Noise Isolation Provided by Gypsum Board Partitions

INTRODUCTION

In October 1995, the Institute of Research in Construction of the National Research Council of Canada published a summary report (internal report IRC-IR-693) containing the results, expressed in terms of Sound Transmission Class (STC), of 285 sound transmission loss tests performed on lightweight walls constructed with gypsum boards. In 1998, the Institute of Research in Construction published its internal report nº 761, which is an extension of its IRC-IR-693 summary report. In the IRC 761 report, we can find the complete results expressed in terms of third octave sound transmission loss from 50 Hz to 6300 Hz of acoustical tests conducted on 350 gypsum wall compositions (the 285 compositions published in the summary report plus an additional 65) along with the physical properties of the materials and the methods used during the construction of the sample partitions. This database provided the basis for a broad general evaluation of sound transmission through gypsum board wall systems.

In July 2001, the CMHC commissioned MJM ACOUSTICAL CONSULTANTS INC. to analyse the data contained in IRC report nº 761, and to prepare the present report in which the main factors influencing the performance of gypsum board partitions are discussed. This report has been organized to reflect the respective influence, on the sound transmission loss of gypsum board partitions, of its four main components: the gypsum boards themselves, the studs and stud arrangements, the resilient furrings, and the sound absorptive materials inserted in the cavity.

CONCLUSIONS OF THE STUDY

The following conclusions were reached:

- From one manufacturer to the next, there are small variations in terms of the surface mass for the same type of gypsum boards with the exception of 13 mm type “X” boards where a maximal variation of 1.6 kg/m^2 (0.32 lbs/ft^2) was noted. Such a small variation in surface mass translates in a variation of approximately 2 dB in the sound transmission loss of partitions constructed with equivalent gypsum boards made by different manufacturers, except around the critical frequency[1] of the gypsum panels where a 5 dB variation can be observed.
- Generally speaking, the STC rating of a partition increases proportionately to the surface mass of the gypsum boards used in its construction. However, around the 1000 Hz to 3150 Hz range, better transmission losses are generally obtained using thinner gypsum boards for which the critical frequency is higher than that of thicker boards. The best compromise is to use a thinner gypsum board (better transmission loss at higher frequencies) whose surface mass is sufficiently heavy to avoid substantially reducing the transmission loss at low frequencies and hence the STC rating. Based on the results of this study it seems preferable to build a sound isolating partition using 13 mm type “X” gypsum boards rather than 16 mm type “X” boards.

[1] Critical frequency: The lowest frequency at which the length of the bending waves in a material is the same as that of the sound waves in the air; it is at the critical frequency that a material irradiates sound most effectively.

- With the exception of partitions built with single wood studs without resilient furrings, there is an approximate 5 point STC rating increase each time the gypsum boards are doubled on either side of the partition. At low frequencies, the transmission loss is increased by about 5 dB for every doubling of the gypsum boards on one side of the partition. As the frequency rises however the increase becomes less obvious and can be nil in certain cases at high frequencies; this could be due to a mechanical coupling occurring between the two sides of the partition, or it could also be due to a mass-air-mass resonance created by a thin layer of air between the two layers of gypsum boards composing each side of the partition, (where the joints of the two sheets of drywall overlap for example).
- For a single stud partition constructed with one 16 mm gypsum board on one side and two 16 mm boards on the other side, replacing one 16 mm gypsum board by a 13 mm gypsum board on the side of the partition where the gypsum is doubled did not produce significant changes in the STC rating, but provided a slight improvement in the TL[2] of the partition around the critical frequency of the gypsum boards.
- The spacing of the studs has practically no effect on the acoustical performance of single stud partitions (metal or wood, with or without resilient furrings) whose cavity contains no sound absorptive material, or of a double wood stud partition. However, when the cavity of a single stud partition (metal or wood, with or without resilient furrings) is filled with glass fiber, a higher STC rating is obtained when the studs are spaced at 610 mm on center rather than at 406 mm on center. The same is true for staggered wood stud partitions; for these partitions however, better transmission losses are obtained above the critical frequency when the studs are spaced at 406 mm on center.
- When resilient furrings are used in single steel stud partitions, the stud gauge has little influence on the STC rating obtained. There is however, a slight increase in transmission loss as the gauge is increased (lighter stud).
- Generally speaking, a partition with a deeper cavity will provide better TL at low frequencies and consequently a higher STC rating.
- The installation of resilient furrings on one side of a single wood stud partition containing a sound absorptive material increases its STC rating by a minimum of 10 points; for a partition constructed with staggered wood studs, installing resilient furrings on one side leads to an improvement of the STC rating of 3 to 4 points. Wood stud partitions built with resilient furrings on both sides instead of just one side provide superior sound transmission loss, notably for frequencies above 160 Hz when the stud spacing is 406 mm on center.
- The spacing of the resilient furrings has little or no effect on the performance of a partition when the studs are spaced at 610 mm on center. When the studs are spaced at 406 mm on center, installing resilient furrings at 610 mm rather than at 406 mm on center provides a 2 to 4 point increase in STC rating of the partition. The most effective arrangement for the studs and resilient furrings of a partition is to have them both spaced at 610 mm on center.
- The orientation (horizontal or vertical, installed facing up or down), the side of the partition on which they are installed, and the manufacturer of resilient furrings do not have a significant effect on its sound isolating performance expressed in terms of STC.
- Installing resilient furrings on a single steel stud partition constructed with heavy gauge studs offers equal or better transmission loss than an identical partition built using standard gauge studs (25 gauge) without resilient furrings.
- Installing resilient furrings on wood stud partitions is much more effective than a fiberboard panel to mechanically decouple the gypsum board from the structure of the partition and hence to increase its sound transmission loss, especially above 250 Hz.
- Adding a sound absorptive material inside the cavity of a single stud partition (wood with resilient furrings or steel) or a staggered wood stud partition increases the STC rating by 5 to 9 points depending on the type of sound absorptive material used. For double stud partitions, an increase of 10 to 13 points was obtained depending on the amount of glass fiber insulation added to the cavity.

- Generally, at low frequencies, the increase in the transmission loss of a partition obtained by adding a sound absorptive material inside its cavity is equivalent regardless of the material used. Above 250 Hz, mineral fiber and blown cellulose give the best results; mineral fiber insulation provides slightly better transmission losses than glass fiber, especially around the critical frequency. Also, in the case of glass fiber, a greater transmission loss can be achieved by using denser batts.

- With the exception of sprayed cellulose, the best transmission losses were obtained when the entire cavity of the partitions were filled with a sound absorptive material. When the entire cavity is filled, caution must be taken not to use a material that is too dense, otherwise a mechanical coupling could occur between the two sides of the partition which could result in a degradation of the sound isolating performance of the partition, as was observed in the case of a partition whose cavity was filled with sprayed-on cellulose.

- Inserting a panel in the middle of a double wood stud partition, making it a triple leaf partition, substantially increases the transmission loss above 250 Hz (frequencies for human speech) so long as the panel does not create a mechanical link between the two rows of studs. The use of a fiberboard panel seems to be superior to that of a gypsum board for this application. However, inserting a third panel, wether it be made of gypsum or fiberboard, reduces the transmission loss at low frequencies (stereo systems, home theater) as well as the STC rating of the partition. Installing an additional gypsum board on the outside of a double stud partition seems preferable to installing it in the middle of the partition: it provided equivalent sound isolation at mid and high frequencies and noticeably better sound isolation at low frequency, which in turn increased the STC rating of the partition by 7 points.

- The use of gypsum board gussets to bridge and stiffen the two rows of steel studs in a double stud partition substantially deteriorates its transmission loss at mid and high frequencies.

- Double stud (wood or metal) partitions provide better sound isolation than single stud partitions because of the greater depth of the cavity inside the partition, but also because of the greater mechanical decoupling between the two sides of the partition achieved by the two separate rows of studs.

- Staggered wood stud partitions are a compromise between single and double stud partitions: the depth of the cavity of such partitions is between that of a single and a double stud partition, and the mechanical decoupling achieved from the staggered studs is not quite as good as that achieved with a double row of studs, but better than a single wood stud partition constructed with the gypsum boards mounted directly to the studs (i.e. no resilient furrings).

CONTRIBUTION TO THE CONSTRUCTION INDUSTRY

The first phase of this study completed by the Institute of Research in Construction provided a large database documenting the sound transmission loss provided by the gypsum board partition compositions commonly used. All the measurements have been conducted under the same acoustical conditions inside the acoustics laboratory of the National Research Council of Canada, using the most recent measuring methods, which makes it a very reliable database. In addition to acoustical data, the reports published by the IRC document the physical characteristics of the materials entering in the composition of the partitions, as well as the methods used to construct the partitions, which was rarely the case in the preceding studies.

Using the database created by the IRC, the present research project report highlighted the main factors influencing the acoustical performance of gypsum board partitions (the gypsum boards themselves, the studs and stud arrangements, the resilient furrings, and the sound absorptive materials inserted in the cavity) and hence to optimize the acoustical performance of these partitions in function of their composition and cost.

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