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Guide to Calculating Airborne Sound Transmission in Buildings

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Second Edition
April 2016

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Changes in the Second Edition

This Second Edition supersedes the first version that was published in October 2013. Errors and omissions have been rectified, input sound transmission data have been updated, and the calculation examples have been modified slightly to make the effect of rounding more consistent.

Changes in the new version of this Guide include:

- ***Updated data:***
  - New laboratory data for concrete block walls, linings on concrete block walls, and cast-in-place concrete floors in Chapters 2 and 5
  - Updated data for CLT assemblies and for linings on CLT assemblies in Chapter 3
  - Updated data for wood-framed and steel-framed assemblies in Chapter 5
- ***Improved examples:***
  - Consistent rounding of input data in all examples
  - New equations to explain calculation details, especially for the simplified calculations in Section 2.4 and Section 5.3
  - Explicit correction to include the effect of airborne leakage through the separating assembly and other flanking paths
  - Expanded explanations in the simplified examples in Section 2.4 and Section 5.3 to show the numeric details at each step
- ***Changes to the technical content:***
  - New appendix to explain the calculation of ΔSTC
  - Minor revisions in Chapter 1 to explain corrections for leakage and other airborne flanking paths in the examples

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 7.2 of this Guide for access details).

Although it is not repeated at every step of this Guide, it should be understood that some variation is to be expected in practice due to changing specific design details, or construction deficiencies, or substitution of "generic equivalents", or simply rebuilding the same construction. Hence, judicious design to meet a specific target should allow a margin of a few decibels.

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.

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Steering Committee Member	**Representing**
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Paul Hargest, Gary Sturgeon	Canadian Concrete Masonry Producers Association
Steve Fox, John Rice	Canadian Sheet Steel Building Institute
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Advisory Committee Member	**Representing**
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Dave Nicholson	Maxxon Corporation
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Contents

1. Sound Transmission via Many Paths

The simplest approach to sound transmission between adjacent rooms in buildings considers only the sound transmission through the separating wall or floor. This perspective has been entrenched in North American building codes, which for many decades have considered only the ratings for the separating assembly: Sound Transmission Class (STC) or Field Sound Transmission Class (FSTC) for airborne sources and Impact Insulation Class (IIC) or Field Impact Insulation Class (FIIC) 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 ascribed to errors in either 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. In reality, the technical issue is more complex, as illustrated in Figure 1.2.

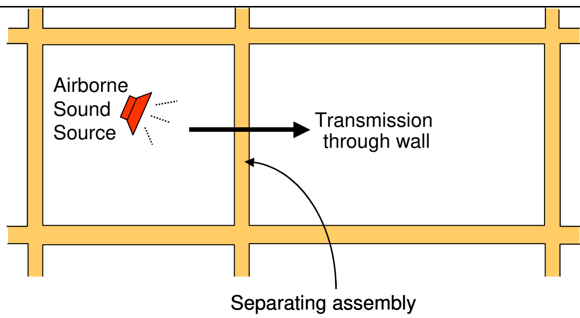


Figure 1.1: The drawings in Figure 1.1 and 1.2 show a cross-section through a building with two adjacent rooms. Part of the sound from an airborne source in one unit (represented by red loudspeaker in the drawings, which could include anything from a home theatre to people talking loudly) is transmitted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

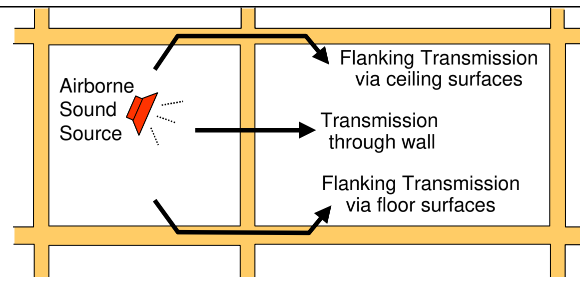


Figure 1.2: In reality, there are many paths for sound transmission between adjacent rooms, including both direct transmission through the separating assembly and indirect structure-borne paths, a few of which are indicated here. (See Section 1.4 for more detail.) The structure-borne paths usually significantly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

There is direct transmission of sound through the separating assembly. But that is only part of the story. 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, where part is radiated as sound. This is called flanking 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 and any leaks, plus sound due to structure-borne flanking transmission involving all the other elements coupled to the separating assembly.

Of course, this has long been recognized in principle (and the fundamental science was largely explained decades ago, by Cremer et al [12]). 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. There are other variants using different normalization or weighting schemes that have arguable advantages, but this Guide uses ASTC as the basic measure of sound insulation for airborne sound.

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

In 2005, ISO published a calculation method, ISO 15712-1, “Building acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 1: Airborne sound insulation between rooms”. This is one part of a series of standards: Part 2 deals with “impact sound insulation between rooms”, Part 3 deals with “airborne sound insulation against outdoor sound”, and Part 4 deals with “transmission of indoor sound to the outside”. ISO 15712-1 was prepared by the European Commission for Normalization (Committee CEN/TC 126) as EN 12354-1:2000; it was subsequently adopted as an ISO standard without modification by Technical Committee ISO/TC 43/2. It is often referred to by its original designation “EN 12354-1”.

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 low-rise and mid-rise 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 to support transition of construction industry practice to using 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 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 cast-in-place 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 by working groups of ISO TC43/2 to deal with measuring flanking transmission for various combinations of construction types and junctions. Because the current (2005) edition of ISO 15712-1 replicates a European standard developed before 2000, it does not reference more recent standards such as the ISO 10848 series, or the ISO 10140 series that have replaced the ISO 140 series referenced in ISO 15712-1.

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 ***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:

- cast-in-place 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

When dealing with the prediction of sound transmission between adjoining spaces in a building, the predicted attenuation for the various paths depends not just on the constructions involved, but also on the size and shape of each of these room surfaces, and on the sound absorption in the receiving room. Arguably, the ability to adjust the calculation to fit the dimensions in a specific building or to normalize to different receiving room conditions enables a skilled designer to obtain more accurate predictions.

However, for purposes of this 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 and using a consistent rating (ASTC) to describe overall system performance. There are many pairs of examples in the following sections where such comparisons are instructive. This is particularly useful where only one part of the construction is changed from one example to another, since the construction change can be unequivocally related to the change in predicted ASTC.

Hence a Standard Scenario has been used for all the examples, with:

- 2 adjacent rooms, either side-by-side or one-above-the-other;
- Rooms that 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.

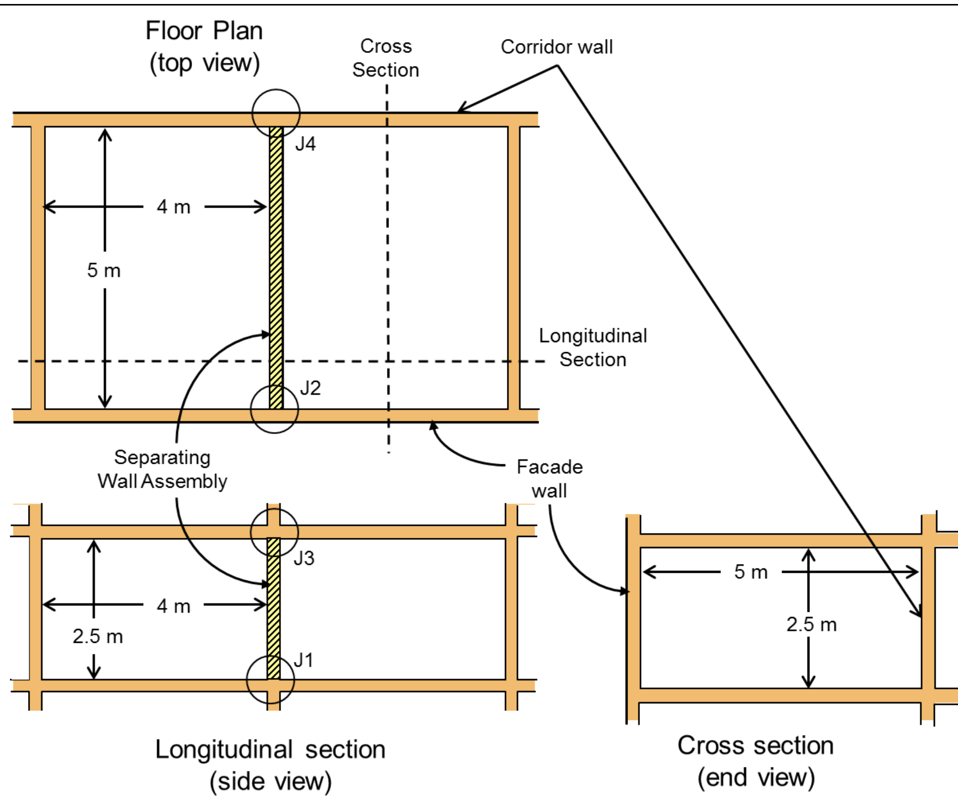
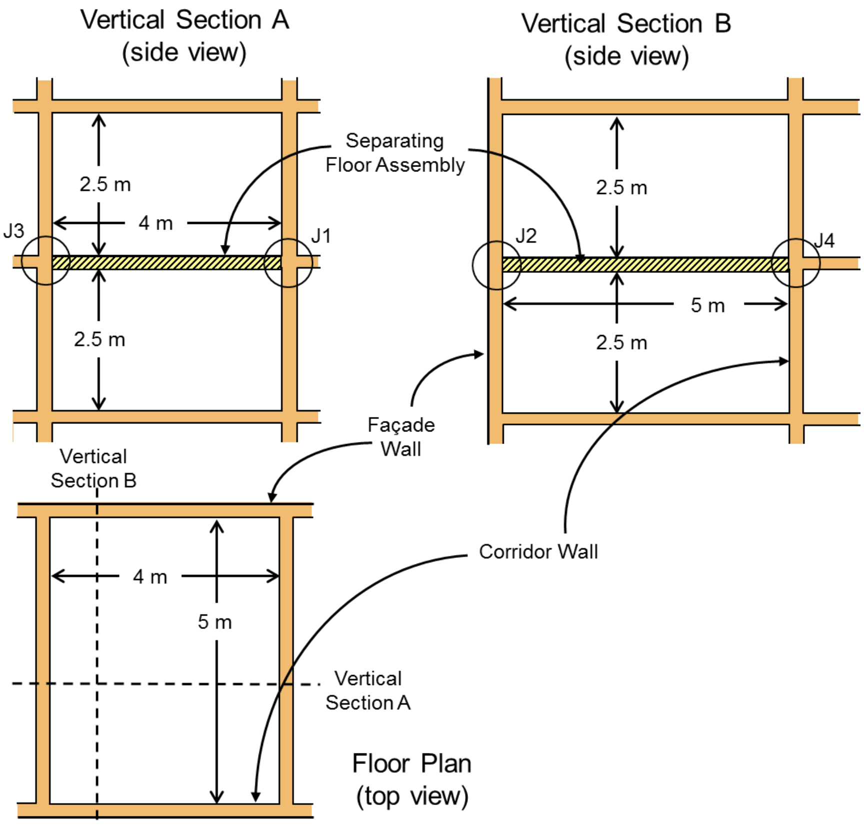


Figure 1.4:
Standard Scenario for "vertical room pair" case where one of the pair of rooms is above the other, with the floor/ceiling assembly between the two rooms.



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

- 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.
- 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.

In a building, cases with cross-junctions at separating walls on either side and at the corridor side seem quite common, and deviations from this Standard Scenario, such as pairs where one is an end unit, should tend to give slightly higher ASTC results.

1.3. Applying the Concepts of ISO Standards in an ASTM Environment

Although the building acoustics standards developed by ASTM Committee E33 are very similar in concept to corresponding standards developed by ISO TC43/2, they do present numerous barriers to using a mix of standards from the two domains – both due to terminology differences and due to different technical requirements for some measurement procedures and ratings.

Even though ASTM standard E336 recognizes the contribution of flanking to apparent sound transmission, there is neither an ASTM standard for measuring the structure-borne flanking transmission that often dominates sound transmission between rooms, nor an ASTM counterpart of ISO 15712-1 for predicting the combination of direct and flanking transmission. In the absence of suitable ASTM standards, this 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 combines identifying where data from ASTM laboratory tests can reasonably be used in place of their ISO counterparts, and presenting the results using ASTM terminology (or new terminology for flanking transmission that is consistent with existing ASTM terms) to facilitate their use and understanding by a North American audience. Some obvious counterparts are indicated in Table 1.1, and a detailed lexicon is given in ISO 15712-1.

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

Table 1.1: Key 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, but in some cases they are very similar. The laboratory test procedures used to measure airborne sound transmission through wall or floor assemblies – ASTM E90 and its ISO counterparts (ISO 140-3 and ISO 10140-2) – are based on essentially the same procedure, with minor variants in facility requirements. Hence, the measured quantities "airborne sound transmission loss" from the ASTM E90 test and "sound reduction index" from the ISO standards are sufficiently similar so that data from ASTM E90 measurements can be used in place of data from ISO 140-3 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 values to predict the ASTC. But R_W and STC are not interchangeable, and neither are R'_W and ASTC because of systematic differences in the calculation procedures. The close parallel between "sound reduction index" and "sound transmission loss" also means that results from ISO 15712-1 calculation (normally expressed as R' values) can confidently be treated as calculated

Apparent Transmission Loss (ATL) values and then used in the procedure of ASTM E413 to calculate the ASTC rating which is the suggested 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 and ISO 10848 are presented in Table 1.2.

Other Terms used in this Guide	Description
Structural reverberation time	Structural reverberation time (T_S) is a measure indicating the rate of decay of structural vibration energy in an assembly and can apply either to a laboratory wall or floor specimen, or to a wall or floor assembly in-situ in a building.
Transmission loss in-situ	Transmission loss in-situ is the counterpart of sound reduction index in-situ (R_{situ}) described in ISO 15712 as "the sound reduction index of an element in the actual field situation". For the detailed calculation of ISO 15712, this depends on structural reverberation time of the element (wall or floor assembly) in the laboratory and in-situ.
Vibration reduction index	Vibration reduction index (K_{ij}) is described in ISO 15712 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". For practical application, a value of K_{ij} may be determined using equations in Annex E of ISO 15712-1 or the measurement procedures of ISO 10848.
Velocity level difference	Velocity level difference (VLD) is described in ISO 15712 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 K_{ij} to allow for edge loss conditions (identified through structural reverberation times) of the assemblies in-situ.
Flanking transmission loss	Flanking transmission loss (Flanking TL) is the counterpart of flanking sound reduction index (R_{ij}) in ISO 15712. It is a measure of sound transmission via the flanking path from element i in the source room to element j in the receiving room, normalised like apparent sound transmission loss and ASTC, as described in Section 1.4 of this Guide.
Flanking STC	Flanking STC is the single number rating calculated following the STC calculation procedure of ASTM E413, using values of the flanking transmission loss as the input data.

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

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

1.4.Combining Sound Transmitted via Many Paths

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

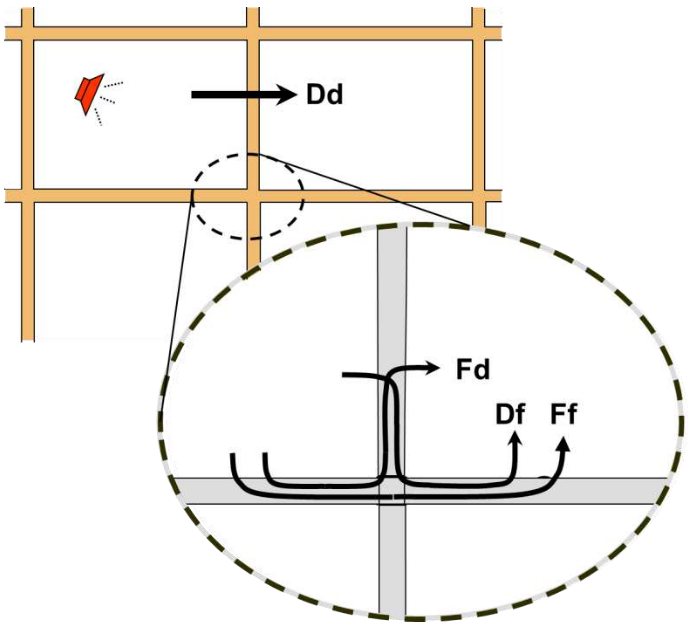


Figure 1.5: This figure shows the labelling convention for transmission paths used in ISO 15712-1. Consider transmission from a source room at the left to the receiving room beside it. Each transmission path involves one surface in the source room (denoted by a capital letter) and one in the receive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

Note that the letter "F" or "f" denotes **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, as detailed in the following Table 1.3.

Room Pair	Surfaces D and d	Flanking Surfaces F and f	Junction (Standard Scenario)
Horizontal	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 (see Fig. 1.3) T-junction Cross junction T-junction
Vertical	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 (see Fig. 1.4) T-junction Cross junction Cross junction

Table 1.3: Surfaces (D, d, F and f) for flanking paths at each junction, as applied in the examples using the Standard Scenario in this Guide.

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

ASTC is determined from the apparent sound transmission loss (ATL) for the set of frequency bands from 125 to 4000 Hz, following the procedure in ASTM E413. ATL is the logarithmic expression of total transmission factor (τ') as:

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

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

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

where the indices Ff, Fd, and Df refer to the three flanking paths at each edge of the separating assembly, as illustrated in Figure 1.5.

The transmission factors are defined as follows:

- τ' is the ratio of total sound power radiated into the receiving room relative to sound power incident on the separating element;
- τ_{Dd} is the ratio of sound power radiated by the separating element relative to sound power incident on the separating element;
- τ_{Df} is the ratio of 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 sound power incident on the separating element;
- τ_{Ff} is the ratio of 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 sound power incident on the separating element;
- τ_{Fd} is the ratio of 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 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 (TL for flanking path ij) $= -10 \log \tau_{ij}$ dB Eq. 1.3

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

Here the terms "direct transmission loss" and "flanking transmission loss" have been defined to provide consistency with ASTM terminology, but match the function of the direct and flanking sound reduction index, as defined in ISO 15712-1, in keeping with the discussion of terms in Section 1.3. Each of these flanking transmission loss values for a specific path is normalized like the apparent sound transmission loss, and can be considered as the ATL that would be observed if only this single path were contributing to the sound transmitted into the receiving room.

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 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 ($\mathrm{TL}_{Ff,}$ 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:

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

Eq. 1.4 is universally valid for all building systems, and the remaining challenge is to find the right expressions to calculate the path transmission for the chosen building system and situation.

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

- cast-in-place 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.

Where Normalised Flanking Level Difference ($D_{n,f}$) values measured according to ISO 10848 are to be converted into Flanking Transmission Loss for these calculations, they must be re-normalized to reflect room dimension differences between the test situation and the prediction scenario (indicated in Eq.1.5 by the subscript "situ"). This also applies to laboratory results re-normalized as Flanking TL in-situ. The expressions to use in the calculation are:

$$\text{Flanking}\, TL_{situ} = \mathrm{D}_{n,f}(\text{lab}) + 10\log(S_{situ}/10) + 10\log(l_{lab}/l_{situ}) \text{ in dB} \quad \text{Eq. 1.5a}$$

$$\text{Flanking}\, TL_{situ} = \text{Flanking}\, TL_{lab} + 10\log(S_{situ}/S_{lab}) + 10\log(l_{lab}/l_{situ}) \text{ in dB} \quad \text{Eq. 1.5b}$$

Here S_{situ} is area (in m^2) of the separating assembly and l_{situ} is 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 expressions in Eq. 1.5 apply for lightweight framed assemblies, as discussed in Chapter 4, and are also used in some cases in Chapter 5.

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, and simplifications were made in the presentation to meet the specific needs of that application, where sound insulation is addressed only in the context of multi-unit residential buildings.

- Transmission around or through the separating assembly due to leaks at its perimeter, or leakage through a porous construction (as in some examples in Section 3) is not explicitly addressed in the equations above in Section 1.4.
- Indirect airborne transmission (for example airborne flanking via an unblocked attic or crawl space or ventilation systems opening into both spaces) are not explicitly addressed in the equations above in Section 1.4.
- Normalization of direct and flanking transmission to the case where receiving room absorption is numerically equal to the area of the separating assembly (i.e. using apparent sound transmission loss and ASTC as the measure of system performance) requires suitable corrections in the calculations of ISO 15712-1, or values of flanking transmission loss measured according to ISO 10848, so that the set of transmission factors or path transmission loss values can be properly combined or compared. These are addressed by Equations 1.5.

For adjacent occupancies in a multi-family residential building, the first two issues should usually be dealt with by normal good practice for fire and sound control between adjoining dwellings. These are examples of airborne flanking which can be included as a correction to transmission through the separating assembly. Some examples in this Guide include corrections to incorporate such effects into the transmission via the Direct Path.

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 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.

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 loss between adjacent rooms includes the combination of direct airborne transmission through the separating assembly and structure-borne flanking 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 process 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 both direct transmission through each floor or wall assembly, and the strength of structure-borne transmission via the flanking surfaces.

For 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 transmission loss in-situ 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.

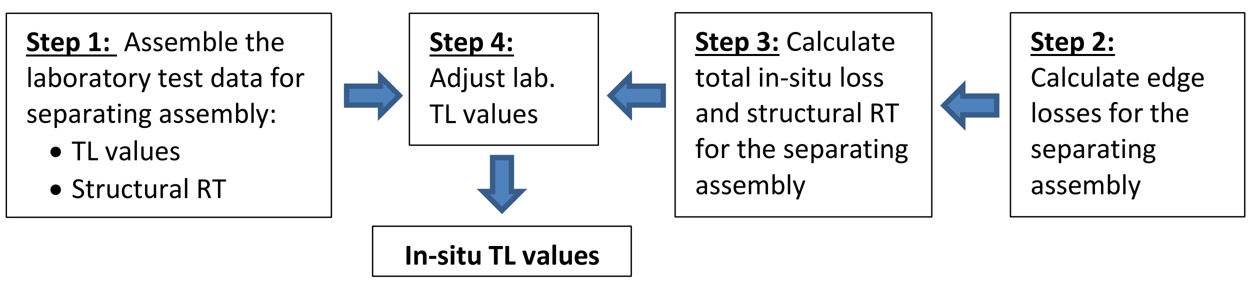


Figure 2.1: Steps to calculate in-situ TL for the separating assembly (more details below).

Step 1: Assemble required laboratory test data for constructions:

- Laboratory sound transmission loss (TL) values according to ASTM E90 for the structural floor or wall assembly of bare concrete or masonry without added linings (see Section 2.3.).
- Measured structural reverberation time (T_S) if available. ISO standards require measurement according to ISO 10848-1. Alternatively, a conservative estimate of 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 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 junction geometry and on the ratio of mass/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 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.

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.

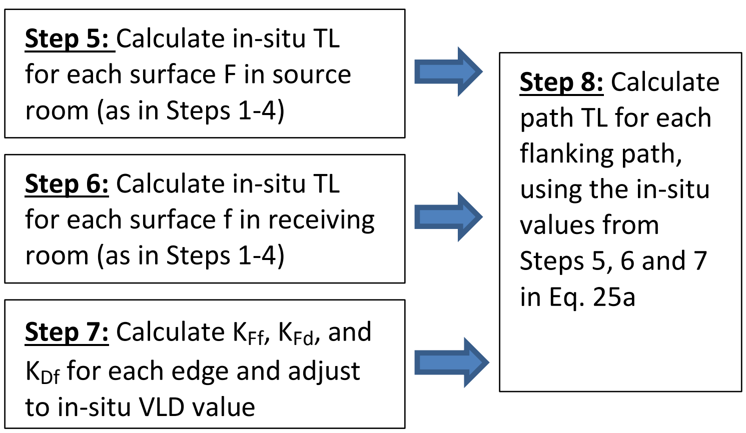


Figure 2.2: Steps to calculate flanking transmission loss for each flanking path (as detailed below).

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.

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 required calculations for only two room surfaces: one floor/ceiling assembly and one flanking sidewall. The standard is more general.)

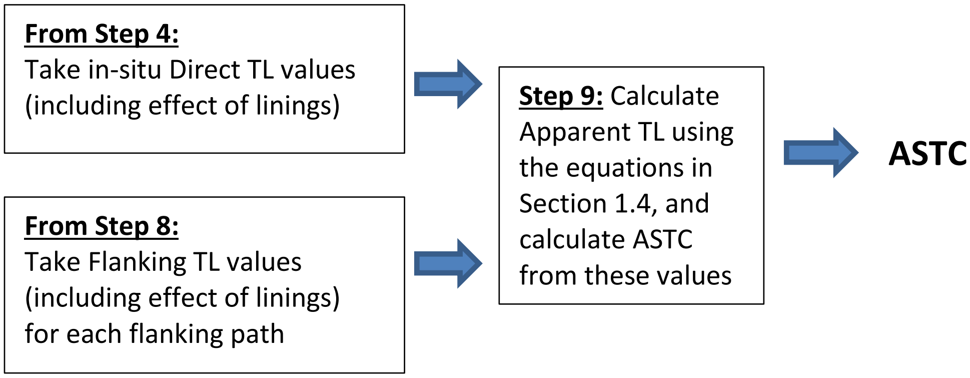
Step 7: Calculate in-situ velocity level difference (VLD) values for the junction attenuation:

- 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.

<u>Final Step: combine the sound power transmitted via the direct and flanking paths</u>:



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 Apparent TL.
- Use resulting values of Apparent TL in procedure of ASTM E413 to calculate ASTC.

NOTE 1: When the calculated Flanking TL value for a given path exceeds 90, the value in the examples is limited to 90 to allow for the inevitable effect of higher order flanking paths which cause the higher calculated value to be unrepresentative of the true situation. These noticeable limits indicate that further enhancements to elements in these paths will give negligible benefit to the ASTC value. The consequence of this limit is that the combined 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.

NOTE 2: This calculation procedure assumes that the floor and wall assemblies can be treated as homogeneous, and that an average value of K_{ij} suitable for a rigid junction of homogeneous assemblies is appropriate. This has been demonstrated to be reasonable in extensive testing for floors of cast-in-place concrete and for masonry walls of several types. It may not be true for floors of precast concrete panels, and is clearly not true for lightweight framed assemblies. These issues are addressed in the examples in the following sections of this Guide.

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 cast-in-place 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 cast-in-place concrete slab. For cast-in-place concrete or normal weight block assembly, the "bare" surface could be painted or sealed, or have a thin coat of plaster without appreciably changing the sound transmission. The effect of adding a lining is discussed in detail in Section 2.3. "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 ISO 15712-1 detailed calculation procedure, 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 100 Hz). Typical floor and wall assemblies of cast-in-place concrete and masonry match these expectations.

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 TL corrections have been set to zero.

The worked examples present all the pertinent physical characteristics of the assemblies and junctions, plus extracts from calculations performed with a more detailed spreadsheet that includes values for all the one-third-octave bands from 100 Hz to 5 kHz and has intermediate steps in some calculations. In order to condense the examples to 2-page format, the corresponding extracts present just the single number ratings (such as ASTC and Path STC) and a subset of the calculated values for the frequency bands. All examples conform to the Standard Scenario presented in Section 1.2 of this Guide.

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, ASTC, etc." the examples present single number ratings (each calculated from a set of 1/3-octave data according to the rules for STC ratings defined in ASTM E413) to provide a consistent set of summary single number measures at each stage of the calculation. These include:

- 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 the effect of linings,
- Flanking STC values calculated for each flanking transmission path at each junction including the effect of linings,
- Apparent STC (ASTC) for the combination of direct and flanking transmission via all paths.

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 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 by ± 1.

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

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 concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1]) with no lining.

Junction 1: Bottom Junction (separating wall / floor) with:
- cast-in-place concrete floor with mass 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.

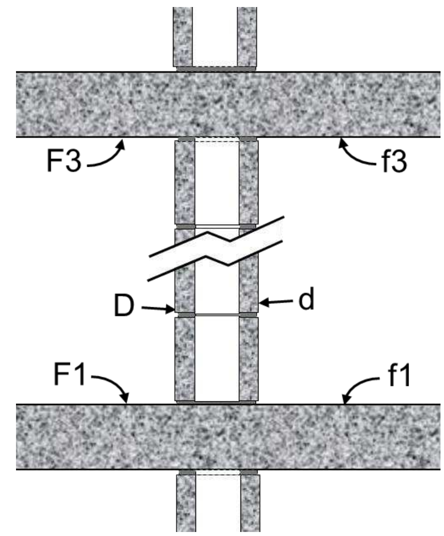
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- abutting side wall and separating wall of concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1]), with no lining
- rigid mortared T-junctions

Junction 3: Top Junction (separating wall / ceiling) with:
- cast-in-place concrete ceiling with mass 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.

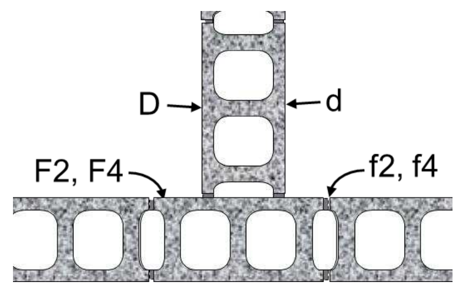
Acoustical Parameters:

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 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).

Separating Partition (190 mm concrete block)									
Input Data	**ISO Symbol**	**Reference**	**STC, ASTC,etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_D,lab	RR-334, NRC Mean BLK190(NW)	49	35	38	44	50	58	62
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency				1	1	1	1	1	1
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 Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.256	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		8.8	9.5	10.5	12.0	14.2	17.3
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	**49.0**	**36**	**39**	**44**	**50**	**58**	**62**

(See footnotes at end of document)

Junction 1 (Rigid Cross junction, 190 mm block separating wall / 150 mm concrete floor)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC,etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.439	0.369	0.250	0.205	0.146	0.077
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.347	0.238	0.159	0.104	0.066	0.041
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		10.4	10.7	11.3	12.3	13.6	15.6
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	55	41.0	43.9	52.0	60.9	69.4	77.8
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	55	41.0	43.9	52.0	60.9	69.4	77.8
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		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		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		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	**62**	**48**	**51**	**60**	**69**	**78**	**87**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**63**	**49**	**52**	**59**	**67**	**76**	**83**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**63**	**49**	**52**	**59**	**67**	**76**	**83**
Junction 2 (Rigid T-Junction, 190 mm block separating wall / 190 mm block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-334, NRC Mean BLK190(NW)	49	35	38	44	50	58	62
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.219	0.146	0.094	0.059	0.036	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.2	8.8	9.6	10.8	12.5	15.0
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.8	58.7	62.5
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.8	58.7	62.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		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		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		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	**62**	**48**	**51**	**58**	**64**	**72**	**77**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**62**	**48**	**51**	**57**	**63**	**72**	**77**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**62**	**48**	**51**	**57**	**63**	**72**	**77**
Junction 3 (Rigid Cross junction, 190 mm block separating wall / 150 mm concrete ceiling slab)									
All values the same as for Junction 1									
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									
Flanking Element F4 and f4: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.238	0.158	0.102	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.6	8.1	8.9	10.1	11.9	14.4
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		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		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		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	**62**	**47**	**51**	**57**	**63**	**72**	**77**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**61**	**47**	**51**	**56**	**63**	**72**	**76**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**61**	**47**	**51**	**56**	**63**	**72**	**76**
Total Flanking STC (combined transmission for all flanking paths)			51						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**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 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping / flooring on top, or ceiling lining below.

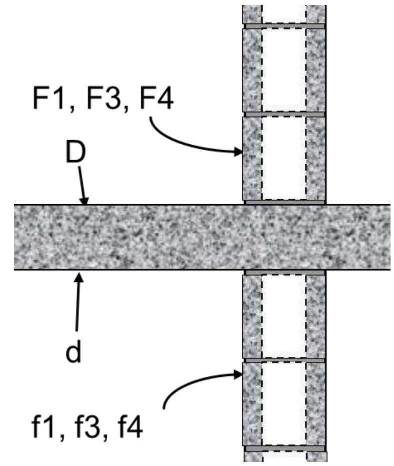
Junction 1, 3, 4: Cross Junction of separating floor / flanking wall with:
- rigid mortared cross junction with concrete block wall assemblies.
- wall above and below floor of one wythe of concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1]) with no lining of walls.

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 concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1]) with no lining of walls.

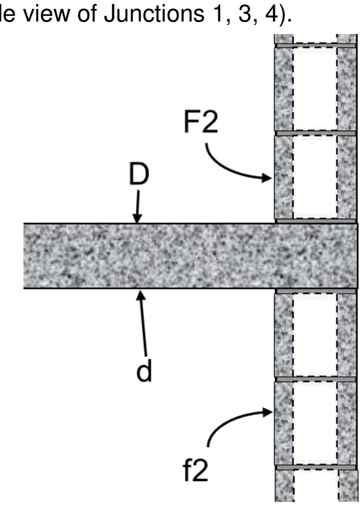
Acoustical Parameters:

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).

Separating Partition (150 mm concrete floor)

Input Data	ISO Symbol	Reference	STC, ASTC, etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_D,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.44	0.37	0.25	0.21	0.15	0.08
Radiation Efficiency				1	1	1	1	1	1
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 Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.346	0.237	0.159	0.104	0.066	0.041
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		10.4	10.8	11.4	12.3	13.7	15.7
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	**55**	**41**	**44**	**52**	**61**	**69**	**78**

(See footnotes at end of document)

Junction 1 (Rigid Cross junction, 150 mm concrete floor / 190 mm block flanking wall)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-334, NRC Mean BLK190(NW)	49	35.0	38.0	44.0	50.0	58.0	62.0
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.256	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.8	9.5	10.5	12.0	14.2	17.3
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	49	35.7	38.5	44.4	50.3	58.2	62.2
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	49	35.7	38.5	44.4	50.3	58.2	62.2
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		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		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		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	**66**	**52**	**55**	**61**	**68**	**76**	**81**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**65**	**51**	**54**	**61**	**69**	**78**	**85**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**65**	**51**	**54**	**61**	**69**	**78**	**85**
Junction 2 (Rigid T-Junction, 150 mm concrete floor / 190 mm block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-334, NRC Mean BLK190(NW)	49	35.0	38.0	44.0	50.0	58.0	62.0
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.218	0.145	0.094	0.059	0.036	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.3	8.8	9.6	10.8	12.6	15.1
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.9	58.7	62.5
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.9	58.7	62.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		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		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		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	**65**	**51**	**54**	**60**	**66**	**75**	**79**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**64**	**50**	**53**	**60**	**68**	**76**	**83**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**64**	**50**	**53**	**60**	**68**	**76**	**83**
Junction 3 (Rigid Cross junction, 150 mm concrete ceiling / 190 mm block flanking wall)									
All values the same as for Junction 1									
Junction 4 (Rigid Cross-Junction, 150 mm concrete floor / 190 mm block flanking 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									
Flanking Element F4 and f4: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.237	0.157	0.101	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.6	8.1	8.9	10.1	11.9	14.4
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		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		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		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	**68**	**53**	**57**	**63**	**69**	**78**	**83**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**67**	**52**	**55**	**63**	**71**	**79**	**86**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**67**	**52**	**55**	**63**	**71**	**79**	**86**
Total Flanking STC (combined transmission for all flanking paths)			55						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**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 with mass 345 kg/m^2 (e.g. normal weight concrete with thickness of 150 mm) with no lining on either side.

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

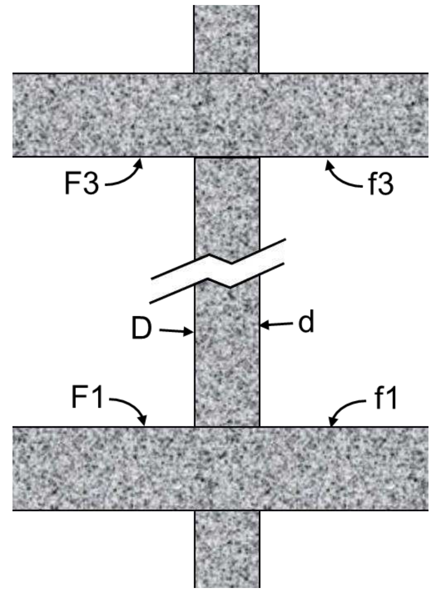
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- abutting side wall and separating wall of cast-in-place concrete with mass 345 kg/m^2 (e.g. normal weight concrete 150 mm thick), with no lining
- rigid T-junctions

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

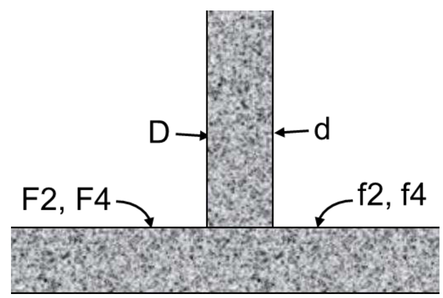
Acoustical Parameters:

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)

Separating Partition (150 mm concrete)									
Input Data	**ISO Symbol**	**Reference**	**STC, ASTC,etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_D,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.439	0.369	0.250	0.205	0.146	0.077
Radiation Efficiency				1	1	1	1	1	1
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 Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.325	0.223	0.150	0.099	0.063	0.039
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		6.9	7.1	7.5	8.1	9.0	10.2
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	**55**	**41**	**44**	**52**	**61**	**70**	**78**

(See footnotes at end of document)

Junction 1 (Rigid Cross junction, 150 mm concrete separating wall / 200 mm concrete floor)

Flanking Element F1 and f1: Input	ISO Symbol	Reference	STC, ASTC,etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_F1,lab	RR-333, CON200, TLF-12-011	59	41.0	49.0	55.0	62.0	69.0	75.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.324	0.250	0.240	0.170	0.093	0.060
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.317	0.217	0.146	0.096	0.061	0.038
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		11.4	11.8	12.4	13.3	14.7	16.7
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	60	41.1	49.6	57.2	64.5	70.8	77.0
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	60	41.1	49.6	57.2	64.5	70.8	77.0
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		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		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		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	**68**	**49**	**58**	**66**	**73**	**80**	**87**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**68**	**51**	**57**	**65**	**74**	**82**	**89**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**68**	**51**	**57**	**65**	**74**	**82**	**89**
Junction 2 (Rigid T-Junction, 150 mm concrete separating wall / 150 mm concrete flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-333, CON150, TLF-15-045	53	40.0	42.0	50.0	58.0	66.0	75.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.439	0.369	0.250	0.205	0.146	0.077
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.264	0.182	0.124	0.082	0.053	0.034
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		6.8	7.0	7.3	7.8	8.5	9.5
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	56	42.2	45.1	53.1	62.0	70.4	78.6
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	56	42.2	45.1	53.1	62.0	70.4	78.6
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		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		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		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	**67**	**53**	**56**	**64**	**74**	**82**	**90**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**66**	**52**	**55**	**63**	**73**	**82**	**90**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**66**	**52**	**55**	**63**	**73**	**82**	**90**
Junction 3 (Rigid Cross junction, 150 mm concrete separating wall / 200 mm concrete ceiling slab)									
All values the same as for Junction 1									
Junction 4 (Rigid T-junction, 150 mm concrete separating wall / 150 mm concrete flanking wall)									
All input data the same as for Junction 2, but different junctions at ceiling and floor change loss factors from Junction 2									
Flanking Element F4 and f4: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.296	0.204	0.138	0.091	0.059	0.034
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		6.1	6.3	6.6	7.0	7.7	8.7
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	56	41.7	44.6	52.6	61.5	70.0	78.2
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	56	41.7	44.6	52.6	61.5	70.0	78.2
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		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		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		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	**66**	**52**	**55**	**63**	**73**	**82**	**90**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**66**	**52**	**55**	**63**	**72**	**81**	**90**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**66**	**52**	**55**	**63**	**72**	**81**	**90**
Total Flanking STC (combined transmission for all flanking paths)			56						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**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 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 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no lining of walls.

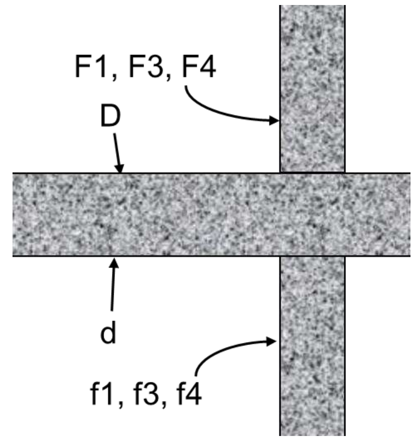
Junction 2: T-Junction of separating floor / flanking wall with:

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

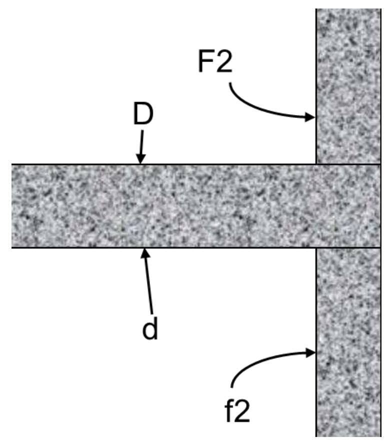
Acoustical Parameters:

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	Σ l_k . α_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, η_tot,2	ISO 15712-1, Eq. C.1			0.0355	(at 500 Hz)	
Total loss, η_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)

Separating Partition (200 mm concrete floor)									
Input Data	ISO Symbol	Reference	STC, ASTC, etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_D,lab	RR-333, CON200, TLF-12-011	59	41	49	55	62	69	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.32	0.25	0.24	0.17	0.09	0.06
Radiation Efficiency				1	1	1	1	1	1
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 Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.317	0.217	0.146	0.096	0.061	0.038
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		11.4	11.8	12.4	13.3	14.7	16.7
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	**60**	**41**	**50**	**57**	**64**	**71**	**77**

(See footnotes at end of document)

Junction 1 (Rigid Cross junction, 200 mm concrete floor /150 mm concrete flanking wall)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-333, CON150, TLF-15-045	53	40.0	42.0	50.0	58.0	66.0	75.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.439	0.369	0.250	0.205	0.146	0.077
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.325	0.223	0.150	0.099	0.063	0.039
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		6.944	7.149	7.520	8.101	8.963	10.210
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	55	41.3	44.2	52.2	61.2	69.7	77.9
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	55	41.3	44.2	52.2	61.2	69.7	77.9
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		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		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		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	**70**	**56**	**59**	**67**	**76**	**85**	**90**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**70**	**53**	**60**	**67**	**76**	**84**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**70**	**53**	**60**	**67**	**76**	**84**	**90**
Junction 2 (Rigid T-Junction, 200 mm concrete floor / 150 mm concrete flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-333, CON150, TLF-15-045	53	40.0	42.0	50.0	58.0	66.0	75.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.439	0.369	0.250	0.205	0.146	0.077
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.265	0.183	0.124	0.082	0.053	0.034
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		6.829	6.993	7.290	7.755	8.444	9.442
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	56	42.2	45.1	53.0	62.0	70.4	78.6
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	56	42.2	45.1	53.0	62.0	70.4	78.6
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		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		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		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	**69**	**55**	**58**	**66**	**75**	**84**	**90**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**69**	**52**	**58**	**66**	**74**	**82**	**90**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**69**	**52**	**58**	**66**	**74**	**82**	**90**
Junction 3 (Rigid Cross junction, 200 mm concrete ceiling / 150 mm concrete flanking wall)									
All values the same as for Junction 1									
Junction 4 (Rigid Cross-Junction, 200 mm concrete floor / 150 mm concrete flanking 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									
Flanking Element F4 and f4: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.296	0.204	0.138	0.091	0.059	0.034
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		6.093	6.258	6.555	7.019	7.709	8.706
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	56	41.7	44.6	52.6	61.5	70.0	78.2
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	56	41.7	44.6	52.6	61.5	70.0	78.2
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		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		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		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	**71**	**57**	**60**	**69**	**78**	**87**	**90**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**72**	**55**	**61**	**69**	**77**	**85**	**90**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**72**	**55**	**61**	**69**	**77**	**85**	**90**
Total Flanking STC (combined transmission for all flanking paths)			59						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**56**						

Summary for Section 2.1: Constructions of Cast-in-place Concrete and Concrete Masonry with Rigid Junctions

The worked examples 2.1.1 to 2.1.4 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.

For both the side-by-side room pair (Examples 2.1.1 and 2.1.3) and the rooms one-above-the-other (Example 2.1.2 and 2.1.4) the ASTC tends to be slightly lower than the STC of 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 points and 0 points, and 1 point and 3 points for the vertical room pairs. Different mass ratios of the building elements and different laboratory structural decay times could alter the specific differences.

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.

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.

<u>The worked examples</u> present the pertinent physical characteristics of the assemblies and junctions, plus extracts from calculations performed with a more detailed spreadsheet that includes values for all the one-third-octave bands from 100 Hz to 5 kHz and has intermediate steps in some calculations. In order 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 the frequency bands. All examples conform to the Standard Scenario presented in Section 1.2 of this Guide Precision and rounding of values in the worked examples are the same as outlined in Section 2.1.

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, ASTC, etc.", the examples present single number ratings (each calculated from a set of 1/3-octave 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.

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 concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1]) with no lining.

Junction 1: Bottom Junction (separating wall / floor) with:
- cast-in-place concrete floor with mass 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

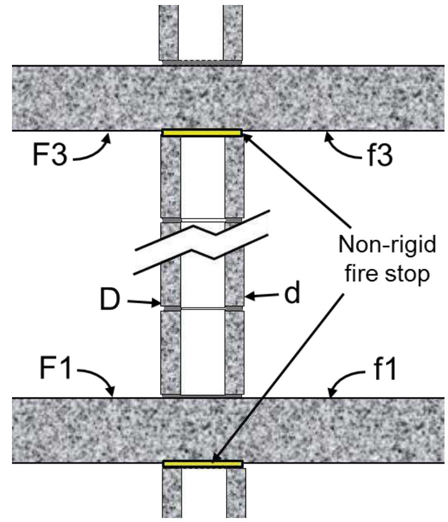
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- abutting side wall and separating wall of concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1]), with no lining of walls
- rigid mortared T-junctions

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 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).

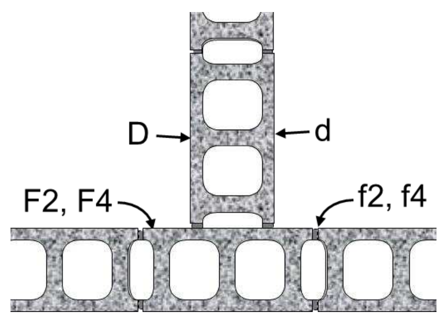
Acoustical Parameters:

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).

Separating Partition (190 mm concrete block)									
Input Data	ISO Symbol	Reference	STC, ASTC,etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_D,lab	RR-334, NRC Mean BLK190(NW)	49	35	38	44	50	58	62
Structural Reverberation Time	T_s,lab	Estimate, Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency				1	1	1	1	1	1
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 Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.278	0.182	0.115	0.071	0.042	0.024
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		8.1	8.8	9.8	11.3	13.5	16.6
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	**49**	**35**	**38**	**44**	**50**	**58**	**62**

(See footnotes at end of document)

Junction 1 (NON-Rigid Cross-junction, 190 mm block separating wall / 150 mm concrete floor, no connection to wall below)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC,etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-333, CON150, TLF-15-045	53	40.0	42.0	50.0	58.0	66.0	75.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.439	0.369	0.250	0.205	0.146	0.077
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.293	0.202	0.136	0.090	0.058	0.036
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		12.3	12.6	13.2	14.2	15.5	17.5
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	56	41.8	44.6	52.6	61.6	70.0	78.3
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	56	41.8	44.6	52.6	61.6	70.0	78.3
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		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		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		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	**61**	**47**	**50**	**58**	**68**	**76**	**85**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**61**	**46**	**49**	**57**	**65**	**73**	**80**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**61**	**46**	**49**	**57**	**65**	**73**	**80**
Junction 2 (Rigid T-Junction, 190 mm block separating wall / 190 mm block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-334, NRC Mean BLK190(NW)	49	35.0	38.0	44.0	50.0	58.0	62.0
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
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.219	0.146	0.094	0.059	0.036	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.2	8.8	9.6	10.8	12.5	15.0
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.8	58.7	62.5
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.8	58.7	62.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		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		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		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	**62**	**48**	**51**	**58**	**64**	**72**	**77**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**61**	**47**	**50**	**57**	**63**	**72**	**76**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**61**	**47**	**50**	**57**	**63**	**72**	**76**
Junction 3 (NON-Rigid Cross-junction, 190 mm block wall above / 150 mm concrete ceiling, no connection to separating wall below)									
All values the same as for Junction 1, except negligible transmission for Fd and Df (through fire stop at top of wall)									
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25a	**64**	**50**	**53**	**61**	**71**	**79**	**88**
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 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									
Flanking Element F4 and f4: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.238	0.158	0.102	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.6	8.1	8.9	10.1	11.9	14.4
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		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		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		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	**62**	**47**	**51**	**57**	**63**	**72**	**77**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**61**	**47**	**50**	**56**	**63**	**71**	**76**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**61**	**47**	**50**	**56**	**63**	**71**	**76**
Total Flanking STC (combined transmission for all flanking paths)			51						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**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 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping / flooring on top surface, or ceiling lining below.

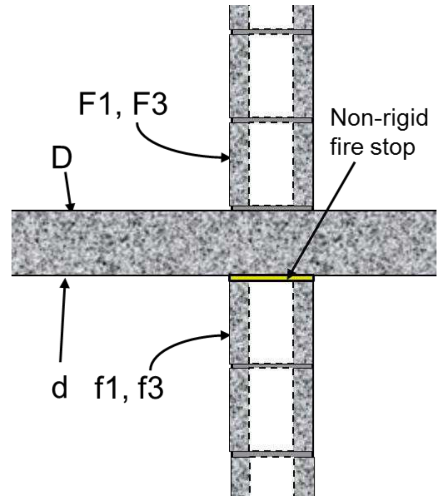
Junction 1 and 3: Separating floor with non-loadbearing flanking walls:
- rigid mortared cross junction to concrete floor slab at bottom of concrete block wall assemblies.
- Non-load-bearing junction (fire stop system of non-rigid materials that transmit negligible vibration) between top of wall and underside of concrete slab above.
- walls above and below floor of one wythe of concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1]) with no lining of walls.

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 concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1]) with no lining of walls.

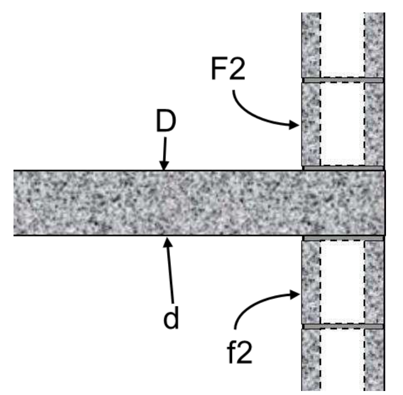
Acoustical Parameters:

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-load-bearing 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).

Separating Partition (150 mm concrete floor)									
Input Data	ISO Symbol	Reference	STC, ASTC, etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_D,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.44	0.37	0.25	0.21	0.15	0.08
Radiation Efficiency				1	1	1	1	1	1
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 Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.293	0.202	0.136	0.090	0.058	0.036
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		12.3	12.7	13.3	14.2	15.6	17.6
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	**56**	**42**	**45**	**53**	**62**	**70**	**78**

(See footnotes at end of document)

Junction 1 (NON-Rigid Cross-junction, 190 mm block separating wall above / 150 mm concrete floor, no connection to wall below)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-334, Mean TL-BLK190(NW)	49	35	38	44	50	58	62
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.278	0.182	0.115	0.071	0.042	0.024
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.1	8.8	9.8	11.3	13.5	16.6
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	49	35.3	38.2	44.1	50.1	58.0	62.0
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	49	35.3	38.2	44.1	50.1	58.0	62.0
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		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	**63**	**49**	**52**	**59**	**67**	**75**	**82**
Flanking TL for Path Df_1	R_Df	Negligible connection	**90**	**90**	**90**	**90**	**90**	**90**	**90**
Junction 2 (Rigid T-Junction, 150 mm concrete floor / 190 mm block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-334, Mean TL-BLK190(NW)	49	35	38	44	50	58	62
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.218	0.145	0.094	0.059	0.036	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.3	8.8	9.6	10.8	12.6	15.1
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.9	58.7	62.5
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.9	58.7	62.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		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		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		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	**65**	**51**	**54**	**60**	**66**	**75**	**79**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**65**	**51**	**54**	**61**	**69**	**77**	**84**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**65**	**51**	**54**	**61**	**69**	**77**	**84**
Junction 3 (NON-Rigid Cross-junction, 190 mm block separating wall / 150 mm concrete floor, no connection to wall below)									
All values the same as for Junction 1									
Junction 4 (Rigid Cross-Junction, 150 mm concrete floor / 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									
Flanking Element F4 and f4: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.237	0.157	0.101	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.6	8.1	8.9	10.1	11.9	14.4
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		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		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		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	**68**	**53**	**57**	**63**	**69**	**78**	**83**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**67**	**53**	**56**	**64**	**71**	**80**	**86**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**67**	**53**	**56**	**64**	**71**	**80**	**86**
Total Flanking STC (combined transmission for all flanking paths)			56						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**53**						

<u>Summary for Section 2.2: Cast-in-place Concrete and Concrete Masonry Constructions with Non-Rigid Junctions</u>

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, 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[2] in the cavities between the bare assembly and the gypsum board.

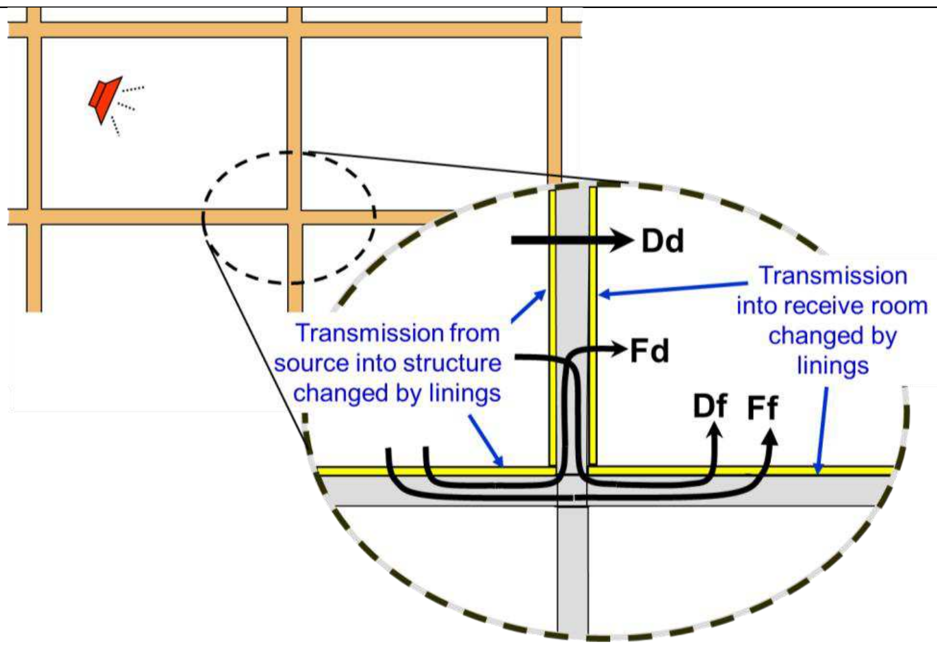


Figure 2.3: Transmission combines direct path through separating wall (Dd) and structure-borne flanking via paths Df, Fd, and Ff at each of the four edges of the separating assembly. Transmission via these paths is altered by addition of linings in the source room and/or receiving room.

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.

The worked examples present the pertinent physical characteristics of the assemblies and junctions, plus 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 and has intermediate steps in some calculations. In order 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 the frequency bands.

Under the single heading "STC, ASTC, etc." the examples present single number ratings (each calculated from a set of 1/3-octave 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 including the effect of added linings,
- Direct STC for in-situ transmission through the separating assembly including linings,
- Flanking STC values calculated for each flanking transmission path at each junction including the effect of added linings,
- 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 explicit references to applicable equations and sections of ISO 15712-1 at each stage of the calculation, plus symbols and subscripts corresponding to those used in the standard.

All examples in this Section conform to the Standard Scenario presented in Section 1.2 of this Guide.

Precision and rounding of values in the worked examples are the same as outlined in Section 2.1.

Validation studies in Europe for such 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.

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 concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1])
- separating wall lined on both sides with 13 mm gypsum board[3] supported on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c., with no absorptive material[2] filling stud cavities.

Junction 1: Bottom Junction (separating wall / floor) with:
- cast-in-place concrete floor with mass 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.

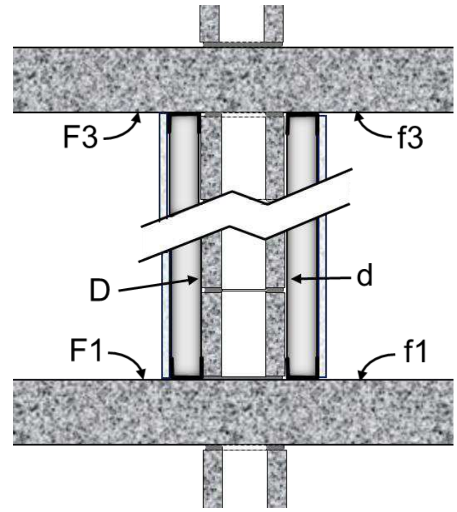
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- side wall and separating wall of concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1]) with rigid mortared T-junctions
- flanking walls lined with 13 mm gypsum board[3] supported on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c. with no absorptive material[2] filling stud cavities.

Junction 3: Top Junction (separating wall / ceiling) with:
- cast-in-place concrete ceiling with mass 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.

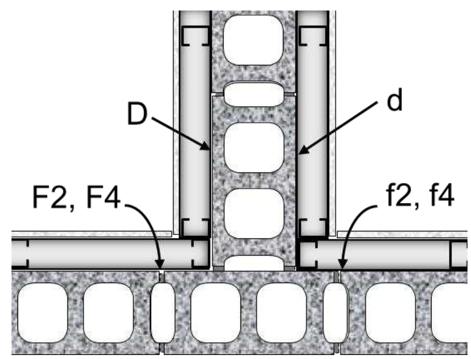
Acoustical Parameters:

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 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 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).

Separating Partition (190 mm concrete block)									
Input Data	**ISO Symbol**	**Reference**	**STC, ASTC,etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_D,lab	RR-334, NRC Mean BLK190(NW)	49	35	38	44	50	58	62
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency				1	1	1	1	1	1
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
Transferred Data In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.256	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		8.8	9.5	10.5	12.0	14.2	17.3
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	**52.0**	**28**	**55**	**72**	**80**	**84**	**90**

(See footnotes at end of document)

Junction 1 (Rigid Cross junction, 190 mm block separating wall / 150 mm concrete floor)

Flanking Element F1 and f1: Input	ISO Symbol	Reference	STC, ASTC,etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_F1,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.439	0.369	0.250	0.205	0.146	0.077
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.347	0.238	0.159	0.104	0.066	0.041
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		10.4	10.7	11.3	12.3	13.6	15.6
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	55	41.0	43.9	52.0	60.9	69.4	77.8
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	55	41.0	43.9	52.0	60.9	69.4	77.8
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		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		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		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	**62**	**48**	**51**	**60**	**69**	**78**	**87**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**69**	**45**	**60**	**73**	**82**	**89**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**69**	**45**	**60**	**73**	**82**	**89**	**90**
Junction 2 (Rigid T-Junction, 190 mm block separating wall / 190 mm block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-334, NRC Mean BLK190(NW)	49	35	38	44	50	58	62
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.219	0.146	0.094	0.059	0.036	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.2	8.8	9.6	10.8	12.5	15.0
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.8	58.7	62.5
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.8	58.7	62.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		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		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		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	**64**	**40**	**67**	**86**	**90**	**90**	**90**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**64**	**40**	**67**	**85**	**90**	**90**	**90**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**64**	**40**	**67**	**85**	**90**	**90**	**90**
Junction 3 (Rigid Cross junction, 190 mm block separating wall / 150 mm concrete ceiling slab)									
All values the same as for Junction 1									
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									
Flanking Element F4 and f4: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.238	0.158	0.102	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.6	8.1	8.9	10.1	11.9	14.4
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		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		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		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	**63**	**39**	**67**	**85**	**90**	**90**	**90**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**63**	**39**	**67**	**84**	**90**	**90**	**90**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**63**	**39**	**67**	**84**	**90**	**90**	**90**
Total Flanking STC (combined transmission for all flanking paths)			55						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**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 concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1])
- separating wall lined both sides with 13 mm gypsum board[3] on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c., with absorptive material[2] filling stud cavities.

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

- cast-in-place concrete floor with mass 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 concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1])
- flanking walls lined with 13 mm gypsum board[3] on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c., with absorptive material[2] filling stud cavities.

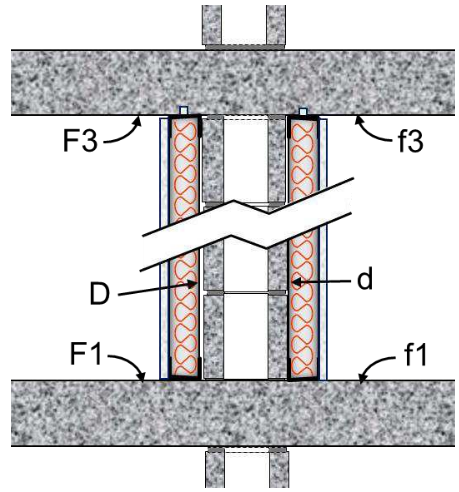
Junction 3: Top Junction (separating wall / ceiling) with:

- cast-in-place concrete ceiling with mass 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.

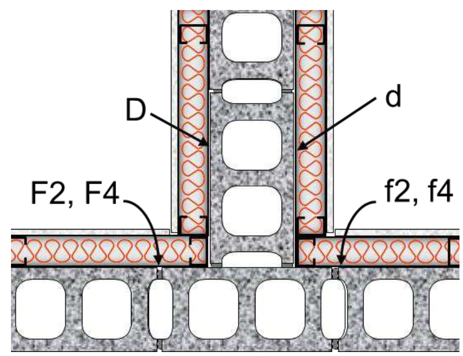
Acoustical Parameters:

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 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 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).

Separating Partition (190 mm concrete block)									
Input Data	ISO Symbol	Reference	STC, ASTC,etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_D,lab	RR-334, NRC Mean BLK190(NW)	49	35	38	44	50	58	62
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB65_G13		11	19	21	18	17	21
Change by Lining on receive side	ΔR_d	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB65_G13		11	19	21	18	17	21
Transferred Data In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.256	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		8.8	9.5	10.5	12.0	14.2	17.3
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	**82**	**58**	**77**	**86**	**86**	**90**	**90**

(See footnotes at end of document)

Junction 1 (Rigid Cross junction, 190 mm block separating wall / 150 mm concrete floor)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC,etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.439	0.369	0.250	0.205	0.146	0.077
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.347	0.238	0.159	0.104	0.066	0.041
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		10.4	10.7	11.3	12.3	13.6	15.6
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	55	41.0	43.9	52.0	60.9	69.4	77.8
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	55	41.0	43.9	52.0	60.9	69.4	77.8
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		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		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		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	**62**	**48**	**51**	**60**	**69**	**78**	**87**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**82**	**60**	**71**	**80**	**85**	**90**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**82**	**60**	**71**	**80**	**85**	**90**	**90**
Junction 2 (Rigid T-Junction, 190 mm block separating wall / 190 mm block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-334, NRC Mean BLK190(NW)	49	35	38	44	50	58	62
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
Change by Lining on source side	ΔR_F2	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB65_G13		11	19	21	18	17	21
Change by Lining on receive side	ΔR_f2	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB65_G13		11	19	21	18	17	21
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.219	0.146	0.094	0.059	0.036	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.2	8.8	9.6	10.8	12.5	15.0
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.8	58.7	62.5
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.8	58.7	62.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		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		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		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	**89**	**70**	**89**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**89**	**70**	**89**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**89**	**70**	**89**	**90**	**90**	**90**	**90**
Junction 3 (Rigid Cross junction, 190 mm block separating wall / 150 mm concrete ceiling slab)									
All values the same as for Junction 1									
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									
Flanking Element F4 and f4: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.238	0.158	0.102	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.6	8.1	8.9	10.1	11.9	14.4
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		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		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		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	**89**	**69**	**89**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**89**	**69**	**89**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**89**	**69**	**89**	**90**	**90**	**90**	**90**
Total Flanking STC (combined transmission for all flanking paths)			59						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**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 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 blocks with normal weight aggregate[1], with mass 238 kg/m^2.
- flanking walls lined with 13 mm gypsum board[3] on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c. with no absorptive material[2] filling stud cavities

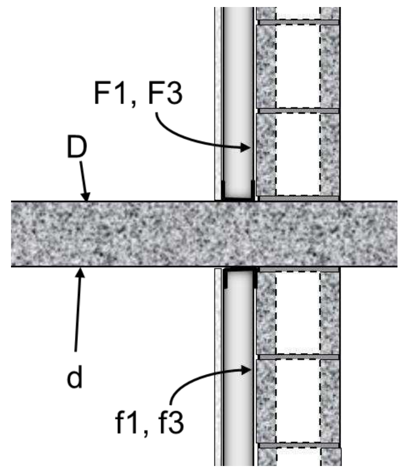
Junction 2: T-Junction of separating floor / flanking wall with:

- rigid mortared T-junctions with concrete block wall assemblies
- wall above and below floor of one wythe of 190 mm hollow concrete blocks with normal weight aggregate[1], with mass 238 kg/m^2.
- flanking walls lined with 13 mm gypsum board[3] on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c. with no absorptive material[2] filling stud cavities

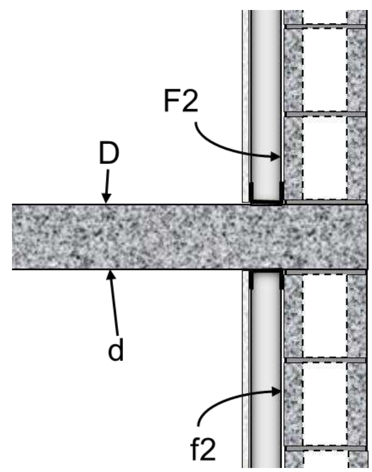
Acoustical Parameters:

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)

Separating Partition (150 mm concrete floor)									
Input Data	ISO Symbol	Reference	STC, ASTC, etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_D,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.44	0.37	0.25	0.21	0.15	0.08
Radiation Efficiency				1	1	1	1	1	1
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 Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.346	0.237	0.159	0.104	0.066	0.041
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		10.4	10.8	11.4	12.3	13.7	15.7
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	**55**	**41**	**44**	**52**	**61**	**69**	**78**

(See footnotes at end of document)

Junction 1 (Rigid Cross junction, 150 mm concrete floor / 190 mm block flanking wall)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-334, NRC Mean BLK190(NW)	49	35.0	38.0	44.0	50.0	58.0	62.0
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.256	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.8	9.5	10.5	12.0	14.2	17.3
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	49	35.7	38.5	44.4	50.3	58.2	62.2
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	49	35.7	38.5	44.4	50.3	58.2	62.2
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		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		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		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	**68**	**44**	**71**	**89**	**90**	**90**	**90**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**71**	**47**	**62**	**75**	**84**	**90**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**71**	**47**	**62**	**75**	**84**	**90**	**90**
Junction 2 (Rigid T-Junction, 150 mm concrete floor / 190 mm block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-334, NRC Mean BLK190(NW)	49	35.0	38.0	44.0	50.0	58.0	62.0
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.218	0.145	0.094	0.059	0.036	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.3	8.8	9.6	10.8	12.6	15.1
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.9	58.7	62.5
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.9	58.7	62.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		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		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		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	**67**	**43**	**70**	**88**	**90**	**90**	**90**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**70**	**46**	**61**	**74**	**83**	**89**	**90**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**70**	**46**	**61**	**74**	**83**	**89**	**90**
Junction 3 (Rigid Cross junction, 150 mm concrete floor / 190 mm block flanking wall)									
All values the same as for Junction 1									
Junction 4 (Rigid Cross-Junction, 150 mm concrete floor / 190 mm block flanking 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									
Flanking Element F4 and f4: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.237	0.157	0.101	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.6	8.1	8.9	10.1	11.9	14.4
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		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		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		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	**69**	**45**	**73**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**72**	**48**	**63**	**77**	**86**	**90**	**90**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**72**	**48**	**63**	**77**	**86**	**90**	**90**
Total Flanking STC (combined transmission for all flanking paths)			59						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**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 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 blocks with normal weight aggregate[1], with mass 238 kg/m^2.
- flanking walls lined with 13 mm gypsum board[3] on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c. with absorptive material[2] filling stud cavities.

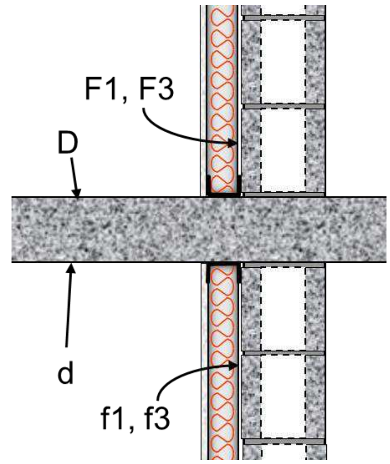
Junction 2: T-Junction of separating floor / flanking wall with:

- rigid mortared T-junctions with concrete block wall assemblies
- wall above and below floor of one wythe of 190 mm hollow concrete blocks with normal weight aggregate[1], with mass 238 kg/m^2.
- flanking walls lined with 13 mm gypsum board[3]on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c. with absorptive material[2] filling stud cavities.

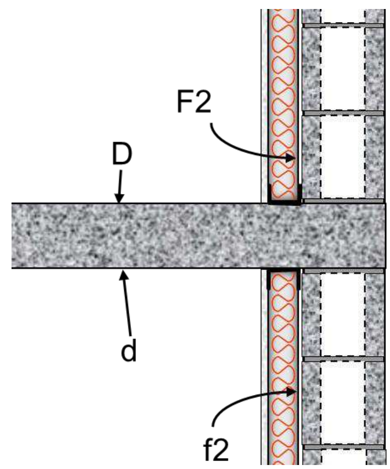
Acoustical Parameters:

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)

Separating Partition (150 mm concrete floor)

Input Data	ISO Symbol	Reference	STC, ASTC, etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_D,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.44	0.37	0.25	0.21	0.15	0.08
Radiation Efficiency				1	1	1	1	1	1
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 Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.346	0.237	0.159	0.104	0.066	0.041
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		10.4	10.8	11.4	12.3	13.7	15.7
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	**55**	**41**	**44**	**52**	**61**	**69**	**78**

(See footnotes at end of document)

Junction 1 (Rigid Cross junction, 150 mm concrete floor / 190 mm block flanking wall)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-334, NRC Mean BLK190(NW)	49	35.0	38.0	44.0	50.0	58.0	62.0
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
Change by Lining on source side	ΔR_F1	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB65_G13		11	19	21	18	17	21
Change by Lining on receive side	ΔR_f1	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB65_G13		11	19	21	18	17	21
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.256	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.8	9.5	10.5	12.0	14.2	17.3
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	49	35.7	38.5	44.4	50.3	58.2	62.2
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	49	35.7	38.5	44.4	50.3	58.2	62.2
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		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		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		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	**90**	**74**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**84**	**62**	**73**	**82**	**87**	**90**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**84**	**62**	**73**	**82**	**87**	**90**	**90**
Junction 2 (Rigid T-Junction, 150 mm concrete floor / 190 mm block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-334, NRC Mean BLK190(NW)	49	35.0	38.0	44.0	50.0	58.0	62.0
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
Change by Lining on source side	ΔR_F2	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB65_G13		11	19	21	18	17	21
Change by Lining on receive side	ΔR_f2	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB65_G13		11	19	21	18	17	21
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.218	0.145	0.094	0.059	0.036	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.3	8.8	9.6	10.8	12.6	15.1
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.9	58.7	62.5
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.9	58.7	62.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		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		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		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	**90**	**73**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**83**	**61**	**72**	**81**	**86**	**90**	**90**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**83**	**61**	**72**	**81**	**86**	**90**	**90**
Junction 3 (Rigid Cross junction, 150 mm concrete ceiling / 190 mm block flanking wall)									
All values the same as for Junction 1									
Junction 4 (Rigid Cross-Junction, 150 mm concrete floor / 190 mm block flanking 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									
Flanking Element F4 and f4: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.237	0.157	0.101	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.6	8.1	8.9	10.1	11.9	14.4
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		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		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		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	**90**	**75**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**85**	**63**	**74**	**84**	**89**	**90**	**90**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**85**	**63**	**74**	**84**	**89**	**90**	**90**
Total Flanking STC (combined transmission for all flanking paths)			74						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**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 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping or flooring on top
- ceiling lining below: 16 mm gypsum board[3] fastened to hat-channels supported on cross-channels hung on wires, cavity of 150 mm between concrete and ceiling, with 150 mm absorptive material[2]

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 blocks with normal weight aggregate[1], with mass 238 kg/m^2.
- flanking walls lined with 13 mm gypsum board[3] on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c. with no absorptive material[2] filling stud cavities

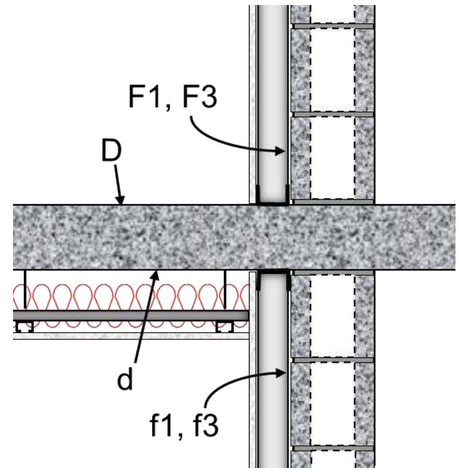
Junction 2: T-Junction of separating floor / flanking wall with:

- rigid mortared T-junctions with concrete block wall assemblies
- wall above and below floor of one wythe of 190 mm hollow concrete blocks with normal weight aggregate[1], with mass 238 kg/m^2.
- flanking walls lined with 13 mm gypsum board[3] on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c. with no absorptive material[2] filling stud cavities

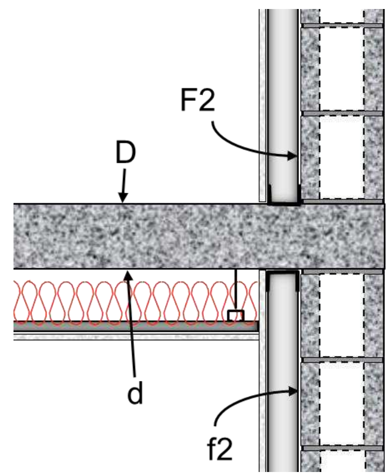
Acoustical Parameters:

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)

Separating Partition (150 mm concrete floor)

Input Data	ISO Symbol	Reference	STC, ASTC, etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_D,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.44	0.37	0.25	0.21	0.15	0.08
Radiation Efficiency				1	1	1	1	1	1
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
Transferred Data In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.346	0.237	0.159	0.104	0.066	0.041
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		10.4	10.8	11.4	12.3	13.7	15.7
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	**73**	**49**	**65**	**76**	**85**	**90**	**90**

(See footnotes at end of document)

Junction 1 (Rigid Cross junction, 150 mm concrete floor / 190 mm block flanking wall)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-334, NRC Mean BLK190(NW)	49	35.0	38.0	44.0	50.0	58.0	62.0
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.256	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.8	9.5	10.5	12.0	14.2	17.3
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	49	35.7	38.5	44.4	50.3	58.2	62.2
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	49	35.7	38.5	44.4	50.3	58.2	62.2
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		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		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		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	**68**	**44**	**71**	**89**	**90**	**90**	**90**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**79**	**55**	**83**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**71**	**47**	**62**	**75**	**84**	**90**	**90**
Junction 2 (Rigid T-Junction, 150 mm concrete floor / 190 mm block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-334, NRC Mean BLK190(NW)	49	35.0	38.0	44.0	50.0	58.0	62.0
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.218	0.145	0.094	0.059	0.036	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.3	8.8	9.6	10.8	12.6	15.1
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.9	58.7	62.5
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.9	58.7	62.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		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		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		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	**67**	**43**	**70**	**88**	**90**	**90**	**90**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**78**	**54**	**82**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**70**	**46**	**61**	**74**	**83**	**89**	**90**
Junction 3 (Rigid Cross junction, 150 mm concrete ceiling / 190 mm block flanking wall)									
All values the same as for Junction 1									
Junction 4 (Rigid Cross-Junction, 150 mm concrete floor / 190 mm block flanking 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									
Flanking Element F4 and f4: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.237	0.157	0.101	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.6	8.1	8.9	10.1	11.9	14.4
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		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		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		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	**69**	**45**	**73**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**80**	**56**	**84**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**72**	**48**	**63**	**77**	**86**	**90**	**90**
Total Flanking STC (combined transmission for all flanking paths)			60						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**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 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping or flooring on top
- ceiling lining below: 16 mm gypsum board[3] fastened to hat-channels supported on cross-channels hung on wires, cavity of 150 mm between concrete and ceiling, with 150 mm absorptive material[2]

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 blocks with normal weight aggregate[1], with mass 238 kg/m^2.
- flanking walls lined with 13 mm gypsum board[3] on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c. with absorptive material[2] filling stud cavities

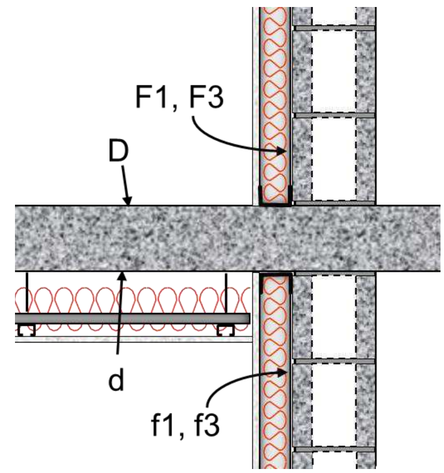
Junction 2: T-Junction of separating floor / flanking wall with:

- rigid mortared T-junctions with concrete block wall assemblies
- wall above and below floor of one wythe of 190 mm hollow concrete blocks with normal weight aggregate[1], with mass 238 kg/m^2.
- flanking walls lined with 13 mm gypsum board[3] on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c. with absorptive material[2] filling stud cavities

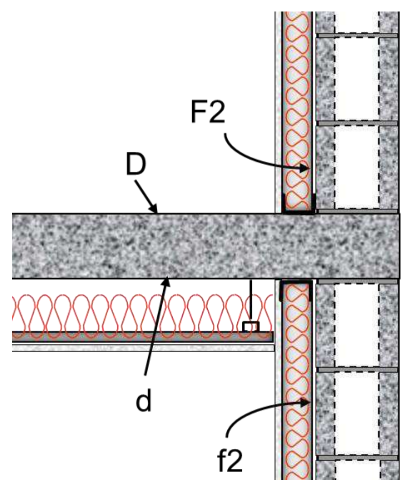
Acoustical Parameters:

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)

Separating Partition (150 mm concrete floor)									
Input Data	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_D,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.44	0.37	0.25	0.21	0.15	0.08
Radiation Efficiency				1	1	1	1	1	1
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
Transferred Data In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.346	0.237	0.159	0.104	0.066	0.041
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		10.4	10.8	11.4	12.3	13.7	15.7
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	**73**	**49**	**65**	**76**	**85**	**90**	**90**

(See footnotes at end of document)

Junction 1 (Rigid Cross junction, 150 mm concrete floor / 190 mm block flanking wall)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-334, NRC Mean BLK190(NW)	49	35.0	38.0	44.0	50.0	58.0	62.0
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
Change by Lining on source side	ΔR_F1	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB65_G13		11	19	21	18	17	21
Change by Lining on receive side	ΔR_f1	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB65_G13		11	19	21	18	17	21
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.256	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.8	9.5	10.5	12.0	14.2	17.3
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	49	35.7	38.5	44.4	50.3	58.2	62.2
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	49	35.7	38.5	44.4	50.3	58.2	62.2
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		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		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		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	**90**	**74**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**89**	**70**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**84**	**62**	**73**	**82**	**87**	**90**	**90**
Junction 2 (Rigid T-Junction, 150 mm concrete floor / 190 mm block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-334, NRC Mean BLK190(NW)	49	35.0	38.0	44.0	50.0	58.0	62.0
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
Change by Lining on source side	ΔR_F2	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB65_G13		11	19	21	18	17	21
Change by Lining on receive side	ΔR_f2	RR-334 , ΔTL-BLK190(NW)-62, SS65_GFB65_G13		11	19	21	18	17	21
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.218	0.145	0.094	0.059	0.036	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.3	8.8	9.6	10.8	12.6	15.1
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.9	58.7	62.5
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	50	36.4	39.2	45.0	50.9	58.7	62.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		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		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		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	**90**	**73**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**89**	**69**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**83**	**61**	**72**	**81**	**86**	**90**	**90**
Junction 3 (Rigid Cross junction, 150 mm concrete ceiling / 190 mm block flanking wall)									
All values the same as for Junction 1									
Junction 4 (Rigid Cross-Junction, 150 mm concrete floor / 190 mm block flanking 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									
Flanking Element F4 and f4: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.237	0.157	0.101	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.6	8.1	8.9	10.1	11.9	14.4
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	36.0	38.8	44.7	50.6	58.4	62.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		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		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		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	**90**	**75**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**89**	**71**	**90**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**85**	**63**	**74**	**84**	**89**	**90**	**90**
Total Flanking STC (combined transmission for all flanking paths)			76						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**72**						

Summary for Section 2.3: Adding Linings to Constructions of Cast-in-place concrete and Concrete Masonry

The worked examples 2.3.1 to 2.3.6 illustrate the calculation of sound transmission between rooms in a building of concrete and masonry when linings are added to some or all of the bare concrete and masonry floor and wall assemblies. Here, as before, “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 cast-in-place 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.

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 absorptive material[2]. Many other lining options are possible, and these may be easily substituted if the necessary laboratory test data for improvement in the transmission loss due to the proposed lining is available.

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[2]. 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[2]. 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 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[2] 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[2] 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[2] 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 2.2 and explained in more detail below:

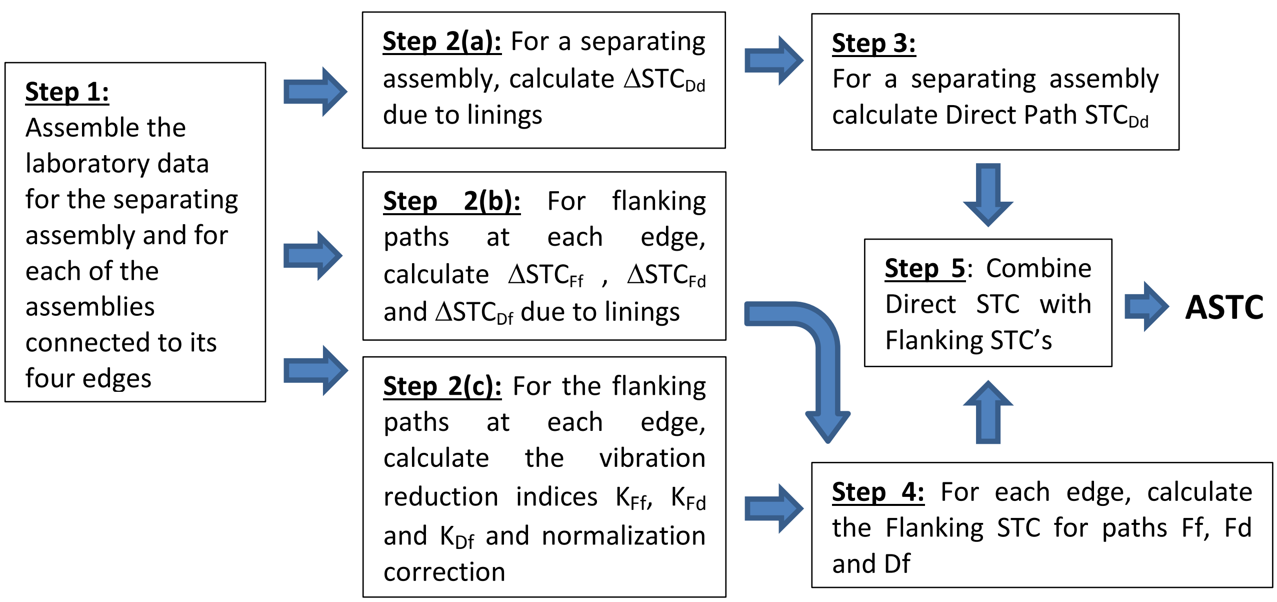


Figure 2.2: Steps to calculate the Direct STC and the Flanking STC for each flanking path (as detailed below).

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.

<u>Expressing the Process using Equations</u>

The examples presented in this Section of this Guide use the Simplified Method of ISO 15712-1 to calculate the ASTC. The Simplified Method uses the single number ratings (STC or Flanking STC) as the values for each path transmission loss (TL_{Dd}, TL_{Ff}, TL_{Fd} or TL_{Df}) transforming Equation 1.4 to:

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

Where:

(a) In this adaptation of the Simplified Method, the Apparent Sound Transmission Class (ASTC) is substituted for the ATL in Eq. 1.4.

(b) Direct path STC_{Dd} is obtained from the laboratory measured STC rating of the bare 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:

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

(c) Flanking STC for each path (STC_{ij}) is calculated using equivalent of Eq. 28 and 31 in ISO 15712-1:

$$STC_{ij} = \frac{STC_i}{2} + \frac{STC_j}{2} + K_{ij} + max\left(\Delta STC_i, \Delta STC_j\right) + \frac{min\left(\Delta STC_i, \Delta STC_j\right)}{2} + 10\log_{10}\left(\frac{S_s}{l_o l_{ij}}\right) \qquad \text{Eq. 2.4.3}$$

where the indices *i* and *j* refer to the coupled flanking elements. Therefore, "*i*" can either be "D" or "F" and "*j*" can be "f" or "d". The geometric correction factor at the end of Eq. 2.4.3 depends on the surface area of the separating assembly (s_S), the length of the junction between flanking and separating elements (l_{ij}) and the reference length l_0 = 1 m.

The worked examples present 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 in this section conform to the Standard Scenario presented in Section 1.2 of this Guide. The precision and rounding of values in the worked examples are the same as given in Section 2.1.

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, Δ_STC", examples present input data from laboratory tests according to ASTM E90 which includes the following integer values:

- STC values for laboratory sound transmission loss of wall or floor assemblies, and
- 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 "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,
- 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 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. 1.4 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.

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 concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1]) with no lining.

Junction 1: Bottom Junction (separating wall / floor) with:
- cast-in-place concrete floor with mass 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.

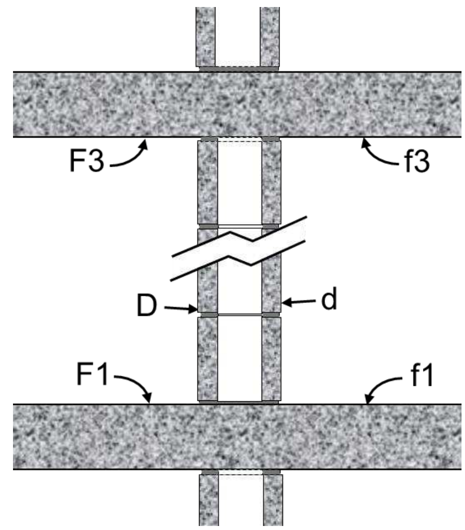
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- abutting side wall and separating wall of concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1]), with no lining of the walls
- rigid mortared T-junctions

Junction 3: Top Junction (separating wall / ceiling) with:
- cast-in-place concrete ceiling with mass 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.

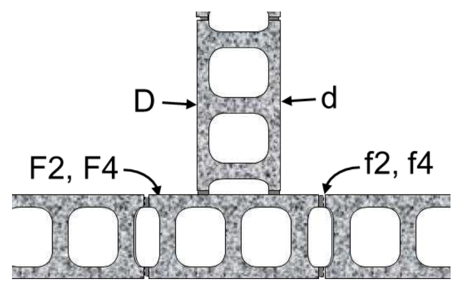
Acoustical Parameters:

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	
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).

Junction		Mass ratio for Ff	Path Ff Kij(in dB) =	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

(See footnotes at end of document)

	ISO Symbol	Reference		STC, Δ_STC	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	ISO 15712-1, Eq. 24 and 30	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	ISO 15712-1, Eq. 28a & 31	53/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 6.1 + 4 =		**63**
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	53/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 4 =		**64**
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	49/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 4 =		**64**
Junction 1: Flanking STC for all paths		Subset of Eq. 1.4	- 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	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =		**62**
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =		**62**
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =		**62**
Junction 2: Flanking STC for all paths		Subset of Eq. 1.4	- 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 slab)					
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	ISO 15712-1, Eq. 28a & 31	53/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 6.1 + 4 =		**63**
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	53/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 4 =		**64**
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	49/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 4 =		**64**
Junction 3: Flanking STC for all paths		Subset of Eq. 1.4	- 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	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =		**62**
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =		**62**
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.7 + 7 =		**62**
Junction 4: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.2 + 10^- 6.2 + 10^- 6.2) =		**57**
Total Flanking STC (4 Junctions)		Subset of Eq. 1.4	Combining 12 Flanking STC values		**52**
ASTC due to Direct plus All Flanking Paths		Equation 1.4 of this Report	Combining Direct STC with 12 Flanking STC values		**47**

EXAMPLE 2.4.2: **SIMPLIFIED METHOD**

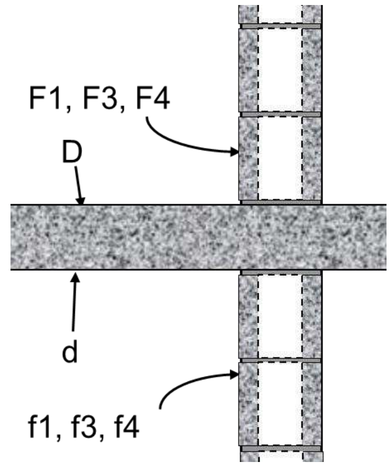
- **Rooms one-above-the-other**
- **Cast-in-place concrete floors and normal weight concrete block walls with rigid junctions**
- **Same structure as Example 2.1.2**

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

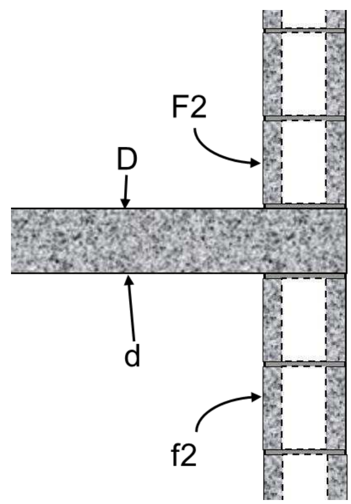
Junction 1, 3,or 4: Cross Junction of separating floor / flanking wall with:
- rigid mortared cross junction with concrete block wall assemblies.
- wall above and below floor of one wythe of concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1]) with no lining of the walls.

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 concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1]) with no lining of the walls.

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	(Wall at junctions 1&3)
	238	(Wall at junctions 2&4)
For 150 mm concrete floor:		
Mass/unit area (kg/m^2) =		345
Separating partition area (m^2) =		20
Junction 1 and 3 length (m) =		5.0
Junction 2 and 4 length (m) =		4.0
10*log(S_Partition/l_junction 1&3) =		6.0
10*log(S_Partition/l_junction2 &4) =		7.0

Junction		Mass ratio for Ff	Path Ff Kij (in dB) =	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

(See footnotes at end of document)

	ISO Symbol	Reference		STC, Δ_STC	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	No Lining ,		0	
Direct STC in-situ	R_Dd,w	ISO 15712-1, Eq. 24 and 30	53 + MAX(0,0) + MIN(0,0)/2 =		**53**
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-334, NRC-Mean BLK190(NW)		49	
ΔSTC change by Lining	ΔR_F1,w	No Lining ,		0	
Flanking Element f1:					
Laboratory STC for f1	R_f1,w	RR-334, NRC-Mean BLK190(NW)		49	
ΔSTC change by Lining	ΔR_f1,w	No Lining ,		0	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 11.6 + 6 =		**67**
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	49/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 6 =		**66**
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	53/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 6 =		**66**
Junction 1: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.7 + 10^- 6.6 + 10^- 6.6) =		**62**
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	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 8.1 + 7 =		**64**
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	49/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 5.8 + 7 =		**64**
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	53/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 5.8 + 7 =		**64**
Junction 2: Flanking STC for all paths		Subset of Eq. 1.4	- 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 slab)					
Flanking Element F3:					
Laboratory STC for F3	R_F3,w	RR-334, NRC-Mean BLK190(NW)		49	
ΔSTC change by Lining	ΔR_F3,w	No Lining ,		0	
Flanking Element f3:					
Laboratory STC for f3	R_f3,w	RR-334, NRC-Mean BLK190(NW)		49	
ΔSTC change by Lining	ΔR_f3,w	No Lining ,		0	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 11.6 + 6 =		**67**
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	49/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 6 =		**66**
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	53/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 6 =		**66**
Junction 3: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.7 + 10^- 6.6 + 10^- 6.6) =		**62**
Junction 4 (Rigid Cross-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	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 11.6 + 7 =		**68**
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	49/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 7 =		**67**
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	53/2 + 49/2 + MAX(0,0) + MIN(0,0)/2 + 8.8 + 7 =		**67**
Junction 4: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.8 + 10^- 6.7 + 10^- 6.7) =		**63**
Total Flanking STC (4 Junctions)		Subset of Eq. 1.4	Combining 12 Flanking STC values		**55**
ASTC due to Direct plus All Flanking Paths		Equation 1.4 of this Report	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 concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1])
- separating wall lined both sides with 13 mm gypsum board[3] on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c., with absorptive material[2] filling inter-stud cavities

Junction 1: Bottom Junction (separating wall / floor) with:
- cast-in-place concrete floor with mass 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

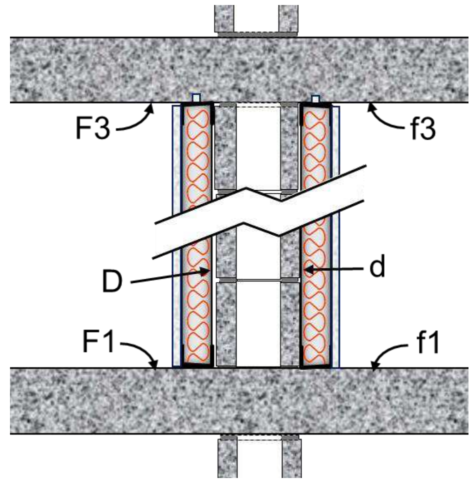
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- rigid mortared T-junctions of abutting side wall and separating wall of concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1])
- flanking walls lined with 13 mm gypsum board[3] on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c., with absorptive material[2] filling inter-stud cavities

Junction 3: Top Junction (separating wall / ceiling) with:
- cast-in-place concrete ceiling with mass 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

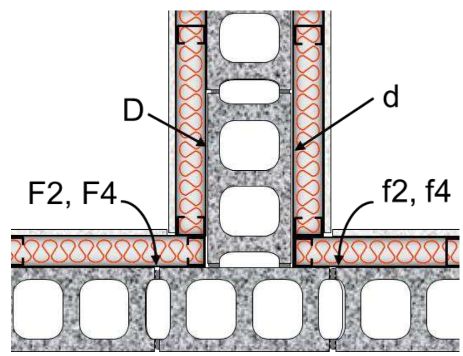
Acoustical Parameters:

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
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).

			Path Ff	Path Fd	Path Df	
Junction		Mass ratio for Ff	Kij(in dB) =			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

(See footnotes at end of document)

	ISO Symbol	Reference		STC, Δ_STC	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	ISO 15712-1, Eq. 24 and 30	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	ISO 15712-1, Eq. 28a & 31	53/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 6.1 + 4 =		**63**	
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	53/2 + 49/2 + MAX(0,19) + MIN(0,19)/2 + 8.8 + 4 =		**83**	
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	49/2 + 53/2 + MAX(19,0) + MIN(19,0)/2 + 8.8 + 4 =		**83**	
Junction 1: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.3 + 10^- 8.3 + 10^- 8.3) =		**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	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(19,19) + MIN(19,19)/2 + 5.7 + 7 =		**90**	(limit)
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(19,19) + MIN(19,19)/2 + 5.7 + 7 =		**90**	(limit)
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(19,19) + MIN(19,19)/2 + 5.7 + 7 =		**90**	(limit)
Junction 2: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-9 + 10^- 9 + 10^- 9) =		**85**	
Junction 3 (Rigid Cross junction, 190 mm block separating wall / 150 mm concrete ceiling slab)						
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	ISO 15712-1, Eq. 28a & 31	53/2 + 53/2 + MAX(0,0) + MIN(0,0)/2 + 6.1 + 4 =		**63**	
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	53/2 + 49/2 + MAX(0,19) + MIN(0,19)/2 + 8.8 + 4 =		**83**	
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	49/2 + 53/2 + MAX(19,0) + MIN(19,0)/2 + 8.8 + 4 =		**83**	
Junction 3: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.3 + 10^- 8.3 + 10^- 8.3) =		**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	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(19,19) + MIN(19,19)/2 + 5.7 + 7 =		**90**	(limit)
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(19,19) + MIN(19,19)/2 + 5.7 + 7 =		**90**	(limit)
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(19,19) + MIN(19,19)/2 + 5.7 + 7 =		**90**	(limit)
Junction 4: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-9 + 10^- 9 + 10^- 9) =		**85**	
Total Flanking STC (4 Junctions)		Subset of Eq. 1.4	Combining 12 Flanking STC values		**60**	
ASTC due to Direct plus All Flanking Paths		Equation 1.4 of this Report	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 345 kg/m^2 (e.g. normal weight concrete 150 mm thick) with no topping / flooring on top
- ceiling lining below: 16 mm gypsum board[3] fastened to hat-channels supported on cross-channels hung on wires, cavity of 150 mm between concrete and ceiling, with 150 mm absorptive material[2]

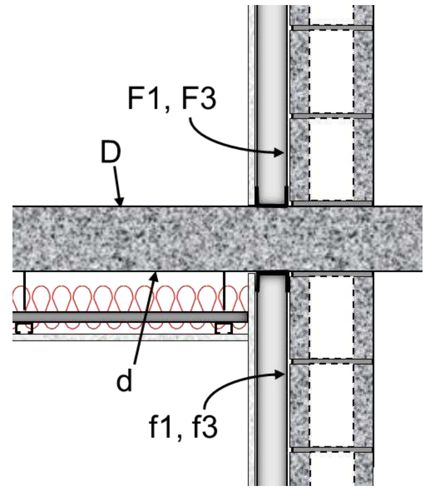
Junction 1, 3 or 4: Cross Junction of separating floor / flanking wall with:
- rigid mortared cross junction with concrete block wall assemblies
- wall above and below floor of one wythe of 190 mm hollow concrete blocks with normal weight aggregate[1], with mass 238 kg/m^2
- flanking walls lined with 13 mm gypsum board[3] on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c. with no absorptive material[2] 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 blocks with normal weight aggregate[1], with mass 238 kg/m^2
- flanking walls lined with 13 mm gypsum board[3] on 65 mm non-loadbearing steel studs[4] spaced 600 mm o.c. with no absorptive material[2] in inter-stud cavities

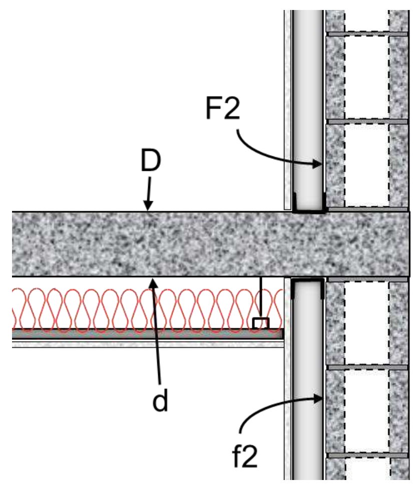
Acoustical Parameters:

For 190 mm concrete block walls:		
Mass/unit area (kg/m^2) =	238	(Wall at junctions 1&3)
	238	(Wall at junctions 2&4)
For 150 mm concrete floor:		
Mass/unit area (kg/m^2) =		345
Separating partition area (m^2) =		20
Junction 1 and 3 length (m) =		5.0
Junction 2 and 4 length (m) =		4.0
10*log(S_Partition/l_junction 1&3) =		6.0
10*log(S_Partition/l_junction2 &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)

Junction		Mass ratio for Ff	Path Ff Kij (in dB) =	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

(See footnotes at end of document)

	ISO Symbol	Reference		STC, Δ_STC	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	ISO 15712-1, Eq. 24 & 30	53 + MAX(0,19) + MIN(0,19)/2 =		**72**
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-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	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(2,2) + MIN(2,2)/2 + 11.6 + 6 =		**70**
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	49/2 + 53/2 + MAX(2,19) + MIN(2,19)/2 + 8.8 + 6 =		**86**
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	53/2 + 49/2 + MAX(0,2) + MIN(0,2)/2 + 8.8 + 6 =		**68**
Junction 1: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-7 + 10^- 8.6 + 10^- 6.8) =		**66**
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)-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	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(2,2) + MIN(2,2)/2 + 8.1 + 7 =		**67**
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	49/2 + 53/2 + MAX(2,19) + MIN(2,19)/2 + 5.8 + 7 =		**84**
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	53/2 + 49/2 + MAX(0,2) + MIN(0,2)/2 + 5.8 + 7 =		**66**
Junction 2: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.7 + 10^- 8.4 + 10^- 6.6) =		**63**
Junction 3 (Rigid-Cross junction, 190 mm block separating wall / 150 mm concrete ceiling slab)					
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	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(2,2) + MIN(2,2)/2 + 11.6 + 6 =		**70**
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	49/2 + 53/2 + MAX(2,19) + MIN(2,19)/2 + 8.8 + 6 =		**86**
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	53/2 + 49/2 + MAX(0,2) + MIN(0,2)/2 + 8.8 + 6 =		**68**
Junction 3: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-7 + 10^- 8.6 + 10^- 6.8) =		**66**
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)-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	ISO 15712-1, Eq. 28a & 31	49/2 + 49/2 + MAX(2,2) + MIN(2,2)/2 + 11.6 + 7 =		**71**
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a & 31	49/2 + 53/2 + MAX(2,19) + MIN(2,19)/2 + 8.8 + 7 =		**87**
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a & 31	53/2 + 49/2 + MAX(0,2) + MIN(0,2)/2 + 8.8 + 7 =		**69**
Junction 4: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-7.1 + 10^- 8.7 + 10^- 6.9) =		**67**
Total Flanking STC (4 Junctions)		Subset of Eq. 1.4	Combining 12 Flanking STC values		**59**
ASTC due to Direct plus All Flanking Paths		Equation 1.4 of this Report	Combining Direct STC with 12 Flanking STC values		**59**

Summary for Section 2.4: 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 cast-in-place 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 absorptive 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 Calculation Method presented in Sections 2.1 to 2.3.

Each of the examples has a counterpart in the detailed calculations in Section 2.1 and 2.3, and the differences (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-laminate timber (CLT) construction is based on structural floor and wall assemblies fabricated by laminating timber elements together into panels with layers of alternating grain orientation. Typical panels have three or more layers or plies, with overall thickness ranging from about 75 to 250 mm.

Although CLT panels have lower weight and higher internal losses than the heavy concrete and masonry walls and floor assemblies considered in Chapter 2, flanking transmission in buildings composed of CLT panels can also be predicted using the detailed calculation method of ISO 15712-1. However, the differences between CLT assemblies and walls or floors of “bare” concrete or masonry require appreciable 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 panels and their junctions:

1) The internal loss factors for CLT panels 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 panels, measurements of the loss factors for laboratory wall and floor specimens have established values of 0.06 or higher. This is well above the threshold of 0.03 specified in ISO 15712-1 above which the effect of edge losses can be safely ignored, and hence there is no need to apply the absorption correction to obtain in-situ TL from the laboratory TL data in Equation 19 of ISO 15712-1. Thus, the Direct TL of the bare separating CLT wall or floor (and the in-situ TL for each bare CLT flanking surface) is taken as equal to laboratory TL determined by testing according to ASTM E90.
2) For flanking surfaces, Section 4.2.2 in ISO 15712-1 notes that only resonant transmission should be included; this would require a correction of the measured TL below the critical frequency. For the bare concrete and masonry assemblies in Chapter 2, the critical frequency is below 125 Hz, so no correction to remove the non-resonant transmission is needed. For thin 3-ply CLT panels, the critical frequency is about 800 Hz (i.e. in the middle of the frequency range of interest when calculating the ASTC rating) so corrections to the laboratory TL are recommended at lower frequencies. Unfortunately, the current version of ISO 15712-1 does not give a method to obtain resonant TL from measured TL. Hence, in the following examples for CLTs, the uncorrected measured TL is used as input data. This should lead to conservative results, especially for Flanking TL of thin 3-ply CLT panels. This issue is discussed in more detail in NRC Research Report RR-335, which also presents a correction method to estimate the resonant part to give a more realistic estimate of Flanking TL.
3) The effect of adding linings to the surfaces of “bare” CLT walls and floors can be treated with an additive correction, as for concrete and masonry assemblies (see discussion in Section 2.3 of this Guide). Because the weight of CLT panels 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 weight of the bare assembly. Data on improvements due to linings for several common thicknesses (weights) of CLT panels are given in NRC report RR-335. Using the improvement of a lining added to a heavier CLT provides a slightly conservative estimate for other cases.
4) At junctions, CLT panels are usually connected with nailed metal plates or long screws. These junctions differ from the rigid cross- and T-junctions considered in Chapter 2 for concrete and masonry construction. Hence, the vibration reduction index (K_{ij}) for junctions must be measured according to ISO 10848.
5) Because of the high internal losses in CLT panels, the equivalent absorption length a_{situ} is set numerically equal to the area of the CLT assembly when calculating the velocity level difference from measured K_{ij} 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 transmission loss measurements according to ASTM E90 (for the bare CLT panels and for the change in TL due to linings applied to these panels) and junction attenuation measurements according to ISO 10848.

The Calculation Process requires specific laboratory test data in the 1/3-octave frequency bands from 125 to 4000 Hz, and follows the steps illustrated in Figure 3.1, and explained in detail below

Step 2a: (Optional)
Adjust TL data from ASTM E90 lab test for the 3 connected CLT assemblies at each edge, to determine Resonant TL

Step 1a: For the bare separating assembly in-situ TL = TL from ASTM E90 laboratory test

Step 2b: For each flanking surface, In-situ TL = Resonant TL for bare CLT plus ΔTL corrections for any lining(s)

Step 1 b: If there is a lining on either side, add ΔTL correction to TL for bare CLT, to get Direct TL for Path Dd

Step 3: Combine Direct TL with Flanking TL for all flanking paths, and calculate ASTC

Step 2c: Calculate Flanking TL for each flanking path, using Eq. 25b of ISO 15712-1 with in-situ TL values from Step 2b, plus K_{Ff}, K_{Fd}, and K_{Df} values for each junction determined according to ISO 10848.

ASTC

Figure 3.1: Steps to calculate the ASTC between rooms for CLT construction (as detailed below).

Step 1: (a) For the bare separating assembly, the in-situ TL for each frequency is equal to the TL measured in the laboratory according to ASTM E90.
(b) Add ΔTL corrections obtained in accordance with 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: (a) For each flanking surface, use laboratory TL determined according to ASTM E90 as a conservative estimate of the Resonant TL. (A correction is recommended in ISO 15712-1, but not defined, and hence not used here.) Set 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 TL values.
(c) For each flanking path, combine values of vibration reduction index (K_{Ff}, K_{Fd}, and K_{Df} measured according to ISO 10848) with in-situ TL 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: Combine the transmission via the direct and flanking paths, using Equation 1.4 in Chapter 1 of this Guide (equivalent to Eq. 26 in Section 4.4 of ISO 15712-1), and calculate ASTC, using these combined TL values as Apparent TL in the procedure of ASTM E413.

Comparison with the Simplified Method for Concrete and Masonry Buildings reveals a strong formal resemblance between the procedure in Figure 3.1 and the Simplified Method presented in Chapter 2.4. The combination of setting the equivalent absorption length for each surface equal to its area in m^2 and the adjustments for surface and junction dimensions in Equation 25b (in Step 2c) give an expression for the Flanking TL that has the same normalization term as Equation 28a for the Simplified Method. However, in addition to the obvious difference between using STC values in Chapter 2.4 versus the set of values for 16 frequency bands for CLT in this chapter, specific steps in the two calculations differ:

- For direct transmission, results from ASTM E90 tests are used without change to characterize in-situ transmission through the "bare" separating assembly. The procedure here for CLT adds the full incremental ΔTL correction for linings on each side, but the Simplified Method of Section 2.4 reduces the correction by half of the lesser ΔSTC correction when both sides have linings.
- For each flanking transmission path, results from ASTM E90 tests are used without change to characterize in-situ transmission through each "base" flanking assembly (but the optional correction to Resonant TL could provide an increase for CLT assemblies). The procedure here for CLT adds the full incremental ΔTL corrections for linings on the source and receiving surfaces, but the Simplified Method of Section 2.4 reduces the correction by half of the lesser ΔSTC correction when both flanking surfaces have linings.
- For CLT systems, values of vibration reduction index K_{ij} measured according to ISO 10848 are used to characterize the junctions, versus the frequency-independent values for rigid junctions from Annex E of ISO 15712-1 that are used for concrete and masonry.

The Simplified Method of Section 2.4 could be applied to CLT construction using frequency-averaged values derived from the measured K_{ij} data, but the simplification of the calculation would be minimal, and the predicted ASTC values would be lower due to the differences noted above.

The worked examples present the pertinent physical characteristics of the assemblies and junctions, plus 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 and has intermediate steps in some calculations. 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 the frequency bands. All examples in this Section conform to the Standard Scenario presented in Section 1.2 of this Guide

Under the single heading "STC, ASTC, etc." the examples present single number ratings (each calculated from a set of 1/3-octave 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 including the change due to linings,
- 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 3.1: DETAILED METHOD

- **Rooms side-by-side**
- **Bare CLT floors and CLT walls**

Separating wall assembly (loadbearing) with:
- 3-ply 78 mm thick CLT panel with mass 42.4 kg/m²
- CLT wall panels oriented so face ply strands are vertical
- no added lining on either side.

Junction 1: Bottom Junction (separating wall / floor) with:
- 5-ply 175 mm thick CLT floor panel with mass 92.1 kg/m², continuous through cross junction with CLT separating wall assembly,
- CLT floor/ceiling panels oriented so face ply strands are perpendicular to load bearing junction 1 & 3
- Connected with 90 mm equal leg angle brackets nailed/screwed to both sides of the separating element and to the abutting assemblies and spaced 300 mm o.c.
- with no added topping or flooring

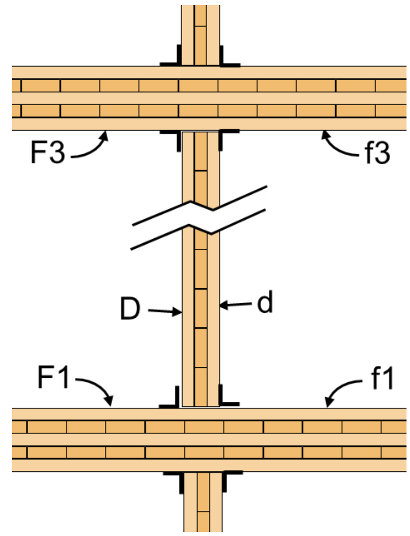
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- abutting side walls of 3-ply 78 mm thick CLT with mass 42.4 kg/m² continuous through T-junctions with separating CLT wall
- CLT side wall panels oriented so face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed to both sides of the separating element and to the abutting assemblies, spaced 600 mm o.c.
- with no added lining

Junction 3: Top Junction (separating wall / ceiling) with:
- 5-ply 175 mm thick CLT ceiling panel with mass 92.1 kg/m², continuous through cross junction with CLT separating wall assembly
- CLT floor/ceiling panels oriented so face ply strands are perpendicular to load bearing junction 1 & 3
- Connected with 90 mm equal leg angle brackets nailed/screwed to both sides of the separating element and spaced 300 mm o.c.
- with no added ceiling lining

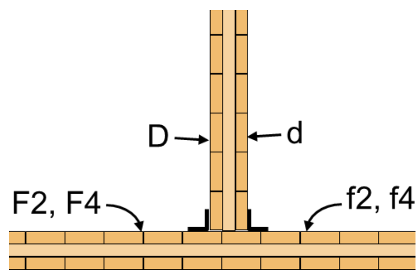
Acoustical Parameters:

For separating assembly:			
internal loss, η_i =	0.050	c_L =	1150
mass (kg/m²) =	42.4	f_c =	723
Similarly, for flanking elements F and f at Junction 1 & 3,			
internal loss, η_i =	0.050	c_L =	1150
mass (kg/m²) =	92.1	f_c =	322
Similarly, for flanking elements F and f at Junction 2 & 4,			
internal loss, η_i =	0.050	c_L =	1150
mass (kg/m²) =	42.4	f_c =	723

Illustration for this case



Cross junctions of 78 mm thick 3-ply CLT separating wall with 175mm 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 Junction 2 or 4)

(See footnotes at end of document)

Separating Partition (78 mm 3-ply CLT)									
Input Data	ISO Symbol	Reference	STC, ASTC, etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_D,lab	RR-335, Base-CLT03	36	26	28	31	37	46	50
Correction, Resonant Transmission				0	0	0	0	0	0
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									
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, 4.2.2		12.5	12.5	12.5	12.5	12.5	12.5
Effect of Airborne Flanking		RR-335, Leakage CLT03		-1.0	-3.0	-3.0	-3.0	-4.0	-1.0
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**33**	**25**	**25**	**28**	**34**	**42**	**49**
Junction 1 (Cross junction, 78 mm 3-ply CLT separating wall / 175 mm 5-ply CLT floor)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC or ASTC**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-335, Base-CLT05	42	32	30	39	43	52	49
Correction, Resonant Transmission				0.0	0.0	0.0	0.0	0.0	0.0
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Equivalent Absorption Length	alpha_situ	ISO 15712-1, 4.2.2		20.0	20.0	20.0	20.0	20.0	20.0
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
Junction J1 - Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, CLT-WF-Xa-01		0.8	0.8	0.8	0.8	0.8	0.8
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 - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25b	**47**	**37**	**35**	**44**	**48**	**57**	**54**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25b	**53**	**43**	**43**	**49**	**54**	**63**	**64**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25b	**53**	**43**	**43**	**49**	**54**	**63**	**64**
Junction 2 (T-Junction, 78 mm 3-ply CLTseparating wall / 78 mm 3-ply CLT flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-335, Base-CLT03	36	26	28	31	37	46	50
Correction, Resonant Transmission				0.0	0.0	0.0	0.0	0.0	0.0
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Equivalent Absorption Length	alpha_situ	ISO 15712-1, 4.2.2		10.0	10.0	10.0	10.0	10.0	10.0
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36	26.0	28.0	31.0	37.0	46.0	50.0
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36	26.0	28.0	31.0	37.0	46.0	50.0
Junction J2 - 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		5.8	5.8	5.8	5.8	5.8	5.8
Vibration Reduction Index for Df	K_Df,2	RR-335, CLT-WW-Tb-01		5.8	5.8	5.8	5.8	5.8	5.8
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25b	**46**	**36**	**38**	**41**	**47**	**56**	**60**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25b	**49**	**39**	**41**	**44**	**50**	**59**	**63**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25b	**49**	**39**	**41**	**44**	**50**	**59**	**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									
Junction 4 (T-junction, 78 mm 3-ply CLT separating wall / 78 mm 3-ply CLT flanking wall)									
All input data the same as for Junction 2									
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25b	**46**	**36**	**38**	**41**	**47**	**56**	**60**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25b	**49**	**39**	**41**	**44**	**50**	**59**	**63**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25b	**49**	**39**	**41**	**44**	**50**	**59**	**63**
Total Flanking STC (combined transmission for all flanking paths)			38						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**32**						

EXAMPLE 3.2: **DETAILED METHOD**

- **Rooms side-by-side**
- **CLT floors and CLT walls**
- **Same structure as Example 3.1, plus linings**

Separating wall assembly (loadbearing) with:
- 3-ply 78 mm thick CLT panel with mass 42.4 kg/m^2
- CLT wall panels oriented so face ply strands are vertical
- lining on each side of 2 layers of 13 mm gypsum board[3] supported on 38 mm wood furring spaced 600 mm o.c. with absorptive material[2] in cavities.

Junction 1: Bottom Junction (separating wall / floor) with:
- 5-ply 175 mm thick CLT floor panel with mass 92.1 kg/m^2, continuous through cross junction with CLT separating wall,
- CLT floor/ceiling panels oriented so face ply strands are perpendicular to load bearing junction 1 & 3
- connected with 90 mm equal leg angle brackets nailed/screwed to both sides of the separating element and spaced 300 mm o.c.
- floor lining of 38 mm concrete over 13 mm wood fiber board

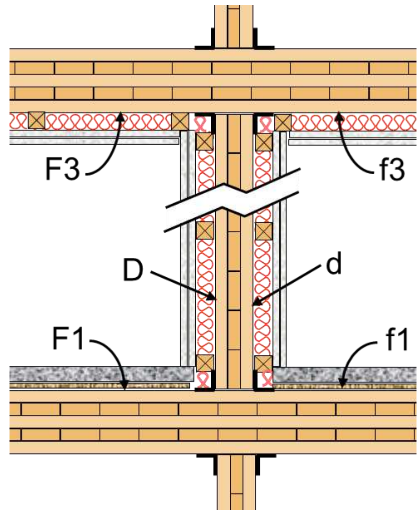
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- abutting side walls of 3-ply 78 mm thick CLT with mass 42.4 kg/m^2 continuous through T-junctions with separating CLT wall
- CLT side wall panels oriented so face ply strands are vertical
- connected with 90 mm equal leg angle brackets nailed/screwed to both sides of the separating element and spaced 600 mm o.c.
- lining on each side of 2 layers of 13 mm gypsum board[3] supported on 38 mm wood furring spaced 600 mm o.c. with absorptive material[2] in cavities.

Junction 3: Top Junction (separating wall / ceiling) with:
- 5-ply 175 mm thick CLT ceiling panel with mass 92.1 kg/m^2, continuous through cross junction with CLT separating wall
- CLT floor/ceiling panels oriented so face ply strands are perpendicular to load bearing junction 1 & 3
- connected with 90 mm equal leg angle brackets nailed/screwed to both sides of the separating element and spaced 300 mm o.c.
- ceiling lining on each side of 2 layers of 13 mm gypsum board[3] supported on 38 mm wood furring spaced 600 mm o.c. with absorptive material[2] in cavities.

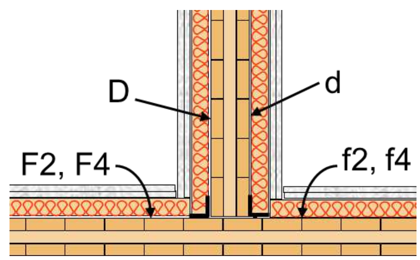
Acoustical Parameters:

For separating assembly:			
internal loss, η_i =	0.050	c_L =	1150
mass (kg/m²) =	42.4	f_c =	723
Similarly, for flanking elements F and f at Junction 1 & 3,			
internal loss, η_i =	0.050	c_L =	1150
mass (kg/m²) =	92.1	f_c =	322
Similarly, for flanking elements F and f at Junction 2 & 4,			
internal loss, η_i =	0.050	c_L =	1150
mass (kg/m²) =	42.4	f_c =	723

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 Junction 2 or 4)

(See footnotes at end of document)

Separating Partition (78 mm 3-ply CLT)									
Input Data	ISO Symbol	Reference	STC, ASTC, etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_D,lab	RR-335, Base-CLT03	36	26	28	31	37	46	50
Correction, Resonant Transmission				0	0	0	0	0	0
Change by Lining on source side	ΔR_D	RR-335, ΔTL-CLT03-W03		4	7	9	12	10	10
Change by Lining on receive side	ΔR_d	RR-335, ΔTL-CLT03-W03		4	7	9	12	10	10
Transferred Data In-situ									
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, 4.2.2		12.5	12.5	12.5	12.5	12.5	12.5
Effect of Airborne Flanking		Linings block CLT03 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	**52**	**34**	**42**	**49**	**61**	**66**	**70**
Junction 1 (Cross junction, 78 mm 3-ply CLT separating wall / 175 mm 5-ply CLT floor)									
Flanking Element F1 and f1: Input	ISO Symbol	Reference	STC or ASTC	125	250	500	1000	2000	4000
Sound Transmission Loss	R_F1,lab	RR-335, Base-CLT05	42	32	30	39	43	52	49
Correction, Resonant Transmission				0.0	0.0	0.0	0.0	0.0	0.0
Change by Lining on source side	ΔR_F1	RR-335 , ΔTL-CLT-F03		4	11	8	21	29	32
Change by Lining on receive side	ΔR_f1	RR-335 , ΔTL-CLT-F03		4	11	8	21	29	32
Flanking Element F1 and f1: Transferred Data - In-situ									
Equivalent Absorption Length	alpha_situ	ISO 15712-1, 4.2.2		20.0	20.0	20.0	20.0	20.0	20.0
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
Junction J1 - Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, CLT-WF-Xa-01		0.8	0.8	0.8	0.8	0.8	0.8
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 - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25b	**67**	**45**	**57**	**60**	**90**	**90**	**90**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25b	**72**	**51**	**61**	**66**	**87**	**90**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25b	**72**	**51**	**61**	**66**	**87**	**90**	**90**
Junction 2 (T-Junction, 78 mm 3-ply CLTseparating wall / 78 mm 3-ply CLT flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-335, Base-CLT03	36	26	28	31	37	46	50
Correction, Resonant Transmission				0.0	0.0	0.0	0.0	0.0	0.0
Change by Lining on source side	ΔR_F2	RR-335 , ΔTL-CLT03-W03		4	7	9	12	10	10
Change by Lining on receive side	ΔR_f2	RR-335 , ΔTL-CLT03-W03		4	7	9	12	10	10
Flanking Element F2 and f2: Transferred Data - In-situ									
Equivalent Absorption Length	alpha_situ	ISO 15712-1, 4.2.2		10.0	10.0	10.0	10.0	10.0	10.0
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36	26.0	28.0	31.0	37.0	46.0	50.0
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36	26.0	28.0	31.0	37.0	46.0	50.0
Junction J2 - 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		5.8	5.8	5.8	5.8	5.8	5.8
Vibration Reduction Index for Df	K_Df,2	RR-335, CLT-WW-Tb-01		5.8	5.8	5.8	5.8	5.8	5.8
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25b	**62**	**44**	**52**	**59**	**71**	**76**	**80**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25b	**65**	**47**	**55**	**62**	**74**	**79**	**83**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25b	**65**	**47**	**55**	**62**	**74**	**79**	**83**
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									
Change by Lining on source side	ΔR_F2	RR-335 , ΔTL-CLT-C01		2	11	5	12	11	11
Change by Lining on receive side	ΔR_f2	RR-335 , ΔTL-CLT-C01		2	11	5	12	11	11
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25b	**62**	**41**	**57**	**54**	**72**	**79**	**76**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25b	**69**	**49**	**61**	**63**	**78**	**84**	**85**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25b	**69**	**49**	**61**	**63**	**78**	**84**	**85**
Junction 4 (T-junction, 78 mm 3-ply CLT separating wall / 78 mm 3-ply CLT flanking wall)									
All input data the same as for Junction 2									
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25b	**62**	**44**	**52**	**59**	**71**	**76**	**80**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25b	**65**	**47**	**55**	**62**	**74**	**79**	**83**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25b	**65**	**47**	**55**	**62**	**74**	**79**	**83**
Total Flanking STC (combined transmission for all flanking paths)			55						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**50**						

EXAMPLE 3.3: DETAILED METHOD

- **Rooms side-by-side**
- **CLT floors and CLT walls**
- **Same as Example 3.2, except lining of separating wall**

Separating wall assembly (loadbearing) with:

- 3-ply 78 mm thick CLT panel with mass 42.4 kg/m^2
- CLT wall panels oriented so face ply strands are vertical
- lining on each side of 2 layers of 13 mm gypsum board[3] supported on resilient metal channels[5] spaced 600 mm o.c., on 38 mm wood furring spaced 400 mm o.c. with absorptive material[2] in cavities.

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

- 5-ply 175 mm thick CLT floor panel with mass 92.1 kg/m^2, continuous through cross junction with CLT separating wall,
- CLT floor/ceiling panels oriented so face ply strands are perpendicular to load bearing junction 1 & 3
- connected with 90 mm equal leg angle brackets nailed/screwed to both sides of the separating element and spaced 300 mm o.c.
- floor lining of 38 mm concrete over 12 mm wood fiber board

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

- abutting side walls of 3-ply 78 mm thick CLT with mass 42.4 kg/m^2 continuous through T-junctions with separating CLT wall
- CLT wall panels oriented so face ply strands are vertical
- connected with 90 mm equal leg angle brackets nailed/screwed to both sides of the separating element and spaced 600 mm o.c.
- lining on each side of 2 layers of 13 mm gypsum board[3] supported on 38 mm wood furring spaced 600 mm o.c. with absorptive material[2] in cavities.

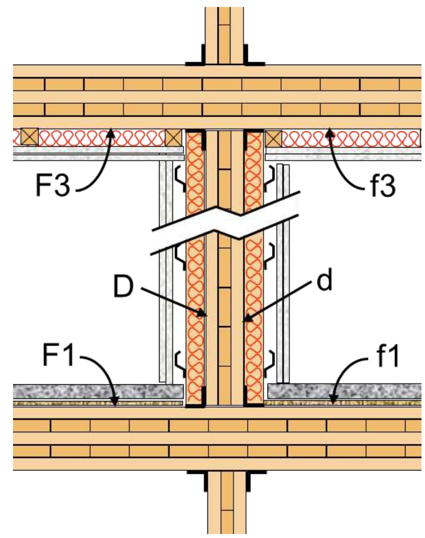
Junction 3: Top Junction (separating wall / ceiling) with:

- 5-ply 175 mm thick CLT ceiling panel with mass 92.1 kg/m^2, continuous through cross junction with CLT separating wall
- CLT floor/ceiling panels oriented so face ply strands are perpendicular to load bearing junction 1 & 3
- connected with 90 mm equal leg angle brackets nailed/screwed to both sides of the separating element and spaced 300 mm o.c.
- ceiling lining on each side of 2 layers of 13 mm gypsum board[3] supported on 38 mm wood furring spaced 600 mm o.c. with absorptive material[2] in cavities.

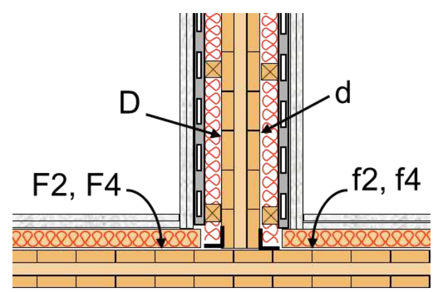
Acoustical Parameters:

For separating assembly:				
internal loss, η_i =	0.050	c_L =	1150	
mass (kg/m²) =	42.4	f_c =	723	
Similarly, for flanking elements F and f at Junction 1 & 3,				
internal loss, η_i =	0.050	c_L =	1150	
mass (kg/m²) =	92.1	f_c =	322	
Similarly, for flanking elements F and f at Junction 2 & 4,				
internal loss, η_i =	0.050	c_L =	1150	
mass (kg/m²) =	42.4	f_c =	723	

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 Junction 2 or 4)

(See footnotes at end of document)

Separating Partition (78 mm 3-ply CLT)									
Input Data	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_D,lab	RR-335, Base-CLT03	36	26	28	31	37	46	50
Correction, Resonant Transmission				0	0	0	0	0	0
Change by Lining on source side	ΔR_D	RR-335, ΔTL-CLT-W04		6	17	20	24	20	22
Change by Lining on receive side	ΔR_d	RR-335, ΔTL-CLT-W04		6	17	20	24	20	22
Transferred Data In-situ									
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, 4.2.2		12.5	12.5	12.5	12.5	12.5	12.5
Effect of Airborne Flanking		Linings block CLT03 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	**62**	**38**	**62**	**71**	**85**	**86**	**90**
Junction 1 (Cross junction, 78 mm 3-ply CLT separating wall / 175 mm 5-ply CLT floor)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC or ASTC**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-335, Base-CLT05	42	32	30	39	43	52	49
Correction, Resonant Transmission				0.0	0.0	0.0	0.0	0.0	0.0
Change by Lining on source side	ΔR_F1	RR-335 , ΔTL-CLT-F03		4	11	8	21	29	32
Change by Lining on receive side	ΔR_f1	RR-335 , ΔTL-CLT-F03		4	11	8	21	29	32
Flanking Element F1 and f1: Transferred Data - In-situ									
Equivalent Absorption Length	alpha_situ	ISO 15712-1, 4.2.2		20.0	20.0	20.0	20.0	20.0	20.0
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
Junction J1 - Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, CLT-WF-Xa-01		0.8	0.8	0.8	0.8	0.8	0.8
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 - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25b	**67**	**45**	**57**	**60**	**90**	**90**	**90**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25b	**77**	**53**	**71**	**77**	**90**	**90**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25b	**77**	**53**	**71**	**77**	**90**	**90**	**90**
Junction 2 (T-Junction, 78 mm 3-ply CLTseparating wall / 78 mm 3-ply CLT flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-335, Base-CLT03	36	26	28	31	37	46	50
Correction, Resonant Transmission				0.0	0.0	0.0	0.0	0.0	0.0
Change by Lining on source side	ΔR_F2	RR-335 , ΔTL-CLT03-W03		4	7	9	12	10	10
Change by Lining on receive side	ΔR_f2	RR-335 , ΔTL-CLT03-W03		4	7	9	12	10	10
Flanking Element F2 and f2: Transferred Data - In-situ									
Equivalent Absorption Length	alpha_situ	ISO 15712-1, 4.2.2		10.0	10.0	10.0	10.0	10.0	10.0
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	36	26.0	28.0	31.0	37.0	46.0	50.0
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	36	26.0	28.0	31.0	37.0	46.0	50.0
Junction J2 - 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		5.8	5.8	5.8	5.8	5.8	5.8
Vibration Reduction Index for Df	K_Df,2	RR-335, CLT-WW-Tb-01		5.8	5.8	5.8	5.8	5.8	5.8
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25b	**62**	**44**	**52**	**59**	**71**	**76**	**80**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25b	**73**	**49**	**65**	**73**	**86**	**89**	**90**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25b	**73**	**49**	**65**	**73**	**86**	**89**	**90**
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									
Change by Lining on source side	ΔR_F3	RR-335 , ΔTL-CLT-C01		2	11	5	12	11	11
Change by Lining on receive side	ΔR_f3	RR-335 , ΔTL-CLT-C01		2	11	5	12	11	11
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25b	**62**	**41**	**57**	**54**	**72**	**79**	**76**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25b	**75**	**51**	**71**	**74**	**90**	**90**	**90**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25b	**75**	**51**	**71**	**74**	**90**	**90**	**90**
Junction 4 (T-junction, 78 mm 3-ply CLT separating wall / 78 mm 3-ply CLT flanking wall)									
All input data the same as for Junction 2									
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25b	**62**	**44**	**52**	**59**	**71**	**76**	**80**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25b	**73**	**49**	**65**	**73**	**86**	**89**	**90**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25b	**73**	**49**	**65**	**73**	**86**	**89**	**90**
Total Flanking STC (combined transmission for all flanking paths)			57						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**56**						

EXAMPLE 3.4: DETAILED METHOD

- **Rooms one-above-the-other**
- **Bare CLT floors and CLT walls**

Separating floor assembly with:

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

Junction 1, 3 or 4: (separating floor / walls) with:

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

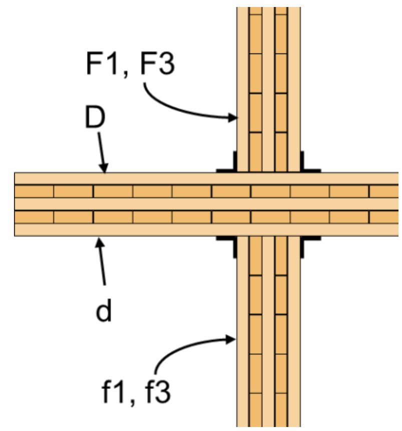
Junction 2: Each Side (separating floor / walls) with:

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

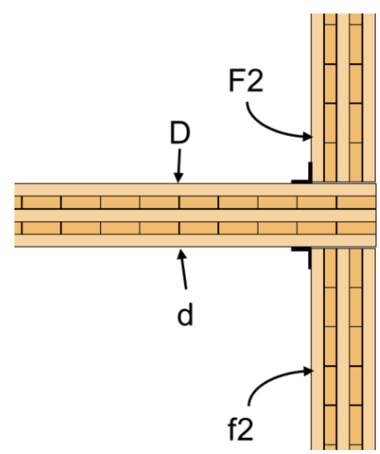
Acoustical Parameters:

For separating assembly:				
internal loss, η_i =	0.050	c_L =	1150	
mass (kg/m²) =	92.1	f_c =	322	
Similarly, for flanking elements F and f at Junction 1 & 3,				
internal loss, η_i =	0.050	c_L =	1150	
mass (kg/m²) =	94.1	f_c =	322	
Similarly, for flanking elements F and f at Junction 2 & 4,				
internal loss, η_i =	0.050	c_L =	1150	
mass (kg/m²) =	94.1	f_c =	322	

Illustration for this case



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

(See footnotes at end of document)

Separating Partition (175 mm 5-ply CLT floor)									
Input Data	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_D,lab	RR-335, Base-CLT05	42	32	30	39	43	52	49
Correction, Resonant Transmission				0	0	0	0	0	0
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									
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, 4.2.2		20.0	20.0	20.0	20.0	20.0	20.0
Effect of Airborne Flanking		RR-335, Leakage Bare CLT05		0	-1	-3	1	-1	-3
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**40**	**32**	**29**	**36**	**44**	**51**	**46**
Junction 1 (Cross junction, 175 mm 5-ply CLT wall / 175 mm 5-ply CLT separating floor)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-335, Base-CLT05	42	32	30	39	43	52	49
Correction, Resonant Transmission				0.0	0.0	0.0	0.0	0.0	0.0
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Equivalent Absorption Length	alpha_situ	ISO 15712-1, 4.2.2		12.5	12.5	12.5	12.5	12.5	12.5
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
Junction J1 - Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, CLT-FW-Xa-05		17.50	17.50	17.50	17.50	17.50	17.50
Vibration Reduction Index for Fd	K_Fd,1	RR-335, CLT-FW-Xa-05		10.10	10.10	10.10	10.10	10.10	10.10
Vibration Reduction Index for Df	K_Df,1	RR-335, CLT-FW-Xa-05		10.10	10.10	10.10	10.10	10.10	10.10
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25b	**66**	**56**	**54**	**63**	**67**	**76**	**73**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25b	**58**	**48**	**46**	**55**	**59**	**68**	**65**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25b	**58**	**48**	**46**	**55**	**59**	**68**	**65**
Junction 2 (T-junction, 175 mm 5-ply CLT wall / 175 mm 5-ply CLT separating floor)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-335, Base-CLT05	42	32	30	39	43	52	49
Correction, Resonant Transmission				0.0	0.0	0.0	0.0	0.0	0.0
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Equivalent Absorption Length	alpha_situ	ISO 15712-1, 4.2.2		10.0	10.0	10.0	10.0	10.0	10.0
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
Junction J2 - Coupling									
Vibration Reduction Index for Ff	K_Ff,2	RR-335, CLT-FW-Ta-05		12.70	12.70	12.70	12.70	12.70	12.70
Vibration Reduction Index for Fd	K_Fd,2	RR-335, CLT-FW-Ta-05		6.70	6.70	6.70	6.70	6.70	6.70
Vibration Reduction Index for Df	K_Df,2	RR-335, CLT-FW-Ta-05		6.70	6.70	6.70	6.70	6.70	6.70
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25b	**62**	**52**	**50**	**59**	**63**	**72**	**69**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25b	**56**	**46**	**44**	**53**	**57**	**66**	**63**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25b	**56**	**46**	**44**	**53**	**57**	**66**	**63**
Junction 3 (Cross junction, 175 mm 5-ply CLT wall / 175 mm 5-ply CLT separating floor)									
All values the same as for Junction 1									
Junction 4 (Cross-junction, 175 mm 5-ply CLT wall / 175 mm 5-ply CLT separating floor)									
All input data the same as for Junction 2									
Junction coupling (vibration reduction index) same as Junctions 1 or 3									
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25b	**66**	**56**	**54**	**63**	**67**	**76**	**73**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25b	**59**	**49**	**47**	**56**	**60**	**69**	**66**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25b	**59**	**49**	**47**	**56**	**60**	**69**	**66**
Total Flanking STC (combined transmission for all flanking paths)			48						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**40**						

EXAMPLE 3.5: DETAILED METHOD

- **Rooms one-above-the-other**
- **CLT floors and CLT walls**
- **Same as 3.4 with added wall and floor/ceiling linings**

Separating floor assembly with:

- 5-ply 175 mm thick CLT floor panel with mass 92.1 kg/m², continuous through cross junction with CLT wall assemblies
- CLT floor/ceiling panels oriented so face ply strands are perpendicular to load bearing junction 1 &3
- connected with 90 mm equal leg angle brackets nailed/screwed to both sides of the separating element and to the abutting wall assemblies and spaced 300 mm o.c.
- floor lining of 38 mm concrete over 12 mm wood fiber board
- ceiling lining of 16 mm gypsum board[3] fastened to hat-channels supported on cross-channels hung on wires, cavity of 150 mm between CLT and ceiling, with 140 mm absorptive material[2]

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

- 5-ply 175 mm thick CLT wall panels with mass 94.1 kg/m², above and below cross junction with CLT separating floor assembly that is continuous across these junctions
- CLT wall panels oriented so face ply strands are vertical
- connected with 90 mm equal leg angle brackets nailed/screwed to both sides of the separating floor element and to the abutting wall assemblies and spaced 300 mm o.c.
- wall lining 2 layers of 13 mm gypsum board[3] supported on 38 mm wood furring spaced 600 mm o.c., absorptive material[2] in cavities

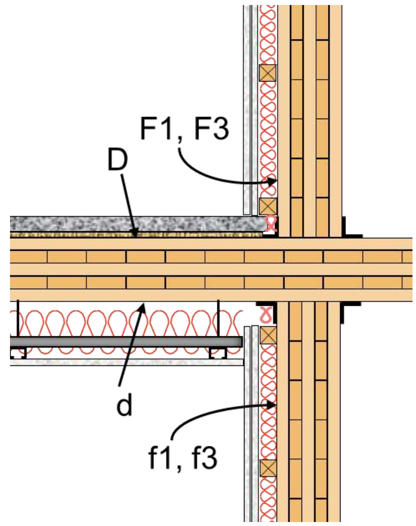
Junction 2: Each Side (separating floor / flanking walls) with:

- 5-ply 175 mm thick CLT wall panels with mass 94.1 kg/m², above and below T-junction with CLT separating floor assembly that terminates at this junction
- CLT wall panels oriented so face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed to the separating floor element and to the abutting wall assemblies, spaced 300 mm o.c.
- wall lining of 2 layers of 13 mm gypsum board[3] supported on 38 mm wood furring spaced 600 mm o.c., absorptive material[2] in cavities

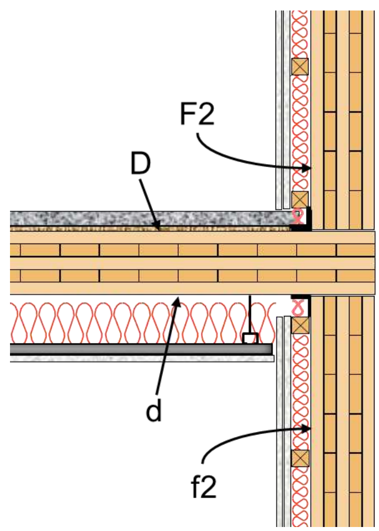
Acoustical Parameters:

For separating assembly:			
internal loss, η_i =	0.050	c_L =	1150
mass (kg/m²) =	92.1	f_c =	322
Similarly, for flanking elements F and f at Junction 1 & 3,			
internal loss, η_i =	0.050	c_L =	1150
mass (kg/m²) =	94.1	f_c =	322
Similarly, for flanking elements F and f at Junction 2 & 4,			
internal loss, η_i =	0.050	c_L =	1150
mass (kg/m²) =	94.1	f_c =	322

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 Junction 1, 3 or 4, except orientation of floor panels 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)

(See footnotes at end of document)

Separating Partition (175 mm 5-ply CLT floor)									
Input Data	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_D,lab	RR-335, Base-CLT05	42	32	30	39	43	52	49
Correction, Resonant Transmission				0	0	0	0	0	0
Change by Lining on source side	ΔR_D	RR-335, ΔTL-CLT-F03		4	11	8	21	29	32
Change by Lining on receive side	ΔR_d	RR-335, ΔTL-CLT-C03		15	25	30	36	34	30
Transferred Data In-situ									
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, 4.2.2		20.0	20.0	20.0	20.0	20.0	20.0
Effect of Airborne Flanking		Linings block CLT05 leakage		0	0	0	0	0	0
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**75**	**51**	**66**	**77**	**90**	**90**	**90**
Junction 1 (Cross junction, 175 mm 5-ply CLT wall / 175 mm 5-ply CLT separating floor)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-335, Base-CLT05	42	32	30	39	43	52	49
Correction, Resonant Transmission				0.0	0.0	0.0	0.0	0.0	0.0
Change by Lining on source side	ΔR_F1	RR-335 , ΔTL-CLT05-W03		3	8	5	11	10	11
Change by Lining on receive side	ΔR_f1	RR-335 , ΔTL-CLT05-W03		3	8	5	11	10	11
Flanking Element F1 and f1: Transferred Data - In-situ									
Equivalent Absorption Length	alpha_situ	ISO 15712-1, 4.2.2		12.5	12.5	12.5	12.5	12.5	12.5
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
Junction J1 - Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, CLT-FW-Xa-05		17.50	17.50	17.50	17.50	17.50	17.50
Vibration Reduction Index for Fd	K_Fd,1	RR-335, CLT-FW-Xa-05		10.10	10.10	10.10	10.10	10.10	10.10
Vibration Reduction Index for Df	K_Df,1	RR-335, CLT-FW-Xa-05		10.10	10.10	10.10	10.10	10.10	10.10
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25b	**81**	**62**	**70**	**73**	**89**	**90**	**90**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25b	**88**	**66**	**79**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25b	**76**	**55**	**65**	**68**	**90**	**90**	**90**
Junction 2 (T-junction, 175 mm 5-ply CLT wall / 175 mm 5-ply CLT separating floor)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-335, Base-CLT05	42	32	30	39	43	52	49
Correction, Resonant Transmission				0.0	0.0	0.0	0.0	0.0	0.0
Change by Lining on source side	ΔR_F2	RR-335 , ΔTL-CLT05-W03		3	8	5	11	10	11
Change by Lining on receive side	ΔR_f2	RR-335 , ΔTL-CLT05-W03		3	8	5	11	10	11
Flanking Element F2 and f2: Transferred Data - In-situ									
Equivalent Absorption Length	alpha_situ	ISO 15712-1, 4.2.2		10.0	10.0	10.0	10.0	10.0	10.0
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	42	32.0	30.0	39.0	43.0	52.0	49.0
Junction J2 - Coupling									
Vibration Reduction Index for Ff	K_Ff,2	RR-335, CLT-FW-Ta-05		12.70	12.70	12.70	12.70	12.70	12.70
Vibration Reduction Index for Fd	K_Fd,2	RR-335, CLT-FW-Ta-05		6.70	6.70	6.70	6.70	6.70	6.70
Vibration Reduction Index for Df	K_Df,2	RR-335, CLT-FW-Ta-05		6.70	6.70	6.70	6.70	6.70	6.70
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25b	**77**	**58**	**66**	**69**	**85**	**90**	**90**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25b	**87**	**64**	**77**	**88**	**90**	**90**	**90**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25b	**74**	**53**	**63**	**66**	**89**	**90**	**90**
Junction 3 (Cross junction, 175 mm 5-ply CLT wall / 175 mm 5-ply CLT separating floor)									
All values the same as for Junction 1, including linings									
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25b	**81**	**62**	**70**	**73**	**89**	**90**	**90**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25b	**88**	**66**	**79**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25b	**76**	**55**	**65**	**68**	**90**	**90**	**90**
Junction 4 (Cross-junction, 175 mm 5-ply CLT wall / 175 mm 5-ply CLT separating floor)									
All input data the same as for Junction 2									
Junction coupling (vibration reduction index) same as Junctions 1 or 3									
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25b	**81**	**62**	**70**	**73**	**89**	**90**	**90**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25b	**88**	**67**	**80**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25b	**77**	**56**	**66**	**69**	**90**	**90**	**90**
Total Flanking STC (combined transmission for all flanking paths)			68						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**67**						

Summary for Section 3: Calculation for CLT Constructions

The worked examples 3.1 to 3.5 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 show the performance for two cases with "bare" CLT assemblies (Examples 3.1 and 3.4) and for three 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, wood framing, and absorptive material. Many other lining options are possible.

For the horizontal room pair, Examples 3.2 and 3.3 show typical improvements relative to Example 3.1. Even with the rather light 3-ply base separating wall assembly, the addition of a gypsum board lining screwed directly to wood furring on all wall surfaces (Example 3.2) brings the ASTC up to 50. Inspection of the path STC values in Example 3.2 shows that direct 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 62 and the overall ASTC to 56.

For a vertical room pair, Example 3.5 shows the improvement relative to Example 3.4 when some typical linings are added. The ASTC is increased to 67, and even higher values could be achieved by improvements to the linings on the floor or the walls of the room below.

4. Buildings with Lightweight Framed Wall and Floor Assemblies

The transmission of structure-borne vibration in a building with lightweight frame structure differs markedly from that in heavy homogeneous structures of concrete and masonry. There is both good news and bad news:

- For direct transmission through the separating assembly, the high internal loss factors result in minimal dependence on connection to the adjoining structures, so laboratory sound transmission values can be used without adjustment.
- For flanking transmission, a different approach is required – the calculation process is very simple, but it requires a new type of test 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 wood-framed floor assembly excited by a localized impact source, as presented in Figure 4.1.

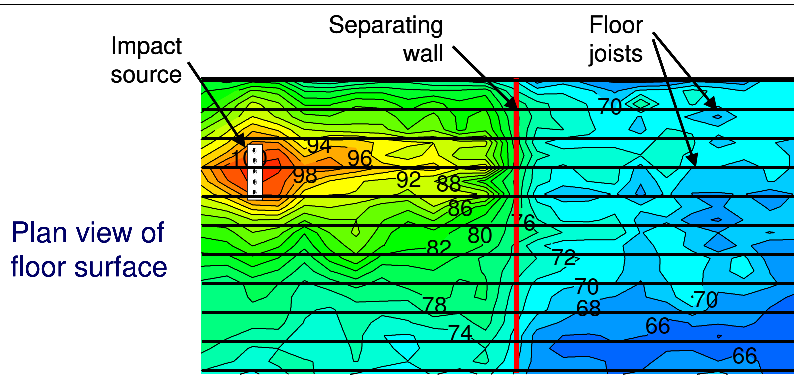


Figure 4.1: Variation across the floor surface of the vibration levels (2 kHz band) due to an impact source. The floor construction has a 19 mm plywood subfloor on wood joists that are perpendicular to the separating wall between the two side-by-side rooms.

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. Equations 1.5 in Section 1.4 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 adding a floor topping over the basic subfloor, or 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 on a floor) then its effect depends on 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.

While *fudge factors* can undoubtedly be developed to deal with flanking transmission by lightweight framed constructions within the framework of ISO 15712-1, it is inherently like fitting a square peg into a round hole. Hence, this Guide presents a calculation approach that uses test data from the ISO 10848-3 standard for measuring flanking transmission in lightweight construction when the junction has substantial influence. Fortunately, there is a significant accumulation of such test data for lightweight framed construction.

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 4.2.

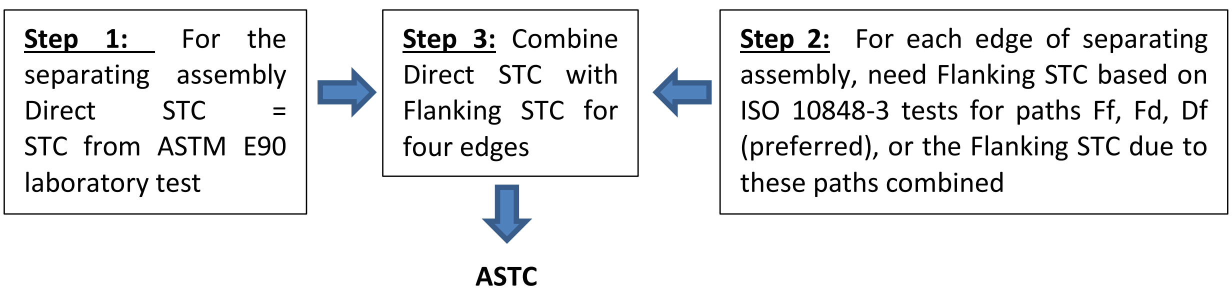


Figure 4.2: Steps to calculate the ASTC for lightweight framed construction (as detailed below). Note that this figure and the steps below are for the Simplified Method (which is used in the examples in this Section) but that the Detailed Method using 1/3-octave band data can also be used and provides slightly more reliable predictions.

Step 1: For the separating assembly, the Direct Path STC is equal to the STC measured in the laboratory according to ASTM E90

Step 2: Determine the Flanking STC for the set of surfaces connected at each edge of the separating assembly (i.e. via paths Ff, Fd, and Df):
- If data are available, use the Flanking STC for each of the 3 paths Ff, Fd and Df.
- If these data are in the form of $D_{n,f}$ values from ISO 10848-3, or measured values of Flanking TL, adjust them using Equations 1.5 from Section 1.4 of this Guide.
- If only data for combined transmission by the set of paths at a junction are available, those may be used for the calculation of ASTC. Data for the individual paths Ff, Fd and Df would provide more insight about which path(s) limit the ASTC, as shown in the following examples.

Step 3: Combine the transmission via the direct and flanking paths, using Equation 1.4 in Chapter 1 of this Guide (equivalent to Eq. 26 in Section 4.4 of ISO 15712-1), as follows:
- If the Flanking STC for any path is over 90, limit the value for these calculations.
- Round the final result to the nearest integer.

4.1. 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 10848-3 with some extensions), and can be performed using frequency band data or single number ratings, following the steps illustrated in Figure 4.2 above.

Previous publications from NRC have presented predicted ASTC values and a procedure based on the same prediction approach, but presented in tabular form. These publications include NRC Research Report RR-219, “Guide for Sound Insulation in Wood Frame Construction”, and Construction Technology Update 66. See the Reference Publications Section of this Guide for access details for those reports and the new expanded data compilation in NRC Research Report RR-336 “Apparent Sound Insulation in Wood-framed Buildings”.

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” 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, and pertinent information on the resulting sound transmission with various fire blocking details is provided in the NRC Research Reports RR-219 and RR-336.

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 near the beginning of Chapter 4 (see Figure 4.2).

Under the heading “Path STC / ASTC”, the examples present the values for transmission via specific paths (Direct STC for in-situ transmission loss of the separating wall or floor assembly, and Flanking STC for the set of paths at each junction) plus the overall Apparent STC (ASTC) for the combination of direct and flanking transmission via all paths.

Repeatability studies in the NRC test 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.

EXAMPLE 4.1.1 **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[2] filling the inter-stud cavities
- resilient metal channels[5] on one side, spaced 600 mm o.c.
- 1 layer of 16 mm fire-rated gypsum board[3] attached to the resilient channels[4] and 2 layers screwed directly to framing on the other side

Bottom Junction1 (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[2] 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[2] 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[3]) screwed directly to bottom of ceiling framing

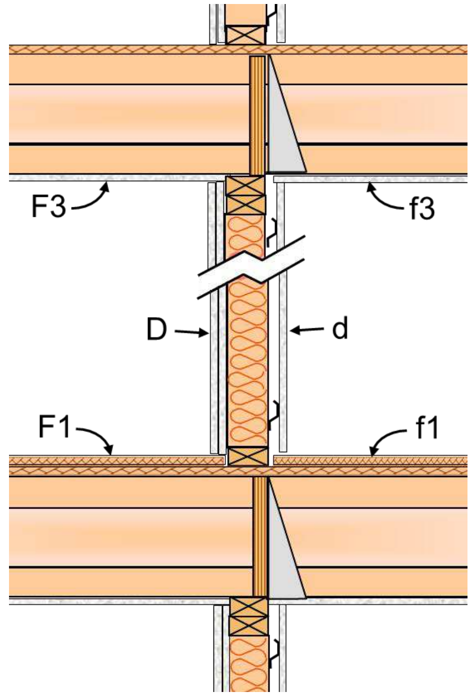
Side Junctions 2&4 (separating wall and abutting side walls) with:
- 1 layer of 16 mm fire-rated gypsum board[3] on side walls attached directly to framing and terminating at the separating wall;
- side wall framing with single row of wood studs spaced 400 mm o.c. with absorptive material[2] filling 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)

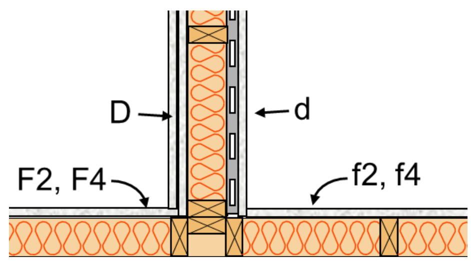
Note 2:

	In Scenario	In Laboratory
Separating partition area (m^2) =	12.5	10.4
Floor/separating wall junction length (m) =	5.0	4.6
Wall/separating wall junction length (m) =	2.5	2.26
Normalization For Junctions 1 and 3:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.44	Guide Eq. 1.5
Normalization For Junctions 2 & 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.36	Guide Eq. 1.5

Illustration for this case



Junction 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)

(See footnotes at end of document)

Separating Partition (Wood-framed separating wall)				
	Reference	**Lab (STC, etc.)**	**Path STC, ASTC**	
Lab. Sound Transmission Class (STC)	RR-336, TLW-13-WS89-001	53		
Effect of Airborne Flanking	No Leakage	0.0		
Direct STC in-situ (Path DD through separating wall)			**53**	
Junction 1 (Load-bearing junction, wood-framed separating wall / flanking floor assemblies)				
Flanking Path Ff_1				
Laboratory Flanking STC for Ff	RR-336, FTL-13-WS89-WF-LB-002	53.0		
Normalization correction	Guide, Eq. 1.5	0.4		
Flanking STC for path Ff_1		53.4	**53**	
Flanking Path Fd_1				
Laboratory Flanking STC for Fd	RR-336, FTL-13-WS89-WF-LB-002	56.0		
Normalization correction	Guide, Eq. 1.5	0.4		
Flanking STC for path Fd_1		56.4	**56**	
Flanking Path Df_1				
Laboratory Flanking STC for Df	RR-336, FTL-13-WS89-WF-LB-002	57.0		
Normalization correction	Guide, Eq. 1.5	0.4		
Flanking STC for path Df_1		57.4	**57**	
Flanking STC for Junction_1	Guide, Subset of Eq. 1.4	- 10*LOG10(10^-5.3 + 10^- 5.6 + 10^- 5.7) =		50
Junction 2 (wood-framed separating wall / flanking wall assemblies)				
Flanking Path Ff_2				
Laboratory Flanking STC for Ff	RR-336, FTL-13-WS89-WW-LB-001	70.0		
Normalization correction	Guide, Eq. 1.5	0.4		
Flanking STC for path Ff_2		70.4	**70**	
Flanking Path Fd_2				
Laboratory Flanking STC for Fd	RR-336, FTL-13-WS89-WW-LB-001	68.0		
Normalization correction	Guide, Eq. 1.5	0.4		
Flanking STC for path Fd_2		68.4	**68**	
Flanking Path Df_2				
Laboratory Flanking STC for Df	RR-336, FTL-13-WS89-WW-LB-001	69.0		
Normalization correction	Guide, Eq. 1.5	0.4		
Flanking STC for path Df_2		69.4	**69**	
Flanking STC for Junction_2	Guide, Subset of Eq. 1.4	- 10*LOG10(10^-7 + 10^- 6.8 + 10^- 6.9) =		64
Junction 3 (Load-bearing junction, wood-framed separating wall / flanking ceiling assemblies)				
Flanking Path Ff_3				
Laboratory Flanking STC for Ff	RR-336,FTL-13-WS89-WC-LB-001	65.0		
Normalization correction	Guide, Eq. 1.5	0.4		
Flanking STC for path Ff_3		65.4	**65**	
Flanking Path Fd_3				
Laboratory Flanking STC for Fd	RR-336,FTL-13-WS89-WC-LB-001	64.0		
Normalization correction	Guide, Eq. 1.5	0.4		
Flanking STC for path Fd_3		64.4	**64**	
Flanking Path Df_3				
Laboratory Flanking STC for Df	RR-336,FTL-13-WS89-WC-LB-001	79.0		
Normalization correction	Guide, Eq. 1.5	0.4		
Flanking STC for path Df_3		79.4	**79**	
Flanking STC for Junction_3	Guide, Subset of Eq. 1.4	- 10*LOG10(10^-6.5 + 10^- 6.4 + 10^- 7.9) =		61
Junction 4 (Wood-framed separating wall / flanking wall assemblies)				
All values the same as for Junction 2				
Flanking STC for Junction_4			**64**	64
Combined transmission via all Flanking Paths	Guide, Subset of Eq. 1.4 for 12 flanking paths		**50**	
ASTC due to Direct plus Flanking Transmission	Guide, Eq. 1.4 (Combine Direct and 12 Flanking Paths)		**48**	

EXAMPLE 4.1.2: SIMPLIFIED METHOD

- **Rooms side-by-side**
- **Wood-framed floors and walls**
- **Same structure as 4.1.1 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[2] filling the inter-stud cavities
- resilient metal channels[5] on one side, spaced 600 mm o.c.
- 2 layers of 16 mm fire-rated gypsum board[3] 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 glass fiber batts 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[2] in cavities between joists
- ceiling (1 layer of 13 mm regular gypsum board[3]) screwed directly to bottom of ceiling framing

Side Junctions 2&4 (separating wall and abutting side walls) with:
- 1 layer of 16 mm fire-rated gypsum board[3] 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[2] in cavities
- side wall framing structurally-connected to the separating wall, but continuous across junction (as illustrated)

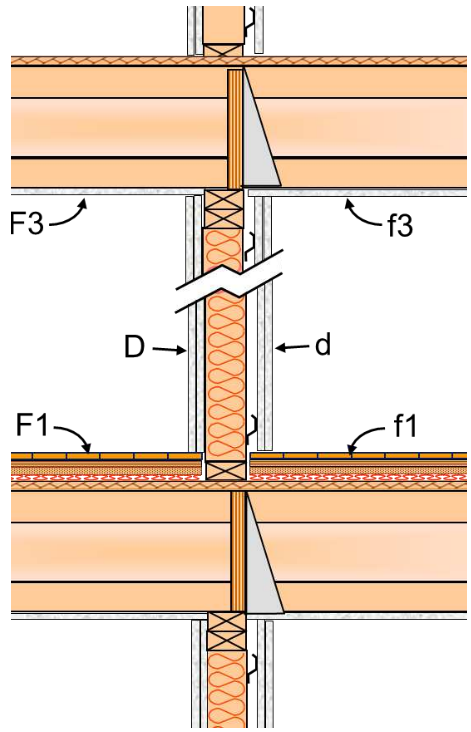
Note 1: For path/surface designations in the procedure below, treat the room at left as the source room (surfaces D and F)

Note 2:

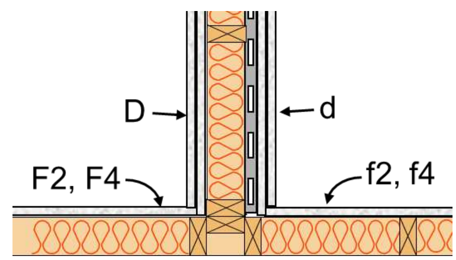
	In Scenario	In Laboratory
Separating partition area (m^2) =	12.5	10.4
Floor/separating wall junction length (m) =	5.0	4.6
Wall/separating wall junction length (m) =	2.5	2.26
Normalization For Junctions 1 and 3:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.44	Guide Eq. 1.5
Normalization For Junctions 2 & 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.36	Guide Eq. 1.5

(See footnotes at end of document)

Illustration for this case



Junction 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)

Separating Partition (Wood-framed separating wall)				
	Reference	**Lab (STC, etc.)**	**Path STC, ASTC**	
Lab. Sound Transmission Class (STC)	RR-336, TLW-13-WS89-001	57		
Effect of Airborne Flanking	No Leakage	0.0		
Direct STC in-situ (Path DD through separating wall)			**57**	
Junction 1 (Load-bearing junction, wood-framed separating wall / flanking floor assemblies)				
Flanking Path Ff_1				
Laboratory Flanking STC for Ff	RR-336, FTL-13-WS89-WF-LB-010	67.0		
Normalization correction	Guide Eq. 1.5	0.4		
Flanking STC for path Ff_1		67.4	**67**	
Flanking Path Fd_1				
Laboratory Flanking STC for Fd	RR-336, FTL-13-WS89-WF-LB-010	66.0		
Normalization correction	Guide Eq. 1.5	0.4		
Flanking STC for path Fd_1		66.4	**66**	
Flanking Path Df_1				
Laboratory Flanking STC for Df	RR-336, FTL-13-WS89-WF-LB-010	69.0		
Normalization correction	Guide Eq. 1.5	0.4		
Flanking STC for path Df_1		69.4	**69**	
Flanking STC for Junction_1	Guide, Subset of Eq. 1.4	- 10*LOG10(10^-6.7 + 10^- 6.6 + 10^- 6.9) =		62
Junction 2 (T-junction, wood-framed separating wall / flanking wall assemblies)				
Flanking Path Ff_2				
Laboratory Flanking STC for Ff	RR-336, FTL-13-WS89-WW-LB-010	70.0		
Normalization correction	Guide Eq. 1.5	0.4		
Flanking STC for path Ff_2		70.4	**70**	
Flanking Path Fd_2				
Laboratory Flanking STC for Fd	RR-336, FTL-13-WS89-WW-LB-010	68.0		
Normalization correction	Guide Eq. 1.5	0.4		
Flanking STC for path Fd_2		68.4	**68**	
Flanking Path Df_2				
Laboratory Flanking STC for Df	RR-336, FTL-13-WS89-WW-LB-010	71.0		
Normalization correction	Guide Eq. 1.5	0.4		
Flanking STC for path Df_2		71.4	**71**	
Flanking STC for Junction_2	Guide, Subset of Eq. 1.4	- 10*LOG10(10^-7 + 10^- 6.8 + 10^- 7.1) =		65
Junction 3 (Load-bearing junction, wood-framed separating wall / flanking ceiling assemblies)				
Flanking Path Ff_3				
Laboratory Flanking STC for Ff	RR-336, FTL-13-WS89-WC-LB-010	65.0		
Normalization correction	Guide Eq. 1.5	0.4		
Flanking STC for path Ff_3		65.4	**65**	
Flanking Path Fd_3				
Laboratory Flanking STC for Fd	RR-336, FTL-13-WS89-WC-LB-010	65.0		
Normalization correction	Guide Eq. 1.5	0.4		
Flanking STC for path Fd_3		65.4	**65**	
Flanking Path Df_3				
Laboratory Flanking STC for Df	RR-336, FTL-13-WS89-WC-LB-010	81.0		
Normalization correction	Guide Eq. 1.5	0.4		
Flanking STC for path Df_3		81.4	**81**	
Flanking STC for Junction_3	Guide, Subset of Eq. 1.4	- 10*LOG10(10^-6.5 + 10^- 6.5 + 10^- 8.1) =		62
Junction 4 (Cross-junction, wood-framed separating wall / flanking wall assemblies)				
All values the same as for Junction 2				
Flanking STC for Junction_4	Same as Junction 2		**65**	65
Combined transmission via all Flanking Paths	Guide, Subset of Eq. 1.4 for 12 flanking paths		**57**	
ASTC due to Direct plus Flanking Transmission	Guide, Eq. 1.4 (Combine Direct and 12 Flanking Paths)		**54**	

EXAMPLE 4.1.3 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[2] in cavities
- ceiling of 1 layer of 16 mm fire-rated gypsum board[3], attached to resilient metal channels[5] spaced 400 mm o.c.
- subfloor of oriented strand board (OSB) 19 mm thick
- no floor topping
- no floor covering

Junction 1&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[2] in wall cavities give equivalent flanking
- 16 mm fire-rated gypsum board[3] on side walls ends at floor/ceiling assembly; and is attached directly to wall framing

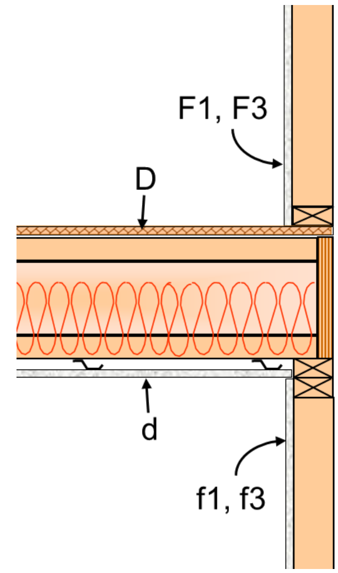
Junction 2&4 with non-loadbearing walls above and below floor) with:
- joists of floor assembly parallel to these walls
- wall framing of 38 mm x 89 mm wood studs spaced 400 mm o.c
- wall framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm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

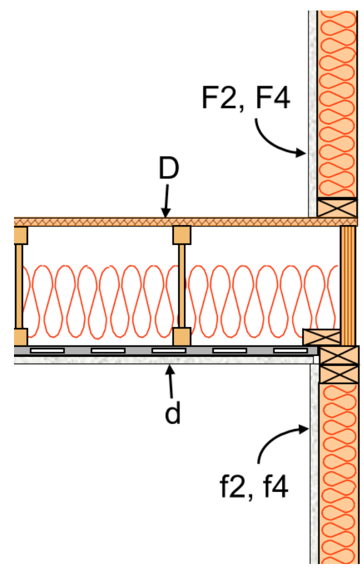
Note 2:

	In Scenario	In Laboratory
Separating partition area (m^2) =	20	19.6
Floor/separating wall junction length (m) =	5.0	4.58
Wall/separating wall junction length (m) =	4.0	4.58
Normalization For Junctions 1 and 3:		
For Fd, Df: $10*\log(S_{situ}/S_{lab}) + 10*\log(l_{lab}/l_{situ})$ =	-0.29	Guide Eq. 1.5
Normalization For Junctions 2 & 4:		
$10*\log(S_{situ}/S_{lab}) + 10*\log(l_{lab}/l_{situ})$ =	0.68	Guide Eq. 1.5

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)

(See footnotes at end of document)

Separating Partition (Wood-framed separating floor/ceiling)				
	Reference	**Lab (STC, etc.)**	**Path STC, ASTC**	
Lab. Sound Transmission Class (STC)	RR-336, TLF-13-WIJ305-001	51.0		
Effect of Airborne Flanking	No Leakage	0.0		
Direct STC in situ (Path DD through separating floor)			**51**	
Junction 1 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)				
Flanking Path Ff_1				
Laboratory Flanking STC for Ff	RR-336, FTL-13-WIJ305-FW-LB-001	64.0		
Normalization correction	Guide Eq. 1.5	-0.3		
Flanking STC for path Ff_1		63.7	**64**	
Flanking Path Fd_1				
Laboratory Flanking STC for Fd	RR-336, FTL-13-WIJ305-FW-LB-001	57.0		
Normalization correction	Guide Eq. 1.5	-0.3		
Flanking STC for path Fd_1		56.7	**57**	
Flanking Path Df_1				
Laboratory Flanking STC for Df	RR-336, FTL-13-WIJ305-FW-LB-001	90+		
Normalization correction	Guide Eq. 1.5	-0.3		
Flanking STC for path Df_1		90.0	**90**	
Flanking STC for Junction_1	Guide, Subset of Eq. 1.4	- 10*LOG10(10^-6.4 + 10^- 5.7 + 10^- 9) =		56
Junction 2 (Non-loadbearing junction, wood-framed separating floor / flanking wall assemblies)				
Flanking Path Ff_2				
Laboratory Flanking STC for Ff	RR-336, FTL-13-WIJ305-FW-NLB-001	64.0		
Normalization correction	Guide Eq. 1.5	0.7		
Flanking STC for path Ff_2		64.7	**65**	
Flanking Path Fd_2				
Laboratory Flanking STC for Fd	RR-336, FTL-13-WIJ305-FW-NLB-001	61.0		
Normalization correction	Guide Eq. 1.5	0.7		
Flanking STC for path Fd_2		61.7	**62**	
Flanking Path Df_2				
Laboratory Flanking STC for Df	RR-336, FTL-13-WIJ305-FW-NLB-001	90+		
Normalization correction	Guide Eq. 1.5	0.7		
Flanking STC for path Df_2		90.0	**90**	
Flanking STC for Junction_2	Guide, Subset of Eq. 1.4	- 10*LOG10(10^-6.5 + 10^- 6.2 + 10^- 9) =		60
Junction 3 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)				
All values the same as Junction 1				
Flanking STC for Junction_3	Same as Junction 1		**56**	56
Junction 4 (Non-loadbearing junction, wood-framed separating floor / flanking wall assemblies)				
All values the same as for Junction 2				
Flanking STC for Junction_4	Same as Junction 2		60	60
Combined transmission via all Flanking Paths	Guide, Subset of Eq. 1.4 for 12 flanking paths			52
ASTC due to Direct plus Flanking Transmission	Guide, Eq. 1.4 (Combine Direct and 12 Flanking Paths)		48	

EXAMPLE 4.1.4 **SIMPLIFIED METHOD**

- **Rooms one-above-the-other**
- **Wood-framed floors and walls**
  (Same structure as 4.1.3 + 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[2] in cavities
- ceiling of 1 layer of 16 mm fire-rated gypsum board[3], attached to resilient metal channels[5] 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

Junction 1&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[2] in wall cavities give equivalent flanking
- 16 mm fire-rated gypsum board[3] on side walls ends at floor/ceiling assembly; and is attached directly to wall framing

Junction 2&4 with non-loadbearing walls above and below floor) with:

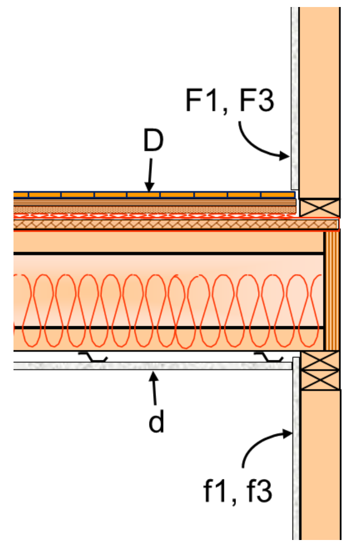
- joists of floor assembly parallel to these walls
- walls have 38 mm x 89 mm wood studs spaced 400 mm o.c
- wall framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates) with or without absorptive material[2] in wall cavities give equivalent flanking
- 16 mm fire-rated gypsum board[3] 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)

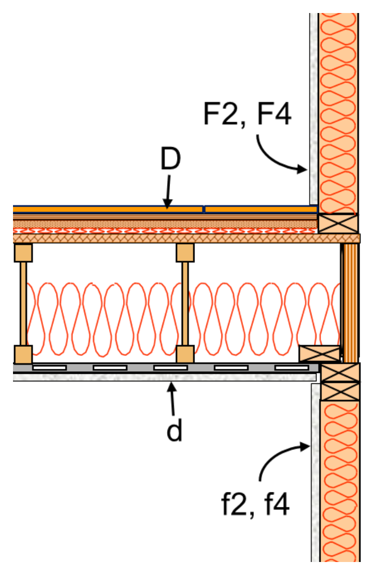
Note 2:

	In Scenario	In Laboratory
Separating partition area (m^2) =	20	19.6
Floor/separating wall junction length (m) =	5.0	4.58
Wall/separating wall junction length (m) =	4.0	4.58
Normalization For Junctions 1 and 3:		
For Fd, Df: $10*\log(S_{situ}/S_{lab}) + 10*\log(l_{lab}/l_{situ})$ =	-0.29	Guide Eq. 1.5
Normalization For Junctions 2 & 4:		
$10*\log(S_{situ}/S_{lab}) + 10*\log(l_{lab}/l_{situ})$ =	0.68	Guide Eq. 1.5

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)

(See footnotes at end of document)

Separating Partition (Wood-framed separating floor/ceiling)				
	Reference	Lab (STC, etc.)	Path STC, ASTC	
Lab. Sound Transmission Class (STC)	RR-336, TLF-13-WIJ305-011	66		
Effect of Airborne Flanking	No Leakage	0.0		
Direct STC in situ (Path DD through separating floor)			**66**	
Junction 1 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)				
Flanking Path Ff_1				
Laboratory Flanking STC for Ff	RR-336, FTL-13-WIJ305-FW-LB--010	64.0		
Normalization correction	Guide Eq. 1.5	-0.3		
Flanking STC for path Ff_1		63.7	**64**	
Flanking Path Fd_1				
Laboratory Flanking STC for Fd	RR-336, FTL-13-WIJ305-FW-LB--010	74.0		
Normalization correction	Guide Eq. 1.5	-0.3		
Flanking STC for path Fd_1		73.7	**74**	
Flanking Path Df_1				
Laboratory Flanking STC for Df	RR-336, FTL-13-WIJ305-FW-LB--010	90+		
Normalization correction	Guide Eq. 1.5	-0.3		
Flanking STC for path Df_1		90.0	**90**	
Flanking STC for Junction_1	Guide, Subset of Eq. 1.4	- 10*LOG10(10^-6.4 + 10^- 7.4 + 10^- 9) =		64
Junction 2 (Non-loadbearing junction, wood-framed separating floor / flanking wall assemblies)				
Flanking Path Ff_2				
Laboratory Flanking STC for Ff	RR-336, FTL-13-WIJ305-FW-NLB--010	64.0		
Normalization correction	Guide Eq. 1.5	0.7		
Flanking STC for path Ff_2		64.7	**65**	
Flanking Path Fd_2				
Laboratory Flanking STC for Fd	RR-336, FTL-13-WIJ305-FW-NLB--010	73.0		
Normalization correction	Guide Eq. 1.5	0.7		
Flanking STC for path Fd_2		73.7	**74**	
Flanking Path Df_2				
Laboratory Flanking STC for Df	RR-336, FTL-13-WIJ305-FW-NLB--010	90+		
Normalization correction	Guide Eq. 1.5	0.7		
Flanking STC for path Df_2		90.0	**90**	
Flanking STC for Junction_2	Guide, Subset of Eq. 1.4	- 10*LOG10(10^-6.5 + 10^- 7.4 + 10^- 9) =		64
Junction 3 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)				
All values the same as Junction 1				
Flanking STC for Junction_3	Same as Junction 1		**64**	64
Junction 4 (Non-loadbearing junction, wood-framed separating floor / flanking wall assemblies)				
All values the same as for Junction 2				
Flanking STC for Junction_4	Same as Junction 2		64	64
Combined transmission via all Flanking Paths	Guide, Subset of Eq. 1.4 for 12 flanking paths			58
ASTC due to Direct plus Flanking Transmission	Guide, Eq. 1.4 (Combine Direct and 12 Flanking Paths)		57	

EXAMPLE 4.1.5 **SIMPLIFIED METHOD**

- **Rooms one-above-the-other**
- **Wood-framed floors and walls**
  (Same structure as 4.1.3 + 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[2] in cavities
- ceiling of 1 layer of 16 mm fire-rated gypsum board[3], attached to resilient metal channels[5] 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

Junction 1&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[2] in wall cavities give equivalent flanking
- 16 mm fire-rated gypsum board[3] on side walls ends at floor/ceiling assembly; supported on resilient metal channels[5] that are spaced 600 mm o.c. and attached to wall framing

Junction 2&4 with non-loadbearing walls above and below floor) with:

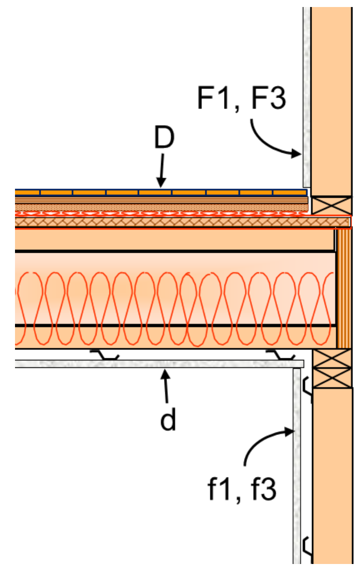
- joists of floor assembly parallel to these walls
- walls have 38 mm x 89 mm wood studs spaced 400 mm o.c
- wall framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates) with or without absorptive material[2] in wall cavities give equivalent flanking
- 16 mm fire-rated gypsum board[3] on side walls ends at floor/ceiling assembly; supported on resilient metal channels[5] 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)

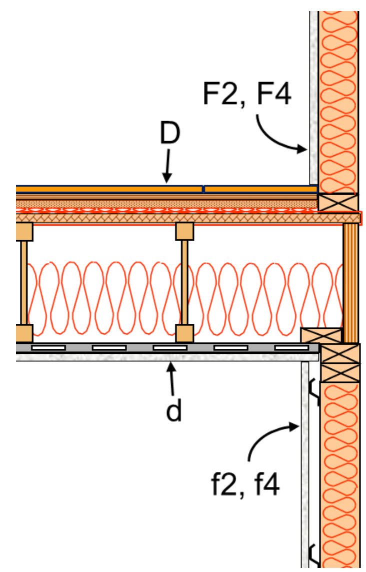
Note 2:

	In Scenario	In Laboratory
Separating partition area (m^2) =	20	19.6
Floor/separating wall junction length (m) =	5.0	4.58
Wall/separating wall junction length (m) =	4.0	4.58
Normalization For Junctions 1 and 3:		
For Fd, Df: $10*\log(S_{situ}/S_{lab}) + 10*\log(l_{lab}/l_{situ})$ =	-0.29	Guide Eq. 1.5
Normalization For Junctions 2 & 4:		
$10*\log(S_{situ}/S_{lab}) + 10*\log(l_{lab}/l_{situ})$ =	0.68	Guide Eq. 1.5

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)

(See footnotes at end of document)

Separating Partition (Wood-framed separating floor/ceiling)				
	Reference	**Lab (STC, etc.)**	**Path STC, ASTC**	
Lab. Sound Transmission Class (STC)	RR-336, TLF-13-WIJ305-011	66.0		
Effect of Airborne Flanking	No Leakage	0.0		
Direct STC in situ (Path DD through separating floor)			**66**	
Junction 1 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)				
Flanking Path Ff_1				
Laboratory Flanking STC for Ff	RR-336, FTL-13-WIJ305-FW-LB-011	80.0		
Normalization correction	Guide Eq. 1.5	-0.3		
Flanking STC for path Ff_1		79.7	**80**	
Flanking Path Fd_1				
Laboratory Flanking STC for Fd	RR-336, FTL-13-WIJ305-FW-LB-011	90+		
Normalization correction	Guide Eq. 1.5	-0.3		
Flanking STC for path Fd_1		90.0	**90**	
Flanking Path Df_1				
Laboratory Flanking STC for Df	RR-336, FTL-13-WIJ305-FW-LB-011	90+		
Normalization correction	Guide Eq. 1.5	-0.3		
Flanking STC for path Df_1		90.0	**90**	
Flanking STC for Junction_1	Guide, Subset of Eq. 1.4	- 10*LOG10(10^-8 + 10^- 9 + 10^- 9) =		79
Junction 2 (Non-loadbearing junction, wood-framed separating floor / flanking wall assemblies)				
Flanking Path Ff_2				
Laboratory Flanking STC for Ff	RR-336, FTL-13-WIJ305-FW-NLB-011	80.0		
Normalization correction	Guide Eq. 1.5	0.7		
Flanking STC for path Ff_2		80.7	**81**	
Flanking Path Fd_2				
Laboratory Flanking STC for Fd	RR-336, FTL-13-WIJ305-FW-NLB-011	90+		
Normalization correction	Guide Eq. 1.5	0.7		
Flanking STC for path Fd_2		90.0	**90**	
Flanking Path Df_2				
Laboratory Flanking STC for Df	RR-336, FTL-13-WIJ305-FW-NLB-011	90+		
Normalization correction	Guide Eq. 1.5	0.7		
Flanking STC for path Df_2		90.0	**90**	
Flanking STC for Junction_2	Guide, Subset of Eq. 1.4	- 10*LOG10(10^-8.1 + 10^- 9 + 10^- 9) =		80
Junction 3 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)				
All values the same as Junction 1				
Flanking STC for Junction_3	Same as Junction 1		**79**	79
Junction 4 (Non-loadbearing junction, wood-framed separating floor / flanking wall assemblies)				
All values the same as for Junction 2				
Flanking STC for Junction_4	Same as Junction 2		80	80
Combined transmission via all Flanking Paths	Guide, Subset of Eq. 1.4 for 12 flanking paths			74
ASTC due to Direct plus Flanking Transmission	Guide, Eq. 1.4 (Combine Direct and 12 Flanking Paths)		65	

EXAMPLE 4.1.6 **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 filling the inter-stud cavities of one row of studs
- 1 layer of 16 mm fire-rated gypsum board[3] on each side

Bottom Junction 1 (separating wall and floor) with:
- floor framed with 38x235 mm wood joists spaced 400 mm o.c., with joists oriented parallel to separating wall and framing not continuous across junction, with 150 mm thick absorptive material in cavities
- subfloor on both sides of oriented strand board (OSB) 19 mm thick, continuous across junction
- 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 in cavities between joists
- ceiling (2 layers of 16 mm fire-rated gypsum board[3]) supported on resilient metal channels[5] attached to bottom of joists on each side

Side Junctions 2&4 (separating wall and abutting side walls) with:
- 16 mm fire-rated gypsum board[3] on side walls ends at separating wall assembly; supported on resilient metal channels[5] attached to wall framing
- side wall framing with single row of wood studs with absorptive material filling stud cavities
- side wall framing structurally-connected to the separating wall, but continuous across junction (as illustrated)

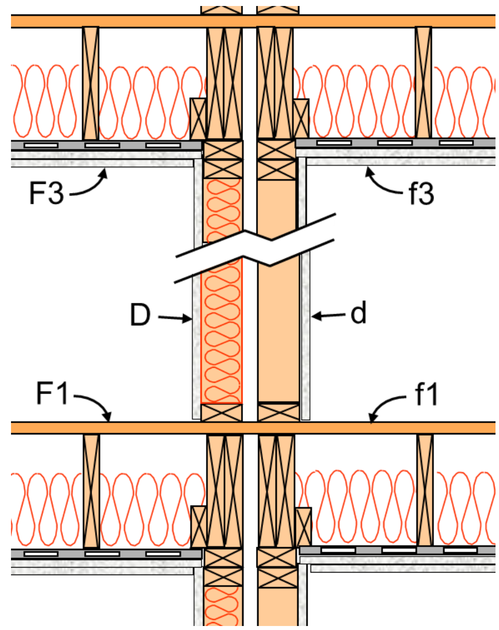
Note: For this case, individual path Flanking TL data are not available.

Direct and Flanking Sound Transmission:

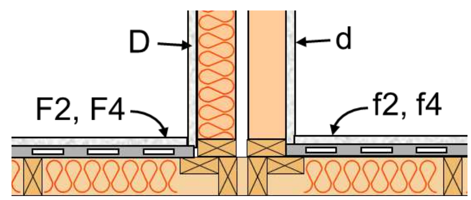
Path		**Path STC / ASTC**
Direct (Path Dd through separating wall) (RR-336, TLW-13-DWS203-001)		55
Bottom Junction 1, Flanking STC = (RR-336, FTL-13-DWS203-WF-NLB-001)	47	
Side wall Junction 2, Flanking STC = (RR-336, FTL-13-DWS203-WW-NLB-001)	65	
Top Junction 3, Flanking STC = (RR-336, FTL-13-DWS203-WC-NLB-001)	65	
Side wall Junction 4, Flanking STC = (RR-336, FTL-13-DWS203-WW-NLB-001)	65	
Combined Transmission via all Flanking Paths		46
Combined (all paths) ASTC		**46**

(See footnotes at end of document)

Illustration for this case



Junction 1 and 3 of non-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)

EXAMPLE 4.1.7 **SIMPLIFIED METHOD**

- **Rooms side-by-side**
- **Wood-framed floors and walls**
- **Same as 4.1.6 but with improved floor surface**

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 filling the inter-stud cavities of one row of studs
- 1 layer of 16 mm fire-rated gypsum board[3] on each side

Bottom Junction 1 (separating wall and floor) with:
- floor framed with 38x235 mm wood joists spaced 400 mm o.c., with joists oriented parallel to separating wall and framing not continuous across junction, with 150 mm thick absorptive material in cavities
- subfloor on both sides of oriented strand board (OSB) 19 mm thick, continuous across junction
- floor topping of 38 mm 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 in cavities between joists
- ceiling (2 layers of 16 mm fire-rated gypsum board[3]) supported on resilient metal channels[5] attached to bottom of joists on each side

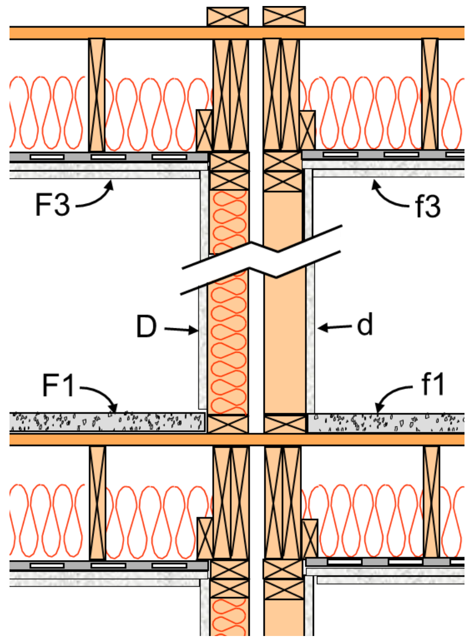
Side Junctions 2&4 (separating wall and abutting side walls) with:
- 16 mm fire-rated gypsum board[3] on side walls ends at separating wall and is supported on resilient metal channels[5] attached to studs
- side wall framing with single row of wood studs with absorptive material filling stud cavities
- side wall framing structurally-connected to the separating wall, but continuous across junction (as illustrated)

Note: For this case, individual path Flanking TL data are not available

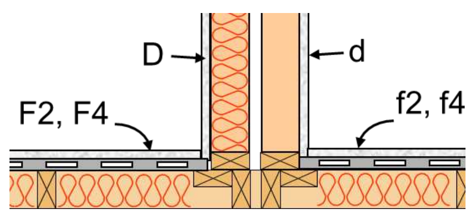
Direct and Flanking Sound Transmission:

Path		**Path STC / ASTC**
Direct (Path Dd through separating wall) (RR-336, TLW-13-DWS203-001)		55
Bottom Junction 1, Flanking STC = (RR-336, FTL-13-DWS203-WF-NLB-002)	61	
Side wall Junction 2, Flanking STC = (RR-336, FTL-13-DWS203-WW-NLB-001)	65	
Top Junction 3, Flanking STC = (RR-336, FTL-13-DWS203-WC-NLB-001)	65	
Side wall Junction 4, Flanking STC = (RR-336, FTL-13-DWS203-WW-NLB-001)	65	
Combined Transmission via all Flanking Paths		58
Combined (all paths) ASTC		**53**

Illustration for this case



Junction 1 and 3 of non-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)

(See footnotes at end of document)

(See footnotes at end of document)

Summary for Section 4.1: Wood-framed Walls and Floors

The worked examples 4.1.1 to 4.1.7 illustrate the calculation of sound transmission between rooms in a building with wood-framed floor and wall assemblies using the Simplified Method. The examples show improvements in direct and/or flanking transmission loss via specific paths due to selected changes in the surface layers of the walls and floors.

Example 4.1.2 for a horizontal pair of rooms separated by a single-stud wall shows improvements relative to the base case (4.1.1) 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 at the four junctions, and between direct transmission and flanking. The ASTC of 54 is near the maximum feasible with this wall construction.

Examples 4.1.4 and 4.1.5 for a vertical pair of rooms show the improvements relative to the base case (4.1.3) as the floor and walls surfaces are upgraded. As shown in 4.1.4, 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 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 10dB, but flanking still dominates the transmission in case 4.1.4. For all these wall/floor junctions, the dominant flanking is path Ff (wall above to wall below) with Df a weaker second concern. Changing surface f (walls in the room below) by mounting the gypsum board in the room below on resilient metal channels, as shown in 4.1.5, 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.

Examples 4.1.6 and 4.1.7 illustrate the effect of changing some surfaces for a horizontal pair of rooms separated by a double stud wall. The base case in 4.1.6 has a Direct STC of 55, but the ASTC is limited to 46 by flanking 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. If the continuous subfloor is essential for structural reasons, the flanking can be moderated by adding a floor topping as shown in 4.1.7, where the concrete topping improves the Flanking STC at the floor/wall junction from 47 to 61. The ASTC could be raised to the high 50's by doubling the gypsum board and insulation in the separating wall. Eliminating the rigid connection at the floor/wall junction using semi-rigid absorptive material as the fire block would permit the same changes in the wall to raise the ASTC over 65.

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

4.2. Lightweight Steel-Framed Wall and Floor Assemblies

For buildings with lightweight steel-framed walls and floor/ceiling assemblies, the calculation procedure outlined in the introductory section of Chapter 4 can be used in precisely the same manner as presented for wood-framed construction in Section 4.1.

This Section applies to buildings where the floors are framed with lightweight steel joists and the walls are framed with loadbearing steel studs, both formed from sheet steel. These 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 1/3-octave sound transmission data or single number ratings derived from that data, following the steps illustrated in Figure 4.2 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 10848-3 for the pairs of flanking surfaces at each edge of the separating assembly.

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 can be applied to one or more of the constructions, and those values can be combined with test results of flanking transmission (measured according to ISO 10848) or direct transmission through a separating wall or floor (measured according to ASTM E90) to predict the overall ASTC between a pair of adjacent rooms.

5.1. Concrete Floors with Steel-Framed Walls and Heavy or Lightweight Façade

Large cast-in-place concrete floors combined with lightweight framed wall assemblies are identified in ISO 15712-1 as a special concern for which the standard approach may become inaccurate. To ensure a reasonably conservative approach, this Guide recommends a more complex approach to the calculation procedure of ISO 15712-1 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 wall assemblies, the response of the heavy element is influenced by response of the extended structure, not only of the part visible in the room. This affects both cast-in-place concrete floors and other adjoining heavy elements such as concrete or masonry supporting walls which are "divided" by lightweight partitions. In this situation, 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, vibration attenuation at the intersection is small, so the heavy wall responds over an extended surface bounded by junctions to other heavy elements.

To obtain a conservative estimate, 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 transmission at junctions with lightweight walls. The Standard recommends calculating the in-situ loss in two ways – for the section of floor in one room, and for the extended floor area bounded by rigid junctions with heavy elements. The smaller of these two losses should then be used in the 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. This affects 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.
- Each pair of adjacent rooms has the same dimensions as the Standard Scenario used elsewhere in the Guide.
- At the perimeter are rigid T-junctions of the floor with façade walls above and below. Here, "rigid" means firmly fastened so that vibration can readily be transmitted between assemblies.

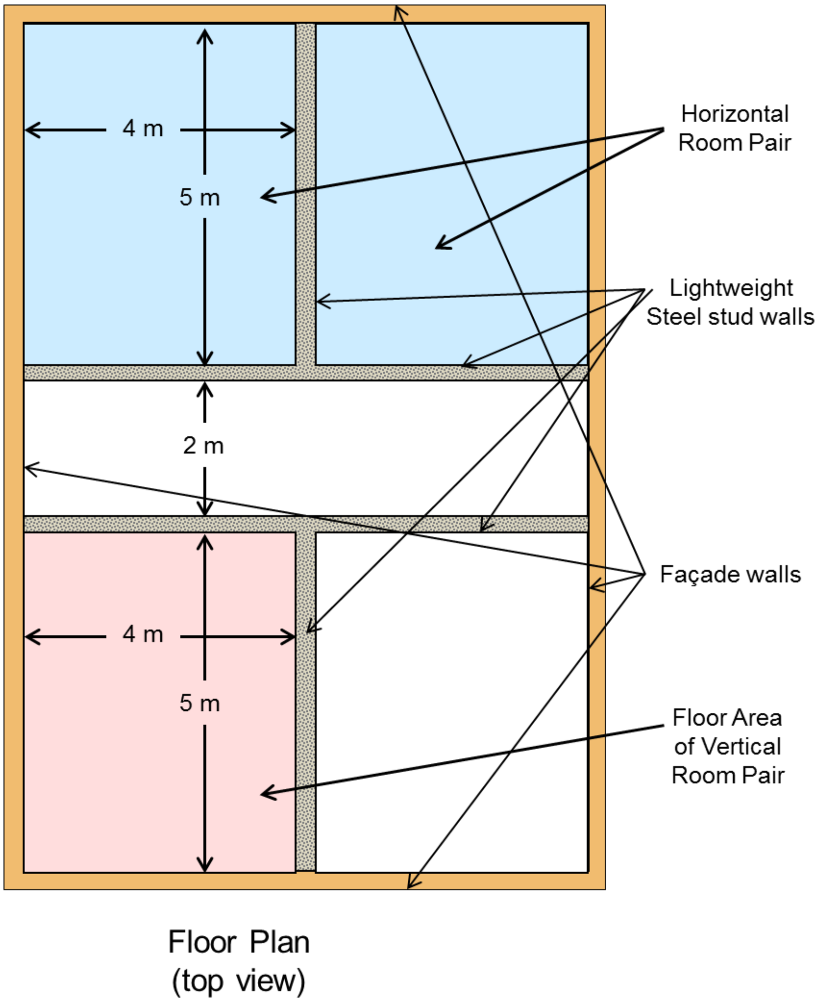


Figure 5.1: Extended Scenario for the case with concrete structural floors and rigid junctions with a facade wall at the perimeter of the floor. Lightweight framed interior walls divide the interior space into two pairs of adjacent rooms with a corridor between. The room pairs have the same dimensions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

For Examples 5.1.1 to 5.1.3, the façade wall is of heavy concrete or masonry. For examples 5.1.4 and 5.1.5, the façade wall is a much lighter glass curtain wall.

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

1. For direct transmission through the separating assembly of non-loadbearing steel studs[4], the calculation process is simple. The in-situ TL is equal to the laboratory TL values, 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 steel-framed walls in these examples could have either loadbearing or non-loadbearing studs[4]. Normally such assemblies would use non-loadbearing studs[4], but the same calculation can be used in either case. In either case, the top and bottom tracks of the wall framing are mechanically attached to the cast-in-place concrete floor/ceiling assemblies above and below. For non-loadbearing steel studs[4], 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 detail may also include a fire stop. These variations could reduce floor/wall flanking transmission slightly (i.e. give higher Flanking STC) but the calculations here ignore this effect because the rather weak coupling from the cast-in-place concrete floor/ceiling to the steel stud 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. However, the wall/wall paths are affected by differences between loadbearing or non-loadbearing studs[4]

3. For flanking at the cross-junctions of the cast-in-place concrete floor assembly with lightweight steel-framed separating walls (Junctions 1 and 3) the calculation steps are unchanged from those in Chapter 2, except that junction attenuations are calculated according to Eq. E.7 of ISO 15712-1, and the losses for the cast-in-place concrete slab are calculated differently. In-situ edge loss for the concrete floor or wall assemblies is calculated for the junctions at the perimeter of the extended surface, in accordance with Annex C of ISO 15712-1. This changes the calculated total loss for the concrete floor surfaces in each room, and hence in-situ TL and junction attenuation.
4. For flanking at the T-junction with the concrete block perimeter wall (Junction 2), 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 calculated loss for the concrete block flanking surfaces in each room, and hence the in-situ TL and the junction attenuation.
5. For flanking 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 TL (for paths Ff, Fd and Df) determined by measurements according to ISO 10848, as explained in Chapter 4.
6. The Direct TL and Flanking TL values are combined, as in Section 1.4 of this Guide.

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

1. For the separating cast-in-place 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. (See Annex C of ISO 15712-1.) This change affects the calculated total loss, and hence the in-situ TL and the in-situ attenuation at junctions with flanking walls at the four edges of the room.
2. For flanking transmission at the cross-junctions with the steel stud wall assemblies (Junctions 1 and 4), the calculation process is simpler. The in-situ TL for the wall is equal to laboratory TL, and the equivalent absorption length for subsequent junction calculations is taken as 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 TL follows the same process presented in Chapter 2.
3. For flanking transmission at the T-junction with the concrete block perimeter wall (Junctions 2 and 3 in the Extended Scenario), the calculation steps are unchanged from those in Chapter 2 except that the in-situ edge loss is calculated for the junctions at the perimeter of the extended surface area. (See Annex C.) This change affects the calculated total loss for the concrete block surfaces in each room, and hence the in-situ TL for the masonry surfaces and the resulting junction attenuation.
4. The Direct TL and Flanking TL values are combined, as in Section 1.4 of the Guide.

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, with extensions conforming to the Extended Scenario to allow for the response of the extended floor area to a more localized excitation. Calculations were performed using a mixture of the steps presented near the beginning of Chapters 2 and 4, as discussed in this Section. The changes in process and results due to 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 1/3-octave 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[4] of 1.37 mm thick steel, spaced 600 mm o.c., with absorptive material[2] filling the cavities between studs.
- 2 layers of 16 mm fire-rated gypsum board[3] attached directly to one side and supported on resilient metal channels[5] 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
- rigid cross junction with steel-framed[4] separating wall assembly.

Junction 2: Separating wall / abutting perimeter side wall) with:
- abutting wall of concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1])
- no lining of flanking walls

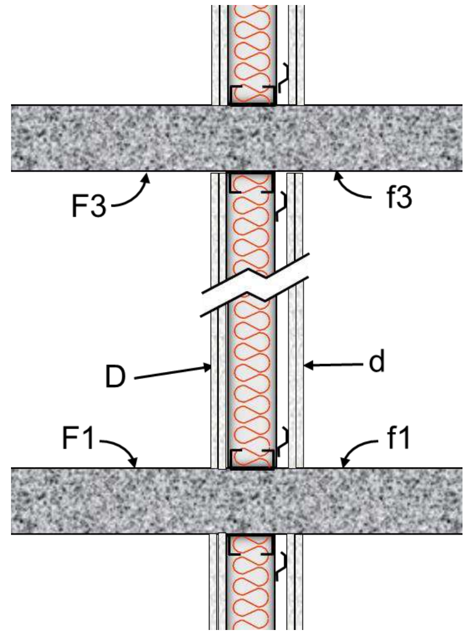
Junction 3: Top Junction (separating wall / ceiling) with:
- cast-in-place concrete ceiling slab with mass 345 kg/m^2 (e.g. normal weight concrete with thickness of 150 mm) with no ceiling lining
- cross junction with steel stud[4] separating wall assembly.

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

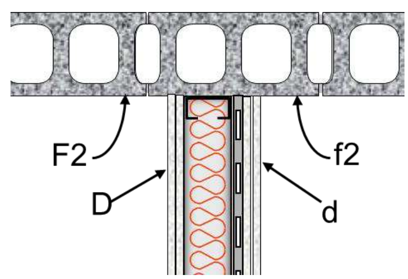
Acoustical Parameters:

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 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	6.497
Total loss, η_{tot}	ISO 15712-1, Eq. C.1		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		
Total loss, $\eta\_{tot,2}$	ISO 15712-1, Eq. C.1		0.089	(at 500 Hz)	

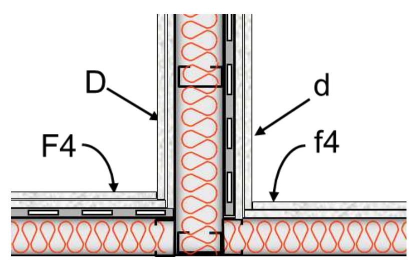
Illustration for this case



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).

(See footnotes at end of document)

Separating Partition (Steel stud wall)									
Input Data	ISO Symbol	Reference	STC, ASTC, etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_D,lab	RR-337,	58	38	50	58	61	55	63
Transferred Data In-situ		2G16_SS(LB)152_GFB150_RC13_2G16							
Equivalent Absorption Length	alpha_D,situ	4.2.2: Equal to wall area		12.5	12.5	12.5	12.5	12.5	12.5
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	4.2.2: Equal to lab. TL	**58**	**38**	**50**	**58**	**61**	**55**	**63**
Junction 1 (Cross junction, steel stud separating wall / 150 mm concrete floor)									
Flanking Element F1 and f1: Input	ISO Symbol	Reference	STC, ASTC, etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_F1,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.439	0.369	0.250	0.205	0.146	0.077
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.178	0.124	0.085	0.058	0.038	0.025
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		20.3	20.7	21.3	22.2	23.6	25.6
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	58	43.9	46.7	54.7	63.5	71.8	79.9
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	58	43.9	46.7	54.7	63.5	71.8	79.9
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		3.1	3.2	3.3	3.5	3.7	4.1
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		20.8	21.9	22.9	24.0	25.1	26.3
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		20.8	21.9	22.9	24.0	25.1	26.3
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**59**	**45**	**48**	**56**	**65**	**73**	**82**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**80**	**61**	**69**	**78**	**85**	**88**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**80**	**61**	**69**	**78**	**85**	**88**	**90**
Junction 2 (T-Junction, steel stud separating wall / 190 mm concrete block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-334, NRC Mean BLK190(NW)	49	35	38	44	50	58	62
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.106	0.073	0.049	0.033	0.021	0.013
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		17.1	17.6	18.4	19.6	21.3	23.9
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	53	39.5	42.2	47.8	53.4	61.0	64.5
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	53	39.5	42.2	47.8	53.4	61.0	64.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		5.3	5.5	5.7	5.9	6.3	6.8
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		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		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	**59**	**46**	**49**	**54**	**60**	**68**	**72**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**80**	**61**	**70**	**77**	**83**	**85**	**90**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**80**	**61**	**70**	**77**	**83**	**85**	**90**
Junction 3 (Cross junction, steel stud separating wall / 150 mm concrete ceiling)									
All values the same as for Junction 1, except linings									
Change by Lining on source side	ΔR_F3	No Lining ,		0.0	0.0	0.0	0.0	0.0	0.0
Change by Lining on receive side	ΔR_f3	No Lining ,		0.0	0.0	0.0	0.0	0.0	0.0
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25a	**57**	**44**	**47**	**54**	**61**	**68**	**79**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**79**	**60**	**69**	**77**	**84**	**85**	**90**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25a	**79**	**60**	**69**	**77**	**84**	**85**	**90**
Junction 4 (T-junction, steel stud separating wall / steel stud flanking corridor wall)									
Flanking Transmission Loss - Measured									
Flanking TL for Path Ff_4	R_Ff	RR-337, SS(LB)150-WW-01	**82**	**63**	**79**	**85**	**90**	**78**	**90**
Flanking TL for Path Fd_4	R_Fd	RR-337, SS(LB)150-WW-01	**82**	**67**	**75**	**85**	**90**	**78**	**90**
Flanking TL for Path Df_4	R_Df	RR-337, SS(LB)150-WW-01	**76**	**65**	**68**	**77**	**81**	**72**	**83**
Total Flanking STC (combined transmission for all flanking paths)			53						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**52**						

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[4] of 1.37 mm thick steel, spaced 600 mm o.c., with absorptive material[2] filling the cavities between studs.
- 2 layers of 16 mm fire-rated gypsum board[3] attached directly to one side and supported on resilient metal channels[5] 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 lightweight steel-framed separating wall assembly.

Junction 2: Separating wall / abutting perimeter side wall) with:
- abutting side wall of concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1])
- lining of one layer of 16 mm fire-rated gypsum board[3] on 65 mm steel studs spaced 600 mm o.c., with no absorptive material[2] 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[3] fastened to hat-channels supported on cross-channels hung on wires, cavity of 150 mm between concrete and ceiling, with 150 mm absorptive material[2]
- cross junction with steel-framed[4] separating wall assembly.

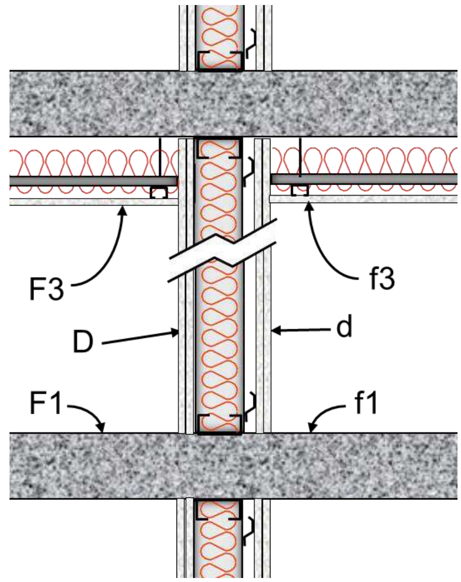
Junction 4: Separating wall / abutting corridor wall with:
- abutting corridor wall with non-loadbearing 90 mm steel studs[4] of 0.46 mm thick steel, with two layers of fire-rated gypsum board on each side, mounted on resilient metal channels[5] in one room.
- Rigid T-junction with steel stud[4] separating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

Acoustical Parameters:

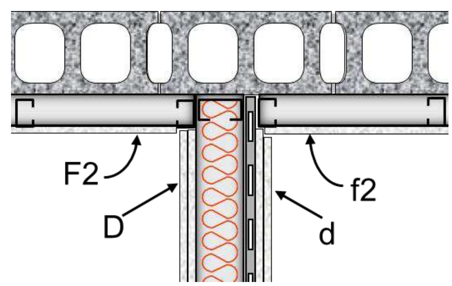
For separating assembly:					
internal loss, η_i =	dominant (same loss for laboratory and in-situ, See 4.2.2)				
mass (kg/m²) =	56.8	f_c =	2500		
For Flanking Corridor Wall:	Parameters the same except mass = 46 kg/m²				
For flanking elements F and f at Junction 1 & 3	(Extended Concrete floor and ceiling)				
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	6.497
Total loss, η_{tot}	ISO 15712-1, Eq. C.1		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		
Total loss, $\eta_{tot,2}$	ISO 15712-1, Eq. C.1		0.089	(at 500 Hz)	

(See footnotes at end of document)

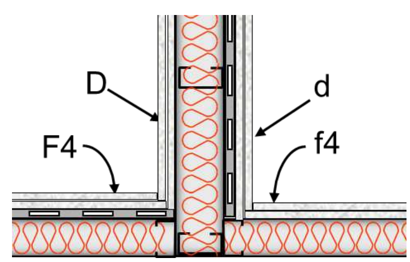
Illustration for this case



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).

Separating Partition (Non-loadbearing steel stud wall)									
Input Data	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_D,lab	RR-337,	58	38	50	58	61	55	63
Transferred Data - In-situ		2G16_SS(LB)152_GFB150_RC13_2G16							
Equivalent Absorption Length	alpha_D,situ	4.2.2: Equal to wall area		12.5	12.5	12.5	12.5	12.5	12.5
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	4.2.2: Equal to lab. TL	**58**	**38**	**50**	**58**	**61**	**55**	**63**
Junction 1 (Cross junction, steel stud separating wall / 150 mm concrete floor)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.439	0.369	0.250	0.205	0.146	0.077
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.178	0.124	0.085	0.058	0.038	0.025
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		20.3	20.7	21.3	22.2	23.6	25.6
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	58	43.9	46.7	54.7	63.5	71.8	79.9
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	58	43.9	46.7	54.7	63.5	71.8	79.9
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		3.1	3.2	3.3	3.5	3.7	4.1
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		20.8	21.9	22.9	24.0	25.1	26.3
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		20.8	21.9	22.9	24.0	25.1	26.3
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**59**	**45**	**48**	**56**	**65**	**73**	**82**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**80**	**61**	**69**	**78**	**85**	**88**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**80**	**61**	**69**	**78**	**85**	**88**	**90**
Junction 2 (T-Junction, steel stud separating wall / 190 mm concrete block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-334, NRC Mean BLK190(NW)	49	35	38	44	50	58	62
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.106	0.073	0.049	0.033	0.021	0.013
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		17.1	17.6	18.4	19.6	21.3	23.9
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	53	39.5	42.2	47.8	53.4	61.0	64.5
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	53	39.5	42.2	47.8	53.4	61.0	64.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		5.3	5.5	5.7	5.9	6.3	6.8
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		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		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	**62**	**38**	**65**	**82**	**90**	**90**	**90**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**81**	**57**	**78**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**81**	**57**	**78**	**90**	**90**	**90**	**90**
Junction 3 (Cross junction, steel stud separating wall / 150 mm concrete ceiling)									
All values the same as for Junction 1, except linings									
Change by Lining on source side	ΔR_F3	No Lining ,		0.0	0.0	0.0	0.0	0.0	0.0
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	**76**	**52**	**68**	**78**	**85**	**90**	**90**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**79**	**60**	**69**	**77**	**84**	**85**	**90**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25a	**89**	**68**	**90**	**90**	**90**	**90**	**90**
Junction 4 (T-junction, steel stud separating wall / steel stud flanking corridor wall)									
Flanking Transmission Loss - Measured									
Flanking TL for Path Ff_4	R_Ff	RR-337, SS(LB)150-WW-01	**82**	**63**	**79**	**85**	**90**	**78**	**90**
Flanking TL for Path Fd_4	R_Fd	RR-337, SS(LB)150-WW-01	**82**	**67**	**75**	**85**	**90**	**78**	**90**
Flanking TL for Path Df_4	R_Df	RR-337, SS(LB)150-WW-01	**76**	**65**	**68**	**77**	**81**	**72**	**83**
Total Flanking STC (combined transmission for all flanking paths)			58						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**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[4] of 1.37 mm thick steel, spaced 600 mm o.c., with absorptive material[2] filling the cavities between studs.
- 2 layers of 16 mm fire-rated gypsum board[3] attached directly to one side and supported on resilient metal channels[5] 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 concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate1) with no lining of walls.

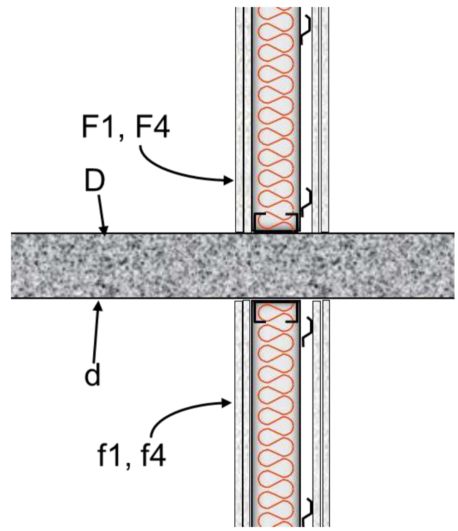
Junction 4: Junction of separating floor / corridor wall with:

- non-loadbearing 90 mm steel studs[4] 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[5] on the other side (total weight per unit area of 46 kg/m^2). .

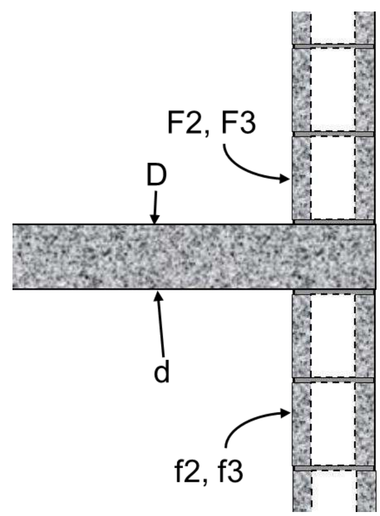
Acoustical Parameters:

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	6.497
Total loss, η_tot	ISO 15712-1, Eq. C.1		0.052	(at 500 Hz)	
Similarly, for masonry flanking elements 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		
Total loss, η_tot,2	ISO 15712-1, Eq. C.1		0.089	(at 500 Hz)	
Total loss, η_tot,3	ISO 15712-1, Eq. C.1		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)					
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).

(See footnotes at end of document)

Separating Partition (150 mm concrete floor)									
Input Data	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_D,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.44	0.37	0.25	0.21	0.15	0.08
Radiation Efficiency				1	1	1	1	1	1
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 Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.178	0.124	0.085	0.058	0.038	0.025
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		20.3	20.6	21.3	22.0	23.8	25.5
Effect of Airborne Flanking		No leakage		0	0	0	0	0	0
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**58**	**44**	**47**	**55**	**63**	**72**	**80**
Junction 1 (Cross junction, 150 mm concrete floor / steel stud flanking wall)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-337, SS(LB)150-WW-01, Dd(LB)	58	38	50	58	61	55	63
Equivalent Absorption Length	alpha_situ	4.2.2: Equal to wall area		12.5	12.5	12.5	12.5	12.5	12.5
TL in-situ for F1	R_F1,situ	4.2.2: Equal to lab. TL	58	38.0	50.0	58.0	61.0	55.0	63.0
TL in-situ for f1	R_f1,situ	4.2.2: Equal to lab. TL	58	38.0	50.0	58.0	61.0	55.0	63.0
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		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		20.8	21.9	22.9	24.0	25.2	26.3
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		20.8	21.9	22.9	24.0	25.2	26.3
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**88**	**72**	**83**	**90**	**90**	**85**	**90**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**82**	**63**	**71**	**80**	**87**	**90**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**82**	**63**	**71**	**80**	**87**	**90**	**90**
Junction 2 (Rigid T-Junction, 150 mm concrete floor / 190 mm concrete block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	RR-334, NRC Mean BLK190(NW)	49	35.0	38.0	44.0	50.0	58.0	62.0
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.106	0.073	0.049	0.033	0.021	0.013
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		17.1	17.6	18.4	19.6	21.3	23.9
TL in-situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	53	39.5	42.2	47.8	53.4	61.0	64.5
TL in-situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	53	39.5	42.2	47.8	53.4	61.0	64.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		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		12.5	12.6	12.7	13.0	13.3	13.7
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		12.5	12.6	12.7	13.0	13.3	13.7
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**71**	**57**	**60**	**66**	**71**	**79**	**83**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**70**	**56**	**59**	**66**	**73**	**81**	**87**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**70**	**56**	**59**	**66**	**73**	**81**	**87**
Junction 3 (Rigid T-junction, 150 mm concrete ceiling / 190 mm concrete block flanking wall)									
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	**69**	**56**	**59**	**65**	**70**	**78**	**82**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**69**	**55**	**58**	**65**	**72**	**80**	**86**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25a	**69**	**55**	**58**	**65**	**72**	**80**	**86**
Junction 4 (Cross-Junction, 150 mm concrete floor / steel stud flanking wall)									
Like Junction 1, but different studs and junction length change Flanking TL									
Flanking Element F4 and f4: Transferred Data In-situ		RR-337, SS(LB)150-WW-01, Dd(NLB)							
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	58	35.0	50.0	62.0	69.0	60.0	62.0
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	58	35.0	50.0	62.0	69.0	60.0	62.0
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**89**	**71**	**85**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**84**	**63**	**73**	**84**	**90**	**90**	**90**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**84**	**63**	**73**	**84**	**90**	**90**	**90**
Total Flanking STC (combined transmission for all flanking paths)			62						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	56						

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 cast-in-place concrete floor assembly, the loss calculation changes from what is presented earlier in Section 5.1 because 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 coupled facade assemblies. In addition, losses to the lightweight interior stud partitions (ignored, as recommended in ISO 15712-1, when performing the loss calculation for the floor coupled to the heavy façade) become significant. Thus with the lightweight façade, losses via all junctions with lightweight assemblies (curtain wall and internal gypsum board partitions) over the extended surface area of the cast-in-place concrete floor/ceiling are included. (See Annex C of ISO 15712-1.) This changes the total losses for the concrete assembly which causes lower in-situ TL for these concrete surfaces.
3. The calculation of losses to connected assemblies depends on the critical frequency of the attached assemblies. For the gypsum board interior partitions, this is taken as 2500 Hz (evident from the transmission loss curves). For the curtain wall, the mean of the critical frequencies for the two types of glass (1425 Hz) in the tested curtain wall is used.
4. For flanking via the curtain wall façade surfaces, the calculation is greatly simplified relative to that for a heavy concrete or masonry facade. The Flanking TL can be taken directly from the values of $D_{n,f}$ measured according to ISO 10848, with re-normalization according to Equation 1.5 in Section 1.4 of this Guide.

The data used here 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 8mm glass on one face and laminated glass (two layers of 5mm glass with elastomeric interlayer) on the other face. The air cavity depth between panes is 18±2 mm.

These data were measured using the procedures of ISO 10140 and ISO 10848 and are used here, with permission, to illustrate the effect of such a lightweight façade on the calculations of ISO 15712-1.

	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 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 4.8 m	47	36.1	35.5	42.4	50.0	50.4	53.4

—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.

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, with extensions conforming to the Extended Scenario to allow for the response of the extended floor area to a more localized excitation. Calculations were performed using a mixture 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 1/3-octave 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 5.1.4: 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 facade**

Separating framed wall assembly with:

- one row of loadbearing 152 mm steel studs[4] of 1.37 mm thick steel, spaced 600 mm o.c., with absorptive material[2] filling the cavities between studs.
- 2 layers of 16 mm fire-rated gypsum board[3] attached directly to one side and supported on resilient metal channels[5] 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[3] fastened to hat-channels supported on cross-channels hung on wires, 150 mm between concrete and ceiling, with 150 mm absorptive material[2]
- cross junction with steel-framed separating wall assembly.

Junction 4: Separating wall / abutting corridor wall with:

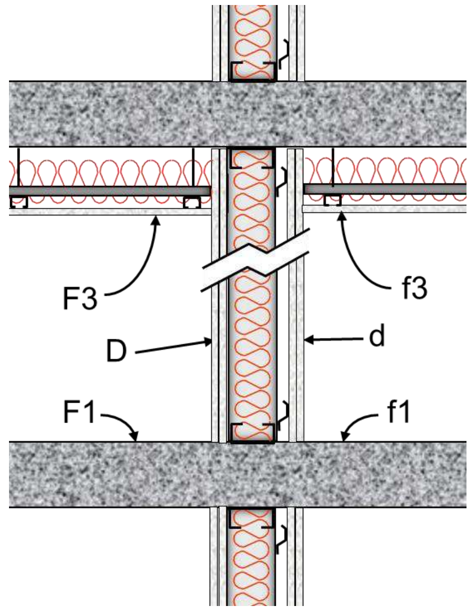
- abutting corridor wall with non-loadbearing 90 mm steel studs[4] of 0.46 mm thick steel, with two layers of fire-rated gypsum board on each side, mounted on resilient metal channels[5] in one room.

Acoustical Parameters:

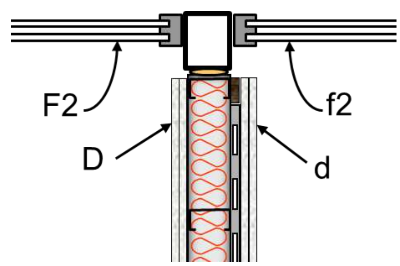
For separating assembly:					
internal loss, η_i =	dominant (same loss for laboratory and in-situ, See 4.2.2)				
mass (kg/m²) =	56.8	f_c =	2500		
For Flanking Corridor Wall:	Parameters the same except mass = 46 kg/m²				
For flanking elements F and f at Junction 1 & 3	(Extended Concrete floor and ceiling)				
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 wa	ISO 15712-1, Eq. 23 & E.7	-3.0	17.8	17.8	1.364
For extended concrete floor or ceiling slab,					
Total loss, η_{tot} =	ISO 15712-1, Eq. C.1		0.026	(at 500 Hz)	
For flanking elements F and f at Junction 2 (Lightweight Curtain Wall Facade)					
internal loss, η_i =	dominant (same loss for laboratory and in-situ, See 4.2.2)				
mass (kg/m²) =	50	f_c =	1425		

(See footnotes at end of document)

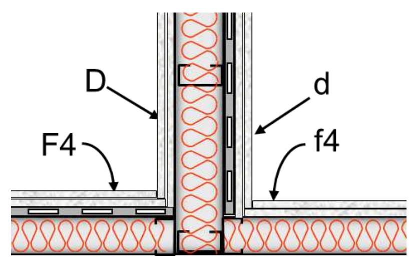
Illustration for this case



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).

Separating Partition (Non-loadbearing steel stud wall)									
Input Data	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_D,lab	RR-337,	58	38	50	58	61	55	63
Transferred Data - In-situ		2G16_SS(LB)152_GFB150_2G16							
Equivalent Absorption Length	alpha_D,situ	4.2.2: Equal to wall area		12.5	12.5	12.5	12.5	12.5	12.5
Effect of Airborne Flanking		No leakage		0	0	0	0	0	0
Direct TL in-situ	R_D,situ	4.2.2: Equal to lab. TL	**58**	**38**	**50**	**58**	**61**	**55**	**63**
Junction 1 (Cross junction, steel stud separating wall / 150 mm concrete floor)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.439	0.369	0.250	0.205	0.146	0.077
Radiation Efficiency	σ			1.00	1.00	1.00	1.00	1.00	1.00
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
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.374	0.255	0.171	0.111	0.070	0.043
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		9.7	10.0	10.6	11.5	12.9	14.9
TL in-situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	55	40.7	43.6	51.7	60.7	69.2	77.5
TL in-situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	55	40.7	43.6	51.7	60.7	69.2	77.5
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		0.00	0.01	0.26	0.63	1.12	1.74
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		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		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	**53**	**39**	**42**	**50**	**59**	**68**	**77**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**77**	**58**	**66**	**75**	**82**	**85**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**77**	**58**	**66**	**75**	**82**	**85**	**90**
Junction 2 (T-Junction, steel stud separating wall / glazed curtain wall facade)									
Flanking Element F2 and f2: Input Data									
Horizontal flanking (measured)	D_n, f	CSTB, Acoubat example	52	42.3	46.8	51.8	46.9	59.1	59.4
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. 1.4	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Flanking Transmission Loss - Path data									
Flanking TL forJunction_2		Guide, Section 1.4	**53**	**43**	**48**	**53**	**48**	**60**	**60**
Junction 3 (Cross junction, steel stud separating wall / 150 mm concrete ceiling)									
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	**79**	**55**	**84**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**89**	**66**	**87**	**90**	**90**	**90**	**90**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25a	**89**	**66**	**87**	**90**	**90**	**90**	**90**
Junction 4 (T-junction, steel stud separating wall / steel stud flanking corridor wall)									
Flanking Transmission Loss - measured									
Flanking TL for Path Ff_4	R_Ff	RR-337, SS(LB)150-WW-01	**82**	**64**	**79**	**86**	**90**	**78**	**90**
Flanking TL for Path Fd_4	R_Fd	RR-337, SS(LB)150-WW-01	**82**	**68**	**76**	**85**	**90**	**78**	**90**
Flanking TL for Path Df_4	R_Df	RR-337, SS(LB)150-WW-01	**76**	**65**	**68**	**78**	**81**	**72**	**83**
Total Flanking STC (combined transmission for all flanking paths)			50						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**49**						

EXAMPLE 5.1.5: **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 facade**

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[4] of 1.37 mm thick steel, spaced 600 mm o.c., with absorptive material[2] filling the cavities between studs.
- 2 layers of 16 mm fire-rated gypsum board[3] attached directly to one side and supported on resilient metal channels[5] on the other side (total weight per unit area of 56.8 kg/m^2).
-

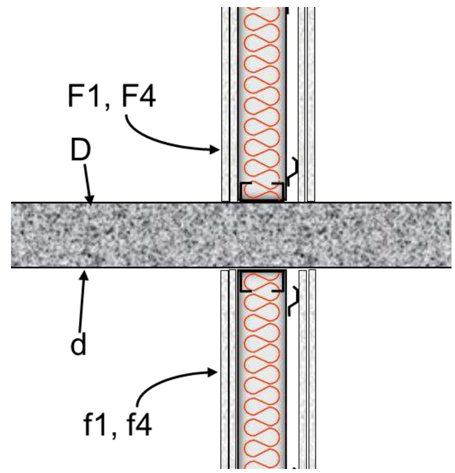
Junction 2 and 3: T-Junction of separating floor / flanking wall with:
- perimeter glass curtain wall façade assemblies connected to the floor structure as specified by manufacturer
- wall above and below floor is glass curtain wall with aluminum frame elements and double glazing with 8mm glass on one 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[4] 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[5] on the other side (total weight per unit area of 46 kg/m^2).

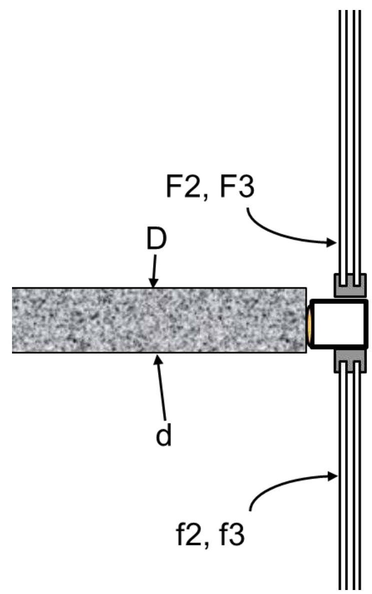
Acoustical Parameters:

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. E.3	25.7	17.8	17.8	1.354
For extended concrete floor/ceiling slab,					
Total loss, η_{tot}	ISO 15712-1, Eq. C.1		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)					
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 facade.
(Side view of Junction 2 and 3).

(See footnotes at end of document)

Separating Partition (150 mm concrete floor)									
Input Data	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_D,lab	RR-333, CON150, TLF-15-045	53	40	42	50	58	66	75
Structural Reverberation Time	T_s,lab	Measured T_s		0.439	0.369	0.250	0.205	0.146	0.077
Radiation Efficiency				1	1	1	1	1	1
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 Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.375	0.256	0.171	0.111	0.070	0.043
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		9.6	10.0	10.6	11.5	12.9	14.9
Effect of Airborne Flanking		No leakage		0	0	0	0	0	0
Direct TL in-situ	R_D,situ	ISO 15712-1, Eq. 24	**55**	**41**	**44**	**52**	**61**	**69**	**78**
Junction 1 (Cross junction, 150 mm concrete / steel stud flanking wall)									
Flanking Element F1 and f1: Input	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-337, SS(LB)150-WW-01, Dd(LB)	58	38	50	58	61	55	63
Equivalent Absorption Length	alpha_situ	4.2.2: Equal to wall area		12.5	12.5	12.5	12.5	12.5	12.5
TL in-situ for F1	R_F1,situ	4.2.2: Equal to lab. TL	58	38.0	50.0	58.0	61.0	55.0	63.0
TL in-situ for f1	R_f1,situ	4.2.2: Equal to lab. TL	58	38.0	50.0	58.0	61.0	55.0	63.0
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		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		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		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	**88**	**72**	**83**	**90**	**90**	**85**	**90**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**79**	**60**	**68**	**77**	**85**	**87**	**90**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**79**	**60**	**68**	**77**	**85**	**87**	**90**
Junction 2 (T-Junction, 150 mm concrete / glass curtain wall)									
Flanking Element F2 and f2: Input Data									
Vertical flanking (measured, ISO-1084	D_n, f	CSTB, Acoubat example	47	36.1	35.5	42.4	50.0	50.4	53.4
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. 1.4		3.8	3.8	3.8	3.8	3.8	3.8
Flanking Transmission Loss - Path data									
Flanking TL for Junction_2	(only path Ff)	Guide, Section 1.4	**51**	**40**	**39**	**46**	**54**	**54**	**57**
Junction 3 T-junction, 150 mm concrete / glass curtain wall)									
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. 1.4		2.8	2.8	2.8	2.8	2.8	2.8
Flanking Transmission Loss - Path data									
Flanking TL for Paths (Ff+Fd+Df)_3	R_Ff	Guide, Section 1.4	**50**	**39**	**38**	**45**	**53**	**53**	**56**
Junction 4 (Cross-Junction, 150 mm concrete / steel stud flanking wall)									
Like Junction 1, but different studs and junction length change Flanking TL									
Flanking Element F4 and f4: Transferred Data In-situ		RR-337, SS(LB)150-WW-01, Dd(NLB)							
TL in-situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	58	35.0	50.0	62.0	69.0	60.0	62.0
TL in-situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	58	35.0	50.0	62.0	69.0	60.0	62.0
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**89**	**71**	**85**	**90**	**90**	**90**	**90**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**81**	**60**	**70**	**81**	**90**	**90**	**90**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**81**	**60**	**70**	**81**	**90**	**90**	**90**
Total Flanking STC (combined transmission for all flanking paths)			47						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**47**						

Summary for Section 5.1: Cast-in-place concrete Floors with Lightweight Framed Interior Walls

For heavy concrete or concrete masonry facade walls, examples 5.1.1 to 5.1.3 show calculation procedures for the Extended Scenario in a building with steel-framed wall assemblies dividing the interior area and heavy cast-in-place 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 of 58. With this wall, the ASTC between rooms was 52; with a wall of STC 50, the ASTC would drop to 47. The overall Flanking STC of 53 was dominated by 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 with a better separating wall, these flanking paths would hold the ASTC to 52.
- In the horizontal case, substantially increasing the ASTC is difficult, as shown in Example 5.1.2 where the design of 5.1.1 is upgraded with better linings on the ceiling and the masonry facade wall. The flanking paths involving the ceiling and the heavy facade wall can easily be treated with added gypsum board linings, but no matter how high the STC of the separating steel stud wall, the ASTC will not exceed 55 unless the floor is improved with an effective lining.
- 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 for the separating floor is 58, significantly higher than the corresponding laboratory STC of 53 or the in-situ STC in Example 2.1.2 with rigid junctions to masonry walls. The combined flanking for the four junctions has Flanking STC of 62, even with bare concrete block for two wall surfaces in each room, so flanking only marginally reduces the ASTC to 56. Adding a ceiling and lining the concrete block walls could increase the ASTC to well over 60.

For glass curtain wall façades, examples 5.1.4 and 5.1.5 show the calculation procedures for the Extended Scenario in a building where the façade is a glass curtain wall assembly. With this lightweight façade that extends across junctions, significantly reduced ASTC values are observed.

- Example 5.1.4 gives a horizontal case identical to 5.1.2 except that glass curtain walls are substituted for the heavy masonry façade. The ASTC is reduced by the combination of rather low Flanking STC for the curtain wall façade and lower Flanking STC via the floor paths (mainly due to smaller edge losses from the concrete floor to the façade).
- Example 5.1.5 shows the corresponding vertical case identical to 5.1.3 except that glass curtain walls are substituted for the heavy masonry façade. The ASTC is reduced by both lower Direct STC via the separating floor (due to smaller edge losses from the concrete floor to the façade) and rather low Flanking STC for the curtain wall façade.

Overall, these examples emphasize the need to focus improvements on the weakest path(s). High ASTC between spaces requires both separating partitions with high STC and suitable linings over the heavy cast-in-place concrete or masonry surfaces. When a curtain wall replaces the heavy façade, the latter is not feasible.

5.2. Concrete Masonry Walls with Heavy Non-Isotropic Floors

A cast-in-place concrete floor can be described as isotropic in the sense that vibration transmission is the same in both directions across the floor. Such floors were considered in the procedures and examples in Chapter 2 and in Section 5.1.

This Section considers scenarios where a concrete block wall is combined with floor/ceiling assemblies whose concrete floor surface has different stiffness and hence transmission of vibration in orthogonal directions. Examples of such floors include:

- Precast concrete floors comprised of solid-core or hollow-core precast panels, whose long dimension extends between loadbearing walls, with several abutting panels comprising the floor of a room,
- Floors with steel joists and a concrete floor surface.

The first edition of this Guide included examples for one such system estimated assuming rigid junctions and ignoring the orthogonal difference in stiffness. Tests are currently underway to provide a more thorough assessment of such systems, and this section will be updated in a future edition after the test results are available.

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 wood-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-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 wood-framed, the calculation process is very simple, but it requires use of flanking transmission loss data measured according to ISO 10848-3 (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 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.

<u>The Calculation Process</u> 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.

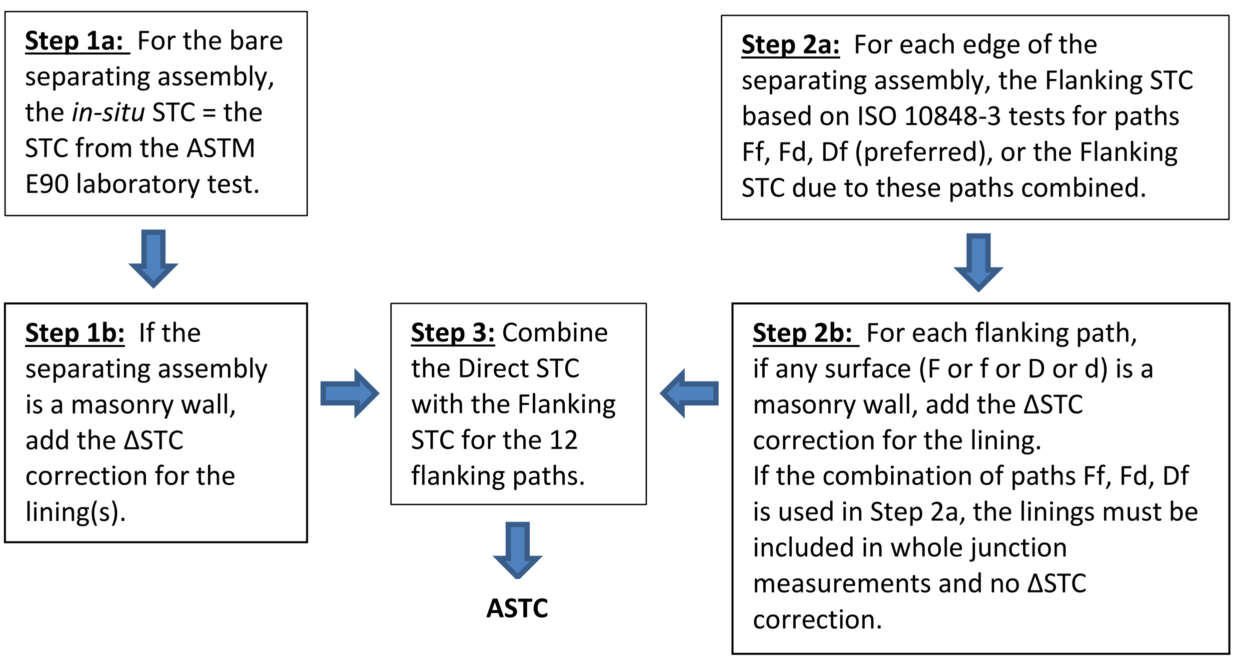


Figure 5.3.1: Steps to calculate the ASTC for lightweight framed construction (as detailed below).

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 10848-3 should be normalized using Equation 1.5a or b.
- 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 10848-3, 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.
- Round the final ASTC result to the nearest integer.

Expressing the Calculation Process using Equations:

As in Section 2.4 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 with the geometry of the Standard Scenario, and is applied here using the following expressions to calculate the sound transmission for each individual path. It is a special case of Eq. 1.4 in this Guide:

(a) In this adaptation of the Simplified Method, 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:

$$STC_{Dd} = STC_{lab} + max(\Delta STC_D, \Delta STC_d) + \frac{min(\Delta STC_D, \Delta STC_d)}{2} \quad \text{Eq. 5.3.2}$$

(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 10848-3 may be used to determine the Flanking STC (after re-normalization using Eq. 1.5a or 1.5b from Section 1.4).
- 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}.

$$Flanking\ STC_{ij} = \frac{STC_i}{2} + \frac{STC_j}{2} + K_{ij} + max\left(\Delta STC_i, \Delta STC_j\right) + \frac{min\left(\Delta STC_i, \Delta STC_j\right)}{2} + 10\log_{10}\left(\frac{S_s}{l_o l_{ij}}\right) \qquad \text{Eq. 5.3.3}$$

<u>The worked examples</u> 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, Δ_STC" 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. 1.5.

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 according to Eq. 1.5, 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 $10^{-0.1 \cdot STC_{ij}}$ 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 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 reinforced concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1], with reinforcing steel and grout-filled cells at 1200 mm o.c.)
- no lining of separating concrete block walls.

Bottom Junction 1 (separating wall and floor) with:

- 2x10 (38x235 mm) wood ledger plate on each side, fastened through with 16 mm diameter bolts spaced 400 mm o.c.
- cells in concrete block assembly between the ledger plates are filled with grout, and floor joists are supported on joist hangers attached to these plates
- floor framed with 38x235 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 in the inter-joist cavities
- floor deck of 16 mm oriented strand board (OSB) on surfaces F1 and f1.
- no floor finish or floor topping

Top Junction 3 (separating wall and ceiling) with:

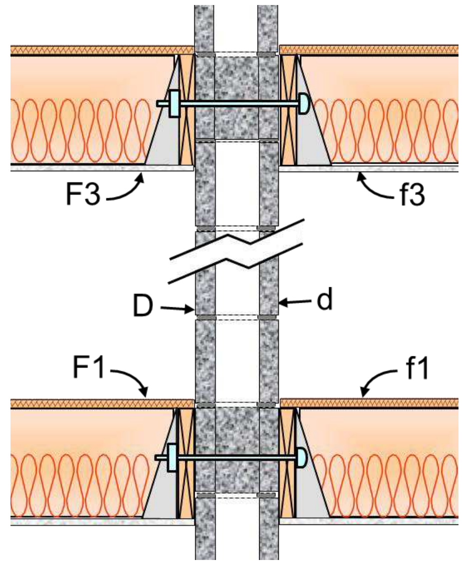
- ceiling framed with wood joists (same details as Junction 1)
- ceiling with 1 layer of 13 mm gypsum board[3] fastened directly to bottom of floor framing on each side

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

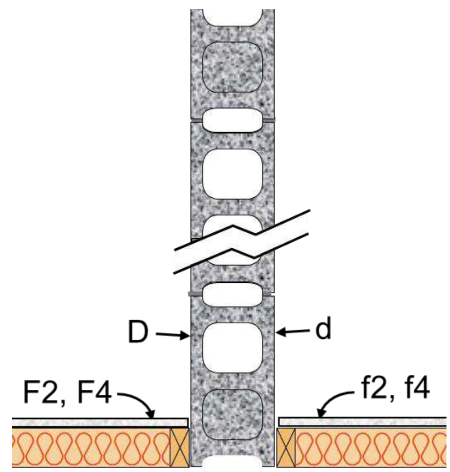
- side wall framing with single row of wood studs
- side wall framing structurally-connected to the separating concrete block wall, but not continuous across the junction
- 13 mm gypsum board[3] on the side walls ends at separating wall assembly and is attached directly to wall framing of 38x89 mm wood studs spaced 400 mm o.c., with absorptive material[2] in the stud cavities

	In Scenario	In Laboratory
Separating partition area (m^2) =	12.5	10.4
Floor/separating wall junction length (m) =	5.0	4.6
Wall/separating wall junction length (m) =	2.5	2.26
Normalization For Junctions 1 and 3:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.44	Guide, Eq. 1.5b
Normalization For Junctions 2 & 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.36	Guide, Eq. 1.5b

Illustration for this case



Junction 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)

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

(See footnotes at end of document)

	ISO Symbol	Reference		STC, Δ_STC		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		
Effect of Airborne Flanking		No Leakage		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 (Cross junction, 190 mm block separating wall / Wood joist floor)						
For Flanking Path Ff_1:						
Laboratory Flanking STC		R334, BLK190-WF-LB-01		59		
Flanking STC for path Ff_1	R_Ff,w	Guide, Eq. 1.5b		59 + 0.44 =	**59**	
For Flanking Path Fd_1:						
Laboratory Flanking STC	R_Fd,w	R334, 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	Guide, Eq. 1.5b		59 + 0 + 0.44 =	**59**	
For Flanking Path Df_1:						
Laboratory Flanking STC	R_Df,w	R334, 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	Guide, Eq. 1.5b		59 + 0 + 0.44 =	**59**	
Junction 1: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-5.9 + 10^- 5.9 + 10^- 5.9) =		**54**	
Junction 2 (T-Junction, 190 mm block separating wall / wood stud flanking wall)						
For Flanking Path Ff_2:						
Laboratory Flanking STC		R334, BLK190-WW-LB-01		81		
Flanking STC for path Ff_2	R_Ff,w	Guide, Eq. 1.5b		81 + 0.36 =	**81**	
For Flanking Path Fd_2:						
Laboratory Flanking STC	R_Fd,w	R334, 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	Guide, Eq. 1.5b		71 + 0 + 0.36 =	**71**	
For Flanking Path Df_2:						
Laboratory Flanking STC	R_Df,w	R334, 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	Guide, Eq. 1.5b		71 + 0 + 0.36 =	**71**	
Junction 2: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-8.1 + 10^- 7.1 + 10^- 7.1) =		**68**	
Junction 3 (Cross junction, 190 mm block separating wall / Wood joist ceiling)						
For Flanking Path Ff_3:						
Laboratory Flanking STC		R334, BLK190-WC-LB-01		65		
Flanking STC for path Ff_3	R_Ff,w	Guide, Eq. 1.5b		65 + 0.44 =	**65**	
For Flanking Path Fd_3:						
Laboratory Flanking STC	R_Fd,w	R334, 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	Guide, Eq. 1.5b		65 + 0 + 0.44 =	**65**	
For Flanking Path Df_3:						
Laboratory Flanking STC	R_Df,w	R334, 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	Guide, Eq. 1.5b		65 + 0 + 0.44 =	**65**	
Junction 3: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.5 + 10^- 6.5 + 10^- 6.5) =		**60**	
Junction 4 (T-Junction, 190 mm block separating wall / wood stud 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 + 0.36 =	**81**	
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2		71 + 0 + 0.36 =	**71**	
Flanking STC for path Fd_4	R_ Df,w	Same as for Df_2		71 + 0 + 0.36 =	**71**	
Junction 4: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-8.1 + 10^- 7.1 + 10^- 7.1) =		**68**	
Total Flanking STC (4 Junctions)		Subset of Eq. 1.4	Combining 12 Flanking STC values			**53**
ASTC due to Direct plus Total Flanking		Equation 1.4	Combining Direct STC with 12 Flanking STC values			**48**

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 reinforced concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1], with reinforcing steel and grout-filled cells at 1200 mm o.c.)
- concrete block assembly lined on each side by 1 layer of 13 mm gypsum board[3] supported on 41 mm steel studs[4] that are not in contact with the concrete blocks and are spaced 600 mm o.c., with absorptive material[2] filling the stud cavities

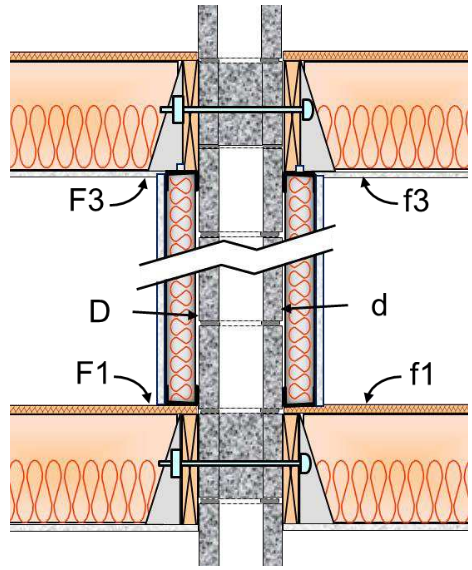
Bottom Junction 1 (separating wall and floor) with:
- 2x10 (38x235 mm) wood ledger plate on each side, fastened through with 16 mm diameter bolts spaced 400 mm o.c.
- cells in concrete block assembly between the ledger plates are filled with grout,
- floor framed with 38x235 mm wood joists spaced 400 mm o.c., with joists oriented perpendicular to separating wall and supported on joist hangers, with 150 mm thick absorptive material[2] in the inter-joist cavities
- floor deck of 16 mm thick oriented strand board (OSB) on surfaces F1 and f1.
- 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[3] fastened directly to bottom of floor framing on each side

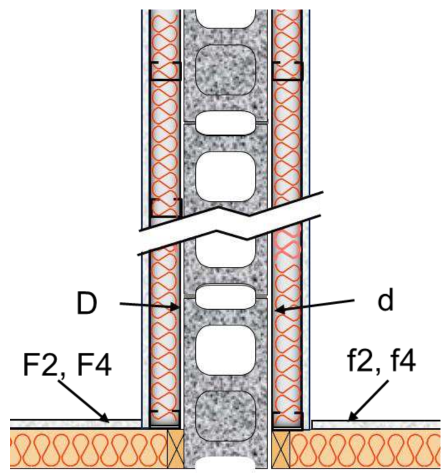
Side Junctions 2 or 4 (separating wall and abutting side walls) with:
- side wall framing with single row of wood studs
- side wall framing structurally-connected to the separating concrete block wall, but not continuous across the junction
- 13 mm gypsum board[3] on the side wall ends at separating wall assembly and is attached directly to wall framing of 38x89 mm wood studs spaced 400 mm o.c., with absorptive material[2] filling the stud cavities

	In Scenario	In Laboratory
Separating partition area (m^2) =	12.5	10.4
Floor/separating wall junction length (m) =	5.0	4.6
Wall/separating wall junction length (m) =	2.5	2.26
Normalization For Junctions 1 and 3:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.44	Guide, Eq. 1.5b
Normalization For Junctions 2 & 4:		
10*log(S_situ/S_lab) + 10*log(l_lab/l_situ) =	0.36	Guide, Eq. 1.5b

Illustration for this case



Junction 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)

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

(See footnotes at end of document)

	ISO Symbol	Reference		STC, Δ_STC	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		9.0	
ΔSTC change by Lining on d	ΔR_d,w	RR-334, ΔTL-BLK(NW)-42		9.0	
Effect of Airborne Flanking		No Leakage		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 (Cross junction, 190 mm block separating wall / Wood joist floor)					
For Flanking Path Ff_1:					
Laboratory Flanking STC		R334, BLK190-WF-LB-01		59	
Flanking STC for path Ff_1	R_Ff,w	Guide, Eq. 1.5b		59 + 0.44 =	**59**
For Flanking Path Fd_1:					
Laboratory Flanking STC	R_Fd,w	R334, 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	Guide, Eq. 1.5b		59 + 9 + 0.44 =	**68**
For Flanking Path Df_1:					
Laboratory Flanking STC	R_Df,w	R334, 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	Guide, Eq. 1.5b		59 + 9 + 0.44 =	**68**
Junction 1: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-5.9 + 10^- 6.8 + 10^- 6.8) =		**58**
Junction 2 (T-Junction, 190 mm block separating wall / wood stud flanking wall)					
For Flanking Path Ff_2:					
Laboratory Flanking STC		R334, BLK190-WW-LB-01		81	
Flanking STC for path Ff_2	R_Ff,w	Guide, Eq. 1.5b		81 + 0.36 =	**81**
For Flanking Path Fd_2:					
Laboratory Flanking STC	R_Fd,w	R334, 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	Guide, Eq. 1.5b		71 + 9 + 0.36 =	**80**
For Flanking Path Df_2:					
Laboratory Flanking STC	R_Df,w	R334, 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	Guide, Eq. 1.5b		71 + 9 + 0.36 =	**80**
Junction 2: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-8.1 + 10^- 8 + 10^- 8) =		**76**
Junction 3 (Cross junction, 190 mm block separating wall / Wood joist ceiling)					
For Flanking Path Ff_3:					
Laboratory Flanking STC		R334, BLK190-WC-LB-01		65	
Flanking STC for path Ff_3	R_Ff,w	Guide, Eq. 1.5b		65 + 0.44 =	**65**
For Flanking Path Fd_3:					
Laboratory Flanking STC	R_Fd,w	R334, 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	Guide, Eq. 1.5b		65 + 9 + 0.44 =	**74**
For Flanking Path Df_3:					
Laboratory Flanking STC	R_Df,w	R334, 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	Guide, Eq. 1.5b		65 + 9 + 0.44 =	**74**
Junction 3: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.5 + 10^- 7.4 + 10^- 7.4) =		**64**
Junction 4 (T-Junction, 190 mm block separating wall / wood stud flanking wall)					
All values the same as for Junction_2					
Flanking STC for path Ff_4	R_Ff,w	All values the same as for Junction_2		81 + 0.36 =	**81**
Flanking STC for path Fd_4	R_ Fd,w	All values the same as for Junction_2		71 + 9 + 0.36 =	**80**
Flanking STC for path Fd_4	R_ Df,w	All values the same as for Junction_2		71 + 9 + 0.36 =	**80**
Junction 4: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-8.1 + 10^- 8 + 10^- 8) =		**76**
Total Flanking STC (4 Junctions)		Subset of Eq. 1.4	Combining 12 Flanking STC values		**57**
ASTC due to Direct plus Total Flanking		Equation 1.4	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**

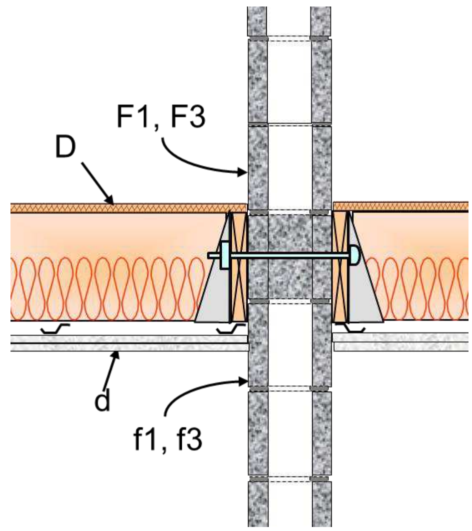
Separating floor/ceiling assembly with:
- floor framed with 38x235 mm wood joists spaced 400 mm o.c., with joists oriented perpendicular to concrete block wall, with 150 mm thick absorptive material[2] in the inter-joist cavities
- ceiling of 2 layers of 16 mm fire-rated gypsum board[3], attached to resilient metal channels[5] 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:
- one wythe of reinforced concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1], with reinforcing steel and grout-filled cells at 1200 mm o.c.)
- cells in concrete block assembly between the ledger plates are filled with grout
- 2x10 (38x235 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
- no lining on concrete block walls

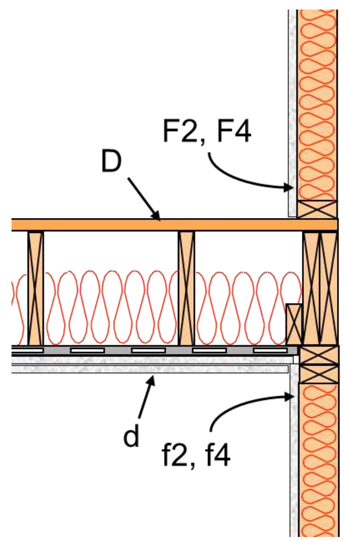
Junction 2 or 4 with non-loadbearing walls above and below floor with:
- joists of floor assembly parallel to these walls
- walls have 38 mm x 89 mm wood studs spaced 400 mm o.c with several framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates)
- walls with or without absorptive material[2] in the stud cavities give equivalent flanking
- single layer of 13 mm gypsum board[3] that ends at floor/ceiling assembly; and is attached directly to wall framing

	In Scenario	In Laboratory
Separating partition area (m^2) =	20	19.6
Floor/separating wall junction length (m) =	5.0	4.58
Wall/separating wall junction length (m) =	4.0	4.58
Normalization For Junctions 1 and 3:		
$10*\log(S_{situ}/S_{lab}) + 10*\log(l_{lab}/l_{situ})$ =	-0.29	Guide, Eq. 1.5b
Normalization For Junctions 2 & 4:		
$10*\log(S_{situ}/S_{lab}) + 10*\log(l_{lab}/l_{situ})$ =	0.68	Guide, Eq. 1.5b

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 separating floor. (Plan view)

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

(See footnotes at end of document)

	ISO Symbol	Reference		STC, Δ_STC		ASTC
Separating partition (wood joist floor)						
Laboratory STC for Dd	R_s,w	RR-336, WJ235-02		53		
Effect of Airborne Flanking		No Leakage		0		
Direct STC in-situ	R_Dd,w	No adjustment, ISO 15712-1, 4.2.2				53
Junction 1 (Cross junction, Concrete block flanking wall / Wood joist separating floor)						
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		Guide, Eq. 1.5b		-0.3		
Flanking STC for path Ff_1	R_Ff,w	Same with linings	59 + MAX(0,0) + MIN(0,0)/2 + -0.29 =		**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	Guide, Eq. 1.5b	73 + 0 + -0.29 =		**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	Guide, Eq. 1.5b	67 + 0 + -0.29 =		**67**	
Junction 1: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-5.9 + 10^- 7.3 + 10^- 6.7) =		**58**	
Junction 2 (T-Junction, Wood stud flanking wall / Wood joist separating floor)						
For Flanking Path Ff_2:						
Laboratory Flanking STC		R336, WJ235-VF_NLB-02		63		
Flanking STC for path Ff_2	R_Ff,w	Guide, Eq. 1.5b	63 + 0.68 =		**64**	
For Flanking Path Fd_2:						
Laboratory Flanking STC	R_Fd,w	R336, WJ235-VF_NLB-02		80		
Flanking STC for path Fd_2	R_ Fd,w	Guide, Eq. 1.5b	80 + 0.68 =		**81**	
For Flanking Path Df_2:						
Laboratory Flanking STC	R_Df,w	R336, WJ235-VF_NLB-02		60		
Flanking STC for path Fd_2	R_ Df,w	Guide, Eq. 1.5b	60 + 0.68 =		**61**	
Junction 2: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.4 + 10^- 8.1 + 10^- 6.1) =		**59**	
Junction 3 (Cross junction, Concrete block flanking wall / Wood joist separating floor)						
Flanking STC for path Ff_3	R_Ff,w	Same as for Ff_1	59 + MAX(0,0) + MIN(0,0)/2 + -0.29 =		**59**	
Flanking STC for path Fd_3	R_ Fd,w	Same as for Fd_1	73 + 0 + -0.29 =		**73**	
Flanking STC for path Fd_3	R_ Df,w	Same as for Df_1	67 + 0 + -0.29 =		**67**	
Junction 3: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-5.9 + 10^- 7.3 + 10^- 6.7) =		**58**	
Junction 4 (Cross-Junction, Wood stud flanking wall / Wood joist separating floor)						
All values the same as for Junction 2						
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2	63 + 0.68 =		**64**	
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2	80 + 0.68 =		**81**	
Flanking STC for path Fd_4	R_ Df,w	Same as for Df_2	60 + 0.68 =		**61**	
Junction 4: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.4 + 10^- 8.1 + 10^- 6.1) =		**59**	
Total Flanking STC (4 Junctions)		Subset of Eq. 1.4	Combining 12 Flanking STC values			**53**
ASTC due to Direct plus Total Flanking		Subset of Eq. 1.4	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**

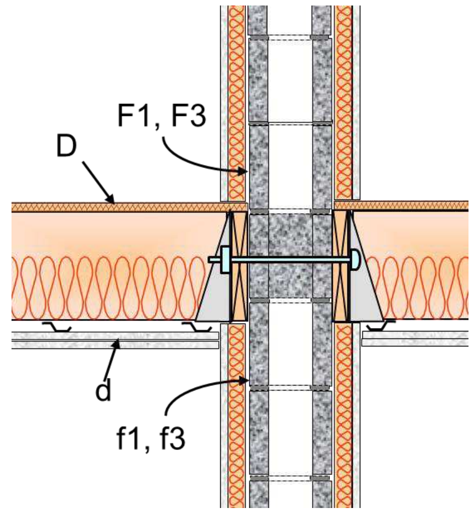
Separating floor/ceiling assembly with:
- floor framed with 38x235 mm wood joists spaced 400 mm o.c., with joists oriented perpendicular to concrete block wall, with 150 mm thick absorptive material[2] in the inter-joist cavities
- ceiling of 2 layers of 16 mm fire-rated gypsum board[3], attached to resilient metal channels[5] 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:
- one wythe of reinforced concrete blocks with mass 238 kg/m^2 (e.g. 190 mm hollow blocks with normal weight aggregate[1], with reinforcing steel and grout-filled cells at 1200 mm o.c.)
- cells in concrete block assembly between the ledger plates are filled with grout
- 2x10 (38x235 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 of 1 layer of 13 mm gypsum board[3] supported on 38x38 wood furring spaced 600 mm o.c. and fastened to the concrete blocks, with absorptive material[2] filling the cavities

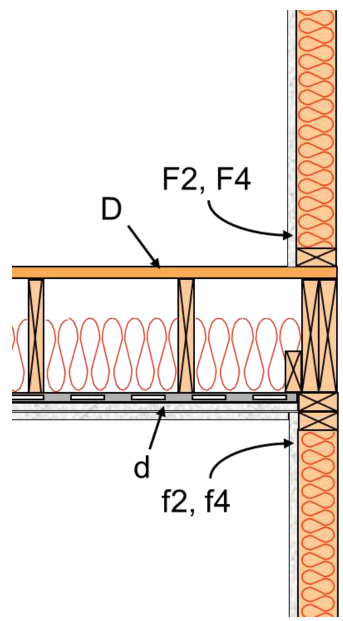
Junction 2 or 4 with non-loadbearing walls above and below floor with:
- joists of floor assembly parallel to these walls
- walls have 38 mm x 89 mm wood studs spaced 400 mm o.c with several framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates)
- walls with or without absorptive material[2] in the stud cavities give equivalent flanking
- single layer of 13 mm gypsum board[3] that ends at floor/ceiling assembly; and is attached directly to wall framing

		In Scenario	In Laboratory
Separating partition area (m^2) =		20	19.6
Floor/separating wall junction length (m) =		5.0	4.58
Wall/separating wall junction length (m) =		4.0	4.58
Normalization For Junctions 1 and 3:			
$10*\log(S_{situ}/S_{lab}) + 10*\log(l_{lab}/l_{situ})$ =		-0.29	Guide, Eq. 1.5b
Normalization For Junctions 2 & 4:			
$10*\log(S_{situ}/S_{lab}) + 10*\log(l_{lab}/l_{situ})$ =		0.68	Guide, Eq. 1.5b

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 separating floor. (Plan view)

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

(See footnotes at end of document)

	ISO Symbol	Reference		STC, Δ_STC		ASTC
Separating partition (wood joist floor)						
Laboratory STC for Dd	R_s,w	RR-336, WJ235-02		53		
Effect of Airborne Flanking		No Leakage		0		
Direct STC in-situ	R_Dd,w	No adjustment, ISO 15712-1, 4.2.2				53
Junction 1 (Cross junction, Concrete block flanking wall / Wood joist separating floor)						
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		Guide, Eq. 1.5b		-0.3		
Flanking STC for path Ff_1	R_Ff,w	same plus linings	59 + MAX(4,4) + MIN(4,4)/2 + -0.29 =		**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	Guide, Eq. 1.5b	73 + 4 + -0.29 =		**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	Guide, Eq. 1.5b	67 + 4 + -0.29 =		**71**	
Junction 1: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.5 + 10^- 7.7 + 10^- 7.1) =		**64**	
Junction 2 (T-Junction, Wood stud flanking wall / Wood joist separating floor)						
For Flanking Path Ff_2:						
Laboratory Flanking STC		R336, WJ235-VF_NLB-02		63		
Flanking STC for path Ff_2	R_Ff,w	Guide, Eq. 1.5b	63 + 0.68 =		**64**	
For Flanking Path Fd_2:						
Laboratory Flanking STC	R_Fd,w	R336, WJ235-VF_NLB-02		80		
Flanking STC for path Fd_2	R_ Fd,w	Guide, Eq. 1.5b	80 + 0.68 =		**81**	
For Flanking Path Df_2:						
Laboratory Flanking STC	R_Df,w	R336, WJ235-VF_NLB-02		60		
Flanking STC for path Fd_2	R_ Df,w	Guide, Eq. 1.5b	60 + 0.68 =		**61**	
Junction 2: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.4 + 10^- 8.1 + 10^- 6.1) =		**59**	
Junction 3 (Cross junction, Concrete block flanking wall / Wood joist separating floor)						
Flanking STC for path Ff_3	R_Ff,w	Same as for Ff_1	59 + MAX(4,4) + MIN(4,4)/2 + -0.29 =		**65**	
Flanking STC for path Fd_3	R_ Fd,w	Same as for Fd_1	73 + 4 + -0.29 =		**77**	
Flanking STC for path Fd_3	R_ Df,w	Same as for Df_1	67 + 4 + -0.29 =		**71**	
Junction 3: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.5 + 10^- 7.7 + 10^- 7.1) =		**64**	
Junction 4 (Cross-Junction, Wood stud flanking wall / Wood joist separating floor)						
All values the same as for Junction 2						
Flanking STC for path Ff_4	R_Ff,w	Same as for Ff_2	63 + 0.68 =		**64**	
Flanking STC for path Fd_4	R_ Fd,w	Same as for Fd_2	80 + 0.68 =		**81**	
Flanking STC for path Fd_4	R_ Df,w	Same as for Df_2	60 + 0.68 =		**61**	
Junction 4: Flanking STC for all paths		Subset of Eq. 1.4	- 10*LOG10(10^-6.4 + 10^- 8.1 + 10^- 6.1) =		**59**	
Total Flanking STC (4 Junctions)		Subset of Eq. 1.4	Combining 12 Flanking STC values			55
ASTC due to Direct plus Total Flanking		Subset of Eq. 1.4	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 worked examples 5.3.1 to 5.3.4 use a blend of the simplified procedures from Chapter 4 for lightweight flanking assemblies with wood- or steel-framing, and the simplified methods from Section 2.4 for calculating transmission between rooms in a building with cast-in-place 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 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 is 50 which is 3 points lower than the STC of the separating floor. But 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 and 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 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. Other Construction Systems

Not all possible constructions or combinations of constructions have been considered in the procedures and examples in Chapters 2 to 5.

Further, in some cases, the (deliberately conservative) approximations used in the calculation process following ISO 15712-1 could be replaced by suitable test data.

- Some of these are proprietary systems but others (such as the CLT systems considered in Chapter 3) may be treated as generic and the approaches given in this Guide could be applied.
- Some commonly-used constructions have junction details that have been experimentally proven to provide different attenuation (typically more attenuation) than the rigid junction estimates provided in the standardized procedures of ISO 15712-1. For these systems, the calculations may follow the ISO 15712-1 procedures of Chapter 2, or the calculation procedures introduced in Chapter 5 for mixed types of construction, substituting test values for the measured junction transmission or for the measured flanking path transmission (determined according to the appropriate part of ISO 10848) for calculated values in the ISO 15712-1 procedures.
- Examples for CLT construction in Chapter 3 show the modification of the detailed calculation process of ISO 15712-1 for heavy CLT assemblies to allow for the characteristic junction attenuation and high internal losses of these systems.
- Examples in Chapter 5 illustrate modified approaches for some mixed types of construction.

7. Reference Material

7.1. Appendix A1: Calculation of ΔTL and ΔSTC Values

A single number rating called ΔSTC is introduced to characterize the change in sound transmission loss due to adding a specific lining to a heavy base wall or floor.

Key issues concerning ΔSTC include:

- ΔSTC is a required input for calculation of ASTC using the Simplified Method of ISO 15712-1 which is presented in Sections 2.4, 4.1, and 5.3 along with examples using that method.
- Values of ΔSTC presented in the examples 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 ISO standards. The procedure used in this Appendix is modified from its ISO counterpart in two ways:

1. STC calculation according to ASTM E413 is substituted for the ISO single number rating calculation of R_W, plus additional Steps 4 and 5 are included, as shown schematically in Figure A1.1 and explained in more detail in the adjacent text.
2. A Reference curve to represent the base specimen is required for the calculation. The ISO standards provide a set of three reference curves; these include a reference curve for heavy concrete floors and two for base wall assemblies. For calculations of ΔSTC, a fourth reference curve has been added for wall assemblies intermediate between the two ISO wall cases (denoted Reference Wall 2, and 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 procedures to calculate ΔR_W are smoothed average sound transmission loss curves for some constructions common in Europe – a homogeneous concrete floor (140 mm thick and 300 kg/m^2 mass per unit area), a heavy masonry wall with low coincidence frequency (350 kg/m^2 mass per unit area), and a lighter masonry wall of gypsum blocks (70 kg/m^2 mass per unit area) described as a "wall with medium-high coincidence frequency".

In selecting the appropriate reference curve for calculation of ΔSTC, the weight 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 1/3-octave in frequency.

<u>To establish the most suitable reference curve</u> for a given base wall or floor specimen, 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 TL 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 versus the STC calculated for the curve obtained by adding the ΔTL values at each frequency to the reference curve.

The procedure to establish the change in transmission loss ΔTL due to adding each tested lining was 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 explains how those values for ΔTL (in 1/3-octave bands) for each lining are used to calculate corresponding single number ΔSTC values.

The 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 measurement results (with and without the added lining) for each frequency band, including at least 125 Hz to 4 kHz. This may involve averaging results from several pairs of specimens as explained in the NRC Research Reports RR-333 to RR-337.

Step 2. (a) Calculate the sum of the TL for the chosen Reference Curve (See Figures A1.2 to A1.5.) plus ΔTL for each frequency band. $STC_{1\text{-Side}}$ is the STC calculated for this set of TL values.
(b) Calculate the sum of the TL for the chosen Reference Curve plus 2 x ΔTL for each frequency band. $STC_{2\text{-Sides}}$ is the STC calculated for this set of TL values.
(c) Calculate STC value for the chosen Reference Curve (STC_{REF}).

Step 3. Subtract the STC value for the Reference Curve (STC_{REF}) from $STC_{1\text{-side}}$ to obtain $\Delta STC_{1\text{-Side}}$.

Step 4. Subtract the STC value for the Reference Curve (STC_{REF}) from $STC_{2\text{-sides}}$ to obtain $\Delta STC_{2\text{-Sides}}$.

Step 5. ΔSTC is the smaller of $\Delta STC_{1\text{-Side}}$ or $\Delta STC_{2\text{-Sides}}$ /1.5, rounded to integer dB (e.g. 20/1.5 ⇨ 13).

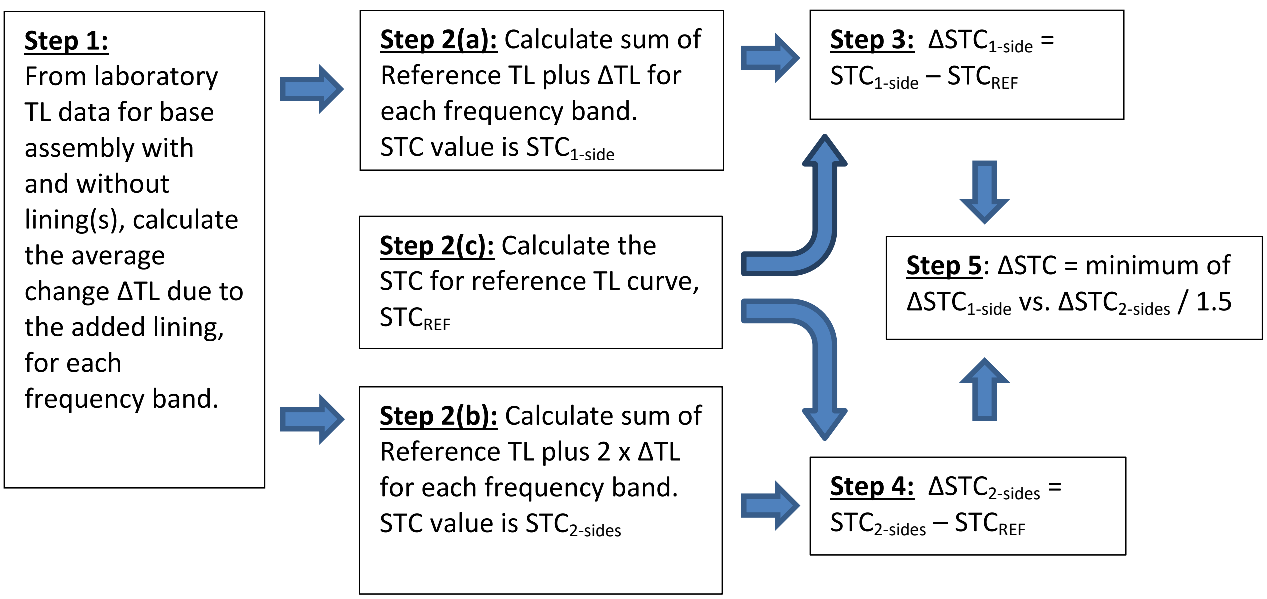


Figure A1.1: Steps to calculate the single number rating ΔSTC for added linings (as detailed above).

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 Eq. 4.1.1 and 4.1.2 and in the worked examples in Chapter 4. Selection of the more conservative value (at Step 5) is required to avoid a misleading (over-optimistic) ΔSTC rating in the simplified calculation procedure when there is a low frequency resonance in the ΔTL values for a lining.

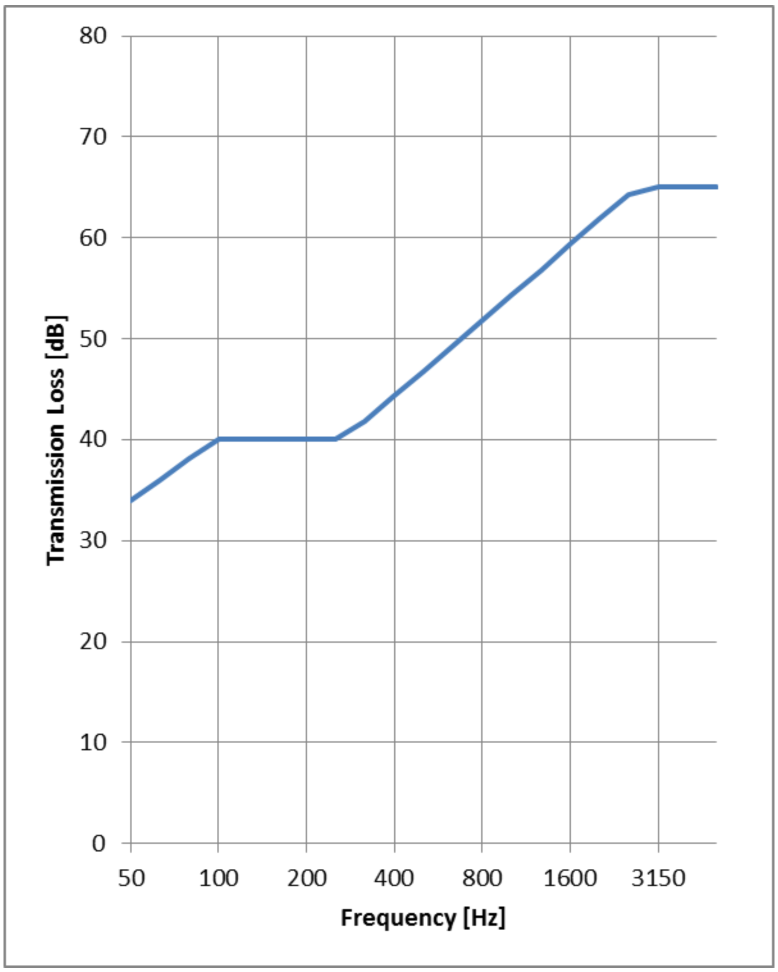
Reference Curves for Calculation of ΔSTC Rating

A set of four reference curves are presented here:

- One curve for concrete floors,
- Three curves for wall assemblies with different coincidence frequencies.

Three of these curves match ISO Reference curves.

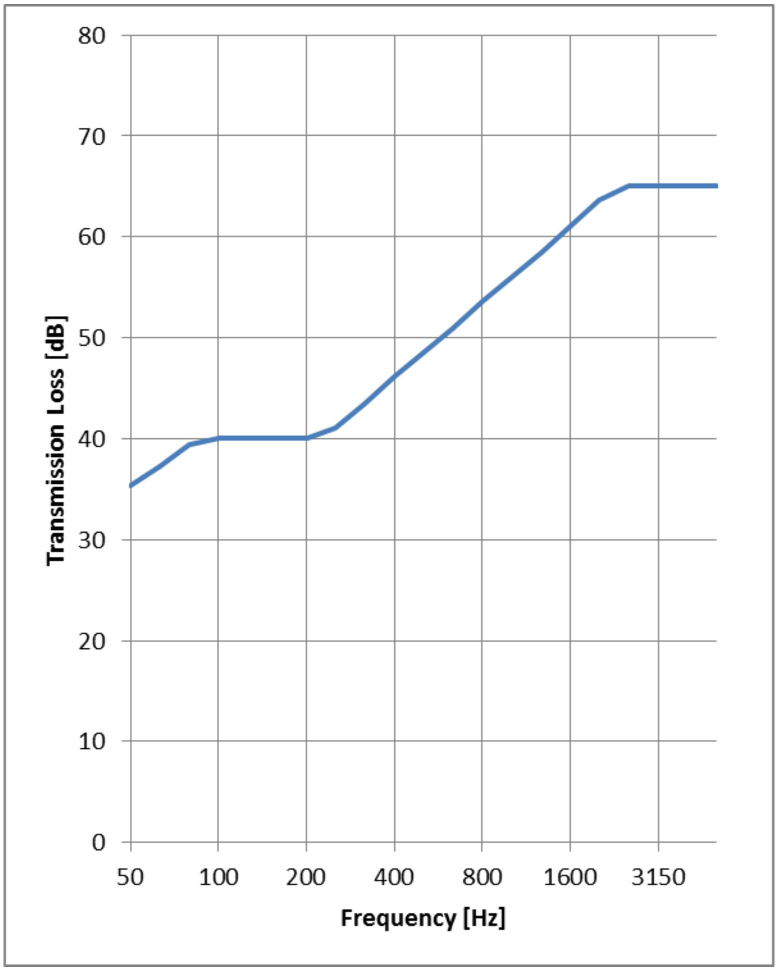
Figure A1.2:
Reference curve for calculation of ΔSTC **for concrete floor assembly with low coincidence frequency.**



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**

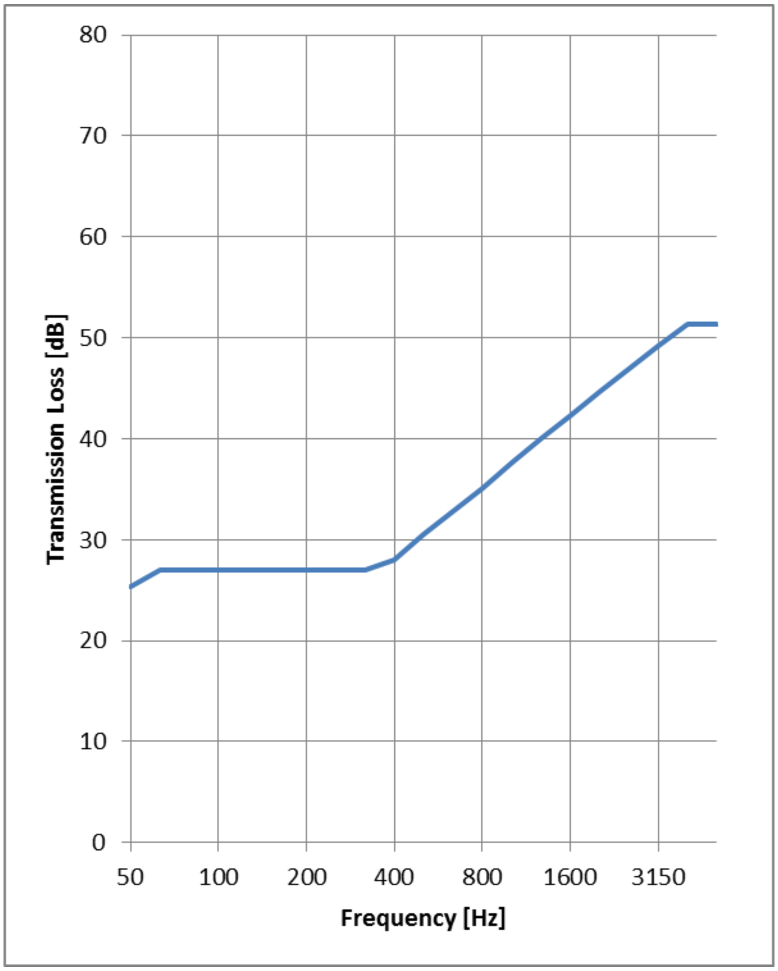
Figure A1.3:
Reference curve for calculation of ΔSTC **for wall assembly with low coincidence frequency.**



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**

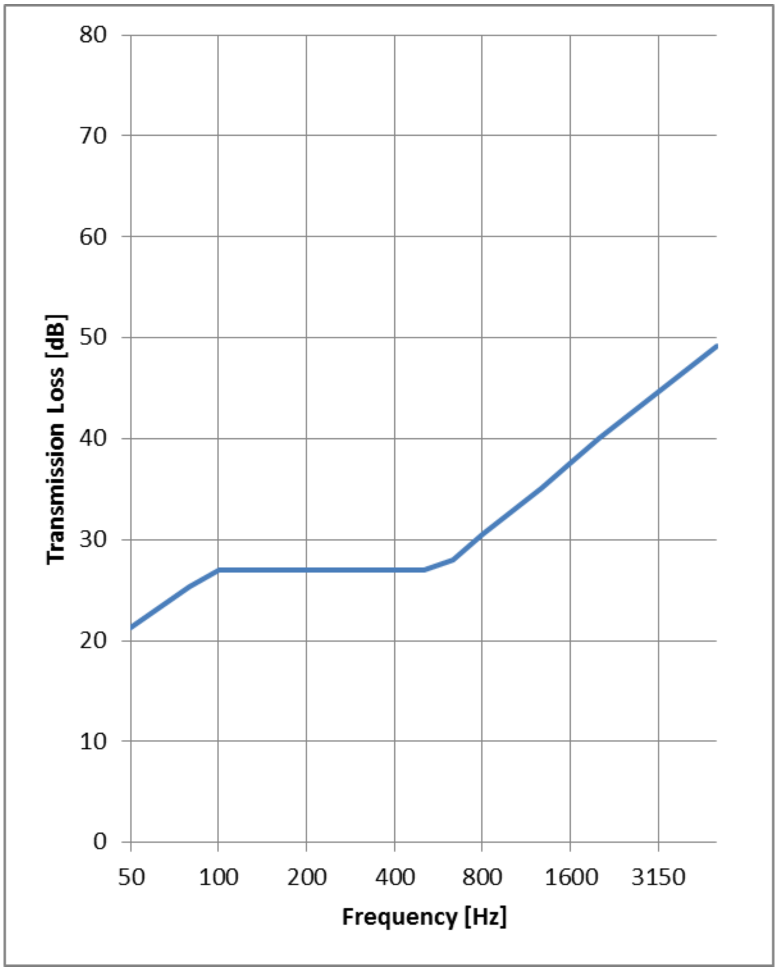
Figure A1.4:
New Reference curve for calculation of ΔSTC **for wall assembly with medium low coincidence frequency.**



Reference Curve Wall 2
New curve produced by shifting Reference Curve B.3 from Annex B of ISO 140-16 to lower frequency by two 1/3-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 calculation of ΔSTC **for wall assembly 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**

7.2.Technical Reference Documents

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 E413-10, "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 website of the National Research Council Canada at http://nparc.cisti-icist.nrc-cnrc.gc.ca/npsi/ctrl.

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 the Detailed Method, using 1/3-octave data for direct and flanking paths determined by experimental studies in the laboratories of the National Research Council Canada. Technical details concerning the measurement protocol (consistent with ISO 10848) and discussion of the findings of the experimental studies are presented in a series of NRC reports:

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, National Research Council Canada, Ottawa. (2006). Uses a subset of the database used for *soundPATHS* software in a table-based framework to predict ASTC values for a range of wood framed assemblies. 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 (2016)
    11.2. RR-334 Apparent Sound Insulation in Concrete Block Buildings (2015)
    11.3. RR-335 Apparent Sound Insulation in Cross Laminated Timber Buildings (2016)
    11.4. RR-336 Apparent Sound Insulation in Wood-framed Buildings (2016)
    11.5. RR-337 Apparent Sound Insulation in Steel-framed Buildings (2016)

Other Technical References

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)

7.3. Explanatory Footnotes to Examples

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 core units are not less than 53% solid, and 140 mm hollow core 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 Sound absorptive 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.

3 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 and these details are presented together with the sound transmission data for these assemblies in the NRC reports referenced in Section 7.1. The 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.

4 Steel 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-load-bearing 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.

5 Resilient metal channels are formed from sheet steel with maximum thickness 0.46 mm (25 gauge), with profile essentially as shown in Figure 7.1, 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.

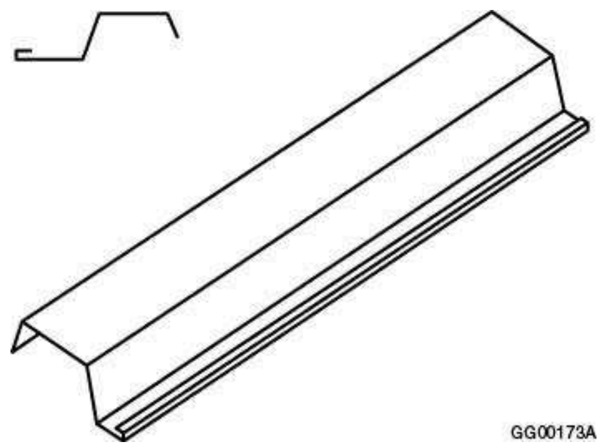


Figure 7.1: Drawing to illustrate typical profile of resilient metal channel; approximate dimensions in cross-section 13 mm x 60 mm (not precisely to scale).

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