NRC · CNRC

Construction Technology Update No. 13

Controlling Sound Transmission through Concrete Block Walls

by A.C.C. Warnock

This Update discusses the various factors that affect sound transmission through different types of concrete block walls, including single-leaf walls, double-leaf walls and walls with gypsum board attached. Knowledge of these factors will assist construction practitioners to design and build walls with high levels of acoustic performance economically.

Concrete block walls are commonly used to separate dwelling units from each other and to enclose mechanical equipment rooms in both residential and office buildings because of their inherent mass and stiffness. The bending stiffness of the material making up the wall is also important. Neither of these fundamental properties (mass and stiffness) can be altered by users.

> **Some Basic Concepts — Transmission Loss (TL) and Sound Transmission Class (STC)**
>
> For significant noise reduction between two rooms, the wall (or floor) separating them must transmit only a small fraction of the sound energy that strikes it. The ratio of the sound energy striking the wall to the transmitted sound energy, expressed in decibels (dB), is called the transmission loss (TL). The less sound energy transmitted, the higher the transmission loss. In other words, the greater the TL, the better the wall is at reducing noise.
>
> Sound transmission class (STC) is a single-number rating that summarizes transmission loss data. It is obtained by fitting a standard reference contour to the data (see Figures 2 and 3).

However, there are additional factors that need to be considered in building high-quality walls.

Single-Leaf Concrete Block Walls

Mass per Unit Area

For single-leaf walls, the most important determinant of sound transmission class (STC) is the mass per unit area: the higher it is, the better. A single-leaf concrete block wall is heavy enough to provide STC ratings of about 45 to 55 when the block surface is sealed with paint or plaster.

Figure 1 shows measured STC ratings for single-leaf concrete block walls from a number of published sources. The considerable scatter demonstrates that, while important, block weight is not the only factor that determines the STC for this type of wall. In the absence of measured data, the regression line in Figure 1 can be used to estimate the STC from the block weight. Alternatively, Table 1 provides representative STC values for 50% solid blocks that have been sealed on at least one side. It shows the relatively modest effects of significant increases in wall thickness on STC.

Adding materials such as sand or grout to the cores of the blocks simply increases the weight; the increase in STC can be

construction

Published by

Institute for Research in Construction

IRC

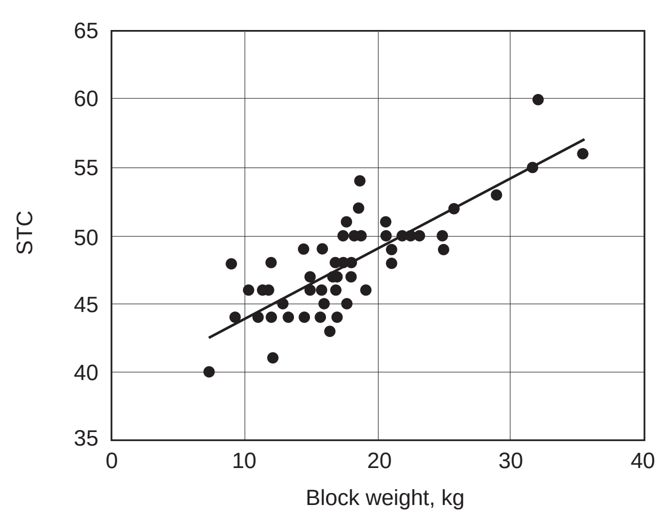

Figure 1. Effect of block weight on STC for single-layer concrete block walls

estimated from Figure 1. Adding sound-absorbing materials to the cores is not effective because the sound bypasses the insulation, taking the more direct path through the block.

Figure 1 also shows that using heavier block to get an STC rating of much more than 50 leads to impractically heavy constructions. High STC ratings are more easily obtained by adding layers of gypsum board mounted on studs or resilient (flexible) furring that do not have a solid connection to the concrete block.

Table 1. STC ratings for 50% solid normal-weight and lightweight block walls sealed on at least one side

Wall Thickness, mm	Lightweight block	Normal weight block
	STC	STC
90	43	44
140	44	46
190	46	48
240	47	49
290	49	51

Effect of Porosity

When the concrete block is porous, sealing the surface with plaster or block sealer significantly improves the sound insulation; the more porous the block, the greater the improvement. Improvements of 5 to 10 STC points, or even more, are not uncommon for some lightweight block walls after sealing. Conversely, normal-weight blocks usually show little or no improvement after sealing. This improvement in STC in lightweight blocks is related to the increased airflow resistivity of these blocks. The leakage of sound through the material of the block is different only in degree from leakage of sound through inadequate mortar joints. To ensure good sound insulation, mortar joints must always be properly finished — that is, free from obvious penetrations.

Gypsum board attached directly to blocks by means of glue or screws does not seal the surface as well as plaster or paint since the gypsum board does not bond completely to the blocks and behaves as a separate layer. Sound radiated from the gypsum board continues to leak through the blocks. Table 2 provides examples of two very different types of block and their relative STC ratings. In each case, the plaster allows the sound insulation of the wall to reach its full potential; the gypsum board does not. The effect of the plaster on the very porous (wood-aggregate) blocks, which have been included for purposes of comparison, is particularly dramatic. Block sealer would yield the same result as plaster.

Table 2. STC for very porous wood-aggregate blocks and lightweight concrete blocks sealed with gypsum board or plaster

Concrete block treatment	90-mm wood-aggregate blocks	190-mm lightweight concrete blocks
Unsealed	14	42
Gypsum board on one face	29	46
Plastered	43	49

Double-Leaf Concrete Block Walls

In principle, double-leaf masonry walls can provide excellent sound insulation. They appear to meet the prescription for an ideal double wall: two independent, heavy layers separated by an air space. In practice, constructing two block walls that are not solidly connected somewhere is very difficult. There is always some transmission of sound energy along the wire ties, the floor, the ceiling and the walls abutting the periphery of the double-leaf wall, and through other parts of the structure. This transmitted energy, known as flanking transmission, seriously impairs the effectiveness of the sound insulation. Flexible ties and physical breaks in the floor, ceiling and abutting walls are needed to reduce it.

Even if such measures are considered in the design, mortar droppings or other debris can bridge the gap between the layers and increase sound transmission. Such errors are usually concealed and impossible to rectify after the wall has been built. In one test conducted by IRC researchers, a double-leaf wall that was expected to attain an STC of more than 70 provided an STC of only 60 because of mortar droppings that connected the two leaves of the wall.

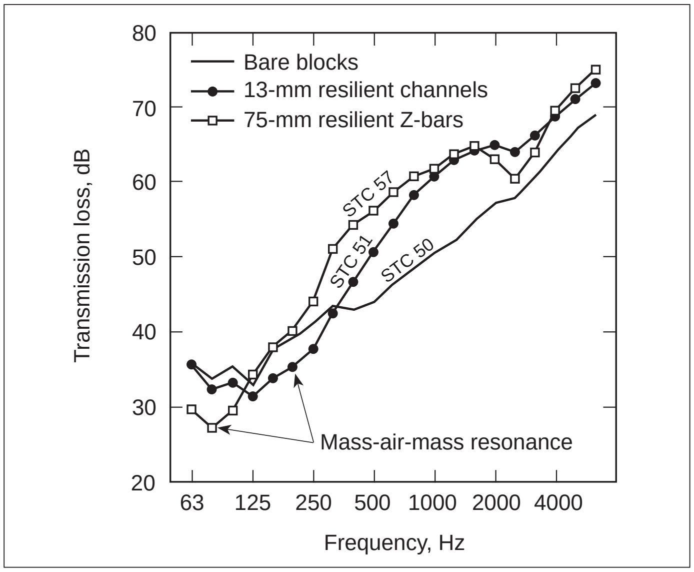

Figure 2. *Sound Transmission Loss (STC) through a 190-mm concrete block wall with 15.9-mm gypsum board attached to one side using a) 13-mm resilient metal channels, and b) 75-mm resilient Z-bars*

In other tests carried out at IRC, a number of double-leaf cavity block walls, in which the layers were structurally isolated from each other, achieved STC ratings in the range of 70 to 80. The constructions provided the least amount of structural vibration transmission that can be achieved in the laboratory, which is better than what can be achieved in normal practice. In practical situations, careful design, meticulous workmanship and skilled supervision are needed for such walls to achieve their full potential.

Concrete Block Walls with Gypsum Board Added

Adding gypsum board supported on furring or studs at a distance from the surface of the block wall can greatly improve the sound insulation of the wall assembly. Three factors that govern the degree of improvement are:

1. The method of support — ideally, the gypsum board should not be solidly connected to the block;
2. The depth of the cavity (the distance between facing surfaces of the block and the gypsum board);
3. The use of sound-absorbing material in the cavity between the gypsum board and the surface of the block.

If the furring supporting the gypsum board is rigid, sound can travel directly through it from the gypsum board to the blocks. However, if the furring is sufficiently flexible, the sound will be attenuated. But the best method of support for the gypsum board is the use of independent studs that have no direct connection to the block. Resilient metal furring may be used on its own or in combination with wood furring.

Figure 2 provides two sets of transmission loss (TL) data for walls with unfilled cavities of two different depths, as well as data for an unfinished block wall. The effect of the added gypsum board on acoustic performance is striking — at high frequencies, the performance of the walls with the gypsum board is better than that of the bare block wall; at low frequencies, it is worse. There is a decrease in TL at low frequencies and an increase in TL at high frequencies in both walls relative to the unfinished block wall.

In general, the greater the cavity depth and the greater the mass, the lower the mass-air-mass resonance frequency, which usually means an increase in STC. There is an exception to this trend, however, which occurs at frequencies around 100 Hz, where the STC of the cavity walls decreases relative to that of the unfinished block wall. While voices are not a source of low-frequency noise, modern stereos can be, as can mechanical equipment, meaning that walls around machine rooms should be designed with great care if these rooms are adjacent or close to living or working spaces.

> **Mass-air-mass resonance frequency**
> This is the specific frequency at which two layers of material separated by an air space resonate, somewhat like the skin of a drum. In the case of a block wall with gypsum board added, vibrational energy transfers from the gypsum board through the air in the cavity to the block wall more effectively than it does through the bare block wall.

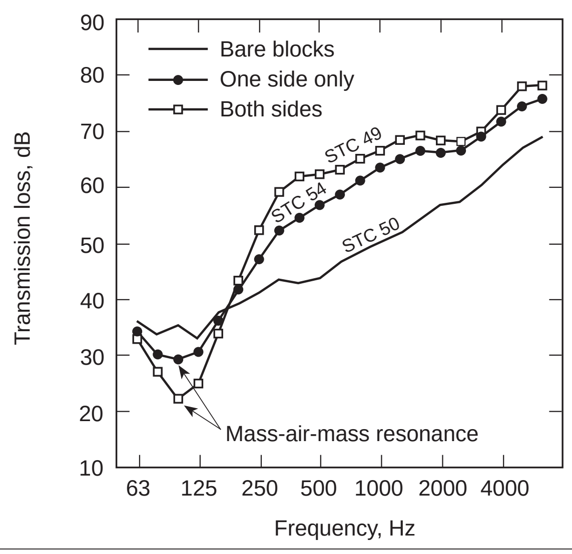

Figure 3. Sound Transmission Loss (STC) for a 190-mm concrete block wall with glass fibre batts in the cavity and with 15.9-mm gypsum board attached on 13-mm resilient metal channels to a) one side and b) both sides of the wall

Sound-absorbing material is commonly added to the cavity in a wall or floor to improve the sound insulation. The addition of this material:

- lowers the mass-air-mass frequency and usually improves the STC, and
- reduces the detrimental effects of other cavity resonances at higher frequencies.

Fibrous materials, such as cellulose fibre, glass fibre or rock wool insulation, are good materials for this purpose; closed-cell materials, such as expanded polystyrene, are not, as they do not significantly absorb sound.

Figure 3 shows the effect of adding glass fibre to the cavity of the wall with 13-mm resilient metal channels. The mass-air-mass resonance frequency drops to around 100 Hz and the STC increases to 54.

Figure 3 also shows that when gypsum board is applied to both sides of the blocks, the TL increases to a greater degree at higher frequencies, but decreases dramatically around the mass-air-mass resonance. The STC for the wall with gypsum board on both sides is one point less than that for the wall that does not have gypsum board added. More importantly, in the case of the wall with gypsum board added to both sides, the effectiveness of the sound insulation around 100 Hz is significantly reduced by the added material. This diminished performance occurs because the cavity depth is too small, which leads to a mass-air-mass resonance that lowers the STC. To maximize the improvement in sound insulation, the cavity depth should be as large as is practical. As a general guideline, the product of the mass per unit area of the gypsum board (in kg/m^2) and the cavity depth (in mm) should exceed 425 for a cavity filled with sound-absorbing material, and 720 for an unfilled cavity.

Estimating STC for Concrete Block Walls with Gypsum Board Added

Normal-weight, non-porous block

Data from an extensive series of measurements on normal-weight block walls were used to develop an empirical method for predicting STC for block walls with gypsum board supported on resilient furring or independent studs. The simplified version of this method, provided in Table 3, uses only STC ratings but still provides reasonable accuracy. The equations give the STC increment (ΔSTC) that can be achieved, with or without sound-absorbing material, when gypsum board is added to one or both sides of a bare block wall.

For example, if 15.9-mm gypsum board is added to both sides of a block wall filled with sound-absorbing material, using 65-mm steel studs, ΔSTC is 0.44x65 - 7.37 = 21.2. Thus the STC rating of the bare wall improves from 46 to about 46 + 21 = 67.

Note that for small values of d (i.e., small cavities), ΔSTC can be negative — in other words, the effectiveness of the wall in controlling sound is reduced. Predictions made using this procedure have an uncertainty of about ±2dB, but can be used with some degree of reliability for 12.7- or 15.9-mm thick gypsum board.

Table 3. Equations for estimating increments in STC using the cavity depth d (in mm) and assuming a single layer of gypsum board

No sound-absorbing material in the cavity	ΔSTC = 0.11xd - 1.22	one side only
	ΔSTC = 0.14xd - 2.78	both sides
Cavity filled with sound-absorbing material	ΔSTC = 0.12xd + 1.87	one side only
	ΔSTC = 0.44xd - 7.37	both sides

Porous block walls

The leakage of sound through a porous concrete block wall can be used to advantage when gypsum board is added to finish the wall. Because sound penetrates the block, the effective depth of the cavity is greater than the actual distance between the inner faces of the gypsum board and the block. The effective depth depends on the porosity of the block. The best way to finish a leaky concrete block wall is as follows:

- Plaster or paint one side only. If a gypsum board finish is required on this side, it should be glued or screwed on directly as this has the least detrimental effect on STC.
- On the second side of the wall, use resilient metal furring or independent studs to support a layer of gypsum board. As with non-porous block, the larger the cavity depth, the better.
- Add sound-absorbing material to the cavity.

Porous block walls finished in this manner can provide STC ratings as good as those provided by non-porous, heavier blocks. Currently, it is not possible to predict the STC for composite walls such as these. Approximate estimates may be obtained using the procedures for non-porous blocks. In critical situations, measurement of the sound transmission loss (TL) values may be needed.

Summary

Because of their weight, with little effort on the part of the designer, concrete block walls provide good sound insulation. In general, the greater the

- mass of the wall
- the depth of the cavity
- the amount of sound-absorbing material

the better the performance of the block wall, although there are some exceptions to this approach. However, by applying the principles described in this Update, it is possible to construct high-quality walls that can meet the most acoustically demanding situations.

References

1. A.C.C. Warnock and D.W. Monk. Sound transmission loss of masonry walls: tests on 90, 140, 190, 240 and 290 mm concrete block walls with various surface finishes. Division of Building Research, National Research Council, Building Research Note 217, June 1984.
2. T.D. Northwood and D.W. Monk. Sound transmission loss of masonry walls: twelve-inch lightweight concrete blocks — comparison of latex and plaster sealers. Division of Building Research, National Research Council, Building Research Note 93. September 1974.

3. T.D. Northwood and D.W. Monk. Sound transmission loss of masonry walls: twelve-inch lightweight concrete blocks with various surface finishes. Division of Building Research, National Research Council, Building Research Note 90. April 1974.
4. A.C.C. Warnock. Factors affecting sound transmission loss. Institute for Research in Construction, National Research Council, Canadian Building Digest 239, Ottawa, 1985.
5. A.C.C. Warnock. Sound transmission loss measurements through 190 mm and 140 mm blocks with added drywall and through cavity block walls. Institute for Research in Construction, National Research Council, Internal Report 586, 1990.

Dr. A.C.C. Warnock *is a senior research officer in the Indoor Environment Program of the National Research Council's Institute for Research in Construction.*

May 1998
ISSN 1206-1220

"Construction Technology Updates" is a series of technical articles containing practical information distilled from recent construction research.

For more information, contact Institute for Research in Construction, National Research Council of Canada, Ottawa K1A 0R6
Telephone: (613) 993-2607; Facsimile: (613) 952-7673; Internet: http://irc.nrc-cnrc.gc.ca

Canada