Ser
TH1
N21b8
no.44
1988

ISSN 0701-5232

# BUILDING PRACTICE NOTE

HOW TO REDUCE NOISE TRANSMISSION BETWEEN HOMES (APARTMENTS)

by

A.C.C. Warnock

Division of Building Research, National Research Council Canada

Ottawa, July 1983

Revised January 1988

National Research Council Canada
Conseil national de recherches Canada

NO. 44

HOW TO REDUCE NOISE TRANSMISSION BETWEEN
HOMES (APARTMENTS)

by

A.C.C. Warnock
Division of Building Research
National Research Council of Canada

## INTRODUCTION

Noise from neighbours is a common source of annoyance in multi-family homes. Occasionally the annoyance is so great that one occupant decides to alter the structure to try to reduce the intrusive noise. This note is meant as a guide to such people. It deals only with sound transmission through walls and floors between adjacent homes and not with aircraft, traffic or other external noises. In the latter cases, sound enters the home most often through the windows.

Improvements proposed here can be carried out by one tenant acting alone, but cooperation from the neighbour is usually very useful. Obviously in rented accommodation the owner would have to be consulted before making structural changes; although repairs are sometimes minor and inexpensive, extra construction could require some fairly drastic and quite expensive changes.

### Sound Transmission Class and Noise Reduction

The amount of sound energy that passes through a partition depends on the frequency of the sound; low frequencies are transmitted much more easily than high frequencies. The sound transmission class (STC) is a single number rating system which takes account of these frequency variations and makes it easier to discuss the sound transmission performance of building structures. The higher the STC number, the better the wall; i.e., the greater the noise reduction it can provide between homes.

The amount of noise you hear in your home depends on the amount of noise your neighbour makes, the sound-transmitting properties of the common wall or floor, and the level of background noise present in your own home. All three factors are important. For example:

- a quiet neighbour may make you think you have a good common wall; a noisy neighbour may make you think you have a bad wall;

- if you live in a very quiet home, you may be disturbed by almost every sound even though the common wall is very good;

- if your own radio or TV is played often, you may not hear your neighbour (but he may hear you).

Finally, the degree of annoyance is a personal reaction and some people are more easily annoyed than others.

Building regulations simplify this complex situation by requiring a minimum value of STC for walls and floors and accepting that some percentage of occupants will still be annoyed even when the regulations are met. In Canada an STC value of 45 has been used in building regulations for many years although acousticians would prefer to see values greater than 50, such as are common in Europe. STC values around 60 can be achieved in typical homes and only require a little bit of care and attention to detail during design and construction.

## Two-Layer Cavity Walls

The most practical form of construction that provides good sound insulation is the cavity wall or floor formed from two layers of non-porous, heavy material. There should be no rigid connections between the two layers and the cavity should contain sound-absorbing material. Each time either the total weight/unit area of the wall or the distance between the layers is doubled, an improvement of about five STC points should result.

It is very important to have sound-absorbing material in the cavity. Common effective materials include glass fibre, cellulose fibre or rock wool thermal insulation. A thickness of approximately 75 mm is enough except in very deep cavity walls or floors, where more can be added. The addition of sound-absorbing materials such as cork or carpet to the outside surfaces of a wall reduces the sound transmission only slightly and only at high frequencies.

To illustrate these basic points, Fig. 1 shows the large changes in STC caused by quite small changes in construction of a simple wood stud and gypsum board wall.

The wall in Fig. 1b uses staggered studs to avoid rigid connections between the layers of gypsum wallboard. Figure 2 shows this in more detail and two other common methods of avoiding rigid connections between the wall surfaces. Resilient channels are formed from thin strips of steel, have a "Z" cross section and are sometimes called "Zed-bars" (Fig. 2b). They are commonly used in noise control work and are usually available in building supply stores.

## Flanking Transmission

Sound travels between homes not only through the common wall but also along more roundabout routes such as those shown in Figs. 3 and 4. This is known as flanking transmission, and can make it very difficult at times to find the real reason for poor sound isolation. In some cases these flanking paths transmit more sound than the direct path through the common wall. Some other common flanking paths for sound include:

1) out through a window and back in through a neighbouring window;

2) out through, under or around the edges of a door into a hallway and then in by way of a neighbouring door;

3) through ventilation or heating ducts that are not fitted with sound attenuating devices.

Flanking paths are not always obvious, so a warning is necessary at this point:

> If significant sound transmission is occurring along paths other than through the common wall, then improving this wall alone may make only a small improvement. In some cases it might be necessary to improve other walls and floors in the home to reduce noise intrusion to an acceptable level.

Inspection of building plans if they are available, may reveal possible flanking paths; if not, careful listening to intruding noise might.

## Sound Leaks

Before dealing with methods to improve walls it is useful to talk about possible construction faults that can cause a wall that ought to be a good sound barrier to transmit excessive amounts of noise. An ordinary wall or floor appears at first glance to be a fairly solid structure, without obvious holes. Stopping sound transmission however, is very much like containing water. As a rule of thumb, if the wall is not watertight or airtight, then it is very likely that sound will leak through it. To ensure maximum performance from a wall or floor, all fissures and cracks, no matter how small, must be well sealed using a non-hardening caulking compound. A place where leaks are very commonly found is at the bottom of the wall, where the baseboard may conceal a large uncaulked gap where the gypsum wallboard meets the floor. This is one of the first places to look for sound leaks. A thin-bladed knife can often be used as a probe to identify a leak in this region but it may be necessary to remove the baseboard to be sure that there is enough caulking behind it. Sound leaks can also be hidden behind power outlet cover plates, TV antenna outlets, light switches, light fixtures, or other service outlets. They can also occur around duct and pipe penetrations and sometimes through inset cabinets installed back-to-back between bathrooms. Many of these places are hidden from view and can be difficult to find, but once a leak or flanking path has been identified, it must be plugged with non-hardening caulking if the hole is small or some solid material if the hole is large.

The importance of the thorough use of caulking to seal peripheral cracks and fissures cannot be emphasized too strongly. Figure 5 shows some examples of where continuous beads of caulking should be applied.

## Steps to Improvement

When noise from a neighbouring home is annoying, one of the following cases applies.

1) The wall design is inadequate (STC less than 45) and the construction is faulty as well.

2) The wall design is inadequate although it has been correctly constructed.

3) The wall design is adequate (STC more than 50) but the construction is faulty.

4) The wall design is adequate and the construction properly carried out.

In the last case, annoyance usually results because neighbours are unusually noisy, the people who are annoyed are very sensitive, the home where annoyance is experienced is unusually quiet, or any combination of these. In this latter case there may be little that can be done except to move, or extensively rebuild the house.

This note provides help when improvements are to be made. The first step is to find out, if possible, how the common wall or floor is constructed and then, from the information in Tables 1 to 3, to estimate its STC.

Once the potential STC of the wall has been estimated, Table 4 gives a rough guide for estimating the actual STC based on voice transmission between homes. This table incidentally expresses the difference in privacy provided by different constructions in everyday terms. (It may be necessary to get help from the neighbours to apply this table.)

A large discrepancy between the two STC values means serious sound leaks or flanking paths. These should be looked for and repairs made. In many cases this will solve the problem and may be all that is reasonable to do.

When all obvious leaks and flanking paths have been dealt with and noise intrusion is still a problem, then the common wall or floor has to be improved. The following sections give some guidance on how to do it.

## METHODS FOR IMPROVING WALLS AND FLOORS

The basic idea is to make the construction as similar as possible to one of the better constructions in Tables 1 to 3.

## Stud Walls

With stud walls containing at least 75 mm of sound-absorbing material in the cavity and constructed with either staggered studs, separate studs, wood studs with resilient channels, or metal studs, all that is required is to caulk all leaks and add extra layers of gypsum wallboard to build one of the better constructions in Tables 1 or 2. It does not matter much to which side the extra gypsum board is applied. Thus, if a design calls for a total of four layers of wallboard, and the existing wall has only one on each side, two more can be added to one side only. It is good practice, however, to stop leaks on both sides of the wall, which obviously requires the cooperation of your neighbour.

In some homes, especially older homes converted to apartments, these acceptable types of stud systems will not have been used and there may not be any sound-absorbing material in the cavity. In this case the best procedure is to remove the plaster or wallboard from one side and convert the wall to one of the preferred types. Resilient channels can be used or, preferably, a separate stud structure can be constructed.

The maximum number of layers of gypsum board shown in the tables for stud walls, is four. There would still be some benefit in adding one more if desired. Thus, if the original construction has one layer of board on each side, another three or four layers could be added to one side.

## Concrete Walls

Table 3 shows that it is relatively easy to get good sound insulation from a block or solid concrete wall. The most common problem with concrete block walls is missing or inadequate caulking where the gypsum wallboard meets the floor. This allows sound to leak through the porous blocks. If no leaks or flanking paths have been identified and if the sound isolation is not adequate, then the best procedure is to add extra layers of wallboard using the techniques shown in Figs. 6 to 8.

The method illustrated in Fig. 6 can be used on any wall no matter how it is constructed. A frame that does not contact the existing wall is constructed from wood or metal studs, sound-absorbing material is placed in the cavity and two layers of gypsum board are applied, taped, caulked and finished in the usual way. The disadvantage of this method is the loss of approximately 120 mm from the length or width of the room. The stud size and air space can be reduced, but this reduces the extra sound isolation provided particularly at low frequencies.

Less space is used by the two methods illustrated in Figs. 7 and 8. In Fig. 7, wood furring strips are nailed or screwed to the existing wall and resilient channels are then secured to the furring strips to give a resilient connection. In Fig. 8, the resilient channels are screwed directly to the wall surface. This last method is not as good as the previous two because the air space is smaller. There might be no improvement at low frequencies.

## Floors

Excessive noise transmission through floors can be particularly difficult to deal with because in addition to airborne sound, there is also the problem of footsteps and other impact noise. Fortunately, changes made to reduce airborne noise will also reduce the transmission of impact noise. It is common knowledge that adding carpet and underlay to the walking surface will greatly reduce footstep noise but this only slightly reduces airborne noise transmission. If the occupant in an upper apartment does not wish to use carpets, there is little to be done to alleviate footstep noise problems except to improve the ceiling.

As with walls, the principle involved with floors is to improve the construction by altering it to more closely resemble the ideal, i.e., two layers of material resiliently connected, with sound-absorbing material in the cavity.

## Joist Floors

Figure 9 gives three examples of good floor construction using solid wood joists. The use of steel joists or wood trusses would not change the sound transmission significantly. These three floors are the same in principle. Most of the weight of the assembly is in the floor. This is because it is not practical to have any more than two layers of gypsum board suspended from resilient channels and it is physically easier to add heavy materials on top.

If a joist floor is judged inadequate and if alterations can be made from both sides, then it is a straightforward task to alter the construction so that it resembles one of those shown in Fig. 9. If the ceiling is directly attached to the joists, then it should be removed, resilient channels installed and sound-absorbing material added if necessary. Gypsum wallboard is a fairly heavy, relatively inexpensive material that can be used to add weight on floors, but it should be protected with a new wood subfloor on top to avoid damage.

With floor systems where the floor and ceiling are resiliently connected but there is no sound-absorbing material in the joist space, it might be possible to have sound-absorbing material blown into the ceiling cavity through small holes.

If alterations to a joist floor can only be made from below, the best approach is to remove the existing ceiling and alter the floor using the technique shown in Fig. 9b. The gypsum board can be added to the underside of the floor above in pieces conveniently sized to make working easier. Once extra weight has been added to the underside of the floor, the cavity can be partially filled with sound-absorbing material and then up to two layers of gypsum board can be attached to resilient channels to form the ceiling. The assembly should be thoroughly caulked in the usual way.

## Floating Floors

If there is a solid connection between the floor and ceiling and alterations can only be made from above, then a different approach using a floating floor is necessary.

The basic principle of a floating floor is shown in Fig. 10. The resilient layer reduces the direct transmission of sound from the upper layers to the structure below. The stiffness of the resilient layer is important. Glass or rock wool fibre sheets with a density of about 100 $kg/m^3$ (6 $lb/ft^3$) give acceptable floor deflections (about 2 mm) and reduce the impact transmission. Other resilient materials, such as rubber, could be used together with different sound-absorbing materials. The new surface layer should be relatively heavy; for example, a wood subfloor resting on the battens, two layers of gypsum wallboard and then an upper layer of wood to protect the gypsum.

## Concrete Floors

Concrete floors are usually thick enough, and heavy enough, to provide reasonable sound isolation, e.g., a 150-mm solid concrete slab provides about STC 52. If a noise transmission problem exists with a concrete floor, then either a floating floor should be added on top (Fig. 10) or a resiliently suspended ceiling should be added below using the techniques shown in Figs. 6 to 8 for walls.

## Conclusion

It is not difficult to obtain high values of sound isolation between homes. It only requires reasonable design and attention to detail. Although it is usually more troublesome to improve a construction after it is built, it can usually be done, as described in this note. The cost, however, may be considered too high.

TABLE 1: Wood Stud Walls

(All walls have at least 75 mm of sound-absorbing material in the cavity)

| STC | Construction Description |
|---|---|
| 49 | Staggered wood studs, single layer gypsum board each side. |
| 53 | Staggered wood studs, double layer gypsum board one side, single layer other side. |
| 56 | Staggered wood studs, double layer gypsum board each side. |
| 56 | Single wood studs, resilient channel, double layer gypsum board each side. |
| 56 | Double wood studs, single layer gypsum board each side. |
| 60 | Double wood studs, double layer gypsum board one side, single layer other side. |
| 63 | Double wood studs, double layer gypsum board each side. |

TABLE 2: Metal Stud Walls

(All walls have at least 75 mm of sound-absorbing material in the cavity)

| STC | Construction Description |
|---|---|
| 46 | metal studs, single layer gypsum board each side. |
| 49 | metal studs, double layer gypsum board one side, single layer other side. |
| 56 | metal studs, double layer gypsum board each side. |

TABLE 3: Concrete Block Walls

| Side 1 | Side 2 | Approximate STC |
|---|---|---|
| Gypsum board directly applied | As Side 1 | 50 |
| Gypsum board on wood furring strips | As Side 1 | 52 |
| Sound-absorbing material and gypsum board on wood furring strips | Gypsum board directly applied | 55 |
| Sound-absorbing material and gypsum board on resilient channels | Gypsum board directly applied | 58 |
| 25 mm air space, 40 mm metal studs, sound-absorbing material and gypsum board | Gypsum board directly applied | 60 |

TABLE 4: Estimating Sound Transmission Class

| STC Rating | Privacy Afforded |
|---|---|
| 25 | Normal speech easily understood |
| 30 | Normal speech audible but not intelligible |
| 35 | Loud speech audible and fairly understandable |
| 40 | Loud speech audible but not intelligible |
| 45 | Loud speech barely audible |
| 50 | Shouting barely audible |
| 55 | Shouting not audible |

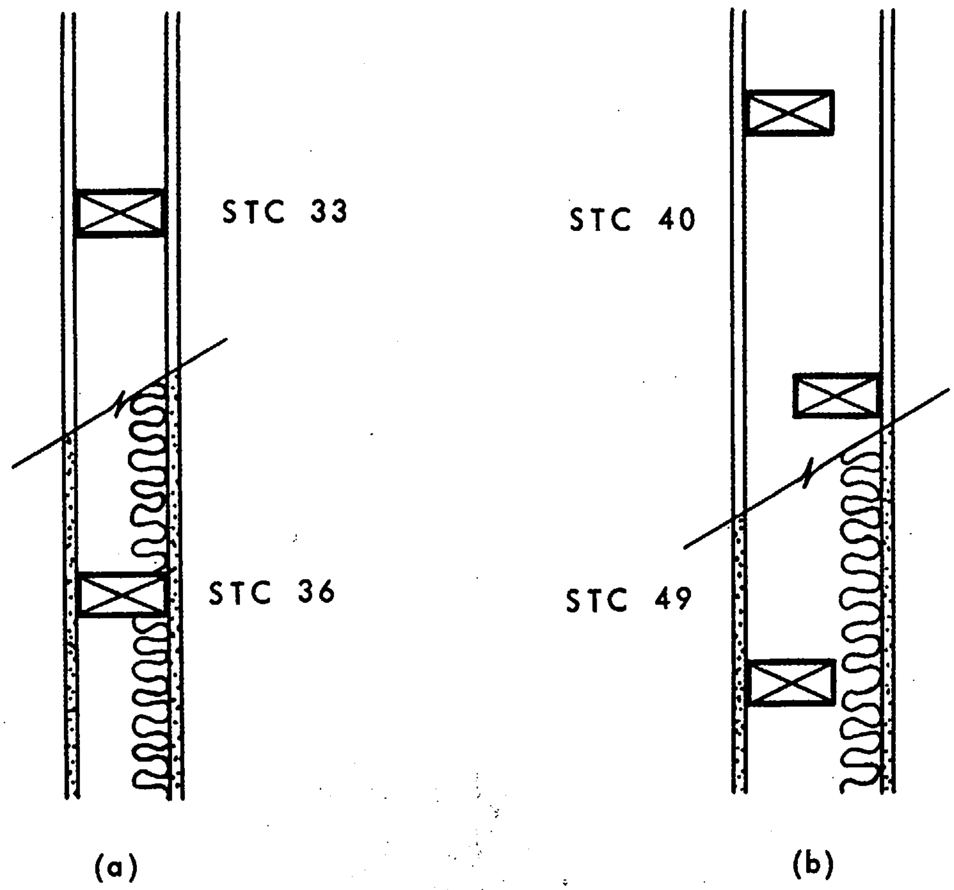



FIGURE 1

CHANGES IN SOUND TRANSMISSION CLASS CAUSED BY CHANGES IN CONSTRUCTION

BR 6403-1

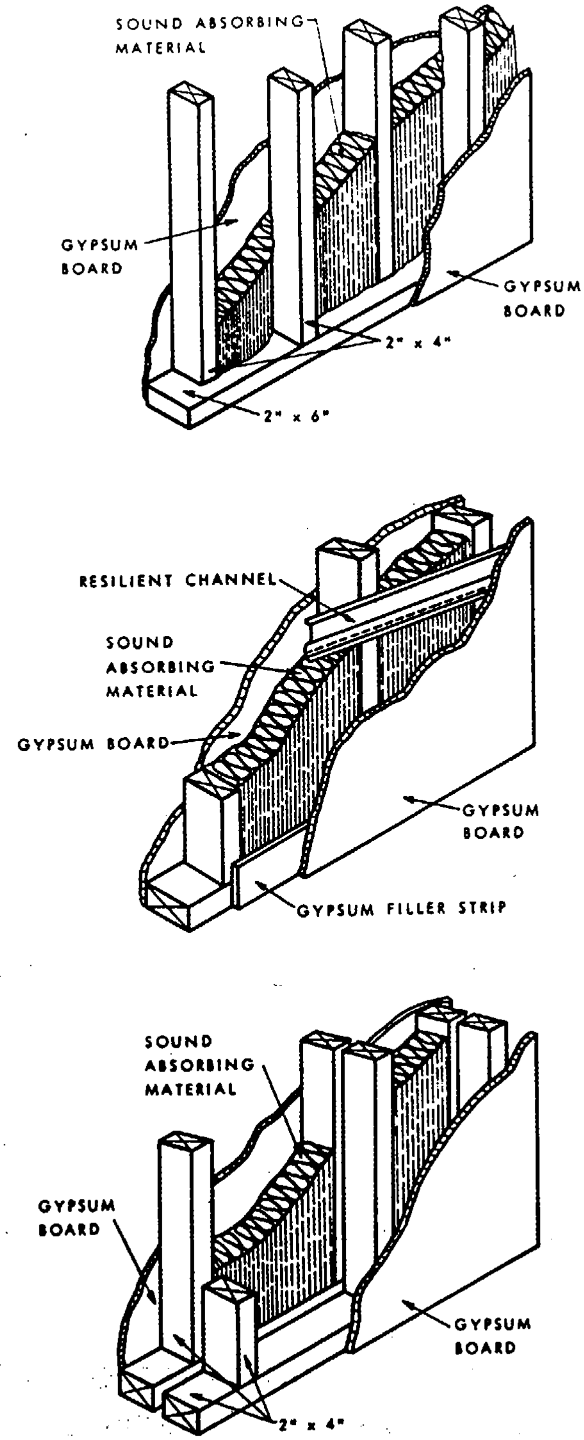



FIGURE 2

THREE METHODS OF OBTAINING STRUCTURAL SEPARATION IN WOOD STUD WALLS

BR 6403-2

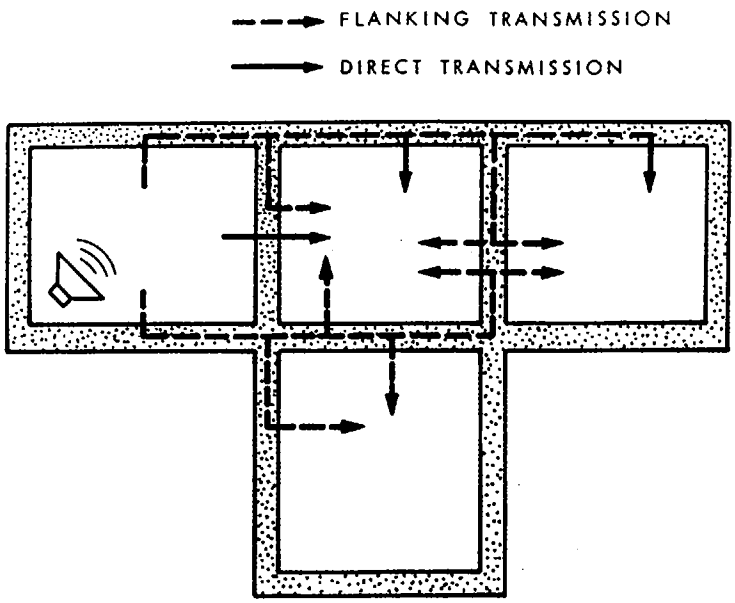



FIGURE 3

FLANKING PATHS IN BUILDINGS

BR 6403-3

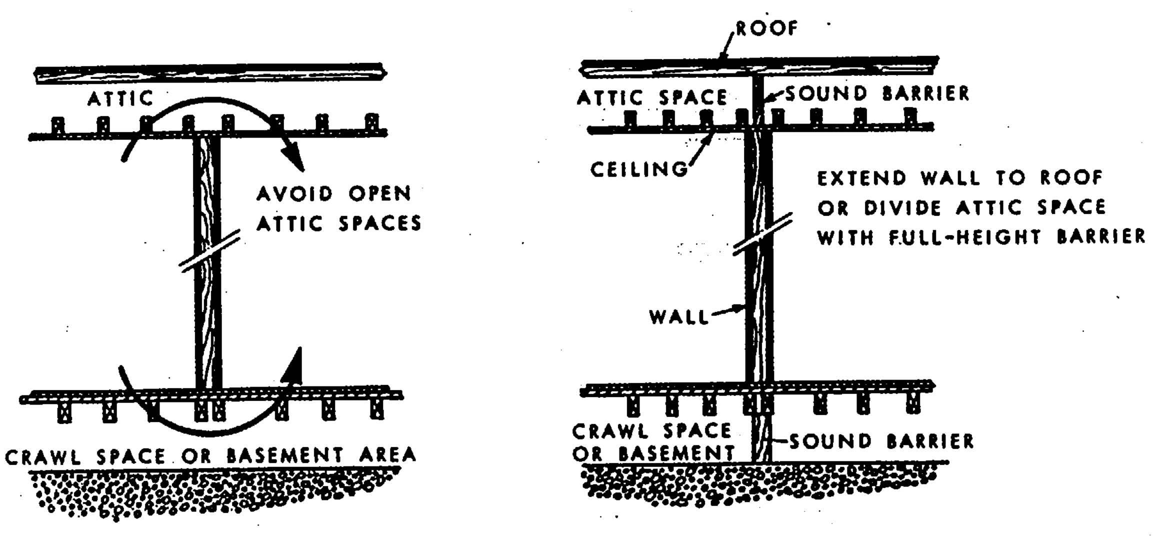
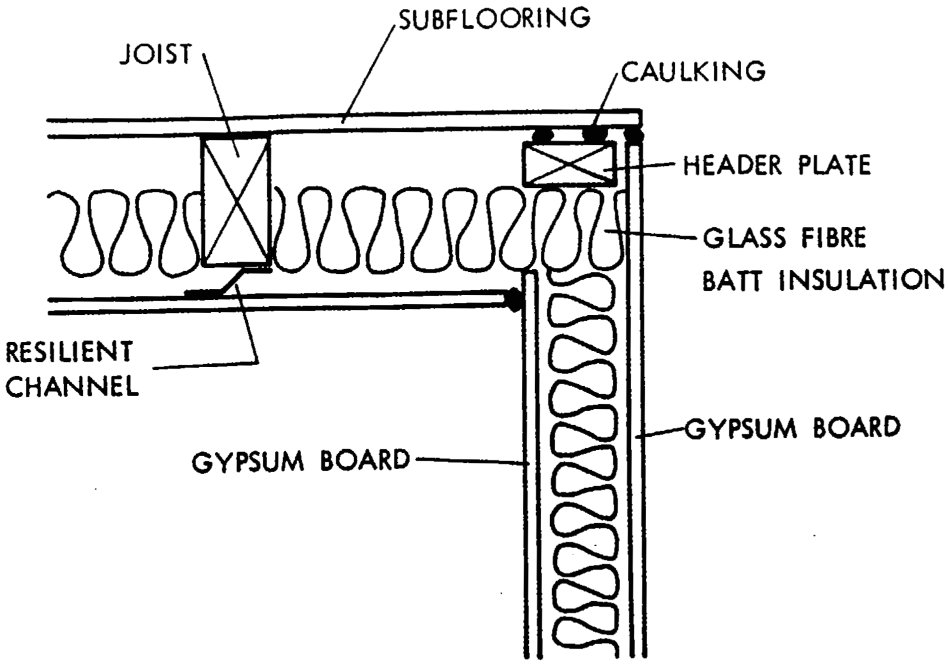



FIGURE 4

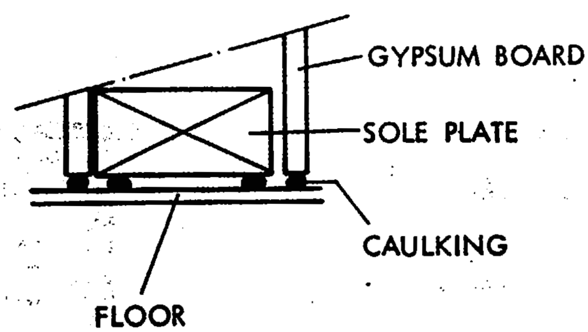
FLANKING IN ATTIC OR BASEMENT SPACES

BR 6403-4




(a) CAULKING AT EDGE OF CEILING

BR 6217-8




(b) CAULKING AT BASE OF WALL

FIGURE 5

EXAMPLES OF CAULKING

BR 6217-9

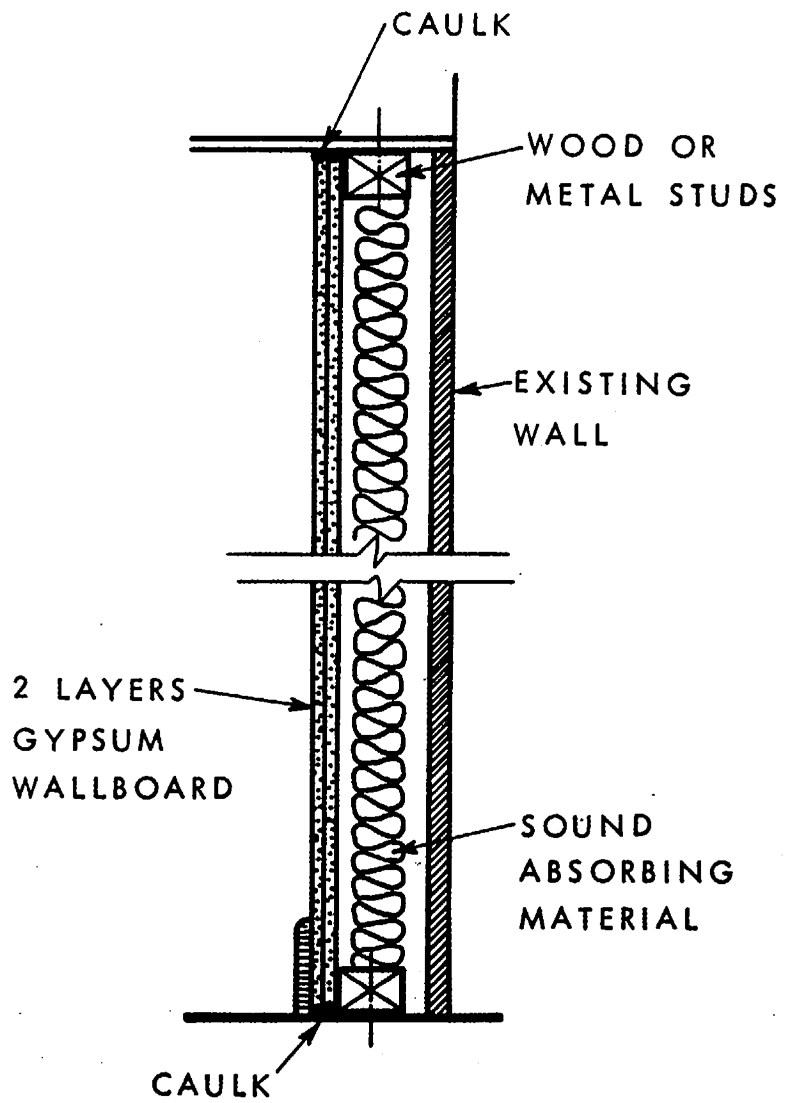



FIGURE 6

METHOD FOR IMPROVING ANY WALL

BR 6403-5

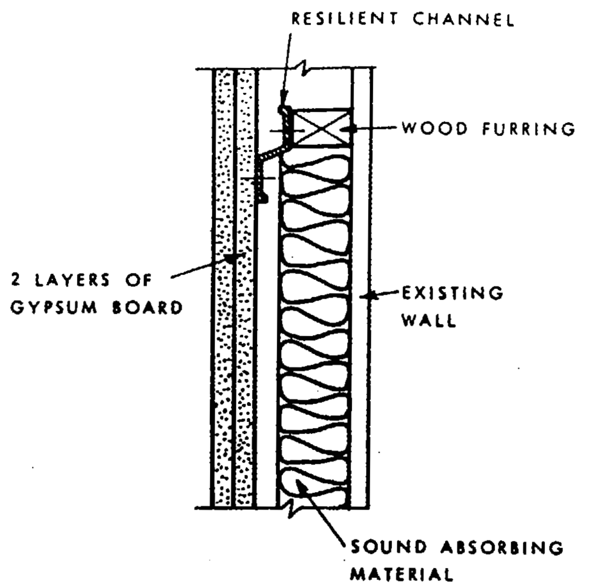



FIGURE 7

METHOD FOR IMPROVING A WALL USING FURRING AND RESILIENT CHANNELS. NOT QUITE AS GOOD AS METHOD IN FIGURE 6 AT LOW FREQUENCIES

BR 6403-6

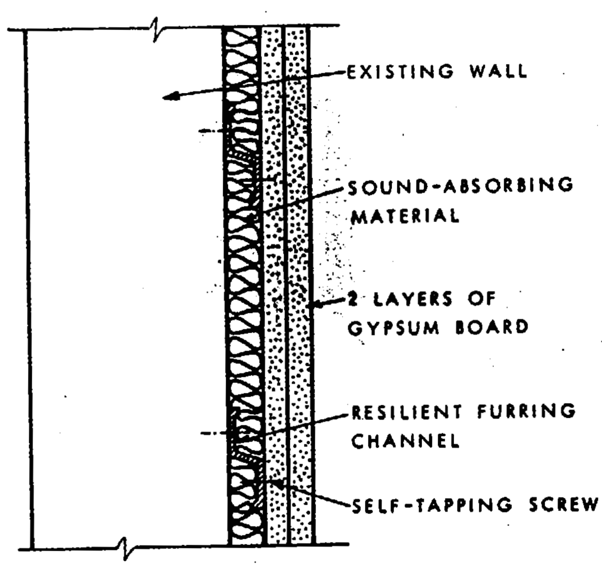



FIGURE 8

METHOD FOR IMPROVING A WALL USING RESILIENT CHANNELS ONLY. NOT AS GOOD AS METHOD IN FIGURE 7 AT LOW FREQUENCIES

BR 6403-7

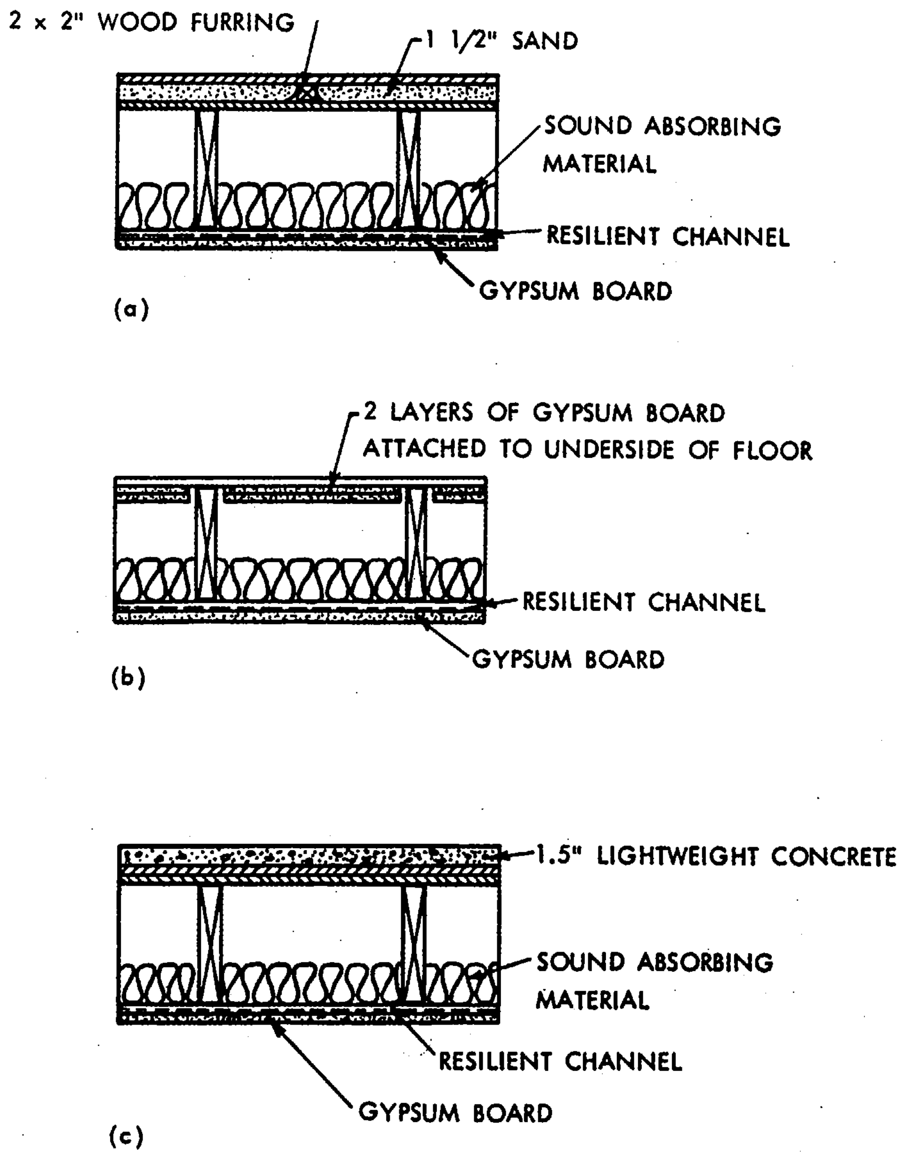



FIGURE 9

SOME EXAMPLES OF JOIST FLOOR CONSTRUCTIONS PROVIDING GOOD ACOUSTICAL PERFORMANCE

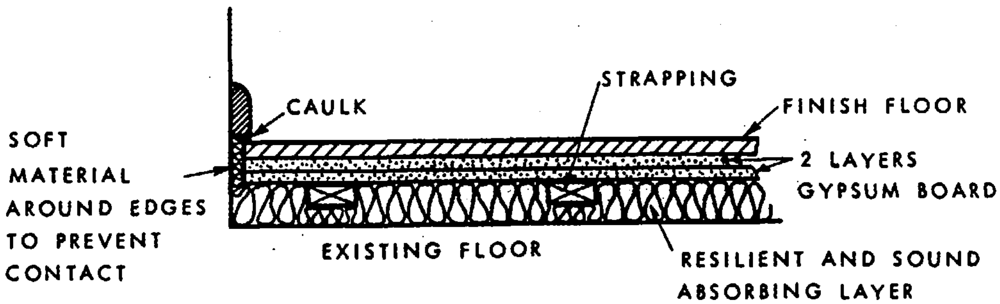



FIGURE 10

EXAMPLE OF A FLOATING FLOOR