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Guide to Calculating Airborne Sound Transmission in Buildings

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National Research Council Canada
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Canada

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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 poor workmanship, or substitution of "generic equivalents", or simply rebuilding the construction.

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.

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 of 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.

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Steering Committee Member	**Representing**
Robert Wessel	Gypsum Association
Gary Sturgeon	Canadian Concrete Masonry Producers Association
John Rice	Canadian Sheet Steel Building Institute
Peggy Lepper	Canadian Wood Council
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The Advisory Committee that reviewed the draft Guide included the following additional members:

Advisory Committee Member	**Representing**
Bob Mercer	Canadian Gypsum Company Inc.
Dave Nicholson	Maxxon Corporation
J. David Quirt	Consultant
Robert Burak	Canadian Precast/Prestressed Concrete Institute

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 wall or floor separating adjacent spaces. This perspective has been entrenched in North American building codes, which for many decades have considered only the ratings for the individual separating assembly: Sound Transmission Class (STC) or Field Sound Transmission Class (FSTC) for airborne sources or Impact Insulation Class (IIC) for footstep noise.

Implicit in this approach is the simplistic assumption (illustrated in Figure 1.1) 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.

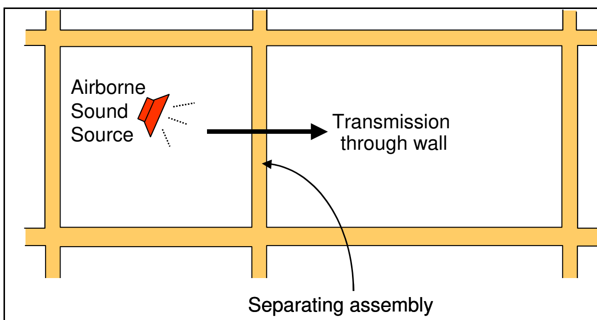


Figure 1.1: The drawings in Figure 1.1 and 1.2 show a cross-section through a building with two adjacent rooms. Part of the sound from an airborne source in one unit (represented by red loudspeaker in the drawings, which could include anything from a home theatre to people talking loudly) is transmitted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

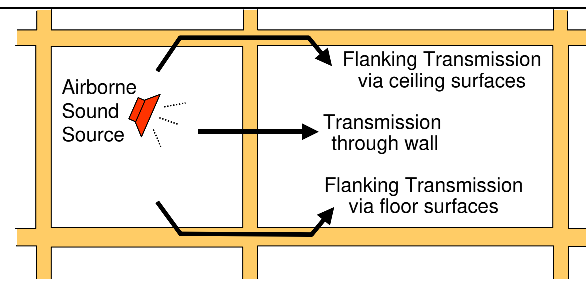


Figure 1.2: In reality, there are many paths for sound transmission between adjacent rooms, including both direct transmission through the separating assembly and indirect structure-borne paths, a few of which are indicated here. (See Section 1.4 for more detail.) The structure-borne paths usually significantly 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 has recently defined 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 of 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 concrete floors and walls of concrete or masonry, but it is less accurate for other common types of construction, especially for lightweight 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 are replacing 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:

- 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, as described above, 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:

- two 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:

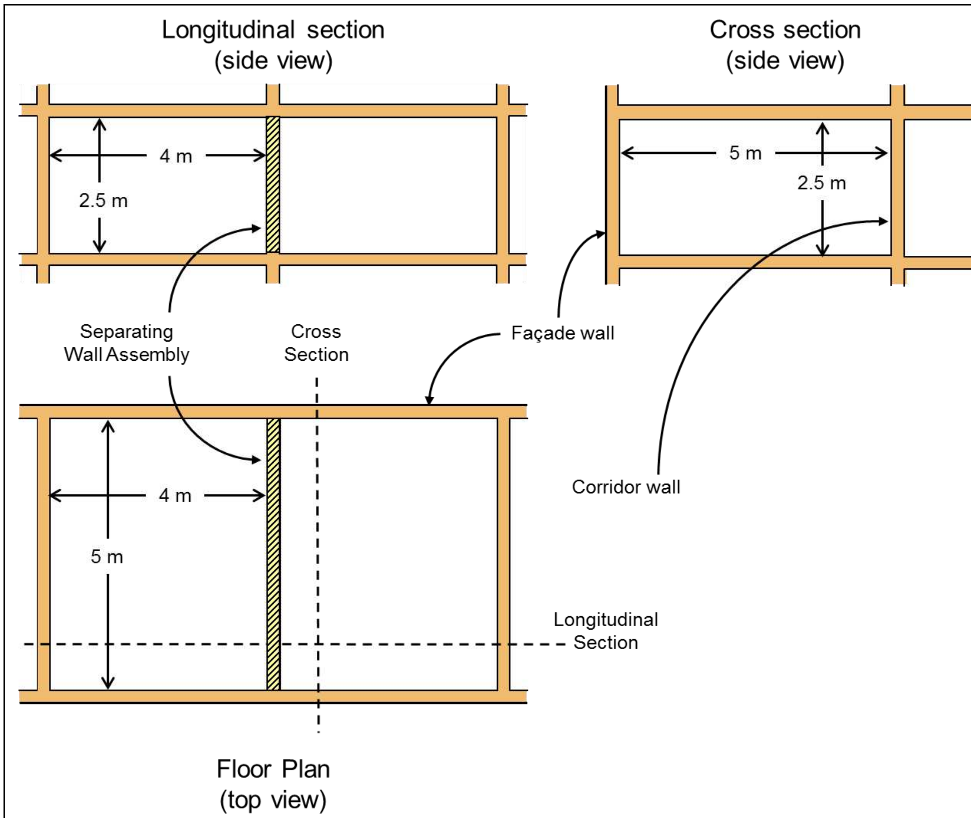


Figure 1.3: Standard Scenario for “horizontal room pair” case where the pair of rooms are side-by side with a separating wall assembly between the two rooms

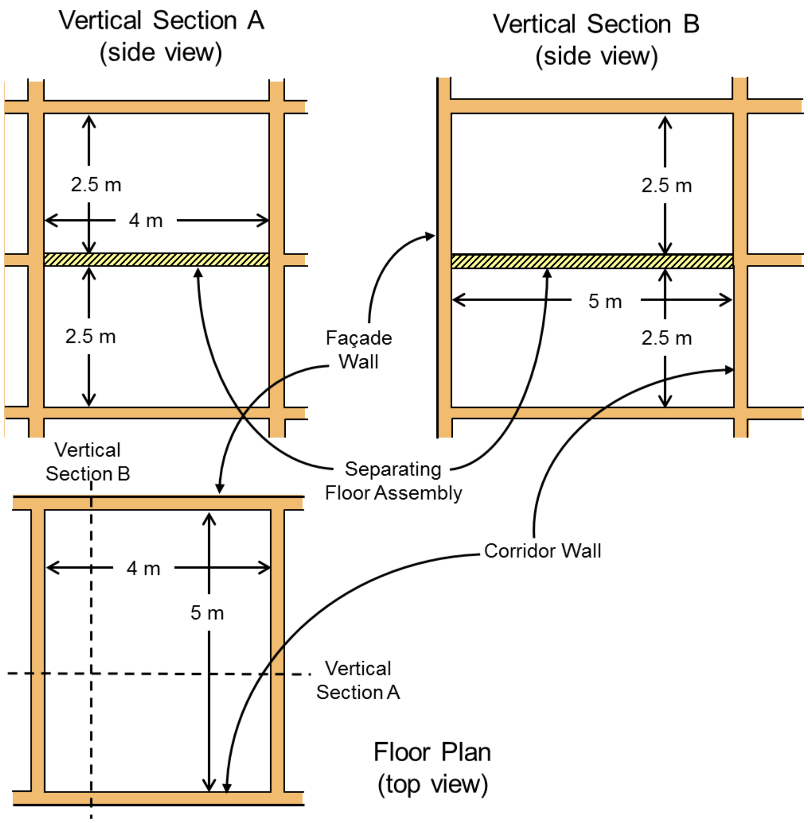


Figure 1.4:
Standard Scenario for "vertical room pair" case where one of the pair of rooms is above the other, with a floor/ceiling assembly between the two rooms

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

- for horizontal room pairs (i.e. - rooms are side-by-side) the separating wall is 2.5 m high by 5 m wide, flanking floor/ceilings are 4 m by 5 m and flanking walls are 2.5 m high by 4 m wide,
- for vertical room pairs (i.e. – one room is above the other) the separating floor/ceiling is 4 m by 5 m wide and flanking walls in both rooms are 2.5 m high,
- In general, it is assumed that junctions at one side of the room (at the separating wall if rooms are side-by-side) are cross junctions, while one or both of the other two junctions are T-junctions. This enables the examples to illustrate typical differences between the two common junction cases.
- For a horizontal pair, the separating wall has T-junctions with the flanking walls at both the façade and corridor sides, and cross junctions at floor and ceiling.
- For a vertical pair, the façade wall has a T-junction with the separating floor, but the opposing corridor wall has a cross junction, as do the other two walls.

In 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 rom 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 are no ASTM standards for measuring the structure-borne flanking transmission that often dominates sound transmission between rooms, nor is there 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 or ISO 140-3	Laboratory measurement of airborne sound transmission through a wall or floor	ASTM E90
sound reduction index, R (from ISO 140-3 or 10140-2 test)	Fraction of sound power transmitted (in dB) at each frequency, in laboratory test	sound transmission loss, TL (from ASTM E90 test)
weighted sound reduction index, R_W	Single-number rating determined from R or TL values for standard frequency bands	sound transmission class, STC
apparent sound reduction index, R’ (from ISO 140-4 test)	Fraction of sound power transmitted (in dB) at each frequency, including all paths in a building	apparent transmission loss, ATL (from ASTM E336 test)
weighted apparent sound reduction index, R'_W	Single-number rating determined from R’ or ATL values for standard frequency bands	apparent sound transmission class, ASTC

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

Note that this description “counterpart” does not imply 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, nor are R'_W and ASTC because of significant 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 according to ASTM 413 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 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, and is described in detail in Section 1.4
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 combination of the sound power transmitted via the direct path and 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.

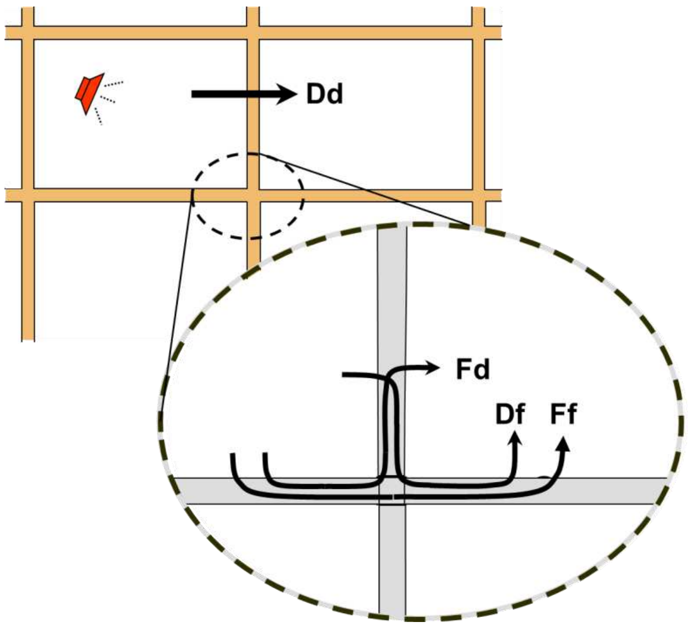


Figure 1.5: This figure shows the labelling convention for transmission paths used in ISO 15712-1. Consider transmission from a source room at the left to the receiving room beside it. Each transmission path involves one surface in the source room (denoted by a capital letter) and one in the receive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

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

Room Pair	Surfaces D and d	Flanking Surfaces F and f	Junction (Standard Scenario)
Horizontal	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. 1.5) 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 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:

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

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

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

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   Equation 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.

This list of transmission factors 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 a proposed transition to ASTC ratings for sound control objectives of 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 penetrations such as ventilation systems, are assumed negligible (and included in τ_{Dd}).
- Indirect airborne transmission (for example airborne flanking via an unblocked attic or crawl space) is assumed to be insignificant.
- 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.

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

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

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 differences between the test situation and the prediction scenario. This also applies to laboratory results expressed as Flanking TL. The expressions to use in the calculation are:

$$\text{Flanking TL (in situ)} = \mathrm{D}_{n,f}(\text{lab}) + 10\log(S_{situ}/10) + 10\log(l_{lab}/l_{situ}) \text{ in dB} \qquad \text{Eq. 1.4}$$

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

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.1.4 apply for lightweight framed assemblies, as discussed in Chapter 4.

2. Buildings with Concrete or Masonry Walls and Concrete Floors

This chapter begins with an introduction outlining the concepts of the detailed calculation method of ISO 15712-1. 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.

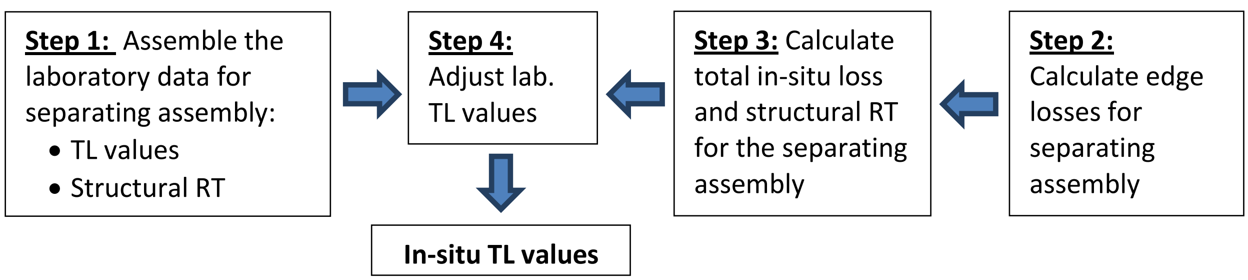


Figure 2.1: Steps to calculate in-situ TL for the separating assembly (more details below)

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 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.

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

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

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

→ **Step 8:** Calculate path TL for each flanking path, using in-situ values from Steps 5, 6 and 7 in Eq. 25a

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>:

<u>From Step 4:</u>
Take in-situ Direct TL values (including effect of linings)

<u>From Step 8:</u>
Take Flanking TL values (including effect of linings) for each flanking path

<u>Step 9:</u> Calculate Apparent TL using the equations in Section 1.4, and calculate ASTC from these values

ASTC

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 1.1 to 1.3 in Section 1.4 of this Guide (equivalent to Section 4.1 of ISO 15712-1) to calculate Apparent TL.
- Use values of Apparent TL in procedure of ASTM E413 to calculate ASTC.

2.1. Concrete and Masonry Buildings with Rigid Junctions

This section presents worked examples for the most basic sort of concrete and masonry building which has structural floor slabs of bare concrete and walls of bare concrete or masonry connecting at rigid cross-junctions or T-junctions. Here "bare" is taken to mean the assembly of concrete or masonry without a lining such as an added gypsum board finish on the walls or ceiling, or flooring over the concrete slab. The "bare" surface could be painted or sealed, or have a thin coat of plaster. 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.

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 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.

<u>The worked examples</u> 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. 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, to condense the examples to 2-page format. 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 (2005) 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 figure 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-figure measures at each stage of the calculation. These include:

- STC values for laboratory sound transmission loss data for wall or floor assemblies,
- ΔSTC values for change in STC due to adding a 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.

Validation studies [13] 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 measured values in actual buildings with these characteristics.

EXAMPLE 2.1.1:

- **Rooms side-by-side**
- **Concrete Floors and Masonry 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:

- concrete floor with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) 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

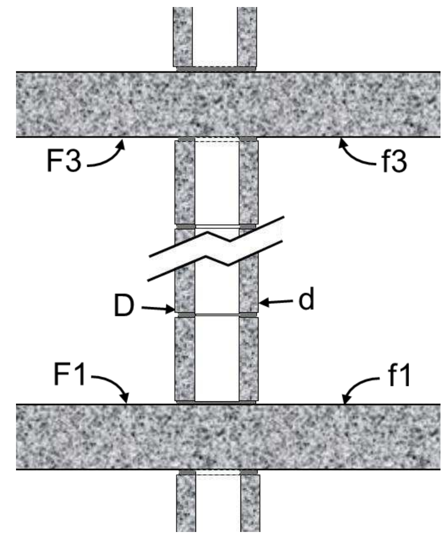
Junction 3: Top Junction (separating wall / ceiling) with:

- concrete ceiling slab with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) with no added ceiling lining
- rigid mortared cross junction with concrete block wall assembly.

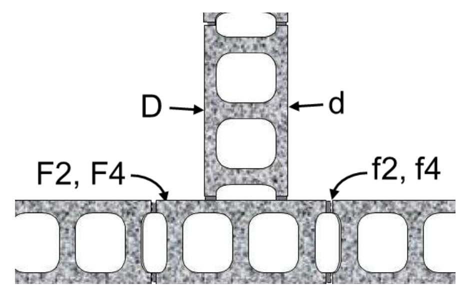
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	0.015	c_L = 3500			
mass (kg/m²) =	237.5	f_c = 98			
	Reference	K_13	K_12	K_14	Σ l_k . α_k
X-Junction 1 or 3	ISO 15712-1, Eq. E.3	11.6	8.8	8.8	0.566
T-Junction 2 or 4	ISO 15712-1, Eq. E.4		5.7	5.7	0.420
Total loss, η_tot	ISO 15712-1, Eq. C.1		0.041		(Eq. C.2)
			(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 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	IR-586, TL-88-356	50	33	41.2	44	50.4	57	63.9
Structural Reverberation Time	T_s,lab	ISO 15712-1, Eq. C.5		0.30	0.19	0.12	0.07	0.04	0.02
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	No Lining ,	0	0	0	0	0	0	0
Change by Lining on receive side	ΔR_d	No Lining ,	0	0	0	0	0	0	0
Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.257	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		8.8	9.4	10.4	12.0	14.2	17.3
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**50**	**33.7**	**41.7**	**44.4**	**50.7**	**57.3**	**64.1**

(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	IR-811, TLF-97-107a	52	39.0	39.0	49.0	58.0	67.0	76.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.345	0.293	0.176	0.092	0.046	0.042
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	0.0
Change by Lining on receive side	ΔR_f1	No Lining ,	0	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		0.348	0.238	0.160	0.104	0.066	0.041
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		10.395	10.724	11.318	12.247	13.626	15.621
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	53	39.0	39.9	49.4	57.4	65.4	76.1
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	53	39.0	39.9	49.4	57.4	65.4	76.1
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		9.26	9.39	9.62	9.97	10.43	11.02
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**60**	**46.2**	**47.3**	**57.0**	**65.4**	**73.8**	**85.1**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**63**	**47.0**	**51.7**	**58.1**	**65.8**	**73.6**	**83.1**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**63**	**47.0**	**51.7**	**58.1**	**65.8**	**73.6**	**83.1**
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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	0.0	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	0.0
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		8.250	8.756	9.565	10.774	12.532	15.049
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		10.89	11.14	11.53	12.04	12.70	13.50
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		11.02	11.31	11.72	12.27	12.96	13.80
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		11.02	11.31	11.72	12.27	12.96	13.80
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**63**	**46.2**	**54.5**	**57.5**	**64.3**	**71.4**	**78.9**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**63**	**45.5**	**53.8**	**56.9**	**63.8**	**70.9**	**78.6**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**63**	**45.5**	**53.8**	**56.9**	**63.8**	**70.9**	**78.6**
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									
Flanking Element F4 and f4: Transferred Data - In-situ (different junctions at ceiling and floor change loss factors from junction 2)									
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		7.577	8.083	8.892	10.102	11.859	14.377
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		10.52	10.80	11.21	11.76	12.46	13.30
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21		10.84	11.13	11.56	12.13	12.84	13.70
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21		10.84	11.13	11.56	12.13	12.84	13.70
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**63**	**45.5**	**53.8**	**56.9**	**63.7**	**70.9**	**78.5**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**62**	**45.2**	**53.5**	**56.6**	**63.5**	**70.7**	**78.4**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**62**	**45.2**	**53.5**	**56.6**	**63.5**	**70.7**	**78.4**
Total Flanking STC (combined transmission for all flanking paths)			51						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**48**						

EXAMPLE 2.1.2:

- **Rooms one-above-the-other**
- **Concrete Floor and Masonry Walls with Rigid Junctions**

Separating floor/ceiling assembly with:
- 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.

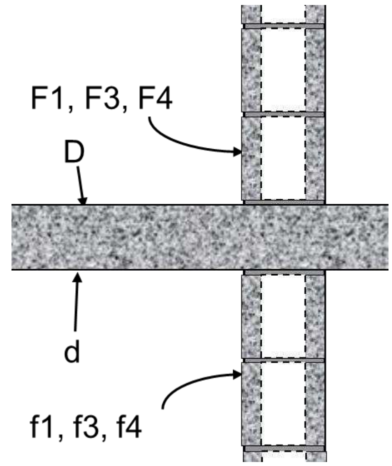
Junction 1, 3, 4: Cross Junction of separating floor / flanking wall with:
- rigid mortared cross junction with concrete block wall assemblies.
- wall above and below floor of one wythe of concrete blocks with mass 238 kg/m^2 (e.g. - 190 mm hollow blocks with normal weight aggregate[1]) with no lining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

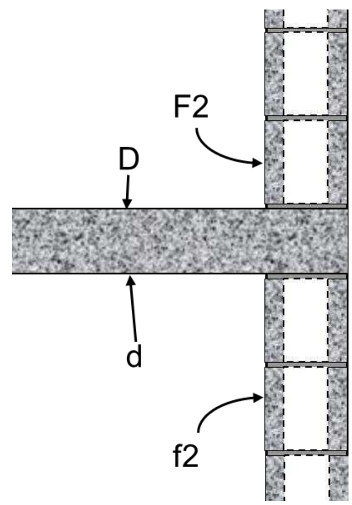
Acoustical Parameters:

For separating assembly:					
nternal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_13	K_12	K_14	Σ l_k . α_k
X-Junction 1, 3, 4	ISO 15712-1, Eq. E.3	6.1	8.8	8.8	0.841
T-Junction 2	ISO 15712-1, Eq. E.4		5.8	5.8	0.650
Total loss, η_{tot}	ISO 15712-1, Eq. C.1		0.028		(Eq. C.2)
			(at 500 Hz)		
Similarly, for flanking elements F and f at Junction 1 & 3,					
nternal 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,					
nternal loss, η_i =	0.015	c_L =	3500		
mass (kg/m²) =	238	f_c =	98		
otal loss, $\eta_{tot,2}$	ISO 15712-1, Eq. C.1		0.047	(at 500 Hz)	
otal loss, $\eta_{tot,4}$	ISO 15712-1, Eq. C.1		0.043	(at 500 Hz)	

Illustration for this case



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



T-Junction of separating floor of 150 mm thick concrete floor 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	IR-811, TLF-97-107a	52	39	39	49	58	67	76
Structural Reverberation Time	T_s,lab	Measured T_s		0.35	0.29	0.18	0.09	0.05	0.04
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	0
Change by Lining on receive side	ΔR_d	No lining ,	0	0	0	0	0	0	0
Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.348	0.238	0.160	0.104	0.066	0.041
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		10.4	10.7	11.3	12.2	13.6	15.6
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**53**	**39.0**	**39.9**	**49.4**	**57.4**	**65.4**	**76.1**

(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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	0.0	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	0.0
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.257	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.799	9.431	10.442	11.954	14.151	17.298
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	50	33.7	41.7	44.4	50.7	57.3	64.1
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	50	33.7	41.7	44.4	50.7	57.3	64.1
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		14.08	14.38	14.82	15.41	16.14	17.01
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**67**	**49.8**	**58.2**	**61.3**	**68.2**	**75.4**	**83.2**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**65**	**49.0**	**53.7**	**60.2**	**67.8**	**75.6**	**85.2**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**65**	**49.0**	**53.7**	**60.2**	**67.8**	**75.6**	**85.2**
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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	0.0	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	0.0
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		8.250	8.756	9.565	10.774	12.532	15.049
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		11.28	11.54	11.92	12.44	13.10	13.89
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		9.50	9.69	10.00	10.43	10.99	11.69
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		9.50	9.69	10.00	10.43	10.99	11.69
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**66**	**48.6**	**56.9**	**59.9**	**66.7**	**73.8**	**81.4**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**63**	**47.7**	**52.3**	**58.7**	**66.3**	**74.0**	**83.5**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**63**	**47.7**	**52.3**	**58.7**	**66.3**	**74.0**	**83.5**
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		0.238	0.158	0.102	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.577	8.083	8.892	10.102	11.859	14.377
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		14.40	14.68	15.09	15.65	16.34	17.18
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21		12.31	12.52	12.84	13.29	13.87	14.59
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21		12.31	12.52	12.84	13.29	13.87	14.59
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**68**	**51.4**	**59.7**	**62.8**	**69.6**	**76.8**	**84.5**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**66**	**50.3**	**55.0**	**61.4**	**69.0**	**76.8**	**86.3**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**66**	**50.3**	**55.0**	**61.4**	**69.0**	**76.8**	**86.3**
Total Flanking STC (combined transmission for all flanking paths)			54						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	50						

EXAMPLE 2.1.3:

- **Rooms side-by-side**
- **Concrete Floors and Concrete Walls with Rigid Junctions**

Separating wall assembly (loadbearing) with:
- solid 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:
- concrete floor with mass 460 kg/m^2 (e.g. – normal weight concrete with thickness of 200 mm) with no topping or flooring
- rigid cross junction with concrete wall assembly.

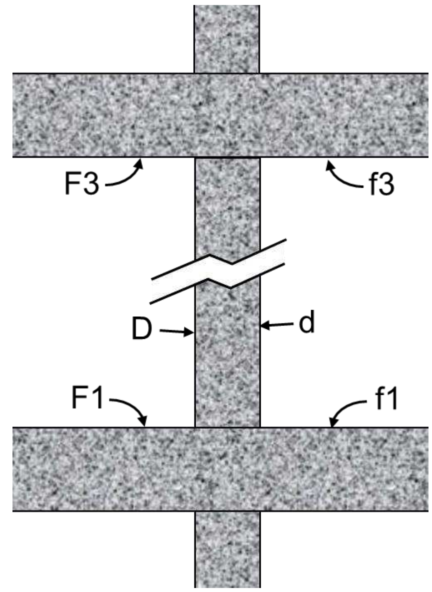
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- abutting side wall and separating wall of solid concrete with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm), with no lining
- rigid T-junctions

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

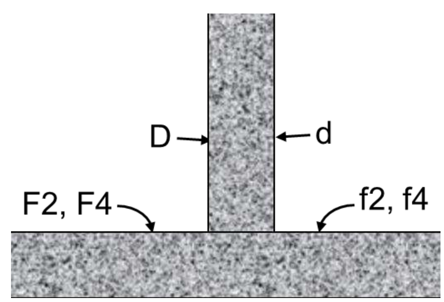
Acoustical Parameters:

For separating assembly:					
nternal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_{13}	K_{12}	K_{14}	$\Sigma\, l_k \cdot \alpha_k$
X-Junction 1 or 3	ISO 15712-1, Eq. E.3	10.9	8.8	8.8	0.544
T-Junction 2 or 4	ISO 15712-1, Eq. E.4		5.7	5.7	0.473
Total loss, η_{tot}	ISO 15712-1, Eq. C.1		0.0293		(Eq. C.2)
			(at 500 Hz)		
Similarly, for flanking elements F and f at Junction 1 & 3,					
nternal 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		0.0303	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 2 & 4,					
nternal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
Total loss, $\eta_{tot,2}$	ISO 15712-1, Eq. C.1		0.0356	(at 500 Hz)	
Total loss, $\eta_{tot,4}$	ISO 15712-1, Eq. C.1		0.0319	(at 500 Hz)	

Illustration for this case



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



Junction of separating wall with side wall, both of 150 mm 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	IR-811, TLF-97-107a	52	39	39	49	58	67	76
Structural Reverberation Time	T_s,lab	Measured T_s		0.35	0.29	0.18	0.09	0.05	0.04
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	No Lining ,	0	0	0	0	0	0	0
Change by Lining on receive side	ΔR_d	No Lining ,	0	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	7.2	7.5	8.1	9.0	10.2
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**53**	**39.3**	**40.2**	**49.7**	**57.7**	**65.6**	**76.3**

(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	TLF-12-013	58	41.8	47.9	54.6	59.8	66.8	70.2
Structural Reverberation Time	T_s,lab	Measured T_s		0.176	0.115	0.109	0.108	0.080	0.076
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	0.0
Change by Lining on receive side	ΔR_f1	No Lining ,	0	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		0.316	0.216	0.145	0.095	0.061	0.038
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		11.430	11.804	12.430	13.382	14.777	16.784
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	56	39.3	45.1	53.3	60.3	67.9	73.2
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	56	39.3	45.1	53.3	60.3	67.9	73.2
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		10.24	10.38	10.61	10.93	11.36	11.91
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		11.30	11.43	11.65	11.97	12.41	12.97
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		11.30	11.43	11.65	11.97	12.41	12.97
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**65**	**47.5**	**53.5**	**61.9**	**69.2**	**77.3**	**83.1**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**65**	**49.5**	**53.1**	**62.2**	**70.0**	**78.2**	**86.7**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**65**	**49.5**	**53.1**	**62.2**	**70.0**	**78.2**	**86.7**
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	IR-811, TLF-97-107a	52	39.0	39.0	49.0	58.0	67.0	76.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.345	0.293	0.176	0.092	0.046	0.042
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	0.0
Change by Lining on receive side	ΔR_f2	No Lining ,	0	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		6.849	7.014	7.311	7.776	8.465	9.463
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	54	40.2	41.1	50.5	58.5	66.3	77.0
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	54	40.2	41.1	50.5	58.5	66.3	77.0
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		10.08	10.18	10.36	10.63	11.00	11.48
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		10.11	10.22	10.42	10.72	11.12	11.65
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		10.11	10.22	10.42	10.72	11.12	11.65
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**65**	**51.2**	**52.2**	**61.9**	**70.1**	**78.3**	**89.4**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**64**	**50.3**	**51.3**	**61.0**	**69.3**	**77.6**	**88.8**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**64**	**50.3**	**51.3**	**61.0**	**69.3**	**77.6**	**88.8**
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									
Flanking Element F4 and f4: Transferred Data - In-situ (different junctions at ceiling and floor change loss factors from junction 2)									
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		6.094	6.259	6.555	7.020	7.710	8.707
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	53	39.7	40.6	50.1	58.0	65.9	76.6
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	53	39.7	40.6	50.1	58.0	65.9	76.6
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		9.57	9.69	9.89	10.18	10.59	11.12
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21		9.85	9.97	10.19	10.50	10.92	11.47
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21		9.85	9.97	10.19	10.50	10.92	11.47
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**64**	**50.2**	**51.2**	**60.9**	**69.2**	**77.5**	**88.7**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**64**	**49.8**	**50.8**	**60.5**	**68.8**	**77.2**	**88.4**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**64**	**49.8**	**50.8**	**60.5**	**68.8**	**77.2**	**88.4**
Total Flanking STC (combined transmission for all flanking paths)			54						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**50**						

EXAMPLE 2.1.4:

- **Rooms one-above-the-other**
- **Concrete Floor and Concrete Walls with Rigid Junctions**

Separating floor/ceiling assembly with:
- concrete floor with mass 460 kg/m^2 (e.g. – normal weight concrete with thickness of 200 mm) with no topping / flooring on top, or ceiling lining below.

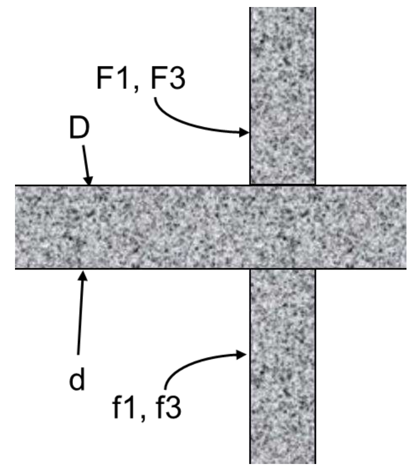
Junction 1, 3, 4: Cross Junction of separating floor / flanking wall with:
- rigid cross junction with concrete wall assemblies.
- wall above and below floor of solid concrete with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) with no lining of walls.

Junction 2: T-Junction of separating floor / flanking wall with:
- rigid T-junctions with concrete wall assemblies
- wall above and below floor of solid concrete with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) with no lining of walls.

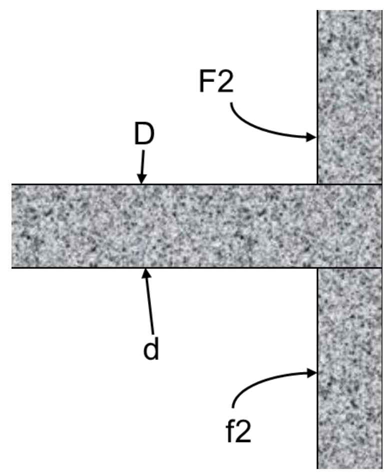
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	460	f_c =	93		
	Reference	K_13	K_12	K_14	Σ l_k . α_k
X-Junction 1, 3, 4	ISO 15712-1, Eq. E.3	6.7	8.8	8.8	0.794
T-Junction 2	ISO 15712-1, Eq. E.4		5.8	5.8	0.742
Total loss, η_tot	ISO 15712-1, Eq. C.1		0.0303		(Eq. C.2)
			(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		0.0356	(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 concrete with 150 mm thick concrete wall.
(Side view of Junctions 1, 3 or 4)



T-Junction of separating floor of 200 mm thick concrete floor with 150 mm thick 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	TLF-12-013	58	41.8	47.9	54.6	59.8	66.8	70.2
Structural Reverberation Time	T_s,lab	Measured T_s		0.18	0.11	0.11	0.11	0.08	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	0
Change by Lining on receive side	ΔR_d	No lining ,	0	0	0	0	0	0	0
Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.316	0.216	0.145	0.095	0.061	0.038
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		11.4	11.8	12.4	13.4	14.8	16.8
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**56**	**39.3**	**45.1**	**53.3**	**60.3**	**67.9**	**73.2**

(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	IR-811, TLF-97-107a	52	39.0	39.0	49.0	58.0	67.0	76.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.345	0.293	0.176	0.092	0.046	0.042
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	0.0
Change by Lining on receive side	ΔR_f1	No lining ,	0	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		6.945	7.150	7.521	8.102	8.964	10.211
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	53	39.3	40.2	49.7	57.7	65.6	76.3
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	53	39.3	40.2	49.7	57.7	65.6	76.3
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		12.35	12.48	12.70	13.02	13.46	14.03
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		11.30	11.43	11.65	11.97	12.41	12.97
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		11.30	11.43	11.65	11.97	12.41	12.97
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**68**	**53.7**	**54.7**	**64.4**	**72.7**	**81.1**	**92.4**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**67**	**51.6**	**55.1**	**64.2**	**72.0**	**80.2**	**88.8**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**67**	**51.6**	**55.1**	**64.2**	**72.0**	**80.2**	**88.8**
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	IR-811, TLF-97-107a	52	39.0	39.0	49.0	58.0	67.0	76.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.345	0.293	0.176	0.092	0.046	0.042
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	0.0
Change by Lining on receive side	ΔR_f2	No lining ,	0	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		6.849	7.014	7.311	7.776	8.465	9.463
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	54	40.2	41.1	50.5	58.5	66.3	77.0
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	54	40.2	41.1	50.5	58.5	66.3	77.0
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		9.89	9.99	10.17	10.44	10.81	11.29
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		9.24	9.36	9.56	9.85	10.25	10.77
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		9.24	9.36	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	**67**	**53.1**	**54.1**	**63.7**	**71.9**	**80.2**	**91.3**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**66**	**50.5**	**54.0**	**63.0**	**70.8**	**78.9**	**87.4**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**66**	**50.5**	**54.0**	**63.0**	**70.8**	**78.9**	**87.4**
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		6.094	6.259	6.555	7.020	7.710	8.707
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	53	39.7	40.6	50.1	58.0	65.9	76.6
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	53	39.7	40.6	50.1	58.0	65.9	76.6
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		12.75	12.87	13.07	13.37	13.78	14.30
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21		11.98	12.11	12.32	12.63	13.05	13.59
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21		11.98	12.11	12.32	12.63	13.05	13.59
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**69**	**55.4**	**56.5**	**66.1**	**74.4**	**82.7**	**93.9**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**69**	**53.0**	**56.5**	**65.5**	**73.3**	**81.5**	**90.0**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**69**	**53.0**	**56.5**	**65.5**	**73.3**	**81.5**	**90.0**
Total Flanking STC (combined transmission for all flanking paths)			57						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**53**						

Summary for Section 2.1: Concrete and Masonry Constructions 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 masonry walls and concrete floor assemblies. 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. The surface could be painted or sealed, or have a thin coat of plaster.

This absence of finishing surface linings is not typical of occupied 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 or ceiling finishes, or flooring) is presented in Section 2.3.

For both the side-by-side pair of rooms (Examples 2.1.1 and 2.1.3) and the rooms one-above-the-other (Example 2.1.2 and 2.1.4) the Apparent Sound Transmission Class (ASTC) is a few decibels lower than the STC of the separating assembly. For these specific wall and floor assemblies, the differences are 2 and 5 for the vertical pairs and 2 for both horizontal pairs, but different mass ratios and laboratory structural decay times could alter the specific differences. What matters is that ASTC values are systematically lower than the STC, 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 Examples 2.1.1 and 2.1.3 for the horizontal pair of rooms shows that the worst flanking paths (lowest Flanking STC) are for the floor-floor and ceiling-ceiling paths with the 150 mm floor slabs, but the sidewall flanking is marginally worse than floor-floor flanking when the floor is 200mm thick. Overall, the flanking paths are all rather similar, and the total flanking is of similar importance to the direct transmission.

In Examples 2.1.2 and 2.1.4 for the vertical pair of rooms, there is little difference between the trends with concrete block or solid concrete walls, presumably because the ratio of floor to wall mass per unit area is similar in both cases. The direct transmission through the floor/ceiling assembly is slightly worse than the combined flanking paths in both cases. As shown in Section 2.3, this tendency can be enhanced by addition of wall linings, or reversed by lining the floor and ceiling.

2.2. Non-Rigid Junctions in Concrete and Masonry Buildings

This section presents worked examples for adjacent rooms in a building which has structural floor slabs of bare 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 concrete floor assembly. The “bare” surface could be painted or sealed, or have a thin coat of plaster. 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 masonry walls can be evaluated by a minor adaptation of the procedure presented in the examples of Section 2.1. Such walls would normally have a fire stop installed between the top of the masonry wall assembly and the bottom of the 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 depend on 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.

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 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.

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 (2005) 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 figure 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 a 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.

EXAMPLE 2.2.1:

- **Rooms side-by-side**
- **Concrete Floors and Masonry Walls with Rigid Junctions, except at top of non-loadbearing separating wall**
- **(Same as 2.1.1 except junction at top of separating wall)**

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:
- concrete floor with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) with no topping or flooring
- rigid mortared T- junction with concrete block wall assembly above, with negligible connection through fire stop to wall below

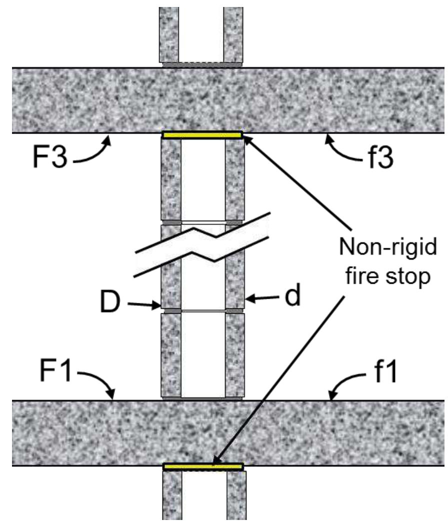
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- abutting side wall and separating wall of concrete blocks with mass 238 kg/m^2 (e.g.- 190 mm hollow blocks with normal weight aggregate[1]), with no lining of walls
- rigid mortared T-junctions

Junction 3: Top Junction (separating wall / ceiling) with:
- concrete ceiling slab with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) 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).

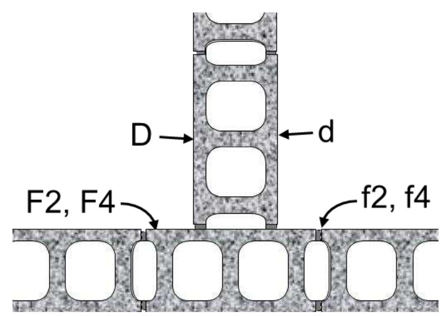
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	0.015	c_L =	3500		
mass (kg/m²) =	237.5	f_c =	98		
	Reference	K_13	K_12	K_14	Σ l_k . α_k
T-Junction 1 or 3	ISO 15712-1, Eq. E.4	3.6	5.8	5.8	0.914
T-Junction 2 or 4	ISO 15712-1, Eq. E.4		5.7	5.7	0.420
Total loss, η_{tot}	ISO 15712-1, Eq. C.1		0.038		(Eq. C.2)
			(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, $\eta_{tot,2}$	ISO 15712-1, Eq. C.1		0.047	(at 500 Hz)	
Total loss, $\eta_{tot,4}$	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 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	IR-586, TL-88-356	50	33	41.2	44	50.4	57	63.9
Structural Reverberation Time	T_s,lab	Estimate, Eq. C.5		0.30	0.19	0.12	0.07	0.04	0.02
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	No Lining ,	0	0	0	0	0	0	0
Change by Lining on receive side	ΔR_d	No Lining ,	0	0	0	0	0	0	0
Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.279	0.183	0.116	0.071	0.042	0.024
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		8.1	8.7	9.7	11.3	13.5	16.6
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**50**	**33.3**	**41.4**	**44.1**	**50.5**	**57.0**	**63.9**

(See footnotes at end of document)

Junction 1 (Rigid T-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	IR-811, TLF-97-107a	52	39.0	39.0	49.0	58.0	67.0	76.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.345	0.293	0.176	0.092	0.046	0.042
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	0.0
Change by Lining on receive side	ΔR_f1	No Lining ,	0	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		0.293	0.202	0.136	0.090	0.058	0.036
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		12.324	12.653	13.246	14.176	15.555	17.550
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	53	39.7	40.6	50.1	58.1	66.0	76.7
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	53	39.7	40.6	50.1	58.1	66.0	76.7
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		7.48	7.60	7.79	8.09	8.49	9.02
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		8.86	9.08	9.42	9.88	10.46	11.18
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		8.86	9.08	9.42	9.88	10.46	11.18
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**59**	**45.1**	**46.2**	**55.9**	**64.1**	**72.4**	**83.6**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**60**	**44.3**	**49.1**	**55.5**	**63.1**	**71.0**	**80.5**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**60**	**44.3**	**49.1**	**55.5**	**63.1**	**71.0**	**80.5**
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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	0.0	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	0.0
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		8.250	8.756	9.565	10.774	12.532	15.049
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		10.89	11.14	11.53	12.04	12.70	13.50
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		10.85	11.14	11.57	12.14	12.86	13.71
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		10.85	11.14	11.57	12.14	12.86	13.71
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**63**	**46.2**	**54.5**	**57.5**	**64.3**	**71.4**	**78.9**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**62**	**45.2**	**53.5**	**56.6**	**63.5**	**70.7**	**78.4**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**62**	**45.2**	**53.5**	**56.6**	**63.5**	**70.7**	**78.4**
Junction 3 (Rigid T-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	**59**	**45.1**	**46.2**	**55.9**	**64.1**	**72.4**	**83.6**
Flanking TL for Path Fd_3	R_Fd	Negligible connection	>85						
Flanking TL for Path Df_3	R_Df	Negligible connection	>85						
Junction 4 (Rigid T-junction, 190 mm block separating wall / 190 mm block flanking wall)									
All input data the same as for Junction 2									
Flanking Element F4 and f4: Transferred Data - In-situ (different junctions at ceiling and floor change loss factors from junction 2)									
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		7.577	8.083	8.892	10.102	11.859	14.377
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		10.52	10.80	11.21	11.76	12.46	13.30
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21		10.66	10.97	11.41	12.00	12.74	13.61
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21		10.66	10.97	11.41	12.00	12.74	13.61
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**63**	**45.5**	**53.8**	**56.9**	**63.7**	**70.9**	**78.5**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**62**	**44.8**	**53.2**	**56.3**	**63.2**	**70.5**	**78.2**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**62**	**44.8**	**53.2**	**56.3**	**63.2**	**70.5**	**78.2**
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:

- **Rooms one-above-the-other**
- **Concrete Floor and Masonry Walls (Like 2.1.2 except Cross Junctions replaced by Non-Loadbearing Junctions)**

Separating floor/ceiling assembly with:

- concrete floor with mass 345 kg/m² (e.g. – normal weight concrete with thickness of 150 mm) with no topping / flooring on top, 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.
- wall above and below floor of one wythe of concrete blocks with mass 238 kg/m² (e.g. - 190 mm hollow blocks with normal weight aggregate[1]) with no lining of walls.

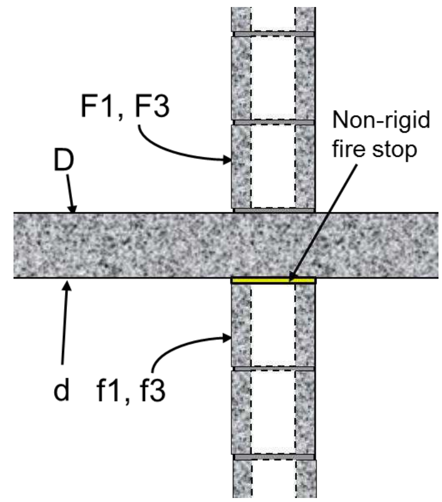
Junction 2 or 4: Rigid Junction of separating floor / flanking wall with:

- 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/m² (e.g. - 190 mm hollow blocks with normal weight aggregate[1]) with no lining of walls.

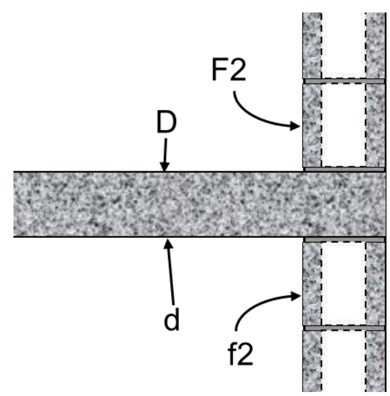
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_13	K_12	K_14	Σ l_k . α_k
T-Junction 1 or 3	ISO 15712-1, Eq. E.4	3.6	5.8	5.8	1.180
T-Junction 2	ISO 15712-1, Eq. E.4		5.8	5.8	0.650
X-Junction 4	ISO 15712-1, Eq. E.3	6.1	8.8	8.8	0.673
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, $\eta_{tot,2}$	ISO 15712-1, Eq. C.1		0.047	(at 500 Hz)	
Total loss, $\eta_{tot,4}$	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 & 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	IR-811, TLF-97-107a	52	39	39	49	58	67	76
Structural Reverberation Time	T_s,lab	Measured T_s		0.35	0.29	0.18	0.09	0.05	0.04
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	0
Change by Lining on receive side	ΔR_d	No lining ,	0	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	13.2	14.2	15.6	17.6
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**53**	**39.7**	**40.6**	**50.1**	**58.1**	**66.0**	**76.7**

(See footnotes at end of document)

Junction 1 (Rigid T-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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	0.0	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	0.0
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.279	0.183	0.116	0.071	0.042	0.024
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.104	8.736	9.747	11.259	13.456	16.603
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	50	33.3	41.4	44.1	50.5	57.0	63.9
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	50	33.3	41.4	44.1	50.5	57.0	63.9
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		8.86	9.08	9.42	9.88	10.46	11.18
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	>85						
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**62**	**46.4**	**51.1**	**57.6**	**65.2**	**73.0**	**82.5**
Flanking TL for Path Df_1	R_Df	Negligible connection	>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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	0.0	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	0.0
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		8.250	8.756	9.565	10.774	12.532	15.049
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		11.28	11.54	11.92	12.44	13.10	13.89
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		9.87	10.05	10.34	10.75	11.28	11.94
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		9.87	10.05	10.34	10.75	11.28	11.94
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**66**	**48.6**	**56.9**	**59.9**	**66.7**	**73.8**	**81.4**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**64**	**48.4**	**53.1**	**59.4**	**66.9**	**74.6**	**84.0**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**64**	**48.4**	**53.1**	**59.4**	**66.9**	**74.6**	**84.0**
Junction 3 (Rigid T-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 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		0.238	0.158	0.102	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.577	8.083	8.892	10.102	11.859	14.377
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		14.40	14.68	15.09	15.65	16.34	17.18
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21		12.68	12.88	13.18	13.61	14.16	14.84
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21		12.68	12.88	13.18	13.61	14.16	14.84
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**68**	**51.4**	**59.7**	**62.8**	**69.6**	**76.8**	**84.5**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**67**	**51.0**	**55.7**	**62.1**	**69.6**	**77.4**	**86.8**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**67**	**51.0**	**55.7**	**62.1**	**69.6**	**77.4**	**86.8**
Total Flanking STC (combined transmission for all flanking paths)			56						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**51**						

Summary for Section 2.2: Concrete and Masonry Constructions with Non-rigid Junctions

The worked examples 2.2.1 and 2.2.2 illustrate the process for calculating sound transmission between rooms in a building with bare concrete and masonry floor and wall assemblies where some of the junctions are non-rigid.

For both the side-by-side pair of rooms (Example 2.2.1) and the rooms one-above-the-other (Example 2.2.2) the Apparent Sound Transmission Class (ASTC) is a few decibels lower than the STC of the separating assembly. For these specific wall and floor assemblies, the difference is 3 for the horizontal pair and 1 for the vertical pair, but different mass ratios would alter the specific differences. The basic issue is that ASTC values are systematically lower than the STC, 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 Example 2.2.1 for the horizontal pair of rooms shows that the worst flanking (lowest Flanking STC) is observed for the floor-floor and ceiling-ceiling paths Ff, and comparison with the examples for rigid joints shows that the introduction of a non-loadbearing junction at the top of the separating wall increases this transmission via the floor and ceiling surfaces, slightly lowering the overall ASTC between the horizontal pair of rooms, because elimination of paths Fd and Df at the wall/ceiling junction is more than offset by the increase for the other flanking paths involving the floor and ceiling. In Example 2.1.2, for the vertical pair of rooms, the paths involving the non-loadbearing wall junctions (Ff and Df at Junctions 1 and 3) have negligible flanking (very high Flanking STC), but this only slightly improves the ASTC because eight of the twelve flanking paths still involve rigid junctions, so there is only a small change in total flanking transmission.

Other non-rigid junction details with more rigid fire stop materials would presumably fall somewhere between the cases presented in Section 2.1 and Section 2.2.

Overall, the key conclusion seems to be that introducing non-loadbearing masonry walls has only a small effect on the overall ASTC between the adjacent rooms.

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 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" and 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.

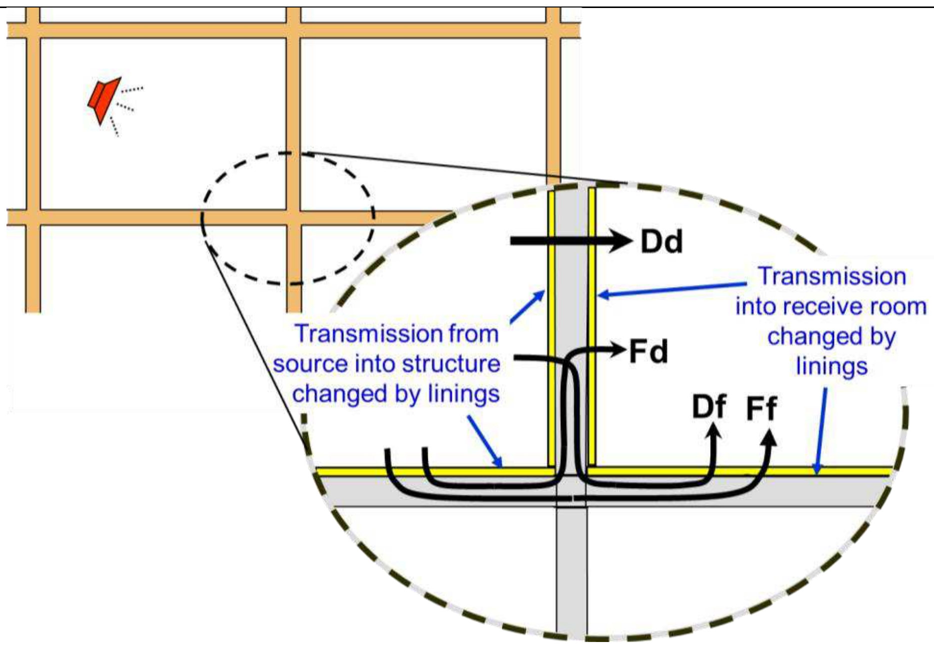


Figure 2.3: Transmission combines direct path through separating wall (Dd) and structure-borne flanking via paths Df, Fd, and FF at each of the four edges of the separating assembly. Transmission via these paths is altered by addition of linings in the source room and/or receiving room.

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 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 $\Delta_{RD,situ}$ and $\Delta_{Rd,situ}$ 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 $\Delta_{Ri,situ}$ and $\Delta_{Rj,situ}$ 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. 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, to condense the examples to 2-page format.

Under the single heading “STC, ASTC, etc.” the examples present single figure 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 a 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 explicit references to applicable equations and sections of ISO 15712-1 (2005) 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.

Validation studies [13] 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:

- **Rooms side-by-side**
- **Concrete Floors and Masonry 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/m² (e.g.- 190 mm hollow blocks with normal weight aggregate[1])
- separating wall lined on both sides with 16 mm gypsum board[3] supported on 65 mm non-loadbearing steel studs spaced 600 mm o.c., with no absorptive material[2] filling stud cavities.

Junction 1: Bottom Junction (separating wall / floor) with:
- concrete floor with mass 345 kg/m² (e.g. – normal weight concrete with thickness of 150 mm) with no topping or flooring
- rigid mortared cross junction with concrete block wall assembly.

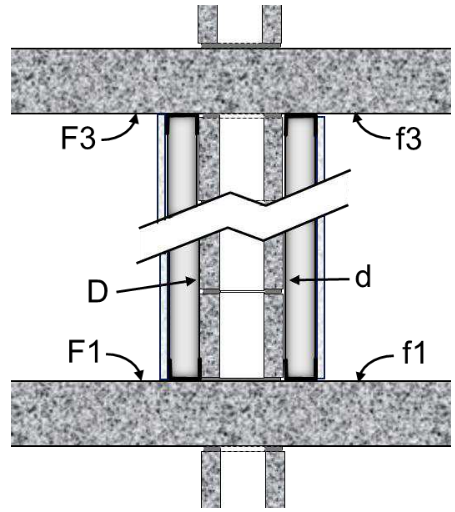
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- side wall and separating wall of concrete blocks with mass 238 kg/m² (e.g.- 190 mm hollow blocks with normal weight aggregate[1]) with rigid mortared T-junctions
- flanking walls lined with 16 mm gypsum board[3] supported on 65 mm non-loadbearing steel studs spaced 600 mm o.c. with no absorptive material[2] filling stud cavities.

Junction 3: Top Junction (separating wall / ceiling) with:
- concrete ceiling slab with mass 345 kg/m² (e.g. – normal weight concrete with thickness of 150 mm) with no added ceiling lining
- rigid mortared cross junction with concrete block wall assembly.

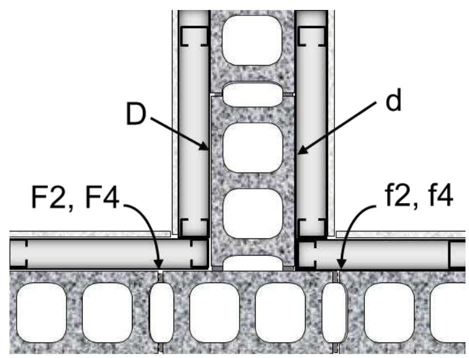
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	0.015	c_L =	3500		
mass (kg/m²) =	237.5	f_c =	98		
	Reference	K_13	K_12	K_14	Σ l_k . α_k
X-Junction 1 or 3	ISO 15712-1, Eq. E.3	11.6	8.8	8.8	0.566
T-Junction 2 or 4	ISO 15712-1, Eq. E.4		5.7	5.7	0.420
Total loss, η_tot	ISO 15712-1, Eq. C.1		0.041		(Eq. C.2)
			(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 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	IR-586, TL-88-356	50	33	41.2	44	50.4	57	63.9
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.30	0.19	0.12	0.07	0.04	0.02
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	IR-586 , SS65_G16	8	1	8.8	16.6	13.3	7.7	7.6
Change by Lining on receive side	ΔR_d	IR-586 , SS65_G16	8	1	8.8	16.6	13.3	7.7	7.6
Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.257	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		8.8	9.4	10.4	12.0	14.2	17.3
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**60**	**35.7**	**59.3**	**77.6**	**77.3**	**72.7**	**79.3**

(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	IR-811, TLF-97-107a	52	39.0	39.0	49.0	58.0	67.0	76.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.345	0.293	0.176	0.092	0.046	0.042
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	0.0
Change by Lining on receive side	ΔR_f1	No Lining ,	0	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		0.348	0.238	0.160	0.104	0.066	0.041
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		10.395	10.724	11.318	12.247	13.626	15.621
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	53	39.0	39.9	49.4	57.4	65.4	76.1
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	53	39.0	39.9	49.4	57.4	65.4	76.1
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		9.26	9.39	9.62	9.97	10.43	11.02
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**60**	**46.2**	**47.3**	**57.0**	**65.4**	**73.8**	**85.1**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**72**	**48.0**	**60.5**	**74.7**	**79.1**	**81.3**	**90.7**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**72**	**48.0**	**60.5**	**74.7**	**79.1**	**81.3**	**90.7**
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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	IR-586 , SS65_G16	8	1.0	8.8	16.6	13.3	7.7	7.6
Change by Lining on receive side	ΔR_f2	IR-586 , SS65_G16	8	1.0	8.8	16.6	13.3	7.7	7.6
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		8.250	8.756	9.565	10.774	12.532	15.049
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		10.89	11.14	11.53	12.04	12.70	13.50
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		11.02	11.31	11.72	12.27	12.96	13.80
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		11.02	11.31	11.72	12.27	12.96	13.80
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**72**	**48.2**	**72.1**	**90.7**	**90.9**	**86.8**	**94.1**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**72**	**47.5**	**71.4**	**90.1**	**90.4**	**86.3**	**93.8**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**72**	**47.5**	**71.4**	**90.1**	**90.4**	**86.3**	**93.8**
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									
Flanking Element F4 and f4: Transferred Data - In-situ (different junctions at ceiling and floor change loss factors from junction 2)									
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		7.577	8.083	8.892	10.102	11.859	14.377
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		10.52	10.80	11.21	11.76	12.46	13.30
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21		10.84	11.13	11.56	12.13	12.84	13.70
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21		10.84	11.13	11.56	12.13	12.84	13.70
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**71**	**47.5**	**71.4**	**90.1**	**90.3**	**86.3**	**93.7**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**71**	**47.2**	**71.1**	**89.8**	**90.1**	**86.1**	**93.6**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**71**	**47.2**	**71.1**	**89.8**	**90.1**	**86.1**	**93.6**
Total Flanking STC (combined transmission for all flanking paths)			56						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**55**						

EXAMPLE 2.3.2:

- **Rooms side-by-side**
- **Concrete Floors and Masonry 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 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs spaced 600 mm o.c., with absorptive material[2] filling stud cavities.

Junction 1: Bottom Junction (separating wall / floor) with:
- concrete floor with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) with no topping or flooring
- rigid mortared cross junction with concrete block wall assembly.

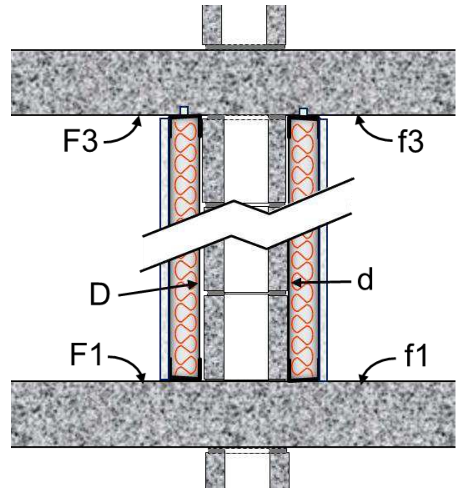
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- rigid mortared T-junctions of abutting side wall and separating wall of concrete blocks with mass 238 kg/m^2 (e.g.- 190 mm hollow blocks with normal weight aggregate[1])
- flanking walls lined with 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs spaced 600 mm o.c., with absorptive material[2] filling stud cavities.

Junction 3: Top Junction (separating wall / ceiling) with:
- concrete ceiling slab with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) with no added ceiling lining
- rigid mortared cross junction with concrete block wall assembly.

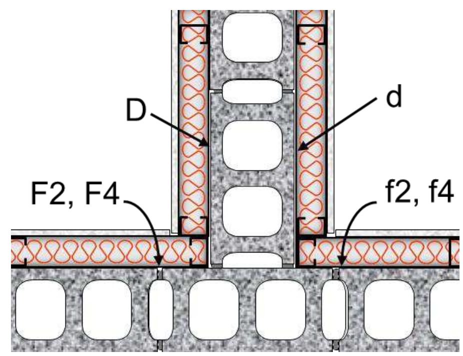
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	0.015	c_L =	3500		
mass (kg/m²) =	237.5	f_c =	98		
	Reference	K_13	K_12	K_14	Σ l_k . α_k
X-Junction 1 or 3	ISO 15712-1, Eq. E.3	11.6	8.8	8.8	0.566
T-Junction 2 or 4	ISO 15712-1, Eq. E.4		5.7	5.7	0.420
Total loss, η_{tot}	ISO 15712-1, Eq. C.1		0.041		(Eq. C.2)
			(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, $\eta_{tot,2}$	ISO 15712-1, Eq. C.1		0.047	(at 500 Hz)	
Total loss, $\eta_{tot,4}$	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 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	IR-586, TL-88-356	50	33	41.2	44	50.4	57	63.9
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.30	0.19	0.12	0.07	0.04	0.02
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	IR-586 , SS65_GFB65_G16	11	7.1	13.7	14.8	11	7.8	8.4
Change by Lining on receive side	ΔR_d	IR-586 , SS65_GFB65_G16	11	7.1	13.7	14.8	11	7.8	8.4
Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.257	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		8.8	9.4	10.4	12.0	14.2	17.3
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**72**	**47.9**	**69.1**	**74.0**	**72.7**	**72.9**	**80.9**

(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: Inpu	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	IR-811, TLF-97-107a	52	39.0	39.0	49.0	58.0	67.0	76.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.345	0.293	0.176	0.092	0.046	0.042
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	0.0
Change by Lining on receive side	ΔR_f1	No Lining ,	0	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		0.348	0.238	0.160	0.104	0.066	0.041
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		10.395	10.724	11.318	12.247	13.626	15.621
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	53	39.0	39.9	49.4	57.4	65.4	76.1
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	53	39.0	39.9	49.4	57.4	65.4	76.1
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		9.26	9.39	9.62	9.97	10.43	11.02
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**60**	**46.2**	**47.3**	**57.0**	**65.4**	**73.8**	**85.1**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**75**	**54.1**	**65.4**	**72.9**	**76.8**	**81.4**	**91.5**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**75**	**54.1**	**65.4**	**72.9**	**76.8**	**81.4**	**91.5**
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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	IR-586 , SS65_GFB65_G16	11	7.1	13.7	14.8	11.0	7.8	8.4
Change by Lining on receive side	ΔR_f2	IR-586 , SS65_GFB65_G16	11	7.1	13.7	14.8	11.0	7.8	8.4
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		8.250	8.756	9.565	10.774	12.532	15.049
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		10.89	11.14	11.53	12.04	12.70	13.50
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		11.02	11.31	11.72	12.27	12.96	13.80
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		11.02	11.31	11.72	12.27	12.96	13.80
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**84**	**60.4**	**81.9**	**87.1**	**86.3**	**87.0**	**95.7**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**84**	**59.7**	**81.2**	**86.5**	**85.8**	**86.5**	**95.4**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**84**	**59.7**	**81.2**	**86.5**	**85.8**	**86.5**	**95.4**
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									
Flanking Element F4 and f4: Transferred Data - In-situ (different junctions at ceiling and floor change loss factors from junction 2)									
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		7.577	8.083	8.892	10.102	11.859	14.377
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		10.52	10.80	11.21	11.76	12.46	13.30
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21		10.84	11.13	11.56	12.13	12.84	13.70
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21		10.84	11.13	11.56	12.13	12.84	13.70
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**84**	**59.7**	**81.2**	**86.5**	**85.7**	**86.5**	**95.3**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**83**	**59.4**	**80.9**	**86.2**	**85.5**	**86.3**	**95.2**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**83**	**59.4**	**80.9**	**86.2**	**85.5**	**86.3**	**95.2**
Total Flanking STC (combined transmission for all flanking paths)			57						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**57**						

EXAMPLE 2.3.3:

- **Rooms one-above-the-other**
- **Concrete Floor and Masonry Walls with Rigid Junctions (Same structure as Example 2.1.2, plus lining of walls)**

Separating floor/ceiling assembly with:
- 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.

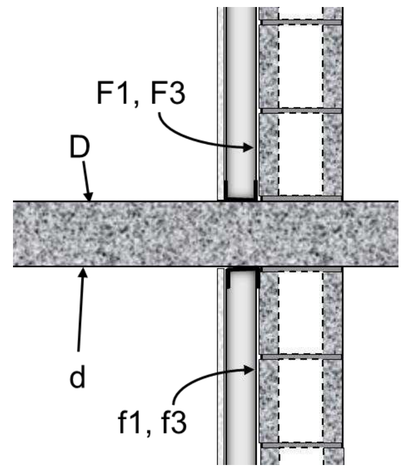
Junction 1, 3 or 4: Cross Junction of separating floor / flanking wall with:
- rigid mortared cross junction with concrete block wall assemblies.
- wall above and below floor of one wythe of 190 mm hollow concrete blocks with normal weight aggregate[1], with mass 238 kg/m^2.
- flanking walls lined with 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs 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 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs spaced 600 mm o.c. with no absorptive material[2] filling stud cavities

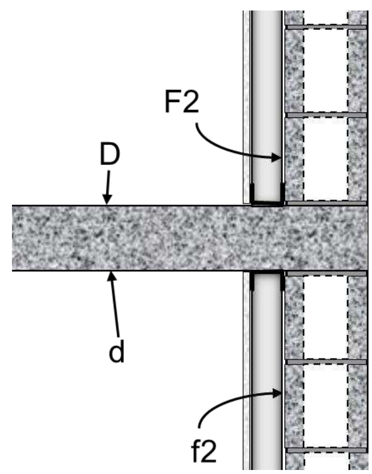
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_13	K_12	K_14	Σ l_k . α_k
X-Junction 1, 3 or 4	ISO 15712-1, Eq. E.3	6.1	8.8	8.8	0.841
T-Junction 2	ISO 15712-1, Eq. E.4		5.8	5.8	0.650
Total loss, η_tot	ISO 15712-1, Eq. C.1		0.028		(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		0.041	(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 concrete with 190 mm concrete block wall. (Side view of Junction 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	IR-811, TLF-97-107a	52	39	39	49	58	67	76
Structural Reverberation Time	T_s,lab	Measured T_s		0.35	0.29	0.18	0.09	0.05	0.04
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	0
Change by Lining on receive side	ΔR_d	No lining ,	0	0	0	0	0	0	0
Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.348	0.238	0.160	0.104	0.066	0.041
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		10.4	10.7	11.3	12.2	13.6	15.6
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**53**	**39.0**	**39.9**	**49.4**	**57.4**	**65.4**	**76.1**

(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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	IR-586 , SS65_G16	8	1.0	8.8	16.6	13.3	7.7	7.6
Change by Lining on receive side	ΔR_f1	IR-586 , SS65_G16	8	1.0	8.8	16.6	13.3	7.7	7.6
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.257	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.799	9.431	10.442	11.954	14.151	17.298
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	50	33.7	41.7	44.4	50.7	57.3	64.1
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	50	33.7	41.7	44.4	50.7	57.3	64.1
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		14.08	14.38	14.82	15.41	16.14	17.01
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**76**	**51.8**	**75.8**	**94.5**	**94.8**	**90.8**	**98.4**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**74**	**50.0**	**62.5**	**76.8**	**81.1**	**83.3**	**92.8**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**74**	**50.0**	**62.5**	**76.8**	**81.1**	**83.3**	**92.8**
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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	IR-586 , SS65_G16	8	1.0	8.8	16.6	13.3	7.7	7.6
Change by Lining on receive side	ΔR_f2	IR-586 , SS65_G16	8	1.0	8.8	16.6	13.3	7.7	7.6
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		8.250	8.756	9.565	10.774	12.532	15.049
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		11.28	11.54	11.92	12.44	13.10	13.89
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		9.50	9.69	10.00	10.43	10.99	11.69
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		9.50	9.69	10.00	10.43	10.99	11.69
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**75**	**50.6**	**74.5**	**93.1**	**93.3**	**89.2**	**96.6**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**73**	**48.7**	**61.1**	**75.3**	**79.6**	**81.7**	**91.1**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**73**	**48.7**	**61.1**	**75.3**	**79.6**	**81.7**	**91.1**
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		0.238	0.158	0.102	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.577	8.083	8.892	10.102	11.859	14.377
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		14.40	14.68	15.09	15.65	16.34	17.18
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21		12.31	12.52	12.84	13.29	13.87	14.59
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21		12.31	12.52	12.84	13.29	13.87	14.59
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**77**	**53.4**	**77.3**	**96.0**	**96.2**	**92.2**	**99.7**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**75**	**51.3**	**63.8**	**78.0**	**82.3**	**84.5**	**93.9**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**75**	**51.3**	**63.8**	**78.0**	**82.3**	**84.5**	**93.9**
Total Flanking STC (combined transmission for all flanking paths)			64						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**52**						

EXAMPLE 2.3.4:

- **Rooms one-above-the-other**
- **Concrete Floor and Masonry Walls with Rigid Junctions (Same structure as Example 2.1.2, enhanced lining of walls)**

Separating floor/ceiling assembly with:
- 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.

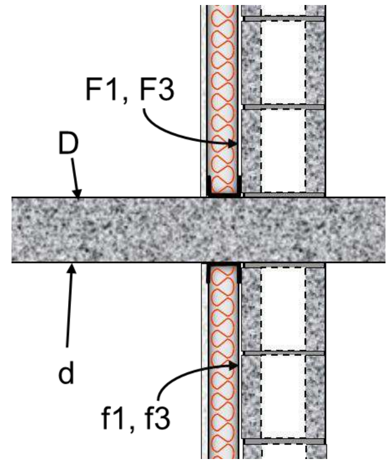
Junction 1, 3, 4: Cross Junction of separating floor / flanking wall with:
- rigid mortared cross junction with concrete block wall assemblies.
- wall above and below floor of one wythe of 190 mm hollow concrete blocks with normal weight aggregate[1], with mass 238 kg/m^2.
- flanking walls lined with 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs 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 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs spaced 600 mm o.c. with absorptive material[2] filling stud cavities.

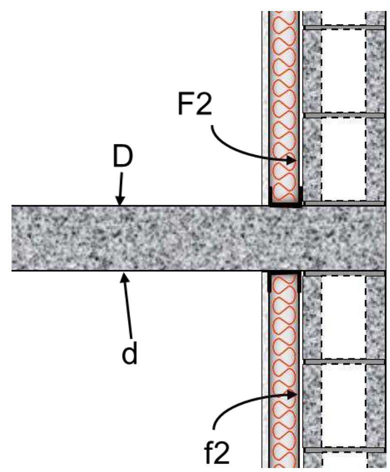
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_{13}	K_{12}	K_{14}	$\Sigma l_k . \alpha_k$
X-Junction 1, 3 or 4	ISO 15712-1, Eq. E.3	6.1	8.8	8.8	0.841
T-Junction 2	ISO 15712-1, Eq. E.4		5.8	5.8	0.650
Total loss, η_{tot}	ISO 15712-1, Eq. C.1		0.028		(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		0.041	(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, $\eta_{tot,2}$	ISO 15712-1, Eq. C.1		0.047	(at 500 Hz)	
Total loss, $\eta_{tot,4}$	ISO 15712-1, Eq. C.1		0.043	(at 500 Hz)	

Illustration for this case



Cross junction of separating floor of 150 mm thick 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	IR-811, TLF-97-107a	52	39	39	49	58	67	76
Structural Reverberation Time	T_s,lab	Measured T_s		0.35	0.29	0.18	0.09	0.05	0.04
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	0
Change by Lining on receive side	ΔR_d	No lining ,	0	0	0	0	0	0	0
Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.348	0.238	0.160	0.104	0.066	0.041
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		10.4	10.7	11.3	12.2	13.6	15.6
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**53**	**39.0**	**39.9**	**49.4**	**57.4**	**65.4**	**76.1**

(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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	IR-586 , SS65_GFB65_G16	11	7.1	13.7	14.8	11.0	7.8	8.4
Change by Lining on receive side	ΔR_f1	IR-586 , SS65_GFB65_G16	11	7.1	13.7	14.8	11.0	7.8	8.4
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.257	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.799	9.431	10.442	11.954	14.151	17.298
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	50	33.7	41.7	44.4	50.7	57.3	64.1
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	50	33.7	41.7	44.4	50.7	57.3	64.1
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		14.08	14.38	14.82	15.41	16.14	17.01
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**88**	**64.0**	**85.6**	**90.9**	**90.2**	**91.0**	**100.0**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**77**	**56.1**	**67.4**	**75.0**	**78.8**	**83.4**	**93.6**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**77**	**56.1**	**67.4**	**75.0**	**78.8**	**83.4**	**93.6**
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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	IR-586 , SS65_GFB65_G16	11	7.1	13.7	14.8	11.0	7.8	8.4
Change by Lining on receive side	ΔR_f2	IR-586 , SS65_GFB65_G16	11	7.1	13.7	14.8	11.0	7.8	8.4
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		8.250	8.756	9.565	10.774	12.532	15.049
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		11.28	11.54	11.92	12.44	13.10	13.89
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		9.50	9.69	10.00	10.43	10.99	11.69
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		9.50	9.69	10.00	10.43	10.99	11.69
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**87**	**62.8**	**84.3**	**89.5**	**88.7**	**89.4**	**98.2**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**76**	**54.8**	**66.0**	**73.5**	**77.3**	**81.8**	**91.9**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**76**	**54.8**	**66.0**	**73.5**	**77.3**	**81.8**	**91.9**
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		0.238	0.158	0.102	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.577	8.083	8.892	10.102	11.859	14.377
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		14.40	14.68	15.09	15.65	16.34	17.18
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21		12.31	12.52	12.84	13.29	13.87	14.59
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21		12.31	12.52	12.84	13.29	13.87	14.59
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**90**	**65.6**	**87.1**	**92.4**	**91.6**	**92.4**	**101.3**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**78**	**57.4**	**68.7**	**76.2**	**80.0**	**84.6**	**94.7**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**78**	**57.4**	**68.7**	**76.2**	**80.0**	**84.6**	**94.7**
Total Flanking STC (combined transmission for all flanking paths)			68						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**53**						

EXAMPLE 2.3.5:

- **Rooms one-above-the-other**
- **Concrete Floor and Masonry Walls with Rigid Junctions (Same structure as Example 2.1.2, lining of walls and ceiling)**

Separating floor/ceiling assembly with:
- concrete floor with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) 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]

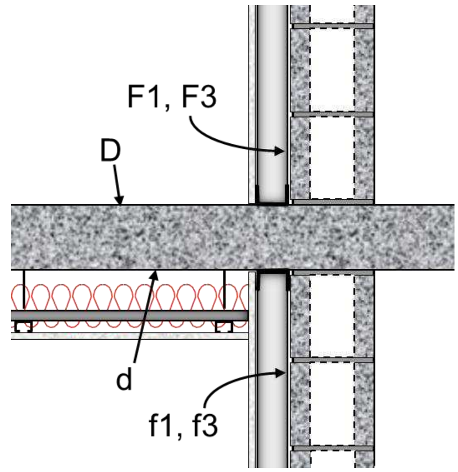
Junction 1, 3 or 4: Cross Junction of separating floor / flanking wall with:
- rigid mortared cross junction with concrete block wall assemblies.
- wall above and below floor of one wythe of 190 mm hollow concrete blocks with normal weight aggregate[1], with mass 238 kg/m^2.
- flanking walls lined with 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs 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 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs spaced 600 mm o.c. with no absorptive material[2] filling stud cavities

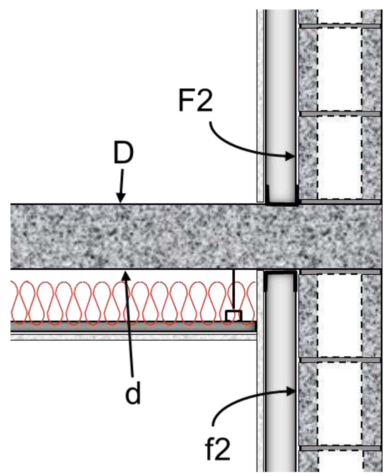
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_13	K_12	K_14	Σ l_k . α_k
‹-Junction 1, 3 or 4	ISO 15712-1, Eq. E.3	6.1	8.8	8.8	0.841
T-Junction 2	ISO 15712-1, Eq. E.4		5.8	5.8	0.650
Total loss, η_tot	ISO 15712-1, Eq. C.1		0.028		(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		0.041	(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 concrete with 190 mm concrete block wall. (Side view of Junctions 1 & 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	IR-811, TLF-97-107a	52	39	39	49	58	67	76
Structural Reverberation Time	T_s,lab	Measured T_s		0.35	0.29	0.18	0.09	0.05	0.04
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	0
Change by Lining on receive side	ΔR_d	RR-333 , ΔTLF-CON150-01	19	7.6	20.8	23.7	24.3	21.5	18.5
Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.348	0.238	0.160	0.104	0.066	0.041
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		10.4	10.7	11.3	12.2	13.6	15.6
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**71**	**46.6**	**60.7**	**73.1**	**81.7**	**86.9**	**94.6**

(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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	IR-586 , SS65_G16	8	1.0	8.8	16.6	13.3	7.7	7.6
Change by Lining on receive side	ΔR_f1	IR-586 , SS65_G16	8	1.0	8.8	16.6	13.3	7.7	7.6
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.257	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.799	9.431	10.442	11.954	14.151	17.298
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	50	33.7	41.7	44.4	50.7	57.3	64.1
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	50	33.7	41.7	44.4	50.7	57.3	64.1
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		14.08	14.38	14.82	15.41	16.14	17.01
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**76**	**51.8**	**75.8**	**94.5**	**94.8**	**90.8**	**98.4**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**82**	**57.6**	**83.3**	**100.5**	**105.4**	**104.8**	**111.3**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**74**	**50.0**	**62.5**	**76.8**	**81.1**	**83.3**	**92.8**
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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	IR-586 , SS65_G16	8	1.0	8.8	16.6	13.3	7.7	7.6
Change by Lining on receive side	ΔR_f2	IR-586 , SS65_G16	8	1.0	8.8	16.6	13.3	7.7	7.6
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		8.250	8.756	9.565	10.774	12.532	15.049
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		11.28	11.54	11.92	12.44	13.10	13.89
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		9.50	9.69	10.00	10.43	10.99	11.69
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		9.50	9.69	10.00	10.43	10.99	11.69
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**75**	**50.6**	**74.5**	**93.1**	**93.3**	**89.2**	**96.6**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**80**	**56.3**	**81.9**	**99.0**	**103.9**	**103.2**	**109.6**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**73**	**48.7**	**61.1**	**75.3**	**79.6**	**81.7**	**91.1**
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		0.238	0.158	0.102	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.577	8.083	8.892	10.102	11.859	14.377
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	Eq. 21		14.40	14.68	15.09	15.65	16.34	17.18
Velocity Level Difference for Fd	D_v,Fd_4,situ	Eq. 21		12.31	12.52	12.84	13.29	13.87	14.59
Velocity Level Difference for Df	D_v,Df_4,situ	Eq. 21		12.31	12.52	12.84	13.29	13.87	14.59
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**77**	**53.4**	**77.3**	**96.0**	**96.2**	**92.2**	**99.7**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**83**	**58.9**	**84.6**	**101.7**	**106.6**	**106.0**	**112.4**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**75**	**51.3**	**63.8**	**78.0**	**82.3**	**84.5**	**93.9**
Total Flanking STC (combined transmission for all flanking paths)			65						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**64**						

EXAMPLE 2.3.6:

- **Rooms one-above-the-other**
- **Concrete Floor and Masonry Walls with Rigid Junctions (Same structure as Example 2.1.2, lining of walls and ceiling)**

Separating floor/ceiling assembly with:
- concrete floor with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) 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]

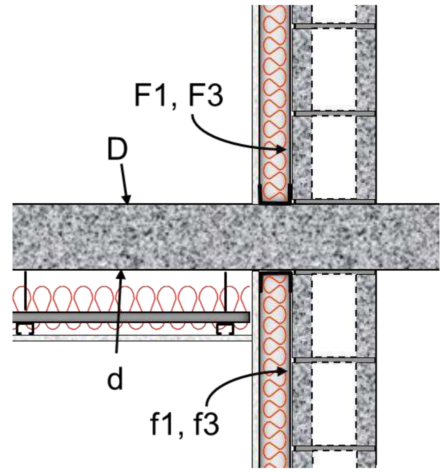
Junction 1, 3 or 4: Cross Junction of separating floor / flanking wall with:
- rigid mortared cross junction with concrete block wall assemblies.
- wall above and below floor of one wythe of 190 mm hollow concrete blocks with normal weight aggregate[1], with mass 238 kg/m^2.
- flanking walls lined with 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs 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 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs spaced 600 mm o.c. with absorptive material[2] filling stud cavities

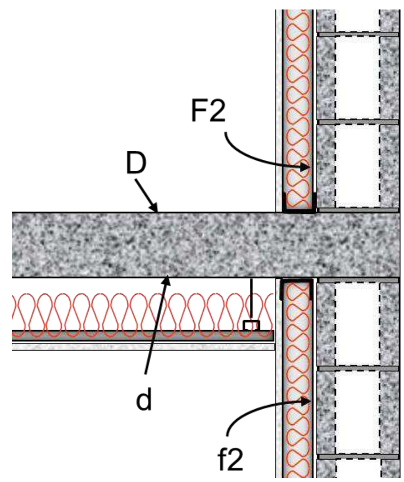
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_{13}	K_{12}	K_{14}	$\Sigma l_k . \alpha_k$
X-Junction 1,3 or 4	ISO 15712-1, Eq. E.3	6.1	8.8	8.8	0.841
T-Junction 2	ISO 15712-1, Eq. E.4		5.8	5.8	0.650
Total loss, η_{tot}	ISO 15712-1, Eq. C.1		0.028		(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		0.041	(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, $\eta_{tot,2}$	ISO 15712-1, Eq. C.1		0.047	(at 500 Hz)	
Total loss, $\eta_{tot,4}$	ISO 15712-1, Eq. C.1		0.043	(at 500 Hz)	

Illustration for this case



Cross junction of separating floor of 150 mm thick concrete with 190 mm concrete block wall. (Side view of Junctions 1 & 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	IR-811, TLF-97-107a	52	39	39	49	58	67	76
Structural Reverberation Time	T_s,lab	Measured T_s		0.35	0.29	0.18	0.09	0.05	0.04
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	0
Change by Lining on receive side	ΔR_d	RR-333 , ΔTLF-CON150-01	19	7.6	20.8	23.7	24.3	21.5	18.5
Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.348	0.238	0.160	0.104	0.066	0.041
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		10.4	10.7	11.3	12.2	13.6	15.6
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**71**	**46.6**	**60.7**	**73.1**	**81.7**	**86.9**	**94.6**

(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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	IR-586 , SS65_GFB65_G16	11	7.1	13.7	14.8	11.0	7.8	8.4
Change by Lining on receive side	ΔR_f1	IR-586 , SS65_GFB65_G16	11	7.1	13.7	14.8	11.0	7.8	8.4
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.257	0.169	0.108	0.067	0.040	0.023
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.799	9.431	10.442	11.954	14.151	17.298
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	50	33.7	41.7	44.4	50.7	57.3	64.1
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	50	33.7	41.7	44.4	50.7	57.3	64.1
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		14.08	14.38	14.82	15.41	16.14	17.01
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		11.67	11.88	12.22	12.69	13.29	14.02
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**88**	**64.0**	**85.6**	**90.9**	**90.2**	**91.0**	**100.0**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**88**	**63.7**	**88.2**	**98.7**	**103.1**	**104.9**	**112.1**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**77**	**56.1**	**67.4**	**75.0**	**78.8**	**83.4**	**93.6**
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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	IR-586 , SS65_GFB65_G16	11	7.1	13.7	14.8	11.0	7.8	8.4
Change by Lining on receive side	ΔR_f2	IR-586 , SS65_GFB65_G16	11	7.1	13.7	14.8	11.0	7.8	8.4
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		8.250	8.756	9.565	10.774	12.532	15.049
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	51	34.4	42.4	45.0	51.3	57.7	64.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		11.28	11.54	11.92	12.44	13.10	13.89
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		9.50	9.69	10.00	10.43	10.99	11.69
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		9.50	9.69	10.00	10.43	10.99	11.69
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**87**	**62.8**	**84.3**	**89.5**	**88.7**	**89.4**	**98.2**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**86**	**62.4**	**86.8**	**97.2**	**101.6**	**103.3**	**110.4**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**76**	**54.8**	**66.0**	**73.5**	**77.3**	**81.8**	**91.9**
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		0.238	0.158	0.102	0.063	0.038	0.021
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		7.577	8.083	8.892	10.102	11.859	14.377
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	50	34.0	42.0	44.7	51.0	57.5	64.3
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		14.40	14.68	15.09	15.65	16.34	17.18
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21		12.31	12.52	12.84	13.29	13.87	14.59
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21		12.31	12.52	12.84	13.29	13.87	14.59
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**90**	**65.6**	**87.1**	**92.4**	**91.6**	**92.4**	**101.3**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**89**	**65.0**	**89.5**	**99.9**	**104.3**	**106.1**	**113.2**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**78**	**57.4**	**68.7**	**76.2**	**80.0**	**84.6**	**94.7**
Total Flanking STC (combined transmission for all flanking paths)			70						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**68**						

Summary for Section 2.3: Adding Linings on Concrete and Masonry Constructions

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 concrete slab. The surface could be painted or sealed, or have a thin coat of plaster.

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 a horizontal pair of rooms show the improvements relative to Example 2.1.1 which has the same structural elements and junctions 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 48 with bare walls to 55 with the basic lining and 57 with addition of absorptive material[2]. Examination of the Direct STC and the Flanking STC for paths involving the walls shows that these increase more than the ASTC. But the response of the complete system is limited by the significant transmission via paths Ff for junctions 1 and 3 (i.e. - the floor-floor and ceiling-ceiling paths) which are still bare concrete. Adding a lining to the ceiling would increase the ASTC by about 3, but to raise the ASTC over 60 a substantial improvement to the floor surface such as a heavy floating floor would be required.

Examples 2.3.3 and 2.3.4 for a vertical pair of rooms show the improvements relative to Example 2.1.2 which has the same structural elements and junctions 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 2.3.4, the cavities between the studs are filled with absorptive material[2]. The ASTC is increased from 50 with bare walls to 52 (for 2.3.3, with the basic lining) and 53 (for 2.3.4, with addition of absorptive material[2] to wall cavities). In both cases, the benefit due to wall linings is limited by the direct transmission through the floor.

Examples 2.3.5 and 2.3.6 have the same structural elements and junctions and wall linings as 2.3.3 and 2.3.4 respectively, but show the effect of adding a ceiling lining. The ASTC rises from 52 and 53 without the ceiling to 64 with ceiling and basic wall lining, and 68 with ceiling and better wall lining that includes absorptive material[2] in the cavities. In Example 2.3.5, without absorptive material[2] in the walls, the flanking is dominated by the wall-wall paths. With the addition of absorptive material[2] to the walls in 2.3.6, flanking and direct transmission are nearly equal.

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

2.4.Simplified Calculation Method for Concrete/Masonry Buildings

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

- The simplified method uses a set of ad hoc approximations that are appropriate for buildings with concrete and masonry construction, with or without linings.
- The Standard states the application of the simplified method "is restricted to primarily homogeneous constructions", and this Guide emphasizes the restriction 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 excludes lightweight framed assemblies.
- Within that restricted context, the calculation has been structured to be slightly conservative, so it tends to predict an ASTC slightly lower than that from the "detailed method" used in the examples presented in this Guide. The predicted standard deviation is about 2 dB, slightly worse than the detailed method, but it is a much easier calculation.

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 "in an average way", 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 STC ratings for the structural wall and floor assemblies and ΔSTC values for any linings as the input data, and the final output is the overall ASTC.

The Simplified Method predicts the overall ASTC, by following the steps in Figure 2.2, which are explained in detail below:

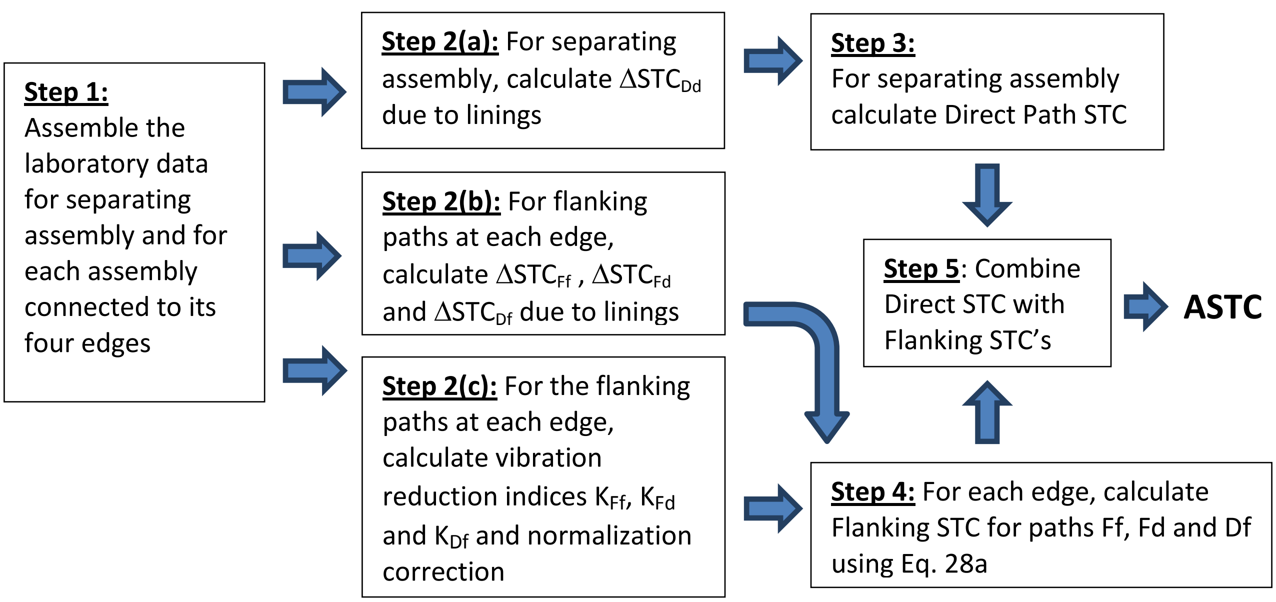


Figure 2.2: Steps to calculate the Direct STC and the Flanking STC for each flanking path (as detailed below)

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

- Laboratory sound transmission class (STC) values based on TL measured according to ASTM E90 for the structural floor or wall assemblies (of bare concrete or masonry),
- Mass/unit area for these bare assemblies,
- Measured change in sound transmission class (ΔSTC) determined according to ASTM E90 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 junction geometry and the ratio of the mass/m^2 for the connected assemblies. Also calculate the normalization correction, which depends on the length of the flanking junction and area of the separating assembly.

Step 3: Calculate the Direct STC for 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, using Equations 1.1 and 1.2 in Section 1.4 of this Guide (equivalent to Eq. 26 in Section 4.4 of ISO 15712-1).

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.

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 (2005) at each stage of the calculation. Symbols and subscripts identifying the corresponding variable in ISO 15712-1 are given in the adjacent column.

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

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

- 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.

Under the heading "ASTC", the examples present the calculated values for transmission via specific paths, 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.

Validation studies in Europe for such constructions have confirmed that these detailed predictions should be expected to exhibit a standard deviation of about 2 dB, with a small negative bias, relative to the detailed method or measured values in actual buildings with these characteristics.

EXAMPLE 2.4.1: **SIMPLIFIED METHOD**

- **Rooms side-by-side**
- **Concrete Floors and Masonry 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:
- concrete floor with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) with no topping or flooring
- rigid mortared cross junction with concrete block wall assembly.

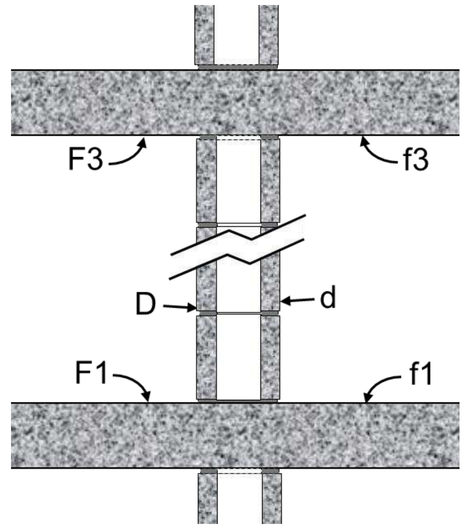
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- abutting side wall and separating wall of concrete blocks with mass 238 kg/m^2 (e.g.- 190 mm hollow blocks with normal weight aggregate[1]), with no lining of the walls
- rigid mortared T-junctions

Junction 3: Top Junction (separating wall / ceiling) with:
- concrete ceiling slab with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) with no added ceiling lining
- rigid mortared cross junction with concrete block wall assembly.

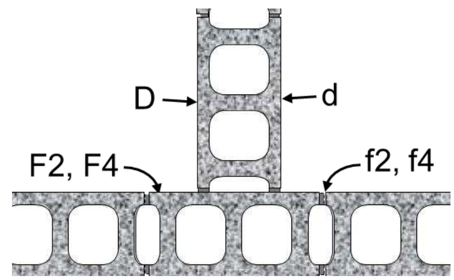
Acoustical Parameters:

For 190 mm concrete block walls:				
Mass per unit area (kg/m^2) =	238			
For 150 mm concrete floor:				
Mass per unit area (kg/m2) =	345			
	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3:				
Rigid cross-junction, mass ratio =	0.69			
Kij[dB] =	6.1	8.8	8.8	Eq. E.3
10*log(S_Partition/l_junction) =	4.0			
For Junctions 2 & 4:				
Rigid T-junction, mass ratio =	1.00			
Kij[dB] =	5.7	5.7	5.7	Eq. E.4
10*log(S_Partition/l_junction) =	7.0			

Illustration for this case



Junction of 190 mm concrete block separating wall with 150 mm thick 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)				
	ISO Symbol	**Reference**	**STC, Δ_STC**	**ASTC**
Lab. Sound Transmission Class (STC)	R_s,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_D,w	No Lining ,	0	
ΔSTC change by Lining on receive side	ΔR_d,w	No Lining ,	0	
Direct STC in situ	R_Dd,w	ISO 15712-1, Eq. 24 and 30		50.0

(See footnotes at end of document)

	ISO Symbol	Reference	STC, Δ_STC	ASTC
Junction 1 (Rigid Cross junction, 190 mm block separating wall / 150 mm concrete floor)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	IR-811, TLF-97-107a	52	
ΔSTC change by Lining on source side	ΔR_F1,w	No Lining ,	0	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	IR-811, TLF-97-107a	52	
ΔSTC change by Lining on receive side	ΔR_f1,w	No Lining ,	0	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		62.1
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		63.8
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		63.8
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	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_F2,w	No Lining ,	0	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on receive side	ΔR_f2,w	No Lining ,	0	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		62.7
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		62.7
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		62.7
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	IR-811, TLF-97-107a	52	
ΔSTC change by Lining on source side	ΔR_F3,w	No Lining ,	0	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	IR-811, TLF-97-107a	52	
ΔSTC change by Lining on receive side	ΔR_f3,w	No Lining ,	0	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		62.1
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		63.8
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		63.8
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	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_F4,w	No Lining ,	0	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on receive side	ΔR_f4,w	No Lining ,	0	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		62.7
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		62.7
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		62.7
Total Flanking STC (combined transmission for all flanking paths)				52.1
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4		48

EXAMPLE 2.4.2: SIMPLIFIED METHOD

- **Rooms one-above-the-other**
- **Concrete Floor and Masonry Walls with Rigid Junctions (Same structure as Example 2.1.2)**

Separating floor/ceiling assembly with:
- 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.

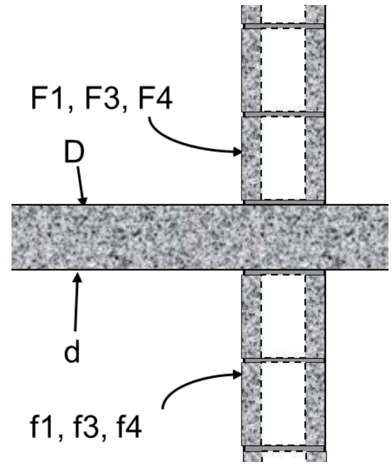
Junction 1, 3,or 4: Cross Junction of separating floor / flanking wall with:
- rigid mortared cross junction with concrete block wall assemblies.
- wall above and below floor of one wythe of concrete blocks with mass 238 kg/m^2 (e.g.- 190 mm hollow blocks with normal weight aggregate[1]) with no lining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

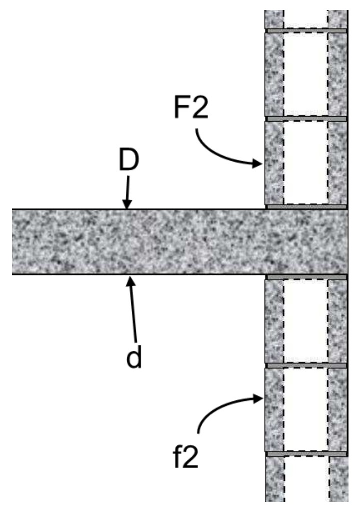
Acoustical Parameters:

For 190 mm concrete block walls:				
Mass per unit area (kg/m^2) =	238			
For 150 mm concrete floor:				
Mass per unit area (kg/m2) =	345			
	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3 and 4:				
Rigid cross-junction, mass ratio =	1.45			
Kij[dB] =	11.6	8.8	8.8	Eq. E.3
10*log(S_Partition/l_junction) =	6.0	(for junctions 1 and 3)		
	7.0	(for Junction 4)		
For Junction 2 :				
Rigid T-junction, mass ratio =	1.45			
Kij[dB] =	8.1	5.8	5.8	Eq. E.4
10*log(S_Partition/l_junction) =	7.0			

Illustration for this case



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



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

Separating Partition (150 mm concrete floor)				
	ISO Symbol	**Reference**	**STC, Δ_STC**	**ASTC**
Lab. Sound Transmission Class (STC)	R_s,w	IR-811, TLF-97-107a	52	
ΔSTC change by Lining on source side	ΔR_D,w	No lining ,	0	
ΔSTC change by Lining on receive side	ΔR_d,w	No lining ,	0	
Direct STC in situ	R_Dd,w	ISO 15712-1, Eq. 24 and 30		52.0

(See footnotes at end of document)

	ISO Symbol	Reference	STC, Δ_STC	ASTC
Junction 1 (Rigid Cross junction, 150 mm concrete floor / 190 mm block flanking walls)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_F1,w	No lining ,	0	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on receive side	ΔR_f1,w	No lining ,	0	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		67.6
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		65.9
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		65.9
Junction 2 (Rigid T- junction, 150 mm concrete floor / 190 mm block flanking walls)				
Flanking Element F2:				
Laboratory STC for F2	R_F2,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_F2,w	No lining ,	0	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on receive side	ΔR_f2,w	No lining ,	0	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		65.1
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		63.8
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		63.8
Junction 3 (Rigid Cross junction, 150 mm concrete floor / 190 mm block flanking walls)				
Flanking Element F3:				
Laboratory STC for F3	R_F3,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_F3,w	No lining ,	0	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on receive side	ΔR_f3,w	No lining ,	0	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		67.6
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		65.9
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		65.9
Junction 4 (Rigid Cross-junction, 150 mm concrete floor / 190 mm block flanking walls)				
Flanking Element F4:				
Laboratory STC for F4	R_F4,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_F4,w	No lining ,	0	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on receive side	ΔR_f4,w	No lining ,	0	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		68.6
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		66.8
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		66.8
Total Flanking STC (combined transmission for all flanking paths)				55.1
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4		50

EXAMPLE 2.4.3: **SIMPLIFIED METHOD**

- **Rooms side-by-side**
- **Concrete Floors and Masonry 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 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs spaced 600 mm o.c. with absorptive material[2] filling stud cavities.

Junction 1: Bottom Junction (separating wall / floor) with:
- concrete floor with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) with no topping or flooring
- rigid mortared cross junction with concrete block wall assembly.

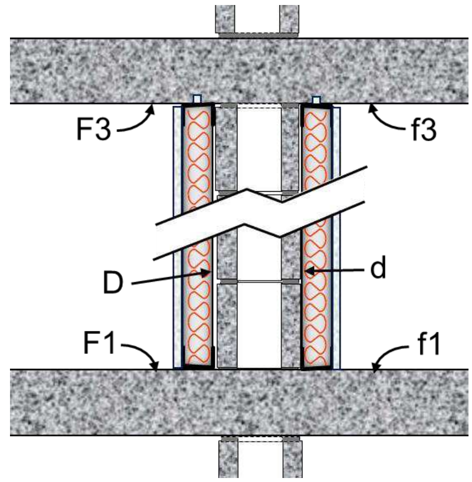
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- abutting side wall and separating wall of concrete blocks with mass 238 kg/m^2 (e.g.- 190 mm hollow blocks with normal weight aggregate[1])
- separating wall and flanking walls lined with 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs spaced 600 mm o.c. with absorptive material[2] in the stud cavities.
- rigid mortared T-junctions

Junction 3: Top Junction (separating wall / ceiling) with:
- concrete ceiling slab with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) with no added ceiling lining
- rigid mortared cross junction with concrete block wall assembly.

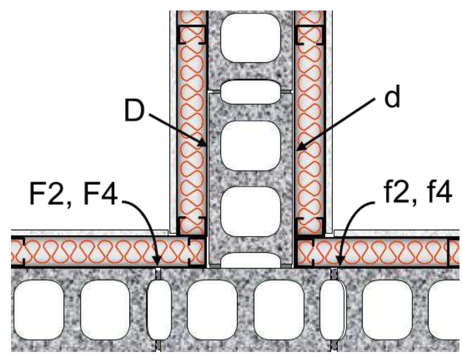
Acoustical Parameters:

For 190 mm concrete block walls:				
Mass per unit area (kg/m^2) =	238			
For 150 mm concrete floor:				
Mass per unit area (kg/m2) =	345			
	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3:				
Rigid cross-junction, mass ratio =	0.69			
Kij[dB] =	6.1	8.8	8.8	Eq. E.3
10*log(S_Partition/l_junction) =	4.0			
For Junctions 2 & 4:				
Rigid T-junction, mass ratio =	1.00			
Kij[dB] =	5.7	5.7	5.7	Eq. E.4
10*log(S_Partition/l_junction) =	7.0			

Illustration for this case



Junction of 190 mm concrete block separating wall (with enhanced gypsum board lining) with 150 mm thick 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)				
	ISO Symbol	**Reference**	**STC, Δ_STC**	**ASTC**
Lab. Sound Transmission Class (STC)	R_s,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_D,w	IR-586 , SS65_GFB65_G16	11	
ΔSTC change by Lining on receive side	ΔR_d,w	IR-586 , SS65_GFB65_G16	11	
Direct STC in situ	R_Dd,w	ISO 15712-1, Eq. 24 and 30		66.5

(See footnotes at end of document)

	ISO Symbol	Reference	STC, Δ_STC	ASTC
Junction 1 (Rigid Cross junction, 190 mm block separating wall / 150 mm concrete floor)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	IR-811, TLF-97-107a	52	
ΔSTC change by Lining on source side	ΔR_F1,w	No Lining ,	0	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	IR-811, TLF-97-107a	52	
ΔSTC change by Lining on receive side	ΔR_f1,w	No Lining ,	0	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		62.1
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		74.8
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		74.8
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	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_F2,w	IR-586 , SS65_GFB65_G16	11	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on receive side	ΔR_f2,w	IR-586 , SS65_GFB65_G16	11	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		79.2
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		79.2
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		79.2
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	IR-811, TLF-97-107a	52	
ΔSTC change by Lining on source side	ΔR_F3,w	No Lining ,	0	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	IR-811, TLF-97-107a	52	
ΔSTC change by Lining on receive side	ΔR_f3,w	No Lining ,	0	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		62.1
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		74.8
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		74.8
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	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_F4,w	IR-586 , SS65_GFB65_G16	11	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on receive side	ΔR_f4,w	IR-586 , SS65_GFB65_G16	11	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		79.2
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		79.2
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		79.2
Total Flanking STC (combined transmission for all flanking paths)				58.4
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4		58

EXAMPLE 2.4.4: **SIMPLIFIED METHOD**

- **Rooms one-above-the-other**
- **Concrete Floor and Masonry Walls with Rigid Junctions (Same structure and linings as Example 2.3.5)**

Separating floor/ceiling assembly with:
- concrete floor with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) with no topping / flooring on top
- ceiling lining below of 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].

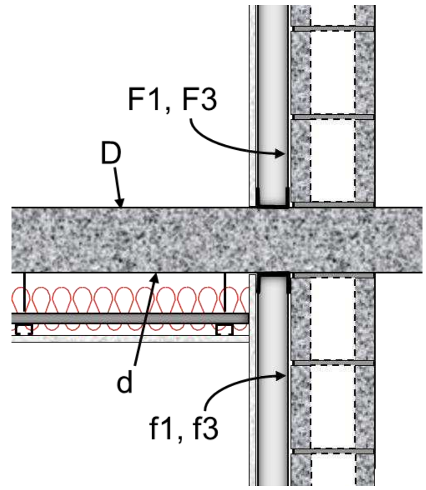
Junction 1, 3 or 4: Cross Junction of separating floor / flanking wall with:
- rigid mortared cross junction with concrete block wall assemblies.
- wall above and below floor of one wythe of concrete blocks with mass 238 kg/m^2 (e.g.- 190 mm hollow blocks with normal weight aggregate[1])
- flanking walls lined with 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs 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-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])
- flanking walls lined with 16 mm gypsum board[3] on 65 mm non-loadbearing steel studs spaced 600 mm o.c. with no absorptive material[2] filling stud cavities

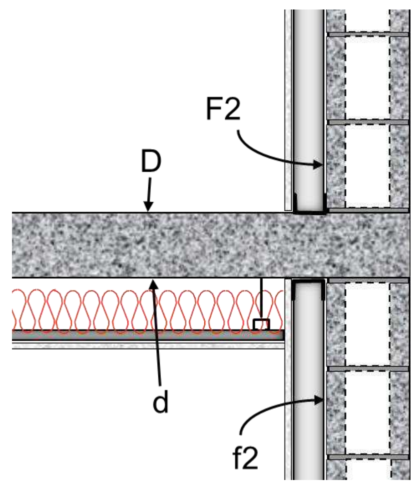
Acoustical Parameters:

For 190 mm concrete block walls:				
Mass per unit area (kg/m^2) =	238			
For 150 mm concrete floor:				
Mass per unit area (kg/m2) =	345			
	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3 and 4:				
Rigid cross-junction, mass ratio =	1.45			
Kij[dB] =	11.6	8.8	8.8	Eq. E.3
10*log(S_Partition/l_junction) =	6.0	(for junctions 1 and 3)		
	7.0	(for Junction 4)		
For Junction 2 :				
Rigid T-junction, mass ratio =	1.45			
Kij[dB] =	8.1	5.8	5.8	Eq. E.4
10*log(S_Partition/l_junction) =	7.0			

Illustration for this case



Cross junction of separating floor of 150 mm thick concrete with 190 mm concrete block wall. (Side view of Junctions 1 & 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)				
	ISO Symbol	**Reference**	**STC, Δ_STC**	**ASTC**
Lab. Sound Transmission Class (STC)	R_s,w	IR-811, TLF-97-107a	52	
ΔSTC change by Lining on source side	ΔR_D,w	No lining ,	0	
ΔSTC change by Lining on receive side	ΔR_d,w	RR-333 , ΔTLF-CON150-01	19	
Direct STC in situ	R_Dd,w	ISO 15712-1, Eq. 24 and 30		71.0

(See footnotes at end of document)

	ISO Symbol	Reference	STC, Δ_STC	ASTC
Junction 1 (Rigid Cross junction, 150 mm concrete floor / 190 mm block flanking walls)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_F1,w	IR-586 , SS65_G16	8	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on receive side	ΔR_f1,w	IR-586 , SS65_G16	8	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		79.6
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		88.9
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		73.9
Junction 2 (Rigid T- junction, 150 mm concrete floor / 190 mm block flanking walls)				
Flanking Element F2:				
Laboratory STC for F2	R_F2,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_F2,w	IR-586 , SS65_G16	8	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on receive side	ΔR_f2,w	IR-586 , SS65_G16	8	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		77.1
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		86.8
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		71.8
Junction 3 (Rigid Cross junction, 150 mm concrete floor / 190 mm block flanking walls)				
Flanking Element F3:				
Laboratory STC for F3	R_F3,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_F3,w	IR-586 , SS65_G16	8	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on receive side	ΔR_f3,w	IR-586 , SS65_G16	8	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		79.6
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		88.9
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		73.9
Junction 4 (Rigid Cross-junction, 150 mm concrete floor / 190 mm block flanking walls)				
Flanking Element F4:				
Laboratory STC for F4	R_F4,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on source side	ΔR_F4,w	IR-586 , SS65_G16	8	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	IR-586, TL-88-356	50	
ΔSTC change by Lining on receive side	ΔR_f4,w	IR-586 , SS65_G16	8	
Flanking STC for path Ff	R_ Ff,w	ISO 15712-1, Eq. 28a and 31		80.6
Flanking STC for path Fd	R_ Fd,w	ISO 15712-1, Eq. 28a and 31		89.8
Flanking STC for path Df	R_ Df,w	ISO 15712-1, Eq. 28a and 31		74.8
Total Flanking STC (combined transmission for all flanking paths)				66.3
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4		65

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

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

The examples show the performance for two cases with "bare" concrete and masonry assemblies and two cases with improvements in direct and/or flanking transmission loss via specific paths due to the addition of some common types of linings using gypsum board, light steel framing, and 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 - Simplified) are readily compared:

Detailed Method		Simplified Method		Comparison (Detailed minus Simplified)		
Example	ASTC	Example	ASTC	Direct STC	Total Flanking STC	ASTC
2.1.1	48	2.4.1	48	50-50	51-52	48-48
2.1.2	50	2.4.2	50	53-52	54-55	50-50
2.3.2	57	2.4.3	58	72-66	57-58	57-58
2.3.5	64	2.4.4	65	71-71	65-66	64-65

This limited set of comparisons is not fully consistent with larger validation studies, which have shown the Detailed Method tends to give slightly higher values of R'_w than the Simplified Method. Part of this discrepancy is due to differences between the ASTC and R'_w ratings.

The basic conclusion that can be drawn for these examples is that the Simplified and Detailed Methods predict similar ASTC for concrete and masonry buildings - no changes exceeded 1.

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 linings on both flanking 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, which is well above the threshold of 0.03 specified in ISO 15712-1 where 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 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 the 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 which should lead to conservative results, especially for Flanking TL of thin 3-ply CLT panels. This issue is discussed in more detail in NRC 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 appreciably affected by the weight of the bare assembly. Data on improvements due to linings are available for several common thicknesses (weights) of CLT panels. 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, equivalent absorption length a_{situ} is simply set numerically equal to area of the CLT assembly when calculating 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 1a: For the bare separating assembly in-situ TL = TL from ASTM E90 laboratory test

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

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

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.

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

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 TL measured in 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 Equations 1.1 and 1.2 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 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 "bare" 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 figure 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 a 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 (2005) 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:

- **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/m^2
- 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/m^2, 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/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 to the abutting assemblies, spaced 600 mm o.c.
- with no added lining

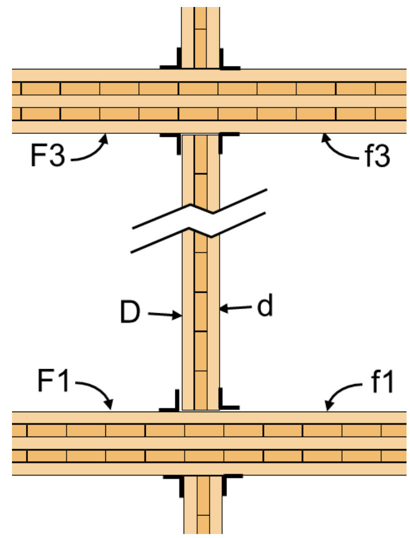
Junction 3: Top Junction (separating wall / ceiling) with:
- 5-ply 175 mm thick CLT ceiling panel with mass 92.1 kg/m^2, continuous through cross junction with CLT separating wall assembly
- CLT floor/ceiling panels oriented so face ply strands are perpendicular to load bearing junction 1 & 3
- Connected 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:

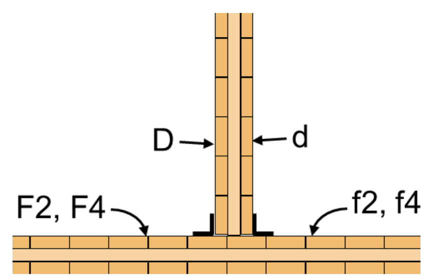
For separating assembly:				
internal loss, η_i =	0.050	c_L =	1150	
mass (kg/m²) =	42.4	f_c =	723	
Similarly, for flanking elements F and f at Junction 1 & 3,				
internal loss, η_i =	0.050	c_L =	1150	
mass (kg/m²) =	92.1	f_c =	322	
Similarly, for flanking elements F and f at Junction 2 & 4,				
internal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

(See footnotes at end of document)

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)

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, TLW-CLT3-01	33	25.4	24.7	28.3	33.5	42.4	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	0
Change by Lining on receive side	ΔR_d	, No Lining	0	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
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**33**	**25.4**	**24.7**	**28.3**	**33.5**	**42.4**	**49.0**
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, TLF-CLT5-01	41	30.7	30.7	37.3	44.3	52.7	44.7
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	0.0
Change by Lining on receive side	ΔR_f1	, No Lining	0	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	41	30.7	30.7	37.3	44.3	52.7	44.7
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	41	30.7	30.7	37.3	44.3	52.7	44.7
Junction J1 - Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, K-CLT-F01X		4.81	4.54	1.34	-1.97	-2.20	-1.16
Vibration Reduction Index for Fd	K_Fd,1	RR-335, K-CLT-F01X		11.07	10.27	9.96	10.33	10.82	9.35
Vibration Reduction Index for Df	K_Df,1	RR-335, K-CLT-F01X		11.07	10.27	9.96	10.33	10.82	9.35
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25b	**46**	**39.5**	**39.2**	**42.6**	**46.3**	**54.5**	**47.5**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25b	**52**	**43.1**	**41.9**	**46.7**	**53.2**	**62.3**	**60.2**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25b	**52**	**43.1**	**41.9**	**46.7**	**53.2**	**62.3**	**60.2**
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, TLW-CLT3-01	33	25.4	24.7	28.3	33.5	42.4	49.0
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	0.0
Change by Lining on receive side	ΔR_f2	, No Lining	0	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	33	25.4	24.7	28.3	33.5	42.4	49.0
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	33	25.4	24.7	28.3	33.5	42.4	49.0
Junction J2 - Coupling									
Vibration Reduction Index for Ff	K_Ff,2	RR-335, K-CLT-W02T		-2.26	2.84	5.42	2.88	4.75	14.69
Vibration Reduction Index for Fd	K_Fd,2	RR-335, K-CLT-W02T		-1.48	2.26	4.94	7.33	10.96	21.34
Vibration Reduction Index for Df	K_Df,2	RR-335, K-CLT-W02T		-1.48	2.26	4.94	7.33	10.96	21.34
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25b	**44**	**30.1**	**34.5**	**40.7**	**43.4**	**54.1**	**70.7**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25b	**45**	**30.9**	**33.9**	**40.2**	**47.8**	**60.4**	**77.3**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25b	**45**	**30.9**	**33.9**	**40.2**	**47.8**	**60.4**	**77.3**
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	**44**	**30.1**	**34.5**	**40.7**	**43.4**	**54.1**	**70.7**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25b	**45**	**30.9**	**33.9**	**40.2**	**47.8**	**60.4**	**77.3**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25b	**45**	**30.9**	**33.9**	**40.2**	**47.8**	**60.4**	**77.3**
Total Flanking STC (combined transmission for all flanking paths)			35						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**31**						

EXAMPLE 3.2:

- **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.

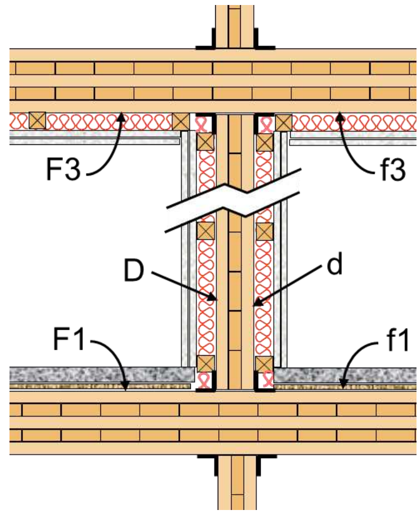
Junction 3: Top Junction (separating wall / ceiling) with:

- 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.

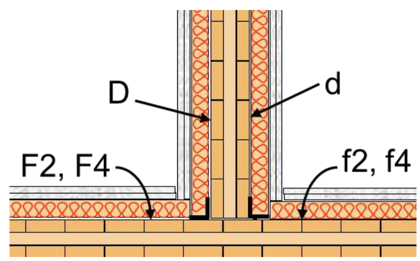
Acoustical Parameters:

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, TLW-CLT3-01	33	25.4	24.7	28.3	33.5	42.4	49
Correction, Resonant Transmission				0	0	0	0	0	0
Change by Lining on source side	ΔR_D	RR-335, ΔTLW-CLT3-01	10	4.2	8.5	8.95	13.1	11.25	9.7
Change by Lining on receive side	ΔR_d	RR-335 , ΔTLW-CLT3-01	10	4.2	8.5	8.95	13.1	11.25	9.7
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
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**51**	**33.8**	**41.7**	**46.2**	**59.7**	**64.9**	**68.4**
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, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-335, TLF-CLT5-01	41	30.7	30.7	37.3	44.3	52.7	44.7
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 , ΔTLF-CLT5-01	11	4.4	10.3	9.8	18.8	25.9	35.6
Change by Lining on receive side	ΔR_f1	RR-335 , ΔTLF-CLT5-01	11	4.4	10.3	9.8	18.8	25.9	35.6
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	41	30.7	30.7	37.3	44.3	52.7	44.7
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	41	30.7	30.7	37.3	44.3	52.7	44.7
Junction J1 - Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, K-CLT-F01X		4.81	4.54	1.34	-1.97	-2.20	-1.16
Vibration Reduction Index for Fd	K_Fd,1	RR-335, K-CLT-F01X		11.07	10.27	9.96	10.33	10.82	9.35
Vibration Reduction Index for Df	K_Df,1	RR-335, K-CLT-F01X		11.07	10.27	9.96	10.33	10.82	9.35
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25b	**69**	**48.3**	**59.8**	**62.2**	**83.9**	**106.3**	**118.7**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25b	**72**	**51.7**	**60.7**	**65.5**	**85.1**	**99.5**	**105.5**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25b	**72**	**51.7**	**60.7**	**65.5**	**85.1**	**99.5**	**105.5**
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, TLW-CLT3-01	33	25.4	24.7	28.3	33.5	42.4	49.0
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 , ΔTLW-CLT3-01	10	4.2	8.5	9.0	13.1	11.3	9.7
Change by Lining on receive side	ΔR_f2	RR-335 , ΔTLW-CLT3-01	10	4.2	8.5	9.0	13.1	11.3	9.7
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	33	25.4	24.7	28.3	33.5	42.4	49.0
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	33	25.4	24.7	28.3	33.5	42.4	49.0
Junction J2 - Coupling									
Vibration Reduction Index for Ff	K_Ff,2	RR-335, K-CLT-W02T		-2.26	2.84	5.42	2.88	4.75	14.69
Vibration Reduction Index for Fd	K_Fd,2	RR-335, K-CLT-W02T		-1.48	2.26	4.94	7.33	10.96	21.34
Vibration Reduction Index for Df	K_Df,2	RR-335, K-CLT-W02T		-1.48	2.26	4.94	7.33	10.96	21.34
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25b	**62**	**38.5**	**51.5**	**58.6**	**69.6**	**76.6**	**90.1**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25b	**62**	**39.3**	**50.9**	**58.1**	**74.0**	**82.9**	**96.7**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25b	**62**	**39.3**	**50.9**	**58.1**	**74.0**	**82.9**	**96.7**
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, ΔTLF-CLT5-02	9	2.1	10.4	6.9	9.8	7.8	14.0
Change by Lining on receive side	ΔR_f3	RR-335, ΔTLF-CLT5-02	9	2.1	10.4	6.9	9.8	7.8	14.0
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25b	**62**	**43.7**	**60.0**	**56.4**	**65.9**	**70.1**	**75.5**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25b	**69**	**49.4**	**60.8**	**62.6**	**76.1**	**81.4**	**83.9**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25b	**69**	**49.4**	**60.8**	**62.6**	**76.1**	**81.4**	**83.9**
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**	**38.5**	**51.5**	**58.6**	**69.6**	**76.6**	**90.1**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25b	**62**	**39.3**	**50.9**	**58.1**	**74.0**	**82.9**	**96.7**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25b	**62**	**39.3**	**50.9**	**58.1**	**74.0**	**82.9**	**96.7**
Total Flanking STC (combined transmission for all flanking paths)			54						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**50**						

EXAMPLE 3.3:

- **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[4] 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

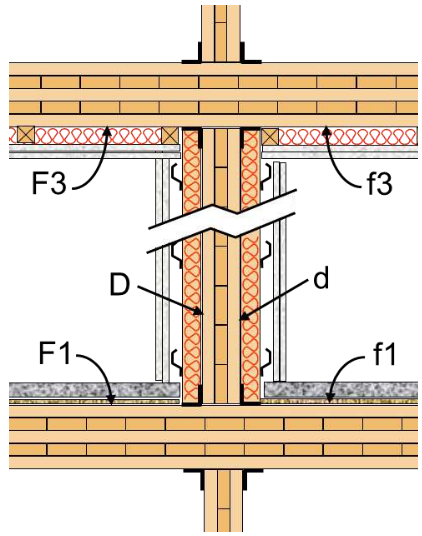
Junction 2 or 4: Each Side (separating wall /abutting side wall) with:
- abutting side walls of 3-ply 78 mm thick CLT with mass 42.4 kg/m^2 continuous through T-junctions with separating CLT wall
- CLT wall panels oriented so face ply strands are vertical
- connected with 90 mm equal leg angle brackets 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.

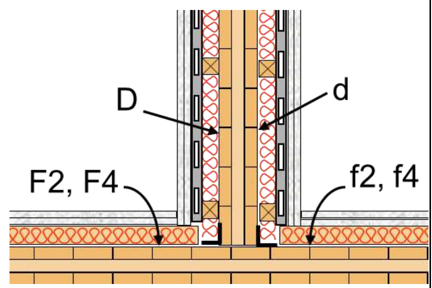
Acoustical Parameters:

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, TLW-CLT3-01	33	25.4	24.7	28.3	33.5	42.4	49
Correction, Resonant Transmission				0	0	0	0	0	0
Change by Lining on source side	ΔR_D	RR-335, ΔTLW-CLT3-02	20	6.8	19.15	22.8	23.25	21.9	23.9
Change by Lining on receive side	ΔR_d	RR-335 , ΔTLW-CLT3-02	20	6.8	19.15	22.8	23.25	21.9	23.9
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
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**63**	**39.0**	**63.0**	**73.9**	**80.0**	**86.2**	**96.8**
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, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	RR-335, TLF-CLT5-01	41	30.7	30.7	37.3	44.3	52.7	44.7
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 , ΔTLF-CLT5-01	11	4.4	10.3	9.8	18.8	25.9	35.6
Change by Lining on receive side	ΔR_f1	RR-335 , ΔTLF-CLT5-01	11	4.4	10.3	9.8	18.8	25.9	35.6
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	41	30.7	30.7	37.3	44.3	52.7	44.7
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	41	30.7	30.7	37.3	44.3	52.7	44.7
Junction J1 - Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, K-CLT-F01X		4.81	4.54	1.34	-1.97	-2.20	-1.16
Vibration Reduction Index for Fd	K_Fd,1	RR-335, K-CLT-F01X		11.07	10.27	9.96	10.33	10.82	9.35
Vibration Reduction Index for Df	K_Df,1	RR-335, K-CLT-F01X		11.07	10.27	9.96	10.33	10.82	9.35
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25b	**69**	**48.3**	**59.8**	**62.2**	**83.9**	**106.3**	**118.7**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25b	**78**	**54.3**	**71.4**	**79.3**	**95.3**	**110.1**	**119.7**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25b	**78**	**54.3**	**71.4**	**79.3**	**95.3**	**110.1**	**119.7**
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, TLW-CLT3-01	33	25.4	24.7	28.3	33.5	42.4	49.0
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 , ΔTLW-CLT3-01	10	4.2	8.5	9.0	13.1	11.3	9.7
Change by Lining on receive side	ΔR_f2	RR-335 , ΔTLW-CLT3-01	10	4.2	8.5	9.0	13.1	11.3	9.7
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	33	25.4	24.7	28.3	33.5	42.4	49.0
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	33	25.4	24.7	28.3	33.5	42.4	49.0
Junction J2 - Coupling									
Vibration Reduction Index for Ff	K_Ff,2	RR-335, K-CLT-W02T		-2.26	2.84	5.42	2.88	4.75	14.69
Vibration Reduction Index for Fd	K_Fd,2	RR-335, K-CLT-W02T		-1.48	2.26	4.94	7.33	10.96	21.34
Vibration Reduction Index for Df	K_Df,2	RR-335, K-CLT-W02T		-1.48	2.26	4.94	7.33	10.96	21.34
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25b	**62**	**38.5**	**51.5**	**58.6**	**69.6**	**76.6**	**90.1**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25b	**66**	**41.9**	**61.6**	**71.9**	**84.2**	**93.5**	**110.9**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25b	**66**	**41.9**	**61.6**	**71.9**	**84.2**	**93.5**	**110.9**
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, ΔTLF-CLT5-02	9	2.1	10.4	6.9	9.8	7.8	14.0
Change by Lining on receive side	ΔR_f3	RR-335, ΔTLF-CLT5-02	9	2.1	10.4	6.9	9.8	7.8	14.0
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25b	**62**	**43.7**	**60.0**	**56.4**	**65.9**	**70.1**	**75.5**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25b	**76**	**52.0**	**71.5**	**76.4**	**86.3**	**92.0**	**98.1**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25b	**76**	**52.0**	**71.5**	**76.4**	**86.3**	**92.0**	**98.1**
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	**62**	**38.5**	**51.5**	**58.6**	**69.6**	**76.6**	**90.1**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25b	**66**	**41.9**	**61.6**	**71.9**	**84.2**	**93.5**	**110.9**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25b	**66**	**41.9**	**61.6**	**71.9**	**84.2**	**93.5**	**110.9**
Total Flanking STC (combined transmission for all flanking paths)			56						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**55**						

EXAMPLE 3.4:

- **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)

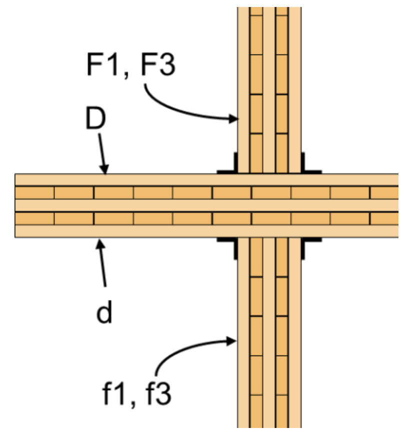
Junction 1, 3 or 4: (separating floor / walls) with:
- 5-ply 175 mm thick CLT wall panels with mass 94.1 kg/m^2, above and below cross junction with CLT separating floor assembly that is continuous or lapped and glued across these junctions
- CLT wall panels oriented so face ply strands are vertical
- 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

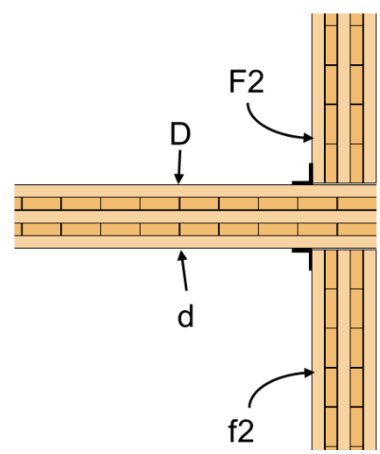
Acoustical Parameters:

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 Junctions 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, TLF-CLT5-01	41	30.7	30.7	37.3	44.3	52.7	44.7
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	0
Change by Lining on receive side	ΔR_d	, No Lining	0	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
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**41**	**30.7**	**30.7**	**37.3**	**44.3**	**52.7**	**44.7**
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, TLW-CLT5-01	38	34.7	28.3	34.5	43.3	50.3	47.0
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	0.0
Change by Lining on receive side	ΔR_f1	, No Lining	0	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	38	34.7	28.3	34.5	43.3	50.3	47.0
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	38	34.7	28.3	34.5	43.3	50.3	47.0
Junction J1 - Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, K-CLT-F02X		11.26	13.25	10.34	22.56	20.47	21.15
Vibration Reduction Index for Fd	K_Fd,1	RR-335, K-CLT-F02X		6.80	6.57	9.83	12.90	7.72	5.85
Vibration Reduction Index for Df	K_Df,1	RR-335, K-CLT-F02X		6.80	6.57	9.83	12.90	7.72	5.85
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25b	**59**	**52.0**	**47.6**	**50.9**	**71.9**	**76.8**	**74.2**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25b	**55**	**45.5**	**42.1**	**51.7**	**62.7**	**65.2**	**57.7**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25b	**55**	**45.5**	**42.1**	**51.7**	**62.7**	**65.2**	**57.7**
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, TLW-CLT5-01	38	34.7	28.3	34.5	43.3	50.3	47.0
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	0.0
Change by Lining on receive side	ΔR_f2	, No Lining	0	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	38	34.7	28.3	34.5	43.3	50.3	47.0
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	38	34.7	28.3	34.5	43.3	50.3	47.0
Junction J2 - Coupling									
Vibration Reduction Index for Ff	K_Ff,2	RR-335, K-CLT-F02T		11.92	9.36	10.60	16.33	18.77	21.86
Vibration Reduction Index for Fd	K_Fd,2	RR-335, K-CLT-F02T		4.06	1.92	9.36	8.21	6.71	2.34
Vibration Reduction Index for Df	K_Df,2	RR-335, K-CLT-F02T		4.06	1.92	9.36	8.21	6.71	2.34
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25b	**57**	**53.6**	**44.7**	**52.1**	**66.6**	**76.1**	**75.9**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25b	**52**	**43.8**	**38.4**	**52.2**	**59.0**	**65.2**	**55.2**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25b	**52**	**43.8**	**38.4**	**52.2**	**59.0**	**65.2**	**55.2**
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	**60**	**52.9**	**48.5**	**51.8**	**72.8**	**77.8**	**75.1**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25b	**56**	**46.5**	**43.1**	**52.7**	**63.7**	**66.2**	**58.7**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25b	**56**	**46.5**	**43.1**	**52.7**	**63.7**	**66.2**	**58.7**
Total Flanking STC (combined transmission for all flanking paths)			45						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**40**						

EXAMPLE 3.5:

- **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/m^2, 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/m^2, 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:

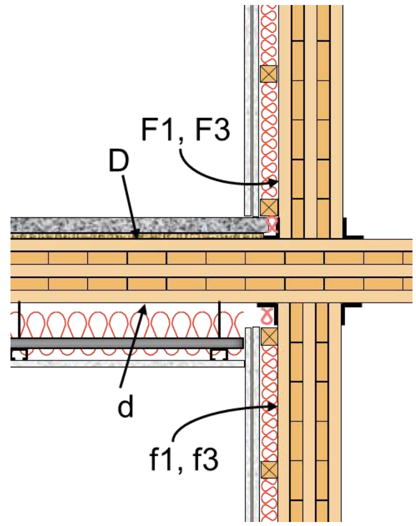
- 5-ply 175 mm thick CLT wall panels with mass 94.1 kg/m^2, above and below T-junction with CLT separating floor assembly that terminates at this junction
- CLT wall panels oriented so face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed to the separating floor 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:

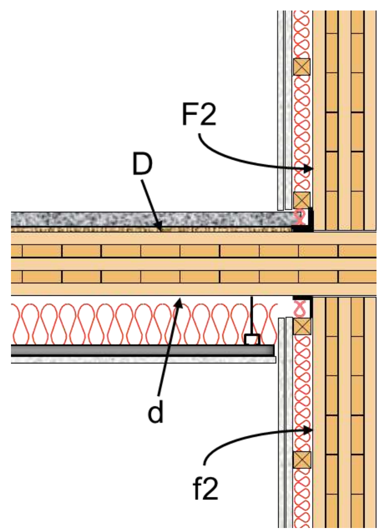
For separating assembly:			
internal loss, η_i =	0.050	c_L =	1150
mass (kg/m²) =	92.1	f_c =	322
Similarly, for flanking elements F and f at Junction 1 & 3,			
internal loss, η_i =	0.050	c_L =	1150
mass (kg/m²) =	94.1	f_c =	322
Similarly, for flanking elements F and f at Junction 2 & 4,			
internal loss,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

(See footnotes at end of document)

Illustration for this case



Cross junction of separating floor of continuous 175mm thick 5-ply CLT with 5-ply CLT walls above and below.
(Side view of Junctions 1, 3 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)

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, TLF-CLT5-01	41	30.7	30.7	37.3	44.3	52.7	44.7
Correction, Resonant Transmission				0	0	0	0	0	0
Change by Lining on source side	ΔR_D	RR-335, ΔTLF-CLT5-01	11	4.4	10.3	9.8	18.8	25.9	35.6
Change by Lining on receive side	ΔR_d	RR-335 , ΔTLF-CLT5-03	26	13	23.7	34.1	32.8	26.6	29.8
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
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**72**	**48.1**	**64.7**	**81.2**	**95.9**	**105.2**	**110.1**
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, TLW-CLT5-01	38	34.7	28.3	34.5	43.3	50.3	47.0
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 , ΔTLW-CLT5-01	9	1.9	7.7	6.9	10.5	10.9	11.9
Change by Lining on receive side	ΔR_f1	RR-335 , ΔTLW-CLT5-01	9	1.9	7.7	6.9	10.5	10.9	11.9
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	38	34.7	28.3	34.5	43.3	50.3	47.0
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	38	34.7	28.3	34.5	43.3	50.3	47.0
Junction J1 - Coupling									
Vibration Reduction Index for Ff	K_Ff,1	RR-335, K-CLT-F02X		11.26	13.25	10.34	22.56	20.47	21.15
Vibration Reduction Index for Fd	K_Fd,1	RR-335, K-CLT-F02X		6.80	6.57	9.83	12.90	7.72	5.85
Vibration Reduction Index for Df	K_Df,1	RR-335, K-CLT-F02X		6.80	6.57	9.83	12.90	7.72	5.85
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25b	**73**	**55.7**	**62.9**	**64.7**	**92.9**	**98.5**	**97.9**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25b	**84**	**60.4**	**73.4**	**92.7**	**106.0**	**102.7**	**99.4**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25b	**73**	**51.8**	**60.0**	**68.4**	**92.0**	**102.0**	**105.2**
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, TLW-CLT5-01	38	34.7	28.3	34.5	43.3	50.3	47.0
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 , ΔTLW-CLT5-01	9	1.9	7.7	6.9	10.5	10.9	11.9
Change by Lining on receive side	ΔR_f2	RR-335 , ΔTLW-CLT5-01	9	1.9	7.7	6.9	10.5	10.9	11.9
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	38	34.7	28.3	34.5	43.3	50.3	47.0
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	38	34.7	28.3	34.5	43.3	50.3	47.0
Junction J2 - Coupling									
Vibration Reduction Index for Ff	K_Ff,2	RR-335, K-CLT-F02T		11.92	9.36	10.60	16.33	18.77	21.86
Vibration Reduction Index for Fd	K_Fd,2	RR-335, K-CLT-F02T		4.06	1.92	9.36	8.21	6.71	2.34
Vibration Reduction Index for Df	K_Df,2	RR-335, K-CLT-F02T		4.06	1.92	9.36	8.21	6.71	2.34
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25b	**74**	**57.3**	**60.0**	**65.9**	**87.6**	**97.8**	**99.6**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25b	**83**	**58.6**	**69.8**	**93.2**	**102.3**	**102.6**	**96.8**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25b	**71**	**50.0**	**56.4**	**68.9**	**88.3**	**101.9**	**102.6**
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 flanking surface input data (for F and f) 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	**74**	**56.6**	**63.8**	**65.6**	**93.8**	**99.5**	**98.8**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25b	**85**	**61.3**	**74.4**	**93.7**	**107.0**	**103.7**	**100.3**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25b	**74**	**52.7**	**61.0**	**69.4**	**93.0**	**103.0**	**106.1**
Total Flanking STC (combined transmission for all flanking paths)			65						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**64**						

Summary for Section 3: Calculation for CLT Constructions

The worked examples 3.1 to 3.5 illustrate 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 a side-by-side pair of rooms, 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 63 and the overall ASTC to 55.

For a vertical room pair, Example 3.5 shows the improvement relative to Example 3.4 when some typical linings are added. Even with rather basic wall linings, the ASTC is increased to 64, and higher values could be achieved by improvements to the floor surface.

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.

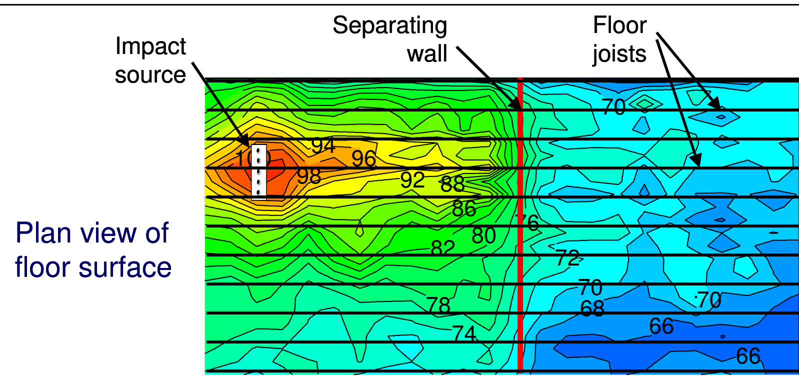


Figure 4.1: Variation across the floor surface of the vibration levels (2 kHz band) due to an impact source. The floor construction has a 19 mm plywood subfloor on wood joists that are perpendicular to the separating wall between the two side-by-side rooms.

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 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 1.4 in Section 1.4 of this Guide provide more appropriate normalization for highly-damped assemblies such as lightweight wood- or steel-framed wall 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, but can be performed using single-number ratings, following the steps illustrated in Figure 4.2, and explained in detail below.

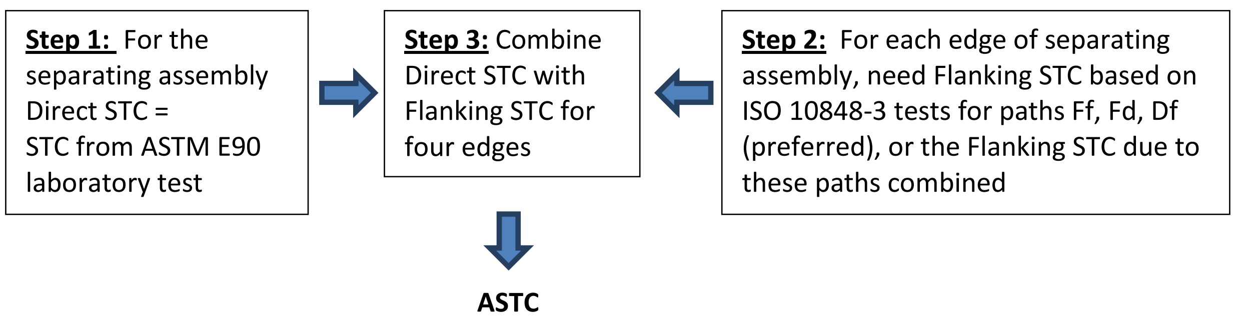


Figure 4.2: Steps to calculate the ASTC for lightweight framed construction (as detailed below)

Step 1: For the separating assembly, the Direct Path STC is equal to STC measured in 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 1.4 from Section 1.4 of this Guide.
- If only data for combined transmission by the set of paths at a junction is available, that may be used for the calculation of ASTC. Data for the individual paths Ff, Fd and Df is preferred, because that provides more insight about which path(s) limit the ASTC, as shown in some of the following examples.

Step 3: Combine the transmission via the direct and flanking paths, using Equations 1.1 and 1.2 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 85, ignore that path in 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), but can be performed using 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-Construction 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 RR-336 “Apparent Sound Insulation in Wood-framed Buildings”.

The 1/3-ocatve values from the same NRC database of flanking transmission data are used by the software application ***SoundPATHS*** which is accessible on the NRC website at

http://irc-eguide.irc.nrc.ca/flankingui_v2.html

(See Reference Publications for more details.)

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 publication RR-219 and its supporting technical reports included such fire blocking. Fire blocking materials installed to protect the rimboard/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 NRC publications 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 [9.4] 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

- **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 on one side, spaced 610 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:

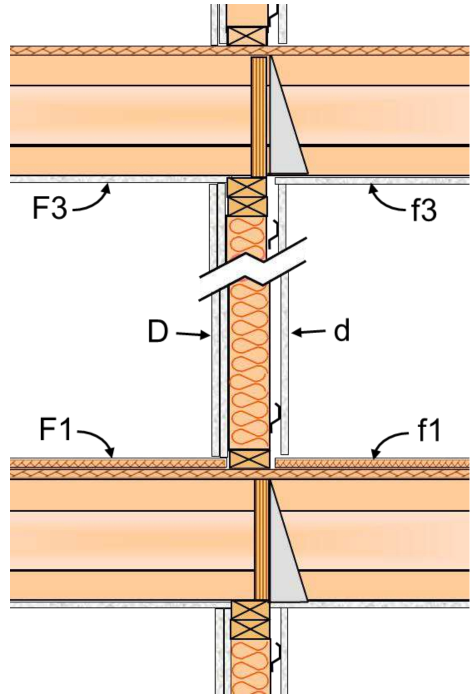
- 1 layer of 16 mm fire-rated gypsum board[3] on side walls attached directly to framing and terminating at the separating wall;
- side wall framing with single row of wood studs spaced 400 mm o.c. with absorptive material[2] filling stud cavities
- side wall framing structurally-connected to the separating 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)

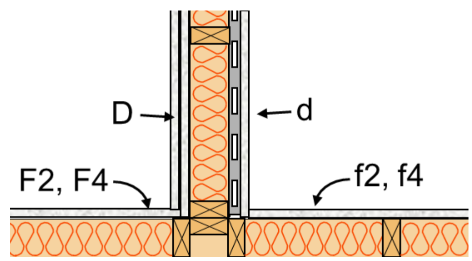
Note 2: For the laboratory test specimens, dimensions required for normalization corrections are:

- Separating surface area = 10.4 m^2
- Wall/floor or wall/ceiling junction length = 4.6 m
- Wall/wall junction length = 2.26 m

Illustration for this case



Junction 1&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-335, TLW-13-WS89-001	53	
Direct STC in situ (Path DD through separating wall)			**53.0**
Junction 1 (Load-bearing junction, wood-framed separating wall / flanking floor assemblies)			
Flanking Path Ff_1			
Laboratory Flanking STC for Ff	RR-335, FTL-13-WS89-WF-LB-002	53	
Normalization correction	Guide, Eq. 1.4	0.45	
Flanking STC for path Ff_1		53.5	
Flanking Path Fd_1			
Laboratory Flanking STC for Fd	RR-335, FTL-13-WS89-WF-LB-002	56	
Normalization correction	Guide, Eq. 1.4	0.45	
Flanking STC for path Fd_1		56.5	
Flanking Path Df_1			
Laboratory Flanking STC for Df	RR-335, FTL-13-WS89-WF-LB-002	57	
Normalization correction	Guide, Eq. 1.4	0.45	
Flanking STC for path Df_1		57.5	
Flanking STC for Junction_1	Guide, Section 1.4		50.7
Junction 2 (wood-framed separating wall / flanking wall assemblies)			
Flanking Path Ff_2			
Laboratory Flanking STC for Ff	RR-335, FTL-13-WS89-WW-LB-001	70	
Normalization correction	Guide, Eq. 1.4	0.36	
Flanking STC for path Ff_2		70.4	
Flanking Path Fd_2			
Laboratory Flanking STC for Fd	RR-335, FTL-13-WS89-WW-LB-001	68	
Normalization correction	Guide, Eq. 1.4	0.36	
Flanking STC for path Fd_2		68.4	
Flanking Path Df_2			
Laboratory Flanking STC for Df	RR-335, FTL-13-WS89-WW-LB-001	69	
Normalization correction	Guide, Eq. 1.4	0.36	
Flanking STC for path Df_2		69.4	
Flanking STC for Junction_2	Guide, Section 1.4		64.5
Junction 3 (Load-bearing junction, wood-framed separating wall / flanking ceiling assemblies)			
Flanking Path Ff_3			
Laboratory Flanking STC for Ff	RR-335,FTL-13-WS89-WC-LB-001	65	
Normalization correction	Guide, Eq. 1.4	0.45	
Flanking STC for path Ff_3		65.5	
Flanking Path Fd_3			
Laboratory Flanking STC for Fd	RR-335,FTL-13-WS89-WC-LB-001	64	
Normalization correction	Guide, Eq. 1.4	0.45	
Flanking STC for path Fd_3		64.5	
Flanking Path Df_3			
Laboratory Flanking STC for Df	RR-335,FTL-13-WS89-WC-LB-001	79	
Normalization correction	Guide, Eq. 1.4	0.45	
Flanking STC for path Df_3		79.5	
Flanking STC for Junction_3	Guide, Section 1.4		61.8
Junction 4 (Wood-framed separating wall / flanking wall assemblies)			
All values the same as for Junction 2			
Flanking STC for Junction_4	Guide, Section 1.4		64.5
Combined transmission via all Flanking Paths			50.0
ASTC due to Direct plus Flanking Transmission	Guide, Section 1.4		**48**

EXAMPLE 4.1.2

- **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[4] on one side, spaced 610 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:

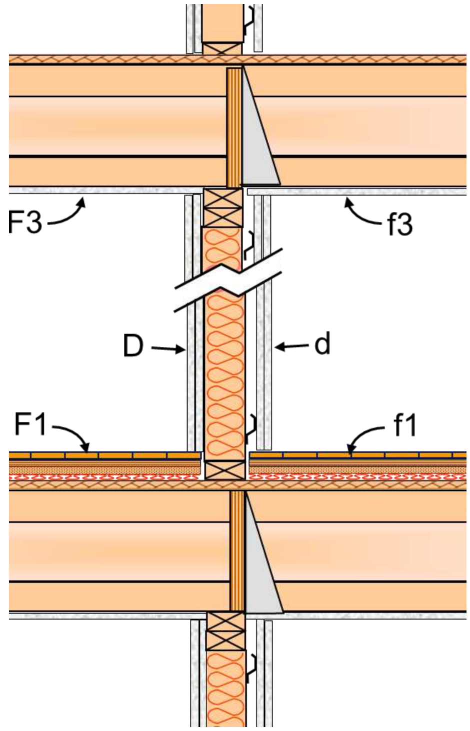
- 1 layer of 16 mm fire-rated gypsum board[3] on side walls attached directly to framing and terminating at the separating wall;
- side wall framing with single row of wood studs spaced 400 mm o.c. with absorptive material[2] in cavities
- side wall framing structurally-connected to the separating wall, 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)

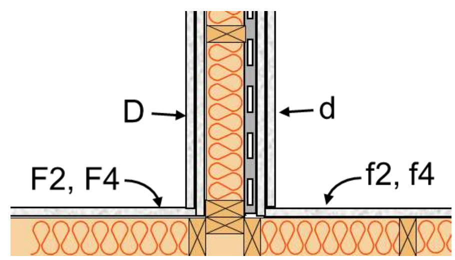
Note 2: For the laboratory test specimens, dimensions required for normalization corrections are:

- Separating surface area = 10.4 m^2
- Wall/floor or wall/ceiling junction length = 4.6 m
- Wall/wall junction length = 2.26 m

Illustration for this case



Junction 1&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-335, TLW-13-WS89-001	57	
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-335, FTL-13-WS89-WF-LB-010	67	
Normalization correction	Guide, Eq. 1.4	0.45	
Flanking STC for path Ff_1		67.5	
Flanking Path Fd_1			
Laboratory Flanking STC for Fd	RR-335, FTL-13-WS89-WF-LB-010	66	
Normalization correction	Guide, Eq. 1.4	0.45	
Flanking STC for path Fd_1		66.5	
Flanking Path Df_1			
Laboratory Flanking STC for Df	RR-335, FTL-13-WS89-WF-LB-010	69	
Normalization correction	Guide, Eq. 1.4	0.45	
Flanking STC for path Df_1		69.5	
Flanking STC for Junction_1	Guide, Section 1.4		62.8
Junction 2 (T-junction, wood-framed separating wall / flanking wall assemblies)			
Flanking Path Ff_2			
Laboratory Flanking STC for Ff	RR-335, FTL-13-WS89-WW-LB-010	70	
Normalization correction	Guide, Eq. 1.4	0.36	
Flanking STC for path Ff_2		70.4	
Flanking Path Fd_2			
Laboratory Flanking STC for Fd	RR-335, FTL-13-WS89-WW-LB-010	68	
Normalization correction	Guide, Eq. 1.4	0.36	
Flanking STC for path Fd_2		68.4	
Flanking Path Df_2			
Laboratory Flanking STC for Df	RR-335, FTL-13-WS89-WW-LB-010	71	
Normalization correction	Guide, Eq. 1.4	0.36	
Flanking STC for path Df_2		71.4	
Flanking STC for Junction_2	Guide, Section 1.4		65.1
Junction 3 (Load-bearing junction, wood-framed separating wall / flanking ceiling assemblies)			
Flanking Path Ff_3			
Laboratory Flanking STC for Ff	RR-335, FTL-13-WS89-WC-LB-010	65	
Normalization correction	Guide, Eq. 1.4	0.45	
Flanking STC for path Ff_3		65.5	
Flanking Path Fd_3			
Laboratory Flanking STC for Fd	RR-335, FTL-13-WS89-WC-LB-010	65	
Normalization correction	Guide, Eq. 1.4	0.45	
Flanking STC for path Fd_3		65.5	
Flanking Path Df_3			
Laboratory Flanking STC for Df	RR-335, FTL-13-WS89-WC-LB-010	81	
Normalization correction	Guide, Eq. 1.4	0.45	
Flanking STC for path Df_3		81.5	
Flanking STC for Junction_3	Guide, Section 1.4		62.4
Junction 4 (Cross-junction, wood-framed separating wall / flanking wall assemblies)			
All values the same as for Junction 2			
Flanking STC for Junction_4	Guide, Section 1.4		65.1
Combined transmission via all Flanking Paths			57.6
ASTC due to Direct plus Flanking Transmission	Guide, Section 1.4		**54**

EXAMPLE 4.1.3

- **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[4] spaced 406 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
- 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

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

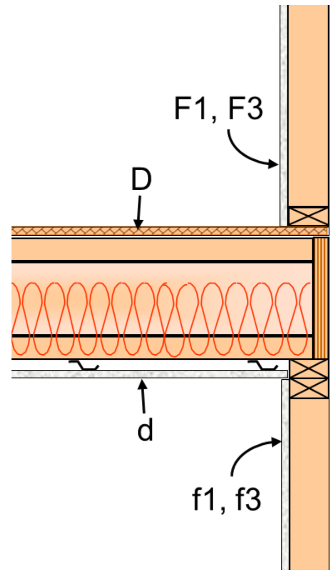
- joists of floor assembly parallel to these walls
- walls have 38 mm x 89 mm wood studs spaced 400 mm o.c
- wall framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates) with or without absorptive 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)

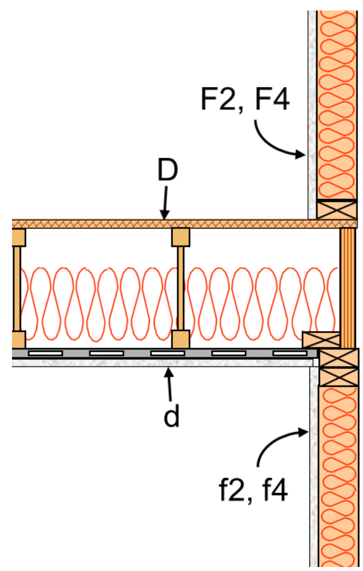
Note 2: For the laboratory test specimens, dimensions required for normalization corrections are:

- Separating surface area = 19.6 m^2
- Wall/floor junction length = 4.6 m

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-335, TLF-13-WIJ305-001	51	
Direct STC in situ (Path DD through separating floor)			**51**
	Reference	**Lab (STC, etc.)**	**Path STC, ASTC**
Junction 1 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)			
Flanking Path Ff_1			
Laboratory Flanking STC for Ff	RR-335, FTL-13-WIJ305-FW-LB-001	64	
Normalization correction	Guide, Eq. 1.4	-0.29	
Flanking STC for path Ff_1		63.7	
Flanking Path Fd_1			
Laboratory Flanking STC for Fd	RR-335, FTL-13-WIJ305-FW-LB-001	57	
Normalization correction	Guide, Eq. 1.4	-0.29	
Flanking STC for path Fd_1		56.7	
Flanking Path Df_1			
Laboratory Flanking STC for Df	RR-335, FTL-13-WIJ305-FW-LB-001	85+	
Normalization correction	Guide, Eq. 1.4	-0.29	
Flanking STC for path Df_1		-	
Flanking STC for Junction_1	Guide, Section 1.4		55.9
Junction 2 (Non-loadbearing junction, wood-framed separating floor / flanking wall assemblies)			
Flanking Path Ff_2			
Laboratory Flanking STC for Ff	RR-335, FTL-13-WIJ305-FW-NLB-001	64	
Normalization correction	Guide, Eq. 1.4	0.68	
Flanking STC for path Ff_2		64.7	
Flanking Path Fd_2			
Laboratory Flanking STC for Fd	RR-335, FTL-13-WIJ305-FW-NLB-001	61	
Normalization correction	Guide, Eq. 1.4	0.68	
Flanking STC for path Fd_2		61.7	
Flanking Path Df_2			
Laboratory Flanking STC for Df	RR-335, FTL-13-WIJ305-FW-NLB-001	85+	
Normalization correction	Guide, Eq. 1.4	0.68	
Flanking STC for path Df_2		-	
Flanking STC for Junction_2	Guide, Section 1.4		59.9
Junction 3 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)			
All values the same as Junction 1			
Flanking STC for Junction_3	Guide, Section 1.4		55.9
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	Guide, Section 1.4		59.9
Combined transmission via all Flanking Paths			51.5
ASTC due to Direct plus Flanking Transmission	Guide, Section 1.4		**48**

EXAMPLE 4.1.4

- **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 channels[4] spaced 406 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

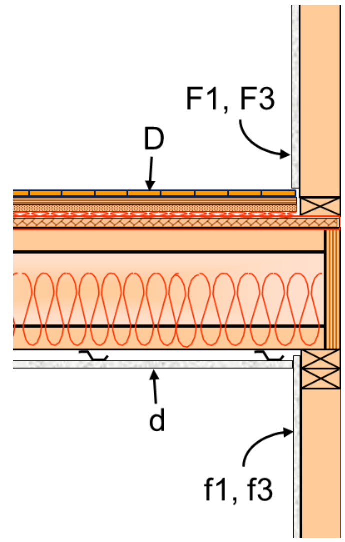
Junction 1&3 with loadbearing walls above and below floor) with:
- joists of floor assembly perpendicular to these walls
- walls have 38 mm x 89 mm wood studs spaced 400 mm o.c
- wall framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 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

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

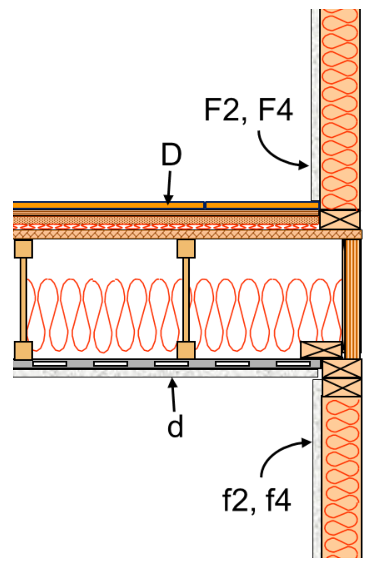
Note 1: For path/surface designations in the procedure below, treat the upper room as the source room (surfaces D and F)

Note 2: For the laboratory test specimens, dimensions required for normalization corrections are:
- Separating surface area = 19.6 m^2
- Wall/floor junction length = 4.6 m

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-335, TLF-13-WIJ305-011	66	
Direct STC in situ (Path DD through separating floor)			**66**
	Reference	**Lab (STC, etc.)**	**Path STC, ASTC**
Junction 1 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)			
Flanking Path Ff_1			
Laboratory Flanking STC for Ff	RR-335, FTL-13-WIJ305-FW-LB--010	64	
Normalization correction	Guide, Eq. 1.4	-0.29	
Flanking STC for path Ff_1		63.7	
Flanking Path Fd_1			
Laboratory Flanking STC for Fd	RR-335, FTL-13-WIJ305-FW-LB--010	74	
Normalization correction	Guide, Eq. 1.4	-0.29	
Flanking STC for path Fd_1		73.7	
Flanking Path Df_1			
Laboratory Flanking STC for Df	RR-335, FTL-13-WIJ305-FW-LB--010	85+	
Normalization correction	Guide, Eq. 1.4	-0.29	
Flanking STC for path Df_1		-	
Flanking STC for Junction_1	Guide, Section 1.4		63.3
Junction 2 (Non-loadbearing junction, wood-framed separating floor / flanking wall assemblies)			
Flanking Path Ff_2			
Laboratory Flanking STC for Ff	RR-335, FTL-13-WIJ305-FW-NLB--010	64	
Normalization correction	Guide, Eq. 1.4	0.68	
Flanking STC for path Ff_2		64.7	
Flanking Path Fd_2			
Laboratory Flanking STC for Fd	RR-335, FTL-13-WIJ305-FW-NLB--010	73	
Normalization correction	Guide, Eq. 1.4	0.68	
Flanking STC for path Fd_2		73.7	
Flanking Path Df_2			
Laboratory Flanking STC for Df	RR-335, FTL-13-WIJ305-FW-NLB--010	85+	
Normalization correction	Guide, Eq. 1.4	0.68	
Flanking STC for path Df_2		-	
Flanking STC for Junction_2	Guide, Section 1.4		64.2
Junction 3 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)			
All values the same as Junction 1			
Flanking STC for Junction_3	Guide, Section 1.4		63.3
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	Guide, Section 1.4		64.2
Combined transmission via all Flanking Paths			57.7
ASTC due to Direct plus Flanking Transmission	Guide, Section 1.4		**57**

EXAMPLE 4.1.5

- **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 channels[4] spaced 406 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

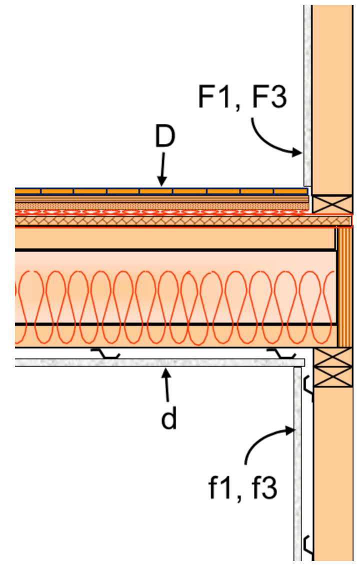
Junction 1&3 with loadbearing walls above and below floor) with:
- joists of floor assembly perpendicular to these walls
- walls have 38 mm x 89 mm wood studs spaced 400 mm o.c
- wall framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 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 channels 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 channels that are spaced 600 mm o.c. and attached to wall framing

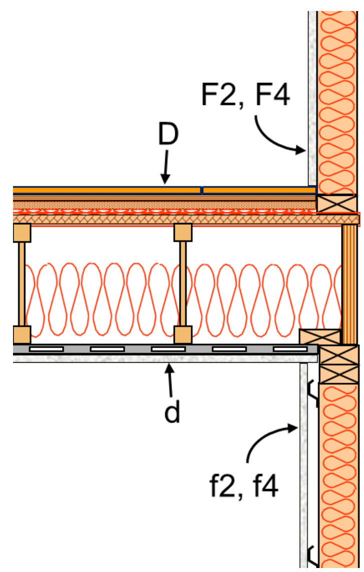
Note 1: For path/surface designations in the procedure below, treat the upper room as the source room (surfaces D and F)

Note 2: For the laboratory test specimens, dimensions required for normalization corrections are:
- Separating surface area = 19.6 m^2
- Wall/floor junction length = 4.6 m

Illustration for this case



Junction1 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-335, TLF-13-WIJ305-011	66	
Direct STC in situ (Path DD through separating floor)			**66**
	Reference	**Lab (STC, etc.)**	**Path STC, ASTC**
Junction 1 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)			
Flanking Path Ff_1			
Laboratory Flanking STC for Ff	RR-335, FTL-13-WIJ305-FW-LB-011	80	
Normalization correction	Guide, Eq. 1.4	-0.29	
Flanking STC for path Ff_1		79.7	
Flanking Path Fd_1			
Laboratory Flanking STC for Fd	RR-335, FTL-13-WIJ305-FW-LB-011	85+	
Normalization correction	Guide, Eq. 1.4	-0.29	
Flanking STC for path Fd_1		-	
Flanking Path Df_1			
Laboratory Flanking STC for Df	RR-335, FTL-13-WIJ305-FW-LB-011	85+	
Normalization correction	Guide, Eq. 1.4	-0.29	
Flanking STC for path Df_1		-	
Flanking STC for Junction_1	Guide, Section 1.4		79.7
Junction 2 (Non-loadbearing junction, wood-framed separating floor / flanking wall assemblies)			
Flanking Path Ff_2			
Laboratory Flanking STC for Ff	RR-335, FTL-13-WIJ305-FW-NLB-011	80	
Normalization correction	Guide, Eq. 1.4	0.68	
Flanking STC for path Ff_2		80.7	
Flanking Path Fd_2			
Laboratory Flanking STC for Fd	RR-335, FTL-13-WIJ305-FW-NLB-011	85+	
Normalization correction	Guide, Eq. 1.4	0.68	
Flanking STC for path Fd_2		-	
Flanking Path Df_2			
Laboratory Flanking STC for Df	RR-335, FTL-13-WIJ305-FW-NLB-011	85+	
Normalization correction	Guide, Eq. 1.4	0.68	
Flanking STC for path Df_2		-	
Flanking STC for Junction_2	Guide, Section 1.4		80.7
Junction 3 (Load-bearing junction, wood-framed separating floor / flanking wall assemblies)			
All values the same as Junction 1			
Flanking STC for Junction_3	Guide, Section 1.4		79.7
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	Guide, Section 1.4		80.7
Combined transmission via all Flanking Paths			74.1
ASTC due to Direct plus Flanking Transmission	Guide, Section 1.4		**65**

EXAMPLE 4.1.6

- **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 channels[4] 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 channels 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)

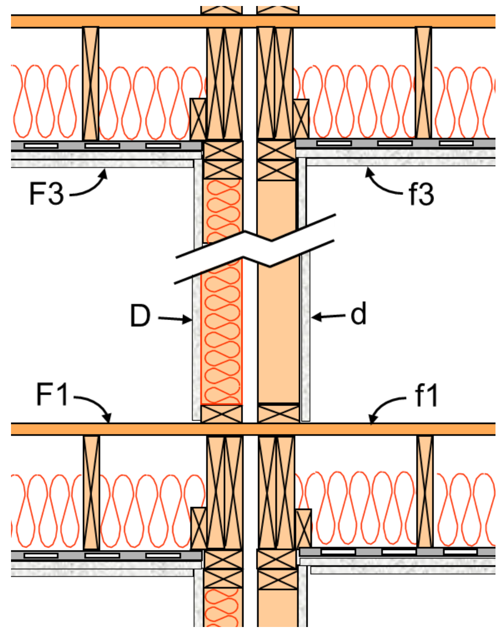
Note: For this case, individual path Flanking TL data are not available.

Direct and Flanking Sound Transmission:

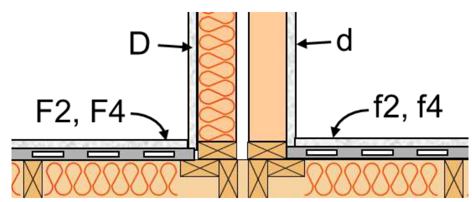
Path			**Path STC / ASTC**
Direct (Path Dd through separating wall) (RR-335, TLW-13-DWS203-001)			55
Bottom Junction 1, (RR-335, FTL-13-DWS203-WF-NLB-001)	Flanking STC =	47	
Side wall Junction 2, (RR-335, FTL-13-DWS203-WW-NLB-001)	Flanking STC =	65	
Top Junction 3, (RR-335, FTL-13-DWS203-WC-NLB-001)	Flanking STC =	65	
Side wall Junction 4, (RR-335, FTL-13-DWS203-WW-NLB-001)	Flanking STC =	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&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

- **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 channels[4] 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 channels 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)

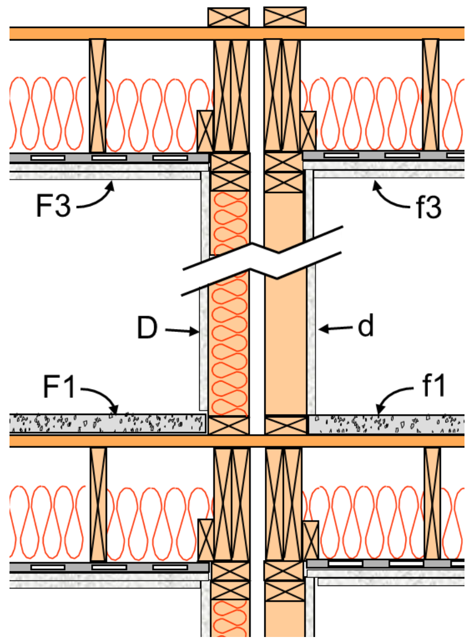
Note: For this case, individual path Flanking TL data are not available

Direct and Flanking Sound Transmission:

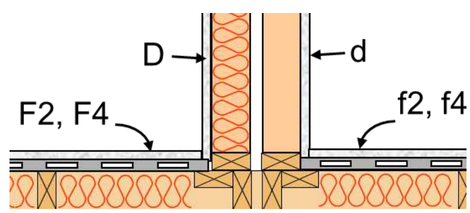
Path		**Path STC / ASTC**
Direct (Path Dd through separating wall) (RR-335, TLW-13-DWS203-001)		55
Bottom Junction 1, Flanking STC = (RR-335, FTL-13-DWS203-WF-NLB-002)	61	
Side wall Junction 2, Flanking STC = (RR-335, FTL-13-DWS203-WW-NLB-001)	65	
Top Junction 3, Flanking STC = (RR-335, FTL-13-DWS203-WC-NLB-001)	65	
Side wall Junction 4, Flanking STC = (RR-335, FTL-13-DWS203-WW-NLB-001)	65	
Combined Transmission via all Flanking Paths		58
Combined (all paths) ASTC		**53**

(See footnotes at end of document)

Illustration for this case



Junction 1&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)

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. 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 a slight increase to path Fd at both sidewall junctions. The main improvement is adding hardwood flooring on an engineered wood topping, which increases Flanking STC at the floor/wall junction from 50 to 63. 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. Other options can be explored online with the *SoundPATHS* calculator at http://irc-eguide.irc.nrc.ca/flankingui_v2.html .

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 total flanking STC increases to 74, and overall ASTC approaches the limit of 66 due to direct transmission through the floor. Many other surface options can be explored online with the *SoundPATHS* calculator available at http://irc-eguide.irc.nrc.ca/flankingui_v2.html .

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 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 chapter applies to buildings where the floors are framed with lightweight steel joists and the walls are framed with loadbearing steel suds, 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 specific 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 Lightweight Steel-Framed Partition Walls and either Heavy or Lightweight Façade.

Large 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 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 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.

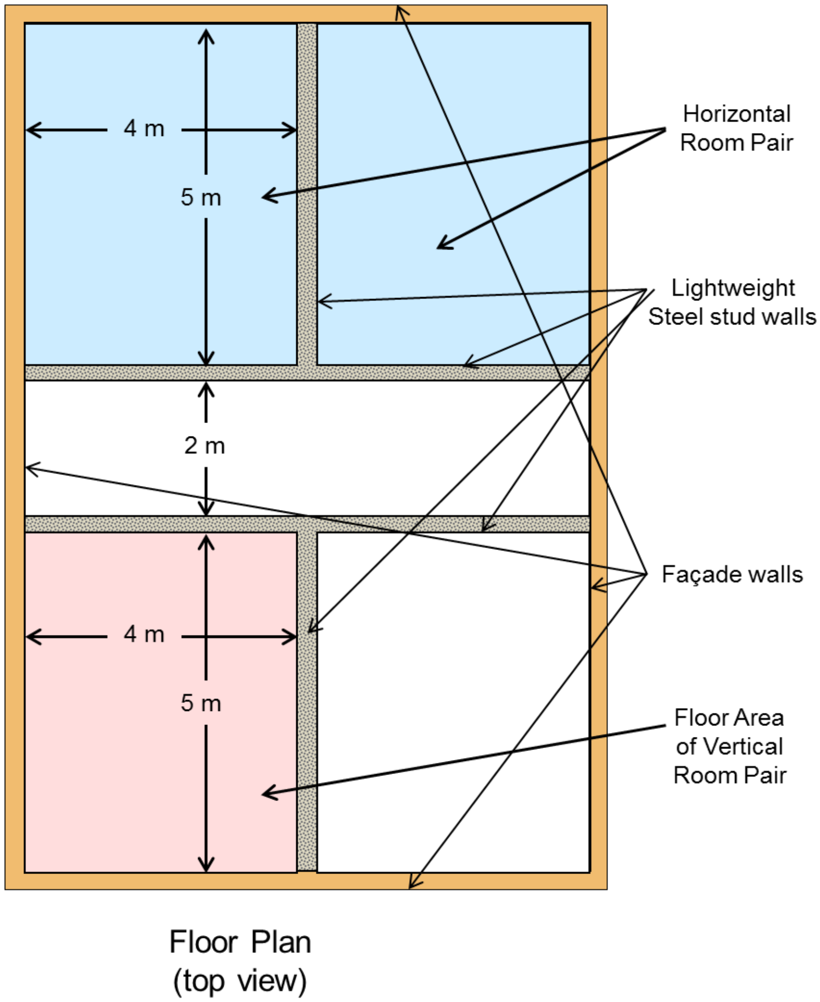


Figure 5.1: Extended Scenario for case with concrete structural floors and rigid junctions with a facade wall at the perimeter of the floor. Lightweight framed interior walls divide the interior space into two pairs of adjacent rooms with a corridor between. The room pairs have the same dimensions as 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 Masonry:

1. For direct transmission through the separating assembly of non-loadbearing steel studs, 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. Normally such assemblies would use non-loadbearing studs, 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 concrete floor/ceiling assemblies above and below. For non-loadbearing steel studs, it is common practice to use a nested pair of tracks at the top of the wall assembly, with the studs attached to the lower member of the pair; the detail may also include a fire stop. These variations could reduce the flanking transmission slightly (i.e. – give higher Flanking ASTC) but the calculations here ignore this effect, because the rather weak coupling from the concrete to the steel stud walls results in Flanking STC of about 80 or higher for these paths even for loadbearing studs, so they have negligible effect on the overall system performance.

3. For flanking at the cross-junctions of the 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 concrete slab are calculated differently. In-situ edge loss for the concrete 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 with the lightweight steel stud corridor wall, one should use values of the Flanking TL for paths Ff, Fd and Df, determined by measurements according to ISO 10848, as explained in Chapter 4. Unfortunately, no data are available for flanking transmission for walls with non-loadbearing steel studs. To provide a rough estimate, the Flanking TL for a wood-stud wall junction with the same dimensions and gypsum board surface layers was used. From a practical perspective, this demonstrates the procedure and the exact flanking transmission for this junction is not critical for the examples presented here because other paths dominate the transmission.
6. The Direct TL and Flanking TL values are combined, as in Section 1.4 of the Guide.

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

1. For the separating concrete floor assembly, the calculation steps are unchanged from the discussion in Chapter 2 except that the in-situ edge loss is calculated for the junctions at the perimeter of the extended surface area. (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 lightweight 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. (See Section 4.2.2 of ISO 15712-1.) The K_{ij} values are calculated using 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 figure 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 (2005) 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:

- **Rooms side-by-side, Extended Scenario**
- **Concrete floors and heavy concrete/masonry façade with lightweight steel stud internal walls**

Separating framed wall assembly with:

- one row of non-loadbearing 65 mm steel studs 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 to one side and one layer of 16 mm fire-rated gypsum board[3] on the other side (total weight per unit area of 33.8 kg/m^2).

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

- 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 lightweight steel-framed 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:

- concrete ceiling slab with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm) with no added ceiling lining
- cross junction with steel stud separating wall assembly.

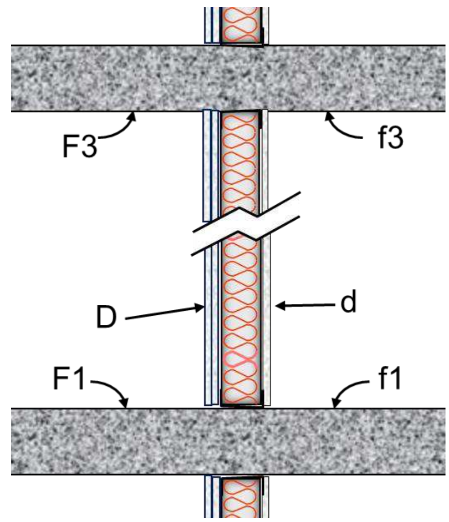
Junction 4: Separating wall / abutting corridor wall with:

- abutting corridor wall with non-loadbearing 65 mm steel studs and all construction details the same as the separating wall, with one layer of gypsum board on the side facing the rooms of concern.
- junction with steel stud separating wall

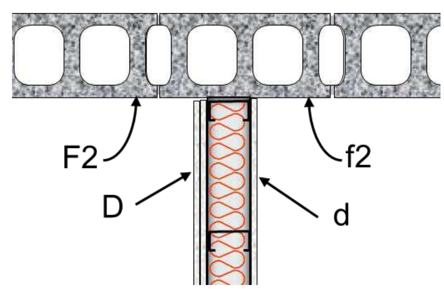
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	dominant (same loss for laboratory and in situ, See 4.2.2)				
mass (kg/m²) =	33.8	f_c =	2500		
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_{13}	K_{12}	K_{14}	$\Sigma\, l_k \cdot \alpha_k$
X-Junction 1 or 3	ISO 15712-1, Eq. E.7	-5.4	20.1	20.1	(ignore)
T-Junction 2	ISO 15712-1, Eq. E.4		18.5	18.5	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)	

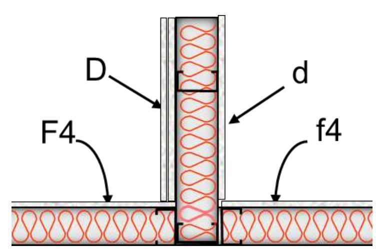
Illustration for this case



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 (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	IR-761, TL-93-036	51	26.6	46	58.9	63.7	52.4	55.5
Transferred Data - In-situ									
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
Direct TL in situ	R_D,situ	4.2.2: Equal to lab. TL	**51**	**26.6**	**46.0**	**58.9**	**63.7**	**52.4**	**55.5**
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	IR-811, TLF-97-107a	52	39.0	39.0	49.0	58.0	67.0	76.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.345	0.293	0.176	0.092	0.046	0.042
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	0.0
Change by Lining on receive side	ΔR_f1	No Lining ,	0	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		0.178	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	55	41.9	42.8	52.2	60.0	67.8	78.3
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	55	41.9	42.8	52.2	60.0	67.8	78.3
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		0.67	0.74	0.86	1.05	1.31	1.66
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		23.14	24.17	25.22	26.31	27.43	28.60
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		23.14	24.17	25.22	26.31	27.43	28.60
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**54**	**40.5**	**41.4**	**51.0**	**59.0**	**67.0**	**77.9**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**79**	**56.4**	**67.5**	**79.7**	**87.1**	**86.5**	**94.5**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**79**	**56.4**	**67.5**	**79.7**	**87.1**	**86.5**	**94.5**
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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	0.0	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	0.0
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	54	37.5	45.4	47.8	53.8	60.0	66.5
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	54	37.5	45.4	47.8	53.8	60.0	66.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		3.49	3.61	3.81	4.09	4.46	4.94
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		24.14	25.20	26.29	27.42	28.60	29.84
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		24.14	25.20	26.29	27.42	28.60	29.84
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**58**	**42.0**	**50.0**	**52.6**	**58.9**	**65.4**	**72.4**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**81**	**56.7**	**71.4**	**80.2**	**86.7**	**85.3**	**91.3**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**81**	**56.7**	**71.4**	**80.2**	**86.7**	**85.3**	**91.3**
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	0.0
Change by Lining on receive side	ΔR_f3	No Lining ,	0	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	**54**	**40.5**	**41.4**	**51.0**	**59.0**	**67.0**	**77.9**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**79**	**56.4**	**67.5**	**79.7**	**87.1**	**86.5**	**94.5**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25a	**79**	**56.4**	**67.5**	**79.7**	**87.1**	**86.5**	**94.5**
Junction 4 (T-junction, steel stud separating wall / steel stud flanking corridor wall)									
Flanking Transmission Loss - Estimate from path data measured for wood-stud wall with same gypsum board									
Flanking TL for Path Ff_4	R_Ff	Rough Estimate	**70**	**56.1**	**62.1**	**66.0**	**72.2**	**67.3**	**80.9**
Flanking TL for Path Fd_4	R_Fd	Rough Estimate	**67**	**53.2**	**55.6**	**63.2**	**73.4**	**68.8**	**76.1**
Flanking TL for Path Df_4	R_Df	Rough Estimate	**69**	**53.2**	**59.2**	**65.3**	**75.6**	**70.6**	**78.2**
Total Flanking STC (combined transmission for all flanking paths)			50						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**48**						

EXAMPLE 5.1.2:

- **Rooms side-by-side, Extended Scenario**
- **Concrete floors and heavy concrete/masonry façade with lightweight steel stud internal walls (Same structure as 5.1.1 with linings and improved stud walls)**

Separating framed wall assembly with:
- one row of 90 mm non-loadbearing steel studs 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 to the steel framing on each side (total weight per unit area of 45.6 kg/m^2).

Junction 1: Bottom Junction (separating wall / floor) with:
- 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] filling stud cavities

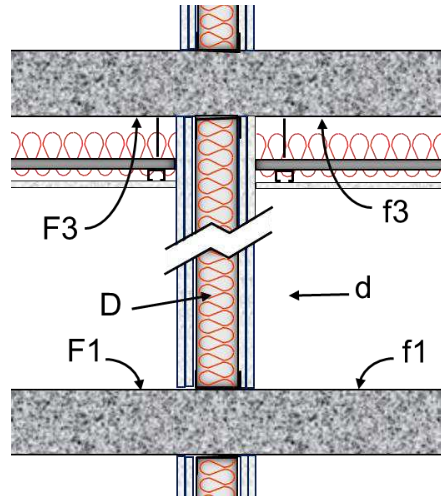
Junction 3: Top Junction (separating wall / ceiling) with:
- concrete ceiling slab with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm)
- ceiling lining below of 16 mm gypsum board[3] fastened to hat-channels supported on cross-channels hung on wires, cavity of 150 mm between concrete and ceiling, with 150 mm absorptive material[2]
- cross junction with lightweight steel-framed separating wall assembly.

Junction 4: Separating wall / abutting corridor wall with:
- abutting corridor wall with non-loadbearing 90 mm steel studs and all construction details the same as the separating wall.

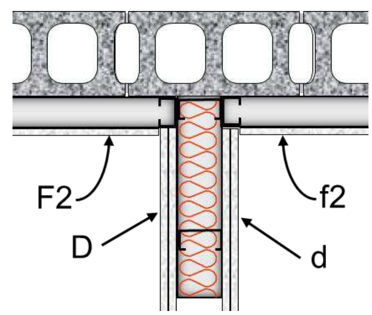
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	dominant (same loss for laboratory and in situ, See 4.2.2)				
mass (kg/m²) =	45.6	f_c =	2500		
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_{13}	K_{12}	K_{14}	$\Sigma\, l_k \cdot \alpha_k$
X-Junction 1 or 3	ISO 15712-1, Eq. E.7	-5.0	18.8	18.8	(ignore)
T-Junction 2	ISO 15712-1, Eq. E.4		17.2	17.2	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)	

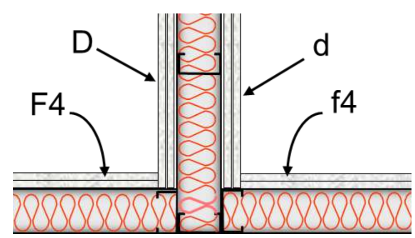
Illustration for this case



Cross-junctions 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 (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	IR-761, TL-92-369	58	35.3	50.1	62.4	68.9	59.7	61.9
Transferred Data - In-situ									
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
Direct TL in situ	R_D,situ	4.2.2: Equal to lab. TL	**58**	**35.3**	**50.1**	**62.4**	**68.9**	**59.7**	**61.9**
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	IR-811, TLF-97-107a	52	39.0	39.0	49.0	58.0	67.0	76.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.345	0.293	0.176	0.092	0.046	0.042
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	0.0
Change by Lining on receive side	ΔR_f1	No Lining ,	0	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		0.178	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	55	41.9	42.8	52.2	60.0	67.8	78.3
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	55	41.9	42.8	52.2	60.0	67.8	78.3
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		1.10	1.17	1.30	1.48	1.74	2.10
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		21.84	22.87	23.92	25.01	26.13	27.30
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		21.84	22.87	23.92	25.01	26.13	27.30
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**55**	**40.9**	**41.9**	**51.4**	**59.5**	**67.5**	**78.3**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**80**	**59.4**	**68.3**	**80.2**	**88.4**	**88.8**	**96.4**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**80**	**59.4**	**68.3**	**80.2**	**88.4**	**88.8**	**96.4**
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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	IR-586 , SS65_G16	8	1.0	8.8	16.6	13.3	7.7	7.6
Change by Lining on receive side	ΔR_f2	IR-586 , SS65_G16	8	1.0	8.8	16.6	13.3	7.7	7.6
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	54	37.5	45.4	47.8	53.8	60.0	66.5
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	54	37.5	45.4	47.8	53.8	60.0	66.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		4.16	4.29	4.48	4.76	5.13	5.62
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		22.84	23.90	24.99	26.12	27.30	28.54
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		22.84	23.90	24.99	26.12	27.30	28.54
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**69**	**44.6**	**68.3**	**86.5**	**86.2**	**81.5**	**88.3**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**85**	**60.7**	**80.9**	**97.2**	**101.3**	**95.3**	**100.8**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**85**	**60.7**	**80.9**	**97.2**	**101.3**	**95.3**	**100.8**
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	Ceiling ,	8	7.6	20.8	23.7	24.3	21.5	18.5
Change by Lining on receive side	ΔR_f3	Ceiling ,	8	7.6	20.8	23.7	24.3	21.5	18.5
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25a	**80**	**56.1**	**83.5**	**98.8**	**108.1**	**110.5**	**115.3**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**91**	**67.0**	**89.1**	**103.9**	**112.7**	**110.3**	**114.9**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25a	**91**	**67.0**	**89.1**	**103.9**	**112.7**	**110.3**	**114.9**
Junction 4 (T-junction, steel stud separating wall / steel stud flanking corridor wall)									
Flanking Transmission Loss - Estimate from path data measured for wood-stud wall with same gypsum board									
Flanking TL for Path Ff_4	R_Ff	Rough Estimate	**74**	**60.9**	**67.0**	**70.1**	**76.6**	**70.8**	**85.2**
Flanking TL for Path Fd_4	R_Fd	Rough Estimate	**72**	**57.0**	**63.0**	**69.0**	**77.9**	**72.4**	**80.3**
Flanking TL for Path Df_4	R_Df	Rough Estimate	**72**	**57.0**	**63.0**	**69.0**	**77.9**	**72.4**	**80.3**
Total Flanking STC (combined transmission for all flanking paths)			54						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**53**						

EXAMPLE 5.1.3:

- **Rooms one-above-the-other, Extended Scenario**
- **Concrete separating floor and heavy concrete/masonry façade with lightweight steel stud internal flanking walls**

Separating floor/ceiling assembly with:
- concrete floor with mass 345 kg/m² (e.g. – normal weight concrete with thickness of 150 mm) with no topping / flooring on top, or ceiling lining below.

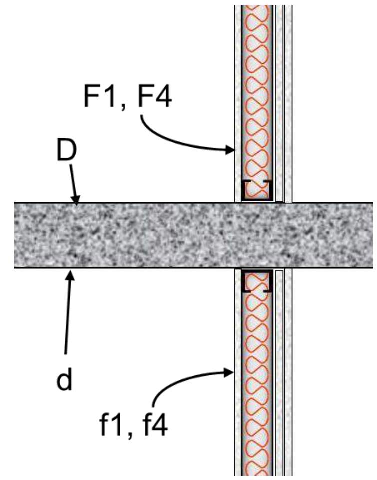
Junction 1 and 4: Cross Junction of separating floor / flanking wall with:
- cross junction with steel stud wall assemblies.
- walls above and below the floor have one row of non-loadbearing 65 mm steel studs spaced 600 mm o.c., with absorptive material[2] filling the cavities between studs.
- 2 layers of 16 mm fire-rated gypsum board[3] attached to one side of the steel studs and one layer of 16 mm fire-rated gypsum board[3] on the other side (total weight per unit area of 33.8 kg/m²).

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/m² (e.g.- 190 mm hollow blocks with normal weight aggregate[1]) with no lining of walls.

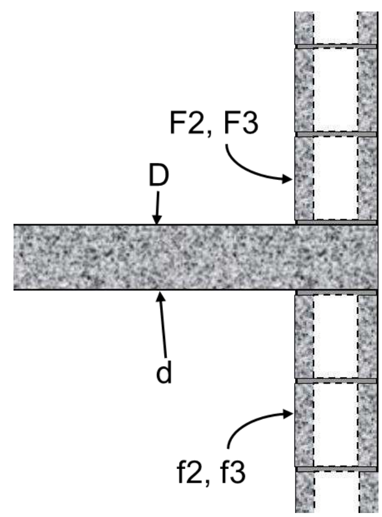
Acoustical Parameters:

For separating assembly (Extended concrete floor surface) :					
nternal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_13	K_12	K_14	Σ l_k . α_k
X-Junction 1 or 4	ISO 15712-1, Eq. E.3	-5.4	20.1	20.1	(ignore)
T-Junctions 2&3	ISO 15712-1, Eq. E.4		5.8	5.8	6.497
Total loss, η_{tot}	ISO 15712-1, Eq. C.1		0.052	(at 500 Hz)	
Similarly, for façade flanking elements F and f at Junction 2 & 3 (Extended masonry façade),					
nternal loss, η_i =	0.015	c_L =	3500		
mass (kg/m²) =	238	f_c =	98		
otal loss, $\eta_{tot,2}$	ISO 15712-1, Eq. C.1		0.089	(at 500 Hz)	
otal loss, $\eta_{tot,3}$	ISO 15712-1, Eq. C.1		0.089	(at 500 Hz)	
For lightweight flanking elements F and f at Junction 1 & 4,					
For lightweight steel stud walls, assume loss in situ = laboratory loss (mainly internal)					

Illustration for this case



Cross junction of separating floor of 150 mm thick concrete with non-loadbearing steel stud wall.
(Side view of Junctions 1 and 4)



T-Junction of separating floor of 150 mm thick 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	IR-811, TLF-97-107a	52	39	39	49	58	67	76
Structural Reverberation Time	T_s,lab	Measured T_s		0.35	0.29	0.18	0.09	0.05	0.04
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	0
Change by Lining on receive side	ΔR_d	No lining ,	0	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	20.7	21.3	22.2	23.6	25.6
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**55**	**41.9**	**42.8**	**52.2**	**60.0**	**67.8**	**78.3**
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	IR-761, TL-93-036	51	26.6	46.0	58.9	63.7	52.4	55.5
Equivalent Absorption Length	alpha_situ	4.2.2: Equal to wall area		12.50	12.50	12.50	12.50	12.50	12.50
TL in situ for F1	R_F1,situ	4.2.2: Equal to lab. TL	51	26.6	46.0	58.9	63.7	52.4	55.5
TL in situ for f1	R_f1,situ	4.2.2: Equal to lab. TL	51	26.6	46.0	58.9	63.7	52.4	55.5
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		36.14	35.15	34.16	33.16	32.17	31.18
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		23.14	24.17	25.22	26.31	27.43	28.60
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		23.14	24.17	25.22	26.31	27.43	28.60
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**86**	**64.8**	**83.2**	**95.1**	**98.9**	**86.6**	**88.7**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**81**	**58.4**	**69.6**	**81.8**	**89.2**	**88.5**	**96.5**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**81**	**58.4**	**69.6**	**81.8**	**89.2**	**88.5**	**96.5**
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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	0.0	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	0.0
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		17.053	17.559	18.368	19.577	21.334	23.852
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	54	37.5	45.4	47.8	53.8	60.0	66.5
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	54	37.5	45.4	47.8	53.8	60.0	66.5
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		14.43	14.56	14.76	15.03	15.41	15.89
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		12.53	12.63	12.79	13.02	13.34	13.75
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		12.53	12.63	12.79	13.02	13.34	13.75
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**71**	**55.0**	**63.0**	**65.6**	**71.9**	**78.4**	**85.4**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**69**	**53.7**	**58.2**	**64.3**	**71.5**	**78.7**	**87.6**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**69**	**53.7**	**58.2**	**64.3**	**71.5**	**78.7**	**87.6**
Junction 3 (Rigid T-junction, 150 mm concrete ceiling / 190 mm 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	**70**	**53.9**	**61.9**	**64.6**	**70.9**	**77.4**	**84.3**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**68**	**52.7**	**57.2**	**63.3**	**70.5**	**77.7**	**86.6**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25a	**68**	**52.7**	**57.2**	**63.3**	**70.5**	**77.7**	**86.6**
Junction 4 (Cross-Junction, 150 mm concrete floor / lightweight steel stud flanking wall)									
All input data the same as for Junction 1, but different junction length changes Flanking TL									
Flanking Element F4 and f4: Transferred Data - In-situ									
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	51	26.6	46.0	58.9	63.7	52.4	55.5
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	51	26.6	46.0	58.9	63.7	52.4	55.5
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**87**	**65.8**	**84.2**	**96.1**	**99.9**	**87.6**	**89.7**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**82**	**59.4**	**70.5**	**82.7**	**90.2**	**89.5**	**97.5**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**82**	**59.4**	**70.5**	**82.7**	**90.2**	**89.5**	**97.5**
Total Flanking STC (combined transmission for all flanking paths)			61						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**54**						

Calculation Steps for Horizontal or Vertical Pair of Rooms with Lightweight Glass Curtain Wall Façade:

The following set of examples show the change in performance when a lightweight façade is substituted for the heavy concrete or masonry façade of Examples 5.1.1 to 5.1.3.

1. Most steps of the calculation (and the comments about details of the steel framing) are unchanged from those presented at the beginning of Section 5.1 using the Extended Scenario.
2. For the concrete floor assembly, the 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 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 1.4 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.

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 figure 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 (2005) 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:

- **Rooms side-by-side, Extended Scenario**
- **Concrete floors and lightweight glass curtain wall façade with lightweight steel stud internal walls (Same construction as 5.1.2 except changed facade)**

Separating framed wall assembly with:
- one row of 90 mm non-loadbearing steel studs 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 to the steel framing on each side (total weight per unit area of 45.6 kg/m^2).

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

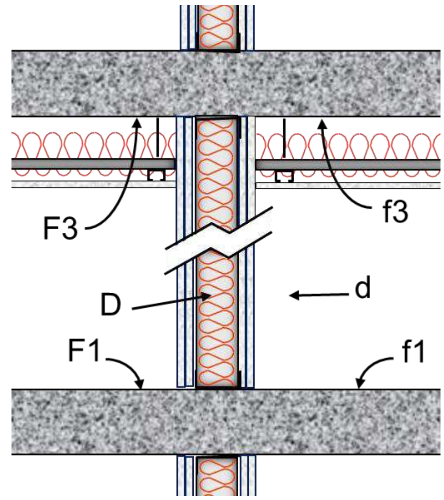
Junction 3: Top Junction (separating wall / ceiling) with:
- concrete ceiling slab with mass 345 kg/m^2 (e.g. – normal weight concrete with thickness of 150 mm)
- ceiling lining below of 16 mm gypsum board[3] fastened to hat-channels supported on cross-channels hung on wires, cavity of 150 mm between concrete and ceiling, with 150 mm absorptive material[2]
- cross junction with lightweight steel-framed separating wall assembly.

Junction 4: Separating wall / abutting corridor wall with:
- abutting corridor wall with non-loadbearing 90 mm steel studs and all construction details the same as the separating wall.

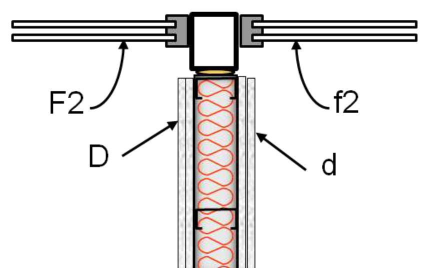
Acoustical Parameters:

For separating assembly:					
internal loss, η_i =	dominant (same loss for laboratory and in situ, See 4.2.2)				
mass (kg/m²) =	45.6	f_c =	2500		
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_24	K_21	K_23	Σ l_k . α_k
X-Junction (gyp.walls	ISO 15712-1, Eq. E.7	-5.0	18.8	18.8	1.087
T-Junction (façade)	ISO 15712-1, Eq. E.6		18.4	18.4	1.384
Total loss, η_tot =	ISO 15712-1, Eq. C.1		0.024	(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		

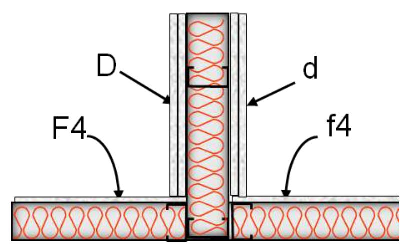
Illustration for this case



Cross-junctions 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 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).

(See footnotes at end of document)

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	IR-761, TL-92-369	58	35.3	50.1	62.4	68.9	59.7	61.9
Transferred Data - In-situ									
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
Direct TL in situ	R_D,situ	4.2.2: Equal to lab. TL	**58**	**35.3**	**50.1**	**62.4**	**68.9**	**59.7**	**61.9**
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	IR-811, TLF-97-107a	52	39.0	39.0	49.0	58.0	67.0	76.0
Structural Reverberation Time	T_s,lab	Measured T_s		0.345	0.293	0.176	0.092	0.046	0.042
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	0.0
Change by Lining on receive side	ΔR_f1	No Lining ,	0	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		0.407	0.277	0.184	0.119	0.075	0.045
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		8.9	9.2	9.8	10.7	12.1	14.1
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	52	38.3	39.2	48.8	56.9	64.9	75.7
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	52	38.3	39.2	48.8	56.9	64.9	75.7
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		0.00	0.00	0.00	0.00	0.00	0.00
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		20.04	21.11	22.24	23.43	24.69	26.01
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		20.04	21.11	22.24	23.43	24.69	26.01
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**50**	**36.2**	**37.2**	**46.8**	**54.8**	**62.8**	**73.7**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**77**	**55.8**	**64.8**	**76.8**	**85.3**	**86.0**	**93.8**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**77**	**55.8**	**64.8**	**76.8**	**85.3**	**86.0**	**93.8**
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		Guide, Eq. 1.4		1.0	1.0	1.0	1.0	1.0	1.0
Flanking Transmission Loss - Path data									
Flanking TL forJunction_2		Guide, Section 1.4	**53**	**43.3**	**47.8**	**52.8**	**47.9**	**60.1**	**60.4**
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 , ΔTLF-CON150-01	8	7.6	20.8	23.7	24.3	21.5	18.5
Change by Lining on receive side	ΔR_f3	RR-333 , ΔTLF-CON150-01	8	7.6	20.8	23.7	24.3	21.5	18.5
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25a	**75**	**51.4**	**78.8**	**94.2**	**103.4**	**105.8**	**110.7**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**87**	**63.4**	**85.6**	**100.5**	**109.6**	**107.5**	**112.3**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25a	**87**	**63.4**	**85.6**	**100.5**	**109.6**	**107.5**	**112.3**
Junction 4 (T-junction, steel stud separating wall / steel stud flanking corridor wall)									
Flanking Transmission Loss - Estimate from path data measured for wood-stud wall with same gypsum board									
Flanking TL for Path Ff_4	R_Ff	Rough Estimate	**70**	**56.1**	**62.1**	**66.0**	**72.2**	**67.3**	**80.9**
Flanking TL for Path Fd_4	R_Fd	Rough Estimate	**67**	**53.2**	**55.6**	**63.2**	**73.4**	**68.8**	**76.1**
Flanking TL for Path Df_4	R_Df	Rough Estimate	**69**	**53.2**	**59.2**	**65.3**	**75.6**	**70.6**	**78.2**
Total Flanking STC (combined transmission for all flanking paths)			48						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**47**						

EXAMPLE 5.1.5:

- **Rooms one-above-the-other, Extended Scenario**
- **Concrete separating floor and glass curtain wall façade with lightweight steel stud internal flanking walls (Same construction as 5.1.3 except changed facade)**

Separating floor/ceiling assembly with:

- 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 and 4: Cross Junction of separating floor / flanking wall with:

- cross junction with steel stud wall assemblies.
- walls above and below the floor have one row of non-loadbearing 65 mm steel studs 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 to one side of the steel studs and one layer of 16 mm fire-rated gypsum board[3] on the other side (total weight per unit area of 33.8 kg/m^2).

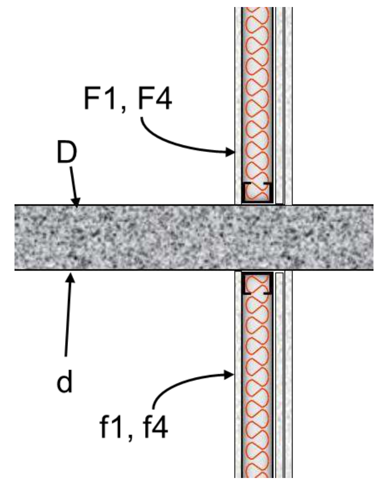
Junction 2 and 3: T-Junction of separating floor / flanking wall with:

- 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.

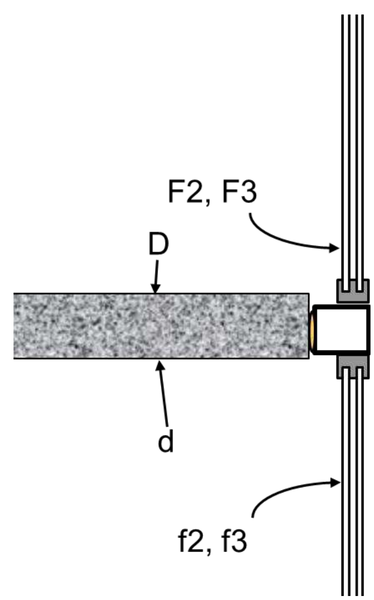
Acoustical Parameters:

For separating as:	(Extended Concrete floor)				
nternal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	345	f_c =	124		
	Reference	K_13	K_12	K_14	Σ l_k . α_k
X-Junction 1 or 4	ISO 15712-1, Eq. E.3	-5.0	18.8	18.8	1.087
T-Junctions 2&3	ISO 15712-1, Eq. E.4		18.4	18.4	1.384
Total loss, η_tot	ISO 15712-1, Eq. C.1		0.024	(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 lightweight steel stud walls, assume loss in situ = laboratory loss (mainly internal)					

Illustration for this case



Cross junction of separating floor of 150 mm thick concrete with non-loadbearing steel stud wall.
(Side view of Junctions 1 and 4)



T-Junction of separating floor of 150 mm thick 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	IR-811, TLF-97-107a	52	39	39	49	58	67	76
Structural Reverberation Time	T_s,lab	Measured T_s		0.35	0.29	0.18	0.09	0.05	0.04
Radiation Efficiency				1	1	1	1	1	1
Change by Lining on source side	ΔR_D	No lining ,	0	0	0	0	0	0	0
Change by Lining on receive side	ΔR_d	No lining ,	0	0	0	0	0	0	0
Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.407	0.277	0.184	0.119	0.075	0.045
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		8.9	9.2	9.8	10.7	12.1	14.1
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**52**	**38.3**	**39.2**	**48.8**	**56.9**	**64.9**	**75.7**
Junction 1 (Cross junction, 150 mm concrete floor / lightweight steel stud flanking wall)									
Flanking Element F1 and f1: Inpu	ISO Symbol	Reference	STC, ASTC, etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_F1,lab	IR-761, TL-92-369	58	35.3	50.1	62.4	68.9	59.7	61.9
Equivalent Absorption Length	alpha_situ	4.2.2: Equal to wall area		12.50	12.50	12.50	12.50	12.50	12.50
TL in situ for F1	R_F1,situ	4.2.2: Equal to lab. TL	58	35.3	50.1	62.4	68.9	59.7	61.9
TL in situ for f1	R_f1,situ	4.2.2: Equal to lab. TL	58	35.3	50.1	62.4	68.9	59.7	61.9
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		33.54	32.55	31.56	30.56	29.57	28.58
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		20.04	21.11	22.24	23.43	24.69	26.01
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		20.04	21.11	22.24	23.43	24.69	26.01
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**90**	**70.9**	**84.7**	**96.0**	**101.5**	**91.3**	**92.5**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**79**	**57.9**	**66.8**	**78.9**	**87.3**	**88.0**	**95.8**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**79**	**57.9**	**66.8**	**78.9**	**87.3**	**88.0**	**95.8**
Junction 2 (T-Junction, 150 mm concrete floor / glass curtain wall)									
Flanking Element F2 and f2: Input Data									
Vertical flanking (measured)	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**	**39.9**	**39.3**	**46.2**	**53.8**	**54.2**	**57.2**
Junction 3 T-junction, 150 mm concrete ceiling / 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)_	R_Ff	Guide, Section 1.4	**50**	**38.9**	**38.3**	**45.2**	**52.8**	**53.2**	**56.2**
Junction 4 (Cross-Junction, 150 mm concrete floor / lightweight steel stud flanking wall)									
All input data the same as for Junction 1, but different junction length changes Flanking TL									
Flanking Element F4 and f4: Transferred Data - In-situ									
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	58	35.3	50.1	62.4	68.9	59.7	61.9
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	58	35.3	50.1	62.4	68.9	59.7	61.9
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**94**	**74.5**	**88.3**	**99.6**	**105.1**	**94.9**	**96.1**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**81**	**60.1**	**69.1**	**81.1**	**89.6**	**90.3**	**98.1**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**81**	**60.1**	**69.1**	**81.1**	**89.6**	**90.3**	**98.1**
Total Flanking STC (combined transmission for all flanking paths)			48						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**46**						

<u>Summary for Section 5.1: Concrete Floors with Lightweight Framed Interior Walls</u>

<u>For heavy concrete or masonry facade walls</u> examples 5.1.1 to 5.1.3 show the calculation procedures for the Extended Scenario in a building with lightweight steel-framed wall assemblies dividing the interior area and heavy concrete structural floor assemblies above and below. See page 93 for issues related to details of the steel framing.

- Example 5.1.1 shows the calculation for a horizontal pair of rooms separated by a steel-framed wall with laboratory STC of 51. With this wall, the ASTC between rooms was 48; with a wall of STC 50, the ASTC would drop to 47. The overall flanking STC of 50 was dominated by paths Ff at Junctions 1 and 3 (floor-floor and ceiling-ceiling paths), but transmission via the bare concrete block façade wall is only a slightly smaller concern. For a better separating wall, these flanking paths would hold the ASTC to 50 or lower.
- 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 a better separating wall and 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 linings, but no matter how high the STC of the separating stud wall, the ASTC will not exceed 55 unless the floor is significantly improved with a lining such as a floating floor.
- Example 5.1.3 shows the calculation for a vertical pair of rooms separated by a bare concrete floor assembly of 150 mm concrete. Due to the extended response of the floor, the in-situ STC for the separating floor is 55, which is higher than the corresponding laboratory STC of 52 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 61, even with bare concrete block for two wall surfaces in each room, so flanking only marginally reduces the ASTC to 54. Adding a ceiling and lining the concrete block walls could increase the ASTC to well over 60.

<u>For glass curtain wall façade,</u> examples 5.1.4 and 5.1.5 show the significantly reduced ASTC expected with a lightweight façade that extends across the junctions.

- 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 both lower Flanking STC via the floor (due to smaller edge losses from the concrete floor to the façade) and rather low Flanking STC for the curtain wall 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 lightweight partitions with high STC and suitable linings over the heavy concrete masonry façade surfaces. When curtain wall replaces the heavy façade, the latter is not feasible

5.2. Masonry or Concrete Walls with Joist Floors whose Concrete Deck has Rigid Floor/Wall Junctions

Flanking transmission involving joist floor assemblies with a concrete floor deck can be evaluated in several ways, depending on the type of wall assemblies, the junction details, and available test data:

1. When such floors are connected to wall assemblies with wood or steel studs, then ASTC for the combination of wall and floor systems should be evaluated following the procedures presented in Chapter 4. Significant flanking transmission via the concrete floor deck is likely, especially if the concrete is continuous across the junction or is bonded to the separating wall's structure.
2. When such floors are connected to walls of heavy concrete or masonry, and measured flanking transmission test data according to ISO 10848 are available, then the procedure of Section 5.3 or Chapter 6 is recommended; this is similar to the procedure of Chapter 2, substituting flanking transmission data from ISO 10848 where applicable.
3. However, when such floors are combined with heavy wall assemblies of concrete or masonry but flanking test data according to ISO 10848 are not available, a worst-case estimate can be made using a variation on the detailed calculation process of ISO 15712-1, as presented in Chapter 2. ***The third case is the focus of this Section. Because it assumes a rigid connection at the wall/floor junction, this should give a conservative estimate for a not rigid junction with resilient connection between the floor deck and the concrete/masonry separating wall***

The required input data (as in Chapter 2) are laboratory sound transmission data according to ASTM E90 for the wall assemblies and for the floor/ceiling assembly, with one extension. The floor/ceiling assembly must be tested both as a complete assembly (typically including a gypsum board ceiling and absorptive material[2] in the cavities between the joists) and as a bare assembly (no ceiling or absorption). The "bare assembly" without ceiling or absorption is treated as the structural assembly for the basic flanking calculations which use the detailed calculation procedure of ISO 15712-1. The change in laboratory TL when the ceiling and absorption are added is treated as the effect of a lining. For this approach to be consistent with the cautions in ISO 15712-1, there are some restrictions on the floor/ceiling elements:

- The floor deck should have mass per unit area not less than 1/3 of that for the connected masonry or concrete wall assemblies.
- The ceiling layers should have mass per unit area less than 1/4 of that for the floor deck.

The worked examples present the pertinent physical characteristics of the assemblies and junctions. The "References" column gives 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 (2005) at each stage of the calculation.. All examples conform to the Standard Scenario presented in Section 1.2 of this Guide.

Under the single heading "STC, ASTC, etc." the examples present single figure 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 a lining to the specified wall or floor assembly,
- In-situ STC values for the calculated in-situ transmission loss of bare 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 5.2.1:

- **Rooms side-by-side**
- **Floors with concrete deck supported on steel joists**
- **Rigid Junctions of Floor Deck with Masonry 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]) with no lining.

Junction 1: Bottom Junction (separating wall / floor) with:
- floor deck with mass 92 kg/m^2 (normal weight concrete of average thickness 40 mm on corrugated steel pan) supported on 203 mm steel joists spaced 406 mm o.c. (See note below illustrations.)
- no topping or flooring over concrete floor surface
- cross junction of concrete deck with concrete block wall assembly above and below (treated as a rigid junction).

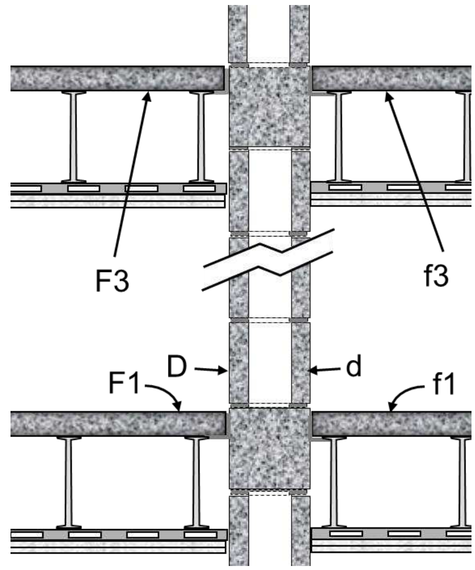
Junction 2 or 4: (separating wall /abutting side wall) with:
- abutting side wall and separating wall of 190 mm hollow concrete blocks with mass 238 kg/m^2 with no lining
- rigid mortared T-junctions

Junction 3: Top Junction (separating wall / ceiling) with:
- concrete floor deck with mass 92 kg/m^2 (normal weight concrete of average thickness 40 mm on corrugated steel pan) supported on 203 mm steel joists spaced 406 mm o.c., no absorptive material in cavities between joists (See note below illustrations.)
- cross junction of concrete deck with concrete block wall assembly above and below (treated as a rigid junction).
- ceiling on each side (2 layers of 13 mm fire-rated gypsum board[3] on resilient channels spaced 406 mm o.c. attached to joists)

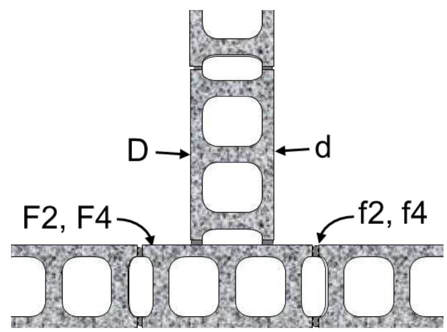
Acoustical Parameters:

For separating assembly:					
internal loss, η_i = 0.015		c_L = 3500			
mass (kg/m²) = 237.5		f_c = 98			
	Reference	K_13	K_12	K_14	Σ l_k . α_k
X-Junction 1 or 3	ISO 15712-1, Eq. E.3	2.6	9.7	9.7	1.588
T-Junction 2 or 4	ISO 15712-1, Eq. E.4		5.7	5.7	0.420
Total loss, η_tot	ISO 15712-1, Eq. C.1		0.066	(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) = 92		f_c = 463			
Total loss, η_tot	ISO 15712-1, Eq. C.1		0.015	(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		0.079	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1		0.069	(at 500 Hz)	

Illustration for this case



Cross-junction of 190 mm concrete block separating wall with concrete deck of floor and ceiling. (Side view of Junctions 1 and 3)



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

NOTE: Floor/wall junction is illustrated for case where joists are parallel to separating wall, but this simple worst-case calculation ignores direction of joists. Junction with joists perpendicular is illustrated in Example 5.2.2.

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	IR-586, TL-88-356	50	33	41.2	44	50.4	57	63.9
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.30	0.19	0.12	0.07	0.04	0.02
Change by Lining on either side	ΔR_D, ΔR_d	No Lining ,	0	0	0	0	0	0	0
Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.147	0.100	0.066	0.043	0.027	0.017
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		15.3	16.0	17.0	18.5	20.7	23.8
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**52**	**36.1**	**44.0**	**46.5**	**52.6**	**58.9**	**65.5**

(See footnotes at end of document)

Junction 1 (Rigid Cross junction, 190 mm block separating wall / floor with 40 mm concrete deck on steel joists)									
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-169, TLF-02-047a	42	34.0	32.0	36.0	43.0	49.0	54.0
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.766	0.489	0.304	0.183	0.107	0.061
Change by Lining on either side	ΔR_F1, ΔR_f1	No Lining ,	0	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		0.599	0.436	0.296	0.188	0.113	0.065
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		6.026	5.857	6.099	6.779	7.982	9.853
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	42	35.1	32.5	36.1	42.9	48.8	53.7
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	42	35.1	32.5	36.1	42.9	48.8	53.7
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		17.52	17.40	17.57	18.03	18.74	19.66
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		12.51	12.53	12.75	13.17	13.77	14.53
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		12.51	12.53	12.75	13.17	13.77	14.53
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**58**	**50.5**	**47.9**	**51.6**	**58.9**	**65.5**	**71.4**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**59**	**47.1**	**49.8**	**53.1**	**59.9**	**66.6**	**73.1**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**59**	**47.1**	**49.8**	**53.1**	**59.9**	**66.6**	**73.1**
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	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.299	0.191	0.119	0.072	0.042	0.024
Change by Lining on either side	ΔR_F2, ΔR_f2	No Lining ,	0	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		0.120	0.082	0.055	0.036	0.023	0.015
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		15.000	15.506	16.315	17.524	19.281	21.799
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	53	37.0	44.9	47.3	53.4	59.6	66.1
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	53	37.0	44.9	47.3	53.4	59.6	66.1
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		13.48	13.63	13.85	14.16	14.57	15.10
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		13.53	13.69	13.93	14.28	14.73	15.30
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		13.53	13.69	13.93	14.28	14.73	15.30
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**68**	**51.4**	**59.5**	**62.1**	**68.5**	**75.1**	**82.2**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**67**	**50.5**	**58.6**	**61.4**	**67.8**	**74.5**	**81.6**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**67**	**50.5**	**58.6**	**61.4**	**67.8**	**74.5**	**81.6**
Junction 3 (Rigid Cross junction, 190 mm block separating wall / ceiling with 40 mm concrete deck on steel joists)									
All values the same as for Junction 1, except ceiling lining added									
Change by Lining on either side	ΔR_F3, ΔR_f3	RR-169 , TLF-03-011a	20	11.0	21.0	20.0	19.0	23.0	23.0
Flanking TL for Path Ff_3	R_Ff	ISO 15712-1, Eq. 25a	**96.0**	**72.5**	**89.9**	**91.6**	**96.9**	**111.5**	**117.4**
Flanking TL for Path Fd_3	R_Fd	ISO 15712-1, Eq. 25a	**78.0**	**58.1**	**70.8**	**73.1**	**78.9**	**89.6**	**96.1**
Flanking TL for Path Df_3	R_Df	ISO 15712-1, Eq. 25a	**78.0**	**58.1**	**70.8**	**73.1**	**78.9**	**89.6**	**96.1**
Junction 4 (Rigid T-junction, 190 mm block separating wall / 190 mm block flanking wall)									
All input data the same as for Junction 2									
Flanking Element F4 and f4: Transferred Data - In-situ (different junctions at ceiling and floor change loss factors from junction 2)									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.141	0.096	0.064	0.042	0.026	0.015
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		12.817	13.323	14.132	15.342	17.099	19.617
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	52	36.3	44.2	46.7	52.8	59.1	65.6
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	52	36.3	44.2	46.7	52.8	59.1	65.6
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		12.80	12.97	13.22	13.58	14.05	14.65
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21		13.19	13.36	13.62	13.99	14.47	15.07
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21		13.19	13.36	13.62	13.99	14.47	15.07
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**66**	**50.0**	**58.1**	**60.9**	**67.3**	**74.1**	**81.2**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**66**	**49.9**	**58.0**	**60.7**	**67.2**	**73.9**	**81.1**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**66**	**49.9**	**58.0**	**60.7**	**67.2**	**73.9**	**81.1**
Total Flanking STC (combined transmission for all flanking paths)			53						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**50**						

EXAMPLE 5.2.2:

- **Rooms one-above-the-other**
- **Floor with concrete deck on steel joists, and rigid junctions of floor deck to masonry walls**

Separating floor/ceiling assembly with:
- concrete floor deck with mass 92 kg/m^2 (normal weight concrete with average thickness 40 mm on corrugated steel pan) supported on 203 mm steel joists spaced 406 mm o.c. with no absorptive material in cavities between joists
- ceiling lining on each side (2 layers of 13 mm fire-rated gypsum board[3] supported on resilient channels spaced 406 mm o.c. and attached to bottom of steel joists)
- no topping or flooring over concrete deck

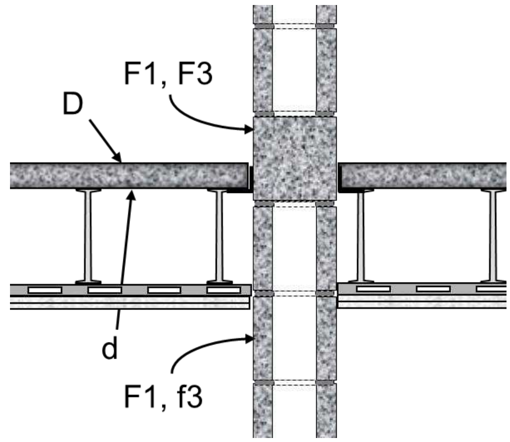
Junction 1, 3, 4: Cross Junction of separating floor/ wall with:
- cross junction of floor deck with concrete block wall assemblies above and below. (treated as a rigid junction)
- wall above and below floor of one wythe of concrete blocks with mass 238 kg/m^2 (e.g.- 190 mm hollow blocks with normal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

Junction 2: T-Junction of separating floor / flanking wall with:
- T-junction of the floor deck with concrete block wall assemblies above and below (treated as a rigid junction)
- 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.

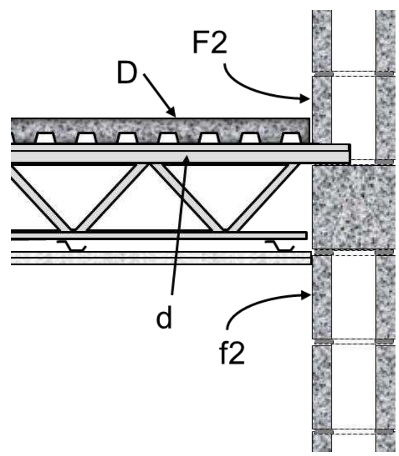
Acoustical Parameters:

For separating assembly:					
nternal loss, η_i =	0.006	c_L =	3500		
mass (kg/m²) =	92	f_c =	463		(Eq. C.2)
	Reference	K_13	K_12	K_14	Σ l_k . α_k
X-Junction 1, 3, 4	ISO 15712-1, Eq. E.3	16.7	9.7	9.7	0.410
T-Junction 2	ISO 15712-1, Eq. E.4		6.7	6.7	0.538
Total loss, η_tot	ISO 15712-1, Eq. C.1		0.015	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 1 & 3,					
nternal 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		0.066	(at 500 Hz)	
Similarly, for flanking elements F and f at Junction 2 & 4,					
nternal 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		0.079	(at 500 Hz)	
Total loss, η_tot,4	ISO 15712-1, Eq. C.1		0.069	(at 500 Hz)	

Illustration for this case



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



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

Separating Partition (40 mm concrete floor deck on steel joists)									
Input Data	ISO Symbol	Reference	STC, ASTC, etc.	125	250	500	1000	2000	4000
Sound Transmission Loss	R_D,lab	RR-169, TLF-02-047a	42	34	32	36	43	49	54
Structural Reverberation Time	T_s,lab	Estimate Eq. C.5		0.77	0.49	0.30	0.18	0.11	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	0
Change by Lining on receive side	ΔR_d	RR-169 , TLF-03-011a	20	11	21	20	19	23	23
Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.599	0.436	0.296	0.188	0.113	0.065
Equivalent Absorption Length	alpha_D,situ	ISO 15712-1, Eq. 22		6.0	5.9	6.1	6.8	8.0	9.9
Direct TL in situ	R_D,situ	ISO 15712-1, Eq. 24	**62**	**46.1**	**53.5**	**56.1**	**61.9**	**71.8**	**76.7**

(See footnotes at end of document)

Junction 1 (Rigid Cross junction, 40 mm concrete floor deck / 190 mm block flanking wall)									
Flanking Element F1 and f1: Inpu	**ISO Symbol**	**Reference**	**STC, ASTC, etc.**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Sound Transmission Loss	R_F1,lab	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	0.0	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	0.0
Flanking Element F1 and f1: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.147	0.100	0.066	0.043	0.027	0.017
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		15.349	15.981	16.992	18.504	20.701	23.848
TL in situ for F1	R_F1,situ	ISO 15712-1, Eq. 19	52	36.1	44.0	46.5	52.6	58.9	65.5
TL in situ for f1	R_f1,situ	ISO 15712-1, Eq. 19	52	36.1	44.0	46.5	52.6	58.9	65.5
Junction J1 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_1,situ	ISO 15712-1, Eq. 21		7.49	7.67	7.94	8.31	8.79	9.41
Velocity Level Difference for Fd	D_v,Fd_1,situ	ISO 15712-1, Eq. 21		12.51	12.53	12.75	13.17	13.77	14.53
Velocity Level Difference for Df	D_v,Df_1,situ	ISO 15712-1, Eq. 21		12.51	12.53	12.75	13.17	13.77	14.53
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_1	R_Ff	ISO 15712-1, Eq. 25a	**62**	**45.6**	**53.7**	**56.5**	**63.0**	**69.8**	**76.9**
Flanking TL for Path Fd_1	R_Fd	ISO 15712-1, Eq. 25a	**80**	**60.1**	**72.8**	**75.1**	**80.9**	**91.6**	**98.2**
Flanking TL for Path Df_1	R_Df	ISO 15712-1, Eq. 25a	**61**	**49.1**	**51.8**	**55.1**	**61.9**	**68.6**	**75.2**
Junction 2 (Rigid T-Junction, 40 mm concrete floor deck/ 190 mm block flanking wall)									
Flanking Element F2 and f2: Input Data									
Sound Transmission Loss	R_F2,lab	IR-586, TL-88-356	50	33.0	41.2	44.0	50.4	57.0	63.9
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	0.0	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	0.0
Flanking Element F2 and f2: Transferred Data - In-situ									
Structural Reverberation time	T_s,situ	ISO 15712-1, Eq. C.1-C.3		0.120	0.082	0.055	0.036	0.023	0.015
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		15.000	15.506	16.315	17.524	19.281	21.799
TL in situ for F2	R_F2,situ	ISO 15712-1, Eq. 19	53	37.0	44.9	47.3	53.4	59.6	66.1
TL in situ for f2	R_f2,situ	ISO 15712-1, Eq. 19	53	37.0	44.9	47.3	53.4	59.6	66.1
Junction J2 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_2,situ	ISO 15712-1, Eq. 21		6.60	6.74	6.96	7.28	7.69	8.22
Velocity Level Difference for Fd	D_v,Fd_2,situ	ISO 15712-1, Eq. 21		10.43	10.44	10.64	11.02	11.58	12.31
Velocity Level Difference for Df	D_v,Df_2,situ	ISO 15712-1, Eq. 21		10.43	10.44	10.64	11.02	11.58	12.31
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_2	R_Ff	ISO 15712-1, Eq. 25a	**63**	**46.6**	**54.6**	**57.3**	**63.7**	**70.3**	**77.3**
Flanking TL for Path Fd_2	R_Fd	ISO 15712-1, Eq. 25a	**79**	**58.9**	**71.6**	**73.9**	**79.7**	**90.3**	**96.7**
Flanking TL for Path Df_2	R_Df	ISO 15712-1, Eq. 25a	**60**	**47.9**	**50.6**	**53.9**	**60.7**	**67.3**	**73.7**
Junction 3 (Rigid Cross junction, 40 mm concrete floor deck / 190 mm block flanking wall)									
All values the same as for Junction 1									
Junction 4 (Rigid Cross-Junction, 40 mm concrete floor deck / 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		0.141	0.096	0.064	0.042	0.026	0.015
Equivalent Absorption Length	alpha_situ	ISO 15712-1, Eq. 22		12.817	13.323	14.132	15.342	17.099	19.617
TL in situ for F4	R_F4,situ	ISO 15712-1, Eq. 19	52	36.3	44.2	46.7	52.8	59.1	65.6
TL in situ for f4	R_f4,situ	ISO 15712-1, Eq. 19	52	36.3	44.2	46.7	52.8	59.1	65.6
Junction J4 - Coupling									
Velocity Level Difference for Ff	D_v,Ff_4,situ	ISO 15712-1, Eq. 21		7.68	7.85	8.11	8.46	8.93	9.53
Velocity Level Difference for Fd	D_v,Fd_4,situ	ISO 15712-1, Eq. 21		13.09	13.11	13.32	13.73	14.32	15.08
Velocity Level Difference for Df	D_v,Df_4,situ	ISO 15712-1, Eq. 21		13.09	13.11	13.32	13.73	14.32	15.08
Flanking Transmission Loss - Path data									
Flanking TL for Path Ff_4	R_Ff	ISO 15712-1, Eq. 25a	**63**	**47.0**	**55.1**	**57.8**	**64.3**	**71.0**	**78.2**
Flanking TL for Path Fd_4	R_Fd	ISO 15712-1, Eq. 25a	**81**	**61.3**	**74.0**	**76.2**	**82.1**	**92.7**	**99.3**
Flanking TL for Path Df_4	R_Df	ISO 15712-1, Eq. 25a	**62**	**50.3**	**53.0**	**56.2**	**63.1**	**69.7**	**76.3**
Total Flanking STC (combined transmission for all flanking paths)			53						
ASTC due to Direct plus Flanking Transmission		Guide, Section 1.4	**52**						

Summary for Section 5.2:

The worked examples 5.2.1 and 5.2.2 illustrate the calculation of sound transmission between rooms in a building with rigid junctions between the 40 mm-thick concrete floor deck of a steel joist floor and the concrete block walls at the perimeter of each room.

Overall, these examples show that substitution of the lighter joist floor assembly changes the ASTC only slightly from that observed with a heavy concrete floor deck with an added ceiling.

Comparing the horizontal room pair of Example 5.2.1 with Example 2.1.1, the lower in-situ STC for the much lighter concrete deck of the joist floor assembly (42 vs. 52) is offset by much reduced vibration transmission across the floor/wall junction due to the increased ratio of wall to floor mass per unit area. The total Flanking STC 53 for all flanking paths between the side-by-side rooms in Example 5.2.1 is higher than the value of 51 in Example 2.1.1 with bare floor and ceiling assemblies of 150 mm concrete, but adding a gypsum board ceiling to case 2.1.1 would bring the combined Flanking STC to 53, like this example. As in the cases presented in Section 2.3, improving the walls with linings will provide only limited increase in the ASTC, unless an effective lining is added to the floor surface.

In the vertical room pair in 5.2.2, the in-situ Direct TL for the separating floor/ceiling assembly is almost the same as the laboratory result. At all four edges of the floor, the flanking transmission is dominated by nearly equal contributions from paths Df and Ff. As in Section 2.3, adding linings to the walls could greatly reduce the flanking transmission, raising the ASTC close to that for direct transmission through the floor/ceiling assembly (Direct STC is 62 in this case), and that could in turn be raised by improving the ceiling lining by addition of absorptive material[2].

Note that with wall/floor junction details that provide less vibration transmission (such as soft junctions where resilient materials separate the concrete deck from the adjacent concrete blocks) even higher ASTC might be predicted by substituting the expected junction attenuation or path attenuation (verified by testing according to ISO 10848) for the rigid junction values used here. The rigid junction values used here should provide a conservative “worst case estimate” but the procedure of Chapter 6 (using values measured according to ISO 10848) is more appropriate for such systems if test data 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 concrete block.

The calculation process presented here greatly resembles the simplified approach for wood- or steel-framed assemblies presented in Chapter 4, with the extension that linings on the concrete block surfaces (either for direct or flanking transmission) may be treated using a simple additive correction.

An experimental study of such systems is currently underway at NRC, and this is expected to provide the basis for a less conservative (but probably more complicated) approach in future editions of this Guide.

The Calculation Process requires specific laboratory test data, but can be performed using single-number ratings, following the steps illustrated in Figure 5.3.1, and explained in detail below.

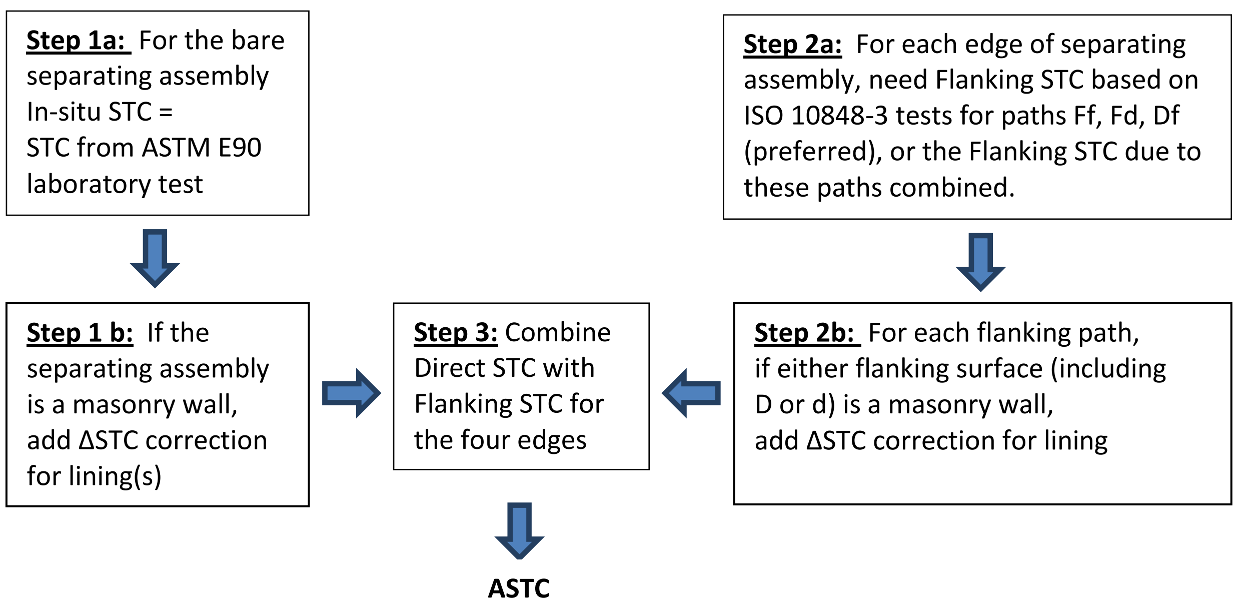


Figure 5.3.1: Steps to calculate the ASTC for lightweight framed construction (as detailed below)

Step 1: (a) For the bare separating assembly, the in-situ STC is equal to STC measured in laboratory according to ASTM E90.
(b) If the separating assembly is a masonry wall, add 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 should follow that of Section 2.4 (If there are two linings, the correction = larger of two lining corrections plus ½ of lesser one).

Step 2: (a) Determine the Flanking STC for the set of surfaces connected at each edge of the separating assembly: If data are available, use the Flanking STC for each of the 3 paths Ff, Fd and Df at each edge. If these data are values of $D_{n,f}$ measured in accordance with ISO 10848-3, apply the corrections from Equation 1.4 in Section 1.4 of this Guide. If only data for combined transmission by the set of 3 paths at a junction are available, these may be used. Data for the individual paths Ff, Fd and Df are preferred because these provide more insight to identify

which path(s) limit the ASTC and hence are priorities for improvement, as shown in some of the following examples.
(b) If either surface for a flanking path is a masonry wall, add the ΔSTC correction for any lining on that source room or receiving room surface to obtain the Flanking STC. This correction procedure should follow that of Section 2.4 (If there are two linings, the correction = larger of two lining corrections plus ½ of lesser one).

Step 3: Combine the transmission via the direct and flanking paths using Equations 1.1 and 1.2 in Section 1.4 of this Guide (broadly equivalent to Eq. 26 in Section 4.4 of ISO 15712-1), as follows:

- If the Flanking STC for any path is over 85, ignore that path in these calculations.
- Round interim calculations to the nearest 0.1dB.
- Round the final result to the nearest integer.

<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 near the beginning of Section 5.3 (See Figure 5.3.2).

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,
- Flanking STC for a specific set of flanking surfaces, measured according to ISO 10848.

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 predictions should be expected to agree with actual construction within a standard deviation of about 3 dB, in the absence of construction errors.

EXAMPLE 5.3.1

- **Rooms side-by-side**
- **Separating wall of 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 cavities at 1200 mm o.c.)
- no lining of separating concrete block walls.

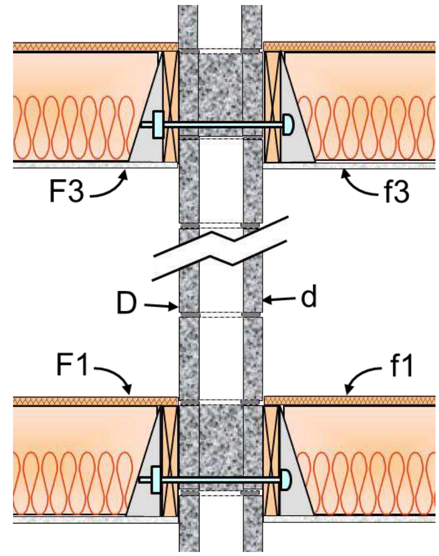
Bottom Junction 1 (separating wall and floor) with:
- 2x10 (38x235 mm) wood ledger plate on each side, fastened through with 16 mm diameter bolts spaced 406 mm o.c.
- floor framed with 38x235 mm wood joists spaced 406 mm o.c., with joists oriented perpendicular to separating wall and supported on joist 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 bottom junction)
- ceiling with 1 layer of 13 mm gypsum board[3] fastened directly to bottom of floor framing on each side

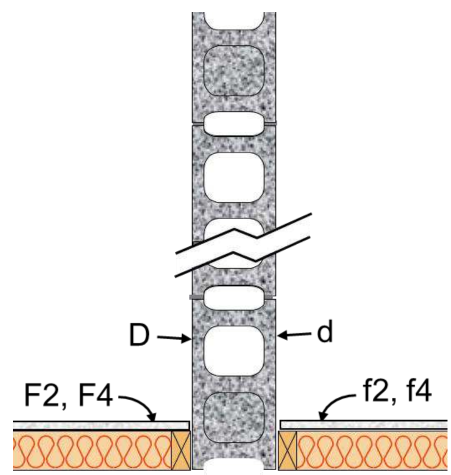
Side Junctions 2 or 4 (separating wall and abutting side walls) with:
- side wall framing with single row of wood studs
- side wall framing structurally-connected to the separating concrete block wall, but not continuous across the junction
- 13 mm gypsum board[3] on the side walls ends at separating 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

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

Illustration for this case



Junction 1 & 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)

Separating Partition (Concrete block separating wall)			
	Reference	**STC, Δ_STC**	**Path STC, ASTC**
Lab. Sound Transmission Class (STC)	IR-811, TLF-97-107a	50	
ΔSTC change by Lining on D (source side)	No lining	0	
ΔSTC change by Lining on d (receive side)	No lining	0	
Direct STC in situ (Path DD through separating wall)			**50**

(See footnotes at end of document)

	Reference	STC, Δ_STC	Path STC, ASTC
Junction 1 (Cross junction, concrete block separating wall / flanking floor assemblies)			
Flanking Path Ff_1			
Laboratory Flanking STC for Ff	RR-334, BLK-HB-LB-1	58	
Flanking STC for path Ff_1			58
Flanking Path Fd_1			
Laboratory Flanking STC for Fd (bare)	RR-334, BLK-HB-LB-1	60	
ΔSTC change by Lining on d	No lining	0	
Flanking STC for path Fd_1			60
Flanking Path Df_1			
Laboratory Flanking STC for Df (bare)	RR-334, BLK-HB-LB-1	60	
ΔSTC change by Lining on D	No lining	0	
Flanking STC for path Df_1			60
Junction 2 (T-junction, concrete block separating wall / flanking wall assemblies)			
Flanking Path Ff_2			
Laboratory Flanking STC for Ff	RR-334, BLK-WW-LB-1	69	
Flanking STC for path Ff_2			69
Flanking Path Fd_2			
Laboratory Flanking STC for Fd (bare)	RR-334, BLK-WW-LB-1	65	
ΔSTC change by Lining on d	No lining	0	
Flanking STC for path Fd_2			65
Flanking Path Df_2			
Laboratory Flanking STC for Df (bare)	RR-334, BLK-WW-LB-1	65	
ΔSTC change by Lining on D	No lining	0	
Flanking STC for path Df_2			65
Junction 3 (Cross junction, concrete block separating wall / flanking ceiling assemblies)			
Flanking Path Ff_3			
Laboratory Flanking STC for Ff	RR-334, BLK-HT-LB-1	65	
Flanking STC for path Ff_3			65
Flanking Path Fd_3			
Laboratory Flanking STC for Fd (bare)	RR-334, BLK-HT-LB-1	66	
ΔSTC change by Lining on d	No lining	0	
Flanking STC for path Fd_3			66
Flanking Path Df_3			
Laboratory Flanking STC for Df (bare)	RR-334, BLK-HT-LB-1	66	
ΔSTC change by Lining on D	No lining	0	
Flanking STC for path Df_3			66
Junction 4 (Cross-junction, concrete block separating wall / flanking wall assemblies)			
All values the same as for Junction 2			
Flanking STC for path Ff_4			69
Flanking STC for path Fd_4			65
Flanking STC for path Df_4			65
Combined transmission via all Flanking Paths			52.3
ASTC due to Direct plus Flanking Transmission	Guide, Section 1.4		**48**

EXAMPLE 5.3.2

- **Rooms side-by-side**
- **Separating wall of 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 cavities at 1200 mm o.c.)
- concrete block assembly lined on each side by 1 layer of 13 mm gypsum board supported on 41 mm steel studs 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 406 mm o.c.
- floor framed with 38x235 mm wood joists spaced 406 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:

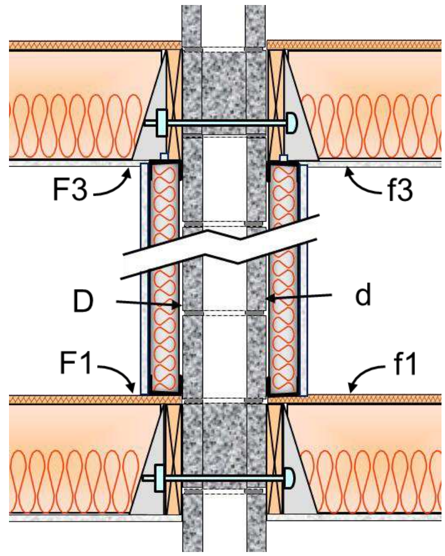
- ceiling framed with wood joists (same details as bottom junction)
- ceiling with one layer of 13 mm gypsum board[3] fastened directly to bottom of floor framing on each side

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

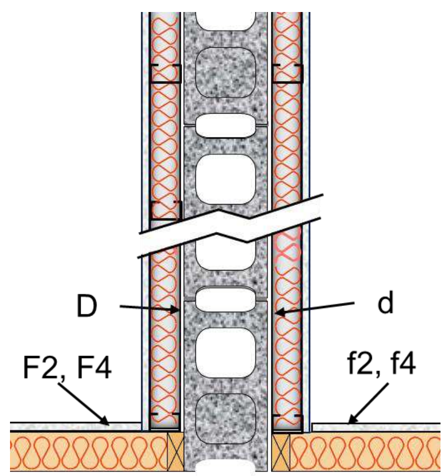
- side wall framing with single row of wood studs
- side wall framing structurally-connected to the separating concrete block wall, but not continuous across the junction
- 13 mm gypsum board[3] on the side walls ends at separating wall assembly and is attached directly to wall framing of 38x89 mm wood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

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

Illustration for this case



Junction 1 & 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)

Separating Partition (Concrete block separating wall)			
	Reference	STC, Δ_STC	Path STC, ASTC
Lab. Sound Transmission Class (STC)	Report IR-811, TLF-97-107a	50	
ΔSTC change by Lining on D (source side)	Report RR-334, D-BLK-SS41-1	8	
ΔSTC change by Lining on d (receive side)	Report RR-334, D-BLK-SS41-1	8	
Direct STC in situ (Path DD through separating wall)			**62**

(See footnotes at end of document)

	Reference	STC, Δ_STC	Path STC, ASTC
Junction 1 (Cross junction, concrete block separating wall / flanking floor assemblies)			
Flanking Path Ff_1			
Laboratory Flanking STC for Ff	RR-334, BLK-HB-LB-1	58	
Flanking STC for path Ff_1			58
Flanking Path Fd_1			
Laboratory Flanking STC for Fd (bare)	RR-334, BLK-HB-LB-1	60	
ΔSTC change by Lining on d	RR-334, ΔTLW-BLK190-02	8	
Flanking STC for path Fd_1			68
Flanking Path Df_1			
Laboratory Flanking STC for Df (bare)	RR-334, BLK-HB-LB-1	60	
ΔSTC change by Lining on D	RR-334, ΔTLW-BLK190-02	8	
Flanking STC for path Df_1			68
Junction 2 (T-junction, concrete block separating wall / flanking wall assemblies)			
Flanking Path Ff_2			
Laboratory Flanking STC for Ff	RR-334, BLK-WW-LB-1	69	
Flanking STC for path Ff_2			69
Flanking Path Fd_2			
Laboratory Flanking STC for Fd (bare)	RR-334, BLK-WW-LB-1	65	
ΔSTC change by Lining on d	RR-334, ΔTLW-BLK190-02	8	
Flanking STC for path Fd_2			73
Flanking Path Df_2			
Laboratory Flanking STC for Df (bare)	RR-334, BLK-WW-LB-1	65	
ΔSTC change by Lining on D	RR-334, ΔTLW-BLK190-02	8	
Flanking STC for path Df_2			73
Junction 3 (Cross junction, concrete block separating wall / flanking ceiling assemblies)			
Flanking Path Ff_3			
Laboratory Flanking STC for Ff	RR-334, BLK-HT-LB-1	65	
Flanking STC for path Ff_3			65
Flanking Path Fd_3			
Laboratory Flanking STC for Fd (bare)	RR-334, BLK-HT-LB-1	66	
ΔSTC change by Lining on d	RR-334, ΔTLW-BLK190-02	8	
Flanking STC for path Fd_3			74
Flanking Path Df_3			
Laboratory Flanking STC for Df (bare)	RR-334, BLK-HT-LB-1	66	
ΔSTC change by Lining on D	RR-334, ΔTLW-BLK190-02	8	
Flanking STC for path Df_3			74
Junction 4 (Cross-junction, concrete block separating wall / flanking wall assemblies)			
All values the same as for Junction 2			
Flanking STC for path Ff_4			69
Flanking STC for path Fd_4			73
Flanking STC for path Df_4			73
Combined transmission via all Flanking Paths			56
ASTC due to Direct plus Flanking Transmission	Guide, Section 1.4		**55**

EXAMPLE 5.3.3

- **Rooms one-above-the-other**
- **Separating wood-framed floor assembly with joists perpendicular to flanking walls of concrete block and parallel to wood-framed flanking walls**

Separating floor/ceiling assembly with:

- floor framed with 38x235 mm wood joists spaced 406 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[4] spaced 406 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:

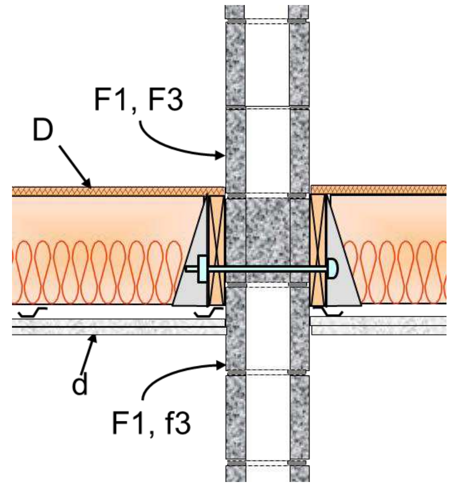
- one wythe of reinforced concrete blocks with mass 238 kg/m^2 (e.g.- 190 mm hollow blocks with normal weight aggregate[1], with reinforcing steel and grout-filled cavities at 1200 mm o.c.)
- 2x10 (38x235 mm) wood ledger plate on each side of concrete blocks, fastened through with 16 mm diameter bolts spaced 406 mm o.c.
- cavities in concrete block assembly between the ledger plates are filled with grout, 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:

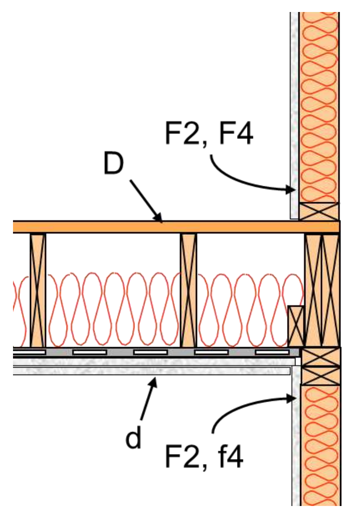
- joists of floor assembly parallel to these walls
- walls have 38 mm x 89 mm wood studs spaced 400 mm o.c with several framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates)
- walls with 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

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

Illustration for this case



Junction 1 & 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)

Separating Partition (lightweight framed floor/ceiling)			
	Reference	**STC, Δ_STC, etc.**	**Path STC, ASTC**
Lab. Sound Transmission Class (STC)	RR-334, BLK-V-LB-1	53	
Direct STC in situ (Path DD through separating floor/ceiling)			**53**

(See footnotes at end of document)

	Reference	STC, Δ_STC, etc.	Path STC, ASTC
Junction 1 (Cross junction, concrete block flanking wall / separating floor)			
Flanking Path Ff_1			
Laboratory STC for F	IR-811, TLF-97-107a	50	
ΔSTC change by Lining on F	No lining	0	
ΔSTC change by Lining on f	No lining	0	
Vibration Reduction Index for Ff	RR-334, K-BLK-V-LB-1	4	
Normalization correction	ISO 15712-1, Eq. 28a	6	
Flanking STC for path Ff_1			60.0
Flanking Path Fd_1			
Laboratory Flanking STC for Fd (bare)	RR-334, BLK-V-LB-1	68	
ΔSTC change by Lining on F	No lining	0	
Flanking STC for path Fd_1			68.0
Flanking Path Df_1			
Laboratory Flanking STC for Df (bare)	RR-334, BLK-V-LB-1	60	
ΔSTC change by Lining on f	No lining	0	
Flanking STC for path Df_1			60.0
Junction 2 (T-junction, lightweight framed flanking wall / separating floor)			
Laboratory Flanking STC for Ff	RR-336, WJ235-VF-NLB-01	63	
Laboratory Flanking STC for Fd (bare)	RR-336, WJ235-VF-NLB-01	80+	
Laboratory Flanking STC for Df (bare)	RR-336, WJ235-VF-NLB-01	60	
Flanking STC for paths Ff,Fd and dF at Junction_4			58.2
Junction 3 (Cross junction, concrete block flanking wall / separating floor)			
All values the same as Junction 1			
Flanking STC for path Ff_3			60.0
Flanking STC for path Fd_3			68.0
Flanking STC for path Df_3			60.0
Junction 4 (Cross-junction, lightweight framed flanking wall / separating floor)			
Laboratory Flanking STC for Ff	RR-336, WJ235-VF-NLB-01	63	
Laboratory Flanking STC for Fd (bare)	RR-336, WJ235-VF-NLB-01	80+	
Laboratory Flanking STC for Df (bare)	RR-336, WJ235-VF-NLB-01	60	
Flanking STC for paths Ff,Fd and dF at Junction_4			58.2
Combined transmission via all Flanking Paths			51.3
ASTC due to Direct plus Flanking Transmission	Guide, Section 1.4		**49**

EXAMPLE 5.3.4

- **Rooms one-above-the-other**
- **Separating wood-framed floor assembly with joists perpendicular to flanking walls of 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 406 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[4] spaced 406 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:

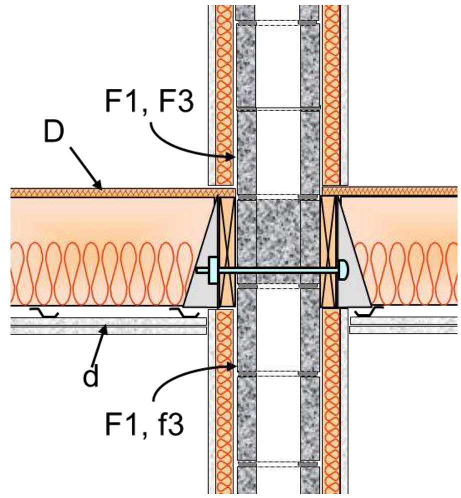
- one wythe of reinforced concrete blocks with mass 238 kg/m[2] (e.g.- 190 mm hollow blocks with normal weight aggregate[1], with reinforcing steel and grout-filled cavities at 1200 mm o.c.)
- 2x10 (38x235 mm) wood ledger plate on each side of concrete blocks, fastened through with 16 mm diameter bolts spaced 406 mm o.c.
- cavities in concrete block assembly between the ledger plates are filled with grout, 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:

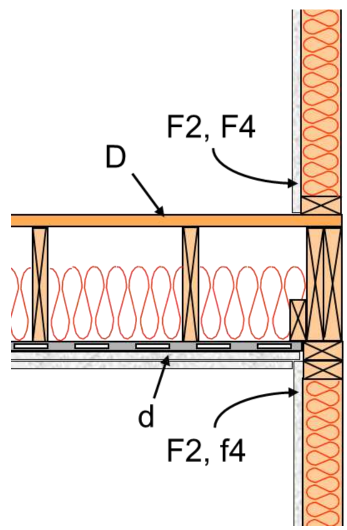
- joists of floor assembly parallel to these walls
- walls have 38 mm x 89 mm wood studs spaced 400 mm o.c with several framing options (single row of wood studs, or staggered studs on a single 38 mm x 140 mm plate, or 2 rows of 38 mm x 89 mm wood studs on separate 38 mm x 89 mm plates)
- walls with 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

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

Illustration for this case



Junction 1 & 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)

Separating Partition (lightweight framed floor/ceiling)			
	Reference	**STC, Δ_STC**	**Path STC, ASTC**
Lab. Sound Transmission Class (STC)	RR-334, BLK-V-LB-1	53	
Direct STC in situ (Path DD through separating floor/ceiling)			**53**

(See footnotes at end of document)

	Reference	STC, Δ_STC	Path STC, ASTC
Junction 1 (Cross junction, concrete block flanking wall / separating floor)			
Flanking Path Ff_1			
Laboratory STC for F	Report IR-811, TLF-97-107a	50	
ΔSTC change by Lining on F	RR-334, ΔTLW-BLK190-01	3	
ΔSTC change by Lining on f	RR-334, ΔTLW-BLK190-01	3	
Vibration Reduction Index for Ff	RR-334, K-BLK-V-LB-1	4	
Normalization correction	ISO 15712-1, Eq. 28a	6	
Flanking STC for path Ff_1			64.5
Flanking Path Fd_1			
Laboratory Flanking STC for Fd (bare)	RR-334, BLK-V-LB-1	68	
ΔSTC change by Lining on F	RR-334, ΔTLW-BLK190-01	3	
Flanking STC for path Fd_1			71.0
Flanking Path Df_1			
Laboratory Flanking STC for Df (bare)	RR-334, BLK-V-LB-1	60	
ΔSTC change by Lining on f	RR-334, ΔTLW-BLK190-01	3	
Flanking STC for path Df_1			63.0
Junction 2 (T-junction, lightweight framed flanking wall / separating floor)			
Laboratory Flanking STC for Ff	RR-336, WJ235-VF-NLB-01	63	
Laboratory Flanking STC for Fd	RR-336, WJ235-VF-NLB-01	80+	
Laboratory Flanking STC for Df	RR-336, WJ235-VF-NLB-01	60	
Flanking STC for paths Ff,Fd and dF at Junction_4			58.2
Junction 3 (Cross junction, concrete block flanking wall / separating floor)			
All values the same as Junction 1			
Flanking STC for path Ff_3			64.5
Flanking STC for path Fd_3			71.0
Flanking STC for path Df_3			63.0
Junction 4 (Cross-junction, lightweight framed flanking wall / separating floor)			
Laboratory Flanking STC for Ff	RR-336, WJ235-VF-NLB-01	63	
Laboratory Flanking STC for Fd	RR-336, WJ235-VF-NLB-01	80+	
Laboratory Flanking STC for Df	RR-336, WJ235-VF-NLB-01	60	
Flanking STC for paths Ff,Fd and dF at Junction_4			58.2
Combined transmission via all Flanking Paths			53.1
ASTC due to Direct plus Flanking Transmission	Guide, Section 1.4		**50**

Summary for Section 5.3: Calculation for Concrete Masonry Wall Assembly with Lightweight Framed Wall and Floor Assemblies

The worked examples 5.3.1. to 5.3.4 use a blend of the simplified procedures for lightweight flanking assemblies with wood- or steel- framing in Chapter 4, and the simplified methods of Section 2.4 for calculating transmission between rooms in a building with concrete floors and concrete or masonry wall assemblies.

The examples show that flanking does play a significant role in determining the performance of these systems. For Example 5.3.1, with a bare concrete block wall between the side-by-side rooms, the ASTC is 2 lower than the direct STC for the separating assembly. For example 5.3.3 with one room above the other, the ASTC is 4 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.

When linings are added to the concrete block walls in Example 5.3.2, it becomes obvious that the floor-floor path is dominant between the side-by-side rooms. Without improvement to the lightweight OSB deck of the wood-framed floor, the ASTC cannot rise above 58, even with the best of linings on the concrete block surfaces. However, with suitable floor improvements, the ASTC can readily be increased to over 60.

When linings are added to the concrete block walls in Example 5.3.4, the ASTC rises only slightly to 50, and it becomes obvious that the flanking paths involving the wood-framed flanking walls are comparable to those involving the concrete block walls. Further improvement in this case should involve both improvement of the floor surface and some improvement of the walls below the separating floor. With such changes, ASTC values over 60 can be achieved.

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 junction transmission or for the flanking path transmission (measured 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. 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, "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 National Research Council Canada at http://nparc.cisti-icist.nrc-cnrc.gc.ca/npsi/ctrl?lang=en

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://irc-eguide.irc.nrc.ca/flankingui_v2.html The calculations are based on a detailed calculation, using 1/3-octave data for direct and flanking paths determined by experimental

studies in the laboratories of 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 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:
11.1. RR-333 Apparent Sound Insulation in Concrete Buildings (2014)
11.2. RR-334 Apparent Sound Insulation in Concrete Block Buildings (2013)
11.3. RR-335 Apparent Sound Insulation in Cross Laminated Timber Buildings (2014)
11.4. RR-336 Apparent Sound Insulation in Wood-framed Buildings (2014)
11.5. RR-337 Apparent Sound Insulation in Steel-framed Buildings (2015)

<u>Other Technical References</u>

12. L. Cremer and M. Heckl, "Structure-borne sound", edited by E.E. Ungar, , Springer-Verlag, New York (original edition 1973, 2nd edition 1996).

13. E. Gerretsen, "Calculation of the sound transmission between dwellings by partitions and flanking structures", Applied Acoustics, Vol. 12, pp 413-433 (1979), and "Calculation of airborne and impact sound insulation between dwellings", Applied Acoustics, Vol. 19, pp 245-264 (1986).

14. R.J.M. Craik, "Sound transmission through buildings: Using statistical energy analysis", Gower Publishing (1996).

15. D.B. Pedersen, `Evaluation of EN 12354 part 1 and 2 for Nordic Dwelling Houses`, Applied Acoustics, Vol. pp 259-268 (2000), (Validation and background studies for the ISO 15712 procedures).
16. J. K. Richardson, J. D. Quirt, R. Hlady, "Best Practice Guide on Fire Stops and Fire Blocks and their Impact on Sound Transmission, NRCC #49677 (2007)

7.2. 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

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.

4 Resilient metal channels are formed from 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.

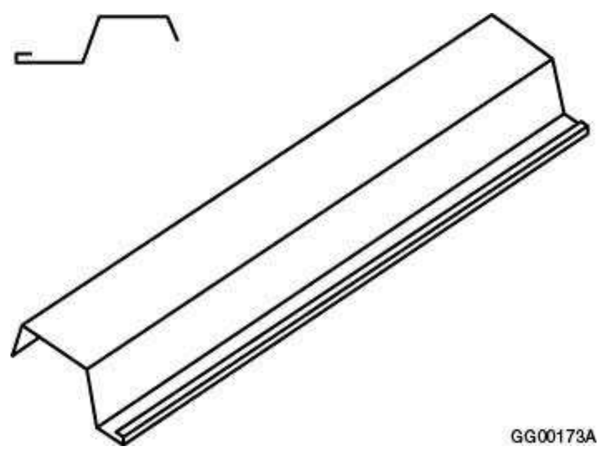


Figure 7.1: Drawing to illustrate typical profile of resilient metal channel; approximate dimensions in cross-section 13 mm x 60 mm (not precisely to scale).

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