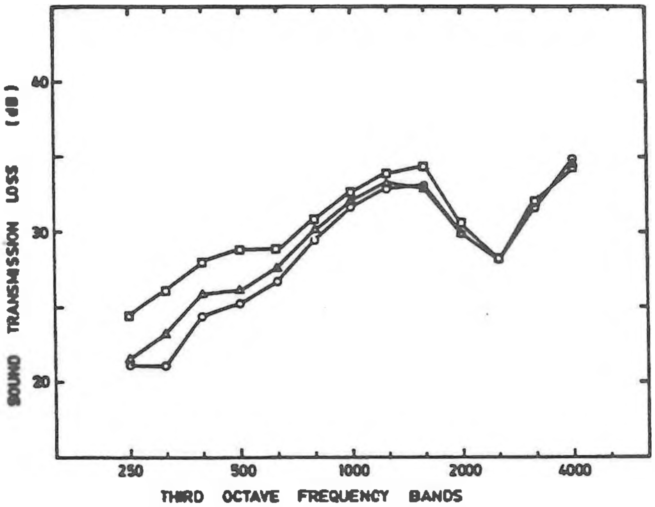



FIGURE 2 TRANSMISSION LOSS FOR A 1.3 m² SQUARE PANEL WITH A 39 cm REVEAL IN THE PRESENCE OF □-□ NO SILL, △-△ 19 cm SILL, ○-○ 38 cm SILL. TRANSMITTED INTENSITY MEASUREMENTS TAKEN 5.4 cm (2") FROM THE PANEL SURFACE.

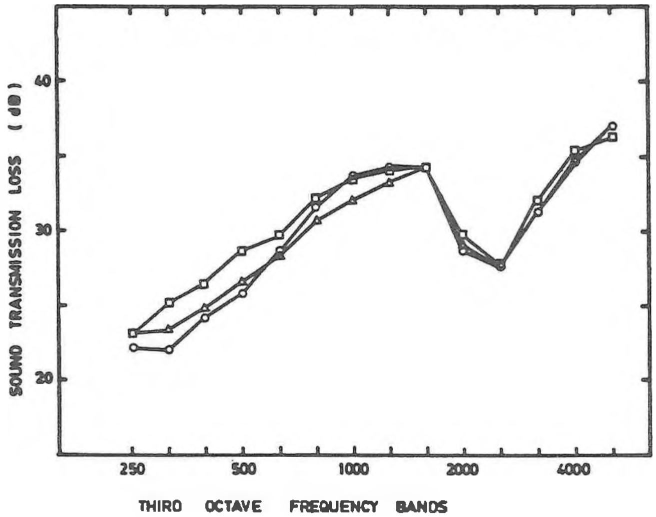



FIGURE 3 TRANSMISSION LOSS FOR A 2.3 m² SQUARE PANEL WITH A 39 cm REVEAL IN THE PRESENCE OF □-□ NO SILL, △-△ 19 cm SILL, ○-○ 38 cm SILL. TRANSMITTED INTENSITY MEASUREMENTS TAKEN AT 5.4 cm (2") FROM THE PANEL SURFACE.

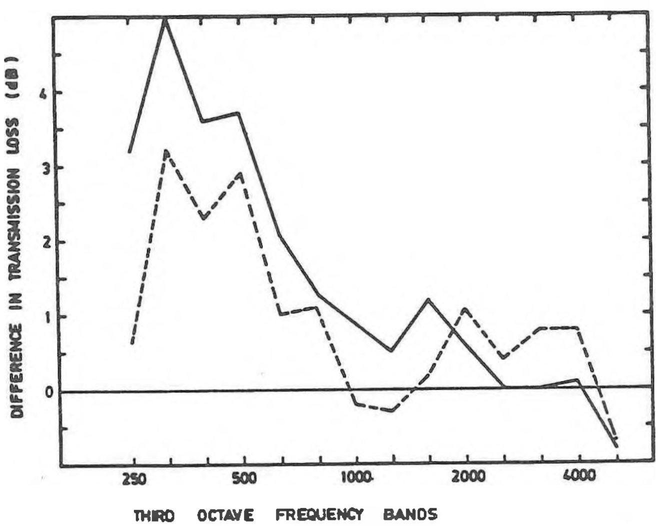



FIGURE 4 TRANSMISSION LOSS WITH A 38 cm SILL SUBTRACTED FROM THE TRANSMISSION LOSS WITH THE SILL REMOVED, FOR A 1.3 m AND 2.3 m SQUARE PANEL.
LEGEND —— 1.3 m² SQUARE PANEL
--- 2.3 m² SQUARE PANEL

| Octave Band Centre Frequency HZ | Thickness | |
|---|---|---|
| | 2.54 cm (1") | 5.08 cm (2") |
| 125 | 8 | 27 |
| 250 | 19 | 68 |
| 500 | 57 | 91 |
| 1000 | 88 | 98 |
| 2000 | 96 | 98 |
| 4000 | 88 | 99 |

TABLE 1: The Sabine Absorption Coefficient of the Reveal Absorbent Lining Material. (as supplied by the manufacturer)

The second series of tests involved lining the reveal with progressive thickness 2.54 cm (1"), 5.08 cm (2"), and 10.16 cm (4") of a propriatory open cell polyurethane foam sound absorption material. The absorbent material's sabine sound aborption coefficients, as supplied by the manufacturer, are shown in Table 1 for the 2.54 cm and 5.08 cm thickness.

For this series of tests there was no sill projection and to compare the overall effect of differing sound absorbent material thickness, the transmitted sound intensity was measured over the plane of the reveal at the reception room side.

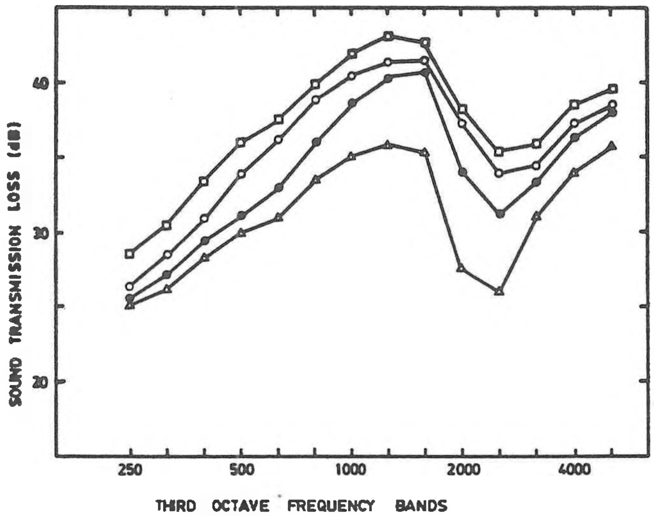



FIGURE 5 SOUND TRANSMISSION LOSS OF A 2.3 m² SQUARE PANEL FOR SUCCESSIVE INCREASE OF 38cm REVEAL ABSORBENT MATERIAL THICKNESS.

LEGEND: ▲-▲ NO ABSORBENT.
●-● 2.54 cm (1") ABSORBENT.
○-○ 5.08 cm (2") ABSORBENT.
□-□ 10.16 cm (4") ABSORBENT.

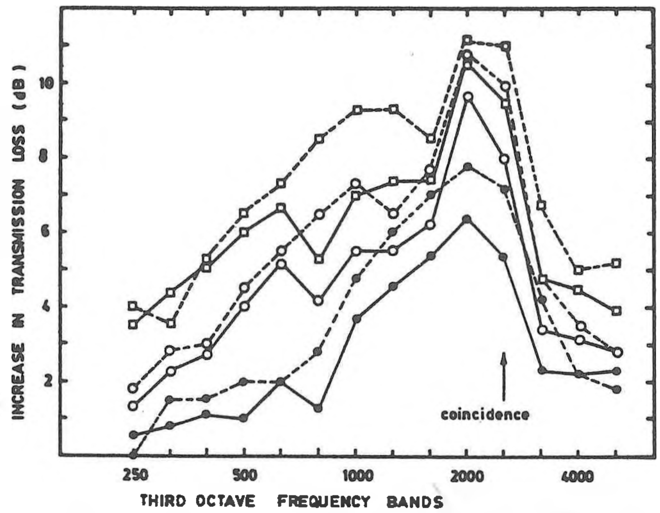



FIGURE 6. INCREASE IN TRANSMISSION LOSS FOR LINING THE 38 cm REVEAL WITH SOUND ABSORBENT MATERIAL IN RELATION TO SIZE OF PANEL AND THICKNESS OF ABSORBENT.

LEGEND --- 1.3 m² SQUARE PANEL
— 2.3 m² SQUARE PANEL
● ● 2.54 cm (1") ABSORBENT
○ ○ 5.08 cm (2") ABSORBENT
□ □ 10.16cm (4") ABSORBENT

Figure 5 displays the results of lining the reveal for the 1.3 m$^2$ panel whilst Figure 6 displays the increase in transmission loss for the 1.3 m$^2$ and 2.3 m$^2$ square panels for varying thickness of sound absorbent reveal lining.

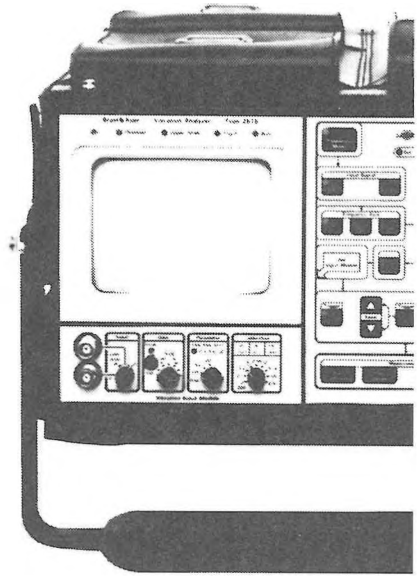
As part of the lined reveal series, measurements of the transmitted intensity over cross sectional planes located at varying distances from the panel surface were taken.

## 5. DISCUSSION

The effect of sills in relation to reveal dimensions have been discussed by others [1], [2], and Figures 2 and 3 display a usual finding of lowest transmission loss for matched sill and reveal whilst the no sill condition in the presence of a large reveal leads to the highest transmission loss. Differences in transmission loss values may be seen in Figure 4 to be most prominent at low frequencies, with a maximum difference of 5 dB, gradually reducing to below 1 dB at and above the coincidence third octave band of 2500 Hz.

Both panel sizes display the same total trend but below coincidence the smaller panel (1.3 m$^2$) yields a higher difference, that is, the smaller the panel - the greater the sill influence; this finding is also true when the curves of Figure 4 are corrected for differences resulting from the use of different panels (see Ref. [5]).

About and above the coincidence region, the sill effect appears more to influence the larger panel however, because the differences in this region



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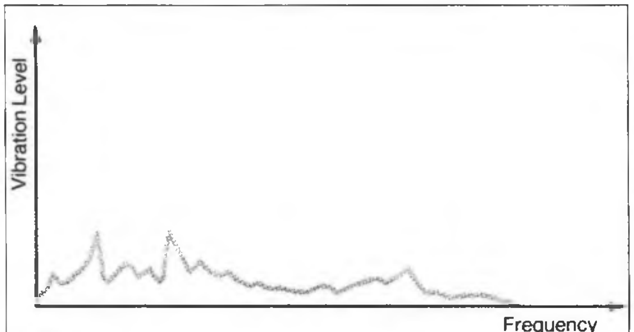


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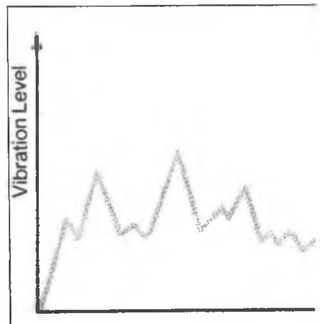


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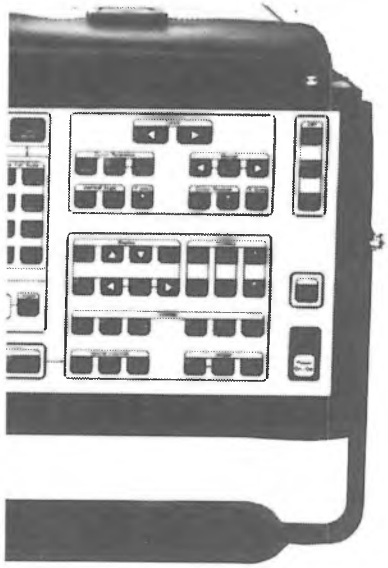

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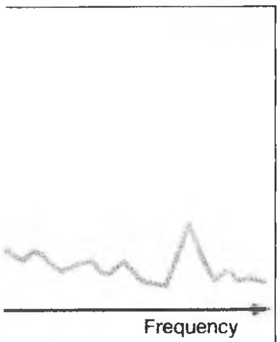


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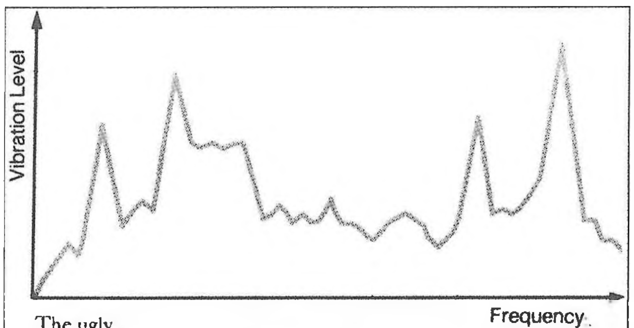


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Figure 5 displays the results of lining the reveal with absorbent material. Clearly, the thicker the absorbent, the greater the attenuation, with increases of sound transmission loss ranging from 6 to 10 dB over much of the spectrum for the 10.16 cm (4") thick absorbent.

Figure 6 displays the increase in sound transmission loss for both sizes of panel whilst varying, the reveal absorbent thickness.

The general trends are the same for both panels and for absorbent thickness, namely a gradual increase of sound transmission loss from low frequency up to the coincidence region and then a rapid reduction in effect. The 1.3 $m^2$ panel with the exception of minor excursion, displays the greater effect being typically 1 to 2 dB higher in attenuation than the 2.3 $m^2$ panel.

| Absorbent Thickness mm | Increased Attenuation / Third Octave (dB) | |
|---|---|---|
| | 1.3 $m^2$ panel | 2.3 $m^2$ panel |
| 25.4 (1") | 3.7 | 2.9 |
| 50.8 (2") | 5.7 | 4.7 |
| 101.6 (4") | 7.4 | 6.4 |

TABLE 2: The average increase in attenuation for each third octave from 250 to 4000 Hz for varying area of panel and thickness of reveal absorbent material. Lined reveal depth 38 cm.

Table 2 highlights this aspect further by displaying the increased attenuation averaged over the third octaves from 250 Hz to 4000 Hz, for each panel size and absorbent lining thickness. Based upon this measure the 1.3 $m^2$ panel typically exhibits a 1 dB per third octave improvement over the 2.3 $m^2$ panel.

It may also be noted from Table 2 that the average increase of attenuation is about 2 dB for doubling of lining thickness - naturally this trend cannot continue indefinitely, however, its limits may not simply be a matter of improved sound absorption coefficient for increased thickness.

Returning to Figure 6, it can be seen for both panel size and absorbent thickness that the region of greatest attenuation is from about 1K Hz to coincidence at 2.5 kHz; initially one may ascribe this result to the high absorption coefficients reported for this material at those frequencies, however this influence is not evident at the frequencies above coincidence, in fact the increased attenuation above coincidence is similar to the attenuation at very low frequency where the absorbent material exhibitslower absorption coefficients.

This finding can be explained by considering the power flow regimes determined for these panels (see Reference [5]), namely at lower frequencies 250 Hz to 630 Hz the prominent energy transmission is from corner radiation, from 800 Hz to 2000 Hz panel perimeter radiation is prominent, whilst above coincidence a planar full panel radiation is found. The present results suggest maximum attenuation for good absorption coefficient in the presence of panel perimeter radiation although useful attenuation might be achieved in the presence of low frequency type corner radiation and high absorption coefficients.

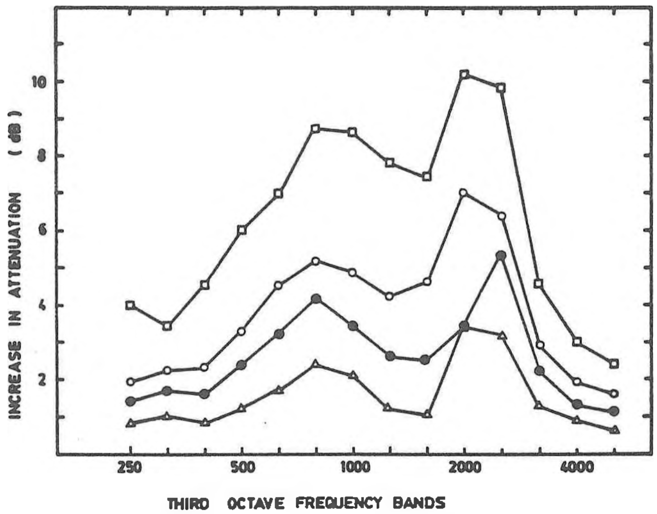


FIGURE 7 INCREASE IN ATTENUATION WITH MEASUREMENT PLANE FROM THE PANEL WITH A 38 cm (15") ABSORBENT LINED REVEAL FOR A 1.3 $m^2$ SQUARE PANEL AND 5.08 cm (2") ABSORBENT. DATUM: TRANSMITTED INTENSITY AT 7.5 cm (3") FROM PANEL.
LEGEND: △–△ 15cm (6") FROM PANEL;
●–● 22.5 cm (9") FROM PANEL;
○–○ 30 cm (12") FROM PANEL;
□–□ 38 cm (15") FROM PANEL.

Figure 7, displays the results of increased attenuation at different intensity measurement planes from the panel surface; the datum for this series of tests is the sound transmission loss measured at 7.5 cm (3") from the panel surface and the planes are successive 7.5 cm (3") intervals from the datum up to 38 cm (15") from the panel.

For all measurement distances, the general observations made with respect to Figure 6 are evident and the increased attenuation (dB) generally appears to progress constantly for measurement plane distances up to 30 cm. (12") from the panel, an enhanced attenuation is then apparent to the next measurement plane at 38 cm (15") for all frequencies below coincidence; this may be the result of 'view factor' considerations with respect to the proximity and view the active portions of the panel have of the lined reveal. This may also explain why in all measurement cases, the low frequency attenuation is higher than found at very high frequency even though the absorption coefficient of the reveal lining material will be better at the high frequencies. One may suppose a finite limit to the achievable increased attenuation for increased lined reveal depth, however, the present measurements indicate that this limit has not yet been encountered for the lining material used here.

## 6. CONCLUSIONS

The conclusions of the present work may be stated as follows:

i) Sill and reveal effects reported by other workers are confirmed, with most influence being found at low frequencies and for matched sill and reveal conditions.

ii) The sill effect does depend upon panel size, with a smaller panel for given sill exhibiting stronger influence.

iii) The presence of absorbent lined reveals can appreciably enhance the sound insulation of a panel system.

iv) The increase in sound insulation was relatively constant as a function of transmission path, although non linear geometry or view factor effects may be encountered for longer transmission paths (greater than 30 cm. (12") in the present measurements).

v) Maximum increase of sound insulation can be achieved in the presence of edge type panel radiation.

vi) Sound insulation with lined reveals does depend upon panel size with increased insulation being associated with the smaller panel for given reveal.

vii) Increase of sound insulation can be expected for lined reveals longer than 38 (15") centimetres.

viii) Increase of sound insulation can be expected for thickness of reveal lining greater than 10 (4") centimetres.

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