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Sound transmission through two kinds of porous concrete blocks with attached drywall.

by

A.C.C. Warnock

**National Research Council Canada
Institute for Research in Construction**

ABSTRACT

The airflow resistance of concrete blocks plays a significant role in determining sound transmission losses for block walls with drywall added on furring. Two blocks types were tested. One was so porous that sound passed easily through it and there was no sign of a mass-air-mass resonance behind the added drywall. Such blocks must be plastered else their contribution to the attenuation of sound is very small. Once plastered, the low porosity increased the effective depth of the air cavity behind the added drywall on the unplastered side with attendant increases in sound transmission loss. The mass-air-mass resonance occurred at a lower frequency corresponding to the distance from the drywall through the block to the plaster. The other block type tested had a higher airflow resistance that added a loss mechanism to the wall systems; the mass-air-mass resonance was damped and transmission loss was not reduced by the resonance. The benefits of having drywall added on furring were still obtained with these blocks. Their sound transmission losses were increased when plaster was applied on one face but the increase was not so great as for the very porous blocks. Airflow resistance is an important parameter that should be considered when designing block walls.

RÉSUMÉ

La résistance des blocs en béton au passage de l'air joue un rôle important dans la détermination de la perte de transmission sonore provoquée par les murs en blocs comportant une paroi de plâtre sur tasseaux. Les essais ont porté sur deux types de blocs. Le premier présentait une porosité suffisante pour que l'air passe facilement; par ailleurs, on n'a décelé aucun signe de résonance masse-air-masse derrière la paroi de plâtre. Lorsqu'ils ne sont pas enduits de plâtre, ces blocs contribuent très peu à l'affaiblissement acoustique. Après qu'ils ont été plâtrés, leur faible porosité a fait augmenter l'épaisseur effective de la lame d'air se trouvant derrière la paroi de plâtre, du côté non enduit, ce qui s'est traduit par une plus grande perte de transmission sonore. La résonance masse-air-masse s'est produite à une fréquence plus basse correspondant à la distance entre la paroi de plâtre sur blocs et l'enduit. Le second type de bloc testé présentait une plus grande résistance au passage de l'air, ce qui a introduit un autre mécanisme de dissipation de l'énergie vibratoire, dans les murs; la résonance masse-air-masse a été amortie et n'a pas réduit la perte de transmission sonore. Dans ce cas, la pose d'une paroi de plâtre sur tasseaux est restée bénéfique. La perte de transmission sonore a augmenté par suite de l'application d'un enduit sur une face, mais pas autant que

dans le cas des blocs très poreux. La résistance au passage de l'air est un paramètre important à prendre en compte lors de la conception des murs en blocs de béton

INTRODUCTION

A previous paper¹ presented sound transmission loss data for normal weight concrete blocks with drywall attached to the block surface in different ways. The depth of the air cavity behind the drywall and the presence of sound-absorbing material in the cavity were shown to be important. Reductions in transmission loss at low frequencies were obvious and were attributed to a resonance involving the drywall, the air in the cavity and the blocks: the mass-air-mass resonance. The position of the resonance was not always clear, however, and to deal with this, the idea of a crossover frequency, f_x , was introduced. (This is the frequency where the transmission loss curve for the blocks with added drywall crosses over and rises above the curve for the bare blocks.) Below f_x , transmission loss is reduced relative to the bare block result; above f_x , sound transmission loss is increased relative to the bare block result. For normal weight block walls, f_x is given by

$$f_x = K/(M d)^{1/2} \quad (1)$$

where M is the surface mass of the drywall, kg/m², and d is the depth of the cavity behind it, meters. K is 108 for an empty cavity and 60 for a cavity filled with fibrous sound-absorbing material.

In the Tenth Sir Richard Fairey Memorial Lecture, Heckl² presented results from reference³ to show that there can be an advantage to using porous stone or block as part of a double wall. The effective cavity depth behind the surface layer, usually drywall or something similar, is increased because of the porosity and the mass-air-mass resonance moves to a lower frequency. Not discussed in Ref. 2 was the idea that the airflow resistance of the porous wall material might also increase energy dissipation in the wall cavity and reduce the depth of the mass-air-mass resonance. Increasing airflow resistance will offset, however, the increase in effective cavity depth resulting from porosity. This suggests there may be an optimum value of airflow resistance for block walls when they are used as the core layer in a system incorporating drywall.

Watters⁴ presented data for single-wythe block walls and discussed the importance of the block porosity. For the blocks he looked at, he concluded that many lightweight-aggregate concrete blocks would not require sealing to ensure that there was no significant sound transmission due to porosity. The airflow resistance was high enough that sound propagating through the pores of the block would be greatly attenuated and would be negligible compared to sound propagating as vibration in the concrete. Sabine⁵ presented data for several painted and unpainted block walls. He found that unpainted walls with an airflow resistance of about 6 acoustic ohms or less suffered a reduction in transmission loss because of sound transmission through the pores of the block. The transmission losses increased when such blocks were painted. Williamson and Mackenzie⁶ found similar results for walls constructed from 4-inch concrete blocks with a wide range in flow resistance.

Mackenzie et al.⁷ reported transmission loss data for block walls that had plasterboard attached on furring strips and were given a coat of cement to seal the

surface. The data showed the detrimental effects of the mass-air-mass resonance and that the cement coat under the drywall made this worse. The block porosity reduced the negative effects of the mass-air-mass resonance. The authors concluded that, for the blocks they used, plasterboard alone was sufficient to seal the surface of the blockwork. The data presented below show that this conclusion cannot be extended to all types of block.

It might be possible to produce simple mathematical models that will predict some of the effects described in the references above and those to be presented here. This paper does not do this. It merely presents sound transmission loss data for two types of concrete block: very porous blocks manufactured using a wood fiber aggregate, and lightweight blocks manufactured using slag aggregate. While the data do not allow the specification of an optimum value of airflow resistance for blocks, they do illustrate some effects block porosity or block airflow resistance have on sound transmission loss for block walls.

I. MATERIALS

A. Block properties

Two types of blocks were used in these measurements. One was a solid, 9 cm thick block manufactured using a coarse wood fiber aggregate (WFA). These blocks are significantly lighter than conventional blocks and are quite porous. The second type was a hollow core (50% solid), 19 cm thick, lightweight (LW) block. Table 1 gives some physical data including airflow resistance. Because they are referred to later, data for the normal weight (NW) blocks from reference 1 are included in the table. Airflow resistance was measured in accordance with ASTM C522⁸. For the hollow blocks, the material resistivity was calculated from the airflow resistance value taking account of flow through the block faces and webs.

Table 1: Physical data for the concrete blocks used in the measurements. The wall weight is for a bare wall with no attachments. The normal weight (NW) blocks are those used in Ref. 1.

Thickness (mm)	Weight per block (kg)	Wall weight (kg/m ²)	Airflow resistance (mks ohms)	Airflow resistivity (mks rays/m)
90 WFA	7.1	98	1.9×10^4	1.4×10^4
190 LW	13.4	183	1.2×10^5	1.3×10^5
190 NW	17.5	236	1.8×10^6	1.7×10^6

The wood fiber aggregate blocks were laid in a running bond pattern. The lightweight blocks were laid in a stack bond pattern. On every second course, wire trusses were embedded in the mortar to give horizontal reinforcement.

B. Methods of attaching drywall

13 mm drywall was attached to the blocks in different ways. It was screwed on directly, or supported on 13 mm resilient metal channels, 40 mm steel studs or 65 mm steel studs. The stud systems had top and bottom tracks and were not in contact with the blocks. This resulted in airspaces being about 5 - 10 mm larger than the stud depth. Channels and studs were formed from 0.5 mm thick galvanized sheet metal and were installed 600 mm apart. Figure 1 shows cross-sections and dimensions of the channels and the studs. For measurements with the wood fiber aggregate blocks, the drywall weighed 8.8 kg/m². For the lightweight block series, it weighed 7.1 kg/m².

Figure 1: Cross-sections of the furring and studs used to support drywall. (a) 13 mm resilient metal channels, (b) 40 mm steel studs, (c) 65 mm steel studs.

C. Sound-absorbing materials

The sound-absorbing materials used in the wall systems are described in Table 2. The airflow resistivity of these sound-absorbing materials was not measured but representative values are included in the table.

Table 2: Sound absorbing material used in cavities. CGC - Canadian Gypsum Corporation; FC - Fiberglas Canada.			
Type	Thickness (mm)	Surface Weight (kg/m ²)	Airflow resistivity (mks rayls/m)
unfaced duct wrap	25	0.3	5000
CGC Thermafiber	38	2.3	20000
FC R8	65	0.8	5000

II. DESCRIPTION OF MEASUREMENT FACILITIES AND PROCEDURES

Measurements were made in the sound transmission loss suite at the National Research Council Canada in accordance with ASTM E90⁹. For wall transmission loss measurements, the source room has a volume of 65 m³ and the receiving room has a volume of 250 m³. Wall specimens measure 2.44 x 3.05 m and are

constructed on a steel, wheeled frame lined with wood. The frame fits between the rooms and is isolated from both. Each room has fixed and rotating diffusers and four corner-mounted loudspeaker systems fed with independent, pseudo-random noise sources. To measure transmission loss, white noise is fed to the loudspeakers in the source room. Pink noise is used to measure decays in the receiving room. Electret condenser microphones sample the sound fields at nine positions in the central volume of each room. Measurements are controlled by a computer system interfaced to a Norwegian Electronics 830 real time analyzer and cover the one-third octave band frequencies from 63 to 6300 hertz.

III. RESULTS FOR WOOD FIBER AGGREGATE BLOCKS

The bare wood fiber aggregate (WFA) block result in Fig. 2 makes it clear that sound passes easily through the porous block; the sound transmission loss is much less than expected for a wall of this weight.

Figure 2: Result for bare wood fiber aggregate (WFA) blocks, for WFA blocks with a single layer of 13 mm drywall screwed directly to them, and for plastered WFA blocks. A result for a single layer of drywall mounted on 13 mm resilient metal channels on 90 mm wood studs is included for comparison.

Figure 2 also shows that a sheet of 13 mm drywall screwed to one face of the block may provide an effective air seal, but the sound transmission class for the system is the same as that for the drywall on its own. To illustrate this, Fig. 2 includes a result for a single layer of drywall mounted on 13 mm resilient metal channels attached to 90 mm wood studs. With the drywall screwed directly to the block, the block weight begins to contribute to the sound transmission loss at frequencies below about 160 Hz, where transmission loss values increase. Above about 800 Hz, sound transmission loss increases relative to the result for the drywall, probably because of the block porosity. These data show that the drywall

is free to vibrate fairly independently and behaves, for the most part, as though the blocks were not there.

To improve the result for the bare block, one face must be sealed with plaster or a similar material. Figure 2 shows the transmission loss that resulted when one surface of the block wall was sealed using a layer of plaster about 2 mm thick; there was no added drywall in this case. The full benefit of the block weight is obtained and an STC of 43 results. The plaster added a mass of about 3.5 kg/m² to the weight of the wood fiber aggregate block wall.

A. 13 mm Drywall on 40 mm steel studs

Figure 3 shows the result for the case where a layer of 13 mm drywall was screwed directly to one face of the blocks and on the second face a second layer was mounted on 40 mm steel studs. Data are given for the cavity empty and filled with sound-absorbing material. The STC rating is about the same as for two layers of drywall with a 140 mm-deep cavity between them. The addition of sound-absorbing material in the cavity increased sound transmission loss values at all frequencies but the block mass still contributes very little to the wall sound transmission loss.

Figure 3: Wood fiber aggregate (WFA) blocks with 13 mm drywall screwed directly to one face. On the second face, 13 mm drywall is mounted on 40 mm steel studs. Data are for two cases: with and without mineral fiber batts in the 40 mm cavity.

B. Plastered wood fiber aggregate blocks with added drywall

Once the wood fiber aggregate blocks were plastered, adding drywall on steel studs gave much better STC ratings than those obtained for the same materials applied to the unplastered block. Figure 5 shows the results for 13 mm drywall supported on 40 mm studs first on the unplastered side and then on the plastered side of the wall. The two curves and the STC ratings are different. The plaster defines the boundary of the cavity, so for drywall on the plastered side, the cavity depth is about 45 mm, the distance from the rear face of the drywall to the plaster. For drywall on the unplastered face, the porosity of the block increases the

effective cavity depth to about 135 mm, the distance from the rear face of the drywall, through the porous block to the plaster. The deeper air-cavity gives a lower crossover frequency and improvements in transmission loss relative to the bare block begin at lower frequency.

Figure 4: Effects of adding 13 mm drywall on 40 mm studs to the plastered face and to the unplastered face of the wood fiber aggregate (WFA) block wall. The result for the bare, plastered blocks is included for reference.

The dip around 450 Hz in the dotted curve was influenced by the softness of the added plaster layer. The result shown was measured after the plaster had cured. When the plaster was fresh, the transmission loss values at the dip were about 4 dB higher. It is not obvious what physical mechanism this resonance is associated with.

Reference 1 gave transmission losses for a system similar to that for the dotted curve shown in Figure 5 but using 190 mm normal-weight concrete blocks described in Table 1. Figure 6 compares the results, and it can be seen that the heavier wall gave a slightly lower STC rating and lower transmission loss values at low frequencies. Because of the larger effective air-gap, the mass-air-mass resonance occurs at a lower frequency for the wood fiber aggregate block wall and it gives better sound insulation at low frequencies than does the heavier wall.

Figure 5: Results for the 90 mm wood fiber aggregate (WFA) blocks with 13 mm drywall on 40 mm steel studs on the unplastered face only and on both faces. A 190 mm normal weight (NW) system from Ref. 1 is shown for comparison. The NW system has 16 mm drywall attached on one side with 25 ga. steel Z-bars that support the drywall 50 mm from the block surface.

Figure 5 also shows results for the wall with 13 mm drywall mounted on 40 mm steel studs on both faces of the plastered wood fiber aggregate blocks. This system had an STC one point higher than the wall with the drywall on the plastered side only. There is, however, a general decrease in transmission loss at frequencies below about 250 Hz. This is due to the mass-air-mass resonance associated with the smaller cavity on the plastered side of the block. Adding sound-absorbing material to the cavity on the plastered side of the wood fiber aggregate blocks would improve the sound insulation. Just how much is estimated later.

IV. RESULTS FOR LIGHTWEIGHT CONCRETE BLOCKS

A. Unplastered

1. 13 mm Drywall on resilient metal channels and 40 mm steel studs

Figure 6: Transmission loss data for lightweight (LW) 190 mm blocks with 13 mm drywall mounted on both sides on 13 mm resilient metal channels and 40 mm steel studs.

Each side of the unplastered lightweight (LW) block wall was finished with 13 mm drywall mounted on resilient metal channels or 40 mm steel studs. The cavities were empty or had sound-absorbing material in them. Figure 6 shows measured transmission losses; the result for the bare block is included for comparison. The results resemble those in Ref. 1 more than those for the wood fiber aggregate blocks do. There are significant increases in transmission loss due to the cavity behind the added drywall. As the cavity depth increases or as sound-absorbing material is added, the improvements in transmission loss begin at lower frequencies. There is, however, no sign of any significant decrease in transmission loss that can be associated with a mass-air-mass resonance, nor any clear crossover frequency. One explanation for this is that the block airflow resistance or porosity provides a loss mechanism that reduces the depth of the mass-air-mass resonance. This mechanism, whatever it is, does not change the position of the mass-air-mass resonance. This contrasts with the action of the added glass and mineral fiber which cause the mass-air-mass resonance to move but do not influence the depth of the resonance.

B. Plastered lightweight blocks

1. Effect of plaster on bare blocks

Figure 7: Effect of plastering one face of lightweight blocks.

Plastering one face of the 190 mm lightweight blocks produced the change in transmission loss shown in Fig. 7. Improvement is most marked at low frequencies and decreases as frequency increases. The dip in the transmission loss curve seen in the bare block result at 1.6 kHz disappeared after plastering. No explanation for this dip has been found. A sound leak or other construction flaw was suspected, but none could be discovered.

2. Plastered blocks - 13 mm Drywall on steel studs

Figure 8: Effect of adding 13 mm drywall on 40 mm steel studs to each side of lightweight plastered blocks.

Figure 8 shows transmission loss results for drywall attached on 40 mm steel studs on the plastered side of the block wall and on the unplastered side. In the latter case, the detrimental effects of the mass-air-mass resonance are gone, presumably because of the losses associated with block porosity. Similar effects were seen for 65 mm steel studs. Adding sound-absorbing material in the cavity on each side gave similar results except that the crossover frequency moved to a lower frequency; the mass-air-mass resonance was still present when drywall was added to the plastered face and not evident when it was added to the unplastered face.

V. DISCUSSION

A. Effect of plaster on bare blocks

It is common experience that the more porous the block, the more important it is to seal one face with paint or plaster when no other finish is to be added. References 5 and 6 showed relationships between airflow resistance and transmission loss. R.K. Mackenzie kindly supplied the data from the work in reference 5 and the results were converted to STC and airflow resistivity, in mks rayl/m. The data in reference 6 were also converted to the same units. The data include results for 9, 14, and 19 cm blocks both dense and lightweight. The different block weights would give different STC ratings even if all were correctly sealed. To compensate for the differences in weight, it was assumed that STC would increase approximately as $20 \log M$, where M is the surface mass of the block wall in kg/m^2 . Thus, a normalized STC, STC_n , was calculated from STC_n

$= \text{STC}_m - 20 \log (M/100)$. Both sets of published data together with the three values from the present work are plotted in Figure 9 in this form.

Figure 9: Relationship between normalized STC and airflow resistivity for unsealed concrete blocks. The solid line is a linear fit to the data below 5×10^5 rayl/m.

The agreement from research work spanning a thirty year period is satisfying. This figure can be used to estimate what change in STC will occur when blocks are sealed.

B. Delta TI curves

In Ref. 1, the effects of adding drywall to normal weight block walls were most clearly seen by looking at transmission loss differences relative to the single-weight block case. The difference spectrum is called the ΔTL curve. This approach is adopted again in what follows.

Figure 10: ΔTL curves for 13 mm resilient metal channels. The solid curve is from the present work and applies to the unplastered lightweight (LW) blocks and 13 mm drywall. The dotted curve is from Ref. 1 and applies to normal weight (NW) blocks and 16 mm drywall.

Figure 10 shows the ΔTL curve for 13 mm drywall on 13 mm resilient metal channels attached to the lightweight blocks. For comparison, the ΔTL curve for 16 mm drywall on resilient metal channels from reference (1) is included. The absence of a mass-air-mass resonance with the lightweight blocks is clear. For the normal weight blocks in reference (1), adding drywall on resilient channels on both sides caused a drop in STC from 50 to 49. For these lightweight blocks, the same construction increased the STC rating from 42 to 47. So, the overall performance of the lightweight blocks is, in this case, about as good as the normal-weight blocks.

Figure 11: DTL curves for wood fiber aggregate (WFA), lightweight (LW), and normal weight (NW) blocks. The LW and WFA blocks were plastered; the curves apply to 40 mm studs and 13 mm drywall attached on the plastered side. The NW blocks were not plastered; the curve applies to 50 mm Z-bars and 16 mm drywall.

The effect of block porosity is perhaps clearer in Figures 11 and 12. Figure 11 shows ΔTL for 13 mm drywall supported on 40 mm steel studs for the three types of block. The lightweight and the wood fiber aggregate blocks were plastered and the studs and drywall were attached on the plastered side. Although the steel studs were 40 mm deep, the drywall was actually supported at a distance of about 45 mm from the block surface because of small gaps between the studs and the blocks. The ΔTL curve for 50 mm Z-bars from reference (1) is included for comparison. The three curves show similar behavior and clear mass-air-mass resonances around 125 Hz.

Figure 12: *DTL curves for 40 mm steel studs and 13 mm drywall on lightweight (LW) and wood fiber aggregate blocks (WFA). The WFA curve and one of the LW curves apply to plastered blocks with the drywall applied on the unplastered side. The second LW curve applies to unplastered blocks.*

Figure 12 is only for the lightweight and wood fiber aggregate blocks. In this case, the 40 mm steel studs were on the unplastered side of the blocks. The ΔTL curve for the wood fiber aggregate blocks clearly shows the benefits of the increase in effective air cavity but there is still a mass-air-mass resonance around 80 Hz. The unplastered lightweight blocks do not show any strong mass-air-mass resonance. Nor do the plastered lightweight blocks, but the added plaster on the second face strongly influences the shape of the ΔTL curve. Since no explanation of the physical processes involved has been given, the reasons for the differences are not explained. Similar effects were seen for 65 mm steel studs. The lightweight block porosity seems to add a loss mechanism that almost eliminates negative ΔTL at the low frequencies but there is still an increase in transmission loss at higher frequencies above where the crossover frequency could be expected.

Table 5 lists the ΔTL values for each combination tested. In all cases where a cross-over frequency is evident, it moves to lower frequencies as the air gap is larger.

Figure 13: Sound transmission for the two block types used in this study and that in Ref. 1. The result for the wood fiber aggregate (WFA) blocks is a calculated result for 13 mm drywall on 40 mm steel studs on each side of the plastered blocks. The cavity on the plastered side is filled with sound-absorbing material. The result for the lightweight (LW) block is for the same system but is a measured result. The result for the 190 mm normal weight (NW) blocks from Ref. 1 is for 16 mm drywall on 50 mm Z-bars on each side of the block. The cavity is filled on one side with sound-absorbing material.

Above it was stated that the sound transmission losses for the wood fiber aggregate wall finished on both sides with drywall on 40 mm steel studs could be improved if sound-absorbing material were added to the cavity on the plastered side. The ΔTL values for 40 mm steel studs and sound-absorbing material applied over plaster in Table 5 were used to estimate the result for the construction. The prediction is compared in Figure 13 with that for measured data for similar systems using the lightweight blocks in this paper (wall number 92 in Table 4) and the normal weight blocks from Ref. 1. The normal weight block system used 50 mm Z-bars and 16 mm drywall. The predicted transmission loss values are most uncertain at frequencies above about 500 Hz but, in this case, these values have no effect on the STC rating which is 63.

Figure 14: Measured versus calculated crossover frequency for the wood fiber aggregate (WFA) and lightweight (LW) block wall systems. The solid line is the locus where both are equal.

To compare the position of the measured crossover frequency with that calculated from Eq. 1, one has to know the cavity depth and the influence of sound-absorbing materials. For some value of block airflow resistance, because air penetrates the block surface, the effective depth of the cavity behind the drywall is increased somewhat. These measurements, however, showed that there was no such increase. The cavity depth was assigned as follows: for the lightweight blocks-- the distance from the rear of the drywall to the surface of the blocks (plastered or unplastered); for the wood fiber aggregate blocks-- the distance from the rear of the drywall to the surface of the plaster, including the block thickness if necessary. The measurements also showed that the block porosity did not move the mass-air-mass resonance to a lower frequency in the same way that the addition of glass or mineral fiber does. Thus, no allowance was made for block porosity when using Eq. 1.

In some cases, the ΔTL curve approaches zero gradually and the position of the crossover frequency is somewhat uncertain. In such cases, its position was estimated by extending the ΔTL curve back to zero from the steeply rising part. For example, the solid line in Fig. 12 has an estimated crossover frequency about 250 Hz while the dashed line has a crossover frequency at 200 Hz. The positive ΔTL values below these frequencies were considered to be random fluctuations associated with the uncertainties in the testing process.

Calculated and measured values of crossover frequency are shown in Fig. 14. With the exception of three or four points, the agreement is good.

VI. CONCLUSIONS

The wood fiber aggregate blocks are too porous to provide good sound transmission loss without being correctly sealed. The data show that sealing blocks correctly requires the use of plaster or some other material that adheres completely to the block. Sheet materials attached at points by screws or the like will not be adequate. This result has implications for other situations. For example, if a normal weight block wall is poorly constructed with sound leaks due to faulty mortar, applying drywall to one face with screws or on furring strips will not bring the sound transmission losses up to the values for a properly sealed block. Filling cavities with sound-absorbing material might help to reduce the detrimental effects of a poorly constructed block wall, but sealing the blocks properly is a more certain procedure.

The porosity of the wood fiber aggregate blocks increases the effective cavity depth if the blocks are plastered, but there are still marked negative ΔTL values associated with the mass-air-mass resonance. There is thus no significant absorption added to the cavity by the blocks.

The porosity of the wood fiber aggregate blocks can be turned to advantage if they are completely sealed on one face, either during manufacture or on-site. Then, despite their comparatively low weight, correct design procedures allow the construction of block wall systems that provide high STC ratings.

Sound transmission loss for the lightweight block walls is improved when one face is sealed with plaster. Some loss mechanism associated with the porosity makes the depth of the mass-air-mass resonance negligible while the improved transmission loss above the crossover frequency is still obtained. The loss mechanism does not, however, seem to change the location of the mass-air-mass resonance. Walls constructed with these blocks can give transmission loss values about as good as those for heavier walls.

The work presented here and that in Reference 1 covers a large range in airflow resistance. At one extreme, the block was extremely porous and presented little impediment to the passage of sound. At the other, the blocks had such high airflow resistance that sealing caused no change in transmission loss. Despite this range and the differences in surface mass, it is evident from Fig. 13 that high sound transmission losses can be obtained with very lightweight blocks.

There are many variables to be considered when designing block walls, and it would be preferable to have a better understanding of the processes that take place in the sound-absorbing material and in the porous blocks. It is possible that there is some block airflow resistance that would allow construction of a wall giving maximum transmission loss for a given cavity airspace and with a minimum degree of complexity in the construction. It will, however, require more research to determine if this is so and what is practical. One thing is certain: having airflow resistance data easily available when blocks are to be used would make it easier to decide how to finish them.

Table 3: Sound transmission losses for 90 mm wood fiber aggregate blocks with different surface finishes. The codes used in columns Side 1 and Side 2 have the following meaning: G13 - 13 mm drywall; RC13 - 13 mm resilient metal channels; SS40 - 40 mm steel studs; SS65 - 65 mm steel studs; GFB - glass or mineral fiber batts; PLA - plaster (the number following gives the thickness in mm).

Wall #	Side 1	Side 2	STC	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300
041	Bare	Bare	14	10	8	7	8	6	7	9	10	10	10	11	11	13	15	16	17	19	21	24	28	32
042	G13	Bare	29	23	19	17	16	15	16	19	20	21	23	27	30	32	35	38	40	40	39	43	50	56
043	G13	SS40_GFB38_G13	47	24	20	22	24	28	31	36	40	43	48	53	59	63	67	69	68	66	64	67	70	72
044	G13	SS40_G13	43	21	17	18	22	24	27	32	35	38	42	46	51	55	60	63	64	58	56	63	68	70
045	Bare	SS40_G13	31	13	11	12	14	13	15	18	22	26	30	33	36	39	43	46	47	45	44	50	54	62
046	G13_SS40	SS40_G13	43	10	10	12	20	22	28	32	35	39	44	48	54	57	63	66	66	61	59	66	71	72
049	PLA2	SS40_G13	54	28	28	32	37	40	45	47	48	46	46	48	53	57	60	63	64	63	62	65	69	71
050	G13_SS40_PLA2	SS40_G13	55	22	22	24	31	36	44	47	48	50	53	57	65	69	72	73	71	69	66	69	74	78
051	G13_SS40_PLA2	Bare	47	31	28	26	28	27	32	37	39	42	45	48	55	59	63	64	64	64	63	65	68	71
052	PLA2	Bare	43	34	33	31	34	33	34	36	38	38	37	38	41	43	46	47	48	51	53	55	57	58

Table 4: Sound transmission losses for 190 mm lightweight blocks with different surface finishes. The codes used in columns Side 1 and Side 2 have the following meaning: G13 - 13 mm drywall; RC13 - 13 mm resilient metal channels; SS40 - 40 mm steel studs; SS65 - 65 mm steel studs; GFB - glass or mineral fiber batts; PLA - plaster (the number following gives the thickness in mm).

Wall			STC	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300
#	Side 1	Side 2																						
073	bare	bare	42	23	23	22	26	26	31	31	34	37	39	41	43	46	47	45	52	54	57	59	62	63
074	G13	bare	46	26	25	24	29	30	35	36	38	39	41	45	49	53	55	56	60	58	58	59	63	65
075	G13	RC13_G13	49	28	26	25	31	33	37	37	40	42	45	50	55	59	64	68	68	65	63	64	67	70
076	bare	RC13_G13	45	22	21	21	27	28	32	32	36	38	41	46	52	57	61	63	65	63	62	62	66	68
078	G13_RC13	RC13_G13	47	22	22	22	28	31	34	34	37	40	44	51	58	61	67	71	70	68	67	67	70	73
079	G13_RC13_GFB13	RC13_G13	51	22	22	23	27	30	34	38	45	51	56	60	59	61	67	71	70	68	67	68	71	72
080	G13_RC13_GFB13	RC13_GFB13_G13	49	20	21	20	26	28	35	42	54	61	62	61	59	61	66	71	70	69	68	69	72	74
081	G13_RC13_GFB13	bare	48	21	21	21	26	27	33	37	43	49	52	55	57	60	64	66	65	63	62	63	67	70
082	G13_SS40	bare	46	20	21	21	26	27	31	33	37	41	46	51	57	61	66	68	69	66	65	68	72	73
083	G13_SS40	SS40_G13	47	20	21	20	25	28	32	34	37	43	50	57	66	71	73	78	78	74	70	72	76	73
084	G13_SS40	SS40_GFB38_G13	53	20	21	22	29	35	42	47	55	64	70	73	73	73	74	79	79	75	72	73	77	76
086	G13_GFB38_SS40	SS40_GFB38_G13	56	20	21	24	32	41	50	57	67	75	75	77	74	73	75	79	79	76	72	72	76	75
087	bare	SS40_GFB38_G13	52	20	21	21	28	34	41	45	52	58	61	64	65	66	68	70	71	69	67	68	71	72
089	PLA3	SS40_GFB38_G13	63	34	36	32	39	42	47	51	57	61	63	65	65	66	68	70	70	68	66	67	70	72
090	PLA3	SS40_G13	57	34	35	30	37	36	40	43	49	56	60	63	64	64	67	69	70	68	65	67	70	72
091	G13_SS40_PLA3	SS40_G13	53	29	28	24	30	32	37	43	49	61	70	73	74	73	74	78	78	75	71	72	76	79
092	G13_GFB38_SS40_PLA3	SS40_G13	61	27	29	29	37	40	46	54	65	73	76	77	74	73	74	79	79	76	72	73	77	79
093	G13_GFB38_SS40_PLA3	SS40_GFB38_G13	64	28	29	29	40	46	54	62	72	77	78	78	75	74	75	80	81	78	74	75	77	79
103	G13_GFB38_SS40_PLA3	bare	62	29	30	29	38	43	47	51	58	61	62	62	61	64	70	72	72	69	67	69	73	76
104	G13_SS40_PLA3	bare	53	30	29	24	29	32	37	41	47	55	59	61	61	63	68	70	70	67	66	68	73	75
105	G13_SS65_PLA3	bare	56	27	29	26	33	35	40	44	51	57	60	63	65	68	70	73	73	70	70	73	78	80
106	G13_GFB65_SS65_PLA3	bare	65	29	33	34	41	45	49	53	60	63	65	66	67	69	72	74	75	73	71	74	79	83
107	G13_GFB65_SS65_PLA3	SS65_GFB65_G13	69	30	35	36	45	51	58	64	76	80	84	84	84	82	82	85	86	83	76	79	86	84
108	G13_GFB65_SS65_PLA3	SS65_G13	64	29	33	34	40	46	51	58	68	77	79	82	82	81	81	84	85	81	74	77	85	85
110	G13_SS65_PLA3	SS65_G13	55	23	26	24	31	35	42	46	53	66	74	78	82	81	81	83	84	80	74	77	86	84
111	PLA3	SS65_G13	58	36	35	31	36	37	41	45	50	57	61	64	66	68	69	71	72	70	68	70	75	78
112	PLA3	SS65_GFB65_G13	64	37	36	33	40	44	49	53	60	63	66	69	69	70	71	72	74	74	71	72	77	79
113	PLA3	bare	49	36	34	31	36	38	39	39	42	43	44	47	48	50	51	53	55	54	57	58	61	62

Table 5: Δ TL for lightweight and wood fiber aggregate blocks. 13 mm drywall was used in each case.

Method of Attachment	Frequency, Hz																				
	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300
190 mm Lightweight blocks unplastered																					
Direct	3.1	1.8	2.5	3.1	4.0	4.5	4.8	4.0	2.7	2.2	3.5	5.5	7.4	7.8	11.2	7.4	4.7	1.6	0.0	0.3	1.5
RC13	-0.5	-0.7	0.1	0.9	1.9	1.4	1.2	1.4	1.9	3.2	4.9	5.8	6.8	9.2	12.2	8.7	7.1	4.9	3.9	3.9	4.0
GFB13_RC13	-0.8	-0.9	0.2	0.0	1.3	2.1	5.3	9.2	12.7	13.5	12.7	9.4	8.5	10.6	14.1	9.1	7.2	5.4	4.9	5.2	5.7
SS40	-1.6	-1.0	-0.3	0.2	1.1	0.9	1.6	2.3	4.6	7.5	8.9	11.1	11.7	12.8	16.0	12.5	9.7	6.7	6.9	7.6	6.6
SS40_GFB40	-1.2	-1.1	0.4	2.8	7.6	10.1	13.5	17.7	20.9	21.6	20.7	17.4	15.1	14.0	17.6	13.8	11.9	8.2	6.7	6.8	5.8
190mm lightweight blocks, plastered on one side. Attachment on the bare block side																					
SS40	-1.6	-0.2	-0.1	0.0	-1.5	-0.3	3.4	4.9	10.5	13.7	14.7	13.5	11.3	8.8	10.3	10.2	9.8	6.0	5.5	5.4	5.7
SS40_GFB40	-1.3	0.3	0.3	2.3	3.8	7.1	11.9	14.5	16.9	17.6	17.2	15.3	13.2	11.0	12.3	12.1	11.5	7.7	7.0	6.8	6.7
SS65	-1.3	-0.8	-0.7	-1.0	0.0	1.6	4.1	6.2	12.3	15.2	16.1	16.8	14.5	12.8	12.4	12.3	11.3	6.4	6.5	9.3	7.4
SS65_GFB65	1.1	1.7	2.3	4.2	6.4	9.3	12.7	17.1	19.0	20.5	19.7	18.8	16.2	14.8	15.0	15.0	14.8	9.6	9.3	11.2	9.2
190mm lightweight blocks, plastered on one side. Attachment on the plastered block side																					
SS40	-5.8	-6.4	-6.8	-6.9	-4.8	-2.6	0.7	3.0	8.8	12.5	12.1	11.7	11.2	12.0	12.2	11.4	10.0	7.1	7.9	9.0	9.9
SS40_GFB40	-6.9	-5.6	-1.8	1.3	4.7	7.1	11.6	15.7	17.3	16.3	14.2	11.4	10.3	11.1	12.7	12.4	11.4	8.4	8.3	8.6	9.3
SS65	-10.6	-7.1	-5.9	-3.9	-2.6	0.7	3.5	5.7	11.4	14.4	14.7	16.0	15.6	15.6	15.9	15.1	13.2	9.4	10.7	13.5	12.2
SS65_GFB65	-6.9	-1.7	3.0	4.3	7.7	9.4	13.2	17.3	19.1	19.0	17.6	16.5	14.9	14.6	15.8	15.3	13.3	8.8	10.0	12.7	10.9
Plastered 90 mm wood fiber aggregate blocks																					
Attachment on the bare block side																					
SS40	-5.6	-5.5	0.8	3.2	7.3	10.4	11.0	10.2	8.0	8.8	10.6	12.1	13.5	14.0	16.6	15.6	12.2	8.5	9.8	12.0	13.8
Attachment on the plastered block side																					
SS40	-3.3	-4.7	-4.9	-5.9	-5.5	-2.2	0.5	0.8	3.9	7.9	10.5	13.8	15.3	16.8	16.7	15.7	12.9	10.0	9.9	10.9	13.8

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⁸ ASTM C522, Standard Test Method for Airflow Resistance of Acoustical Materials.

⁹ ASTM E90, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions.