Guide to calculating airborne sound transmission in buildings: third edition, September 2017

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Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/23002279
Research Report (National Research Council of Canada. Construction), 2017-09

NRC·CNRC Construction

RR-331
Guide to Calculating Airborne Sound Transmission in Buildings

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Third Edition
September 2017

National Research Council Canada
Conseil national de recherches Canada

Canada

Guide to Calculating Airborne Sound Transmission in Buildings

Applying ISO Measurement and Prediction Standards in a North American Context

Abstract: In recent years, the science and engineering for controlling sound transmission in buildings have shifted from a focus on individual assemblies such as walls or floors, to a focus on performance of the complete system. Standardized procedures for calculating the overall transmission, combined with standardized measurements to characterize sub-assemblies, provide much better prediction of sound transmission between adjacent indoor spaces. The International Standards Organization (ISO) has published a calculation method, ISO 15712-1 that uses laboratory test data for sub-assemblies such as walls and floors as inputs for a detailed procedure to calculate the expected sound transmission between adjacent rooms in a building. This standard works very well for some types of construction, but to use it in a North American context one must overcome two obstacles – incompatibility with the ASTM standards used by our construction industry, and low accuracy of its predictions for lightweight wood or steel frame construction. To bypass limitations of ISO 15712-1, this Guide explains how to merge ASTM and ISO test data in the ISO calculation procedure, and provides recommendations for applying extended measurement and calculation procedures for specific common types of construction. This Guide was developed in a project established by the National Research Council Canada to support the transition of construction industry practice to using apparent sound transmission class (ASTC) 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 Guide also facilitates design to provide enhanced sound insulation, and should be generally applicable to construction in both Canada and the USA.

This publication contains a limited set of examples for several types of construction, to provide an introduction and overview of the ASTC calculation procedure. Additional examples and measurement data can be found in the companion documents to this Guide, namely NRC Research Reports RR-333 to RR-337. Furthermore, the calculation procedure outlined and illustrated in this Guide is also used by the software web application *soundPATHS*, which is available for free on the website of the National Research Council Canada (see the references in Section 7 of this Guide for access details).

Although it is not repeated at every step of this Guide, it should be understood that some variation in sound insulation is to be expected in practice due to changes in the specific design details, quality of workmanship, substitution of "generic equivalents", or simply rebuilding the construction. It would be prudent to allow a margin of error of 2-3 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.

Changes in the Third Edition

This third edition supersedes the first and second editions of the NRC Research Report RR-331, which were published in October 2013 and April 2016, respectively.

Changes in the third edition include:

- New worked examples for constructions consisting of concrete masonry walls with hollowcore precast concrete floors in Chapter 2 ("Buildings with Concrete or Concrete Masonry Walls and Concrete Floors")
- Complete revision of Chapter 3 ("Buildings with CLT Wall and Floor Assemblies"), based on the recently published NRC Research Report RR-335, "Apparent Sound Insulation in Cross-Laminated Timber Buildings"
- Update of the worked examples for double wood-stud constructions in Section 4.2 ("Wood-Framed Wall and Floor Assemblies")
- Complete revision of Section 4.3 ("Cold-Formed Steel-Framed Wall and Floor Assemblies"), based on the recently published NRC Research Report RR-337, "Apparent Sound Insulation in Cold-Formed Steel-Framed Buildings"
- Minor reorganizations of Chapters 2, 4, and 5
- Move to a consistent layout for the worked examples throughout the entire Guide
- Changes in the normalization to the input data in the worked examples in Sections 4.2 and 5.3

Acknowledgements

The authors gratefully acknowledge that the development of this Guide was supported by a Special Interest Group of industry partners who co-funded the project, and participated in the planning and review process. The Steering Committee for the project included the following members:

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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.

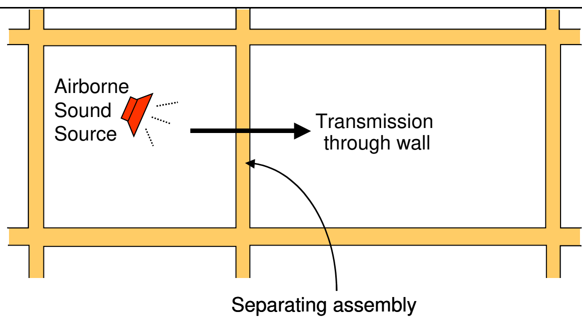


Figure 1.1: The drawings in Figure 1.1 and 1.2 show a cross-section through a building with two adjacent rooms. Part of the sound from an airborne source in one unit (represented by red loudspeaker in the drawings, which could include anything from a home theatre to people talking loudly) is transmitted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

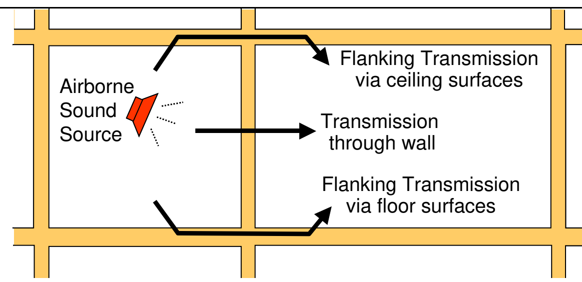


Figure 1.2: In reality, there are many paths for sound transmission between adjacent rooms, including both direct transmission through the separating assembly and indirect structure-borne paths, a few of which are indicated here. (See Section 1.4 for more detail.) The structure-borne paths usually significantly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

Although measuring the ASTC in a finished building (following ASTM Standard E336) is quite straightforward, predicting the ASTC due to the set of transmission paths in a building design 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 some types of construction, but not for the lightweight framed construction widely used for buildings 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 common types of construction.

This Guide was developed in a project established by the National Research Council Canada and a Special Interest Group of industry partners (see page iii of this Guide) 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 Guide also facilitates design to provide enhanced levels of sound insulation, and should be generally applicable to construction in both Canada and the USA.

1.1. Predicting Sound Transmission for Common Types of Construction

As noted above, ISO 15712-1 provides very reliable estimates for buildings with concrete floors and walls of concrete or masonry, but it is less accurate for other common types of construction, especially for constructions whose stiffness is directional, such as wood-frame and steel-frame constructions.

ISO 15712-1 has other limitations, too. For example, in several places (especially for light frame 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 according to the ISO 10848 series of standards; the four parts of ISO 10848 were developed to deal with measuring flanking transmission for various combinations of construction types and junctions.

To work around these limitations, and to provide more guidance to users on how to use this calculation procedure for specific situations, this Guide presents an approach suited to each type of construction:

- For types of construction where the calculation procedure of ISO 15712-1 ***is accurate***, the Guide outlines the steps of the standardized calculation process. In order to respect copyright, the Guide does not reproduce the equations of ISO 15712-1, but it does indicate which equations apply in each context;
- For types of construction where the calculation procedure of ISO 15712-1 ***is not so accurate***, the Guide presents an alternative approach. This is based on experimental data obtained using the ISO 10848 series of standards for laboratory measurement of flanking transmission. It combines the sound power due to direct and flanking transmission in the same way as ISO 15712-1, as described in Section 1.4 of this Guide.

Each type of construction is presented in a separate chapter of this Guide, as follows:

- Concrete and masonry structures in Chapter 2
- Cross-laminated timber (CLT) structures in Chapter 3
- Lightweight wood-framed and steel-framed structures in Chapter 4
- Hybrid structures integrating different types of construction in Chapter 5

1.2. Standard Scenario for Examples in this Guide

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.

For purposes of this Guide, 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 that 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 "horizontal room pair" case where the pair of rooms are side-by side with a separating wall assembly between the two rooms.

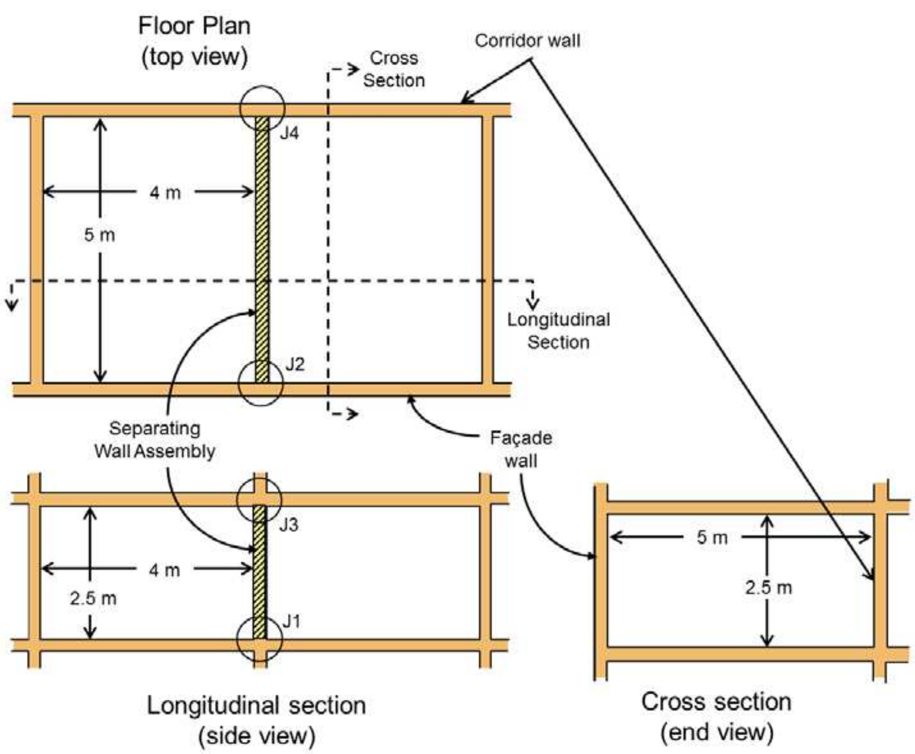
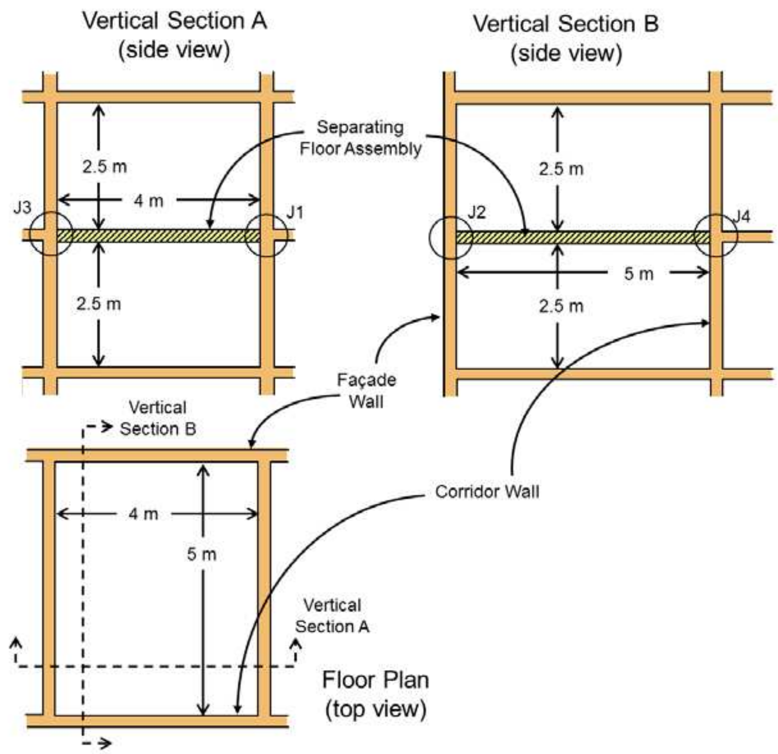


Figure 1.4:
Standard Scenario for the "vertical room pair" case where one of the pair of rooms is above the other, with the floor/ceiling assembly between the two rooms.



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 Guide.
- 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.

Deviations from the Standard Scenario, such as for rooms with different dimensions or for room pairs where one room is an end unit with T-junctions instead of cross-junctions, can be calculated by substituting the appropriate room dimensions and junction details in the calculation procedures and in the worked examples in this Guide.

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 ASTM standard E336 recognizes the contribution of flanking to apparent sound transmission, there is neither an ASTM standard for measuring the structure-borne flanking sound transmission that often dominates sound transmission between rooms, nor an ASTM counterpart of ISO 15712-1 for predicting the combination of direct and flanking sound transmission. In the absence of suitable ASTM standards, this Guide uses the procedures of ISO 15712-1 and data from the complementary ISO 10848 series for some constructions, 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 sound 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 (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 16283-1)	Fraction of sound power transmitted (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 Guide, 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 15712-1 and ISO 10848 is presented in Table 1.2.

In addition, several scientific terms used in ISO 15712-1 at various stages of the calculation have been used without change. These include: radiation efficiency, velocity level difference, 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.

Terms used in this Guide	**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 assembly, or to a wall or floor assembly in-situ in a building.
Sound transmission loss in-situ (TL_{situ})	Sound transmission loss in-situ is the counterpart of sound reduction index in-situ (R_{situ}) described in ISO 15712-1 as "the sound reduction index of an element in the actual field situation".
Change in sound transmission loss (ΔTL)	Change in sound transmission loss is the difference in sound transmission loss due to a lining applied on one side of a wall or floor assembly when measured according to ASTM E90, compared with the sound transmission loss of the same assembly without a lining.
Change in sound transmission class (ΔSTC)	Change in sound transmission class is the difference in single-number rating due to a lining applied on one side of a wall or floor assembly. The calculation procedure for ΔSTC is described in Appendix A1 of this Guide.
Vibration reduction index (K_{ij})	Vibration reduction index (K_{ij}) is described in ISO 15712-1 as "direction-averaged vibration level difference over a junction, normalised to the junction length and the equivalent sound absorption length to make it an invariant quantity". Depending on the type of building element, K_{ij} values may be determined using equations in Annex E of ISO 15712-1 or the measurement procedures of ISO 10848.
Velocity level difference (VLD)	Velocity level difference (VLD) is described in ISO 15712-1 as "junction velocity level difference in-situ between an excited element (wall or floor) and the receiving element (wall or floor)." It is calculated by correcting the K_{ij} value to allow for edge loss conditions (identified through structural reverberation times) of the assemblies in-situ.
Flanking sound transmission loss (Flanking TL_{ij})	Flanking sound transmission loss is the counterpart of flanking sound reduction index (R_{ij}) in ISO 15712-1. 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 of this Guide.
Flanking sound transmission class (Flanking STC_{ij})	Flanking STC is the single-number rating calculated from the flanking sound transmission loss following the STC calculation procedure of ASTM E413.

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

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 keep track of the sound transmission paths, it is useful to introduce the labeling convention for the paths that is used in ISO 15712-1 and is shown in Figure 1.5.

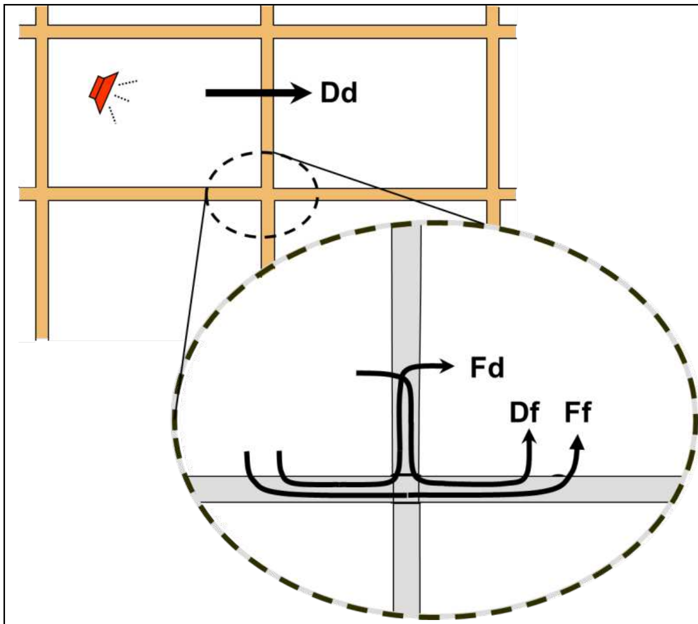


Figure 1.5: This figure shows the labelling convention for transmission paths used in ISO 15712-1. Consider the transmission of airborne sound from a source room (left) to a receiving room (right). Each transmission path involves one surface in the source room (denoted by a capital letter) and one in the receiving room (denoted by a lower case letter). Direct transmission through the separating assembly is path **Dd**. For each edge of the separating assembly there are three flanking paths: **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.

Note that the letter "F" or "f" denotes **flanking** surface, and "D" or "d" denotes the surface for **direct** transmission, i.e. the surface of the separating assembly. These surfaces may be either wall or floor/ceiling assemblies.

The labels for the flanking surfaces of the Standard Scenarios are detailed in the following Table 1.3.

Room Pair	Surfaces D and d	Flanking Surfaces F and f	Junction
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 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 Guide, 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 the apparent sound transmission by combining the sound power transmitted via the direct path and the twelve first-order flanking paths (three paths at each of the four edges 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 Guide.

The apparent sound transmission loss is the logarithmic expression of the total transmission factor (τ'):

$$ATL = -10\log\tau' \text{ dB} \qquad \text{Eq. 1.1}$$

The total transmission factor (τ') is calculated from a sum of transmission factors for individual paths:

$$\tau' = \tau_{Dd} + \sum_{Edge=1}^{4}\left(\tau_{Ff} + \tau_{Fd} + \tau_{Df}\right) \qquad \text{Eq. 1.2}$$

The transmission factors are defined as follows:

- τ' is the ratio of the total sound power radiated into the receiving room relative to the sound power incident on the separating element;
- τ_{Dd} is the ratio of the sound power radiated by the separating element relative to the sound power incident on the separating element;
- τ_{Df} is the ratio of the sound power radiated by a flanking element f in the receiving room due to structure-borne transmission from element D in the source room, relative to the sound power incident on the separating element;
- τ_{Ff} is the ratio of the sound power radiated by a flanking element f in the receiving room due to structure-borne transmission from element F in the source room, relative to the sound power incident on the separating element;
- τ_{Fd} is the ratio of the sound power radiated by element d in the receiving room due to structure-borne transmission from flanking element F in the source room, relative to the sound power incident on the separating element.

Each of the transmission factors τ_{ij} can be related to a corresponding path transmission loss associated with a specific pair of surfaces by the following expressions:

Direct transmission loss (for the separating assembly) $= -10\log\tau_{Dd}$ dB

Flanking transmission loss (for flanking path ij) $= -10\log\tau_{ij}$ dB Eq. 1.3

or conversely, $\tau_{ij} = 10^{-TL_{ij}/10}$

To connect this more obviously to standard laboratory test results, the expressions of Equations 1.1 to 1.3 can readily be recast in terms of sound transmission loss values, as shown in Eq. 1.4.

The apparent sound transmission loss (ATL) between two rooms (assuming the room geometry of Section 1.2 and neglecting the sound that by-passes the building structure, e.g. leaks, 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 (TL_{Ff}, TL_{Fd}, and TL_{Df}) of the three flanking paths for every junction at the edges of the separating element (as shown in Fig. 1.5) such that:

$$ATL = -10\cdot\log_{10}\left(10^{-0.1\cdot TL_{Dd}} + \sum_{edge=1}^{4}\left(10^{-0.1\cdot TL_{Ff}} + 10^{-0.1\cdot TL_{Fd}} + 10^{-0.1\cdot TL_{Df}}\right)\right) \quad \text{Eq. 1.4}$$

Note that this equation differs slightly from the calculation of the apparent sound transmission defined in Equation 14 of ISO 15712-1. Eq. 1.4 of this Guide treats the set of paths at each edge of the separating assembly in turn to match the presentation for the examples in this Guide. Eq. 1.4 is universally valid for all building systems, and the remaining challenge is to find the right expressions to calculate the sound transmission for the different paths for the chosen building system and situation.

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 Guide describes both methods to calculate the apparent sound insulation in a building. The Simplified Method uses the single-number ratings (STC or Flanking STC for each transmission path, as appropriate) instead of the frequency-dependent sound transmission loss values, and yields the ASTC directly:

$$ASTC = -10\cdot\log_{10}\left[10^{-0.1\cdot STC_{Dd}} + \sum_{edge=1}^{4}\left(10^{-0.1\cdot STC_{Ff}} + 10^{-0.1\cdot STC_{Fd}} + 10^{-0.1\cdot STC_{Df}}\right)\right] \quad \text{Eq. 1.5}$$

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. 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.

The calculation process for each type of construction is presented in a separate chapter of this Guide, as follows:

- Concrete and masonry structures in Chapter 2
- Cross-laminated timber (CLT) structures in Chapter 3
- Lightweight wood-framed and steel-framed structures in Chapter 4
- Hybrid structures integrating different types of construction in Chapter 5

For each of these types of construction, an appropriate type of laboratory data should be used, as detailed in that chapter.

The set of transmission factors used in this Guide is less general than the corresponding list of transmission factors in ISO 15712-1 to reflect the simplifications due to the Standard Scenario (see Section 1.2 above) and some further simplifications noted in the following cautions.

Cautions and limitations to examples presented in this Guide:

This Guide 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 sound transmission (for example airborne flanking via an unblocked attic or crawl space) is assumed to be suppressed by normal fire blocking requirements.

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

If this Guide 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 sound 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 Guide allow for such a correction.

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2. Buildings with Concrete or Concrete Masonry Walls and Concrete Floors

This chapter begins with an introduction outlining the concepts of the detailed calculation method of ISO 15712-1. The following sections provide more focussed procedural guidance and worked examples for specific sets of wall, floor, and junction details for concrete and masonry buildings.

Airborne sound in a source room excites vibration of the wall and floor assemblies that form the bounding surfaces of the room. As discussed in Chapter 1, the apparent transmission between adjacent rooms includes the combination of direct airborne sound transmission through the separating assembly and structure-borne flanking sound transmission via the three pairs of wall and floor surfaces (one in the source room and the other in the receiving room) that are connected at each of the four edges of the separating assembly. The detailed calculation method of ISO 15712-1 is focused on the balance between the input sound power and power losses (due to internal losses, sound radiation, and power flow into adjoining assemblies). This balance alters the direct transmission through each floor or wall assembly, and also the structure-borne transmission via the flanking surfaces.

More information on the direct and flanking sound insulation of concrete block wall assemblies connected to concrete floor assemblies can be found in NRC Research Report RR-334, “Apparent Sound Insulation in Concrete Block Buildings.” The report provides the data for direct and flanking sound insulation for a variety of concrete block building configurations.

Direct Transmission through the Separating Assembly

For the direct transmission through the separating assembly, the calculation process is shown in Figure 2.1, and the steps are described in more detail below. To transform the laboratory sound transmission data into the direct in-situ transmission loss requires a correction to adjust for the difference between losses in a laboratory test specimen and the losses when the assembly is connected to adjoining structures in-situ in the building.

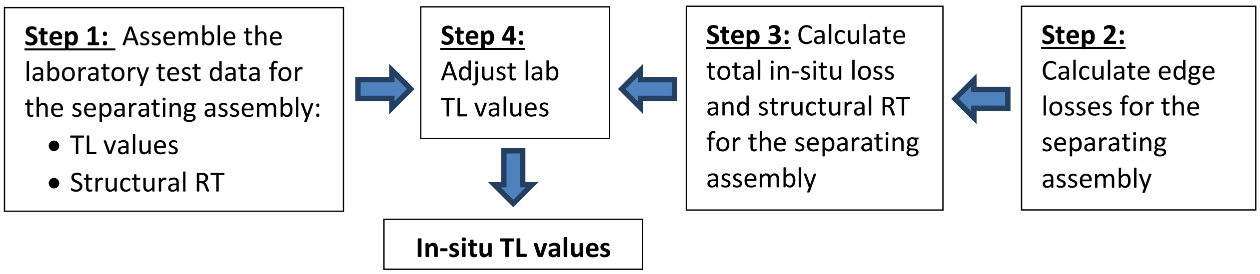


Figure 2.1: Steps to calculate the in-situ transmission loss for the separating assembly.

Step 1: Assemble the required laboratory test data:

- Laboratory sound transmission loss (TL) values measured according to ASTM E90 for the structural floor or wall assembly of bare concrete or masonry without added linings. For the treatment of linings in the calculation, please see Section 2.3.
- Structural reverberation time (T_S) in the laboratory if available. ISO standards require measurement according to ISO 10848-1. Alternatively, a conservative estimate of the total loss factor for a laboratory specimen from Eq. C.5 of Annex C of ISO 15712-1 may be used.

Step 2: Calculate edge losses for the separating assembly in-situ:

- For each edge, calculate the vibration reduction index (K_{ij}) between the separating assembly and each attached assembly using the appropriate case from Annex E of ISO 15712-1. These values depend on the junction geometry and on the ratio of mass per area for the assemblies.
- For each edge, calculate the resulting absorption coefficient using the values of K_{ij} and the coincidence frequency (frequency at which the wavelength on the element and in surrounding air coincide) for the attached assemblies in Eq. C.2 of ISO 15712-1.

Step 3: Calculate total loss for the separating assembly and its in-situ structural reverberation time:

- Use 2nd equation of Eq. C.1 of ISO 15712-1 to calculate the combination of internal losses, radiation losses and edge losses. (Comparison between the values calculated for a common surface for a vertical pair of rooms and a horizontal pair of rooms gives a check on the loss calculations. The total loss is frequency-dependent for most junction types; the worked examples give only the value for 500 Hz band, to provide a benchmark value.)
- Use 1st equation of Eq. C.1 of ISO 15712-1 to calculate the resulting structural reverberation time of the assembly, for each frequency band.

Step 4: Calculate in-situ TL values for the separating assembly using the ratio of structural reverberation times in Eq. 19 in Section 4.2.2 of ISO 15712-1.

Transmission via Flanking Elements

For each flanking path, a similar procedure is required to deal with in-situ losses associated with the connecting junction and the two wall or floor surfaces that comprise the flanking path. The calculation process is presented in Figure 2.2, and each step is subsequently explained.

Step 5: Calculate in-situ TL for each surface F in source room (as in Steps 1-4) →

Step 6: Calculate in-situ TL for each surface f in receiving room (as in Steps 1-4) →

Step 7: Calculate K_{Ff}, K_{Fd}, and K_{Df} for each edge and adjust to in-situ VLD value →

Step 8: Calculate path TL for each flanking path, using the in-situ values from Steps 5, 6 and 7 in Eq. 25a of ISO 15712-1.

Figure 2.2: Steps to calculate the flanking transmission loss for each flanking path.

Step 5: Calculate in-situ TL values for each flanking assembly F in the source room, repeating the procedure of Steps 1 – 4 for these assemblies. Note that for an assembly of concrete (cast-in-place concrete or precast concrete panels or concrete block) the coincidence frequency is below 125 Hz. Hence the radiation efficiency is equal to unity and the resonant sound transmission loss (required for these calculations) is equal to the sound transmission loss measured in the standard ASTM E90 laboratory test.

Step 6: Calculate in-situ TL values for each flanking assembly f in the receiving room, by repeating the procedure of Steps 1 – 4 for these assemblies. (Note that because of the symmetry in the Standard Scenario used in this Guide, and because the preceding calculation for direct transmission provides in-situ values for surfaces D and d, Steps 5 and 6 in calculations for examples in this Guide require calculations for only 4 room surfaces: a floor/ceiling assembly, a separating wall, a corridor wall, and a façade wall. The standard is more general.)

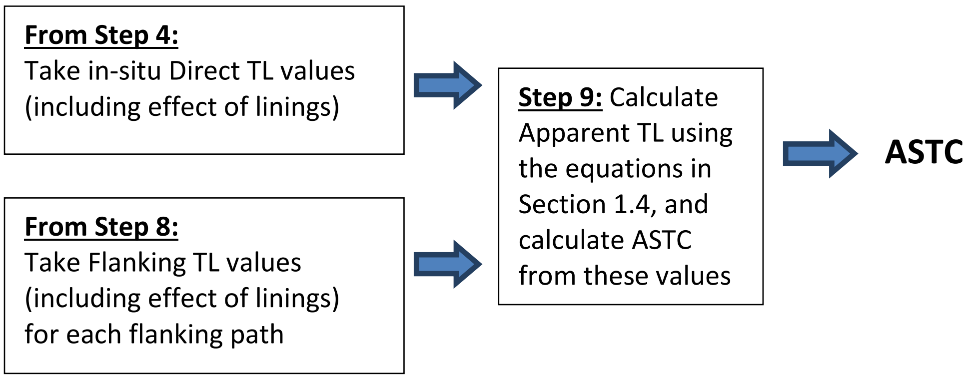
Step 7: Calculate in-situ velocity level difference (VLD) values for the junction attenuation:

- Calculate vibration reduction index (K_{ij}) between the pair of assemblies using the appropriate case from Annex E of ISO 15712-1.
- Calculate VLD for junction using Eq. 21 and 22 of ISO 15712-1.

Step 8: Calculate flanking TL values for each flanking path:

- Use VLD and in-situ TL values for the surfaces in the calculation of Eq. 25a of ISO 15712-1.

Combining Direct and Flanking Sound Transmission



Step 9: Combine the sound power transmitted via the direct path through the separating assembly and the 12 flanking paths (3 at each edge of the separating assembly).

- Use Equations 1.4 in Section 1.4 of this Guide (equivalent to Section 4.1 of ISO 15712-1) to calculate the apparent transmission loss (ATL).
- Use the resulting values of the apparent transmission loss in the procedure of ASTM E413 to calculate the apparent sound transmission class (ASTC) rating.

Worked Examples

The following sections present a number of worked examples that demonstrate the calculation of the ASTC rating for concrete and concrete block constructions according to the Detailed Method described above. All examples conform to the Standard Scenario presented in Section 1.2 of this Guide.

The worked examples in this Guide pertain to masonry walls constructed of normal weight hollow concrete block masonry units. The NRC Research Report RR-334, "Apparent Sound Insulation in Concrete Block Buildings" contains worked examples and detailed information pertaining to masonry walls constructed of both normal weight hollow concrete block units and lightweight hollow concrete block units.

Each worked example 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. The calculations are based on a more detailed spreadsheet that includes values for all the one-third octave bands between 100 Hz and 5 kHz and that has intermediate steps in some calculations. In order to condense the examples to a two-page format, only a subset of the calculated values are presented for some of the frequency bands.

To permit readers to better assess the worked examples, they also show the single-number ratings (such as STC for each assembly and Flanking STC for specific paths), but these summary values are not used in later stages of the calculation process. The full calculation is performed for the one-third octave frequency bands until the very end, and the ASTC rating is then calculated from the values for apparent sound transmission loss in the sixteen one-third octave frequency bands between 125 Hz and 4000 Hz.

Within the table for each worked example, the "References" column presents the source of input data (combining the NRC report number and identifier for each laboratory test result or derived result), or identifies applicable equations and sections of ISO 15712-1 at each stage of the calculation. Symbols and subscripts identifying the corresponding variable in ISO 15712-1 are given in the adjacent column.

Under the heading "STC or ASTC" the examples present single-number ratings (each calculated from a set of one-third octave band data according to ASTM E413) to provide a consistent set of summary single-number measures at each stage of the calculation:

- STC values for the laboratory sound transmission loss of wall or floor assemblies
- In-situ STC values for the calculated in-situ sound transmission loss of wall and floor assemblies
- Direct STC values for the in-situ sound transmission loss through the separating assembly including the effect of linings
- Flanking STC values calculated for each flanking sound transmission path at each junction including the effect of linings
- Apparent STC (ASTC) values for the combination of direct and flanking transmission via all paths

When the calculated Flanking STC value 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 value for the set of 3 paths at each edge of the separating assembly cannot exceed 85, and the Total Flanking STC value for all 4 edges cannot exceed 79.

Colour is used to highlight input and output values in the worked examples:

- Light red is used to indicate input values
- Blue is used for the direct sound transmission loss, including the effect of in-situ loss corrections and any added lining(s) on the separating assembly
- Pale yellow highlights calculated values of the combined flanking sound transmission due to a set of flanking paths
- Green highlights the final result for the ASTC rating

Validation studies in Europe for concrete and concrete masonry constructions have confirmed that these detailed predictions should be expected to exhibit a standard deviation of about 1.5 dB, with negligible bias, relative to values measured in actual buildings with these characteristics.

Rounding and Precision in the Worked Examples

The final ASTC result obtained in each worked example depends slightly on the precision of the input data and on rounding of results at each stage of the calculation. There is no rounding approach explicitly specified in ISO 15712-1, but the worked examples in the ISO standard show input and calculated sound reduction index values rounded to 0.1 dB which is consistent with the requirements for presentation of results in the ISO standards for measuring laboratory sound transmission.

The ASTM standards for the measurement of sound transmission in the laboratory and in the field (ASTM E90 and ASTM E336, respectively) specify that sound transmission loss values should be rounded to the nearest integer, which is arguably more representative of meaningful precision of the result.

The examples in this document follow the ASTM convention of rounding to the nearest integer for input sound transmission loss data from laboratory tests of wall or floor assemblies, for measured or calculated values of flanking transmission loss for individual paths, and for the apparent sound transmission loss calculated from the combination of direct and flanking paths. For input values measured according to ISO standards for which there is no ASTM counterpart, specific rounding rules were used as noted below:

- Sound transmission loss values from measurements according to ASTM E90, and values of ΔTL calculated from such measurements (as explained in Appendix A1), were rounded to the nearest integer.
- Structural reverberation times measured for laboratory wall or floor specimens or calculated for laboratory results according to Annex C of ISO 15712-1 were rounded to 3 decimal places.
- Values of the vibration reduction index (K_{ij}) at junctions between a separating assembly and each attached assembly were rounded to the nearest 0.1 dB both for results measured according to ISO 10848 and for those calculated using the equations from Annex E of ISO 15712-1.

Between the input values and the flanking transmission loss results for each path (which were rounded to the nearest integer), the worked examples are calculated to the full precision of the spreadsheet and interim values are presented to slightly higher precision to permit detailed comparisons for users treating these examples as benchmarks for their own worksheets.

A jurisdiction could specify other rounding approaches. However, these choices provide a reasonable representation of data precision, and should permit unambiguous interpretation of the worked examples presented here. Other rounding approaches could occasionally change the calculated ASTC values by ± 1 point.

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2.1. Rigid Junctions in Concrete and Concrete Masonry Buildings

This section presents worked examples for the most basic sort of concrete and masonry building which has structural floor slabs of bare concrete and walls of bare concrete or masonry connecting at rigid cross-junctions or T-junctions.

- Here, “bare” is taken to mean the assembly of concrete or masonry without a lining such as an added gypsum board finish on the walls or ceiling, or flooring over the concrete slab. For an assembly of concrete or normal weight concrete blocks, the “bare” surface could be painted or sealed, or have a thin coat of plaster without appreciably changing the sound transmission. However, these simple linings significantly improve the sound transmission properties of masonry walls constructed of lightweight units. Obviously, most buildings would have wall finishes (and usually also ceiling finishes) of gypsum board mounted on some sort of lightweight framing, and some sort of flooring over the concrete. The calculation extensions to deal with such “linings” are presented in Section 2.3. The examples in Section 2.1 and 2.2 have placeholders for including the effect of such linings, but those corrections have been set to zero.
- “Rigid” implies that the assemblies meeting at the junction are firmly bonded so that bending vibration is effectively transmitted between the elements. Loadbearing junctions are always rigid; non-loadbearing junctions may or may not be rigid.

The calculations follow the steps of the detailed calculation procedure of ISO 15712-1, as described at the beginning of Chapter 2. The approximations of the calculation make it most suitable for “homogeneous, lightly damped” structural elements whose coincidence frequency is below the frequency range of interest (taken here as below about 125 Hz), and for which an average value of K_{ij} suitable for a rigid junction of homogeneous assemblies is appropriate. Homogeneous concrete walls and floors and masonry walls of several types fall in this category.

Hollowcore precast concrete floors are not homogeneous and isotropic. However, in laboratory testing of mock-up junctions of masonry walls with hollowcore concrete floors it was shown that the methods of ISO 15712-1 and the vibration reduction index values of Annex E of ISO 15712-1 are still appropriate to use for these types of constructions. The measurements on the junction were conducted with the cores of the hollowcore panels oriented perpendicular to the junction. It is expected that hollowcore panels with the cores oriented parallel to the junction would yield similar or higher vibration reduction index values, and hence the vibration reduction index values from Annex E of ISO 15712-1 are appropriate to use independent of core orientation.

Based on the findings described above, homogeneous concrete walls and floors, masonry walls, and hollowcore precast concrete floors are all treated in the same way in this chapter.

EXAMPLE 2.1.1: DETAILED METHOD

- **Rooms side-by-side**
- **Cast-in-place concrete floors and normal weight concrete block walls with rigid junctions**

Separating wall assembly (loadbearing) with:

- One wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m², with no lining

Junction 1: Bottom Junction (separating wall / floor) with:

- Cast-in-place concrete floor with mass per area of 345 kg/m² (e.g. normal weight concrete 150 mm thick) with no topping or flooring
- Rigid mortared cross-junction with concrete block wall assembly

Junction 2 or 4: Each Side (separating wall / abutting side wall) with:

- Abutting side wall and separating wall of hollow concrete block masonry[1] with mass per area of 238 kg/m², with no lining
- Rigid mortared T-junctions

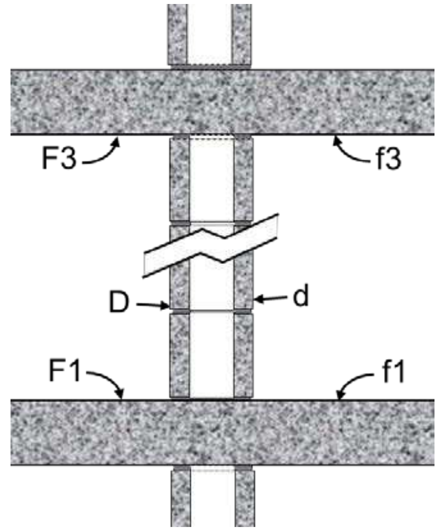
Junction 3: Top Junction (separating wall / ceiling) with:

- Cast-in-place concrete ceiling with mass per area of 345 kg/m² (e.g. normal weight concrete 150 mm thick) with no added ceiling lining
- Rigid mortared cross-junction with concrete block wall assembly

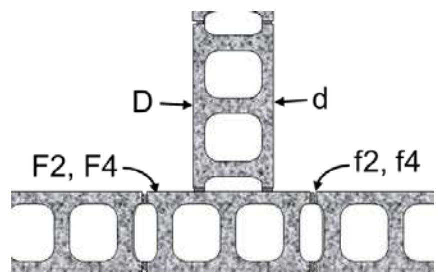
Acoustical Parameters:

For separating assembly:						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		(Eq. C.2)
	Reference	K_Ff	K_Dd'	K_Fd	K_Df	Σ l_k . α_k
X-Junction 1 or 3	ISO 15712-1, Eq. E.3	6.1	11.6	8.8	8.8	0.571
T-Junction 2 or 4	ISO 15712-1, Eq. E.4	5.7		5.7	5.7	0.420
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.041	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 1 & 3,						
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.028	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 2 & 4,						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1			0.047	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1			0.043	(at 500 Hz)	

Illustration for this case



Junction of 190 mm concrete block separating wall with 150 mm thick cast-in-place concrete floor and ceiling. (Side view of Junctions 1 and 3)



Junction of separating wall with side wall, both of 190 mm concrete block. (Plan view of Junction 2 or 4)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (190 mm concrete block)									
Sound Transmission Loss (TL)	R_D,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_D	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.256	0.169	0.108	0.067	0.040	0.023	
Leakage or Airborne Flanking		Sealed & Blocked	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 19, 24	**36**	**39**	**44**	**50**	**58**	**62**	**49**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (Rigid cross-junction, 190 mm block separating wall / 150 mm concrete floor)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.439	0.369	0.250	0.205	0.146	0.077	
Change by Lining on source side	ΔR_F1	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f1	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.347	0.238	0.159	0.104	0.066	0.041	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	41.0	43.9	52.0	60.9	69.4	77.8	55
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	41.0	43.9	52.0	60.9	69.4	77.8	55
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	9.3	9.4	9.7	10.0	10.5	11.1	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.8	12.2	12.6	13.2	14.0	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.8	12.2	12.6	13.2	14.0	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**48**	**51**	**60**	**69**	**78**	**87**	**62**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**49**	**52**	**59**	**67**	**76**	**83**	**63**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**49**	**52**	**59**	**67**	**76**	**83**	**63**
Junction 1: Flanking STC for all paths			- 10*LOG10(10^-6.2 + 10^- 6.3 + 10^- 6.3) =						58
Junction 2 (Rigid T-Junction, 190 mm block separating wall / 190 mm block flanking wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f2	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.219	0.146	0.094	0.059	0.036	0.021	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.8	58.7	62.5	50
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.8	58.7	62.5	50
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	10.9	11.1	11.5	12.0	12.7	13.5	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	11.0	11.3	11.7	12.3	13.0	13.8	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	11.0	11.3	11.7	12.3	13.0	13.8	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**48**	**51**	**58**	**64**	**72**	**77**	**62**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**48**	**51**	**57**	**63**	**72**	**77**	**62**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**48**	**51**	**57**	**63**	**72**	**77**	**62**
Junction 2: Flanking STC for all paths			- 10*LOG10(10^-6.2 + 10^- 6.2 + 10^- 6.2) =						57
Junction 3 (Rigid cross-junction, 190 mm block separating wall / 150 mm concrete ceiling)									
All input values the same as for Junction 1									
Junction 3: Flanking STC for all paths									58
Junction 4 (Rigid T-junction, 190 mm block separating wall / 190 mm block flanking wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change in-situ loss factors from Junction 2									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.238	0.158	0.102	0.063	0.038	0.021	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	10.5	10.8	11.2	11.8	12.5	13.3	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	10.8	11.1	11.6	12.1	12.9	13.7	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	10.8	11.1	11.6	12.1	12.9	13.7	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**47**	**51**	**57**	**63**	**72**	**77**	**62**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**47**	**51**	**56**	**63**	**72**	**76**	**61**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**47**	**51**	**56**	**63**	**72**	**76**	**61**
Junction 4: Flanking STC for all paths			- 10*LOG10(10^-6.2 + 10^- 6.1 + 10^- 6.1) =						57
Total Flanking (for all 4 junctions)									51
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**34**	**37**	**42**	**49**	**57**	**61**	**47**

EXAMPLE 2.1.2: DETAILED METHOD

- **Rooms one-above-the-other**
- **Cast-in-place concrete floor and normal weight concrete block walls with rigid junctions**

Separating floor/ceiling assembly with:
- Cast-in-place concrete floor with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping / flooring on top, or ceiling lining below

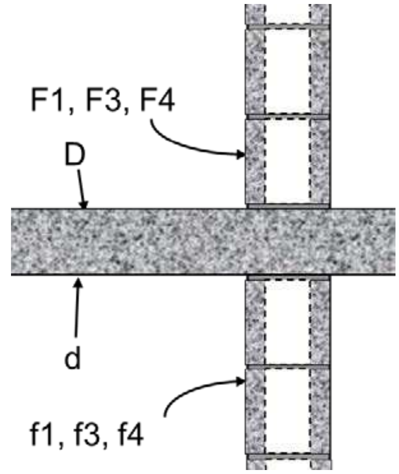
Junction 1, 3, 4: Cross-junction of separating floor / flanking wall with:
- Rigid mortared cross-junction with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2, with no lining

Junction 2: T-Junction of separating floor / flanking wall with:
- Rigid mortared T-junction with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2, with no lining

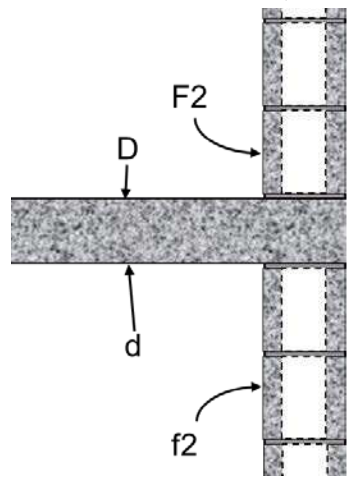
Acoustical Parameters:

	For separating assembly:					
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		(Eq. C.2)
	Reference	K_Ff	K_Dd'	K_Fd	K_Df	Σ l_k . α_k
X-Junction 1, 3, 4	ISO 15712-1, Eq. E.3	11.6	6.1	8.8	8.8	0.843
T-Junction 2	ISO 15712-1, Eq. E.4	8.1		5.8	5.8	0.657
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.028	(at 500 Hz)	
	Similarly, for flanking elements F and f at Junction 1 & 3,					
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.041	(at 500 Hz)	
	Similarly, for flanking elements F and f at Junction 2 & 4,					
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1			0.047	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1			0.043	(at 500 Hz)	

Illustration for this case



Cross-junction of separating floor of 150 mm thick cast-in-place concrete with 190 mm concrete block wall. (Side view of Junctions 1, 3, 4)



T-Junction of separating floor of 150 mm cast-in-place concrete with 190 mm concrete block wall. (Side view of Junction 2)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (150 mm concrete floor)									
Sound Transmission Loss (TL)	R_D,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.44	0.37	0.25	0.21	0.15	0.08	
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.346	0.237	0.159	0.104	0.066	0.041	
Leakage or Airborne Flanking		Sealed & Blocked	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**41**	**44**	**52**	**61**	**69**	**78**	**55**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F1	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f1	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.256	0.169	0.108	0.067	0.040	0.023	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	35.7	38.5	44.4	50.3	58.2	62.2	49
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	35.7	38.5	44.4	50.3	58.2	62.2	49
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	14.1	14.4	14.8	15.4	16.1	17.0	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.9	12.2	12.7	13.2	14.0	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.9	12.2	12.7	13.2	14.0	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**52**	**55**	**61**	**68**	**76**	**81**	**66**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**51**	**54**	**61**	**69**	**78**	**85**	**65**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**51**	**54**	**61**	**69**	**78**	**85**	**65**
Junction 1: Flanking STC for all paths		- 10*LOG10(10^-6.6 + 10^- 6.5 + 10^- 6.5) =							61
Junction 2 (Rigid T-Junction, 150 mm concrete separating floor / 190 mm block wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f2	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.218	0.145	0.094	0.059	0.036	0.021	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.9	58.7	62.5	50
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.9	58.7	62.5	50
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	11.3	11.5	11.9	12.4	13.1	13.9	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	9.5	9.7	10.0	10.4	11.0	11.6	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	9.5	9.7	10.0	10.4	11.0	11.6	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**51**	**54**	**60**	**66**	**75**	**79**	**65**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**50**	**53**	**60**	**68**	**76**	**83**	**64**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**50**	**53**	**60**	**68**	**76**	**83**	**64**
Junction 2: Flanking STC for all paths		- 10*LOG10(10^-6.5 + 10^- 6.4 + 10^- 6.4) =							60
Junction 3 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
All input values the same as for Junction 1									
Junction 3: Flanking STC for all paths									61
Junction 4 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change loss factors and junction attenuation from Junction 2									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.237	0.157	0.101	0.063	0.038	0.021	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	14.4	14.7	15.1	15.6	16.3	17.2	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	12.3	12.5	12.8	13.3	13.8	14.5	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	12.3	12.5	12.8	13.3	13.8	14.5	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**53**	**57**	**63**	**69**	**78**	**83**	**68**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**52**	**55**	**63**	**71**	**79**	**86**	**67**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**52**	**55**	**63**	**71**	**79**	**86**	**67**
Junction 4: Flanking STC for all paths		- 10*LOG10(10^-6.8 + 10^- 6.7 + 10^- 6.7) =							63
Total Flanking (for all 4 junctions)									55
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**38**	**41**	**48**	**56**	**64**	**71**	**52**

EXAMPLE 2.1.3: **DETAILED METHOD**

- **Rooms side-by-side**
- **Cast-in-place concrete floors and concrete walls with rigid junctions**

Separating wall assembly (loadbearing) with:
- Cast-in-place concrete wall with mass per area of 345 kg/m^2 (e.g. normal weight concrete with thickness of 150 mm) with no lining

Junction 1: Bottom Junction (separating wall / floor) with:
- Cast-in-place concrete floor with mass per area of 460 kg/m^2 (e.g. normal weight concrete 200 mm thick) with no topping or flooring
- Rigid cross-junction with concrete wall assembly

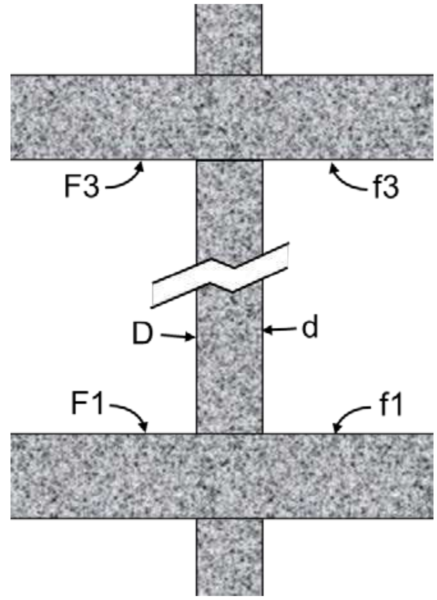
Junction 2 or 4: Each Side (separating wall / abutting side wall) with:
- Abutting side wall and separating wall of cast-in-place concrete with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick), with no lining
- Rigid T-junctions

Junction 3: Top Junction (separating wall / ceiling) with:
- Cast-in-place concrete ceiling with mass per area of 460 kg/m^2 (e.g. normal weight concrete 200 mm thick) with no added ceiling lining
- Rigid cross-junction with concrete wall assembly

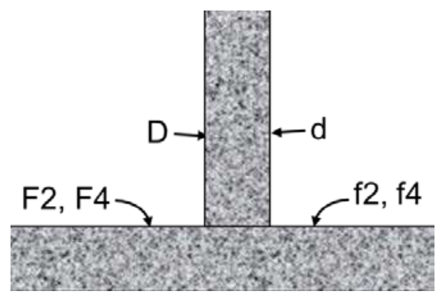
Acoustical Parameters:

For separating assembly:						
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		(Eq. C.2)
	Reference	K_Ff	K_Dd'	K_Fd	K_Df	Σ l_k . α_k
X-Junction 1 or 3	ISO 15712-1, Eq. E.3	6.7	10.9	8.8	8.8	0.544
T-Junction 2 or 4	ISO 15712-1, Eq. E.4	5.7		5.7	5.7	0.473
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.0293	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 1 & 3,						
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	460		f_c =	93		
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.0302	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 2 & 4,						
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1			0.0356	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1			0.0319	(at 500 Hz)	

Illustration for this case



Junctions of 150 mm cast-in-place concrete separating wall with 150 mm thick cast-in-place concrete floor and ceiling. (Side view of Junctions 1 and 3)



Junction of separating wall with side wall, both of 150 mm cast-in-place concrete. (Plan view of Junction 2 or 4)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (150 mm concrete)									
Sound Transmission Loss (TL)	R_D,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.439	0.369	0.250	0.205	0.146	0.077	
Change by Lining on source side	ΔR_D	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.325	0.223	0.150	0.099	0.063	0.039	
Leakage or Airborne Flanking		Sealed & Blocked	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**41**	**44**	**52**	**61**	**70**	**78**	**55**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (Rigid cross-junction, 150 mm concrete wall / 200 mm concrete floor)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-333, CON200, TLF-12-011	41	49	55	62	69	75	59
Structural Reverberation Time	T_s,lab	Measured T_s	0.324	0.250	0.240	0.170	0.093	0.060	
Change by Lining on source side	ΔR_F1	No Lining ,	0.0	0.0	0.0	0.0	0.0	0.0	
Change by Lining on receive side	ΔR_f1	No Lining ,	0.0	0.0	0.0	0.0	0.0	0.0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.317	0.217	0.146	0.096	0.061	0.038	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	41.1	49.6	57.2	64.5	70.8	77.0	60
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	41.1	49.6	57.2	64.5	70.8	77.0	60
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	10.3	10.4	10.6	11.0	11.4	11.9	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	11.3	11.4	11.7	12.0	12.4	13.0	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	11.3	11.4	11.7	12.0	12.4	13.0	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	**R_Ff**	ISO 15712-1, Eq. 25a	**49**	**58**	**66**	**73**	**80**	**87**	**68**
Flanking TL for Path Fd_1	**R_Fd**	ISO 15712-1, Eq. 25a	**51**	**57**	**65**	**74**	**82**	**89**	**68**
Flanking TL for Path Df_1	**R_Df**	ISO 15712-1, Eq. 25a	**51**	**57**	**65**	**74**	**82**	**89**	**68**
Junction 1: Flanking STC for all paths		- 10*LOG10(10^-6.8 + 10^- 6.8 + 10^- 6.8) =							63
Junction 2 (Rigid T-Junction, 150 mm concrete wall / 150 mm concrete wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.439	0.369	0.250	0.205	0.146	0.077	
Change by Lining on source side	ΔR_F2	No Lining ,	0.0	0.0	0.0	0.0	0.0	0.0	
Change by Lining on receive side	ΔR_f2	No Lining ,	0.0	0.0	0.0	0.0	0.0	0.0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.264	0.182	0.124	0.082	0.053	0.034	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	42.2	45.1	53.1	62.0	70.4	78.6	56
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	42.2	45.1	53.1	62.0	70.4	78.6	56
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	10.1	10.2	10.4	10.6	11.0	11.5	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	10.1	10.2	10.4	10.7	11.1	11.6	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	10.1	10.2	10.4	10.7	11.1	11.6	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	**R_Ff**	ISO 15712-1, Eq. 25a	**53**	**56**	**64**	**74**	**82**	**90**	**67**
Flanking TL for Path Fd_2	**R_Fd**	ISO 15712-1, Eq. 25a	**52**	**55**	**63**	**73**	**82**	**90**	**66**
Flanking TL for Path Df_2	**R_Df**	ISO 15712-1, Eq. 25a	**52**	**55**	**63**	**73**	**82**	**90**	**66**
Junction 2: Flanking STC for all paths		- 10*LOG10(10^-6.7 + 10^- 6.6 + 10^- 6.6) =							62
Junction 3 (Rigid cross-junction, 150 mm concrete wall / 200 mm concrete ceiling)									
All values the same as for Junction 1									
Junction 3: Flanking STC for all paths									63
Junction 4 (Rigid T-junction, 150 mm concrete wall / 150 mm concrete wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change loss factors from Junction 2									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.296	0.204	0.138	0.091	0.059	0.034	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	41.7	44.6	52.6	61.5	70.0	78.2	56
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	41.7	44.6	52.6	61.5	70.0	78.2	56
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	9.6	9.7	9.9	10.2	10.6	11.1	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	9.9	10.0	10.2	10.5	10.9	11.5	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	9.9	10.0	10.2	10.5	10.9	11.5	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	**R_Ff**	ISO 15712-1, Eq. 25a	**52**	**55**	**63**	**73**	**82**	**90**	**66**
Flanking TL for Path Fd_4	**R_Fd**	ISO 15712-1, Eq. 25a	**52**	**55**	**63**	**72**	**81**	**90**	**66**
Flanking TL for Path Df_4	**R_Df**	ISO 15712-1, Eq. 25a	**52**	**55**	**63**	**72**	**81**	**90**	**66**
Junction 4: Flanking STC for all paths		- 10*LOG10(10^-6.6 + 10^- 6.6 + 10^- 6.6) =							61
Total Flanking (for all 4 junctions)									56
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**38**	**42**	**50**	**59**	**67**	**75**	**53**

EXAMPLE 2.1.4: DETAILED METHOD

- **Rooms one-above-the-other**
- **Cast-in-place concrete floor and walls with rigid junctions**

Separating floor/ceiling assembly with:

- Cast-in-place concrete floor with mass per area of 460 kg/m^2 (e.g. normal weight concrete 200 mm thick) with no topping / flooring on top, or ceiling lining below

Junction 1, 3, 4: Cross-junction of separating floor / flanking wall with:

- Rigid cross-junction with concrete wall assemblies
- Wall above and below floor of cast-in-place concrete with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no lining

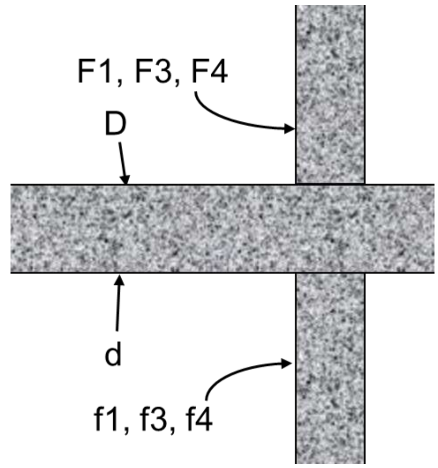
Junction 2: T-Junction of separating floor / flanking wall with:

- Rigid T-junction with concrete wall assemblies
- Wall above and below floor of cast-in-place concrete with mass per area of 345 kg/m^2 (e.g. normal weight concrete with thickness of 150 mm) with no lining

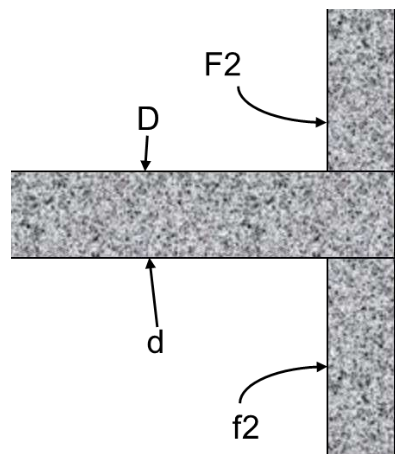
Acoustical Parameters:

For separating assembly:						
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	460		f_c =	93		(Eq. C.2)
	Reference	K_{Ff}	$K_{Dd'}$	K_{Fd}	K_{Df}	$\Sigma\, l_k \cdot \alpha_k$
X-Junction 1, 3, 4	ISO 15712-1, Eq. E.3	10.9	6.7	8.8	8.8	0.789
T-Junction 2	ISO 15712-1, Eq. E.4	7.6		5.8	5.8	0.740
Total loss, η_{tot}	ISO 15712-1, Eq. C.1			0.0302	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 1 & 3,						
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		
Total loss, η_{tot}	ISO 15712-1, Eq. C.1			0.0293	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 2 & 4,						
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		
Total loss, $\eta_{tot,2}$	ISO 15712-1, Eq. C.1			0.0355	(at 500 Hz)	
Total loss, $\eta_{tot,4}$	ISO 15712-1, Eq. C.1			0.0319	(at 500 Hz)	

Illustration for this case



Cross-junction of separating floor of 200 mm thick cast-in-place concrete with 150 mm thick cast-in-place concrete wall. (Side view of Junctions 1, 3 or 4)



T-Junction of separating floor of 200 mm thick cast-in-place concrete floor with 150 mm thick cast-in-place concrete wall. (Side view of Junction 2)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (200 mm concrete floor)									
Sound Transmission Loss (TL)	$R_{D,lab}$	RR-333, CON200, TLF-12-011	41	49	55	62	69	75	59
Structural Reverberation Time	$T_{s,lab}$	Measured T_s	0.32	0.25	0.24	0.17	0.09	0.06	
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	$T_{s,situ}$	ISO 15712-1, Eq. C.1-C.3	0.317	0.217	0.146	0.096	0.061	0.038	
Leakage or Airborne Flanking		Sealed & Blocked	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	$R_{D,situ}$	ISO 15712-1, Eq. 24	**41**	**50**	**57**	**64**	**71**	**77**	**60**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (Rigid cross-junction, 200 mm concrete floor / 150 mm concrete wall)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.439	0.369	0.250	0.205	0.146	0.077	
Change by Lining on source side	ΔR_F1	No lining ,	0.0	0.0	0.0	0.0	0.0	0.0	
Change by Lining on receive side	ΔR_f1	No lining ,	0.0	0.0	0.0	0.0	0.0	0.0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.325	0.223	0.150	0.099	0.063	0.039	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	41.3	44.2	52.2	61.2	69.7	77.9	55
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	41.3	44.2	52.2	61.2	69.7	77.9	55
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	12.33	12.45	12.67	13.00	13.43	14.00	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	11.30	11.43	11.66	11.98	12.41	12.97	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	11.30	11.43	11.66	11.98	12.41	12.97	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**56**	**59**	**67**	**76**	**85**	**90**	**70**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**53**	**60**	**67**	**76**	**84**	**90**	**70**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**53**	**60**	**67**	**76**	**84**	**90**	**70**
Junction 1: Flanking STC for all paths			- 10*LOG10(10^-7 + 10^- 7 + 10^- 7) =						65
Junction 2 (Rigid T-Junction, 200 mm concrete floor / 150 mm concrete wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.439	0.369	0.250	0.205	0.146	0.077	
Change by Lining on source side	ΔR_F2	No lining ,	0.0	0.0	0.0	0.0	0.0	0.0	
Change by Lining on receive side	ΔR_f2	No lining ,	0.0	0.0	0.0	0.0	0.0	0.0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.265	0.183	0.124	0.082	0.053	0.034	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	42.2	45.1	53.0	62.0	70.4	78.6	56
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	42.2	45.1	53.0	62.0	70.4	78.6	56
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	9.92	10.03	10.21	10.48	10.85	11.33	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	9.23	9.35	9.56	9.85	10.25	10.77	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	9.23	9.35	9.56	9.85	10.25	10.77	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**55**	**58**	**66**	**75**	**84**	**90**	**69**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**52**	**58**	**66**	**74**	**82**	**90**	**69**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**52**	**58**	**66**	**74**	**82**	**90**	**69**
Junction 2: Flanking STC for all paths			- 10*LOG10(10^-6.9 + 10^- 6.9 + 10^- 6.9) =						64
Junction 3 (Rigid cross-junction, 200 mm concrete floor / 150 mm concrete wall)									
All values the same as for Junction 1									
Junction 3: Flanking STC for all paths									65
Junction 4 (Rigid T-Junction, 200 mm concrete floor / 150 mm concrete wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change loss factors and junction attenuation vs. Junction 2									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.296	0.204	0.138	0.091	0.059	0.034	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	41.7	44.6	52.6	61.5	70.0	78.2	56
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	41.7	44.6	52.6	61.5	70.0	78.2	56
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	12.73	12.84	13.04	13.34	13.75	14.28	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	11.98	12.11	12.33	12.64	13.05	13.60	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	11.98	12.11	12.33	12.64	13.05	13.60	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**57**	**60**	**69**	**78**	**87**	**90**	**71**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**55**	**61**	**69**	**77**	**85**	**90**	**72**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**55**	**61**	**69**	**77**	**85**	**90**	**72**
Junction 4: Flanking STC for all paths			- 10*LOG10(10^-7.1 + 10^- 7.2 + 10^- 7.2) =						67
Total Flanking (for all 4 junctions)									59
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**39**	**46**	**54**	**61**	**69**	**75**	**56**

EXAMPLE 2.1.5: **DETAILED METHOD**

- **Rooms side-by-side**
- **Floors of hollowcore precast concrete panels[2] with walls of normal weight concrete block walls with rigid junctions**

Separating wall assembly (loadbearing) with:

- One wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m², with no lining

Junction 1: Bottom Junction (separating wall / floor) with:

- Floor assembly of hollowcore precast concrete panels[2] of cross-section 203 mm thick and 2440 mm wide, fully grouted at joints between adjacent panels, with mass per area of 344 kg/m²
- No topping or flooring
- Rigid mortared cross-junction with concrete block wall assembly

Junction 2 or 4: Each Side (separating wall / abutting side wall) with:

- Abutting side wall and separating wall of hollow concrete block masonry[1] with mass per area of 238 kg/m², with no lining
- Rigid mortared T-junctions

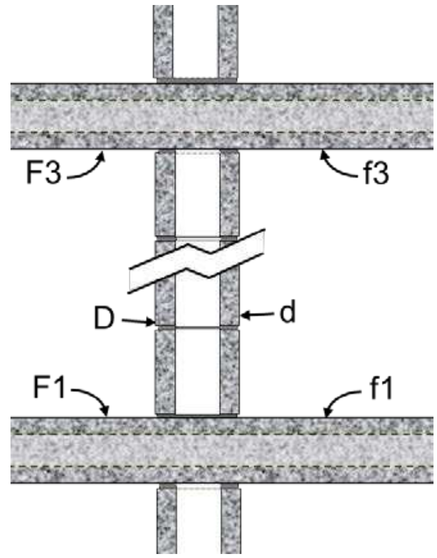
Junction 3: Top Junction (separating wall / ceiling) with:

- Ceiling assembly of hollowcore precast concrete panels[2] of cross-section 203 mm thick and 2440 mm wide, fully grouted at joints between adjacent panels, with mass per area of 344 kg/m²
- No added ceiling lining
- Rigid mortared cross-junction with concrete block wall assembly

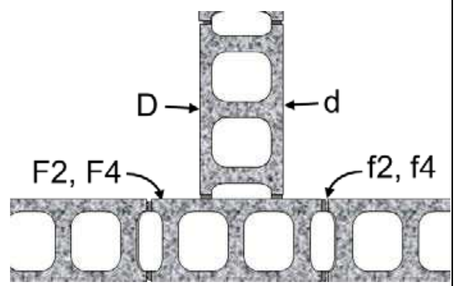
Acoustical Parameters:

	For separating assembly:					
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		(Eq. C.2)
	Reference	K_Ff	K_Dd'	K_Fd	K_Df	Σ l_k . α_k
X-Junction 1 or 3	ISO 15712-1, Eq. E.3	6.1	11.6	8.8	8.8	0.506
T-Junction 2 or 4	ISO 15712-1, Eq. E.4	5.7		5.7	5.7	0.420
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.039	(at 500 Hz)	
	Similarly, for flanking elements F and f at Junction 1 & 3,					
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	344		f_c =	91		
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.030	(at 500 Hz)	
	Similarly, for flanking elements F and f at Junction 2 & 4,					
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1			0.045	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1			0.042	(at 500 Hz)	

Illustration for this case



Junction of 190 mm concrete block separating wall with floor and ceiling of 203 mm hollowcore precast concrete panels. (Side view of Junctions 1 and 3)



Junction of separating wall with side wall, both of 190 mm concrete blocks. (Plan view of Junction 2 or 4)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (190 mm concrete block)									
Sound Transmission Loss (TL)	R_D,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_D	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.268	0.176	0.112	0.069	0.041	0.024	
Leakage or Airborne Flanking		Sealed & Blocked	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 19, 24	**35**	**38**	**44**	**50**	**58**	**62**	**49**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (Rigid cross-junction, 190 mm block wall / 203 mm HC precast concrete floor)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-333, CON203(HC)	38	46	52	60	65	72	56
Structural Reverberation Time	T_s,lab	Measured T_s	0.458	0.328	0.200	0.168	0.109	0.061	
Change by Lining on source side	ΔR_F1	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f1	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.321	0.221	0.148	0.097	0.062	0.039	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	39.5	47.7	53.3	62.4	67.4	74.0	58
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	39.5	47.7	53.3	62.4	67.4	74.0	58
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	9.6	9.7	10.0	10.3	10.7	11.3	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	11.7	11.9	12.3	12.7	13.3	14.0	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	11.7	11.9	12.3	12.7	13.3	14.0	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**47**	**55**	**61**	**71**	**76**	**83**	**65**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**48**	**54**	**60**	**68**	**75**	**81**	**65**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**48**	**54**	**60**	**68**	**75**	**81**	**65**
Junction 1: Flanking STC for all paths		- 10*LOG10(10^-6.5 + 10^- 6.5 + 10^- 6.5) =							60
Junction 2 (Rigid T-Junction, 190 mm block separating wall / 190 mm block flanking wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f2	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.228	0.152	0.098	0.061	0.037	0.022	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36.2	39.0	44.9	50.7	58.5	62.4	50
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36.2	39.0	44.9	50.7	58.5	62.4	50
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	10.7	11.0	11.4	11.9	12.6	13.4	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	10.8	11.1	11.6	12.1	12.8	13.7	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	10.8	11.1	11.6	12.1	12.8	13.7	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**48**	**51**	**57**	**64**	**72**	**77**	**62**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**47**	**50**	**56**	**63**	**72**	**76**	**61**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**47**	**50**	**56**	**63**	**72**	**76**	**61**
Junction 2: Flanking STC for all paths		- 10*LOG10(10^-6.2 + 10^- 6.1 + 10^- 6.1) =							57
Junction 3 (Rigid cross-junction, 190 mm block wall / 203 mm HC precast concrete ceiling)									
All input values the same as for Junction 1									
Junction 3: Flanking STC for all paths									60
Junction 4 (Rigid T-junction, 190 mm block separating wall / 190 mm block flanking wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change loss factors from Junction 2									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.249	0.165	0.105	0.065	0.039	0.022	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	35.8	38.6	44.5	50.4	58.3	62.2	49
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	35.8	38.6	44.5	50.4	58.3	62.2	49
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	10.3	10.6	11.0	11.6	12.3	13.2	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	10.6	11.0	11.4	12.0	12.7	13.6	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	10.6	11.0	11.4	12.0	12.7	13.6	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**47**	**50**	**57**	**63**	**72**	**76**	**61**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**47**	**50**	**56**	**63**	**71**	**76**	**61**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**47**	**50**	**56**	**63**	**71**	**76**	**61**
Junction 4: Flanking STC for all paths		- 10*LOG10(10^-6.1 + 10^- 6.1 + 10^- 6.1) =							56
Total Flanking (for all 4 junctions)									52
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**33**	**36**	**42**	**49**	**57**	**61**	**47**

EXAMPLE 2.1.6: DETAILED METHOD

- **Rooms one-above-the-other**
- **Floor of hollowcore precast concrete panels[2] with walls of normal weight concrete block walls with rigid junctions**

Separating floor/ceiling assembly with:

- Floor assembly of hollowcore precast concrete panels[2] of cross-section 203 mm thick and 2440 mm wide, fully grouted at joints between adjacent panels, with mass per area of 344 kg/m^2
- No topping / flooring on top, or ceiling lining below

Junction 1, 3, 4: Cross-junction of separating floor / flanking wall with:

- Rigid mortared cross-junction with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2, with no lining

Junction 2: T-Junction of separating floor / flanking wall with:

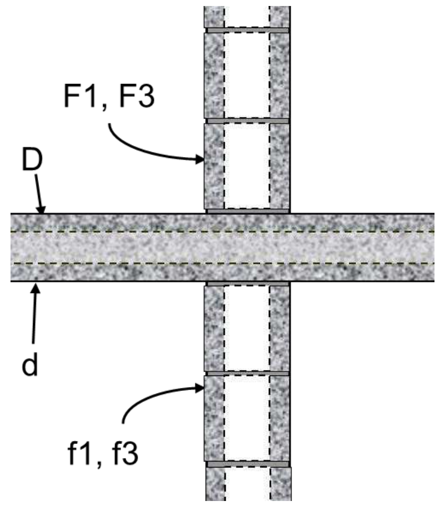
- Rigid mortared T-junctions with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2, with no lining

NOTE: Sound transmission would be essentially unchanged with the hollowcore floor slabs oriented perpendicular to the case illustrated.

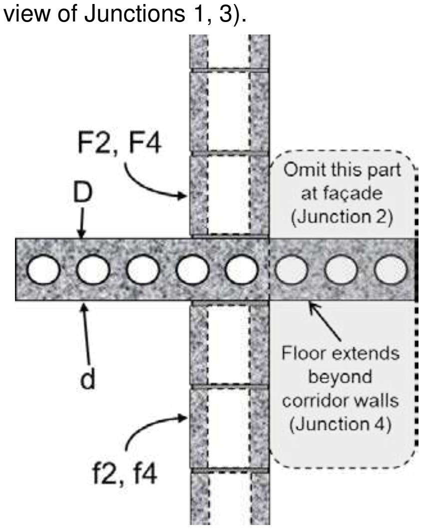
Acoustical Parameters:

For separating assembly:						
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	344		f_c =	91		(Eq. C.2)
	Reference	K_Ff	K_Dd'	K_Fd	K_Df	Σ l_k . α_k
X-Junction 1, 3, 4	ISO 15712-1, Eq. E.3	11.6	6.1	8.8	8.8	0.783
T-Junction 2	ISO 15712-1, Eq. E.4	8.1		5.8	5.8	0.657
Total loss, η_{tot}	ISO 15712-1, Eq. C.1			0.030	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 1 & 3,						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_{tot}	ISO 15712-1, Eq. C.1			0.039	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 2 & 4,						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, $\eta_{tot,2}$	ISO 15712-1, Eq. C.1			0.045	(at 500 Hz)	
Total loss, $\eta_{tot,4}$	ISO 15712-1, Eq. C.1			0.042	(at 500 Hz)	

Illustration for this case



Cross-junction of separating floor assembly of hollowcore precast concrete panels 203 mm thick with 190 mm concrete block flanking wall. (Side view of Junctions 1, 3).



T-Junction of separating floor of hollowcore precast concrete panels 203 mm thick with 190 mm concrete block wall. (Side view of Junction 2 or 4)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (203 mm HC precast concrete floor)									
Sound Transmission Loss (TL)	R_D,lab	RR-333, CON203(HC)	38	46	52	60	65	72	56
Structural Reverberation Time	T_s,lab	Measured T_s	0.46	0.33	0.20	0.17	0.11	0.06	
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	No lining ,	0	0	0	0	0	0	
Transferred Data In-situ									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.320	0.220	0.148	0.097	0.062	0.039	
Effect of Airborne Flanking		No leakage	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**40**	**48**	**53**	**62**	**67**	**74**	**58**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (Rigid cross-junction, 203 mm HC precast concrete floor / 190 mm block wall)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F1	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f1	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.268	0.176	0.112	0.069	0.041	0.024	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	35.5	38.3	44.3	50.2	58.1	62.1	49
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	35.5	38.3	44.3	50.2	58.1	62.1	49
<u>Junction J1 - Coupling</u>									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	13.9	14.2	14.6	15.2	16.0	16.9	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	11.7	11.9	12.3	12.7	13.3	14.0	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	11.7	11.9	12.3	12.7	13.3	14.0	
<u>Flanking Transmission Loss - Path data</u>									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**51**	**55**	**61**	**67**	**76**	**81**	**66**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**50**	**56**	**62**	**70**	**77**	**83**	**67**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**50**	**56**	**62**	**70**	**77**	**83**	**67**
Junction 1: Flanking STC for all paths		- 10*LOG10(10^-6.6 + 10^- 6.7 + 10^- 6.7) =							62
Junction 2 (Rigid T-junction, 203 mm HC precast concrete floor / 190 mm block wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f2	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.227	0.151	0.097	0.061	0.037	0.022	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36.2	39.0	44.9	50.7	58.6	62.4	50
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36.2	39.0	44.9	50.7	58.6	62.4	50
<u>Junction J2 - Coupling</u>									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	11.1	11.4	11.7	12.3	13.0	13.8	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	9.5	9.7	10.0	10.5	11.0	11.7	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	9.5	9.7	10.0	10.5	11.0	11.7	
<u>Flanking Transmission Loss - Path data</u>									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**50**	**53**	**60**	**66**	**75**	**79**	**64**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**49**	**55**	**60**	**68**	**75**	**81**	**65**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**49**	**55**	**60**	**68**	**75**	**81**	**65**
Junction 2: Flanking STC for all paths		- 10*LOG10(10^-6.4 + 10^- 6.5 + 10^- 6.5) =							60
Junction 3 (Rigid cross-junction, 203 mm HC precast concrete floor / 190 mm block wall)									
All input values the same as for Junction 1									
Junction 3: Flanking STC for all paths									62
Junction 4 (Rigid T-junction, 203 mm HC precast concrete floor / 190 mm block wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change loss factors and junction attenuation from Junction 2									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.248	0.164	0.105	0.065	0.039	0.022	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	35.8	38.7	44.5	50.4	58.3	62.2	50
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	35.8	38.7	44.5	50.4	58.3	62.2	50
<u>Junction J4 - Coupling</u>									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	14.2	14.5	14.9	15.5	16.2	17.1	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	12.3	12.6	12.9	13.3	13.9	14.6	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	12.3	12.6	12.9	13.3	13.9	14.6	
<u>Flanking Transmission Loss - Path data</u>									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**53**	**56**	**62**	**69**	**78**	**82**	**67**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**52**	**57**	**63**	**71**	**78**	**84**	**68**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**52**	**57**	**63**	**71**	**78**	**84**	**68**
Junction 4: Flanking STC for all paths		- 10*LOG10(10^-6.7 + 10^- 6.8 + 10^- 6.8) =							63
Total Flanking (for all 4 junctions)									55
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**37**	**43**	**49**	**56**	**63**	**69**	**53**

Summary for Section 2.1: Calculation Examples for Constructions of Concrete and Concrete Masonry with Rigid Junctions

The worked examples 2.1.1 to 2.1.6 illustrate the basic process for calculating sound transmission between rooms in a building with bare concrete or concrete masonry walls and cast-in-place concrete floor assemblies with rigid junctions.

Here, "bare" means the assembly of concrete or masonry without a lining such as an added gypsum board finish on the walls or ceiling, or flooring over the concrete slab. Note that for a concrete block wall constructed using normal weight units, tests have shown that its surface could be painted or sealed, or have a thin coat of plaster with no effect on the sound transmission. "Rigid Junctions" implies that the assemblies meeting at the junction are firmly bonded so bending vibration is effectively transmitted between the elements. Loadbearing junctions are always rigid; non-loadbearing junctions may or may not be rigid.

The absence of finishing surface linings is not typical for occupied residential buildings in North America, but considering the "bare" case gives a clear presentation of the basic structure-borne transmission for a building with these structural subsystems. The effect of adding linings (such as gypsum board wall, ceiling finishes, or flooring) is presented in Section 2.3.

Overview of the Calculation Details:

There are recurrent patterns in the presented examples. The calculation process is in sections, dealing first with the separating wall or floor assembly, then with each of the junctions at the four edges of the separating assembly, In each section:

- In each section the first few lines present input data (shaded beige), followed by the in-situ structural reverberation time for the pertinent separating or flanking surface, which is calculated using the procedures of Annex C in ISO 15712-1.
- For all the floor and wall assemblies in these examples, the structural reverberation time in-situ is shorter than that for the laboratory specimen, due to the higher edge losses when an assembly is attached to all adjacent assemblies in the building scenario.
- The in-situ sound transmission loss (TL) for the wall and floor assemblies (calculated from the laboratory TL and the ratio of structural reverberation times) is consistently higher than the laboratory TL, due to the greater losses in-situ.
- The coupling for each path (Ff, Fd, and Df) across the junctions (velocity level difference) is calculated from the K_{ij} values for each path, with corrections for losses and dimensions of the coupled assemblies, and is consistently higher than the corresponding K_{ij}.
- Finally, the flanking sound transmission loss for each path is calculated from the preceding values, followed by a summary value for the Flanking STC for the junction.

At the end of each example, the apparent sound transmission loss is calculated from the combined transmission via the direct and 12 flanking paths, and then used to determine ASTC.

General Trends in the STC and ASTC Results:

For both the cases with side-by-side rooms (Examples 2.1.1, 2.1.3, and 2.1.5) and the rooms one-above-the-other (Example 2.1.2, 2.1.4, and 2.1.6) the ASTC tends to be slightly lower than the STC measured for the separating assembly. For the wall and floor assemblies in the examples, the differences between STC and ASTC values for the horizontal room pairs are 2, 0, and 2 points, and for the vertical room pairs, the differences are 1, 3, and 3 points. Different mass ratios of the building elements and different laboratory structural decay times could alter the specific differences, but the trend is clear.

What matters is that the ASTC values tend to be lower than the corresponding STC values and that the total Flanking Transmission Loss (due to the combination of 12 flanking paths) is quite similar to the Direct Transmission Loss through the separating wall. However, as shown in Section 2.3, the balance among the various paths can be significantly altered by lining the floor, ceiling, or wall surfaces.

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2.2. Non-Rigid Junctions in Concrete and Concrete Masonry Buildings

This section presents worked examples for adjacent rooms in a building which has structural floor slabs of bare cast-in-place concrete and walls of bare concrete or masonry, but includes some non-rigid junctions. Here, as before, "bare" is taken to mean the assembly of concrete or masonry without a lining such as an added gypsum board finish on the walls or ceiling, or flooring over the cast-in-place concrete floor assembly. The effect of adding a lining is discussed in detail in Section 2.3.

The calculations follow the steps of the ISO 15712-1 detailed calculation procedure, as described at the beginning of Chapter 2, with adaptations to deal with non-rigid joints. Two cases are relevant:

1. Non-loadbearing normal weight concrete block walls can be evaluated by a minor adaptation of the procedure presented in the examples of Section 2.1. Such walls would normally have sealant or a fire stop installed between the top of the masonry wall assembly and the bottom of the cast-in-place concrete floor above, as shown in the detail drawings in Examples 2.2.1 and 2.2.2. A common type of fire stop would comprise compressible rock fiber faced with pliable sealant. Such fire stops would transmit negligible vibration between the top of the wall and the floor above so they do not fit the context for Eq. E.5, but such junctions can readily be treated in the calculation by altering the calculated vibration reduction index for the affected junctions (assuming no connections through the fire stop) and making corresponding changes to the in-situ losses for the adjacent surfaces. As discussed in the summary at the end of this Section, switching from rigid junctions to non-loadbearing junctions only slightly alters the overall calculated ASTC.
2. Wall/wall junctions with flexible interlayers are considered in ISO 15712-1. The vibration reduction index for these can be calculated using Equation E.5. The calculation is like that for rigid junctions except that different expressions are used for junction attenuation which depends on the characteristics of the interlayer. No example was included here for such cases, for which one needs specific data on the material properties of the flexible interlayer.

EXAMPLE 2.2.1: DETAILED METHOD

- **Rooms side-by-side**
- **Cast-in-place concrete floors walls with non-rigid junctions at top of non-loadbearing concrete block separating wall**
- **(Same as 2.1.1 except non-rigid junction at top of walls)**

Separating wall assembly (non-loadbearing) with:
- One wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2, with no lining

Junction 1: Bottom Junction (separating wall / floor) with:
- Cast-in-place concrete floor with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping or flooring
- Rigid mortared T- junction with concrete block wall assembly above, with negligible connection through fire stop to wall below

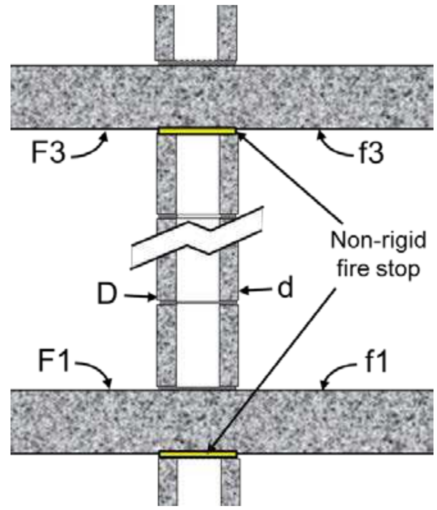
Junction 2 or 4: Each Side (separating wall / abutting side wall) with:
- Abutting side wall and separating wall of hollow concrete block masonry[1] with mass per area of 238 kg/m^2, with no lining
- Rigid mortared T-junctions

Junction 3: Top Junction (separating wall / ceiling) with:
- Cast-in-place concrete ceiling with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no added ceiling lining
- Non-loadbearing junction between concrete ceiling assembly and top of concrete block wall, (with fire stop of flexible materials such as rock fiber and sealant that transmit negligible vibration).

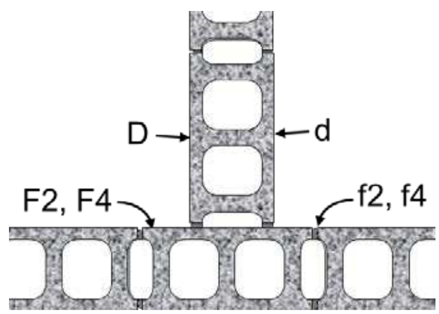
Acoustical Parameters:

For separating assembly:						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		(Eq. C.2)
	Reference	K_Ff	K_Dd'	K_Fd	K_Df	Σ l_k . α_k
T-Junction 1	ISO 15712-1, Eq. E.4	3.6		5.8	5.8	0.925
T-Junction 2 or 4	ISO 15712-1, Eq. E.4	5.70		5.7	5.7	0.420
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.038	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 1 & 3,						
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.032	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 2 & 4,						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1			0.047	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1			0.043	(at 500 Hz)	

Illustration for this case



Junction of 190 mm non-loadbearing concrete block separating wall with 150 mm thick cast-in-place concrete floor and ceiling.
(Side view of Junctions 1 and 3)



Junction of separating wall with side wall, both of 190 mm concrete block. (Plan view of Junctions 2 or 4)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (190 mm concrete block)									
Sound Transmission Loss (TL)	R_D,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	Estimate ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_D	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.278	0.182	0.115	0.071	0.042	0.024	
Leakage or Airborne Flanking		Sealed & Blocked	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**35**	**38**	**44**	**50**	**58**	**62**	**49**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (NON-rigid cross-junction, 190 mm block wall / 150 mm concrete floor)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.439	0.369	0.250	0.205	0.146	0.077	
Change by Lining on source side	ΔR_F1	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f1	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.293	0.202	0.136	0.090	0.058	0.036	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	41.8	44.6	52.6	61.6	70.0	78.3	56
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	41.8	44.6	52.6	61.6	70.0	78.3	56
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	7.5	7.6	7.8	8.1	8.5	9.1	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	8.8	9.0	9.4	9.8	10.4	11.1	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	8.8	9.0	9.4	9.8	10.4	11.1	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**47**	**50**	**58**	**68**	**76**	**85**	**61**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**46**	**49**	**57**	**65**	**73**	**80**	**61**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**46**	**49**	**57**	**65**	**73**	**80**	**61**
Junction 1: Flanking STC for all paths		- 10*LOG10(10^-6.1 + 10^- 6.1 + 10^- 6.1) =							56
Junction 2 (Rigid T-Junction, 190 mm block separating wall / 190 mm block flanking wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	Estimate ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f2	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.219	0.146	0.094	0.059	0.036	0.021	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.8	58.7	62.5	50
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.8	58.7	62.5	50
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	10.9	11.1	11.5	12.0	12.7	13.5	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	10.9	11.1	11.6	12.1	12.9	13.7	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	10.9	11.1	11.6	12.1	12.9	13.7	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**48**	**51**	**58**	**64**	**72**	**77**	**62**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**47**	**50**	**57**	**63**	**72**	**76**	**61**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**47**	**50**	**57**	**63**	**72**	**76**	**61**
Junction 2: Flanking STC for all paths		- 10*LOG10(10^-6.2 + 10^- 6.1 + 10^- 6.1) =							57
Junction 3 (NON-rigid cross-junction, 190 mm block wall / 150 mm concrete floor)									
Input data like Junction 1 except wall/floor connections									
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25a	**50**	**53**	**61**	**71**	**79**	**88**	**64**
Flanking TL for Path Fd_3	R_Fd	Negligible connection	**90**	**90**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_3	R_Df	Negligible connection	**90**	**90**	**90**	**90**	**90**	**90**	**90**
Junction 3: Flanking STC for all paths		- 10*LOG10(10^-6.4 + 10^- 9 + 10^- 9) =							64
Junction 4 (Rigid T-junction, 190 mm block separating wall / 190 mm block flanking wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change in-situ loss factors vs. Junction 2 case									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.238	0.158	0.102	0.063	0.038	0.021	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	10.5	10.8	11.2	11.8	12.5	13.3	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	10.7	11.0	11.4	12.0	12.7	13.6	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	10.7	11.0	11.4	12.0	12.7	13.6	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**47**	**51**	**57**	**63**	**72**	**77**	**62**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**47**	**50**	**56**	**63**	**71**	**76**	**61**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**47**	**50**	**56**	**63**	**71**	**76**	**61**
Junction 4: Flanking STC for all paths		- 10*LOG10(10^-6.2 + 10^- 6.1 + 10^- 6.1) =							57
Total Flanking (for all 4 junctions)									51
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**33**	**36**	**42**	**49**	**57**	**61**	**47**

EXAMPLE 2.2.2: DETAILED METHOD

- **Rooms one-above-the-other**
- **Concrete floor and normal weight concrete block walls (like Example 2.1.2 except two rigid wall/ceiling junctions replaced by non-rigid (non-loadbearing) junctions**

Separating floor/ceiling assembly with:

- Cast-in-place concrete floor with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping / flooring on top surface, or ceiling lining below

Junction 1 and 3: Separating floor with non-loadbearing flanking walls:

- Rigid mortared cross-junction to concrete floor slab at bottom of concrete block wall assemblies
- Non-loadbearing junction (fire stop system of non-rigid materials that transmit negligible vibration) between top of wall and underside of concrete slab above
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2, with no lining

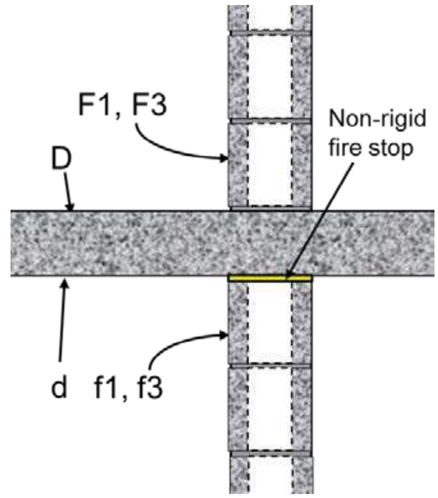
Junction 2 or 4: Rigid Junction of separating floor / flanking wall with:

- Rigid mortared junctions with concrete block wall assemblies (T- and cross-junctions at Junctions 2 and 4, respectively)
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2, with no lining

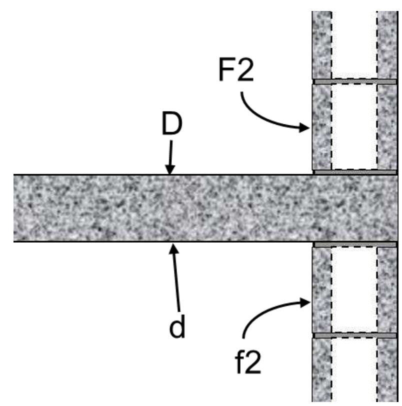
Acoustical Parameters:

For separating assembly:						
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		
	Reference	K_Ff	K_Dd'	K_Fd	K_Df	Σ l_k . α_k
T-Junction 1 or 3	ISO 15712-1, Eq. E.4		3.6	5.8		1.178
T-Junction 2	ISO 15712-1, Eq. E.4	8.1		5.8	5.8	0.657
X-Junction 4	ISO 15712-1, Eq. E.3	11.6	6.1	8.8	8.8	0.674
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.032		(Eq. C.2)
				(at 500 Hz)		
Similarly, for flanking elements F and f at Junction 1 & 3,						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.038	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 2 & 4,						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1			0.047	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1			0.043	(at 500 Hz)	

Illustration for this case



Junction of separating floor of 150 mm thick concrete with non-loadbearing 190 mm concrete block wall.
(Side view of Junctions 1 and 3)



T-Junction of separating floor of 150 mm thick concrete with 190 mm concrete block wall.
(Side view of Junction 2. Junction 4 has same details, but cross-junction)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (150 mm concrete floor)									
Sound Transmission Loss (TL)	R_D,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.44	0.37	0.25	0.21	0.15	0.08	
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.293	0.202	0.136	0.090	0.058	0.036	
Effect of Airborne Flanking		No leakage	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**42**	**45**	**53**	**62**	**70**	**78**	**56**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (NON-rigid cross-junction, 150 mm concrete floor / 190 mm block wall)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-334, Mean TL-BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F1	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f1	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.278	0.182	0.115	0.071	0.042	0.024	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	35.3	38.2	44.1	50.1	58.0	62.0	49
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	35.3	38.2	44.1	50.1	58.0	62.0	49
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	Negligible connection							
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	8.8	9.0	9.4	9.8	10.4	11.1	
Velocity Level Difference for Df	D_v,Df_1,situ	Negligible connection							
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	Negligible connection	**90**	**90**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**49**	**52**	**59**	**67**	**75**	**82**	**63**
Flanking TL for Path Df_1	R_Df	Negligible connection	**90**	**90**	**90**	**90**	**90**	**90**	**90**
Junction 1: Flanking STC for all paths			- 10*LOG10(10^-9 + 10^- 6.3 + 10^- 9) =						63
Junction 2 (Rigid T-Junction, 150 mm concrete separating floor / 190 mm block wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, Mean TL-BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f2	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.218	0.145	0.094	0.059	0.036	0.021	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.9	58.7	62.5	50
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.9	58.7	62.5	50
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	11.3	11.5	11.9	12.4	13.1	13.9	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	9.8	10.0	10.3	10.7	11.2	11.9	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	9.8	10.0	10.3	10.7	11.2	11.9	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**51**	**54**	**60**	**66**	**75**	**79**	**65**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**51**	**54**	**61**	**69**	**77**	**84**	**65**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**51**	**54**	**61**	**69**	**77**	**84**	**65**
Junction 2: Flanking STC for all paths			- 10*LOG10(10^-6.5 + 10^- 6.5 + 10^- 6.5) =						60
Junction 3 (NON-rigid cross-junction, 150 mm concrete floor / 190 mm block wall)									
All values the same as for Junction 1									
Flanking TL for Path Ff_3	R_Ff	Negligible connection	**90**	**90**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**49**	**52**	**59**	**67**	**75**	**82**	**63**
Flanking TL for Path Df_3	R_Df	Negligible connection	**90**	**90**	**90**	**90**	**90**	**90**	**90**
Junction 3: Flanking STC for all paths			- 10*LOG10(10^-9 + 10^- 6.3 + 10^- 9) =						63
Junction 4 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change loss factors from Junction 2									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.237	0.157	0.101	0.063	0.038	0.021	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	14.4	14.7	15.1	15.6	16.3	17.2	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	12.6	12.8	13.1	13.6	14.1	14.8	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	12.6	12.8	13.1	13.6	14.1	14.8	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**53**	**57**	**63**	**69**	**78**	**83**	**68**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**53**	**56**	**64**	**71**	**80**	**86**	**67**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**53**	**56**	**64**	**71**	**80**	**86**	**67**
Junction 4: Flanking STC for all paths			- 10*LOG10(10^-6.8 + 10^- 6.7 + 10^- 6.7) =						63
Total Flanking (for all 4 junctions)									56
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**39**	**42**	**49**	**57**	**66**	**72**	**53**

Summary for Section 2.2: Calculation Examples for Concrete and Concrete Masonry Constructions with Non-Rigid Junctions

The worked examples 2.2.1 and 2.2.2 illustrate the process for calculating sound transmission between rooms in a building with bare cast-in-place concrete floor/ceilings and concrete masonry wall assemblies where there is a non-rigid (non-loadbearing) junction between the top of the masonry wall and the cast-in-place concrete floor above (due to the presence of a soft firestop material).

For both the side-by-side room pair (Example 2.2.1) and the rooms one-above-the-other (Example 2.2.2) the ASTC is equal or lower than the STC of the separating assembly. For the specific wall and floor assemblies in the examples, the difference is 2 points for the horizontal pair and 0 points for the vertical pair. Different mass ratios of the building elements would alter the specific differences. The basic issue is that ASTC values tend to be lower than the corresponding STC value, and that the total Flanking Transmission Loss (due to the combination of 12 flanking paths) is of similar importance to the Direct Transmission Loss through the separating wall.

Examination of the individual flanking paths in the examples of Section 2.1 and 2.2 shows that some junctions transmit less vibration energy when a non-rigid junction is used, because the soft junction blocks some transmission paths. But this has only a small effect on the ASTC of the complete system because the paths via the remaining rigid connections transmit more vibration energy. Overall, the ASTC for these examples remains the same compared with the rigid case for side-by-side rooms, and increases by 1 point where one room is above the other.

Overall, the key conclusion is that introducing non-loadbearing masonry walls has only a small effect on the overall ASTC between adjacent rooms, and can readily be offset by the choice of suitable linings as shown in the following Section.

2.3. Adding "Linings" to Walls, Floors, and Ceilings in Concrete/Masonry Buildings

The practicality of the calculation framework of ISO 15712-1 comes from the straightforward extension to deal with the incremental effect of "linings" added to the bare structural elements. Here, as before, "bare" is taken to mean the assembly of concrete or masonry without a lining such as an added gypsum board finish on the walls or ceiling, or flooring over the cast-in-place concrete slab. The "bare" surface could be painted or sealed, or have a thin coat of plaster.

It is common practice, especially in residential buildings, to add finish surfaces to the basic structural wall and floor assemblies – for example, various flooring products, and gypsum board wall or ceiling surfaces that conceal both the bare concrete surfaces and building services such as electrical wiring, water pipes and ventilation ducts. These are described in ISO 15712-1 as "linings" or "liners" or "layers". The first term, "linings" is used in this Guide.

__Wall or ceiling linings__ typically include lightweight framing supporting the gypsum board surface layer and often include sound absorptive material[3] in the cavities between the bare assembly and the gypsum board.

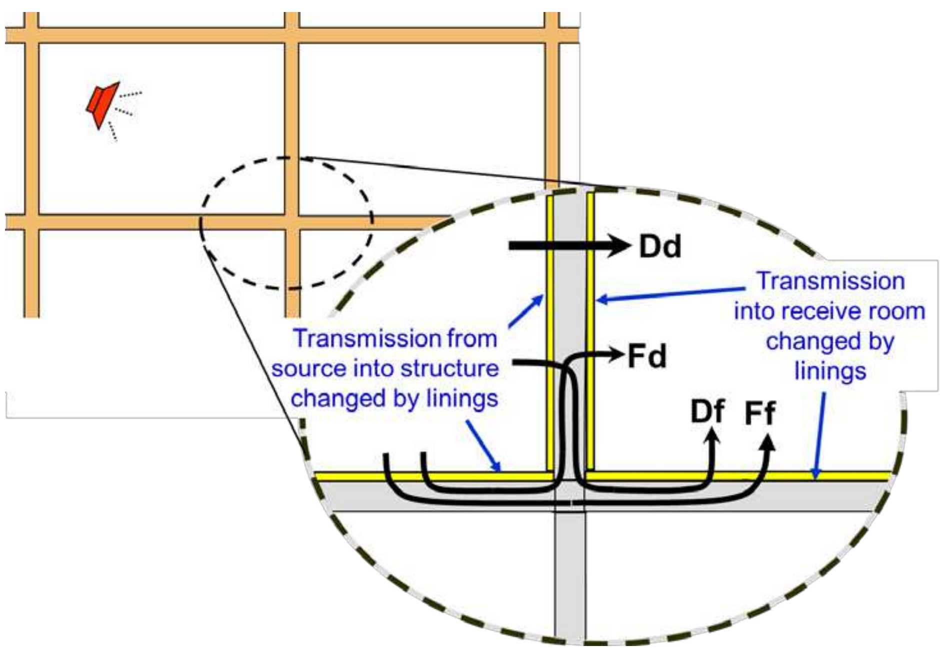


Figure 2.3: Transmission combines direct path through separating wall (Dd) and structure-borne flanking via paths Df, Fd, and Ff at each of the four edges of the separating assembly. Transmission via these paths is altered by addition of linings in the source room and/or receiving room.

Adding a lining can significantly improve the sound attenuation by changing the flow of sound power from the reverberant sound field in the source room to the resonant vibration in the structural assembly. It is assumed that adding the linings does not alter power flow between the heavy structural assemblies. As shown conceptually in Figure 2.3, the practical calculation combines the basic flow of structure-borne power via the coupled structural elements, with simple additive changes due to the linings. This approach works very well for common monolithic supporting structures of cast-in-place concrete or masonry that are much heavier than the linings.

Input Data for the Improvement due to Linings

A standard process for evaluating linings is given in ISO 10140-1; its ASTM counterpart uses ASTM E90 to measure the change between the TL for a bare concrete or masonry assembly and the TL for the same assembly with the lining added. The improvement depends slightly on mass and porosity of the bare assembly. Theoretically, this change in TL should be corrected to remove the non-resonant part of the transmission for flanking paths, but as noted in ISO 15712-1, the laboratory result gives a good (slightly conservative) estimate. Uncorrected ASTM E90 test data for linings are used in this Guide.

Note that the lining may be installed on either the source or the receiving side of the base assembly for the ASTM E90 test, and the result may be used for a lining added on either side of a matching assembly.

Including Linings in the Calculation Process

Adding the changes in sound transmission due to linings requires only minor extensions from the eight steps described at the beginning of Chapter 2:

At Step 4: to calculate direct sound transmission loss in-situ through the separating assembly, add the laboratory data for TL change due to an added lining on the source side and the laboratory data for TL change due to an added lining on the receiving side using Eq. 24 of ISO 15712-1. The changes are identified in Eq. 24 as $\Delta R_{D,situ}$ and $\Delta R_{d,situ}$ respectively.

At Step 8: to calculate flanking sound transmission via each flanking path, add the laboratory data for TL change due to an added lining on the assembly in the source room and the laboratory data for TL change due to an added lining on the assembly in the receiving room, using Eq. 24 of ISO 15712-1. The changes are identified in the equation as $\Delta R_{i,situ}$ and $\Delta R_{j,situ}$ respectively.

Other than these two additions, the process remains unchanged from that described in Section 2.1.

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EXAMPLE 2.3.1: DETAILED METHOD

- **Rooms side-by-side**
- **Cast-in-place concrete floors and normal weight concrete block walls with rigid junctions**
- **Same structure as Example 2.1.1, plus lining of walls**

Separating wall assembly (loadbearing) with:
- One wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Both sides lined with 13 mm gypsum board[4] supported on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c., with no absorptive material[3] filling stud cavities

Junction 1: Bottom Junction (separating wall / floor) with:
- Cast-in-place concrete floor with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping or flooring
- Rigid mortared cross-junction with concrete block wall assembly

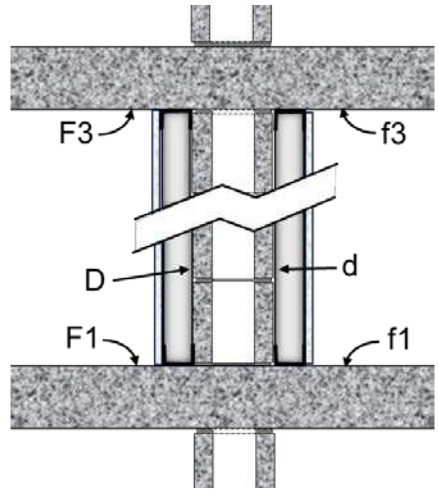
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- Abutting side wall and separating wall of hollow concrete block masonry[1] with mass per area of 238 kg/m^2, with rigid mortared T-junctions
- Flanking walls lined with 13 mm gypsum board[4] supported on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c. with no absorptive material[3] filling stud cavities

Junction 3: Top Junction (separating wall / ceiling) with:
- Cast-in-place concrete ceiling with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no added ceiling lining
- Rigid mortared cross-junction with concrete block wall assembly

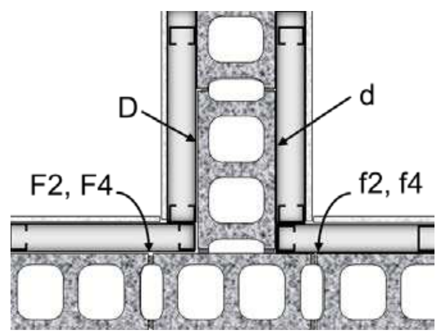
Acoustical Parameters:

	Reference	K_Ff	K_Dd'	K_Fd	K_Df	Σ l_k . α_k
For separating assembly:						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		(Eq. C.2)
X-Junction 1 or 3	ISO 15712-1, Eq. E.3	6.1	11.6	8.8	8.8	0.571
T-Junction 2 or	ISO 15712-1, Eq. E.4	5.7		5.7	5.7	0.420
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.041	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 1 & 3,						
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.028	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 2 & 4,						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1			0.047	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1			0.043	(at 500 Hz)	

Illustration for this case



Junction of 190 mm concrete block separating wall (with gypsum board lining) with 150 mm thick cast-in-place concrete floor and ceiling.
(Side view of Junctions 1 and 3)



Junction of separating wall with flanking side wall, both of 190 mm concrete block with gypsum board linings.
(Plan view of Junction 2 or 4)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (190 mm concrete block)									
Sound Transmission Loss (TL)	R_D,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_D	RR-334 , ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Change by Lining on receive side	ΔR_d	RR-334 , ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.256	0.169	0.108	0.067	0.040	0.023	
Leakage or Airborne Flanking		Sealed & Blocked	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**28**	**55**	**72**	**80**	**84**	**90**	**52**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (Rigid cross-junction, 190 mm block separating wall / 150 mm concrete floor)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.439	0.369	0.250	0.205	0.146	0.077	
Change by Lining on source side	ΔR_F1	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f1	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.347	0.238	0.159	0.104	0.066	0.041	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	41.0	43.9	52.0	60.9	69.4	77.8	55
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	41.0	43.9	52.0	60.9	69.4	77.8	55
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	9.3	9.4	9.7	10.0	10.5	11.1	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.8	12.2	12.6	13.2	14.0	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.8	12.2	12.6	13.2	14.0	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**48**	**51**	**60**	**69**	**78**	**87**	**62**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**45**	**60**	**73**	**82**	**89**	**90**	**69**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**45**	**60**	**73**	**82**	**89**	**90**	**69**
Junction 1: Flanking STC for all paths		- 10*LOG10(10^-6.2 + 10^- 6.9 + 10^- 6.9) =							61
Junction 2 (Rigid T-Junction, 190 mm block separating wall / 190 mm block flanking wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	RR-334 , ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Change by Lining on receive side	ΔR_f2	RR-334 , ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.219	0.146	0.094	0.059	0.036	0.021	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.8	58.7	62.5	50
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.8	58.7	62.5	50
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	10.9	11.1	11.5	12.0	12.7	13.5	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	11.0	11.3	11.7	12.3	13.0	13.8	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	11.0	11.3	11.7	12.3	13.0	13.8	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**40**	**67**	**86**	**90**	**90**	**90**	**64**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**40**	**67**	**85**	**90**	**90**	**90**	**64**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**40**	**67**	**85**	**90**	**90**	**90**	**64**
Junction 2: Flanking STC for all paths		- 10*LOG10(10^-6.4 + 10^- 6.4 + 10^- 6.4) =							59
Junction 3 (Rigid cross-junction, 190 mm block separating wall / 150 mm concrete ceiling)									
All values the same as for Junction 1									
Junction 3: Flanking STC for all paths									61
Junction 4 (Rigid T-junction, 190 mm block separating wall / 190 mm block flanking wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change loss factors from Junction 2									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.238	0.158	0.102	0.063	0.038	0.021	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	10.5	10.8	11.2	11.8	12.5	13.3	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	10.8	11.1	11.6	12.1	12.9	13.7	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	10.8	11.1	11.6	12.1	12.9	13.7	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**39**	**67**	**85**	**90**	**90**	**90**	**63**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**39**	**67**	**84**	**90**	**90**	**90**	**63**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**39**	**67**	**84**	**90**	**90**	**90**	**63**
Junction 4: Flanking STC for all paths		- 10*LOG10(10^-6.3 + 10^- 6.3 + 10^- 6.3) =							58
Total Flanking (for all 4 junctions)									55
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**26**	**46**	**56**	**65**	**73**	**78**	**50**

EXAMPLE 2.3.2: DETAILED METHOD

- **Rooms side-by-side**
- **Cast-in-place concrete floors and normal weight concrete block walls with rigid junctions**
- **Same structure as Example 2.1.1, enhanced lining of walls**

Separating wall assembly (loadbearing) with:
- One wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Separating wall lined both sides with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c., with absorptive material[3] filling stud cavities

Junction 1: Bottom Junction (separating wall / floor) with:
- Cast-in-place concrete floor with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping or flooring
- Rigid mortared cross-junction with concrete block wall assembly

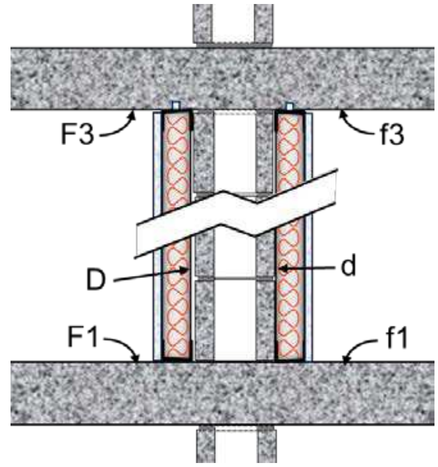
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- Rigid mortared T-junctions of abutting side wall and separating wall of hollow concrete block masonry[1] with mass per area of 238 kg/m^2
- Flanking walls lined with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c., with absorptive material[3] filling stud cavities

Junction 3: Top Junction (separating wall / ceiling) with:
- Cast-in-place concrete ceiling with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no added ceiling lining
- Rigid mortared cross-junction with concrete block wall assembly.

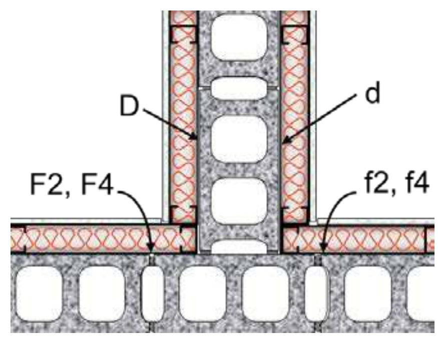
Acoustical Parameters:

	For separating assembly:					
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		(Eq. C.2)
	Reference	K_Ff	K_Dd'	K_Fd	K_Df	Σ l_k . α_k
X-Junction 1 or 3	ISO 15712-1, Eq. E.3	6.1	11.6	8.8	8.8	0.571
T-Junction 2 or	ISO 15712-1, Eq. E.4	5.7		5.7	5.7	0.420
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.041	(at 500 Hz)	
	Similarly, for flanking elements F and f at Junction 1 & 3,					
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.028	(at 500 Hz)	
	Similarly, for flanking elements F and f at Junction 2 & 4,					
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1			0.047	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1			0.043	(at 500 Hz)	

Illustration for this case



Junction of 190 mm concrete block separating wall (with enhanced gypsum board lining) with 150 mm thick cast-in-place concrete floor and ceiling.
(Side view of Junctions 1 and 3)



Junction of separating wall with flanking side wall, both of 190 mm concrete block with enhanced gypsum board linings.
(Plan view of Junction 2 or 4)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (190 mm concrete block)									
Sound Transmission Loss (TL)	R_D,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_D	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB6	11	19	21	18	17	21	
Change by Lining on receive side	ΔR_d	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB6	11	19	21	18	17	21	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.256	0.169	0.108	0.067	0.040	0.023	
Leakage or Airborne Flanking		Sealed & Blocked	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**58**	**77**	**86**	**86**	**90**	**90**	**82**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (Rigid cross-junction, 190 mm block separating wall / 150 mm concrete floor)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.439	0.369	0.250	0.205	0.146	0.077	
Change by Lining on source side	ΔR_F1	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f1	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.347	0.238	0.159	0.104	0.066	0.041	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	41.0	43.9	52.0	60.9	69.4	77.8	55
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	41.0	43.9	52.0	60.9	69.4	77.8	55
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	9.3	9.4	9.7	10.0	10.5	11.1	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.8	12.2	12.6	13.2	14.0	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.8	12.2	12.6	13.2	14.0	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**48**	**51**	**60**	**69**	**78**	**87**	**62**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**60**	**71**	**80**	**85**	**90**	**90**	**82**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**60**	**71**	**80**	**85**	**90**	**90**	**82**
Junction 1: Flanking STC for all paths			- 10*LOG10(10^-6.2 + 10^- 8.2 + 10^- 8.2) =						62
Junction 2 (Rigid T-Junction, 190 mm block separating wall / 190 mm block flanking wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB6	11	19	21	18	17	21	
Change by Lining on receive side	ΔR_f2	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB6	11	19	21	18	17	21	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.219	0.146	0.094	0.059	0.036	0.021	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.8	58.7	62.5	50
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.8	58.7	62.5	50
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	10.9	11.1	11.5	12.0	12.7	13.5	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	11.0	11.3	11.7	12.3	13.0	13.8	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	11.0	11.3	11.7	12.3	13.0	13.8	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**70**	**89**	**90**	**90**	**90**	**90**	**89**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**70**	**89**	**90**	**90**	**90**	**90**	**89**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**70**	**89**	**90**	**90**	**90**	**90**	**89**
Junction 2: Flanking STC for all paths			- 10*LOG10(10^-8.9 + 10^- 8.9 + 10^- 8.9) =						84
Junction 3 (Rigid cross-junction, 190 mm block separating wall / 150 mm concrete ceiling)									
All values the same as for Junction 1									
Junction 3: Flanking STC for all paths									62
Junction 4 (Rigid T-junction, 190 mm block separating wall / 190 mm block flanking wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change loss factors from Junction 2									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.238	0.158	0.102	0.063	0.038	0.021	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	10.5	10.8	11.2	11.8	12.5	13.3	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	10.8	11.1	11.6	12.1	12.9	13.7	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	10.8	11.1	11.6	12.1	12.9	13.7	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**69**	**89**	**90**	**90**	**90**	**90**	**89**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**69**	**89**	**90**	**90**	**90**	**90**	**89**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**69**	**89**	**90**	**90**	**90**	**90**	**89**
Junction 4: Flanking STC for all paths			- 10*LOG10(10^-8.9 + 10^- 8.9 + 10^- 8.9) =						84
Total Flanking (for all 4 junctions)									59
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**44**	**48**	**57**	**66**	**74**	**79**	**59**

EXAMPLE 2.3.3: DETAILED METHOD

- **Rooms one-above-the-other**
- **Cast-in-place concrete floors and normal weight concrete block walls with rigid junctions**
- **Same structure as Example 2.1.2, plus lining of walls**

Separating floor/ceiling assembly with:

- Cast-in-place concrete floor with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping or flooring on top, or ceiling lining below

Junction 1, 3 or 4: Cross-junction of separating floor / flanking wall with:

- Rigid mortared cross-junction with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Flanking walls lined with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c. with no absorptive material[3] filling stud cavities

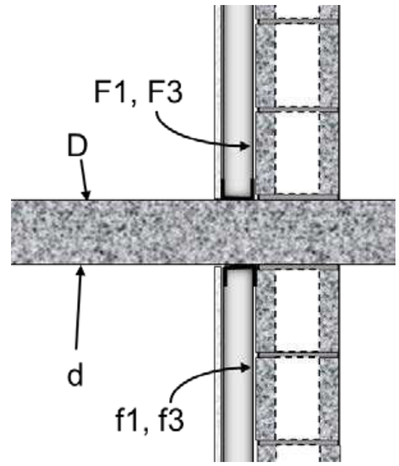
Junction 2: T-Junction of separating floor / flanking wall with:

- Rigid mortared T-junction with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Flanking walls lined with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c. with no absorptive material[3] filling stud cavities

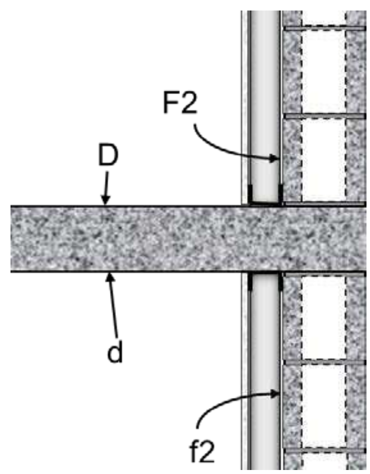
Acoustical Parameters:

	For separating assembly:					
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		(Eq. C.2)
	Reference	K_Ff	K_Dd'	K_Fd	K_Df	Σ l_k . α_k
X-Junction 1, 3, 4	ISO 15712-1, Eq. E.3	11.6	6.1	8.8	8.8	0.843
T-Junction 2	ISO 15712-1, Eq. E.4	8.1		5.8	5.8	0.657
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.028	(at 500 Hz)	
	Similarly, for flanking elements F and f at Junction 1 & 3,					
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.041	(at 500 Hz)	
	Similarly, for flanking elements F and f at Junction 2 & 4,					
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1			0.047	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1			0.043	(at 500 Hz)	

Illustration for this case



Cross-junction of separating floor of 150 mm thick cast-in-place concrete with 190 mm concrete block wall. (Side view of Junctions 1 or 3)



T-Junction of separating floor of 150 mm thick concrete with 190 mm concrete block wall. (Side view of Junction 2. Junction 4 has same lining details, but cross-junction)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (150 mm concrete floor)									
Sound Transmission Loss (TL)	R_D,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.44	0.37	0.25	0.21	0.15	0.08	
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.346	0.237	0.159	0.104	0.066	0.041	
Leakage or Airborne Flanking		Sealed & Blocked	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**41**	**44**	**52**	**61**	**69**	**78**	**55**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F1	RR-334 , ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Change by Lining on receive side	ΔR_f1	RR-334 , ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.256	0.169	0.108	0.067	0.040	0.023	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	35.7	38.5	44.4	50.3	58.2	62.2	49
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	35.7	38.5	44.4	50.3	58.2	62.2	49
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	14.1	14.4	14.8	15.4	16.1	17.0	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.9	12.2	12.7	13.2	14.0	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.9	12.2	12.7	13.2	14.0	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**44**	**71**	**89**	**90**	**90**	**90**	**68**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**47**	**62**	**75**	**84**	**90**	**90**	**71**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**47**	**62**	**75**	**84**	**90**	**90**	**71**
Junction 1: Flanking STC for all paths		- 10*LOG10(10^-6.8 + 10^- 7.1 + 10^- 7.1) =							65
Junction 2 (Rigid T-Junction, 150 mm concrete separating floor / 190 mm block wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	RR-334 , ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Change by Lining on receive side	ΔR_f2	RR-334 , ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.218	0.145	0.094	0.059	0.036	0.021	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.9	58.7	62.5	50
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.9	58.7	62.5	50
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	11.3	11.5	11.9	12.4	13.1	13.9	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	9.5	9.7	10.0	10.4	11.0	11.6	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	9.5	9.7	10.0	10.4	11.0	11.6	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**43**	**70**	**88**	**90**	**90**	**90**	**67**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**46**	**61**	**74**	**83**	**89**	**90**	**70**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**46**	**61**	**74**	**83**	**89**	**90**	**70**
Junction 2: Flanking STC for all paths		- 10*LOG10(10^-6.7 + 10^- 7 + 10^- 7) =							64
Junction 3 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
All values the same as for Junction 1									
Junction 3: Flanking STC for all paths									65
Junction 4 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change loss factors and junction attenuation from Junction 2									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.237	0.157	0.101	0.063	0.038	0.021	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	14.4	14.7	15.1	15.6	16.3	17.2	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	12.3	12.5	12.8	13.3	13.8	14.5	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	12.3	12.5	12.8	13.3	13.8	14.5	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**45**	**73**	**90**	**90**	**90**	**90**	**69**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**48**	**63**	**77**	**86**	**90**	**90**	**72**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**48**	**63**	**77**	**86**	**90**	**90**	**72**
Junction 4: Flanking STC for all paths		- 10*LOG10(10^-6.9 + 10^- 7.2 + 10^- 7.2) =							66
Total Flanking (for all 4 junctions)									59
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**34**	**43**	**52**	**61**	**69**	**76**	**54**

EXAMPLE 2.3.4: **DETAILED METHOD**

- **Rooms one-above-the-other**
- **Cast-in-place concrete floors and normal weight concrete block walls with rigid junctions**
- **Same structure as Example 2.1.2, enhanced lining of walls**

Separating floor/ceiling assembly with:

- Cast-in-place concrete floor with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping or flooring on top, or ceiling lining below

Junction 1, 3, 4: Cross-junction of separating floor / flanking wall with:

- Rigid mortared cross-junction with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Flanking walls lined with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c. with absorptive material[3] filling stud cavities

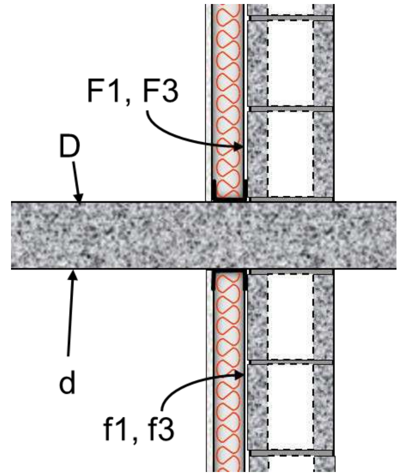
Junction 2: T-Junction of separating floor / flanking wall with:

- Rigid mortared T-junction with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Flanking walls lined with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c. with absorptive material[3] filling stud cavities

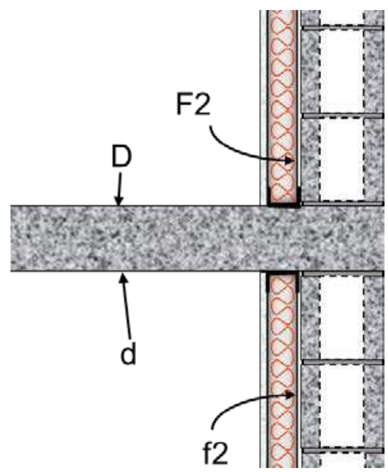
Acoustical Parameters:

For separating assembly:						
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		(Eq. C.2)
	Reference	K_Ff	K_Dd'	K_Fd	K_Df	Σ l_k . α_k
X-Junction 1, 3, 4	ISO 15712-1, Eq. E.3	11.6	6.1	8.8	8.8	0.843
T-Junction 2	ISO 15712-1, Eq. E.4	8.1		5.8	5.8	0.657
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.028	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 1 & 3,						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.041	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 2 & 4,						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1			0.047	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1			0.043	(at 500 Hz)	

Illustration for this case



Cross-junction of separating floor of 150 mm thick cast-in-place concrete with 190 mm concrete block wall. (Side view of Junctions 1 or 3)



T-Junction of separating floor of 150 mm thick cast-in-place concrete with 190 mm concrete block wall. (Side view of Junction 2. Junction 4 has same lining details, but cross-junction)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (150 mm concrete floor)									
Sound Transmission Loss (TL)	R_D,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.44	0.37	0.25	0.21	0.15	0.08	
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.346	0.237	0.159	0.104	0.066	0.041	
Leakage or Airborne Flanking		Sealed & Blocked	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**41**	**44**	**52**	**61**	**69**	**78**	**55**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F1	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB6	11	19	21	18	17	21	
Change by Lining on receive side	ΔR_f1	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB6	11	19	21	18	17	21	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.256	0.169	0.108	0.067	0.040	0.023	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	35.7	38.5	44.4	50.3	58.2	62.2	49
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	35.7	38.5	44.4	50.3	58.2	62.2	49
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	14.1	14.4	14.8	15.4	16.1	17.0	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.9	12.2	12.7	13.2	14.0	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.9	12.2	12.7	13.2	14.0	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**74**	**90**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**62**	**73**	**82**	**87**	**90**	**90**	**84**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**62**	**73**	**82**	**87**	**90**	**90**	**84**
Junction 1: Flanking STC for all paths			- 10*LOG10(10^-9 + 10^- 8.4 + 10^- 8.4) =						80
Junction 2 (Rigid T-Junction, 150 mm concrete separating floor / 190 mm block wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB6	11	19	21	18	17	21	
Change by Lining on receive side	ΔR_f2	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB6	11	19	21	18	17	21	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.218	0.145	0.094	0.059	0.036	0.021	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.9	58.7	62.5	50
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.9	58.7	62.5	50
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	11.3	11.5	11.9	12.4	13.1	13.9	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	9.5	9.7	10.0	10.4	11.0	11.6	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	9.5	9.7	10.0	10.4	11.0	11.6	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**73**	**90**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**61**	**72**	**81**	**86**	**90**	**90**	**83**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**61**	**72**	**81**	**86**	**90**	**90**	**83**
Junction 2: Flanking STC for all paths			- 10*LOG10(10^-9 + 10^- 8.3 + 10^- 8.3) =						80
Junction 3 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
All values the same as for Junction 1									
Junction 3: Flanking STC for all paths									80
Junction 4 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change loss factors and junction attenuation from Junction 2									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.237	0.157	0.101	0.063	0.038	0.021	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	14.4	14.7	15.1	15.6	16.3	17.2	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	12.3	12.5	12.8	13.3	13.8	14.5	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	12.3	12.5	12.8	13.3	13.8	14.5	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**75**	**90**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**63**	**74**	**84**	**89**	**90**	**90**	**85**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**63**	**74**	**84**	**89**	**90**	**90**	**85**
Junction 4: Flanking STC for all paths			- 10*LOG10(10^-9 + 10^- 8.5 + 10^- 8.5) =						81
Total Flanking (for all 4 junctions)									74
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**41**	**44**	**52**	**61**	**69**	**76**	**55**

EXAMPLE 2.3.5: DETAILED METHOD

- **Rooms one-above-the-other**
- **Cast-in-place concrete floors and normal weight concrete block walls with rigid junctions**
- **Same structure as Example 2.1.2, lining of walls and ceiling**

Separating floor/ceiling assembly with:

- Cast-in-place concrete floor with mass per area of 345 kg/m² (e.g. normal weight concrete 150 mm thick) with no topping or flooring
- Ceiling lining below: 16 mm gypsum board[4] fastened to hat-channels supported on cross-channels hung on wires, cavity of 150 mm between concrete and ceiling, with 150 mm absorptive material[3]

Junction 1, 3 or 4: Cross-junction of separating floor / flanking wall with:

- Rigid mortared cross-junction with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m²
- Flanking walls lined with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c. with no absorptive material[3] filling stud cavities

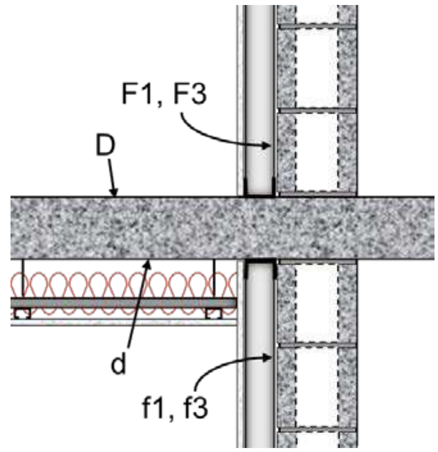
Junction 2: T-Junction of separating floor / flanking wall with:

- Rigid mortared T-junction with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m²
- Flanking walls lined with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c. with no absorptive material[3] filling stud cavities

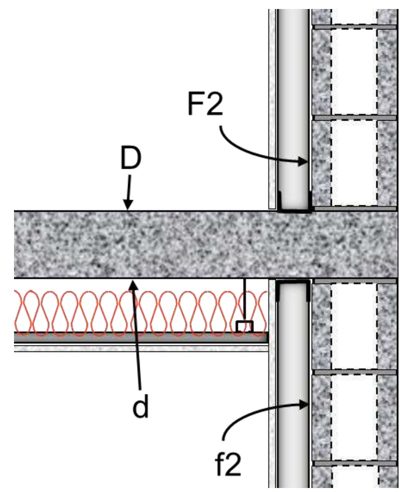
Acoustical Parameters:

For separating assembly:						
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		(Eq. C.2)
	Reference	K_Ff	K_Dd'	K_Fd	K_Df	Σ l_k . α_k
X-Junction 1, 3, 4	ISO 15712-1, Eq. E.3	11.6	6.1	8.8	8.8	0.843
T-Junction 2	ISO 15712-1, Eq. E.4	8.1		5.8	5.8	0.657
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.028	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 1 & 3,						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.041	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 2 & 4,						
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1			0.047	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1			0.043	(at 500 Hz)	

Illustration for this case



Cross-junction of separating floor of 150 mm thick cast-in-place concrete with 190 mm concrete block wall. (Side view of Junctions 1 or 3)



T-Junction of separating floor of 150 mm thick cast-in-place concrete with 190 mm concrete block wall. (Side view of Junction 2. Junction 4 has same lining details, but cross-junction)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (150 mm concrete floor)									
Sound Transmission Loss (TL)	R_D,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.44	0.37	0.25	0.21	0.15	0.08	
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	RR-333 , ΔTL-CON150-C01	12	23	25	24	19	18	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.346	0.237	0.159	0.104	0.066	0.041	
Leakage or Airborne Flanking		Sealed & Blocked	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**49**	**65**	**76**	**85**	**90**	**90**	**73**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F1	RR-334 , ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Change by Lining on receive side	ΔR_f1	RR-334 , ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.256	0.169	0.108	0.067	0.040	0.023	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	35.7	38.5	44.4	50.3	58.2	62.2	49
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	35.7	38.5	44.4	50.3	58.2	62.2	49
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	14.1	14.4	14.8	15.4	16.1	17.0	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.9	12.2	12.7	13.2	14.0	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.9	12.2	12.7	13.2	14.0	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**44**	**71**	**89**	**90**	**90**	**90**	**68**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**55**	**83**	**90**	**90**	**90**	**90**	**79**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**47**	**62**	**75**	**84**	**90**	**90**	**71**
Junction 1: Flanking STC for all paths		- 10*LOG10(10^-6.8 + 10^- 7.9 + 10^- 7.1) =							66
Junction 2 (Rigid T-Junction, 150 mm concrete separating floor / 190 mm block wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	RR-334 , ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Change by Lining on receive side	ΔR_f2	RR-334 , ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.218	0.145	0.094	0.059	0.036	0.021	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.9	58.7	62.5	50
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.9	58.7	62.5	50
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	11.3	11.5	11.9	12.4	13.1	13.9	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	9.5	9.7	10.0	10.4	11.0	11.6	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	9.5	9.7	10.0	10.4	11.0	11.6	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**43**	**70**	**88**	**90**	**90**	**90**	**67**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**54**	**82**	**90**	**90**	**90**	**90**	**78**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**46**	**61**	**74**	**83**	**89**	**90**	**70**
Junction 2: Flanking STC for all paths		- 10*LOG10(10^-6.7 + 10^- 7.8 + 10^- 7) =							65
Junction 3 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
All values the same as for Junction 1									
Junction 3: Flanking STC for all paths									66
Junction 4 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change loss factors and junction attenuation from Junction 2									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.237	0.157	0.101	0.063	0.038	0.021	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	14.4	14.7	15.1	15.6	16.3	17.2	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	12.3	12.5	12.8	13.3	13.8	14.5	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	12.3	12.5	12.8	13.3	13.8	14.5	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**45**	**73**	**90**	**90**	**90**	**90**	**69**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**56**	**84**	**90**	**90**	**90**	**90**	**80**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**48**	**63**	**77**	**86**	**90**	**90**	**72**
Junction 4: Flanking STC for all paths		- 10*LOG10(10^-6.9 + 10^- 8 + 10^- 7.2) =							67
Total Flanking (for all 4 junctions)									60
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**36**	**55**	**68**	**76**	**79**	**79**	**60**

EXAMPLE 2.3.6: DETAILED METHOD

- **Rooms one-above-the-other**
- **Cast-in-place concrete floors and normal weight concrete block walls with rigid junctions**
- **Same structure as Example 2.1.2, lining of walls and ceiling**

Separating floor/ceiling assembly with:

- Cast-in-place concrete floor with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping or flooring
- Ceiling lining below: 16 mm gypsum board[4] fastened to hat-channels supported on cross-channels hung on wires, cavity of 150 mm between concrete and ceiling, with 150 mm absorptive material[3]

Junction 1, 3 or 4: Cross-junction of separating floor / flanking wall with:

- Rigid mortared cross-junction with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Flanking walls lined with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c. with absorptive material[3] filling stud cavities

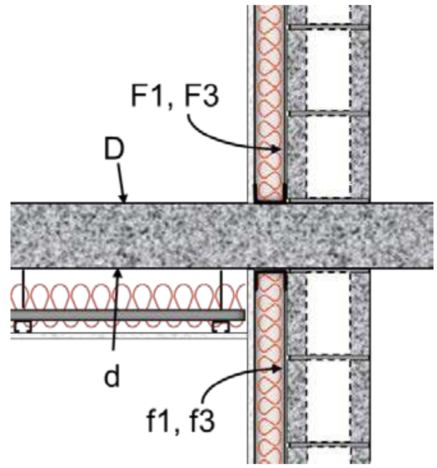
Junction 2: T-Junction of separating floor / flanking wall with:

- Rigid mortared T-junctions with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Flanking walls lined with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c. with absorptive material[3] filling stud cavities

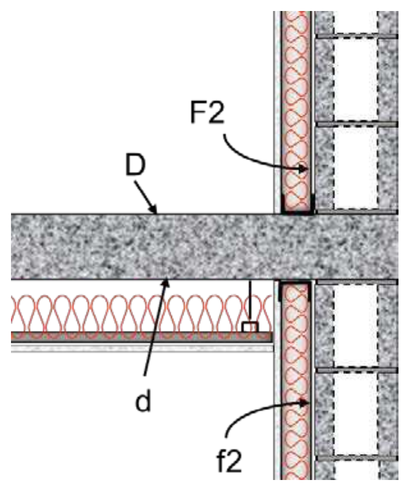
Acoustical Parameters:

	For separating assembly:					
internal loss, η_i =	0.006		c_L =	3500		
mass (kg/m²) =	345		f_c =	124		(Eq. C.2)
	Reference	K_Ff	K_Dd'	K_Fd	K_Df	Σ l_k . α_k
X-Junction 1, 3, 4	ISO 15712-1, Eq. E.3	11.6	6.1	8.8	8.8	0.843
T-Junction 2	ISO 15712-1, Eq. E.4	8.1		5.8	5.8	0.657
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.028	(at 500 Hz)	
	Similarly, for flanking elements F and f at Junction 1 & 3,					
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot	ISO 15712-1, Eq. C.1			0.041	(at 500 Hz)	
	Similarly, for flanking elements F and f at Junction 2 & 4,					
internal loss, η_i =	0.015		c_L =	3500		
mass (kg/m²) =	238		f_c =	98		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1			0.047	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1			0.043	(at 500 Hz)	

Illustration for this case



Cross-junction of separating floor of 150 mm thick cast-in-place concrete with 190 mm concrete block wall. (Side view of Junctions 1 or 3)



T-Junction of separating floor of 150 mm thick cast-in-place concrete with 190 mm concrete block wall. (Side view of Junction 2. Junction 4 has same lining details, but cross-junction)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (150 mm concrete floor)									
Sound Transmission Loss (TL)	R_D,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.439	0.369	0.250	0.205	0.146	0.077	
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	RR-333 , ΔTL-CON150-C01	8	21	24	24	22	19	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.346	0.237	0.159	0.104	0.066	0.041	
Leakage or Airborne Flanking		Sealed & Blocked	0.0	0.0	0.0	0.0	0.0	0.0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**49**	**65**	**76**	**85**	**90**	**90**	**73**

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Junction 1 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F1	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB6	11	19	21	18	17	21	
Change by Lining on receive side	ΔR_f1	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB6	11	19	21	18	17	21	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.256	0.169	0.108	0.067	0.040	0.023	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	35.7	38.5	44.4	50.3	58.2	62.2	49
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	35.7	38.5	44.4	50.3	58.2	62.2	49
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	14.1	14.4	14.8	15.4	16.1	17.0	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.9	12.2	12.7	13.2	14.0	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	11.6	11.9	12.2	12.7	13.2	14.0	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**74**	**90**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**70**	**90**	**90**	**90**	**90**	**90**	**89**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**62**	**73**	**82**	**87**	**90**	**90**	**84**
Junction 1: Flanking STC for all paths			- 10*LOG10(10^-9 + 10^- 8.9 + 10^- 8.4) =						82
Junction 2 (Rigid T-Junction, 150 mm concrete separating floor / 190 mm block wall)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB6	11	19	21	18	17	21	
Change by Lining on receive side	ΔR_f2	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB6	11	19	21	18	17	21	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.218	0.145	0.094	0.059	0.036	0.021	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.9	58.7	62.5	50
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36.4	39.2	45.0	50.9	58.7	62.5	50
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	11.3	11.5	11.9	12.4	13.1	13.9	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	9.5	9.7	10.0	10.4	11.0	11.6	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	9.5	9.7	10.0	10.4	11.0	11.6	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**73**	**90**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**69**	**90**	**90**	**90**	**90**	**90**	**89**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**61**	**72**	**81**	**86**	**90**	**90**	**83**
Junction 2: Flanking STC for all paths			- 10*LOG10(10^-9 + 10^- 8.9 + 10^- 8.3) =						81
Junction 3 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
All values the same as for Junction 1									
Junction 3: Flanking STC for all paths									82
Junction 4 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change loss factors and junction attenuation from Junction 2									
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.237	0.157	0.101	0.063	0.038	0.021	
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	36.0	38.8	44.7	50.6	58.4	62.3	50
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21, 22	14.4	14.7	15.1	15.6	16.3	17.2	
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21, 22	12.3	12.5	12.8	13.3	13.8	14.5	
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21, 22	12.3	12.5	12.8	13.3	13.8	14.5	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**75**	**90**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**71**	**90**	**90**	**90**	**90**	**90**	**89**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**63**	**74**	**84**	**89**	**90**	**90**	**85**
Junction 4: Flanking STC for all paths			- 10*LOG10(10^-9 + 10^- 8.9 + 10^- 8.5) =						83
Total Flanking (for all 4 junctions)									76
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**48**	**63**	**72**	**77**	**79**	**79**	**72**

Summary for Section 2.3: Calculation Examples for Adding Linings to Constructions of Concrete and Concrete Masonry

The worked examples 2.3.1 to 2.3.6 demonstrate the calculation of sound transmission between rooms in a building of concrete/masonry when linings are added to some or all of the bare floor and wall assemblies. The examples show improvements in direct and/or flanking transmission loss via specific paths due to the addition of some common types of linings using gypsum board, light steel framing, and sound absorbing material. Many other lining options are possible, and may be easily substituted if the necessary laboratory test data is available. Note that for a concrete block wall constructed using normal weight units, tests have shown that its surface could be painted or sealed, or have a thin coat of plaster without effect on the sound transmission.

Examples 2.3.1 and 2.3.2 for the horizontal room pair show the improvements relative to Example 2.1.1, which has the same concrete and masonry elements but no linings. For both of these examples, linings of gypsum board mounted on 65 mm lightweight steel studs are installed on all the wall surfaces; for Example 2.3.2, the cavities between the studs are filled with absorptive material. In both cases the ASTC is increased – from 47 with bare walls, to 50 with the basic lining, and to 59 with addition of absorptive material. In Example 2.3.1 with the basic lining (SS65_G13), the combined Flanking STC of 55 is slightly better than the Direct STC of 52, but the contributions of the flanking paths still decrease the ASTC to 50. The better wall linings in Example 2.3.2 raise the Direct STC for the separating partition to over 80, and provide a similar improvement for the wall/wall junctions. The apparent sound insulation of the complete system is limited by the significant transmission via junctions 1 and 3, particularly the floor-floor and ceiling-ceiling paths which are still bare concrete. Adding a lining to the ceiling could make flanking transmission via the ceiling insignificant, but would increase the ASTC by only 3 points to 62. To raise the ASTC to over 62, a substantial improvement to the floor surfaces would be required.

Examples 2.3.3 and 2.3.4 for the vertical room pair show the improvements relative to Example 2.1.2 when the flanking wall surfaces are lined. The ASTC is increased from 52 with bare concrete masonry walls to 54 (for 2.3.3, with the basic lining SS65_G13) and to 55 (for 2.3.4, with absorptive material filling the wall cavities). In both cases, the higher flanking TL due to the wall linings is short-circuited by direct transmission through the floor.

Examples 2.3.5 and 2.3.6 have the same structural assemblies and wall linings as 2.3.3 and 2.3.4 respectively, but show the effect of adding a ceiling lining. The ASTC rises to 60 with the ceiling plus the basic wall lining, and to 72 with ceiling and better wall lining with absorptive material filling the inter-stud cavities. In Example 2.3.5, with the basic SS65_G13 lining on the walls, the ASTC is limited by the flanking paths. With the addition of absorptive material to the wall linings in 2.3.6, the ASTC is mainly limited by direct transmission but an excellent ASTC is achieved.

Overall, these examples show the clear benefit of wall and ceiling linings in achieving high ASTC values, and emphasize the need to focus improvements on the weakest path(s).

2.4. Simplified Calculation Method for Concrete/Masonry Buildings

ISO 15712-1 presents a "Simplified model for structure-borne transmission" in Section 4.4 of the standard. This method has some clearly stated limitations, and some implicit cautions including that:

- The simplified method uses a set of ad hoc approximations that are appropriate for buildings with cast-in-place concrete and concrete masonry construction, with or without linings.
- The application of the simplified method "is restricted to primarily homogeneous constructions", further restricted here to homogeneous lightly-damped structural assemblies. Here "lightly-damped" implies a reverberant vibration field that can be characterized by a mean vibration level, and "homogeneous" implies similar bending stiffness in all directions across the surface. This limitation excludes wood-framed and steel-framed assemblies, but includes typical concrete or concrete masonry walls and cast-in-place concrete floors.
- Within that restricted context, the calculation has been structured to predict an ASTC slightly lower than that from the "detailed method" used in the examples presented in this Guide.

The calculation method of Section 4.4 of ISO 15712-1 is based on two main simplifications:

- The most significant simplification is to deal with losses to connected assemblies "in an average way", which requires ignoring the variation of in-situ transmission loss due to edge losses to adjoining wall and floor constructions, thereby eliminating much of the calculation process of the detailed method.
- The procedure uses only single-number measures. For purposes of this Guide, the single-number measures are laboratory measured STC ratings for the structural wall and floor assemblies and the ΔSTC values for any linings as the input data. The final output is the overall ASTC rating.

The Simplified Method predicts the overall ASTC rating by following the steps indicated in Figure 2.4.1 and explained in more detail below.

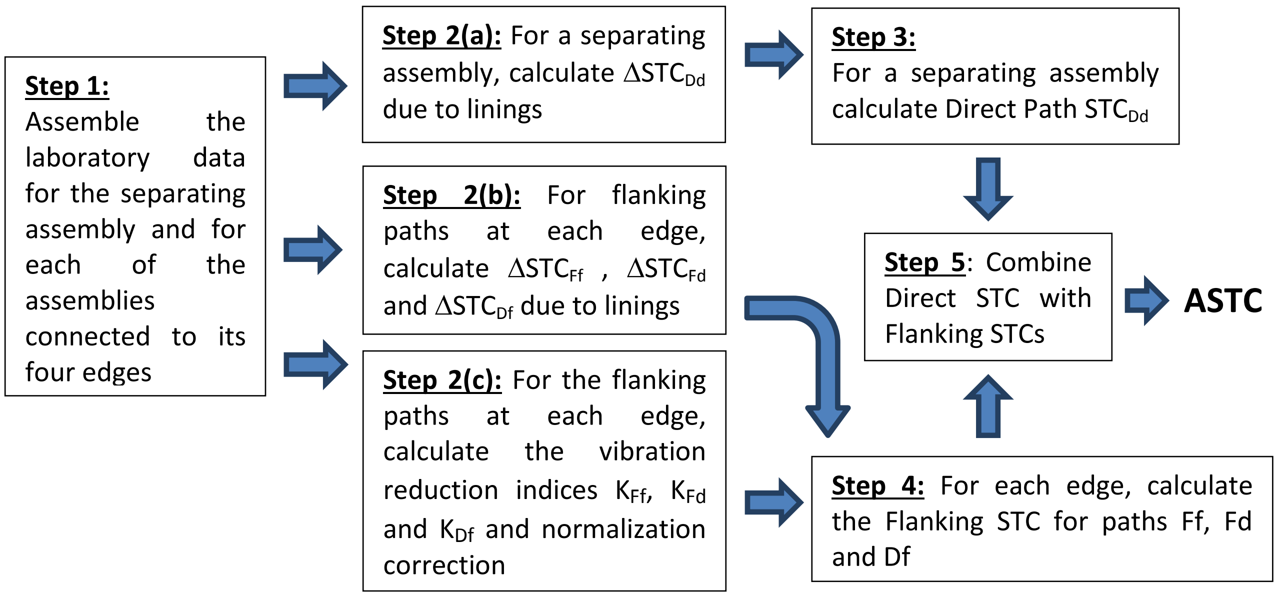


Figure 2.4.1 Steps to calculate the Direct STC and the Flanking STC for each flanking path.

Step 1: Assemble the required laboratory test data for the constructions including the:

- Laboratory sound transmission class (STC) values based on the TL measured according to ASTM E90 for the structural floor or wall assemblies (of bare concrete or masonry),
- Mass per unit area for these bare assemblies,
- Measured change in sound transmission class (ΔSTC) determined according to Appendix A1 of this Guide for each lining that will be added to the bare structural floor or wall assemblies.

Step 2: Determine correction terms as follows:

a) For linings on the source and/or receiving side of the separating assembly, the correction ΔSTC_{Dd} is the sum of the larger of the ΔSTC values for these two linings plus half of the smaller value.

b) For each flanking path *ij*, the correction ΔSTC_{ij} for linings on the source surface *i* and/or the receiving surface *j*, is the sum of the larger of the ΔSTC values for these two linings plus half of the smaller value.

c) For each edge of the separating assembly, calculate the vibration reduction indices K_{Ff}, K_{Fd}, and K_{Df} for the flanking paths between the assembly in the source room (D or F) and the attached assembly in the receiving room (f or d) using the appropriate case from Annex E of ISO 15712-1. These values depend on the junction geometry and the ratio of the mass per unit area for the connected assemblies. Also calculate the normalization correction, which depends on the length of the flanking junction and the area of the separating assembly.

Step 3: Calculate the Direct STC rating for the direct transmission through the separating assembly (STC_{Dd}) using Eq. 27 of ISO 15712-1 with the inputs:

- Laboratory STC value for the bare structural assembly,
- Correction for linings ΔSTC_{Dd} from Step 2(a).

Step 4: Calculate the Flanking STC for transmission via each pair of connected assemblies at each edge of the separating assembly, using Eq. 28a of ISO 15712-1 with inputs:

- Laboratory STC value for each bare structural assembly,
- Correction for linings ΔSTC_{ij} from Step 2(b),
- Value of K_{ij} and normalization correction for this path from Step 2(c).

Step 5: Combine the transmission via the direct and flanking paths to determine the ASTC. In the worked examples, the Direct STC and Flanking STC values are rounded to the nearest integer before they are combined, and the ASTC is also rounded to the nearest integer, to match the nominal precision of the ASTM ratings.

Expressing the Process using Equations

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

$$ASTC = -10\log_{10}\left[10^{-0.1\cdot STC_{Dd}} + \sum_{edge=1}^{4}\left(10^{-0.1\cdot STC_{Ff}} + 10^{-0.1\cdot STC_{Fd}} + 10^{-0.1\cdot STC_{Df}}\right)\right] \quad \text{Eq. 2.4.1}$$

Eq. 2.4.1 is appropriate for all types of building systems similar to the Standard Scenario. The following expressions are used to calculate the transmission for each individual path:

- For the direct path, STC_{Dd} is obtained according to Eq. 2.4.2 from the laboratory STC of the bare separating assembly and the ΔSTC changes due to linings on source “D” and/or receiving side “d” of the assembly. This is the counterpart in ASTM metrics for Eq. 30 of ISO 15712-1.

$$STC_{Dd} = STC_{lab} + \max(\Delta STC_D, \Delta STC_d) + \frac{\min(\Delta STC_D, \Delta STC_d)}{2} \quad \text{Eq. 2.4.2}$$

- For each flanking path, STC_{ij} is calculated using Eq. 2.4.3 where index i and j refer to the coupled flanking assemblies; thus, “i” can either be “D” or “F” and “j” can be “f” or ”d”. The geometric correction factor at the end depends on the surface area of the separating assembly (S_s) and the length of the junction between flanking and separating assemblies (l_{ij}), with l_0 = 1 m. Eq. 2.4.3 is the counterpart in ASTM metrics for Equations 28a and 31 of ISO 15712-1.

$$STC_{ij} = \frac{STC_i}{2} + \frac{STC_j}{2} + K_{ij} + \max(\Delta STC_i, \Delta STC_j) + \frac{\min(\Delta STC_i, \Delta STC_j)}{2} + 10\cdot\log_{10}\frac{S_S}{l_0\cdot l_{ij}} \quad \text{Eq. 2.4.3}$$

Worked Examples

This section presents a number of worked examples that demonstrate the calculation of the ASTC rating for concrete and concrete block constructions according to the Simplified Method. Each worked example 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. All examples conform to the Standard Scenario presented in Section 1.2 of this Guide.

Within the table for each worked example, the “References” column presents the source of input data (combining the NRC report number and identifier for each laboratory test result or derived result), or identifies applicable equations and sections of ISO 15712-1 at each stage of the calculation. Symbols and subscripts identifying the corresponding variable in ISO 15712-1 are given in the adjacent column.

Under the heading “STC or ΔSTC”, the examples present input data determined in laboratory tests:

- STC values for the laboratory sound transmission loss of wall or floor assemblies;
- ΔSTC values measured in the laboratory for the change in STC due to adding that lining to the specified wall or floor assembly, as explained in Appendix A1 of this Guide.

Under the heading “STC or ASTC”, the examples present the calculated values for sound transmission via specific paths:

- Direct STC values for the in-situ transmission loss of the separating wall or floor assembly;
- Flanking STC values for each flanking sound transmission path at each junction;
- Apparent STC (ASTC) values for the combination of direct and flanking transmission via all paths.

The numeric calculations are presented step-by-step in each worked example, using compact notation consistent with the spreadsheet expressions such that:

- For calculation of the Direct STC and the Flanking STC, these expressions are easily recognized as equivalent to Equations 2.4.2 and 2.4.3, respectively. These 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. 2.4.1 is presented in several stages. Note that in the compact notation, a term for transmitted sound power fraction such as $10^{-0.1 \cdot STC_{ij}}$ becomes $10^{-7.4}$, if STC_{ij} = 74.
- At each stage (such as the Flanking STC for the 3 paths at a given junction) the 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 and the final ASTC result.

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EXAMPLE 2.4.1: SIMPLIFIED METHOD

- **Rooms side-by-side**
- **Cast-in-place concrete floors and normal weight concrete block walls with rigid junctions**
- **Same structure as Example 2.1.1**

Separating wall assembly (loadbearing) with:

- One wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2, with no lining

Junction 1: Bottom Junction (separating wall / floor) with:

- Cast-in-place concrete floor with mass per area of 345 kg/m^2 (e.g. normal weight concrete150 mm thick) with no topping or flooring
- Rigid mortared cross-junction with concrete block wall assembly

Junction 2 or 4: Each Side (separating wall /abutting side wall) with:

- Abutting side wall and separating wall of hollow concrete block masonry[1] with mass per area of 238 kg/m^2, with no lining
- Rigid mortared T-junctions

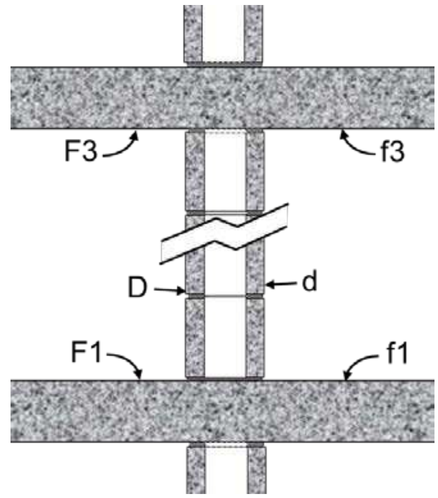
Junction 3: Top Junction (separating wall / ceiling) with:

- Cast-in-place concrete ceiling with mass per area of 345 kg/m^2 (e.g. normal weight concrete150 mm thick) with no added ceiling lining
- Rigid mortared cross-junction with concrete block wall assembly

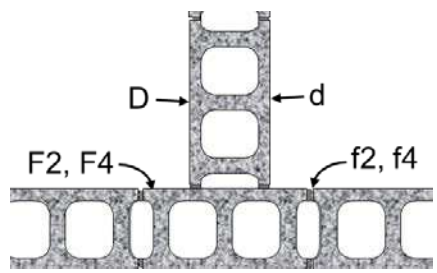
Acoustical Parameters:

For 190 mm concrete block walls:		
Mass/unit area (kg/m^2) =	238	(Separating wall)
	238	(Flanking wall)
For 150 mm concrete floor:		
Mass/unit area (kg/m^2) =	345	
Separating partition area (m^2) =	12.5	
Floor/wall junction length (m) =	5.0	
Separating partition height (m) =	2.5	
10*log(S_Partition/l_junction 1&3) =	4.0	
10*log(S_Partition/l_junction 2&4) =	7.0	

Illustration for this case



Junction of 190 mm concrete block separating wall with 150 mm thick cast-in-place concrete floor and ceiling.
(Side view of Junctions 1 and 3)



Junction of separating wall with side wall, both of 190 mm concrete block. (Plan view of Junction 2 or 4)

			Kij [dB]			
Junction		Mass ratio for Ff	Path Ff	Path Fd	Path Df	Reference
1	Rigid cross-junction	0.69	6.1	8.8	8.8	ISO 15712-1, Eq. E.3
2	Rigid T-junction	1.00	5.7	5.7	5.7	ISO 15712-1, Eq. E.4
3	Rigid cross-junction	0.69	6.1	8.8	8.8	ISO 15712-1, Eq. E.3
4	Rigid T-junction	1.00	5.7	5.7	5.7	ISO 15712-1, Eq. E.4

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (190 mm concrete block)				
Laboratory STC for Dd	R_s,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining on D	ΔR_D,w	No Lining	0	
ΔSTC change by Lining on d	ΔR_d,w	No Lining	0	
Direct STC in-situ	R_Dd,w	RR-331, Eq. 2.4.2	49 + MAX(0,0) + MIN(0,0)/2 =	**49**
Junction 1 (Rigid cross-junction, 190 mm block separating wall / 150 mm concrete floor)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	RR-333, CON150, TLF-15-045	53	
ΔSTC change by Lining	ΔR_F1,w	No Lining ,	0	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	RR-333, CON150, TLF-15-045	53	
ΔSTC change by Lining	ΔR_f1,w	No Lining ,	0	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	53/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 6.1 + 4 =	**63**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	53/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 4 =	**64**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	49/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 4 =	**64**
Junction 1: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-6.3 + 10^- 6.4 + 10^- 6.4) =	59
Junction 2 (Rigid T-Junction, 190 mm block separating wall / 190 mm block flanking wall)				
Flanking Element F2:				
Laboratory STC for F2	R_F2,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_F2,w	No Lining	0	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_f2,w	No Lining	0	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =	**62**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =	**62**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =	**62**
Junction 2: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-6.2 + 10^- 6.2 + 10^- 6.2) =	57
Junction 3 (Rigid cross-junction, 190 mm block separating wall / 150 mm concrete ceiling)				
Flanking Element F3:				
Laboratory STC for F3	R_F3,w	RR-333, CON150, TLF-15-045	53	
ΔSTC change by Lining	ΔR_F3,w	No Lining	0	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	RR-333, CON150, TLF-15-045	53	
ΔSTC change by Lining	ΔR_f3,w	No Lining	0	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	53/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 6.1 + 4 =	**63**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	53/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 4 =	**64**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	49/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 4 =	**64**
Junction 3: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-6.3 + 10^- 6.4 + 10^- 6.4) =	59
Junction 4 (Rigid T-junction, 190 mm block separating wall / 190 mm block flanking wall)				
Flanking Element F4:				
Laboratory STC for F4	R_F4,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_F4,w	No Lining	0	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_f4,w	No Lining	0	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =	**62**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =	**62**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =	**62**
Junction 4: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-6.2 + 10^- 6.2 + 10^- 6.2) =	57
Total Flanking STC (for all 4 junctions)		RR-331, subset of Eq. 2.4.1	Combining 12 Flanking STC values	52
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 2.4.1	**Combining Direct STC with 12 Flanking STC values**	**47**

EXAMPLE 2.4.2: SIMPLIFIED METHOD

- **Rooms one-above-the-other**
- **Cast-in-place concrete floors and normal weight concrete block walls with rigid junctions**
- **Same structure as Example 2.1.2**

Separating floor/ceiling assembly with:

- Cast-in-place concrete floor with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping / flooring on top, or ceiling lining below

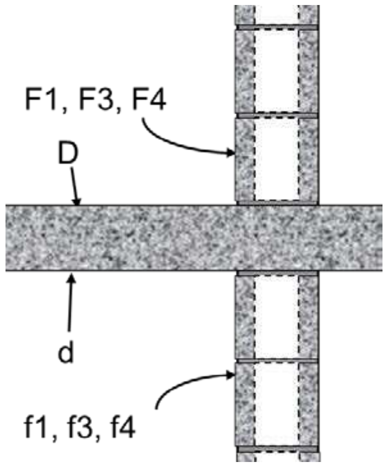
Junction 1, 3,or 4: Cross-junction of separating floor / flanking wall with:

- Rigid mortared cross-junction with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2, with no lining

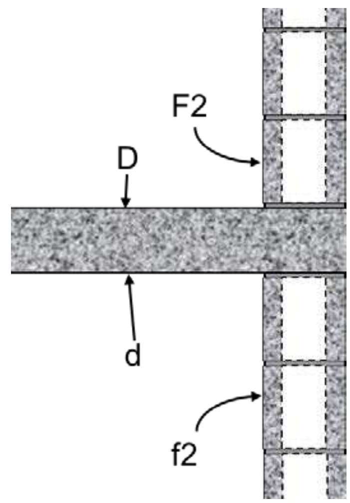
Junction 2: T-Junction of separating floor / flanking wall with:

- Rigid mortared T-junction with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2, with no lining

Illustration for this case



Cross-junction of separating floor of 150 mm thick cast-in-place concrete with 190 mm concrete block wall. (Side view of Junctions 1, 3 or 4)



T-Junction of separating floor of 150 mm thick cast-in-place concrete floor with 190 mm concrete block wall. (Side view of Junction 2)

Acoustical Parameters:

For 190 mm concrete block walls:		
Mass/unit area (kg/m^2) =	238	(Junctions 1&3)
	238	(Junctions 2&4)
For 150 mm concrete floor:		
Mass/unit area (kg/m^2) =	345	
Separating partition area (m^2) =	20	
Junction 1 & 3 length (m) =	5.0	
Junction 2 & 4 length (m) =	4.0	
10*log(S_Partition/l_junction 1&3) =	6.0	
10*log(S_Partition/l_junction 2&4) =	7.0	

			Kij [dB]			
Junction		Mass ratio for Ff	Path Ff	Path Fd	Path Df	Reference
1	Rigid cross-junction	1.45	11.6	8.8	8.8	ISO 15712-1, Eq. E.3
2	Rigid T-junction	1.45	8.1	5.8	5.8	ISO 15712-1, Eq. E.4
3	Rigid cross-junction	1.45	11.6	8.8	8.8	ISO 15712-1, Eq. E.3
4	Rigid cross-junction	1.45	11.6	8.8	8.8	ISO 15712-1, Eq. E.3

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ∆STC	STC or ASTC
Separating Partition (150 mm concrete floor)				
Laboratory STC for Dd	R_s,w	RR-333, CON150, TLF-15-045	53	
∆STC change by Lining on D	∆R_D,w	No Lining	0	
∆STC change by Lining on d	∆R_d,w	No Lining	0	
Direct STC in-situ	R_Dd,w	RR-331, Eq. 2.4.2	53 + MAX(0,0) + MIN(0,0)/2 =	**53**
Junction 1 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	RR-334, NRC-Mean BLK190(NW)	49	
∆STC change by Lining	∆R_F1,w	No Lining	0	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	RR-334, NRC-Mean BLK190(NW)	49	
∆STC change by Lining	∆R_f1,w	No Lining	0	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 11.6 + 6 =	**67**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	49/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 6 =	**66**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	53/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 6 =	**66**
Junction 1: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-6.7 + 10^- 6.6 + 10^- 6.6) =	62
Junction 2 (Rigid T-Junction, 150 mm concrete separating floor / 190 mm block wall)				
Flanking Element F2:				
Laboratory STC for F2	R_F2,w	RR-334, NRC-Mean BLK190(NW)	49	
∆STC change by Lining	∆R_F2,w	No Lining	0	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	RR-334, NRC-Mean BLK190(NW)	49	
∆STC change by Lining	∆R_f2,w	No Lining	0	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 8.1 + 7 =	**64**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	49/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 5.8 + 7 =	**64**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	53/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.8 + 7 =	**64**
Junction 2: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-6.4 + 10^- 6.4 + 10^- 6.4) =	59
Junction 3 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)				
Flanking Element F3:				
Laboratory STC for F3	R_F3,w	RR-334, NRC-Mean BLK190(NW)	49	
∆STC change by Lining	∆R_F3,w	No Lining	0	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	RR-334, NRC-Mean BLK190(NW)	49	
∆STC change by Lining	∆R_f3,w	No Lining ,	0	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 11.6 + 6 =	**67**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	49/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 6 =	**66**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	53/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 6 =	**66**
Junction 3: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-6.7 + 10^- 6.6 + 10^- 6.6) =	62
Junction 4 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)				
Flanking Element F4:				
Laboratory STC for F4	R_F4,w	RR-334, NRC-Mean BLK190(NW)	49	
∆STC change by Lining	∆R_F4,w	No Lining	0	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	RR-334, NRC-Mean BLK190(NW)	49	
∆STC change by Lining	∆R_f4,w	No Lining	0	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 11.6 + 7 =	**68**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	49/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 7 =	**67**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	53/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 7 =	**67**
Junction 4: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-6.8 + 10^- 6.7 + 10^- 6.7) =	63
Total Flanking STC (for all 4 junctions)		RR-331, subset of Eq. 2.4.1	Combining 12 Flanking STC values	55
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 2.4.1	**Combining Direct STC with 12 Flanking STC values**	**51**

EXAMPLE 2.4.3: **SIMPLIFIED METHOD**

- **Rooms side-by-side**
- **Cast-in-place concrete floors and normal weight concrete block walls with rigid junctions**
- **Same structure and lining as Example 2.3.2**

Separating wall assembly (loadbearing) with:
- One wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Separating wall lined both sides with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c., with absorptive material[3] filling inter-stud cavities

Junction 1: Bottom Junction (separating wall / floor) with:
- Cast-in-place concrete floor with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping or flooring
- Rigid mortared cross-junction with concrete block wall assembly

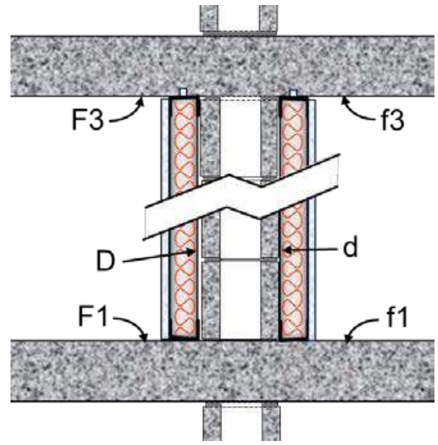
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- Rigid mortared T-junctions of abutting side wall and separating wall of hollow concrete block masonry[1] with mass per area of 238 kg/m^2
- Flanking walls lined with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c., with absorptive material[3] filling inter-stud cavities

Junction 3: Top Junction (separating wall / ceiling) with:
- Cast-in-place concrete ceiling with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no added ceiling lining
- Rigid mortared cross-junction with concrete block wall assembly

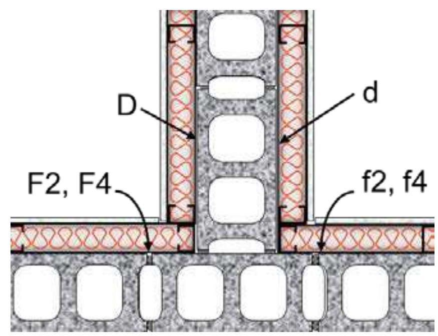
Acoustical Parameters:

For 190 mm concrete block walls:		
Mass/unit area (kg/m^2) =	238	(Separating wall)
	238	(Flanking wall)
For 150 mm concrete floor:		
Mass/unit area (kg/m^2) =	345	
Separating partition area (m^2) =	12.5	
Floor/wall junction length (m) =	5.0	
Separating partition height (m) =	2.5	
10*log(S_Partition/l_junction 1&3) =	4.0	
10*log(S_Partition/l_junction 2&4) =	7.0	

Illustration for this case



Junction of 190 mm concrete block separating wall (with enhanced gypsum board lining) with 150 mm thick cast-in-place concrete floor and ceiling.
(Side view of Junctions 1 and 3)



Junction of separating wall with flanking side wall, both of 190 mm concrete block with enhanced gypsum board linings.
(Plan view of Junction 2 or 4)

			Kij [dB]			
Junction		Mass ratio for Ff	Path Ff	Path Fd	Path Df	Reference
1	Rigid cross-junction	0.69	6.1	8.8	8.8	ISO 15712-1, Eq. E.3
2	Rigid T-junction	1.00	5.7	5.7	5.7	ISO 15712-1, Eq. E.4
3	Rigid cross-junction	0.69	6.1	8.8	8.8	ISO 15712-1, Eq. E.3
4	Rigid T-junction	1.00	5.7	5.7	5.7	ISO 15712-1, Eq. E.4

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (190 mm concrete block)				
Laboratory STC for Dd	R_s,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining on D	ΔR_D,w	RR-334, ΔTL-BLK(NW)-62, SS65_GFB65_G13	19	
ΔSTC change by Lining on d	ΔR_d,w	RR-334, ΔTL-BLK(NW)-62, SS65_GFB65_G13	19	
Direct STC in-situ	R_Dd,w	RR-331, Eq. 2.4.2	49 + MAX(19,19) + MIN(19,19)/2 =	**78**
Junction 1 (Rigid cross-junction, 190 mm block separating wall / 150 mm concrete floor)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	RR-333, CON150, TLF-15-045	53	
ΔSTC change by Lining	ΔR_F1,w	No Lining	0	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	RR-333, CON150, TLF-15-045	53	
ΔSTC change by Lining	ΔR_f1,w	No Lining	0	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	53/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 6.1 + 4 =	**63**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	53/2 + 49/2 + MAX(0,19) + MIN(0,19)/2 + 8.8 + 4 =	**83**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	49/2 + 53/2 + MAX(19,0) + MIN(19,0)/2 + 8.8 + 4 =	**83**
Junction 1: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-6.3 + 10^	63
Junction 2 (Rigid T-Junction, 190 mm block separating wall / 190 mm block flanking wall)				
Flanking Element F2:				
Laboratory STC for F2	R_F2,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_F2,w	RR-334, ΔTL-BLK(NW)-62, SS65_GFB65_G13	19	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_f2,w	RR-334, ΔTL-BLK(NW)-62, SS65_GFB65_G13	19	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(19,19) + MIN(19,19)/2 + 5.7 + 7 =	**90**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(19,19) + MIN(19,19)/2 + 5.7 + 7 =	**90**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(19,19) + MIN(19,19)/2 + 5.7 + 7 =	**90**
Junction 2: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-9 + 10^-	85
Junction 3 (Rigid cross-junction, 190 mm block separating wall / 150 mm concrete ceiling)				
Flanking Element F3:				
Laboratory STC for F3	R_F3,w	RR-333, CON150, TLF-15-045	53	
ΔSTC change by Lining	ΔR_F3,w	No Lining	0	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	RR-333, CON150, TLF-15-045	53	
ΔSTC change by Lining	ΔR_f3,w	No Lining	0	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	53/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 6.1 + 4 =	**63**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	53/2 + 49/2 + MAX(0,19) + MIN(0,19)/2 + 8.8 + 4 =	**83**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	49/2 + 53/2 + MAX(19,0) + MIN(19,0)/2 + 8.8 + 4 =	**83**
Junction 3: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-6.3 + 10^	63
Junction 4 (Rigid T-junction, 190 mm block separating wall / 190 mm block flanking wall)				
Flanking Element F4:				
Laboratory STC for F4	R_F4,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_F4,w	RR-334, ΔTL-BLK(NW)-62, SS65_GFB65_G13	19	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_f4,w	RR-334, ΔTL-BLK(NW)-62, SS65_GFB65_G13	19	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(19,19) + MIN(19,19)/2 + 5.7 + 7 =	**90**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(19,19) + MIN(19,19)/2 + 5.7 + 7 =	**90**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(19,19) + MIN(19,19)/2 + 5.7 + 7 =	**90**
Junction 4: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-9 + 10^-	85
Total Flanking STC (for all 4 junctions)		RR-331, subset of Eq. 2.4.1	Combining 12 Flanking STC values	60
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 2.4.1	**Combining Direct STC with 12 Flanking STC values**	**60**

EXAMPLE 2.4.4: **SIMPLIFIED METHOD**

- **Rooms one-above-the-other**
- **Cast-in-place concrete floors and normal weight concrete block walls with rigid junctions**
- **Same structure as Example 2.3.5**

Separating floor/ceiling assembly with:
- Cast-in-place concrete floor with mass per area of 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping or flooring
- Ceiling lining below: 16 mm gypsum board[4] fastened to hat-channels supported on cross-channels hung on wires, cavity of 150 mm between concrete and ceiling, with 150 mm absorptive material[3]

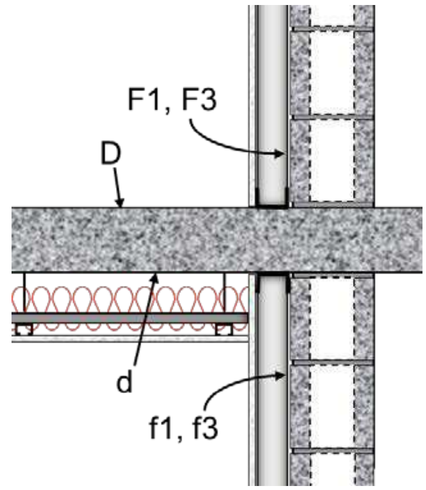
Junction 1, 3 or 4: Cross-junction of separating floor / flanking wall with:
- Rigid mortared cross-junction with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Flanking walls lined with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c. with no absorptive material[3] in inter-stud cavities

Junction 2: T-Junction of separating floor / flanking wall with:
- Rigid mortared T-junctions with concrete block wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Flanking walls lined with 13 mm gypsum board[4] on 65 mm non-loadbearing steel studs[5] spaced 600 mm o.c. with no absorptive material[3] in inter-stud cavities

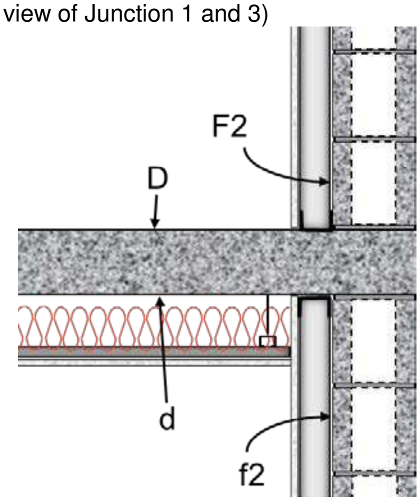
Acoustical Parameters:

For 190 mm concrete block walls:		
Mass/unit area (kg/m^2) =	238	(Junctions 1&3)
	238	(Junctions 2&4)
For 150 mm concrete floor:		
Mass/unit area (kg/m^2) =	345	
Separating partition area (m^2) =	20	
Junction 1 & 3 length (m) =	5.0	
Junction 2 & 4 length (m) =	4.0	
10*log(S_Partition/l_junction 1&3) =	6.0	
10*log(S_Partition/l_junction 2&4) =	7.0	

Illustration for this case



Cross-junction of separating floor of 150 mm thick cast-in-place concrete with 190 mm concrete block wall. (Side view of Junction 1 and 3)



T-Junction of separating floor of 150 mm thick cast-in-place concrete with 190 mm concrete block wall. (Side view of Junction 2. Junction 4 has same lining details, but cross-junction)

			Kij [dB]			
Junction		Mass ratio for Ff	Path Ff	Path Fd	Path Df	Reference
1	Rigid cross-junction	1.45	11.6	8.8	8.8	ISO 15712-1, Eq. E.3
2	Rigid T-junction	1.45	8.1	5.8	5.8	ISO 15712-1, Eq. E.4
3	Rigid cross-junction	1.45	11.6	8.8	8.8	ISO 15712-1, Eq. E.3
4	Rigid cross-junction	1.45	11.6	8.8	8.8	ISO 15712-1, Eq. E.3

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (190 mm concrete block)				
Laboratory STC for Dd	R_s,w	RR-333, CON150, TLF-15-045	53	
ΔSTC change by Lining on D	ΔR_D,w	No Lining ,	0	
ΔSTC change by Lining on d	ΔR_d,w	RR-333, ΔTLF-CON150-01, SUS150_GFB150_G16	19	
Direct STC in-situ	R_Dd,w	RR-331, Eq. 2.4.2	53 + MAX(0,19) + MIN(0,19)/2 =	**72**
Junction 1 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_F1,w	RR-334, ΔTL-BLK(NW)-61, SS65_G13	2	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_f1,w	RR-334, ΔTL-BLK(NW)-61, SS65_G13	2	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(2,2) + MIN(2,2)/2 + 11.6 + 6 =	**70**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	49/2 + 53/2 + MAX(2,19) + MIN(2,19)/2 + 8.8 + 6 =	**86**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	53/2 + 49/2 + MAX(0,2) + MIN(0,2)/2 + 8.8 + 6 =	**68**
Junction 1: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-7 + 10^- 8.6 + 10^- 6.8) =	66
Junction 2 (Rigid T-Junction, 150 mm concrete separating floor / 190 mm block wall)				
Flanking Element F2:				
Laboratory STC for F2	R_F2,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_F2,w	RR-334, ΔTL-BLK(NW)-61, SS65_G13	2	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_f2,w	RR-334, ΔTL-BLK(NW)-61, SS65_G13	2	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(2,2) + MIN(2,2)/2 + 8.1 + 7 =	**67**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	49/2 + 53/2 + MAX(2,19) + MIN(2,19)/2 + 5.8 + 7 =	**84**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	53/2 + 49/2 + MAX(0,2) + MIN(0,2)/2 + 5.8 + 7 =	**66**
Junction 2: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-6.7 + 10^- 8.4 + 10^- 6.6) =	63
Junction 3 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)				
Flanking Element F3:				
Laboratory STC for F3	R_F3,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_F3,w	RR-334, ΔTL-BLK(NW)-61, SS65_G13	2	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_f3,w	RR-334, ΔTL-BLK(NW)-61, SS65_G13	2	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(2,2) + MIN(2,2)/2 + 11.6 + 6 =	**70**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	49/2 + 53/2 + MAX(2,19) + MIN(2,19)/2 + 8.8 + 6 =	**86**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	53/2 + 49/2 + MAX(0,2) + MIN(0,2)/2 + 8.8 + 6 =	**68**
Junction 3: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-7 + 10^- 8.6 + 10^- 6.8) =	66
Junction 4 (Rigid cross-junction, 150 mm concrete separating floor / 190 mm block wall)				
Flanking Element F4:				
Laboratory STC for F4	R_F4,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_F4,w	RR-334, ΔTL-BLK(NW)-61, SS65_G13	2	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining	ΔR_f4,w	RR-334, ΔTL-BLK(NW)-61, SS65_G13	2	
Flanking STC for path Ff	R_ Ff,w	RR-331, Eq. 2.4.3	49/2 + 49/2 + MAX(2,2) + MIN(2,2)/2 + 11.6 + 7 =	**71**
Flanking STC for path Fd	R_ Fd,w	RR-331, Eq. 2.4.3	49/2 + 53/2 + MAX(2,19) + MIN(2,19)/2 + 8.8 + 7 =	**87**
Flanking STC for path Df	R_ Df,w	RR-331, Eq. 2.4.3	53/2 + 49/2 + MAX(0,2) + MIN(0,2)/2 + 8.8 + 7 =	**69**
Junction 4: Flanking STC for all paths		RR-331, subset of Eq. 2.4.1	- 10*LOG10(10^-7.1 + 10^- 8.7 + 10^- 6.9) =	67
Total Flanking STC (for all 4 junctions)		RR-331, subset of Eq. 2.4.1	Combining 12 Flanking STC values	59
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 2.4.1	**Combining Direct STC with 12 Flanking STC values**	**59**

Summary for Section 2.4: Calculation Examples for Simplified Calculation for Concrete and Masonry Constructions

The worked examples 2.4.1 to 2.4.4 illustrate the use of the Simplified Method for calculating sound transmission between rooms in a building with concrete or concrete masonry walls and concrete floor assemblies, with or without linings added to some or all of the walls and floors.

The examples show the performance for two cases with "bare" concrete and masonry assemblies and two cases with improvements in direct and/or flanking transmission loss via specific paths due to the addition of some common types of linings using gypsum board, light steel framing, and sound absorbing material. Many other lining options are possible, but evaluating the benefit of linings is not the focus of this section – rather, it provides a basis for comparing the Simplified Method with the Detailed Method presented in Sections 2.1 to 2.3.

Each of the examples has a counterpart in the detailed calculations in Sections 2.1 and 2.3, and the differences between the results (Detailed Method vs. Simplified Method) are readily compared:

Detailed Method		Simplified Method		Comparison (Detailed vs Simplified)		
Example	ASTC	Example	ASTC	Direct STC	Total Flanking STC	ASTC
2.1.1	47	2.4.1	47	49 vs 49	51 vs 52	47 vs 47
2.1.2	52	2.4.2	51	55 vs 53	55 vs 55	52 vs 51
2.3.2	59	2.4.3	60	82 vs 78	59 vs 60	59 vs 60
2.3.5	60	2.4.4	59	73 vs 72	60 vs 59	60 vs 59

This limited set of comparisons is consistent with larger validation studies of the ISO procedure, which have shown that the Detailed Method tends to give slightly higher values of R'_w (the counterpart of ASTC) than the Simplified Method with a scatter of about ± 1.5 dB.

The basic conclusion that can be drawn from these examples is that the Simplified and Detailed Methods predict similar ASTC values for concrete and masonry buildings – for these cases, the deviations are typically about ±1 ASTC points. But the differences tend to increase with better linings, with the Simplified Method tending to fall farther below the Detailed Method.

A more detailed look at predictions for specific paths suggests that the balance among the direct path and the twelve flanking paths is not always well-reflected by the ad hoc corrections of the Simplified Method, especially where there are matching good linings on both path surfaces. Hence, any detailed design considerations to optimize the choice of linings should use the Detailed Method.

3. Buildings with CLT Wall and Floor Assemblies

Cross-laminated timber (CLT) construction is based on structural floor and wall assemblies fabricated by laminating timber elements together into panels with layers of alternating perpendicular orientation of the timber elements. Typical panels have three or more layers or plies, with overall thickness ranging from about 75 mm to 250 mm.

Section 3.1 and Section 3.2 describe the calculation of the apparent sound insulation in CLT buildings using the Simplified Method and the Detailed Method of ISO 15712-1, respectively. More information on the direct and flanking sound insulation of CLT assemblies and building systems can be found in NRC Research Report RR-335, “Apparent Sound Insulation in CLT Buildings.” The report provides the data for direct and flanking sound insulation for a variety of CLT building configurations.

3.1. Simplified Calculation Procedure for CLT Constructions

ISO 15712-1 states that the application of the Simplified Method “is restricted to primarily homogeneous constructions”, further restricted here to homogeneous lightly-damped structural assemblies. Here, “lightly-damped” implies a reverberant vibration field that can be characterized by a mean vibration level, and “homogeneous” implies similar bending stiffness in all directions across the surface. These definitions exclude wood-framed and steel-framed assemblies, but typical CLT wall or floor/ceiling assemblies are considered appropriate for the Simplified Method.

Within this restricted context, the Simplified Method has been structured to predict an ASTC which is slightly lower than that from the Detailed Method described in Section 3.2 of this Guide.

The Simplified Method uses two main simplifications:

- The most significant simplification is that losses to connected assemblies are dealt with “in an average way”, ignoring the variation of in-situ sound transmission loss due to edge losses to adjoining wall and floor constructions. This simplification eliminates much of the calculation process of the Detailed Method. Since the internal losses of CLT assemblies are high enough that the laboratory sound transmission loss can be used as in-situ sound transmission loss as described in Section 3.2, this simplification does not lead to a loss of accuracy for CLT constructions (unlike for less-damped constructions such as concrete or concrete block).
- The procedure uses only single-number quantities as input data, namely laboratory STC ratings for the wall and floor assemblies, ΔSTC values for any linings, and mean K_{ij} values for the junction attenuation. The output of the calculations using the Simplified Method is the ASTC.

The Simplified Method predicts the overall ASTC, by following the steps in Figure 3.1.1, which are also explained in more detail below the figure.

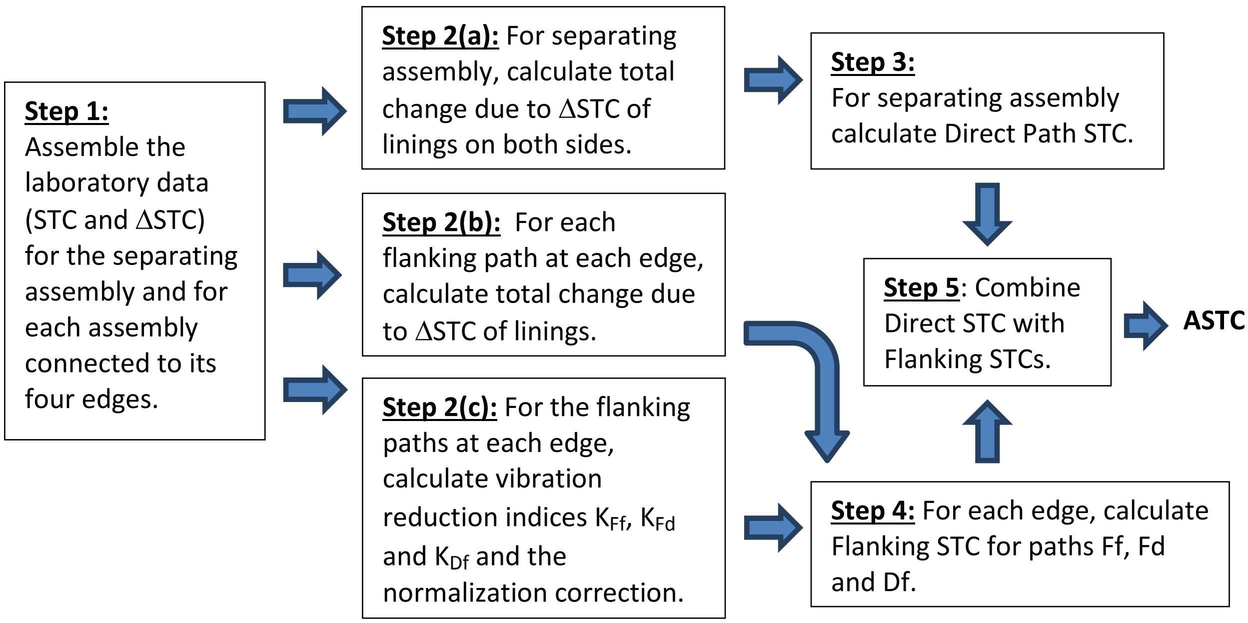


Figure 3.1.1: Steps to calculate the ASTC using the Simplified Method.

Step 1: Assemble the required laboratory test data for the constructions:

- Laboratory sound transmission class (STC) values based on direct sound transmission loss data measured according to ASTM E90 for the CLT floor or wall assemblies;
- Measured change in sound transmission class (ΔSTC) determined according to Appendix A1 for each lining that will be added to the base floor or wall assemblies.

Step 2: Determine the correction terms as follows:

d) For linings on the separating assembly, the correction ΔSTC_{Dd} is the sum of the larger of the ΔSTC values for these two linings plus half of the smaller ΔSTC value.

e) For each flanking path ij, the correction ΔSTC_{ij} for linings on the source surface i and/or the receiving surface j is the sum of the larger of the ΔSTC values for these two linings plus half of the smaller ΔSTC value.

f) For each edge of the separating assembly, determine the vibration reduction indices K_{Ff}, K_{Fd}, and K_{Df} for the flanking paths between the assembly in the source room (D or F) and the attached assembly in the receiving room (f or d). Also calculate the normalization correction, which depends on the length of the flanking junction and the area of the separating assembly.

Step 3: Calculate the Direct STC for direct sound transmission through the separating assembly (STC_{Dd}) according to Eq. 27 of ISO 15712-1 (and Eq. 3.1.2 in this Guide) using the laboratory STC rating for the Base CLT assembly plus any correction for linings ΔSTC_{Dd} from Step 2(a).

Step 4: Calculate the Flanking STC for sound transmission via each pair of connected assemblies at each edge of the separating assembly according to Eq. 28a of ISO 15712-1 (and Eq. 3.1.3 in this Guide) with the following inputs:

- laboratory STC rating for each Base CLT assembly plus lining correction ΔSTC_{ij} from Step 2(b);
- K_{ij} value and normalization correction for this path from Step 2(c).

Step 5: Combine the sound transmission via the direct and flanking paths, using Equation 1.2 in Section 1.4 of this Guide (equivalent to Eq. 3.1.1 below and to Eq. 26 in Section 4.4 of ISO 15712-1).

Expressing the Process using Equations

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

$$ASTC = -10\log_{10}\left[10^{-0.1\cdot STC_{Dd}} + \sum_{edge=1}^{4}\left(10^{-0.1\cdot STC_{Ff}} + 10^{-0.1\cdot STC_{Fd}} + 10^{-0.1\cdot STC_{Df}}\right)\right] \quad \text{Eq. 3.1.1}$$

Eq. 3.1.1 is appropriate for all types of building systems with the geometry of the Standard Scenario, and is applied here using the following expressions to calculate the transmission for each individual path:

- For the direct path, STC_{Dd} is obtained according to Eq. 4.1.2 from the laboratory STC of the Base CLT assembly and the ΔSTC changes due to linings on source “D” and/or receiving side “d” of the separating assembly. Eq. 3.1.2 is the counterpart in ASTM metrics for Eq. 30 of ISO 15712-1.

$$STC_{Dd} = STC_{lab} + \max(\Delta STC_D, \Delta STC_d) + \frac{\min(\Delta STC_D, \Delta STC_d)}{2} \quad \text{Eq. 3.1.2}$$

- For each flanking path, STC_{ij} is calculated using Eq. 3.1.3 where indices i and j refer to the coupled flanking assemblies; thus, “i” can either be “D” or “F” and “j” can be “f” or ”d”. The geometric correction factor at the end depends on the surface area of the separating assembly (S_s) and the length of the junction between flanking and separating assemblies (l_{ij}), with l_0 = 1 m. Eq. 3.1.3 is the counterpart in ASTM metrics for Equations 28a and 31 of ISO 15712-1.

$$STC_{ij} = \frac{STC_i}{2} + \frac{STC_j}{2} + K_{ij} + \max(\Delta STC_i, \Delta STC_j) + \frac{\min(\Delta STC_i, \Delta STC_j)}{2} + 10\cdot\log_{10}\frac{S_S}{l_0\cdot l_{ij}} \quad \text{Eq. 3.1.3}$$

Worked Examples

This section presents a number of worked examples that demonstrate the calculation of the ASTC rating of CLT constructions according to the Simplified Method. 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.

Within the table for each worked example, the “References” column presents the source of input data (combining the NRC report number and identifier for each laboratory test result or derived result), or identifies applicable equations and sections of ISO 15712-1 at each stage of the calculation, or their counterparts using ASTM ratings as presented in Equations 3.1.1 to 3.1.3. Symbols and subscripts identifying the corresponding variable in ISO 15712-1 are given in the adjacent column.

Under the single heading “STC or 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 or floor assemblies; and
- ΔSTC values measured in the laboratory for the change in STC due to adding a lining to the base wall or floor assembly.

Under the heading “STC or ASTC”, the examples present the calculated values for sound transmission via specific paths, including:

- Direct STC ratings for the 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 sound 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 that 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 and the Flanking STC, these expressions are easily recognized as equivalent to Equations 3.1.2 and 3.1.3, respectively.
- For illustrating the combined sound power transmitted via specific paths, the calculation of Eq. 3.1.1 is broken down into several stages. Note that in the compact notation, a term for transmitted sound power fraction such as $10^{-0.1 \cdot TL_{ij}}$ becomes 10^-7.4, if TL_{ij} =74.

- At each stage (such as the Flanking STC for a given junction) the 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 and the final ASTC result.
- The ASTC rating is calculated from the combined sound power transmitted via the direct path and the 12 individual flanking paths.

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.

All examples conform to the Standard Scenario presented in Section 1.2 of this Guide. The worked examples include both scenarios for CLT wall and floor assemblies without linings and scenarios where linings are included.

EXAMPLE 3.1-H1: (SIMPLIFIED METHOD)

- **Rooms side-by-side**
- **Bare CLT Floors and CLT Walls**

Separating wall assembly (loadbearing) with:

- 3-ply 78 mm thick CLT[6] wall assembly with mass 42.4 kg/m^2, oriented so that face ply strands are vertical
- No added linings on either side

Junction 1: Bottom Junction (separating wall / floor) with:

- 5-ply 175 mm thick CLT floor assembly with mass 92.1 kg/m^2, continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- No added topping or flooring

Junction 2 or 4: Each Side (separating wall / abutting side wall) with:

- 3-ply 78 mm thick CLT wall assembly with mass 42.4 kg/m^2, continuous through T-junction with separating assembly and oriented so that face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 600 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- No added linings

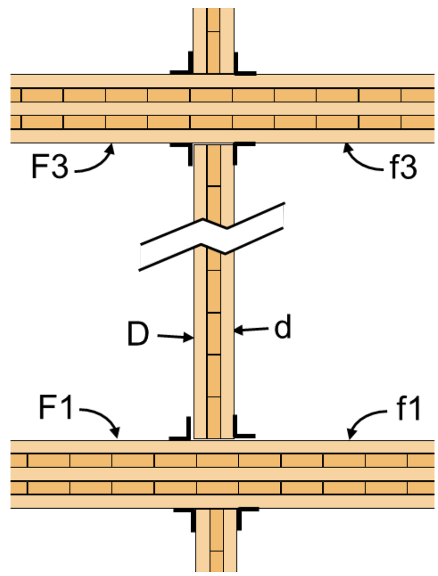
Junction 3: Top Junction (separating wall / ceiling) with:

- 5-ply 175 mm thick CLT ceiling assembly with mass 92.1 kg/m^2, continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- No added ceiling lining

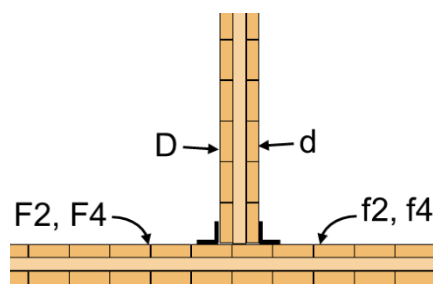
Acoustical Parameters:

Separating partition area (m^2) =			12.5	
Floor/separating wall junction length (m) =			5.0	
Wall/separating wall junction length (m) =			2.5	
	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3:				
Kij [dB] =	1.1	10.5	10.5	RR-335, CLT-WF-Xa-01
10*log(Sep. Area/Junction) =	4.0			or CLT-WC-Xa-01
For Junctions 2 and 4:				
Kij [dB] =	3.5	5.7	5.7	RR-335, CLT-WW-Tb-01
10*log(Sep. Area/Junction) =	7.0			

Illustration for this case



Cross-junctions of 78 mm thick 3-ply CLT separating wall with 175 mm thick 5-ply CLT floor and ceiling.
(Side view of Junctions 1 and 3)



T-junction of separating wall with side wall, both of 78 mm thick 3-ply CLT.
(Plan view of Junctions 2 and 4)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (78 mm 3-ply CLT)				
Laboratory STC for Dd	R_s,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on D	ΔR_D,w	No Lining	0	
ΔSTC change by Lining on d	ΔR_d,w	No Lining	0	
If airborne flanking or bare CLT		RR-335, STC(Bare CLT03) - STC(Base CLT03)	-3	
Direct STC in-situ	R_Dd,w	RR-335, Eq. 4.1.2	36 + MAX(0,0) + MIN(0,0)/2 + -3 =	**33**
Junction 1 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Floor)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F1	ΔR_F1,w	No Lining	0	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f1	ΔR_f1,w	No Lining	0	
Flanking STC for path Ff_1	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(0,0) + MIN(0,0)/2 + 1.1 + 4 =	**47**
Flanking STC for path Fd_1	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 36/2 + MAX(0,0) + MIN(0,0)/2 + 10.5 + 4 =	**54**
Flanking STC for path Df_1	R_ Df,w	RR-335, Eq. 4.1.3	36/2 + 42/2 +MAX(0,0) + MIN(0,0)/2 + 10.5 + 4 =	**54**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-4.7 + 10^- 5.4 + 10^- 5.4) =	46
Junction 2 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)				
Flanking Element F2:				
Laboratory STC for F2	R_F2,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on F2	ΔR_F2,w	No Lining	0	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on f2	ΔR_f2,w	No Lining	0	
Flanking STC for path Ff_2	R_ Ff,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(0,0) + MIN(0,0)/2 + 3.5 + 7 =	**47**
Flanking STC for path Fd_2	R_ Fd,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =	**49**
Flanking STC for path Df_2	R_ Df,w	RR-335, Eq. 4.1.3	36/2 + 36/2 +MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =	**49**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-4.7 + 10^- 4.9 + 10^- 4.9) =	43
Junction 3 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Ceiling)				
Flanking Element F3:				
Laboratory STC for F3	R_F3,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F3	ΔR_F3,w	No Lining	0	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f3	ΔR_f3,w	No Lining	0	
Flanking STC for path Ff_3	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(0,0) + MIN(0,0)/2 + 1.1 + 4 =	**47**
Flanking STC for path Fd_3	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 36/2 + MAX(0,0) + MIN(0,0)/2 + 10.5 + 4 =	**54**
Flanking STC for path Df_3	R_ Df,w	RR-335, Eq. 4.1.3	36/2 + 42/2 +MAX(0,0) + MIN(0,0)/2 + 10.5 + 4 =	**54**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-4.7 + 10^- 5.4 + 10^- 5.4) =	46
Junction 4 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)				
Flanking Element F4:				
Laboratory STC for F4	R_F4,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on F4	ΔR_F4,w	No Lining	0	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on f4	ΔR_f4,w	No Lining	0	
Flanking STC for path Ff_4	R_ Ff,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(0,0) + MIN(0,0)/2 + 3.5 + 7 =	**47**
Flanking STC for path Fd_4	R_ Fd,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =	**49**
Flanking STC for path Df_4	R_ Df,w	RR-335, Eq. 4.1.3	36/2 + 36/2 +MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =	**49**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-4.7 + 10^- 4.9 + 10^- 4.9) =	43
Total Flanking STC (for all 4 junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values:	38
ASTC due to Direct plus Flanking Paths		Eq. 4.1.1	**Combining Direct STC and 12 Flanking STC values:**	**32**

EXAMPLE 3.1-H2: (SIMPLIFIED METHOD)

- **Rooms side-by-side**
- **CLT Floors and CLT Walls**
  (Same as example 3.1-H1, plus linings)

Separating wall assembly (loadbearing) with:
- 3-ply 78 mm thick CLT wall assembly with mass 42.4 kg/m^2, oriented so that face ply strands are vertical
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

Junction 1: Bottom Junction (separating wall / floor) with:
- 5-ply 175 mm thick CLT floor assembly with mass 92.1 kg/m^2, continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Floor lining of 38 mm concrete over 13 mm wood fiber board

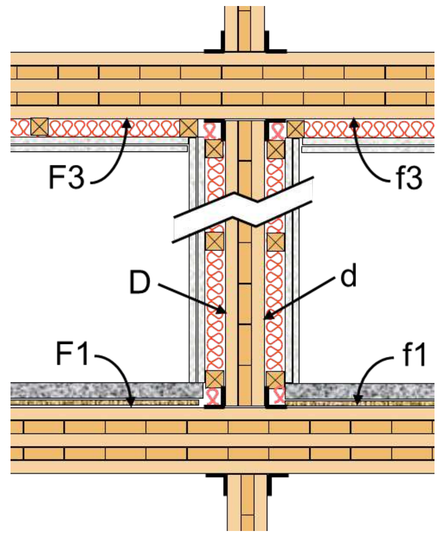
Junction 2 or 4: Each Side (separating wall / abutting side wall) with:
- 3-ply 78 mm thick CLT wall assembly with mass 42.4 kg/m^2, continuous through T-junction with separating assembly and oriented so that face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 600 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

Junction 3: Top Junction (separating wall / ceiling) with:
- 5-ply 175 mm thick CLT ceiling assembly with mass 92.1 kg/m^2, continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

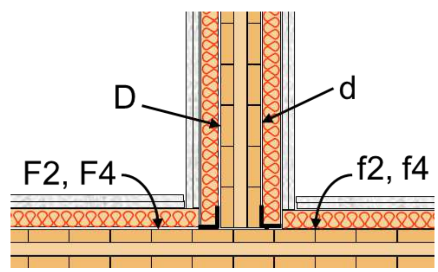
Acoustical Parameters:

Separating partition area (m^2) =			12.5	
Floor/separating wall junction length (m) =			5.0	
Wall/separating wall junction length (m) =			2.5	
	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3:				
Kij [dB] =	1.1	10.5	10.5	RR-335, CLT-WF-Xa-01
10*log(Sep. Area/Junction) =	4.0			or CLT-WC-Xa-01
For Junctions 2 and 4:				
Kij [dB] =	3.5	5.7	5.7	RR-335, CLT-WW-Tb-01
10*log(Sep. Area/Junction) =	7.0			

Illustration for this case



Cross-junctions of 78 mm thick 3-ply CLT separating wall with 150 mm thick 5-ply CLT floor and ceiling.
(Side view of Junctions 1 and 3)



T-junction of separating wall with side wall, both of 78 mm thick 3-ply CLT.
(Plan view of Junctions 2 and 4)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (78 mm 3-ply CLT)				
Laboratory STC for Dd	R_s,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on D	ΔR_D,w	RR-335, ΔTL-CLT03-W03	9	
ΔSTC change by Lining on d	ΔR_d,w	RR-335, ΔTL-CLT03-W03	9	
If airborne flanking or bare CLT		RR-335, STC(Bare CLT03) - STC(Base CLT03)	N/A	
Direct STC in-situ	R_Dd,w	RR-335, Eq. 4.1.2	36 + MAX(9,9) + MIN(9,9)/2 =	**50**
Junction 1 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Floor)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F1	ΔR_F1,w	RR-335, ΔTL-CLT-F03	10	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f1	ΔR_f1,w	RR-335, ΔTL-CLT-F03	10	
Flanking STC for path Ff_1	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(10,10) + MIN(10,10)/2 + 1.1 + 4 =	**62**
Flanking STC for path Fd_1	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 36/2 + MAX(10,9) + MIN(10,9)/2 + 10.5 + 4 =	**68**
Flanking STC for path Df_1	R_ Df,w	RR-335, Eq. 4.1.3	36/2 + 42/2 +MAX(9,10) + MIN(9,10)/2 + 10.5 + 4 =	**68**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.2 + 10^- 6.8 + 10^- 6.8) =	60
Junction 2 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)				
Flanking Element F2:				
Laboratory STC for F2	R_F2,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on F2	ΔR_F2,w	RR-335, ΔTL-CLT03-W03	9	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on f2	ΔR_f2,w	RR-335, ΔTL-CLT03-W03	9	
Flanking STC for path Ff_2	R_ Ff,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(9,9) + MIN(9,9)/2 + 3.5 + 7 =	**60**
Flanking STC for path Fd_2	R_ Fd,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(9,9) + MIN(9,9)/2 + 5.7 + 7 =	**62**
Flanking STC for path Df_2	R_ Df,w	RR-335, Eq. 4.1.3	36/2 + 36/2 +MAX(9,9) + MIN(9,9)/2 + 5.7 + 7 =	**62**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6 + 10^- 6.2 + 10^- 6.2) =	56
Junction 3 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Ceiling)				
Flanking Element F3:				
Laboratory STC for F3	R_F3,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F3	ΔR_F3,w	RR-335, ΔTL-CLT-C01	7	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f3	ΔR_f3,w	RR-335, ΔTL-CLT-C01	7	
Flanking STC for path Ff_3	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(7,7) + MIN(7,7)/2 + 1.1 + 4 =	**58**
Flanking STC for path Fd_3	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 36/2 + MAX(7,9) + MIN(7,9)/2 + 10.5 + 4 =	**66**
Flanking STC for path Df_3	R_ Df,w	RR-335, Eq. 4.1.3	36/2 + 42/2 +MAX(9,7) + MIN(9,7)/2 + 10.5 + 4 =	**66**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-5.8 + 10^- 6.6 + 10^- 6.6) =	57
Junction 4 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)				
Flanking Element F4:				
Laboratory STC for F4	R_F4,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on F4	ΔR_F4,w	RR-335, ΔTL-CLT-W03	9	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on f4	ΔR_f4,w	RR-335, ΔTL-CLT-W03	9	
Flanking STC for path Ff_4	R_ Ff,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(9,9) + MIN(9,9)/2 + 3.5 + 7 =	**60**
Flanking STC for path Fd_4	R_ Fd,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(9,9) + MIN(9,9)/2 + 5.7 + 7 =	**62**
Flanking STC for path Df_4	R_ Df,w	RR-335, Eq. 4.1.3	36/2 + 36/2 +MAX(9,9) + MIN(9,9)/2 + 5.7 + 7 =	**62**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6 + 10^- 6.2 + 10^- 6.2) =	56
Total Flanking STC (for all 4 junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values:	51
ASTC due to Direct plus Flanking Paths		Eq. 4.1.1	**Combining Direct STC and 12 Flanking STC values:**	**48**

EXAMPLE 3.1-H3: (SIMPLIFIED METHOD)

- **Rooms side-by-side**
- **CLT Floors and CLT Walls**
  (Same as example 3.1-H2, except enhanced linings)

Separating wall assembly (loadbearing) with:

- 3-ply 78 mm thick CLT wall assembly with mass 42.4 kg/m^2, oriented so that face ply strands are vertical
- Two layers of 12.7 mm gypsum board[4] on resilient metal channels[7] spaced 600 mm o.c., on 38 x 38 mm wood furring spaced 400 mm o.c. with absorptive material[3] in cavities

Junction 1: Bottom Junction (separating wall / floor) with:

- 5-ply 175 mm thick CLT floor assembly with mass 92.1 kg/m^2, continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Floor lining of 38 mm concrete over 13 mm wood fiber board

Junction 2 or 4: Each Side (separating wall / abutting side wall) with:

- 3-ply 78 mm thick CLT wall assembly with mass 42.4 kg/m^2, continuous through T-junction with separating assembly and oriented so that face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 600 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

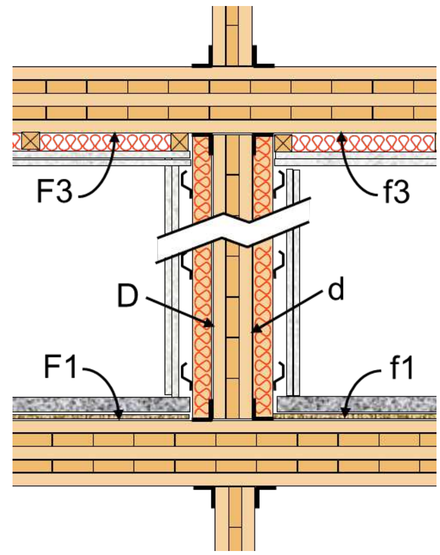
Junction 3: Top Junction (separating wall / ceiling) with:

- 5-ply 175 mm thick CLT ceiling assembly with mass 92.1 kg/m^2, continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

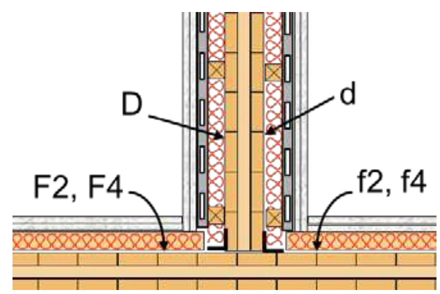
Acoustical Parameters:

Separating partition area (m^2) =	12.5			
Floor/separating wall junction length (m) =	5.0			
Wall/separating wall junction length (m) =	2.5			
	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3:				
Kij [dB] =	1.1	10.5	10.5	RR-335, CLT-WF-Xa-01
10*log(Sep. Area/Junction) =	4.0			or CLT-WC-Xa-01
For Junctions 2 and 4:				
Kij [dB] =	3.5	5.7	5.7	RR-335, CLT-WW-Tb-01
10*log(Sep. Area/Junction) =	7.0			

Illustration for this case



Cross-junctions of 78 mm thick 3-ply CLT separating wall with 150 mm thick 5-ply CLT floor and ceiling.
(Side view of Junctions 1 and 3)



T-junction of separating wall with side wall, both of 78 mm thick 3-ply CLT.
(Plan view of Junctions 2 and 4)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (78 mm 3-ply CLT)				
Laboratory STC for Dd	R_s,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on D	ΔR_D,w	RR-335, ΔTL-CLT-W04	15	
ΔSTC change by Lining on d	ΔR_d,w	RR-335, ΔTL-CLT-W04	15	
If airborne flanking or bare CLT		RR-335, STC(Bare CLT03) - STC(Base CLT03)	N/A	
Direct STC in-situ	R_Dd,w	RR-335, Eq. 4.1.2	36 + MAX(15,15) + MIN(15,15)/2 =	**59**
Junction 1 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Floor)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F1	ΔR_F1,w	RR-335, ΔTL-CLT-F03	10	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f1	ΔR_f1,w	RR-335, ΔTL-CLT-F03	10	
Flanking STC for path Ff_1	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(10,10) + MIN(10,10)/2 + 1.1 + 4 =	**62**
Flanking STC for path Fd_1	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 36/2 + MAX(10,15) + MIN(10,15)/2 + 10.5 + 4 =	**74**
Flanking STC for path Df_1	R_ Df,w	RR-335, Eq. 4.1.3	36/2 + 42/2 +MAX(15,10) + MIN(15,10)/2 + 10.5 + 4 =	**74**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.2 + 10^- 7.4 + 10^- 7.4) =	61
Junction 2 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)				
Flanking Element F2:				
Laboratory STC for F2	R_F2,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on F2	ΔR_F2,w	RR-335, ΔTL-CLT03-W03	9	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on f2	ΔR_f2,w	RR-335, ΔTL-CLT03-W03	9	
Flanking STC for path Ff_2	R_ Ff,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(9,9) + MIN(9,9)/2 + 3.5 + 7 =	**60**
Flanking STC for path Fd_2	R_ Fd,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(9,15) + MIN(9,15)/2 + 5.7 + 7 =	**68**
Flanking STC for path Df_2	R_ Df,w	RR-335, Eq. 4.1.3	36/2 + 36/2 +MAX(15,9) + MIN(15,9)/2 + 5.7 + 7 =	**68**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6 + 10^- 6.8 + 10^- 6.8) =	59
Junction 3 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Ceiling)				
Flanking Element F3:				
Laboratory STC for F3	R_F3,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F3	ΔR_F3,w	RR-335, ΔTL-CLT-C01	7	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f3	ΔR_f3,w	RR-335, ΔTL-CLT-C01	7	
Flanking STC for path Ff_3	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(7,7) + MIN(7,7)/2 + 1.1 + 4 =	**58**
Flanking STC for path Fd_3	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 36/2 + MAX(7,15) + MIN(7,15)/2 + 10.5 + 4 =	**72**
Flanking STC for path Df_3	R_ Df,w	RR-335, Eq. 4.1.3	36/2 + 42/2 +MAX(15,7) + MIN(15,7)/2 + 10.5 + 4 =	**72**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-5.8 + 10^- 7.2 + 10^- 7.2) =	58
Junction 4 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)				
Flanking Element F4:				
Laboratory STC for F4	R_F4,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on F4	ΔR_F4,w	RR-335, ΔTL-CLT03-W03	9	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on f4	ΔR_f4,w	RR-335, ΔTL-CLT03-W03	9	
Flanking STC for path Ff_4	R_ Ff,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(9,9) + MIN(9,9)/2 + 3.5 + 7 =	**60**
Flanking STC for path Fd_4	R_ Fd,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(9,15) + MIN(9,15)/2 + 5.7 + 7 =	**68**
Flanking STC for path Df_4	R_ Df,w	RR-335, Eq. 4.1.3	36/2 + 36/2 +MAX(15,9) + MIN(15,9)/2 + 5.7 + 7 =	**68**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6 + 10^- 6.8 + 10^- 6.8) =	59
Total Flanking STC (for all 4 junctions)		Subset of Eq. 4.1.1	Combining all 12 Flanking STC values:	53
ASTC due to Direct plus Flanking Paths		Eq. 4.1.1	**Combining Direct STC and 12 Flanking STC values:**	**52**

EXAMPLE 3.1-V1: (SIMPLIFIED METHOD)

- **Rooms one-above-the-other**
- **Bare CLT Floors and CLT Walls**

Separating floor assembly with:
- 5-ply 175 mm thick CLT floor assembly with mass 92.1 kg/m^2, continuous through cross-junction with CLT wall assemblies at Junctions 1 and 3 and oriented so that face ply strands are perpendicular to loadbearing Junctions 1 and 3
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting wall assemblies
- No added linings (floor topping or ceiling)

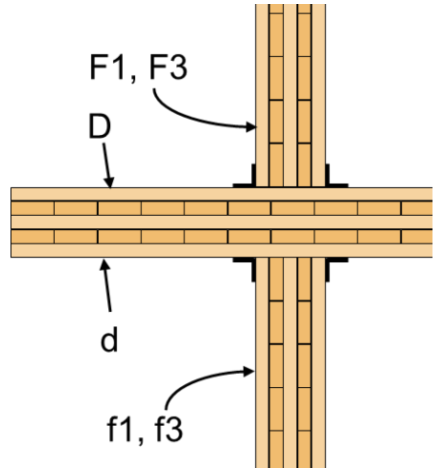
Junction 1, 3 or 4: Separating floor / walls with:
- 5-ply 175 mm thick CLT wall assembly with mass 94.1 kg/m^2, above and below cross-junctions with separating assembly that is continuous or lapped and glued across these junctions
- CLT wall assembly oriented so face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to the wall assemblies and to the floor assembly
- No added lining on walls

Junction 2: Separating floor / walls with:
- 5-ply 175 mm thick CLT wall assembly with mass 94.1 kg/m^2, above and below T-junction with separating assembly that terminates at this junction
- CLT wall assembly oriented so face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to one side of the wall assembly and to the abutting floor assemblies
- No added lining on walls

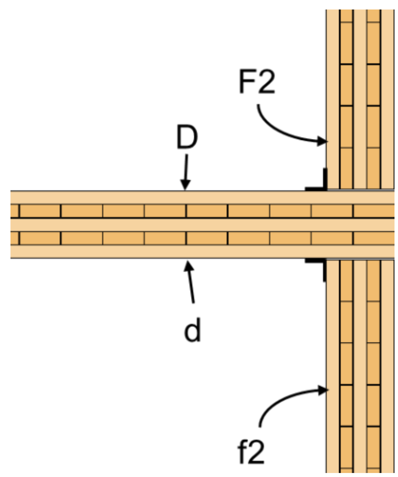
Acoustical Parameters:

Separating partition area (m^2) =			20.0	
Wall/separating floor junction length (m) =			5.0	
Wall/separating floor junction length (m) =			4.0	
	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3 and 4:				
Kij [dB] =	17.6	10.2	10.2	RR-335, CLT-FW-Xa-05
10*log(Sep. Area/Junction) =	6.0	For Junctions 1 and 3		
10*log(Sep. Area/Junction) =	7.0	For Junction 4		
For Junction 2:				
Kij [dB] =	12.9	6.8	6.8	RR-335, CLT-FW-Ta-05
10*log(Sep. Area/Junction) =	7.0			

Illustration for this case



Cross-junction of separating floor of continuous 175 mm thick 5-ply CLT with 5-ply CLT wall assemblies above and below.
(Side view of Junctions 1, 3 and 4, except orientation of floor assemblies differs for Junction 4)



T-junction of 175 mm thick 5-ply CLT floor with 5-ply CLT walls above and below.
(Side view of Junction 2)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (175 mm 5-ply CLT)				
Laboratory STC for Dd	R_s,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on D	ΔR_D,w	No Lining	0	
ΔSTC change by Lining on d	ΔR_d,w	No Lining	0	
If airborne flanking or bare CLT		RR-335, STC(Bare CLT05) - STC(Base CLT05)	-1	
Direct STC in-situ	R_Dd,w	RR-335, Eq. 4.1.2	42 + MAX(0,0) + MIN(0,0)/2 + -1 =	**41**
Junction 1 (Cross-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F1	ΔR_F1,w	No Lining	0	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f1	ΔR_f1,w	No Lining	0	
Flanking STC for path Ff_1	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(0,0) + MIN(0,0)/2 + 17.6 + 6 =	**66**
Flanking STC for path Fd_1	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(0,0) + MIN(0,0)/2 + 10.2 + 6 =	**58**
Flanking STC for path Df_1	R_ Df,w	RR-335, Eq. 4.1.3	42/2 + 42/2 +MAX(0,0) + MIN(0,0)/2 + 10.2 + 6 =	**58**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.6 + 10^- 5.8 + 10^- 5.8) =	55
Junction 2 (T-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)				
Flanking Element F2:				
Laboratory STC for F2	R_F2,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F2	ΔR_F2,w	No Lining	0	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f2	ΔR_f2,w	No Lining	0	
Flanking STC for path Ff_2	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(0,0) + MIN(0,0)/2 + 12.9 + 7 =	**62**
Flanking STC for path Fd_2	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(0,0) + MIN(0,0)/2 + 6.8 + 7 =	**56**
Flanking STC for path Df_2	R_ Df,w	RR-335, Eq. 4.1.3	42/2 + 42/2 +MAX(0,0) + MIN(0,0)/2 + 6.8 + 7 =	**56**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.2 + 10^- 5.6 + 10^- 5.6) =	52
Junction 3 (Cross-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)				
Flanking Element F3:				
Laboratory STC for F3	R_F3,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F3	ΔR_F3,w	No Lining	0	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f3	ΔR_f3,w	No Lining	0	
Flanking STC for path Ff_3	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(0,0) + MIN(0,0)/2 + 17.6 + 6 =	**66**
Flanking STC for path Fd_3	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(0,0) + MIN(0,0)/2 + 10.2 + 6 =	**58**
Flanking STC for path Df_3	R_ Df,w	RR-335, Eq. 4.1.3	42/2 + 42/2 +MAX(0,0) + MIN(0,0)/2 + 10.2 + 6 =	**58**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.6 + 10^- 5.8 + 10^- 5.8) =	55
Junction 4 (Cross-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)				
Flanking Element F4:				
Laboratory STC for F4	R_F4,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F4	ΔR_F4,w	No Lining	0	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f4	ΔR_f4,w	No Lining	0	
Flanking STC for path Ff_4	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(0,0) + MIN(0,0)/2 + 17.6 + 7 =	**67**
Flanking STC for path Fd_4	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(0,0) + MIN(0,0)/2 + 10.2 + 7 =	**59**
Flanking STC for path Df_4	R_ Df,w	RR-335, Eq. 4.1.3	42/2 + 42/2 +MAX(0,0) + MIN(0,0)/2 + 10.2 + 7 =	**59**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.7 + 10^- 5.9 + 10^- 5.9) =	56
Total Flanking STC (for all 4 junctions)		Subset of Eq. 4.1.1	Combining all 12 Flanking STC values:	48
ASTC due to Direct plus Flanking Paths		Eq. 4.1.1	**Combining Direct STC and 12 Flanking STC values:**	**40**

EXAMPLE 3.1-V2: (SIMPLIFIED METHOD)

- **Rooms one-above-the-other**
- **CLT Floors and CLT Walls**
  (Same as example 3.1-V1, plus linings)

<u>Separating floor assembly with:</u>

- 5-ply 175 mm thick CLT floor assembly with mass 92.1 kg/m^2, continuous through cross-junction with CLT wall assemblies at Junctions 1 and 3 and oriented so that face ply strands are perpendicular to loadbearing Junctions 1 and 3
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting wall assemblies
- Floor lining of 38 mm concrete over 13 mm wood fiber board
- Ceiling lining of 15.9 mm gypsum board[4] fastened to hat-channels supported on cross-channels hung on wires, cavity of 150 mm between CLT and ceiling, with 140 mm absorptive material[3]

<u>Junction 1, 3 or 4: (separating floor / flanking walls) with:</u>

- 5-ply 175 mm thick CLT wall assembly with mass 94.1 kg/m^2, above and below cross-junctions with separating assembly that is continuous or lapped and glued across these junctions
- CLT wall assembly oriented so face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to the wall assemblies and to the floor assembly
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

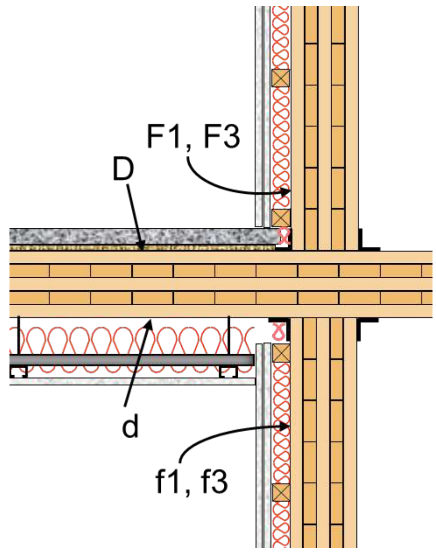
<u>Junction 2: Each Side (separating floor / flanking walls) with:</u>

- 5-ply 175 mm thick CLT wall assembly with mass 94.1 kg/m^2, above and below T-junction with separating assembly that terminates at this junction
- CLT wall assembly oriented so face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to one side of the wall assembly and to the abutting floor assemblies
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

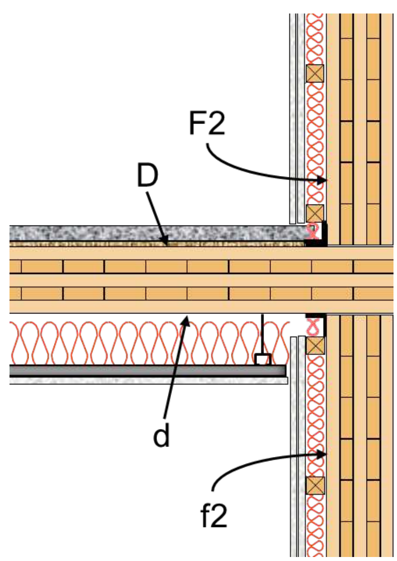
<u>Acoustical Parameters:</u>

Separating partition area (m^2) =			20.0	
Wall/separating floor junction length (m) =			5.0	
Wall/separating floor junction length (m) =			4.0	
	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3 and 4:				
Kij [dB] =	17.6	10.2	10.2	RR-335, CLT-FW-Xa-05
10*log(Sep. Area/Junction) =	6.0	For Junctions 1 and 3		
10*log(Sep. Area/Junction) =	7.0	For Junction 4		
For Junction 2:				
Kij [dB] =	12.9	6.8	6.8	RR-335, CLT-FW-Ta-05
10*log(Sep. Area/Junction) =	7.0			

Illustration for this case



Cross-junction of separating floor of continuous 175 mm thick 5-ply CLT with 5-ply CLT walls above and below.
(Side view of Junctions 1, 3 and 4, except orientation of floor assemblies differs for Junction 4)



T-junction of 175 mm thick 5-ply CLT floor with 5-ply CLT walls above and below.
(Side view of Junction 2)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (175 mm 5-ply CLT)				
Laboratory STC for Dd	R_s,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on D	ΔR_D,w	RR-335, ΔTL-CLT-F03	10	
ΔSTC change by Lining on d	ΔR_d,w	RR-335, ΔTL-CLT-C03	25	
If airborne flanking or bare CLT		RR-335, STC(Bare CLT05) - STC(Base CLT05)	N/A	
Direct STC in-situ	R_Dd,w	RR-335, Eq. 4.1.2	42 + MAX(10,25) + MIN(10,25)/2 =	**72**
Junction 1 (Cross-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F1	ΔR_F1,w	RR-335, ΔTL-CLT05-W03	8	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f1	ΔR_f1,w	RR-335, ΔTL-CLT05-W03	8	
Flanking STC for path Ff_1	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(8,8) + MIN(8,8)/2 + 17.6 + 6 =	**78**
Flanking STC for path Fd_1	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(8,25) + MIN(8,25)/2 + 10.2 + 6 =	**87**
Flanking STC for path Df_1	R_ Df,w	RR-335, Eq. 4.1.3	42/2 + 42/2 +MAX(10,8) + MIN(10,8)/2 + 10.2 + 6 =	**72**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7.8 + 10^- 8.7 + 10^- 7.2) =	71
Junction 2 (T-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)				
Flanking Element F2:				
Laboratory STC for F2	R_F2,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F2	ΔR_F2,w	RR-335, ΔTL-CLT05-W03	8	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f2	ΔR_f2,w	RR-335, ΔTL-CLT05-W03	8	
Flanking STC for path Ff_2	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(8,8) + MIN(8,8)/2 + 12.9 + 7 =	**74**
Flanking STC for path Fd_2	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(8,25) + MIN(8,25)/2 + 6.8 + 7 =	**85**
Flanking STC for path Df_2	R_ Df,w	RR-335, Eq. 4.1.3	42/2 + 42/2 +MAX(10,8) + MIN(10,8)/2 + 6.8 + 7 =	**70**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7.4 + 10^- 8.5 + 10^- 7) =	68
Junction 3 (Cross-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)				
Flanking Element F3:				
Laboratory STC for F3	R_F3,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F3	ΔR_F3,w	RR-335, ΔTL-CLT05-W03	8	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f3	ΔR_f3,w	RR-335, ΔTL-CLT05-W03	8	
Flanking STC for path Ff_3	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(8,8) + MIN(8,8)/2 + 17.6 + 6 =	**78**
Flanking STC for path Fd_3	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(8,25) + MIN(8,25)/2 + 10.2 + 6 =	**87**
Flanking STC for path Df_3	R_ Df,w	RR-335, Eq. 4.1.3	42/2 + 42/2 +MAX(10,8) + MIN(10,8)/2 + 10.2 + 6 =	**72**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7.8 + 10^- 8.7 + 10^- 7.2) =	71
Junction 4 (Cross-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)				
Flanking Element F4:				
Laboratory STC for F4	R_F4,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F4	ΔR_F4,w	RR-335, ΔTL-CLT05-W03	8	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f4	ΔR_f4,w	RR-335, ΔTL-CLT05-W03	8	
Flanking STC for path Ff_4	R_ Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(8,8) + MIN(8,8)/2 + 17.6 + 7 =	**79**
Flanking STC for path Fd_4	R_ Fd,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(8,25) + MIN(8,25)/2 + 10.2 + 7 =	**88**
Flanking STC for path Df_4	R_ Df,w	RR-335, Eq. 4.1.3	42/2 + 42/2 +MAX(10,8) + MIN(10,8)/2 + 10.2 + 7 =	**73**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7.9 + 10^- 8.8 + 10^- 7.3) =	72
Total Flanking STC (for all 4 junctions)		Subset of Eq. 4.1.1	Combining all 12 Flanking STC values:	64
ASTC due to Direct plus Flanking Paths		Eq. 4.1.1	**Combining Direct STC and 12 Flanking STC values:**	**64**

Summary for Section 3.1: Calculation Examples using the Simplified Method

The worked examples (3.1-H1 to H3 and 3.1-V1 to V2) illustrate the use of the Simplified Method for calculating the sound transmission between rooms in a building with CLT floor and wall assemblies, with or without linings added to some or all of the walls and floors.

The examples show the performance for two cases with bare CLT assemblies without linings (Examples 3.1-H1 and 3.1-V1) and for three cases with improvements in direct and/or flanking sound transmission loss via specific paths due to the addition of some common types of linings using gypsum board, supporting framing, and sound absorbing material. Many other lining options are possible using the ΔSTC values for linings in NRC Research Report RR-335, "Apparent Sound Insulation in CLT Buildings."

For a side-by-side pair of rooms, Examples 3.1-H2 and 3.1-H3 show typical improvements relative to Example 3.1-H1. Even with the rather light 3-ply CLT separating wall assembly, the addition of a gypsum board lining screwed directly to wood furring on all wall surfaces (Example 3.1-H2) brings the ASTC rating up to 48. Inspection of the path STC ratings in Example 3.1-H2 shows that direct sound transmission through the separating wall is dominant, and that flanking paths involving the surfaces of the separating wall are also significant. Improving these weak paths by adding resilient channels to the lining on the separating wall, raises the Direct STC to 59 and the overall ASTC rating to 52. Further improvement is possible but would require changes to all the flanking surfaces to raise the value above ASTC 60.

For a vertical room pair, Example 3.1-V2 shows the improvement relative to Example 3.1-V1 when some typical linings are added. Even with rather basic wall linings with ΔSTC = 8, the ASTC rating is increased to 64, and higher values could be achieved by better wall linings and/or improvements to the floor surface.

Section 3.2 presents worked examples for the same set of constructions presented in Section 3.1, but uses the Detailed Method for calculating the sound transmission between rooms. Comparison of the corresponding examples in the two sections provides a clear indication of the difference in results with the two calculation methods.

3.2. Detailed Calculation Procedure for CLT Constructions

The calculation process of the Detailed Method of ISO 15712-1 is designed for constructions involving heavy, homogeneous building elements which support reverberant vibration fields. Although CLT assemblies have lower mass and higher internal losses than the heavy concrete and masonry walls and floor assemblies considered in Chapter 2, flanking sound transmission in buildings composed of CLT assemblies can also be predicted using the Detailed Method of ISO 15712-1. However, the differences between CLT assemblies and walls or floors of bare concrete or masonry require some changes to the calculation approach and the laboratory test data required as inputs.

There are five key changes in the calculations due to properties of CLT assemblies and their junctions:

1. The internal loss factors for CLT assemblies are much higher than those typical of concrete and masonry (which range from 0.006 for solid concrete to 0.015 for typical concrete masonry). For CLT assemblies, measurements of the loss factors for laboratory wall and floor assemblies have established values of 0.03 or higher for most of the frequency range of interest (see Section 2.4 in NRC Research Report RR-335). This is above the threshold specified in ISO 15712-1 above which the effect of edge losses can be safely ignored, and hence there is no need to apply an absorption correction to obtain the in-situ sound transmission loss from the laboratory sound transmission loss in Equation 19 of ISO 15712-1. Thus, the direct sound transmission loss of the bare separating CLT wall or floor (and the in-situ sound transmission loss for each bare CLT flanking surface) is taken as equal to the laboratory sound transmission loss determined according to ASTM E90.
2. For flanking surfaces, Section 4.2.2 in ISO 15712-1 notes that only resonant sound transmission should be included. This requires a correction of the sound transmission loss measured in the laboratory below the critical frequency. For bare concrete and masonry assemblies, the critical frequency is below 125 Hz, so no correction to remove the non-resonant sound transmission is needed. For 3-ply CLT assemblies, the critical frequency is about 500 Hz, i.e. in the middle of the frequency range of interest when calculating the ASTC rating. Corrections to the laboratory sound transmission loss are therefore recommended at lower frequencies. Unfortunately, the current version of ISO 15712-1 does not specify a method to obtain the resonant sound transmission loss from the measured sound transmission loss. Hence, in the procedure below and in the worked examples, the uncorrected laboratory sound transmission loss is used as input data. This should lead to conservative results, especially for the flanking sound transmission loss of thin 3-ply CLT assemblies.
3. The effect of adding linings to the surfaces of CLT wall and floor assemblies can be treated with an additive correction, as for concrete and masonry assemblies (see discussion in Section 2.3 of this Guide). Because the mass of the CLT assemblies is much closer to that of typical linings than it is for the concrete and masonry assemblies in Section 2.3, the improvement due to linings is affected by the mass of the bare assembly. Data on the improvements due to linings for several common types of CLT assemblies are provided in NRC Research Report RR-335.

4. Because the connections provided by angle brackets at CLT junctions are not consistent with the symmetric rigid junction assumptions of Annex E of ISO 15712-1 (which are suitable for mortar-bonded junctions of concrete and masonry), the junction attenuation for a range of cases needs to be determined using measurements of junction transmission following the appropriate parts of ISO 10848. NRC Research Report RR-335 provides vibration reduction index data for a variety of floor/wall and wall/wall CLT junctions.
5. Because of the high internal losses in CLT assemblies, the equivalent absorption length a_{situ} is set numerically equal to the surface area of the CLT assembly when calculating the velocity level difference from measured K_{ij} values using Equation 21 of ISO 15712-1, following Section 4.2.2 of ISO 15712-1.

The input data required for the calculations include both laboratory sound transmission loss data measured according to ASTM E90 (for the Base CLT assemblies and for the change in sound transmission loss due to linings applied to these assemblies) and junction attenuation data measured according to ISO 10848.

The calculation process follows the steps illustrated in Figure 3.2.1, and explained in detail below.

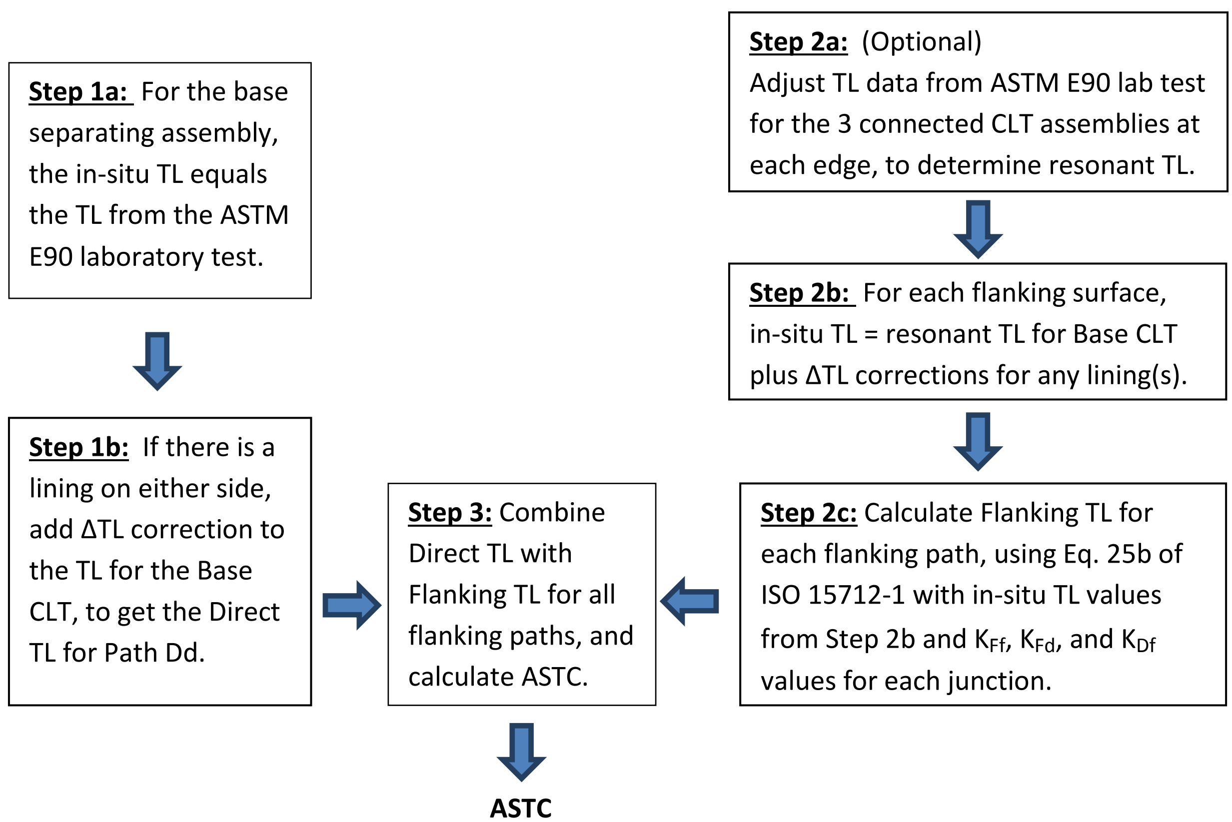


Figure 3.2.1: Steps to calculate the ASTC using the Detailed Method.

Step 1: Determine the sound transmission loss of the separating assembly (Direct TL):

(a) For the base separating assembly, the in-situ sound transmission loss for each frequency is equal to the sound transmission loss measured in the laboratory according to ASTM E90.

(b) Add ΔTL corrections obtained following the procedures of ASTM E90 for changes due to added lining(s) on the source room and/or receiving room side of the separating assembly (surfaces D and d) to obtain the Direct TL.

Step 2: Determine the sound transmission loss of the flanking assemblies (Flanking TL):

(a) For each flanking surface, use the laboratory sound transmission loss determined according to ASTM E90 as a conservative estimate of the resonant sound transmission loss. A correction to calculate the resonant sound transmission loss is recommended in ISO 15712-1, but not defined, and hence not used here. Set the equivalent absorption length for each surface numerically equal to the area of the CLT assembly, as required in Section 4.2.2 of ISO 15712-1.

(b) Add ΔTL corrections, obtained in accordance with ASTM E90 for changes due to adding a lining on a matching CLT assembly, to calculate the in-situ sound transmission loss values.

(c) For each flanking path, combine the values of the vibration reduction index (K_{Ff}, K_{Fd}, and K_{Df} measured following the procedures of ISO 10848) with in-situ sound transmission loss values (including the change due to linings from Step 2b) using Eq. 25b of ISO 15712-1 to obtain the Flanking TL values.

Step 3: Calculate the Apparent TL by combining Direct TL and Flanking TL:

Combine the sound transmission via the direct path and the flanking paths, using Equation 1.1 in Chapter 1 of this Guide (equivalent to Eq. 26 in Section 4.4 of ISO 15712-1), and calculate the ASTC rating using the combined sound transmission loss values as apparent transmission loss in the procedure of ASTM E413.

Worked Examples

This section presents a number of worked examples that demonstrate the calculation of sound transmission in CLT constructions according to the Detailed Method. Each worked example 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.

Within the table for each worked example, the “References” column presents the source of input data (combining the NRC report number and identifier for each laboratory test result or derived result), or identifies applicable equations and sections of ISO 15712-1 at each stage of the calculation. Symbols and subscripts identifying the corresponding variable in ISO 15712-1 are given in the adjacent column.

Under the single heading “STC or ASTC” the examples present single-number ratings at each step (calculated from a set of one-third octave band data according to the rules for STC ratings defined in ASTM E413) to provide a consistent set of summary measures at each stage of the calculation:

- STC ratings for laboratory sound transmission loss data for wall or floor assemblies;
- Direct STC ratings for the in-situ sound transmission through the separating assembly including linings;
- Flanking STC ratings for each flanking sound transmission path including the change due to linings;
- ASTC ratings for the combination of direct and flanking sound transmission paths.

Note that these STC ratings shown at each stage of the calculation are presented only to provide readers with a convenient indication of the relative strength of the 13 sound transmission paths. The actual calculation at each step is performed in the individual one-third octave bands, and at the final steps, the sound transmission loss values for the 13 paths are combined to arrive at the overall apparent sound transmission loss (ATL) for each frequency band. These one-third octave values of ATL are used as inputs to the calculation of ASTM E413 to determine the ASTC rating.

When the calculated Flanking TL 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 90 dB limit is that the Junction TL for the set of 3 paths at each edge of the separating assembly cannot exceed 85 and the Total Flanking TL for all 4 edges cannot exceed 79.

The tables present extracts from calculations performed with a more detailed spreadsheet that includes values for all the one-third octave bands from 125 Hz to 4 kHz. To condense the examples to 2-page format, the extracts here present just the single-number ratings (such as ASTC and Path STC) and a subset of the calculated values for some one-third octave frequency bands.

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.

All examples conform to the Standard Scenario presented in Section 1.2 of this Guide. The worked examples include both scenarios for CLT wall and floor assemblies without linings and scenarios where linings are included, for the same set of cases presented in Section 4.2.

EXAMPLE 3.2-H1: (DETAILED METHOD)

- **Rooms side-by-side**
- **Bare CLT Floors and CLT Walls**

Separating wall assembly (loadbearing) with:
- 3-ply 78 mm thick CLT wall assembly with mass 42.4 kg/m^2, oriented so that face ply strands are vertical
- No added linings on either side

Junction 1: Bottom Junction (separating wall / floor) with:
- 5-ply 175 mm thick CLT floor assembly with mass 92.1 kg/m^2, continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- No added topping or flooring

Junction 2 or 4: Each Side (separating wall / abutting side wall) with:
- 3-ply 78 mm thick CLT wall assembly with mass 42.4 kg/m^2, continuous through T-junction with separating assembly and oriented so that face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 600 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- No added linings

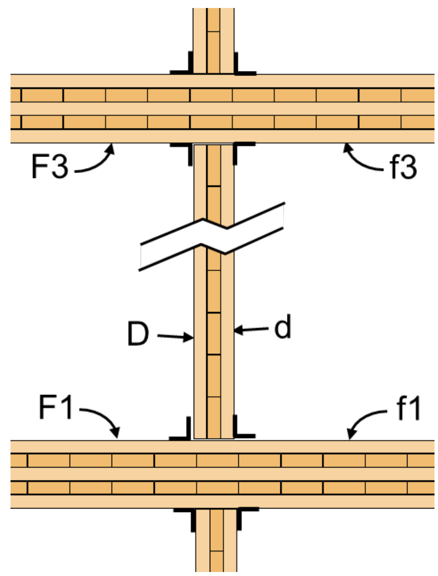
Junction 3: Top Junction (separating wall / ceiling) with:
- 5-ply 175 mm thick CLT ceiling assembly with mass 92.1 kg/m^2, continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- No added ceiling lining

Acoustical Parameters:

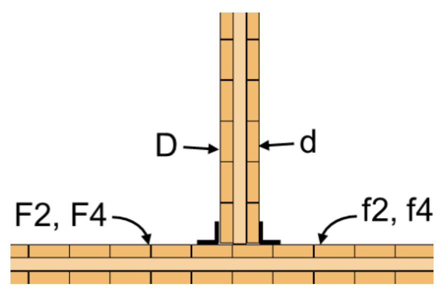
Separating wall area (m^2) =	12.5	Sep. wall internal loss, η_i =	>0.03
Floor/sep. wall junction (m) =	5.0	Floor internal loss, η_i =	>0.03
Wall/sep. wall junction (m) =	2.5	Flanking wall int. loss, η_i =	>0.03

	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3:				
Kij [dB] =	1.1	10.5	10.5	RR-335, CLT-WF-Xa-01
10*log(Sep. Area/Junction) =	4.0			or CLT-WC-Xa-01
For Junctions 2 and 4:				
Kij [dB] =	3.5	5.7	5.7	RR-335, CLT-WW-Tb-01
10*log(Sep. Area/Junction) =	7.0			

Illustration for this case



Cross-junctions of 78 mm thick 3-ply CLT separating wall with 175 mm thick 5-ply CLT floor and ceiling.
(Side view of Junctions 1 and 3)



T-junction of separating wall with side wall, both of 78 mm thick 3-ply CLT.
(Plan view of Junctions 2 and 4)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (78 mm 3-ply CLT)									
Laboratory Transmission Loss	R_D,lab	RR-335, Base CLT03	26	28	31	37	46	50	36
Correction Resonant Transmission		N/A	0	0	0	0	0	0	
ΔTL change by Lining on D	ΔR_D	No Lining	0	0	0	0	0	0	
ΔTL change by Lining on d	ΔR_d	No Lining	0	0	0	0	0	0	
If airborne flanking or bare CLT		RR-335, TL(Bare CLT03) - TL(Base CLT03)	-1	-3	-3	-3	-4	-1	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**25**	**25**	**28**	**34**	**42**	**49**	**33**
Junction 1 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Floor)									
Transmission Loss of Flanking Elements									
TL of element F1, laboratory	R_F1,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
TL of element f1, laboratory	R_f1,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
Correction Resonant Transmission F1		N/A	0	0	0	0	0	0	
Correction Resonant Transmission f1		N/A	0	0	0	0	0	0	
TL of element F1, in-situ	R_F1,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
TL of element f1, in-situ	R_f1,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
ΔTL change by Lining on F	ΔR_F1	No Lining	0	0	0	0	0	0	
ΔTL change by Lining on f	ΔR_f1	No Lining	0	0	0	0	0	0	
Junction Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, CLT-WF-Xa-01	1.1	1.1	1.1	1.1	1.1	1.1	
Vibration Reduction Index for Fd	K_Fd,1	RR-335, CLT-WF-Xa-01	10.5	10.5	10.5	10.5	10.5	10.5	
Vibration Reduction Index for Df	K_Df,1	RR-335, CLT-WF-Xa-01	10.5	10.5	10.5	10.5	10.5	10.5	
Flanking Transmission Loss									
Flanking TL for path Ff_1	R_ Ff	ISO 15712-1, Eq. 25b	**37**	**35**	**44**	**48**	**57**	**54**	**47**
Flanking TL for path Fd_1	R_ Fd	ISO 15712-1, Eq. 25b	**44**	**44**	**50**	**55**	**64**	**64**	**54**
Flanking TL for path Df_1	R_ Df	ISO 15712-1, Eq. 25b	**44**	**44**	**50**	**55**	**64**	**64**	**54**
Junction 1: Flanking TL for all paths			36	34	42	47	56	53	46
Junction 2 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)									
Transmission Loss of Flanking Elements									
TL of element F2, laboratory	R_F2,lab	RR-335, Base CLT03	26	28	31	37	46	50	36
TL of element f2, laboratory	R_f2,lab	RR-335, Base CLT03	26	28	31	37	46	50	36
Correction Resonant Transmission F2		N/A	0	0	0	0	0	0	
Correction Resonant Transmission f2		N/A	0	0	0	0	0	0	
TL of element F2, in-situ	R_F2,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	26	28	31	37	46	50	36
TL of element f2, in-situ	R_f2,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	26	28	31	37	46	50	36
ΔTL change by Lining on F	ΔR_F2	No Lining	0	0	0	0	0	0	
ΔTL change by Lining on f	ΔR_f2	No Lining	0	0	0	0	0	0	
Junction Coupling									
Vibration Reduction Index for Ff	K_Ff,2	RR-335, CLT-WW-Tb-01	3.5	3.5	3.5	3.5	3.5	3.5	
Vibration Reduction Index for Fd	K_Fd,2	RR-335, CLT-WW-Tb-01	5.7	5.7	5.7	5.7	5.7	5.7	
Vibration Reduction Index for Df	K_Df,2	RR-335, CLT-WW-Tb-01	5.7	5.7	5.7	5.7	5.7	5.7	
Flanking Transmission Loss									
Flanking TL for path Ff_2	R_ Ff	ISO 15712-1, Eq. 25b	**37**	**39**	**42**	**48**	**57**	**61**	**47**
Flanking TL for path Fd_2	R_ Fd	ISO 15712-1, Eq. 25b	**39**	**41**	**44**	**50**	**59**	**63**	**49**
Flanking TL for path Df_2	R_ Df	ISO 15712-1, Eq. 25b	**39**	**41**	**44**	**50**	**59**	**63**	**49**
Junction 2: Flanking TL for all paths			33	35	38	44	53	57	43
Junction 3 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Ceiling)									
All values the same as for Junction 1									
Flanking TL for path Ff_3	R_ Ff	ISO 15712-1, Eq. 25b	**37**	**35**	**44**	**48**	**57**	**54**	**47**
Flanking TL for path Fd_3	R_ Fd	ISO 15712-1, Eq. 25b	**44**	**44**	**50**	**55**	**64**	**64**	**54**
Flanking TL for path Df_3	R_ Df	ISO 15712-1, Eq. 25b	**44**	**44**	**50**	**55**	**64**	**64**	**54**
Junction 3: Flanking TL for all paths			36	34	42	47	56	53	46
Junction 4 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)									
All values the same as for Junction 2									
Flanking TL for path Ff_4	R_ Ff	ISO 15712-1, Eq. 25b	**37**	**39**	**42**	**48**	**57**	**61**	**47**
Flanking TL for path Fd_4	R_ Fd	ISO 15712-1, Eq. 25b	**39**	**41**	**44**	**50**	**59**	**63**	**49**
Flanking TL for path Df_4	R_ Df	ISO 15712-1, Eq. 25b	**39**	**41**	**44**	**50**	**59**	**63**	**49**
Junction 4: Flanking TL for all paths			33	35	38	44	53	57	43
Total Flanking (for all 4 junctions)			28	29	34	39	48	49	38
ASTC due to Direct plus Flanking Paths		RR-335, Eq. 1.1	**23**	**23**	**27**	**33**	**41**	**46**	**32**

EXAMPLE 3.2-H2: (DETAILED METHOD)

- **Rooms side-by-side**
- **CLT Floors and CLT Walls**
  (Same as example 3.2-H1, plus linings)

Separating wall assembly (loadbearing) with:
- 3-ply 78 mm thick CLT wall assembly with mass 42.4 kg/m², oriented so that face ply strands are vertical
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

Junction 1: Bottom Junction (separating wall / floor) with:
- 5-ply 175 mm thick CLT floor assembly with mass 92.1 kg/m², continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Floor lining of 38 mm concrete over 13 mm wood fiber board

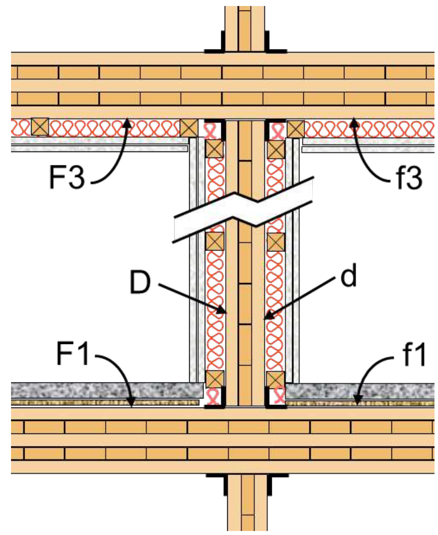
Junction 2 or 4: Each Side (separating wall / abutting side wall) with:
- 3-ply 78 mm thick CLT wall assembly with mass 42.4 kg/m², continuous through T-junction with separating assembly and oriented so that face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 600 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

Junction 3: Top Junction (separating wall / ceiling) with:
- 5-ply 175 mm thick CLT ceiling assembly with mass 92.1 kg/m², continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

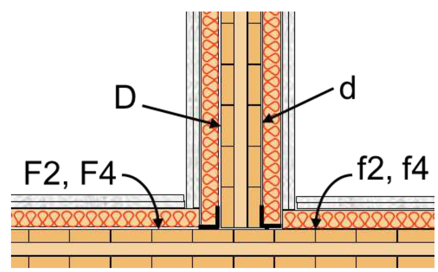
Acoustical Parameters:

Separating wall area (m²) =	12.5	Sep. wall internal loss, η_i =		>0.03
Floor/sep. wall junction (m) =	5.0	Floor internal loss, η_i =		>0.03
Wall/sep. wall junction (m) =	2.5	Flanking wall int. loss, η_i =		>0.03
	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3:				
Kij [dB] =	1.1	10.5	10.5	RR-335, CLT-WF-Xa-01
10*log(Sep. Area/Junction) =	4.0			or CLT-WC-Xa-01
For Junctions 2 and 4:				
Kij [dB] =	3.5	5.7	5.7	RR-335, CLT-WW-Tb-01
10*log(Sep. Area/Junction) =	7.0			

Illustration for this case



Cross-junctions of 78 mm thick 3-ply CLT separating wall with 150 mm thick 5-ply CLT floor and ceiling.
(Side view of Junctions 1 and 3)



T-junction of separating wall with side wall, both of 78 mm thick 3-ply CLT.
(Plan view of Junctions 2 and 4)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (78 mm 3-ply CLT)									
Laboratory Transmission Loss	R_D,lab	RR-335, Base CLT03	26	28	31	37	46	50	36
Correction Resonant Transmission		N/A	0	0	0	0	0	0	
ΔTL change by Lining on D	ΔR_D	RR-335, ΔTL-CLT03-W03	4	7	9	12	10	10	
ΔTL change by Lining on d	ΔR_d	RR-335, ΔTL-CLT03-W03	4	7	9	12	10	10	
If airborne flanking or bare CLT		N/A	0	0	0	0	0	0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**34**	**42**	**49**	**61**	**66**	**70**	**52**
Junction 1 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Floor)									
Transmission Loss of Flanking Elements									
TL of element F1, laboratory	R_F1,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
TL of element f1, laboratory	R_f1,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
Correction Resonant Transmission F1		N/A	0	0	0	0	0	0	
Correction Resonant Transmission f1		N/A	0	0	0	0	0	0	
TL of element F1, in-situ	R_F1,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
TL of element f1, in-situ	R_f1,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
ΔTL change by Lining on F	ΔR_F1	RR-335, ΔTL-CLT-F03	4	11	8	21	29	32	
ΔTL change by Lining on f	ΔR_f1	RR-335, ΔTL-CLT-F03	4	11	8	21	29	32	
Junction Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, CLT-WF-Xa-01	1.1	1.1	1.1	1.1	1.1	1.1	
Vibration Reduction Index for Fd	K_Fd,1	RR-335, CLT-WF-Xa-01	10.5	10.5	10.5	10.5	10.5	10.5	
Vibration Reduction Index for Df	K_Df,1	RR-335, CLT-WF-Xa-01	10.5	10.5	10.5	10.5	10.5	10.5	
Flanking Transmission Loss									
Flanking TL for path Ff_1	R_ Ff	ISO 15712-1, Eq. 25b	**45**	**57**	**60**	**90**	**90**	**90**	**67**
Flanking TL for path Fd_1	R_ Fd	ISO 15712-1, Eq. 25b	**52**	**62**	**67**	**88**	**90**	**90**	**73**
Flanking TL for path Df_1	R_ Df	ISO 15712-1, Eq. 25b	**52**	**62**	**67**	**88**	**90**	**90**	**73**
Junction 1: Flanking TL for all paths			44	55	59	84	85	85	65
Junction 2 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)									
Transmission Loss of Flanking Elements									
TL of element F2, laboratory	R_F2,lab	RR-335, Base CLT03	26	28	31	37	46	50	36
TL of element f2, laboratory	R_f2,lab	RR-335, Base CLT03	26	28	31	37	46	50	36
Correction Resonant Transmission F2		N/A	0	0	0	0	0	0	
Correction Resonant Transmission f2		N/A	0	0	0	0	0	0	
TL of element F2, in-situ	R_F2,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	26	28	31	37	46	50	36
TL of element f2, in-situ	R_f2,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	26	28	31	37	46	50	36
ΔTL change by Lining on F	ΔR_F2	RR-335, ΔTL-CLT03-W03	4	7	9	12	10	10	
ΔTL change by Lining on f	ΔR_f2	RR-335, ΔTL-CLT03-W03	4	7	9	12	10	10	
Junction Coupling									
Vibration Reduction Index for Ff	K_Ff,2	RR-335, CLT-WW-Tb-01	3.5	3.5	3.5	3.5	3.5	3.5	
Vibration Reduction Index for Fd	K_Fd,2	RR-335, CLT-WW-Tb-01	5.7	5.7	5.7	5.7	5.7	5.7	
Vibration Reduction Index for Df	K_Df,2	RR-335, CLT-WW-Tb-01	5.7	5.7	5.7	5.7	5.7	5.7	
Flanking Transmission Loss									
Flanking TL for path Ff_2	R_ Ff	ISO 15712-1, Eq. 25b	**45**	**53**	**60**	**72**	**77**	**81**	**63**
Flanking TL for path Fd_2	R_ Fd	ISO 15712-1, Eq. 25b	**47**	**55**	**62**	**74**	**79**	**83**	**65**
Flanking TL for path Df_2	R_ Df	ISO 15712-1, Eq. 25b	**47**	**55**	**62**	**74**	**79**	**83**	**65**
Junction 2: Flanking TL for all paths			41	49	56	68	73	77	59
Junction 3 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Ceiling)									
All values the same as for Junction 1, except linings									
ΔTL change by Lining on F	ΔR_F3	RR-335, ΔTL-CLT-C01	2	11	5	12	11	11	
ΔTL change by Lining on f	ΔR_f3	RR-335, ΔTL-CLT-C01	2	11	5	12	11	11	
Flanking Transmission Loss									
Flanking TL for path Ff_3	R_ Ff	ISO 15712-1, Eq. 25b	**41**	**57**	**54**	**72**	**79**	**76**	**62**
Flanking TL for path Fd_3	R_ Fd	ISO 15712-1, Eq. 25b	**50**	**62**	**64**	**79**	**85**	**85**	**70**
Flanking TL for path Df_3	R_ Df	ISO 15712-1, Eq. 25b	**50**	**62**	**64**	**79**	**85**	**85**	**70**
Junction 3: Flanking TL for all paths			40	55	53	71	77	75	60
Junction 4 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)									
All values the same as for Junction 2									
Flanking TL for path Ff_4	R_ Ff	ISO 15712-1, Eq. 25b	**45**	**53**	**60**	**72**	**77**	**81**	**63**
Flanking TL for path Fd_4	R_ Fd	ISO 15712-1, Eq. 25b	**47**	**55**	**62**	**74**	**79**	**83**	**65**
Flanking TL for path Df_4	R_ Df	ISO 15712-1, Eq. 25b	**47**	**55**	**62**	**74**	**79**	**83**	**65**
Junction 4: Flanking TL for all paths			41	49	56	68	73	77	59
Total Flanking (for all 4 junctions)			35	45	50	64	70	72	55
ASTC due to Direct plus Flanking Paths		RR-335, Eq. 1.1	**32**	**40**	**46**	**59**	**64**	**68**	**50**

EXAMPLE 3.2-H3: (DETAILED METHOD)

- **Rooms side-by-side**
- **CLT Floors and CLT Walls**
  (Same as example 3.2-H2, except enhanced linings)

Separating wall assembly (loadbearing) with:
- 3-ply 78 mm thick CLT wall assembly with mass 42.4 kg/m^2, oriented so that face ply strands are vertical
- Two layers of 12.7 mm gypsum board[4] on resilient metal channels[7] spaced 600 mm o.c., on 38 x 38 mm wood furring spaced 400 mm o.c. with absorptive material[3] in cavities

Junction 1: Bottom Junction (separating wall / floor) with:
- 5-ply 175 mm thick CLT floor assembly with mass 92.1 kg/m^2, continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Floor lining of 38 mm concrete over 13 mm wood fiber board

Junction 2 or 4: Each Side (separating wall / abutting side wall) with:
- 3-ply 78 mm thick CLT wall assembly with mass 42.4 kg/m^2, continuous through T-junction with separating assembly and oriented so that face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 600 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

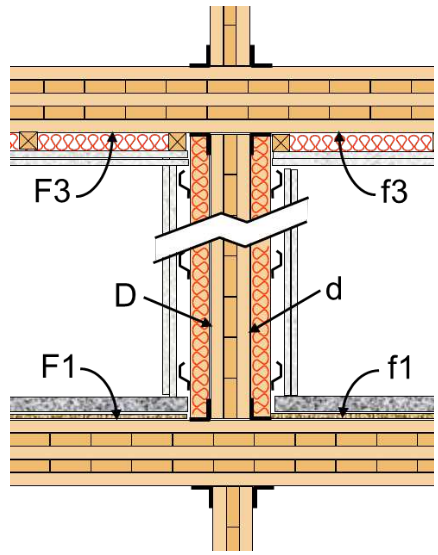
Junction 3: Top Junction (separating wall / ceiling) with:
- 5-ply 175 mm thick CLT ceiling assembly with mass 92.1 kg/m^2, continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

Acoustical Parameters:

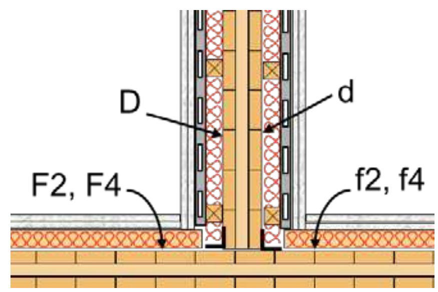
Separating wall area (m^2) =	12.5	Sep. wall internal loss, η_i =	>0.03
Floor/sep. wall junction (m) =	5.0	Floor internal loss, η_i =	>0.03
Wall/sep. wall junction (m) =	2.5	Flanking wall int. loss, η_i =	>0.03

	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3:				
Kij [dB] =	1.1	10.5	10.5	RR-335, CLT-WF-Xa-01
10*log(Sep. Area/Junction) =	4.0			or CLT-WC-Xa-01
For Junctions 2 and 4:				
Kij [dB] =	3.5	5.7	5.7	RR-335, CLT-WW-Tb-01
10*log(Sep. Area/Junction) =	7.0			

Illustration for this case



Cross-junctions of 78 mm thick 3-ply CLT separating wall with 150 mm thick 5-ply CLT floor and ceiling.
(Side view of Junctions 1 and 3)



T-junction of separating wall with side wall, both of 78 mm thick 3-ply CLT.
(Plan view of Junctions 2 and 4)

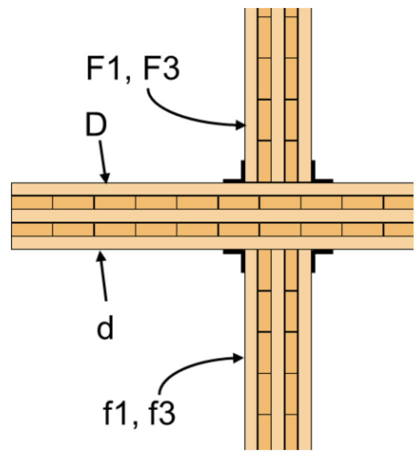
(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (78 mm 3-ply CLT)									
Laboratory Transmission Loss	R_D,lab	RR-335, Base CLT03	26	28	31	37	46	50	36
Correction Resonant Transmission		N/A	0	0	0	0	0	0	
ΔTL change by Lining on D	ΔR_D	RR-335, ΔTL-CLT-W04	6	17	20	24	20	22	
ΔTL change by Lining on d	ΔR_d	RR-335, ΔTL-CLT-W04	6	17	20	24	20	22	
If airborne flanking or bare CLT		N/A	0	0	0	0	0	0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**38**	**62**	**71**	**85**	**86**	**90**	**62**
Junction 1 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Floor)									
Transmission Loss of Flanking Elements									
TL of element F1, laboratory	R_F1,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
TL of element f1, laboratory	R_f1,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
Correction Resonant Transmission F1		N/A	0	0	0	0	0	0	
Correction Resonant Transmission f1		N/A	0	0	0	0	0	0	
TL of element F1, in-situ	R_F1,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
TL of element f1, in-situ	R_f1,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
ΔTL change by Lining on F	ΔR_F1	RR-335, ΔTL-CLT-F03	4	11	8	21	29	32	
ΔTL change by Lining on f	ΔR_f1	RR-335, ΔTL-CLT-F03	4	11	8	21	29	32	
Junction Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, CLT-WF-Xa-01	1.1	1.1	1.1	1.1	1.1	1.1	
Vibration Reduction Index for Fd	K_Fd,1	RR-335, CLT-WF-Xa-01	10.5	10.5	10.5	10.5	10.5	10.5	
Vibration Reduction Index for Df	K_Df,1	RR-335, CLT-WF-Xa-01	10.5	10.5	10.5	10.5	10.5	10.5	
Flanking Transmission Loss									
Flanking TL for path Ff_1	R_ Ff	ISO 15712-1, Eq. 25b	**45**	**57**	**60**	**90**	**90**	**90**	**67**
Flanking TL for path Fd_1	R_ Fd	ISO 15712-1, Eq. 25b	**54**	**72**	**78**	**90**	**90**	**90**	**78**
Flanking TL for path Df_1	R_ Df	ISO 15712-1, Eq. 25b	**54**	**72**	**78**	**90**	**90**	**90**	**78**
Junction 1: Flanking TL for all paths			44	57	60	85	85	85	67
Junction 2 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)									
Transmission Loss of Flanking Elements									
TL of element F2, laboratory	R_F2,lab	RR-335, Base CLT03	26	28	31	37	46	50	36
TL of element f2, laboratory	R_f2,lab	RR-335, Base CLT03	26	28	31	37	46	50	36
Correction Resonant Transmission F2		N/A	0	0	0	0	0	0	
Correction Resonant Transmission f2		N/A	0	0	0	0	0	0	
TL of element F2, in-situ	R_F2,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	26	28	31	37	46	50	36
TL of element f2, in-situ	R_f2,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	26	28	31	37	46	50	36
ΔTL change by Lining on F	ΔR_F2	RR-335, ΔTL-CLT03-W03	4	7	9	12	10	10	
ΔTL change by Lining on f	ΔR_f2	RR-335, ΔTL-CLT03-W03	4	7	9	12	10	10	
Junction Coupling									
Vibration Reduction Index for Ff	K_Ff,2	RR-335, CLT-WW-Tb-01	3.5	3.5	3.5	3.5	3.5	3.5	
Vibration Reduction Index for Fd	K_Fd,2	RR-335, CLT-WW-Tb-01	5.7	5.7	5.7	5.7	5.7	5.7	
Vibration Reduction Index for Df	K_Df,2	RR-335, CLT-WW-Tb-01	5.7	5.7	5.7	5.7	5.7	5.7	
Flanking Transmission Loss									
Flanking TL for path Ff_2	R_ Ff	ISO 15712-1, Eq. 25b	**45**	**53**	**60**	**72**	**77**	**81**	**63**
Flanking TL for path Fd_2	R_ Fd	ISO 15712-1, Eq. 25b	**49**	**65**	**73**	**86**	**89**	**90**	**73**
Flanking TL for path Df_2	R_ Df	ISO 15712-1, Eq. 25b	**49**	**65**	**73**	**86**	**89**	**90**	**73**
Junction 2: Flanking TL for all paths			42	52	60	72	76	80	63
Junction 3 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Ceiling)									
All values the same as for Junction 1, except linings									
ΔTL change by Lining on F	ΔR_F3	RR-335, ΔTL-CLT-C01	2	11	5	12	11	11	
ΔTL change by Lining on f	ΔR_f3	RR-335, ΔTL-CLT-C01	2	11	5	12	11	11	
Flanking Transmission Loss									
Flanking TL for path Ff_3	R_ Ff	ISO 15712-1, Eq. 25b	**41**	**57**	**54**	**72**	**79**	**76**	**62**
Flanking TL for path Fd_3	R_ Fd	ISO 15712-1, Eq. 25b	**52**	**72**	**75**	**90**	**90**	**90**	**76**
Flanking TL for path Df_3	R_ Df	ISO 15712-1, Eq. 25b	**52**	**72**	**75**	**90**	**90**	**90**	**76**
Junction 3: Flanking TL for all paths			40	57	54	72	78	76	61
Junction 4 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)									
All values the same as for Junction 2									
Flanking TL for path Ff_4	R_ Ff	ISO 15712-1, Eq. 25b	**45**	**53**	**60**	**72**	**77**	**81**	**63**
Flanking TL for path Fd_4	R_ Fd	ISO 15712-1, Eq. 25b	**49**	**65**	**73**	**86**	**89**	**90**	**73**
Flanking TL for path Df_4	R_ Df	ISO 15712-1, Eq. 25b	**49**	**65**	**73**	**86**	**89**	**90**	**73**
Junction 4: Flanking TL for all paths			42	52	60	72	76	80	63
Total Flanking (for all 4 junctions)			36	48	51	67	72	73	57
ASTC due to Direct plus Flanking Paths		RR-335, Eq. 1.1	**34**	**48**	**51**	**67**	**72**	**73**	**57**

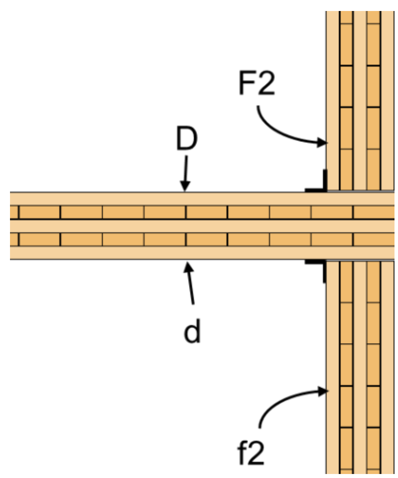
EXAMPLE 3.2-V1: (DETAILED METHOD)

- **Rooms one-above-the-other**
- **Bare CLT Floors and CLT Walls**

Illustration for this case



Cross-junction of separating floor of continuous 175 mm thick 5-ply CLT with 5-ply CLT wall assemblies above and below.
(Side view of Junctions 1, 3 and 4, except orientation of floor assemblies differs for Junction 4)



T-junction of 175 mm thick 5-ply CLT floor with 5-ply CLT walls above and below.
(Side view of Junction 2)

Separating floor assembly with:

- 5-ply 175 mm thick CLT floor assembly with mass 92.1 kg/m^2, continuous through cross-junction with CLT wall assemblies at Junctions 1 and 3 and oriented so that face ply strands are perpendicular to loadbearing Junctions 1 and 3
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting wall assemblies
- No added linings (floor topping or ceiling)

Junction 1, 3 or 4: Separating floor / walls with:

- 5-ply 175 mm thick CLT wall assembly with mass 94.1 kg/m^2, above and below cross-junctions with separating assembly that is continuous or lapped and glued across these junctions
- CLT wall assembly oriented so face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to the wall assemblies and to the floor assembly
- No added lining on walls

Junction 2: Separating floor / walls with:

- 5-ply 175 mm thick CLT wall assembly with mass 94.1 kg/m^2, above and below T-junction with separating assembly that terminates at this junction
- CLT wall assembly oriented so face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to one side of the wall assembly and to the abutting floor assemblies
- No added lining on walls

Acoustical Parameters:

Separating floor area (m^2) =	20.0		Floor internal loss, η_i =	>0.03
oor/wall junctions 1 and 3 (m) =	5.0		Wall internal loss, η_i =	>0.03
oor/wall junctions 2 and 4 (m) =	4.0		Wall internal loss, η_i =	>0.03

	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3 and 4:				
Kij [dB] =	17.6	10.2	10.2	RR-335, CLT-FW-Xa-05
10*log(Sep. Area/Junction) =	6.0	For Junctions 1 and 3		
10*log(Sep. Area/Junction) =	7.0	For Junction 4		
For Junction 2:				
Kij [dB] =	12.9	6.8	6.8	RR-335, CLT-FW-Ta-05
10*log(Sep. Area/Junction) =	7.0	For Junction 2		

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (175 mm 5-ply CLT)									
Laboratory Transmission Loss	R_D,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
Correction Resonant Transmission		N/A	0	0	0	0	0	0	
ΔTL change by Lining on D	ΔR_D	No Lining	0	0	0	0	0	0	
ΔTL change by Lining on d	ΔR_d	No Lining	0	0	0	0	0	0	
If airborne flanking or bare CLT		RR-335, TL(Bare CLT05) - TL(Base CLT05)	0	-1	-3	1	-1	-3	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**32**	**29**	**36**	**44**	**51**	**46**	**40**
Junction 1 (Cross-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)									
Transmission Loss of Flanking Elements									
TL of element F1, laboratory	R_F1,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
TL of element f1, laboratory	R_f1,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
Correction Resonant Transmission F1		N/A	0	0	0	0	0	0	
Correction Resonant Transmission f1		N/A	0	0	0	0	0	0	
TL of element F1, in-situ	R_F1,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
TL of element f1, in-situ	R_f1,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
ΔTL change by Lining on F	ΔR_F1	No Lining	0	0	0	0	0	0	
ΔTL change by Lining on f	ΔR_f1	No Lining	0	0	0	0	0	0	
Junction Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, CLT-FW-Xa-05	17.6	17.6	17.6	17.6	17.6	17.6	
Vibration Reduction Index for Fd	K_Fd,1	RR-335, CLT-FW-Xa-05	10.2	10.2	10.2	10.2	10.2	10.2	
Vibration Reduction Index for Df	K_Df,1	RR-335, CLT-FW-Xa-05	10.2	10.2	10.2	10.2	10.2	10.2	
Flanking Transmission Loss									
Flanking TL for path Ff_1	R_ Ff	ISO 15712-1, Eq. 25b	**56**	**54**	**63**	**67**	**76**	**73**	**66**
Flanking TL for path Fd_1	R_ Fd	ISO 15712-1, Eq. 25b	**48**	**46**	**55**	**59**	**68**	**65**	**58**
Flanking TL for path Df_1	R_ Df	ISO 15712-1, Eq. 25b	**48**	**46**	**55**	**59**	**68**	**65**	**58**
Junction 1: Flanking TL for all paths			45	43	52	56	65	62	55
Junction 2 (T-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)									
Transmission Loss of Flanking Elements									
TL of element F2, laboratory	R_F2,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
TL of element f2, laboratory	R_f2,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
Correction Resonant Transmission F2		N/A	0	0	0	0	0	0	
Correction Resonant Transmission f2		N/A	0	0	0	0	0	0	
TL of element F2, in-situ	R_F2,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
TL of element f2, in-situ	R_f2,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
ΔTL change by Lining on F	ΔR_F2	No Lining	0	0	0	0	0	0	
ΔTL change by Lining on f	ΔR_f2	No Lining	0	0	0	0	0	0	
Junction Coupling									
Vibration Reduction Index for Ff	K_Ff,2	RR-335, CLT-FW-Ta-05	12.9	12.9	12.9	12.9	12.9	12.9	
Vibration Reduction Index for Fd	K_Fd,2	RR-335, CLT-FW-Ta-05	6.8	6.8	6.8	6.8	6.8	6.8	
Vibration Reduction Index for Df	K_Df,2	RR-335, CLT-FW-Ta-05	6.8	6.8	6.8	6.8	6.8	6.8	
Flanking Transmission Loss									
Flanking TL for path Ff_2	R_ Ff	ISO 15712-1, Eq. 25b	**52**	**50**	**59**	**63**	**72**	**69**	**62**
Flanking TL for path Fd_2	R_ Fd	ISO 15712-1, Eq. 25b	**46**	**44**	**53**	**57**	**66**	**63**	**56**
Flanking TL for path Df_2	R_ Df	ISO 15712-1, Eq. 25b	**46**	**44**	**53**	**57**	**66**	**63**	**56**
Junction 2: Flanking TL for all paths			42	40	49	53	62	59	52
Junction 3 (Cross-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)									
All values the same as for Junction 1									
Flanking TL for path Ff_3	R_ Ff	ISO 15712-1, Eq. 25b	**56**	**54**	**63**	**67**	**76**	**73**	**66**
Flanking TL for path Fd_3	R_ Fd	ISO 15712-1, Eq. 25b	**48**	**46**	**55**	**59**	**68**	**65**	**58**
Flanking TL for path Df_3	R_ Df	ISO 15712-1, Eq. 25b	**48**	**46**	**55**	**59**	**68**	**65**	**58**
Junction 3: Flanking TL for all paths			45	43	52	56	65	62	55
Junction 4 (Cross-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)									
Transmission loss values of flanking elements are the same as for Junction 2, but Kij values are the same as for Junction 1 and 3 (cross-junction).									
Flanking TL for path Ff_4	R_ Ff	ISO 15712-1, Eq. 25b	**57**	**55**	**64**	**68**	**77**	**74**	**67**
Flanking TL for path Fd_4	R_ Fd	ISO 15712-1, Eq. 25b	**49**	**47**	**56**	**60**	**69**	**66**	**59**
Flanking TL for path Df_4	R_ Df	ISO 15712-1, Eq. 25b	**49**	**47**	**56**	**60**	**69**	**66**	**59**
Junction 4: Flanking TL for all paths			46	44	53	57	66	63	56
Total Flanking (for all 4 junctions)			38	36	45	49	58	55	48
ASTC due to Direct plus Flanking Paths		RR-335, Eq. 1.1	**31**	**28**	**36**	**43**	**50**	**46**	**40**

EXAMPLE 3.2-V2: (DETAILED METHOD)

- **Rooms one-above-the-other**
- **CLT Floors and CLT Walls**
  (Same as example 3.2-V1, plus linings)

Separating floor assembly with:
- 5-ply 175 mm thick CLT floor assembly with mass 92.1 kg/m^2, continuous through cross-junction with CLT wall assemblies at Junctions 1 and 3 and oriented so that face ply strands are perpendicular to loadbearing Junctions 1 and 3
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting wall assemblies
- Floor lining of 38 mm concrete over 13 mm wood fiber board
- Ceiling lining of 15.9 mm gypsum board[4] fastened to hat-channels supported on cross-channels hung on wires, cavity of 150 mm between CLT and ceiling, with 140 mm absorptive material[3]

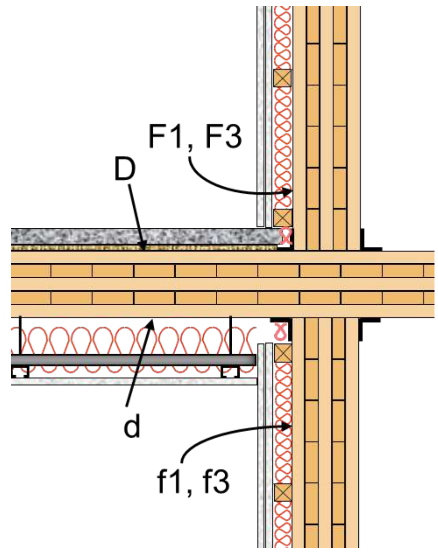
Junction 1, 3 or 4: (separating floor / flanking walls) with:
- 5-ply 175 mm thick CLT wall assembly with mass 94.1 kg/m^2, above and below cross-junctions with separating assembly that is continuous or lapped and glued across these junctions
- CLT wall assembly oriented so face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to the wall assemblies and to the floor assembly
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

Junction 2: Each Side (separating floor / flanking walls) with:
- 5-ply 175 mm thick CLT wall assembly with mass 94.1 kg/m^2, above and below T-junction with separating assembly that terminates at this junction
- CLT wall assembly oriented so face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to one side of the wall assembly and to the abutting floor assemblies
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

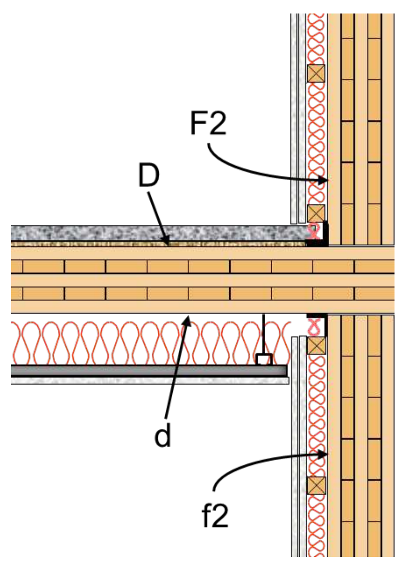
Acoustical Parameters:

Separating floor area (m^2) =	20.0		Floor internal loss, η_i =	>0.03
oor/wall junctions 1 and 3 (m) =	5.0		Wall internal loss, η_i =	>0.03
oor/wall junctions 2 and 4 (m) =	4.0		Wall internal loss, η_i =	>0.03
	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3 and 4:				
Kij [dB] =	17.6	10.2	10.2	RR-335, CLT-FW-Xa-05
10*log(Sep. Area/Junction) =	6.0	For Junctions 1 and 3		
10*log(Sep. Area/Junction) =	7.0	For Junction 4		
For Junction 2:				
Kij [dB] =	12.9	6.8	6.8	RR-335, CLT-FW-Ta-05
10*log(Sep. Area/Junction) =	7.0	For Junction 2		

Illustration for this case



Cross-junction of separating floor of continuous 175mm thick 5-ply CLT with 5-ply CLT walls above and below.
(Side view of Junctions 1, 3 and 4, except orientation of floor assemblies differs for Junction 4)



T-junction of 175mm thick 5-ply CLT floor with 5-ply CLT walls above and below.
(Side view of Junction 2)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	500	1000	2000	4000	STC or ASTC
Separating Partition (175 mm 5-ply CLT)									
Laboratory Transmission Loss	R_D,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
Correction Resonant Transmission		N/A	0	0	0	0	0	0	
ΔTL change by Lining on D	ΔR_D	RR-335, ΔTL-CLT-F03	4	11	8	21	29	32	
ΔTL change by Lining on d	ΔR_d	RR-335, ΔTL-CLT-C03	15	25	30	36	34	30	
If airborne flanking or bare CLT		N/A	0	0	0	0	0	0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**51**	**66**	**77**	**90**	**90**	**90**	**75**
Junction 1 (Cross-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)									
Transmission Loss of Flanking Elements									
TL of element F1, laboratory	R_F1,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
TL of element f1, laboratory	R_f1,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
Correction Resonant Transmission F1		N/A	0	0	0	0	0	0	
Correction Resonant Transmission f1		N/A	0	0	0	0	0	0	
TL of element F1, in-situ	R_F1,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
TL of element f1, in-situ	R_f1,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
ΔTL change by Lining on F	ΔR_F1	RR-335, ΔTL-CLT05-W03	3	8	5	11	10	11	
ΔTL change by Lining on f	ΔR_f1	RR-335, ΔTL-CLT05-W03	3	8	5	11	10	11	
Junction Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, CLT-FW-Xa-05	17.6	17.6	17.6	17.6	17.6	17.6	
Vibration Reduction Index for Fd	K_Fd,1	RR-335, CLT-FW-Xa-05	10.2	10.2	10.2	10.2	10.2	10.2	
Vibration Reduction Index for Df	K_Df,1	RR-335, CLT-FW-Xa-05	10.2	10.2	10.2	10.2	10.2	10.2	
Flanking Transmission Loss									
Flanking TL for path Ff_1	R_ Ff	ISO 15712-1, Eq. 25b	**62**	**70**	**73**	**89**	**90**	**90**	**81**
Flanking TL for path Fd_1	R_ Fd	ISO 15712-1, Eq. 25b	**66**	**79**	**90**	**90**	**90**	**90**	**88**
Flanking TL for path Df_1	R_ Df	ISO 15712-1, Eq. 25b	**55**	**65**	**68**	**90**	**90**	**90**	**76**
Junction 1: Flanking TL for all paths			54	64	67	85	85	85	75
Junction 2 (T-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)									
Transmission Loss of Flanking Elements									
TL of element F2, laboratory	R_F2,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
TL of element f2, laboratory	R_f2,lab	RR-335, Base CLT05	32	30	39	43	52	49	42
Correction Resonant Transmission F2		N/A	0	0	0	0	0	0	
Correction Resonant Transmission f2		N/A	0	0	0	0	0	0	
TL of element F2, in-situ	R_F2,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
TL of element f2, in-situ	R_f2,situ	ISO 15712-1, Eq. 19, T_s,situ = T_s,lab	32	30	39	43	52	49	42
ΔTL change by Lining on F	ΔR_F2	RR-335, ΔTL-CLT05-W03	3	8	5	11	10	11	
ΔTL change by Lining on f	ΔR_f2	RR-335, ΔTL-CLT05-W03	3	8	5	11	10	11	
Junction Coupling									
Vibration Reduction Index for Ff	K_Ff,2	RR-335, CLT-FW-Ta-05	12.9	12.9	12.9	12.9	12.9	12.9	
Vibration Reduction Index for Fd	K_Fd,2	RR-335, CLT-FW-Ta-05	6.8	6.8	6.8	6.8	6.8	6.8	
Vibration Reduction Index for Df	K_Df,2	RR-335, CLT-FW-Ta-05	6.8	6.8	6.8	6.8	6.8	6.8	
Flanking Transmission Loss									
Flanking TL for path Ff_2	R_ Ff	ISO 15712-1, Eq. 25b	**58**	**66**	**69**	**85**	**90**	**90**	**77**
Flanking TL for path Fd_2	R_ Fd	ISO 15712-1, Eq. 25b	**64**	**77**	**88**	**90**	**90**	**90**	**87**
Flanking TL for path Df_2	R_ Df	ISO 15712-1, Eq. 25b	**53**	**63**	**66**	**89**	**90**	**90**	**74**
Junction 2: Flanking TL for all paths			52	61	64	83	85	85	72
Junction 3 (Cross-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)									
All values the same as for Junction 1									
Flanking TL for path Ff_3	R_ Ff	ISO 15712-1, Eq. 25b	**62**	**70**	**73**	**89**	**90**	**90**	**81**
Flanking TL for path Fd_3	R_ Fd	ISO 15712-1, Eq. 25b	**66**	**79**	**90**	**90**	**90**	**90**	**88**
Flanking TL for path Df_3	R_ Df	ISO 15712-1, Eq. 25b	**55**	**65**	**68**	**90**	**90**	**90**	**76**
Junction 3: Flanking TL for all paths			54	64	67	85	85	85	75
Junction 4 (Cross-Junction, 175 mm 5-ply CLT Separating Floor / 175 mm 5-ply CLT Wall)									
Transmission loss values of flanking elements are the same as for Junction 2, but Kij values are the same as for Junction 1 or 3 (cross-junction).									
Flanking TL for path Ff_4	R_ Ff	ISO 15712-1, Eq. 25b	**63**	**71**	**74**	**90**	**90**	**90**	**82**
Flanking TL for path Fd_4	R_ Fd	ISO 15712-1, Eq. 25b	**67**	**80**	**90**	**90**	**90**	**90**	**88**
Flanking TL for path Df_4	R_ Df	ISO 15712-1, Eq. 25b	**56**	**66**	**69**	**90**	**90**	**90**	**77**
Junction 4: Flanking TL for all paths			55	65	68	85	85	85	76
Total Flanking (for all 4 junctions)			47	57	60	78	79	79	68
ASTC due to Direct plus Flanking Paths		RR-335, Eq. 1.1	**46**	**57**	**60**	**78**	**79**	**79**	**67**

Summary for Section 3.2: Calculation Examples using the Detailed Method

The worked examples (3.2-H1 to H3 and 3.2-V1 to V2) illustrate the use of the Detailed Method for calculating sound transmission between rooms in a building with CLT floor and wall assemblies, with or without linings added to some or all of the walls and floors.

The examples present the calculations for the same set of scenarios used to illustrate the Simplified Method in Section 3.1.

- For the cases without linings (3.2-H1 and 3.2-V1), the detailed calculations give the same ASTC ratings as the simplified calculations. This agreement (aside from possible rounding errors of ±1) is to be expected since they simply combine the same data in slightly different order.
- For the cases with linings, the differences are larger, because the Simplified Method treats the ΔSTC improvement due to linings using a deliberately conservative approximation. In the Detailed Method, the value of ΔTL for the two linings in each transmission path are simply added to the sound transmission loss values for the base assemblies, which tends to give higher predicted values of ASTC.
- In each of the cases with linings shown in these examples, the Detailed Method gives a result that is higher by 2 to 5 ASTC points than the Simplified Method. For linings with higher values of ΔSTC, the difference between the two methods would increase further.

4. Buildings with Lightweight Framed Wall and Floor Assemblies

The focus of this chapter is to present the method for predicting the apparent sound insulation between adjacent rooms in a building constructed from lightweight framed wall and floor assemblies. The prediction method uses an empirical calculation approach described in ISO 15712-1 [7] that combines laboratory sound transmission data for individual lightweight 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.

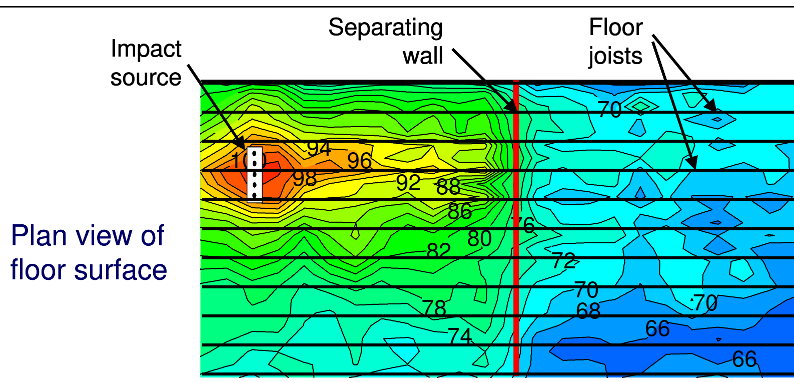


Figure 4.1: Variation across the floor surface of the vibration levels (2 kHz band) due to an impact source. The floor construction has a 19 mm plywood subfloor on wood joists that are perpendicular to the separating wall between the two side-by-side rooms.

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 Guide provide more appropriate normalization for highly-damped assemblies such as lightweight wood- or steel-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 Guide do allow using ΔTL and ΔSTC corrections for floor finishes on a gypsum concrete subfloor, which is more reverberant.

4.1. Calculation Procedure for Lightweight 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 Method of ISO 15712-1 combines the set of one-third octave band transmission loss data for the direct path and all flanking paths using Eq. 1.4 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 lightweight 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 Sections 4.2 and 4.3.

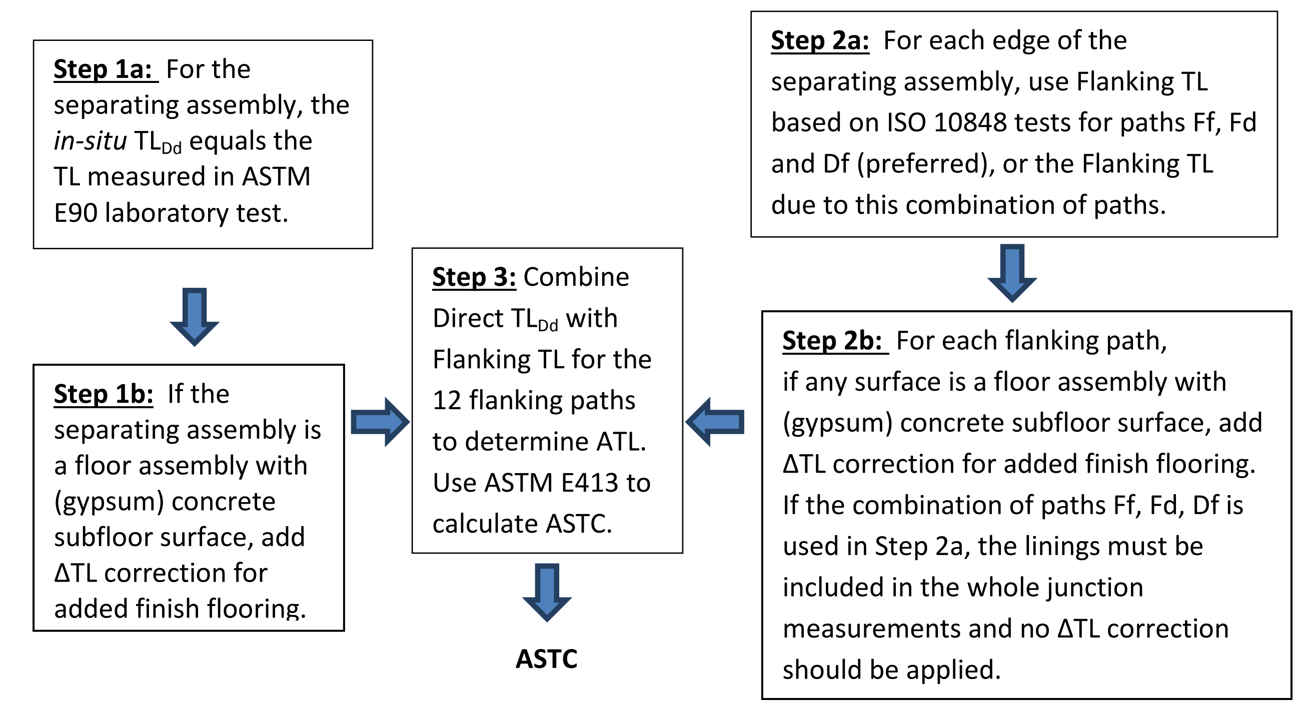


Figure 4.1.1: Steps to calculate the ASTC rating for wood- or steel-framed constructions using transmission loss data. For the simplified procedure with STC ratings, substitute "STC" for "TL".

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 assembly with (gypsum) concrete subfloor 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 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 a floor assembly with (gypsum) concrete subfloor surface, add the ΔSTC correction for any added floor finish:

- If one surface in a flanking path is a floor assembly with (gypsum) concrete subfloor surface, add the ΔSTC for the added finish flooring to the value for the bare floor to obtain the Flanking STC rating.
- If both surfaces are floor assemblies with (gypsum) concrete subfloor surface, 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 to allow for the inevitable effect of higher order flanking paths.
- 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 similar to the Standard Scenario. It is applied here using the following notes to calculate the sound transmission for each individual path:

For the Separating Assembly:
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 assembly with (gypsum) concrete subfloor 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.

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

For Each Flanking Path:

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 area 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 (in metres) 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:

$$\text{Flanking STC}_{ij,situ} = \text{Flanking STC}_{ij,lab} + 10\log(S_{situ}/S_{lab}) + 10\log(l_{lab}/l_{situ}) \qquad \text{Eq. 4.1.3}$$

  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 assembly with (gypsum) concrete subfloor 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 subfloor 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 framed assemblies with surfaces other than (gypsum) concrete (such as OSB for floors or gypsum board for walls).

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

Worked Examples

The following sections present a number of worked examples that demonstrate the calculation of the ASTC rating for wood-framed and CFS-framed constructions according to the Simplified Method. Each worked example 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. All examples conform to the Standard Scenario presented in Section 1.2 of this Guide.

Within the table for each worked example, the "References" column presents the source of input data (combining the NRC report number and identifier for each laboratory test result or derived result), or identifies applicable equations and sections of ISO 15712-1 at each stage of the calculation, or their counterparts using ASTM ratings as presented in Equations 4.1.1 to 4.1.5. Symbols and subscripts identifying the corresponding variable in ISO 15712-1 are given in the adjacent column.

Under the heading "STC or ΔSTC", the examples present input data determined in laboratory tests:

- STC values for laboratory sound transmission loss data for wall and floor assemblies
- ΔSTC values measured in the laboratory for the change in STC due to adding a finish flooring to a base floor assembly with concrete or gypsum concrete topping
- Flanking STC values for each flanking path at each junction measured following ISO 10848 and re-normalized using Eq. 4.1.3

NOTE: In previous versions of this Guide, measured values of Flanking STC for each path were presented with normalization to the actual dimensions of the flanking facilities at NRC. Starting in 2017, data measured at NRC according to ISO 10848 has been normalized to a set of nominal dimensions that correspond more closely to the Standard Scenario used in this Guide. The pertinent dimensions for the laboratory data are identified clearly in the worked examples. This change only affects the laboratory values presented under the heading "STC or ΔSTC ". It had no effect on the resulting Flanking STC values for each path in the worked examples, since the values were always normalized to the dimensions of the Standard Scenario for the calculation of the ASTC rating.

Under the heading "STC or ASTC", the examples present the calculated values for sound transmission via specific paths:

- 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 sound 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 that may include corrections for added floor finishes if the separating assembly is a floor assembly with (gypsum) concrete subfloor 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 one or both of the flanking surfaces is a floor assembly with (gypsum) concrete subfloor surface
- 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.

Repeatability studies in the NRC laboratories for such constructions suggest that these detailed predictions should be expected to agree with actual construction within a standard deviation of about 2 dB, in the absence of construction errors.

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4.2. Wood-Framed Wall and Floor Assemblies

For buildings with lightweight wood-framed walls and floors, the calculation procedure outlined in the preceding section can be used. The procedure requires specific laboratory test data (determined according to ASTM E90 and ISO 10848 with some extensions), and can be performed using frequency band data or single-number ratings, following the steps illustrated in Figure 4.1.1.

Previous NRC publications have presented predicted ASTC values and a procedure based on the same prediction approach, e. g. the NRC Research Report RR-219, “Guide for Sound Insulation in Wood Frame Construction”, and Construction Technology Update 66 [10]. More information on the direct and flanking sound insulation of wood-framed assemblies and building systems can be found in NRC Research Report RR-336, “Apparent Sound Insulation in Wood-Framed Buildings” (in preparation at the time of publication of this Guide). The report provides the data for direct and flanking sound insulation for a variety of wood-framed building configurations.

With lightweight framed assemblies, it is common practice to add layers of material such as gypsum board within hidden cavities at junctions between units, to block the spread of fire. This issue is beyond the scope of this Guide, but is discussed in considerable detail in the publication “Best Practice Guide on Fire Stops and Fire Blocks and their Impact on Sound Transmission” [16]. The specimens tested to provide the design information in NRC Research Report RR-219 and its supporting technical reports included such fire blocking. Fire blocking materials installed to protect the rimboard or header within floor cavities have minimal effect on the structure-borne flanking sound transmission. However, fire blocking within the cavity in a separating wall with a double row of studs can significantly alter the flanking sound transmission if they provide a rigid connection between the two rows of studs. Pertinent information on the resulting sound transmission with various fire blocking details is provided in the NRC Research Reports RR-219 and RR-336.

EXAMPLE 4.2-H1 **SIMPLIFIED METHOD**

- **Rooms side-by-side**
- **Wood-framed floors and walls**

Separating wall assembly with:
- Single row of 38 mm x 89 mm wood studs spaced 400 mm o.c., with 89 mm thick absorptive material[3] filling the inter-stud cavities
- Resilient metal channels[7] on one side, spaced 600 mm o.c.
- 1 layer of 16 mm fire-rated gypsum board[4] attached to the resilient channels[7] and 2 layers screwed directly to framing on the other side

Bottom Junction 1 (separating wall and floor) with:
- Floor framed with 305 mm wood I-joists spaced 400 mm o.c., with joists oriented perpendicular to separating wall but not continuous across junction, and 150 mm thick absorptive material[3] in cavities
- Rimboard at junction may be covered with fire blocking material such as gypsum board without changing sound transmission rating
- Subfloor on both sides of oriented strand board (OSB) 19 mm thick
- Floor topping of 19 mm OSB mechanically fastened over subfloor

Top Junction 3 (separating wall and ceiling) with:
- Ceiling framed with wood I-joists (details same as for bottom junction) with 150 mm thick absorptive material[3] in cavities between joists
- Rimboard at junction may be covered with fire blocking material such as gypsum board without changing sound transmission rating
- Ceiling (1 layer of 13 mm regular gypsum board[4]) screwed directly to bottom of ceiling framing

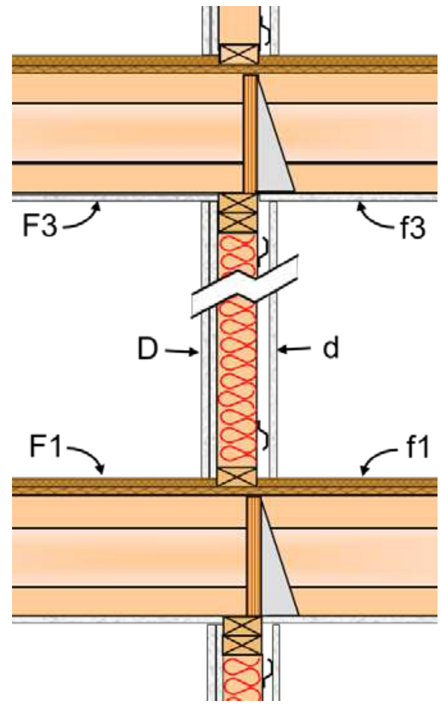
Side Junctions 2 and 4 (separating wall and abutting side walls) with:
- 1 layer of 16 mm fire-rated gypsum board[4] on side walls attached directly to framing and terminating at the separating wall
- Side wall framing with single row of wood studs spaced 400 mm o.c. with absorptive material[3] filling stud cavities
- Side wall framing structurally-connected to the separating wall, but continuous across junction (as illustrated)

Note 1: For path/surface designations in the procedure below, treat the room at left as the source room (surfaces D and F)

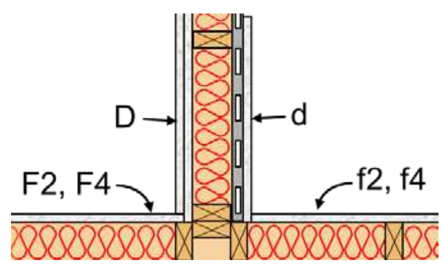
Acoustical Parameters:

	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-331, Eq. 4.1.3
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-331, Eq. 4.1.3

Illustration for this case



Junctions 1 and 3 of loadbearing separating wall with floor and ceiling. (Side view)



Junction 2 or 4 of separating wall with abutting side walls with side walls' framing continuous across junction and gypsum board terminating at separating wall. (Plan view)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (Loadbearing Wood-Framed Wall)				
Laboratory STC for Dd	R_s,w	RR-336, TLW-13-WS89-001	53	
Direct STC in situ	R_Dd,w	RR-331, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**53**
Junction 1 (Loadbearing Wall / Wood-Framed Floor)				
For Flanking Path Ff_1:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WF-LB-002	53	
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-331, Eq. 4.1.3 and Eq. 4.1.5	53 + MAX(0,0)) + MIN(0,0)/2 + 0 =	**53**
For Flanking Path Fd_1:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WF-LB-002	56	
ΔSTC change by Lining on F	ΔR_F,w	No flooring	0	
Flanking STC for path Fd_1	R_ Fd,w	RR-331, Eq. 4.1.3 and Eq. 4.1.4	56 + 0 + 0 =	**56**
For Flanking Path Df_1:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WF-LB-002	57	
ΔSTC change by Lining on f	ΔR_f,w	No flooring	0	
Flanking STC for path Df_1	R_ Df,w	RR-331, Eq. 4.1.3 and Eq. 4.1.4	57 + 0 + 0 =	**57**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-5.3 + 10^- 5.6 + 10^- 5.7) =	50
Junction 2 (Loadbearing Wood-Framed Separating Wall / Wood-Framed Flanking Walls)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WW-LB-001	70	
Flanking STC for path Ff_2	R_Ff,w	RR-331, Eq. 4.1.3	70 + 0 =	**70**
For Flanking Path Fd_2:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WW-LB-001	69	
Flanking STC for path Fd_2	R_ Fd,w	RR-331, Eq. 4.1.3	69 + 0 =	**69**
For Flanking Path Df_2:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WW-LB-001	68	
Flanking STC for path Df_2	R_ Df,w	RR-331, Eq. 4.1.3	68 + 0 =	**68**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7 + 10^- 6.9 + 10^- 6.8) =	64
Junction 3 (Loadbearing Wood-Framed Wall / Wood-Framed Floor/Ceiling)				
For Flanking Path Ff_3:				
Laboratory Flanking STC		RR-336,FTL-13-WS89-WC-LB-001	65	
Flanking STC for path Ff_3	R_Ff,w	RR-331, Eq. 4.1.3	65 + 0 =	**65**
For Flanking Path Fd_3:				
Laboratory Flanking STC		RR-336,FTL-13-WS89-WC-LB-001	64	
Flanking STC for path Fd_3	R_ Fd,w	RR-331, Eq. 4.1.3	64 + 0 =	**64**
For Flanking Path Df_3:				
Laboratory Flanking STC		RR-336,FTL-13-WS89-WC-LB-001	79	
Flanking STC for path Df_3	R_ Df,w	RR-331, Eq. 4.1.3	79 + 0 =	**79**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.5 + 10^- 6.4 + 10^- 7.9) =	61
Junction 4 (Loadbearing Wood-Framed Separating Wall / Wood-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		**70**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2		**69**
Flanking STC for path Df_4	R_ Df,w	Same as for Df_2		**68**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7 + 10^- 6.9 + 10^- 6.8) =	64
Total Flanking STC (for all 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-H2: **SIMPLIFIED METHOD**

- **Rooms side-by-side**
- **Wood-framed floors and walls**
- **Same structure as 4.2-H1 but improved wall and floor surfaces**

Separating wall assembly with:
- Single row of 38 mm x 89 mm wood studs spaced 400 mm o.c., with 89 mm thick absorptive material[3] filling the inter-stud cavities
- Resilient metal channels[7] on one side, spaced 600 mm o.c.
- 2 layers of 16 mm fire-rated gypsum board[4] attached to the resilient channels and 2 layers screwed directly to framing on the other side

Bottom Junction 1 (separating wall and floor) with:
- Floor framed with 305 mm wood I-joists spaced 400 mm o.c., with joists oriented perpendicular to separating wall but not continuous across junction, and 150 mm thick absorptive material[3] in cavities
- Subfloor on both sides of oriented strand board (OSB) 19 mm thick
- Engineered floor topping of 16 mm plywood bonded to 16 mm OSB on 9 mm thick resilient mat
- Strip hardwood flooring 19 mm thick, nailed to topping, oriented with long axis perpendicular to joists

Top Junction 3 (separating wall and ceiling) with:
- Ceiling framed with wood I-joists (details same as for bottom junction) with 150 mm thick absorptive material[3] in cavities between joists
- Ceiling (1 layer of 13 mm regular gypsum board[4]) screwed directly to bottom of ceiling framing

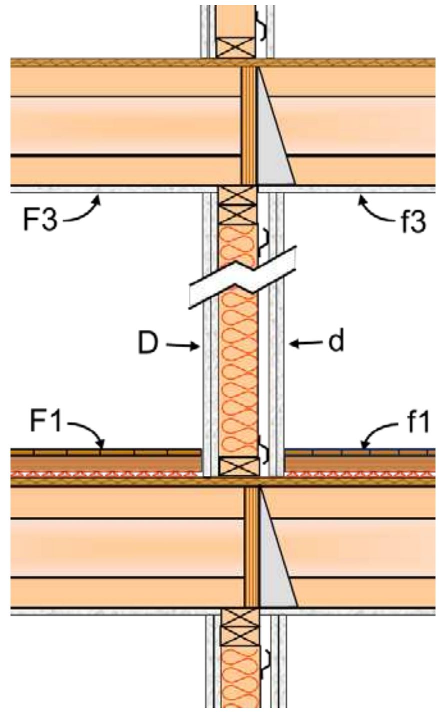
Side Junctions 2 and 4 (separating wall and abutting side walls) with:
- 1 layer of 16 mm fire-rated gypsum board[4] on side walls attached directly to framing and terminating at the separating wall
- Side wall framing with single row of wood studs spaced 400 mm o.c. with absorptive material[3] in cavities
- Side wall framing structurally-connected to the separating wall, but continuous across junction (as illustrated)

Note 1: For path/surface designations in the procedure below, treat the room at left as the source room (surfaces D and F)

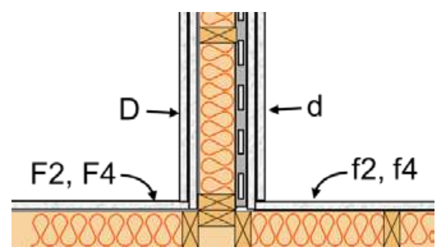
Acoustical Parameters:

	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-331, Eq. 4.1.3
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-331, Eq. 4.1.3

Illustration for this case



Junctions 1 and 3 of loadbearing separating wall with floor and ceiling. (Side view)



Junction 2 or 4 of separating wall with abutting side walls with side walls' framing continuous across junction and gypsum board terminating at separating wall. (Plan view)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (Loadbearing Wood-Framed Wall)				
Laboratory STC for Dd	R_s,w	RR-336, TLW-13-WS89-010	57	
Direct STC in situ	R_Dd,w	RR-331, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**57**
Junction 1 (Loadbearing Wall / Wood-Framed Floor)				
For Flanking Path Ff_1:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WF-LB-010	67	
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-331, Eq. 4.1.3 and Eq. 4.1.5	67 + MAX(0,0)) + MIN(0,0)/2 + 0 =	**67**
For Flanking Path Fd_1:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WF-LB-010	69	
ΔSTC change by Lining on F	ΔR_F,w	No flooring	0	
Flanking STC for path Fd_1	R_ Fd,w	RR-331, Eq. 4.1.3 and Eq. 4.1.4	69 + 0 + 0 =	**69**
For Flanking Path Df_1:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WF-LB-010	66	
ΔSTC change by Lining on f	ΔR_f,w	No flooring	0	
Flanking STC for path Df_1	R_ Df,w	RR-331, Eq. 4.1.3 and Eq. 4.1.4	66 + 0 + 0 =	**66**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.7 + 10^- 6.9 + 10^- 6.6) =	62
Junction 2 (Loadbearing Wood-Framed Separating Wall / Wood-Framed Flanking Walls)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WW-LB-010	70	
Flanking STC for path Ff_2	R_Ff,w	RR-331, Eq. 4.1.3	70 + 0 =	**70**
For Flanking Path Fd_2:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WW-LB-010	71	
Flanking STC for path Fd_2	R_ Fd,w	RR-331, Eq. 4.1.3	71 + 0 =	**71**
For Flanking Path Df_2:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WW-LB-010	68	
Flanking STC for path Df_2	R_ Df,w	RR-331, Eq. 4.1.3	68 + 0 =	**68**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7 + 10^- 7.1 + 10^- 6.8) =	65
Junction 3 (Loadbearing Wood-Framed Wall / Wood-Framed Floor/Ceiling)				
For Flanking Path Ff_3:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WC-LB-010	65	
Flanking STC for path Ff_3	R_Ff,w	RR-331, Eq. 4.1.3	65 + 0 =	**65**
For Flanking Path Fd_3:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WC-LB-010	81	
Flanking STC for path Fd_3	R_ Fd,w	RR-331, Eq. 4.1.3	81 + 0 =	**81**
For Flanking Path Df_3:				
Laboratory Flanking STC		RR-336, FTL-13-WS89-WC-LB-010	65	
Flanking STC for path Df_3	R_ Df,w	RR-331, Eq. 4.1.3	65 + 0 =	**65**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.5 + 10^- 8.1 + 10^- 6.5) =	62
Junction 4 (Loadbearing Wood-Framed Separating Wall / Wood-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		**70**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2		**71**
Flanking STC for path Df_4	R_ Df,w	Same as for Df_2		**68**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-7 + 10^- 7.1 + 10^- 6.8) =	65
Total Flanking STC (for all 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-V1 **SIMPLIFIED METHOD**

- **Rooms one-above-the-other**
- **Wood-framed floors and walls**

Separating floor/ceiling assembly with:
- Floor framed with 305 mm wood I-joists spaced 400 mm o.c., with joists oriented perpendicular to loadbearing wall but not continuous across junction, and 150 mm thick absorptive material[3] in cavities
- Ceiling of 1 layer of 16 mm fire-rated gypsum board[4], attached to resilient metal channels[7] spaced 400 mm o.c.
- Subfloor of oriented strand board (OSB) 19 mm thick
- No floor topping
- No floor covering

Junctions 1 and 3 (with loadbearing walls above and below floor) with:
- Joists of floor assembly perpendicular to these walls
- Wall framed with 38 mm x 89 mm wood studs spaced 400 mm o.c.
- Wall framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates) with or without absorptive material[3] in wall cavities give equivalent flanking
- 16 mm fire-rated gypsum board[4] on side walls ends at floor/ceiling assembly; and is attached directly to wall framing

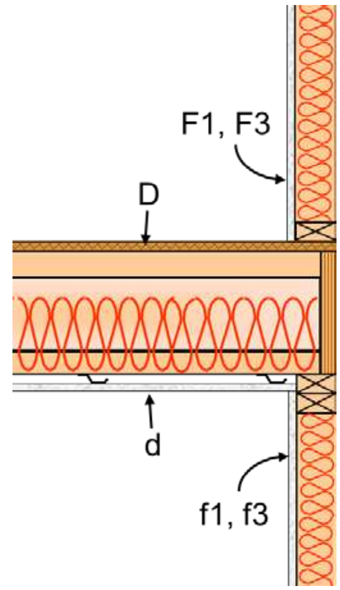
Junctions 2 and 4 (with non-loadbearing walls above and below floor) with:
- Joists of floor assembly parallel to these walls
- Wall framing of 38 mm x 89 mm wood studs spaced 400 mm o.c.
- Wall framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates) with or without absorptive material[3] in wall cavities give equivalent flanking
- 16 mm fire-rated gypsum board[4] on side walls ends at floor/ceiling assembly; and is attached directly to wall framing

Note 1: For path/surface designations in the procedure below, treat the upper room as the source room (surfaces D and F)

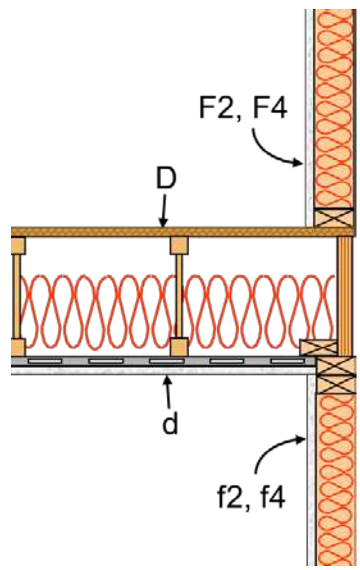
Acoustical Parameters:

	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-331, Eq. 4.1.3
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.97	RR-331, Eq. 4.1.3

Illustration for this case



Junction 1 or 3 with loadbearing side walls above and below the floor/ceiling assembly (wood I-joists of floor are perpendicular to loadbearing wall). (Side view)



Junction 2 or 4 with non-loadbearing side walls above and below the floor/ceiling assembly (wood I-joists of floor are parallel to the non-loadbearing wall). (Side view)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (Wood-Framed Floor)				
Laboratory STC for Dd	R_s,w	RR-336, TLF-13-WIJ305-001	51	
ΔSTC change by Lining on D	ΔR_D,w	No finish flooring	0	
Direct STC in situ	R_Dd,w	RR-331, Eq. 4.1.2	51 + 0 =	**51**
Junction 1 (Wood-Framed Floor / Loadbearing Wood-Framed Wall)				
For Flanking Path Ff_1:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-LB-001	64	
Flanking STC for path Ff_1	R_Ff,w	RR-331, Eq. 4.1.3	64 + 0 =	**64**
For Flanking Path Fd_1:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-LB-001	57	
Flanking STC for path Fd_1	R_ Fd,w	RR-331, Eq. 4.1.3	57 + 0 =	**57**
For Flanking Path Df_1:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-LB-001	90	
ΔSTC change by Lining on D	ΔR_D,w	No finish flooring	0	
Flanking STC for path Df_1	R_ Df,w	RR-331, Eq. 4.1.3 and Eq. 4.1.4	90 + 0 + 0 =	**90**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.4 + 10^- 5.7 + 10^- 9) =	56
Junction 2 (Wood-Framed Floor / Non-loadbearing Wood-Framed Wall)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-NLB-001	64	
Flanking STC for path Ff_2	R_Ff,w	RR-331, Eq. 4.1.3	64 + 1 =	**65**
For Flanking Path Fd_2:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-NLB-001	61	
Flanking STC for path Fd_2	R_ Fd,w	RR-331, Eq. 4.1.3	61 + 1 =	**62**
For Flanking Path Df_2:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-NLB-001	90	
ΔSTC change by Lining on D	ΔR_D,w	No finish flooring	0	
Flanking STC for path Df_2	R_ Df,w	RR-331, Eq. 4.1.3 and Eq. 4.1.4	90 + 0 + 1 =	**90**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.5 + 10^- 6.2 + 10^- 9) =	60
Junction 3 (Wood-Framed Floor / Loadbearing Wood-Framed Wall)				
Flanking STC for path Ff_3	R_Ff,w	Same as for Ff_1		**64**
Flanking STC for path Fd_3	R_ Fd,w	Same as for Fd_1		**57**
Flanking STC for path Df_3	R_ Df,w	Same as for Df_1		**90**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.4 + 10^- 5.7 + 10^- 9) =	56
Junction 4 (Wood-Framed Floor / Non-loadbearing Wood-Framed Wall)				
All values the same as for Junction_2				
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2		**65**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2		**62**
Flanking STC for path Df_4	R_ Df,w	Same as for Df_2		**90**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.5 + 10^- 6.2 + 10^- 9) =	60
Total Flanking STC (for all 4 junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values	52
ASTC due to Direct plus Total Flanking		Equation 4.1.1	Combining Direct STC with 12 Flanking STC values	**48**

EXAMPLE 4.2-V2 **SIMPLIFIED METHOD**

- **Rooms one-above-the-other**
- **Wood-framed floors and walls**
  (Same structure as 4.2-V1 plus improved floor surfaces)

Separating floor/ceiling assembly with:

- Floor framed with 305 mm wood I-joists spaced 400 mm o.c., with joists oriented perpendicular to loadbearing wall but not continuous across junction, and 150 mm thick absorptive material[3] in cavities
- Ceiling of 1 layer of 16 mm fire-rated gypsum board[4], attached to resilient metal channels[7] spaced 400 mm o.c.
- Subfloor of oriented strand board (OSB) 19 mm thick
- Engineered floor topping of 16 mm plywood bonded to 16 mm OSB on 9 mm thick resilient mat
- Strip hardwood flooring 19 mm thick, nailed to topping, oriented with long axis perpendicular to joists

Junctions 1 and 3 (with loadbearing walls above and below floor) with:

- Joists of floor assembly perpendicular to these walls
- Wall framed with 38 mm x 89 mm wood studs spaced 400 mm o.c.
- Wall framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates) with or without absorptive material[3] in wall cavities give equivalent flanking
- 16 mm fire-rated gypsum board[4] on side walls ends at floor/ceiling assembly; and is attached directly to wall framing

Junctions 2 and 4 (with non-loadbearing walls above and below floor) with:

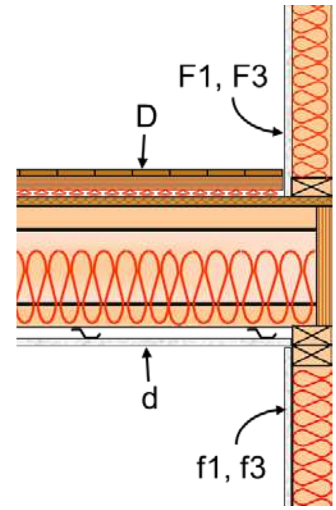
- Joists of floor assembly parallel to these walls
- Walls have 38 mm x 89 mm wood studs spaced 400 mm o.c.
- Wall framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates) with or without absorptive material[3] in wall cavities give equivalent flanking
- 16 mm fire-rated gypsum board[4] on side walls ends at floor/ceiling assembly; and is attached directly to wall framing

Note 1: For path/surface designations in the procedure below, treat the upper room as the source room (surfaces D and F)

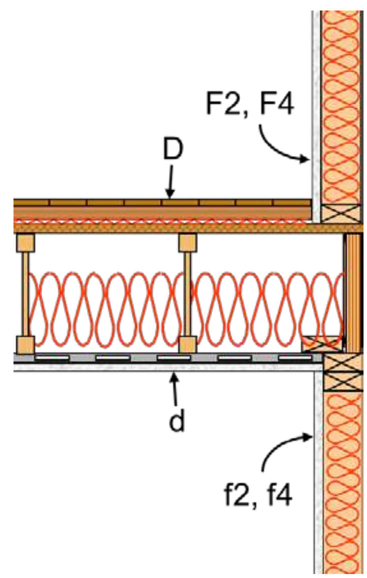
Acoustical Parameters:

	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-331, Eq. 4.1.3
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.97	RR-331, Eq. 4.1.3

Illustration for this case



Junction 1 or 3 with loadbearing side walls above and below the floor/ceiling assembly (wood I-joists of floor are perpendicular to loadbearing wall). (Side view)



Junction 2 or 4 with non-loadbearing side walls above and below the floor/ceiling assembly (wood I-joists of floor are parallel to the non-loadbearing wall). (Side view)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (Wood-Framed Floor)				
Laboratory STC for Dd	R_s,w	RR-336, TLF-13-WIJ305-011	66	
ΔSTC change by Lining on D	ΔR_D,w	N/A	0	
Direct STC in situ	R_Dd,w	RR-331, Eq. 4.1.2	66 + 0 =	**66**
Junction 1 (Wood-Framed Floor / Loadbearing Wood-Framed Wall)				
For Flanking Path Ff_1:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-LB--010	64	
Flanking STC for path Ff_1	R_Ff,w	RR-331, Eq. 4.1.3	64 + 0 =	**64**
For Flanking Path Fd_1:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-LB--010	74	
Flanking STC for path Fd_1	R_ Fd,w	RR-331, Eq. 4.1.3	74 + 0 =	**74**
For Flanking Path Df_1:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-LB--010	90	
ΔSTC change by Lining on D	ΔR_D,w	N/A	0	
Flanking STC for path Df_1	R_ Df,w	RR-331, Eq. 4.1.3 and Eq. 4.1.4	90 + 0 + 0 =	**90**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.4 + 10^- 7.4 + 10^- 9) =	64
Junction 2 (Wood-Framed Floor / Non-loadbearing Wood-Framed Wall)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-NLB--010	64	
Flanking STC for path Ff_2	R_Ff,w	RR-331, Eq. 4.1.3	64 + 1 =	**65**
For Flanking Path Fd_2:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-NLB--010	73	
Flanking STC for path Fd_2	R_ Fd,w	RR-331, Eq. 4.1.3	73 + 1 =	**74**
For Flanking Path Df_2:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-NLB--010	90	
ΔSTC change by Lining on D	ΔR_D,w	N/A	0	
Flanking STC for path Df_2	R_ Df,w	RR-331, Eq. 4.1.3 and Eq. 4.1.4	90 + 0 + 1 =	**90**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.5 + 10^- 7.4 + 10^- 9) =	64
Junction 3 (Wood-Framed Floor / Loadbearing Wood-Framed Wall)				
Flanking STC for path Ff_3	R_Ff,w	Same as for Ff_1		**64**
Flanking STC for path Fd_3	R_ Fd,w	Same as for Fd_1		**74**
Flanking STC for path Df_3	R_ Df,w	Same as for Df_1		**90**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.4 + 10^- 7.4 + 10^- 9) =	64
Junction 4 (Wood-Framed Floor / Non-loadbearing Wood-Framed Wall)				
All values the same as for Junction 2				
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2		**65**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2		**74**
Flanking STC for path Df_4	R_ Df,w	Same as for Df_2		**90**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.5 + 10^- 7.4 + 10^- 9) =	64
Total Flanking STC (for all 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	**57**

EXAMPLE 4.2-V3 **SIMPLIFIED METHOD**

- **Rooms one-above-the-other**
- **Wood-framed floors and walls**
  (Same structure as 4.2-V1 + improved floor and wall surfaces)

Separating floor/ceiling assembly with:

- Floor framed with 305 mm wood I-joists spaced 400 mm o.c., with joists oriented perpendicular to loadbearing wall but not continuous across junction, and 150 mm thick absorptive material[3] in cavities
- Ceiling of 1 layer of 16 mm fire-rated gypsum board[4], attached to resilient metal channels[7] spaced 400 mm o.c.
- Subfloor of oriented strand board (OSB) 19 mm thick
- Engineered floor topping of 16 mm plywood bonded to 16 mm OSB on 9 mm thick resilient mat
- Strip hardwood flooring 19 mm thick, nailed to topping, oriented with long axis perpendicular to joists

Junctions 1 and 3 (with loadbearing walls above and below floor) with:

- Joists of floor assembly perpendicular to these walls
- Wall framed with f 38 mm x 89 mm wood studs spaced 400 mm o.c.
- Wall framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates) with or without absorptive material[3] in wall cavities give equivalent flanking
- 16 mm fire-rated gypsum board[4] on side walls ends at floor/ceiling assembly; supported on resilient metal channels[7] that are spaced 600 mm o.c. and attached to wall framing

Junctions 2 and 4 (with non-loadbearing walls above and below floor) with:

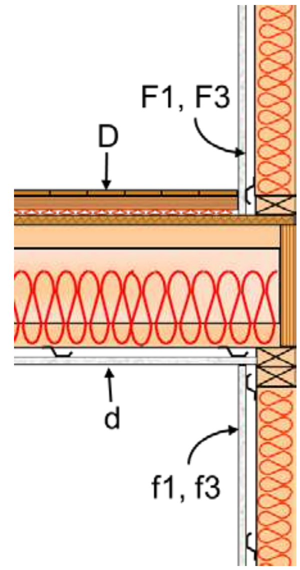
- Joists of floor assembly parallel to these walls
- Walls have 38 mm x 89 mm wood studs spaced 400 mm o.c.
- Wall framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates) with or without absorptive material[3] in wall cavities give equivalent flanking
- 16 mm fire-rated gypsum board[4] on side walls ends at floor/ceiling assembly; supported on resilient metal channels[7] that are spaced 600 mm o.c. and attached to wall framing

Note 1: For path/surface designations in the procedure below, treat the upper room as the source room (surfaces D and F)

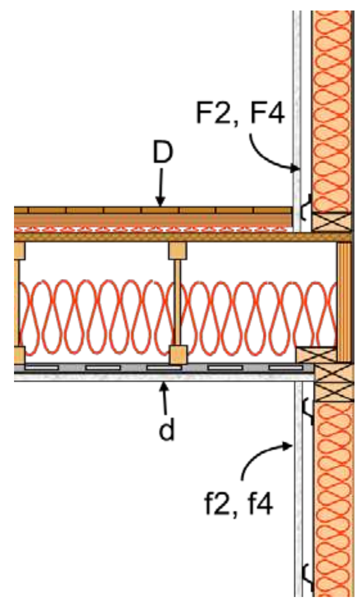
Acoustical Parameters:

	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-331, Eq. 4.1.3
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.97	RR-331, Eq. 4.1.3

Illustration for this case



Junction 1 or 3 with loadbearing side walls above and below the floor/ceiling assembly (wood I-joists of floor are perpendicular to loadbearing wall). (Side view)



Junction 2 or 4 with non-loadbearing side walls above and below the floor/ceiling assembly (wood I-joists of floor are parallel to the non-loadbearing wall). (Side view)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (Wood-Framed Floor)				
Laboratory STC for Dd	R_s,w	RR-336, TLF-13-WIJ305-011	66	
ΔSTC change by Lining on D	ΔR_D,w	N/A	0	
Direct STC in situ	R_Dd,w	RR-331, Eq. 4.1.2	66 + 0 =	**66**
Junction 1 (Wood-Framed Floor / Loadbearing Wood-Framed Wall)				
For Flanking Path Ff_1:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-LB-011	80	
Flanking STC for path Ff_1	R_Ff,w	RR-331, Eq. 4.1.3	80 + 0 =	**80**
For Flanking Path Fd_1:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-LB-011	90	
Flanking STC for path Fd_1	R_ Fd,w	RR-331, Eq. 4.1.3	90 + 0 =	**90**
For Flanking Path Df_1:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-LB-011	90	
ΔSTC change by Lining on D	ΔR_D,w	N/A	0	
Flanking STC for path Df_1	R_ Df,w	RR-331, Eq. 4.1.3 and Eq. 4.1.4	90 + 0 + 0 =	**90**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8 + 10^- 9 + 10^- 9) =	79
Junction 2 (Wood-Framed Floor / Non-loadbearing Wood-Framed Wall)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-NLB-001	80	
Flanking STC for path Ff_2	R_Ff,w	RR-331, Eq. 4.1.3	80 + 1 =	**81**
For Flanking Path Fd_2:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-NLB-001	90	
Flanking STC for path Fd_2	R_ Fd,w	RR-331, Eq. 4.1.3	90 + 1 =	**90**
For Flanking Path Df_2:				
Laboratory Flanking STC		RR-336, FTL-13-WIJ305-FW-NLB-001	90	
ΔSTC change by Lining on D	ΔR_D,w	N/A	0	
Flanking STC for path Df_2	R_ Df,w	RR-331, Eq. 4.1.3 and Eq. 4.1.4	90 + 0 + 1 =	**90**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8.1 + 10^- 9 + 10^- 9) =	80
Junction 3 (Wood-Framed Floor / Loadbearing Wood-Framed Wall)				
Flanking STC for path Ff_3	R_Ff,w	Same as for Ff_1		**80**
Flanking STC for path Fd_3	R_ Fd,w	Same as for Fd_1		**90**
Flanking STC for path Df_3	R_ Df,w	Same as for Df_1		**90**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8 + 10^- 9 + 10^- 9) =	79
Junction 4 (Wood-Framed Floor / Non-loadbearing Wood-Framed Wall)				
All values the same as for Junction 2				
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2		**81**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2		**90**
Flanking STC for path Df_4	R_ Df,w	Same as for Df_2		**90**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-8.1 + 10^- 9 + 10^- 9) =	80
Total Flanking STC (for all 4 junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values	74
ASTC due to Direct plus Total Flanking		Equation 4.1.1	Combining Direct STC with 12 Flanking STC values	**65**

EXAMPLE 4.2-H3 **SIMPLIFIED METHOD**

- **Rooms side-by-side**
- **Wood-framed floors and walls**
- **Double wood stud separating wall**

Separating wall assembly with:

- Double row of 38 mm x 89 mm wood studs spaced 400 mm o.c., with 25 mm space between rows and 89 mm thick absorptive material[3] filling the inter-stud cavities of one row of studs
- 1 layer of 16 mm fire-rated gypsum board[4] on each side

Bottom Junction 1 (separating wall and floor) with:

- Floor framed with 38 mm x 235 mm wood joists spaced 400 mm o.c., framing not continuous across junction, with 150 mm thick absorptive material[3] in cavities
- Subfloor on both sides of oriented strand board (OSB) 19 mm thick, continuous across junction, with no floor topping

Top Junction 3 (separating wall and ceiling) with:

- Ceiling framed with wood joists (details same as for bottom junction) with 150 mm thick absorptive material[3] in cavities between joists
- Ceiling (2 layers of 16 mm fire-rated gypsum board[4]) supported on resilient metal channels[7] attached to bottom of joists on each side

Two options are compared:

⇨ **Case A** with the joists of the floor and ceiling **parallel** to separating wall as illustrated above,

⇨ **Case B** with floor and ceiling joists **perpendicular** to the separating wall as illustrated in lower detail.

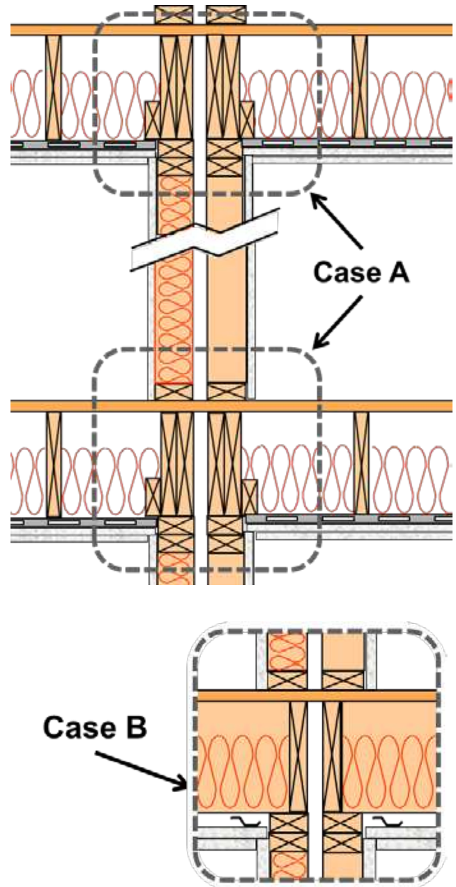
Side Junctions 2 and 4 (separating wall and abutting side walls) with:

- 16 mm fire-rated gypsum board[4] on side walls ends at separating wall assembly; supported on resilient metal channels[7] attached to wall framing
- Side wall framing with single row of wood studs with absorptive material[3] filling stud cavities
- Side wall framing structurally-connected to the separating wall, but continuous across junction (as illustrated)

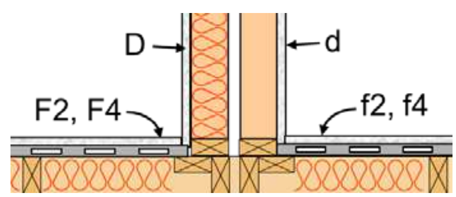
Acoustical Parameters:

	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-331, Eq. 4.1.3
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-331, Eq. 4.1.3

Illustration for this case:



Two choices for Junctions 1 and 3 where the framing of the floor and ceiling connects to the separating wall. (Side view)



Junction 2 or 4 of separating wall with abutting side walls with side walls' framing continuous across junction and gypsum board terminating at separating wall. (Plan view)

(For the notes in this table please see the corresponding endnotes on page 195.)

Note: For these examples, Flanking TL data for individual paths at each junction are not available, so these examples use the available data for junctions.

CASE A: Floor Joists Parallel to Separating Wall

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (Wall Framed with 2 Rows of Studs)				
Laboratory STC for Dd	R_s,w	RR-336, TLW-13-DWS203-001	55	
Direct STC in situ	R_Dd,w	RR-331, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**55**
Junction 1 (Wall/Floor Junction: Non-loadbearing Wall / Floor Joists Parallel to Wall)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WF-NLB-001	47	
Junction 1: Flanking STC for all paths			47 + 0 =	**47**
Junction 2 (Non-loadbearing Separating Wall / Wood-Framed Flanking Walls)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WW-NLB-001	65	
Junction 2: Flanking STC for all paths			65 + 0 =	**65**
Junction 3 (Wall/Ceiling Junction: Non-loadbearing Wall / Ceiling Joists Parallel to Wall)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WC-NLB-001	65	
Junction 3: Flanking STC for all paths			65 + 0 =	**65**
Junction 4 (Non-loadbearing Separating Wall / Wood-Framed Flanking Walls)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WW-NLB-001	65	
Junction 4: Flanking STC for all paths			65 + 0 =	**65**
Total Flanking STC (for all 4 junctions)		RR-331, Subset of Eq. 4.1.1	Combining 4 Junction Flanking STC values	47
ASTC due to Direct plus Total Flanking		RR-331, Eq. 4.1.1	Combining Direct STC with Flanking STC values	**46**

CASE B: Floor Joists Perpendicular to Separating Wall

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (Wall Framed with 2 Rows of Studs)				
Laboratory STC for Dd	R_s,w	RR-336, TLW-13-DWS203-001	55	
Direct STC in situ	R_Dd,w	RR-331, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**55**
Junction 1 (Wall/Floor Junction: Separating Wall / Floor Joists Perpendicular to Wall)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WF-LB-001	49	
Junction 1: Flanking STC for all paths			49 + 0 =	**49**
Junction 2 (Separating Wall / Wood-Framed Flanking Walls)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WW-LB-001	65	
Junction 2: Flanking STC for all paths			65 + 0 =	**65**
Junction 3 (Wall/Ceiling Junction: Separating Wall / Ceiling Joists Perpendicular to Wall)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WC-LB-001	65	
Junction 3: Flanking STC for all paths			65 + 0 =	**65**
Junction 4 (Separating Wall / Wood-Framed Flanking Walls)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WW-LB-001	65	
Junction 4: Flanking STC for all paths			65 + 0 =	**65**
Total Flanking STC (for all 4 junctions)		RR-331, Subset of Eq. 4.1.1	Combining 4 Junction Flanking STC values	49
ASTC due to Direct plus Total Flanking		RR-331, Eq. 4.1.1	Combining Direct STC with Flanking STC values	**48**

EXAMPLE 4.2-H4 **SIMPLIFIED METHOD**

- **Rooms side-by-side**
- **Wood-framed floors and walls**
- **Double wood stud separating wall**

Separating wall assembly with:
- Double row of 38 mm x 89 mm wood studs spaced 400 mm o.c., with 25 mm space between rows and 89 mm thick absorptive material[3] filling the inter-stud cavities of both rows of studs
- 1 layer of 16 mm fire-rated gypsum board[4] on each side

Bottom Junction 1 (separating wall and floor) with:
- Floor framed with 38 mm x 235 mm wood joists spaced 400 mm o.c., framing not continuous across junction, with 150 mm thick absorptive material[3] in cavities
- Subfloor on both sides of oriented strand board (OSB) 19 mm thick, with no floor topping

Top Junction 3 (separating wall and ceiling) with:
- Ceiling framed with wood joists (details same as for bottom junction) with 150 mm thick absorptive material[3] in cavities between joists
- Ceiling (2 layers of 16 mm fire-rated gypsum board[4]) supported on resilient channels[7] attached to bottom of joists on each side

Two options are compared:

⇨ **Case A** with the OSB subfloor continuous across the floor and ceiling junctions, as illustrated above,

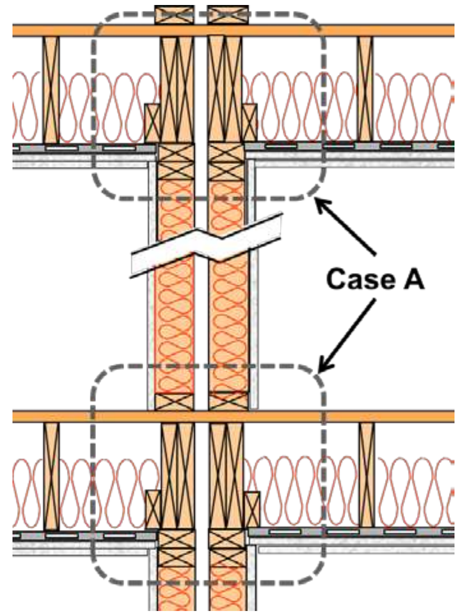
⇨ **Case B** with OSB subfloor **not** continuous across the junctions as illustrated in lower detail. Because both wall cavities are full of absorptive material, the solid fire block is not required.

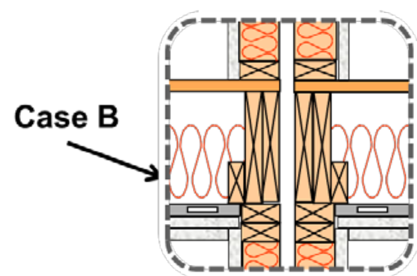
Side Junctions 2 and 4 (separating wall and abutting side walls) with:
- 16 mm fire-rated gypsum board[4] on side walls ends at separating wall assembly; supported on resilient metal channels[7] attached to wall framing
- Side wall framing with single row of wood studs with absorptive material[3] filling stud cavities
- Side wall framing structurally-connected to the separating wall, but continuous across junction (as illustrated)

Acoustical Parameters:

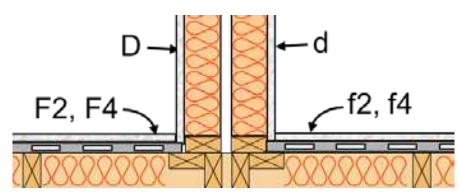
	In Scenario	In Laboratory
Separating partition area (m^2) =	12.5	12.5
Floor/separating wall junction length (m) =	5.0	5.0
Wall/separating wall junction length (m) =	2.5	2.5
Normalization for Junctions 1 and 3:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-331, Eq. 4.1.3
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-331, Eq. 4.1.3

Illustration for this case:





Two choices for Junctions 1 and 3 where the framing of the floor and ceiling connects to the separating wall. (Side view)



Junction 2 or 4 of separating wall with abutting side walls with side walls' framing continuous across junction and gypsum board terminating at separating wall. (Plan view)

(For the notes in this table please see the corresponding endnotes on page 195.)

Note: For these examples, Flanking TL data for individual paths at each junction are not available, so these examples use the available data for junctions.

CASE A: Floor Joists Parallel to Separating Wall				
	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (Wall Framed with 2 Rows of Studs)				
Laboratory STC for Dd	R_s,w	RR-336, TLW-13-DWS203-002	58	
Direct STC in situ	R_Dd,w	RR-331, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**58**
Junction 1 (Wall/Floor Junction: Non-loadbearing Wall / Floor Joists Parallel to Wall)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WF-NLB-001	47	
Junction 1: Flanking STC for all paths			47 + 0 =	**47**
Junction 2 (Non-loadbearing Separating Wall / Wood-Framed Flanking Walls)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WW-NLB-001	65	
Junction 2: Flanking STC for all paths			65 + 0 =	**65**
Junction 3 (Wall/Ceiling Junction: Non-loadbearing Wall / Ceiling Joists Parallel to Wall)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WC-NLB-001	65	
Junction 3: Flanking STC for all paths			65 + 0 =	**65**
Junction 4 (Non-loadbearing Separating Wall / Wood-Framed Flanking Walls)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WW-NLB-001	65	
Junction 4: Flanking STC for all paths			65 + 0 =	**65**
Total Flanking STC (for all 4 junctions)		RR-331, Subset of Eq. 4.1.1	Combining 4 Junction Flanking STC values	47
ASTC due to Direct plus Total Flanking		RR-331, Eq. 4.1.1	Combining Direct STC with Flanking STC values	**46**

CASE B: Floor Joists Perpendicular to Separating Wall				
	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (Wall Framed with 2 Rows of Studs)				
Laboratory STC for Dd	R_s,w	RR-336, TLW-13-DWS203-002	58	
Direct STC in situ	R_Dd,w	RR-331, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**58**
Junction 1 (Wall/Floor Junction: Non-loadbearing Wall / Floor Joists Perpendicular to Wall)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WF-NLB-002	85	
Junction 1: Flanking STC for all paths			85 + 0 =	**85**
Junction 2 (Non-loadbearing Separating Wall / Wood-Framed Flanking Walls)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WW-NLB-002	65	
Junction 2: Flanking STC for all paths			65 + 0 =	**65**
Junction 3 (Wall/Ceiling Junction: Non-loadbearing Wall / Ceiling Joists Perpendicular to Wall)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WC-NLB-002	85	
Junction 3: Flanking STC for all paths			85 + 0 =	**85**
Junction 4 (Non-loadbearing Separating Wall / Wood-Framed Flanking Walls)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WW-NLB-002	65	
Junction 4: Flanking STC for all paths			65 + 0 =	**65**
Total Flanking STC (for all 4 junctions)		RR-331, Subset of Eq. 4.1.1	Combining 4 Junction Flanking STC values	62
ASTC due to Direct plus Total Flanking		RR-331, Eq. 4.1.1	Combining Direct STC with Flanking STC values	**57**

EXAMPLE 4.2-H5 **SIMPLIFIED METHOD**

- **Rooms side-by-side**
- **Double wood stud separating wall**
- **Wood-framed floors with concrete topping**

Separating wall assembly with:
- Double row of 38 mm x 89 mm wood studs spaced 400 mm o.c., with 25 mm space between rows and 89 mm thick absorptive material[3] filling the inter-stud cavities of both rows of studs
- 1 layer of 16 mm fire-rated gypsum board[4] on each side

Bottom Junction 1 (separating wall and floor) with:
- Floor framed with 38 mm x 235 mm wood joists spaced 400 mm o.c., framing not continuous across junction, with 150 mm thick absorptive material[3] in cavities
- Subfloor on both sides of oriented strand board (OSB) 19 mm thick, with floor topping of 38 mm thick concrete on each side

Top Junction 3 (separating wall and ceiling) with:
- Ceiling framed with wood joists (details same as for bottom junction) with 150 mm thick absorptive material[3] in cavities between joists
- Ceiling (2 layers of 16 mm fire-rated gypsum board[4]) supported on resilient channels[7] attached to bottom of joists on each side

Two options are compared:

⇨ **Case A** with the OSB subfloor continuous across the floor and ceiling junctions, as illustrated above,

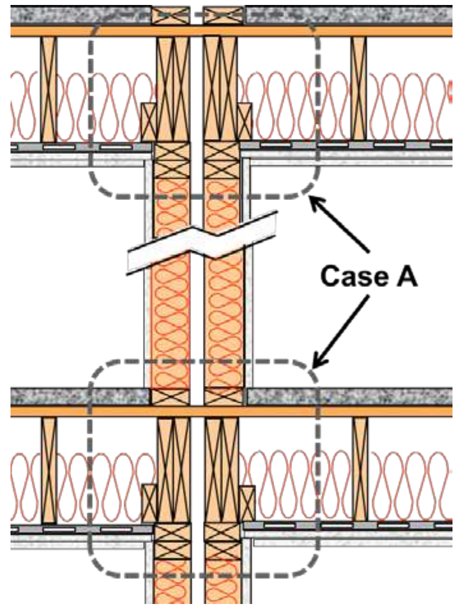
⇨ **Case B** with OSB subfloor **not** continuous across the junctions as illustrated in lower detail. Because both wall cavities are full of absorptive material, the solid fire block is not required.

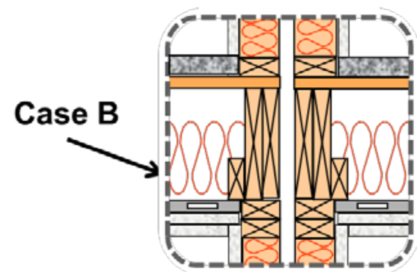
Side Junctions 2 and 4 (separating wall and abutting side walls) with:
- 16 mm fire-rated gypsum board[4] on side walls ends at separating wall assembly; supported on resilient metal channels[7] attached to wall framing
- Side wall framing with single row of wood studs with absorptive material[3] filling stud cavities
- Side wall framing structurally-connected to the separating wall, but continuous across junction (as illustrated)

Acoustical Parameters:

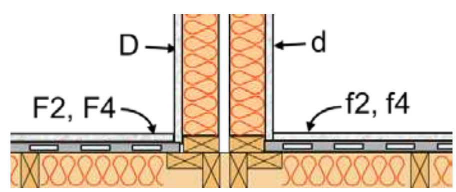
	In Scenario	In Laboratory
Separating partition area (m^2) =	12.5	12.5
Floor/separating wall junction length (m) =	5.0	5.0
Wall/separating wall junction length (m) =	2.5	2.5
Normalization for Junctions 1 and 3:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	Guide, Eq. 4.1.3
Normalization for Junctions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

Illustration for this case:





Two choices for Junctions 1 and 3 where the framing of the floor and ceiling connects to the separating wall. (Side view)



Junction 2 or 4 of separating wall with abutting side walls with side walls' framing continuous across junction and gypsum board terminating at separating wall. (Plan view)

(For the notes in this table please see the corresponding endnotes on page 195.)

Note: For these examples, Flanking TL data for individual paths at each junction are not available, so these examples use the available data for junctions.

CASE A: Floor Joists Parallel to Separating Wall				
	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (Wall Framed with 2 Rows of Studs)				
Laboratory STC for Dd	R_s,w	RR-336, TLW-13-DWS203-002	58	
Direct STC in situ	R_Dd,w	RR-331, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**58**
Junction 1 (Wall/Floor Junction: Non-loadbearing Wall / Floor Joists Parallel to Wall)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WF-NLB-003	61	
Junction 1: Flanking STC for all paths			61 + 0 =	**61**
Junction 2 (Non-loadbearing Separating Wall / Wood-Framed Flanking Walls)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WW-NLB-003	65	
Junction 2: Flanking STC for all paths			65 + 0 =	**65**
Junction 3 (Wall/Ceiling Junction: Non-loadbearing Wall / Ceiling Joists Parallel to Wall)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WC-NLB-003	65	
Junction 3: Flanking STC for all paths			65 + 0 =	**65**
Junction 4 (Non-loadbearing Separating Wall / Wood-Framed Flanking Walls)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WW-NLB-003	65	
Junction 4: Flanking STC for all paths			65 + 0 =	**65**
Total Flanking STC (for all 4 junctions)		RR-331, Subset of Eq. 4.1.1	Combining 4 Junction Flanking STC values	58
ASTC due to Direct plus Total Flanking		RR-331, Eq. 4.1.1	Combining Direct STC with Flanking STC values	**55**

CASE B: Floor Joists Parallel to Separating Wall, Discontinuous Subfloor				
	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (Wall Framed with 2 Rows of Studs)				
Laboratory STC for Dd	R_s,w	RR-336, TLW-13-DWS203-002	58	
Direct STC in situ	R_Dd,w	RR-331, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**58**
Junction 1 (Wall/Floor Junction: Non-loadbearing Wall / Floor Joists Parallel to Wall)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WF-NLB-004	85	
Junction 1: Flanking STC for all paths			85 + 0 =	**85**
Junction 2 (Non-loadbearing Separating Wall / Wood-Framed Flanking Walls)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WW-NLB-004	65	
Junction 2: Flanking STC for all paths			65 + 0 =	**65**
Junction 3 (Wall/Ceiling Junction: Non-loadbearing Wall / Ceiling Joists Parallel to Wall)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WC-NLB-004	85	
Junction 3: Flanking STC for all paths			85 + 0 =	**85**
Junction 4 (Non-loadbearing Separating Wall / Wood-Framed Flanking Walls)				
Measured Laboratory Flanking STC		RR-336, FTL-13-DWS203-WW-NLB-004	65	
Junction 4: Flanking STC for all paths			65 + 0 =	**65**
Total Flanking STC (for all 4 junctions)		RR-331, Subset of Eq. 4.1.1	Combining 4 Junction Flanking STC values	62
ASTC due to Direct plus Total Flanking		RR-331, Eq. 4.1.1	Combining Direct STC with Flanking STC values	**57**

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

The worked examples (4.2-H1 to H4 and 4.2-V1 to V3) illustrate the use of the Simplified Method for calculating the apparent sound transmission class (ASTC) ratings between rooms in a building with wood-framed floor and wall assemblies.

The examples show the performance for cases with bare floor surfaces and for cases with improvements in direct and/or flanking transmission loss via specific paths due to selected changes in the surface layers of the walls and floors.

The first set of examples (4.2-H1 to 4.2-V3) concerns cases where the loadbearing walls are framed with a single row of wood studs. The second group of examples (4.2-H3 and 4.2-H4) have loadbearing walls framed with a double row of wood studs.

Separating Walls with Single Row of Wood Studs

Example 4.2-H2 for a horizontal pair of rooms separated by a single-stud wall shows improvements relative to the base case (4.2-H1) due to improving the weakest paths – the separating wall and the set of paths at the floor/wall junction.

- Improving the wall by adding a layer of gypsum board increases the Direct STC to 57 and also provides an improvement to path Fd at both sidewall junctions.
- The main improvement is adding hardwood flooring on an engineered wood topping, which increases the Flanking STC at the floor/wall junction from 50 to 62. This gives a good balance between flanking transmission at the four junctions, and between direct transmission and flanking transmission. The ASTC of 54 is near the maximum feasible with this wall construction.

Examples 4.2-V2 and 4.2-V3 for a vertical pair of rooms show the improvements relative to the base case (4.2-V1) as the floor and wall surfaces are upgraded.

- As shown in 4.2-V2, the obvious first step to increase ASTC is to improve the floor surface, in this case by adding hardwood flooring supported on an engineered wood topping, which increases the Direct STC from 51 to 66. The change to the floor surface also improves Flanking STC for paths Df at all four wall junctions by more than 10 dB, but flanking transmission still dominates the transmission in case 4.2-V2. For all these wall/floor junctions, the dominant flanking path is path Ff (wall above to wall below), with path Df a weaker secondary concern.
- Changing the surface f (walls in the room below) by mounting the gypsum board in the room below on resilient metal channels, as shown in 4.2-V3, improves the key flanking paths, so the total Flanking STC increases to 74, and the overall ASTC approaches the limit of 66 due to direct transmission through the floor.

Separating Walls with Double Row of Wood Studs

Examples 4.2-H3 to 4.2-H5 illustrate the effect of changing some details for a horizontal pair of rooms separated by a double-stud wall.

- In the base Case A in 4.2-H3, the separating wall has a Direct STC rating of 55, but the ASTC is limited to 46 by flanking transmission at the floor/wall junction due to the rigid connection provided by the continuous OSB subfloor. This junction detail has advantages for shear bracing and provides a fire block, but also causes low Flanking STC values. If the continuous subfloor is essential for structural reasons, the flanking transmission can be moderated by orienting the floor joists perpendicular to the separating wall as shown in Case B of 4.2-H3. This raises the ASTC over 47, with no changes in the details of the wall or floor assemblies.
- In Example 4.2-H4, sound absorbing material is added to the stud cavities on both sides of the separating wall, which raises the Direct STC from 55 to 58. However, adding the sound absorbing material has negligible effect on the structure-borne flanking transmission, so flanking transmission via the wall/floor junction limits the ASTC for Case A to only 46, as in the previous example. In this example, because there is absorptive material filling the stud cavities on both sides of the wall, a solid fire block at the junctions is not required, and eliminating continuity of the OSB subfloor across the junctions (as shown in Case B), if not required for structural reasons, eliminates the flanking transmission there, raising the ASTC to 57.

For larger buildings, the continuity of the subfloor (or some other solid fire block) may be necessary for structural stability. In such cases, two obvious options to improve the ASTC are to increase the Direct STC by adding more gypsum board on the separating walls, or to add a heavy topping (such as a concrete subfloor, or an extra layer of OSB, or even strip hardwood flooring) on the floor surfaces to control the dominant flanking path.

- In Example 4.2-H5, the effect of adding a topping over the OSB subfloor on both sides of the separating wall is illustrated. The Direct STC is 58, as in Example 4.2-H4. However, adding the floor topping has a significant effect on the structure-borne flanking transmission, so the ASTC for Case A improves from 46 to 53 due to reduced flanking transmission via the wall/floor junction. In this example, because there is absorptive material filling the stud cavities on both sides of the wall, a solid fire block at the junctions is not required, and eliminating continuity of the OSB subfloor across the junctions (as shown in Case B) eliminates the flanking transmission there, raising the ASTC to 57, limited only by direct transmission and flanking via the side walls as in the previous example. Although the ASTC is not better than for Option B in 4.2-H4, addition of the floor topping would also benefit the sound insulation between units one-above-the-other.

Overall, these examples show the clear benefit of suitable wall and ceiling surface layers in achieving high ASTC values, and emphasize the cost/benefit of focussing improvements on the weakest path(s).

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4.3. Cold-Formed Steel-Framed Wall and Floor Assemblies

For buildings with cold-formed steel-framed[8] (CFS-framed) walls and floor/ceiling assemblies, the calculation procedure outlined in Section 4.1 can be used in precisely the same manner as presented for wood-framed constructions in Section 4.2.

This section applies to buildings where the floors are framed with cold-formed steel joists[8] and the walls are framed with cold-formed steel studs[8]. These joists and studs typically have a C-shaped cross-section, but other possibilities such as I-shaped floor joists are also possible. Common surfaces include gypsum board walls and ceilings, and floor decks of plywood or OSB.

As for wood-framed construction, the ASTC between the pair of adjacent rooms can be calculated using one-third octave band sound transmission data or single-number ratings derived from that data, following the steps illustrated in Figure 4.1.1 and the explanatory notes following that figure.

The calculation procedure requires two types of laboratory test data as inputs:

1) Sound transmission loss data determined according to ASTM E90 for direct sound transmission through the separating assembly, and
2) Flanking sound transmission data determined according to ISO 10848 for the pairs of flanking surfaces at each edge of the separating assembly.

More information on the direct and flanking sound insulation of cold-formed steel-framed assemblies and building systems can be found in NRC Research Report RR-337, “Apparent Sound Insulation in Cold-Formed Steel-Framed Buildings.” The report provides the data for direct and flanking sound insulation for a variety of CFS-framed building configurations.

EXAMPLE 4.3-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[8] 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[5] 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[7], and vice versa.

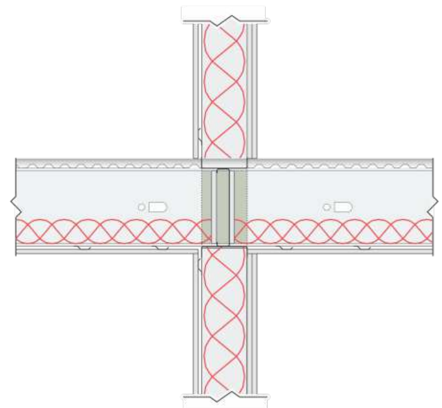
Junction 3: Separating wall / ceiling with:

- Junction code CFS-WC-LBc-13

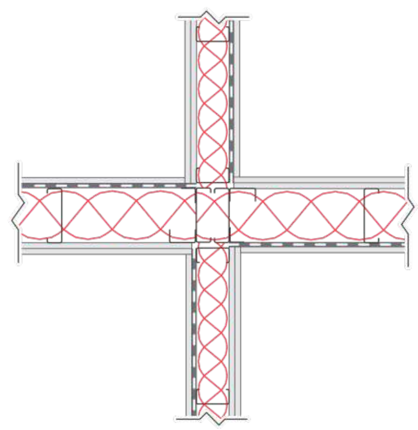
Acoustical Parameters:

	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-331, Eq. 4.1.3
RR-331 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-331, Eq. 4.1.3
RR-331 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)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or 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-331, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**54**
Junction 1 (Wall/Floor Junction LBc with CFS-Framed Floor)				
For Flanking Path Ff_1:				
Laboratory Flanking STC		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-331, 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		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-331, Eq. 4.1.3 and Eq. 4.1.4	53 + 0 + 0 =	**53**
For Flanking Path Df_1:				
Laboratory Flanking STC		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-331, 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 (LB CFS-Framed Separating Wall / NLB CFS-Framed Flanking Walls)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-337, CFS-WW-LB152-01	82	
Flanking STC for path Ff_2	R_Ff,w	RR-331, Eq. 4.1.3	82 + 0 =	**82**
For Flanking Path Fd_2:				
Laboratory Flanking STC		RR-337, CFS-WW-LB152-01	76	
Flanking STC for path Fd_2	R_ Fd,w	RR-331, Eq. 4.1.3	76 + 0 =	**76**
For Flanking Path Df_2:				
Laboratory Flanking STC		RR-337, CFS-WW-LB152-01	82	
Flanking STC for path Df_2	R_ Df,w	RR-331, 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 with CFS-Framed Floor/Ceiling)				
For Flanking Path Ff_3:				
Laboratory Flanking STC		RR-337, CFS-WC-LBc-13	65	
Flanking STC for path Ff_3	R_Ff,w	RR-331, Eq. 4.1.3	65 + 0 =	**65**
For Flanking Path Fd_3:				
Laboratory Flanking STC		RR-337, CFS-WC-LBc-13	73	
Flanking STC for path Fd_3	R_ Fd,w	RR-331, Eq. 4.1.3	73 + 0 =	**73**
For Flanking Path Df_3:				
Laboratory Flanking STC		RR-337, CFS-WC-LBc-13	69	
Flanking STC for path Df_3	R_ Df,w	RR-331, 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 (LB CFS-Framed Separating Wall / NLB 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 (for all 4 junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values	47
ASTC due to Direct plus Flanking Paths		Eq. 4.1.1	**Combining Direct STC with 12 Flanking STC values**	**46**

EXAMPLE 4.3-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[8] 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[7], and vice versa.

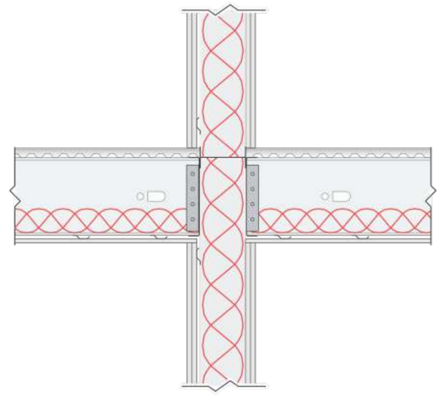
Junction 3: Separating wall / ceiling with:

- Junction code CFS-WC-LBd-21

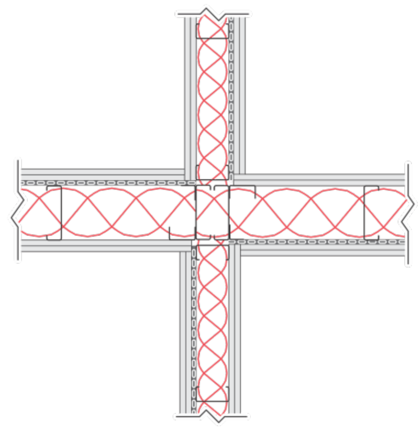
Acoustical Parameters:

	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-331, Eq. 4.1.3
RR-331 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-331, Eq. 4.1.3
RR-331 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)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or 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-331, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**58**
Junction 1 (Wall/Floor Junction LBd with CFS-Framed Floor)				
For Flanking Path Ff_1:				
Laboratory Flanking STC		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-331, 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		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-331, Eq. 4.1.3 and Eq. 4.1.4	62 + 0 + 0 =	**62**
For Flanking Path Df_1:				
Laboratory Flanking STC		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-331, 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 (LB CFS-Framed Separating Wall / NLB CFS-Framed Flanking Walls)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-337, CFS-WW-LB152-01	82	
Flanking STC for path Ff_2	R_Ff,w	RR-331, Eq. 4.1.3	82 + 0 =	**82**
For Flanking Path Fd_2:				
Laboratory Flanking STC		RR-337, CFS-WW-LB152-01	76	
Flanking STC for path Fd_2	R_ Fd,w	RR-331, Eq. 4.1.3	76 + 0 =	**76**
For Flanking Path Df_2:				
Laboratory Flanking STC		RR-337, CFS-WW-LB152-01	82	
Flanking STC for path Df_2	R_ Df,w	RR-331, 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 with CFS-Framed Floor/Ceiling)				
For Flanking Path Ff_3:				
Laboratory Flanking STC		RR-337, CFS-WC-LBd-21	75	
Flanking STC for path Ff_3	R_Ff,w	RR-331, Eq. 4.1.3	75 + 0 =	**75**
For Flanking Path Fd_3:				
Laboratory Flanking STC		RR-337, CFS-WC-LBd-21	64	
Flanking STC for path Fd_3	R_ Fd,w	RR-331, Eq. 4.1.3		**64**
For Flanking Path Df_3:				
Laboratory Flanking STC		RR-337, CFS-WC-LBd-21	70	
Flanking STC for path Df_3	R_ Df,w	RR-331, 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 (LB CFS-Framed Separating Wall / NLB 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 (for all 4 junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values	58
ASTC due to Direct plus Flanking Paths		Eq. 4.1.1	**Combining Direct STC with 12 Flanking STC values**	**55**

EXAMPLE 4.3-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[8] 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[5] 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[7], and vice versa.

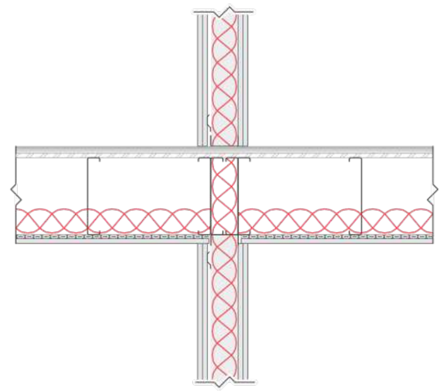
Junction 3: Separating wall / ceiling with:

- Junction code CFS-WC-NLBc-31

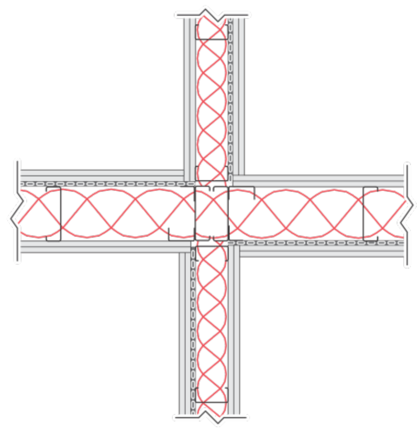
Acoustical Parameters:

		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-331, Eq. 4.1.3
	RR-331 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-331, Eq. 4.1.3
	RR-331 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)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or 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-331, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**57**
Junction 1 (Wall/Floor Junction NLBc with CFS-Framed Floor)				
For Flanking Path Ff_1:				
Laboratory Flanking STC		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-331, 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		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-331, Eq. 4.1.3 and Eq. 4.1.4	49 + 0 + 0 =	**49**
For Flanking Path Df_1:				
Laboratory Flanking STC		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-331, 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 (NLB CFS-Framed Separating Wall / LB CFS-Framed Flanking Walls)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-337, CFS-WW-NLB92-01	84	
Flanking STC for path Ff_2	R_Ff,w	RR-331, Eq. 4.1.3	84 + 0 =	**84**
For Flanking Path Fd_2:				
Laboratory Flanking STC		RR-337, CFS-WW-NLB92-01	82	
Flanking STC for path Fd_2	R_ Fd,w	RR-331, Eq. 4.1.3	82 + 0 =	**82**
For Flanking Path Df_2:				
Laboratory Flanking STC		RR-337, CFS-WW-NLB92-01	81	
Flanking STC for path Df_2	R_ Df,w	RR-331, 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 with CFS-Framed Floor/Ceiling)				
For Flanking Path Ff_3:				
Laboratory Flanking STC		RR-337, CFS-WC-NLBc-31	67	
Flanking STC for path Ff_3	R_Ff,w	RR-331, Eq. 4.1.3	67 + 0 =	**67**
For Flanking Path Fd_3:				
Laboratory Flanking STC		RR-337, CFS-WC-NLBc-31	65	
Flanking STC for path Fd_3	R_ Fd,w	RR-331, Eq. 4.1.3	65 + 0 =	**65**
For Flanking Path Df_3:				
Laboratory Flanking STC		RR-337, CFS-WC-NLBc-31	71	
Flanking STC for path Df_3	R_ Df,w	RR-331, 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 (NLB CFS-Framed Separating Wall / LB 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 (for all 4 junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values	39
ASTC due to Direct plus Flanking Paths		Eq. 4.1.1	**Combining Direct STC with 12 Flanking STC values**	**39**

EXAMPLE 4.3-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[8] 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[5] 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[7], and vice versa.

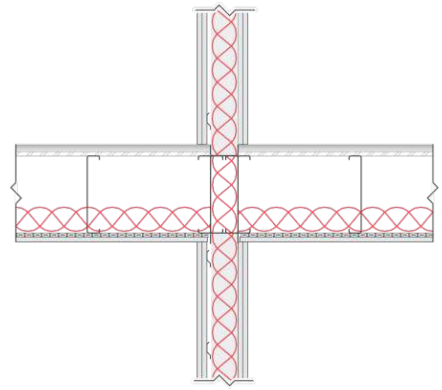
Junction 3: Separating wall / ceiling with:

- Junction code CFS-WC-NLBd-41

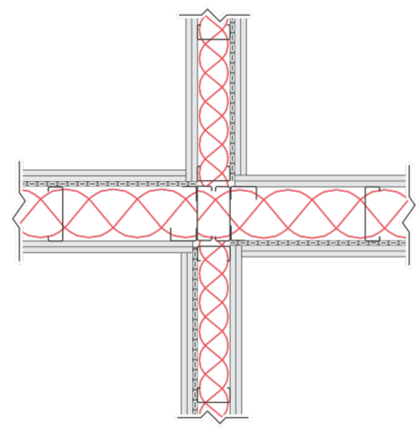
Acoustical Parameters:

		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-331, Eq. 4.1.3
	RR-331 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-331, Eq. 4.1.3
	RR-331 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)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or 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-331, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**57**
Junction 1 (Wall/Floor Junction NLBd with CFS-Framed Floor)				
For Flanking Path Ff_1:				
Laboratory Flanking STC		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-331, 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		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-331, Eq. 4.1.3 and Eq. 4.1.4	63 + 0 + 0 =	**63**
For Flanking Path Df_1:				
Laboratory Flanking STC		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-331, 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 (NLB CFS-Framed Separating Wall / LB CFS-Framed Flanking Walls)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-337, CFS-WW-NLB92-01	84	
Flanking STC for path Ff_2	R_Ff,w	RR-331, Eq. 4.1.3	84 + 0 =	**84**
For Flanking Path Fd_2:				
Laboratory Flanking STC		RR-337, CFS-WW-NLB92-01	82	
Flanking STC for path Fd_2	R_ Fd,w	RR-331, Eq. 4.1.3	82 + 0 =	**82**
For Flanking Path Df_2:				
Laboratory Flanking STC		RR-337, CFS-WW-NLB92-01	81	
Flanking STC for path Df_2	R_ Df,w	RR-331, 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 with CFS-Framed Floor/Ceiling)				
For Flanking Path Ff_3:				
Laboratory Flanking STC		RR-337, CFS-WC-NLBd-41	77	
Flanking STC for path Ff_3	R_Ff,w	RR-331, Eq. 4.1.3	77 + 0 =	**77**
For Flanking Path Fd_3:				
Laboratory Flanking STC		RR-337, CFS-WC-NLBd-41	70	
Flanking STC for path Fd_3	R_ Fd,w	RR-331, Eq. 4.1.3	70 + 0 =	**70**
For Flanking Path Df_3:				
Laboratory Flanking STC		RR-337, CFS-WC-NLBd-41	69	
Flanking STC for path Df_3	R_ Df,w	RR-331, 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 (NLB CFS-Framed Separating Wall / LB 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 (for all 4 junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values	57
ASTC due to Direct plus Flanking Paths		Eq. 4.1.1	**Combining Direct STC with 12 Flanking STC values**	**54**

EXAMPLE 4.3-H5: (SIMPLIFIED METHOD)

- **Rooms side-by-side**
- **Loadbearing junction with continuous joists and subfloor**
- **Same as EXAMPLE 4.3-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[8] 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.

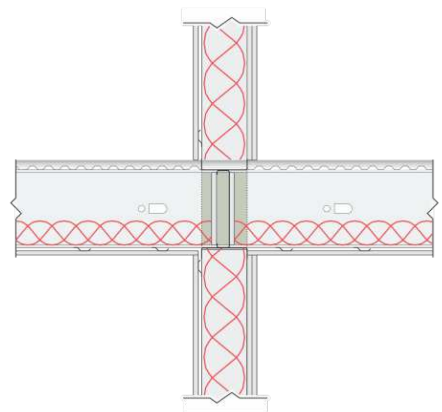
Junction 2 or 4: Separating wall / abutting side wall with:
- Junction code CFS-WW-LB152-01
- Non-loadbearing flanking walls with short code 2G16_SS92(406)_GFB152_RC13(406)_G16, framing formed from steel 0.54 mm thick
- Closest CFS studs[5] of the non-loadbearing walls spaced 10 mm from framing of loadbearing 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[7], and vice versa.

Junction 3: Separating wall / ceiling with:
- Junction code CFS-WC-LBc-13

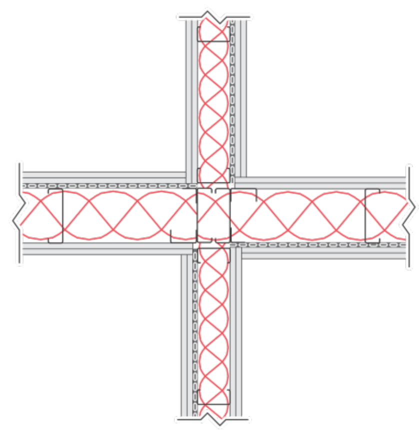
Acoustical Parameters:

	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-331, Eq. 4.1.3
RR-331 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-331, Eq. 4.1.3
RR-331 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)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or 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-331, Eq. 4.1.2 (not a floor, so no ΔSTC correction)		**54**
Junction 1 (Wall/Floor Junction LBc with CFS-Framed Floor)				
For Flanking Path Ff_1:				
Laboratory Flanking STC		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-331, Eq. 4.1.3 and Eq. 4.1.5	50 + MAX(2,2)) + MIN(2,2)/2 + 0 =	**53**
For Flanking Path Fd_1:				
Laboratory Flanking STC		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-331, Eq. 4.1.3 and Eq. 4.1.4	53 + 2 + 0 =	**55**
For Flanking Path Df_1:				
Laboratory Flanking STC		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-331, 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
Junction 2 (LB CFS-Framed Separating Wall / NLB CFS-Framed Flanking Walls)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-337, CFS-WW-LB152-01	82	
Flanking STC for path Ff_2	R_Ff,w	RR-331, Eq. 4.1.3	82 + 0 =	**82**
For Flanking Path Fd_2:				
Laboratory Flanking STC		RR-337, CFS-WW-LB152-01	76	
Flanking STC for path Fd_2	R_ Fd,w	RR-331, Eq. 4.1.3	76 + 0 =	**76**
For Flanking Path Df_2:				
Laboratory Flanking STC		RR-337, CFS-WW-LB152-01	82	
Flanking STC for path Df_2	R_ Df,w	RR-331, 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 with CFS-Framed Floor/Ceiling)				
For Flanking Path Ff_3:				
Laboratory Flanking STC		RR-337, CFS-WC-LBc-13	65	
Flanking STC for path Ff_3	R_Ff,w	RR-331, Eq. 4.1.3	65 + 0 =	**65**
For Flanking Path Fd_3:				
Laboratory Flanking STC		RR-337, CFS-WC-LBc-13	73	
Flanking STC for path Fd_3	R_ Fd,w	RR-331, Eq. 4.1.3	73 + 0 =	**73**
For Flanking Path Df_3:				
Laboratory Flanking STC		RR-337, CFS-WC-LBc-13	69	
Flanking STC for path Df_3	R_ Df,w	RR-331, 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 (LB CFS-Framed Separating Wall / NLB 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 (for all 4 junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values	50
ASTC due to Direct plus Flanking Paths		Eq. 4.1.1	**Combining Direct STC with 12 Flanking STC values**	**48**

EXAMPLE 4.3-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[7] (Junction 1) or attached directly to wall framing (Junction 3).
- CFS floor joists[8] perpendicular to the loadbearing wall and continuous across the junction and gypsum concrete floor deck continuous across the junction.

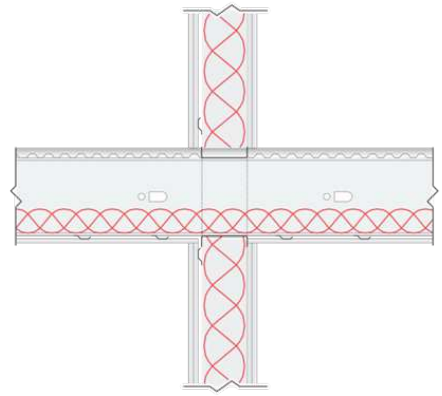
Junction 2 or 4: Separating floor / non-loadbearing walls with:

- 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[8] parallel to the non-loadbearing wall.
- Gypsum concrete floor deck discontinuous across the junction.

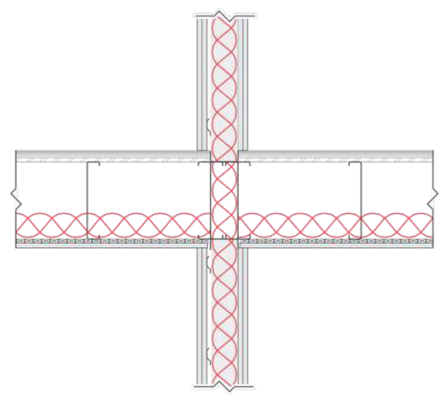
Acoustical Parameters:

	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-331, Eq. 4.1.3
RR-331 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-331, Eq. 4.1.3
RR-331 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)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or 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-331, 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		RR-337, CFS-FW-LBc-11r, wall gypsum board on RC	67	
Flanking STC for path Ff_1	R_Ff,w	RR-331, Eq. 4.1.3	67 + 0 =	**67**
For Flanking Path Fd_1:				
Laboratory Flanking STC		RR-337, CFS-FW-LBc-11r, wall gypsum board on RC	71	
Flanking STC for path Fd_1	R_ Fd,w	RR-331, Eq. 4.1.3	71 + 0 =	**71**
For Flanking Path Df_1:				
Laboratory Flanking STC		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-331, 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		RR-337, CFS-FW-NLBd-41d, wall gypsum board direct	72	
Flanking STC for path Ff_2	R_Ff,w	RR-331, Eq. 4.1.3	72 + 1 =	**73**
For Flanking Path Fd_2:				
Laboratory Flanking STC		RR-337, CFS-FW-NLBd-41d, wall gypsum board direct	76	
Flanking STC for path Fd_2	R_ Fd,w	RR-331, Eq. 4.1.3	76 + 1 =	**77**
For Flanking Path Df_2:				
Laboratory Flanking STC		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-331, 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		RR-337, CFS-FW-LBc-11d, wall gypsum board direct	67	
Flanking STC for path Ff_3	R_Ff,w	RR-331, Eq. 4.1.3	67 + 0 =	**67**
For Flanking Path Fd_3:				
Laboratory Flanking STC		RR-337, CFS-FW-LBc-11d, wall gypsum board direct	69	
Flanking STC for path Fd_3	R_ Fd,w	RR-331, Eq. 4.1.3	69 + 0 =	**69**
For Flanking Path Df_3:				
Laboratory Flanking STC		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-331, 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 (for all 4 junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values	59
ASTC due to Direct plus Flanking Paths		Eq. 4.1.1	**Combining Direct STC with 12 Flanking STC values**	**55**

EXAMPLE 4.3-V2: (SIMPLIFIED METHOD)

- **Rooms one above the other**
- **Same as EXAMPLE 4.3-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[7] (Junction 1) or attached directly to wall framing (Junction 3).
- CFS floor joists[8] 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.

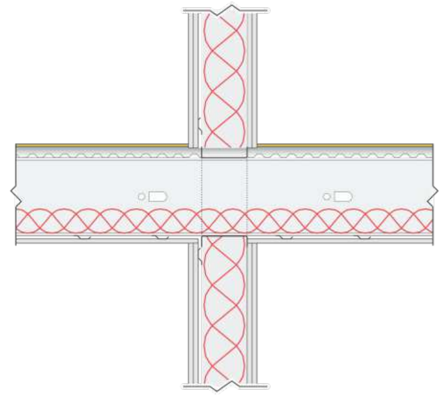
Junction 2 or 4: Junction of separating floor / non-loadbearing walls:

- 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[8] parallel to the non-loadbearing wall.
- Gypsum concrete floor deck discontinuous across the junction.
- Finish flooring LAM10_FOAM3 installed over the subfloor.

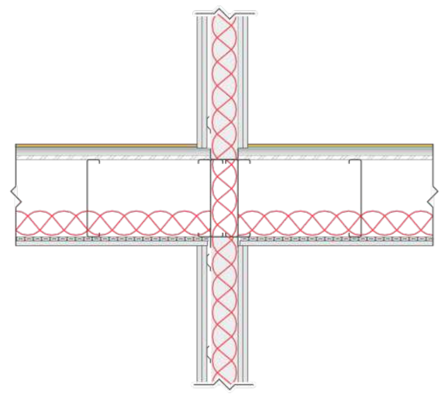
Acoustical Parameters:

	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-331, Eq. 4.1.3
RR-331 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-331, Eq. 4.1.3
RR-331 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)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or 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-331, 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		RR-337, CFS-FW-LBc-11r, wall gypsum board on RC	67	
Flanking STC for path Ff_1	R_Ff,w	RR-331, Eq. 4.1.3	67 + 0 =	**67**
For Flanking Path Fd_1:				
Laboratory Flanking STC		RR-337, CFS-FW-LBc-11r, wall gypsum board on RC	71	
Flanking STC for path Fd_1	R_ Fd,w	RR-331, Eq. 4.1.3	71 + 0 =	**71**
For Flanking Path Df_1:				
Laboratory Flanking STC		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-331, 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		RR-337, CFS-FW-NLBd-41d, wall gypsum board direct	72	
Flanking STC for path Ff_2	R_Ff,w	RR-331, Eq. 4.1.3	72 + 1 =	**73**
For Flanking Path Fd_2:				
Laboratory Flanking STC		RR-337, CFS-FW-NLBd-41d, wall gypsum board direct	76	
Flanking STC for path Fd_2	R_ Fd,w	RR-331, Eq. 4.1.3	76 + 1 =	**77**
For Flanking Path Df_2:				
Laboratory Flanking STC		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-331, 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		RR-337, CFS-FW-LBc-11d, wall gypsum board direct	67	
Flanking STC for path Ff_3	R_Ff,w	RR-331, Eq. 4.1.3	67 + 0 =	**67**
For Flanking Path Fd_3:				
Laboratory Flanking STC		RR-337, CFS-FW-LBc-11d, wall gypsum board direct	69	
Flanking STC for path Fd_3	R_ Fd,w	RR-331, Eq. 4.1.3	69 + 0 =	**69**
For Flanking Path Df_3:				
Laboratory Flanking STC		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-331, 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 (for all 4 junctions)		Subset of Eq. 4.1.1	Combining 12 Flanking STC values	60
ASTC due to Direct plus Flanking Paths		Eq. 4.1.1	**Combining Direct STC with 12 Flanking STC values**	**56**

Summary for Section 4.3: Calculation Examples for CFS-Framed Constructions

The worked examples (4.3-H1 to H5 and 4.3-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 4.3-H1 to H4 and 4.3-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 4.3-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. Buildings with Hybrid Construction

This chapter presents extended procedures to deal with cases that combine two types of construction.

In each case, the calculation procedures of ISO 15712-1 can be applied to one or more of the constructions, and those values can be combined with test results of flanking sound transmission (measured according to ISO 10848) or direct sound transmission through a separating wall or floor assembly (measured according to ASTM E90) to predict the apparent sound transmission loss and ASTC rating between a pair of adjacent rooms.

5.1. Concrete Floors with Lightweight Framed Walls and Heavy Façades

Building constructions of concrete floors combined with lightweight framed interior wall assemblies are identified in ISO 15712-1 as a special concern for which the standard approach may not give accurate results. To ensure a reasonably conservative approach, this Guide recommends the approach of Annex C of ISO 15712-1 to the calculation procedure for these systems.

As noted in Annex C and Section 4.2.4 of ISO 15712-1, if a surface of one room is part of a larger heavy structural element, and some of the bounding junctions are formed by light elements such as steel-framed or wood-framed wall assemblies, the response of the heavy element is influenced not only by the elements in the room but by the response of the extended structure. This affects both concrete floors (cast-in-place or precast) and other adjoining heavy elements such as concrete or masonry supporting walls which are "divided" by lightweight partitions. In this situation, the excitation of the floor by airborne sound in one room can create nearly uniform vibration levels over the entire extended floor surface. Similarly, for a heavy concrete or masonry wall intersecting lightweight wall assemblies, the vibration attenuation at the intersection is small, so the heavy wall responds over an extended surface bounded by junctions with other heavy elements.

To obtain a conservative estimate of the in-situ losses, Annex C of ISO 15712-1 recommends a modified approach to calculating the in-situ loss of heavy extended floor or wall assemblies when evaluating the transmission at junctions with lightweight walls. The Standard recommends calculating the in-situ loss both for the section of floor in one room, and for the extended floor area bounded by rigid junctions with heavy elements. The larger of these two losses should then be used in the loss calculations which otherwise follow the same procedures shown in Chapter 2 of this Guide.

In addition, there are a number of changes for dealing with in-situ estimates of direct transmission through a lightweight wall assembly and flanking transmission at the intersection of lightweight wall assemblies. These affect the calculations at several stages.

To illustrate the resulting changes in the calculation process, this Guide uses an **Extended Scenario**, which is presented in Figure 5.1, and has the following features:

- The Extended Scenario comprises a floor area considerably larger than that of the Standard Scenario, with lightweight partitions dividing the area into two pairs of adjacent rooms with a corridor between. In Figure 5.1, the floor area would be the entire floor with an area of approximately 96 m^2.
- Each pair of adjacent rooms has the same dimensions as the Standard Scenario used elsewhere in the Guide.
- At the perimeter are T-junctions of the floor with the façade walls above and below. In the case of heavy concrete or masonry façade walls, the junctions will be rigid junctions which means firmly fastened so that vibration can readily be transmitted between assemblies.

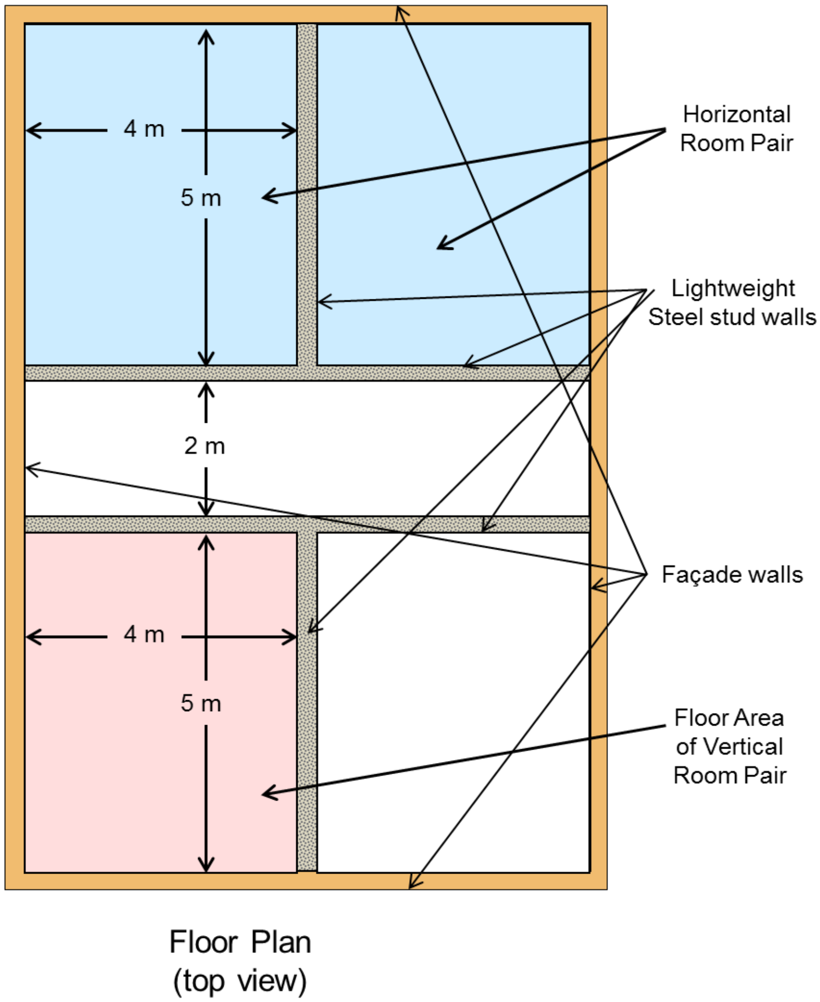


Figure 5.1: Extended Scenario for the case with concrete structural floors and rigid junctions with a façade wall at the perimeter of the floor. Lightweight framed interior walls divide the interior space into two pairs of adjacent rooms with a corridor between. The room pairs have the same dimensions as in the Standard Scenario used elsewhere in the Guide. The rooms above and below have the same floor plan. The floor area for the horizontal pair is shaded blue. The floor area for the vertical pair is shaded pink.

For Examples 5.1.1 to 5.1.3, the façade wall is of heavy concrete or masonry. For Examples 5.2.1 and 5.2.2, the façade wall is a much lighter glass curtain wall.

Calculation Steps for Horizontal Pair of Rooms with a Heavy Façade Wall of Concrete or Concrete Masonry:

1. For the direct sound transmission through the separating assembly of non-loadbearing wood or steel studs[5], the calculation process is simple, because the high internal losses of the wall mask any effect due to edge losses. The in-situ direct transmission loss is equal to the laboratory transmission loss, and the equivalent absorption length for subsequent junction calculations is taken as equal to the partition area (see Section 4.2.2 of ISO 15712-1).
2. The lightweight framed walls in these examples could use either loadbearing or non-loadbearing studs. Normally the walls would use non-loadbearing studs, but the same calculation can be used in either case. The top and bottom tracks of the wall framing are mechanically attached to the concrete floor/ceiling assemblies above and below. For non-loadbearing steel studs, it is common practice to use a nested pair of tracks at the top of the wall assembly, with the studs attached to the lower member of the pair. The attachment may also include a fire stop. These variations could reduce the floor/wall and ceiling/wall flanking sound transmission slightly (i.e. give a higher Flanking

STC values), but the calculations here ignore this effect because the rather weak coupling from the concrete floor/ceiling to the lightweight framed walls results in Flanking STC values of 80 or higher for these paths even for loadbearing studs, so they have negligible effect on the overall ASTC rating. However, the wall/wall flanking sound transmission paths may be affected by differences between loadbearing or non-loadbearing studs.

3. For flanking sound transmission at the cross-junctions of the concrete floor assembly with lightweight wood-framed or steel-framed separating walls (Junctions 1 and 3 in the examples in this chapter) the calculation steps are unchanged from those in Chapter 2, except that the vibration reduction index values are calculated according to Eq. E.7 of ISO 15712-1, and the losses for the concrete slab are calculated differently. In-situ edge losses for the concrete floor or wall assemblies are calculated for the junctions at the perimeter of the extended surface where it connects with the heavyweight façade, using Equations C.1 and C.2 of Annex C of ISO 15712-1 and the K_{ij} values from Annex E of ISO 15712-1. This controls the calculated total loss factors for the concrete floor surfaces in each room, and hence the in-situ sound transmission loss and junction attenuation values. (The calculated loss values are given in "Acoustical Parameters" below the specimen description in each of the worked examples.)
4. For flanking sound transmission at the T-junction with the concrete block perimeter wall (Junction 2 in the examples in this chapter), the calculation steps are unchanged from the discussion in Chapter 2 except that the in-situ edge loss is calculated for the junctions at the perimeter of the extended surface area for the concrete block surfaces. This change affects the calculated loss factors for the concrete block flanking surfaces in each room, and hence the in-situ transmission loss and junction attenuation values.
5. For flanking sound transmission at the T-junction of the steel stud separating wall with the non-loadbearing steel stud corridor wall, the calculation uses values of the flanking transmission loss determined by measurements according to ISO 10848, as explained in Chapter 4.
6. The Direct TL and Flanking TL values are combined as described in Section 1.4 of this Guide.

Calculation Steps for Vertical Pair of Rooms with a Heavy Façade Wall of Concrete or Concrete Masonry:

1. For the separating concrete floor assembly, the calculation steps are unchanged from the discussion in Chapter 2 except that the in-situ edge loss is calculated for the junctions at the perimeter of the extended surface area where it connects with the heavyweight façade using Equations C.1 and C.2 of Annex C of ISO 15712-1 and the K_{ij} values from Annex E of ISO 15712-1. This change affects the calculated total loss, and hence the in-situ transmission loss and the in-situ attenuation at junctions with flanking walls at the four edges of the room.

2. For flanking sound transmission at the cross-junctions with the lightweight framed wall assemblies (Junctions 1 and 4 in the examples in this chapter), the calculation process is simpler. The in-situ transmission loss of the wall is equal to the laboratory transmission loss, and the equivalent

absorption length for subsequent junction calculations is taken as numerically equal to the partition area as required in Section 4.2.2 of ISO 15712-1. The K_{ij} values are calculated using the appropriate mass ratios in equation E.7 in Annex E of ISO 15712-1. The final stages of determining the flanking transmission loss follow the process presented in Chapter 2.

3. For flanking sound transmission at the T-junction with the concrete block perimeter wall (Junctions 2 and 3 in the examples in this chapter), the calculation steps are unchanged from those in Chapter 2 except that the in-situ edge loss of the concrete block perimeter wall is calculated for the junctions at the perimeter of the extended surface area (see Annex C of ISO 15712-1). This change affects the calculated total loss for the concrete block surfaces in each room, and hence the in-situ transmission loss for the masonry surfaces and the resulting junction attenuation. (The calculated loss values are given in “Acoustical Parameters” below the specimen description in each of the worked example.)
4. The Direct TL and Flanking TL values are combined as described in Section 1.4 of this Guide.

Worked Examples

The worked examples present all the pertinent physical characteristics of the assemblies and junctions, including references for the source of the laboratory test data. All examples conform to the Standard Scenario presented in Section 1.2 of this Guide but also use extensions conforming to the Extended Scenario shown in Figure 5.1 for the calculation of the loss factors of the heavyweight walls or floors.

The calculations in the examples use a combination of the steps presented near the beginning of Chapters 2 and 4, as discussed in this Section. The changes in the calculations and the results due to the use of the extended response of the concrete and masonry assemblies can be seen by comparing the worked examples 5.1.1 and 5.1.3 in this Section with their counterparts 2.1.1 and 2.1.2 in Section 2.1.

Under the single heading “STC, ASTC, etc.”, the examples present single-number ratings (each calculated from a set of one-third octave band data according to the rules for STC ratings defined in ASTM E413) to provide a consistent set of summary measures at each stage of the calculation:

- STC values for laboratory sound transmission loss data for wall or floor assemblies,
- In-situ STC values for the calculated in-situ transmission loss of wall and floor assemblies,
- Direct STC for in-situ transmission through the separating assembly including linings,
- Flanking STC values calculated for each flanking transmission path at each junction,
- Apparent STC (ASTC) for the combination of direct and flanking transmission via all paths.

The “References” column presents the source of input data (combining the NRC report number and identifier for each laboratory test result or derived result), or identifies applicable equations and sections of ISO 15712-1 at each stage of the calculation. Symbols and subscripts identifying the corresponding variable in ISO 15712-1 are given in the adjacent column.

EXAMPLE 5.1.1: **DETAILED METHOD**

- **Rooms side-by-side, EXTENDED SCENARIO**
- **Cast-in-place concrete floors and heavy concrete or masonry façade with lightweight steel stud internal walls**

Separating framed wall assembly with:
- One row of loadbearing 152 mm steel studs[8] of 1.37 mm thick steel, spaced 600 mm o.c., with absorptive material[3] filling the cavities between studs
- 2 layers of 16 mm fire-rated gypsum board[4] attached directly to one side and supported on resilient metal channels[7] on the other side

Junction 1: Bottom Junction (separating wall / floor) with:
- Cast-in-place concrete floor with mass 345 kg/m^2 (e.g. normal weight concrete with thickness of 150 mm) with no topping or flooring
- Rigid cross-junction with steel-framed[8] separating wall assembly

Junction 2: Separating wall / abutting perimeter side wall with:
- Abutting side wall of 190 mm hollow concrete block masonry constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2 , with no lining

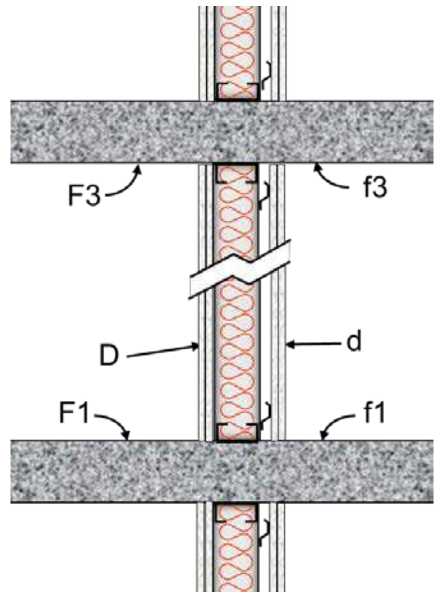
Junction 3: Top Junction (separating wall / ceiling) with:
- Cast-in-place concrete ceiling slab with mass 345 kg/m^2 (e.g. normal weight concrete with thickness of 150 mm) with no ceiling lining
- Cross-junction with steel stud[8] separating wall assembly

Junction 4: Separating wall / abutting corridor wall with:
- Abutting corridor wall with non-loadbearing 90 mm steel studs[5] of 0.46 mm thick steel, with two layers of fire-rated gypsum board on each side, mounted on resilient metal channels[7] in one room
- T-junction with steel stud[8] separating wall

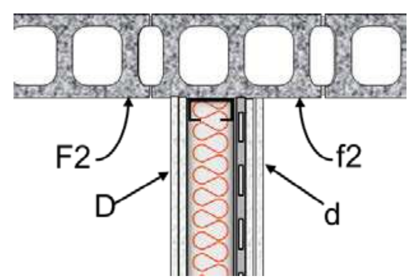
Acoustical Parameters:

For Separating Assembly:					
internal loss, η_i =	dominant (same loss for laboratory and in-situ, See 4.2.2)				
mass (kg/m²) =	56.8	f_c =	2500		
For Flanking Corridor Wall:	Parameters are the same except mass = 46 kg/m²				
For Flanking Elements F and f at Junction 1 & 3 (Extended concrete floor / ceiling)					
internal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_Ff	K_Fd	K_dF	Σ l_k . α_k
X-Junction 1 or 3	ISO 15712-1, Eq. 23 & E.7	-3.0	17.8	17.8	(ignore)
T-Junction 2	ISO 15712-1, Eq. 23 & E.4	-3.0	16.2	16.2	6.57
Total loss, η_{tot}	ISO 15712-1, Eq. C.1-C.3		0.052	(at 500 Hz)	
Similarly, for Flanking Elements F and f at Junction 2 (Extended masonry façade)					
internal loss, η_i =	0.015	c_L =	3500		
mass (kg/m²) =	238	f_c =	98		
	Reference	K_Ff	K_Fd	K_dF	Σ l_k . α_k
T- (above,below)	ISO 15712-1, Eq. 23 & E.4	8.1	5.8		4.7
corner edges	ISO 15712-1, Eq. 23 & E.9		-2.0		
Total loss, $\eta_{tot,2}$	ISO 15712-1, Eq. C.1-C.3		0.090	(at 500 Hz)	

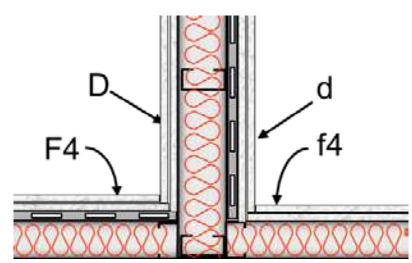
Illustration for this case



Junction of steel stud separating wall with 150 mm thick concrete floor and ceiling.
(Side view of Junctions 1 and 3)



Junction of separating wall with flanking façade wall, of 190 mm concrete block.
(Plan view of Junction 2)



Junction of separating wall with flanking corridor wall framed with steel studs.
(Plan view of Junction 4)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	630	1250	2500	5000	STC or ASTC
Separating Partition (Steel stud wall)									
Sound Transmission Loss (TL)	R_D,lab	RR-337, CFS-S152-W33	37	51	56	63	57	64	58
Leakage or Airborne Flanking		Sealed & Blocked	0	0	0	0	0	0	
Direct TL in-situ	R_D,situ	4.2.2: Equal to lab. TL	37	51	56	63	57	64	58
Junction 1 (Cross-junction, steel stud separating wall / 150 mm concrete floors)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.439	0.369	0.250	0.205	0.146	0.077	
Change by Lining on source side	ΔR_F1	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f1	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.176	0.122	0.084	0.057	0.038	0.025	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	44.0	46.8	54.7	63.6	71.8	79.9	58
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	44.0	46.8	54.7	63.6	71.8	79.9	58
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	3.1	3.2	3.3	3.5	3.8	4.1	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	20.9	21.9	23.0	24.0	25.2	26.3	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	20.9	21.9	23.0	24.0	25.2	26.3	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**45**	**48**	**56**	**65**	**74**	**82**	**59**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**60**	**70**	**77**	**86**	**89**	**90**	**80**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**60**	**70**	**77**	**86**	**89**	**90**	**80**
Junction 1: Flanking STC for all paths			- 10*LOG10(10^-5.9 + 10^- 8 + 10^- 8) =						**59**
Junction 2 (T-Junction, steel stud separating wall / 190 mm concrete block flanking walls)									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f2	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.105	0.072	0.049	0.032	0.021	0.013	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	39.5	42.2	47.9	53.5	61.0	64.5	53
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	39.5	42.2	47.9	53.5	61.0	64.5	53
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	5.4	5.5	5.7	6.0	6.3	6.8	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	21.9	22.9	24.0	25.2	26.3	27.6	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	21.9	22.9	24.0	25.2	26.3	27.6	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**46**	**49**	**55**	**60**	**68**	**72**	**59**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**61**	**70**	**76**	**84**	**86**	**90**	**80**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**61**	**70**	**76**	**84**	**86**	**90**	**80**
Junction 2: Flanking STC for all paths			- 10*LOG10(10^-5.9 + 10^- 8 + 10^- 8) =						**59**
Junction 3 (Cross-junction, steel stud separating wall / 150 mm concrete ceilings)									
All input values the same as for Junction 1									
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25a	**45**	**48**	**56**	**65**	**74**	**82**	**59**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**60**	**70**	**77**	**86**	**89**	**90**	**80**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25a	**60**	**70**	**77**	**86**	**89**	**90**	**80**
Junction 3: Flanking STC for all paths									**59**
Junction 4 (T-junction, steel stud separating wall / steel stud flanking corridor walls)									
Flanking Transmission Loss - Measured									
Flanking TL for Path Ff_4	R_Ff	RR-337, CFS-WW-LB152-01	**63**	**79**	**85**	**90**	**78**	**90**	**82**
Flanking TL for Path Fd_4	R_Fd	RR-337, CFS-WW-LB152-01	**67**	**75**	**85**	**90**	**78**	**90**	**82**
Flanking TL for Path Df_4	R_Df	RR-337, CFS-WW-LB152-01	**65**	**68**	**77**	**81**	**72**	**83**	**76**
Junction 4: Flanking STC for all paths			- 10*LOG10(10^-8.2 + 10^- 8.2 + 10^- 7.6) =						**74**
Total Flanking (for all 4 junctions)									54
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**35**	**43**	**50**	**57**	**56**	**63**	**53**

EXAMPLE 5.1.2: DETAILED METHOD

- **Rooms side-by-side, EXTENDED SCENARIO**
- **Cast-in-place concrete floors and heavy concrete or masonry façade with lightweight steel stud internal walls (Same structure as 5.1.1 with linings improved)**

Separating framed wall assembly with:
- One row of loadbearing 152 mm steel studs[8] of 1.37 mm thick steel, spaced 600 mm o.c., with absorptive material[3] in the cavities
- 2 layers of 16 mm fire-rated gypsum board[4] attached directly to one side and supported on resilient metal channels[7] on the other side

Junction 1: Bottom Junction (separating wall / floor) with:
- Cast-in-place concrete floor with mass 345 kg/m^2 (e.g. normal weight concrete with thickness of 150 mm) with no topping or flooring
- Cross-junction with steel-framed[8] separating wall assembly

Junction 2: Separating wall / abutting perimeter side wall with:
- Abutting side wall of 190 mm hollow concrete block masonry constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Lining of 16 mm fire-rated gypsum board[4] on 65 mm steel studs spaced 600 mm o.c., with no absorptive material[3] in cavities

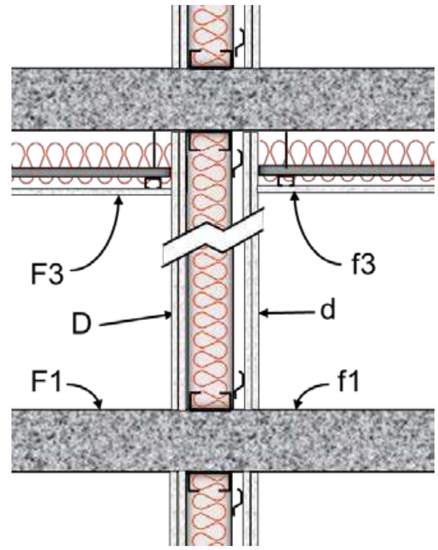
Junction 3: Top Junction (separating wall / ceiling) with:
- Cast-in-place concrete ceiling slab with mass 345 kg/m^2 (e.g. normal weight concrete with thickness of 150 mm)
- Ceiling lining below of 13 mm gypsum board[4] fastened to hat-channels supported on cross-channels hung on wires, cavity of 150 mm between concrete and ceiling, with 150 mm absorptive material[3]
- Cross-junction with steel-framed[5] separating wall assembly

Junction 4: Separating wall / abutting corridor wall with:
- Abutting corridor wall with non-loadbearing 90 mm steel studs[5] of 0.46 mm thick steel, with two layers of fire-rated gypsum board on each side, mounted on resilient metal channels[7] in one room
- Rigid T-junction with steel stud[8] separating wall

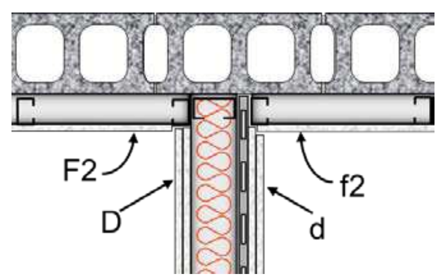
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	dominant (same loss for laboratory and in-situ, See 4.2.2)				
mass (kg/m²) =	56.8	f_c =	2500		
For Flanking Corridor Wall:	Parameters are the same except mass = 46 kg/m²				
For flanking elements F and f at Junction 1 & 3 (Extended Concrete floor and ceiling)					
internal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_{Ff}	K_{Fd}	K_{dF}	$\Sigma l_k \cdot \alpha_k$
X-Junction 1 or 3	ISO 15712-1, Eq. 23 & E.7	-3.0	17.8	17.8	(ignore)
T-Junction 2	ISO 15712-1, Eq. 23 & E.4	-3.0	16.2	16.2	6.57
Total loss, η_{tot}	ISO 15712-1, Eq. C.1-C.3		0.052	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 2 (Extended masonry façade)					
internal loss, η_i =	0.015	c_L =	3500		
mass (kg/m²) =	238	f_c =	98		
	Reference	K_{Ff}	K_{Fd}	K_{dF}	$\Sigma l_k \cdot \alpha_k$
T- (above,below)	ISO 15712-1, Eq. 23 & E.4	8.1	5.8		4.73
corner edges	ISO 15712-1, Eq. 23 & E.9		-2.0		
Total loss, $\eta_{tot,2}$	ISO 15712-1, Eq. C.1-C.3		0.090	(at 500 Hz)	

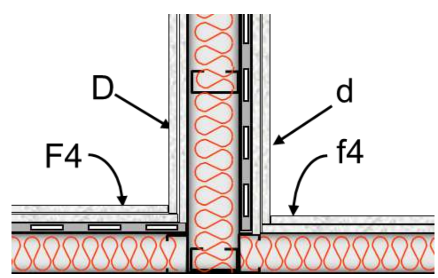
Illustration for this case



Cross-junctions of steel stud separating wall with 150 mm thick cast-in-place concrete floor and ceiling. (Side view of Junctions 1 and 3)



Junction of separating wall with flanking façade wall, of 190 mm concrete block. (Plan view of Junction 2)



Junction of separating wall with flanking corridor wall framed with steel studs. (Plan view of Junction 4)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	630	1250	2500	5000	STC or ASTC
Separating Partition (Steel stud wall)									
Sound Transmission Loss (TL)	R_D,lab	RR-337, CFS-S152-W33	37	51	56	63	57	64	58
Leakage or Airborne Flanking		Sealed & Blocked	0	0	0	0	0	0	
Direct TL in-situ	R_D,situ	4.2.2: Equal to lab. TL	37	51	56	63	57	64	**58**
Junction 1 (Cross-junction, steel stud separating wall / 150 mm concrete floors)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.439	0.369	0.250	0.205	0.146	0.077	
Change by Lining on source side	ΔR_F1	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f1	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.176	0.122	0.084	0.057	0.038	0.025	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	44.0	46.8	54.7	63.6	71.8	79.9	58
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	44.0	46.8	54.7	63.6	71.8	79.9	58
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	3.1	3.2	3.3	3.5	3.8	4.1	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	20.9	21.9	23.0	24.0	25.2	26.3	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	20.9	21.9	23.0	24.0	25.2	26.3	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**45**	**48**	**56**	**65**	**74**	**82**	**59**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**60**	**70**	**77**	**86**	**89**	**90**	**80**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**60**	**70**	**77**	**86**	**89**	**90**	**80**
Junction 1: Flanking STC for all paths			- 10*LOG10(10^-5.9 + 10^- 8 + 10^- 8) =						**59**
Junction 2 (T-Junction, steel stud separating wall / 190 mm concrete block flanking walls)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Change by Lining on receive side	ΔR_f2	ΔTL-BLK190(NW)-61, SS65_G13	-4	8	14	15	13	16	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.105	0.072	0.049	0.032	0.021	0.013	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	39.5	42.2	47.9	53.5	61.0	64.5	53
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	39.5	42.2	47.9	53.5	61.0	64.5	53
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	5.4	5.5	5.7	6.0	6.3	6.8	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	21.9	22.9	24.0	25.2	26.3	27.6	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	21.9	22.9	24.0	25.2	26.3	27.6	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**38**	**65**	**83**	**90**	**90**	**90**	**62**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**57**	**78**	**90**	**90**	**90**	**90**	**81**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**57**	**78**	**90**	**90**	**90**	**90**	**81**
Junction 2: Flanking STC for all paths			- 10*LOG10(10^-6.2 + 10^- 8.1 + 10^- 8.1) =						**62**
Junction 3 (Cross-junction, steel stud separating wall / 150 mm concrete ceilings)									
All values the same as for Junction 1, except linings									
Change by Lining on source side	ΔR_F3	RR-333 , ΔTL-CON150-C01	8	21	24	24	22	19	
Change by Lining on receive side	ΔR_f3	RR-333 , ΔTL-CON150-C01	8	21	24	24	22	19	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25a	**61**	**90**	**90**	**90**	**90**	**90**	**85**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**68**	**90**	**90**	**90**	**90**	**90**	**89**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25a	**68**	**90**	**90**	**90**	**90**	**90**	**89**
Junction 3: Flanking STC for all paths									**82**
Junction 4 (T-junction, steel stud separating wall / steel stud flanking corridor walls)									
Flanking Transmission Loss - Measured									
Flanking TL for Path Ff_4	R_Ff	RR-337, CFS-WW-LB152-01	**63**	**79**	**85**	**90**	**78**	**90**	**82**
Flanking TL for Path Fd_4	R_Fd	RR-337, CFS-WW-LB152-01	**67**	**75**	**85**	**90**	**78**	**90**	**82**
Flanking TL for Path Df_4	R_Df	RR-337, CFS-WW-LB152-01	**65**	**68**	**77**	**81**	**72**	**83**	**76**
Junction 4: Flanking STC for all paths			- 10*LOG10(10^-8.2 + 10^- 8.2 + 10^- 7.6) =						**74**
Total Flanking (for all 4 junctions)									58
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**34**	**46**	**53**	**61**	**57**	**64**	**55**

EXAMPLE 5.1.3: DETAILED METHOD

- **Rooms one-above-the-other, EXTENDED SCENARIO**
- **Cast-in-place concrete separating floor and heavy concrete or masonry façade with lightweight steel stud internal flanking walls**

Separating floor/ceiling assembly with:

- Cast-in-place concrete floor with mass 345 kg/m^2 (e.g. normal weight concrete with thickness of 150 mm) with no topping / flooring on top, or ceiling lining below

Junction 1: Cross-junction of separating floor / flanking walls with:

- Walls above and below the floor have one row of loadbearing 152 mm steel studs[8] of 1.37 mm thick steel, spaced 600 mm o.c., with absorptive material[3] filling the cavities between studs
- 2 layers of 16 mm fire-rated gypsum board[4] attached directly to one side and supported on resilient metal channels[7] on the other side (total weight per unit area of 56.8 kg/m^2)

Junction 2 and 3: T-Junction of separating floor / flanking wall with:

- Rigid mortared T-junctions with perimeter concrete block façade wall assemblies
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2 , with no lining

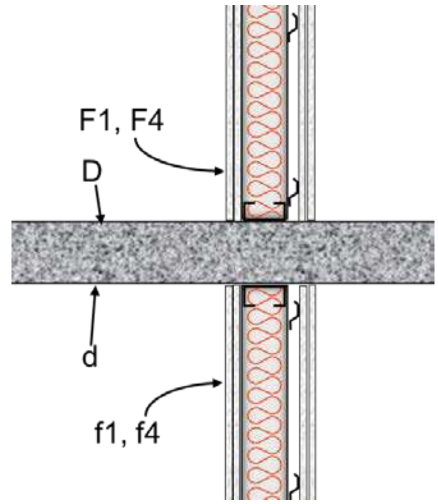
Junction 4: Junction of separating floor / corridor wall with:

- Non-loadbearing 90 mm steel studs[5] of 0.46 mm thick steel, with two layers of fire-rated gypsum board attached directly to one side and supported on resilient metal channels[7] on the other side (total weight per unit area of 46 kg/m^2)

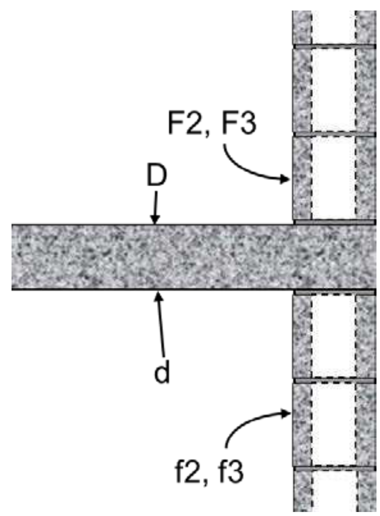
Acoustical Parameters:

For separating assembly (Extended concrete floor surface) :					
internal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_Ff	K_Fd	K_Df	Σ l_k . α_k
X-Junction 1 or 4	ISO 15712-1, Eq. E.7	25.7	17.8	17.8	(ignore)
T-Junctions 2&3	ISO 15712-1, Eq. E.4	8.1	5.8	5.8	6.57
Total loss, η_tot	ISO 15712-1, Eq. C.1-C.3		0.052	(at 500 Hz)	
Similarly, for masonry flanking walls F and f at Junction 2 & 3 (Extended façade)					
internal loss, η_i =	0.015	c_L =	3500		
mass (kg/m²) =	238	f_c =	98		
	Reference	K_Ff	K_Fd	K_Df	Σ l_k . α_k
T- (above,below)	ISO 15712-1, Eq. 23 & E.4	8.1	5.8		5.85
corner edges	ISO 15712-1, Eq. 23 & E.9		-2.0		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1-C.3		0.090	(at 500 Hz)	
Total loss, η_tot,3	ISO 15712-1, Eq. C.1-C.3		0.089	(at 500 Hz)	
For lightweight flanking elements F and f at Junction 1 & 4,					
For steel stud walls, assume loss in-situ = laboratory loss (mainly internal losses)					
Mass for LB wall =	56.8 kg/m²		Mass for NLB wall =		46 kg/m²

Illustration for this case



Cross-junction of separating floor of 150 mm thick cast-in-place concrete with steel stud wall with 152 mm LB or 90 mm NLB studs.
(Side view of Junctions 1 or 4)



T-Junction of separating floor of 150 mm thick cast-in-place concrete floor with 190 mm concrete block wall.
(Side view of Junction 2 and 3)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	630	1250	2500	5000	STC or ASTC
Separating Partition (150 mm concrete floor)									
Sound Transmission Loss (TL)	R_D,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.44	0.37	0.25	0.21	0.15	0.08	
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.176	0.122	0.084	0.057	0.038	0.025	
Leakage or Airborne Flanking		Sealed & Blocked	0	0	0	0	0	0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**44**	**47**	**55**	**64**	**72**	**80**	**58**
Junction 1 (Cross-junction, 150 mm concrete floor / steel stud flanking walls)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-337, CFS-WW-LB152-01, Dd(LB)	38	50	58	61	55	63	58
TL in-situ for F1	R_F1,situ	4.2.2: Equal to lab. TL	38	50	58	61	55	63	58
TL in-situ for f1	R_f1,situ	4.2.2: Equal to lab. TL	38	50	58	61	55	63	58
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	31.7	30.7	29.7	28.7	27.7	26.7	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	20.9	21.9	23.0	24.0	25.2	26.3	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	20.9	21.9	23.0	24.0	25.2	26.3	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**72**	**83**	**90**	**90**	**85**	**90**	**88**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**63**	**71**	**80**	**88**	**90**	**90**	**82**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**63**	**71**	**80**	**88**	**90**	**90**	**82**
Junction 1: Flanking STC for all paths		- 10*LOG10(10^-8.8 + 10^- 8.2 + 10^- 8.2) =							**78**
Junction 2 (Rigid T-Junction, 150 mm concrete floor / 190 mm concrete block flanking walls)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss, F2 or f2	R_F2,lab	RR-334, NRC Mean BLK190(NW)	35	38	44	50	58	62	49
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5	0.299	0.191	0.119	0.072	0.042	0.024	
Change by Lining on source side	ΔR_F2	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f2	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.105	0.072	0.049	0.032	0.021	0.013	
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	39.5	42.2	47.9	53.5	61.0	64.5	53
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	39.5	42.2	47.9	53.5	61.0	64.5	53
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21, 22	14.4	14.5	14.7	15.0	15.4	15.9	
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21, 22	12.5	12.6	12.8	13.0	13.3	13.7	
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21, 22	12.5	12.6	12.8	13.0	13.3	13.7	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**57**	**60**	**66**	**71**	**79**	**83**	**71**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**56**	**59**	**66**	**73**	**81**	**87**	**70**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**56**	**59**	**66**	**73**	**81**	**87**	**70**
Junction 2: Flanking STC for all paths		- 10*LOG10(10^-7.1 + 10^- 7 + 10^- 7) =							**66**
Junction 3 (Rigid T-junction, 150 mm concrete ceiling / 190 mm concrete block flanking walls)									
All input data the same as for Junction 2, but different junction length changes Flanking TL									
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25a	**56**	**59**	**65**	**70**	**78**	**82**	**70**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**55**	**58**	**65**	**72**	**80**	**86**	**69**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25a	**55**	**58**	**65**	**72**	**80**	**86**	**69**
Junction 3: Flanking STC for all paths		- 10*LOG10(10^-7 + 10^- 6.9 + 10^- 6.9) =							**65**
Junction 4 (Cross-junction, 150 mm concrete floor / steel stud flanking walls)									
Like Junction 1, but different studs and junction length change Flanking TL									
Sound Transmission Loss, F4 or f4		RR-337, CFS-WW-NLB90-01, Dd(NLB)	35.0	50.0	62.0	69.0	60.0	62.0	58
TL in-situ for F4	R_F4,situ	4.2.2: Equal to lab. TL	35.0	50.0	62.0	69.0	60.0	62.0	58
TL in-situ for f4	R_f4,situ	4.2.2: Equal to lab. TL	35.0	50.0	62.0	69.0	60.0	62.0	58
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**71**	**85**	**90**	**90**	**90**	**90**	**89**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**63**	**73**	**84**	**90**	**90**	**90**	**84**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**63**	**73**	**84**	**90**	**90**	**90**	**84**
Junction 4: Flanking STC for all paths		- 10*LOG10(10^-8.9 + 10^- 8.4 + 10^- 8.4) =							**80**
Total Flanking (for all 4 junctions)									62
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**42**	**46**	**53**	**61**	**69**	**74**	**56**

Summary for Section 5.1: Calculation Examples for Concrete Floors with Lightweight Framed Walls and Heavy Façades

Examples 5.1.1 to 5.1.3 show calculation examples for the Extended Scenario in a building with heavy concrete or concrete masonry façade walls, steel-framed wall assemblies dividing the interior area, and heavy concrete structural floor assemblies above and below.

Example 5.1.1 shows the calculation for a horizontal pair of rooms separated by a steel-framed wall with laboratory STC rating of 58. The ASTC rating of this configuration is 52. If the separating wall is replaced by a wall with laboratory STC rating of 50, the ASTC rating drops to 47. The overall Flanking STC of 53 is dominated by the flanking sound transmission paths Ff at Junctions 1, 2 and 3 (floor-floor, wall-wall and ceiling-ceiling paths via the extended heavy concrete and masonry assemblies). Even if a separating wall with a higher STC rating was used, the dominance of these flanking paths would limit the ASTC rating to a maximum value of 52.

Example 5.1.2 shows that it is not possible to substantially increase the ASTC rating by applying linings on the ceiling and the masonry façade wall. Despite the use of linings or a separating wall with a higher STC rating, the ASTC rating will not exceed a value of 55 unless the floor is improved with an effective lining and/or a thicker concrete floor is used.

Example 5.1.3 shows the calculation for a vertical pair of rooms separated by a bare cast-in-place concrete floor assembly of 150 mm thickness. Due to the extended response of the floor, the in-situ STC rating for the separating floor is 58, which is significantly higher than the corresponding laboratory STC rating of 53 or the in-situ STC rating of 55 in Example 2.1.2. The combined flanking sound transmission for the four junctions has a Flanking STC rating of 62, even with bare concrete block for two wall surfaces in each room. This means that the contribution from flanking sound transmission only marginally reduces the ASTC to 56. Adding a ceiling and linings to the concrete block walls could increase the ASTC to well over 60.

Overall, these examples emphasize the need to focus improvements on the weakest path(s). A high ASTC rating between rooms requires both a separating partitions with a high STC rating and suitable linings over the heavy concrete or masonry surfaces.

5.2. Concrete Floors with Lightweight Framed Walls and Lightweight Façades

Calculation Steps for Horizontal or Vertical Pair of Rooms with Lightweight Glass Curtain Wall Façade:

The following set of examples show the change in performance when a lightweight façade is substituted for the heavy concrete or masonry façade of Examples 5.1.1 to 5.1.3.

1. Most steps of the calculation (and the comments about details of the steel framing) are unchanged from those presented at the beginning of Section 5.1 using the Extended Scenario.
2. For the concrete floor assembly, the calculation of the loss factor differs from what is presented in Section 5.1 because the substitution of the lighter curtain wall façade for the heavy masonry façade of Examples 5.1.1 to 5.1.3 significantly reduces the losses to the coupled façade assemblies. In addition, losses due to the lightweight interior stud partitions become significant. These losses due to the lightweight walls were ignored in Examples 5.1.1 to 5.1.3 when performing the loss calculations for the floor coupled to the heavyweight façade since they were insignificant compared with the losses due to the rigid connection between the floor/ceiling assembly and the heavyweight façade. The inclusion of the lightweight interior stud partitions appears to be consistent with Annex C of ISO 15712-1 for the calculation of the loss factors. The total losses for the concrete floor/ceiling calculated for this section therefore differ from those calculated in Section 5.1 for the examples with heavyweight façades.
3. The calculation of the losses to connected assemblies depends on the critical frequency of the attached assemblies. For the gypsum board interior partitions used in the examples, the critical frequency is taken as 2500 Hz, as evident from the measured transmission loss curves. For the curtain walls used in the examples, the mean of the critical frequencies for the two types of glass in the tested curtain wall is used (1425 Hz).
4. For flanking sound transmission via the curtain wall façade surfaces, the calculation is greatly simplified relative to that for a heavy concrete or masonry façade. The flanking transmission loss can be taken directly from the values of $D_{n,f}$ measured according to ISO 10848, with conversion to flanking transmission loss and re-normalization according to Equation 4.1.3 of this Guide.

The data used in the examples for glass curtain wall assemblies are from the *ACOUBAT* software developed at the Centre Scientifique et Technique du Bâtiment (CSTB) in France. The glass curtain wall has aluminum frame elements and double glazing with 8 mm glass on one face and laminated glass (two layers of 5 mm glass with elastomeric interlayer) on the other face. The air cavity depth between the panes is 18 ± 2 mm.

The data are presented in Table 5.2.1. The data were measured using the procedures of ISO 10140 and ISO 10848-3 and are used here, with permission, to illustrate the effect of such a lightweight façade on the calculations of ISO 15712-1.

Table 5.2.1: Experimental data for flanking sound transmission by a curtain wall assembly.

	R_W etc.	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4 kHz
Sound Reduction Index, R	44	30.9	33.5	41.0	43.9	49.8	54.6
Horizontal Normalized Flanking Level Difference, $D_{n,f}$ for junction length of 2.5 m	52	42.3	46.8	51.8	46.9	59.1	59.4
Vertical Normalized Flanking Level Difference, $D_{n,f}$ for junction length of 4.8 m	47	36.1	35.5	42.4	50.0	50.4	53.4

—THESE DATA SHOULD NOT BE TREATED AS GENERIC—

Significant variation is to be expected between proprietary products from different manufacturers, and data for the intended curtain wall system should always be used.

For proprietary constructions such as a curtain walls, the manufacturer's installation instructions normally include specification of an appropriate fire stop assembly to prevent the spread of smoke and fire via the junction where the lightweight façade assembly meets the walls and floor/ceiling of the building structure. For acoustical testing of flanking sound transmission by a curtain wall or other lightweight façade assembly, the installation should include the specified fire stop, to ensure that any sound transmission through this connecting element is included in the measured result.

Worked Examples

The worked examples present all the pertinent physical characteristics of the assemblies and junctions, including references for the source of the laboratory test data. All examples conform to the Standard Scenario presented in Section 1.2 of this Guide but also use extensions conforming to the Extended Scenario shown in Figure 5.1 for the calculation of the loss factor of the floor and ceiling. The calculations use a combination of the steps presented near the beginning of Chapters 2 and 4, as discussed in this Section.

Under the single heading “STC, ASTC, etc.”, the examples present single-number ratings (each calculated from a set of one-third octave band data according to the rules for STC ratings defined in ASTM E413) to provide a consistent set of summary measures at each stage of the calculation:

- STC values for laboratory sound transmission loss data for wall or floor assemblies,
- ΔSTC values for change in STC due to adding the lining to the specified wall or floor assembly,
- In-situ STC values for the calculated in-situ transmission loss of wall and floor assemblies,
- Direct STC for in-situ transmission through the separating assembly including linings,
- Flanking STC values calculated for each flanking transmission path at each junction,
- Apparent STC (ASTC) for the combination of direct and flanking transmission via all paths.

The “References” column presents the source of input data (combining the NRC report number and identifier for each laboratory test result or derived result), or identifies applicable equations and sections of ISO 15712-1 at each stage of the calculation. Symbols and subscripts identifying the corresponding variable in ISO 15712-1 are given in the adjacent column.

EXAMPLE 5.2.1: DETAILED METHOD

- **Rooms side-by-side, EXTENDED SCENARIO**
- **Cast-in-place concrete floors and lightweight glass curtain wall façade with steel stud internal walls**
- **Same construction as 5.1.2 except changed façade**

Separating framed wall assembly with:

- One row of loadbearing 152 mm steel studs[8] of 1.37 mm thick steel, spaced 600 mm o.c., with absorptive material[3] filling the cavities between studs
- 2 layers of 16 mm fire-rated gypsum board[4] attached directly to one side and supported on resilient metal channels[7] on the other side (total weight per unit area of 56.8 kg/m^2)

Junction 1: Bottom Junction (separating wall / floor) with:

- Cast-in-place concrete floor with mass 345 kg/m^2 (e.g. normal weight concrete with thickness of 150 mm) with no topping or flooring
- Cross-junction with steel-framed separating wall assembly

Junction 2: Separating wall / abutting perimeter side wall) with:

- Perimeter glass curtain wall façade assemblies connected to the floor structure and sealed to the separating partition
- Glass curtain wall has aluminum frame elements and double glazing with 8mm glass on one face and laminated glass (two layers of 5mm glass with elastomeric interlayer) on the other face. The data of the proprietary glass curtain wall comes from the *ACOUBAT* software and is used with permission of CSTB. Its acoustical properties are presented earlier in this section

Junction 3: Top Junction (separating wall / ceiling) with:

- Cast-in-place concrete ceiling slab with mass 345 kg/m^2 (e.g. normal weight concrete with thickness of 150 mm)
- Ceiling lining below of 16 mm fire-rated gypsum board[4] fastened to hat-channels supported on cross-channels hung on wires, 150 mm between concrete and ceiling, with 150 mm absorptive material[3]
- Cross-junction with steel-framed separating wall assembly

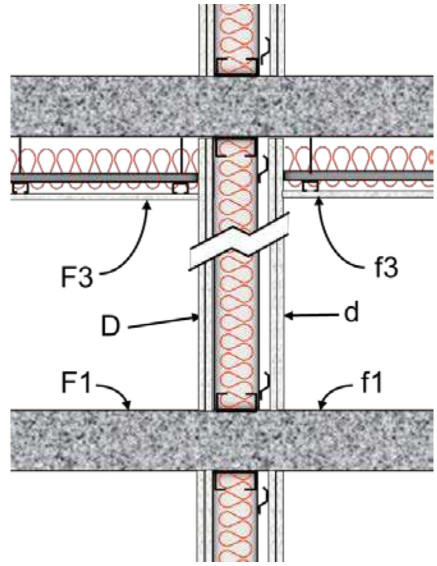
Junction 4: Separating wall / abutting corridor wall with:

- Abutting corridor wall with non-loadbearing 90 mm steel studs[5] of 0.46 mm thick steel, with two layers of fire-rated gypsum board on each side, mounted on resilient metal channels[7] in one room

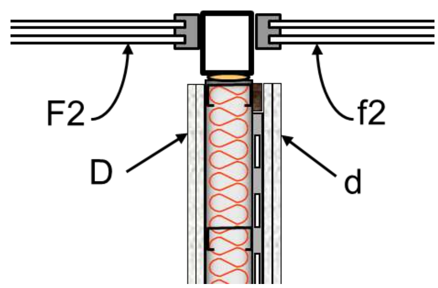
Acoustical Parameters:

For separating assembly:					
internal loss, η_i > .03	dominant (same loss for laboratory and in-situ, See 4.2.2)				
mass (kg/m²) =	56.8	f_c =	2500		
For Flanking Corridor Wall:	Parameters the same except mass = 46 kg/m²				
For flanking elements F and f at Junction 1 & 3 (Extended Concrete floor and ceiling)					
internal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_Ff	K_Fd	K_Df	Σ l_k . α_k
X-Junction (stud walls)	ISO 15712-1, Eq. 23 & E.7	-3.0	17.8	17.8	1.364
Façade	ISO 15712-1, Eq. 23 & E.6		18.4	18.4	1.380
	ISO 15712-1, Eq. C.1-C.3	Total loss, η_{tot} =		0.026	(at 500 Hz)
For flanking elements F and f at Junction 2 (Lightweight Curtain Wall Facade)					
internal loss, η_i > .03	same loss for laboratory and in-situ, See ISO 15712-1, 4.2.2				
mass (kg/m²) =	50	f_c =	1425		

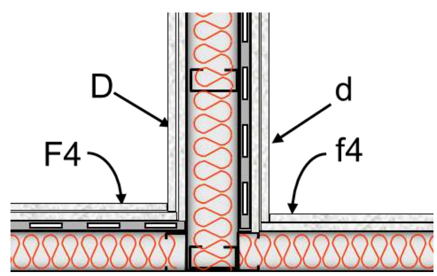
Illustration for this case



Cross-junctions of steel stud separating wall with 150 mm thick cast-in-place concrete floor and ceiling. (Side view of Junctions 1 and 3)



Junction of separating wall with flanking glass curtain wall façade. (Plan view of Junction 2)



Junction of separating wall with flanking corridor wall framed with steel studs. (Plan view of Junction 4)

(For the notes in this table please see the corresponding endnotes on page 193.)

	ISO Symbol	Reference	125	250	630	1250	2500	5000	STC or ASTC
Separating Partition (Loadbearing steel stud wall)									
Sound Transmission Loss (TL)	R_D,lab	RR-337,CFS-S152-W33	37	51	56	63	57	64	58
Leakage or Airborne Flanking		Sealed & Blocked	0	0	0	0	0	0	
Direct TL in-situ	R_D,situ	4.2.2: Equal to lab. TL	**37**	**51**	**56**	**63**	**57**	**64**	**58**
Junction 1 (Cross-junction, steel stud separating wall / 150 mm concrete floors)									
Sound Transmission Loss, F1 or f1	R_F1,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.439	0.369	0.250	0.205	0.146	0.077	
Change by Lining on source side	ΔR_F1	No Lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_f1	No Lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.374	0.256	0.171	0.111	0.070	0.043	
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	41	44	52	61	69	78	55
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	41	44	52	61	69	78	55
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	0.00	0.01	0.26	0.62	1.11	1.74	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	19.2	20.3	21.4	22.6	23.8	25.1	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	19.2	20.3	21.4	22.6	23.8	25.1	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**39**	**42**	**50**	**59**	**68**	**77**	**52**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**57**	**67**	**74**	**83**	**86**	**90**	**77**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**57**	**67**	**74**	**83**	**86**	**90**	**77**
Junction 1: Flanking STC for all paths		- 10*LOG10(10^-5.2 + 10^- 7.7 + 10^- 7.7) =							**52**
Junction 2 (T-Junction, steel stud separating wall / glazed curtain façade walls)									
Flanking Element F2 and f2: Input Data									
Horizontal flanking (measured)	D_n, f	CSTB, Acoubat example	42.3	46.8	51.8	46.9	59.1	59.4	52
		(Measured, ISO-10848-3)							
		Note: These data were furnished by CSTB in France and are used with permission. THESE DATA SHOULD NOT BE TREATED AS GENERIC. Wide variation is to be expected between proprietary products from different manufacturers, and data for the intended curtain wall system should always be used.							
Correction D_n to Flanking TL in Scenario		Guide, Eq. 4.1.3	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Flanking Transmission Loss - Path data									
Junction 2: Flanking STC for all paths		Guide, Section 1.4	**43**	**48**	**53**	**48**	**60**	**60**	**53**
Junction 3 (Cross-junction, steel stud separating wall / 150 mm concrete ceilings)									
All values the same as for Junction 1, except linings									
Change by Lining on source side	ΔR_F3	RR-333 , ΔTL-CON150-C01	8	21	24	24	22	19	
Change by Lining on receive side	ΔR_f3	RR-333 , ΔTL-CON150-C01	8	21	24	24	22	19	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25a	**55**	**84**	**90**	**90**	**90**	**90**	**79**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**65**	**88**	**90**	**90**	**90**	**90**	**88**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25a	**65**	**88**	**90**	**90**	**90**	**90**	**88**
Junction 3: Flanking STC for all paths		- 10*LOG10(10^-7.9 + 10^- 8.8 + 10^- 8.8) =							**78**
Junction 4 (T-junction, steel stud separating wall / steel stud flanking corridor walls)									
Flanking Transmission Loss - measured									
Flanking TL for Path Ff_4	R_Ff	RR-337, CFS-WW-LB152-01	**64**	**79**	**86**	**90**	**78**	**90**	**82**
Flanking TL for Path Fd_4	R_Fd	RR-337, CFS-WW-LB152-01	**68**	**76**	**85**	**90**	**78**	**90**	**82**
Flanking TL for Path Df_4	R_Df	RR-337, CFS-WW-LB152-01	**65**	**68**	**78**	**81**	**72**	**83**	**76**
Junction 4: Flanking STC for all paths		- 10*LOG10(10^-8.2 + 10^- 8.2 + 10^- 7.6) =							**74**
Total Flanking (for all 4 junctions)									49
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**34**	**41**	**48**	**48**	**55**	**58**	**49**

EXAMPLE 5.2.2: DETAILED METHOD

- **Rooms one-above-the-other, EXTENDED SCENARIO**
- **Cast-in-place concrete separating floor and glass curtain wall façade with steel stud internal flanking walls**
- **Same construction as 5.1.3 except changed façade**

Separating floor/ceiling assembly with:
- Cast-in-place concrete floor with mass 345 kg/m^2 (e.g. normal weight concrete with thickness of 150 mm) with no topping / flooring on top, or ceiling lining below

Junction 1: Cross-junction of separating floor / flanking walls with:
- One row of loadbearing 152 mm steel studs[8] of 1.37 mm thick steel, spaced 600 mm o.c., with absorptive material[3] filling the cavities between studs
- 2 layers of 16 mm fire-rated gypsum board[4] attached directly to one side and supported on resilient metal channels[7] on the other side (total weight per unit area of 56.8 kg/m^2)

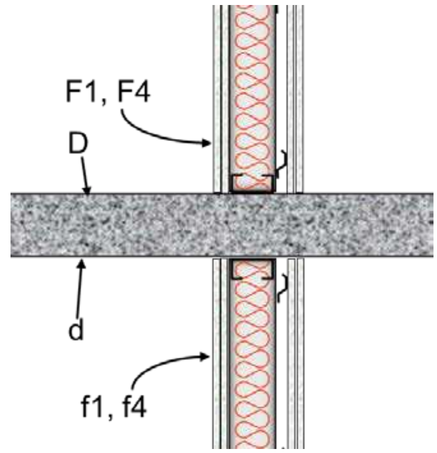
Junction 2 and 3: T-Junction of separating floor / flanking wall with:
- Perimeter glass curtain wall façade assemblies connected to the floor structure as specified by manufacturer
- Wall above and below floor is glass curtain wall with aluminum frame elements and double glazing with 8mm glass on one face and laminated glass (two layers of 5mm glass with elastomeric interlayer) on the other face. The data of the proprietary glass curtain wall comes from the *ACOUBAT* software and is used with permission of CSTB. Its acoustical properties are presented earlier in this section

Junction 4: Junction of separating floor / corridor wall with:
- One row of non-loadbearing 90 mm steel studs[5] of 0.46 mm thick steel, with two layers of fire-rated gypsum board attached directly to one side and supported on resilient metal channels[7] on the other side (total weight per unit area of 46 kg/m^2)

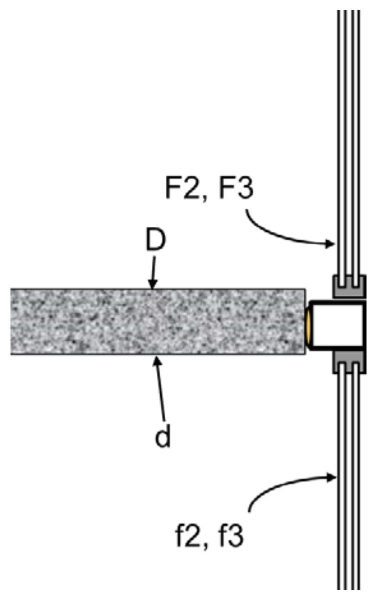
Acoustical Parameters:

For separating assembly (Extended Concrete floor):					
internal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_Ff	K_Fd	K_Df	Σ l_k . α_k
X-Junction 1 or 4	ISO 15712-1, Eq. 23 & E.7	25.7	17.8	17.8	1.364
Façade	ISO 15712-1, Eq. 23 & E.6		18.4	18.4	1.380
Total loss, η_tot	ISO 15712-1, Eq. C.1 to C.3		0.026	(at 500 Hz)	
For facade elements F and f at Junction 2 & 3,					
For glass curtain walls, assume loss in-situ = laboratory loss (mainly internal)					
mass (kg/m²) =	50	f_c =	1425		
For lightweight flanking elements F and f at Junction 1 & 4,					
For steel stud walls, assume loss in-situ = laboratory loss (mainly internal)					
Mass for LB wall =	56.8 kg/m²			Mass for NLB wall =	46 kg/m²

Illustration for this case



Cross-junction of separating floor of 150 mm thick cast-in-place concrete with steel stud wall with 152 mm LB or 90 mm NLB studs. (Side view of Junctions 1 or 4)



T-Junction of separating floor of 150 mm thick cast-in-place concrete with glass curtain wall façade. (Side view of Junction 2 and 3)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	125	250	630	1250	2500	5000	STC or ASTC
Separating Partition (150 mm concrete floor)									
Sound Transmission Loss (TL)	R_D,lab	RR-333, CON150, TLF-15-045	40	42	50	58	66	75	53
Structural Reverberation Time	T_s,lab	Measured T_s	0.439	0.369	0.250	0.205	0.146	0.077	
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	
Change by Lining on receive side	ΔR_d	No lining ,	0	0	0	0	0	0	
Structural Reverb. Time in-situ	T_s,situ	ISO 15712-1, Eq. C.1-C.3	0.374	0.256	0.171	0.111	0.070	0.043	
Leakage or Airborne Flanking		Sealed & Blocked	0	0	0	0	0	0	
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**41**	**44**	**52**	**61**	**69**	**78**	**55**
Junction 1 (Cross-junction, 150 mm concrete / steel stud flanking walls)									
Flanking Element F1 and f1: Input									
Sound Transmission Loss	R_F1,lab	RR-337, SS(LB)150-WW-01, Dd(LB)	38	50	58	61	55	63	58
TL in-situ for F1	R_F1,situ	4.2.2: Equal to lab. TL	38	50	58	61	55	63	58
TL in-situ for f1	R_f1,situ	4.2.2: Equal to lab. TL	38	50	58	61	55	63	58
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21, 22	31.7	30.7	29.7	28.7	27.7	26.7	
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21, 22	19.2	20.3	21.4	22.6	23.8	25.1	
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21, 22	19.2	20.3	21.4	22.6	23.8	25.1	
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**72**	**83**	**90**	**90**	**85**	**90**	**88**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**60**	**68**	**77**	**85**	**87**	**90**	**79**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**60**	**68**	**77**	**85**	**87**	**90**	**79**
Junction 1: Flanking STC for all paths		- 10*LOG10(10^-8.8 + 10^- 7.9 + 10^- 7.9) =							**76**
Junction 2 (T-Junction, 150 mm concrete / glass curtain walls)									
Flanking Element F2 and f2: Input Data									
Vertical flanking	D_n, f	CSTB, Acoubat example	36.1	35.5	42.4	50.0	50.4	53.4	47
		(Measured, ISO-10848-3)							
	Note: These data were furnished by CSTB in France and are used with permission.								
		THESE DATA SHOULD NOT BE TREATED AS GENERIC.							
	Wide variation is to be expected between proprietary products from different manufacturers,								
	and data for the intended curtain wall system should always be used.								
Correction (D_n,f to Flanking TL)		Guide, Eq. 4.1.3	3.8	3.8	3.8	3.8	3.8	3.8	
Flanking Transmission Loss - Path data									
Junction 2: Flanking STC for Path Ff		Guide, Section 1.4	40	**39**	**46**	**54**	**54**	**57**	**51**
Junction 3 (T-junction, 150 mm concrete / glass curtain walls)									
All input data the same as for Junction 2, but different junction length changes Flanking TL									
Correction (D_n,f to Flanking TL)		Guide, Eq. 4.1.3	2.8	2.8	2.8	2.8	2.8	2.8	
Flanking Transmission Loss - Path data									
Junction 3: Flanking STC for all paths	**R_Ff**	Guide, Section 1.4	39	**38**	**45**	**53**	**53**	**56**	**50**
Junction 4 (Cross-junction, 150 mm concrete / steel stud flanking walls)									
Like Junction 1, but different studs and junction length change Flanking TL									
Flanking Element F4 and f4:		RR-337, CFS-WW-NLB90-01, Dd(NLB)	35	50	62	69	60	62	58
TL in-situ for F4	R_F4,situ	4.2.2: Equal to lab. TL	35	50	62	69	60	62	58
TL in-situ for f4	R_f4,situ	4.2.2: Equal to lab. TL	35	50	62	69	60	62	58
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**71**	**85**	**90**	**90**	**90**	**90**	**89**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**60**	**70**	**81**	**90**	**90**	**90**	**81**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**60**	**70**	**81**	**90**	**90**	**90**	**81**
Junction 4: Flanking STC for all paths		- 10*LOG10(10^-8.9 + 10^- 8.1 + 10^- 8.1) =							**78**
Total Flanking (for all 4 junctions)									47
ASTC due to Direct plus Flanking Paths		RR-331, Eq. 1.4	**35**	**35**	**42**	**50**	**50**	**53**	**47**

Summary for Section 5.2: Calculation Examples for Concrete Floors with Lightweight Framed Walls and Lightweight Façade

Examples 5.1.4 and 5.1.5 show the calculation procedures for the Extended Scenario in a building whose façade is a glass curtain wall assembly. Compared with the same buildings with concrete masonry façades presented in Section 5.1, the ASTC ratings of the lightweight façade that extends across junctions are significantly reduced.

Example 5.2.1 shows a horizontal case identical to Example 5.1.2 except that glass curtain walls are substituted for the heavy masonry façade. The ASTC rating is reduced by the combination of the rather low Flanking STC value for the curtain wall façade and the lower Flanking STC values via the floor paths, primarily due to low edge losses from the concrete floor to the façade.

Example 5.2.2 shows the corresponding vertical case which is identical to Example 5.1.3 except that glass curtain walls are substituted for the heavy masonry façade. The ASTC rating is reduced by both a lower Direct STC value via the separating floor (due to lower edge losses from the concrete floor to the façade) and the rather low Flanking STC value for the curtain wall façade.

Overall, these examples emphasize the need to focus improvements on the weakest paths. Even with a heavy façade, achieving high ASTC ratings between spaces requires both separating partitions with high STC ratings and suitable linings over the heavy concrete or masonry surfaces. Replacing a heavy façade with a lightweight façade can both provide more significant flanking sound transmission via the façade surfaces and can reduce the in-situ STC rating of the floor due to the lower losses of the extended concrete floor/ceiling.

The calculations for this Section have used an extension that goes beyond the explicit guidance in Annex C of ISO 15712-1 but is still quite conservative. For this situation, extended response of the concrete floor/ceiling occurs because the lightweight interior partitions provide almost no resistance to transmission of the vibration from the excited surface in the source room to the entire floor surface of the Extended Scenario. For the case in Section 5.1 where most of the energy is transferred to the heavy façade assemblies, the process in Annex C that considers only the transfer at the perimeter is appropriate. But with a lightweight façade, it is more appropriate to include the transfers from the concrete to all of the connected walls including the lightweight façade and the internal partitions. In a typical building, however, there would be other connections such as stairwells, elevators, interior concrete or masonry walls to provide fire separations or shear bracing, and columns or other framing to support the structural load. All of these elements would transfer vibration energy away from the concrete floor and thereby increase the in-situ STC rating of the floor. Ignoring the contribution of all of these other elements, especially the framing that supports the structural load, makes the estimated ASTC ratings in Section 5.2 conservative.

5.3. Concrete Masonry Walls with Lightweight Framed Floors and Walls

This section presents the calculation approach for buildings that combine lightweight framed assemblies (walls and floors) with walls of normal weight or lightweight concrete blocks. The transmission of structure-borne vibration in a building with lightweight framed assemblies differs markedly from that in heavy homogeneous structures of masonry and concrete.

- For direct transmission through the separating lightweight framed assembly, the high internal loss factors of the wood- or steel-framed assembly result in minimal dependence on the connections to the adjoining structures, so laboratory measured sound transmission values are used without adjustment.
- For flanking paths where one or both of the assemblies is a lightweight framed assembly, the calculation process is very simple, but it requires use of flanking sound transmission loss data measured according to ISO 10848 (like the calculations for framed assemblies in Chapter 4).
- Linings on the concrete block surfaces (either for direct or flanking transmission) may be treated using a simple additive correction (ΔSTC) as in Chapter 2.

An experimental study of such systems with concrete block walls and wood-framed floors was performed at the NRC, as described in the NRC Research Report RR-334, and results from that study were used for the examples in this section.

The calculation process requires specific laboratory test data, but can be performed using single-number ratings, following the steps illustrated in Figure 5.3.1, and explained in detail below.

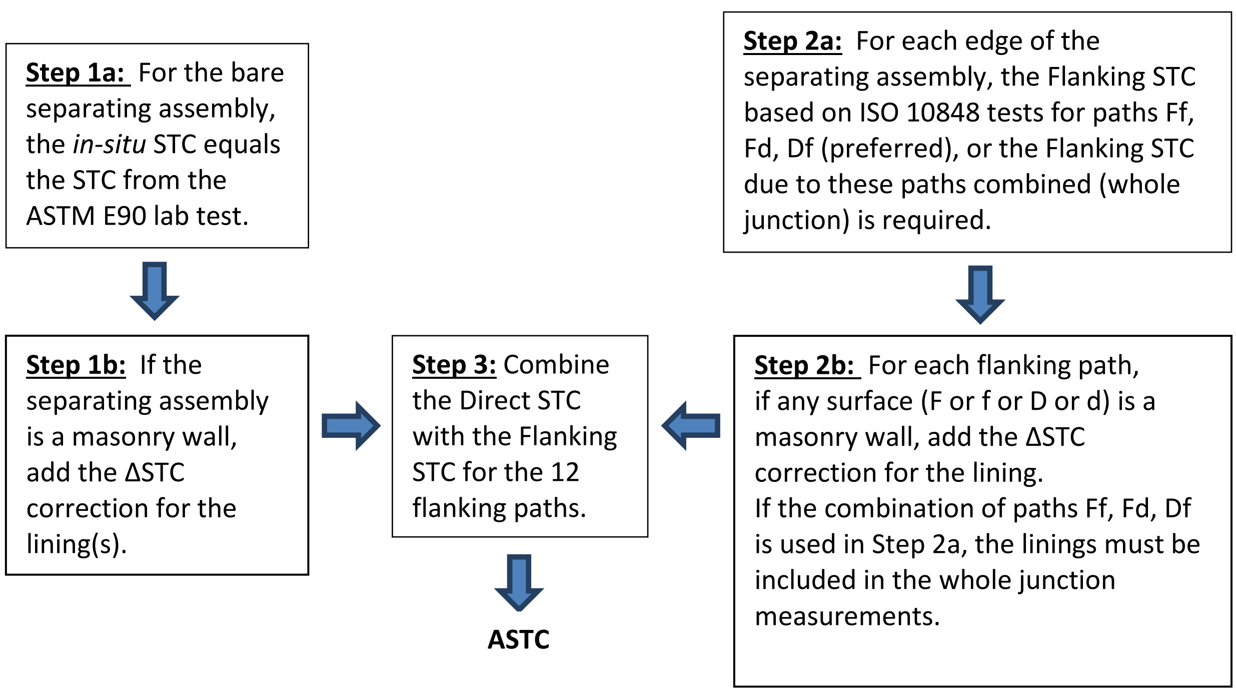


Figure 5.3.1: Steps to calculate the ASTC for masonry walls with lightweight framed assemblies.

Step 1: (a) For the bare separating assembly, the in-situ STC is equal to the STC measured in the laboratory according to ASTM E90.
(b) If the separating assembly is a masonry wall, add the ΔSTC correction for lining(s) on the source room and/or receiving room surfaces (D and d) to obtain the Direct STC. This correction procedure matches that of Section 2.4. If there are two linings, the correction equals the larger of the two lining ΔSTC corrections plus half of the lesser one (see Eq. 5.3.2).

Step 2: (a) Determine the Flanking STC rating for the 3 flanking paths Ff, Fd and Df at each edge of the separating assembly with the following adaptations:

- Values measured according to ISO 10848 should be normalized using Equation 4.1.3 as explained in Section 4.1.
- If only the Flanking STC for combined transmission by the set of 3 paths at a junction is available, that data may be used.
- If both flanking surfaces F and f are concrete masonry walls, the Flanking STC for path Ff may either be taken from measurement according to ISO 10848, or calculated using the assembly STC rating and vibration reduction index (measured or calculated) as in Section 2.4.

(b) If one surface for a flanking path (source room or receiving room) is a masonry wall, add the ΔSTC correction for any lining added to the masonry surface to obtain the Flanking STC for that path. If both flanking surfaces are concrete block walls with linings, the correction equals the larger of the two lining ΔSTC corrections plus half of the lesser one (see Eq. 5.3.3.)

Step 3: Combine the transmission via the direct path and the 12 flanking paths using Equation 5.3.1 (equivalent to Eq. 26 in Section 4.4 of ISO 15712-1 or Eq. 1.4 of this Guide), with the following adaptations:

- If the Flanking STC rating calculated for any flanking path is over 90, set the value to 90 to allow for the inevitable effect of higher order flanking paths.
- Round the final ASTC result to the nearest integer.

Expressing the Calculation Process using Equations:

As in Sections 2.4 and 4.1 of this Guide and Section 4.4.1 of ISO 15712-1, the ASTC value between two rooms (neglecting sound that is by-passing the building structure, e.g. leaks, ducts,…) is estimated in the Simplified Method from the logarithmic expression of the combination of 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 which may be expressed as:

$$ASTC = -10\log_{10}\left[10^{-0.1\cdot STC_{Dd}} + \sum_{edge=1}^{4}\left(10^{-0.1\cdot STC_{Ff}} + 10^{-0.1\cdot STC_{Fd}} + 10^{-0.1\cdot STC_{Df}}\right)\right] \quad \text{Eq. 5.3.1}$$

Eq. 5.3.1 is appropriate for all types of building systems similar to the Standard Scenario. It is applied here using the following expressions to calculate the sound transmission for individual paths.

Eq. 5.3.1 is a special case of Eq. 1.4 in this Guide:

(a) The single-number rating ASTC is substituted for the ATL in Eq. 1.4.

(b) If the separating assembly is a framed wall or floor assembly, then the direct path STC_{Dd} is equal to the laboratory STC for that assembly. Alternatively, if the separating assembly is a concrete masonry wall, the direct path STC_{Dd} is obtained from the laboratory measured STC rating of the unlined element and the ΔSTC changes due to linings on source "D" and/or receiving side "d" of the separating assembly using the equivalent of Eq. 24 and 30 in ISO 15712-1:

$$STC_{Dd} = STC_{lab} + max(\Delta STC_D, \Delta STC_d) + \frac{min(\Delta STC_D, \Delta STC_d)}{2} \qquad \text{Eq. 5.3.2}$$

(c) The calculation of Flanking STC_{ij} for each flanking path depends on the constructions involved. Here, indices i and j refer to the coupled flanking elements, where "i" can either be "D" or "F" and "j" can be "f" or "d".

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

- In all cases, values of $D_{n,f}$ or Flanking STC_{ij} measured according to ISO 10848 may be used to determine the Flanking STC (after re-normalization as explained in Section 4.1).

> NOTE: In previous versions of this Guide and in NRC Research Report RR-334, experimental Flanking STC data for each path were normalized to the actual dimensions of the flanking facilities at NRC. Starting in 2017, data measured at NRC according to ISO 10848 has been normalized to a set of nominal dimensions that correspond more closely to the Standard Scenario used in this Guide. The pertinent dimensions for laboratory data are identified clearly in the worked examples, and this change had no effect on the resulting Flanking STC values for each path in the worked examples.

- Note that lining corrections are not appropriate for framed assemblies.
- If one of the flanking elements is a concrete masonry wall, then the appropriate ΔSTC should be added to the Flanking STC_{ij} measured for this path without a lining, as the correction due to any lining added on that surface.
- If both flanking elements i and j are concrete masonry wall assemblies, and there are added linings then add $\left\{max\left(\Delta STC_i, \Delta STC_j\right) + \frac{min\left(\Delta STC_i, \Delta STC_j\right)}{2}\right\}$ to the Flanking STC_{ij} measured for this path without the lining(s).
- Alternatively, if both flanking elements i and j are concrete masonry wall assemblies, then the following equation (Eq. 5.3.3, the equivalent of Eq. 28 and 31 in ISO 15712-1 and the same as Eq. 2.4.3 of Section 2.4) could be used to determine the Flanking STC_{ij}.

$$\text{Flanking STC}_{ij} = \frac{\mathrm{STC_i}}{2} + \frac{\mathrm{STC_j}}{2} + \mathrm{K_{ij}} + \max\left(\Delta\mathrm{STC_i}, \Delta\mathrm{STC_j}\right) + \frac{\min\left(\Delta\mathrm{STC_i}, \Delta\mathrm{STC_j}\right)}{2} + 10\log_{10}\left(\frac{S_s}{l_o l_{ij}}\right) \qquad \text{Eq. 5.3.3}$$

Worked Examples

The worked examples present all the pertinent physical characteristics of the assemblies and junctions, including references for the source of the laboratory test data. All examples conform to the Standard Scenario presented in Section 1.2 of this Guide, and calculations were performed following the steps presented above in Section 5.3.

Under the heading "STC, ΔSTC" the examples present input data determined by applying the calculation process of ASTM E413 to laboratory test data of several types:

- STC values for laboratory sound transmission loss of wall or floor assemblies, measured according to ASTM E90,
- ΔSTC values measured in the laboratory according to ASTM E90 for the change in STC due to adding a given lining to the specified wall or floor assembly (as discussed in Appendix A1),
- Flanking STC values for each flanking path at each junction measured according to ISO 10848 and renormalized using Eq. 4.1.3, as explained in Section 4.1.

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

- Direct STC for the calculated in-situ transmission loss of the separating wall or floor assembly,
- Flanking STC calculated for each flanking transmission path at each junction, and for the combined set of paths at each junction,
- Apparent STC (ASTC) for the combination of direct and flanking transmission via all paths.

The numeric calculations are presented step-by-step in each worked example using compact notation consistent with spreadsheet expressions such that:

- For calculation of Direct STC, these expressions are easily recognized either as:
  - measured STC values without correction for a lining if the separating assembly is a lightweight wall, or
  - equivalent to Equations 5.3.2 with correction(s) for lining(s) if the separating assembly is a concrete block wall
- For calculation of Flanking STC, these expressions are easily recognized either as:
  - measured flanking STC values re-normalised using Eq. 4.1.3, possibly with a correction for a lining if the concrete block wall is one of the flanking surfaces, or
  - equivalent to Equations 5.3.3 if both flanking surfaces are concrete block walls.

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. 5.3.1 (an adapted version of Eq. 1.4) 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 direct 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 $\mathrm{STC_{ij}}$ = 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 and the final ASTC.

EXAMPLE 5.3.1: **SIMPLIFIED METHOD**

- **Rooms side-by-side**
- **Separating loadbearing wall of normal weight concrete block with wood-framed flanking floors and walls**

Separating wall assembly with:
- One wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2, with no lining

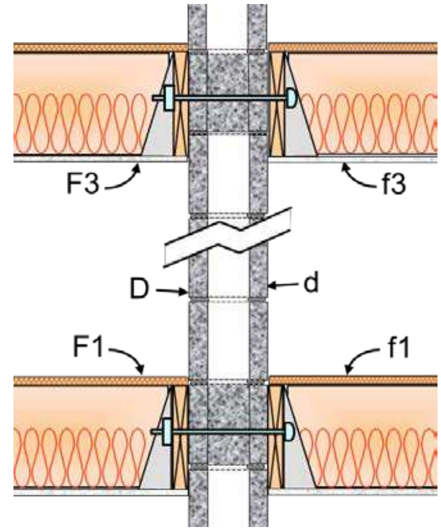
Bottom Junction 1 (separating wall and floor) with:
- 38 mm x 235 mm wood ledger plate on each side, fastened through with 16 mm diameter bolts spaced 400 mm o.c.
- Cells in concrete block[1] assembly between the ledger plates are filled with grout, and floor joists are supported on joist hangers attached to these plates
- Floor framed with 38 mm x 235 mm wood joists spaced 400 mm o.c., with joists oriented perpendicular to separating wall and supported on joist hangers, with 150 mm thick absorptive material[3] in the inter-joist cavities
- Floor deck of 16 mm oriented strand board (OSB)
- No floor finish or floor topping

Top Junction 3 (separating wall and ceiling) with:
- Ceiling framed with wood joists (same details as Junction 1)
- Ceiling with 1 layer of 13 mm gypsum board[4] fastened directly to bottom of floor framing on each side

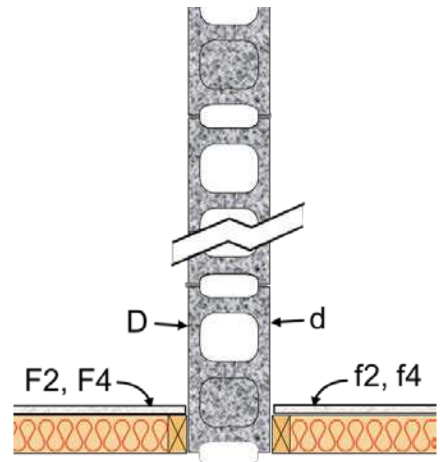
Side Junction 2 or 4 (separating wall and abutting side walls) with:
- Side wall framing with single row of wood studs
- Side wall framing structurally-connected to the separating concrete block[1] wall, but not continuous across the junction
- 13 mm gypsum board[4] on the side walls ends at separating wall assembly and is attached directly to wall framing of 38 mm x 89 mm wood studs spaced 400 mm o.c., with absorptive material[3] in the stud cavities

	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-334, Eq. 4.2.1
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-334, Eq. 4.2.1

Illustration for this case



Junctions 1 and 3 of loadbearing separating concrete block wall with wood-framed flanking floor and ceiling. (Side view)



Junction 2 or 4 of separating concrete block wall with abutting side walls, with side walls' framing and gypsum board terminating at separating wall. (Plan view)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (190 mm concrete block)				
Laboratory STC for Dd	R_s,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining on D	ΔR_D,w	No Lining	0	
ΔSTC change by Lining on d	ΔR_d,w	No Lining	0	
Leakage or Airborne Flanking		Sealed & Blocked	0	
Direct STC in-situ	R_Dd,w	ISO 15712-1, Eq. 24 and 30	49 + MAX(0,0) + MIN(0,0) /2 + 0 =	**49**
Junction 1 (190 mm concrete block separating wall / wood-framed floor)				
For Flanking Path Ff_1:				
Laboratory Flanking STC		RR-334, BLK190-WF-LB-01	59	
Flanking STC for path Ff_1	R_Ff,w	ISO 15712-1, Eq. 28 - 31	59 + 0 =	**59**
For Flanking Path Fd_1:				
Laboratory Flanking STC	R_Fd,w	RR-334, BLK190-WF-LB-01	59	
ΔSTC change by Lining on d	ΔR_d,w	No Lining	0	
Flanking STC for path Fd_1	R_ Fd,w	ISO 15712-1, Eq. 28 - 31	59 + 0 + 0 =	**59**
For Flanking Path Df_1:				
Laboratory Flanking STC	R_Df,w	RR-334, BLK190-WF-LB-01	59	
ΔSTC change by Lining on D	ΔR_D,w	No Lining	0	
Flanking STC for path Fd_1	R_ Df,w	ISO 15712-1, Eq. 28 - 31	59 + 0 + 0 =	**59**
Junction 1: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-5.9 + 10^- 5.9 + 10^- 5.9) =	54
Junction 2 (190 mm concrete block separating wall / wood-framed flanking wall)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-334, BLK190-WW-LB-01	81	
Flanking STC for path Ff_2	R_Ff,w	ISO 15712-1, Eq. 28 - 31	81 + 0 =	**81**
For Flanking Path Fd_2:				
Laboratory Flanking STC	R_Fd,w	RR-334, BLK190-WW-LB-01	71	
ΔSTC change by Lining on d	ΔR_d,w	No Lining	0	
Flanking STC for path Fd_2	R_ Fd,w	ISO 15712-1, Eq. 28 - 31	71 + 0 + 0 =	**71**
For Flanking Path Df_2:				
Laboratory Flanking STC	R_Df,w	RR-334, BLK190-WW-LB-01	71	
ΔSTC change by Lining on D	ΔR_D,w	No Lining	0	
Flanking STC for path Fd_2	R_ Df,w	ISO 15712-1, Eq. 28 - 31	71 + 0 + 0 =	**71**
Junction 2: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-8.1 + 10^- 7.1 + 10^- 7.1) =	68
Junction 3 (190 mm concrete block separating wall / wood-framed ceiling)				
For Flanking Path Ff_3:				
Laboratory Flanking STC		RR-334, BLK190-WC-LB-01	65	
Flanking STC for path Ff_3	R_Ff,w	ISO 15712-1, Eq. 28 - 31	65 + 0 =	**65**
For Flanking Path Fd_3:				
Laboratory Flanking STC	R_Fd,w	RR-334, BLK190-WC-LB-01	65	
ΔSTC change by Lining on d	ΔR_d,w	No Lining	0	
Flanking STC for path Fd_3	R_ Fd,w	ISO 15712-1, Eq. 28 - 31	65 + 0 + 0 =	**65**
For Flanking Path Df_3:				
Laboratory Flanking STC	R_Df,w	RR-334, BLK190-WC-LB-01	65	
ΔSTC change by Lining on D	ΔR_D,w	No Lining	0	
Flanking STC for path Fd_3	R_ Df,w	ISO 15712-1, Eq. 28 - 31	65 + 0 + 0 =	**65**
Junction 3: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-6.5 + 10^- 6.5 + 10^- 6.5) =	60
Junction 4 (190 mm concrete block separating wall / wood-framed flanking wall)				
All values the same as for Junction 2				
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2	81 + 0 =	**81**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2	71 + 0 + 0 =	**71**
Flanking STC for path Fd_4	R_ Df,w	Same as for Df_2	71 + 0 + 0 =	**71**
Junction 4: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-8.1 + 10^- 7.1 + 10^- 7.1) =	68
Total Flanking STC (4 Junctions)		Subset of Eq. 5.3.1	Combining 12 Flanking STC values	53
ASTC due to Direct plus Total Flanking		RR-331, Equation 5.3.1	Combining Direct STC with 12 Flanking STC values	**48**

EXAMPLE 5.3.2 **SIMPLIFIED METHOD**	**Illustration for this case**

EXAMPLE 5.3.2 **SIMPLIFIED METHOD**

- **Rooms side-by-side**
- **Separating loadbearing wall of normal weight concrete block with wood-framed flanking floors and walls (Same structure as Example 5.3.1, plus linings)**

Separating wall assembly with:
- One wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Concrete block assembly lined on each side by 1 layer of 13 mm gypsum board[4] supported on 41 mm steel studs[5] that are not in contact with the concrete blocks and are spaced 600 mm o.c., with absorptive material[3] filling the stud cavities

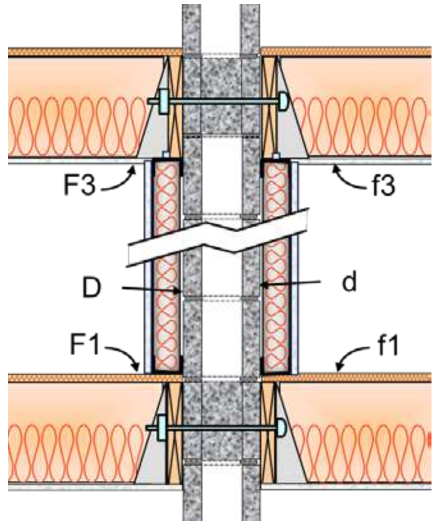
Bottom Junction 1 (separating wall and floor) with:
- 38 mm x 235 mm wood ledger plate on each side, fastened through with 16 mm diameter bolts spaced 400 mm o.c.
- Cells in concrete block[1] assembly between the ledger plates are filled with grout
- Floor framed with 38 mm x 235 mm wood joists spaced 400 mm o.c., with joists oriented perpendicular to separating wall and supported on joist hangers, with 150 mm thick absorptive material[3] in the inter-joist cavities
- Floor deck of 16 mm thick oriented strand board (OSB)
- No floor finish or floor topping

Top Junction 3 (separating wall and ceiling) with:
- Ceiling framed with wood joists (same details as Junction 1)
- Ceiling with one layer of 13 mm gypsum board[4] fastened directly to bottom of floor framing on each side

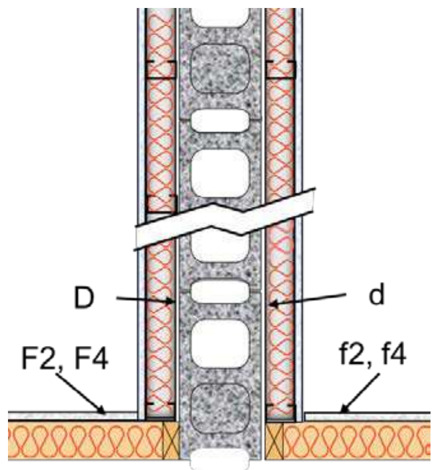
Side Junction 2 or 4 (separating wall and abutting side walls) with:
- Side wall framing with single row of wood studs
- Side wall framing structurally-connected to the separating concrete block wall, but not continuous across the junction
- 13 mm gypsum board[4] on the side wall ends at separating wall assembly and is attached directly to wall framing of 38 mm x 89 mm wood studs spaced 400 mm o.c., with absorptive material[3] filling the stud cavities

	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-334, Eq. 4.2.1
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.00	RR-334, Eq. 4.2.1

Illustration for this case



Junctions 1 and 3 of loadbearing separating concrete block wall with wood-framed flanking floor and ceiling. (Side view)



Junction 2 or 4 of separating concrete block wall with abutting side walls, with side walls' framing and gypsum board terminating at separating wall. (Plan view)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (190 mm concrete block)				
Laboratory STC for Dd	R_s,w	RR-334, NRC-Mean BLK190(NW)	49	
ΔSTC change by Lining on D	ΔR_D,w	RR-334, ΔTL-BLK(NW)-42	9	
ΔSTC change by Lining on d	ΔR_d,w	RR-334, ΔTL-BLK(NW)-42	9	
Leakage or Airborne Flanking		Sealed & Blocked	0	
Direct STC in situ	R_Dd,w	ISO 15712-1, Eq. 24 and 30	49 + MAX(9,9) + MIN(9,9) /2 + 0 =	**63**
Junction 1 (190 mm concrete block separating wall / wood-framed floor)				
For Flanking Path Ff_1:				
Laboratory Flanking STC		RR-334, BLK190-WF-LB-01	59	
Flanking STC for path Ff_1	R_Ff,w	ISO 15712-1, Eq. 28 - 31	59 + 0 =	**59**
For Flanking Path Fd_1:				
Laboratory Flanking STC	R_Fd,w	RR-334, BLK190-WF-LB-01	59	
ΔSTC change by Lining on d	ΔR_d,w	RR-334, ΔTL-BLK(NW)-42	9	
Flanking STC for path Fd_1	R_ Fd,w	ISO 15712-1, Eq. 28 - 31	59 + 9 + 0 =	**68**
For Flanking Path Df_1:				
Laboratory Flanking STC	R_Df,w	RR-334, BLK190-WF-LB-01	59	
ΔSTC change by Lining on D	ΔR_D,w	RR-334, ΔTL-BLK(NW)-42	9	
Flanking STC for path Fd_1	R_ Df,w	ISO 15712-1, Eq. 28 - 31	59 + 9 + 0 =	**68**
Junction 1: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-5.9 + 10^- 6.8 + 10^- 6.8) =	58
Junction 2 (190 mm concrete block separating wall / wood-framed flanking wall)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-334, BLK190-WW-LB-01	81	
Flanking STC for path Ff_2	R_Ff,w	ISO 15712-1, Eq. 28 - 31	81 + 0 =	**81**
For Flanking Path Fd_2:				
Laboratory Flanking STC	R_Fd,w	RR-334, BLK190-WW-LB-01	71	
ΔSTC change by Lining on d	ΔR_d,w	RR-334, ΔTL-BLK(NW)-42	9	
Flanking STC for path Fd_2	R_ Fd,w	ISO 15712-1, Eq. 28 - 31	71 + 9 + 0 =	**80**
For Flanking Path Df_2:				
Laboratory Flanking STC	R_Df,w	RR-334, BLK190-WW-LB-01	71	
ΔSTC change by Lining on D	ΔR_D,w	RR-334, ΔTL-BLK(NW)-42	9	
Flanking STC for path Fd_2	R_ Df,w	ISO 15712-1, Eq. 28 - 31	71 + 9 + 0 =	**80**
Junction 2: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-8.1 + 10^- 8 + 10^- 8) =	76
Junction 3 (190 mm concrete block separating wall / wood-framed ceiling)				
Laboratory Flanking STC		RR-334, BLK190-WC-LB-01	65	
Flanking STC for path Ff_3	R_Ff,w	ISO 15712-1, Eq. 28 - 31	65 + 0 =	**65**
For Flanking Path Fd_3:				
Laboratory Flanking STC	R_Fd,w	RR-334, BLK190-WC-LB-01	65	
ΔSTC change by Lining on d	ΔR_d,w	RR-334, ΔTL-BLK(NW)-42	9	
Flanking STC for path Fd_3	R_ Fd,w	ISO 15712-1, Eq. 28 - 31	65 + 9 + 0 =	**74**
For Flanking Path Df_3:				
Laboratory Flanking STC	R_Df,w	RR-334, BLK190-WC-LB-01	65	
ΔSTC change by Lining on D	ΔR_D,w	RR-334, ΔTL-BLK(NW)-42	9	
Flanking STC for path Fd_3	R_ Df,w	ISO 15712-1, Eq. 28 - 31	65 + 9 + 0 =	**74**
Junction 3: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-6.5 + 10^- 7.4 + 10^- 7.4) =	64
Junction 4 (190 mm concrete block separating wall / wood-framed flanking wall)				
All values the same as for Junction 2				
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2	81 + 0 =	**81**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2	71 + 9 + 0 =	**80**
Flanking STC for path Fd_4	R_ Df,w	Same as for Df_2	71 + 9 + 0 =	**80**
Junction 4: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-8.1 + 10^- 8 + 10^- 8) =	**76**
Total Flanking STC (4 Junctions)		Subset of Eq. 5.3.1	Combining 12 Flanking STC values	57
ASTC due to Direct plus Total Flanking		RR-331, Equation 5.3.1	Combining Direct STC with 12 Flanking STC values	**56**

EXAMPLE 5.3.3 **SIMPLIFIED METHOD**

- **Rooms one-above-the-other**
- **Separating wood-framed floor assembly with joists perpendicular to flanking walls of normal weight concrete block and parallel to wood-framed flanking walls**

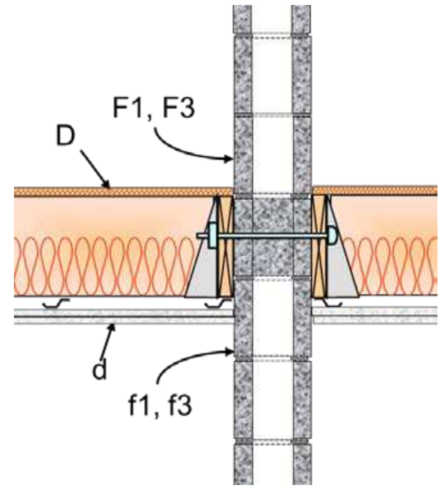
Separating floor/ceiling assembly with:
- Floor framed with 38 mm x 235 mm wood joists spaced 400 mm o.c., with joists oriented perpendicular to concrete block wall, with 150 mm thick absorptive material[3] in the inter-joist cavities
- Ceiling of 2 layers of 16 mm fire-rated gypsum board[4], attached to resilient metal channels[7] spaced 400 mm o.c.
- Subfloor of oriented strand board (OSB) 16 mm thick
- No floor topping and no floor finish

Junction 1 or 3 (with loadbearing walls above and below floor) with:
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Cells in concrete block assembly between the ledger plates are filled with grout
- 38 mm x 235 mm wood ledger plate on each side of the concrete blocks[1], fastened through with 16 mm diameter bolts spaced 400 mm o.c., and floor joists are supported on joist hangers attached to these plates
- No lining on concrete block walls

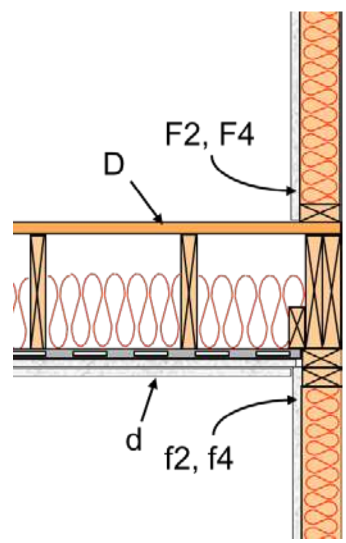
Junction 2 or 4 (with non-loadbearing walls above and below floor) with:
- Joists of floor assembly parallel to these walls
- Walls have 38 mm x 89 mm wood studs spaced 400 mm o.c with several framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates)
- Walls with or without absorptive material[3] in the stud cavities give equivalent flanking
- Single layer of 13 mm gypsum board[4] that ends at floor/ceiling assembly and is attached directly to wall framing

	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-334, Eq. 4.2.1
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.97	RR-334, Eq. 4.2.1

Illustration for this case



Junction 1 or 3 of separating wood-framed floor/ceiling assembly with loadbearing flanking concrete block wall. (Side view)



Junction 2 or 4 of separating wood-framed floor/ceiling assembly with abutting side walls, with side walls' framing and gypsum board terminating at framing of floor. (Plan view)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating partition (Wood-framed floor)				
Laboratory STC for Dd	R_s,w	RR-336, WJ235-02	53	
Leakage or Airborne Flanking		Sealed & Blocked	0	
Direct STC in-situ	R_Dd,w	No adjustment, ISO 15712-1, 4.2.2		**53**
Junction 1 (Wood-framed separating floor / 190 mm concrete block flanking wall)				
For Flanking Path Ff_1:				
Laboratory Flanking STC	R_s,w	RR-334, WJ235-FW-LB-02	59	
ΔSTC change by Lining on F	ΔR_F,w	No Lining	0	
ΔSTC change by Lining on f	ΔR_f,w	No Lining	0	
Normalization correction		ISO 15712-1, Eq.28a	0	
Flanking STC for path Ff_1	R_Ff,w	ISO 15712-1, Eq. 28 - 31	59 + MAX(0,0) + MIN(0,0)/2 + 0 =	**59**
For Flanking Path Fd_1:				
Laboratory Flanking STC	R_Fd,w	RR-334, WJ235-FW-LB-02	73	
ΔSTC change by Lining on F	ΔR_d,w	No Lining	0	
Flanking STC for path Fd_1	R_ Fd,w	ISO 15712-1, Eq. 28 - 31	73 + 0 + 0 =	**73**
For Flanking Path Df_1:				
Laboratory Flanking STC	R_Df,w	RR-334, WJ235-FW-LB-02	67	
ΔSTC change by Lining on f	ΔR_D,w	No Lining	0	
Flanking STC for path Fd_1	R_ Df,w	ISO 15712-1, Eq. 28 - 31	67 + 0 + 0 =	**67**
Junction 1: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-5.9 + 10^- 7.3 + 10^- 6.7) =	58
Junction 2 (Wood-framed separating floor / wood-framed flanking wall)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-336, WJ235-VF_NLB-02	63	
Flanking STC for path Ff_2	R_Ff,w	ISO 15712-1, Eq. 28 - 31	63 + 0.97 =	**64**
For Flanking Path Fd_2:				
Laboratory Flanking STC	R_Fd,w	RR-336, WJ235-VF_NLB-02	80	
Flanking STC for path Fd_2	R_ Fd,w	ISO 15712-1, Eq. 28 - 31	80 + 0.97 =	**81**
For Flanking Path Df_2:				
Laboratory Flanking STC	R_Df,w	RR-336, WJ235-VF_NLB-02	60	
Flanking STC for path Fd_2	R_ Df,w	ISO 15712-1, Eq. 28 - 31	60 + 0.97 =	**61**
Junction 2: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-6.4 + 10^- 8.1 + 10^- 6.1) =	59
Junction 3 (Wood-framed separating floor / 190 mm concrete block flanking wall)				
Flanking STC for path Ff_3	R_Ff,w	Same as for Ff_1	59 + MAX(0,0) + MIN(0,0)/2 + 0 =	**59**
Flanking STC for path Fd_3	R_ Fd,w	Same as for Fd_1	73 + 0 + 0 =	**73**
Flanking STC for path Fd_3	R_ Df,w	Same as for Df_1	67 + 0 + 0 =	**67**
Junction 3: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-5.9 + 10^- 7.3 + 10^- 6.7) =	58
Junction 4 (Wood-framed separating floor / wood-framed flanking wall)				
All values the same as for Junction 2				
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2	63 + 0.97 =	**64**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2	80 + 0.97 =	**81**
Flanking STC for path Fd_4	R_ Df,w	Same as for Df_2	60 + 0.97 =	**61**
Junction 4: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-6.4 + 10^- 8.1 + 10^- 6.1) =	59
Total Flanking STC (4 Junctions)		Subset of Eq. 5.3.1	Combining 12 Flanking STC values	53
ASTC due to Direct plus Total Flanking		RR-331, Equation 5.3.1	Combining Direct STC with 12 Flanking STC values	**50**

EXAMPLE 5.3.4 SIMPLIFIED METHOD

- **Rooms one-above-the-other**
- **Separating wood-framed floor assembly with joists perpendicular to flanking walls of normal weight concrete block and parallel to wood-framed flanking walls**
- **Same structure as Example 5.3.3, plus linings**

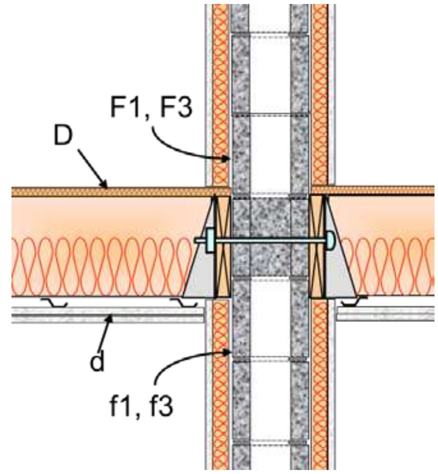
Separating floor/ceiling assembly with:
- Floor framed with 38 mm x 235 mm wood joists spaced 400 mm o.c., with joists oriented perpendicular to concrete block wall, with 150 mm thick absorptive material[3] in the inter-joist cavities
- Ceiling of 2 layers of 16 mm fire-rated gypsum board[4], attached to resilient metal channels[7] spaced 400 mm o.c.
- Subfloor of oriented strand board (OSB) 16 mm thick
- No floor topping and no floor finish

Junction 1 or 3 (with loadbearing walls above and below floor) with:
- Wall above and below floor of one wythe of 190 mm hollow concrete block masonry[1] constructed using normal weight units not less than 53% solid, and with mass per area of 238 kg/m^2
- Cells in concrete block assembly between the ledger plates are filled with grout
- 38 mm x 235 mm wood ledger plate on each side of concrete blocks, fastened through with 16 mm diameter bolts spaced 400 mm o.c. and floor joists are supported on joist hangers attached to these plates
- Lining on each side of the concrete block walls[1] of 1 layer of 13 mm gypsum board[4] supported on 38 mm x 38 mm wood furring spaced 600 mm o.c. and fastened to the concrete blocks, with absorptive material[3] filling the cavities

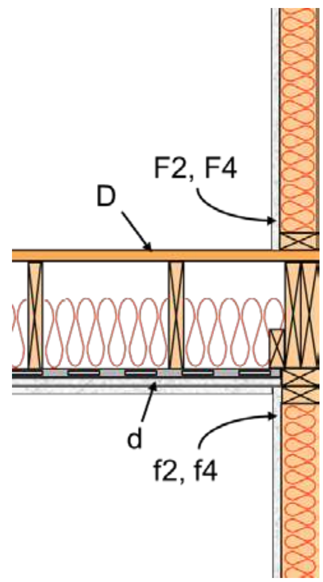
Junction 2 or 4 (with non-loadbearing walls above and below floor) with:
- Joists of floor assembly parallel to these walls
- Walls have 38 mm x 89 mm wood studs spaced 400 mm o.c with several framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates)
- Walls with or without absorptive material[3] in the stud cavities give equivalent flanking
- Single layer of 13 mm gypsum board[4] that ends at floor/ceiling assembly and is attached directly to wall framing

	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-334, Eq. 4.2.1
Normalization for Junctions 2 and 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.97	RR-334, Eq. 4.2.1

Illustration for this case



Junction 1 or 3 of separating wood-framed floor/ceiling assembly with loadbearing flanking concrete block wall. (Side view)



Junction 2 or 4 of separating wood-framed floor/ceiling assembly with abutting side walls, with side walls' framing and gypsum board terminating at framing of floor. (Plan view)

(For the notes in this table please see the corresponding endnotes on page 195.)

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating partition (Wood-framed floor)				
Laboratory STC for Dd	R_s,w	RR-336, WJ235-02	53	
Leakage or Airborne Flanking		Sealed & Blocked	0	
Direct STC in-situ	R_Dd,w	No adjustment, ISO 15712-1, 4.2.2		**53**
Junction 1 (Wood-framed separating floor / 190 mm concrete block flanking wall)				
For Flanking Path Ff_1:				
Laboratory Flanking STC	R_s,w	RR-334, WJ235-FW-LB-02	59	
ΔSTC change by Lining on F	ΔR_F,w	RR-334, ΔTL-BLK(NW)-33	4	
ΔSTC change by Lining on f	ΔR_f,w	RR-334, ΔTL-BLK(NW)-33	4	
Normalization correction		ISO 15712-1, Eq.28a	0	
Flanking STC for path Ff_1	R_Ff,w	ISO 15712-1, Eq. 28 - 31	59 + MAX(4,4) + MIN(4,4)/2 + 0 =	**65**
For Flanking Path Fd_1:				
Laboratory Flanking STC	R_Fd,w	RR-334, WJ235-FW-LB-02	73	
ΔSTC change by Lining on F	ΔR_d,w	RR-334, ΔTL-BLK(NW)-33	4	
Flanking STC for path Fd_1	R_ Fd,w	ISO 15712-1, Eq. 28 - 31	73 + 4 + 0 =	**77**
For Flanking Path Df_1:				
Laboratory Flanking STC	R_Df,w	RR-334, WJ235-FW-LB-02	67	
ΔSTC change by Lining on f	ΔR_D,w	RR-334, ΔTL-BLK(NW)-33	4	
Flanking STC for path Fd_1	R_ Df,w	ISO 15712-1, Eq. 28 - 31	67 + 4 + 0 =	**71**
Junction 1: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-6.5 + 10^- 7.7 + 10^- 7.1) =	64
Junction 2 (Wood-framed separating floor / wood-framed flanking wall)				
For Flanking Path Ff_2:				
Laboratory Flanking STC		RR-336, WJ235-VF_NLB-02	63	
Flanking STC for path Ff_2	R_Ff,w	ISO 15712-1, Eq. 28 - 31	63 + 0.97 =	**64**
For Flanking Path Fd_2:				
Laboratory Flanking STC	R_Fd,w	RR-336, WJ235-VF_NLB-02	80	
Flanking STC for path Fd_2	R_ Fd,w	ISO 15712-1, Eq. 28 - 31	80 + 0.97 =	**81**
For Flanking Path Df_2:				
Laboratory Flanking STC	R_Df,w	RR-336, WJ235-VF_NLB-02	60	
Flanking STC for path Fd_2	R_ Df,w	ISO 15712-1, Eq. 28 - 31	60 + 0.97 =	**61**
Junction 2: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-6.4 + 10^- 8.1 + 10^- 6.1) =	59
Junction 3 (Wood-framed separating floor / 190 mm concrete block flanking wall)				
Flanking STC for path Ff_3	R_Ff,w	Same as for Ff_1	59 + MAX(4,4) + MIN(4,4)/2 + 0 =	**65**
Flanking STC for path Fd_3	R_ Fd,w	Same as for Fd_1	73 + 4 + 0 =	**77**
Flanking STC for path Fd_3	R_ Df,w	Same as for Df_1	67 + 4 + 0 =	**71**
Junction 3: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-6.5 + 10^- 7.7 + 10^- 7.1) =	64
Junction 4 (Wood-framed separating floor / wood-framed flanking wall)				
All values the same as for Junction 2				
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2	63 + 0.97 =	**64**
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2	80 + 0.97 =	**81**
Flanking STC for path Fd_4	R_ Df,w	Same as for Df_2	60 + 0.97 =	**61**
Junction 4: Flanking STC for all paths		Subset of Eq. 5.3.1	- 10*LOG10(10^-6.4 + 10^- 8.1 + 10^- 6.1) =	59
Total Flanking STC (4 Junctions)		Subset of Eq. 5.3.1	Combining 12 Flanking STC values	55
ASTC due to Direct plus Total Flanking		RR-331, Equation 5.3.1	Combining Direct STC with 12 Flanking STC values	**51**

Summary for Section 5.3: Calculation for Concrete Masonry Walls with Lightweight Framed Wall and Floor Assemblies

The Examples 5.3.1 to 5.3.4 use a combination of the simplified procedures from Chapter 4 for lightweight framed assemblies, and the simplified methods from Section 2.4 for calculating transmission between rooms in a building with concrete floors and concrete or masonry wall assemblies.

The examples show that flanking does play a significant role in determining the performance of these systems. For Example 5.3.1 with a bare concrete block wall between the side-by-side rooms, the ASTC rating is 48, which is 1 point lower than the STC of the separating assembly. For Example 5.3.3 with one room above the other, the ASTC rating is 50 which is 3 points lower than the STC of the separating floor. In neither case do the flanking paths via the bare concrete block surfaces dominate the flanking.

For the side-by-side pair of rooms

The effect of added linings is shown in Example 5.3.2. The following trends are observed:

- Adding a lining with ΔSTC = 9 to the concrete block surfaces (both sides of separating wall) raises the ASTC rating from 48 to 56. Even this moderate improvement of the STC rating of the separating wall makes flanking transmission the dominant transmission, especially for the floor-floor and ceiling-ceiling paths.
- If the ceiling in Example 5.3.3 is also improved by mounting the gypsum board ceiling on resilient channels, the Flanking STC value for the ceiling paths (Junction 3) would improve to 75. However, this would increase the ASTC rating by only 1 point because the benefit is limited by flanking at the floor junction combined with the appreciable direct transmission.
- Significant further improvement in the ASTC rating requires the treatment of both the floor and the ceiling surfaces as well as the use of better linings on the separating wall. With these changes, the ASTC rating could be raised to 65 or higher.

With one room above the other

The effect of added linings on the concrete block flanking walls is shown in Example 5.3.4.

Example 5.3.4 shows the effect of adding a minimal wall lining with ΔSTC = 4 to all of the concrete block surfaces. Even this small improvement makes the flanking transmission via the concrete block walls nearly insignificant. The use of better wall linings could raise the Flanking STC for Junctions 1 and 3 (paths involving the concrete block walls) to the point where they are clearly insignificant, but would not improve the ASTC rating appreciably.

Achieving significantly higher ASTC ratings requires the improvement of the floor surface and the wood-framed flanking walls, as well as the use of better linings on the concrete block flanking walls. With such changes, the ASTC rating could be raised to 65 or higher.

6. Appendices

6.1. Appendix A1: Calculation of ΔTL and ΔSTC Values

To characterize the change in sound transmission loss due to adding a specific lining to a heavy base wall or floor a single-number rating called ΔSTC is introduced.

Key issues concerning ΔSTC include:

- The ΔSTC is a required input for the calculation of ASTC using the Simplified Method of ISO 15712-1, as discussed in Sections 2.4, 3.1, 4.1, and 5.3 of this Guide.
- Values of ΔSTC calculated from the experimental data in this Guide were calculated from experimental data using the procedure here, and are presented in tables in the companion reports for specific types of base construction; see NRC Research Reports RR-333 to RR-337. Readers of this Guide can simply use the tabulated ΔSTC values from those reports without the need to perform the calculations explained here.
- The general procedure for calculating ΔSTC is presented in this Appendix, but its application for specific constructions is explained in more detail for each material in the appendices of the NRC Research Reports RR-333 to RR-337.

ASTM does not define a ΔSTC rating, but it has a counterpart (ΔR_W) in the ISO standards. The procedure used here is modified from its ISO counterpart in two ways:

1. The STC calculation according to ASTM E413 is substituted for the ISO calculation of R_W, plus additional Steps 4 and 5 are included, as explained in Figure A1.1 and the adjacent text.
2. A reference curve to represent the base assembly is required for the calculation. The ISO standards provide a set of three reference curves, one for heavy concrete floors and two for base wall assemblies. For calculations of the ΔSTC value for CLT assemblies, a fourth reference curve has been added for wall assemblies that fall between the two ISO wall cases. The new reference curve is denoted as Reference Wall 2, and is described as “wall with medium-low coincidence frequency.” The four reference curves are presented at the end of this Appendix.

The reference curves for the ISO procedure to calculate ΔR_W are smoothed average sound transmission loss curves for some constructions common in Europe – a homogeneous concrete floor (140 mm thick with mass per unit area of 300 kg/m^2), a heavy masonry wall with low coincidence frequency (mass per unit area of 350 kg/m^2) and a lighter masonry wall of gypsum blocks (mass per unit area of 70 kg/m^2) described as a “wall with medium-high coincidence frequency.”

In selecting the appropriate reference curve for the calculation of ΔSTC, the mass or thickness of the unlined base wall or floor assembly is irrelevant. What matters is the frequency dependence of its sound transmission loss curve, especially around the frequency where the curve transitions from a comparatively flat plateau at low frequencies to rising at about 2 dB per one-third octave band.

To establish the best reference curve for a given base wall or floor assembly, the reference curve should be shifted up or down to match the STC of the tested assembly. This permits clear identification of the fit below and above the frequency where the curve bends up. The reference curve can be shifted up or down (changing the sound transmission loss at all frequency bands by the same amount) without altering the calculation of ΔSTC because, as detailed in the calculation procedure below, ΔSTC is the *difference* between the STC for the reference curve and the STC calculated for the curve obtained by adding the ΔTL values at each frequency to the reference curve.

Procedure for Calculating ΔSTC Ratings

The procedure to establish the change in sound transmission loss ΔTL due to adding linings is presented in the reports on sound transmission for specific base assemblies such as concrete block walls or CLT assemblies (NRC Research Reports RR-333 to RR-337). The following procedure uses those values for ΔTL (in one-third octave bands) for each lining to calculate the corresponding single-number ΔSTC ratings.

Steps in the procedure are detailed here and shown schematically in Figure A1.1:

Step 1. The change in sound transmission loss (ΔTL) due to adding the lining is calculated from the laboratory test results according to ASTM E90 (for the base assembly without any added lining and for that assembly with lining(s) added) for each frequency band, including at least 125 Hz to 4 kHz. This may involve averaging results from several pairs of assemblies as explained in the NRC Research Reports RR-333 to RR-337.

Step 2. (a) Calculate the sum of the sound transmission loss for the chosen reference curve plus ΔTL for each frequency band. The STC rating for this case is $STC_{1\text{-Side}}$.
(b) Calculate the sum of the sound transmission loss for the chosen reference curve plus 2 x ΔTL for each frequency band. The STC rating for this case is $STC_{2\text{-Sides}}$.
(c) Calculate the STC rating for the chosen reference curve (STC_{REF}).

Step 3. Subtract the STC rating of the reference curve (STC_{REF}) from $STC_{1\text{-side}}$ to obtain $\Delta STC_{1\text{-Side}}$.

Step 4. Subtract the STC rating of the reference curve (STC_{REF}) from $STC_{2\text{-sides}}$ to obtain $\Delta STC_{2\text{-Sides}}$.

Step 5. Calculate the ΔSTC value: ΔSTC is the smaller of $\Delta STC_{1\text{-Side}}$ and $\Delta STC_{2\text{-Sides}}/1.5$, rounded to integers (e.g. 20/1.5 ⇨ 13).

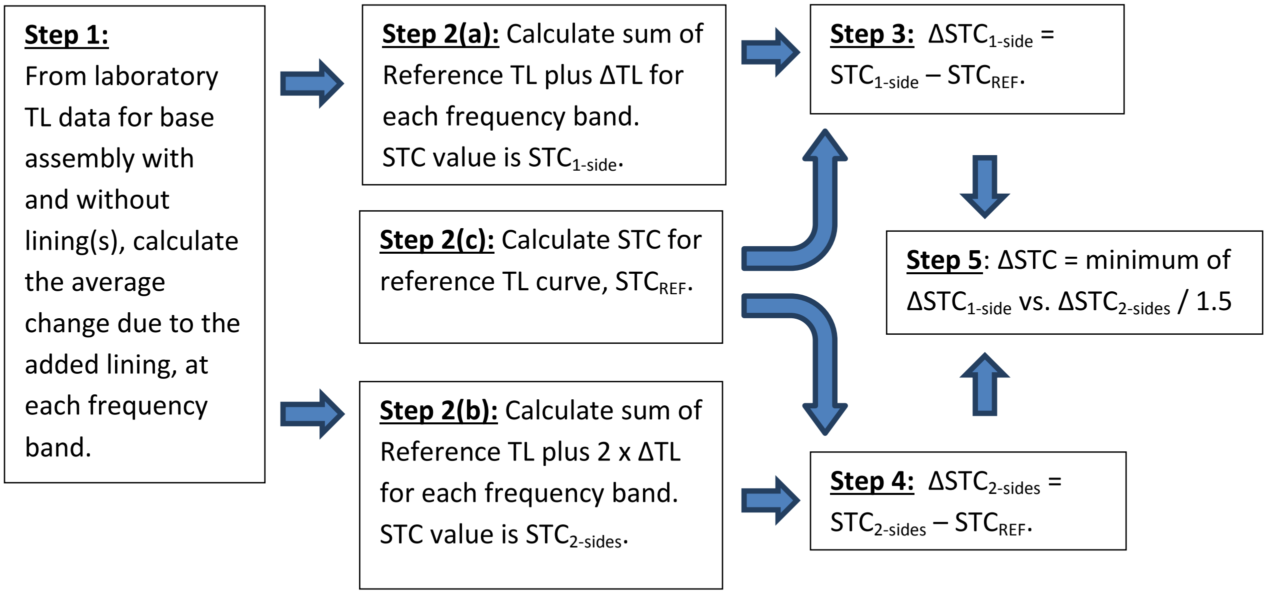


Figure A1.1: Steps to calculate the single-number rating ΔSTC for added linings (as detailed above).

Consideration of the change in STC when there is a lining on both sides of the wall (Step 4) and dividing $\Delta STC_{2\text{-sides}}$ by 1.5 in Step 5 can be understood by considering the use of ΔSTC values in Equations 2.4.2 and 2.4.3, in Equations 3.1.2 and 3.1.3, and in the worked examples in Sections 2.4 and 3.1.

Selection of the more conservative value (at Step 5) is required to avoid a misleading (over-optimistic) ΔSTC rating in the calculation procedure of the Simplified Method.

Reference Curves for Calculation of ΔSTC Ratings

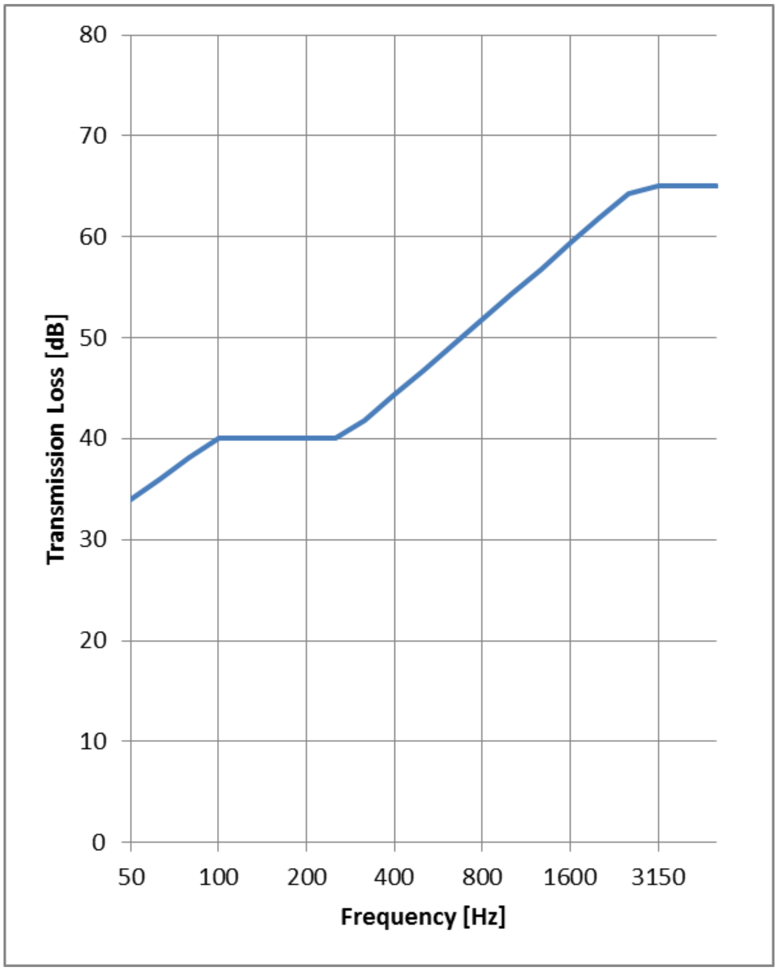
A set of four reference curves are presented here:

- One curve for concrete floors with low coincidence frequency
- Three curves for wall assemblies (or CLT floor assemblies) with different coincidence frequencies

Three of these curves match ISO Reference curves.

Figure A1.2:

Reference curve for the calculation of ΔSTC values **for concrete floor assemblies with low coincidence frequency.**



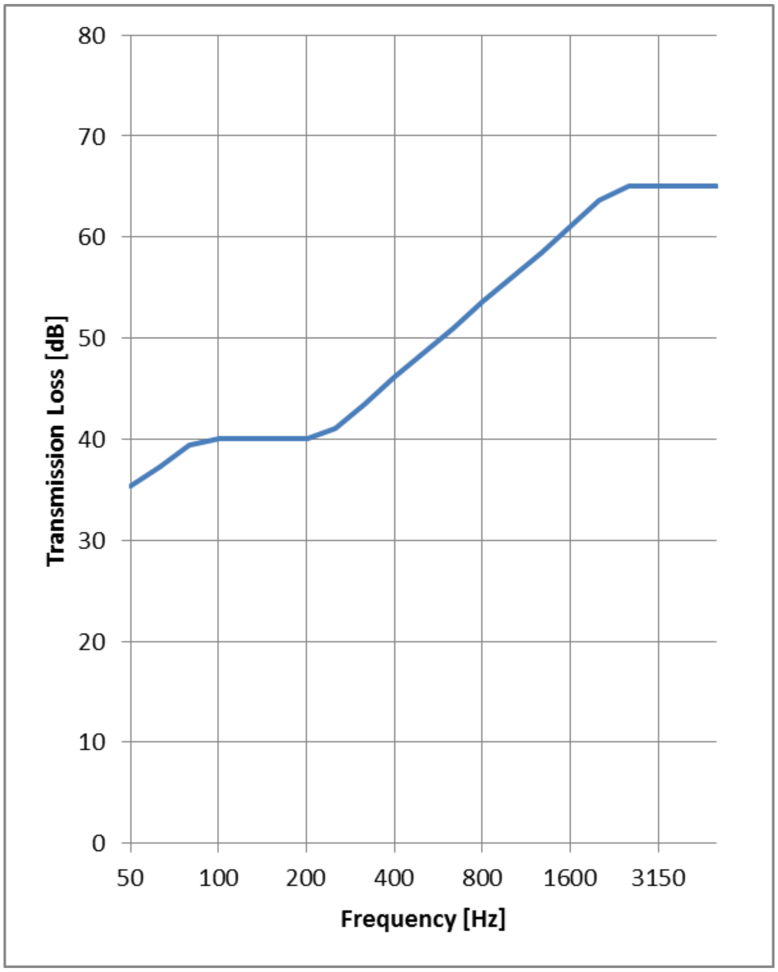
Reference Curve Floor 1

(aka Reference Curve B.2 from Annex B of ISO 140-16).

Frequency, Hz	TL, dB
50 Hz	34.0
63 Hz	36.0
80 Hz	38.1
100 Hz	40.0
125 Hz	40.0
160 Hz	40.0
200 Hz	40.0
250 Hz	40.0
315 Hz	41.8
400 Hz	44.4
500 Hz	46.8
630 Hz	49.3
800 Hz	51.9
1000 Hz	54.4
1250 Hz	56.8
1600 Hz	59.5
2000 Hz	61.9
2500 Hz	64.3
3150 Hz	65.0
4000 Hz	65.0
5000 Hz	65.0
STC	**52**

Figure A1.3:

Reference curve for the calculation of ΔSTC values **for wall assemblies with low coincidence frequency.** This reference curve may also be used for CLT floor assemblies with low coincidence frequency (see NRC Research Report RR-335).



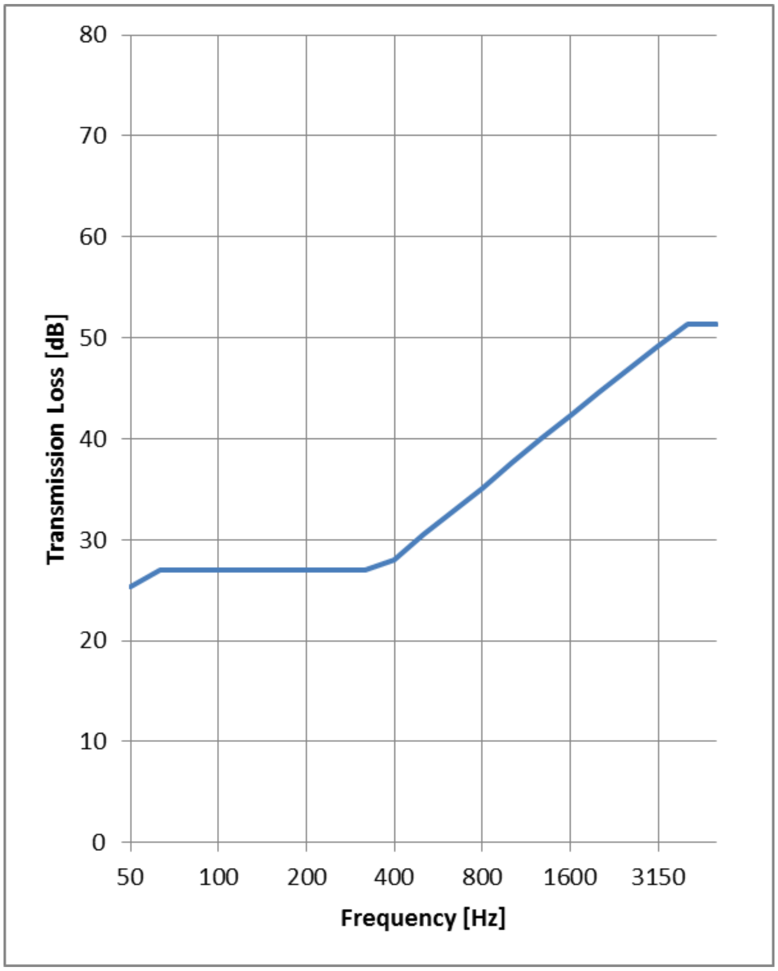
Reference Curve Wall 1

(aka Reference Curve B.1 from Annex B of ISO 140-16).

Frequency, Hz	**TL, dB**
50 Hz	35.3
63 Hz	37.3
80 Hz	39.4
100 Hz	40.0
125 Hz	40.0
160 Hz	40.0
200 Hz	40.0
250 Hz	41.0
315 Hz	43.5
400 Hz	46.1
500 Hz	48.5
630 Hz	51.0
800 Hz	53.6
1000 Hz	56.0
1250 Hz	58.4
1600 Hz	61.1
2000 Hz	63.6
2500 Hz	65.0
3150 Hz	65.0
4000 Hz	65.0
5000 Hz	65.0
STC	**53**

Figure A1.4:

Reference curve for the calculation of ΔSTC values **for wall assemblies with medium low coincidence frequency.**



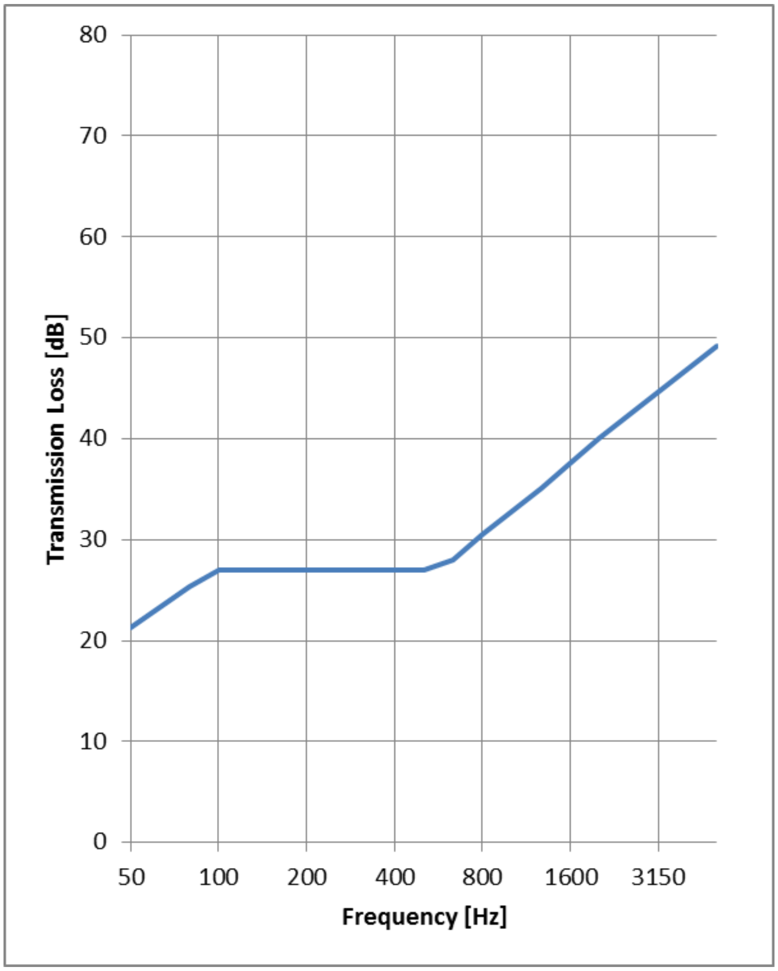
Reference Curve Wall 2

New curve produced by shifting Reference Curve B.3 from Annex B of ISO 140-16 to lower frequencies by two one-third octave bands.

Frequency, Hz	TL, dB
50 Hz	25.3
63 Hz	27.0
80 Hz	27.0
100 Hz	27.0
125 Hz	27.0
160 Hz	27.0
200 Hz	27.0
250 Hz	27.0
315 Hz	27.0
400 Hz	28.0
500 Hz	30.5
630 Hz	32.8
800 Hz	35.1
1000 Hz	37.6
1250 Hz	40.0
1600 Hz	42.3
2000 Hz	44.6
2500 Hz	46.9
3150 Hz	49.2
4000 Hz	51.3
5000 Hz	51.3
STC	**36**

Figure A1.5:

Reference curve for the calculation of ΔSTC values **for wall assemblies with medium high coincidence frequency**.



Reference Curve Wall 3

(aka Reference Curve B.3 from Annex B of ISO 140-16).

Frequency, Hz	TL, dB
50 Hz	21.3
63 Hz	23.3
80 Hz	25.3
100 Hz	27.0
125 Hz	27.0
160 Hz	27.0
200 Hz	27.0
250 Hz	27.0
315 Hz	27.0
400 Hz	27.0
500 Hz	27.0
630 Hz	28.0
800 Hz	30.5
1000 Hz	32.8
1250 Hz	35.1
1600 Hz	37.6
2000 Hz	40.0
2500 Hz	42.3
3150 Hz	44.6
4000 Hz	46.9
5000 Hz	49.2
STC	**33**

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7. References and Endnotes

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.
2. ASTM E336-10, "Standard Test Method for Measurement of Airborne Sound Insulation in Buildings", ASTM International, West Conshohocken, PA.
3. ASTM E413-16, "Classification for Rating Sound Insulation", ASTM International, West Conshohocken, PA.
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.

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 according to 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.

8. Collections of conventional laboratory test results for wall or floor assemblies evaluated according to ASTM E90 are presented in a series of NRC publications:
   8.1. IR-761 "Gypsum Board Walls : Transmission Loss Data", A.C.C. Warnock and J.A. Birta (1998),
   8.2. 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),
   8.3. IR-811 "Detailed Report for Consortium on Fire Resistance and Sound Insulation of Floors: Sound Transmission and Impact Insulation Data in 1/3 Octave Bands", A.C.C. Warnock and J.A. Birta (2000),
   8.4. 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),
   8.5. IR-586 "Sound Transmission Loss Measurements Through 190 mm and 140 mm Blocks With Added Drywall and Through Cavity Block Walls", A.C.C. Warnock (1990)

9. The software application *soundPATHS* is accessible online at the website of National Research Council Canada at http://www.nrc-cnrc.gc.ca/eng/solutions/advisory/soundpaths/index.html. Calculations are based on experimental studies in the laboratories of the National Research Council. Technical details concerning the measurement protocol and discussion of the findings of the experimental studies are presented in a series of NRC reports:

9.1. 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),

9.2. 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 J.D. Quirt (2002),

9.3. 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),

9.4. RR-218 "Flanking Transmission in Multi-Family Dwellings Phase IV", T.R.T. Nightingale, J.D. Quirt, F. King and R.E. Halliwell, (2006),

10. Research Report RR-219 "Guide for Sound Insulation in Wood Frame Construction", J.D. Quirt, T.R.T. Nightingale, and F. King, NRC Canada, Ottawa. (2006). See also NRC Construction Technology Update 66 "Airborne Sound Insulation in Multi-Family Buildings", J.D. Quirt and T.R.T. Nightingale (2008)

11. The databases of flanking transmission data used in this Guide and in *soundPATHS* will be consolidated in a series of NRC publications presenting data from recent studies in collaboration with industry partners, which will be updated as new data become available:

11.1. RR-333 Apparent Sound Insulation in Concrete Buildings (2017)

11.2. RR-334 Apparent Sound Insulation in Concrete Block Buildings (2015)

11.3. RR-335 Apparent Sound Insulation in Cross-Laminated Timber Buildings (2017)

11.4. RR-336 Apparent Sound Insulation in Wood-Framed Buildings (2017)

11.5. RR-337 Apparent Sound Insulation in Cold-Formed Steel-Framed Buildings (2017)

<u>Other Technical References</u>

12. L. Cremer and M. Heckl, "Structure-borne sound", edited by E.E. Ungar, Springer-Verlag, New York (original edition 1973, 2nd edition 1996).

13. 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).

14. R.J.M. Craik, "Sound transmission through buildings: Using statistical energy analysis", Gower Publishing (1996).

15. 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).

16. 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)

Endnotes

1 For the concrete block walls in these examples, the value of 238 kg/m^2 is the measured mass per unit area for the tested wall specimen including mortar. Normal weight concrete block masonry units conform to CSA A165.1 and have a concrete mass density of not less than 2000 kg/m^3. 190 mm hollow block units are not less than 53% solid, and 140 mm hollow block units are not less than 73% solid, each giving a minimum wall mass per area over 200 kg/m^2. Additional information on material properties and sound transmission for other concrete block wall assemblies are given in NRC Research Report RR-334.

2 Precast concrete wall and floor panels are structural panels formed from normal weight concrete aggregate. The walls are typically formed as solid panels and the floors as hollowcore planks. The hollowcore floors considered in the worked examples in this Guide, as shown in Figure 7.1, were 203 mm thick with a mass per area of 344 kg/m^2 including grout. The hollowcore floors used in junction mock-up tests to confirm the validity of the vibration reduction index values from Annex E of ISO 15712-1 were 203 mm thick with a mass per area of 323 kg/m^2 without grout. This means that the methods described in Chapter 2 of this Guide are appropriate for hollowcore floors with a mass per area down to at least 323 kg/m^2 without grout.

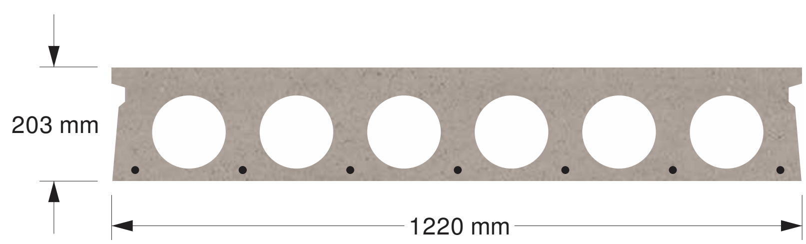

Figure 7.1: Profile of hollowcore precast concrete floor panels. Approximate dimensions in cross-section 203 mm x 1220 mm (not to scale).

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 of concrete, concrete block or CLT. Note that overfilling the cavity could diminish the benefit.

4 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 panels are installed with framing, fasteners, and fastener spacing conforming to installation details required by CSA A82.31-M or ASTM C754. Sound transmission results should only be used where the actual construction details correspond to the details of the test specimens on which ratings are based. “Fire-rated gypsum board” is typically heavier than non-fire-rated

gypsum board, which gives improved resistance to sound transmission through the assembly. The term "fire-rated" is used in this Guide to denote gypsum board 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.

5 Non-loadbearing steel studs 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 their description as cold-formed steel framing. The studs are formed from sheet steel with a "C-shaped" cross-section profile in accordance with AISI S201, and are joined top and bottom by a rectangular U-shaped runner. "Non-loadbearing steel studs" are formed from sheet steel with a maximum thickness of 0.46 mm (25 gauge). Their profile permits some flexing of the faces to which gypsum board is attached, which limits vibration transmission between the gypsum board layers comprising the two faces of a wall assembly. Appropriate fastening details are specified in Section 9.29 of the National Building Code of Canada or in CSA A82.31-M or ASTM C754.

6 Cross-Laminated Timber (CLT) assemblies are structural panels fabricated by bonding wood elements together in layers with alternating perpendicular orientation of the timber elements. The CLT panels evaluated in this study had adhesive bonding between the faces of timber elements in adjacent layers, but no adhesive bonding the adjacent timber elements within a given layer. There were noticeable gaps between the timber elements comprising each layer of the CLT assembly. These CLT panels could be called "Face-laminated CLT Panels" but are simply referred to as CLT panels in the body of this Guide. For the 3-ply panels considered in this Guide, each layer or ply has a thickness of 26 mm and is comprised of parallel wood boards whose cross section is 26 x 89 mm. For the 5-ply and 7-ply panels, the ply thickness increases from 26 mm to 35 mm. The physical properties of the tested bare laminated panels are:

- 3-ply panels: 78 mm thick, 42.4 kg/m^2
- 5-ply panels: 175mm thick, 91.4 kg/m^2
- 7-ply panels: 245 mm thick, 130 kg/m^2

7 Resilient metal channels are formed from sheet steel with maximum thickness 0.46 mm (25 gauge), with profile essentially as shown in Figure 7.2, with slits or holes in the single “leg” between the faces fastened to the framing and to the gypsum board. Installation must conform to ASTM C754.

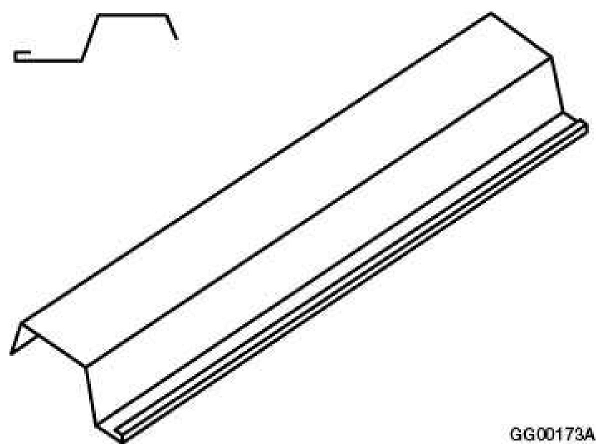

Figure 7.2: Drawing to illustrate typical profile of resilient metal channel; approximate dimensions in cross-section 13 mm x 60 mm (not precisely to scale).

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

8 Loadbearing 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.