Apparent sound insulation in cold-formed steel-framed buildings

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Apparent Sound Insulation in Cold-Formed Steel-Framed Buildings

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Scope

This Report presents the results from substantial experimental studies of sound transmission, together with an explanation of calculation procedures to predict the sound transmission between adjacent spaces in a building whose walls and floors have cold-formed steel (CFS) framing.

This first edition contains mainly data for loadbearing steel framing formed from sheet steel with thickness from 1.37 mm (16 gauge) to 0.94 mm (20 gauge).

Non-loadbearing CFS studs formed from thinner steel (nominally 0.54 mm) are also commonly used but these are not included in the data tables for sound transmission through wall assemblies in this Report.

Acknowledgments

The research studies on which this Report is based were supported by the Canadian Sheet Steel Building Institute. The financial support and guidance on construction practices are gratefully acknowledged.

Disclaimer

Although it is not repeated at every step of this Report, it should be understood that some variation in sound insulation is to be expected in practice due to changes in the specific design details, poor workmanship, substitution of “generic equivalents”, or simply rebuilding the construction. It would be prudent to allow a margin of error of several ASTC points to ensure that a design will satisfy a specific requirement.

Despite this caveat, the authors believe that methods and results shown here do provide a good estimate of the apparent sound insulation for the types of constructions presented.

Contents

1 Sound Transmission via Many Paths

The simplest approach to sound transmission between adjacent rooms in buildings considers only the sound transmission through the separating wall or floor. This perspective has been entrenched in North American building codes, which for many decades have considered only the ratings for the separating assembly: sound transmission class (STC) or field sound transmission class (FSTC) for airborne sources and impact insulation class (IIC) for footstep noise.

Implicit in this approach (illustrated in Figure 1.1) is the simplistic assumption that sound is transmitted only through the obvious separating assembly – the separating wall assembly when the rooms are side-by-side, or the floor/ceiling assembly when rooms are one-above-the-other. If the sound insulation is inadequate, this is attributed to errors in either the design of the separating assembly or the workmanship of those who built it, and remediation focusses on that assembly. Unfortunately, this paradigm is still common among designers and builders in North America.

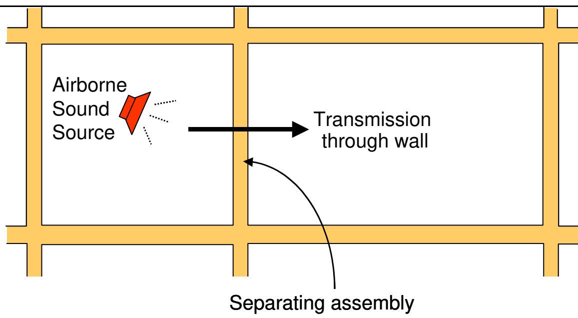


Figure 1.1: The drawings in Figure 1.1 and 1.2 show a cross-section through a building with two adjacent rooms. Part of the sound from an airborne source in one unit (represented by red loudspeaker in the drawings, which could include anything from a home theatre to people talking loudly) is transmitted to the adjacent unit. The historic approach, illustrated in Figure 1.1, considers *only* the direct sound transmission through the separating assembly.

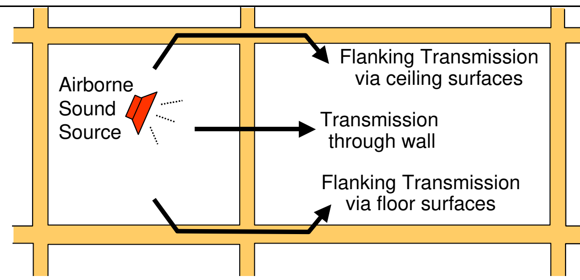


Figure 1.2: In reality, there are many paths for sound transmission between adjacent rooms, including both direct transmission through the separating assembly and indirect structure-borne paths, a few of which are indicated here (see Section 1.4 for more detail.) The structure-borne paths usually significantly affect the overall sound transmission.

In reality, the technical issue is more complex, as illustrated in Figure 1.2. There is direct transmission of sound through the separating assembly, but that is only part of the story of how sound is transmitted between adjacent rooms. As shown in the figure, the airborne sound source excites all the surfaces in the source space and all of these surfaces vibrate in response. Some of this vibrational energy is transmitted as structure-borne sound across the surfaces abutting the separating assembly, through the junctions where these surfaces join the separating assembly, and into surfaces of the adjoining space. These surfaces in the receiving room then radiate part of the vibrational energy as airborne sound. The sound transmission by these paths is called flanking sound transmission.

It follows that the sound insulation between adjacent rooms is always worse than the sound insulation provided by the obvious separating assembly. Occupants of the adjacent room actually hear the combination of sound due to direct transmission through the separating assembly plus sound due to structure-borne flanking transmission involving all the other elements coupled to the separating assembly. Furthermore, there is also transmission of sound through leaks (openings) in the walls. The importance of including all of the transmission paths has long been recognized in principle (and the fundamental science was largely explained decades ago, by Cremer et al [8]). The challenge has been to reduce the complicated calculation process to manageable engineering that yields trustworthy quantitative estimates, and to standardize that process to facilitate its inclusion in a regulatory framework.

For design or regulation, there is well-established terminology to describe the overall sound transmission including all paths between adjacent rooms. ISO ratings such as the weighted apparent sound reduction index (R'_w) have been used in many countries for decades, and ASTM E336 defines the corresponding apparent sound transmission class (ASTC), which is used in the examples in this Report.

Although measuring the ASTC in a building (following ASTM Standard E336) is quite straightforward, predicting the ASTC due to the set of transmission paths in a building is more complex. However, standardized frameworks for calculating the overall sound transmission have been developed. These start from standardized measurements to characterize sub-assemblies, and have been used for more than a decade to support performance-based European code systems.

In 2005, ISO published a calculation method, ISO 15712-1, "Building acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 1: Airborne sound insulation between rooms". This is one part of a series of standards: Part 2 deals with "impact sound insulation between rooms", Part 3 deals with "airborne sound insulation against outdoor sound", and Part 4 deals with "transmission of indoor sound to the outside".

There are two significant impediments to applying the methods of ISO 15712-1 in a North American context:

- ISO 15712-1 provides very reliable estimates for buildings constructed from heavy, homogeneous building elements, but not for buildings constructed from lightweight (steel- or wood-) framed elements widely used in North America.
- ISO standards for building acoustics have many differences from the ASTM standards used by the construction industry in North America – both in their terminology and in specific technical requirements for measurement procedures and ratings.

The following sections of this chapter outline a strategy for dealing with these limitations, both explaining how to merge ASTM and ISO test data and procedures, and providing recommendations for adapting the calculation procedures for cold-formed steel-framed constructions.

This Report was developed in a project established by the National Research Council Canada and the Canadian Sheet Steel Building Institute to support the transition of construction industry practice to using ASTC rather than STC for sound control objectives in the National Building Code of Canada (NBCC). However, the potential range of application goes beyond the minimum requirements of the NBCC. The Report also facilitates design to provide enhanced levels of sound insulation, and should be generally applicable to construction with CFS-framed assemblies in both Canada and the USA.

1.1 Predicting Sound Transmission in a Building

As noted above, ISO 15712-1 provides reliable estimates for buildings constructed from heavy, homogeneous building elements, but it is less accurate for other common types of construction, especially for constructions whose stiffness is directional such as lightweight wood-framed and steel-framed constructions.

ISO 15712-1 has other limitations, too. For example, in several places (especially for lightweight framed construction) the Standard identifies situations where the detailed calculation is not appropriate, but does not provide specific guidance on how to deal with such cases. Many of these limitations can be overcome by using data from laboratory testing following the procedures of the ISO 10848 series of standards; the four parts of ISO 10848 were developed by working groups of ISO TC43/2 to deal with measuring flanking transmission for various combinations of construction types and junctions. Because the current (2005) edition of ISO 15712-1 replicates a European standard developed before 2000, it does not reference more recent standards such as the ISO 10848 series, or the ISO 10140 series that are replacing the ISO 140 series referenced in ISO 15712-1. The 2015 edition of the National Building Code of Canada deals with these issues by specifying suitable procedures and test data to deal with calculating ASTC for different types of construction. These procedures are also explained in the NRC Research Report RR-331, "Guide to Calculating Airborne Sound Transmission in Buildings."

For CFS-framed constructions[1], the normal calculation procedure of ISO 15712-1 (both the Detailed Method and the Simplified Method) must be modified to obtain accurate results. This Report outlines the steps of the calculation process and the standard measurement data required for such calculations. These modifications are consistent with the requirements in the 2015 edition of the National Building Code of Canada.

This Report is restricted to consideration of buildings where all wall and floor assemblies are framed with cold-formed steel (CFS) studs or joists. The scope could be expanded to include the combination of CFS-framed assemblies with heavy concrete floor assemblies, by measuring the flanking sound transmission for such combinations following the procedures of ISO 10848. However, at the time of publication of this report, such data was not available.

In order to respect copyright, the Report does not reproduce the equations of ISO 15712-1, but it does indicate which equations apply in each context and provides key adaptations of the ISO expressions needed to apply the concepts in an ASTM context.

1.2 Standard Scenario for Examples in this Report

The prediction of the sound transmitted in buildings depends not only on the construction details of the transmission paths, but also on the size and shape of each of the room surfaces and on the sound absorption in the receiving room. The ability to adjust the calculation to fit the dimensions in a specific building or to normalize to different receiving room conditions enables a skilled designer to obtain more accurate predictions.

However, for purposes of this Report where results will be presented for a variety of constructions, easy and meaningful comparison of results is facilitated by calculating all the examples for a common set of room geometry and dimensions. This is particularly useful where only small changes are made between the construction details in the examples, since any change in the ASTC rating can then be attributed to the changes which were made in the construction details.

Therefore, a Standard Scenario has been adopted for all the examples, with the following constraints:

- Sound is transmitted between adjacent rooms, either side-by-side or one-above-the-other.
- The adjacent rooms are mirror images of each other, (with one side of the separating assembly facing each room, and constituting one complete face of each rectangular room).

The Standard Scenario is illustrated in Figures 1.3 and 1.4, for the cases where one room is beside the other, or one is above the other, respectively.

Figure 1.3:
Standard Scenario for the "horizontal room pair" case where the pair of rooms are side-by side with a separating wall assembly between the two rooms.

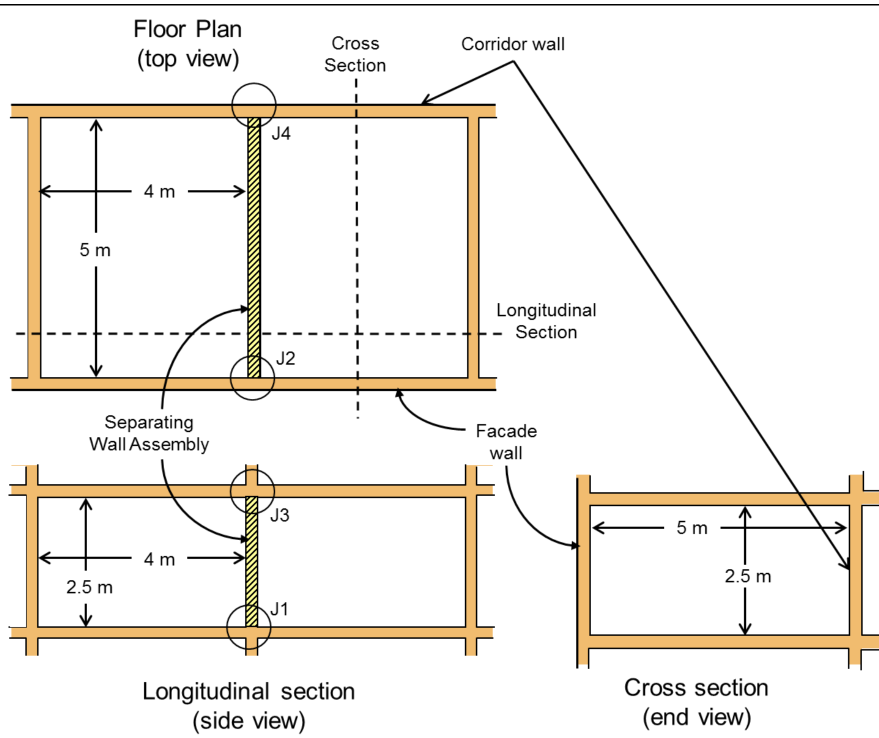
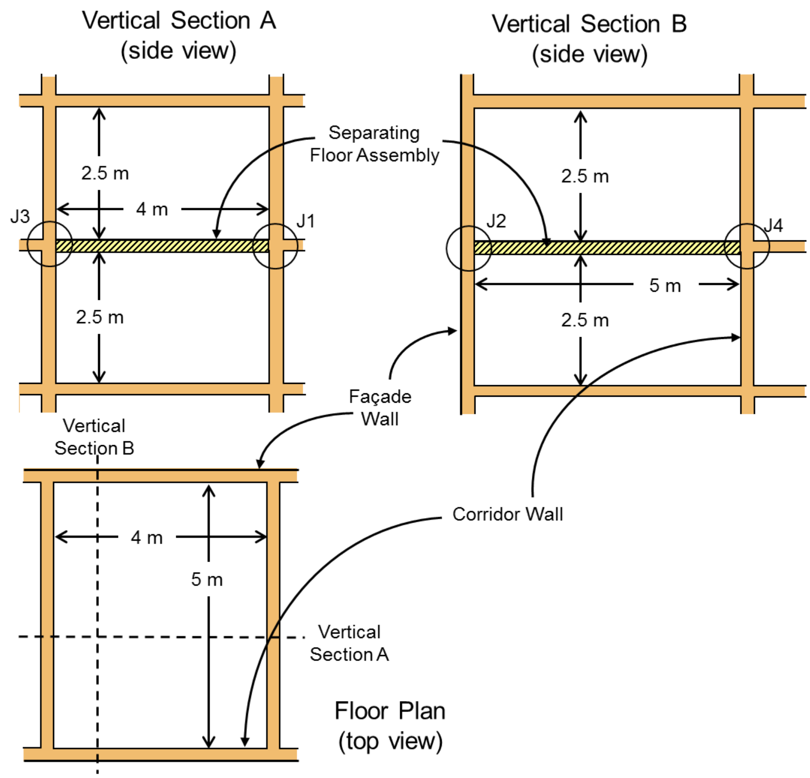


Figure 1.4:
Standard Scenario for the "vertical room pair" case where one of the pair of rooms is above the other, with the floor/ceiling assembly between the two rooms.



The pertinent dimensions and junction details are shown in Figures 1.3 and 1.4.

- Note the labelling of junctions at the four edges of the separating assembly (J1 to J4) in Figures 1.3 and 1.4. These junction designations are used in the design examples throughout this Report.
- For horizontal room pairs (i.e. rooms are side-by-side) the separating wall is 2.5 m high by 5 m wide, flanking floor/ceilings are 4 m by 5 m and flanking walls are 2.5 m high by 4 m wide.
- For vertical room pairs (i.e. one room is above the other) the separating floor/ceiling is 4 m by 5 m wide and flanking walls in both rooms are 2.5 m high.
- In general, it is assumed that junctions at one side of the room (at the separating wall if rooms are side-by-side) are cross-junctions, while one or both of the other two junctions are T-junctions. This enables the examples to illustrate typical differences between the two common junction cases.
- For a horizontal pair, the separating wall has T-junctions with the flanking walls at both the façade and corridor sides, and cross-junctions at floor and ceiling.
- For a vertical pair, the façade wall has a T-junction with the separating floor, but the opposing corridor wall has a cross-junction, as do the other two walls.

In practice, cases with cross-junctions at separating walls on either side and at the corridor side seem quite common. Deviations from the Standard Scenario, such as room pairs where one room is an end unit with T-junctions instead of cross-junctions, should tend to result in slightly higher ASTC ratings than the Standard Scenario.

1.3 Applying the Concepts of ISO Standards in an ASTM Environment

Although the building acoustics standards developed by ASTM are very similar in concept to the corresponding ISO standards, there are differences in the terminology and technical requirements between the two which present numerous barriers to using a mix of standards from the two domains.

Although the ASTM standard E336 recognizes the contribution of flanking to apparent sound transmission, there is neither an ASTM standard for measuring the structure-borne flanking transmission that often dominates sound transmission between rooms, nor an ASTM counterpart of ISO 15712-1 for predicting the combination of direct and flanking transmission. In the absence of suitable ASTM standards, this Report uses the procedures of ISO 15712-1 and data from the complementary ISO 10848 series, but connects this ISO calculation framework to the ASTM terms and test data widely used by the North American construction industry. This methodology combines identifying where data from ASTM laboratory tests can reasonably be used in place of their ISO counterparts, and presenting the results using ASTM terminology (or new terminology for flanking transmission that is consistent with existing ASTM terms) to facilitate their use and understanding by a North American audience. Some obvious counterparts in the terminology are presented in Table 1.1.

ISO Designation	Description	ASTM Counterpart
ISO 10140 Parts 1 and 2 (formerly ISO 140-3)	Laboratory measurement of airborne sound transmission through a wall or floor	ASTM E90
sound reduction index, R (from ISO 10140-2)	Fraction of sound power transmitted (in dB) at each frequency, in laboratory test	sound transmission loss TL (ASTM E90)
weighted sound reduction index, R_w (ISO 717-1)	Single-number rating determined from R or TL values in standard frequency bands	sound transmission class STC (ASTM E413)
apparent sound reduction index, R’ (ISO 140-4)	Fraction of sound power transmitted (expressed in dB) at each frequency, including all paths in a building	apparent sound transmission loss ATL (ASTM E336)
weighted apparent sound reduction index, R'_w (ISO 717-1)	Single-number rating determined from R’ or ATL values in standard frequency bands	apparent sound transmission class, ASTC (ASTM E413)

Table 1.1: Standards and terms used in ISO 15712-1 for which ASTM has close counterparts

Note that the description “counterpart” does not imply that the ASTM and ISO standards or terms are exactly equivalent. R_W and STC are not interchangeable. Neither are R'_W and ASTC because of systematic differences in the calculation procedures. However, the laboratory test used to measure airborne sound transmission through wall or floor assemblies – ASTM E90 and its counterpart ISO 10140-2 – are based on essentially the same procedure, with minor variants in facility requirements. Therefore, the measured quantities “sound transmission loss” from the ASTM E90 test and “sound reduction index” from the ISO standard are sufficiently similar so that data from ASTM E90 tests can be used in place of data from ISO 10140-2 tests in the calculations of ISO 15712-1 to obtain a sensible answer. Similarly, the simplified calculation of ISO 15712-1 may be performed using STC ratings to predict the ASTC rating. The close parallel between “sound reduction index” and “sound transmission loss” also means that results from ISO 15712-1 calculations (normally expressed as R’ values) can confidently be treated as calculated apparent sound transmission loss (ATL) values and then used in the procedure of ASTM E413 to calculate the ASTC rating which is the objective for designers or regulators in the North American context.

For purposes of this Report, a glossary of new terms with counterparts in ISO 15712-1 (using terminology consistent with measures used in ASTM standards) and of other key terms from pertinent ISO standards such as ISO 15712 and ISO 10848 is presented in Table 1.2.

Terms used in this Report	Description
Structural reverberation time (T_S)	Structural reverberation time is a measure indicating the rate of decay of vibration energy in an element and can apply either to a laboratory wall or floor specimen, or to a wall or floor assembly in-situ in a building.
Transmission loss in-situ (TL_{situ})	Transmission loss in-situ is the counterpart of sound reduction index in-situ (R_{situ}) described in ISO 15712 as "the sound reduction index of an element in the actual field situation".
Flanking sound transmission loss (Flanking TL_{ij})	Flanking transmission loss is the counterpart of flanking sound reduction index (R_{ij}) in ISO 15712. It is a measure of sound transmission via the flanking path from element i in the source room to element j in the receiving room, normalised like apparent sound transmission loss, as described in Section 1.4.
Flanking sound transmission class (Flanking STC_{ij})	Flanking STC is the single-number rating calculated from the flanking transmission loss following the STC calculation procedure of ASTM E413.

Table 1.2: Key terms used in this Report to deal with concepts from ISO 15712-1 and ISO 10848 for which ASTM acoustics standards have no counterparts.

In addition, several scientific terms used in ISO-15712 at various stages of the calculation have been used without change. These include: radiation efficiency, internal loss factor, total loss factor, equivalent absorption length, and transmission factor. They are described in the glossary in Annex A of ISO 15712-1.

1.4 Combining Sound Transmitted via Many Paths

The calculations of ISO 15712-1 must deal with combining the sound power transmitted via the direct path and via a set of flanking paths. To discuss this, it is useful to introduce the convention for labelling the transmission paths that is used in ISO 15712-1, as explained in Figure 1.5.

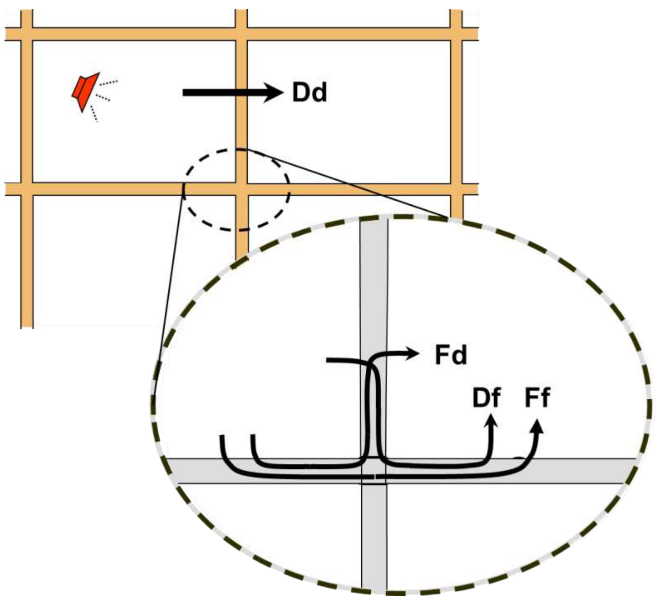


Figure 1.5: This figure shows the labelling convention for transmission paths used in ISO 15712-1. Consider transmission from a source room at the left to the receiving room beside it. Each transmission path involves one surface in the source room (denoted by a capital letter) and one in the receive room (lower case). Direct transmission through the separating wall is path **Dd**. For each edge of the separating assembly there are three flanking paths, each involving a surface in the source room and one in the receiving room, that connect at this edge: **Ff** from flanking surface F to flanking surface f, **Df** from direct surface D to flanking surface f, and **Fd** from flanking surface F to direct surface d in the receiving room.

Note that the letter "F" or "f" denotes **f**lanking surface, and "D" or "d" denotes the surface for **d**irect transmission, i.e. the surface of the separating assembly. These surfaces may be either wall or floor/ceiling assemblies, as detailed in the following Table 1.3.

Room Pair	Surfaces D and d	Flanking Surfaces F and f	Junction (Standard Scenario)
Horizontal (Fig. 1.3)	Separating wall	Junction 1: floor F and f Junction 2: façade wall F and f Junction 3: ceiling F and f Junction 4: corridor wall F and f	Cross junction T-junction Cross junction T-junction
Vertical (Fig. 1.4)	Separating floor/ceiling	Junction 1: wall F and f Junction 2: façade wall F and f Junction 3: wall F and f Junction 4: corridor wall F and f	Cross junction T-junction Cross junction Cross junction

Table 1.3: Surfaces (D, d, F and f) for flanking paths at each junction, as in the Standard Scenario

In Canada, building elements are normally tested according to the ASTM E90 [1] standard and building code requirements are given in terms of apparent sound transmission class (ASTC) determined from the apparent sound transmission loss (ATL) for the set of frequency bands from 125 Hz to 4000 Hz, following the procedure in ASTM E413. Merging this context with using the ISO 15712-1 procedures in this Report, the terms "direct sound transmission loss" and "flanking sound transmission loss" have been introduced to provide consistency with ASTM terminology while matching the function of the direct and flanking sound reduction indices defined in ISO 15712-1.

Section 4.1 of ISO 15712-1 defines a process to calculate apparent sound transmission by combining the sound power transmitted via the direct path and the twelve first-order flanking paths (3 at each edge of the separating assembly, as illustrated in Figure 1.5). Equation 14 in ISO 15712-1 is recast here with slightly different grouping of the paths (treating the set of paths at each edge of the separating assembly in turn) to match the presentation approach chosen for the examples in this Report.

The apparent sound transmission loss (ATL) between two rooms (assuming the room geometry of Section 1.2 and neglecting sound that is by-passing the building structure, for example sound transmitted through leaks and ducts) is the resultant of the direct sound transmission loss (TL_{Dd}) through the separating wall or floor element and the set of flanking sound transmission loss contributions of the three flanking paths (TL_{Ff}, TL_{Fd}, and TL_{Df}) for each junction at the four edges of the separating element as shown in Fig. 1.5.

$$ATL = -10 \cdot \log_{10}\left(10^{-0.1\cdot TL_{Dd}} + \sum_{edge=1}^{4}\left(10^{-0.1\cdot TL_{Ff}} + 10^{-0.1\cdot TL_{Fd}} + 10^{-0.1\cdot TL_{Df}}\right)\right) \quad \text{Eq. 1.1}$$

Note that this equation differs slightly from the calculation of the apparent sound transmission defined in Equation 14 of ISO 15712-1. Eq. 1.1 of this Report treats the set of paths at each edge of the separating assembly in turn to match the presentation for the examples in this Report. Eq. 1.1 is universally valid for all building systems, and the remaining challenge is to find the right expressions to calculate the path transmission for the chosen building system and situation.

Each of the flanking sound transmission loss values for a specific path is normalized like the apparent sound transmission loss, and can be considered as the ATL that would be observed if only this single path were contributing to the sound transmitted into the receiving room. Normalization of direct and flanking transmission input data so that the receiving room absorption is numerically equal to the area of the separating assembly (i.e. using apparent sound transmission loss and ASTC as the measure of system performance) requires suitable corrections to data calculated according to ISO 15712-1, or values of flanking transmission loss from laboratory testing according to ISO 10848, so that the set of path transmission loss values can be properly combined or compared. This normalization process is fully described in the calculation procedures in Chapter 4.

The standard ISO 15712-1 describes two methods of calculating the apparent sound insulation in a building: the Detailed Method and the Simplified Method. This Report describes the Simplified Method to calculate the apparent sound insulation in a building consisting of CFS-framed elements. The Simplified Method uses the single-number ratings (STC or Flanking STC for each transmission path) instead of the frequency-dependent transmission loss values and yields the ASTC directly:

$$ASTC = -10 \cdot \log_{10}\left[10^{-0.1 \cdot STC_{Dd}} + \sum_{edge=1}^{4}\left(10^{-0.1 \cdot STC_{Ff}} + 10^{-0.1 \cdot STC_{Fd}} + 10^{-0.1 \cdot STC_{Df}}\right)\right] \quad \text{Eq. 1.2}$$

The Simplified Method has been widely used by designers in Europe for many years for calculations based on R_W data. Its primary advantage is the simplicity of the procedure, which makes it usable by non-specialists, as illustrated by the worked examples in Section 4.2. Although it is less rigorous than the Detailed Method, the differences between the results using the two methods are small, and the calculations for the Simplified Method use approximations that should ensure the results are slightly conservative.

Cautions and limitations to examples presented in this Report:

This Report was developed to support the transition to ASTC ratings for sound control objectives in the National Building Code of Canada. Simplifications were made to meet the specific needs of that application, where sound insulation is addressed only in the context of multi-unit residential buildings. The simplifications include that:

- Transmission around or through the separating assembly due to leaks at its perimeter or penetrations such as ventilation systems are assumed negligible.
- Indirect airborne transmission (for example airborne flanking via an unblocked attic or crawl space) is assumed to be suppressed by normal fire blocking requirements.

For adjacent occupancies in a multi-family residential building, these two issues should be dealt with by normal good practice for fire and sound control between adjoining dwellings.

If this Report is applied to situations other than separation between adjacent units in multi-family residential buildings, some of these issues may have to be explicitly addressed in the calculation process. For example, for adjoining rooms within a single office or home, flanking paths such as ventilation ducts or open shared plenum spaces may be an issue. The flanking transmission associated with these additional paths should be determined and included in the calculated ASTC. ISO 15712-1 includes specific guidance for such issues, and the examples in this Report allow for such a correction.

2 Sound Transmission through CFS-Framed Walls and Floors

This chapter presents the results of experimental sound transmission loss tests of wall and floor assemblies with several variants of CFS framing. The tested assemblies include assemblies with a variety of framing details and linings covering the surfaces of the CFS framing.

ASTM E90 Test Method

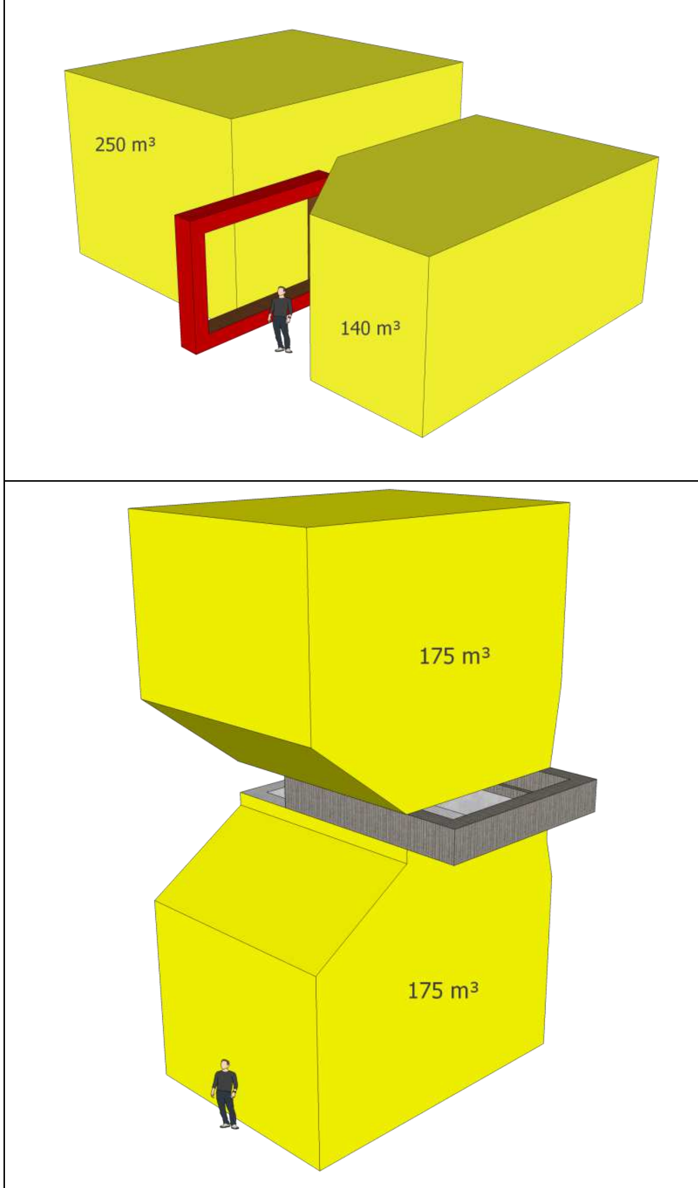
Transmission loss tests of wall and floor specimens were conducted in NRC's Wall and Floor Sound Transmission Facilities according to the ASTM E90 test protocol [1]. Concept drawings of the sound transmission facilities are presented in Figure 2.1.

Figure 2.1: A concept drawing of the Wall Sound Transmission Facility at the NRC is presented in the upper drawing. The NRC Floor Sound Transmission Facility, shown in the lower drawing, is similar except that one room is above the other.

In both cases, full scale test assemblies are mounted in the massive concrete movable test frames between the two reverberant rooms. The test openings are 3.66 m wide and 2.44 m high for walls and 4.70 m by 3.78 m for floors.

In the wall facility, the rooms (designated "large chamber" and "small chamber") have approximate volumes of 250 m^3 and 140 m^3 respectively. In the floor facility, both chambers have volumes of approximately 175 m^3. All the facility rooms are hard-walled reverberation chambers that are vibration-isolated from each other and from the specimen frame. The rooms have fixed and/or moving diffusor panels to enhance diffusivity of the sound fields.

The facilities (including instrumentation) and the test procedures satisfy or exceed all requirements of ASTM E90.



Each facility is equipped with an automated measurement system for data acquisition and post processing. In each room, a calibrated Brüel & Kjær condenser microphone (type 4166 or 4165) with preamp is moved under computer control to nine positions, and measurements are made in both rooms using a National Instruments NI-4472 data acquisition system installed in a computer. Each room has four bi-amped loudspeakers driven by separate amplifiers and noise sources. To increase randomness of the sound field, there are fixed diffusing panels in each room.

Measurements of the airborne sound transmission loss (TL) were conducted in accordance with the requirements of ASTM E90-09, "Standard Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions". Airborne sound transmission loss tests were performed in both directions – from the large chamber to the small chamber and vice-versa for walls, and from the upper chamber to the lower chamber and vice-versa for floors. The results presented in this Report are given as the average of the two transmission directions to reduce measurement uncertainty due to factors such as calibration errors and local variations in the sound fields.

For every measurement, sound transmission loss values were calculated from the average sound pressure levels in the source room and the receiving room and the average reverberation times of the receiving room. One-third octave band sound pressure levels were measured for 32 seconds at nine microphone positions in each room and then averaged to get the average sound pressure level in each room. Five sound decays were averaged to get the reverberation time at each microphone position in the receiving room; these times were averaged to get the average reverberation times for each room.

The frequency-dependent sound transmission loss was measured in one-third octave bands in the frequency range from 50 Hz to 5000 Hz. However, only the frequency range between 125 Hz and 4000 Hz is considered in the calculation of the sound transmission class (STC) single-number rating according to ASTM E413 [3].

The impact sound transmission was also measured with both the standardized tapping machine (according to ASTM E492) and the heavy soft rubber ball (according to ISO 10140), but those results are not within the scope of this edition of this Report.

The sound transmission loss data are presented as follows in this Report:

- The sets of one-third octave band sound transmission loss results from 50 Hz to 5000 Hz are presented in the Appendix A1.
- Graphs of the transmission loss data for some wall and floor assemblies are presented in the discussion of trends in Sections 2.2.1 and 2.3.1.
- This chapter presents a more compact summary of results in terms of the single-number STC ratings that are required for the calculations in Chapter 4 to determine the ASTC rating.

2.1 Coding System for Specimen Descriptions

A coding system is used throughout this Report to avoid long descriptions of floor or wall constructions. Each surface layer in a floor or wall is coded as follows:

- An integer representing the number of layers of material; if the number of layers is one, the leading 1 is omitted;
- A sequence of letters to indicate the material in the layer (see Table 2.1 below);
- A number representing the thickness in mm of each sheet or element in the layer;
- Underscores separating the codes for each layer.

The coding system is also applied to elements that do not constitute surface layers such as joists, studs, and resilient metal channels. For such elements, the number following the letters is the depth of each element (the dimension along the axis perpendicular to the surface of the assembly) and the number in parentheses following the depth code is the separation between adjacent elements.

Table 2.1: Examples of the codes used to identify materials and to describe constructions.

Code	Material
CARxx	Carpet “xx” mm thick
VINxx	Vinyl sheet flooring “xx” mm thick
LAMxx	Laminate flooring planks “xx” mm thick
CONxx	Concrete “xx” mm thick
Gxx	Gypsum board “xx” mm thick
GCONxx	Gypsum concrete “xx” mm thick
GFBxx	Glass fibre batts “xx” mm thick
MFBxx	Mineral fibre batts “xx” mm thick
CFLxx	Blown-in cellulose fibre “xx” mm thick
OSBxx	Oriented strand board “xx” mm thick
SJxx(ss)	Cold-formed steel (CFS) C-joists with nominal depth of “xx” mm, spaced “ss” mm on centers
SSxx(ss)	Cold-formed steel (CFS) studs with nominal depth of “xx” mm, spaced “ss” mm on centers
RCxx(ss)	Resilient metal channels with nominal depth of “xx” mm, spaced “ss” mm on centers
CORSTExx	Corrugated steel deck formed with profile “xx” mm deep

Note that the coding system is a convenience and actual dimensions may not be exactly as coded. For example, the nominal 16 mm thick gypsum board would be labelled by the manufacturer as 5/8 in or 15.9 mm thick. Other details are given for each specimen in Sections 2.2 and 2.3 and in the appendices.

For brevity, not all pertinent parameters are included in the short codes. For example, the thickness of the steel in CFS joists or studs is not indicated. This information is given separately in specimen descriptions in the tables of measurement results and the calculation examples.

Thus the code OSB15_SJ203(406)_GFB150_RC13(610)_2G16 describes a floor with the following construction details:

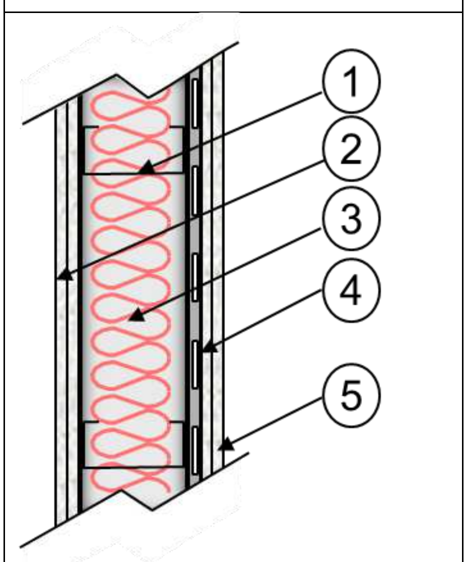
- A 15 mm thick oriented strand board subfloor;
- 38 x 203 mm cold-formed steel joists, spaced 406 mm on centers;
- 150 mm thick glass fibre batts in the joist cavities;
- 12.7 mm deep resilient metal channels screwed to the joists and oriented perpendicular to the joists, spaced 610 mm on centers;
- Two layers of gypsum board, each 15.9 mm thick, attached to the resilient metal channels.

2.2 Wall Assemblies with CFS Framing

The focus of this section is the measured sound transmission loss of wall assemblies comprised of a frame of cold-formed steel (CFS) studs with gypsum board attached on both sides of the studs. The gypsum board was either fastened directly to the studs or supported on resilient metal channels. Most of the tested assemblies had sound absorbing material in the cavities between the studs.

The typical construction of the wall specimens tested as part of this study had a single row of loadbearing CFS studs as shown in Figure 2.2.1.

Figure 2.2.1:
Horizontal cross-section of a wall assembly with a single row of loadbearing CFS studs showing typical components. Variations and element properties are listed in more detail on the right.



Drawings are not to scale; see Figure 3.2.2 for a scale drawing of one variant.

1. Single row of cold-formed steel (CFS) loadbearing studs[1] (either 38 x 92 mm or 38 x 152 mm cross section) spaced either 406 mm or 610 mm on center.
2. Surface of 1 or 2 layers of fire-rated gypsum board[2] screwed directly to one face of the CFS studs. Gypsum board may be designated either as G13 (nominal thickness of 1/2 inch, 12.7 mm) or as G16 (nominal thickness of 5/8 inch, 15.9 mm).
3. Sound absorbing material[3] in the cavities between studs may be glass fiber batts (GFB) or mineral fiber batts (MFB) or blown-in cellulose fiber (CFL) of various thicknesses.
4. Resilient metal channels designated RC13 in the coding, formed from light sheet steel with suitable profile[4] and screwed to the faces of the CFS studs. Resilient channels spaced either 406 mm or 610 mm on center.
5. Surface of 1 or 2 layers of fire-rated gypsum board[2] screwed to resilient metal channels whose other flange is supported from the CFS studs. Gypsum board may be designated either as G13 (nominal thickness of 1/2 inch, 12.7 mm) or as G16 (nominal thickness of 5/8 inch, 15.9 mm).

NOTE: The wall tests reported here include a series of specimens tested in 2014, plus some specimens tested in 1999-2000. All aspects of the facility and measurement procedure were identical for the two datasets. For comparable cases, the STC rating differed by 0 or 1.

Table 2.2.1(a): Measured STC values for wall assemblies with a single row of loadbearing CFS studs[1] with a cross section of 38 x 152 mm. The results are numbered and organized in groups by common features within each group. Specimens 01-09 have no resilient metal channels. Specimens 11-19 have resilient metal channels but no sound absorbing material. Specimens numbered 21 or higher have both resilient metal channels and sound absorbing material. These are grouped by thickness of sound absorbing batts, spacing between studs, or thickness of the studs' steel.

Specimen ID	Descriptive Short Code	Steel Thickness	Test Reference	STC
CFS-S152-W01	G16_SS152(406)_GFB152_G16	1.37 mm	TLA-14-051	**42**
CFS-S152-W02	G16_SS152(406)_GFB152_2G16	1.37 mm	TLA-14-052	**45**
CFS-S152-W03	2G16_SS152(406)_GFB152_2G16	1.37 mm	TLA-14-053	**48**
CFS-S152-W11	G16_SS152(406)_RC13(406)_G16	1.37 mm	TLA-14-047	**42**
CFS-S152-W12	2G16_SS152(406)_RC13(406)_G16	1.37 mm	TLA-14-048	**47**
CFS-S152-W13	G16_SS152(406)_RC13(406)_2G16	1.37 mm	TLA-14-050	**48**
CFS-S152-W14	2G16_SS152(406)_RC13(406)_2G16	1.37 mm	TLA-14-049	**53**
CFS-S152-W21	G16_SS152(406)_GFB92_RC13(406)_G16	1.37 mm	TLA-14-044	**49**
CFS-S152-W22	2G16_SS152(406)_GFB92_RC13(406)_G16	1.37 mm	TLA-14-045	**53**
CFS-S152-W23	2G16_SS152(406)_GFB92_RC13(406)_2G16	1.37 mm	TLA-14-046	**57**
CFS-S152-W31	G16_SS152(406)_GFB152_RC13(406)_G16	1.37 mm	TLA-14-041,054,055	**49**
CFS-S152-W32	2G16_SS152(406)_GFB152_RC13(406)_G16	1.37 mm	TLA-14-056	**54**
CFS-S152-W33	2G16_SS152(406)_GFB152_RC13(406)_2G16	1.37 mm	TLA-14-042,057,059	**58**
CFS-S152-W34	2G13_SS152(406)_GFB152_RC13(406)_2G13	1.37 mm	TLA-14-043	**57**
CFS-S152-W41	G16_SS152(610)_GFB92_RC13(406)_G16	1.37 mm	TLA-14-063	**50**
CFS-S152-W42	2G16_SS152(610)_GFB92_RC13(406)_G16	1.37 mm	TLA-14-064	**55**
CFS-S152-W43	2G16_SS152(610)_GFB92_RC13(406)_2G16	1.37 mm	TLA-14-065	**59**
CFS-S152-W44	2G16_SS152(610)_GFB152_RC13(406)_2G16	1.37 mm	TLA-14-066	**60**
CFS-S152-W51	G16_SS152(406)_GFB152_RC13(406)_G16	1.09 mm	TLA-14-074	**50**
CFS-S152-W52	2G16_SS152(406)_GFB152_RC13(406)_G16	1.09 mm	TLA-14-075	**54**
CFS-S152-W53	2G16_SS152(406)_GFB152_RC13(406)_2G16	1.09 mm	TLA-14-076	**58**

NOTE: In some cases, tests were repeated on nominally identical specimens. In such cases, the STC values differed by 0 or 1, and the results were averaged; these cases can be identified in the table by their multiple test references.

Table 2.2.1(b): Measured STC values for wall assemblies with a single row of loadbearing CFS studs[1] with a cross section of 38 x 92 mm. The results are numbered and organized in groups by common features within each group. Specimens 01-02 have no resilient metal channels. Specimens 11-12 have resilient metal channels but no sound absorbing material. Specimens numbered 21 or higher have both resilient metal channels and sound absorbing material. These are grouped by thickness of the studs' steel (21-27 were designated as 16 gauge) or by spacing between the framing elements (studs or resilient channels).

Specimen ID	Descriptive Short Code	Steel Thickness	Test Reference	STC
CFS-S92-W01	G16_SS92(406)_GFB92_G16	1.37 mm	TLA-14-073	**38**
CFS-S92-W02	G13_SS92(406)_MFB89_2G13	0.94 mm	TLA-99-133a	**40**
CFS-S92-W11	2G13_SS92(406)_RC13(610)_2G13	0.94 mm	TLA-00-063a	**50**
CFS-S92-W12	2G16_SS92(406)_RC13(610)_2G16	0.94 mm	TLA-00-075a	**51**
CFS-S92-W21	G16_SS92(406)_GFB92_RC13(406)_G16	1.37 mm	TLA-14-067	**45**
CFS-S92-W22	G16_SS92(406)_GFB92_RC13(406)_2G16	1.50 mm	TLA-00-083a	**50**
CFS-S92-W23	2G16_SS92(406)_GFB92_RC13(406)_G16	1.37 mm	TLA-14-068	**52**
CFS-S92-W24	2G16_SS92(406)_GFB92_RC13(406)_2G16	1.37 mm	TLA-14-069	**57**
CFS-S92-W25	2G16_SS92(406)_GFB92_RC13(406)_2G16	1.50 mm	TLA-00-085a	**57**
CFS-S92-W26	2G13_SS92(406)_GFB92_RC13(406)_2G13	1.50 mm	TLA-00-079a	**57**
CFS-S92-W27	2G13_SS92(406)_MFB89_RC13(406)_2G13	1.50 mm	TLA-00-081a	**56**
CFS-S92-W31	G13_SS92(406)_GFB92_RC13(406)_G13	0.94 mm	TLA-00-105a	**45**
CFS-S92-W32	G13_SS92(406)_GFB92_RC13(406)_2G13	0.94 mm	TLA-00-103a	**51**
CFS-S92-W33	G13_SS92(406)_MFB89_RC13(406)_2G13	0.94 mm	TLA-99-127a,129a	**51**
CFS-S92-W34	G13_SS92(406)_CFL92_RC13(406)_2G13	0.94 mm	TLA-00-067a	**51**
CFS-S92-W35	G13_OSB12_SS92(406)_MFB89_RC13(406)_2G13	0.94 mm	TLA-99-135a	**57**
CFS-S92-W36	2G13_SS92(406)_GFB92_RC13(406)_2G13	0.94 mm	TLA-00-065a,101a	**57**
CFS-S92-W37	G16_SS92(406)_GFB92_RC13(406)_2G16	0.94 mm	TLA-00-069a	**51**
CFS-S92-W38	2G16_SS92(406)_GFB92_RC13(406)_2G16	0.94 mm	TLA-00-071a	**58**
CFS-S92-W41	G13_SS92(610)_MFB89_RC13(406)_2G13	0.94 mm	TLA-99-137a	**55**
CFS-S92-W51	G13_SS92(406)_GFB92_RC13(610)_G13	0.94 mm	TLA-00-095a	**47**
CFS-S92-W52	G13_SS92(406)_GFB92_RC13(610)_2G13	0.94 mm	TLA-00-097a	**54**
CFS-S92-W53	G13_SS92(406)_MFB89_RC13(610)_2G13	0.94 mm	TLA-99-123a	**52**
CFS-S92-W54	2G13_SS92(406)_GFB92_RC13(610)_2G13	0.94 mm	TLA-00-099a	**59**
CFS-S92-W55	G16_SS92(406)_GFB92_RC13(610)_G16	0.94 mm	TLA-00-089a	**49**
CFS-S92-W56	G16_SS92(406)_GFB92_RC13(610)_2G16	0.94 mm	TLA-00-091a	**54**
CFS-S92-W57	2G16_SS92(406)_GFB92_RC13(610)_2G16	0.94 mm	TLA-00-073a,093a	**59**

NOTE: In some cases, tests were repeated on nominally identical specimens. In such cases, the STC values differed by 0 or 1, and the results were averaged; these cases can be identified in the table by their multiple test references.

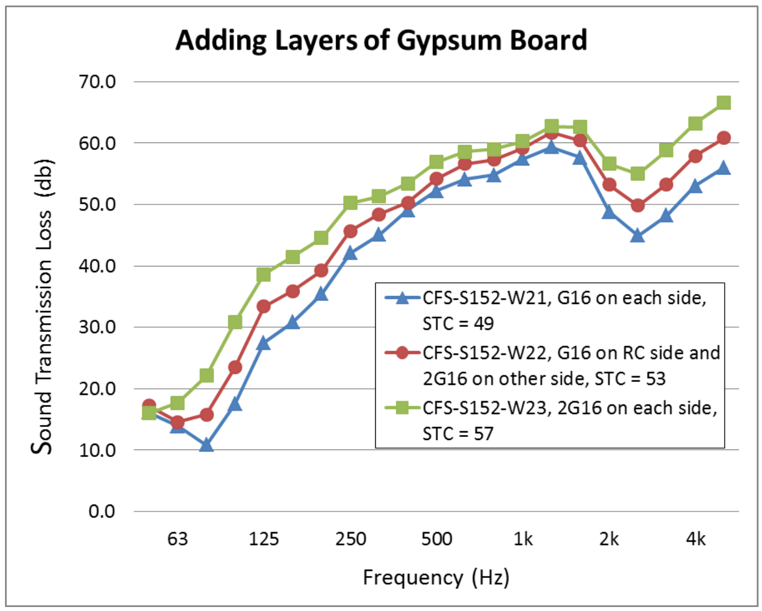
2.2.1 Trends in the Sound Transmission for CFS-Framed Walls

The effects of key parameters on the sound transmission loss of CFS-framed walls are described briefly in this section. A more thorough parametric study was presented in previous publications [16].

Effect of Gypsum Board Layers:

The change in the construction detail of the CFS-framed walls with the most obvious effect on the sound transmission loss values was the addition of extra layers of gypsum board. Figure 2.2.2 presents the sound transmission loss observed when an additional layer of gypsum board is added on each side of wall CFS-S152-W21 (which has resilient channels on one side).

Figure 2.2.2:
Sound transmission loss for a set of CFS-framed wall assemblies with identical framing and sound insulating batts, but different layers of gypsum board. Each of the three wall assemblies had resilient channels on one side.



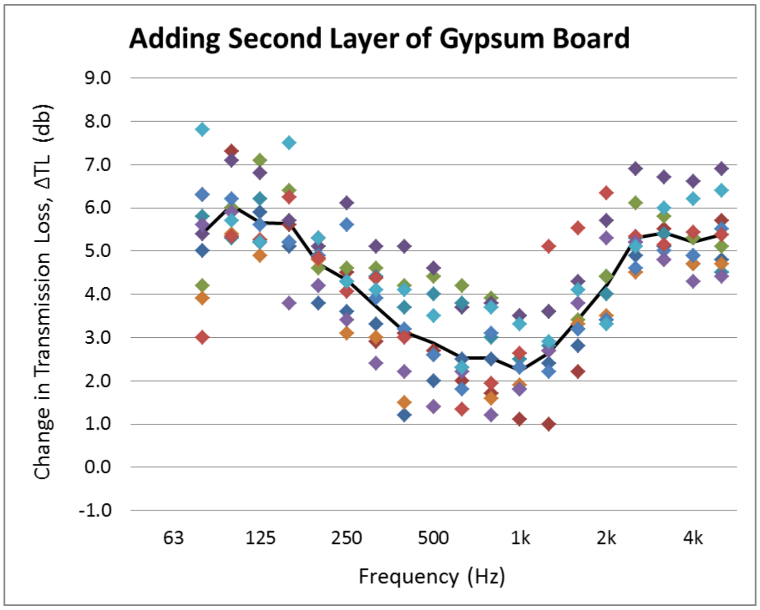
Changes very similar to those evident in Figure 2.2.2 were observed for other cases (different framing details, different insulation, different type of gypsum board, etc.) when a second layer of gypsum board was added on either side of the wall.

The individual changes and the mean change due to adding a second layer on either side are shown in Figure 2.2.3 for all the specimens with 152 mm CFS studs.

The individual changes due to adding a second layer of gypsum board were scattered around the mean, with a standard deviation of about 1 dB. There was a clear overall trend, with an increase in the sound transmission loss of 5 to 6 dB at the lower and higher frequencies and a broad dip in the mid frequencies. The trend is consistent between samples and the same trend was observed for the specimens with 92 mm CFS studs in this study, and in previous studies [13.6] including other types of framing.

Figure 2.2.3:
Change in sound transmission loss for pairs of CFS-framed wall assemblies with identical framing and sound insulating batts, when a second layer of gypsum board is added on either side.

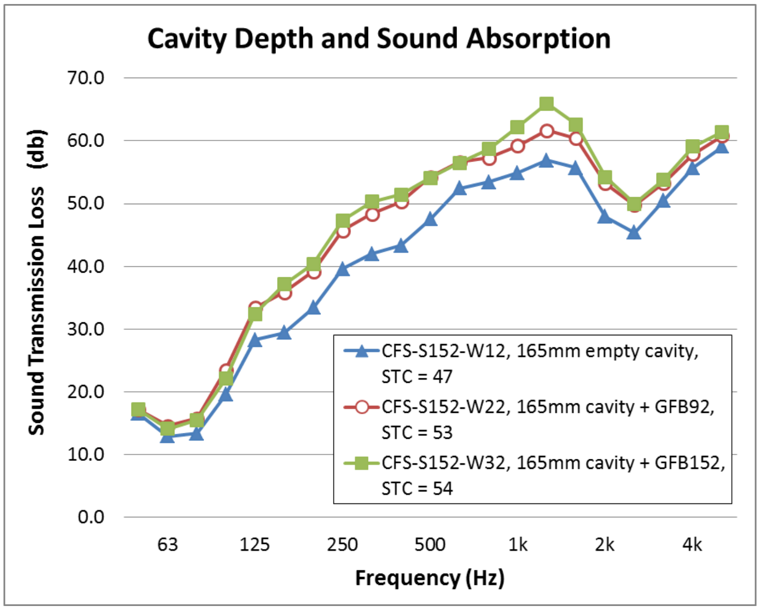
The mean change is shown by the solid line. Individual cases scatter around the mean with a standard deviation of about 1 dB for each third-octave band.



Effect of Cavity Absorption

Adding sound absorbing material to the wall cavity has a significant effect if the gypsum board on at least one side is mounted on resilient metal channels as shown in Figure 2.2.4.

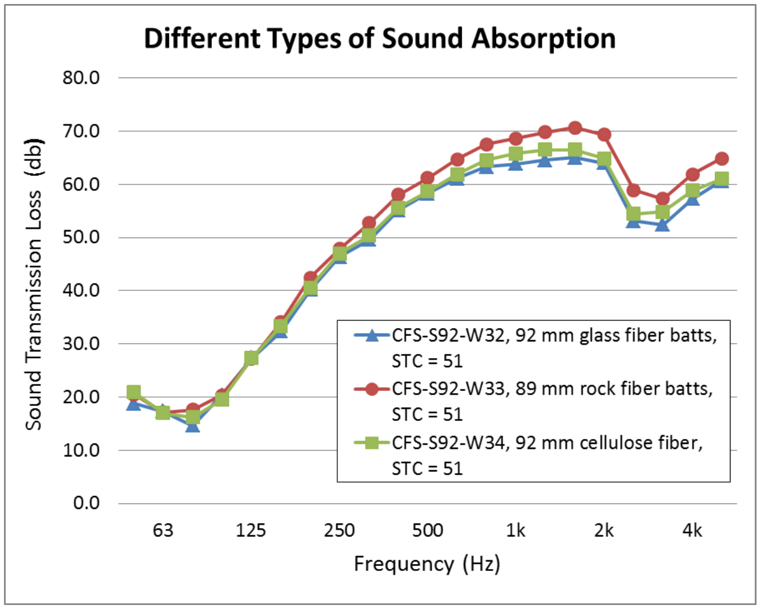
Figure 2.2.4:
Sound transmission loss for a set of CFS-framed wall assemblies with identical framing and layers of gypsum board, but different amounts of sound absorbing material in the inter-stud cavities.



The change in STC rating due to filling the inter-stud cavities with sound absorbing material is similar to the improvement observed when the layers of gypsum board are doubled on both sides. Partially filling the cavity (the case with 92 mm absorbing batts) provides most of the effect.

The effect of changing the type of sound absorbing material filling the cavities is shown in Figure 2.2.5.

Figure 2.2.5:
Sound transmission loss for a set of CFS-framed wall assemblies with identical framing and layers of gypsum board, but different types of sound absorbing material in the inter-stud cavities.



Although differences are evident among the sound transmission loss data with the 3 types of sound absorbing materials, the differences are insignificant between 100 Hz and 300 Hz (which are dominant in determining the STC rating for these specimens). All three specimens have an STC rating of 51, despite the change from glass fiber to mineral fiber to cellulose fiber. This minimal effect on the STC rating is consistent with the finding in previous NRC studies [13.7 and 13.8.] with other types of framing.

Effect of Other Parameters

The effect of other specimen parameters on the sound transmission loss can be summarized as follows:

- The thickness of the material used to fabricate the CFS studs has only a small effect. The STC rating increases by 1-2 points if studs with thinner steel are used.
- Increasing the spacing between the CFS studs from 406 mm on centers to 610 mm on centers typically increases the STC rating by 1-2 points for the walls used in this study; increasing the spacing between resilient metal channels has a similar effect.
- Changing the depth of the steel studs from 92 mm to 152 mm studs can increase the STC rating by up to 4 points on walls with resilient channels.
- The use of flat straps and bridging channels in loadbearing CFS-framed walls was found to have a negligible effect on the STC rating.

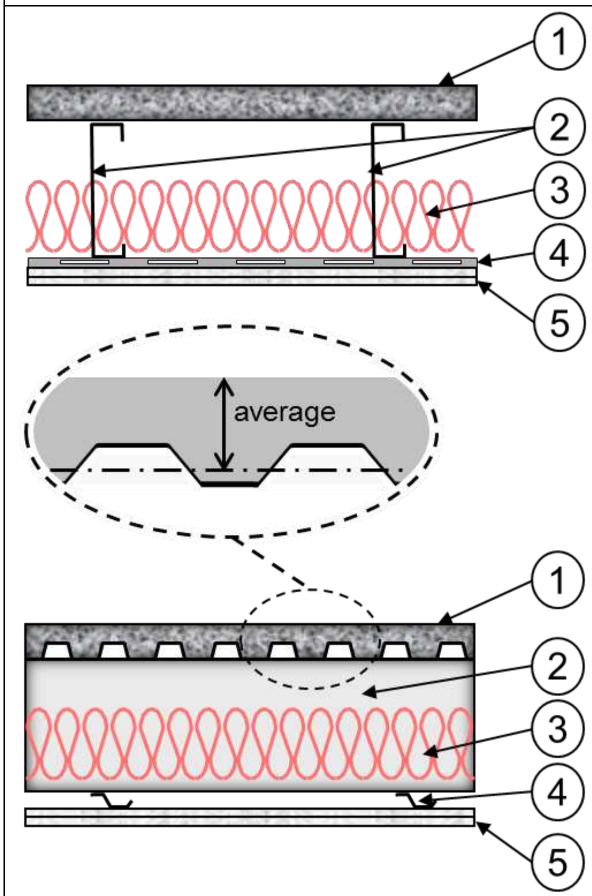
A more detailed analysis of these parameters is presented in a previous publication [16].

2.3 Floor/Ceiling Assemblies with CFS Framing

The focus of this section is on sound transmission through floor/ceiling assemblies comprised of a cold-formed steel (CFS) frame with a floor deck fastened directly to the top of the joists and a gypsum board ceiling supported below the joists on resilient metal channels.

The typical construction of the floor specimens framed with CFS C-joists is shown in Figure 2.3.1. The changes for adding typical flooring are given in Table 2.3.2

Figure 2.3.1:
Vertical cross-section through a floor assembly with loadbearing CFS joists showing typical components. The upper drawing shows a cross-section perpendicular to the long axis of the joists. The drawing below shows a cross-section parallel to the joists. Variations and element properties are listed in more detail on the right.



Drawings are not exactly to scale; see Figure 3.2.3 for a scale drawing of one variant.

1. Subfloor comprised of a corrugated steel pan screwed to the top of the joists, with concrete or gypsum concrete installed on top of the pan. The thicknesses tested include concrete with average thickness of 40 mm (CON40) and gypsum concrete with average thickness of 32 mm (GCON32). The total thickness of the subfloor was about 7 mm greater than the average concrete thickness.
2. Cold-formed steel (CFS) loadbearing joists [1] (sizes tested include cross sections of 38 x 317 mm, 38 x 254 mm, or 38 x 203 mm). The joists were spaced 406 mm on center and were fastened to framing headers of matching depth. The thickness of the steel from which the joists were formed is listed in Table 2.3.1.
3. Sound absorbing material[3] in the joist cavities may be glass fiber batts (GFB) or mineral fiber batts (MFB) or blown-in cellulose fiber (CFL).
4. Resilient metal channels[4] designated RC13 in the coding were formed from light sheet steel with a suitable profile, and were screwed to the faces of the CFS joists. They may be spaced either 406 mm or 610 mm on centers.
5. Fire-rated gypsum board[2] screwed to resilient metal channels whose other flange was supported from the CFS joists. Gypsum board may be designated either as G13 (nominal thickness of 1/2 inch, 12.7 mm) or as G16 (nominal thickness of 5/8 inch, 15.9 mm).

Table 2.3.1: Measured STC values for floor assemblies with cold-formed steel (CFS) C-joists with a cross section of 38 x 203 mm, 38 x 254 mm, or 38 x 317 mm. The results are organized in groups by common subfloor and steel framing within each group, and the specimen numbers reflect differences in the gypsum board ceilings or differences in the sound absorbing material installed between the joists.

Specimen	Descriptive Short Code	Steel Thickness	Test Reference	STC
CFS-J317-F01	GCON32_CORSTE14_SJ317(406)_GFB92_RC13(305)_G16	1.37 mm	TLF-14-063,067	**56**
CFS-J317-F02	GCON32_CORSTE14_SJ317(406)_GFB92_RC13(305)_2G16	1.37 mm	TLF-14-066	**60**
CFS-J254-F01	GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16	1.37 mm	TLF-14-050,059	**57**
CFS-J254-F02	GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_2G16	1.37 mm	TLF-14-046,048,049	**60**
CFS-J254-F03	GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G13	1.37 mm	TLF-14-061	**56**
CFS-J254-F04	GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_2G13	1.37 mm	TLF-14-062	**60**
CFS-J203-F01	CON40_CORSTE15_SJ203(406)_RC13(406)_2G13	1.22 mm	TLF-03-009a,011a	**62**
CFS-J203-F02	CON40_CORSTE15_SJ203(406)_GFB90_RC13(406)_2G13	1.22 mm	TLF-03-005a	**68**
CFS-J203-F03	CON40_CORSTE15_SJ203(406)_MFB90_RC13(406)_2G13	1.22 mm	TLF-03-007a	**68**
CFS-J203-F04	CON40_CORSTE15_SJ203(406)_CFL200_RC13(406)_2G13	1.22 mm	TLF-03-031a	**70**
CFS-J203-F05	CON40_CORSTE15_SJ203(406)_CFS130_RC13(406)_2G13	1.22 mm	TLF-03-039a	**68**

Table 2.3.2: The measured ΔSTC values for floor finishes installed on top of the floor assemblies with a gypsum concrete topping. The results for laminated flooring (LAM10_FOAM3) and for carpet (CAR11_UDLY9) are average values with the same finish floor installed on multiple floor assemblies. All of these ΔSTC values are suitable for flooring installed over gypsum concrete subfloor of similar thickness to the tested case. (GCON32 has an average thickness of 32 mm).

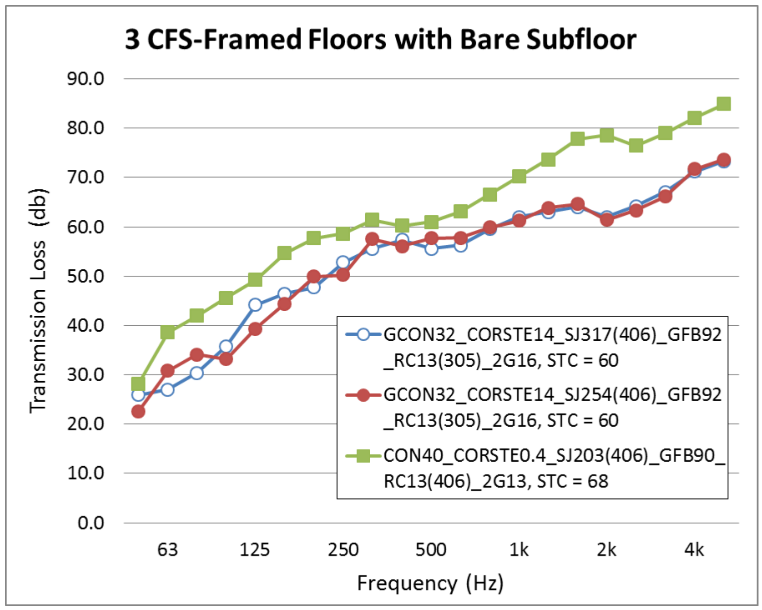
Flooring ID	Descriptive Short Code	Test Reference	ΔSTC
ΔTL-CFS-F01	VIN2 on GCON32	TLF-14-070,063	**0**
ΔTL-CFS-F02	LAM10_FOAM3 on GCON32	TLF-14-047,052,064,065	**2**
ΔTL-CFS-F03	CAR11_UDLY9 on GCON32	TLF-14-053,054	**1**

2.3.1 Trends in the Sound Transmission for CFS-Framed Floors

The three sets of floor assemblies evaluated had the CFS joists spaced 406 mm on centers, and all had resilient channel spacing of 406 mm on centers or less. These common features of the floors rule out demonstrating the acoustical benefits of changing these parameters, but are common features in practice to ensure adequate fire resistance.

Figure 2.3.2 compares the sound transmission loss observed for one floor from each set of test specimens. These were chosen to provide the most consistent cases.

Figure 2.3.2:
Sound transmission loss for one floor from each set of test specimens. The floors differ in joist depth and the details of the floor deck, but the other features (spacing of the joists and resilient channels, absorption in the cavity, layers of gypsum board) are similar.



Effect of Subfloor

The most obvious difference between the specimens in the figure is that the floor with a thicker deck of regular concrete (CON40) has significantly higher sound transmission loss across the whole frequency range, despite having the joists with the smallest depths. The combination of the 25% thicker concrete layer and the 16% higher density of the concrete (2260 kg/m^3 for regular concrete compared to 1950 kg/m^3 for gypsum concrete) gives a significant increase in the mass per area and hence higher sound transmission loss for the top surface. This is augmented slightly by improvements due to thinner steel of the joists and larger spacing between the resilient channels, but the mass per area of the top surface is the primary factor.

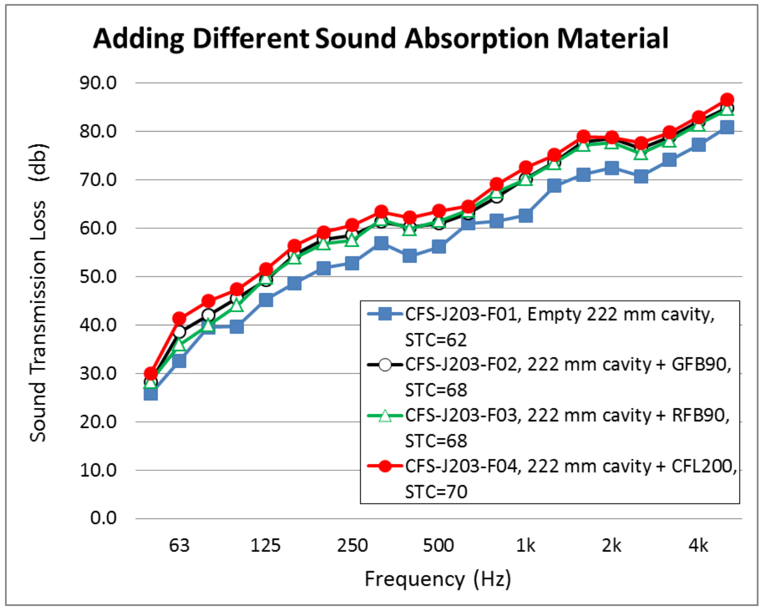
Effect of Gypsum Board Layers

Changing from 1 to 2 layers of 15.9 mm fire-resistant gypsum board on the ceiling consistently increased the STC rating by about 4 points. The typical change in sound transmission loss as a function of frequency roughly matched that shown in Figure 2.2.3 for wall specimens: an improvement of about 5 or 6 dB at the low and high frequencies and a broad dip between.

Effect of Cavity Absorption

As in the case of CFS-framed walls, the depth and the type of sound absorbing material in the cavities between the framing members is also a factor that should be considered. Figure 2.3.3 shows the effect of changing the sound absorbing material in a set of floors that are otherwise identical.

Figure 2.3.3: Sound transmission loss for a set of floors that are identical except for the amount and type of sound absorbing material in the spaces between joists. Note that the transmission loss results with added absorption are significantly higher than the transmission loss results for the empty cavity.



The addition of sound absorbing material between the floor joists has a significant effect on the STC rating of the floor assembly:

- Adding 90 mm of absorption (filling about 40 % of the cavity volume) increases the STC rating by 6 from 62 for the empty cavity to 68 after adding the absorbing glass fiber or mineral fiber batts.
- Increasing the depth of the absorption to 200 mm (which nearly fills the cavity) increases the STC rating by 2 more to 70.
- The overall increase due to filling the cavity with absorption (+8) is very similar to the increase in STC rating observed when the layers of gypsum board are doubled.

The effect of using different types of sound absorbing material is small. For the floors in Figure 2.3.3, the glass fiber batts and mineral fiber batts resulted in nearly identical transmission loss values. The figure shows that the curves are almost identical above 125 Hz. The use of cellulose fiber resulted in a higher transmission loss, but this improvement is best ascribed to the thickness of the CFL200 batts which filled 90% of the cavity (versus 40% for the glass fiber and mineral fiber batts). This interpretation is supported by the observations that floor CFS-J203-F05 with 120 mm of cellulose fiber (not plotted) had the same STC rating as the walls with 90 mm glass fiber or mineral fiber batts. As for the walls presented in Section 2.2, this study suggests no significant change in the STC rating due to the type of sound absorbing material.

Effect of Cavity Depth

Comparison studies were performed between a CFS-framed floor with a joist depth of 254 mm and a nominally identical CFS-framed floor with a joist depth of 317 mm. The STC ratings for the two floors differed by 0 to 1 points, and the transmission loss values were generally within ±3 dB. For these cases it was therefore concluded that the cavity depth does not significantly influence the sound insulation.

Effect of Floor Finishes

When floor finishes were added over the gypsum concrete subfloor surfaces, an appreciable change in sound transmission loss was observed, as presented in Figure 2.3.4.

Figure 2.3.4:
Change in sound transmission loss (ΔTL) due to adding floor finishes over the bare subfloor of the floors with gypsum concrete surface. In each plot, the mean change is shown by a solid line.

The upper graph shows the changes due to adding laminate flooring (ΔTL-CFS-F02 in Table 2.3.2) on four floors. The changes are very similar except above 2 kHz, and the changes in STC were consistent.

The lower graph shows the changes due to adding carpet and underlay (ΔTL-CFS-F03 in Table 2.3.2) on two floors. The changes are very similar except above 2 kHz, and the changes in STC rating were similar.

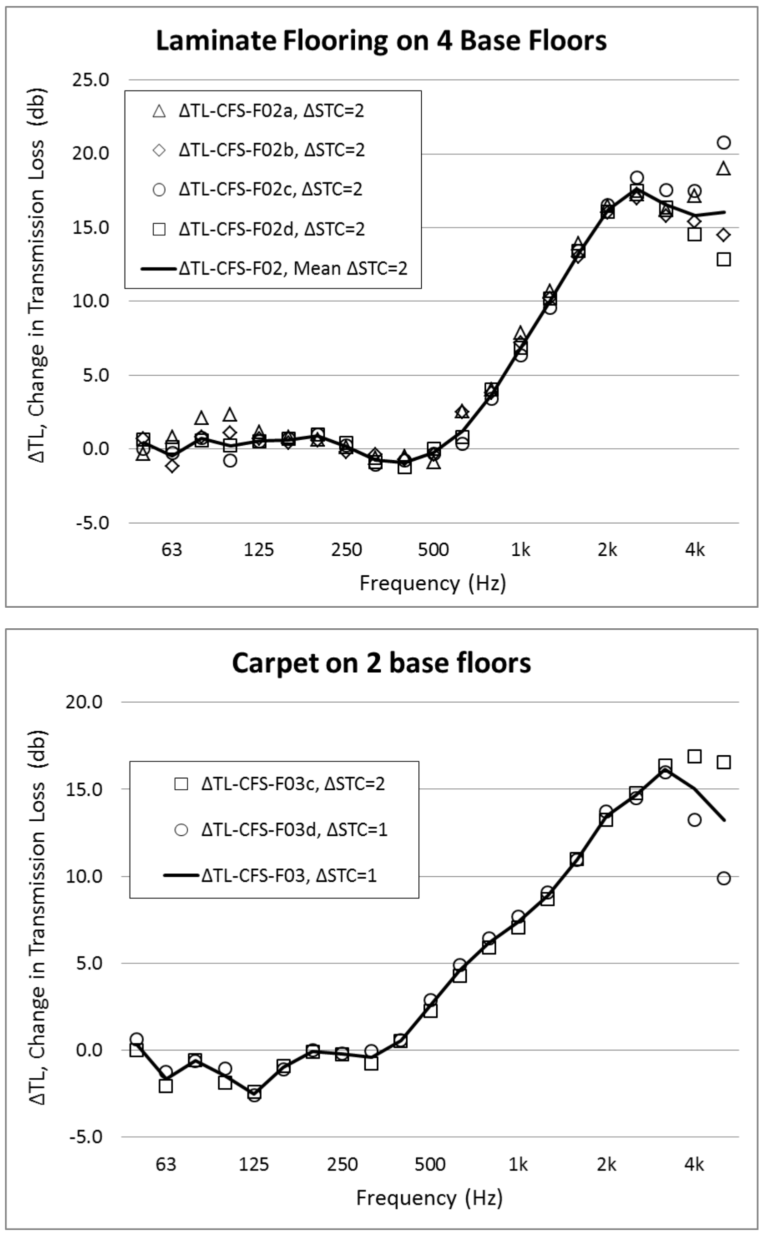
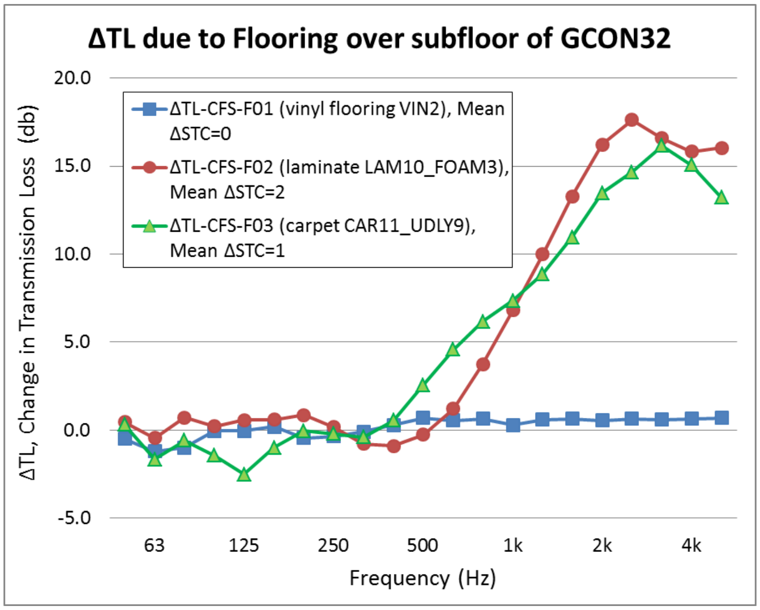


Figure 2.3.5 presents the mean change in sound transmission loss observed for the three types of floor finishes that were tested on these floors.

Figure 2.3.5:
Mean change in the sound transmission loss (ΔTL) due to the 3 types of floor finishes added over the bare gypsum concrete floor surfaces.

Note that despite the large increases at the higher frequencies for carpet and laminate flooring, the increase in the STC rating is small, because the STC ratings are limited by the low frequency performance of the floor.



The effects of the floor coverings on the impact insulation class (IIC) are greater than for the STC rating, but the impact noise insulation is out of the scope of this edition of the Report.

3 Flanking Sound Transmission in CFS-Framed Constructions

The focus of this chapter is the experimental testing conducted on a series of building mock-ups comprising CFS-framed walls connected to CFS-framed floors. ISO 15712-1 [7] provides a procedure for predicting sound transmission in buildings where the structure is composed of connected homogeneous wall and floor assemblies. CFS-framed constructions do not fall within this scope.

The same basic concept of combining the sound power transmitted via direct and flanking paths does apply to CFS-framed assemblies, but different test methods are required to evaluate flanking paths. Instead of using the procedures of ISO 15712-1, which are appropriate only for heavy homogeneous constructions, experimental data from measurements following the procedures of ISO 10848 [6] are used to characterize the flanking transmission for CFS constructions.

3.1 Test Facility and Procedures for CFS-Framed Assemblies

This introduction provides a brief description of the setup and standardised test methods used to measure flanking sound transmission loss values for specific structure-borne transmission paths in CFS-framed assemblies.

Measurements were conducted in the fully-automated 8-room flanking sound transmission facility at the NRC, depicted in Figure 3.1.1. Each room in the facility is equipped with four loudspeakers with independent/incoherent sources and one microphone that can be positioned by a robot at a set of selected positions for each test sequence. The test specimen consists of eight walls, four floors, and six junctions. The permanent shell of the facility (upper ceiling/roof, perimeter walls, and foundation floor) is constructed of highly sound insulating elements that are resiliently isolated from each other and from the test specimens, with vibration breaks in the permanent surfaces where the specimens are installed. The upper rooms have a ceiling height of 2.7 m while the lower rooms have a height of 2.4 m. The volume of the rooms used to assess flanking transmission in this study ranged between 34 m^3 and 53 m^3. Specimens are installed with the loadbearing walls under a hydraulic loading system, which permits simulation of buildings more than 2 stories in height.

The individual flanking paths between adjacent rooms (horizontally and vertically separated) were determined following the indirect method described in ISO 10848. Sound transmission loss measurements were conducted in both directions and the average was used as the final result. This procedure reduces errors associated with the microphone calibration. For each room pair, the source room was excited with pink noise using the four uncorrelated loudspeakers in that room. The sound pressure levels were recorded in the source room and the other seven rooms at nine positions each, using a microphone which was moved by a computer-controlled robot in each room. The reverberation times were measured using the interrupted noise method as specified in ASTM E2235 [3]. Background noise levels were measured in each room as part of the transmission loss measurements. The impact sound insulation of the specimen was also tested using the standard tapping machine and the heavy soft rubber ball, but those results are out of the scope of this edition of the Report.

Figure 3.1.1(a): Schematic representation of a specimen installed in the 8-room flanking facility

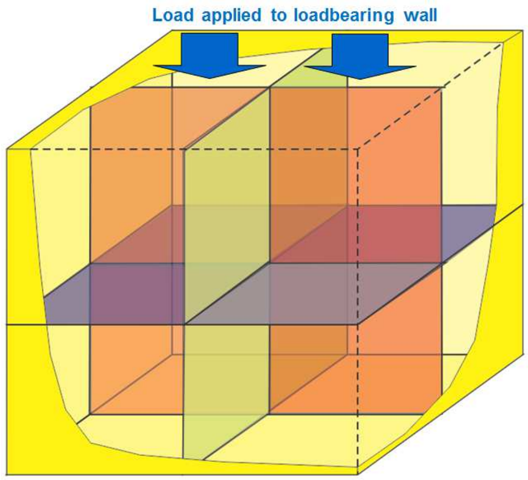


Figure 3.1.1(b): The interior of the flanking facility before construction of the specimen.

Determining Flanking TL for Individual Transmission Paths

In many cases, the flanking path of interest could be measured directly by shielding all other paths between the rooms. The wall shielding consisted of two layers of 15.9 mm gypsum board which were installed in front of the specimen surface without any structural connection (i. e. the shielding was supported by the permanent facility floor or ceiling instead of being attached to the test specimen). The 120 mm deep cavity between the shielding layers and the specimen surface was filled with fibrous insulation, and the perimeter was sealed with tape. Tests showed that this type of wall shielding provided an additional transmission loss between 15 dB and 25 dB over most of the frequency range of interest when installed on both sides of the wall.

In the upper rooms, floor shielding consisted of two layers of 16 mm plywood held together with acoustic dampening glue and supported on 70 mm thick mineral fiber board. The additional transmission loss provided by the shielding layers was insufficient for evaluating the wall paths in the upper rooms. For this reason, the wall paths from the lower rooms are considered to be more reliable than the wall paths from the upper rooms, and were used to assess wall-wall paths.

In some cases, it was necessary to extract the flanking path of interest from a set of measurements with different shielding conditions. For example, the ceiling surfaces in the lower rooms could not be shielded due to the practical difficulties of suspending the shielding layers without structurally connecting them to the specimen. As a consequence, the ceiling-ceiling path is always included in any measurement between horizontally adjacent lower rooms. In order to determine the direct path through a separating wall in the lower rooms, it was therefore necessary to first determine the ceiling-ceiling path and the wall-ceiling and ceiling-wall paths. The sound power of these three paths was then removed from the apparent transmission, yielding the direct path through the separating wall. Throughout this procedure it was important to take proper account of flanking limits and background noise.

Effect of Structural Loading

Normally the tests were conducted with an axial load of approximately 5000 lbs applied to the top of the loadbearing wall, but a comparison was made between data measured both with and without the load. The apparent transmission loss of the loadbearing walls without loading is about 2 dB higher above 315 Hz than with load, but within 0.5 dB below that frequency. For all other paths the change due to removing loading was less than 0.5 dB. Generally, the configuration without loading has a slightly higher transmission loss, but the ASTC ratings are all within 1 point. Thus vertical loading has only a minor influence on the measured transmission loss values, and the normal test procedure with loading can be regarded as providing a slightly conservative estimate.

3.2 Description of Flanking Specimen

Figure 3.2.1 shows some images of the specimen during construction.

Figure 3.2.1: Some images of the CFS-framed assemblies under construction.

The flanking test specimen consisted of four loadbearing walls, four non-loadbearing walls, four floors, and six junctions, which divide the space into 8 rooms.

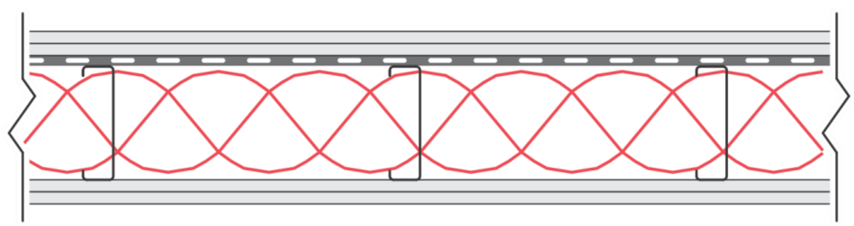
To take advantage of symmetries and to allow for redundant measurements, each of the four loadbearing walls was nominally identical in this study, as were the four non-loadbearing walls and the four floors.

The images show:

1. The top image shows early assembly of the CFS framing for the lower loadbearing walls and the CFS joists for the floor-ceiling assemblies.
2. The middle image shows construction after framing of the floor assembly was complete, with some insulation installed in the joist cavities.
3. The bottom image shows the floor surface after installation of the gypsum concrete with the upper loadbearing walls in place in the foreground. Note the continuous gypsum concrete through the framing on the left (loadbearing Junction LBc) and the break in the gypsum concrete surface on the right (loadbearing Junction LBd). The upper wall framing for the non-loadbearing Junction NLBd is visible in the back, looking through the loadbearing wall. The upper wall for the non-loadbearing Junction NLBc was installed on top of the gypsum concrete in the front.

3.2.1 Walls of CFS-Framed Flanking Specimen

The walls investigated in this study were double-leaf walls with one row of cold-formed steel studs as framing members. Using a short code to describe the various wall parameters (as in Sections 2.1 and 2.2) the loadbearing walls were defined as follows: 2G16_SS152(406)_GFB152_RC13(406)_2G16. Here, 2G16 indicates two layers of 15.9 mm thick gypsum board[2] (mass per area: 11.0 kg/m^2 per layer), SS152(406) indicates 152 mm deep steel studs[1] spaced 406 mm on centers (steel thickness: 1.37 mm), GFB152 indicates 152 mm thick glass fiber insulation[3], and RC13(406) indicates 13 mm deep resilient metal channels[4] spaced 406 mm on centers. The gypsum board was attached with screws spaced 305 mm on centers at the perimeter and in the field. In addition to these elements, the loadbearing walls also included bridging channels and steel straps for bracing against lateral and shear loads.

Figure 3.2.2 shows a horizontal cross section (where the studs are perpendicular to the plane of the drawing) of typical construction for the loadbearing and non-loadbearing wall assemblies.	

The non-loadbearing walls in this study were very similar to the loadbearing walls, except for the following changes:

- The non-loadbearing studs were formed from steel with a thickness of 0.54 mm.
- Stud depth and cavity insulation thickness were reduced from 152 mm to 92 mm.
- The non-loadbearing CFS studs were inserted into the upper track but not screwed to it. The studs were fixed in position by the gypsum board which was screwed to the studs.
- The non-loadbearing walls did not include bridging channels and bracing steel straps, but are described using a similar short code as 2G16_SS92(406)_GFB92_RC13(406)_2G16.

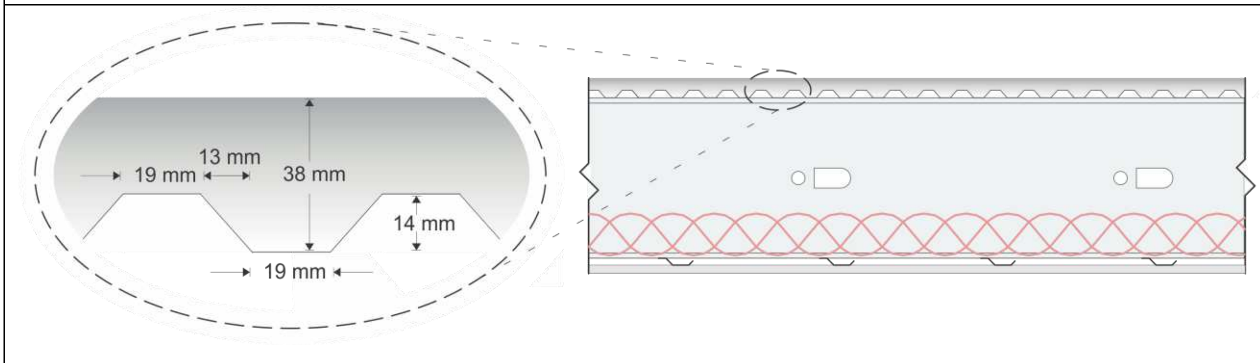
3.2.2 Floors of CFS-Framed Flanking Specimen

The floors investigated in this study consisted of lightweight gypsum concrete with an average thickness of 32 mm on a corrugated steel deck, fastened to steel joists with a gypsum board ceiling. Using a short code to describe the various floor parameters (as in Sections 2.1 and 2.3), the floor assembly was defined as the following: GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16. Here, GCON32 indicates a layer of lightweight gypsum concrete with an average thickness of 32 mm (maximum thickness of 38 mm measured from the bottom of the corrugated steel deck). The gypsum concrete density was 1950 kg/m^3, which gave an average mass per unit area on the corrugated steel deck of

60 kg/m^2. The gypsum concrete was poured onto the steel deck in-situ, and was left to cure for more than a month before testing. The strength of the cured gypsum concrete was 24.8 MPa.

CORSTE14 indicates the corrugated steel deck (depth of corrugation: 14 mm, steel thickness: 0.76 mm), and SJ254(406) indicates 254 mm deep steel joists[1] spaced 406 mm on centers (steel thickness: 1.37 mm). The floor also included blocking strips, installed at the center of the joists between the two last joists on each end and between the two joists in the floor center, and a steel strap connecting the three blocking strips with each other and with the other joists. The corrugated steel deck was fastened to the joists with screws spaced 203 mm on centers. As before, GFB92 indicates 92 mm thick glass fiber batts[3], RC13(305) indicates 13 mm deep resilient metal channels[4] spaced 305 mm on centers, and G16 indicates one layer of 15.9 mm thick gypsum board[2]. The gypsum board was attached with screws spaced 305 mm on centers at the perimeter and in the field. The glass fiber insulation batts were resting on the resilient metal channels. A cross-section of one of the floor assemblies is shown in Figure 3.2.3.

Figure 3.2.3 shows a vertical cross section (plane of the drawing is parallel to the joists) of the construction details for the floor assemblies used in the flanking sound transmission tests.



3.2.3 Junctions of the CFS-Framed Flanking Specimen

The four horizontal wall/floor junctions were chosen to represent a variety of junction details encountered in practice. Table 3.2.1 summarizes some key features of these junction configurations which are described in more detail below.

Table 3.2.1	Walls	Joist Orientation	Joists	Subfloor
Junction LBc	Loadbearing	Perpendicular to junction	Continuous	“Continuous”
Junction LBd	Loadbearing	Perpendicular to junction	Discontinuous	Discontinuous
Junction NLBd	Non-Loadbearing	Parallel to junction	N/A	Discontinuous
Junction NLBc	Non-Loadbearing	Parallel to junction	N/A	Continuous

Loadbearing Junction LBc

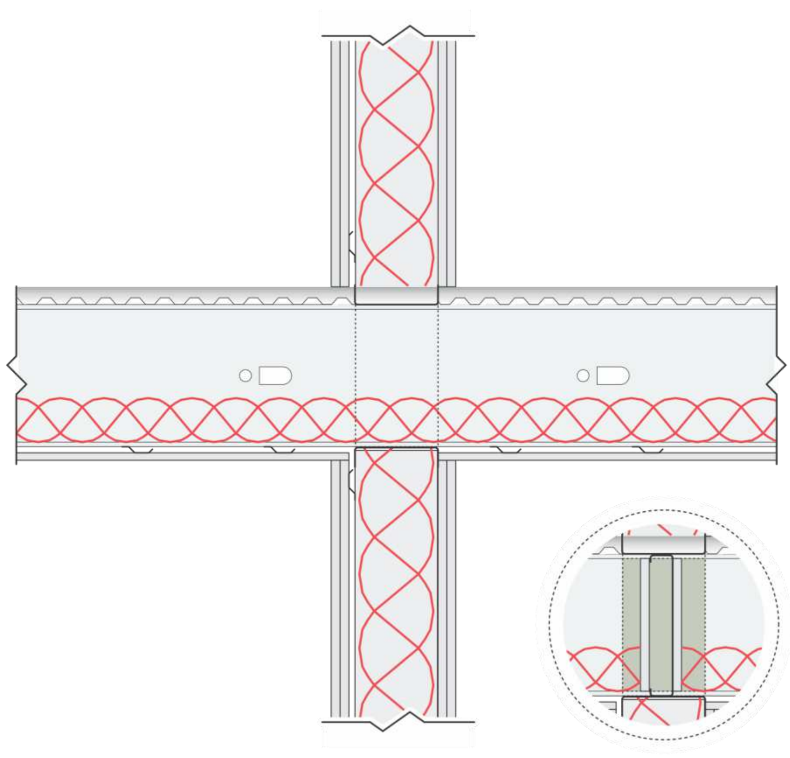
The LBc junction connected the loadbearing CFS-framed walls with CFS-framed floors whose joists were perpendicular to the junction and continuous across the junction. The floor deck was essentially continuous.

- The CFS floor joists[1] were supported on the top track of the lower loadbearing wall, and the bottom track of the upper loadbearing wall was supported on the top of the floor joists. A short stud segment was fastened to each joist to stiffen it at the junction. The floor and wall framing were screwed together at their intersections.
- The corrugated steel deck was installed after the loadbearing walls and the floor joists, and ended at the wall framing. Gypsum concrete was installed on the floor deck, filling the bottom track of the upper loadbearing wall to create a gypsum concrete floor deck that is essentially continuous (interrupted only by the embedded bottom track of the upper loadbearing wall). The gypsum concrete was bonded to the surfaces of the deck and the track of this upper loadbearing wall.
- Details of the wall and floor assemblies are given in Sections 3.2.1 and 3.2.2.
- Different configurations of Junction LBc were tested in this study, including with and without fire blocks in the joist cavities, and with one or two layers of gypsum board on the ceiling.

Figure 3.2.4 shows a vertical cross section (joists are parallel to the plane of the drawing) of the construction details for the loadbearing wall/floor **Junction LBc.**

Note that both the floor joists and the gypsum concrete deck are continuous across the junction.

Drawing is approximately to scale. This junction was also called the “East junction” in some previous publications.



Loadbearing Junction LBd

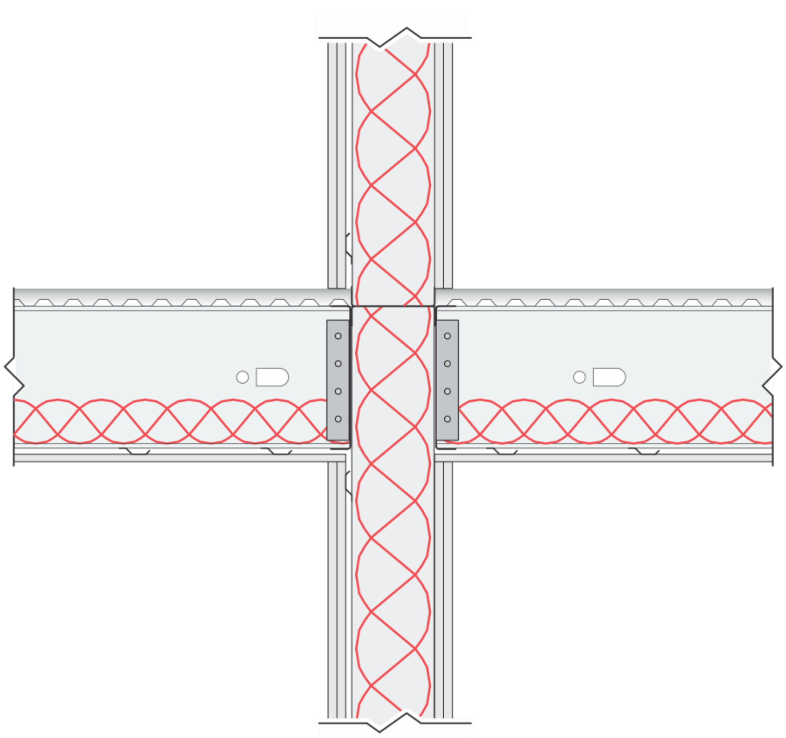
The LBd junction connected the loadbearing CFS-framed wall with CFS-framed floors whose joists were perpendicular to the junction, but not continuous across the junction. The composite floor deck of gypsum concrete on a corrugated metal pan was also discontinuous.

- The end frame of the CFS floor was attached to the top of the lower loadbearing wall so that the top of the joists aligned with the top of the lower wall. Then the CFS floor joists[1] were attached to the end frame and the loadbearing studs using joist hangers. Note that the CFS end frames on both sides of the loadbearing wall completely block the spaces between the joists, thus providing a fire block and suppressing airborne flanking via the joist cavities.
- The bottom track of the upper loadbearing wall was supported on top of the lower wall framing.
- The corrugated steel deck was installed after the loadbearing walls and the floor joists, and ended at the wall framing. Gypsum concrete was installed on the floor deck, but did not fill the bottom track of the upper loadbearing wall, so that the subfloor between the two upper rooms was structurally disconnected. The gypsum concrete was bonded to the surfaces of the corrugated steel deck and to the outer faces of the track of the upper wall.
- Details of the wall and floor assemblies are given in Sections 3.2.1 and 3.2.2.
- Different configurations of Junction LBd were tested in this study, including with one or two layers of gypsum board on the ceiling.

Figure 3.2.5 shows a vertical cross section (joists are parallel to the plane of the drawing) of the construction details for the loadbearing wall/floor **Junction LBd.**

Note that both the floor joists and the gypsum concrete deck are discontinuous across the junction.

Drawing is approximately to scale. This junction was also called the “West junction” in some previous publications.



Non-Loadbearing Junction NLBc

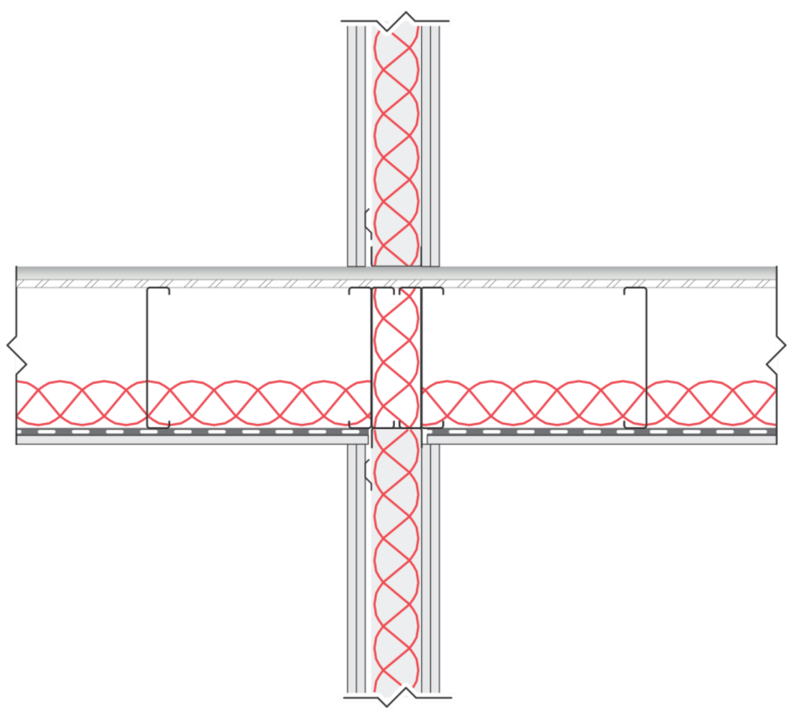
The NLBc junction connected the non-loadbearing CFS-framed walls with CFS-framed floors whose joists were oriented parallel to the junction. The floor deck was installed before the upper non-loadbearing wall, and was continuous across the junction.

- An assembly of 4 CFS floor joists[1] was positioned at the wall/floor junction. Two joists were fastened together to form a "box", which was filled with sound absorbing material; this pair of joists supported the floor deck above, and the top track of the lower non-loadbearing wall was fastened to their bottom surface. Another joist was fastened to each face of the "box" and these provided support for the ends of the resilient metal channels supporting the ceiling below.
- The upper non-loadbearing wall was standing on top of the gypsum concrete floor deck assembly at the junction. This wall assembly was installed after the corrugated steel deck and gypsum concrete were added to form the floor deck. The gypsum concrete was bonded to the corrugated steel deck and the bottom track of the upper wall was fixed to the subfloor deck.
- The upper track of the lower non-loadbearing wall was screwed to the underside of the joists above. The non-loadbearing CFS studs[1] were inserted into the upper track but not screwed to it; the studs were fixed in position by the gypsum board which was screwed to the studs.
- Details of the wall and floor assemblies are given in Sections 3.2.1 and 3.2.2.
- Different configurations of Junction LBd were tested in this study, including with one or two layers of gypsum board on the ceiling.

Figure 3.2.6 shows a vertical cross section (joists are perpendicular to the plane of the drawing) of the construction details for the non-loadbearing wall/floor **Junction NLBc.**

Note that the gypsum concrete deck is continuous across the junction.

Drawing is approximately to scale. This junction was also called the "North junction" in some previous publications.



Non-Loadbearing Junction NLBd

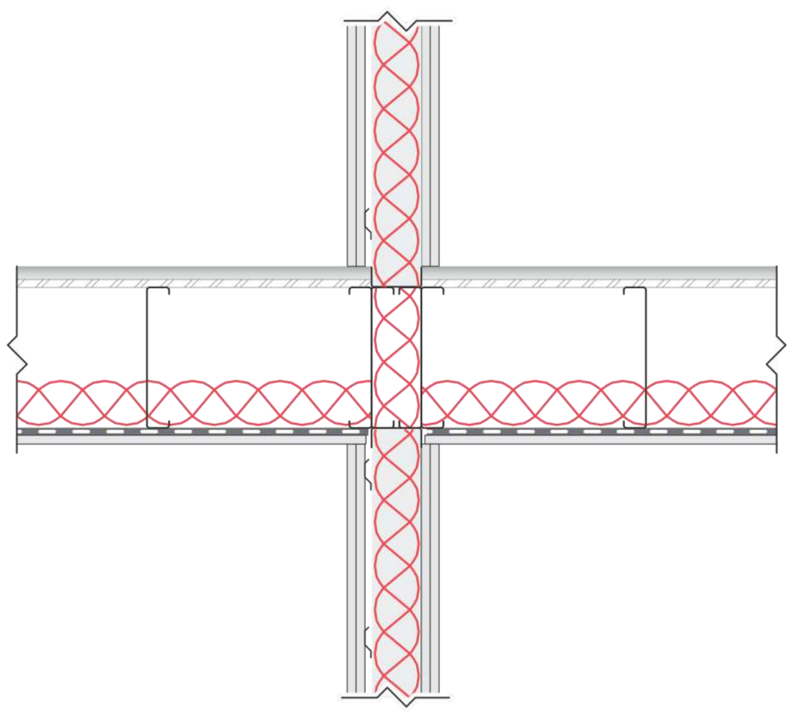
The NLBd junction connected the non-loadbearing CFS-framed walls with CFS-framed floors whose joists were oriented parallel to the junction. The floor deck was discontinuous.

- An assembly of 4 CFS floor joists[1] was positioned at the wall/floor junction. Two joists were fastened together to form a "box", which was filled with sound absorbing material; this pair of joists supported the non-loadbearing wall above, and the track of the lower non-loadbearing wall was fastened to their bottom surface. Another joist was fastened to each face of the "box" and these provided support for the edge of the floor deck above and for the ends of the resilient metal channels supporting the ceiling below.
- The upper non-loadbearing wall was built directly on top of the floor joist assembly at the junction. This wall assembly was installed before the corrugated steel deck and gypsum concrete were added to form the floor deck, so the floor deck ended at the outer faces of its bottom track. Although this configuration is not often found in practice, it was chosen to allow the insertion of vibration breaks in the subfloor.
- The lower non-loadbearing wall terminated at the bottom of the joists. The upper track was screwed to the underside of the joists, and the non-loadbearing CFS studs[1] were inserted into the upper track but not screwed to it; the studs were fixed in position by the gypsum board.
- Details of the wall and floor assemblies are given in Sections 3.2.1 and 3.2.2.
- Different configurations of Junction LBd were tested in this study, including with one or two layers of gypsum board on the ceiling.

Figure 3.2.7 shows a vertical cross section (joists are perpendicular to the plane of the drawing) of the construction details for the non-loadbearing wall/floor **Junction NLBd.**

Note that the gypsum concrete deck is discontinuous across the junction.

Drawing is approximately to scale. This junction was also called the "South junction" in some previous publications.



Wall/Wall Junctions (LB or NLB)

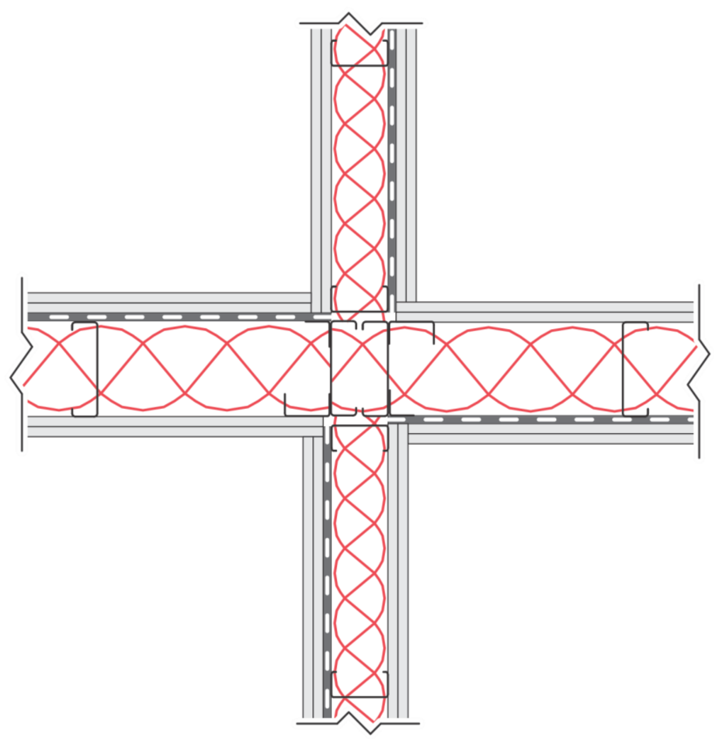
The two vertical wall/wall junctions (in the upper and lower rooms) in this specimen were essentially mirror images. Figure 3.2.8 shows a top view of the wall-wall junction. If a loadbearing wall separates the side-by-side rooms of interest the wall/wall junction is designated “LB”. If a non-loadbearing wall is the separating assembly the junction is designated “NLB”.

- The loadbearing walls (left to right in Figure 3.2.8) and the floors were framed first. An assembly of two loadbearing CFS studs was positioned at the wall/wall junction to form a “box”, which was filled with sound absorbing material and had a slight gap between the two studs for vibration isolation. Clips fastened to the loadbearing studs provided support for the ends of the resilient metal channels, and 65 mm wide metal tracks supported the edge of the directly attached gypsum board on the other side of the wall.
- The non-loadbearing wall assembly on each side was installed after the loadbearing wall, with the closest non-loadbearing stud about 10 mm from the “box” of loadbearing studs.
- The gypsum board on each wall was directly attached to one side of the studs and supported on resilient channels on the other. The resilient channels were always attached first, then the directly attached gypsum board sheets, and then the gypsum board supported on the resilient channels (butting against the directly attached gypsum board).
- Details of the wall assemblies are given in Section 3.2.1.
- Different configurations of the wall/wall junction were tested in this study, including with one or two layers of gypsum board attached to the resilient channels on the walls.

Figure 3.2.8 shows a horizontal cross section (studs are perpendicular to the plane of the drawing) of the construction details for the wall/wall junctions.

The drawing is approximately to scale. This is a top view of the wall assemblies separating the lower rooms; the configuration for the upper floor is identical.

If a loadbearing wall separates the side-by-side rooms of interest the wall/wall junction is designated “LB”. If a non-loadbearing wall is the separating assembly the junction is designated “NLB”.



3.3 Tested Junctions of CFS-Framed Floors with Walls

The following tables present values of the flanking sound transmission via specific paths that were determined from measurements following the procedures of ISO 10848 on a series of mock-up constructions with connected CFS-framed floor and wall assemblies. The facilities and test procedures are described in Section 3.1. The test specimens are described in Section 3.2.

This chapter focusses on single-number results for the flanking sound transmission as was done for the presentation of the STC and ΔSTC results in Chapter 2. In this case, the results are values of flanking sound transmission class (Flanking STC_{ij}), where the subscript i denotes the source room (surface D or F), and the subscript j denotes the connected receiving room (surface d or f) for the transmission path through the junction. These values are used to calculate the ASTC rating in the examples in Chapter 4 which are calculated using the Simplified Method of ISO 15712-1.

Tables 3.3.3.1 to 3.4.4.3 show the Flanking STC values for a set of paths through a junction. Each table consists of several parts:

1. A brief generic description of details of the wall and floor/ceiling assemblies and the junctions where they connect (a summary of the more complete descriptions provided in Section 3.2).
2. A drawing showing the general features of the junction.
3. Each cross-junction of walls with floor/ceiling assemblies can be viewed in several ways:
   (a) as the wall-floor junction between two side-by-side rooms above the floor;
   (b) as the wall-ceiling junction between two side-by-side rooms below the ceiling; and
   (c) as the junction of a flanking wall with the floor/ceiling assembly separating two rooms that are one-above-the-other.
4. Junction cases (a) to (c) are presented in the rows below, with stylized drawings to identify the paths in each case and Flanking STC values for each flanking path ij.

Junction naming follows a simple coding system in four segments:

- The first segment of the code indicates that the junction consist of CFS-framed assemblies.
- The second segment of the code indicates the junction type:
  > WF = wall/floor,
  > WC = wall/ceiling,
  > FW = floor/wall,
- The third segment of the code indicates which of the basic junctions from Section 3.2 is used.
- The fourth segment of the code is the unique number for that junction detail.

NOTE:

All the Flanking STC results in this chapter have been normalized to the Standard Scenario presented in Chapter 1, using Equation 4.1.3. The test results presented in the tables in this Section include:

(a) Values of Flanking STC measured following the procedures of ISO 10848-3 for rooms that are side-by-side (i. e. a wall is the separating assembly), normalized to S = 12.5 m^2 and l = 5 m for the wall/floor or wall/ceiling junction;

(b) Values of Flanking STC measured following ISO 10848-3 for rooms that are one-above-the-other (i. e. a floor/ceiling is the separating assembly), normalized to S = 20 m^2 and l = 5 m; and

(c) Values of STC measured according to ASTM E90 (as tabulated in Sections 2.2 and 2.3) for path Dd, in lieu of the measured Flanking STC for the same path.

Table 3.3.1.1: Floor-Wall Transmission Paths

Loadbearing wall assembly:

- 2G16_SS152(406)_GFB152_RC13(406)_2G16
- CFS framing formed from steel 1.37 mm thick

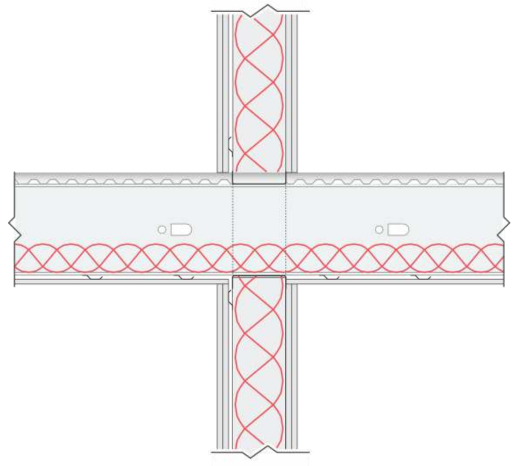
Floor/Ceiling assembly:

- GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16

Junction of wall with floor/ceiling assembly:

- Junction LBc without fire block
- CFS floor joists perpendicular to the loadbearing wall and continuous across the junction
- Gypsum concrete subfloor continuous across junction
- Warning: This design without fire block does not control smoke or fire spread at the junction.

(Complete description of Junction LBc in Section 3.2.)



Floor-Wall Junction LBc. Vertical section, drawn approximately to scale.

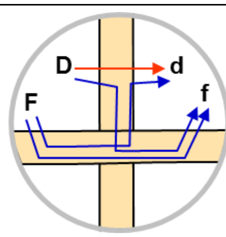
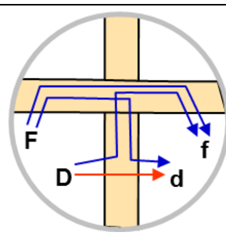
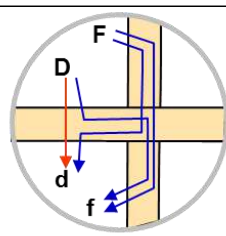
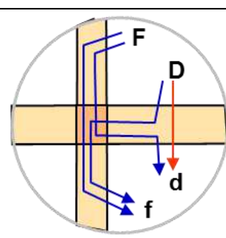
		Path	STC_{ij}	IIC_{ij}
CFS-WF-LBc-11 Wall-Floor Loadbearing Junction		Dd	58	
		Ff	48	
		Fd	49	
		Df	50	
CFS-WC-LBc-11 Wall-Ceiling Loadbearing Junction		Dd	58	
		Ff	62	
		Fd	60	
		Df	64	
CFS-FW-LBc-11r Floor-Wall Loadbearing Junction (Wall gypsum board on resilient channels)		Dd	57	
		Ff	67	
		Fd	71	
		Df	72	
CFS-FW-LBc-11d Floor-Wall Loadbearing Junction (Wall gypsum board attached directly)		Dd	57	
		Ff	67	
		Fd	69	
		Df	65	

Table 3.3.1.2: Floor-Wall Transmission Paths

(same as 3.3.1.1 except 2nd layer of G16 removed on walls where gypsum board is mounted on resilient channels)

Loadbearing wall assembly:

- 2G16_SS152(406)_GFB152_RC13(406)_G16

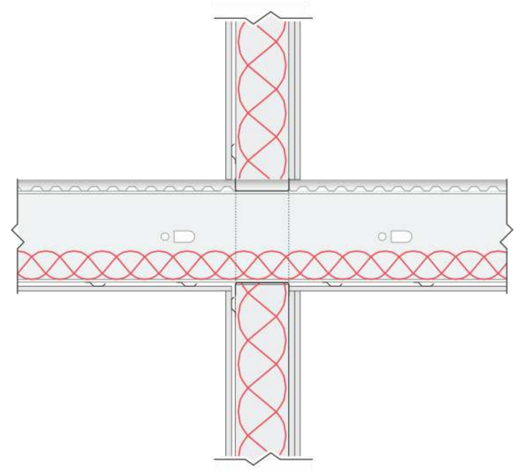
Floor/Ceiling assembly:

- GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16

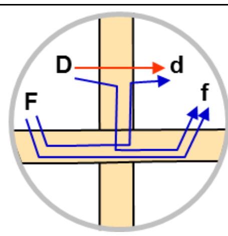
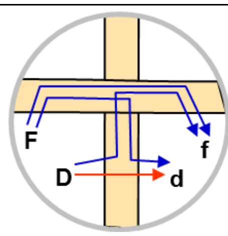
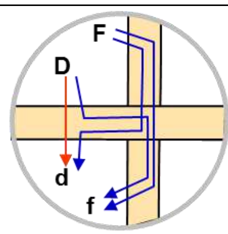
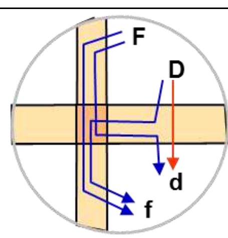
Junction of wall with floor/ceiling assembly:

- Junction LBc without fire block
- CFS floor joists perpendicular to the loadbearing wall and continuous across the junction
- Gypsum concrete subfloor continuous across junction
- Warning: This design without fire block does not control smoke or fire spread at the junction.

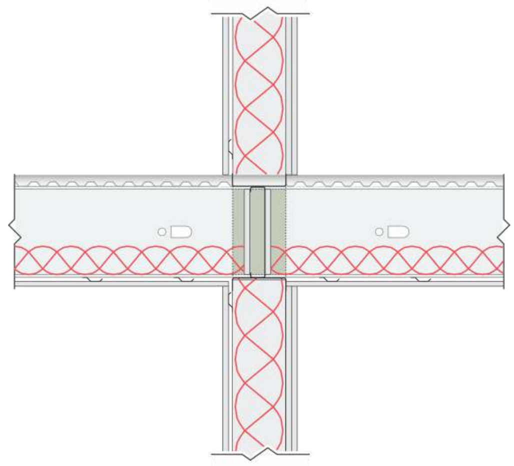
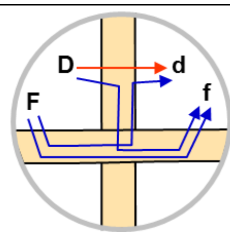
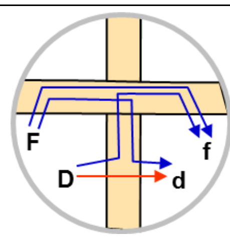
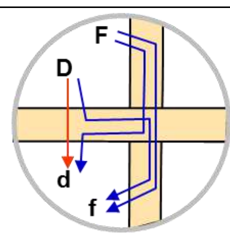
(Complete description of Junction LBc in Section 3.2.)



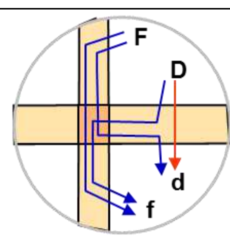
Floor-Wall Junction LBc. Vertical section, drawn approximately to scale.

		Path	STC_{ij}	IIC_{ij}
CFS-WF-LBc-12 Wall-Floor Loadbearing Junction		Dd Ff+Fd+Df	54 ≥44	
CFS-WC-LBc-12 Wall-Ceiling Loadbearing Junction		Dd Ff Fd Df	54 62 60 69	
CFS-FW-LBc-12r Floor-Wall Loadbearing Junction (Wall gypsum board on resilient channels)		Dd Ff+Fd+Df	57 ≥62	
CFS-FW-LBc-12d Floor-Wall Loadbearing Junction (Wall gypsum board attached directly)		Dd Ff Fd Df	57 67 69 65	

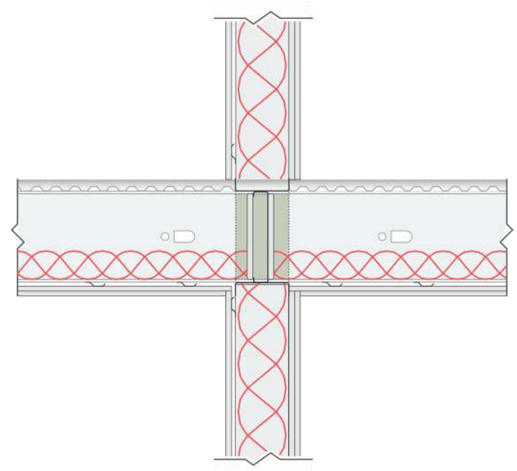
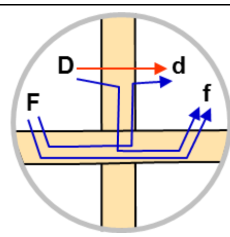
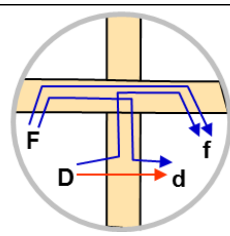
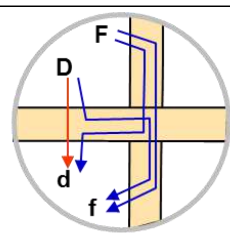
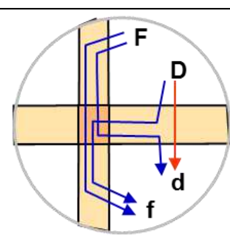
<table>
<tr>
<td colspan="2">Table 3.3.1.3: Floor-Wall Transmission Paths

(same as 3.3.1.2 except fire block installed in the floor cavities where the floor joists cross the loadbearing wall)</td>
<td colspan="3" rowspan="2">
Floor-Wall Junction LBc. Vertical section, drawn approximately to scale.</td>
</tr>
<tr>
<td colspan="2"><u>Loadbearing wall assembly:</u>
• 2G16_SS152(406)_GFB152_RC13(406)_G16
<u>Floor/Ceiling assembly:</u>
• GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16
<u>Junction of wall with floor/ceiling assembly:</u>
• Junction LBc with fire block in joist cavities
• CFS floor joists perpendicular to the loadbearing wall and continuous across the junction
• Gypsum concrete subfloor continuous across junction
• Fire block in floor cavities where floor joists cross wall</td>
</tr>
<tr>
<td colspan="2">(Complete description of Junction LBc in Section 3.2.)</td>
<td>Path</td>
<td>STC_{ij}</td>
<td>IIC_{ij}</td>
</tr>
<tr>
<td>CFS-WF-LBc-13
Wall-Floor
Loadbearing Junction</td>
<td></td>
<td>Dd
Ff
Fd
Df</td>
<td>54
50
53
55</td>
<td></td>
</tr>
<tr>
<td>CFS-WC-LBc-13
Wall-Ceiling
Loadbearing Junction</td>
<td></td>
<td>Dd
Ff
Fd
Df</td>
<td>54
65
73
69</td>
<td></td>
</tr>
<tr>
<td>CFS-FW-LBc-13r
Floor-Wall
Loadbearing Junction
(Wall gypsum board on resilient channels)</td>
<td></td>
<td>Dd

Ff+Fd+Df</td>
<td>57

≥62*</td>
<td></td>
</tr>
<tr>
<td>CFS-FW-LBc-13d
Floor-Wall
Loadbearing Junction
(Wall gypsum board attached directly)</td>
<td></td>
<td>Dd
Ff
Fd
Df</td>
<td>57
67*
69*
65*</td>
<td></td>
</tr>
</table>

(*) Estimates based on the assumption that the fire block has little influence on the vertical paths.

Table 3.3.1.4: Floor-Wall Transmission Paths (same as 3.3.1.3 except 2nd layer of G16 added to ceiling)		 **Floor-Wall Junction LBc**. Vertical section, drawn approximately to scale.		
Loadbearing wall assembly: • 2G16_SS152(406)_GFB152_RC13(406)_2G16 • CFS framing formed from steel 1.37 mm thick Floor/Ceiling assembly: • GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_2G16 Junction of wall with floor/ceiling assembly: • Junction LBc with fire block in joist cavities • CFS floor joists perpendicular to the loadbearing wall and continuous across the junction • Gypsum concrete subfloor continuous across junction • Fire block in floor cavities where floor joists cross wall (Complete description of Junction LBc in Section 3.2.)		**Path**	**STC$_{ij}$**	**IIC$_{ij}$**
CFS-WF-LBc-14 Wall-Floor Loadbearing Junction		Dd Ff Fd Df	54 50 53 55	
CFS-WC-LBc-14 Wall-Ceiling Loadbearing Junction		Dd Ff Fd Df	54 76 77 71	
CFS-FW-LBc-14r Floor-Wall Loadbearing Junction (Wall gypsum board on resilient channels)		Dd Ff+Fd+Df	60 ≥62*	
CFS-FW-LBc-14d Floor-Wall Loadbearing Junction (Wall gypsum board attached directly)		Dd Ff Fd Df	60 67* ≥69* ≥65*	

(*) Estimates based on the assumption that the fire block has little influence on the vertical paths.

Table 3.3.2.1: Floor-Wall Transmission Paths

Loadbearing wall assembly:

- 2G16_SS152(406)_GFB152_RC13(406)_2G16
- CFS framing formed from steel 1.37 mm thick

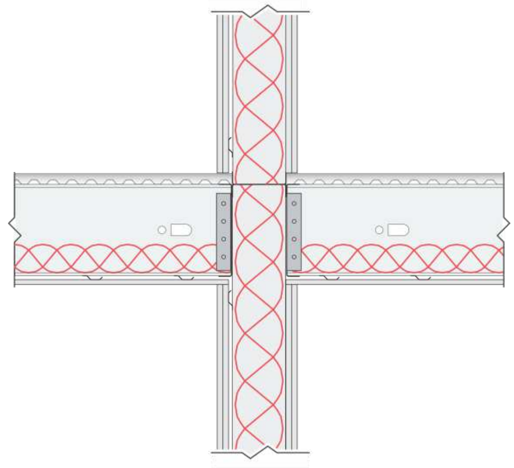
Floor/Ceiling assembly:

- GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16

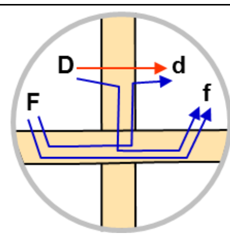
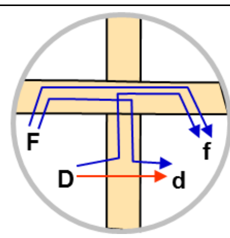
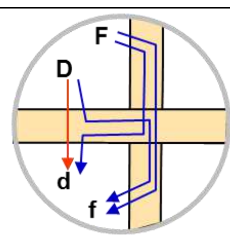
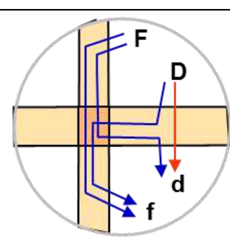
Junction of wall with floor/ceiling assembly:

- Junction LBd
- CFS floor joists perpendicular to the loadbearing wall but not continuous across the junction
- Gypsum concrete subfloor not continuous across the junction

(Complete description of Junction LBd in Section 3.2.)



Floor-Wall Junction LBd. Vertical section, drawn approximately to scale.

Junction		Path	STC_{ij}	IIC_{ij}
CFS-WF-LBd-21 Wall-Floor Loadbearing Junction		Dd Ff Fd Df	58 65 62 67	
CFS-WC-LBd-21 Wall-Ceiling Loadbearing Junction		Dd Ff Fd Df	58 75 64 70	
CFS-FW-LBd-21r Floor-Wall Loadbearing Junction (Wall gypsum board on resilient channels)		Dd Ff Fd Df	57 72 77 75	
CFS-FW-LBd-21d Floor-Wall Loadbearing Junction (Wall gypsum board attached directly)		Dd Ff Fd Df	57 65 72 67	

<table>
<tr>
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Table 3.3.2.2: Floor-Wall Transmission Paths

(same as 3.3.2.1 except 2nd layer of G16 removed on walls where gypsum board is mounted on resilient channels)

<u>Loadbearing wall assembly:</u>
- 2G16_SS152(406)_GFB152_RC13(406)_G16
- CFS framing formed from steel 1.37 mm thick

<u>Floor/Ceiling assembly:</u>
- GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16

<u>Junction of wall with floor/ceiling assembly:</u>
- Junction LBd
- CFS floor joists perpendicular to the loadbearing wall but not continuous across the junction
- Gypsum concrete subfloor not continuous across the junction

(Complete description of Junction LBd in Section 3.2.)

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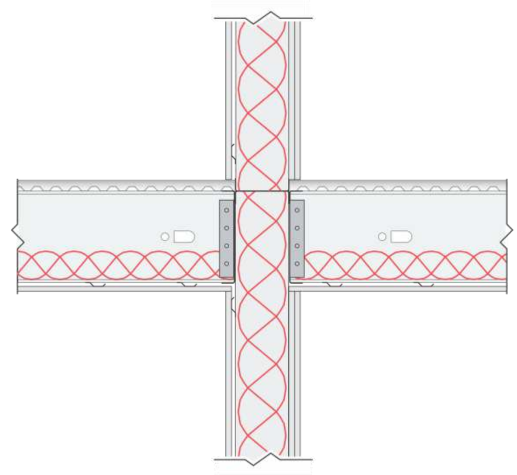

Floor-Wall Junction LBd. Vertical section, drawn approximately to scale.

</td>
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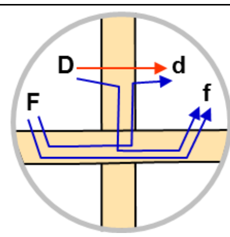
<tr>
<td>Path</td>
<td>STC</td>
<td>IIC</td>
</tr>
<tr>
<td>

CFS-WF-LBd-22
Wall-Floor
Loadbearing Junction

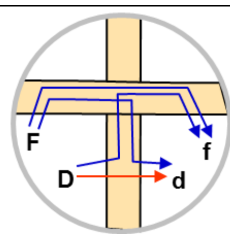


</td>
<td>Dd

Ff+Fd+Df</td>
<td>54

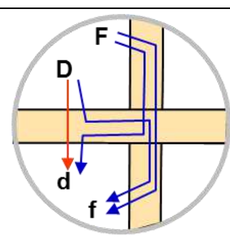
≥54</td>
<td></td>
</tr>
<tr>
<td>

CFS-WC-LBd-22
Wall-Ceiling
Loadbearing Junction



</td>
<td>Dd
Ff
Fd
Df</td>
<td>54
75
64
70</td>
<td></td>
</tr>
<tr>
<td>

CFS-FW-LBd-22r
Floor-Wall
Loadbearing Junction
(Wall gypsum board on
resilient channels)



</td>
<td>Dd

Ff+Fd+Df</td>
<td>57

≥63</td>
<td></td>
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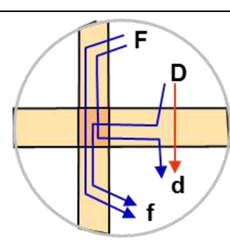
<td>

CFS-FW-LBd-22d
Floor-Wall
Loadbearing Junction
(Wall gypsum board
attached directly)



</td>
<td>Dd
Ff
Fd
Df</td>
<td>57
65
72
67</td>
<td></td>
</tr>
</table>

Table 3.3.2.3: Floor-Wall Transmission Paths

(same as 3.3.2.2 except 2nd layer of G16 added to ceiling)

Loadbearing wall assembly:

- 2G16_SS152(406)_GFB152_RC13(406)_G16
- CFS framing formed from steel 1.37 mm thick

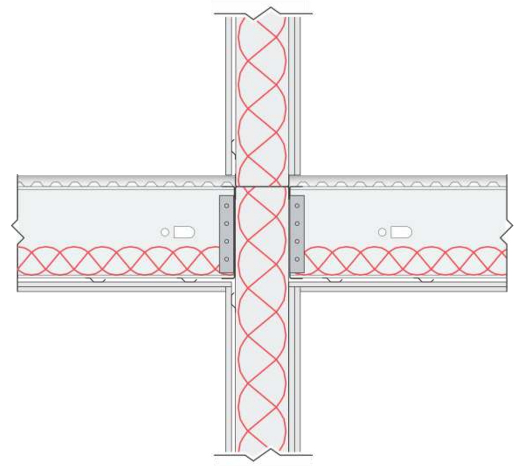
Floor/Ceiling assembly:

- GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_2G16

Junction of wall with floor/ceiling assembly:

- Junction LBd
- CFS floor joists perpendicular to the loadbearing wall but not continuous across the junction
- Gypsum concrete subfloor not continuous across the junction

(Complete description of Junction LBd in Section 3.2.)



Floor-Wall Junction LBd. Vertical section, drawn approximately to scale.

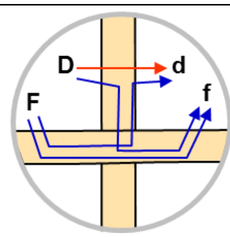
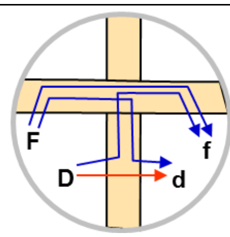
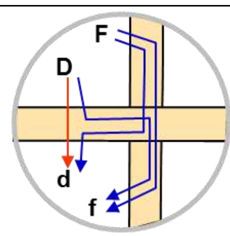
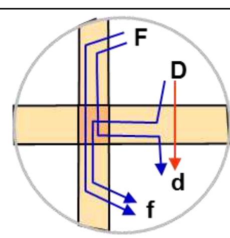
Junction	Diagram	Path	STC_{ij}	IIC_{ij}
CFS-WF-LBd-23 Wall-Floor Loadbearing Junction		Dd Ff+Fd+Df	54 ≥54	
CFS-WC-LBd-23 Wall-Ceiling Loadbearing Junction		Dd Ff Fd Df	54 83 ≥64 74	
CFS-FW-LBd-23r Floor-Wall Loadbearing Junction (Wall gypsum board on resilient channels)		Dd Ff+Fd+Df	60 ≥63	
CFS-FW-LBd-23d Floor-Wall Loadbearing Junction (Wall gypsum board attached directly)		Dd Ff Fd Df	60 65 ≥72 ≥67	

Table 3.3.3.1: Floor-Wall Transmission Paths

<u>Non-loadbearing wall assembly:</u>

- 2G16_SS92(406)_GFB92_RC13(406)_2G16
- CFS framing formed from steel 0.54 mm thick

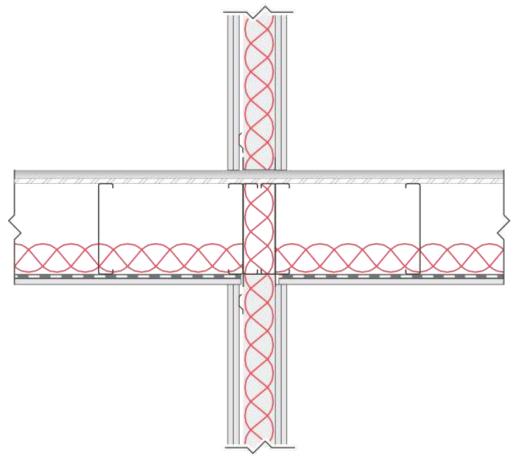
<u>Floor/Ceiling assembly:</u>

- GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16

<u>Junction of wall with floor/ceiling assembly:</u>

- Junction NLBc
- CFS floor joists parallel to the non-loadbearing wall
- Gypsum concrete subfloor continuous across junction

(Complete description of Junction NLBc in Section 3.2.)



Floor-Wall Junction NLBc. Vertical section, drawn approximately to scale.

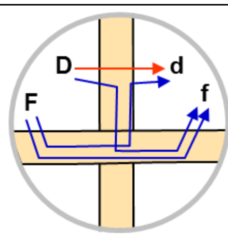
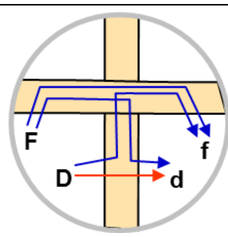
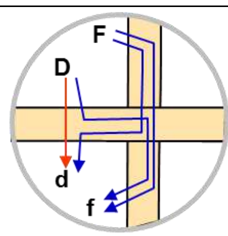
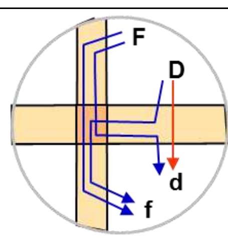
	Path	STC_{ij}	IIC_{ij}
CFS-WF-NLBc-31 Wall-Floor Non-Loadbearing Junction 	Dd Ff Fd Df	57 40 49 50	
CFS-WC-NLBc-31 Wall-Ceiling Non-Loadbearing Junction 	Dd Ff Fd Df	57 67 65 71	
CFS-FW-NLBc-31r Floor-Wall Non-Loadbearing Junction (Wall gypsum board on resilient channels) 	Dd Ff Fd Df	57 72 76 67	
CFS-FW-NLBc-31d Floor-Wall Non-Loadbearing Junction (Wall gypsum board attached directly) 	Dd Ff Fd Df	57 74 72 67	

Table 3.3.3.2: Floor-Wall Transmission Paths

(same as 3.3.3.1 except 2nd layer of G16 removed on walls where gypsum board is mounted on resilient channels)

Non-loadbearing wall assembly:

- 2G16_SS92(406)_GFB92_RC13(406)_G16
- CFS framing formed from steel 0.54 mm thick

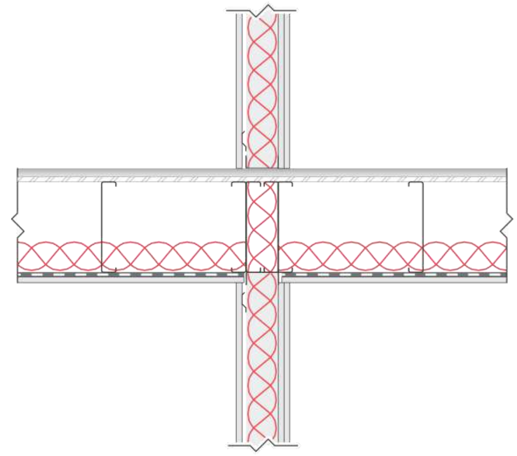
Floor/Ceiling assembly:

- GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16

Junction of wall with floor/ceiling assembly:

- Junction NLBc
- CFS floor joists parallel to the non-loadbearing wall
- Gypsum concrete subfloor continuous across junction

(Complete description of Junction NLBc in Section 3.2.)



Floor-Wall Junction NLBc. Vertical section, drawn approximately to scale.

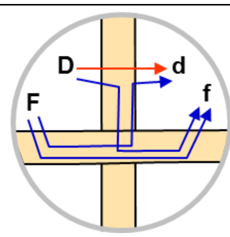
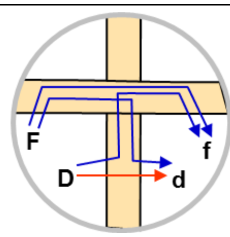
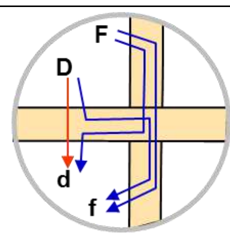
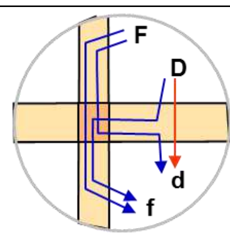
Junction	Diagram	Path	STC_{ij}	IIC_{ij}
CFS-WF-NLBc-32 Wall-Floor Non-Loadbearing Junction		Dd Ff Fd Df	53 40 49 50	
CFS-WC-NLBc-32 Wall-Ceiling Non-Loadbearing Junction		Dd Ff Fd Df	53 67 65 70	
CFS-FW-NLBc-32r Floor-Wall Non-Loadbearing Junction (Wall gypsum board on resilient channels)		Dd Ff+Fd+Df	57 63	
CFS-FW-NLBc-32d Floor-Wall Non-Loadbearing Junction (Wall gypsum board attached directly)		Dd Ff Fd Df	57 74 72 67	

Table 3.3.3.3: Floor-Wall Transmission Paths

(same as 3.3.3.2 except 2nd layer of G16 added to ceiling)

Non-loadbearing wall assembly:

- 2G16_SS92(406)_GFB92_RC13(406)_G16
- CFS framing formed from steel 0.54 mm thick

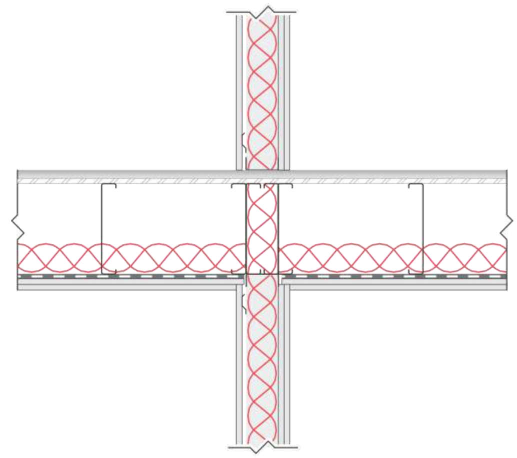
Floor/Ceiling assembly:

- GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_2G16

Junction of wall with floor/ceiling assembly:

- Junction NLBc
- CFS floor joists parallel to the non-loadbearing wall
- Gypsum concrete subfloor continuous across junction

(Complete description of Junction NLBc in Section 3.2.)



Floor-Wall Junction NLBc. Vertical section, drawn approximately to scale.

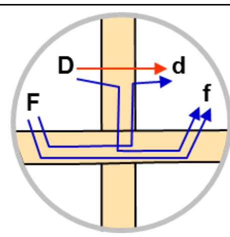
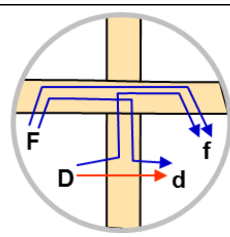
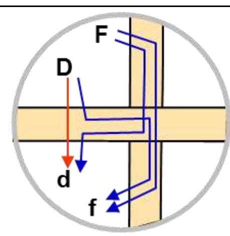
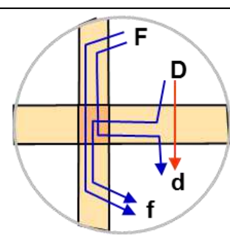
	Path	STC_{ij}	IIC_{ij}
CFS-WF-NLBc-33 Wall-Floor Non-Loadbearing Junction 	Dd Ff Fd Df	53 40 49 50	
CFS-WC-NLBc-33 Wall-Ceiling Non-Loadbearing Junction 	Dd Ff Fd Df	53 76 ≥65 ≥70	
CFS-FW-NLBc-33r Floor-Wall Non-Loadbearing Junction (Wall gypsum board on resilient channels) 	Dd Ff+Fd+Df	60 ≥63	
CFS-FW-NLBc-33d Floor-Wall Non-Loadbearing Junction (Wall gypsum board attached directly) 	Dd Ff Fd Df	60 74 ≥72 ≥67	

Table 3.3.4.1: Floor-Wall Transmission Paths

Non-loadbearing wall assembly:

- 2G16_SS92(406)_GFB92_RC13(406)_2G16
- CFS framing formed from steel 0.54 mm thick

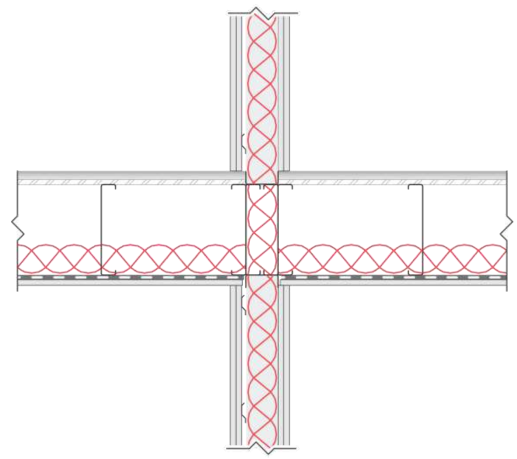
Floor/Ceiling assembly:

- GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16

Junction of wall with floor/ceiling assembly:

- Junction NLBd
- CFS floor joists parallel to the non-loadbearing wall
- Gypsum concrete subfloor not continuous across the junction

(Complete description of Junction NLBd in Section 3.2.)



Floor-Wall Junction NLBd. Vertical section, drawn approximately to scale.

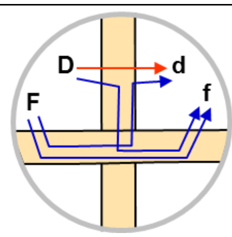
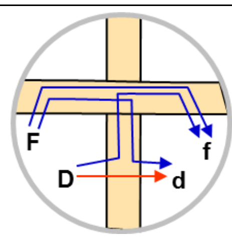
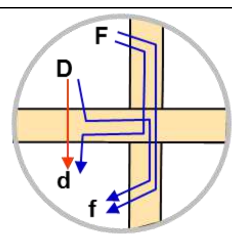
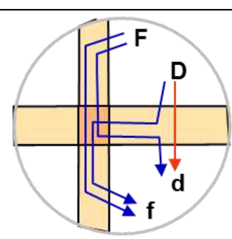
Junction		Path	STC_{ij}	IIC_{ij}
CFS-WF-NLBd-41 Wall-Floor Non-Loadbearing Junction		Dd Ff Fd Df	57 60 63 67	
CFS-WC-NLBd-41 Wall-Ceiling Non-Loadbearing Junction		Dd Ff Fd Df	57 77 70 69	
CFS-FW-NLBd-41r Floor-Wall Non-Loadbearing Junction (Wall gypsum board on resilient channels)		Dd Ff Fd Df	57 72 83 82	
CFS-FW-NLBd-41d Floor-Wall Non-Loadbearing Junction (Wall gypsum board attached directly)		Dd Ff Fd Df	57 72 76 74	

Table 3.3.4.2: Floor-Wall Transmission Paths

(same as 3.3.4.1 except 2nd layer of G16 removed on walls where gypsum board is mounted on resilient channels)

Non-loadbearing wall assembly:

- 2G16_SS92(406)_GFB92_RC13(406)_G16
- CFS framing formed from steel 0.54 mm thick

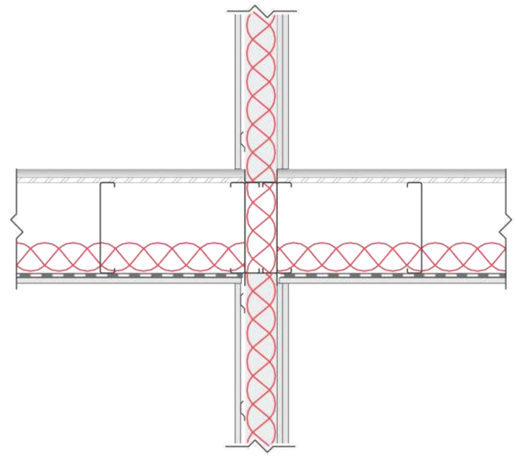
Floor/Ceiling assembly:

- GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16

Junction of wall with floor/ceiling assembly:

- Junction NLBd
- CFS floor joists parallel to the non-loadbearing wall
- Gypsum concrete subfloor not continuous across the junction

(Complete description of Junction NLBd in Section 3.2.)



Floor-Wall Junction NLBd. Vertical section, drawn approximately to scale.

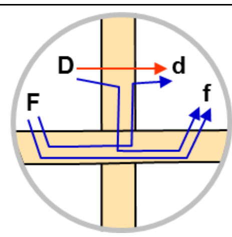
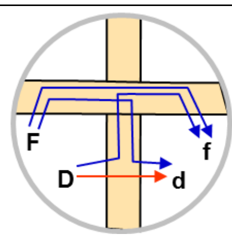
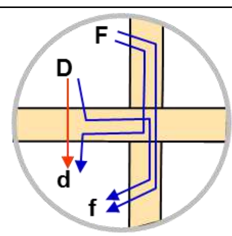
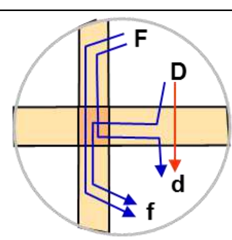
Junction		Path	STC_{ij}	IIC_{ij}
CFS-WF-NLBd-42 Wall-Floor Non-Loadbearing Junction		Dd Ff Fd Df	53 60 63 67	
CFS-WC-NLBd-42 Wall-Ceiling Non-Loadbearing Junction		Dd Ff Fd Df	53 77 70 69	
CFS-FW-NLBd-42r Floor-Wall Non-Loadbearing Junction (Wall gypsum board on resilient channels)		Dd Ff+Fd+Df	57 ≥61	
CFS-FW-NLBd-42d Floor-Wall Non-Loadbearing Junction (Wall gypsum board attached directly)		Dd Ff Fd Df	57 72 76 74	

Table 3.3.4.3: Floor-Wall Transmission Paths

(same as 3.3.4.2 except 2nd layer of G16 added to ceiling)

Non-loadbearing wall assembly:

- 2G16_SS92(406)_GFB92_RC13(406)_G16
- CFS framing formed from steel 0.54 mm thick

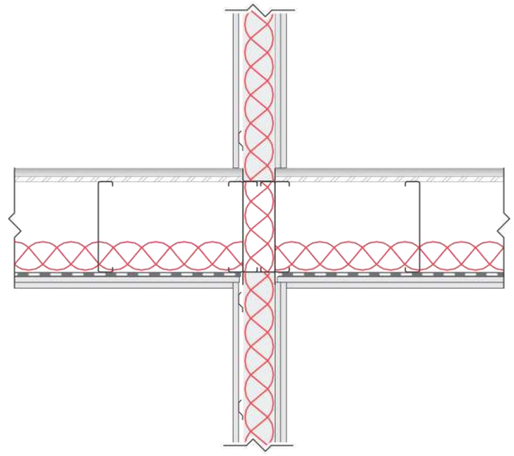
Floor/Ceiling assembly:

- GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_2G16

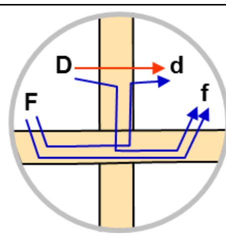
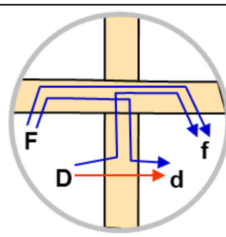
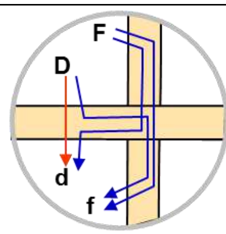
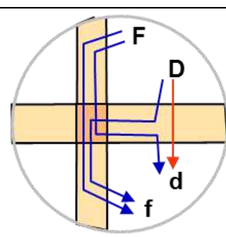
Junction of wall with floor/ceiling assembly:

- Junction NLBd
- CFS floor joists parallel to the non-loadbearing wall
- Gypsum concrete subfloor not continuous across the junction

(Complete description of Junction NLBd in Section 3.2.)



Floor-Wall Junction NLBd. Vertical section, drawn approximately to scale.

Transmission path	Diagram	Path	STC_{ij}	IIC_{ij}
CFS-WF-NLBd-43 Wall-Floor Non-Loadbearing Junction		Dd Ff Fd Df	53 60 63 67	
CFS-WC-NLBd-43 Wall-Ceiling Non-Loadbearing Junction		Dd Ff Fd Df	53 80 72 ≥69	
CFS-FW-NLBd-43r Floor-Wall Non-Loadbearing Junction (Wall gypsum board on resilient channels)		Dd Ff+Fd+Df	60 ≥61	
CFS-FW-NLBd-43d Floor-Wall Non-Loadbearing Junction (Wall gypsum board attached directly)		Dd Ff Fd Df	60 72 ≥76 ≥74	

3.4 Tested Junctions of CFS-Framed Walls with Walls

The following tables present values of the flanking sound transmission via specific paths that were determined from measurements following the procedures of ISO 10848 on a series of mock-up constructions with connected CFS-framed wall assemblies. The facilities and test procedures are described in Section 3.1. The test specimens are described in Section 3.2.

This chapter focusses on single-number results for the flanking sound transmission as was done for the presentation of the STC and ΔSTC results in Chapter 2. In this case, the results are values of flanking sound transmission class (Flanking STC_{ij}), where the subscript i denotes the source room (surface D or F), and the subscript j denotes the connected receiving room (surface d or f) for the transmission path through the junction. These values are used to calculate the ASTC rating in the examples in Chapter 4 which are calculated using the Simplified Method of ISO 15712-1.

Tables 3.4.01 to 3.4.04 show the Flanking STC values for a set of paths through a junction. Each table consists of several parts:

1. A brief generic description of the details of the abutting wall assemblies and their junction.
2. A drawing showing the general features of the junction.
3. Junction cases are presented in the rows below, with stylized drawings to identify the paths in each case, and Flanking STC_{ij} values for each flanking path ij.
4. Note that each junction of wall assemblies comprises the combination of a separating wall and two flanking walls. The separating wall could be a loadbearing wall, or a non-loadbearing wall. If the separating wall is loadbearing, the flanking walls are non-loadbearing and vice versa.
5. The junction name is defined by the type of separating wall (LB… or NLB…).

Junction naming follows a simple coding system in four segments:

- The first segment of the code indicates that the junction consists of CFS-framed assemblies.
- The second segment of the code indicates the junction type (WW=wall-wall).
- The third segment of the code indicates the nature of the junction itself:
  > the first letters (LB or NLB) indicates the type of separating wall,
  > the final letters (92, 152, etc.) indicates the stud depth for the separating wall
- The fourth segment of the code is the unique number for that junction detail.

Note 1.	All the Flanking STC results in this chapter have been normalized to the Standard Scenario presented in Chapter 1, using Equation 4.1.3.
Note 2.	The test results in this section are for wall/wall junctions where the rooms are side-by-side, separated by a wall assembly. Values are normalized to $S = 12.5\ m^2$ and $l = 2.5$ m.
Note 3.	Although only cross-junctions were tested, a T-junction of wall assemblies should have the same flanking sound transmission ratings as a cross-junction for CFS-framed wall assemblies.
Note 4.	STC ratings measured according to ASTM E90 (from tables in Sections 2.2 and 2.3) are given for path Dd in lieu of the measured Flanking STC for path Dd.

Table 3.4.01: Wall-Wall Transmission Paths

<u>Non-loadbearing wall assembly:</u>

- 2G16_SS92(406)_GFB92_RC13(406)_2G16
- CFS framing formed from steel 0.54 mm thick

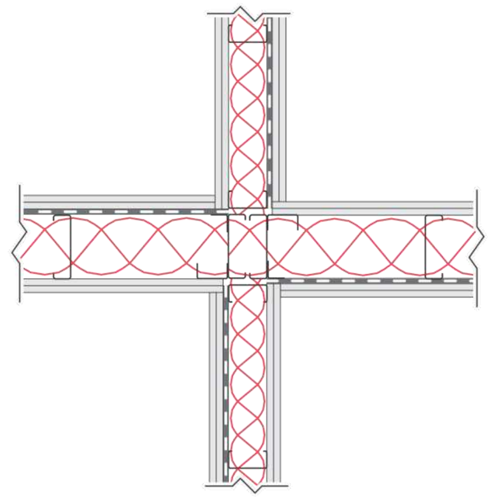
<u>Loadbearing wall assembly:</u>

- 2G16_SS152(406)_GFB152_RC13(406)_2G16
- CFS framing formed from steel 1.37 mm thick

<u>Junction:</u>

- X-junction with closest studs of the non-loadbearing walls spaced 10 mm from framing of loadbearing wall.
- If gypsum board on loadbearing wall is directly attached to the framing, gypsum board on the adjacent non-loadbearing wall is supported on resilient channels, and vice versa.

(Complete descriptions of these assemblies and junctions with larger drawings are provided in Section 3.2.)



Wall-Wall Junction for CFS-framed construction.

Horizontal section viewed from above, drawn approximately to scale.

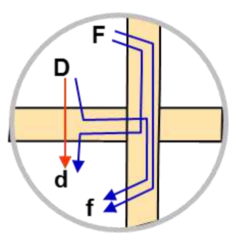
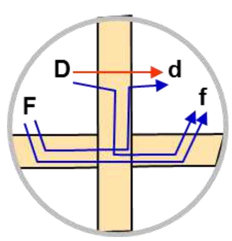
Junction		Path	Flanking STC_{ij}
CFS-WW-LB152-01 Wall-Wall Junction with loadbearing separating wall	 	Dd Ff Fd Df	58 82 76 82
CFS-WW-NLB92-01 Wall-Wall Junction with non-loadbearing separating wall	 	Dd Ff Fd Df	57 84 82 81

Table 3.4.02: Wall-Wall Transmission Paths

(same as 3.4.01 except 2nd layer of G16 removed on walls where gypsum board is mounted on resilient channels)

<u>Non-loadbearing wall assembly:</u>

- 2G16_SS92(406)_GFB92_RC13(406)_G16
- CFS framing formed from steel 0.54 mm thick

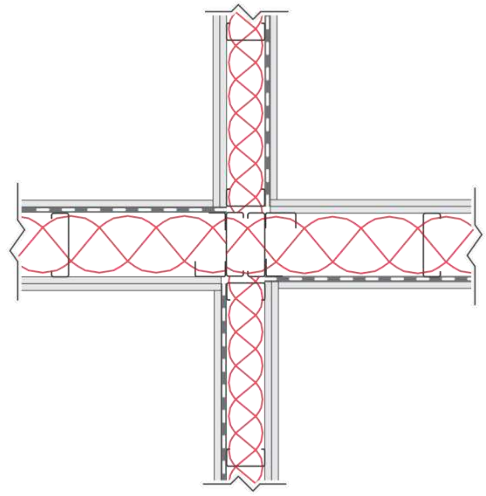
<u>Loadbearing wall assembly:</u>

- 2G16_SS152(406)_GFB152_RC13(406)_G16
- CFS framing formed from steel 1.37 mm thick

<u>Junction:</u>

- X-junction with closest studs of the non-loadbearing walls spaced 10 mm from framing of loadbearing wall.
- If gypsum board on loadbearing wall is directly attached to the framing, gypsum board on adjacent non-loadbearing wall is supported on resilient channels, and vice versa.

(Complete descriptions of these assemblies and junctions with larger drawings are provided in Section 3.2.)



Wall-Wall Junction for CFS-framed construction.

Horizontal section viewed from above, drawn approximately to scale.

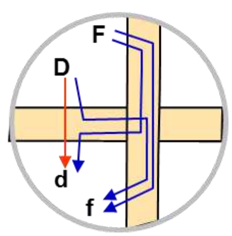
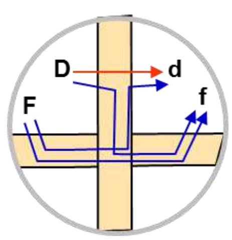
Junction	Path	Flanking STC_{ij}
CFS-WW-LB152-02 Wall-Wall Junction with loadbearing separating wall 	Dd	54
	Ff	82
	Fd	76
	Df	80
CFS-WW-NLB92-02 Wall-Wall Junction with non-loadbearing separating wall 	Dd	53
	Ff	82
	Fd	78
	Df	81

Table 3.4.03: Wall-Wall Transmission Paths

(same as 3.4.02 except resilient channels removed on non-loadbearing separating wall and on loadbearing flanking wall, and the directly attached gypsum board on the flanking wall is continuous across the junction)

<u>Non-loadbearing wall assembly:</u>

- 2G16_SS92(406)_GFB92_G16
- CFS framing formed from steel 0.54 mm thick

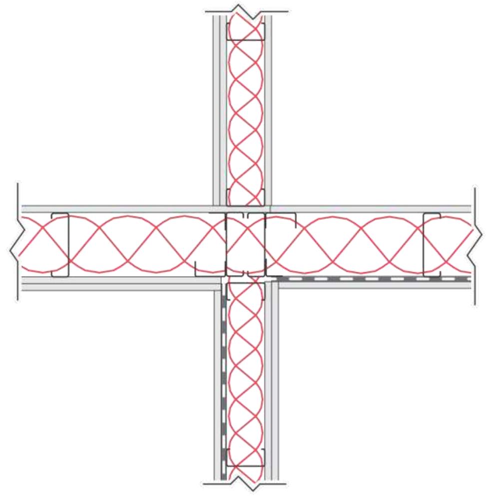
<u>Loadbearing wall assembly:</u>

- G16_SS152(406)_GFB152_2G16 (left) and
- G16_SS152(406)_GFB152_RC13(406)_G16 (right)
- CFS framing formed from steel 1.37 mm thick

<u>Junction:</u>

- X-junction with closest studs of the non-loadbearing walls spaced 10 mm from framing of loadbearing wall.

(Complete descriptions of these assemblies and junctions with larger drawings are provided in Section 3.2.)



Wall-Wall Junction for CFS-framed construction.

Horizontal section viewed from above, drawn approximately to scale.

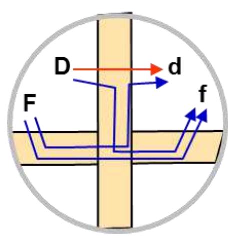
Junction	Path	Flanking STC_{ij}
CFS-WW-NLB92-03 Wall-Wall Junction with non-loadbearing separating wall  	Dd Ff Fd Df	43 48 62 62

Table 3.4.04: Wall-Wall Transmission Paths

(same as 3.4.03 except 2nd layer of G16 installed on the loadbearing flanking walls, directly attached to the studs and continuous across the junction)

<u>Non-loadbearing wall assembly:</u>

- 2G16_SS92(406)_GFB92_G16
- CFS framing formed from steel 0.54 mm thick

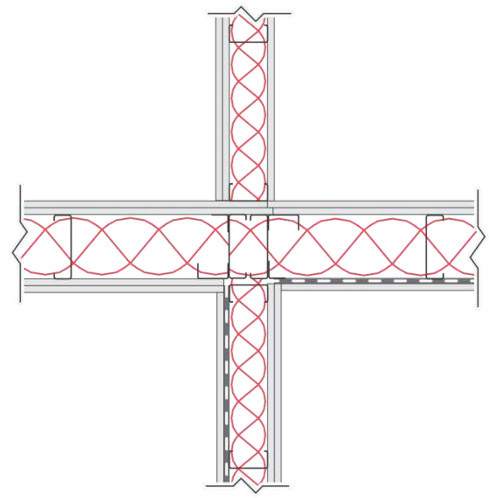
<u>Loadbearing wall assembly:</u>

- 2G16_SS152(406)_GFB152_2G16 (left) and
- 2G16_SS152(406)_GFB152_RC13(406)_G16 (right)
- CFS framing formed from steel 1.37 mm thick

<u>Junction:</u>

- X-junction with closest studs of the non-loadbearing walls spaced 10 mm from framing of loadbearing wall.

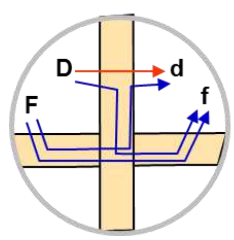
(Complete descriptions of these assemblies and junctions with larger drawings are provided in Section 3.2.)



Wall-Wall Junction for CFS-framed construction.

Horizontal section viewed from above, drawn approximately to scale.

CFS-WW-NLB92-04
Wall-Wall Junction with non-loadbearing separating wall



Path	Flanking STC_{ij}
Dd	43
Ff	53
Fd	61
Df	66

3.5 Trends in Flanking Sound Transmission for CFS-Framed Constructions

The evaluation of the flanking sound transmission in CFS-framed constructions included a wide range of construction details. Flanking STC values for the tested configurations are presented in the tables in the preceding sections for wall/floor and wall/wall junctions.

This section discusses the results for some of the cases to highlight the systematic changes in the Flanking STC values due to specific changes in the construction details.

The discussion focuses on the following differences in the constructions:

- The effect of direction and continuity of the floor joists and of the subfloor;
- The effect of fire blocking of the floor cavities with Junction LBc;
- The effect of adding finish flooring on top of the floor-ceiling assemblies;
- The effect of adding layers of gypsum board to the ceilings;
- The effect of gypsum board continuity and attachment to the studs at wall/wall junctions.

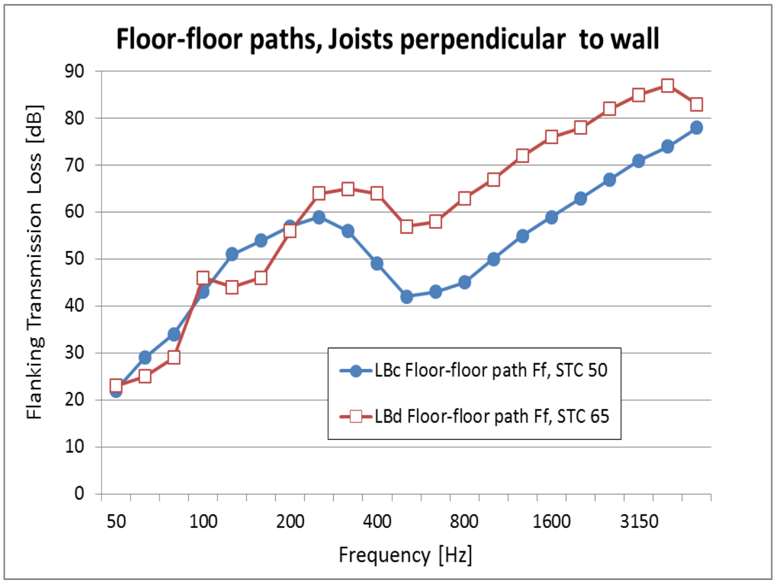
These comparisons clearly identify construction details with the potential to significantly improve or worsen the flanking sound transmission.

Effect of Continuous vs Discontinuous Joists and Subfloor

Flanking transmission is compared for Junction LBc vs. LBd (with floor joists perpendicular to the loadbearing separating wall) and then for NLBc vs. NLBd (with floor joists parallel to the non-loadbearing separating wall). In each case, a pair of graphs shows floor-floor paths and then corresponding ceiling-ceiling paths, to illustrate changes in the flanking transmission loss due to differences in continuity of the gypsum concrete deck and/or floor framing.

Figure 3.5.1:
Flanking sound transmission loss for the floor-floor path Ff for a loadbearing wall/floor junction with joists and subfloor continuous across the junction (Junction LBc) and for a loadbearing wall/floor junction with joists and subfloor discontinuous across the junction (Junction LBd).

Above 200 Hz, the transmission loss for Junction Lbd is significantly higher than for Junction LBc.



The corresponding changes in the ceiling-ceiling paths are shown in Figure 3.5.2. These changes are quite similar to those for the floor-floor paths, although slightly smaller.

Figure 3.5.2:
Flanking sound transmission loss for the ceiling-ceiling path Ff for a loadbearing wall/ceiling junction with joists continuous across the junction (Junction LBc) and for a loadbearing wall/ceiling junction with joists discontinuous across the junction (Junction LBd).

Above 200 Hz, the transmission loss for Junction Lbd is significantly higher than for Junction LBc.

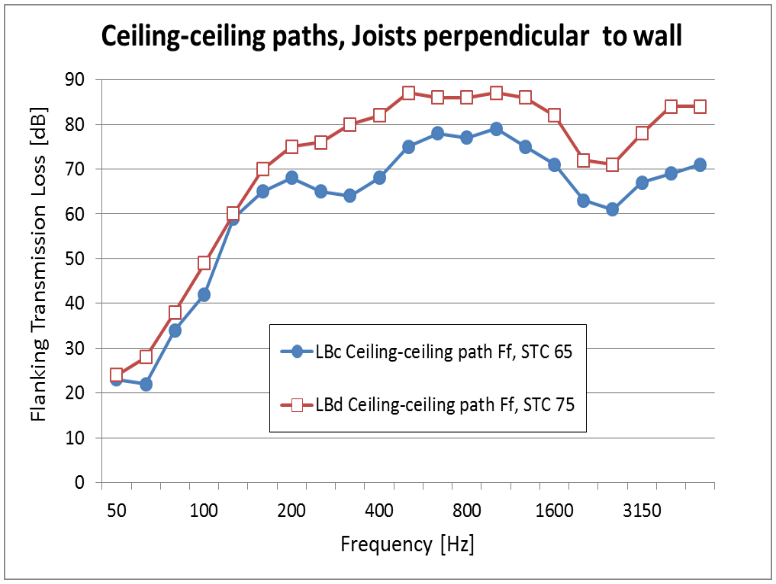


Figure 3.5.3:
Flanking sound transmission loss for the floor-floor path Ff for a non-loadbearing wall/floor junction with continuous subfloor (Junction NLBc) and for a non-loadbearing wall/floor junction with discontinuous subfloor (Junction NLBd).

The transmission loss is significantly higher for Junction NLBd, due to the discontinuity of the gypsum concrete floor deck.

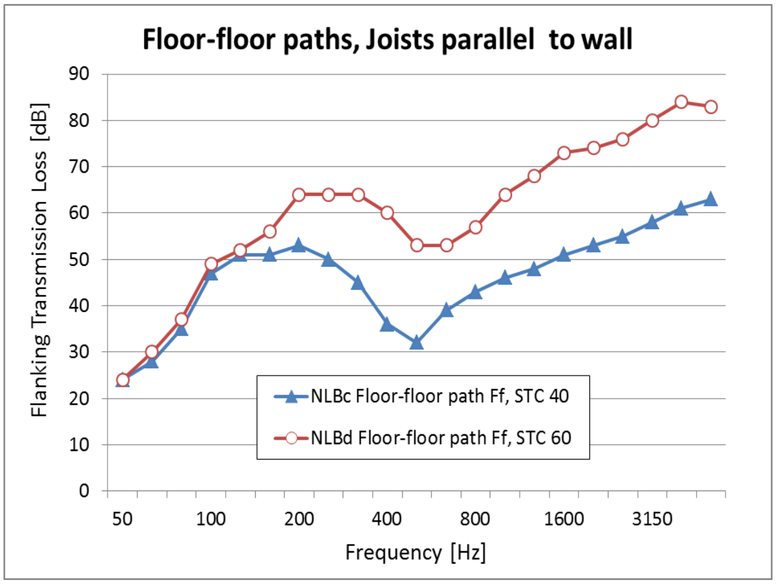
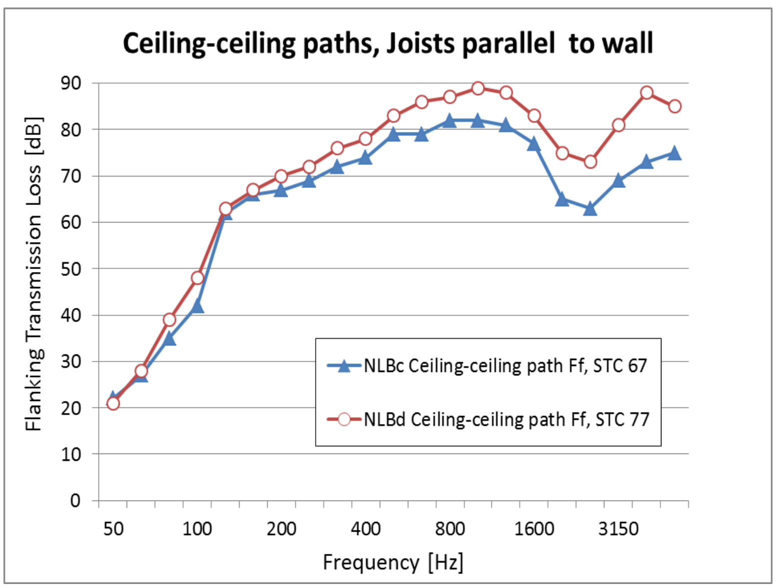


Figure 3.5.3 shows performance for the floor-floor paths at junction NLBc vs. NLBd, and corresponding changes in the ceiling-ceiling paths are shown in Figure 3.5.4. The ceiling-ceiling path changes show similar trends to those for the floor-floor paths, although the changes are much smaller, which is expected since the construction differences are all associated with subassemblies above the floor joists.

Figure 3.5.4:
Flanking sound transmission loss for the ceiling-ceiling path Ff for a non-loadbearing wall/ceiling junction with continuous subfloor (Junction NLBc) and for a non-loadbearing wall/ceiling junction with discontinuous subfloor (Junction NLBd).

The transmission loss is higher for Junction NLBd, due to discontinuity of the gypsum concrete floor deck, although the change is smaller than for the floor-floor path.



Overall, it is clear that a subfloor which is continuous across the junction can cause serious flanking via the floor-surfaces (especially path Ff). For Junction NLBc, the Flanking STC for the floor-floor path is 40, significantly below a value at which occupant satisfaction can be expected. The Flanking STC value of 50 for Junction LBc is at the lower limit of acceptability, no matter how good the separating wall may be.

Effect of Fire Blocking in Floor Cavities

The fire block at the LBc junction is described in Section 3.2.

Figure 3.5.5:
Flanking sound transmission loss for the floor-floor path Ff at wall/floor junction LBc with vs. without a fire block at the junction.

For this junction, the floor joists are perpendicular to the loadbearing separating wall and continuous across the wall. Without a fire block at the junction there is an open cavity that provides an airborne flanking path that decreases the apparent transmission loss.

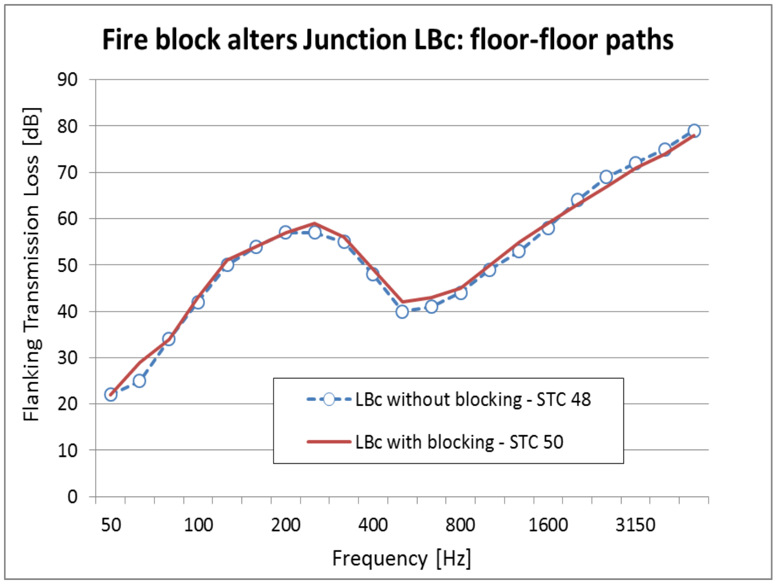
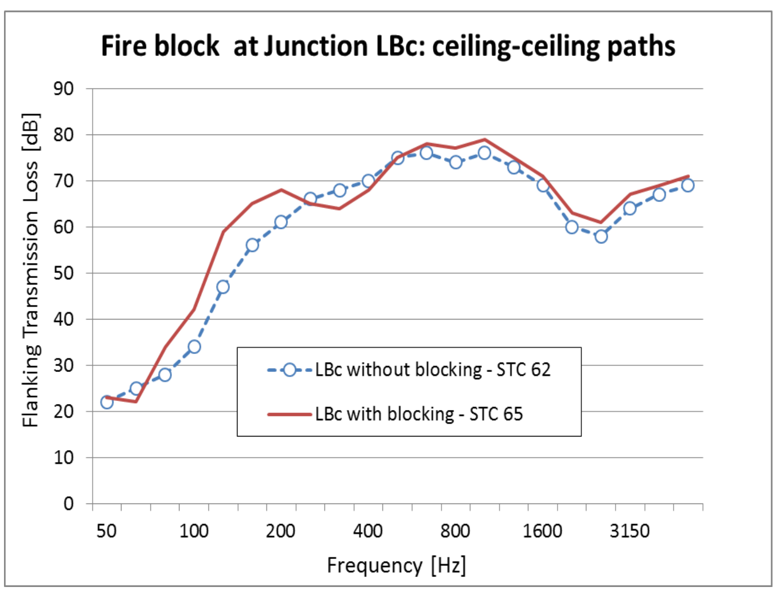


Figure 3.5.5 shows that the performance for the floor-floor paths is only slightly changed by adding the fire block, but the Flanking STC rating does rise by 2 due to the increase between 200 and 2000 Hz. Comparing this with Figure 3.5.6, the ceiling-ceiling path transmission loss increases more at most frequencies when the fire block is added, except for a small dip around 300 Hz that limits the improvement in the Flanking STC rating to 3.

Figure 3.5.6:
Flanking sound transmission loss for the ceiling-ceiling path Ff at wall/floor junction LBc with vs. without a fire block at the junction.

For this junction, the floor joists are perpendicular to the loadbearing separating wall and continuous across the wall. Without a fire block at the junction there is an open cavity that provides an airborne flanking path that decreases the apparent transmission loss.



These changes in the floor-floor and ceiling-ceiling paths can make the difference between a junction design that does not meet the ASTC 47 requirement of the NBCC (without the fire block), and a junction design that does satisfy the ASTC 47 requirement, due to the added fire block. Of course the design without the fire block also fails to satisfy the requirements for control of smoke and fire at the junction. This provides an excellent example of how good design to control smoke and fire penetration across a junction via hidden cavities tends to eliminate potentially problematic airborne flanking paths.

Effect of Adding Finish Flooring

The effect of adding finish flooring to the floors was presented in Section 2.3.1 for direct transmission through the assembly. The corresponding effect for flanking paths involving the top surface of the floor is shown in Figure 3.5.7. The effect on flanking paths is largest for the floor-floor flanking paths, and is illustrated for Junction LBc in Figure 3.5.7. Similar improvements were measured for the other junctions.

Figure 3.5.7:
Flanking sound transmission loss for the floor-floor path Ff at wall/floor junction LBc with a bare gypsum concrete subfloor vs. the case with finish flooring over the gypsum concrete subfloor.

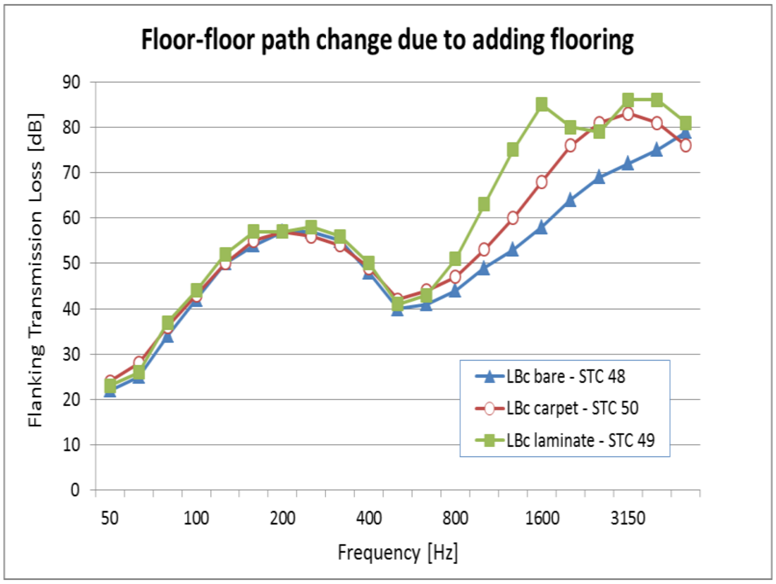


Figure 3.5.7 shows that performance for the floor-floor paths below 500 Hz is not significantly changed by adding the flooring, but the flanking transmission loss is increased appreciably at higher frequencies. This result is consistent with the improvement in direct transmission loss through the floor-ceiling assembly shown in Figures 2.3.4 and 2.3.5. Note that the flanking transmission loss is limited at the higher frequencies by the flanking limit of the test facility.

Although these flanking measurements were slightly affected by other paths, they are generally consistent with the ΔTL measurements in Section 2.3.1 and justify using the latter in the ASTC calculation examples in Chapter 4.

Effect of Adding Gypsum Board Layers to Ceilings

Adding gypsum board to the ceilings increases not only the direct sound transmission loss for the floor-ceiling assembly (as shown in Section 2.3) but also the flanking transmission loss for paths including the ceiling surfaces. Results for ceiling-ceiling paths Ff (where the effect is largest and most consistent) are shown in Figures 3.5.8 and 3.5.9 for junctions LBc and NLBd, respectively.

Figure 3.5.8:
Flanking sound transmission loss for the ceiling-ceiling path Ff at wall/floor junction LBc (joists continuous across the junction) with a ceiling of one layer or two layers of 16 mm thick gypsum board on resilient channels.

Adding the second layer of gypsum board is shown to increase the Flanking STC rating by 11.

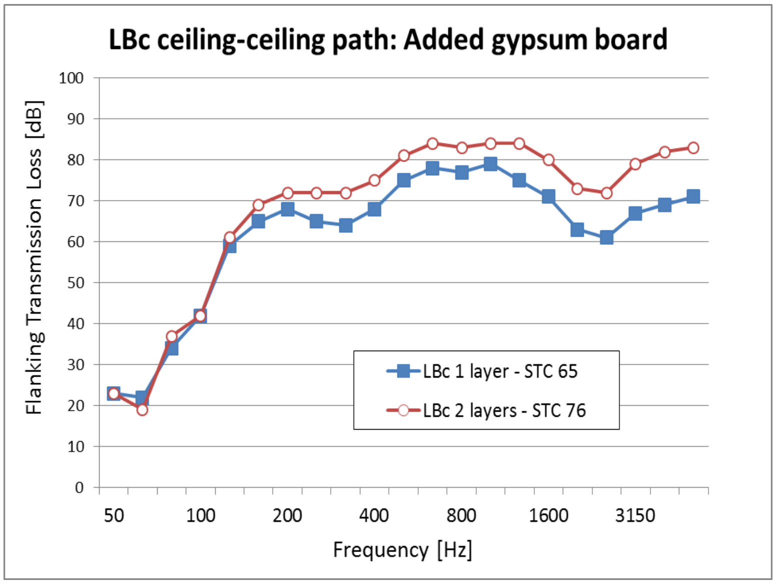
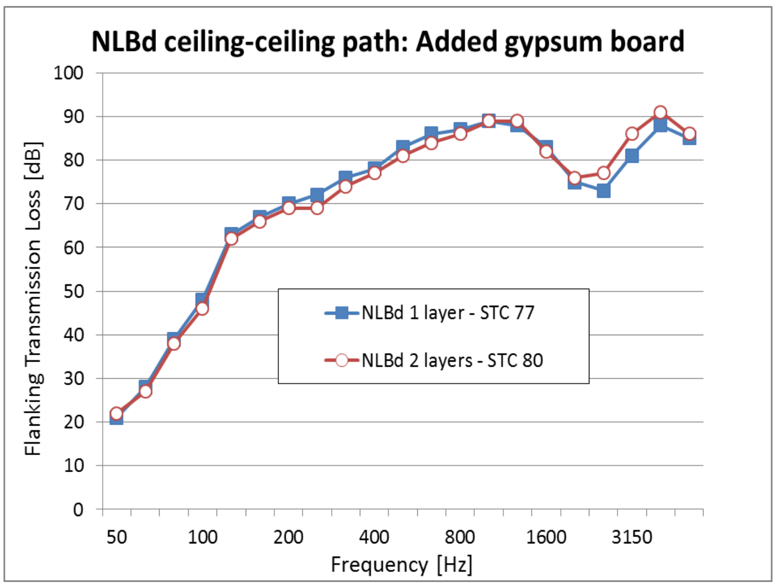


Figure 3.5.9:
Flanking sound transmission loss for the ceiling-ceiling path Ff at wall/floor junction NLBd (joists parallel to the junction) with a ceiling of one layer or two layers of 16 mm thick gypsum board on resilient channels.

Adding the second layer of gypsum board is shown to increase the Flanking STC rating by 3.



The two cases illustrated had the largest and smallest changes due to adding the second layer of gypsum board. The Flanking STC rating increases of 8 and 9 for Junctions LBd and NLBc respectively were intermediate between the illustrated cases.

Effect of Gypsum Board Attachment at the Junction

The flanking transmission at the wall/wall junctions depends significantly on the way the gypsum board is attached to the wall framing. Gypsum board that is continuous across the junction was shown to decrease the Flanking STC rating by about 30 points compared with gypsum board that is interrupted at the junction.

Figure 3.5.10:
Flanking sound transmission loss for the wall-wall path Ff at the wall/wall junction for different variations of gypsum board attachment to the loadbearing flanking walls.

Gypsum board that is continuous across the junction significantly reduces the Flanking STC rating, by about 30 STC points.

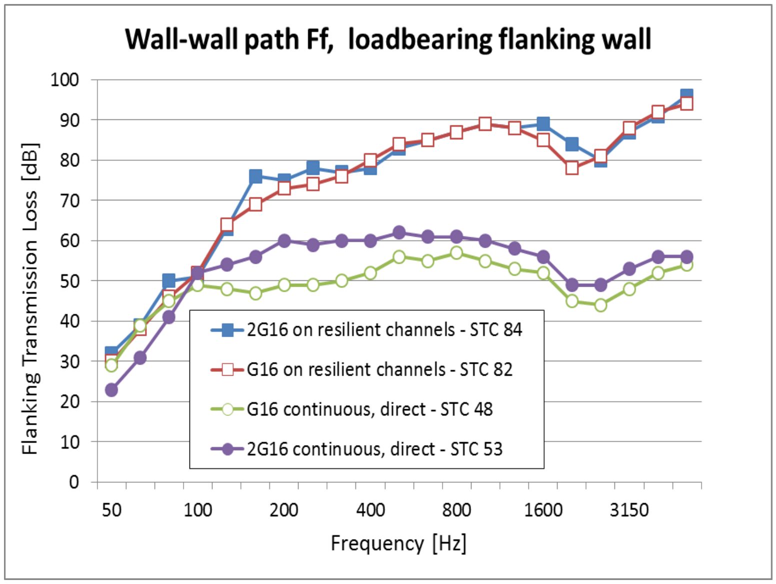


Figure 3.5.10 shows the transmission loss for the wall-wall flanking paths (path Ff) when the flanking wall is loadbearing. The figure illustrates how continuous gypsum board on the flanking walls provides an effective path for sound transmission between adjacent rooms. This can significantly affect the apparent sound insulation, independent of the design of the separating wall.

Summary of Trends in the Flanking Sound Transmission

The comparisons in Section 3.5 and the tabulated Flanking STC values in Sections 3.3 and 3.4 clearly identify construction details with the potential to significantly improve or decrease the flanking sound insulation:

- A break in the subfloor, for example by an intervening wall assembly without concrete filling the bottom track, can significantly reduce the flanking transmission via the floor surfaces. In this case study, the Flanking STC values for the floor-floor path for discontinuous subfloors were 15 points higher than for continuous subfloors in the case of a loadbearing junction, and 20 points higher in the case of a non-loadbearing junction.
- For loadbearing junctions, the continuity of the joists affects both the flanking sound transmission via the floor surfaces and the transmission via the ceiling surfaces. Joists that are continuous across the junction allow sound to travel uninterrupted, and hence should be avoided if possible. In this case study, the Flanking STC values for the ceiling-ceiling path for discontinuous joists were 10 points higher than for continuous joists.
- Fire blocking is usually inserted into the joist cavities at the junction to control smoke and flame spread, but it is also an efficient way to suppress airborne flanking transmission through the cavity. In this case study, the Flanking STC values for the floor-floor and ceiling-ceiling paths increased by 2 and 3 points respectively when fire blocking was installed. Care should be taken though to avoid additional rigid connections at the junction which could lead to higher structure-borne sound transmission.
- Finish flooring on top of a floor-ceiling assembly has only a small effect on the flanking sound transmission via the floor. For the cases tested, the Flanking STC values increased by 1-2 points. Although the improvements are small for airborne sound insulation, the larger effect of flooring on impact sound insulation can significantly improve the overall acoustic performance.
- Adding a second layer of gypsum board to the ceiling was shown to improve the flanking transmission for paths involving the ceiling. The Flanking STC values for the ceiling-ceiling paths increased by 8-11 points for most junctions.
- Gypsum board that is installed continuous across a wall/wall junction can significantly decrease the apparent sound insulation. When the gypsum board and wall studs were well-separated, Flanking STC values above 80 were measured for the wall-wall path. When the gypsum board was installed continuous across the junction, the Flanking STC values dropped to 48 and 53 for one and two layers of gypsum board respectively.

4 Predicting Sound Transmission in CFS-Framed Buildings

The focus of this chapter is to present the method for predicting the apparent sound transmission class (ASTC) rating between adjacent rooms in a building. The prediction method uses an empirical calculation approach described in ISO 15712-1 [7] that combines laboratory sound transmission data for individual CFS-framed wall or floor separating assemblies with flanking sound transmission data for each path at their junctions with adjoining assemblies.

The transmission of structure-borne vibration in a building with lightweight framed structures (made of wood or steel members) differs markedly from that in heavy homogeneous structures of concrete or masonry. There is both good news and bad news:

- The good news: For lightweight framed assemblies, the high internal loss factors result in minimal dependence on the connection to the adjoining structures, so that laboratory sound transmission values can be used without adjustment to estimate the direct transmission through the separating assembly in the finished building.
- The bad news: The standardized method of calculating flanking sound transmission from laboratory sound transmission data for individual wall and floor assemblies combined with junction attenuation data does not yield reliable results for lightweight framed building elements, and a different approach is required. The calculation process explained below is very simple (more good news), but it requires a new type of laboratory input data.

Before presenting the calculation process, some background justification seems appropriate. The characteristic transmission of structure-borne vibration can be illustrated by considering the vibration levels in a framed floor assembly excited by a localized impact source, as presented in Figure 4.1.

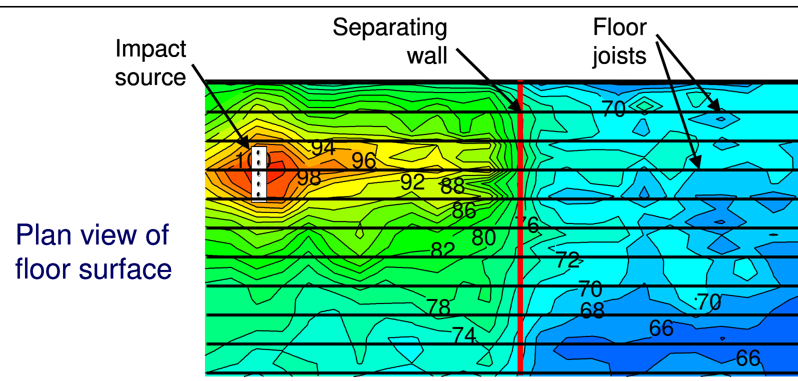


Figure 4.1: Variation across the floor surface of the vibration levels (2 kHz band) due to an impact source. The floor construction has a 19 mm plywood subfloor on wood joists that are perpendicular to the separating wall between the two side-by-side rooms.

Clearly, the lightweight framed floor system is both highly damped and anisotropic – the vibration field exhibits a strong gradient away from the source due to the high internal losses, and the gradient is different in the directions parallel and perpendicular to the joists, unlike the uniform flow of energy in all directions that would be expected in a homogeneous cast-in-place concrete assembly. As a result, the direction of transmission relative to the framing members becomes an additional parameter needed for accurate prediction, and the transmission of sound power to or from a flanking surface is not simply proportional to its area. In general, this vibration field is a poor approximation of a diffuse field, which limits applicability of the energy flow model of ISO 15712-1 (which assumes homogeneous and lightly-damped assemblies that can be sensibly represented by an average vibration level).

Because of the attenuation across a flanking assembly, especially at higher frequencies, the assumption that sound power due to flanking is proportional to the flanking area (implicit in Section 4.1 of ISO 15712-1) is not appropriate. The equations in Section 4.1 of this Report provide more appropriate normalization for highly-damped assemblies such as lightweight CFS-framed walls and floors.

Not only do vibration levels vary strongly across the surface of the structural assembly, but also typical changes to the surfaces (such as changing the gypsum board layers and/or their attachment to the walls and ceiling) *change* the attenuation across the structural assembly, with different changes in the three orthogonal directions pertinent to direct and flanking transmission. The change provided by a layer added to a surface depends on the weight and stiffness of the surface to which it is added, and if the added material is also anisotropic (for example, strip hardwood over a plywood subfloor) then its effect depends on its orientation relative to the supporting framing.

Hence, the concept of a simple correction to account for adding a given lining is not generally applicable for lightweight framed assemblies. However, the procedures presented in this Report do allow using ΔTL and ΔSTC corrections for floor finishes on a gypsum concrete subfloor, which is more reverberant.

4.1 Calculation Procedure for CFS-Framed Walls and Floors

The calculation process requires specific laboratory test data, and can be performed using frequency band data or single-number ratings, following the steps illustrated in Figure 4.1.1.

The detailed calculation combines the set of one-third octave band transmission loss data for the direct path and all flanking paths using Eq. 1.1 to arrive at values of the apparent sound transmission loss (ATL). From the apparent sound transmission loss, the ASTC rating is calculated using the procedure of ASTM E413 [3].

For CFS-framed assemblies, using the Simplified Method presented below should provide essentially the same answer as the Detailed Method (within ±1 ASTC points, with no bias). Hence the Simplified Method is used for the following more complete description of the calculation procedure including equations, and for the examples in Section 4.2.

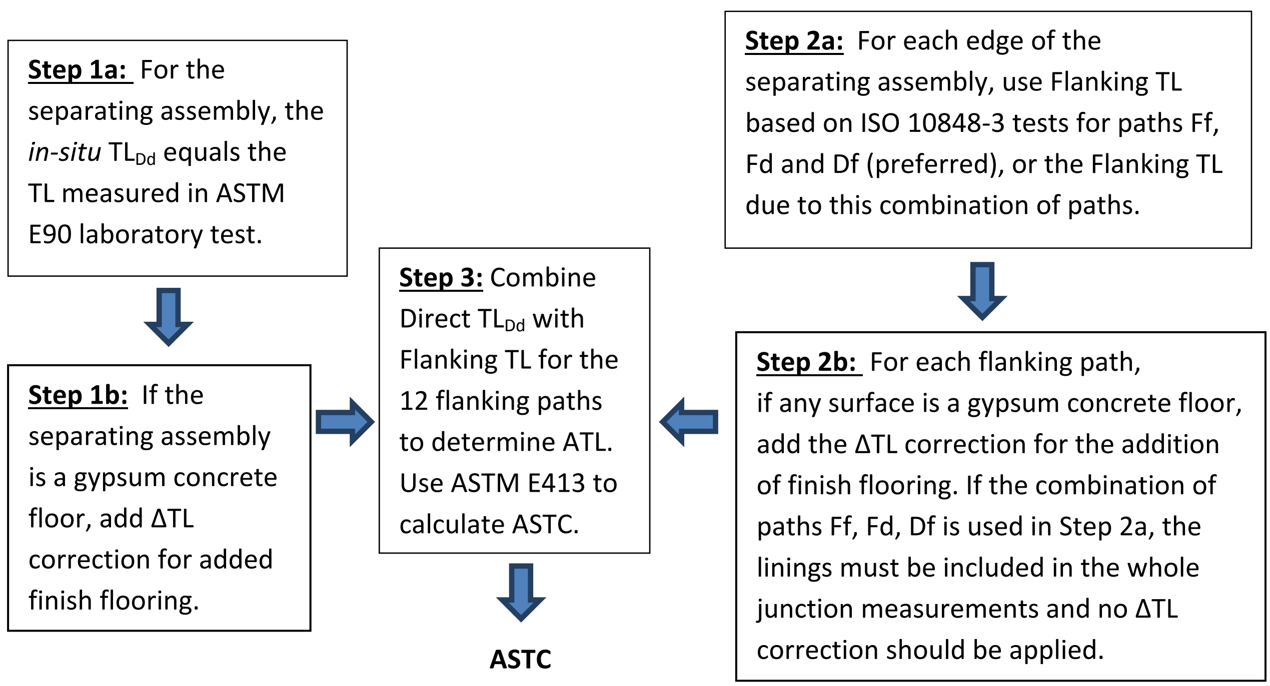


Figure 4.1.1: Steps to calculate the ASTC rating for lightweight CFS-framed constructions using transmission loss data. For the simplified procedure with STC ratings, substitute “STC” for “TL”.

Step 1: (a) For the separating assembly, the in-situ STC_{Dd} is equal to the STC rating determined in the laboratory according to ASTM E90.

(b) If the separating assembly is a floor with gypsum concrete surface, add the ΔSTC correction for added floor finishes to the STC rating for the bare floor to obtain STC_{Dd}.

Step 2: (a) Determine the Flanking STC values (STC_{Ff}, STC_{Fd}, STC_{Df}) for the 3 flanking paths Ff, Fd and Df at each edge of the separating assembly with the following adjustments:

- Values measured following the procedures of ISO 10848-3 must be re-normalized to the scenario dimensions using Equation 4.1.3.
- If only the Flanking STC rating for the combined transmission by the set of 3 paths at a junction is available, that data may be used.

(b) If one (or both) surface(s) for a flanking path is the gypsum concrete surface of a subfloor, add the ΔSTC correction for any added floor finish:

- If one surface in a flanking path is a gypsum concrete surface of a subfloor, add the ΔSTC for the added finish flooring to the value for the bare floor to obtain the Flanking STC rating.
- If both surfaces in a flanking path are gypsum concrete surfaces of a subfloor, the correction equals the larger of the two lining ΔSTC corrections plus half of the lesser one.

Step 3: Combine the transmission via the direct path and the 12 flanking paths using Equation 4.1.1 (equivalent to Eq. 26 in Section 4.4 of ISO 15712-1), with the following adaptations:

- If the Flanking STC rating calculated for any flanking path is over 90, set the value to 90.
- Round the final ASTC rating to the nearest integer.

Expressing the Calculation Process using Equations:

The ASTC rating between two rooms (neglecting sound transmitted by paths that bypass the building structure, e. g. through leaks or ducts) is estimated in the Simplified Method from the logarithmic expression of the combination of the Direct STC rating (STC_{Dd}) of the separating wall or floor element and the combined Flanking STC ratings of the three flanking paths for every junction at the four edges of the separating element. This may be expressed as:

$$\mathrm{ASTC} = -10\log_{10}\left[10^{-0.1\cdot \mathrm{STC}_{Dd}} + \sum_{\mathrm{edge}=1}^{4}\left(10^{-0.1\cdot \mathrm{STC}_{Ff}} + 10^{-0.1\cdot \mathrm{STC}_{Fd}} + 10^{-0.1\cdot \mathrm{STC}_{Df}}\right)\right] \qquad \text{Eq. 4.1.1}$$

Eq. 4.1.1 is appropriate for all types of building systems with the geometry of the Standard Scenario, and is applied here using the following notes to calculate the sound transmission for each individual path:

(a) If the separating assembly is a framed wall assembly, then the direct path STC_{Dd} is equal to the laboratory STC rating for that assembly. Alternatively if the separating assembly is a floor with gypsum concrete surface, add the ΔSTC correction for any added finish flooring to the STC rating for the bare floor to obtain STC_{Dd} for the direct path, as indicated in Eq. 4.1.2.

$$\mathrm{STC}_{Dd} = \mathrm{STC}_{bare} + \Delta\mathrm{STC}_{flooring} \qquad \text{Eq. 4.1.2}$$

(b) The options for the calculation of the Flanking STC_{ij} for each flanking path ij include:

- The procedures described in ISO 10848-3 yield experimental values of the normalized flanking level difference D_{nf}. As per the standard, these D_{nf} values are normalized to an absorption of 10 m^2 in the receiving room. In order to convert the D_{nf} values to Flanking TL_{ij} values, the correction term 10 log(S_{lab}/10) is added, yielding values of Flanking TL normalized to the room dimensions of the laboratory. When the laboratory values for Flanking TL or Flanking STC are to be applied for a calculation scenario where the room dimensions are different, they must be re-normalized to reflect room dimension differences between the laboratory test rooms and the prediction scenario (indicated in Eq. 4.1.3 by the subscript "situ"). The expression to use in the calculation is:

$$\text{Flanking TL}_{situ} = \text{Flanking TL}_{lab} + 10\log(S_{situ}/S_{lab}) + 10\log(l_{lab}/l_{situ}) \text{ in dB} \qquad \text{Eq. 4.1.3}$$

  Here, S_{situ} is the area (in m^2) of the separating assembly and l_{situ} is the junction length (in m) for the prediction scenario, and S_{lab} and l_{lab} are the corresponding values for the specimen in the ISO 10848 laboratory test. The Flanking STC rating may be determined using the procedure of ASTM E413 with the one-third octave band values of Flanking TL as input data.

- If one of the flanking elements is a floor with gypsum concrete surface, add the ΔSTC correction for added floor finishes to the Flanking STC_{ij} for the bare floor to obtain the Flanking STC_{ij} including the flooring.

$$\text{Flanking STC}_{ij} = \text{Flanking STC}_{bare} + \Delta\text{STC}_{flooring} \qquad \text{Eq. 4.1.4}$$

- If flanking elements i and j are both floor assemblies with gypsum concrete surfaces, and both have added finish flooring, add the correction to the Flanking STC_{ij} for the bare floor as in Eq. 4.1.5. Note, however, that lining corrections are not appropriate for CFS-framed assemblies with surfaces other than gypsum concrete or concrete (such as OSB for floors or gypsum board for walls).

$$\text{Flanking STC}_{ij} = \text{Flanking STC}_{bare} + \left\{ max(\Delta\,\text{STC}_i,\ \Delta\,\text{STC}_j) + \frac{min(\Delta\,\text{STC}_i,\ \Delta\,\text{STC}_j)}{2} \right\} \qquad \text{Eq. 4.1.5}$$

4.2 Calculation Examples for CFS-Framed Walls and Floors

This section presents a number of worked examples that demonstrate the calculation of the ASTC rating for CFS-framed constructions according to the Simplified Method described in Section 4.1. Each worked example in this section presents all the pertinent physical characteristics of the assemblies and junctions, together with a summary of key steps in the calculation process for these constructions.

Under the single heading "STC, ΔSTC", the examples present input data determined in laboratory tests according to ASTM E90, including:

- STC ratings for laboratory sound transmission loss data for wall and floor assemblies;
- ΔSTC values measured in the laboratory according to ASTM E90 for the change in STC rating due to adding floor finishes to the specified floor assembly (as discussed in Section 2.3);
- Flanking STC values for each flanking path at each junction measured following ISO 10848 and re-normalized using Eq. 4.1.3.

Under the heading "ASTC", the examples present the calculated values including:

- Direct STC ratings for in-situ transmission through the separating assembly including linings;
- Flanking STC ratings for each flanking transmission path including the change due to linings;
- ASTC ratings for the combination of direct and flanking transmission paths.

When the calculated Flanking STC for a given path exceeds 90 dB, the value is limited to 90, to allow for the inevitable effect of higher order flanking paths which make the higher calculated value not representative of the true situation. Further enhancements to elements in these paths will give negligible benefit. The consequence of this limit is that the Junction STC for the set of 3 paths at each edge of the separating assembly cannot exceed 85 and the Total Flanking STC for all 4 edges cannot exceed 79.

The numeric calculations present the arithmetic step-by-step in each worked example, using compact notation consistent with spreadsheet expressions:

- For the calculation of the Direct STC, these expressions are easily recognized either as:
    - measured STC values without correction for a lining if the separating assembly is a wall;
    - measured STC values which may include corrections for added floor finishes if the separating assembly is a floor with gypsum concrete surface.
- For the calculation of the Flanking STC rating, these expressions are easily recognized as measured Flanking STC values re-normalised according to Eq. 4.1.3, possibly with a ΔSTC correction for added flooring if a floor with gypsum concrete surface is one of the flanking surfaces.
- These STC or Flanking STC values are rounded to the nearest integer for consistency with the corresponding measured values.

For combining the sound power transmitted via specific paths, the calculation of Eq. 4.1.1 is presented in several stages, first for the subset of paths at each junction, then for the combined effect of all four flanking junctions, and finally for the combination of the direct path and all flanking paths. Note that in the compact notation, a term for transmitted sound power fraction such as $10^{-0.1 \cdot \mathrm{STC}_{ij}}$ becomes 10^-7.4, if STC_{ij} = 74.

For each path or junction, the overall transmission result is converted into decibel form by calculating -10*$\log_{10}$ (transmitted sound power fraction) to facilitate comparison of each path or junction with the Direct STC rating and the final ASTC rating.

The numbering of the tables presenting the worked examples end in an alphanumeric such as “H1” or “V2” to indicate Horizontal Case 1 (with rooms side-by-side) or Vertical Case 2 (with rooms one-above-the-other), respectively.

EXAMPLE 4.2-H1: (SIMPLIFIED METHOD)

- **Rooms side-by-side**
- **Loadbearing junction with continuous joists and subfloor**

Loadbearing separating wall assembly with:

- Wall CFS-S152-W33 (see Table 2.2.1) with short code 2G16_SS152(406)_GFB152_RC13(406)_G16

Junction 1: Separating wall / floor with:

- Junction code CFS-WF-LBc-13
- Floor name CFS-J254-F01 (see Table 2.3.1) with short code GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16
- CFS floor joists[1] perpendicular to the loadbearing wall and continuous across the junction, with fire blocking at the junction.
- Gypsum concrete floor deck continuous across the junction.

Junction 2 or 4: Separating wall / abutting side wall with:

- Junction code CFS-WW-LB152-01
- Non-loadbearing flanking walls with short code 2G16_SS92(406)_GFB152_RC13(406)_G16, framing formed from steel 0.54 mm thick
- Closest CFS studs[1] of the non-loadbearing walls are spaced 10 mm from framing of loadbearing wall.
- If gypsum board[2] on loadbearing wall is directly attached to framing, gypsum board on adjacent non-loadbearing wall is supported on resilient channels[4], and vice versa.

Junction 3: Separating wall / ceiling with:

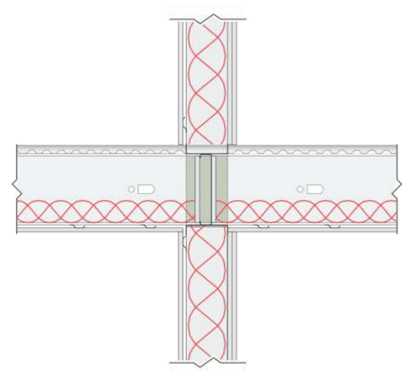
- Junction code CFS-WC-LBc-13

(More complete descriptions of these assemblies and junctions with larger drawings are given in Section 3.2.)

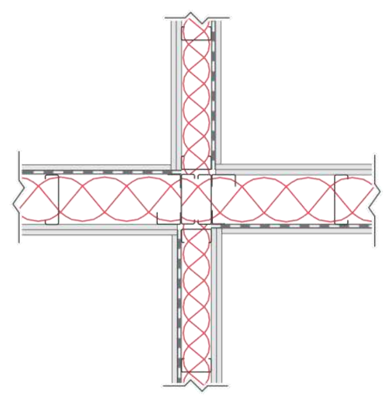
Acoustical Parameters:

	In Scenario	In Laboratory
Separating partition area (m^2) =	12.5	12.5
Floor/separating wall junction length (m) =	5.0	5.0
Wall/separating wall junction length (m) =	2.5	2.5
Normalization for Junctions 1 and 3:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-337, Eq. 4.1.3
RR-337 Flanking TL data normalized to Std. Scenario		
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-337, Eq. 4.1.3
RR-337 Flanking TL data normalized to Std. Scenario		

Illustration for this case



Cross junction LBc of loadbearing CFS-framed separating wall with CFS-framed floor/ceiling assembly (Side view of Junctions 1 and 3)



Junction of separating wall with flanking side wall, both CFS-framed (Plan view of Junctions 2 and 4)

(See footnotes at end of document)

	ISO Symbol	Reference		STC, Δ_STC	ASTC
Separating Partition (Loadbearing CFS-Framed Wall)					
Laboratory STC for Dd	R_s,w	RR-337, Wall CFS-S152-W33		54	
Direct STC in situ	R_Dd,w	RR-337, Eq. 4.1.2 (not a floor, so no ΔSTC correction)			**54**
Junction 1 (Wall/Floor Junction LBc (loadbearing continuous) with CFS-Framed Floor)					
For Flanking Path Ff_1:					
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WF-LBc-13		50	
ΔSTC change by Lining on F	ΔR_F,w	No flooring		0	
ΔSTC change by Lining on f	ΔR_f,w	No flooring		0	
Flanking STC for path Ff_1	R_Ff,w	RR-337, Eq. 4.1.3 and Eq. 4.1.5	50 + MAX(0,0)) + MIN(0,0)/2 + 0 =		**50**
For Flanking Path Fd_1:					
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WF-LBc-13		53	
ΔSTC change by Lining on F	ΔR_F,w	No flooring		0	
Flanking STC for path Fd_1	R_ Fd,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4		53 + 0 + 0 =	**53**
For Flanking Path Df_1:					
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WF-LBc-13		55	
ΔSTC change by Lining on f	ΔR_f,w	No flooring		0	
Flanking STC for path Df_1	R_ Df,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4		55 + 0 + 0 =	**55**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-5 + 10^- 5.3 + 10^- 5.5) =		**47**
Junction 2 (Loadbearing CFS-Framed Separating Wall / Non-loadbearing CFS-Framed Flanking Walls)					
For Flanking Path Ff_2:					
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WW-LB152-01		82	
Flanking STC for path Ff_2	R_Ff,w	RR-337, Eq. 4.1.3		82 + 0 =	**82**
For Flanking Path Fd_2:					
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WW-LB152-01		76	
Flanking STC for path Fd_2	R_ Fd,w	RR-337, Eq. 4.1.3		76 + 0 =	**76**
For Flanking Path Df_2:					
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WW-LB152-01		82	
Flanking STC for path Df_2	R_ Df,w	RR-337, Eq. 4.1.3		82 + 0 =	**82**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8.2 + 10^- 7.6 + 10^- 8.2) =		**74**
Junction 3 (Wall/Ceiling Junction LBc (loadbearing continuous) with CFS-Framed Floor/Ceiling)					
For Flanking Path Ff_3:					
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WC-LBc-13		65	
Flanking STC for path Ff_3	R_Ff,w	RR-337, Eq. 4.1.3		65 + 0 =	**65**
For Flanking Path Fd_3:					
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WC-LBc-13		73	
Flanking STC for path Fd_3	R_ Fd,w	RR-337, Eq. 4.1.3		73 + 0 =	**73**
For Flanking Path Df_3:					
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WC-LBc-13		69	
Flanking STC for path Df_3	R_ Df,w	RR-337, Eq. 4.1.3		69 + 0 =	**69**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.5 + 10^- 7.3 + 10^- 6.9) =		**63**
Junction 4 (Loadbearing CFS-Framed Separating Wall / Non-loadbearing CFS-Framed Flanking Walls)					
All values the same as for Junction_2					
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2			**82**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2			**76**
Flanking STC for path Df_4	R_ Df,w	Same as for Df_2			**82**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8.2 + 10^- 7.6 + 10^- 8.2) =		**74**
Total Flanking STC (4 Junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values		**47**
ASTC due to Direct plus Total Flanking		Equation 4.1.1	Combining Direct STC with 12 Flanking STC values		**46**

EXAMPLE 4.2-H2: (SIMPLIFIED METHOD)

- **Rooms side-by-side**
- **Loadbearing junction with discontinuous joists and subfloor**

Loadbearing separating wall assembly with:
- Wall CFS-S152-W33 (see Table 2.2.1) with short code 2G16_SS152(406)_GFB152_RC13(406)_2G16

Junction 1: Separating wall / floor with:
- Junction code CFS-WF-LBd-21
- Floor name CFS-J254-F01 (see Table 2.3.1) with short code GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16
- CFS floor joists[1] perpendicular to the loadbearing wall but not continuous across the junction.
- Gypsum concrete floor deck discontinuous at the junction.

Junction 2 or 4: Separating wall / abutting side wall with:
- Junction code CFS-WW-LB152-01
- Non-loadbearing flanking walls with short code 2G16_SS92(406)_GFB152_RC13(406)_2G16, framing formed from steel 0.54 mm thick
- Closest CFS studs[1] of the non-loadbearing walls spaced 10 mm from framing of loadbearing wall.
- If gypsum board[2] on loadbearing wall is directly attached to framing, gypsum board on adjacent non-loadbearing wall is supported on resilient channels[4], and vice versa.

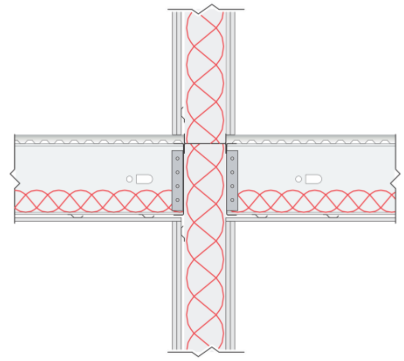
Junction 3: Separating wall / ceiling with:
- Junction code CFS-WC-LBd-21

(More complete descriptions of these assemblies and junctions with larger drawings are given in Section 3.2.)

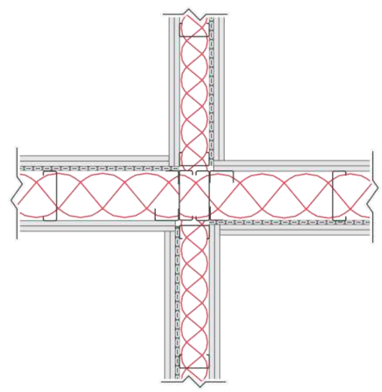
Acoustical Parameters:

	In Scenario	In Laboratory
Separating partition area (m^2) =	12.5	12.5
Floor/separating wall junction length (m) =	5.0	5.0
Wall/separating wall junction length (m) =	2.5	2.5
Normalization for Junctions 1 and 3:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-337, Eq. 4.1.3
	RR-337 Flanking TL data normalized to Std. Scenario	
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-337, Eq. 4.1.3
	RR-337 Flanking TL data normalized to Std. Scenario	

Illustration for this case



Cross junction LBd of loadbearing CFS-framed separating wall with CFS-framed floor/ceiling assembly (Side view of Junctions 1 and 3)



Junction of separating wall with flanking side wall, both CFS-framed (Plan view of Junctions 2 and 4)

(See footnotes at end of document)

	ISO Symbol	Reference		STC, Δ_STC	ASTC
Separating Partition (Loadbearing CFS-Framed Wall)					
Laboratory STC for Dd	R_s,w	RR-337, Wall CFS-S152-W33		58	
Direct STC in situ	R_Dd,w	RR-337, Eq. 4.1.2 (not a floor, so no ΔSTC correction)			**58**
Junction 1 (Wall/Floor Junction LBd (loadbearing discontinuous) with CFS-Framed Floor)					
For Flanking Path Ff_1:					
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WF-LBd-21		65	
ΔSTC change by Lining on F	ΔR_F,w	No flooring		0	
ΔSTC change by Lining on f	ΔR_f,w	No flooring		0	
Flanking STC for path Ff_1	R_Ff,w	RR-337, Eq. 4.1.3 and Eq. 4.1.5	65 + MAX(0,0)) + MIN(0,0)/2 + 0 =		**65**
For Flanking Path Fd_1:					
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WF-LBd-21		62	
ΔSTC change by Lining on F	ΔR_F,w	No flooring		0	
Flanking STC for path Fd_1	R_ Fd,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4	62 + 0 + 0 =		**62**
For Flanking Path Df_1:					
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WF-LBd-21		67	
ΔSTC change by Lining on f	ΔR_f,w	No flooring		0	
Flanking STC for path Df_1	R_ Df,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4	67 + 0 + 0 =		**67**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.5 + 10^- 6.2 + 10^- 6.7) =		**59**
Junction 2 (Loadbearing CFS-Framed Separating Wall / Non-loadbearing CFS-Framed Flanking Walls)					
For Flanking Path Ff_2:					
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WW-LB152-01		82	
Flanking STC for path Ff_2	R_Ff,w	RR-337, Eq. 4.1.3	82 + 0 =		**82**
For Flanking Path Fd_2:					
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WW-LB152-01		76	
Flanking STC for path Fd_2	R_ Fd,w	RR-337, Eq. 4.1.3	76 + 0 =		**76**
For Flanking Path Df_2:					
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WW-LB152-01		82	
Flanking STC for path Df_2	R_ Df,w	RR-337, Eq. 4.1.3	82 + 0 =		**82**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8.2 + 10^- 7.6 + 10^- 8.2) =		**74**
Junction 3 (Wall/Ceiling Junction LBd (loadbearing discontinuous) with CFS-Framed Floor/Ceiling)					
For Flanking Path Ff_3:					
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WC-LBd-21		75	
Flanking STC for path Ff_3	R_Ff,w	RR-337, Eq. 4.1.3	75 + 0 =		**75**
For Flanking Path Fd_3:					
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WC-LBd-21		64	
Flanking STC for path Fd_3	R_ Fd,w	RR-337, Eq. 4.1.3			**64**
For Flanking Path Df_3:					
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WC-LBd-21		70	
Flanking STC for path Df_3	R_ Df,w	RR-337, Eq. 4.1.3	70 + 0 =		**70**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7.5 + 10^- 6.4 + 10^- 7) =		**63**
Junction 4 (Loadbearing CFS-Framed Separating Wall / Non-loadbearing CFS-Framed Flanking Walls)					
All values the same as for Junction_2					
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2			**82**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2			**76**
Flanking STC for path Df_4	R_ Df,w	Same as for Df_2			**82**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8.2 + 10^- 7.6 + 10^- 8.2) =		**74**
Total Flanking STC (4 Junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values		**58**
ASTC due to Direct plus Total Flanking		Equation 4.1.1	Combining Direct STC with 12 Flanking STC values		**55**

EXAMPLE 4.2-H3: (SIMPLIFIED METHOD)

- **Rooms side-by-side**
- **Non-loadbearing junction with continuous subfloor**

Non-loadbearing separating wall assembly with:

- Non-loadbearing separating walls with short code 2G16_SS92(406)_GFB92_RC13(406)_2G16, framing formed from steel 0.54 mm thick

Junction 1: Separating wall / floor with:

- Junction code CFS-WF-NLBc-31
- Floor name CFS-J254-F01 (see Table 2.3.1) with short code GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16
- CFS floor joists[1] parallel to the non-loadbearing wall
- Gypsum concrete floor deck continuous across the junction.

Junction 2 or 4: Separating wall / abutting side wall with:

- Junction code CFS-WW-NLB92-01
- Loadbearing flanking walls Wall CFS-S152-W33 (see Table 2.2.1) with short code 2G16_SS152(406)_GFB152_RC13(406)_2G16
- Closest CFS studs[1] of the non-loadbearing walls spaced 10 mm from framing of loadbearing wall.
- If gypsum board[2] on loadbearing wall is directly attached to framing, gypsum board on adjacent non-loadbearing wall is supported on resilient channels[4], and vice versa.

Junction 3: Separating wall / ceiling with:

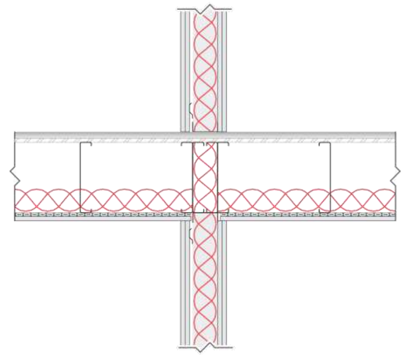
- Junction code CFS-WC-NLBc-31

(More complete descriptions of these assemblies and junctions with larger drawings are given in Section 3.2.)

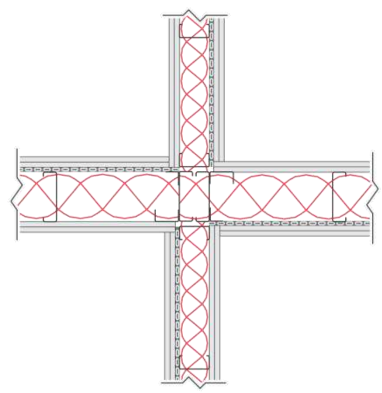
Acoustical Parameters:

	In Scenario	In Laboratory
Separating partition area (m^2) =	12.5	12.5
Floor/separating wall junction length (m) =	5.0	5.0
Wall/separating wall junction length (m) =	2.5	2.5
Normalization for Junctions 1 and 3:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-337, Eq. 4.1.3
RR-337 Flanking TL data normalized to Std. Scenario		
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-337, Eq. 4.1.3
RR-337 Flanking TL data normalized to Std. Scenario		

Illustration for this case



Cross junction NLBc of non-loadbearing CFS-framed separating wall assembly with CFS-framed floor/ceiling assembly
(Side view of Junctions 1 and 3)



Junction of separating wall with flanking side wall, both CFS-framed
(Plan view of Junctions 2 and 4)

(See footnotes at end of document)

	ISO Symbol	Reference	STC, Δ_STC	ASTC
Separating Partition (Non-Loadbearing CFS-Framed Wall)				
Laboratory STC for Dd	R_s,w	RR-337, NLB wall 2G16_SS92(406)_GFB92_RC13(4	57	
Direct STC in situ	R_Dd,w	RR-337, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**57**
Junction 1 (Wall/Floor Junction NLBc (Non-loadbearing continuous) with CFS-Framed Floor)				
For Flanking Path Ff_1:				
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WF-NLBc-31	40	
ΔSTC change by Lining on F	ΔR_F,w	No flooring	0	
ΔSTC change by Lining on f	ΔR_f,w	No flooring	0	
Flanking STC for path Ff_1	R_Ff,w	RR-337, Eq. 4.1.3 and Eq. 4.1.5	40 + MAX(0,0)) + MIN(0,0)/2 + 0 =	**40**
For Flanking Path Fd_1:				
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WF-NLBc-31	49	
ΔSTC change by Lining on F	ΔR_F,w	No flooring	0	
Flanking STC for path Fd_1	R_ Fd,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4	49 + 0 + 0 =	**49**
For Flanking Path Df_1:				
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WF-NLBc-31	50	
ΔSTC change by Lining on f	ΔR_f,w	No flooring	0	
Flanking STC for path Df_1	R_ Df,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4	50 + 0 + 0 =	**50**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-4 + 10^- 4.9 + 10^- 5) =	**39**
Junction 2 (Non-Loadbearing CFS-Framed Separating Wall / Loadbearing CFS-Framed Flanking Walls)				
For Flanking Path Ff_2:				
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WW-NLB92-01	84	
Flanking STC for path Ff_2	R_Ff,w	RR-337, Eq. 4.1.3	84 + 0 =	**84**
For Flanking Path Fd_2:				
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WW-NLB92-01	82	
Flanking STC for path Fd_2	R_ Fd,w	RR-337, Eq. 4.1.3	82 + 0 =	**82**
For Flanking Path Df_2:				
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WW-NLB92-01	81	
Flanking STC for path Df_2	R_ Df,w	RR-337, Eq. 4.1.3	81 + 0 =	**81**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8.4 + 10^- 8.2 + 10^- 8.1) =	**77**
Junction 3 (Wall/Ceiling Junction NLBc (non-loadbearing continuous) with CFS-Framed Floor/Ceiling)				
For Flanking Path Ff_3:				
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WC-NLBc-31	67	
Flanking STC for path Ff_3	R_Ff,w	RR-337, Eq. 4.1.3	67 + 0 =	**67**
For Flanking Path Fd_3:				
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WC-NLBc-31	65	
Flanking STC for path Fd_3	R_ Fd,w	RR-337, Eq. 4.1.3	65 + 0 =	**65**
For Flanking Path Df_3:				
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WC-NLBc-31	71	
Flanking STC for path Df_3	R_ Df,w	RR-337, Eq. 4.1.3	71 + 0 =	**71**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.7 + 10^- 6.5 + 10^- 7.1) =	**62**
Junction 4 (Non-Loadbearing CFS-Framed Separating Wall / loadbearing CFS-Framed Flanking Walls)				
All values the same as for Junction_2				
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2		**84**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2		**82**
Flanking STC for path Df_4	R_ Df,w	Same as for Df_2		**81**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8.4 + 10^- 8.2 + 10^- 8.1) =	**77**
Total Flanking STC (4 Junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values	**39**
ASTC due to Direct plus Total Flanking		Equation 4.1.1	Combining Direct STC with 12 Flanking STC values	**39**

EXAMPLE 4.2-H4: (SIMPLIFIED METHOD)

- **Rooms side-by-side**
- **Non-loadbearing junction with discontinuous subfloor**

Non-loadbearing separating wall assembly with:
- Non-loadbearing separating wall with short code 2G16_SS92(406)_GFB92_RC13(406)_2G16, framing formed from steel 0.54 mm thick

Junction 1: Separating wall / floor with:
- Junction code CFS-WF-NLBd-41
- Floor name CFS-J254-F01 (see Table 2.3.1) with short code GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16
- CFS floor joists[1] parallel to the non-loadbearing wall
- Gypsum concrete floor deck discontinuous at the junction.

Junction 2 or 4: Separating wall / abutting side wall with:
- Junction code CFS-WW-NLB92-01
- Loadbearing flanking walls Wall CFS-S152-W33 (see Table 2.2.1) with short code 2G16_SS152(406)_GFB152_RC13(406)_2G16
- Closest CFS studs[1] of the non-loadbearing walls spaced 10 mm from framing of loadbearing wall.
- If gypsum board[2] on loadbearing wall is directly attached to framing, gypsum board on adjacent non-loadbearing wall is supported on resilient channels[4], and vice versa.

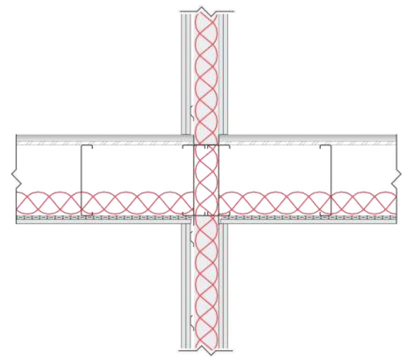
Junction 3: Separating wall / ceiling with:
- Junction code CFS-WC-NLBd-41

(More complete descriptions of these assemblies and junctions with larger drawings are given in Section 3.2.)

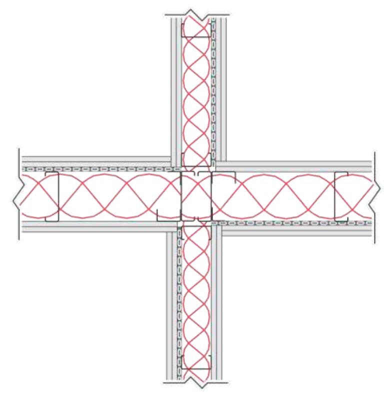
Acoustical Parameters:

	In Scenario	In Laboratory
Separating partition area (m^2) =	12.5	12.5
Floor/separating wall junction length (m) =	5.0	5.0
Wall/separating wall junction length (m) =	2.5	2.5
Normalization for Junctions 1 and 3:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-337, Eq. 4.1.3
	RR-337 Flanking TL data normalized to Std. Scenario	
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-337, Eq. 4.1.3
	RR-337 Flanking TL data normalized to Std. Scenario	

Illustration for this case



Cross junction NLBd of the non-loadbearing CFS-framed separating wall with CFS-framed floor/ceiling assembly
(Side view of Junctions 1 and 3)



Junction of separating wall with flanking side wall, both CFS-framed
(Plan view of Junctions 2 and 4)

(See footnotes at end of document)

	ISO Symbol	Reference	STC, Δ_STC	ASTC
Separating Partition (Non-Loadbearing CFS-Framed Wall)				
Laboratory STC for Dd	R_s,w	RR-337, NLB wall 2G16_SS92(406)_GFB92_RC13(406)	57	
Direct STC in situ	R_Dd,w	RR-337, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**57**
Junction 1 (Wall/Floor Junction NLBd (Non-loadbearing discontinuous) with CFS-Framed Floor)				
For Flanking Path Ff_1:				
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WF-NLBd-41	60	
ΔSTC change by Lining on F	ΔR_F,w	No flooring	0	
ΔSTC change by Lining on f	ΔR_f,w	No flooring	0	
Flanking STC for path Ff_1	R_Ff,w	RR-337, Eq. 4.1.3 and Eq. 4.1.5	60 + MAX(0,0)) + MIN(0,0)/2 + 0 =	**60**
For Flanking Path Fd_1:				
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WF-NLBd-41	63	
ΔSTC change by Lining on F	ΔR_F,w	No flooring	0	
Flanking STC for path Fd_1	R_ Fd,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4	63 + 0 + 0 =	**63**
For Flanking Path Df_1:				
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WF-NLBd-41	67	
ΔSTC change by Lining on f	ΔR_f,w	No flooring	0	
Flanking STC for path Df_1	R_ Df,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4	67 + 0 + 0 =	**67**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6 + 10^- 6.3 + 10^- 6.7) =	**58**
Junction 2 (Non-Loadbearing CFS-Framed Separating Wall / loadbearing CFS-Framed Flanking Walls)				
For Flanking Path Ff_2:				
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WW-NLB92-01	84	
Flanking STC for path Ff_2	R_Ff,w	RR-337, Eq. 4.1.3	84 + 0 =	**84**
For Flanking Path Fd_2:				
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WW-NLB92-01	82	
Flanking STC for path Fd_2	R_ Fd,w	RR-337, Eq. 4.1.3	82 + 0 =	**82**
For Flanking Path Df_2:				
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WW-NLB92-01	81	
Flanking STC for path Df_2	R_ Df,w	RR-337, Eq. 4.1.3	81 + 0 =	**81**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8.4 + 10^- 8.2 + 10^- 8.1) =	**77**
Junction 3 (Wall/Ceiling Junction NLBd (non-loadbearing discontinuous) with CFS-Framed Floor/Ceiling)				
For Flanking Path Ff_3:				
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WC-NLBd-41	77	
Flanking STC for path Ff_3	R_Ff,w	RR-337, Eq. 4.1.3	77 + 0 =	**77**
For Flanking Path Fd_3:				
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WC-NLBd-41	70	
Flanking STC for path Fd_3	R_ Fd,w	RR-337, Eq. 4.1.3	70 + 0 =	**70**
For Flanking Path Df_3:				
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WC-NLBd-41	69	
Flanking STC for path Df_3	R_ Df,w	RR-337, Eq. 4.1.3	69 + 0 =	**69**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7.7 + 10^- 7 + 10^- 6.9) =	**66**
Junction 4 (Non-Loadbearing CFS-Framed Separating Wall / loadbearing CFS-Framed Flanking Walls)				
All values the same as for Junction 2				
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2		**84**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2		**82**
Flanking STC for path Df_4	R_ Df,w	Same as for Df_2		**81**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8.4 + 10^- 8.2 + 10^- 8.1) =	**77**
Total Flanking STC (4 Junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values	**57**
ASTC due to Direct plus Total Flanking		Equation 4.1.1	Combining Direct STC with 12 Flanking STC values	**54**

EXAMPLE 4.2-H5: (SIMPLIFIED METHOD)

- **Rooms side-by-side**
- **Loadbearing junction with continuous joists and subfloor**
- **Same as EXAMPLE 4.2-H1 with added finish flooring**

Loadbearing separating wall assembly with:

- Wall CFS-S152-W33 (see Table 2.2.1) with short code 2G16_SS152(406)_GFB152_RC13(406)_G16

Junction 1: Separating wall / floor with:

- Junction code CFS-WF-LBc-13
- Floor name CFS-J254-F01 (see Table 2.3.1) with short code GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16
- CFS floor joists[1] perpendicular to the loadbearing wall and continuous across the junction with fire blocking at the junction.
- Gypsum concrete floor deck continuous across the junction.
- Finish flooring LAM10_FOAM3 installed over the subfloor.

Junction 2 or 4: Separating wall / abutting side wall with:

- Junction code CFS-WW-LB152-01
- Non-loadbearing flanking walls with short code 2G16_SS92(406)_GFB152_RC13(406)_G16, framing formed from steel 0.54 mm thick
- Closest CFS studs[1] of the non-loadbearing walls spaced 10 mm from framing of loadbearing wall.
- If gypsum board[2] on loadbearing wall is directly attached to framing, gypsum board on adjacent non-loadbearing wall is supported on resilient channels[4], and vice versa.

Junction 3: Separating wall / ceiling with:

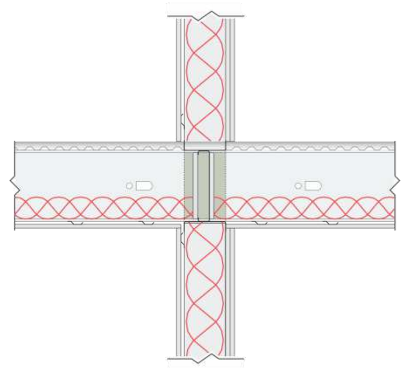
- Junction code CFS-WC-LBc-13

(More complete descriptions of these assemblies and junctions with larger drawings are given in Section 3.2.)

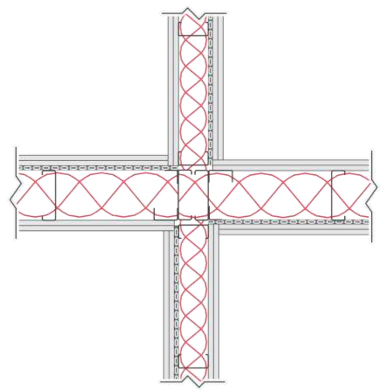
Acoustical Parameters:

	In Scenario	In Laboratory
Separating partition area (m^2) =	12.5	12.5
Floor/separating wall junction length (m) =	5.0	5.0
Wall/separating wall junction length (m) =	2.5	2.5
Normalization for Junctions 1 and 3:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-337, Eq. 4.1.3
RR-337 Flanking TL data normalized to Std. Scenario		
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-337, Eq. 4.1.3
RR-337 Flanking TL data normalized to Std. Scenario		

Illustration for this case



Cross junction LBc of loadbearing CFS-framed separating wall with CFS-framed floor/ceiling assembly (Side view of Junctions 1 and 3)



Junction of separating wall with flanking side wall, both CFS-framed (Plan view of Junctions 2 and 4)

(See footnotes at end of document)

	ISO Symbol	Reference		STC, Δ_STC	ASTC
<u>Separating Partition (Loadbearing CFS-Framed Wall)</u>					
Laboratory STC for Dd	R_s,w	RR-337, wall CFS-S152-W33		54	
Direct STC in situ	R_Dd,w	RR-337, Eq. 4.1.2 (not a floor, so no ΔSTC correction)			**54**
<u>Junction 1 (Wall/Floor Junction LBc (loadbearing continuous) with CFS-Framed Floor)</u>					
<u>For Flanking Path Ff_1:</u>					
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WF-LBc-13		50	
ΔSTC change by Lining on F	ΔR_F,w	ΔTL-CFS-F02, flooring LAM10_FOAM3 on GCON32		2	
ΔSTC change by Lining on f	ΔR_f,w	ΔTL-CFS-F02, flooring LAM10_FOAM3 on GCON32		2	
Flanking STC for path Ff_1	R_Ff,w	RR-337, Eq. 4.1.3 and Eq. 4.1.5	50 + MAX(2,2)) + MIN(2,2)/2 + 0 =		**53**
<u>For Flanking Path Fd_1:</u>					
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WF-LBc-13		53	
ΔSTC change by Lining on F	ΔR_F,w	ΔTL-CFS-F02, flooring LAM10_FOAM3 on GCON32		2	
Flanking STC for path Fd_1	R_ Fd,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4	53 + 2 + 0 =		**55**
<u>For Flanking Path Df_1:</u>					
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WF-LBc-13		55	
ΔSTC change by Lining on f	ΔR_f,w	ΔTL-CFS-F02, flooring LAM10_FOAM3 on GCON32		2	
Flanking STC for path Df_1	R_ Df,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4	55 + 2 + 0 =		**57**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-5.3 + 10^- 5.5 + 10^- 5.7) =		**50**
<u>Junction 2 (Loadbearing CFS-Framed Separating Wall / Non-loadbearing CFS-Framed Flanking Walls)</u>					
<u>For Flanking Path Ff_2:</u>					
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WW-LB152-01		82	
Flanking STC for path Ff_2	R_Ff,w	RR-337, Eq. 4.1.3	82 + 0 =		**82**
<u>For Flanking Path Fd_2:</u>					
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WW-LB152-01		76	
Flanking STC for path Fd_2	R_ Fd,w	RR-337, Eq. 4.1.3	76 + 0 =		**76**
<u>For Flanking Path Df_2:</u>					
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WW-LB152-01		82	
Flanking STC for path Df_2	R_ Df,w	RR-337, Eq. 4.1.3	82 + 0 =		**82**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8.2 + 10^- 7.6 + 10^- 8.2) =		**74**
<u>Junction 3 (Wall/Ceiling Junction LBc (loadbearing continuous) with CFS-Framed Floor/Ceiling)</u>					
<u>For Flanking Path Ff_3:</u>					
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-WC-LBc-13		65	
Flanking STC for path Ff_3	R_Ff,w	RR-337, Eq. 4.1.3	65 + 0 =		**65**
<u>For Flanking Path Fd_3:</u>					
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-WC-LBc-13		73	
Flanking STC for path Fd_3	R_ Fd,w	RR-337, Eq. 4.1.3	73 + 0 =		**73**
<u>For Flanking Path Df_3:</u>					
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-WC-LBc-13		69	
Flanking STC for path Df_3	R_ Df,w	RR-337, Eq. 4.1.3	69 + 0 =		**69**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.5 + 10^- 7.3 + 10^- 6.9) =		**63**
<u>Junction 4 (Loadbearing CFS-Framed Separating Wall / Non-loadbearing CFS-Framed Flanking Walls)</u>					
<u>All values the same as for Junction_2</u>					
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2			**82**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2			**76**
Flanking STC for path Df_4	R_ Df,w	Same as for Df_2			**82**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8.2 + 10^- 7.6 + 10^- 8.2) =		**74**
Total Flanking STC (4 Junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values		**50**
ASTC due to Direct plus Total Flanking		Equation 4.1.1	Combining Direct STC with 12 Flanking STC values		**48**

EXAMPLE 4.2-V1: (SIMPLIFIED METHOD)

- **Rooms one above the other**

Loadbearing separating floor assembly with:

- Separating floor/ceiling CFS-J254-F01 (see Table 2.3.1) with short code GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16

Junction 1 or 3: Separating floor / loadbearing walls with:

- Junction code CFS-FW-LBc-11
- Loadbearing flanking walls CFS-S152-W33 (see Table 2.2.1) with short code 2G16_SS152(406)_GFB152_RC13(406)_2G16
- Gypsum board[2] supported on resilient channels[4] (Junction 1) or attached directly to wall framing (Junction 3).
- CFS floor joists[1] perpendicular to the loadbearing wall and continuous across the junction and gypsum concrete floor deck continuous across the junction.

Junction 2 or 4: Separating floor / non-loadbearing walls with:

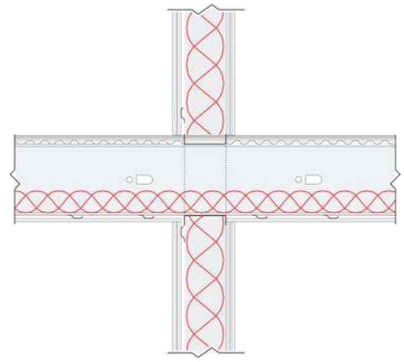
- Junction code CFS-FW-NLBd-41
- Non-loadbearing flanking walls with short code 2G16_SS92(406)_GFB92_RC13(406)_2G16 with CFS studs[1] formed from steel 0.54 mm thick.
- Gypsum board[2] attached directly to wall framing
- CFS floor joists[1] parallel to the non-loadbearing wall.
- Gypsum concrete floor deck discontinuous across the junction.

(More complete descriptions of these assemblies and junctions with larger drawings are given in Section 3.2.)

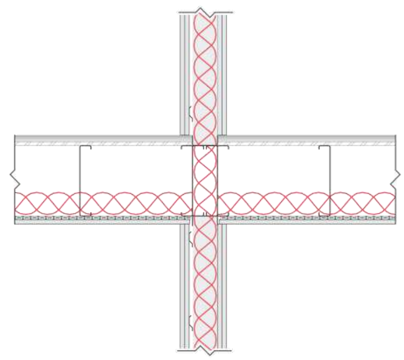
Acoustical Parameters:

		In Scenario	In Laboratory
	Separating partition area (m^2) =	20.0	20.0
	Floor/LB flanking wall junction length (m) =	5.0	5.0
	Floor/NLB flanking wall junction length (m) =	4.0	5.0
Normalization for Junctions 1 and 3:			
	10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-337, Eq. 4.1.3
	RR-337 Flanking TL data normalized to Std. Scenario		
Normalization for Junctions 2 and 4:			
	10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.97	RR-337, Eq. 4.1.3
	RR-337 Flanking TL data normalized to Std. Scenario		

Illustration for this case



Cross junction CFS-FW-LBc-11 of loadbearing CFS-framed separating wall with CFS-framed floor/ceiling (Side view of Junctions 1 and 3)



Cross junction CFS-FW-NLBd-41 of non-loadbearing CFS-framed wall with CFS-framed floor/ceiling (Side view of Junctions 2 and 4)

(See footnotes at end of document)

	ISO Symbol	Reference	STC, Δ_STC	ASTC
Separating Partition (CFS-Framed Floor)				
Laboratory STC for Dd	R_s,w	RR-337, floor CFS-J254-F01	57	
ΔSTC change by Lining on D	ΔR_D,w	No finish flooring	0	
Direct STC in situ	R_Dd,w	RR-337, Eq. 4.1.2	57 + 0 =	**57**
Junction 1 (Floor/Wall Junction LBc of CFS-Framed Floor with Loadbearing Wall)				
For Flanking Path Ff_1:				
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-FW-LBc-11r, wall gypsum board on RC	67	
Flanking STC for path Ff_1	R_Ff,w	RR-337, Eq. 4.1.3	67 + 0 =	**67**
For Flanking Path Fd_1:				
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-FW-LBc-11r, wall gypsum board on RC	71	
Flanking STC for path Fd_1	R_ Fd,w	RR-337, Eq. 4.1.3	71 + 0 =	**71**
For Flanking Path Df_1:				
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-FW-LBc-11r, wall gypsum board on RC	72	
ΔSTC change by Lining on D	ΔR_D,w	No finish flooring	0	
Flanking STC for path Df_1	R_ Df,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4	72 + 0 + 0 =	**72**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.7 + 10^- 7.1 + 10^- 7.2) =	**65**
Junction 2 (Floor/Wall Junction NLBd of CFS-Framed Floor with Non-loadbearing Wall)				
For Flanking Path Ff_2:				
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-FW-NLBd-41d, wall gypsum board direct	72	
Flanking STC for path Ff_2	R_Ff,w	RR-337, Eq. 4.1.3	72 + 1 =	**73**
For Flanking Path Fd_2:				
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-FW-NLBd-41d, wall gypsum board direct	76	
Flanking STC for path Fd_2	R_ Fd,w	RR-337, Eq. 4.1.3	76 + 1 =	**77**
For Flanking Path Df_2:				
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-FW-NLBd-41d, wall gypsum board direct	74	
ΔSTC change by Lining on D	ΔR_D,w	No finish flooring	0	
Flanking STC for path Df_2	R_ Df,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4	74 + 0 + 1 =	**75**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7.3 + 10^- 7.7 + 10^- 7.5) =	**70**
Junction 3 (Floor/Wall Junction LBc of CFS-Framed Floor with Loadbearing Wall)				
For Flanking Path Ff_3:				
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-FW-LBc-11d, wall gypsum board direct	67	
Flanking STC for path Ff_3	R_Ff,w	RR-337, Eq. 4.1.3	67 + 0 =	**67**
For Flanking Path Fd_3:				
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-FW-LBc-11d, wall gypsum board direct	69	
Flanking STC for path Fd_3	R_ Fd,w	RR-337, Eq. 4.1.3	69 + 0 =	**69**
For Flanking Path Df_3:				
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-FW-LBc-11d, wall gypsum board direct	65	
ΔSTC change by Lining on D	ΔR_D,w	No finish flooring	0	
Flanking STC for path Df_3	R_ Df,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4	65 + 0 + 0 =	**65**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.7 + 10^- 6.9 + 10^- 6.5) =	**62**
Junction 4 (Floor/Wall Junction NLBd of CFS-Framed Floor with Non-loadbearing Wall)				
All values the same as for Junction_2				
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2		**73**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2		**77**
Flanking STC for path Df_4	R_ Df,w	Same as for Df_2		**75**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7.3 + 10^- 7.7 + 10^- 7.5) =	**70**
Total Flanking STC (4 Junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values	**59**
ASTC due to Direct plus Total Flanking		Equation 4.1.1	Combining Direct STC with 12 Flanking STC values	**55**

EXAMPLE 4.2-V2: (SIMPLIFIED METHOD)

- **Rooms one above the other**
- **Same as EXAMPLE 4.2-V1 with added finish flooring**

Loadbearing separating floor assembly with:

- Separating floor/ceiling CFS-J254-F01 (see Table 2.3.1) with short code GCON32_CORSTE14_SJ254(406)_GFB92_RC13(305)_G16

Junction 1 or 3: Junction of separating floor / loadbearing walls:

- Junction code CFS-FW-LBc-11
- Loadbearing flanking walls CFS-S152-W33 (see Table 2.2.1) with short code 2G16_SS152(406)_GFB152_RC13(406)_2G16
- Gypsum board[2] supported on resilient channels[4] (Junction 1) or attached directly to wall framing (Junction 3).
- CFS floor joists[1] perpendicular to the loadbearing wall and continuous across the junction and gypsum concrete floor deck continuous across the junction.
- Finish flooring LAM10_FOAM3 installed over the subfloor.

Junction 2 or 4: Junction of separating floor / non-loadbearing walls:

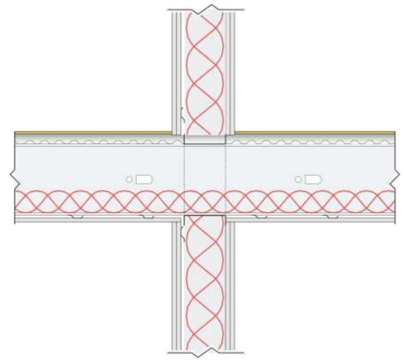
- Junction code CFS-FW-NLBd-41
- Non-loadbearing flanking walls with short code 2G16_SS92(406)_GFB92_RC13(406)_2G16 with CFS studs[1] formed from steel 0.54 mm thick.
- Gypsum board[2] attached directly to wall framing
- CFS floor joists[1] parallel to the non-loadbearing wall.
- Gypsum concrete floor deck discontinuous across the junction.
- Finish flooring LAM10_FOAM3 installed over the subfloor.

(More complete descriptions of these assemblies and junctions with larger drawings are given in Section 3.2.)

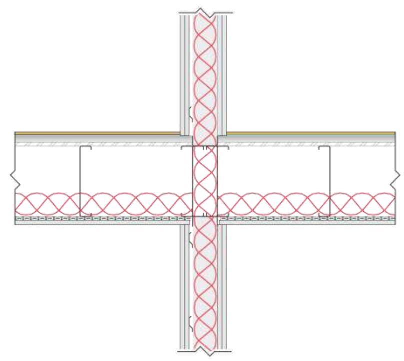
Acoustical Parameters:

	In Scenario	In Laboratory
Separating partition area (m^2) =	20.0	20.0
Floor/LB flanking wall junction length (m) =	5.0	5.0
Floor/NLB flanking wall junction length (m) =	4.0	5.0
Normalization for Junctions 1 and 3:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-337, Eq. 4.1.3
RR-337 Flanking TL data normalized to Std. Scenario		
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.97	RR-337, Eq. 4.1.3
RR-337 Flanking TL data normalized to Std. Scenario		

Illustration for this case



Cross junction CFS-FW-LBc-11 of loadbearing CFS-framed separating wall with CFS-framed floor/ceiling (Side view of Junctions 1 and 3)



Cross junction CFS-FW-NLBd-41 of non-loadbearing CFS-framed wall with CFS-framed floor/ceiling (Side view of Junctions 2 and 4)

(See footnotes at end of document)

	ISO Symbol	Reference		STC, Δ_STC	ASTC
Separating Partition (CFS-Framed Floor)					
Laboratory STC for Dd	R_s,w	RR-337, floor CFS-J254-F01		57	
ΔSTC change by Lining on D	ΔR_D,w	ΔTL-CFS-F02, flooring LAM10_FOAM3 on GCON32		2	
Direct STC in situ	R_Dd,w	RR-337, Eq. 4.1.2		57 + 2 =	**59**
Junction 1 (Floor/Wall Junction LBc of CFS-Framed Floor with Loadbearing Wall)					
For Flanking Path Ff_1:					
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-FW-LBc-11r, wall gypsum board on RC		67	
Flanking STC for path Ff_1	R_Ff,w	RR-337, Eq. 4.1.3		67 + 0 =	**67**
For Flanking Path Fd_1:					
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-FW-LBc-11r, wall gypsum board on RC		71	
Flanking STC for path Fd_1	R_ Fd,w	RR-337, Eq. 4.1.3		71 + 0 =	**71**
For Flanking Path Df_1:					
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-FW-LBc-11r, wall gypsum board on RC		72	
ΔSTC change by Lining on D	ΔR_D,w	ΔTL-CFS-F02, flooring LAM10_FOAM3 on GCON32		2	
Flanking STC for path Df_1	R_ Df,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4		72 + 2 + 0 =	**74**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.7 + 10^- 7.1 + 10^- 7.4) =		**65**
Junction 2 (Floor/Wall Junction NLBd of CFS-Framed Floor with Non-loadbearing Wall)					
For Flanking Path Ff_2:					
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-FW-NLBd-41d, wall gypsum board direct		72	
Flanking STC for path Ff_2	R_Ff,w	RR-337, Eq. 4.1.3		72 + 1 =	**73**
For Flanking Path Fd_2:					
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-FW-NLBd-41d, wall gypsum board direct		76	
Flanking STC for path Fd_2	R_ Fd,w	RR-337, Eq. 4.1.3		76 + 1 =	**77**
For Flanking Path Df_2:					
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-FW-NLBd-41d, wall gypsum board direct		74	
ΔSTC change by Lining on D	ΔR_D,w	ΔTL-CFS-F02, flooring LAM10_FOAM3 on GCON32		2	
Flanking STC for path Df_2	R_ Df,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4		74 + 2 + 1 =	**77**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7.3 + 10^- 7.7 + 10^- 7.7) =		**70**
Junction 3 (Floor/Wall Junction LBc of CFS-Framed Floor with Loadbearing Wall)					
For Flanking Path Ff_3:					
Laboratory Flanking STC	Measured Path Ff	RR-337, CFS-FW-LBc-11d, wall gypsum board direct		67	
Flanking STC for path Ff_3	R_Ff,w	RR-337, Eq. 4.1.3		67 + 0 =	**67**
For Flanking Path Fd_3:					
Laboratory Flanking STC	Measured Path Fd	RR-337, CFS-FW-LBc-11d, wall gypsum board direct		69	
Flanking STC for path Fd_3	R_ Fd,w	RR-337, Eq. 4.1.3		69 + 0 =	**69**
For Flanking Path Df_3:					
Laboratory Flanking STC	Measured Path Df	RR-337, CFS-FW-LBc-11d, wall gypsum board direct		65	
ΔSTC change by Lining on D	ΔR_D,w	ΔTL-CFS-F02, flooring LAM10_FOAM3 on GCON32		2	
Flanking STC for path Df_3	R_ Df,w	RR-337, Eq. 4.1.3 and Eq. 4.1.4		65 + 2 + 0 =	**67**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.7 + 10^- 6.9 + 10^- 6.7) =		**63**
Junction 4 (Floor/Wall Junction NLBd of CFS-Framed Floor with Non-loadbearing Wall)					
All values the same as for Junction_2					
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2			**73**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2			**77**
Flanking STC for path Df_4	R_ Df,w	Same as for Df_2			**77**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7.3 + 10^- 7.7 + 10^- 7.7) =		**70**
Total Flanking STC (4 Junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values		**60**
ASTC due to Direct plus Total Flanking		Equation 4.1.1	Combining Direct STC with 12 Flanking STC values		**56**

Summary for Section 4.2: Calculation Examples for CFS-Framed Constructions

The worked examples (4.2-H1 to H5 and 4.2-V1 to V2) illustrate the use of the Simplified Method for calculating the apparent sound transmission class (ASTC) ratings between rooms in a building with CFS-framed floor and wall assemblies.

The examples show the performance for five cases with “bare” gypsum concrete floor surfaces (Examples 4.2-H1 to H4 and 4.2-V1) and for two cases with improvements in direct and/or flanking transmission loss via specific paths due to the addition of typical finish flooring.

For a horizontal room pair, comparing pairs of examples shows the effect of changing key details of the wall/floor junctions:

- Comparing Example H1 vs. Example H2 shows the change from ASTC 46 to ASTC 55 when a break is introduced in the gypsum concrete floor surface, for the case with joists perpendicular to a loadbearing separating wall.
- Comparing Example H3 vs. Example H4 shows the even larger change from ASTC 39 to ASTC 54 when a break is introduced in the gypsum concrete floor surface, for the case with floor joists parallel to a non-loadbearing separating wall.

From these examples, it is clear that a break in the continuous gypsum concrete surface significantly reduces flanking transmission, which raises the ASTC rating from the unacceptable range to a level which should satisfy a majority of occupants.

Adding laminate flooring to the bare floor surface (Example H5 vs. H1) only slightly increases the Flanking STC ratings for the floor paths, but as the floor paths limit the ASTC rating for the are configuration this small improvement is enough to raise the ASTC rating from 46 to 48, above the minimum requirement of ASTC 47 in the 2015 edition of the National Building Code of Canada.

For a vertical room pair, Example 4.2-V1 shows that the sound transmitted through all 12 flanking paths combined is slightly less than the sound transmitted via the separating floor assembly (Total Flanking STC rating of 59 vs. Direct STC rating of 57). Hence, the ASTC rating of 55 is dominated by the STC rating of the separating floor. Adding finished flooring in Example V2 increases the Direct STC by 2 points to STC 59, and the ASTC increases to 56.

5 Appendices of Sound Transmission Data

This Appendix presents one-third octave band sound transmission loss data, measured according to the ASTM standard E90, for the CFS-framed wall and floor assemblies used in this Report.

Details of the test facilities and the measurement procedures are given in Chapter 2.

The test reports with detailed construction descriptions and results are provided in separate reports [13.7, 13.8, 13.9].

5.1 Appendix A1: Transmission Loss Data for CFS-Framed Wall and Floor Assemblies

Table A1.1(a): Sound transmission loss data for CFS-framed wall assemblies with a single row of loadbearing CFS studs[1] with a cross section of 38 x 152 mm, as described in Section 2.1.

Specimen Code	Description	Steel (mm)	63 Hz			125 Hz			250 Hz		
CFS-S152-W01	G16_SS152(406)_GFB152_G16	1.37	19	18	12	13	19	27	32	38	36
CFS-S152-W02	G16_SS152(406)_GFB152_2G16	1.37	23	20	15	16	21	30	37	41	38
CFS-S152-W03	2G16_SS152(406)_GFB152_2G16	1.37	25	21	17	17	24	33	40	43	40
CFS-S152-W11	G16_SS152(406)_RC13(406)_G16	1.37	16	13	9	14	21	23	29	35	37
CFS-S152-W12	2G16_SS152(406)_RC13(406)_G16	1.37	17	13	13	20	28	29	33	40	42
CFS-S152-W13	G16_SS152(406)_RC13(406)_2G16	1.37	18	15	15	21	28	29	34	41	43
CFS-S152-W14	2G16_SS152(406)_RC13(406)_2G16	1.37	16	14	20	26	34	34	38	45	47
CFS-S152-W21	G16_SS152(406)_GFB92_RC13(406)_G16	1.37	16	14	11	18	28	31	35	42	45
CFS-S152-W22	2G16_SS152(406)_GFB92_RC13(406)_G16	1.37	17	15	16	24	33	36	39	46	48
CFS-S152-W23	2G16_SS152(406)_GFB92_RC13(406)_2G16	1.37	16	18	22	31	39	42	45	50	51
CFS-S152-W31	G16_SS152(406)_GFB152_RC13(406)_G16	1.37	18	15	13	17	27	31	36	43	46
CFS-S152-W32	2G16_SS152(406)_GFB152_RC13(406)_G16	1.37	17	14	16	22	32	37	40	47	50
CFS-S152-W33	2G16_SS152(406)_GFB152_RC13(406)_2G16	1.37	17	18	22	28	37	43	45	51	53
CFS-S152-W34	2G13_SS152(406)_GFB152_RC13(406)_2G13	1.37	17	16	19	27	36	41	45	50	51
CFS-S152-W41	G16_SS152(610)_GFB92_RC13(406)_G16	1.37	15	14	12	20	31	34	40	44	45
CFS-S152-W42	2G16_SS152(610)_GFB92_RC13(406)_G16	1.37	15	16	18	26	36	38	44	47	47
CFS-S152-W43	2G16_SS152(610)_GFB92_RC13(406)_2G16	1.37	13	20	25	32	41	46	49	52	51
CFS-S152-W44	2G16_SS152(610)_GFB152_RC13(406)_2G16	1.37	15	20	27	33	43	45	50	52	52
CFS-S152-W51	G16_SS152(406)_GFB152_RC13(406)_G16	1.09	18	14	13	19	29	31	37	43	46
CFS-S152-W52	2G16_SS152(406)_GFB152_RC13(406)_G16	1.09	18	14	17	24	34	36	42	46	49
CFS-S152-W53	2G16_SS152(406)_GFB152_RC13(406)_2G16	1.09	16	18	23	31	39	41	47	52	53

(Continuation of Table A1.1(a) from opposite page):

500 HZ			1000 HZ			2000 HZ			4000 HZ			STC	Reference
40	43	47	47	51	53	50	44	39	42	47	52	**42**	TLA-14-051
42	45	49	49	53	56	54	47	44	46	52	57	**45**	TLA-14-052
43	47	50	50	54	57	56	50	48	51	56	61	**48**	TLA-14-053
39	43	48	50	51	53	52	44	39	45	50	54	**42**	TLA-14-047
43	48	52	53	55	57	56	48	45	51	56	59	**47**	TLA-14-048
44	48	52	53	55	57	57	49	46	51	57	61	**48**	TLA-14-050
48	52	56	56	57	60	60	53	52	57	62	65	**53**	TLA-14-049
49	52	54	55	57	59	58	49	45	48	53	56	**49**	TLA-14-044
50	54	57	57	59	62	60	53	50	53	58	61	**53**	TLA-14-045
53	57	59	59	60	63	63	57	55	59	63	67	**57**	TLA-14-046
48	53	55	57	60	61	57	48	45	49	54	56	**49**	TLA-14-041,054,055
51	54	57	59	62	66	63	54	50	54	59	61	**54**	TLA-14-056
54	56	58	60	63	66	64	57	55	59	64	67	**58**	TLA-14-042,057,059
54	57	59	59	61	63	64	62	55	57	62	65	**57**	TLA-14-043
49	52	55	58	61	63	60	51	46	50	55	58	**50**	TLA-14-063
51	54	57	59	63	66	64	57	51	54	59	62	**55**	TLA-14-064
55	57	60	63	67	69	68	60	57	60	65	68	**59**	TLA-14-065
56	58	61	64	67	69	68	59	56	60	65	68	**60**	TLA-14-066
51	54	57	59	62	61	59	49	46	50	54	56	**50**	TLA-14-074
53	57	59	60	63	64	62	52	50	54	59	61	**54**	TLA-14-075
56	60	61	63	66	66	66	56	55	59	64	67	**58**	TLA-14-076

Table A1.1(b): Sound transmission loss data for CFS-framed wall assemblies with a single row of loadbearing CFS studs[1] with a cross section of 38 x 92 mm, as described in Section 2.1.

Specimen Code	Description	Steel (mm)	63 Hz			125 Hz			250 Hz		
CFS-S92-W01	G16_SS92(406)_GFB92_G16	1.37	22	17	16	15	14	17	29	37	39
CFS-S92-W02	G13_SS92(406)_MFB89_2G13	0.94	23	20	21	13	16	28	39	41	45
CFS-S92-W11	2G13_SS92(406)_RC13(610)_2G13	0.94	18	17	22	22	27	29	37	41	44
CFS-S92-W12	2G16_SS92(406) _RC13(610)_2G16	0.94	17	17	23	23	30	31	39	43	45
CFS-S92-W21	G16_SS92(406)_GFB92_RC13(406)_G16	1.37	20	17	14	12	21	28	34	42	45
CFS-S92-W22	G16_SS92(406)_GFB92_RC13(406)_2G16	1.5	20	18	18	20	26	33	40	46	51
CFS-S92-W23	2G16_SS92(406)_GFB92_RC13(406)_G16	1.37	22	18	15	18	28	34	39	45	50
CFS-S92-W24	2G16_SS92(406)_GFB92_RC13(406)_2G16	1.37	21	16	16	25	34	39	44	49	53
CFS-S92-W25	2G16_SS92(406)_GFB92_RC13(406)_2G16	1.5	20	16	21	27	33	39	45	50	54
CFS-S92-W26	2G13_SS92(406)_GFB92_RC13(406)_2G13	1.5	20	18	20	24	33	38	44	49	54
CFS-S92-W27	2G13_SS92(406)_MFB89_RC13(406)_2G13	1.5	21	18	18	24	32	38	44	49	54
CFS-S92-W31	G13_SS92(406)_GFB92_RC13(406)_G13	0.94	17	16	13	14	21	27	36	41	45
CFS-S92-W32	G13_SS92(406)_GFB92_RC13(406)_2G13	0.94	19	17	15	20	27	32	40	46	50
CFS-S92-W33	G13_SS92(406)_MFB89_RC13(406)_2G13	0.94	21	17	18	20	27	34	42	48	53
CFS-S92-W34	G13_SS92(406)_CFL92_RC13(406)_2G13	0.94	21	17	16	19	27	33	41	47	50
CFS-S92-W35	G13_OSB12_SS92(406)_MFB89_RC13(406)_2G13	0.94	20	16	21	26	33	38	45	51	55
CFS-S92-W36	2G13_SS92(406)_GFB92_RC13(406)_2G13	0.94	19	18	20	25	33	38	44	50	54
CFS-S92-W37	G16_SS92(406)_GFB92_RC13(406)_2G16	0.94	20	17	18	21	27	34	41	46	51
CFS-S92-W38	2G16_SS92(406)_GFB92_RC13(406)_2G16	0.94	18	18	22	27	35	40	45	51	55
CFS-S92-W41	G13_SS92(610)_MFB89_RC13(406)_2G13	0.94	17	15	19	25	31	37	44	48	53
CFS-S92-W51	G13_SS92(406)_GFB92_RC13(610)_G13	0.94	15	14	13	19	23	28	36	42	45
CFS-S92-W52	G13_SS92(406)_GFB92_RC13(610)_2G13	0.94	18	16	15	22	30	33	41	46	50
CFS-S92-W53	G13_SS92(406)_MFB89_RC13(610)_2G13	0.94	20	16	17	22	28	35	42	48	53
CFS-S92-W54	2G13_SS92(406)_GFB92_RC13(610)_2G13	0.94	17	17	20	29	36	39	45	51	54
CFS-S92-W55	G16_SS92(406)_GFB92_RC13(610)_G16	0.94	16	14	13	19	26	29	37	43	47
CFS-S92-W56	G16_SS92(406)_GFB92_RC13(610)_2G16	0.94	18	17	16	23	31	35	41	47	51
CFS-S92-W57	2G16_SS92(406)_GFB92_RC13(610)_2G16	0.94	18	20	23	29	38	42	46	51	55

(Continuation of Table A1.1(b) from opposite page):

500 HZ			1000 HZ			2000 HZ			4000 HZ			STC	Reference
38	38	45	44	48	49	49	41	37	41	46	51	**38**	TLA-14-073
50	53	55	57	60	60	62	59	50	49	53	56	**40**	TLA-99-133a
47	50	53	56	59	62	63	60	52	52	58	60	**50**	TLA-00-063a
48	52	55	58	59	61	59	52	50	55	61	63	**51**	TLA-00-075a
48	52	53	56	61	62	59	49	47	50	55	57	**45**	TLA-14-067
54	57	60	62	63	63	59	50	48	54	58	61	**50**	TLA-00-083a
52	54	55	57	62	64	63	55	51	54	60	62	**52**	TLA-14-068
55	55	56	60	64	66	66	58	55	59	65	68	**57**	TLA-14-069
58	61	62	64	65	66	63	55	53	59	62	65	**57**	TLA-00-085a
58	59	61	64	66	67	67	65	56	56	61	63	**57**	TLA-00-079a
59	60	62	65	66	67	68	66	57	58	62	64	**56**	TLA-00-081a
50	53	57	60	62	63	63	62	50	48	52	56	**45**	TLA-00-105a
55	58	61	63	64	65	65	64	53	52	57	61	**51**	TLA-00-103a
58	61	65	68	69	70	71	69	59	57	62	65	**51**	TLA-99-127a,129a
56	59	62	65	66	66	66	65	54	55	59	61	**51**	TLA-00-067a
60	64	67	69	70	72	73	71	62	62	68	70	**57**	TLA-99-135a
58	60	63	65	66	66	67	66	56	56	61	64	**57**	TLA-00-065a,101a
55	58	62	63	63	63	61	52	49	55	59	60	**51**	TLA-00-069a
58	61	65	66	65	66	64	56	55	60	64	65	**58**	TLA-00-071a
58	63	66	69	71	72	72	68	57	56	61	65	**55**	TLA-99-137a
50	54	57	60	63	64	64	62	49	48	52	56	**47**	TLA-00-095a
54	58	61	63	65	65	66	65	53	53	58	61	**54**	TLA-00-097a
58	62	65	68	69	70	71	69	60	57	62	64	**52**	TLA-99-123a
57	61	63	65	67	67	68	67	58	58	63	66	**59**	TLA-00-099a
50	54	58	60	62	62	60	51	46	51	55	57	**49**	TLA-00-089a
55	58	61	63	64	64	62	55	51	57	61	63	**54**	TLA-00-091a
58	62	64	66	67	66	65	58	56	61	65	67	**59**	TLA-00-073a,093a

Table A1.2: Sound transmission loss data for CFS-framed floor assemblies with CFS joists of various dimensions and spacing as described in Section 2.2.

Specimen Code	Description	Steel (mm)	63 HZ			125 Hz			250 Hz		
CFS-J317-F01	GCON32_CORSTE14_SJ317(406)_ GFB92_RC13(305)_G16	1.37	24	22	25	30	39	42	45	49	52
CFS-J317-F02	GCON32_CORSTE14_SJ317(406)_ GFB92_RC13(305)_2G16	1.37	26	27	30	36	44	47	48	53	56
CFS-J254-F01	GCON32_CORSTE14_SJ254(406)_ GFB92_RC13(305)_G16	1.37	23	25	29	30	36	41	47	47	54
CFS-J254-F02	GCON32_CORSTE14_SJ254(406)_ GFB92_RC13(305)_2G16	1.37	23	31	34	33	39	44	50	50	58
CFS-J254-F03	GCON32_CORSTE14_SJ254(406)_ GFB92_RC13(305)_G13	1.37	21	24	28	29	36	41	45	46	54
CFS-J254-F04	GCON32_CORSTE14_SJ254(406)_ GFB92_RC13(305)_2G13	1.37	24	30	32	34	40	44	48	50	57
CFS-J203-F01	CON40_CORSTE15_SJ203(406)_ RC13(406)_2G13	1.22	26	33	40	40	45	49	52	53	57
CFS-J203-F02	CON40_CORSTE15_SJ203(406)_ GFB90_RC13(406)_2G13	1.22	28	39	42	46	49	55	58	59	61
CFS-J203-F03	CON40_CORSTE15_SJ203(406)_ MFB90_RC13(406)_2G13	1.22	28	36	40	44	50	54	57	58	62
CFS-J203-F04	CON40_CORSTE15_SJ203(406)_ CFL200_RC13(406)_2G13	1.22	30	41	45	47	52	56	59	61	63
CFS-J203-F05	CON40_CORSTE15_SJ203(406)_ CFS130_RC13(406)_2G13	1.22	28	38	42	45	50	54	58	60	62

(Continuation of Table A1.2 from opposite page):

500 HZ			1000 HZ			2000 HZ			4000 HZ			STC	Reference
53	52	53	56	59	60	60	57	58	61	66	68	**56**	TLF-14-063,067
57	56	56	60	62	63	64	62	64	67	71	73	**60**	TLF-14-066
53	53	54	56	58	62	62	58	59	61	67	69	**57**	TLF-14-050,059
56	58	58	60	61	64	65	61	63	66	72	74	**60**	TLF-14-046,048,049
53	54	54	56	58	62	63	63	58	59	65	67	**56**	TLF-14-061
56	57	57	59	61	65	66	66	62	65	71	73	**60**	TLF-14-062
54	56	61	62	63	69	71	73	71	74	77	81	**62**	TLF-03-009a,011a
60	61	63	67	70	74	78	79	77	79	82	85	**68**	TLF-03-005a
60	62	64	68	70	74	77	78	76	78	81	85	**68**	TLF-03-007a
62	64	65	69	73	75	79	79	78	80	83	87	**70**	TLF-03-031a
60	60	63	68	72	75	79	81	80	82	85	89	**68**	TLF-03-039a

6 References and Explanatory Notes

Technical Standards

1. ASTM E90-09, "Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements", ASTM International, West Conshohocken, PA, USA.
2. ASTM E336-10, "Standard Test Method for Measurement of Airborne Sound Insulation in Buildings", ASTM International, West Conshohocken, PA, USA.
3. Other ASTM standards referenced and used in ASTM E90 and E336 include: ASTM E413-10, "Classification for Rating Sound Insulation" and ASTM E2235-04 "Standard Test Method for Determination of Decay Rates for Use in Sound Insulation Test Methods", ASTM International, West Conshohocken, PA, USA.
4. ISO 717:2013, "Acoustics—Rating of sound insulation in buildings and of building elements—Part 1: Airborne Sound Insulation, Part 2: Impact Sound Insulation" International Organization for Standardization, Geneva.
5. ISO 10140:2011, Parts 1 to 5, "Laboratory measurement of sound insulation of building elements", International Organization for Standardization, Geneva. Note: In 2011 the ISO 10140 series replaced ISO 140 Parts 1, 3, 6, 8, 10, 11 and 16.
6. ISO 10848:2006, Parts 1 to 4, "Laboratory measurement of flanking transmission of airborne and impact sound between adjoining rooms", International Organization for Standardization, Geneva.
7. ISO 15712:2005, Part 1, "Estimation of acoustic performance of buildings from the performance of elements", International Organization for Standardization, Geneva.

Other Technical References

8. L. Cremer and M. Heckl, "Structure-borne sound", edited by E.E. Ungar, Springer-Verlag, New York (original edition 1973, 2nd edition 1996).
9. E. Gerretsen, "Calculation of the sound transmission between dwellings by partitions and flanking structures", Applied Acoustics, Vol. 12, pp 413-433 (1979), and "Calculation of airborne and impact sound insulation between dwellings", Applied Acoustics, Vol. 19, pp 245-264 (1986).
10. R.J.M. Craik, "Sound transmission through buildings: Using statistical energy analysis", Gower Publishing (1996).
11. D.B. Pedersen, "Evaluation of EN 12354 part 1 and 2 for Nordic Dwelling Houses", Applied Acoustics, Vol. pp 259-268 (2000), (Validation and background studies for the ISO 15712 procedures).

Sources for Sound Transmission Data

Source references for sound transmission data (both collections of conventional laboratory test results for wall and floor assemblies according to ASTM E90, and flanking transmission tests following the procedures of ISO 10848) including many NRC Construction reports in the RR- and IR- series are available from the Publications Archive of the National Research Council Canada at http://nparc.cisti-icist.nrc-cnrc.gc.ca/npsi/ctrl?lang=en.

12. The software application *soundPATHS* is accessible online at the website of the National Research Council Canada. The calculations are based on experimental studies in the laboratories of the NRC: http://www.nrc-cnrc.gc.ca/eng/solutions/advisory/soundpaths/index.html
13. Technical details concerning the measurement protocol (consistent with ISO 10848) and discussion of the findings of the experimental studies are presented in a series of NRC reports:
    13.1. IR-754, “Flanking Transmission at Joints in Multi-Family Dwellings. Phase 1: Effects of Fire Stops at Floor/Wall Intersections”, T.R.T. Nightingale and R.E. Halliwell, (1997)
    13.2. RR-103, “Flanking Transmission in Multi-Family Dwellings Phase II: Effects of Continuous Structural Elements at Wall/Floor Junctions”, T.R.T. Nightingale, R.E. Halliwell, and J.D. Quirt (2002)
    13.3. RR-168, “Flanking Transmission at the Wall/Floor Junction in Multifamily Dwellings - Quantification and Methods of Suppression”, T.R.T. Nightingale, R.E. Halliwell, J.D. Quirt and F. King (2005)
    13.4. RR-218, “Flanking Transmission in Multi-Family Dwellings Phase IV”, T.R.T. Nightingale, J.D. Quirt, F. King and R.E. Halliwell, (2006)
    13.5. RR-219, “Guide for Sound Insulation in Wood Frame Construction”, J.D. Quirt, T.R.T. Nightingale, and F. King (2006). See also NRC Construction Technology Update 66, “Airborne Sound Insulation in Multi-Family Buildings”, J.D. Quirt and T.R.T. Nightingale (2008)
    13.6. J. K. Richardson, J. D. Quirt, R. Hlady, “Best Practice Guide on Fire Stops and Fire Blocks and their Impact on Sound Transmission”, NRCC #49677 (2007)
    13.7. IR-832, “Sound Insulation of Load-Bearing Shear-Resistant Wood and Steel Stud Walls”, T.R.T. Nightingale, R.E. Halliwell, J.D. Quirt and J.A. Birta (2002)
    13.8. RR-169, “Summary Report for Consortium on Fire Resistance and Sound Insulation of Floors: Sound Transmission and Impact Insulation Data”, A.C.C. Warnock (2005)
    13.9. NRC Report A1-005007.1, “Transmission Loss and Impact Insulation Data for Cold-Formed Steel Framed Walls and Floors”, C. Hoeller, B. Zeitler, and I. Sabourin (2017)
14. RR-331, “Guide to Calculating Airborne Sound Transmission in Buildings” (2nd Edition, 2016) is a companion to this Report, which presents both the “Detailed Method” of ISO 15712-1 and the “Simplified Method” that is used in this Report for calculating sound transmission in buildings.
15. The databases of flanking transmission data used in Guide RR-331 and in soundPATHS will be consolidated in a series of NRC publications presenting data from recent studies:
    15.1. RR-333 Apparent Sound Insulation in Concrete Buildings (2017)
    15.2. RR-334 Apparent Sound Insulation in Concrete Block Buildings (2015)
    15.3. RR-335 Apparent Sound Insulation in Cross-Laminated Timber Buildings (2017)
    15.4. RR-336 Apparent Sound Insulation in Wood-Framed Buildings (2017)
    15.5. RR-337 Apparent Sound Insulation in Cold-Formed Steel (CFS) Framed Buildings (2017)

Scientific Research Papers Published as Part of this Study:

16. The following scientific research papers were published as part of this study:
    16.1. C. Hoeller, B. Zeitler and J. Mahn, “Direct Sound Transmission Loss of Heavy Gauge Steel Stud Walls“, EURONOISE 2015

16.2. C. Hoeller, B. Zeitler, and I. Sabourin, "Direct airborne and impact sound insulation of steel-framed floors for mid-rise constructions", INTERNOISE 2015

16.3. C. Hoeller and B. Zeitler, "Laboratory Study on Flanking Sound Transmission in Cold-Formed Steel-Framed Constructions", INTERNOISE 2016

1 Cold-formed steel (CFS) framing includes floor joists and wall studs that are made from sheet steel into standard profiles by roll-forming the steel sheets through a series of dies. The process does not require heat to form the profiles, hence the name cold-formed steel. Joists and studs are available in a variety of steel thicknesses, for applications in loadbearing and non-loadbearing walls and floors. In this Report, data is provided for loadbearing steel framing formed from sheet steel with thickness of 1.37 mm and non-loadbearing steel framing formed from sheet steel with thickness of 0.54 mm.

2 Gypsum board panels commonly form the exposed surface on lightweight framed wall or floor assemblies and on linings for heavy homogeneous structural wall or floor assemblies of concrete, concrete block or CLT. The gypsum board in this study had nominal thickness of 12.7 mm (1/2 inch) or 15.9 mm (5/8 inch) denoted in specimen codes as 13 mm and 16 mm respectively.

“Fire-rated gypsum board” is typically heavier than non-fire-rated gypsum board. The higher mass per area of the fire-rated gypsum board gives improved resistance to sound transmission through the assembly. The descriptor “fire-rated” is used in this Report to denote gypsum board with proven fire-resistant properties, with mass per unit area of at least 8.7 kg/m^2 for 12.7 mm thickness, or 10.7 kg/m^2 for 15.9 mm thickness. Gypsum board panels are installed with framing, fasteners and fastener spacing conforming to installation details required by CSA A82.31-M or ASTM C754. The sound transmission results should only be used where the actual construction details correspond to the details of the test specimens on which the ratings are based.

3 Sound absorbing material is porous (closed-cell foam is not included) and readily-compressible, and includes fiber processed from rock, slag, glass or cellulose fiber. Such material provides acoustical benefit for direct transmission through lightweight framed wall or floor assemblies, and for flanking transmission when installed in the cavities between lining surfaces and heavy homogeneous structural elements. Note that overfilling the cavity could diminish the benefit of the sound absorbers.

4 Resilient metal channels are formed from steel with a maximum thickness of 0.46 mm (25 gauge), with a profile essentially as shown in Figure 6.1, with slits or holes in the single “leg” between the faces fastened to the framing and to the gypsum board. Installation of the resilient channels must conform to ASTM C754.

Figure 6.1: Drawing to illustrate the typical profile of resilient metal channels; approximate dimensions in cross-section are 13 mm x 60 mm (not precisely to scale).

(Copied from Figure A-9.10.3.1 of the National Building Code of Canada, used with permission)