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Control of Sound Transmission through Gypsum Board Walls

by A.C.C. Warnock and J.D. Quirt

This Update explains how to achieve effective control of sound transmission through gypsum board walls in multi-family dwellings. The information is derived from the results of an exhaustive industry-supported research project conducted by NRC's Institute for Research in Construction (IRC).^{1,2}

The research project studied the influence of isolating each face of the wall, and of mass, sound absorption and cavity depth on controlling sound transmission through walls. Because the STC between dwelling units was increased from 45 to 50 in the 1990 edition of the National Building Code, this article focuses on the role and relative importance of these key parameters in constructing walls that can attain STC ratings of 50 or more.

The research demonstrated that the major factor to consider in constructing walls to control sound transmission is the isolation of the gypsum board layers on each face of the wall. If at least one of the layers is not resiliently supported, or if the two faces of the wall are not isolated from each other, sound-absorbing material in the cavity is rendered ineffective. When the layers are isolated, sound transmission through the wall can be reduced by increasing the mass, the cavity depth and the amount of sound-absorbing material.

To provide the needed isolation, walls can be constructed of double studs (wood or steel), staggered studs (wood or steel), non-load-bearing steel studs, or wood or load-bearing steel studs with resilient channels.³

The type of sound-absorbing material has a relatively minor effect on the ability of the wall to control sound. There are clear benefits associated with increasing

the spacing between studs and resilient channels – the farther apart they are, the better the sound reduction. Usually the STC increases by one or two points when going from 400-mm to 600-mm spacing.

Rigid Versus Non-Rigid Connections Between Layers

When the gypsum board in a wall is solidly fastened to the wood studs on both sides, much of the sound is transmitted through the studs. It is thus important for the two wall surfaces to be supported independently from one another in order to control sound transmission. This can be done by fastening the gypsum board on each side of the wall to different lines of studs (i.e., by using staggered or double wood-stud arrangements) or by supporting one side of the wall on resilient channels. Resilient channels used on one or both faces of single rows of stiff studs – wood studs or load-bearing steel studs – also help to overcome peripheral transmission through header and sole plates.

Adding resilient metal channels to one face of a single row of studs improves sound reduction considerably, allowing sound-absorbing material in the cavity to be effective. With asymmetrical (1x2) constructions, it did not matter which side the channels were placed on – the STC ratings were not affected.⁴

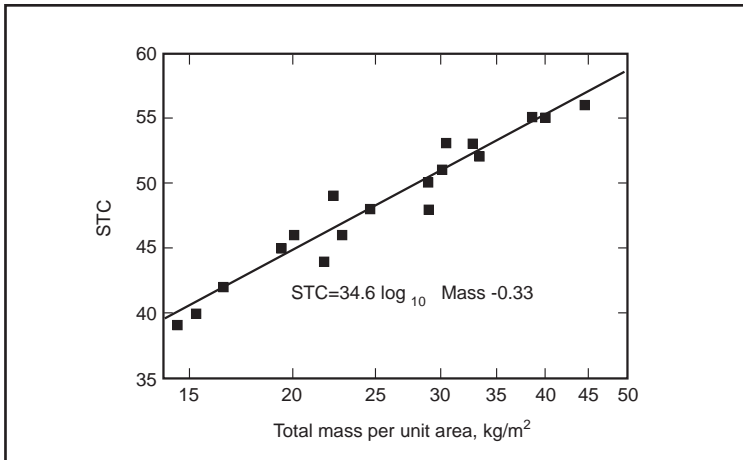


Figure 1. Changes in STC caused by changes in total mass per unit area of gypsum board. The basic wall structure consists of 92-mm non-load-bearing steel studs, 400 mm o.c., with 92-mm glass fibre in the cavity. Changes in mass are due to differences in the type of gypsum board and the number of layers among the various specimens.

Load-bearing steel studs behave in much the same way as do wood studs, but light-gauge non-load-bearing metal studs are flexible enough to reduce sound transmission through the material, and provide about the same sound reduction as wood-stud walls with resilient metal channels on one face.

In this project, all load-bearing stud-wall assemblies were tested with resilient metal channels on one face to eliminate the transmission of excess sound energy through the stud.

Mass of Gypsum Board

The mass per unit area is very important in determining the STC; within practical limits, the heavier the layers, the better. Figure 1 shows that in cavity walls, the total weight of gypsum board used has a major influence on the STC. Doubling the weight of gypsum board in these non-load-bearing steel-stud walls increases the STC

The IRC research project studied the effects of the following parameters on the ability of more than 250 gypsum board wall assemblies to reduce sound transmission.

Type, density and thickness of gypsum board. Two types of gypsum board were studied:

- Regular, with three different densities;
- Type X, which has a specially formulated core to provide greater fire resistance. The Type X gypsum board came in two thicknesses: 12.7 mm and 15.9 mm.

Symmetrical and asymmetrical installation of gypsum board. Three basic wall-assembly arrangements on wood and lightweight steel studs were studied:

- one layer of gypsum board on each side of the assembly (symmetrical, 1x1);
- one layer of gypsum board on one side and two layers on the other (asymmetrical, 1x2); and
- two layers of gypsum board on each side (symmetrical, 2x2).

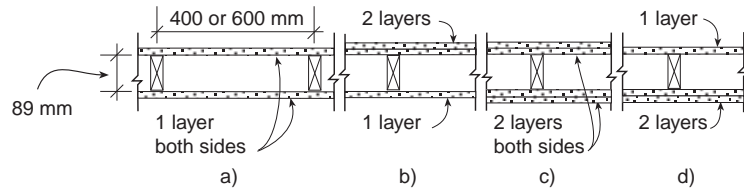
Stud type, spacing and configuration. Wood studs and steel studs – both load-bearing and non-load-bearing – were used. The wood studs were arranged in single, staggered and double-stud configurations. Non-load-bearing steel studs (25 gauge) were 64 mm or 92 mm; load-bearing studs (minimum 20 gauge steel) were 92 mm or 152 mm. Stud spacing was varied for both wood and steel studs and was either 400 mm o.c. or 600 mm o.c.

Resilient channel installation. Some assemblies had resilient channels while others did not. Resilient channel spacing was either 400 mm o.c. or 600 mm o.c.

Type of sound-absorbing materials (insulation). Seven different sound-absorbing materials were tested. The generic materials in the specimens were glass fibre, cellulose fibre and rock fibre.

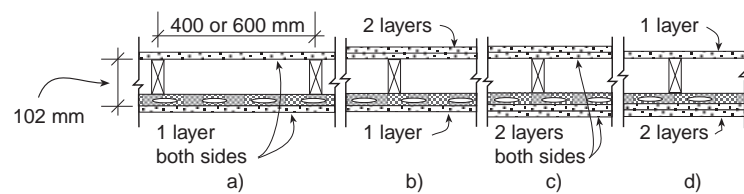
Cavity depth. This varied from 64 mm to 203 mm.

Basic Wall Constructions Tested



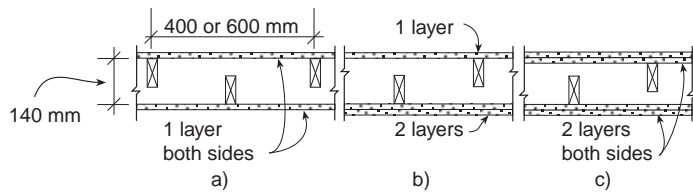
Single wood studs

- one or two layers of gypsum board
- 38-mm x 89-mm studs
- with or without absorptive material
- one or two layers of gypsum board



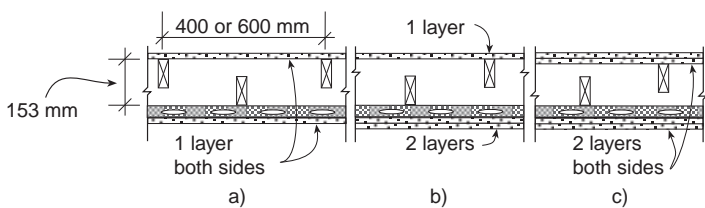
Single wood studs with resilient channels

- one or two layers of gypsum board
- 38-mm x 89-mm studs
- with or without absorptive material
- resilient channels on one side
- one or two layers of gypsum board



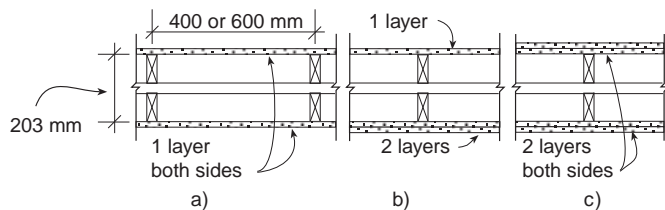
Staggered wood studs

- one or two layers of gypsum board
- two rows 38-mm x 89-mm studs staggered on common 38-mm x 140-mm plate
- with or without absorptive material
- one or two layers of gypsum board



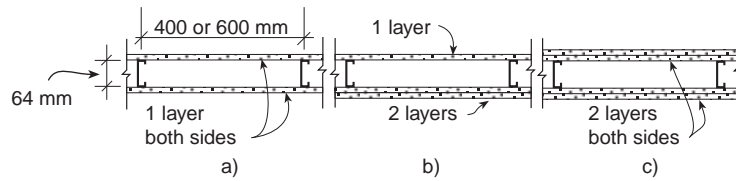
Staggered wood studs with resilient channels

- one or two layers of gypsum board
- two rows 38-mm x 89-mm studs staggered on common 38-mm x 140-mm plate
- with or without absorptive material
- resilient channels
- one or two layers of gypsum board



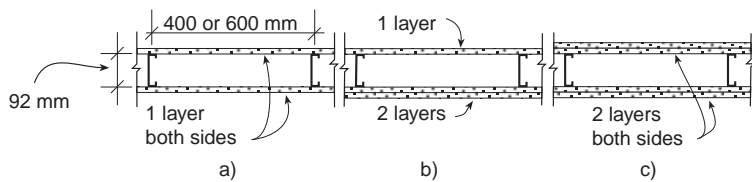
Double wood studs

- one or two layers of gypsum board
- two rows 38-mm x 89-mm studs on separate 38-mm x 89-mm plates set 25 mm apart
- with or without absorptive material
- one or two layers of gypsum board



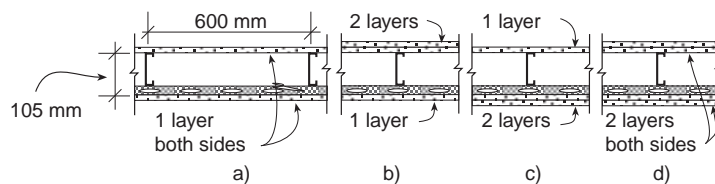
Non-load-bearing steel studs (64 mm)

- one or two layers of gypsum board
- 31-mm x 64-mm non-load-bearing studs
- with or without absorptive material
- one or two layers of gypsum board



Non-load-bearing steel studs (92 mm)

- one or two layers of gypsum board
- 31-mm x 92-mm steel studs
- with or without absorptive material
- one or two layers of gypsum board



Load-bearing steel studs with resilient channels

- one or two layers of gypsum board
- 31-mm x 92-mm (or 152-mm) load-bearing steel studs
- with or without absorptive material
- resilient metal channels on one side
- one or two layers of gypsum board

by about 10 points. Other stud types exhibit similar trends. STC 50 cannot be readily attained with a single layer of gypsum board on each side of 92-mm studs; the combination of mass per unit area, cavity depth and the stiffness of the studs is not quite good enough.

Because of the strong dependence of STC on the total mass per unit area of gypsum board, it is very important when selecting constructions for use in a building not to use outdated test data, as the actual weight for a particular thickness may have decreased, resulting in a significantly lower STC. Therefore, assemblies cannot be chosen on the basis of the thickness of the gypsum board.

Sound-Absorbing Materials

Sound-absorbing materials are only effective when used in assemblies with the faces correctly isolated as described above. Using sound-absorbing materials in a rigidly connected assembly is a waste of money. When the two layers forming the wall cavity do not have rigid connections

between them, adding sound-absorbing material to the cavity increases the STC by about 10 points. The exact STC varies with the type of construction. When high STC ratings are sought, sound-absorbing materials should be used.

The optimal amount and type of sound-absorbing material for use in a cavity were investigated in a preliminary study in which seven different absorptive materials were used in a window-sized specimen formed from two layers of 3-mm-thick plastic. The study showed that:

- sound reduction continuously improves as the thickness of sound-absorbing material covering the whole face of the specimen is increased.
- there is no significant change when the sound-absorbing material is moved from the middle of the cavity to a position near one face.
- partially filling the cavity from bottom to top, or from sides toward the middle, is less effective than having the same amount of material completely covering the whole inner face of the cavity.

- the type of material used influences the sound reduction measured in frequencies ranging from 500 to 2000 Hz. The greater the airflow resistivity of the material, the greater the sound reduction. Because there is a direct correlation between the density of the materials and sound reduction in this frequency range, the sound reduction tends to increase as the density of the sound-absorbing material increases. However, in terms of the STC, no important acoustical differences were found among the sound-absorbing materials used in this preliminary investigation.⁵

Wall systems containing sprayed-on and blown-in cellulose fibre demonstrated greater variation in performance than those with other types of insulation. These variations were attributed to differences in installation (which is difficult to control) rather than to differences in the acoustical properties of the materials. Overfilling a cavity with a material that is fairly dense and rigid, for example, introduces the risk of sound transmission through the sound-absorbing material itself. The stiffer the material, the greater the reduction in the STC.

Weaving sound-absorbing batts between staggered studs in an S-shape has no significant impact on reducing sound transmission and is therefore not beneficial.

Cavity Depth

The benefits of a large cavity are clear, although the difference in the amount of sound-absorbing material used in the various wall assemblies confuses the issue somewhat (in that there was more insulation in the deeper cavities). To reduce the confusion, in tests to study the effects of cavity depth, all cavities were completely filled with glass fibre batts. Within the range of the cavity depths shown here, a doubling of this depth increases the STC by about 10 points. Other types of sound-absorbing material would undoubtedly show the same trend. When there is no sound-absorbing material in the cavity, increasing its depth is beneficial, but not to the same extent. The increase in STC from doubling the depth is only about 4.

The depth of the cavity, i.e., the distance between the inner faces of the gypsum board, is a very important factor in the control of sound transmission.

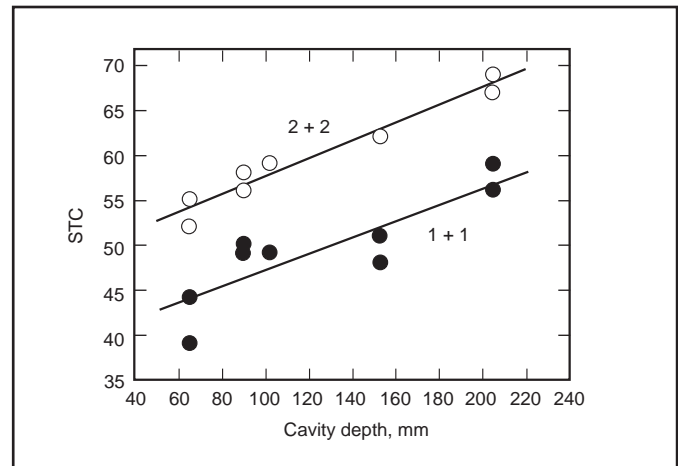


Figure 2. Effect of increasing cavity depth in walls constructed (a) with one layer of 15.9-mm Type-X gypsum board on each side (1x1) and (b) with two layers of the same gypsum board on each side (2x2). Different cavity depths were obtained by using 64-mm and 92-mm non-load-bearing steel studs; 89-mm wood studs with resilient metal channels and a 102-mm cavity; staggered wood studs with resilient metal channels and a 153-mm cavity; and double wood studs with a 203-mm cavity. The amount of sound-absorbing material in the cavity varied for each stud system. Shallower wall cavities accommodated proportionately thinner glass fibre batts.

Use of Internal Layers

It is detrimental to add layers of gypsum board in the middle of a double stud wall (Figure 3). Table 1 shows that the internal layer lowers the STC rating relative to an assembly without an internal layer. There are two flaws in a design with an internal layer. First, the rigid connection of the internal layer to the studs allows sound energy to bypass the sound-absorbing material in the cavity, thus compromising the sound reduction of the assembly.

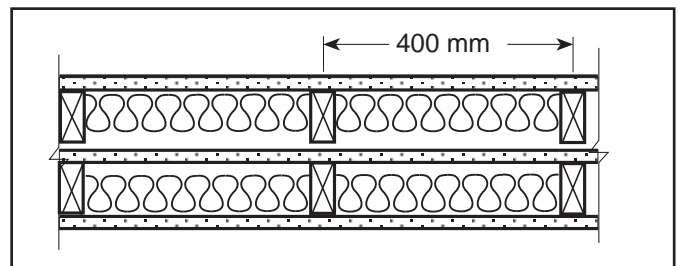


Figure 3. Double stud wall with one layer of 15.9-mm Type-X gypsum board on each face and an additional internal layer of gypsum board or wood fibreboard in the middle

Table 1. STC ratings for double stud walls with internal layers

Thickness and Type of Middle Layer	STC Rating
none	58
19-mm wood fibreboard	54
15.9-mm gypsum board	55

Second, the internal layer reduces the depth of the wall cavity. This is to be avoided. Whereas sound insulation is increased at high frequencies, at low frequencies, which are important for determining STC, sound insulation decreases because of the internal layer.

An internal layer of gypsum board may increase fire resistance, but only at the expense of sound reduction. With proper design of the wall assembly (avoiding internal layers), it is possible to increase both fire resistance and sound reduction.

Resilient metal channels should never be used between two layers of gypsum board in a wall, because small cavities in walls usually lead to low STC ratings.

Summary of Findings

To reduce sound transmission through gypsum board walls:

- use double studs, staggered studs (with or without resilient channels), non-load-bearing steel studs, wood studs with resilient channels or load-bearing steel studs with resilient channels;
- increase mass by increasing the number of layers of gypsum board on each side from one to two;
- increase the depth of the cavity;

- fill the cavity with insulation;
- space studs at 600 mm; and
- space resilient channels at 600 mm.

Impact on the Construction Industry

The data obtained during the project were used to generate new tables of STC ratings for wall assemblies that have been included in the 1995 National Building Code of Canada. From a practical point of view, the STC ratings provide the information needed for selecting wall constructions to satisfy building code requirements.

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1. The project was supported by a consortium that included Canada Mortgage and Housing Corporation (CMHC), Canadian Sheet Steel Building Institute (CSSBI), Cellulose Insulation Manufacturers Association of Canada (CIMAC), Forintek Canada Corp., Gypsum Manufacturers of Canada (GMC), the Institute for Research in Construction of the National Research Council Canada, Owens Corning Fiberglas Canada Inc. and Roxul Inc.
2. Fire testing of some of the wall assemblies was also undertaken as an integral part of the combined project in order to demonstrate that a particular assembly could satisfy Code requirements for fire resistance as well as those for noise control. (Some remedies for improving sound performance are detrimental to fire performance.)
3. A resilient channel is a long strip of thin steel with a stepped configuration. One vertical leg is attached to a stud and the other to the gypsum board. The total width of the channel is about 25 mm.
4. In fire-resistance tests carried out as part of this project, the use of resilient metal channels on the side of the assembly with two layers of gypsum board gave an increased fire-resistance rating.
5. There were, however, significant differences in fire-resistance ratings for full-size walls with constructions that were identical except for the type of sound-absorbing material used.



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