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A simple model of the sound insulation of gypsum board on resilient supports

J. S. Bradley[a] and J. A. Birta[a]

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A simple model is developed to explain the effects of adding resilient channels to a rigid double leaf wall or floor system. The surface layers mounted on resilient channels are treated as a vibration isolator with a fundamental resonance frequency determined by the combination of the stiffness of the resilient channels and the stiffness of the air cavity along with the masses of the surface layers. The effective stiffness of various common forms of resilient channels is found to be approximately equivalent to that of a 160 mm air cavity. The damping of constructions including resilient channels and cavities with sound absorbing material is found to vary with cavity depth. While the model is useful to optimise the low frequency performance of double leaf constructions with resilient channels, it also demonstrates that the practical range of improvements is limited.

Primary subject classification: 33; Secondary subject classification: 51.3

1. INTRODUCTION

Higher sound transmission loss for light-weight wall and floor systems is obtained by using double leaf constructions. A wood stud wall with gypsum board attached to each face is an example of such a double leaf construction. The sound insulation of this type of double leaf system is usually limited by structural propagation through the rigid connections to the wood studs. Breaking the rigid connection between the two faces of the wall can significantly improve the sound transmission loss of the wall. This is usually achieved by resiliently mounting the gypsum board on one of the two faces of the wall using thin metal channels. Figure 1 illustrates the cross sections of four types of resilient channels considered in this work. They all provide a resilient connection because of the flexing of the 0.5 mm thick metal channels. The results of this paper will confirm that they are similarly resilient in that they seem to have the same stiffness at lower frequencies and hence all are referred to as resilient channels.

Although in many situations it is standard procedure to use resilient channels to improve the sound transmission loss of a wall or floor system, there was no simple model of their performance, nor a quantitative understanding of the important properties of the resilient channels. In fact there is much folklore about the considerably superior properties of various brands or designs of resilient channels, even though available measurements do not support the existence of such large differences.

The current paper attempts to resolve this problem by developing a simple model of the effect of adding resilient channels to rigid double leaf constructions. The key parameters describing the properties of the resilient channels and the complete wall or floor system are empirically derived from laboratory measurements of the sound transmission loss of various constructions that include a variety of resilient channels and cavity depths. The model allows the design of the incremental effects of adding resilient channels and helps to provide an understanding of the limits of their performance.

This work is not an attempt to consider all issues related to sound transmission through complex double leaf constructions. The intent is to focus on critically important problems at lower frequencies and the influence of adding resilient channels. The overall performance of many walls is limited by inadequate sound transmission loss at low frequencies. This is a particular problem for exterior walls because typical outdoor sounds usually include strong low frequency components. Thus it is usually most important to improve sound insulation at low frequencies. The results of this paper show that while adding resilient channels can lead to considerable improvements in low frequency sound insulation, resilient channels can also degrade the sound insulation of a partition at particular low frequencies.

2. DEVELOPING THE MODEL

As part of a project on the sound insulation of exterior walls and roofs against aircraft noise, the same exterior wood stud wall was tested with 3 quite different types of resilient channels.[1,2] The laboratory sound transmission loss results from these tests are shown in Fig. 2. The walls were constructed on 140 mm (2” by 6”) wood studs at 406 mm spacing (16”) with 11 mm OSB (Oriented Strand Board) and vinyl siding on the outside surface along with a double layer of 13 mm gypsum board as the inside surface. In all cases the stud cavity was filled with glass fibre thermal insulation. At all but the very lowest frequencies, the walls with resilient channels have clearly superior transmission loss than the wall without resilient channels. However, the results for the 3 walls with the resilient channels are very similar and exhibit only small differences at mid and higher frequencies. The resilient channels were the same basic shape but different in detail and are illustrated in the sketches of Fig. 3. All 3 types of channels were constructed of approximately 0.5 mm thick galvanized steel. They were most different in the sloping section (web) connecting the two flat surfaces of the channels.

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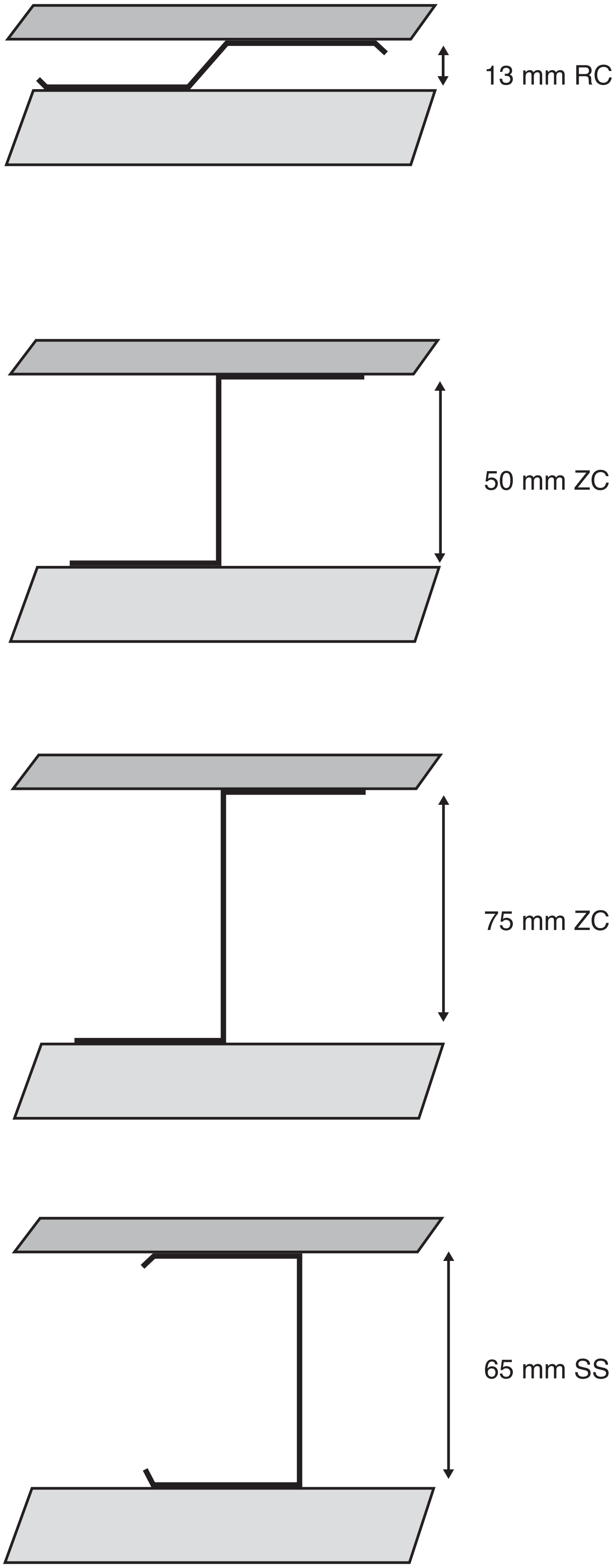

Fig. 1– Sketches of the cross sections of the 4 shapes of resilient channels referred to in this paper in the constructions described in Table 1.

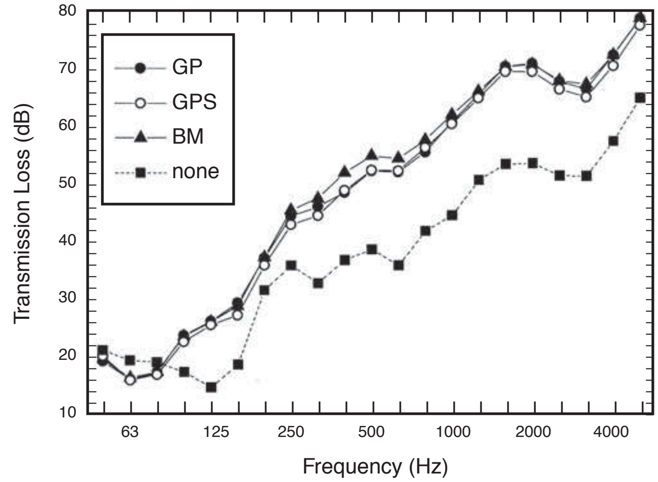

Fig. 2– Laboratory sound transmission loss measurements of wood stud exterior walls with 3 types of resilient channels and the same wall without any channels. The walls were constructed of vinyl siding and 11 mm OSB on the exterior face mounted on 140 mm (2" by 6") woods studs at 406 mm (16") spacing with glass fibre in the cavity and 2 layers of 13 mm gypsum board on the interior face. GP, GPS and BM are the 3 types of resilient channels illustrated in Fig. 3 and described above.

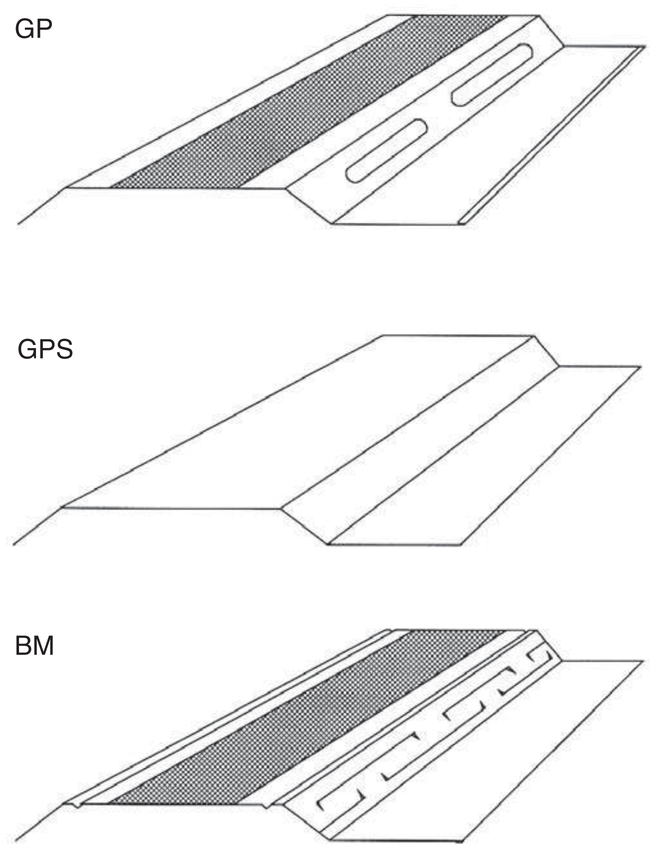

Fig. 3– Sketches of the 3 types of 13 mm resilient channels that were used in the tests illustrated in Figs. 2 and 4.

The BM channels had long cuts in this sloping section and felt more flexible. The GP channels had large holes in this sloping part of the channels and the GPS channels were made by the same manufacturer as the GP channels but without the holes. The 3 types seemed to be representative of the full range of possible designs of this shape of channel.

To better understand the effect of adding resilient channels to these exterior walls, the differences in transmission loss values between those for the walls with and without channels were calculated and are plotted in Fig. 4. Plotted in this way the addition of resilient channels is seen to increase the transmission of sound through the walls in the lowest 3 bands and to decrease sound transmission at higher frequencies. The difference plots are a little irregular and there is a pronounced dip at 125 Hz, which will be explained later. However, the general trend of the difference plots is similar to the transmissibility of a vibration isolator. In fact one can think of the resiliently mounted gypsum board as vibrationally isolated from the rest of the wall or floor. It is therefore proposed that the effect of adding resilient channels to a rigid double leaf construction can be modelled as simply vibrationally isolating the gypsum board.

Machines are vibrationally isolated by designing the mass, and the stiffness of their spring suspension to tune the suspension resonance frequency to be well below that of potential vibration problems. The transmissibility is given by the following, (from Eq. 19.9 in reference 3),

$$T = \sqrt{\frac{1+4D^2\left(\frac{f}{f_0}\right)^2}{\left[1-\left(\frac{f}{f_0}\right)^2\right]^2+4D^2\left(\frac{f}{f_0}\right)^2}} \qquad (1)$$

where, D is the damping ratio re critical damping, f is frequency and f_0 is the resonance frequency.

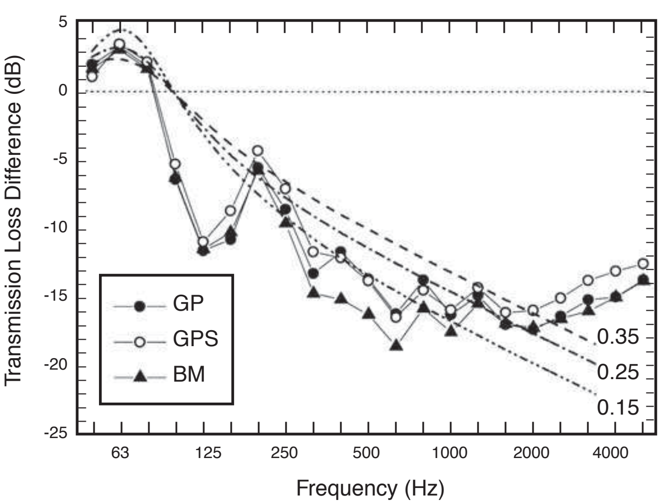

Fig. 4– The differences between the transmission losses of walls with resilient channels and a wall without resilient channels. The figure also shows three fits of Eq. (1) to the measured differences.

To apply this equation to the resiliently mounted gypsum board, one must first determine the effective damping D of the system and the resonance frequency f_0 of the system. The damping will be empirically determined in the next section. The determination of the resonance frequency requires an understanding of the low frequency performance of double leaf walls.

Two rigid panels separated by a contained air cavity have a mass-air-mass resonance determined by the mass of the two panels and the stiffness of the contained air space.[4] At such resonance frequencies the sound transmission loss of the system will be reduced, i.e. more sound energy will be transmitted through the system. Walls with resilient channels will have a modified mass-air-mass resonance frequency because the added stiffness of the resilient channels will add to that of the air cavity. As Fig. 5 illustrates, the stiffness of the resilient channels is in parallel with the stiffness of the air and so the total stiffness is the sum of that due to the air and that due to the resilient channels. (This assumes the stiffness added by the wood studs/joists is negligible, i.e. the studs/joists are much more rigid than the resilient channels).

When the resilient channels are absent and the gypsum board is rigidly attached to both sides of the studs, the system is changed and does not have a simple mass-air-mass resonance. As Lin and Garrelick[5] have explained, the transmission loss dip at 125 Hz in Fig. 2 for the wall without resilient channels is the primary structural resonance of the framed panel system formed by the studs and the rigidly attached gypsum board. Providing a resilient mounting for the gypsum board eliminates this primary structural resonance and introduces the modified mass-air-mass resonance. Thus the transmission loss difference plots in Fig. 4 illustrate a prominent peak in the 63 Hz band because of the addition of the modified mass-air-mass resonance and a notch at 125 Hz because of the elimination of the primary structural resonance.

Fahy's equation 4.82 from reference 4 for the frequency of the simple mass-air-mass resonance and normally incident sound can be modified to predict the expected resonance frequency when resilient channels are also included. The mass-air-mass resonance is explained by considering a system behaving as a simple harmonic oscillator with a resonance frequency f_0,

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{s}{m}} \qquad (2)$$

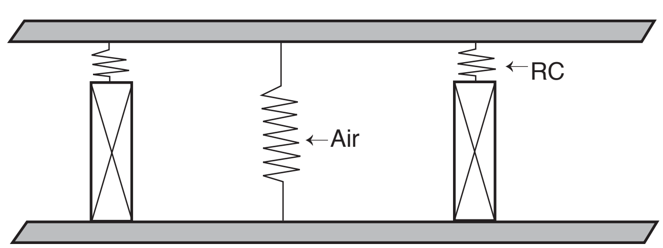

Fig. 5– Schematic description of the vibrational components of a wall including resilient channels (RC).

where s is the stiffness per unit area and m is the mass per unit area. For the mass-air-mass resonance of the double wall, the combined effect of the masses of the two surface layers, m_1 and m_2 is,

$$\frac{1}{m}=\frac{1}{m_1}+\frac{1}{m_2}=\frac{m_1+m_2}{m_1 m_2} \tag{3}$$

and the stiffness of the enclosed air cavity with depth d is,

$$s=\frac{\rho_0 c^2}{d} \tag{4}$$

here ρ_0 is the air density and c is the speed of sound.

When resilient channels are added to a wall, the added stiffness of the resilient channels is added in parallel with the stiffness of the air (see Fig. 5) and the combination of the two determines the total stiffness of the wall system. The stiffness of the resilient channels can be estimated in terms of an equivalent air space, d_2, where the actual air space is d_1. Then the total stiffness is,

$$s=s_1+s_2=\rho_0 c^2\left(\frac{1}{d_1}+\frac{1}{d_2}\right) \tag{5}$$

By substituting Eqs. (3) and (5) into Eq. (2), the equation for the modified mass-air-mass resonance of a double wall including resilient channels can be shown to be given by,

$$f_R=\frac{1}{2\pi}\sqrt{\rho_0 c^2\left(\frac{d_1+d_2}{d_1 d_2}\right)\left(\frac{m_1+m_2}{m_1 m_2}\right)}\ \text{Hz}. \tag{6}$$

The constant factor, $\frac{1}{2\pi}\sqrt{\rho_0 c^2}$ is equal to 1362 for an air filled cavity and 1900 for a cavity filled with sound absorbing material because putting absorbing material in the cavity changes the process from adiabatic to isothermal and reduces the speed of sound.[4] The units of m_1 and m_2 are kg/m^2 and d_1 and d_2 are in mm.

Equation (6) can be used to estimate the frequency of the modified mass-air-mass resonance for a cavity wall with resiliently mounted surface layers. The addition of the stiffness of the resilient channels increases the total stiffness and increases the resonance frequency above that for a similar situation without resilient channels. It will also limit the minimum stiffness and hence the lowest resonance frequency for larger air spaces. By including the stiffness of the resilient channels as an equivalent air space, this additional stiffness can be determined empirically from laboratory sound transmission loss measurements of constructions with resilient channels and various cavity depths. Because the results for the three quite different types of channels in Fig. 4 exhibited very similar resonance frequencies, it will be assumed that the stiffness of all metal resilient channels consisting of flexing 0.5 mm thick steel will be approximately the same.

3. EMPIRICAL DERIVATION OF MODEL PARAMETERS

To use Eq. (1) to explain the additional effect of resilient channels it is necessary to first know appropriate values of the damping D and the system resonance frequency. Eq. (6) indicates that calculation of the modified mass-air-mass resonance frequency of the system also requires knowledge of the effective stiffness of the resilient channels. Both the damping of the system and the stiffness of resilient channels will be derived from an analysis of laboratory sound transmission loss measurements of constructions including resilient channels and a range of cavity depths.

The procedure is illustrated in Fig. 4. Equation 1 was fitted to each transmission loss difference plot (like Fig. 4) by adjusting the resonance frequency f_0 and the damping D until a visual best fit was obtained. Particular attention was paid to the region around the frequency of the modified mass-air-mass resonance, because above this frequency the transmission loss differences can also be influenced by other factors (see Section 4). For this example a resonance frequency of approximately 68 Hz and a damping ratio of 0.25 was judged to provide the best fit. Calculations using less damping (0.15) or more damping (0.35) are shown to not produce good fits to the measured data in Fig. 4.

This procedure was applied to the sound transmission loss measurements of 8 constructions with cavity depths varying from 13 to 286 mm. In each case the difference between the transmission loss for the same construction both with and without resilient channels was first calculated. This could only be done with adequate precision when the data for the reference case without resilient channels were obtained from exactly the same construction as the one that included resilient channels. Rebuilding nominally the same wood stud wall leads to small differences that would lead to significant errors in the difference plots. Of course, the reference case must also represent a construction with a rigid connection between the two exterior surfaces. Table 1 describes the constructions that were used. In all cases the cavities were filled with fibrous absorbing material. They include: concrete block walls with attached gypsum board (constructions 1-4), wood stud walls (constructions 5-7), and a wood joist flat roof (construction

TABLE 1– Description of the double leaf constructions used and the related resonance frequencies: calculated mass-air-mass resonance frequencies, f_A, measured system resonance frequency, f_M, and calculated modified mass-air-mass resonance frequency, f_R. (G13, 13 mm gypsum board; G16, 16 mm gypsum board; OSB11, 11 mm Oriented Strand Board; CB190, 190 mm concrete block; SHN, asphalt shingles).[7] See Fig. 1 for illustrations of resilient channel types.

N	Layer 1	Cavity, mm	Layer 2	Resilient type*	f_A, Hz	f_M, Hz	f_R, Hz	Data Source
1	G16	13	CB190	RC	112.1	111.9	117.6	[6]
2	G16	50	CB190	ZC	61.6	74.2	71.1	[6]
3	G16	65	CB190	SS	54.4	61.2	64.9	[6]
4	G16	75	CB190	ZC	50.8	62.2	61.9	[6]
5	G13	102	G13	RC	67.4	84.3	86.3	[7]
6	G16	102	G16	RC	60.8	82.7	77.8	[7]
7	2G13	153	OSB11	RC	46.1	67.8	64.4	[1]
8	G13	286	OSB11 +SHN	RC	34.9	54.4	58.2	[1]

TABLE 2– Surface densities of the wall materials. (G13, 13 mm gypsum board; G16, 16 mm gypsum board; OSB11, 11 mm Oriented Strand Board; CB190, 190 mm concrete block; SHN, asphalt shingles).

Material	Mass/unit area, kg/m^2
G13	8.0
G16	9.8
OSB11	8.9
SHN	7.1
CB190	147.3

8). The surface densities of the component materials are given in Table 2.

The transmission loss difference plots in Fig. 4 were complicated because adding resilient channels to the wood stud wall system eliminated one resonance and introduced another. That is, adding the resilient channels changed the vibrational properties of the system. This did not occur for the concrete block wall examples and the difference plots are less irregular. For these walls (the first four examples in Table 1), the differences were between the transmission loss for the block walls without gypsum board and for the walls with resiliently mounted gypsum board. The added mass of the gypsum board is insignificant relative to the mass of the 190 mm concrete blocks.

Figure 6 illustrates the fit of Eq. (1) to the transmission loss difference plot for example 1 in Table 1. Here the measured resonance frequency, resulting from fitting Eq. 1 to the difference data, is about 112 Hz and the damping ratio 0.11. The maximum improvement in the transmission loss at frequencies above the resonance is only 8-9 dB. This is less than that for the examples in Fig. 4 where the maximum improvement in transmission loss, when resilient channels were added, was greater than 15 dB. The other difference plots for the 3 other concrete block wall examples were also without the 125 Hz notch seen in Fig. 4. When calculating the resonance frequencies of the 4 systems that included concrete block walls, the cavity depth was increased by 3 mm greater than the measured depth of the resilient channels shown in Table 1. (The surface roughness of the concrete blocks increased the effective cavity depth as evidenced by a mass-air-mass resonance when the gypsum board was screwed directly to the blocks.[6]

Figure 7 illustrates the fit to the difference plot for the sixth construction in Table 1 for an 89 mm stud wall with 16 mm gypsum board. In this example there is again a pronounced notch as in Fig. 4 but one band higher in frequency. The measured (fitted) resonance frequency is about 83 Hz and the fitted damping ratio 0.2.

The measured resonance frequencies, f_M, for all 8 constructions are given in Table 1. As expected, these resonances tend to be at higher frequencies than would occur for the same cavity without the added stiffness of the resilient channels. By comparing the measured resonance of the system with resilient channels, f_M, with that for the same system without channels, f_A, the added stiffness of the resilient channels can be deduced if the resilient channels are all assumed to have approximately the same stiffness. Figure 8 plots the ratio of f_M/f_A versus the cavity depth. This figure shows that as the cavity depth increases, the measured resonance frequencies deviate more from that expected without the added stiffness of the resilient channels (i.e. f_A). As indicated by Eq. (4), the stiffness of the air cavity decreases with increasing cavity depth. Thus for larger cavity depths, the stiffness of the resilient channels is relatively more important. On the other hand, for very small cavity depths, Fig. 8 shows that the added stiffness of the resilient channels

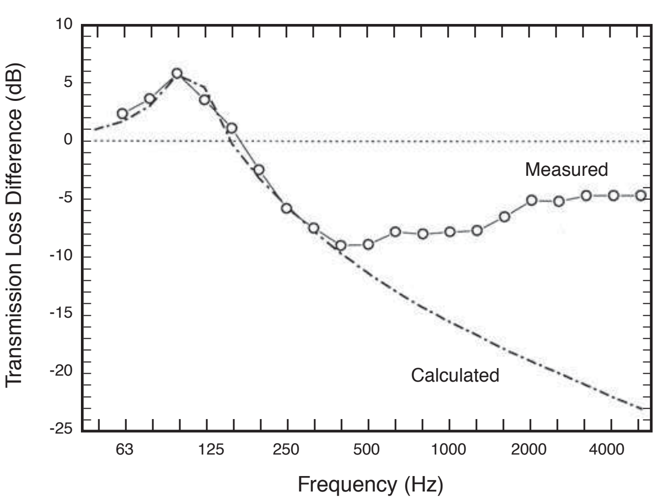

Fig. 6– Fit of Eq. (1) to the difference of transmission loss measurements with and without resilient channels for the first construction in Table 1 consisting of 16 mm gypsum board resiliently mounted to 190 mm concrete blocks using 13 mm resilient channels.

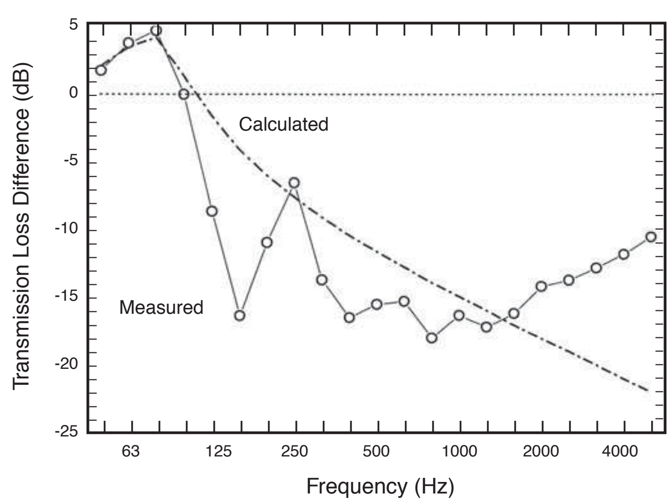

Fig. 7– Fit of Eq. (1) to the difference of transmission loss measurements with and without resilient channels for the sixth construction in Table 1 consisting of 16 mm gypsum board resiliently mounted to 89 mm wood studs on 13 mm resilient channels.

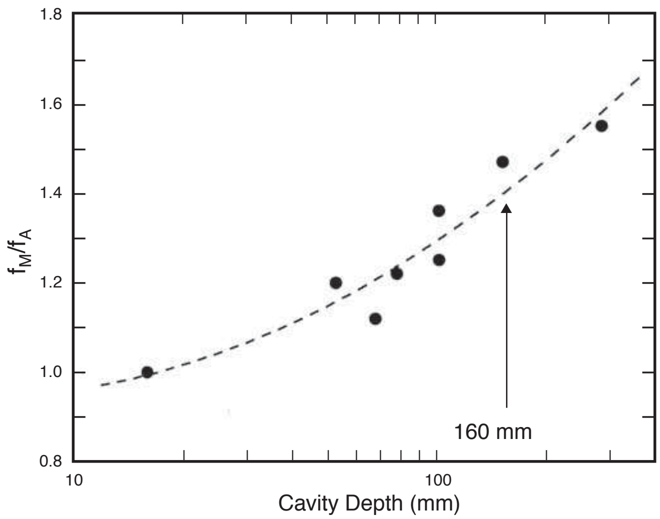

Fig. 8– The ratio of the measured modified mass-air-mass resonance frequency with resilient channels, f_M, to the calculated mass-air-mass resonance frequency for the same cavity depth without resilient channels, f_A, versus the cavity depth.

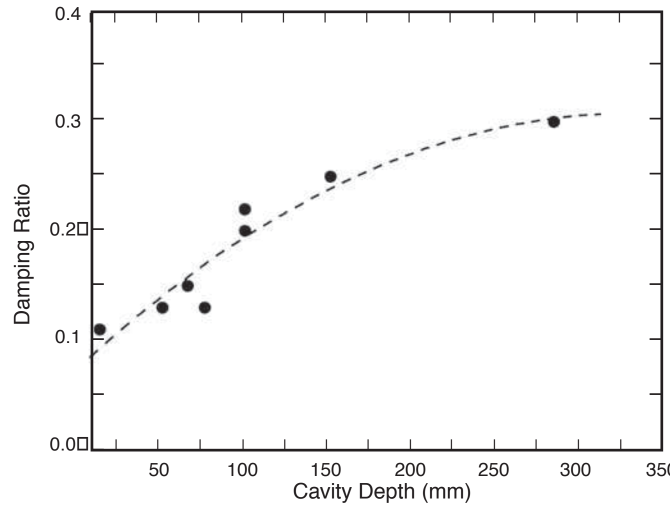

Fig. 9– Measured damping ratio versus cavity depth for the 8 constructions described in Table 1.

seems to be relatively insignificant compared to the stiffness of the air. That is, for the smallest cavity depths, the total stiffness is almost totally due to that of the air cavity, but for the larger cavity depths the total effective stiffness is a combination of the stiffness of the resilient channels and that of the air in the cavity.

At some cavity depth, the stiffness of the air and of the resilient channels are of similar magnitude. The point where the two stiffnesses are equal can be used to determine the effective stiffness of the resilient channels. Equation (2) shows that the resonance frequency is related to the square root of total stiffness. Thus when the stiffness is doubled the resonance frequency will increase by the square root of 2. This occurs for a cavity depth of about 160 mm. Thus for this cavity depth the added stiffness of the resilient channels is equal to that of the air space. More generally, we can say that the stiffness of resilient channels is approximately the same as that of a 160 mm air cavity and this value can be used for d_2 in Eq. (6).

Figure 9 plots the damping ratios that were obtained by fitting Eq. (1) to the difference plots for each of the 8 constructions. These measured damping ratios are seen to increase with increasing cavity depth from values of about 0.1 to 0.3. The rate of increase with increasing cavity depth seems to diminish for larger cavities. These results give an initial estimate of the apparent added damping on adding resilient channels to these double leaf constructions with cavities filled with porous sound absorbing material.

The maximum improvement in sound transmission loss with the addition of resilient channels occurred at frequencies several octaves higher than the resonance frequency. This maximum improvement in transmission loss was also seen to vary with cavity depth. The maximum improvement in transmission loss was determined as the average of the improvements at the 3 bands centred on the actual maximum. These maximum improvements in transmission loss are plotted versus cavity depth in Fig. 10. These results suggest that for small cavity depths the maximum improvement in transmission loss due to the addition of resilient channels increases with increasing cavity depth. However for cavity depths of about 75 mm or more, the maximum improvement is approximately 15 dB and does not vary systematically with cavity depth. For these larger cavities other factors limit the maximum improvement in transmission loss and these are discussed in the following section.

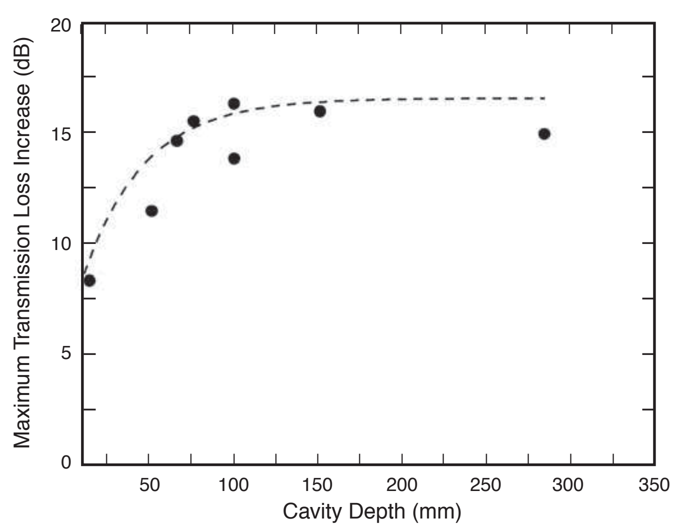

Fig. 10– Measured maximum increase in transmission loss due to the addition of resilient channels versus cavity depth for the 8 constructions described in Table 1.

4. DISCUSSION AND APPLICATION OF THE MODEL

The model allows calculation of the expected incremental effects of adding resilient channels to a double leaf construction where both outer panels are rigidly connected to the supporting system. The current results have verified that the model works for wood stud and concrete block constructions and that it approximately predicts the incremental effects of resiliently mounting one of the gypsum board surfaces in these types of constructions. It also provides an improved understanding of the effects of resilient channels. Although the model can be used to optimise the design of sound insulation with resilient channels, it also points out that the range of possible effects is small.

For small cavity depths the modified mass-air-mass resonance frequency is determined almost totally by the stiffness of the enclosed air. Construction number 1 in Table 1, where gypsum board was mounted on resilient channels to a block wall to create a 13 mm cavity, is an example of a small cavity depth where the stiffness of the resilient channels has little effect. Even if resilient channels with less stiffness could be devised, they would not be expected to change the effect of adding resilient channels for the case of such a small cavity. For small cavities resilient channels are beneficial because they provide a structural break, but the tuning of the resulting modified mass-air-mass resonance is determined largely by the mass of the surfaces and the stiffness of the enclosed air.

For larger cavity depths the stiffness of the resilient channels becomes relatively more important compared to the stiffness of the enclosed air cavity. Although increased cavity depth can be used to lower the frequency of the modified mass-air-mass resonance, the result is limited by the presence of the stiffness of the resilient channels. Thus at some point increasing the cavity depth will have little additional effect because the total system stiffness will be mostly determined by the stiffness of the resilient channels. There is no evidence that the different designs of resilient channels included in these results varied significantly in stiffness. The need to consider the stiffness of both the air and the resilient channels is similar to the problem of resiliently mounted floating slabs discussed by Ungar.[8]

Figure 11 gives 3 calculation examples using the new model. In all cases the maximum transmission loss improvement has been truncated to 15 dB in accord with the results of Fig. 10. The first example shows the incremental effect on transmission loss of adding resilient channels to a wall with single layers of 13 mm gypsum board on 89 mm (2” by 4”) wood studs (Total cavity depth with resilient channels 102 mm). For this example the transmitted sound level is increased 4 dB in the 80 Hz band and there is almost no change in the 125 Hz band. The other two examples show how the low frequency performance might be improved. For the second example, the wall consists of double layers of 13 mm gypsum board on 140 mm (2” by 6”) wood studs (Total cavity depth with resilient channels 153 mm). For this example the change in the transmission loss in the 80 Hz band is now close to 0 dB and at 125 Hz there is a 4.5 dB improvement in

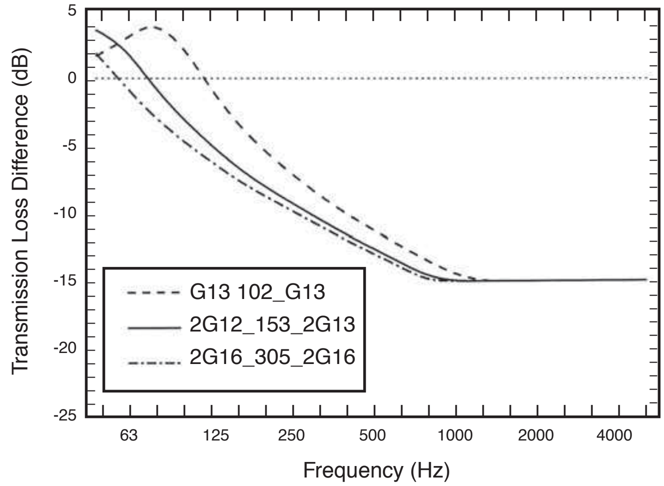

Fig. 11– Calculation examples for 3 different wood stud walls showing the predicted incremental effects of adding resilient channels. (G13_102_G13, 13 mm gypsum board with a 102 mm cavity; 2G13_153_2G13, double layers of 13 mm gypsum board with a 153 mm cavity, and 2G16_305_2G16, double layers of 16 mm gypsum board with a 305 mm cavity).

transmission loss. By going to a wall with double layers of 16 mm gypsum board on 292 mm wood studs (Total cavity depth with resilient channels 305 mm), the transmission loss is improved by more than 3 dB at 80 Hz and just over 6 dB at 125 Hz. Use of the model makes it possible to avoid having the modified mass-air-mass resonance of the wall correspond with prominent frequencies of the sound source but the improvements in this low frequency region are modest.

It has not been possible to examine the effects of some other potentially important parameters because adequate transmission loss data for the same constructions with and without resilient channels were not available. For example, only limited data for walls without sound absorption in the cavity could be found. For cavities without sound absorbing material, the constant factor in Eq. (6) is changed and the modified mass-air-mass resonance will be higher in frequency by a factor of 1.4. This will usually be a disadvantage and hence is another reason for filling the cavity with sound absorbing material. The damping results in Fig. 8 are probably not representative of constructions without sound absorbing material in the cavity.

The influence of the spacing of the resilient channels has not been directly considered. All of the data included in Table 1 were for a 610 mm spacing of the resilient channels. Measurements of the transmission loss of floors with varied resilient channel spacing suggest that, as might be expected, doubling the number of channels per unit surface area simply doubles the stiffness that they contribute.[9] Thus with smaller resilient channel spacing, the effective stiffness of the channels will increase and the resulting modified mass-air-mass resonance will increase in frequency.

The model also does not address the effects at frequencies well above the modified mass-air-mass resonance when resilient channels are added. The results in the difference plots of Figs. 4, 6 and 7 show that in some cases the improvement in transmission loss decreases at the higher frequencies. At frequencies well above the modified mass-air-mass resonance, the improvements in sound transmission loss will be limited by transmission through the cavity and through the resilient channels.[10] The analogy to spring isolators would suggest that, although there is isolation at lower frequencies, at higher frequencies there can be transmission through the steel springs or in this case through the resilient channels.

Sharp's model of sound transmission through building elements[11] gives some insight into the limitations to the improvements to transmission loss in this frequency region. If the gypsum board screwed to resilient channels is considered to be point connections, one can estimate the expected limit to the improvement to transmission loss. Using Eq. 23 of reference 11 for the incremental effect of point connections, leads to maximum transmission loss improvements of between 11 and 17 dB for the 8 constructions listed in Table 1. This is similar to the average of 15 dB for larger cavities indicated in Fig. 10. However, Gu and Wang have suggested that for steel studs further improvements in transmission loss can be obtained.[12]

Measurements of the transmission loss of floors with varied amounts of absorbing material in the cavity suggest, that over a broad range of frequencies, transmission though the cavity is important and that constructions without cavity absorption would be less improved in this region.[9] From the measurements of the transmission loss of floors, it appears that at the highest frequencies transmission through the resilient channels may be more important. On the other hand the current results in Fig. 4 show that the small differences due to the 3 types of resilient channels extend over a wide frequency range above the modified mass-air-mass resonance frequency. Clearly, the effect, at frequencies well above the modified mass-air-mass resonance frequency, of adding resilient channels is complex and will require further study.

5. CONCLUSIONS

We can model the incremental effects of adding resilient channels to a rigid double leaf construction by assuming that the surface layer on the resilient channels behaves like a simple vibration isolator. The system with the resilient channels has a fundamental resonance frequency that is determined by the combined stiffness of the resilient channels and the air space together with the mass of the surface layers. This modified mass-air-mass resonance frequency can be calculated with knowledge of the stiffness of the resilient channels and the surface densities of the surface layers.

The effective stiffness of resilient channels with a 610 mm spacing has been experimentally determined to be equivalent to the stiffness of a 160 mm air cavity. This appears to be valid for various types of resilient channels that create a resilient connection by the flexing of 0.5 mm thick galvanized steel channels.

The effective damping of wall and floor systems that include resilient channels and cavities filled with fibrous sound absorbing material have been shown to vary with cavity depth.

The maximum increase in transmission loss due to the addition of resilient channels is about 15 dB and only occurs for cavity depths greater than about 75 mm where the cavities are filled with sound absorbing material.

Although the new model improves our understanding of the effects of resilient channels and helps us to optimise the benefits of using them, the range of possible improvements are limited. For very small cavities the improvements in transmission loss are limited because the stiffness of the air cavity dominates. Although larger cavities help to lower the modified mass-air-mass resonance frequency this is limited by the stiffness of the resilient channels.

The new understanding of the modified mass-air-mass resonance could be used to extend previous work on the low-frequency sound absorption of gypsum board cavity walls.[13]

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