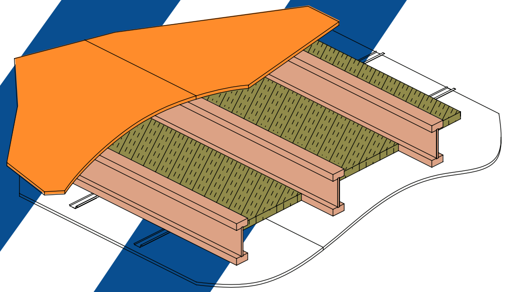
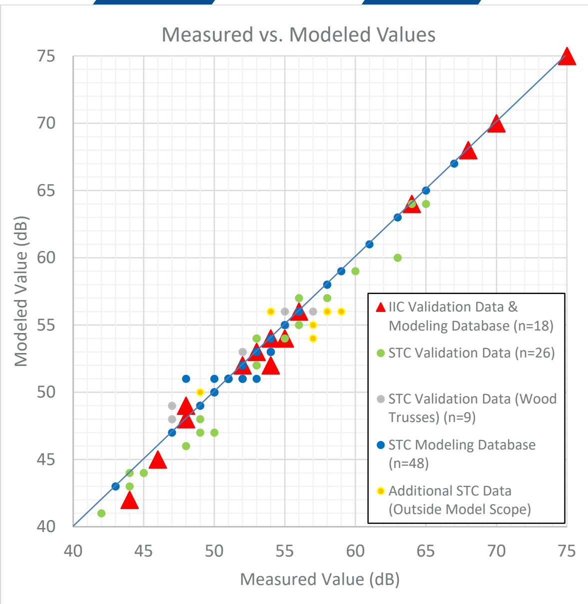




Calculation of Sound Transmission Parameters for Wood-Frame Assemblies

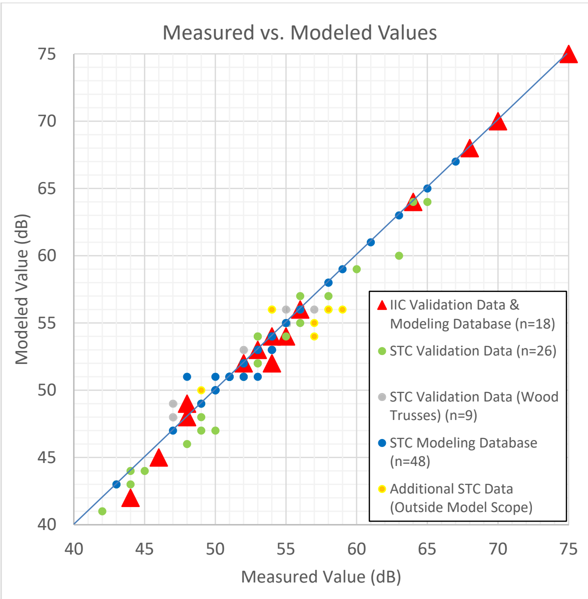
Technical Report No. 15

January, 2019

AMERICAN WOOD COUNCIL

On behalf of the industry it represents, AWC is committed to ensuring a resilient, safe, and sustainable built environment. To achieve these objectives, AWC contributes to the development of sound public policies, codes, and regulations which allow for the appropriate and responsible manufacture and use of wood products. We support the utilization of wood products by developing and disseminating consensus standards, comprehensive technical guidelines, and tools for wood design and construction, as well as providing education regarding their application.

While every effort has been made to insure the accuracy of the information presented, and special effort has been made to assure that the information reflects the state-of-the-art, neither the American Wood Council nor its members assume any responsibility for any particular design prepared from this publication. Those using this document assume all liability from its use.



Calculation of Sound Transmission Parameters for Wood-Frame Assemblies

Technical Report No. 15

info@awc.org
www.awc.org

Table of Contents

Part I: Development of Models for Calculation of Sound Transmission Parameters

1.1 Introduction

1.1.1 General

Building codes stipulate minimum requirements regarding noise transmission through common interior walls and floor/ceiling assemblies that separate a dwelling unit from either a public area or an adjacent dwelling unit. In the 2018 *International Building Code* [1] (IBC), two parameters are used to establish these minimum acoustical requirements: sound transmission class (STC) and impact insulation class (IIC). Sound transmission class is a measure of the attenuation of sound waves that initiate as air-borne sound and pass through the wall or floor/ceiling assembly. This classification gives an indication of the assembly's ability to reduce unwanted noise transmission from air-borne sound sources such as human voices, animal noises, amplified sound systems (e.g., entertainment systems) and appliances. Impact insulation class is a measure of the assembly's ability to insulate against structure-borne sound waves generated when an object strikes the opposite surface of the assembly or otherwise induces sound waves directly into the assembly. This classification provides an indication of how effective the assembly is at reducing noise transmission from vibrations induced directly into the structure such as those generated when an object is dropped onto a floor.

As summarized in Table 1.1.1, sound transmission class (STC) can be determined through testing in accordance with ASTM E90 – *Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements* [2], and analysis in accordance with ASTM E413 – *Classification for Rating Sound Insulation* [3]. Impact insulation class (IIC) can be determined through testing in accordance with ASTM E492 – *Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine* [4], and analysis in accordance with ASTM E989 – *Standard Classification for Determination of Impact Insulation Class (IIC)* [5]. For floor/ceiling assemblies separating a dwelling unit from either a public area or an adjacent dwelling unit, Section 1206 of the IBC requires minimum STC and IIC ratings of 50 if laboratory tested or 45 if field tested. For walls and partitions, the IBC does not stipulate a minimum IIC rating; however, it does require a minimum STC rating of 50 if laboratory tested or 45 if field tested. Alternatively, acoustical performance of floor-ceiling and wall assemblies may also be evaluated through an engineering analysis based on test data from other similar (but not necessarily identical) assemblies. Sections 1206.2 and 1206.3 of the 2018 IBC explicitly allow for such engineering analyses.

1.1.2 Background

Due to the fact that building codes require a separate evaluation of acoustical performance for each assembly, a multitude of acoustics tests and analyses have been performed on various wall and floor/ceiling assemblies since the 1960s. While largely proprietary, a significant amount of this information has been shared in the public domain, such that it can be compiled into one database; thereby allowing for comparison and analysis. However, despite the availability of this data, previous attempts at using it to develop unifying models for predicting the acoustical performance of light frame assemblies have been limited in scope and have not always yielded accurate results. Some complicating factors involved in using this available data for model development include the following:

- The number of possible combinations of various components making up an assembly is practically limitless.

Table 1.1.1 Applicable Test Standards and Code Requirements

		Sound Transmission Class (STC)	Impact Insulation Class (IIC)
Standard	Test Method	ASTM E90	ASTM E492
	Classification	ASTM E413	ASTM E989
Minimum Code Requirement	Floor/Ceiling	50 lab-tested, 45 field-tested (2018 IBC Section 1206.2)	50 lab-tested, 45 field-tested (2018 IBC Section 1206.3)
	Walls	50 lab-tested, 45 field-tested (2018 IBC Section 1206.2)	(no requirement)

- Many of the components used within tested assemblies are proprietary materials, each contributing differently to the overall acoustical performance of the assembly, and some of which have been discontinued or are no longer commonly used.
- Available test data comes from a number of different test series, each with its own unique set of objectives and test variables. Also, data from tests performed at different laboratories are often not comparable due to differences inherent to each respective laboratory, such as differences in laboratory flanking limits, test assembly mounting practices, background noise sound levels and receiving room reverberation times. This limits the degree to which direct comparisons can be made and isolation of variables can be performed.
- Certain components appear to interact with one-another, such that the contribution of one particular component may be affected by the presence and characteristics of other components within the same assembly.

Since STC and IIC values represent idealized sound pressure contours within a limited portion of the frequency range of transmitted sound, they do not express the full complexity and range of the sound transmission contour. One particular area in which this deficiency manifests itself is in the case of structure-borne impact sound transmission resulting from footfall (e.g., heavy walking, stomping, etc.) on light-frame floor/ceiling assemblies. This type of sound transmission is generally characterized by lower frequencies of 100 Hz or less, which are not represented by the IIC rating. Nevertheless, the STC and IIC rating systems are advantageous from a building code / regulatory perspective because they provide a single-number rating that roughly correlates with subjective impressions of airborne sound transmission from sources such as human voices, radio and television, and structure-borne sound transmission from sources such as impacts from dropped objects. Furthermore, many acoustical laboratories are capable of measuring sound pressure levels within the ranges of frequencies associated with STC and IIC values with reasonable accuracy – a quality that does not necessarily hold true for measurement of sound pressure levels at frequencies below 100 Hz.

1.1.3 Scope

In order to provide an additional means of compliance with the alternative analysis provisions of IBC Sections 1206.2 and 1206.3, AWC has developed a calculation-based analysis approach for deriving STC and IIC ratings for assemblies constructed with wood and wood-based framing. As required by IBC Sections 1206.2 and 1206.3, this analysis procedure is based on comparisons of data from floor/ceiling assemblies having STC and IIC ratings as determined by the test procedures set forth in ASTM E90 and ASTM E492, respectively. Currently, the scope of the models presented within this report are limited to estimation of STC and IIC ratings of floor/ceiling assemblies framed with either sawn lumber, prefabricated wood I-joists, or metal-plate-connected wood trusses, and having components as described in Section 1.2.1. It is anticipated that future work will include expansion and further validation of the models to address floor assemblies constructed with structural composite lumber (SCL) and cross laminated timber (CLT), as well as wall assemblies constructed with sawn lumber, SCL, and CLT.

1.2 Data And Analysis

1.2.1 Database

Initially, AWC compiled more than 300 STC and IIC data points from 17 different sources – including data from multiple acoustical laboratories, and proprietary test data provided by flooring, insulation, gypsum, and engineered wood product manufacturers. Model development thus far has focused on floor-ceiling assemblies framed with either sawn lumber, pre-fabricated wood I-joists, or metal plate connected wood trusses. All of the floor/ceiling assemblies within the model development database included gypsum wallboard ceilings attached to RC1 resilient channels which were attached directly to the framing members. Reasons for focusing on floor-ceiling assemblies having these components include:

- A majority of the available sound test data for wood frame floor/ceiling assemblies is on assemblies framed with either sawn lumber, pre-fabricated wood I-joists, or metal plate connected wood trusses.
- Gypsum wallboard (GWB) is a very common ceiling material. Available data on other ceiling types (such as gypsum lath and plaster) is very limited.
- Resilient channels are an important part of an effective sound isolation assembly and are typically necessary in order for the assembly to achieve code-specified minimum acoustical performance. Only a limited number of available data points were for assemblies in which the GWB was attached directly to the framing members. Nearly all of the remaining available data was for assemblies in which the GWB was attached to RC1 resilient channels running perpendicular to the framing members, and attached directly thereto.

The database and model scope were further narrowed to include only assemblies containing RC1 resilient channels spaced at either 16 or 24 inches on center, and framing members spaced at either 16 or 24 inches on center. These limitations were deemed to be reasonable because they envelope typical spacings of both framing and resilient channels within floor/ceiling construction in the US.

Most of the assemblies within the modeling database had either fiberglass batt or mineral wool batt insulation of varying thicknesses. However, there was also sufficient test data to include assemblies without any insulation into the scope of the model.

The database used for development of the STC model consisted exclusively of test data on assemblies without floor coverings (referred to herein as "bare-floor" assemblies). Floor coverings can influence STC values, especially those having considerable mass such as floor tile. For most floor coverings, however, this influence is relatively minor. Thus, the STC model for bare-floor assemblies can be reasonably applied to assemblies having floor coverings regardless of the floor covering type. Where this methodology results in differences between measured and estimated STC values, the difference is usually relatively minor and results in slightly conservative estimates of STC. Furthermore, the bare-floor models presented in this report provide a versatile means of addressing the numerous, constantly changing, and often proprietary floor covering options available on the market. This methodology simplifies the model so that the original STC value for a given floor/ceiling assembly can be considered applicable even if a different type of floor covering is installed during the assembly's service life.

Unlike STC ratings, IIC ratings can be greatly affected by the type and characteristics of floor coverings. The floor covering influence must be determined through a separate analysis of the overall assembly, including the floor covering. Floor coverings can either increase or decrease an IIC rating, in comparison to that of the bare-floor assembly to which it is applied. The magnitude of the effect a floor covering has on the IIC of the overall assembly depends on the physical properties of the covering itself, as well as interactions with other components within the assembly onto which it is applied. That said, most of the available IIC data that allowed isolation of key component variables was from tests performed on bare-floor assemblies. Thus, it was necessary to use data from bare-floor assembly tests, in conjunction with AWC data on assemblies having floor coverings, as the basis for the IIC model.

The measured transmission loss (TL) values from a total of 48 complete bare-floor test assemblies and 16 partial assemblies were used as the database for development of the STC model. These TL measurements, combined with impact sound pressure level (ISPL) measurements from 14 tested assemblies having floor coverings, comprised the database used for development of the IIC model. The majority of the bare-floor TL and ISPL data was from a series of tests conducted and published by the National Research Council of Canada (NRC), in Phase I of a two-phase study (NRC, 2000, 2005) [6, 7]. In addition to this, the database was rounded out with data from two test series commissioned by AWC in 2016 and 2017 [8, 9]. In order to ensure consistency within the database and avoid potential confounding influences brought about by lack of reproducibility between laboratories, these two AWC test series were also performed at NRC. The AWC test series were specifically designed so that the database could be used to model variables that were not addressed in the original two-phase NRC study. For example, the AWC test series included additional assembly configurations with a cast-in-place gypsum concrete topping, as well as assemblies having a range of common generic floor coverings. Information regarding the nominal dimensions, spacings, weights and types of components within each of the bare-floor assemblies represented within the modeling database is listed in Table 1.2.1a. Descriptions of the assemblies having floor coverings are given in Table 1.2.1b. Descriptions of the partial assemblies represented within the database are given in Table 1.2.3. The types of components and ranges of component dimensions and weights represented within the modeling database and validation database are summarized in Table 1.2.1c. Combinations of components within the tested assemblies are shown in Tables 1.2.1d and 1.2.1e.

The reference assembly for the majority of the test data used in model development (i.e., the NRC data) had the following components, listed from the top of the assembly to the bottom:

- One layer of 19/32" oriented strand board (OSB)
- One layer of 6"-thick fiberglass insulation batt between the joists,
- 2x10 joists at 16" o.c.,
- RC1 resilient channels, spaced 24" o.c., running perpendicular to the joists,
- One layer of 5/8" Type X gypsum wallboard (GWB).

The measured TL and ISPL values and reference contours for the reference assembly described above are shown in Figures 1.2.1a and 1.2.1b, respectively. Also depicted in these figures are the ASTM E413 reference contour used to determine STC (Figure 1.2.1a) and the ASTM E989 reference contour used to determine IIC (Figure 1.2.1b).

Figure 1.2.1a **Measured TL for Reference Assembly**

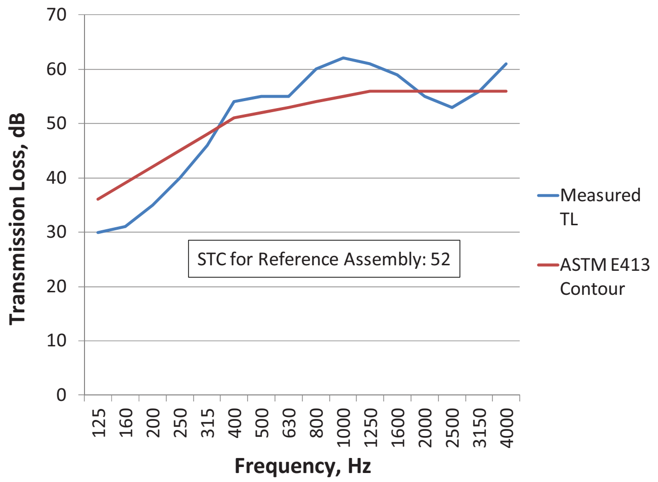
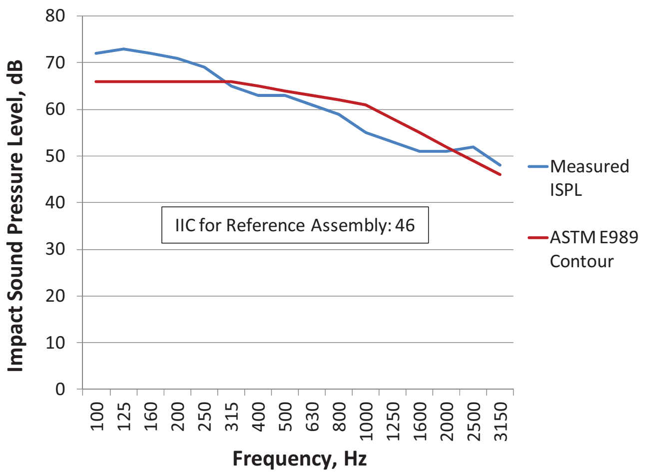


Figure 1.2.1b **Measured ISPL for Reference Assembly**



In the NRC study, the combination of components chosen for the reference assembly represents the baseline for most of the tested variables. This is evident in Table 1.2.1d by the predominance of shaded cells corresponding to these components and the relative scarcity of shaded cells corresponding to combinations in which both components deviate from those of the reference case.

1.2.2 Mass Law

One of the primary factors affecting sound transmission through a solid panel such as the subfloor layer or ceiling layer of a floor/ceiling assembly is the mass-per-unit-area of the panel. The mass law dictates that, in theory, a doubling of the mass of a solid layer or panel through which a sound is transmitted will reduce the sound transmission (i.e., increase the transmission loss of that sound) by 6 decibels (dB). Additionally, the theory holds that transmission loss is related to frequency, such that, for a sound having a frequency that is twice that of another sound (i.e., one octave higher) the transmission loss of the higher frequency sound will be 6 dB greater. This idealized law may be expressed mathematically as follows:

$$R = 20Log_{10}\left(fm\right) - 47$$

Where:

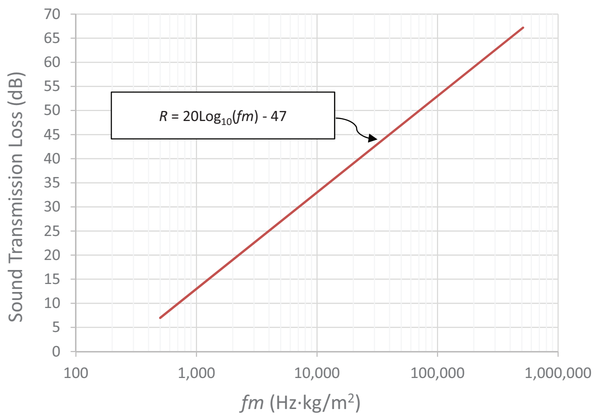
R = Idealized sound reduction index, as predicted by the mass law, dB

f = Frequency of the sound, Hz

m = Mass-per-unit-area of the layer through which the sound is transmitted, kg/m^2

When plotted on a graph with respect to the product of frequency and mass, fm, in which the x-axis is represented on a Log_{10} scale, this is a linear function, as shown in Figure 1.2.2

Figure 1.2.2 **Idealized Sound Reduction Index, R, as Predicted by the Mass Law**



This idealized relationship between sound transmission loss and layer mass provides a useful tool in acoustical analysis of assemblies. As will be discussed in following sections, however, there are often significant differences between these idealized values and actual measured values.

1.2.3 Floor and Ceiling Layer Analysis

In addition to performing extensive testing on floor/ceiling assemblies, NRC also performed tests on partial assemblies consisting of the framing and floor layer alone (i.e., without a ceiling layer), as well as tests on partial assemblies consisting of the framing and ceiling layer alone (i.e., without a floor layer). Data from these partial assembly tests were also analyzed and used in develop-

Table 1.2.1a Descriptions of complete bare-floor assemblies used within the modeling database

STC Test Number	IIC Test Number	Floor Layer Description	Insulation	Framing Description	Ceiling Layer Description
Mean Ref.	Mean Ref.	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-95-063a	IIF-95-019	1 Layer of 19/32" OSB	2.5" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-95-065a	IIF-95-020	1 Layer of 19/32" OSB	3.5" Mineral Wool Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-95-067a	IIF-95-021	1 Layer of 19/32" OSB	8.3" Mineral Wool Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-95-075a	IIF-95-025	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-95-085a	IIF-95-030	1 Layer of 19/32" OSB	3.5" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-95-089a	IIF-95-032	1 Layer of 19/32" OSB	8" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-95-107a	IIF-95-039	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	2 Layers of 5/8" GWB
TLF-95-113a	IIF-95-040	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 1/2" GWB
TLF-95-115a	IIF-95-041	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	2 Layers of 1/2" GWB
TLF-95-123a	IIF-95-043	2 Layers of 19/32" OSB	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-95-127a	IIF-95-045	1 Layer of 23/32" OSB	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-95-129a	IIF-95-046	2 Layers of 1/2" Plywood	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-95-133a	IIF-95-048	1 Layer of 19/32" Plywood	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-95-149a	IIF-95-056	2 Layers of 19/32" Plywood	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-95-155a	IIF-95-059	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 1/2" Lt.Wt. GWB
TLF-95-157a	IIF-95-060	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	2 Layers of 1/2" Lt.Wt. GWB
TLF-95-159a	IIF-95-061	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x8s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-95-215a	IIF-95-075	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x12s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-96-035a	IIF-96-009	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @ 24"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-96-039a	IIF-96-011	1 Layer of 23/32" OSB	6" Fiberglass Batt	2x10s @ 24"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-96-061a	IIF-96-018	1 Layer of 1" Plywood	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-96-063a	IIF-96-019	1 Layer of 19/32" OSB	(no insulation)	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-96-069a	IIF-96-022	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-96-071a	IIF-96-023	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-96-073a	IIF-96-024	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-96-075a	IIF-96-028	1 Layer of 19/32" OSB	6" Fiberglass Batt	14" I-joists @16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-96-101a	IIF-96-044	1 Layer of 19/32" OSB	6" Fiberglass Batt	18" I-joists @16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-96-127a	IIF-96-055	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-96-131a	IIF-96-057	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-96-159a	IIF-96-070	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-97-007a	IIF-97-004	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-97-033a	IIF-97-017	1 Layer of 19/32" OSB	6" Fiberglass Batt	14" Trusses @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-97-043a	IIF-97-021	1 Layer of 19/32" OSB	6" Fiberglass Batt	18" Trusses @ 24"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-97-045a	IIF-97-022	1 Layer of 19/32" OSB	6" Fiberglass Batt	14" Trusses @ 24"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-97-047a	IIF-97-023	1 Layer of 23/32" OSB	6" Fiberglass Batt	14" Trusses @ 24"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-97-049a	IIF-97-024	1 Layer of 23/32" OSB	6" Fiberglass Batt	18" Trusses @ 24"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-16-031	IIF-16-033	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-16-041	IIF-16-041	1 Layer of 23/32" OSB & 1" Gypsum Concrete	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-17-042	IIF-17-033	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-045	IIF-17-035	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-049	IIF-17-038	1 Layer of 23/32" OSB & 1" Gypsum Concrete	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-050	IIF-17-039	1 Layer of 23/32" OSB & 1" Gypsum Concrete	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 16"o.c.	2 Layers of 5/8" GWB
TLF-17-051	IIF-17-040	1 Layer of 23/32" OSB & 1" Gypsum Concrete	(no insulation)	9.5" I-joists @ 16"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-053	IIF-17-042	1 Layer of 23/32" OSB & 1" Gypsum Concrete	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-059	IIF-17-048	1 Layer of 23/32" OSB & 1" Gypsum Concrete	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	2 Layers of 5/8" GWB
TLF-17-062	IIF-17-051	1 Layer of 23/32" OSB & 1" Gypsum Concrete	(no insulation)	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-074	IIF-17-062	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	2 Layers of 5/8" GWB

Table 1.2.1b Descriptions of Complete Assemblies with Floor Coverings

STC Test Number	IIC Test Number	Floor Covering	Floor Layer Description	Insulation	Framing Description	Ceiling Layer Description
TLF-17-043	IIF-17-034	Click Laminate	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-047	IIF-17-036	Thin Carpet & Pad	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-048	IIF-17-037	Thick Carpet & Pad	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-054	IIF-17-043	Thick Carpet & Pad	1 Layer of 23/32" OSB & 1" Gypsum Concrete	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-055	IIF-17-044	Thin Carpet & Pad	1 Layer of 23/32" OSB & 1" Gypsum Concrete	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-056	IIF-17-045	Click Laminate	1 Layer of 23/32" OSB & 1" Gypsum Concrete	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-057	IIF-17-046	Cushioned Vinyl	1 Layer of 23/32" OSB & 1" Gypsum Concrete	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-058	IIF-17-047	Ceramic Tile	1 Layer of 23/32" OSB & 1" Gypsum Concrete	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-060	IIF-17-049	Click Laminate	1 Layer of 23/32" OSB & 1" Gypsum Concrete	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	2 Layers of 5/8" GWB
TLF-17-061	IIF-17-050	Click Laminate	1 Layer of 23/32" OSB & 1" Gypsum Concrete	(no insulation)	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-064	IIF-17-054	Click Laminate	1 Layer of 23/32" OSB & 1" Gypsum Concrete	(no insulation)	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	2 Layers of 5/8" GWB
TLF-17-071	IIF-17-060	Cushioned Vinyl	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-072	IIF-17-061	Ceramic Tile	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-075	IIF-17-063	Click Laminate	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	2 Layers of 5/8" GWB

Table 1.2.1c Tested Assembly Components: Dimension and Weight Ranges

Component	Material Type	Tested Ranges		
		Minimum	Maximum	NRC Reference Case
Topping	Gypsum Concrete	~1" nominal thickness (±$^1/_8$") 9.5 psf – 11 psf		--
	(None)	--	--	--
Subfloor	1-layer OSB	$^{19}/_{32}$"	$^{23}/_{32}$"	$^{19}/_{32}$"
	2-layer OSB	(2 layers $^{19}/_{32}$")		--
	1-layer Plywood	$^{19}/_{32}$"	1"	--
	2-layer Plywood	(2 layers $^1/_2$")	(2 layers $^{19}/_{32}$")	--
Insulation	Fiberglass Batt	2$^1/_2$" thick 0.7 pcf ±0.1 pcf	8" thick 0.7 pcf ±0.1 pcf	6" thick
	Mineral Wool Batt	3$^1/_2$" thick 2 pcf ±0.5 pcf	8.3" thick 2 pcf ±0.5 pcf	--
	(None)	--	--	--
Framing	Sawn Lumber	2x8	2x12	2x10
	Wood I-joist	9.5" deep	18" deep	--
	Wood Truss	14" deep	18" deep	--
Framing Spacing	(any of the above)	16" o.c. or 24" o.c.		16" o.c.
Metal Furring	RC1 Resilient Channels	13mm-deep, 25 gage, spaced 16" or 24" o.c.		13mm-deep, 25 gage, spaced 24" o.c.
Ceiling Membrane	1-layer GWB	$^1/_2$" thick Type C 1.8 psf ±0.2 psf	$^5/_8$" thick Type X 2.2 psf ±0.2 psf	$^5/_8$" thick Type X
	1-layer Lightweight GWB	$^1/_2$" thick Type 1500 1.5 psf ±0.2 psf		--
	2-layer GWB	(2 layers $^1/_2$") Type C 3.6 psf ±0.4 psf	(2 layers $^5/_8$") Type X 4.4 psf ±0.4 psf	--
	2-layer Lightweight GWB	(2 layers $^1/_2$") Type 1500 3 psf ±0.3 psf		--

Table 1.2.1d Component Combinations: Assemblies without Concrete or Gypsum Concrete Toppings

		Ceiling Membrane						Metal Furring		Framing													Insulation						
		1-layer $^{1}/_{2}$" lt.wt. GWB	1-layer $^{1}/_{2}$" GWB	1-layer $^{5}/_{8}$" GWB	2-layer $^{1}/_{2}$" lt.wt. GWB	2-layer $^{1}/_{2}$" GWB	2-layer $^{5}/_{8}$" GWB	RC1 @ 24" o.c.	RC1 @ 16" o.c.	2x8 @ 16" o.c.	2x10 @ 16" o.c.	2x10 @ 24" o.c.	2x12 @ 16" o.c.	9.5" WIJ @ 16" o.c.	9.5" WIJ @ 24" o.c.	14" WIJ @16" o.c.	18" WIJ @16" o.c.	12" WT @ 16" o.c.	14" WT @ 16" o.c.	14" WT @ 24" o.c.	18" WT @ 24" o.c.	24" WT @ 24" o.c.	2.6" Fiberglass Batt	3.5" Fiberglass Batt	6" Fiberglass Batt	8" Fiberglass Batt	3.5" Mineral Wool Batt	8.3" Mineral Wool Batt	(None)
Subfloor	1-layer $^{19}/_{32}$" OSB																												
	1-layer $^{23}/_{32}$" OSB																												
	2-layer $^{19}/_{32}$" OSB																												
	1-layer $^{19}/_{32}$" Plywood																												
	1-layer 1" Plywood																												
	2-layer $^{1}/_{2}$" Plywood																												
	2-layer $^{19}/_{32}$" Plywood																												
Insulation	2.6" Fiberglass Batt																												
	3.5" Fiberglass Batt																												
	6" Fiberglass Batt																												
	8" Fiberglass Batt																												
	3.5" Mineral Wool Batt																												
	8.3" Mineral Wool Batt																												
	(None)																												
Framing	2x8 @ 16" o.c.																												
	2x10 @ 16" o.c.																												
	2x10 @ 24" o.c.																												
	2x12 @ 16" o.c.																												
	9.5" Wood I-joist @16" o.c.																												
	9.5" Wood I-joist @ 24" o.c.																												
	14" Wood I-joist @ 16" o.c.																												
	18" Wood I-joist @ 16" o.c.																												
	12" Wood Truss @ 16" o.c.																												
	14" Wood Truss @ 16" o.c.																												
	14" Wood Truss @ 24" o.c.																												
	18" Wood Truss @ 24" o.c.																												
	24" Wood Truss @ 24" o.c.																												
Metal Furring	RC1 @ 24" o.c.																												
	RC1 @ 16" o.c.																												

Grey shaded cells indicate component combinations in assemblies represented within the modeling database.
Green shaded cells indicate component combinations in assemblies represented within the validation database.

Table 1.2.1e **Component Combinations: Assemblies with 1" Nominal Gypsum Concrete Topping**

		Ceiling Membrane						Metal Furring		Framing													Insulation						
		1-layer $^{1}/_{2}$" lt.wt. GWB	1-layer $^{1}/_{2}$" GWB	1-layer $^{5}/_{8}$" GWB	2-layer $^{1}/_{2}$" lt.wt. GWB	2-layer $^{1}/_{2}$" GWB	2-layer $^{5}/_{8}$" GWB	RC1 @ 24" o.c.	RC1 @ 16" o.c.	2x8 @ 16" o.c.	2x10 @ 16" o.c.	2x10 @ 24" o.c.	2x12 @ 16" o.c.	9.5" WIJ @ 16" o.c.	9.5" WIJ @ 24" o.c.	14" WIJ @16" o.c.	18" WIJ @16" o.c.	12" WT @ 16" o.c.	14" WT @ 16" o.c.	14" WT @ 24" o.c.	18" WT @ 24" o.c.	24" WT @ 24" o.c.	2.6" Fiberglass Batt	3.5" Fiberglass Batt	6" Fiberglass Batt	8" Fiberglass Batt	3.5" Mineral Wool Batt	8.3" Mineral Wool Batt	(None)
Subfloor	1-layer $^{19}/_{32}$" OSB																												
	1-layer $^{23}/_{32}$" OSB																												
	2-layer $^{19}/_{32}$" OSB																												
	1-layer $^{19}/_{32}$" Plywood																												
	1-layer 1" Plywood																												
	2-layer $^{1}/_{2}$" Plywood																												
	2-layer $^{19}/_{32}$" Plywood																												
Insulation	2.6" Fiberglass Batt																												
	3.5" Fiberglass Batt																												
	6" Fiberglass Batt																												
	8" Fiberglass Batt																												
	3.5" Mineral Wool Batt																												
	8.3" Mineral Wool Batt																												
	(None)																												
Framing	2x8 @ 16" o.c.																												
	2x10 @ 16" o.c.																												
	2x10 @ 24" o.c.																												
	2x12 @ 16" o.c.																												
	9.5" Wood I-joist @16" o.c.																												
	9.5" Wood I-joist @ 24" o.c.																												
	14" Wood I-joist @ 16" o.c.																												
	18" Wood I-joist @ 16" o.c.																												
	12" Wood Truss @ 16" o.c.																												
	14" Wood Truss @ 16" o.c.																												
	14" Wood Truss @ 24" o.c.																												
	18" Wood Truss @ 24" o.c.																												
	24" Wood Truss @ 24" o.c.																												
Metal Furring	RC1 @ 24" o.c.																												
	RC1 @ 16" o.c.																												

Grey shaded cells indicate component combinations in assemblies represented within the modeling database.
Green shaded cells indicate component combinations in assemblies represented within the validation database.

ing the models presented in this report. Tests of partial assemblies used in developing the STC and IIC models are listed in Table 1.2.3.

Comparisons of measured transmission losses (TL) from these partial assemblies to idealized values calculated using the mass law, based on the mass of the floor or ceiling layer involved, reveal that actual measured values rarely coincide exactly with the idealized mass law prediction. At relatively low frequencies, the measured TL values can be either higher or lower than the mass law prediction, due to resonance and canceling effects within the assembly at various frequencies. At relatively high frequencies, the measured TL values are almost always lower than the mass law prediction. This is due to coincidence of the airborne sound wavelength in the source room with the wavelength of the bending waves in the floor or ceiling panel. An example of a typical comparison between measured TL values and mass law predictions for a ceiling-only assembly is shown in Figure 1.2.3a. A similar analysis is shown in Figure 1.2.3b for a typical floor-only assembly. Note that the mass law prediction is reasonably accurate for the ceiling-only assembly, up to the critical frequency at which coincidence starts to decrease TL values. This is, in large part, due to the decoupling effect of the resilient channels between the gypsum wallboard and the framing members. Conversely, agreement between the measured TL and the mass law prediction for the floor-only assembly is not as good at the low- to mid-range frequencies since there is effectively no decoupling between the floor layer and the framing.

1.2.4 System and Cavity Effect of Complete Assemblies

The measured transmission loss values for complete bare-floor assemblies (i.e., assemblies having both a floor layer and a ceiling layer, but no floor covering) can be compared to the sum of the individual mass law calculations for each separate layer. This comparison is shown graphically in Figure 1.2.4a for the NRC reference assembly.

The influence of the gypsum wallboard ceiling layer on the overall assembly performance is evident in the similarities between the graphs in Figures 1.2.3a and 1.2.4a. For example, the prominent coincidence dip centered at 2500 Hz is recognizable in both graphs. To a lesser extent, the influence of the OSB floor layer attached to framing is also evident through a comparison of Figures 1.2.3b and 1.2.4a.

A summation of the measured TL values from each of the separate layers (i.e., floor layer and ceiling layer) within an assembly results in values that follow a contour that is similar – but not identical – to that of the measured TL values for the complete assembly. This is illustrated in Figure 1.2.4b for the NRC reference assembly. The difference between the measured TL of the complete assembly and the sum of measured TL values from each separate layer within the assembly, shown graphically in

Table 1.2.3 Partial Assembly Tests Performed at NRC and Used in Model Development

	STC Test Number	IIC Test Number	Floor Layer Description	Framing Description	Ceiling Layer Description
Floor Layer Only	TLF-95-101a	IIF-95-038	1 layer of 19/32" OSB	2x10 @ 16"o.c.	(none)
	TLF-97-009a	IIF-97-005	1 layer of 19/32" OSB	9.5" I-joists @ 16" o.c.	(none)
	TLF-96-097a	IIF-96-042	1 layer of 19/32" OSB	18" I-joists @ 16"o.c.	(none)
	TLF-96-037a	IIF-96-010	1 layer of 19/32" OSB	2x10 @ 24"o.c.	(none)
	TLF-96-041a	IIF-96-012	1 layer of 23/32" OSB	2x10 @ 24"o.c.	(none)
	TLF-96-145a	IIF-96-064	1 layer of 1/2" Plywood	2x10 @ 16"o.c.	(none)
	TLF-96-149a	IIF-96-066	2 layers of 1/2" Plywood	2x10 @ 16"o.c.	(none)
	TLF-96-137a	IIF-96-060	1 Layer of 19/32" Plywood	2x10 @ 16"o.c.	(none)
	TLF-96-141a	IIF-96-062	2 layers of 19/32" Plywood	2x10 @ 16"o.c.	(none)
	TLF-96-067a	IIF-96-021	1 layer of 1" Plywood	2x10 @ 16"o.c.	(none)
Ceiling Layer Only	TLF-95-103a	--	(none)	2x10 @ 16"o.c. & RC1 @ 24"o.c.	1 layer of 5/8" GWB
	TLF-95-105a	--	(none)	2x10 @ 16"o.c. & RC1 @ 24"o.c.	2 layers of 5/8" GWB
	TLF-95-119a	--	(none)	2x10 @ 16"o.c. & RC1 @ 24"o.c.	1 layer of 1/2" GWB
	TLF-95-117a	--	(none)	2x10 @ 16"o.c. & RC1 @ 24"o.c.	2 layers of 1/2" GWB
	TLF-96-183a	--	(none)	2x10 @ 16"o.c. & RC1 @ 24"o.c.	1 layer of 1/2" Lt. Wt. GWB
	TLF-96-185a	--	(none)	2x10 @ 16"o.c. & RC1 @ 24"o.c.	2 layers of 1/2" Lt. Wt. GWB

Figure 1.2.3a **Comparison of Measured TL and Mass Law Prediction for Typical Ceiling Layer**

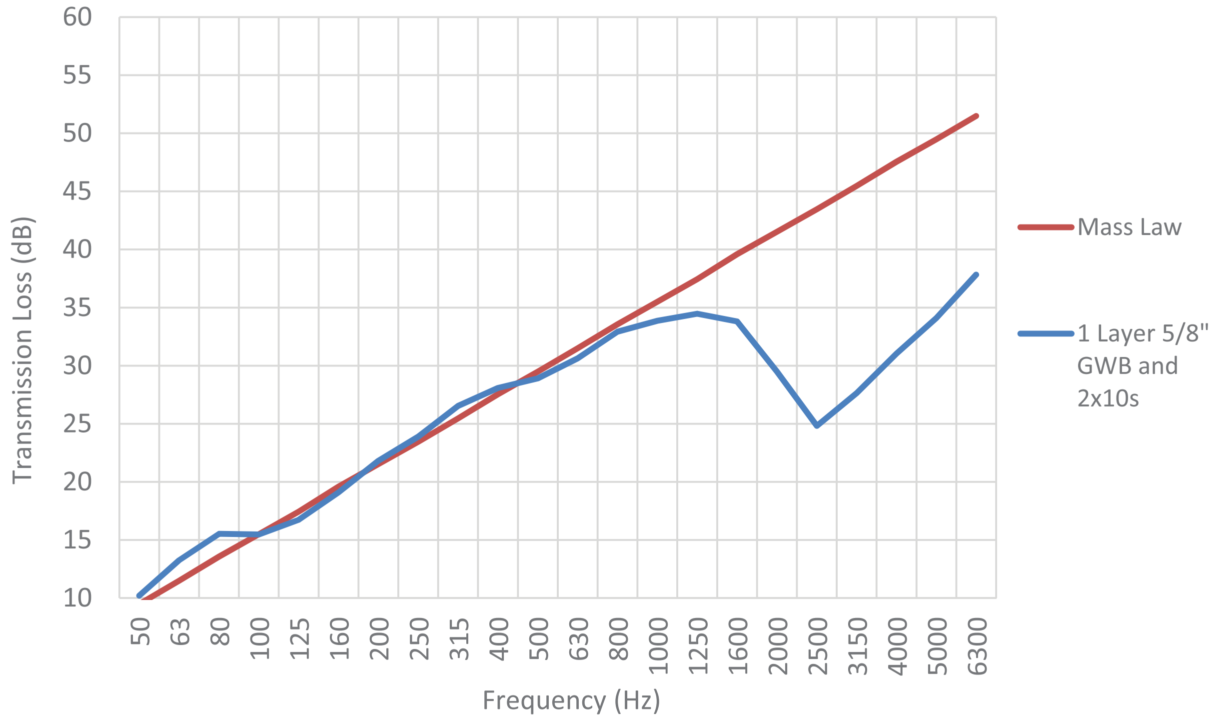


Figure 1.2.3b **Comparison of Measured TL and Mass Law Prediction for Typical Floor Layer**

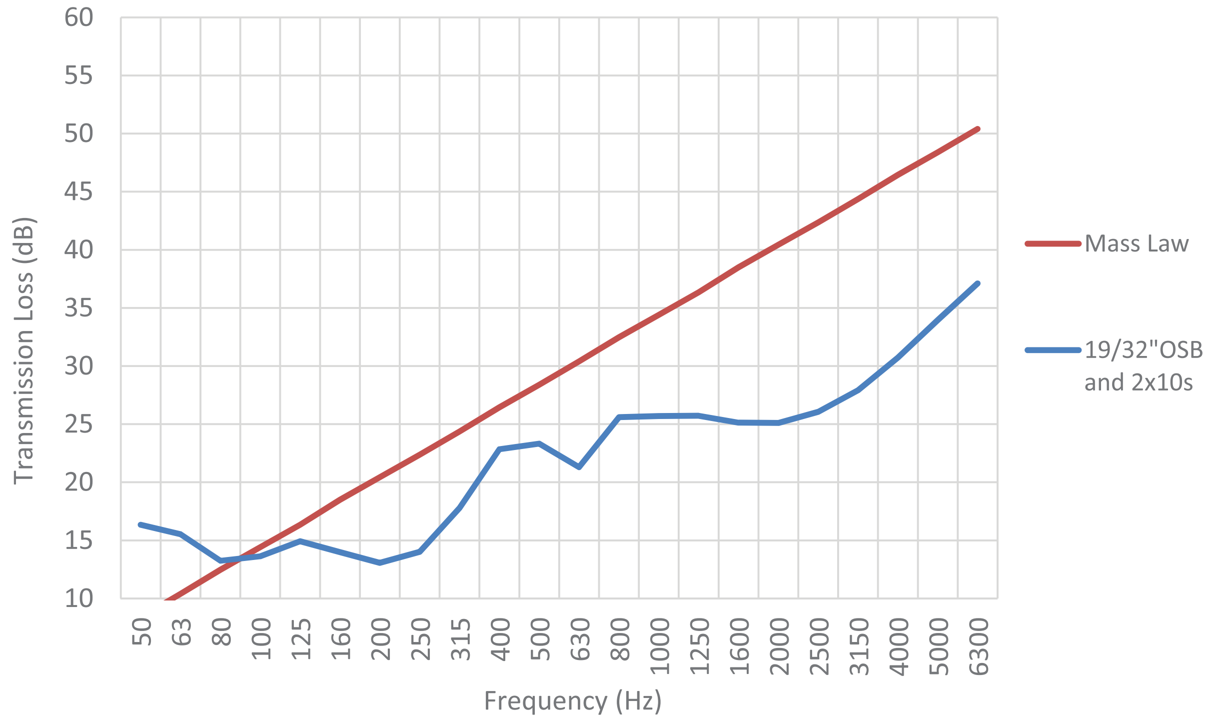


Figure 1.2.4a **Comparison of Measured TL and Mass law Prediction for the Reference Assembly**

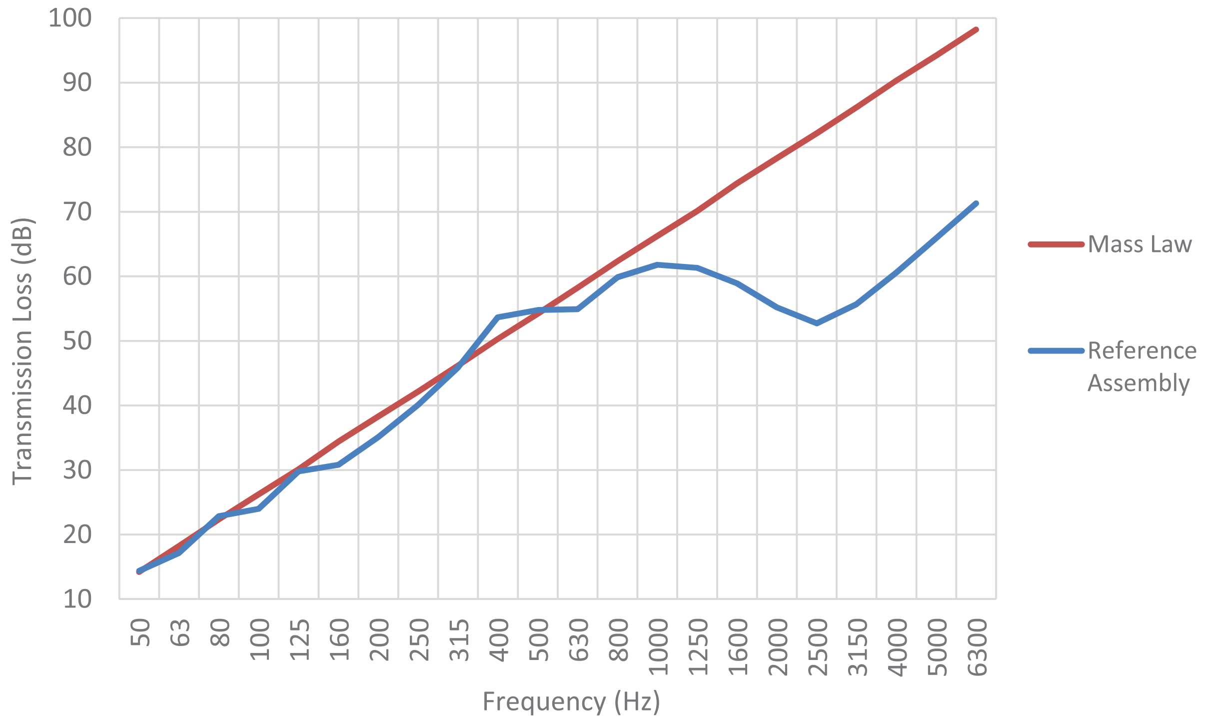


Figure 1.2.4b **Comparison of the Sum of Layer TLs to the Measured TL of the Reference Assembly**

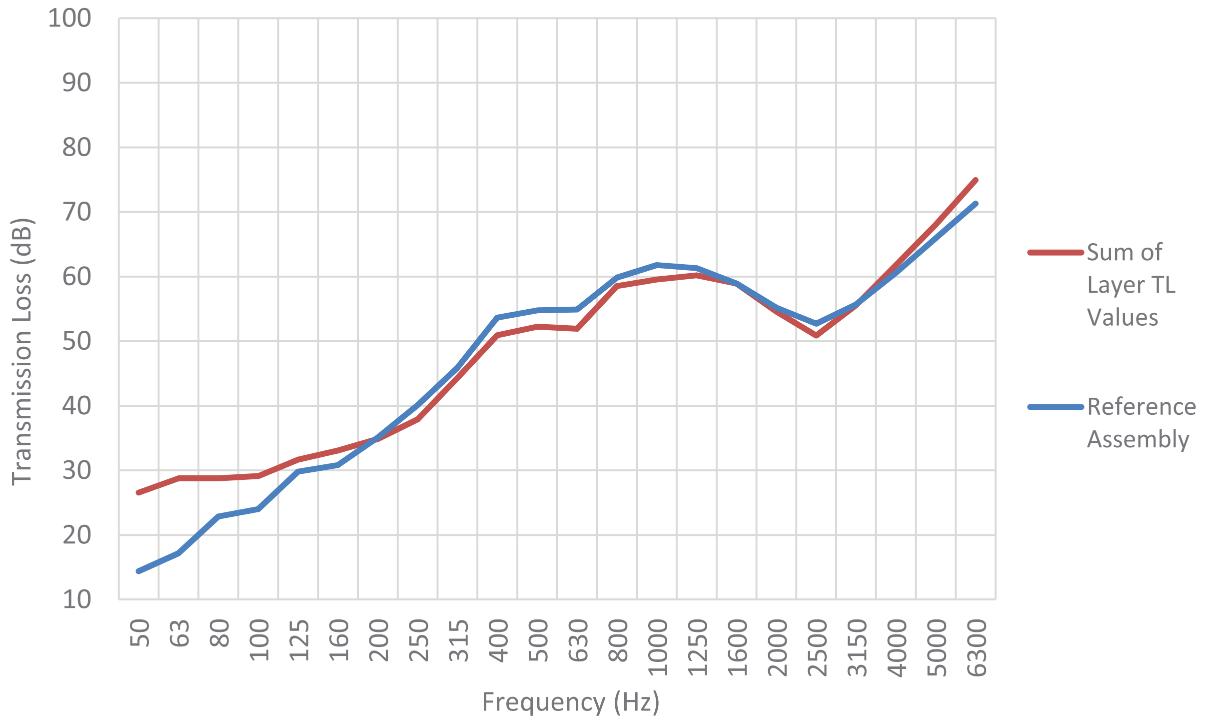


Figure 1.2.4c System Effect of the Reference Assembly

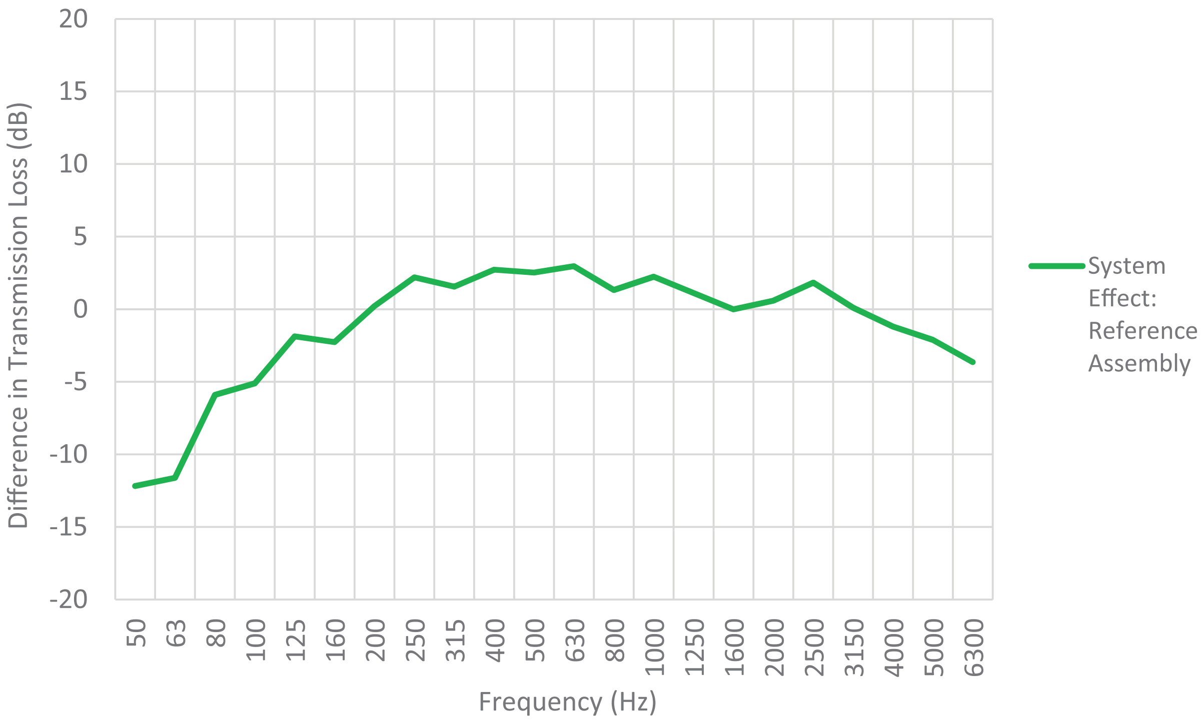


Figure 1.2.4c for the reference assembly, is referred to as the "system effect" in this report. This system effect appears to be the result of a combination of influences, including the following:

- Acoustics of the cavity bounded by the floor layer, ceiling layer, and framing members; including the effects of sound-absorbing material within the cavity (e.g., insulation) and cavity dimensions (governed by joist depth and spacing).
- Interactions between the components within the assembly.

System effects were directly derived using available data from each of the assembly configurations made up of a floor/ceiling combination from the tested partial assemblies listed in Table 1.2.3. For other assembly configurations, system effects were estimated by interpolation and extrapolation of trends observed in available data.

1.2.5 Influence of Single-Component-Variation on System Effect

The term single-component-variation is used in this report to describe the condition in which only one component varies from that of a reference or baseline assembly. In this section, empirical analyses of the influences that certain component variations have on the system effect of the reference assembly are presented.

The methods used to determine the system effects of the baseline assemblies used in the model are described in Section 1.3.3. The empirical models used to define the influences that component variations have on these system effects are described in Section 1.3.4.

1.2.5.1 Insulation Within the Cavity

When located within the cavity formed between the floor layer, ceiling layer, and framing members, thermal insulation provides an added benefit in that it greatly increases sound absorption within the cavity thereby having a positive influence on transmission loss through the assembly. Because of this beneficial effect, the presence of insulation within an assembly always results in an increase in STC and IIC values. The system effects associated with various insulation types and thicknesses within the scope of the STC and IIC models are shown graphically in Figure 1.2.5.1 for assemblies which are otherwise the same as the reference assembly.

While the differences in transmission loss brought about by variations in insulation type or thickness are generally no more than a few decibels at any given frequency, the graph in Figure 1.2.5.1 clearly illustrates the significant difference between the cavity effect of an assembly with insulation versus that of an assembly without insulation. This difference is most pronounced throughout the mid- to upper-range frequencies from about 315 Hz to 3150 Hz, where the difference is generally between 8 dB and 17 dB. Sound transmission class values are typically controlled by performance at the lower end of the frequency spectrum. Thus, for untopped assemblies, STC values for assemblies with insulation are generally between 7 dB and 11 dB higher than those without insulation. For assemblies with gypsum concrete topping, the influence of insulation within the cavity is less significant, providing a 4 dB to 7 dB increase in STC over that for assemblies without insulation.

1.2.5.2 Gypsum Wallboard Ceiling

The influence of the gypsum wallboard on STC and IIC ratings varies with respect to its weight per unit area, thickness, and number of layers. However, as illustrated in Figure 1.2.5.2, the influence of gypsum wallboard on the system effect is relatively minor. Most of the difference in

STC and IIC values brought about by variations in gypsum wallboard weight, thickness, etc. are accounted for by differences in the TL_l values of the ceiling layer alone, as reflected in data from the partial assembly tests discussed in Section 1.2.3. The system effects associated with variations in the ceiling layer within the scope of the STC and IIC models are shown graphically in Figure 1.2.5.2 for assemblies which are otherwise the same as the reference assembly.

1.2.5.3 Floor Layer Variations

1.2.5.3.1 Subfloor

For untopped assemblies, the influence of the floor layer on STC and IIC ratings varies with respect to the subfloor panel weight-per-unit-area, stiffness, thickness, and number of layers. The graph in Figure 1.2.5.3 shows the system effects for several of the subfloor variations included within the scope of the model – including varying types (i.e., OSB vs. plywood), nominal thicknesses and number of layers. One subfloor variation that is included within the scope of the model but is not depicted on this graph is 23/32” OSB. The database does not include any data from a floor-only partial assembly constructed with this subfloor type and thickness. Thus, it is not possible to directly determine the influence of 23/32” OSB on the system effect of the assembly; however, based on a comparison of TL data from complete bare-floor assemblies, it is assumed that the system effect associated with 23/32” OSB is not significantly different from that associated with 19/32” OSB.

As is evident in Figure 1.2.5.3, system effects for untopped assemblies remain relatively consistent despite variations in the floor layer. This is especially the case at the lower frequencies that typically govern STC in untopped assemblies.

Figure 1.2.5.1 System Effects Associated with Various Insulation Types and Thicknesses

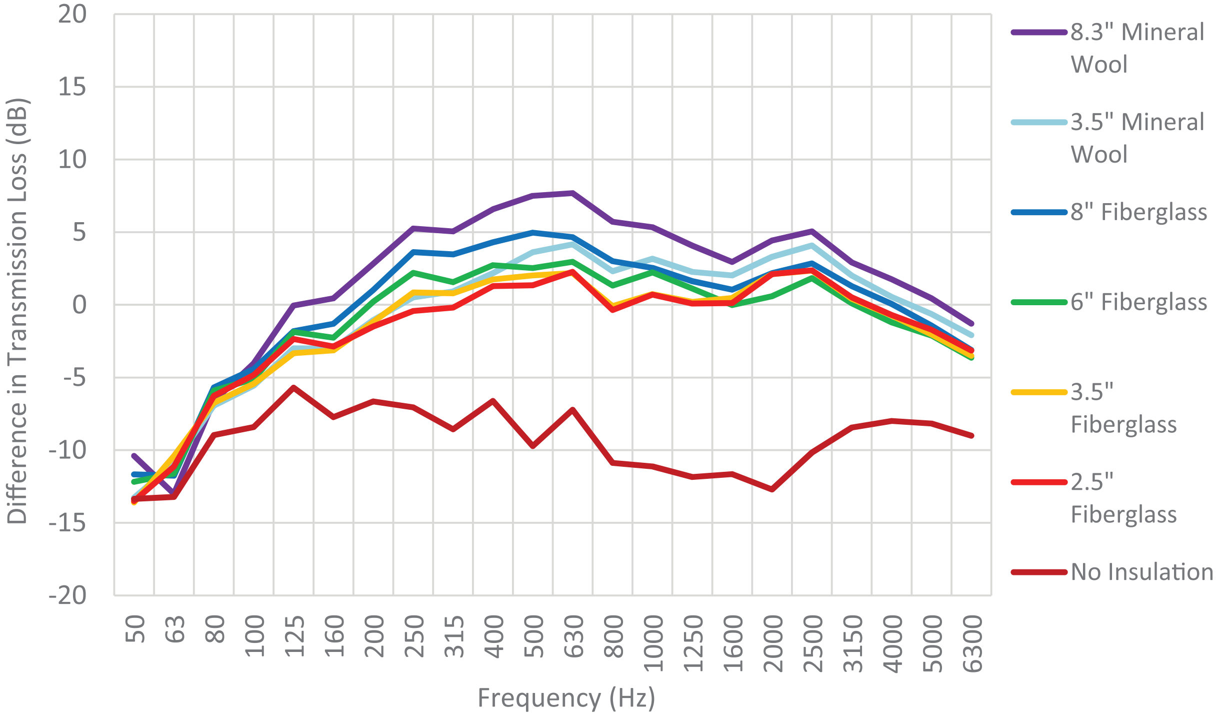


Figure 1.2.5.2 System Effects Associated with Variations in the GWB Ceiling Layer

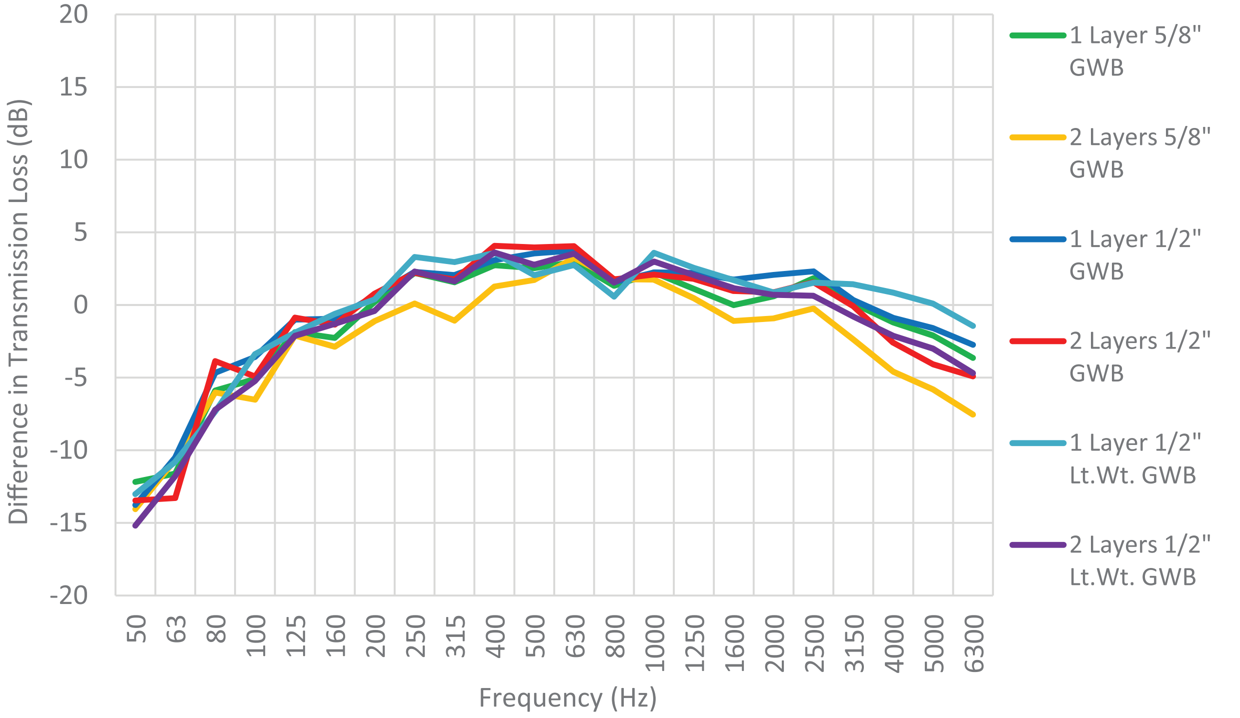
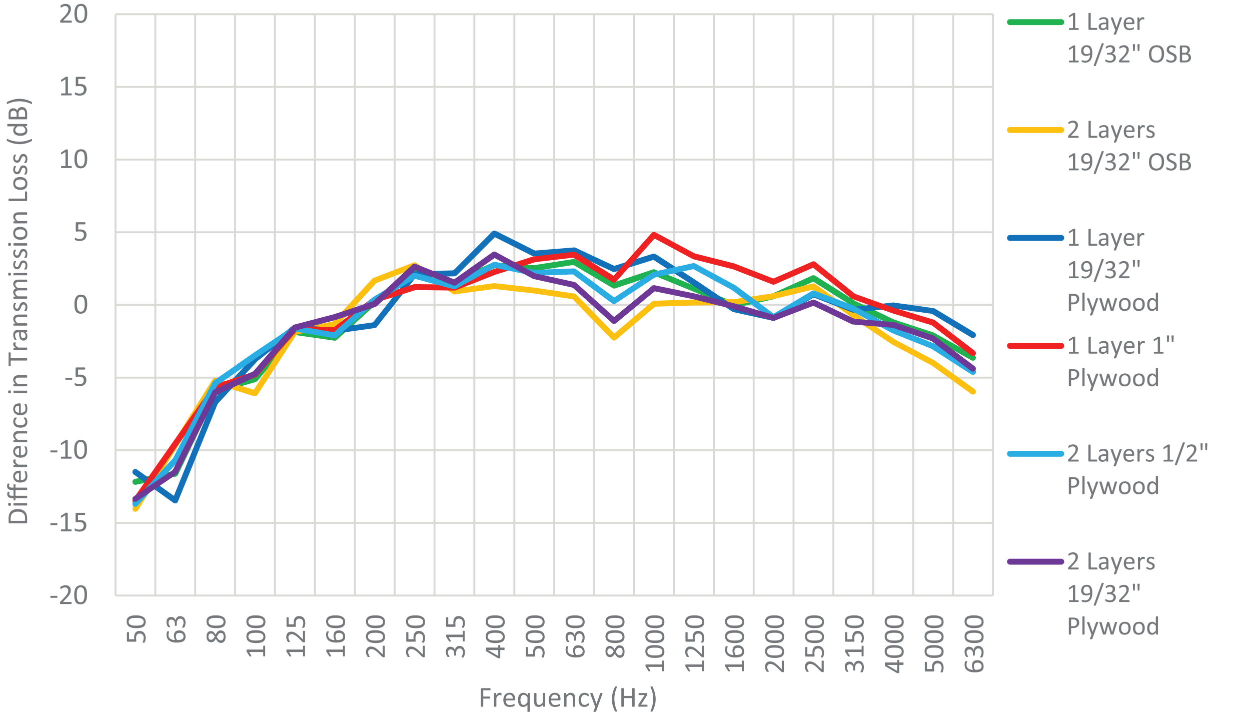


Figure 1.2.5.3 – System Effects Associated with Variations in the Floor Layer (Untopped Assemblies)



1.2.5.3.2 Cast-in-Place Topping

Due in large part to the additional mass it lends to the assembly, cast-in-place toppings such as normal-weight concrete, light-weight concrete, or gypsum concrete greatly affect both STC and IIC ratings. For STC, the effect of a topping on an assembly is always positive. STC values for assemblies topped with 1" nominal gypsum concrete are generally 9 dB to 12 dB higher than those for otherwise-identical assemblies without any topping.

The effect of a topping on IIC values of assemblies having common floor coverings is also generally positive – especially when combined with a resilient floor covering and/or underlayment pad. Conversely, topping can have a deleterious effect on IIC values for certain configurations in which it is directly covered with a thin or rigid floor covering (i.e., without a resilient mat or underlayment between the gypsum concrete and floor covering). In such configurations, the topping creates a hard striking surface and transmits sound unabated to the subfloor. Depending primarily on the floor covering and underlayment characteristics, IIC values for assemblies with common floor coverings over a 1" nominal gypsum concrete topping are typically 4 dB to 9 dB higher than for otherwise-identical assemblies without any topping. This applies also to rigid floor coverings applied over assemblies having a gypsum concrete topping, provided a resilient mat or underlayment is used between the topping and the rigid floor covering.

Since the modeling database does not include any assemblies comparable to the reference assembly in which topping is the isolated variable, it was not possible to directly determine the influence of a topping on the system effect. However, for development of the models presented herein, it was not necessary to isolate this variable because a separate set of baseline assemblies were established for topped assemblies. The baseline assemblies upon which the models are based are described in Section 1.3.3.

1.2.5.4 Variations in Framing

1.2.5.4.1 Joist Type and Size

A comparison of different joist types of approximately the same depth shows that system effects for assemblies framed with I-joists are similar to those of assemblies framed with sawn lumber at the lower and upper ends of the frequency spectrum. Throughout the mid-range frequencies ranging from about 160 Hz to 2000 Hz, the system effects of I-joist-framed assemblies tend to be 2 dB to 4 dB lower than those of assemblies framed with sawn lumber. This slight difference is evident through a comparison of 2x10s versus 9.5" I-joists in Figure 1.2.5.4a.

For a given framing type and depth, the available data does not indicate a strong correlation between STC and joist weight or, in the case of I-joists, flange dimensions. The same is true for the correlation of IIC to these parameters. As can be seen by a comparison of 9.5" I-joists versus 14" and 18" I-joists in Figure 1.2.5.4b, joist depth appears to increase the system effect values across two narrow ranges of frequencies, one at the lower end of the spectrum, and the other at the upper end. Since the

Figure 1.2.5.4a System Effects Associated with Variation in Joist Type (Sawn Lumber vs. I-joists)

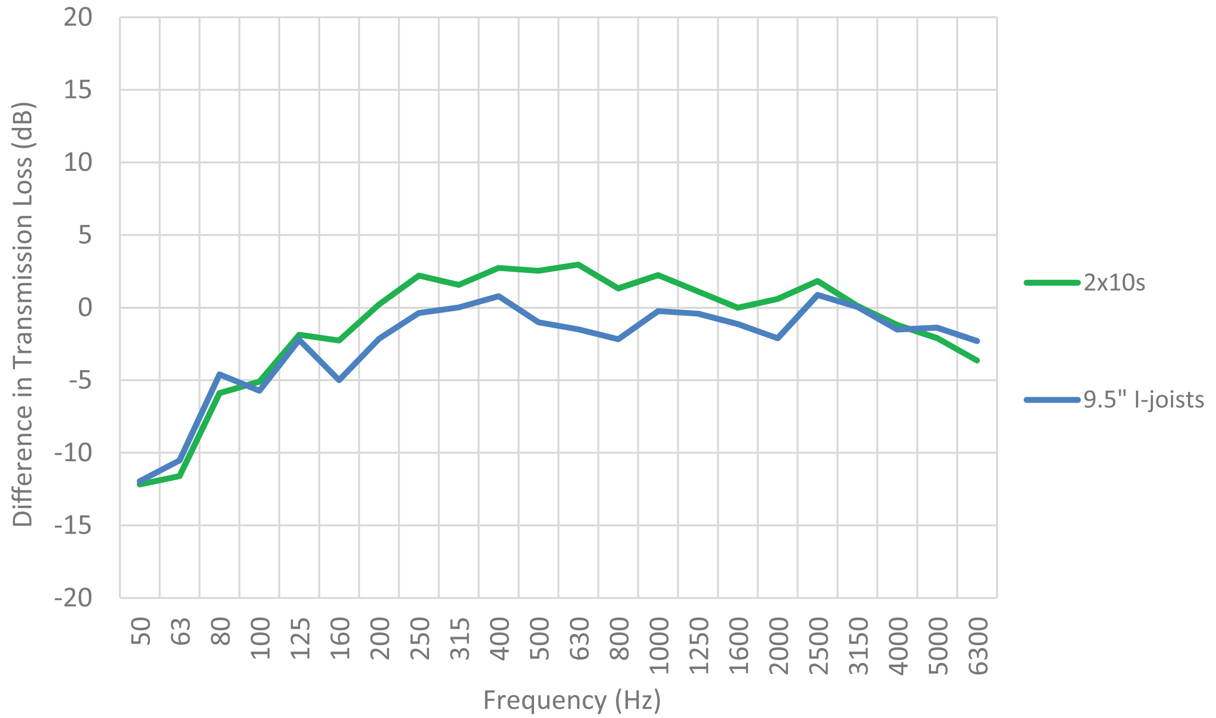
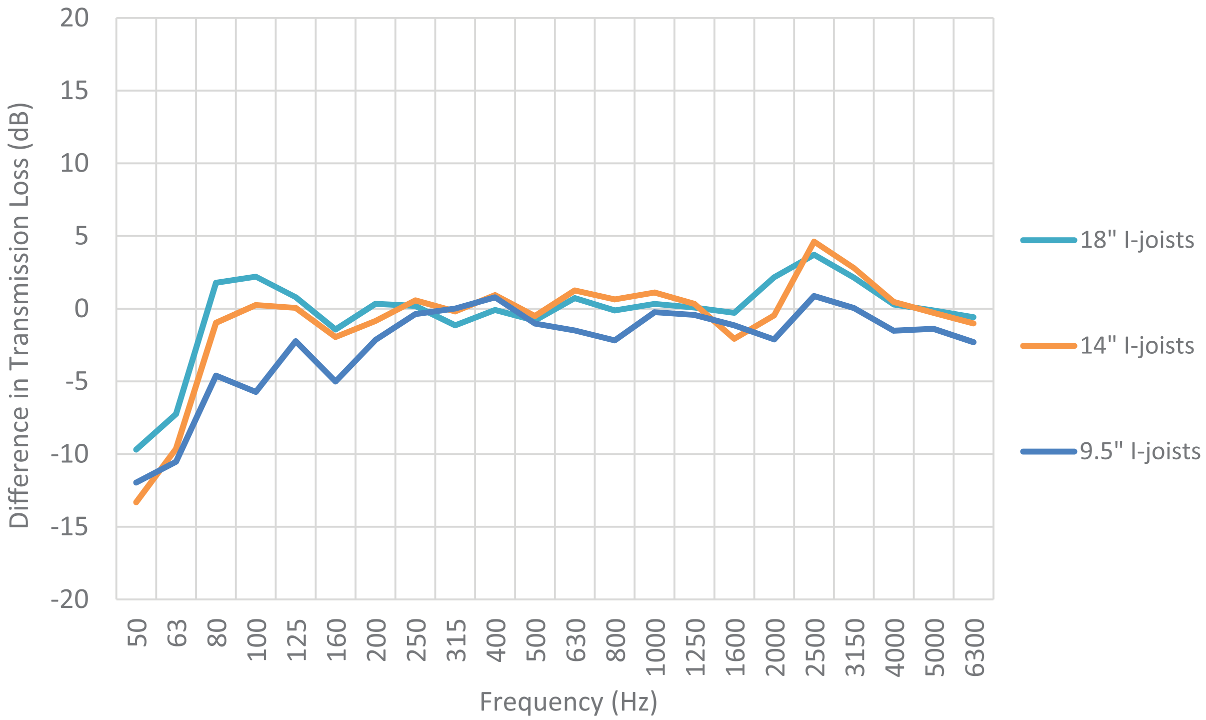


Figure 1.2.5.4b System Effects Associated with Variations in Joist Depth



increase at the lower end affects frequencies (63 Hz to 125 Hz) that partially overlap the governing frequencies of the STC range (starting at 125 Hz), this translates into a positive correlation between joist depth and STC. However, the overall effect of joist depth typically only amounts to a 1 dB or 2 dB difference in STC.

1.2.5.4.2 Joist Spacing

Transmission loss values are generally positively correlated to joist spacing, while the opposite is true for the correlation of ISPL values to joist spacing. Based on a comparison of data from the assemblies represented in Figure 1.2.5.4c, joist spacing variation within the scope of the model (16" o.c. to 24" o.c.) does not appear to have a major influence on system effect. For frequencies between 100 Hz and 4000 Hz, The system effect values for transmission loss through an assembly having 2x10s at 24" o.c. are, on average, about 1 dB higher than the values for an assembly having 2x10s at 16" o.c.

1.2.5.5 Resilient Channels

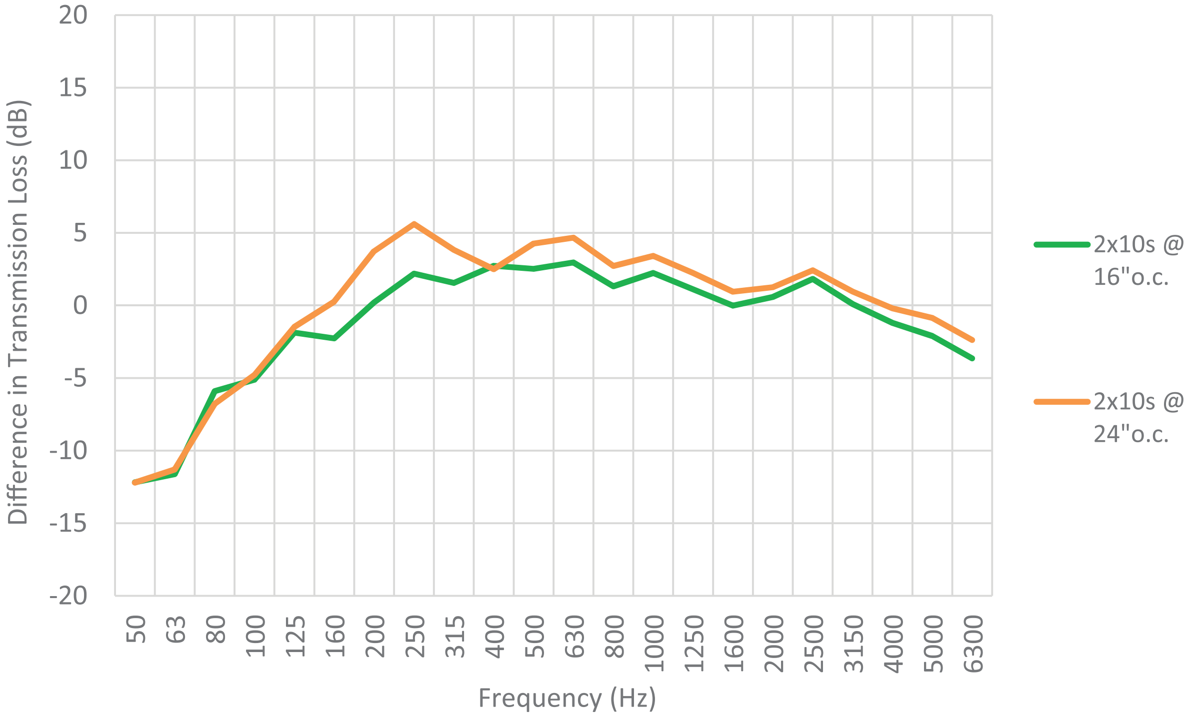
The correlation of resilient channel spacing to STC and IIC appears to vary slightly depending on the framing type. For example, the test data indicates that a change in resilient channel spacing affects ISPL values differently in an assembly framed with I-joists than it does in an assembly framed with 2x10 sawn lumber. Available data indicates that a shift in resilient channel spacing from 24" o.c. to 16" o.c. generally results in a 1 dB or 2 dB decrease in STC and IIC; however, the difference is sometimes greater.

Due to the fact that the database does not include any data for partial (ceiling-only) assemblies having resilient channels at 16" o.c., the influence of resilient channel spacing on the system effects of sawn lumber-framed assemblies and I-joist-framed assemblies had to be estimated based on available TL and ISPL data. These estimated values are described in Section 1.3.4.

1.2.6 Influence of Floor Covering and Base Assembly on ISPL and IIC

The effect that a floor covering has on ISPL values of the various base assemblies to which it can be applied is influenced not only by the characteristics of the floor covering itself, but also by the presence and characteristics of certain components within the base assembly. In other words, there are interactions between the effect of the floor covering on IIC, and certain components within the base assembly. Among the more influential components within the bare-floor assembly are insulation (i.e., presence or absence thereof), the ceiling layer (i.e., number and thickness of gypsum wallboard layers), and cast-in-place toppings (i.e., presence or absence thereof). The manner in which these variables are addressed within the model for common generic floor coverings is explained in Section 1.3.5.

Figure 1.2.5.4c System Effects Associated with Variations in Joist Spacing



1.3 Description of Model

1.3.1 Model Overview

The empirical models presented in this report are based on the data and analysis procedures presented in Section 1.2. A description of the STC model is presented in Section 1.3.1.1, while a description of the IIC model is presented in Section 1.3.1.2.

1.3.1.1 STC Model Description

In the STC model, estimated values of sound transmission loss for the assembly being evaluated, TL_a, are calculated at each 1/3-octave band center frequency using the following equation:

$$TL_a(f) = \sum TL_l(f) + \sum_a(f)$$
$$= \sum TL_l(f) + [X_b(f) + \sum \delta_X(f)]$$

Where:

$TL_a(f)$ = estimated transmission loss through the assembly at frequency f, dB

$\sum TL_l(f)$ = sum of layer TL values for the floor layer and ceiling layer, evaluated at frequency f, dB (see Section 1.3.2)

$X_a(f)$ = system effect of the assembly under evaluation at frequency f, dB

$X_b(f)$ = system effect of the baseline assembly at frequency f, dB (see Section 1.3.3)

$\sum \delta_X(f)$ = sum of applicable system effect adjustments necessary to account for the influence of component variations from the baseline assembly, evaluated at frequency f, dB (see Section 1.3.4)

Specific terms of the equation above are discussed in greater detail in subsequent sections. Information regarding TL_l values for various floor layers and ceiling layers is provided in Section 1.3.2. Descriptions of the baseline assemblies used within the model, and the corresponding system effects, χ_b, for each, are given in Section 1.3.3. The influences of component variations on system effect, δ_χ, are covered in Section 1.3.4.

Once the estimated TL_a values have been calculated at each 1/3-octave band center frequency ranging from 125 Hz up to 4000 Hz, a reference contour is fitted to the estimated TL_a curve and the corresponding STC value is determined using the procedure given in ASTM E413. As in the ASTM E413 procedure, the reference contour, taken as the set of values shown graphically in Figure 1.3.1.1, is shifted up uniformly in 1 dB increments to the highest level at which both of the following conditions are still satisfied:

- The sum of deficiencies evaluated at each 1/3-octave band center frequency does not exceed 32 dB.

- The single-point deficiency does not exceed 8 dB at any 1/3-octave band center frequency from 125 Hz to 4000 Hz.

For the purpose of this evaluation, the term *deficiency* refers to the difference between the estimated transmission loss at a given 1/3-octave band center frequency, $TL_a(f)$, and the value from the shifted reference contour at the same frequency, counted only at frequencies where $TL_a(f)$ is lower than the corresponding value from the shifted reference contour. The estimated STC is taken as being equal to the number of decibels that the reference contour is shifted upward in this procedure.

In addition to depicting the reference contour (shown as a red line in the graph), Figure 1.3.1.1 also includes an example of a contour that has been shifted upward by 50 points. This particular example would correspond to an STC of 50.

1.3.1.2 IIC Model Description

In the IIC model, impact sound pressure levels (ISPL) are estimated based on the estimated TL values described in Section 1.3.1.1, except that additional adjustments are made to account for differences in the acoustical response of the assembly resulting from the direct impacts of the tapping machine. These acoustical differences are governed in large part by the physical characteristics the floor surface upon which the tapping machine rests, as well as the properties of any sub-layer(s) that are underneath, and in direct contact with, the floor surface.

Estimated values of impact sound pressure level for the assembly being evaluated, $ISPL_a$, are calculated at each 1/3-octave band center frequency using the following equation:

$$\begin{aligned} ISPL_a(f) &= 110 - TL_a(f) + \Delta_{ISPL}(f) \\ &= 110 - [\Sigma TL_l(f) + X_b(f) + \Sigma\delta_X(f)] \\ &\quad + \Delta_{ISPL}(f) \end{aligned}$$

Where:

$ISPL_a(f)$ = estimated impact sound pressure level from sound transmitted through the assembly at frequency f, dB

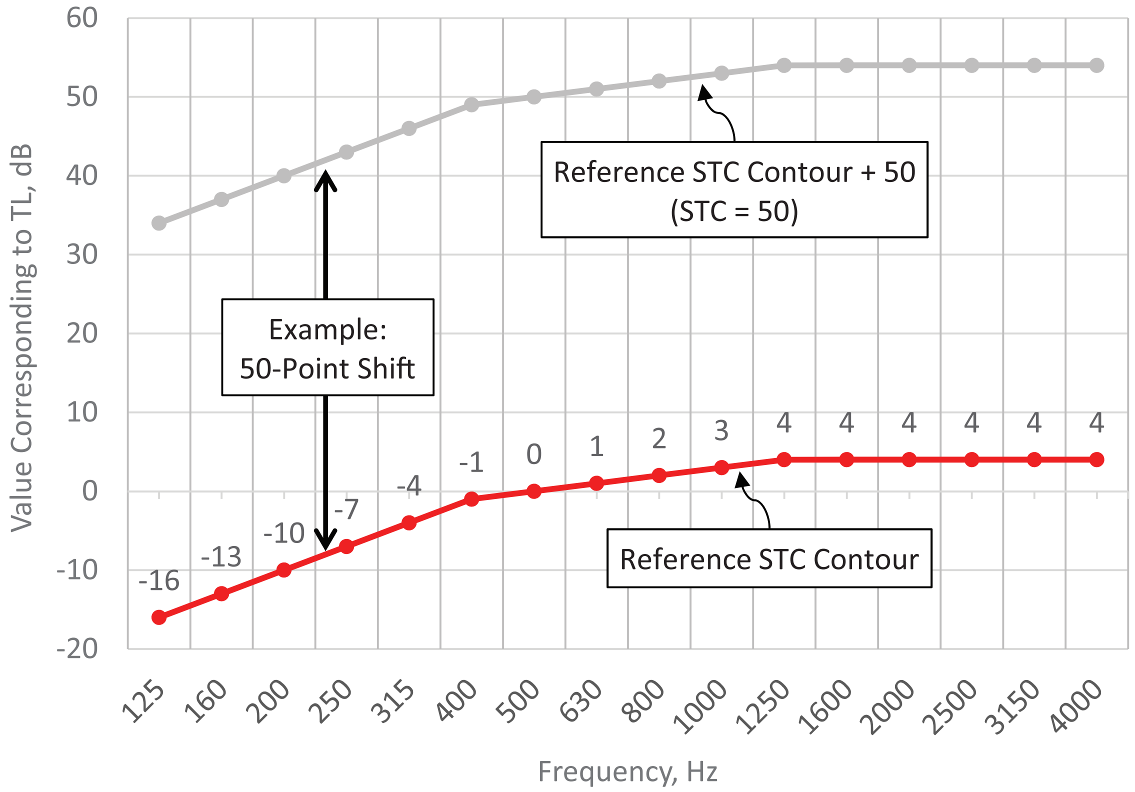
$TL_a(f)$ = estimated transmission loss through the assembly at frequency f, dB

$\Delta_{ISPL}(f)$ = ISPL adjustment at frequency f, dB (see Section 1.3.5)

$\Sigma TL_l(f)$ = sum of layer TL values for the floor layer and ceiling layer, evaluated at frequency f, dB (see Section 1.3.2)

$X_b(f)$ = system effect of the baseline assembly at frequency f, dB (see Section 1.3.3)

Figure 1.3.1.1 — Reference STC Contour (Shown in Red) and Example of Shifted Contour



$\Sigma\delta_X(f)$ = sum of applicable system effect adjustments necessary to account for the influence of component variations from the baseline assembly, evaluated at frequency f, dB (see Section 1.3.4)

With the exception of the ISPL adjustment values, Δ_{ISPL}, the terms used in the IIC model are the same as those used in the STC model described in Section 1.3.1.1. The ISPL adjustment term, Δ_{ISPL}, is described in Section 1.3.5.

In an approach analogous to that described in Section 1.3.1.1 for STC, the estimated $ISPL_a$ values are calculated at each 1/3-octave band center frequency ranging from 100 Hz up to 3150 Hz, and a reference contour is fitted to the estimated $ISPL_a$ curve. The corresponding IIC value is determined using the procedure given in ASTM E989. As in the ASTM E989 procedure, the reference contour is taken as the set of values shown graphically in Figure 1.3.1.2, shifted up uniformly in 1 dB increments to the highest level at which both of the following conditions are still satisfied:

- The sum of deficiencies evaluated at each 1/3-octave band center frequency does not exceed 32 dB.
- The single-point deficiency does not exceed 8 dB at any 1/3-octave band center frequency from 100 Hz to 3150 Hz.

In contrast to the approach taken for STC, the term *deficiency* refers to the difference between the estimated impact sound pressure level at a given 1/3-octave band center frequency, $ISPL_a(f)$, and the value from the shifted reference contour at the same frequency, counted only at frequencies where $ISPL_a(f)$ is *higher* than the corresponding value from the shifted reference contour. The estimated IIC value for the assembly under evaluation is taken as 110 minus the number of decibels that the reference contour is shifted upward in this procedure.

In addition to depicting the reference contour (shown as a red line in the graph), Figure 1.3.1.2 also includes an example of a contour that has been shifted upward by 60 points. This particular example would correspond to an IIC of 50 (110 – 60 = 50).

1.3.2 Transmission Loss Of Individual Layers

As mentioned in Section 1.2.3, tests were performed on partial assemblies consisting of the framing and floor layer alone (i.e., without a ceiling layer), as well as on partial assemblies consisting of the framing and ceiling layer alone (i.e., without a floor layer). Data from these tests were utilized in the derivation of individual layer transmission loss values, $TL_l(f)$, for the floor layer and the ceiling layer. Layer transmission loss values for the floor layer are given in Table 1.3.2a, while layer transmission

Figure 1.3.1.2 Reference IIC Contour (Shown in Red) and Example of Shifted Contour

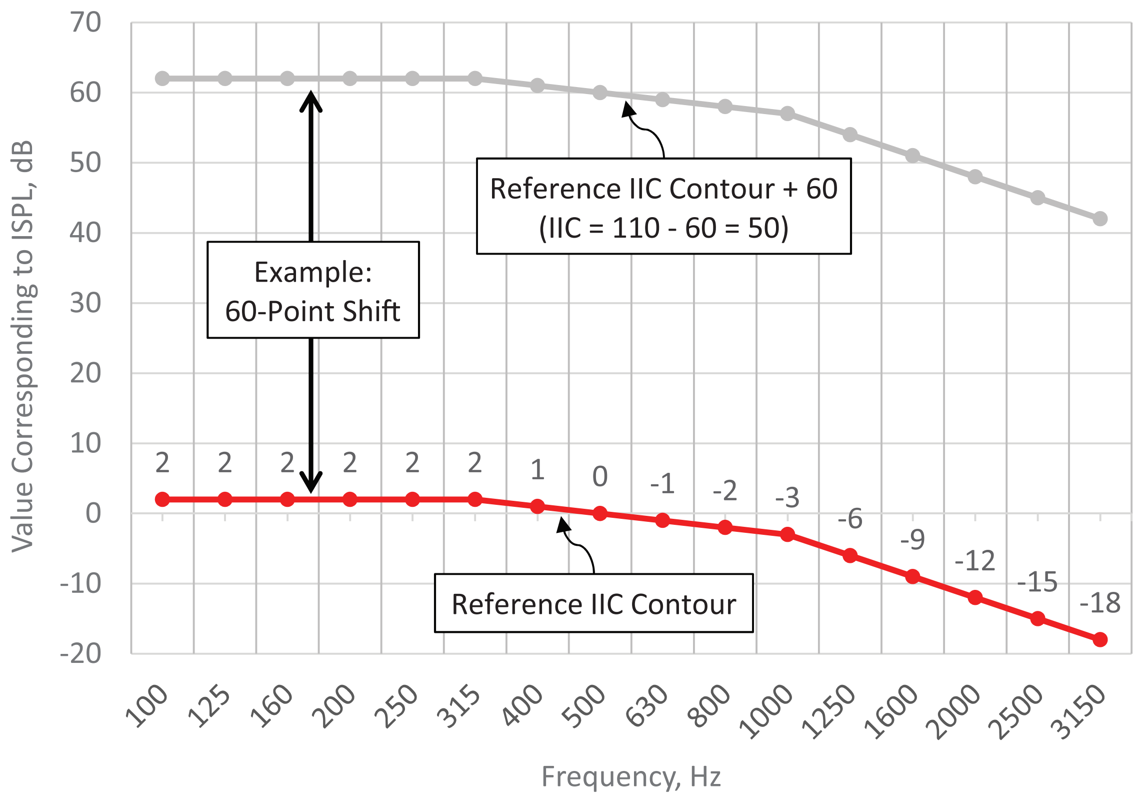


Table 1.3.2a Estimated Layer Transmission Loss Values, TLl, for the Floor Layer

Framing	Subfloor	Estimated Floor Layer TL_l Values (dB) at Frequency:																
		100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz
2x Joists at 16" o.c.	1 Layer 19/32" OSB	13.6	14.9	14.0	13.1	14.0	17.8	22.8	23.3	21.3	25.6	25.7	25.7	25.1	25.1	26.1	27.9	30.7
	1 Layer 23/32" OSB	15.8	16.1	15.8	14.8	14.0	16.8	22.3	24.2	21.5	21.7	23.8	23.1	24.6	24.2	26.2	28.8	31.4
	2 Layers 19/32" OSB	19.9	15.9	15.7	15.8	19.8	24.5	29.0	29.8	28.5	32.4	31.0	31.0	28.7	28.3	30.4	32.7	35.7
	1 Layer 19/32" Plywood	11.6	14.0	13.3	13.1	12.7	14.2	18.9	21.7	19.3	21.7	23.3	22.9	23.7	24.1	24.8	25.4	26.0
	1 Layer 1" Plywood	13.6	14.8	14.4	14.0	14.9	17.2	20.4	21.6	20.3	20.8	20.9	20.6	21.4	23.2	25.6	28.0	30.3
	2 Layers 1/2" Plywood	13.2	13.9	13.5	13.3	15.6	19.5	24.5	25.6	24.6	28.5	27.1	27.9	28.3	28.9	28.7	28.6	30.1
	2 Layers 19/32" Plywood	14.2	14.8	14.9	14.8	16.3	19.4	23.9	26.3	25.3	27.4	27.3	26.9	27.0	28.0	29.4	30.5	31.6
	1" GC over min 19/32" WSP	20.7	22.4	25.2	23.7	23.8	24.1	25.6	28.5	29.3	26.8	24.6	29.6	32.4	35.8	38.4	39.7	41.0
2x Joists at 24" o.c.	1 Layer 19/32" OSB	11.4	13.2	13.9	15.6	19.7	20.9	20.5	24.6	23.6	26.0	25.2	24.5	23.4	23.7	25.1	27.9	31.2
	1 Layer 23/32" OSB	10.6	13.0	13.7	16.3	19.4	22.0	20.3	23.5	24.5	24.1	23.6	22.5	22.9	24.3	26.6	29.9	32.9
	2 Layers 19/32" OSB	17.7	14.2	15.6	18.3	25.4	27.5	26.7	31.1	30.8	32.8	30.4	29.8	27.0	27.0	29.4	32.7	36.2
	1 Layer 19/32" Plywood	9.4	12.2	13.3	15.7	18.4	17.3	16.6	23.0	21.7	22.1	22.8	21.7	22.0	22.7	23.9	25.3	26.4
	1 Layer 1" Plywood	11.4	13.1	14.3	16.5	20.5	20.3	18.0	22.9	22.7	21.2	20.4	19.4	19.7	21.8	24.6	28.0	30.7
	2 Layers 1/2" Plywood	11.0	12.2	13.4	15.9	21.3	22.5	22.1	26.9	26.9	28.9	26.6	26.7	26.6	27.5	27.8	28.6	30.5
	2 Layers 19/32" Plywood	12.0	13.1	14.8	17.3	22.0	22.5	21.5	27.6	27.6	27.8	26.8	25.7	25.4	26.6	28.4	30.4	32.0
	1" GC over min 19/32" WSP	18.5	20.6	25.1	26.3	29.4	27.2	23.2	29.8	31.7	27.2	24.1	28.4	30.7	34.4	37.4	39.6	41.5
I-Joists at 16" o.c.	1 Layer 19/32" OSB	12.8	14.5	16.0	15.0	15.6	18.7	23.1	25.7	24.9	26.0	26.7	25.1	26.2	27.2	27.6	29.1	32.6
	1 Layer 23/32" OSB	12.0	16.2	16.1	15.6	16.5	19.8	22.1	25.4	26.3	26.4	26.2	25.2	23.9	24.1	26.4	29.1	33.5
	2 Layers 19/32" OSB	19.1	15.5	17.7	17.7	21.3	25.4	29.3	32.1	32.1	32.8	32.0	30.4	29.8	30.4	31.9	33.9	37.6
	1 Layer 19/32" Plywood	10.8	13.5	15.4	15.1	14.3	15.1	19.2	24.0	23.0	22.1	24.3	22.3	24.8	26.2	26.3	26.6	27.8
	1 Layer 1" Plywood	12.8	14.4	16.4	15.9	16.5	18.1	20.7	23.9	24.0	21.2	21.9	20.0	22.5	25.3	27.1	29.2	32.2
	2 Layers 1/2" Plywood	12.4	13.5	15.5	15.3	17.2	20.4	24.7	27.9	28.2	28.9	28.1	27.3	29.3	31.0	30.2	29.8	32.0
	2 Layers 19/32" Plywood	13.4	14.4	17.0	16.7	17.9	20.3	24.1	28.7	28.9	27.8	28.3	26.3	28.1	30.1	30.9	31.7	33.4
	1" GC over min 19/32" WSP	20.7	22.4	25.2	23.7	23.8	24.1	25.6	28.5	29.3	26.8	24.6	29.6	32.4	35.8	38.4	39.7	41.0
I-Joists at 24" o.c.	1 Layer 19/32" OSB	10.7	12.8	15.9	17.5	21.2	21.8	20.7	27.0	27.3	26.4	26.2	23.9	24.5	25.8	26.6	29.1	33.0
	1 Layer 23/32" OSB	9.9	14.5	16.0	18.1	22.1	22.8	19.8	26.7	28.6	26.9	25.7	24.1	22.2	22.7	25.4	29.1	33.9
	2 Layers 19/32" OSB	17.0	13.8	17.6	20.3	27.0	28.4	26.9	33.4	34.5	33.2	31.4	29.2	28.1	29.0	30.9	33.8	38.1
	1 Layer 19/32" Plywood	8.6	11.8	15.3	17.6	20.0	18.2	16.8	25.3	25.3	22.5	23.8	21.1	23.1	24.8	25.3	26.5	28.3
	1 Layer 1" Plywood	10.7	12.7	16.3	18.5	22.1	21.2	18.3	25.2	26.3	21.6	21.4	18.8	20.8	23.9	26.1	29.2	32.6
	2 Layers 1/2" Plywood	10.2	11.8	15.4	17.8	22.9	23.5	22.4	29.2	30.6	29.3	27.6	26.1	27.6	29.6	29.3	29.7	32.4
	2 Layers 19/32" Plywood	11.2	12.7	16.9	19.2	23.5	23.4	21.8	30.0	31.3	28.2	27.8	25.1	26.4	28.7	29.9	31.6	33.9
	1" GC over min 19/32" WSP	18.5	20.6	25.1	26.3	29.4	27.2	23.2	29.8	31.7	27.2	24.1	28.4	30.7	34.4	37.4	39.6	41.5
Wood Trusses at 16" o.c.	1 Layer 19/32" OSB	15.1	15.5	15.1	14.3	15.0	18.1	20.8	22.5	21.8	24.0	25.0	24.0	25.9	26.9	29.1	31.7	34.7
	1 Layer 23/32" OSB	15.1	15.5	15.1	14.3	15.0	18.1	20.8	22.5	21.8	24.0	25.0	24.0	25.9	26.9	29.1	31.7	34.7
	2 Layers 19/32" OSB	21.4	16.5	16.8	17.0	20.8	24.8	27.0	28.9	29.0	30.9	30.2	29.3	29.5	30.2	33.4	36.5	39.7
	1 Layer 19/32" Plywood	13.1	14.5	14.5	14.4	13.8	14.6	16.9	20.8	19.9	20.2	22.6	21.2	24.5	25.9	27.8	29.2	29.9
	1 Layer 1" Plywood	15.1	15.4	15.5	15.2	15.9	17.5	18.4	20.7	20.9	19.3	20.2	18.9	22.2	25.0	28.6	31.8	34.3
	2 Layers 1/2" Plywood	14.6	14.5	14.6	14.6	16.7	19.8	22.5	24.7	25.1	27.0	26.4	26.2	29.1	30.7	31.8	32.4	34.0
	2 Layers 19/32" Plywood	15.7	15.4	16.0	16.0	17.3	19.8	21.9	25.5	25.8	25.9	26.6	25.2	27.8	29.8	32.4	34.2	35.5
Wood Trusses at 24" o.c.	1 Layer 19/32" OSB	12.1	13.4	12.1	14.1	18.5	18.9	17.5	21.5	22.4	23.8	23.3	23.0	23.3	24.8	27.6	31.4	34.3
	1 Layer 23/32" OSB	12.1	13.4	12.1	14.1	18.5	18.9	17.5	21.5	22.4	23.8	23.3	23.0	23.3	24.8	27.6	31.4	34.3
	2 Layers 19/32" OSB	18.4	14.4	13.7	16.9	24.3	25.6	23.7	27.9	29.6	30.6	28.5	28.3	26.9	28.0	31.9	36.1	39.3
	1 Layer 19/32" Plywood	10.0	12.4	11.4	14.2	17.3	15.3	13.6	19.8	20.4	19.9	20.9	20.1	21.9	23.7	26.3	28.8	29.5
	1 Layer 1" Plywood	12.1	13.3	12.5	15.1	19.4	18.3	15.1	19.8	21.4	19.0	18.5	17.8	19.6	22.9	27.1	31.5	33.8
	2 Layers 1/2" Plywood	11.6	12.4	11.5	14.4	20.2	20.6	19.2	23.7	25.7	26.7	24.7	25.2	26.4	28.6	30.3	32.0	33.6
	2 Layers 19/32" Plywood	12.7	13.3	13.0	15.9	20.8	20.5	18.6	24.5	26.4	25.6	24.9	24.2	25.2	27.7	30.9	33.9	35.1

Table 1.3.2b Estimated Layer Transmission Loss Values, TLl, for the Ceiling Layer

Framing Spacing	RC Spacing	Ceiling Layer	Estimated Ceiling Layer TL_l Values (dB) at Frequency: 100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz
Framing at 16" o.c.	RCs at 16" o.c.	1 Layer 5/8" GWB	14.0	15.1	18.4	21.3	23.6	26.0	27.4	28.0	29.1	31.5	32.5	33.9	33.1	29.1	23.8	26.3	29.6
		2 Layers 5/8" GWB	19.3	19.8	23.8	27.0	29.3	32.2	32.3	33.0	32.1	33.4	35.5	35.4	35.5	31.8	30.4	34.1	37.5
		1 Layer 1/2" GWB	12.3	13.3	17.0	19.4	21.9	24.7	25.9	26.0	27.0	29.4	30.2	32.1	32.3	31.0	24.2	24.0	27.2
		2 Layers 1/2" GWB	17.8	18.3	21.5	25.0	28.0	30.9	31.2	32.3	31.7	31.9	32.9	32.8	33.8	33.1	29.5	31.1	34.8
		1 Layer Lt.Wt. 1/2" GWB	10.6	11.7	14.8	17.7	20.1	22.4	23.2	24.2	25.4	27.6	28.6	30.5	30.9	30.7	25.1	21.8	24.2
		2 Layers Lt.Wt. 1/2" GWB	16.6	17.1	19.9	23.7	26.1	29.4	29.5	31.3	30.9	30.6	31.5	31.2	32.1	32.3	29.7	28.6	31.9
	RCs at 24" o.c.	1 Layer 5/8" GWB	15.5	16.7	19.1	21.8	23.9	26.5	28.1	28.9	30.6	32.9	33.9	34.5	33.8	29.5	24.8	27.6	31.0
		2 Layers 5/8" GWB	20.0	21.7	24.7	27.1	29.0	31.4	32.2	31.9	32.5	34.9	36.3	37.8	37.9	34.3	31.9	35.4	38.6
		1 Layer 1/2" GWB	13.8	14.9	17.7	19.9	22.2	25.2	26.6	26.9	28.5	30.8	31.5	32.8	32.9	31.4	25.1	25.4	28.7
		2 Layers 1/2" GWB	18.5	20.1	22.5	25.1	27.6	30.1	31.1	31.2	32.1	33.3	33.7	35.2	36.1	35.7	31.0	32.4	35.9
		1 Layer Lt.Wt. 1/2" GWB	12.1	13.4	15.5	18.2	20.4	22.9	23.9	25.1	26.9	29.1	30.0	31.1	31.6	31.2	26.1	23.1	25.6
		2 Layers Lt.Wt. 1/2" GWB	17.3	18.9	20.9	23.8	25.8	28.6	29.4	30.2	31.3	32.1	32.3	33.6	34.5	34.9	31.2	29.9	33.0
Framing at 24" o.c.	RCs at 16" o.c.	1 Layer 5/8" GWB	16.3	17.0	20.9	22.2	21.2	25.1	29.4	28.2	28.3	32.3	34.0	36.0	35.6	30.9	25.2	27.0	30.0
		2 Layers 5/8" GWB	21.6	21.8	26.2	27.8	26.9	31.2	34.2	33.2	31.3	34.3	37.0	37.5	38.0	33.7	31.8	34.8	37.9
		1 Layer 1/2" GWB	14.6	15.2	19.5	20.2	19.5	23.7	27.8	26.3	26.2	30.2	31.7	34.3	34.7	32.9	25.6	24.7	27.6
		2 Layers 1/2" GWB	20.1	20.3	24.0	25.9	25.6	29.9	33.2	32.5	30.9	32.7	34.4	34.9	36.3	35.0	30.8	31.8	35.2
		1 Layer Lt.Wt. 1/2" GWB	12.9	13.6	17.3	18.6	17.7	21.5	25.2	24.5	24.6	28.5	30.2	32.6	33.4	32.6	26.5	22.5	24.6
		2 Layers Lt.Wt. 1/2" GWB	18.9	19.0	22.4	24.6	23.7	28.4	31.4	31.6	30.1	31.5	33.0	33.3	34.6	34.2	31.1	29.4	32.3
	RCs at 24" o.c.	1 Layer 5/8" GWB	17.8	18.7	21.5	22.6	21.5	25.6	30.1	29.2	29.8	33.8	35.4	36.6	36.3	31.4	26.2	28.4	31.5
		2 Layers 5/8" GWB	22.4	23.6	27.2	27.9	26.6	30.4	34.1	32.1	31.7	35.7	37.8	39.9	40.3	36.2	33.3	36.1	39.0
		1 Layer 1/2" GWB	16.1	16.9	20.1	20.7	19.8	24.2	28.5	27.2	27.7	31.6	33.1	34.9	35.4	33.3	26.5	26.1	29.1
		2 Layers 1/2" GWB	20.9	22.1	24.9	25.9	25.3	29.1	33.1	31.4	31.3	34.2	35.2	37.3	38.6	37.5	32.3	33.1	36.3
		1 Layer Lt.Wt. 1/2" GWB	14.4	15.3	17.9	19.0	18.0	22.0	25.9	25.4	26.1	29.9	31.5	33.2	34.0	33.0	27.4	23.9	26.0
		2 Layers Lt.Wt. 1/2" GWB	19.6	20.9	23.3	24.6	23.4	27.6	31.3	30.5	30.5	32.9	33.8	35.7	36.9	36.7	32.6	30.7	33.4

loss values for the ceiling layer are given in Table 1.3.2b. Some of the layer transmission loss values given in Tables 1.3.2a and 1.3.2b are direct measurements from the partial assembly tests listed in Table 1.2.3. For other combinations of subfloor and framing for which partial assembly test data was not available, estimated values were derived based on a combination of available data from the partial assembly tests listed in Table 1.2.3 and available data from complete assembly tests listed in Table 1.2.1a.

1.3.3 Baseline Assemblies

The foundation upon which the models described in this report are built consists of eight separate baseline bare-floor assemblies. These baseline assemblies have components as described in Table 1.3.3. System effect values, χ_b, for each of these baseline assemblies are given in the top rows of Tables 1.3.4a through 1.3.4d.

For the untopped assemblies, separate baseline assembly system effects are used for each framing type included within the scope of the STC and IIC models (i.e., sawn lumber, prefabricated wood I-joists, and metal plate-connected parallel-chord wood trusses). Conversely, for assemblies with a cast-in-place topping, the same system effects are used for both sawn lumber and prefabricated wood I-joists. These system effects are based on data from I-joist-framed assemblies because no data was available to directly derive system effects for sawn lumber-framed assemblies. However, the use of these system effects for sawn lumber-framed assemblies appears to be justified, based on available validation data, as presented in Part II of this report. Since the database did not include any data on topped assemblies framed with metal plate-connected parallel-chord wood trusses, the models presented in this report are not applicable to such assemblies.

Table 1.3.3 Description of Components within Baseline Assemblies

STC Test Number	IIC Test Number	Baseline Assembly	Floor Layer Description	Insulation	Framing Description	Ceiling Layer Description
Mean Ref.	Mean Ref.	Untopped; Framing @ 16"o.c.	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-97-007a	IIF-97-004		1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-97-033a	IIF-97-017		1 Layer of 19/32" OSB	6" Fiberglass Batt	14" Trusses @ 16"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-96-035a	IIF-96-009	Untopped; Framing @ 24"o.c.	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @ 24"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-17-042	IIF-17-033		1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
(estimated)	(estimated)		1 Layer of 19/32" OSB	6" Fiberglass Batt	14" Trusses @ 24"o.c. & RC1 @ 24"o.c.	1 Layer of 5/8" GWB
TLF-17-049	IIF-17-038	Topped; Framing @ 16"o.c.	1 Layer of 23/32" OSB & 1" Gypsum Concrete	6" Fiberglass Batt	9.5" I-joists @ 16"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB
TLF-17-053	IIF-17-042	Topped; Framing @ 24"o.c.	1 Layer of 23/32" OSB & 1" Gypsum Concrete	6" Fiberglass Batt	9.5" I-joists @ 24"o.c. & RC1 @ 16"o.c.	1 Layer of 5/8" GWB

1.3.4 Influence of Component Variation on System Effect

As described in Section 1.2.5, many of the possible variations in components covered under the scope of these models result in differences in the system effect. Since the models are based on the system effects of the limited set of baseline assemblies given in Table 1.3.3, it is necessary to adjust these values to account for the influence of component variations on the system effect when the assembly under analysis has components that differ from those of the corresponding baseline assembly.

For most single-component-variations within assemblies having the same framing configuration and resilient channel spacing as the NRC reference assembly described in Section 1.2.1 (i.e., 2x10s at 16" o.c. and RCs at 24" o.c.), there was sufficient data to directly determine the influence of that component variation on the system effect. Wherever such data was available, the influence contours were derived directly at each frequency as the difference between the system effect value of the assembly having the single-component variation in question and that of the corresponding baseline assembly.

Data for assemblies having framing configurations and/or resilient channel spacing different from that of the NRC reference assembly was more limited. Thus, for many such assembly configurations, it was necessary to estimate the system effects and, by extension, the relative difference between the system effects of two assemblies. It was often possible to perform such estimations of system effects by interpolation and extrapolation of trends observed in other available data. In certain cases where there was insufficient data to derive a reasonable estimate through interpolation or extrapolation from multiple available data points, system effects were conservatively assumed to be equal to values directly derived from available test data on an assembly in which the component under investigation can be reasonably assumed to result in lower TL values for the overall assembly.

Baseline assembly system effect values, χ_b, and corresponding adjustments for component variations, δ_χ, for untopped assemblies (i.e., assemblies without a cast-in-place topping) with framing at 16 and 24 inches on-center are given in Tables 1.3.4a and 1.3.4b, respectively. Likewise, χ_b and δ_χ, values for assemblies having cast-in-place nominal 1-inch-thick gypsum concrete topping, with framing at 16 and 24 inches on-center are given in Tables 1.3.4c and 1.3.4d, respectively. Values shown in black print are derived directly from available test data on assemblies having the corresponding component variation. Values shown in grey print were estimated based on other available test data from similar assemblies.

1.3.5 Estimation of Impact Sound Pressure Levels (ISPL)

As described in Section 1.3.1.2, impact sound pressure levels (ISPL) are estimated for an assembly having a floor covering based on the estimated transmission loss (TL) values for the same bare-floor assembly without any floor covering. These estimated ISPL values are determined using adjustments which account for the effect of the floor covering, as well as other differences in the acoustical response of the assembly resulting from the differences between the test method described in ASTM E90 versus the test method described in ASTM E492. Based on ASTM E492 testing performed on a variety of typical floor coverings applied over six different base assemblies, ISPL adjustment values, Δ_{ISPL}, were derived for each possible combination of the following variations in the base assembly:

Table 1.3.4a **System Effects, X_b, of Baseline Assemblies having no Topping and Joists at 16” o.c.; with Corresponding System Effect Adjustments, δ_X**

Untopped Assemblies; Joists @ 16" o.c.		System Effect and Adjustments for Component Variences (dB) at Frequency:																
		100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz
Baseline Assembly	2x Framing	-5.1	-1.9	-2.3	0.2	2.2	1.6	2.7	2.5	3.0	1.3	2.2	1.1	0.0	0.6	1.8	0.1	-1.2
	I-joist Framing	-5.7	-2.2	-5.0	-2.2	-0.4	0.0	0.8	-1.0	-1.5	-2.2	-0.2	-0.4	-1.1	-2.1	0.9	0.0	-1.5
	Wood Truss Framing	-3.6	-1.3	-1.1	1.4	3.2	1.9	0.7	1.7	3.5	-0.2	1.5	-0.6	0.8	2.4	4.9	3.9	2.7
Joist Depth Variation	2x8s	-0.6	-1.8	-0.5	-0.9	0.3	0.4	0.1	0.3	-0.2	-0.5	-0.5	-0.3	-1.4	-2.4	-2.5	-2.0	-2.1
	2x10s	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2x12s	2.3	1.7	1.9	0.4	-0.6	0.3	0.7	0.1	-0.3	0.2	-1.1	-0.4	-0.1	-0.6	0.2	0.5	0.7
	< 14" I-joists	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	≥ 14" I-joists	7.0	2.7	3.3	1.9	0.8	-0.7	-0.4	0.4	2.5	2.4	1.0	0.6	0.0	3.0	3.3	2.4	1.9
	Wood Trusses (≤ 18")	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceiling Variation	1 Layer 5/8" GWB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2 Layers 5/8" GWB	-1.4	-0.2	-0.6	-1.3	-2.1	-2.6	-1.5	-0.8	0.3	0.4	-0.5	-0.7	-1.1	-1.5	-2.1	-2.5	-3.4
	1 Layer 1/2" GWB	1.5	0.9	1.3	0.4	0.1	0.5	0.4	1.0	0.8	0.2	0.0	1.1	1.8	1.5	0.5	0.2	0.3
	2 layers 1/2" GWB	0.2	1.0	0.9	0.6	0.0	0.2	1.3	1.4	1.1	0.4	-0.2	0.7	1.0	0.3	-0.3	-0.2	-1.4
	1 Layer 1/2" Lt.Wt.GWB	1.7	0.0	1.7	0.2	1.1	1.4	0.8	-0.5	-0.2	-0.8	1.3	1.4	1.7	0.3	-0.3	1.3	2.0
	2 layers 1/2" Lt.Wt.GWB	-0.1	-0.3	1.0	-0.6	0.1	0.1	0.9	0.2	0.6	0.2	0.7	0.9	1.2	0.1	-1.2	-0.9	-0.9
Insulation Variation	No Insulation (2x framing)	-3.3	-3.8	-5.5	-6.9	-9.2	-10.1	-9.3	-12.3	-10.2	-12.2	-13.3	-13.0	-11.6	-13.3	-12.0	-8.5	-6.8
	No Insulation (I-joist framing)	-3.8	-2.7	-3.1	-4.3	-6.8	-8.3	-7.9	-9.3	-7.8	-7.6	-9.4	-10.5	-11.8	-11.8	-14.3	-10.5	-7.4
	2.5" Fiberglass Batt	0.3	-0.5	-0.6	-1.7	-2.6	-1.8	-1.5	-1.2	-0.7	-1.7	-1.5	-1.0	0.1	1.5	0.5	0.4	0.5
	3.5" Fiberglass Batt	-0.3	-1.5	-0.9	-1.4	-1.4	-0.8	-1.0	-0.5	-0.8	-1.4	-1.5	-0.9	0.5	1.5	0.5	0.3	0.5
	6" Fiberglass Batt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8" Fiberglass Batt	0.7	0.1	1.0	0.8	1.4	1.9	1.6	2.4	1.7	1.7	0.3	0.5	1.0	1.6	1.0	1.2	1.3
	3.5" Mineral Wool Batt	-0.5	-1.1	-0.7	-1.3	-1.7	-0.6	-0.6	1.1	1.2	1.0	0.9	11	2.0	2.7	2.2	1.9	1.7
	8.3" Mineral Wool Batt	1.1	1.8	2.7	2.6	3.0	3.5	3.8	5.0	4.7	4.4	3.1	3.0	3.0	3.8	3.2	2.8	3.0
Subfloor Variation	1 Layer 19/32" OSB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2 Layers 19/32" OSB	-1.0	0.0	0.9	1.5	0.5	-0.6	-1.4	-1.5	-2.4	-3.6	-2.2	-1.0	0.2	0.0	-0.6	-0.8	-1.3
	1 Layer 23/32" OSB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2 Layers 1/2" Plywood	1.6	0.2	0.2	0.1	-0.2	-0.3	0.0	-0.3	-0.7	-1.1	-0.2	1.6	1.2	-1.4	-1.1	-0.4	-0.6
	1 Layer 19/32" Plywood	1.3	0.3	0.5	-1.6	-0.1	0.6	2.2	1.0	0.8	1.1	1.1	0.4	-0.3	-1.5	-1.1	-0.4	1.2
	2 Layers 19/32" Plywood	0.4	0.3	1.4	-0.2	0.4	0.0	0.7	-0.5	-1.6	-2.4	-1.1	-0.5	-0.1	-1.5	-1.7	-1.3	-0.2
	1 Layer 1" Plywood	0.3	0.2	0.5	0.1	-1.0	-0.4	-0.5	0.6	0.5	0.4	2.6	2.2	2.7	1.0	1.0	0.5	0.8
RC Spacing Variation	RCs @ 16" o.c. (2x Framed)	-1.0	-1.2	-0.2	0.0	0.2	0.0	-0.2	-0.4	-1.0	-0.9	-0.9	-0.1	-0.2	0.0	-0.5	-0.9	-1.0
	RCs @ 24" o.c. (2x or Truss Framed)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	RCs @ 16" o.c. (I-joist Framed)	-0.9	-3.7	-3.7	-2.0	-2.9	-3.1	-3.8	-2.3	-1.5	-0.4	0.9	0.2	1.2	1.2	-0.4	0.6	0.1
	RCs @ 24" o.c. (I-joist Framed)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 1.3.4b System Effects, X_b, of Baseline Assemblies having no Topping and Joists at 24" o.c.; with Corresponding System Effect Adjustments, δ_X

Untopped Assemblies; Joists @ 24" o.c.		System Effect and Adjustments for Component Variences (dB) at Frequency:																
		100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz
Baseline Assembly	2x Framing	-4.8	-1.5	0.3	3.7	5.6	3.8	2.5	4.3	4.7	2.7	3.4	2.2	1.0	1.3	2.4	1.0	-0.2
	I-joist Framing	-4.1	-3.4	-4.4	-0.3	2.2	-0.5	2.5	0.5	0.5	0.8	1.6	0.3	-0.3	-1.4	0.1	0.4	-1.5
	Wood Truss Framing	-4.2	-1.3	-1.6	2.3	4.5	1.9	-0.4	1.1	3.4	0.5	1.5	0.7	0.8	2.3	4.9	4.4	2.9
Joist Depth Variation	2x8s	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2x10s	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2x12s	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	< 14" I-joists	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	≥ 14" I-joists	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Wood Trusses (≤ 18")	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceiling Variation	1 Layer 5/8" GWB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2 Layers 5/8" GWB	1.5	1.7	1.3	-0.1	0.2	0.7	0.9	-0.6	0.2	0.5	-1.4	-0.3	-0.4	0.5	-0.4	-2.3	-2.5
	1 Layer 1/2" GWB	1.5	0.9	1.3	0.4	0.1	0.5	0.4	1.0	0.8	0.2	0.0	1.1	1.8	1.5	0.5	0.2	0.3
	2 layers 1/2" GWB	0.2	1.0	0.9	0.6	0.0	0.2	1.3	1.4	1.1	0.4	-0.2	0.7	1.0	0.3	-0.3	-0.2	-1.4
	1 Layer 1/2" Lt.Wt.GWB	1.7	0.0	1.7	0.2	1.1	1.4	0.8	-0.5	-0.2	-0.8	1.3	1.4	1.7	0.3	-0.3	1.3	2.0
	2 layers 1/2" Lt.Wt.GWB	-0.1	-0.3	1.0	-0.6	0.1	0.1	0.9	0.2	0.6	0.2	0.7	0.9	1.2	0.1	-1.2	-0.9	-0.9
Insulation Variation	No Insulation (2x framing)	-7.7	-3.9	-5.6	-6.8	-9.5	-14.7	-12.1	-14.1	-14.0	-14.3	-15.4	-15.3	-14.0	-15.2	-13.8	-10.7	-9.1
	No Insulation (I-joist framing)	-7.7	-2.8	-3.2	-4.2	-7.1	-12.9	-10.7	-11.1	-11.6	-9.7	-11.5	-12.8	-14.0	-13.7	-13.8	-10.7	-9.1
	2.5" Fiberglass Batt	0.6	-0.5	-0.6	-1.7	-2.7	-2.5	-1.9	-1.4	-1.0	-2.0	-1.8	-1.2	0.2	1.7	0.6	0.5	0.7
	3.5" Fiberglass Batt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	6" Fiberglass Batt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8" Fiberglass Batt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.5" Mineral Wool Batt	-0.5	-1.1	-0.7	-1.3	-1.7	-0.6	-0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8.3" Mineral Wool Batt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subfloor Variation	1 Layer 19/32" OSB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2 Layers 19/32" OSB	-1.0	0.0	0.9	1.5	0.5	-0.6	-1.4	-1.5	-2.4	-3.6	-2.2	-1.0	0.2	0.0	-0.6	-0.8	-1.3
	1 Layer 23/32" OSB (2x Framing)	1.8	-0.7	-1.3	-0.9	1.3	0.1	-0.6	-0.2	-0.5	-0.5	-0.4	-0.3	-0.8	-1.6	-1.6	-1.1	-0.6
	1 Layer 23/32" OSB (I-joists or Trusses)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2 Layers 1/2" Plywood	1.6	0.2	0.2	0.1	-0.2	-0.3	0.0	-0.3	-0.7	-1.1	-0.2	1.6	1.2	-1.4	-1.1	-0.4	-0.6
	1 Layer 19/32" Plywood	1.3	0.3	0.5	-1.6	-0.1	0.6	2.2	1.0	0.8	1.1	1.1	0.4	-0.3	-1.5	-1.1	-0.4	1.2
	2 Layers 19/32" Plywood	0.4	0.3	1.4	-0.2	0.4	0.0	0.7	-0.5	-1.6	-2.4	-1.1	-0.5	-0.1	-1.5	-1.7	-1.3	-0.2
	1 Layer 1" Plywood	0.3	0.2	0.5	0.1	-1.0	-0.4	-0.5	0.6	0.5	0.4	2.6	2.2	2.7	1.0	1.0	0.5	0.8
RC Spacing Variation	RCs @ 16" o.c. (2x Framed)	-1.0	-1.2	-0.2	0.0	0.2	0.0	-0.2	-0.4	-1.0	-0.9	-0.9	-0.1	-0.2	0.0	-0.5	-0.9	-1.0
	RCs @ 24" o.c. (2x or Truss Framed)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	RCs @ 16" o.c. (I-joist Framed)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	RCs @ 24" o.c. (I-joist Framed)	0.0	1.1	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0

Table 1.3.4c **System Effects, X_b, of Baseline Assembly Having 1" Gypsum Concrete and Joists at 16" o.c.; with Corresponding System Effect Adjustments, δ_X**

	Assemblies with 1" GC over min 19/32" OSB or Plywood; Joists @ 16" o.c.	System Effect and Adjustments for Component Variences (dB) at Frequency:																
		100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz
Baseline Assembly (2x or I-joist Framing)		-7.3	-3.3	-4.2	-0.2	2.9	4.4	5.0	2.5	2.4	4.1	5.8	4.2	4.6	4.1	6.2	7.8	9.1
Ceiling Variation	1 Layer 5/8" GWB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2 Layers 5/8" GWB	-2.6	-1.6	-1.3	-2.4	-2.0	-2.7	-0.4	0.2	1.5	1.2	0.0	0.8	0.7	1.9	-1.0	-2.7	-3.1
	1 Layer 1/2" GWB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2 layers 1/2" GWB	-2.6	-1.6	-1.3	-2.4	-2.0	-2.7	-0.4	0.2	1.5	1.2	0.0	0.8	0.7	1.9	-1.0	-2.7	-3.1
	1 Layer 1/2" Lt.Wt.GWB	0.5	-1.4	0.9	-0.9	1.2	1.4	1.9	0.5	1.0	0.0	1.9	2.9	3.6	3.6	0.7	1.1	2.4
	2 layers 1/2" Lt.Wt.GWB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insulation Variation	No Insulation	-3.3	-3.9	-5.1	-4.9	-5.3	-3.2	-2.9	-3.4	-1.7	-4.6	-6.1	-8.0	-5.8	-4.7	-4.9	-4.2	-3.3
	2.5" Fiberglass Batt	0.3	-0.5	-0.6	-1.2	-1.5	-0.6	-0.5	-0.3	-0.1	-0.6	-0.7	-0.6	0.1	0.5	0.2	0.2	0.2
	3.5" Fiberglass Batt	-0.3	-1.5	-0.8	-1.0	-0.8	-0.2	-0.3	-0.1	-0.1	-0.5	-0.7	-0.6	0.2	0.5	0.2	0.1	0.2
	6" Fiberglass Batt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8" Fiberglass Batt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.5" Mineral Wool Batt	-0.5	-1.2	-0.7	-0.9	-1.0	-0.2	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8.3" Mineral Wool Batt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC Spacing Variation	RCs @ 16" o.c. (2x Framed)	7.4	6.9	5.1	3.8	2.5	1.5	1.6	2.3	1.9	-0.4	-0.3	1.2	0.1	-0.3	0.5	-2.0	-4.7
	RCs @ 24" o.c. (2x Framed)	7.4	6.9	5.1	3.8	2.5	1.5	1.6	2.3	1.9	-0.4	-0.3	1.2	0.1	-0.3	0.5	-2.0	-4.7
	RCs @ 16" o.c. (I-joist Framed)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	RCs @ 24" o.c. (I-joist Framed)	7.4	6.9	5.1	3.8	2.5	1.5	1.6	2.3	1.9	-0.4	-0.3	1.2	0.1	-0.3	0.5	-2.0	-4.7

Table 1.3.4d **System Effects, X_b, of Baseline Assembly Having 1" Gypsum Concrete and Joists at 24" o.c.; with Corresponding System Effect Adjustments, δ_X**

	Assemblies with 1" GC over min 19/32" OSB or Plywood; Joists @ 24" o.c.	System Effect and Adjustments for Component Variences (dB) at Frequency:																
		100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz
Baseline Assembly (2x or I-joist Framing)		1.1	4.4	0.1	2.3	4.8	6.7	9.6	6.9	6.1	7.2	9.2	7.8	7.7	5.8	7.9	9.0	9.5
Ceiling Variation	1 Layer 5/8" GWB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2 Layers 5/8" GWB	1.5	-1.6	-2.8	-6.3	-4.8	-4.3	-2.8	-3.4	-1.9	-2.1	-3.9	-2.8	-3.4	-2.1	-4.4	-6.2	-6.4
	1 Layer 1/2" GWB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2 layers 1/2" GWB	1.5	-1.6	-2.8	-6.3	-4.8	-4.3	-2.8	-3.4	-1.9	-2.1	-3.9	-2.8	-3.4	-2.1	-4.4	-6.2	-6.4
	1 Layer 1/2" Lt.Wt.GWB	-1.2	1.3	3.9	5.1	3.8	3.0	2.2	2.1	2.0	1.8	4.7	3.6	4.0	0.9	2.1	5.0	5.0
	2 layers 1/2" Lt.Wt.GWB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insulation Variation	No Insulation	-7.7	-4.0	-5.2	-4.8	-5.6	-7.8	-5.7	-5.2	-5.5	-6.7	-8.2	-10.3	-8.2	-6.6	-6.7	-6.4	-5.6
	2.5" Fiberglass Batt	0.6	-0.5	-0.6	-1.2	-1.6	-1.3	-0.9	-0.5	-0.4	-0.9	-0.9	-0.8	0.1	0.8	0.3	0.3	0.4
	3.5" Fiberglass Batt	-0.8	-1.5	-0.8	-1.0	-0.8	-0.6	-0.6	-0.2	-0.4	-0.8	-0.9	-0.7	0.3	0.8	0.3	0.2	0.4
	6" Fiberglass Batt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8" Fiberglass Batt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.5" Mineral Wool Batt	-1.1	-1.2	-0.7	-0.9	-1.0	-0.5	-0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8.3" Mineral Wool Batt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC Spacing Variation	RCs @ 16" o.c. (2x Framed)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	RCs @ 24" o.c. (2x Framed)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	RCs @ 16" o.c. (I-joist Framed)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	RCs @ 24" o.c. (I-joist Framed)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

- Presence or absence of a gypsum concrete topping cast in place over the subfloor
- Number of layers of gypsum wallboard in the ceiling (1 or 2 layers)
- Presence or absence of insulation within the floor cavity

The graph in Figure 1.3.5 provides an example of how these variables within the base assembly can affect the ISPL adjustment values, Δ_{ISPL}, across the 1/3-octave band center frequencies ranging from 100 Hz up to 4000 Hz, even when the same floor covering is used. All of the contours shown in Figure 1.3.5 correspond to assemblies having a floating wood laminate (i.e., click laminate) floor covering.

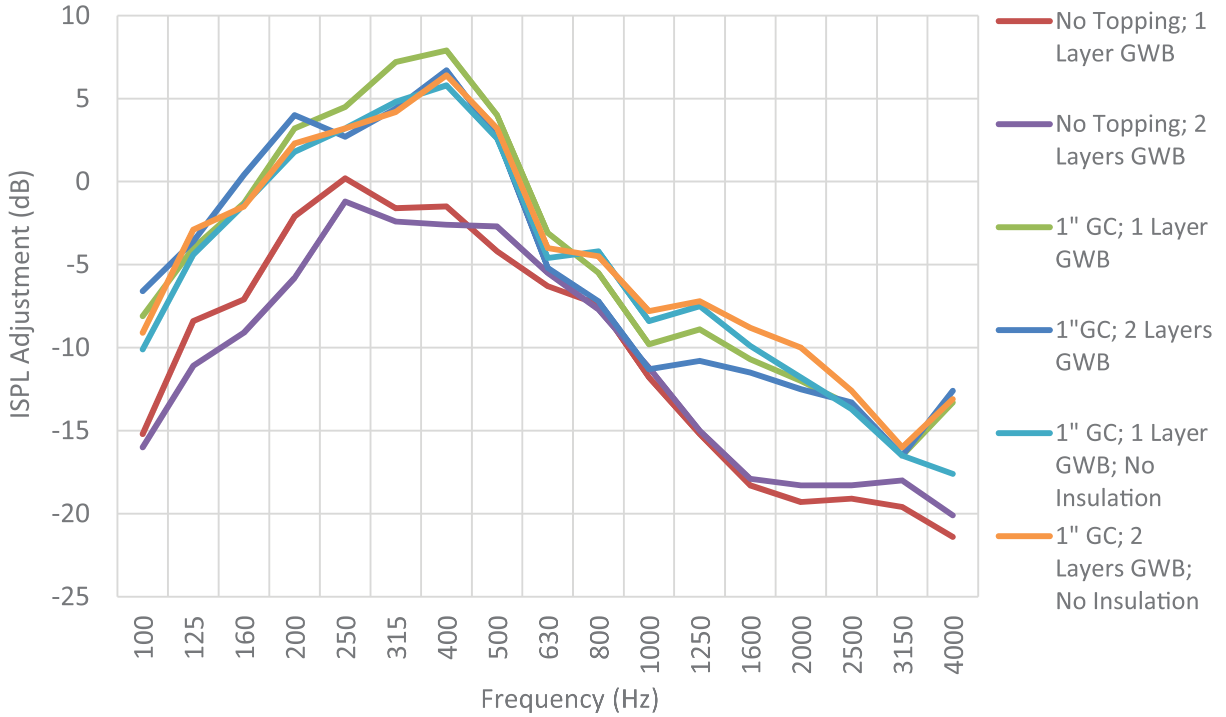
It is neither feasible nor within the scope of this report to derive and publish Δ_{ISPL} values corresponding to all of the floor covering products available on the market at this time. This is due, in part, to the following factors:

- Floor coverings are typically proprietary.
- There is a vast array of different floor covering types available on the market at the present time with widely varying formulations, quality and acoustical performance characteristics.
- As a result of technical innovation, changing fashions and marketing practice, the array of available floor coverings is in a constant state of flux. These changes will likely affect the acoustical performance of the floor coverings.

Because of these factors, product-specific information on the acoustical performance characteristics of proprietary floor coverings should be obtained from the floor covering manufacturer. However, Δ_{ISPL} values were derived for a limited number of some common generic floor covering types. For each combination of the aforementioned variables in a bare-floor assembly, Δ_{ISPL} values were derived or estimated, corresponding to each of the following five generic floor covering types:

- Thin carpet (0.24” thick, 20 oz/yd^2) over a typical underpad (0.31” thick, 0.20 psf)
- Thick carpet (0.63” thick, 60 oz/yd^2) over a typical underpad (0.31” thick, 0.20 psf)
- Cushioned sheet vinyl flooring (0.06” thick, 0.9 psf)
- Floating wood laminate (i.e., click laminate) flooring (0.31” thick, 1.35 psf) over a thin closed-cell foam underlay (0.06” thick, negligible weight)

Figure 1.3.5 ISPL Adjustments for Floating Wood Laminate (i.e., Click Laminate) Floor Covering over Various Base Assemblies



- Ceramic tiles (0.31” thick, 3.1 psf) applied over a rubber underlay (0.12” thick, 0.45 psf), applied over grout and thinset (0.20” thick, 0.66 psf)

The ISPL adjustment values, Δ_{ISPL}, derived for these bare-floor assembly and floor covering combinations are given in Table 1.3.5.

In addition to the ISPL adjustment values, Δ_{ISPL}, it was necessary to derive additional ISPL adjustments for assemblies framed with wood trusses. These adjustment values, given at the bottom of Table 1.3.5, are additive to the Δ_{ISPL} values corresponding to the base assembly and floor covering combination.

Table 1.3.5 ISPL adjustment values, Δ_{ISPL}, for common generic floor coverings over various base assemblies

Base Assembly	Floor Covering	ISPL Adjustments (dB) at Frequency:																
		100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz
No Topping; 1 Layer GWB	Thin Carpet	-31.8	-32.5	-35.6	-28.1	-26.8	-25.4	-23.4	-23.1	-24.3	-29.8	-32.1	-34.8	-39.1	-42.4	-42.8	-39.5	-33.0
	Thick Carpet	-37.5	-36.5	-39.6	-33.8	-29.3	-27.2	-24.2	-24.4	-26.1	-32.0	-34.2	-36.9	-40.6	-44.5	-43.3	-39.9	-33.1
	Cushioned Vinyl	-14.7	-6.2	-4.7	1.0	3.2	3.4	5.2	7.7	8.5	4.1	0.6	-5.0	-10.1	-12.8	-15.6	-15.2	-16.1
	Click Laminate	-15.2	-8.4	-7.1	-2.1	0.2	-1.6	-1.5	-4.2	-6.3	-7.4	-11.8	-15.2	-18.3	-19.3	-19.1	-19.6	-21.4
	Ceramic Tile	-21.1	-14.3	-10.7	-5.6	-1.2	-0.1	2.6	6.2	7.1	6.4	3.5	-0.9	-3.9	-4.4	-5.3	-2.3	-1.4
No Topping; 2 Layers GWB	Thin Carpet	-32.6	-35.2	-37.6	-31.8	-28.2	-26.2	-24.5	-21.6	-23.5	-30.1	-31.5	-34.6	-38.7	-41.4	-42.0	-37.9	-31.7
	Thick Carpet	-38.3	-39.2	-41.6	-37.5	-30.7	-28.0	-25.3	-22.9	-25.3	-32.3	-33.6	-36.7	-40.2	-43.5	-42.5	-38.3	-31.8
	Cushioned Vinyl	-15.5	-8.9	-6.7	-2.7	1.8	2.6	4.1	9.2	9.3	3.8	1.2	-4.8	-9.7	-11.8	-14.8	-13.6	-14.8
	Click Laminate	-16.0	-11.1	-9.1	-5.8	-1.2	-2.4	-2.6	-2.7	-5.5	-7.7	-11.2	-15.0	-17.9	-18.3	-18.3	-18.0	-20.1
	Ceramic Tile	-21.9	-17.0	-12.7	-9.3	-2.6	-0.9	1.5	7.7	7.9	6.1	4.1	-0.7	-3.5	-3.4	-4.5	-0.7	-0.1
1" GC Topping; 1 Layer GWB	Thin Carpet	-22.4	-25.0	-30.6	-25.2	-24.1	-21.6	-19.2	-19.5	-23.1	-28.9	-32.2	-28.6	-26.3	-27.8	-27.2	-21.2	-14.4
	Thick Carpet	-28.7	-29.8	-33.8	-29.4	-26.3	-21.9	-19.3	-21.7	-25.9	-30.8	-33.7	-29.3	-26.6	-28.2	-27.4	-21.2	-14.4
	Cushioned Vinyl	-9.6	-5.1	-1.7	2.9	5.2	9.8	12.1	13.0	14.3	11.2	8.1	7.8	7.6	6.8	5.2	0.0	-4.3
	Click Laminate	-8.1	-4.0	-1.3	3.2	4.5	7.2	7.9	4.0	-3.1	-5.5	-9.8	-8.9	-10.7	-12.0	-13.5	-16.5	-13.3
	Ceramic Tile	-11.1	-6.1	-3.0	1.2	3.9	8.9	11.5	12.9	15.2	13.3	11.4	12.4	11.9	10.9	11.9	9.8	8.0
1" GC Topping; 2 Layers GWB	Thin Carpet	-20.9	-24.6	-28.9	-24.4	-25.9	-24.4	-20.4	-20.8	-25.2	-30.6	-33.7	-30.5	-27.1	-28.3	-27.0	-21.2	-13.7
	Thick Carpet	-27.2	-29.4	-32.1	-28.6	-28.1	-24.7	-20.5	-23.0	-28.0	-32.5	-35.2	-31.2	-27.4	-28.7	-27.2	-21.2	-13.7
	Cushioned Vinyl	-8.1	-4.7	0.0	3.7	3.4	7.0	10.9	11.7	12.2	9.5	6.6	5.9	6.8	6.3	5.4	0.0	-3.6
	Click Laminate	-6.6	-3.6	0.4	4.0	2.7	4.4	6.7	2.7	-5.2	-7.2	-11.3	-10.8	-11.5	-12.5	-13.3	-16.5	-12.6
	Ceramic Tile	-9.6	-5.7	-1.3	2.0	2.1	6.1	10.3	11.6	13.1	11.6	9.9	10.5	11.1	10.4	12.1	9.8	8.7
1" GC Topping; 1 Layer GWB; No Insulation	Thin Carpet	-24.4	-25.4	-30.7	-26.6	-25.4	-24.0	-21.3	-20.9	-24.6	-27.6	-30.8	-27.2	-25.5	-27.6	-27.4	-21.2	-18.7
	Thick Carpet	-30.7	-30.2	-33.9	-30.8	-27.6	-24.3	-21.4	-23.1	-27.4	-29.5	-32.3	-27.9	-25.8	-28.0	-27.6	-21.2	-18.7
	Cushioned Vinyl	-11.6	-5.5	-1.8	1.5	3.9	7.4	10.0	11.6	12.8	12.5	9.5	9.2	8.4	7.0	5.0	0.0	-8.6
	Click Laminate	-10.1	-4.4	-1.4	1.8	3.2	4.8	5.8	2.6	-4.6	-4.2	-8.4	-7.5	-9.9	-11.8	-13.7	-16.5	-17.6
	Ceramic Tile	-13.1	-6.5	-3.1	-0.2	2.6	6.5	9.4	11.5	13.7	14.6	12.8	13.8	12.7	11.1	11.7	9.8	3.7
1" GC Topping; 2 Layers GWB; No Insulation	Thin Carpet	-23.4	-23.9	-30.8	-26.1	-25.4	-24.6	-20.7	-20.3	-24.0	-27.9	-30.2	-26.9	-24.4	-25.8	-26.3	-20.7	-14.2
	Thick Carpet	-29.7	-28.7	-34.0	-30.3	-27.6	-24.9	-20.8	-22.5	-26.8	-29.8	-31.7	-27.6	-24.7	-26.2	-26.5	-20.7	-14.2
	Cushioned Vinyl	-10.6	-4.0	-1.9	2.0	3.9	6.8	10.6	12.2	13.4	12.2	10.1	9.5	9.5	8.8	6.1	0.5	-4.1
	Click Laminate	-9.1	-2.9	-1.5	2.3	3.2	4.2	6.4	3.2	-4.0	-4.5	-7.8	-7.2	-8.8	-10.0	-12.6	-16.0	-13.1
	Ceramic Tile	-12.1	-5.0	-3.2	0.3	2.6	5.9	10.0	12.1	14.3	14.3	13.4	14.1	13.8	12.9	12.8	10.3	8.2
		Additional ISPL Adjustments for Assemblies having Wood Truss Framing:																
Wood Trusses @16"o.c.:		6.3	7.1	9.3	6.2	3.2	3.5	0.8	1.0	1.0	-2.5	-1.2	-3.0	-0.9	-0.1	0.3	1.3	3.5
Wood Trusses @24"o.c.:		4.0	2.0	3.6	5.1	5.9	2.9	2.7	1.6	2.2	0.5	0.5	0.8	0.0	1.5	2.7	3.7	5.4

Part II: Model Accuracy and Validation

2.1 General

For the purpose of validation, the sound transmission class (STC) model described in Part I was used to estimate a total of 90 STC values of tested assemblies for which NRC test data was available. This included data from 83 assemblies with component combinations within the scope of the model, and 7 assemblies having one component that fell outside the scope of the model. In addition, the impact insulation class (IIC) model, which is based on the STC model, was further validated for assemblies having floor coverings using data from another 18 available NRC-tested assemblies. Model-estimated values for all 101 of the assemblies having component combinations within the scope of the models were within ± 3 STC or IIC points, and approximately 97% of them were within ± 2 STC or IIC points. A comparison of model-estimated values to test values from the modeling database is presented in Section 2.2. Comparisons of model-estimated STC and IIC values to validation data and other available data are presented in Section 2.3.

2.2 Model-Estimated Values vs. Modeling Database Test Values

The STC values calculated using the model presented in Part I generally match the measured STC values for each of the 48 test assemblies represented within the modeling database. These 1:1 matches for which the model-estimated STC values are equal to the measured values are represented by the data points falling directly on the diagonal line in the scatterplot shown in Figure 2.2a. The lightly shaded dots in Figure 2.2a represent a single data point, whereas the dots with a darker shading represent multiple data points of assemblies having the same coordinates of measured versus estimated STC.

Cases in which the model-estimated values do not exactly match the measured values are limited to a few of the baseline I-joist-framed and wood truss-framed assemblies. For example, several of the data points having a model-estimated STC of 51, as shown in Figure 2.2a correspond to assemblies having 9.5"-deep prefabricated wood I-joists. The truss-framed assemblies are represented by data points having model-estimated STC values of 53 and 54. For I-joist-framed assemblies and wood truss-framed assemblies, multiple TL data points for otherwise identical assemblies having framing from differing manufacturers and/or joist series were averaged at each frequency. For I-joist-framed assemblies, all of the values averaged in this manner were from assemblies framed with I-joists of the same nominal depth (9.5"). For wood truss-framed assemblies, the available data did not indicate a correlation between truss depth and measured STC values. Thus, the TL data for otherwise identical wood truss-framed assemblies were averaged for all truss depths. Although this averaging approach results in slight underestimates for some of the data points and slight overestimates for others, all except one of the estimated values are within -2 STC points (underestimation) and +1 STC point (overestimation) of the measured value. The single data point falling outside this range had a model-estimated STC that was 3 points higher than the measured value. This is illustrated in the histogram shown in Figure 2.2b.

Assemblies represented within the modeling database used to develop the STC model are listed in Table 2.2, along with the corresponding measured and estimated STC values. Cells shaded in yellow indicate a variation from the corresponding component of the reference assembly, within an assembly in which all other components are the same as those used in the reference assembly. As noted in Section 1.2.5, this is referred to as a single-component variation. Cells shaded in light blue indicate component variations within assemblies having multiple component variations from the reference assembly.

2.3 Comparison Of Model-Estimated Values To Other Available Data

For the purpose of model validation, a number of STC and IIC data points from tests that were not included within the modeling database were compared to values estimated using the STC and IIC models. Although more than 300 STC and IIC data points were initially compiled for this study, most of the data that was available outside the modeling database could not be used to validate the models for one or more of the following reasons:

- Specific information necessary to estimate TL or ISPL values, and hence STC or IIC values, was unavailable for the tested assembly.
- The test data was for an assembly having component combinations or component types, dimensions, etc. that were outside the scope of the model.
- The data was from testing performed at a laboratory other than NRC. As explained in Section 1.2.1, NRC test data was used exclusively in order to ensure

Figure 2.2a **Measured versus modeled STC values for data within the bare-floor modeling database**

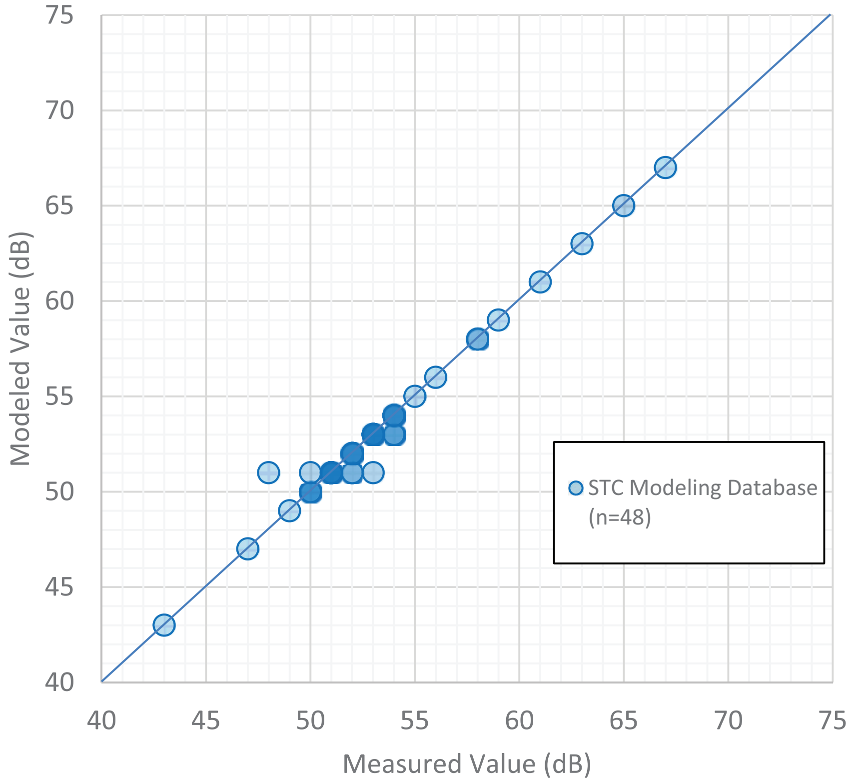


Figure 2.2b **Histogram of differences between model-estimated versus measured values within the modeling database**

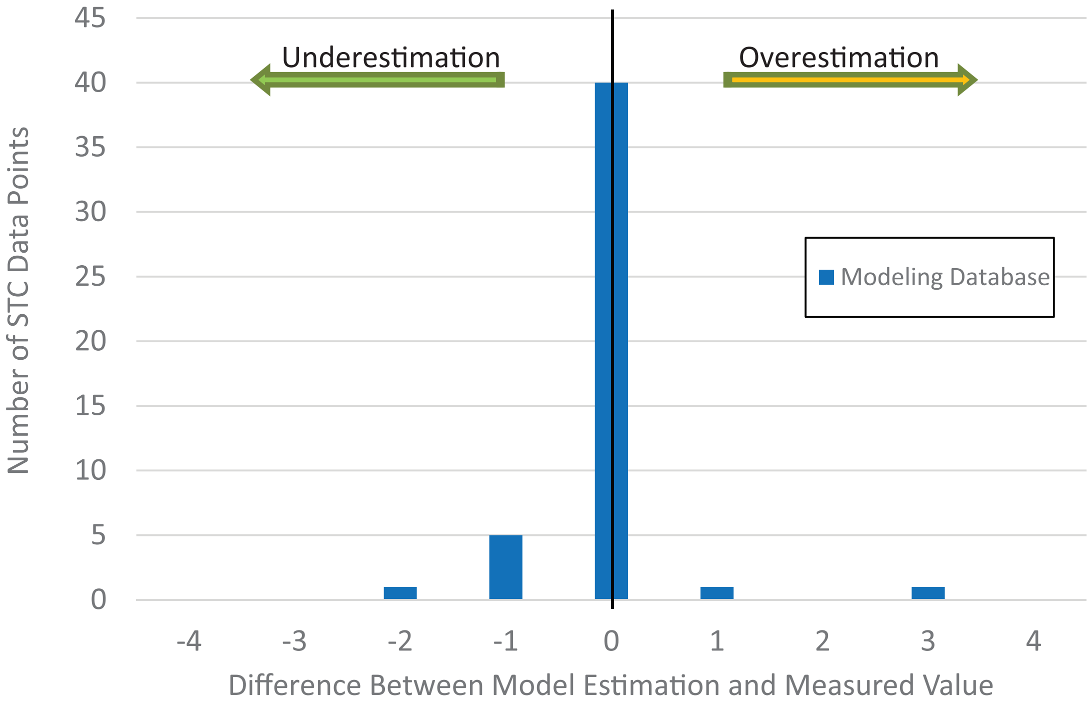


Table 2.2 **Descriptions of assemblies within the modeling database with corresponding measured versus estimated STC values**

STC Test Number	Floor Covering	Floor Layer Description	Insulation	Framing Description	RC Spacing	Ceiling Layer Description	Measured STC	Predicted STC
Mean Ref.	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	52	52
TLF-95-063a	(none)	1 Layer of 19/32" OSB	2.5" Fiberglass Batt	2x10s@ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	50	50
TLF-95-065a	(none)	1 Layer of 19/32" OSB	3.5" Mineral Wool Batt	2x10s @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	51	51
TLF-95-067a	(none)	1 Layer of 19/32" OSB	8.3" Mineral Wool Batt	2x10s @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	54	54
TLF-95-075a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @16"o.c.	16"o.c.	1 Layer of 5/8" GWB	50	50
TLF-95-085a	(none)	1 Layer of 19/32" OSB	3.5" Fiberglass Batt	2x10s@ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	51	51
TLF-95-089a	(none)	1 Layer of 19/32" OSB	8" Fiberglass Batt	2x10s @16"o.c.	24"o.c.	1 Layer of 5/8" GWB	53	53
TLF-95-107a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @16"o.c.	24"o.c.	2 Layers of 5/8" GWB	55	55
TLF-95-113a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @16"o.c.	24"o.c.	1 Layer of 1/2" GWB	51	51
TLF-95-115a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @16"o.c.	24"o.c.	2 Layers of 1/2" GWB	56	56
TLF-95-123a	(none)	2 Layers of 19/32" OSB	6" Fiberglass Batt	2x10s@ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	54	54
TLF-95-127a	(none)	1 Layer of 23/32" OSB	6" Fiberglass Batt	2x10s @16"o.c.	24"o.c.	1 Layer of 5/8" GWB	52	52
TLF-95-129a	(none)	2 Layers of 1/2" Plywood	6" Fiberglass Batt	2x10s @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	51	51
TLF-95-133a	(none)	1 Layer of 19/32" Plywood	6" Fiberglass Batt	2x10s @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	50	50
TLF-95-149a	(none)	2 Layers of 19/32" Plywood	6" Fiberglass Batt	2x10s @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	53	53
TLF-95-155a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @16"o.c.	24"o.c.	1 Layer 1/2" Lt.Wt. GWB	49	49
TLF-95-157a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @16"o.c.	24"o.c.	2 Layers 1/2" Lt.Wt. GWB	54	54
TLF-95-159a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x8s @16"o.c.	24"o.c.	1 Layer of 5/8" GWB	50	50
TLF-95-215a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x12s @16"o.c.	24"o.c.	1 Layer of 5/8" GWB	52	52
TLF-96-035a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @24"o.c.	24"o.c.	1 Layer of 5/8" GWB	54	54
TLF-96-039a	(none)	1 Layer of 23/32" OSB	6" Fiberglass Batt	2x10s @24"o.c.	24"o.c.	1 Layer of 5/8" GWB	53	53
TLF-96-061a	(none)	1 Layer of 1" Plywood	6" Fiberglass Batt	2x10s @16"o.c.	24"o.c.	1 Layer of 5/8" GWB	52	52
TLF-96-063a	(none)	1 Layer of 19/32" OSB	(no insulation)	2x10s @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	43	43
TLF-96-069a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	51	51
TLF-96-071a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	51	51
TLF-96-073a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	52	51
TLF-96-075a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	14" I-joists @16"o.c.	24"o.c.	1 Layer of 5/8" GWB	53	53
TLF-96-101a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	18" I-joists @16"o.c.	24"o.c.	1 Layer of 5/8" GWB	53	53

Table 2.2 (continued) Descriptions of assemblies within the modeling database with corresponding measured versus estimated STC values

STC Test Number	Floor Covering	Floor Layer Description	Insulation	Framing Description	RC Spacing	Ceiling Layer Description	Measured STC	Predicted STC
TLF-96-127a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	52	51
TLF-96-131a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	53	51
TLF-96-159a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	50	51
TLF-97-007a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	48	51
TLF-97-033a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	14" Trusses @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	54	53
TLF-97-043a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	18" Trusses @ 24"o.c.	24"o.c.	1 Layer of 5/8" GWB	53	53
TLF-97-045a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	14" Trusses @ 24"o.c.	24"o.c.	1 Layer of 5/8" GWB	54	53
TLF-97-047a	(none)	1 Layer of 23/32" OSB	6" Fiberglass Batt	14" Trusses @ 24"o.c.	24"o.c.	1 Layer of 5/8" GWB	54	53
TLF-97-049a	(none)	1 Layer of 23/32" OSB	6" Fiberglass Batt	18" Trusses @ 24"o.c.	24"o.c.	1 Layer of 5/8" GWB	53	53
TLF-16-031	(none)	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	51	51
TLF-16-041	(none)	1 Layer of 23/32" OSB & 1" GC	6" Fiberglass Batt	9.5" I-joists @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	63	63
TLF-17-042	(none)	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8" GWB	52	52
TLF-17-045	(none)	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c.	16"o.c.	1 Layer of 5/8" GWB	47	47
TLF-17-049	(none)	1 Layer of 23/32" OSB & 1" GC	6" Fiberglass Batt	9.5" I-joists @ 16"o.c.	16"o.c.	1 Layer of 5/8"GWB	58	58
TLF-17-050	(none)	1 Layer of 23/32" OSB & 1" GC	6" Fiberglass Batt	9.5" I-joists @ 16"o.c.	16"o.c.	2 Layers of 5/8" GWB	61	61
TLF-17-051	(none)	1 Layer of 23/32" OSB & 1" GC	(no insulation)	9.5" I-joists @ 16"o.c.	16"o.c.	1 Layer of 5/8" GWB	54	54
TLF-17-053	(none)	1 Layer of 23/32" OSB & 1" GC	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8"GWB	65	65
TLF-17-059	(none)	1 Layer of 23/32" OSB & 1" GC	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	2 Layers of 5/8" GWB	67	67
TLF-17-062	(none)	1 Layer of 23/32" OSB & 1" GC	(no insulation)	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8" GWB	59	59
TLF-17-074	(none)	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	2 Layers of 5/8" GWB	58	58

consistency within the database and avoid potential confounding influences resulting from lack of reproducibility between laboratories.

Suitable sound transmission class and impact insulation class data from a total of 39 assemblies outside the modeling database were available for use in model validation. In addition, STC and IIC data from seven other assemblies which included a single component falling outside the model scope were available. While data from the seven assemblies falling outside the scope of the model were not included in the model validation analysis, they are depicted in the scatterplots shown in Figures 2.3.1a and 2.3.2a. A validation analysis of the STC model (which also serves as the basis of the IIC model) is presented in Section 2.3.1. An additional validation analysis of the IIC model for assemblies having the five generic floor coverings described in Section 1.3.5 is presented in Section 2.3.2.

2.3.1 STC Model Validation

Of the 39 available validation assemblies made up of component combinations within the scope of the model, 35 were bare-floor (i.e., without a floor covering) and could therefore be used for validation of the STC model. Data from assemblies having sawn lumber or prefabricated wood I-joist framing members comprise about three-quarters of this validation database (26 assemblies), while data from assemblies framed with metal plate-connected wood trusses make up the remaining quarter (9 assemblies). Descriptions of the 26 assemblies framed with sawn lumber and I-joist framing members are listed in Table 2.3.1a, along with corresponding measured and estimated STC values. Descriptions of the 9 assemblies framed with metal plate-connected wood trusses, along with corresponding measured versus estimated STC values, are given in Table 2.3.1b. As indicated by the cells shaded in light blue, each of the assemblies in Tables 2.3.1a and 2.3.1b have at least two components which vary from those of the reference assembly.

A scatterplot of measured versus estimated STC values for assemblies within the validation database is shown in Figure 2.3.1a. The large green dots in this figure represent STC validation data from assemblies framed with sawn lumber and prefabricated wood I-joists, while the large grey dots represent validation data from assemblies framed with wood trusses. Additional data points from the seven assemblies having a component falling outside the model scope are included as small yellow dots. For ease of comparison, data points from the modeling database are also shown in this graph, as small blue dots.

Histograms of differences between model estimations and measured values of data used to validate the STC model are shown in Figures 2.3.1b and 2.3.1c. Figure 2.3.1b represents assemblies framed with sawn lumber and I-joists, while Figure 2.3.1c represents assemblies framed with wood trusses. All 35 of the estimated values for the assemblies within the STC validation database were within -3 STC points (underestimation) and +2 STC points (overestimation), with approximately 83% falling within ±1 STC point.

On average, the difference between model-estimated values and measured values for the STC validation data on sawn lumber and I-joist-framed assemblies was an underestimation of -0.8 points. This conservative tendency of the model to slightly underestimate the STC of assemblies having more than one component variation from the corresponding baseline assembly decreases the likelihood of significant overestimations for assemblies with component combinations not represented within either the modeling database or the validation database.

The average difference between estimated values and measured values for truss-framed assemblies within the validation database was a slight overestimate of +0.4 points. A comparison of the distribution shown in Figure 2.3.1b to that shown in Figure 2.3.1c reveals this difference between the mean error of truss-framed assemblies versus that of lumber and I-joist-framed assemblies. It should be noted that the trusses represented within the validation database were different from any of those represented within the modeling database. Specifically, the trusses represented within the validation database were all 12 inches deep, whereas those represented within the modeling database ranged from 14 inches to 18 inches deep. As noted in Section 2.2, the available data did not indicate a correlation between truss depth and measured STC values; however, since the truss depth represented within the validation database falls outside (below) the range of those represented within the modeling database, it is possible that truss depth may be a confounding factor.

2.3.2 IIC Model Validation

In addition to the test data from 35 bare-floor assemblies available for the purpose of model validation (Section 2.3.1), test data from four assemblies having floor coverings was also available for the purpose of validating the IIC model. These assemblies are described in Table 2.3.2, along with the 14 assemblies within the modeling database having floor coverings, with corresponding estimated and measured IIC values. Impact sound pressure level (ISPL) and transmission loss (TL) data for floor-covered assemblies having IIC test numbers starting with "IIF-17…" were used as part of the IIC modeling database, while IIC data for assemblies having IIC test numbers starting with

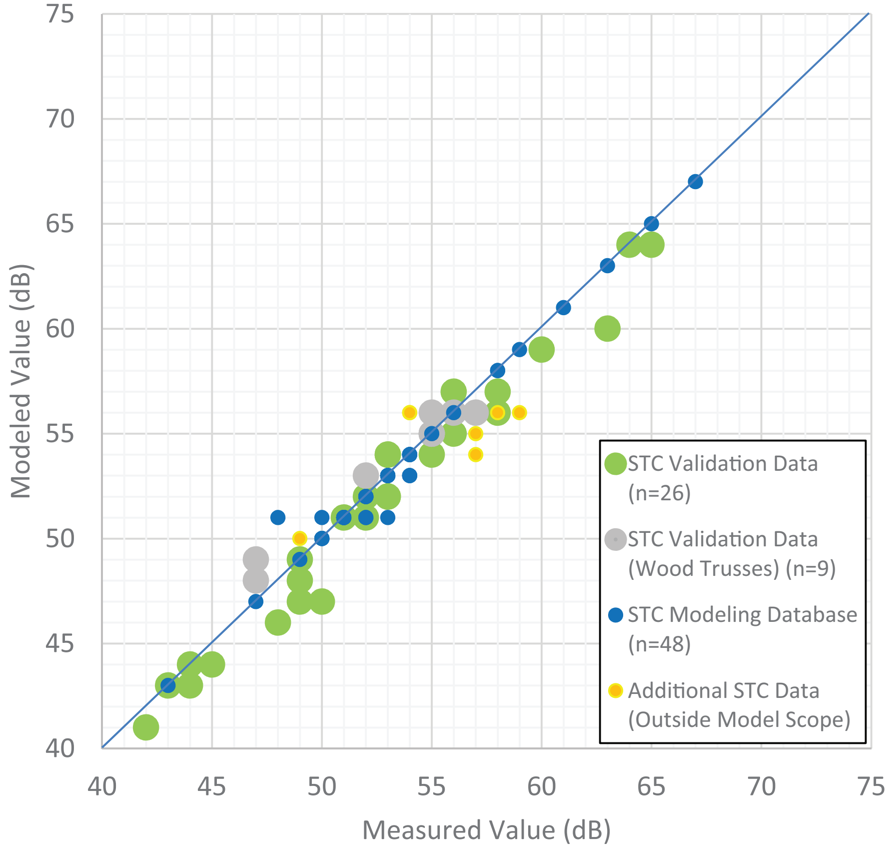
Table 2.3.1a Assemblies corresponding to data used for validation of the STC model (sawn lumber and I-joist-framed assemblies)

STC Test Number	Floor Covering	Floor Layer Description	Insulation	Framing Description	RC Spacing	Ceiling Layer Description	Measured STC	Predicted STC
TLF-96-105a	(none)	1 Layer of 19/32" OSB	3.5" Fiberglass Batt	18" I-joists @16"o.c.	24"o.c.	1 Layer of 5/8" GWB	52	52
TLF-96-119a	(none)	1 Layer of 19/32" OSB	3.5" Mineral Wool Batt	18" I-joists @16"o.c.	24"o.c.	1 Layer of 5/8" GWB	53	52
TLF-96-165a	(none)	1 Layer of 19/32" OSB	(no insulation)	9.5" I-joists @ 16"o.c.	24"o.c.	1 Layer of 1/2" GWB	43	43
TLF-96-179a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @16"o.c.	16"o.c.	2 Layers of 5/8" GWB	53	54
TLF-96-181a	(none)	2 Layers of 19/32" OSB	(no insulation)	9.5" I-joists @ 16"o.c.	24"o.c.	2 Layers of 5/8" GWB	51	51
TLF-96-193a	(none)	1 Layer of 19/32" OSB	(no insulation)	9.5" I-joists @ 16"o.c.	16"o.c.	1 Layer of 1/2" GWB	42	41
TLF-96-197a	(none)	2 Layers of 19/32" OSB	(no insulation)	9.5" I-joists @ 16"o.c.	16"o.c.	2 Layers of 5/8" GWB	49	49
TLF-95-125a	(none)	2 Layers of 19/32" OSB	6" Fiberglass Batt	2x10s @ 16"o.c.	24"o.c.	2 Layers of 5/8" GWB	60	59
TLF-95-131a	(none)	2 Layers of 1/2" Plywood	6" Fiberglass Batt	2x10s @ 16"o.c.	24"o.c.	2 Layers of 5/8" GWB	58	56
TLF-95-147a	(none)	2 Layers of 19/32" Plywood	6" Fiberglass Batt	2x10s @ 16"o.c.	24"o.c.	2 Layers of 5/8" GWB	58	57
TLF-95-145a	(none)	1 Layer of 19/32" Plywood	6" Fiberglass Batt	2x10s @ 16"o.c	24"o.c.	2 Layers of 5/8" GWB	55	54
TLF-96-065a	(none)	1 Layer of 1" Plywood	6" Fiberglass Batt	2x10s @ 16"o.c.	24"o.c.	2 Layers of 5/8" GWB	56	55
TLF-96-201a	(none)	1 Layer of 19/32" OSB	(no insulation)	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 1/2" GWB	44	43
TLF-97-003a	(none)	1 Layer of 19/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 16"o.c.	16"o.c.	1 Layer of 5/8" GWB	50	47
TLF-97-005a	(none)	2 Layers of 19/32" OSB	(no insulation)	9.5" I-joists @ 24"o.c.	16"o.c.	2 Layers of 5/8" GWB	53	52
TLF-01-061a	(none)	2 Layers of 19/32" Plywood	3.5" Mineral Wool Batt	9.5" I-joists @ 16"o.c.	16"o.c.	1 Layer of 1/2" GWB	48	46
TLF-01-063a	(none)	1 Layer of 19/32" Plywood	3.5" Mineral Wool Batt	9.5" I-joists @ 16"o.c.	16"o.c.	1 Layer of 1/2" GWB	45	44
TLF-01-065a	(none)	1 Layer of 19/32" Plywood	3.5" Fiberglass Batt	9.5" I-joists @ 16"o.c.	16"o.c.	1 Layer of 1/2" GWB	44	44
TLF-02-009a	(none)	1 Layer of 23/32" OSB	3.5" Mineral Wool Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 1/2" GWB	49	47
TLF-02-015a	(none)	1 Layer of 23/32" OSB	3.5" Mineral Wool Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8" GWB	49	48
TLF-02-043a	(none)	1 Layer of 23/32" OSB	3.5" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	2 Layers of 1/2" GWB	53	54
TLF-03-033a	(none)	1 Layer of 19/32" Plywood	3.5" Fiberglass Batt	2x8s @ 16"o.c.	16"o.c.	2 Layers of 1/2" GWB	52	51
TLF-04-003a	(none)	1 Layer of 19/32" PW & 1"GC	3.5" Fiberglass Batt	2x10s @ 16"o.c.	24"o.c.	2 Layers of 1/2" GWB	65	64
TLF-04-007a	(none)	1 Layer of 19/32" PW & 1"GC	3.5" Fiberglass Batt	2x10s @ 16"o.c.	16"o.c.	2 Layers of 1/2" GWB	64	64
TLF-17-063	(none)	1 Layer of 23/32" OSB & 1" GC	(no insulation)	9.5" I-joists @ 24"o.c.	16"o.c.	2 Layers of 5/8" GWB	63	60
TLF-17-052	(none)	1 Layer of 23/32" OSB & 1" GC	(no insulation)	9.5" I-joists @ 16"o.c.	16"o.c.	2 Layers of 5/8" GWB	56	57

Table 2.3.1b Assemblies corresponding to data used for validation of the STC model (wood truss-framed assemblies)

STC Test Number	Floor Covering	Floor Layer Description	Insulation	Framing Description	RC Spacing	Ceiling Layer Description	Measured STC	Predicted STC
TLF-01-051a	(none)	2 Layers of 19/32" OSB	3.5" Mineral Wool Batt	12" Trusses @ 16"o.c.	16"o.c.	2 Layers of 1/2" GWB	57	56
TLF-01-057a	(none)	1 Layer of 19/32" OSB	3.5" Mineral Wool Batt	12" Trusses @ 16"o.c.	16"o.c.	2 Layers of 1/2" GWB	55	55
TLF-01-059a	(none)	2 Layers of 19/32" OSB	3.5" Mineral Wool Batt	12" Trusses @ 16"o.c.	16"o.c.	2 Layers of 5/8" GWB	56	56
TLF-01-035a	(none)	2 Layers of 19/32" Plywood	3.5" Fiberglass Batt	12" Trusses @ 16"o.c.	16"o.c.	2 Layers of 5/8" GWB	55	55
TLF-01-037a	(none)	2 Layers of 19/32" Plywood	3.5" Mineral Wool Batt	12" Trusses @ 16"o.c.	16"o.c.	2 Layers of 5/8" GWB	55	56
TLF-01-039a	(none)	2 Layers of 19/32" Plywood	3.5" Mineral Wool Batt	12" Trusses @ 16"o.c.	16"o.c.	2 Layers of 1/2" GWB	55	55
TLF-01-041a	(none)	1 Layer of 19/32" Plywood	3.5" Fiberglass Batt	12" Trusses @ 16"o.c.	16"o.c.	2 Layers of 1/2" GWB	52	53
TLF-01-045a	(none)	1 Layer of 19/32" Plywood	3.5" Fiberglass Batt	12" Trusses @ 16"o.c.	16"o.c.	1 Layer of 1/2" GWB	47	48
TLF-01-047a	(none)	1 Layer of 19/32" Plywood	3.5" Mineral Wool Batt	12" Trusses @ 16"o.c.	16"o.c.	1 Layer of 1/2" GWB	47	49

Figure 2.3.1a **Measured versus modeled STC values: validation data and other available data**



"IIF-96…" were used for validation. The latter of these assembly groups were tested during Phase I of the two-phase NRC study described in Section 1.2.1 (NRC, 1998).

With the exception of assemblies IIF-96-029, -030 and -031, the generic floor coverings listed in Table 2.3.2 correspond with those described in Section 1.3.5. Although the vinyl floor coverings used on assemblies IIF-96-029, -030 and -031 were not exactly the same as that used on the vinyl-floor-covered assemblies within the modeling database, estimated IIC values are within 1 point of the measured values. This indicates that variations between these specific vinyl floor coverings did not result in significant differences in IIC values.

The estimated IIC value for assembly IIF-96-016, which had a "thin carpet and pad" floor covering, was also within 1 point of the measured value (slightly underestimated). The base assembly for IIF-96-016 differed from all of the base assemblies represented within the floor-covered IIC modeling database in at least four characteristics (i.e., floor layer type, framing type, framing spacing and resilient channel spacing). The limited modeling error for this validation point (as well as those for assemblies IIF-96-029, -030 and -031) provides an indication that the IIC model works for other base assembly configurations within the scope of the STC model, besides the six base assemblies represented within the floor-covered IIC modeling database.

Measured versus model-estimated IIC values for each of the assemblies having floor coverings are shown graphically as red triangles in Figure 2.3.2a. The STC validation data points are also shown on this graph, since the IIC model is based on the STC model. Some of the estimated values for I-joist-framed assemblies without a cast-in-place topping did not exactly match the measured values. This is because of the averaging procedure used to establish the system effects of I-joist-framed baseline assemblies, described in Section 2.2.

The distribution of differences between estimated and measured IIC values for assemblies having floor coverings is shown in Figure 2.3.2b. All estimated IIC values for the 18 assemblies with floor coverings were within -2 and +1 point of the measured value. The average of this distribution was -0.4 points. Thus, as is the case for the STC model upon which it is based, the IIC model appears to err more often on the conservative side (slight underestimation).

Figure 2.3.1b **Histogram of differences between estimated values vs. measured validation data (sawn lumber and I-joist-framed assemblies)**

Figure 2.3.1c **Histogram of differences between estimated values vs. measured validation data (truss-framed assemblies)**

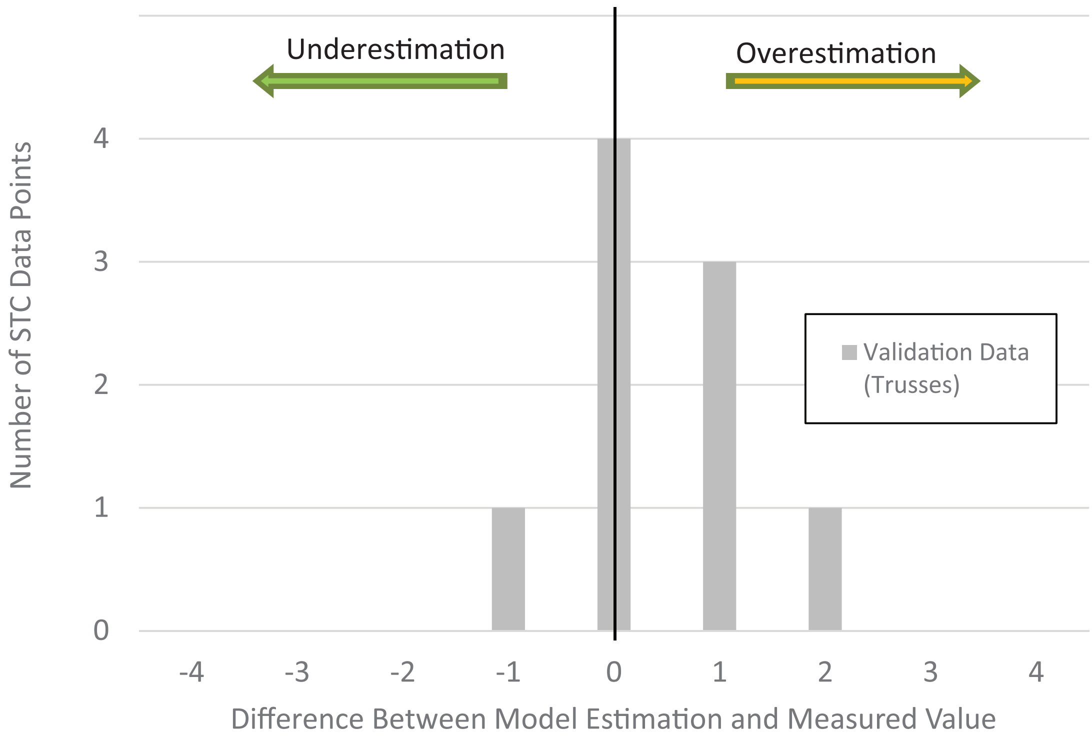


Table 2.3.2 Assemblies with floor coverings used for IIC modeling and validation

IIC Test Number	Floor Covering	Floor Layer Description	Insulation	Framing Description	RC Spacing	Ceiling Layer Description	Measured IIC	Predicted IIC
IIF-96-016	Thin Carpet & Pad	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @16"o.c.	24"o.c.	1 Layer of 5/8" GWB	67	66
IIF-96-029	"Inexpensive" Vinyl	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s@ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	44	44
IIF-96-030	"Expensive" Vinyl	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @16"o.c.	24"o.c.	1 Layer of 5/8" GWB	45	44
IIF-96-031	"Medium-priced" Vinyl	1 Layer of 19/32" OSB	6" Fiberglass Batt	2x10s @ 16"o.c.	24"o.c.	1 Layer of 5/8" GWB	45	44
IIF-17-034	Click Laminate	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8" GWB	46	45
IIF-17-036	Thin Carpet & Pad	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8" GWB	64	64
IIF-17-037	Thick Carpet & Pad	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8" GWB	70	70
IIF-17-043	Thick Carpet & Pad	1 Layer of 23/32" OSB & 1" GC	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8"GWB	75	75
IIF-17-044	Thin Carpet & Pad	1 Layer of 23/32" OSB & 1" GC	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8"GWB	68	68
IIF-17-045	Click Laminate	1 Layer of 23/32" OSB & 1" GC	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8"GWB	54	54
IIF-17-046	Cushioned Vinyl	1 Layer of 23/32" OSB & 1" GC	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8"GWB	53	53
IIF-17-047	Ceramic Tile	1 Layer of 23/32" OSB & 1" GC	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8"GWB	52	52
IIF-17-049	Click Laminate	1 Layer of 23/32" OSB & 1" GC	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	2 Layers of 5/8" GWB	56	56
IIF-17-050	Click Laminate	1 Layer of 23/32" OSB & 1" GC	(no insulation)	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8" GWB	48	48
IIF-17-054	Click Laminate	1 Layer of 23/32" OSB & 1" GC	(no insulation)	9.5" I-joists @ 24"o.c.	16"o.c.	2 Layers of 5/8" GWB	54	52
IIF-17-060	Cushioned Vinyl	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8" GWB	44	42
IIF-17-061	Ceramic Tile	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	1 Layer of 5/8" GWB	48	49
IIF-17-063	Click Laminate	1 Layer of 23/32" OSB	6" Fiberglass Batt	9.5" I-joists @ 24"o.c.	16"o.c.	2 Layers of 5/8" GWB	55	54

Figure 2.3.2a **Measured versus modeled IIC values for validation data, and data from modeling database assemblies with floor coverings**

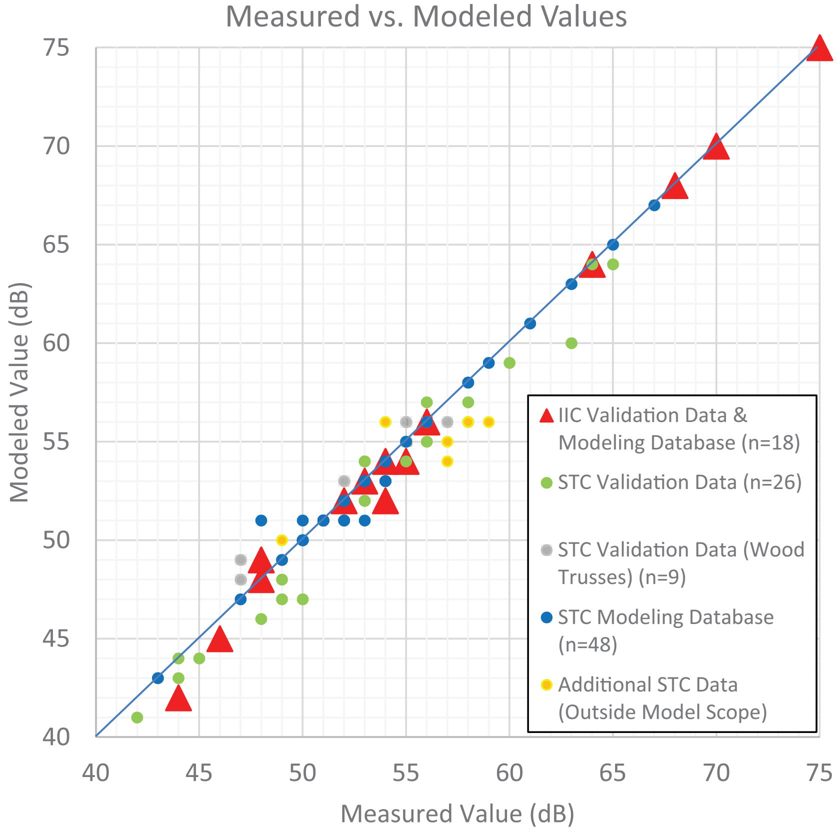
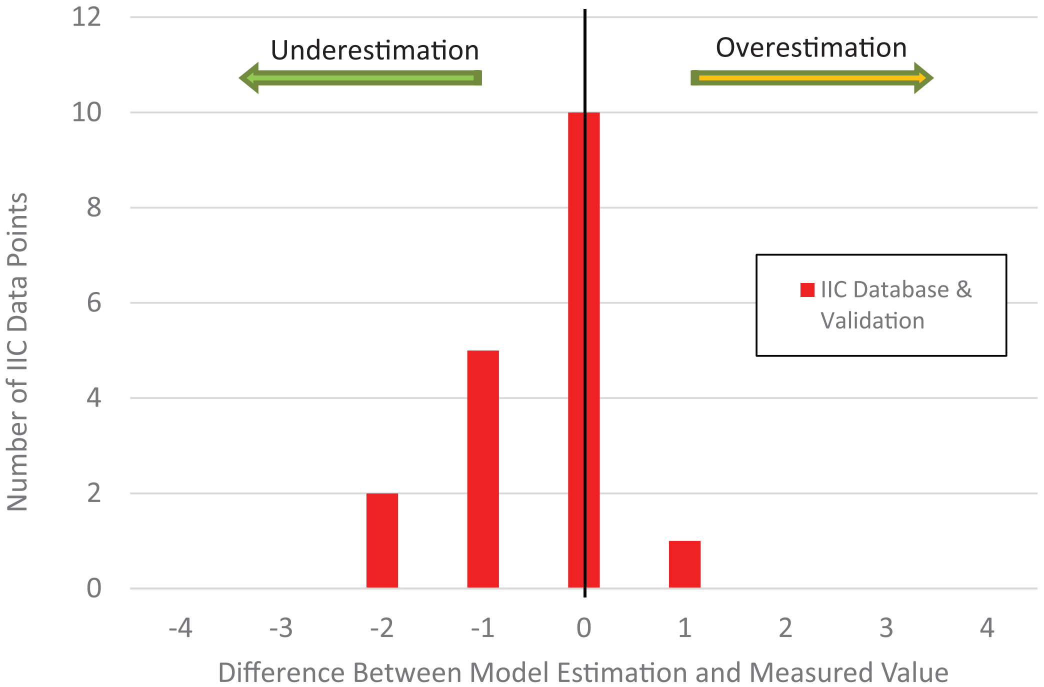


Figure 2.3.2b **Histogram of differences between estimated values vs. measured IIC values for assemblies with floor coverings**

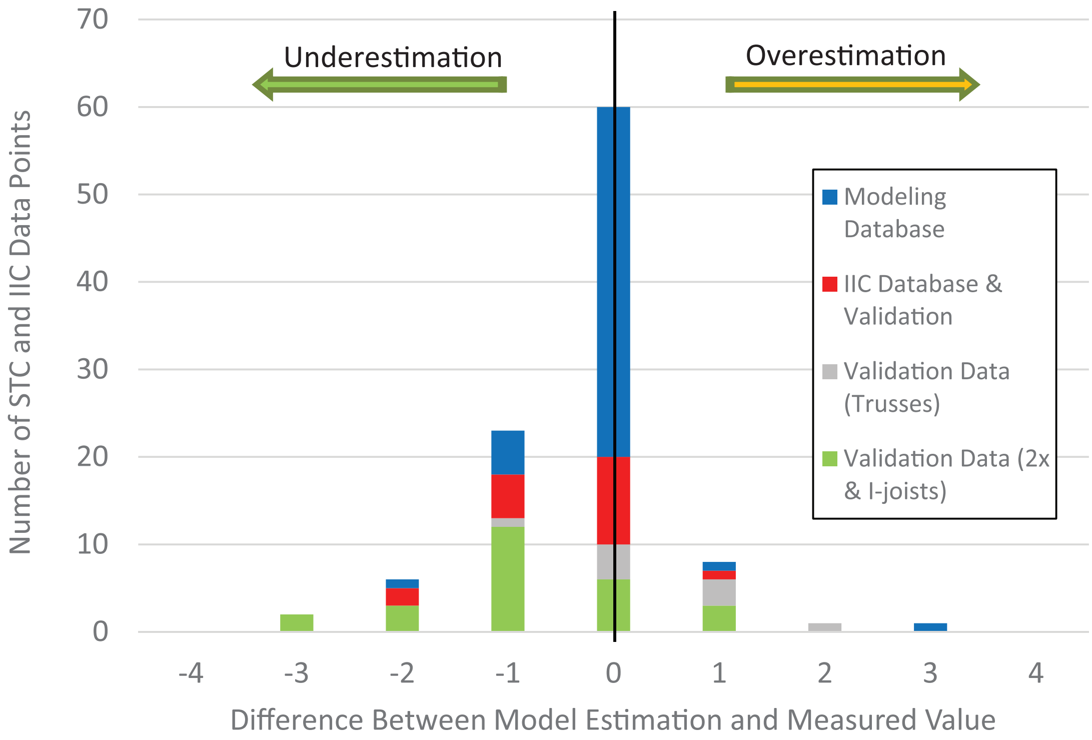


2.4 Conclusion

Based on the validation presented in Part II, the STC model presented in Part I of this report appears to be reasonably accurate for estimation of bare-floor STC values corresponding to light-frame assemblies within the scope of the model. Likewise, this validation shows that the IIC model can be used to calculate reasonably accurate estimates of IIC values for the same assemblies having the five generic floor coverings included within the modeling database. A histogram of the differences between the model-estimated values and measured values for all 101 assemblies having component combinations within the scope of the model is shown in Figure 2.4. This histogram represents a summation of those presented in Figures 2.2b, 2.3.1b, 2.3.1c and 2.3.2b. Each individual group making up this overall data pool (i.e., modeling database, STC validation data, and IIC database & validation data) is identified by a different color, as defined in the figure.

It should be noted that STC and IIC values calculated using these models for assemblies containing components or component combinations that are beyond the scope of the models cannot be assumed accurate. For assemblies having sawn lumber or I-joist framing and component combinations within the scope of the model, available validation data indicates that estimation errors tend to be slightly conservative (i.e., resulting in minor underestimations).

Figure 2.4 **Histogram of differences between model-estimated versus measured values (all STC and IIC data points for assemblies within the model scope)**



Part III: Example Calculations

3.1 General

This section provides example calculations to demonstrate how the models described in Part I are used to estimate sound transmission class (STC) and impact insulation class (IIC) ratings for various assemblies within the model scope. Section 3.2 provides an example of an untopped assembly (i.e., an assembly without any cast-in-place topping) framed with 2x10s. An example of a gypsum concrete-topped assembly framed with $9^1/_2$"-deep prefabricated wood I-joists is provided in Section 3.3. Lastly, Section 3.4 provides an example of an untopped assembly framed with metal plate-connected parallel-chord wood trusses.

3.2 Example 1: Untopped Assembly; 2x10 Framing

Example assembly description:

- Thin carpet (0.24" thick, 20 oz/yd^2) over a typical underpad (0.31" thick, 0.20 psf)
- One layer of 19/32" oriented strand board (OSB)
- One layer of 6"-thick fiberglass insulation batt between the joists,
- 2x10 joists at 16" o.c.,
- RC1 resilient channels, spaced 24" o.c., running perpendicular to the joists,
- One layer of 5/8" Type X gypsum wallboard (GWB).

Note that the example assembly described above is identical to the NRC reference assembly, except that it has a carpet and pad floor covering.

3.2.1 Estimation of STC – Example 1

Although the assembly being evaluated in this example has a floor covering, for reasons explained in Part I, any effect this floor covering may have on airborne sound transmission loss is conservatively neglected for the purpose of estimating STC. As stated in Section 1.3.1.1, the transmission loss through the assembly, TL_a, is estimated at each 1/3-octave band center frequency using the following equation:

$$TL_a(f) = \sum TL_l(f) + [\chi_b(f) + \sum \delta_\chi(f)$$

Where:

$TL_a(f)$ = estimated transmission loss through the assembly at frequency f, dB

$\sum TL_l(f)$ = sum of layer TL values for the floor layer and ceiling layer, evaluated at frequency f, dB

$\chi_b(f)$ = system effect of the baseline assembly at frequency f, dB

$\sum \delta_\chi(f)$ = sum of applicable system effect adjustments necessary to account for the influence of component variations from the baseline assembly, evaluated at frequency f, dB

The frequency range used to determine STC is from 125 Hz to 4000 Hz. However, due to the fact that the IIC model is based on estimated transmission losses calculated using the STC model, and the frequency range used to determine IIC is from 100 Hz to 3150 Hz, each of the terms in the equation above should be evaluated at each 1/3-octave band center frequency ranging from 100 Hz up to 4000 Hz.

Estimated layer TL values, TL_l, for the floor layer (i.e., the OSB subfloor attached directly to 2x10s, in this case) are tabulated in Table 1.3.2a. Estimated TL_l, values for the ceiling layer (i.e., one layer of 5/8" GWB attached to resilient channels) are taken from Table 1.3.2b.

The system effect, x_b, of the baseline assembly applicable to this example is tabulated in Table 1.3.4a, along with the system effect adjustments, δ_χ, which are necessary to account for the influence of component variations from the baseline assembly. It should be noted that, since the bare-floor assembly being evaluated in this example corresponds to one of the baseline assemblies (i.e., the baseline for an untopped assembly framed with sawn lumber at 16" o.c.), there are no component variations from the baseline assembly. Therefore, the sum of system effect adjustments, Σx_χ, is zero at all 1/3-octave band center frequencies.

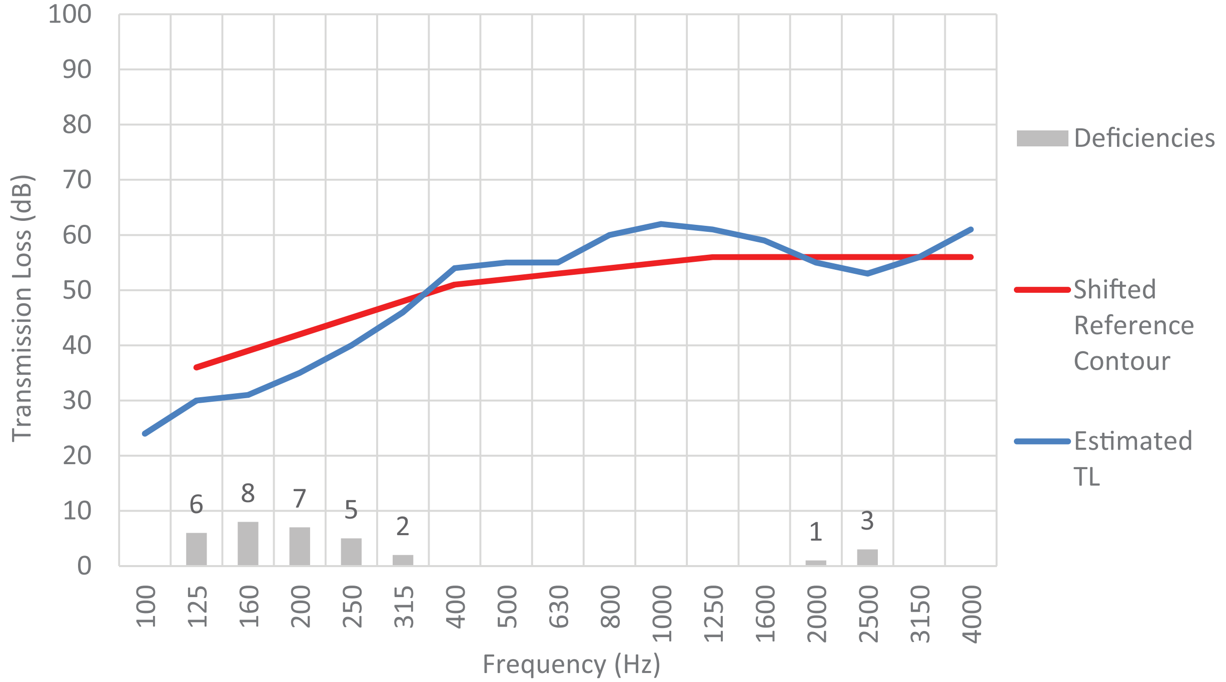
Individual values of TL_l, for the floor layer and ceiling layer, along with values of x_b and δ_χ are tabulated and summed for each frequency in Table 3.2.1. The resulting contour of estimated TL_a values for the assembly is shown graphically in Figure 3.2.1a, along with the shifted reference STC contour fitted to the estimated TL_a curve.

As shown in Table 3.2.1, the estimated STC for this example assembly is 52. This represents the highest level to which the reference contour can be shifted upward,

Table 3.2.1 **Example 1: Calculation of Estimated TL Values and STC**

Example 1 (TL / STC): Untopped Assembly; 2x10 Framing		Values (dB) at Frequency (*f*):																
		100 Hz	**125 Hz**	**160 Hz**	**200 Hz**	**250 Hz**	**315 Hz**	**400 Hz**	**500 Hz**	**630 Hz**	**800 Hz**	**1000 Hz**	**1250 Hz**	**1600 Hz**	**2000 Hz**	**2500 Hz**	**3150 Hz**	**4000 Hz**
Estimated floor layer TL:	$TL_{l1}(f) =$	13.6	14.9	14.0	13.1	14.0	17.8	22.8	23.3	21.3	25.6	25.7	25.7	25.1	25.1	26.1	27.9	30.7
Estimated ceiling layer TL:	$TL_{l2}(f) =$	15.5	16.7	19.1	21.8	23.9	26.5	28.1	28.9	30.6	32.9	33.9	34.5	33.8	29.5	24.8	27.6	31.0
Sum of layer TL values:	$\Sigma TL_l(f) =$	29.1	31.7	33.1	34.9	37.9	44.3	50.9	52.2	51.9	58.5	59.6	60.2	58.9	54.6	50.9	55.6	61.8
System effect:	$\chi_b(f) =$	-5.1	-1.9	-2.3	0.2	2.2	1.6	2.7	2.5	3.0	1.3	2.2	1.1	0.0	0.6	1.8	0.1	-1.2
Sum of system effect adjustments:	$\Sigma\delta_\chi(f) =$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Estimated TL:	$TL_a(f) = \Sigma TL_l(f) + \chi_b(f) + \Sigma\delta_\chi(f) =$	24	30	31	35	40	46	54	55	55	60	62	61	59	55	53	56	61
Reference TL contour (ASTM E413):			-16	-13	-10	-7	-4	-1	0	1	2	3	4	4	4	4	4	4
Shifted reference contour:	**STC = 52**		36	39	42	45	48	51	52	53	54	55	56	56	56	56	56	56
Deficiencies:	Σ(deficiencies) = 32		6	**8**	7	5	2								1	3		

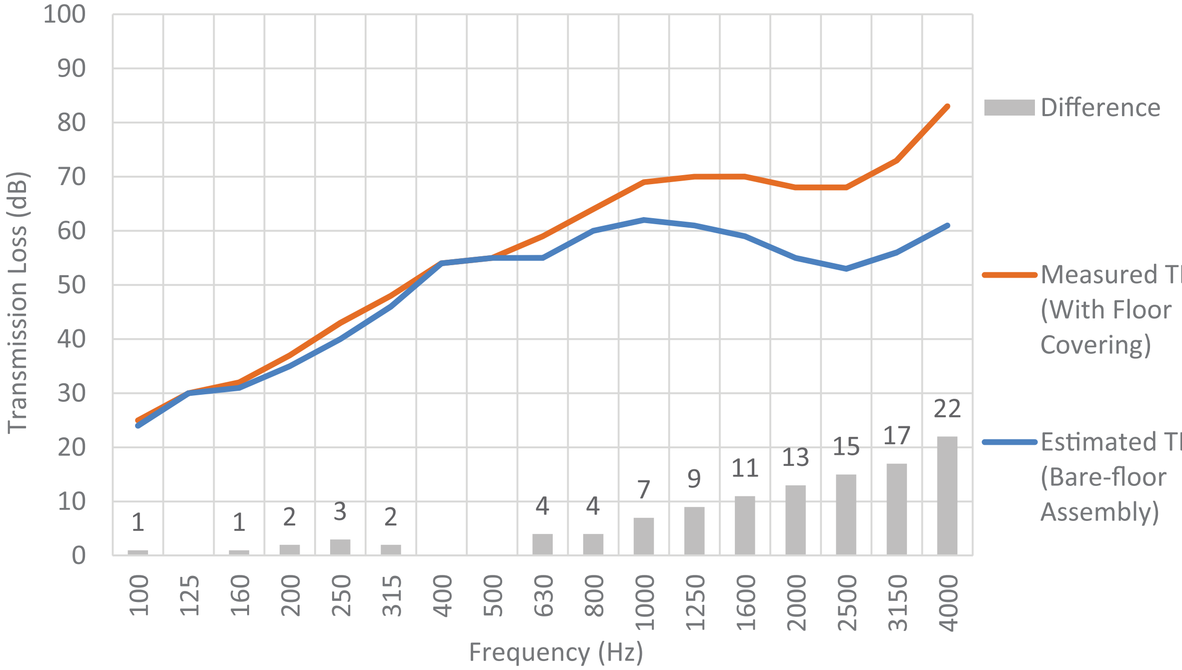
Figure 3.2.1a **Example 1: Estimated TL Contour with Corresponding Shifted Reference Contour and Deficiencies**



while still satisfying both of the conditions specified in Section 1.3.1.1 (i.e., sum of deficiencies ≤ 32; maximum deficiency ≤ 8 dB). In this example, the estimated STC is controlled both by the sum-of-deficiencies limit of 32, as well as the single-point-deficiency limit of 8 dB at 160 Hz.

The bare-floor assembly (i.e., assembly, not including the floor covering) in this example is identical to an assembly represented within the modeling database (NRC Mean Reference assembly). Thus, the estimated $TL_a(f)$ contour is an exact match to the measured TL contour of that bare-floor assembly. However, the assembly described in this example has a floor covering: thin carpet as described in Section 3.2. Due to the influence of this floor covering, the actual measured TL contour of the tested floor-covered assembly matching the assembly described in this example (test TLF 96-057a) diverges from the estimated $TL_a(f)$ contour at frequencies of 630 Hz and higher. This is illustrated in Figure 3.2.1b.

Figure 3.2.1b **Example 1: Estimated TL of Bare-floor Assembly and Measured TL of Floor-Covered Assembly**



At the high end of the frequency spectrum (4000 Hz), the difference between the measured TL of the assembly having the floor covering versus the estimated TL of the bare-floor assembly was as great as 22 dB. This difference, shown in Figure 3.2.1b, is directly attributable to the influence of the thin carpet floor covering.

However, since the STC values of most light-frame floor-ceiling assemblies are governed by transmission losses at the lower end of the frequency range, where the influence of a floor covering is not as great, any error introduced by the fact that the STC model neglects floor coverings is relatively minor. Furthermore, as discussed in Section 1.2.1, these minor differences are generally conservative (i.e., they result in slight under-predictions of STC). In the case of the example assembly described in Section 3.2, the estimated STC of 52 was only one point lower than the actual measured STC of 53, thereby providing justification for the modeling approach of neglecting the contribution of floor coverings when estimating STC.

3.2.2 Estimation of IIC – Example 1

As stated in Section 1.3.1.2, the impact sound pressure level from sound transmitted through the assembly, $ISPL_a$, is estimated at each 1/3-octave band center frequency using the following equation:

$$ISPL_a(f) = 110 - TL_a(f) + \Delta_{ISPL}(f)$$

Where:

$TL_a(f)$ = estimated transmission loss through the assembly at frequency f, dB (see Section 3.2.1)

$\Delta_{ISPL}(f)$ = ISPL adjustment at frequency f, dB

The estimated transmission losses through the assembly, TL_a, have already been calculated for this example assembly, as discussed in Section 3.2.1. The ISPL adjustment values, Δ_{ISPL}, are provided in Table 1.3.5. The assembly considered in this example has a thin carpet and pad floor covering, no gypsum concrete topping, and only one layer of gypsum wallboard. ISPL adjustment values corresponding to this assembly are listed in the top row of Table 1.3.5.

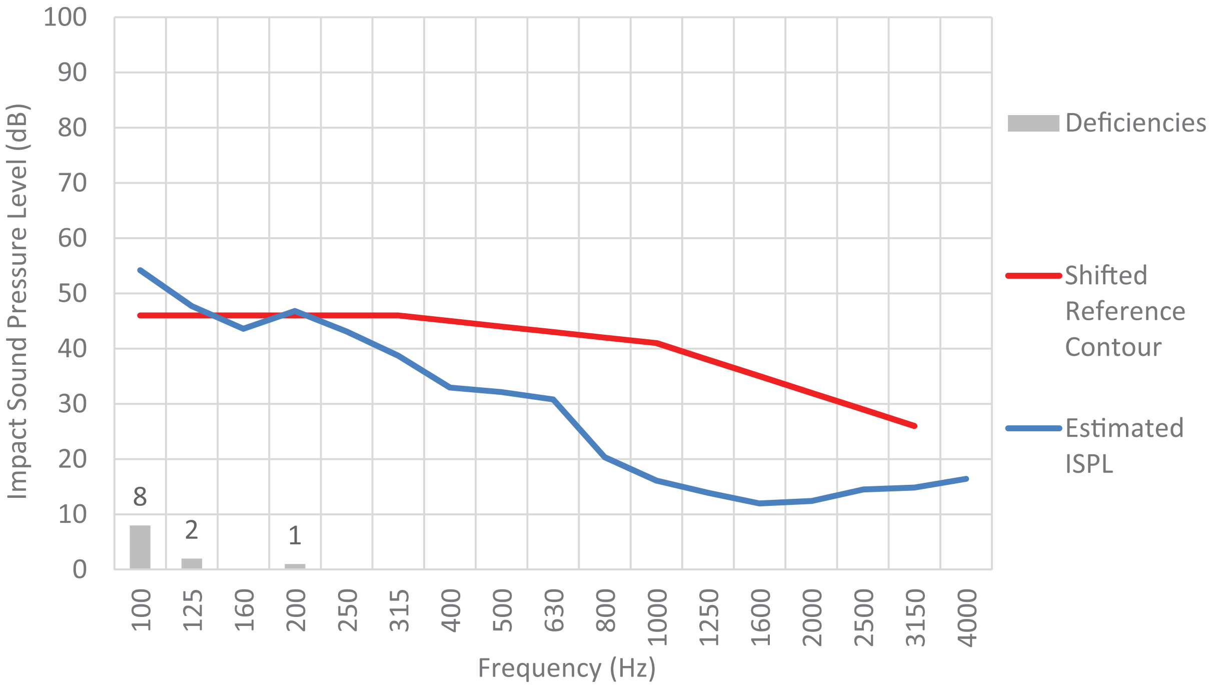
Individual values of TL_a and Δ_{ISPL} for this example assembly are tabulated in Table 3.2.2, along with the estimated ISPL values. The resulting contour of estimated $ISPL_a$ values for the assembly is shown graphically in Figure 3.2.2, along with the shifted reference IIC contour fitted to the estimated $ISPL_a$ curve.

As shown in Table 3.2.2, the estimated IIC for this assembly, with a thin carpet and pad floor covering, is IIC = 66. This estimated IIC is controlled by the 8 dB single-point-deficiency limit at the low end of the frequency spectrum (100 Hz). The estimated sum of ISPL deficiencies is only 11, which is well below the limit of 32. The estimated IIC of 66 for this assembly, is only one point lower that the actual measured IIC of 67, which is included within the validation database as NRC test IIF 96-016.

Table 3.2.2 **Example 1: Calculation of Estimated ISPL Values and IIC**

Example 1 (ISPL / IIC): Untopped Assembly; 2x10 Framing	**Values (dB) at Frequency (*f*):**																
	100 Hz	**125 Hz**	**160 Hz**	**200 Hz**	**250 Hz**	**315 Hz**	**400 Hz**	**500 Hz**	**630 Hz**	**800 Hz**	**1000 Hz**	**1250 Hz**	**1600 Hz**	**2000 Hz**	**2500 Hz**	**3150 Hz**	**4000 Hz**
Estimated TL: $TL_a(f) = \Sigma TL_i(f) + \chi_b(f) + \Sigma\delta_\chi(f) =$	24	30	31	35	40	46	54	55	55	60	62	61	59	55	53	56	61
ISPL adjustment: $\Delta_{ISPL}(f) =$	-32	-33	-36	-28	-27	-25	-23	-23	-24	-30	-32	-35	-39	-42	-43	-40	-33
Estimated ISPL: $ISPL_a(f) = 110 - TL_a(f) + \Delta_{ISPL}(f) =$	54	48	44	47	43	39	33	32	31	20	16	14	12	12	14	15	16
Reference ISPL contour (ASTM E989):	2	2	2	2	2	2	1	0	-1	-2	-3	-6	-9	-12	-15	-18	
Shifted reference contour: **IIC = 66**	46	46	46	46	46	46	45	44	43	42	41	38	35	32	29	26	
Deficiencies: Σ(deficiencies) = 11	**8**	2		1													

Figure 3.2.2 **Example 1: Estimated ISPL Contour with Corresponding Shifted Reference Contour and Deficiencies**



3.3 Example 2: Topped Assembly; I-Joist Framing at 24”o.c.

Example assembly description:

- Floating wood laminate (i.e., click laminate) flooring (0.31” thick, 1.35 psf) over a thin closed-cell foam underlay (0.06” thick, negligible weight)
- Nominal 1” gypsum concrete topping
- One layer of 23/32” oriented strand board (OSB)
- One layer of 6”-thick fiberglass insulation batt between the joists,
- 9.5”-deep prefabricated wood I-joists at 24” o.c.,
- RC1 resilient channels, spaced 16” o.c., running perpendicular to the I-joists,
- Two layers of 5/8” Type X gypsum wallboard (GWB).

Note that the example assembly described above is identical to the assembly tested in NRC test IIF-17-049, which is included within the IIC modeling database. This also corresponds to the bare-floor assembly tested in NRC tests TLF-17-059 and IIF-17-048, except that it has a floating wood laminate floor covering.

3.3.1 Estimation of STC – Example 2

Estimated layer TL values, TL_l, for the floor layer (i.e., 1” gypsum concrete topping with an OSB subfloor attached directly to 2x10s) are tabulated in Table 1.3.2a. Estimated TL_l, values for the ceiling layer (i.e., two layers of 5/8” GWB attached to resilient channels) are taken from Table 1.3.2b.

The system effect, x_b, of the baseline assembly applicable to this example is tabulated in Table 1.3.4d, along with the system effect adjustments, δ_χ, which are necessary to account for the influence of component variations from the baseline assembly. Unlike in Example 1, the system effect adjustments, δ_χ, are not equal to zero. This is because the assembly being considered in this example varies from the applicable baseline assembly, in that it has two layers of gypsum wallboard in the ceiling layer.

Individual values of TL_l, for the floor layer and ceiling layer, along with values of x_b and δ_χ are tabulated and summed for each frequency in Table 3.3.1. The resulting contour of estimated TL_a values for the assembly is shown graphically in Figure 3.3.1a, along with the shifted reference STC contour fitted to the estimated TL_a curve.

As shown in Table 3.3.1, the estimated STC for this example assembly is 67. In this example, the estimated STC is controlled only by the sum-of-deficiencies limit of 32. All of the single-point deficiencies are less than 8 dB. Due to the facts that: a) the reference contour must be shifted upward in increments of whole numbers and b) deficiencies typically occur at more than one 1/3-octave band center frequency, a one-point upward shift will typically increase the sum of deficiencies by multiple points. Because of this, the sum-of-deficiencies limit of 32 may control even if the sum of deficiencies is less than 32.

As in Example 1, the bare-floor assembly in Example 2 is identical to an assembly represented within the modeling database (test TLF-17-059). Because of this similarity, the estimated $TL_a(f)$ contour is an exact match to the measured TL contour of that bare-floor assembly. Again, the influence of the floor covering is apparent in

Table 3.3.1 Example 2: Calculation of Estimated TL Values and STC

Example 2 (TL / STC): Topped Assembly; I-joists @ 24"; 2 Layers GWB		Values (dB) at Frequency (f):																
		100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1000 Hz	1250 Hz	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz
Estimated floor layer TL:	$TL_{l1}(f)$ =	18.5	20.6	25.1	26.3	29.4	27.2	23.2	29.8	31.7	27.2	24.1	28.4	30.7	34.4	37.4	39.6	41.5
Estimated ceiling layer TL:	$TL_{l2}(f)$ =	21.6	21.8	26.2	27.8	26.9	31.2	34.2	33.2	31.3	34.3	37.0	37.5	38.0	33.7	31.8	34.8	37.9
Sum of layer TL values:	$\Sigma TL_l(f)$ =	40.2	42.4	51.3	54.1	56.3	58.4	57.5	63.0	63.0	61.5	61.1	66.0	68.7	68.1	69.2	74.4	79.3
System effect:	$\chi_b(f)$ =	1.1	4.4	0.1	2.3	4.8	6.7	9.6	6.9	6.1	7.2	9.2	7.8	7.7	5.8	7.9	9.0	9.5
Sum of system effect adjustments:	$\Sigma \delta_\chi(f)$ =	1.5	-1.6	-2.8	-6.3	-4.8	-4.3	-2.8	-3.4	-1.9	-2.1	-3.9	-2.8	-3.4	-2.1	-4.4	-6.2	-6.4
Estimated TL:	$TL_a(f) = \Sigma TL_l(f) + \chi_b(f) + \Sigma\delta_\chi(f)$ =	43	45	49	50	56	61	64	67	67	67	67	71	73	72	73	77	83
Reference TL contour (ASTM E413):			-16	-13	-10	-7	-4	-1	0	1	2	3	4	4	4	4	4	4
Shifted reference contour:	**STC = 67**		51	54	57	60	63	66	67	68	69	70	71	71	71	71	71	71
Deficiencies:	Σ(deficiencies) = 32		6	5	7	4	2	2		1	2	3						

Figure 3.3.1a Example 2: Estimated TL Contour with Corresponding Shifted Reference Contour and Deficiencies

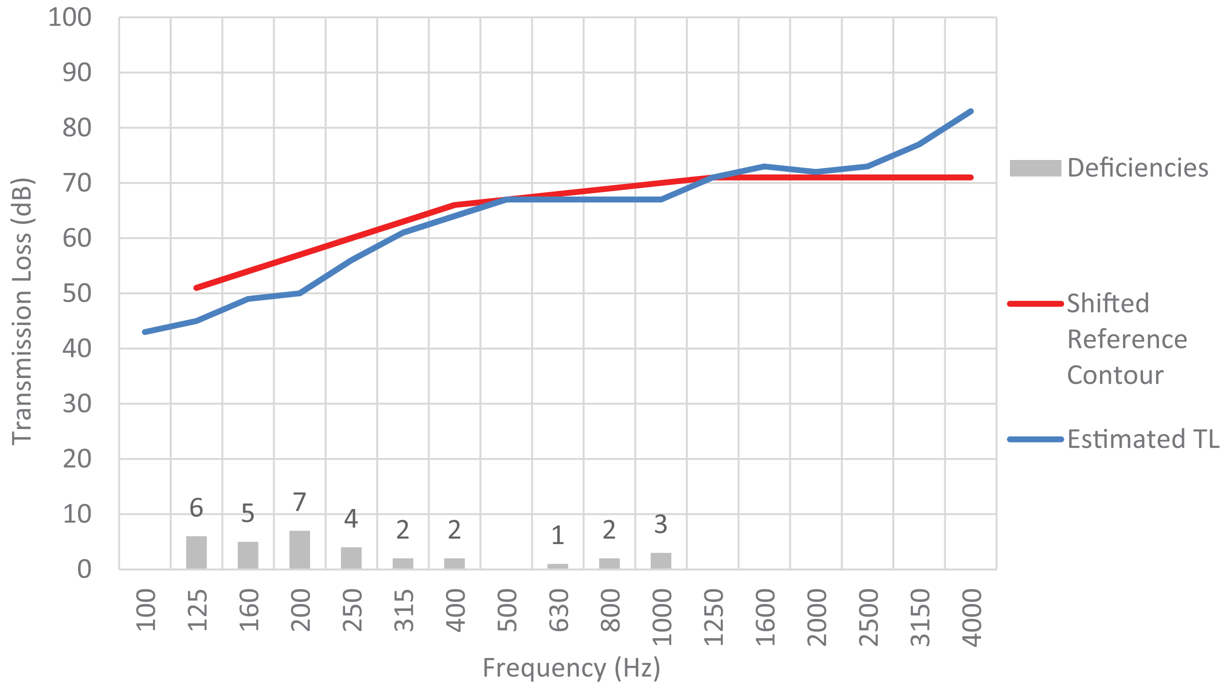
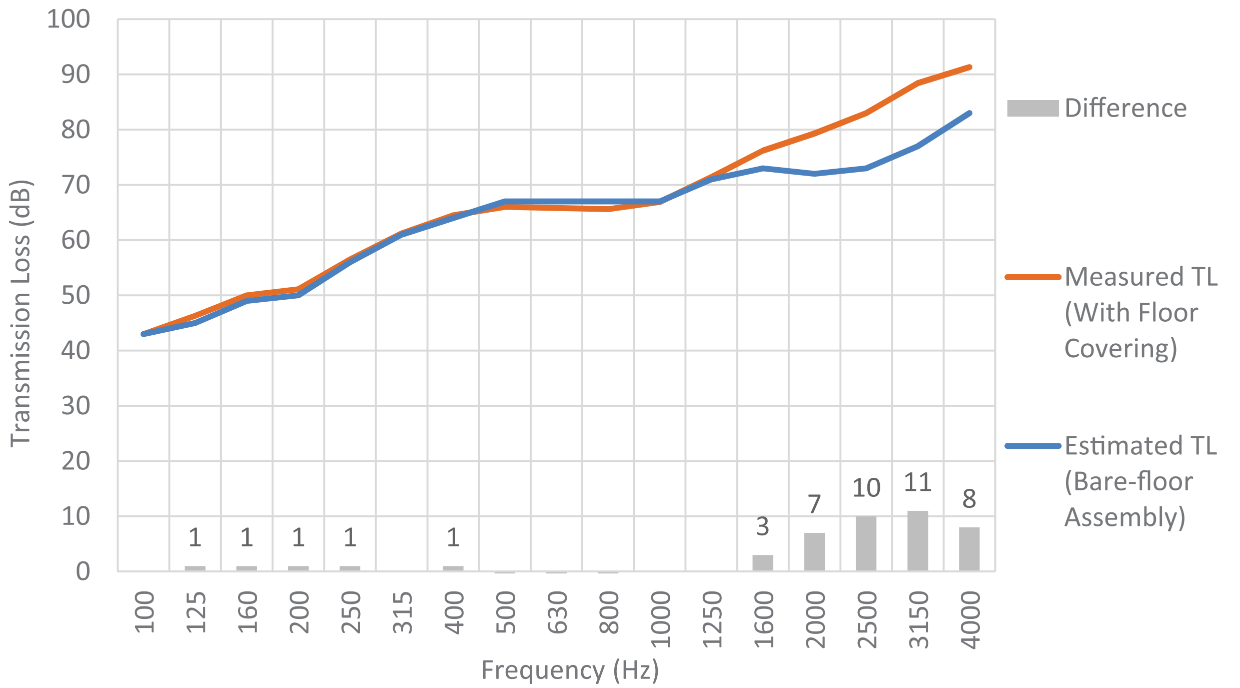


Figure 3.3.1b Example 2: Estimated TL of Bare-floor Assembly and Measured TL of Floor-Covered Assembly



the difference between the actual measured TL contour of the tested floor-covered assembly (test TLF-17-060), versus the estimated $TL_a(f)$, which neglects the influence of the floating wood laminate floor covering. As illustrated in Figure 3.3.1b, this difference is greatest at the higher frequencies (1600 Hz and higher), rather than at the governing lower frequencies.

There is no difference between the actual measured STC of the tested floor-covered assembly (test TLF-17-

060) and the estimated STC of the bare-floor assembly described in Example 2. In both cases, the STC is 67. This is due to the fact that the influence of the floating wood laminate floor covering is significant only at higher frequencies which do not govern in determining STC. This provides further validation to the modeling approach of neglecting the contribution of floor coverings when estimating STC.

3.3.2 Estimation of IIC – Example 2

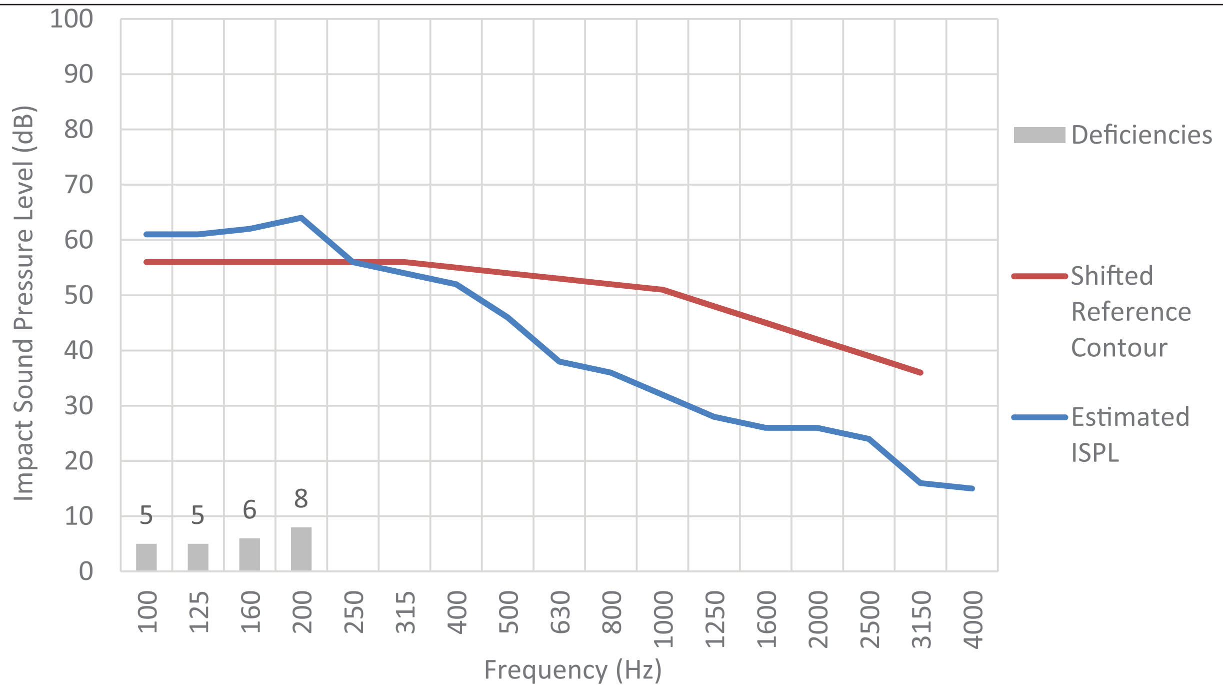
Individual values of TL_a and Δ_{ISPL} for Example 2 are tabulated in Table 3.3.2, along with the estimated ISPL values. The resulting contour of estimated $ISPL_a$ values for the assembly is shown graphically in Figure 3.3.2, along with the shifted reference IIC contour fitted to the estimated $ISPL_a$ curve.

As shown in Table 3.3.2, the estimated IIC for this assembly, which has a floating wood laminate floor covering, is 56. Due to the fact that this assembly matches one which was included within the IIC modeling database (IIF-17-049), the estimated IIC is the same as the measured IIC for this assembly. This estimated IIC is controlled by the 8 dB single-point-deficiency limit at 200 Hz. Deficiencies also occur at each 1/3-octave band center frequency below 200 Hz; however, the estimated sum of ISPL deficiencies is 24, which is well under the limit of 32.

Table 3.3.2 Example 2: Calculation of Estimated ISPL Values and IIC

Example 2 (ISPL / IIC): Topped Assembly; I-joists @ 24"; 2 Layers GWB	**Values (dB) at Frequency (f):**																
	100 Hz	**125 Hz**	**160 Hz**	**200 Hz**	**250 Hz**	**315 Hz**	**400 Hz**	**500 Hz**	**630 Hz**	**800 Hz**	**1000 Hz**	**1250 Hz**	**1600 Hz**	**2000 Hz**	**2500 Hz**	**3150 Hz**	**4000 Hz**
Estimated TL: $TL_a(f) = \Sigma TL_l(f) + \chi_b(f) + \Sigma\delta_\chi(f) =$	43	45	49	50	56	61	64	67	67	67	67	71	73	72	73	77	83
ISPL adjustment: $\Delta_{ISPL}(f) =$	-7	-4	0	4	3	4	7	3	-5	-7	-11	-11	-12	-13	-13	-17	-13
Estimated ISPL: $ISPL_a(f) = 110 - TL_a(f) + \Delta_{ISPL}(f) =$	61	61	62	64	56	54	52	46	38	36	32	28	26	26	24	16	15
Reference ISPL contour (ASTM E989):	2	2	2	2	2	2	1	0	-1	-2	-3	-6	-9	-12	-15	-18	
Shifted reference contour: **IIC = 56**	56	56	56	56	56	56	55	54	53	52	51	48	45	42	39	36	
Deficiencies: Σ(deficiencies) = 24	5	5	6	**8**													

Figure 3.3.2 Example 2: Estimated ISPL Contour with Corresponding Shifted Reference Contour and Deficiencies



3.4 Example 3: Untopped Assembly; Trusses at 24"o.c.

Example assembly description:

- Ceramic tiles (0.31" thick, 3.1 psf) applied over a rubber underlay (0.12" thick, 0.45 psf), applied over grout and thinset (0.20" thick, 0.66 psf)
- One layer of 23/32" oriented strand board (OSB)
- One layer of 6"-thick fiberglass insulation batt between the trusses,
- 14"-deep parallel-chord metal plate-connected wood trusses at 24" o.c.,
- RC1 resilient channels, spaced 16" o.c., running perpendicular to the trusses,
- Two layers of 1/2" gypsum wallboard (GWB).

Although this assembly does not match any of the assemblies in either the modeling database or the validation database, there are other similar bare-floor assemblies within the database to which the estimated results can be compared.

3.4.1 Estimation of STC – Example 3

Estimated layer TL values, TL_l, for the floor layer (i.e., 23/32" OSB subfloor attached directly to the top chord of the wood trusses) are tabulated in Table 1.3.2a. Estimated TL_l, values for the ceiling layer (i.e., two layers of 1/2" GWB attached to resilient channels) are taken from Table 1.3.2b.

The system effect, x_b, of the baseline assembly applicable to this example is tabulated in Table 1.3.4b, along with the system effect adjustments, δ_χ, which are necessary to account for the influence of component variations from the baseline assembly. The assembly being considered in this example varies from the applicable baseline assembly, in that it has one layer of 23/32" OSB in the floor layer, two layers of ½" gypsum wallboard in the ceiling layer, and resilient channels at 16" on-center.

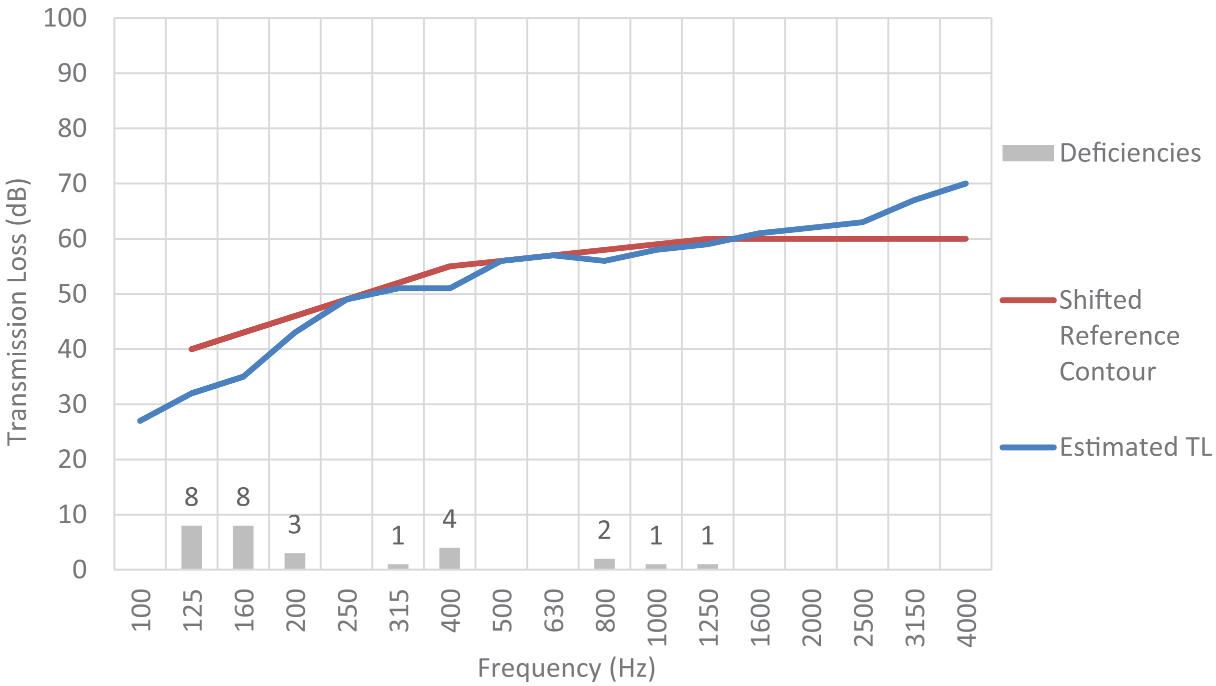
Individual values of TL_l, for the floor layer and ceiling layer, along with values of x_b and $\sum\delta_\chi$ are tabulated and summed for each frequency in Table 3.4.1. It should be noted that the tabulated values of $\sum\delta_\chi$ in Table 3.4.1 represent the sum of individual δ_χ values from Table 1.3.4b, corresponding to variations from the baseline assembly, as noted above. The resulting contour of estimated TL_a values for the assembly is shown graphically in Figure 3.4.1, along with the shifted reference STC contour fitted to the estimated TL_a curve.

As shown in Table 3.4.1, the estimated STC for this example assembly is 56. In this example, the estimated STC is controlled by the 8 dB single-point limit at the 125 Hz and 160 Hz frequencies. However, even if the 8 dB single-point deficiency limit were to be neglected in this example, the STC would still be limited to 56. This is because an additional one-point upward shift in the reference contour would result in a sum of deficiencies that would exceed 32.

Table 3.4.1 Example 3: Calculation of Estimated TL Values and STC

Example 3 (TL / STC): Wood Trusses @ 24"; 2 Layers 1/2" GWB		Values (dB) at Frequency (f):																
		100 Hz	**125 Hz**	**160 Hz**	**200 Hz**	**250 Hz**	**315 Hz**	**400 Hz**	**500 Hz**	**630 Hz**	**800 Hz**	**1000 Hz**	**1250 Hz**	**1600 Hz**	**2000 Hz**	**2500 Hz**	**3150 Hz**	**4000 Hz**
Estimated floor layer TL:	$TL_{l1}(f) =$	12.1	13.4	12.1	14.1	18.5	18.9	17.5	21.5	22.4	23.8	23.3	23.0	23.3	24.8	27.6	31.4	34.3
Estimated ceiling layer TL:	$TL_{l2}(f) =$	20.1	20.3	24.0	25.9	25.6	29.9	33.2	32.5	30.9	32.7	34.4	34.9	36.3	35.0	30.8	31.8	35.2
Sum of layer TL values:	$\Sigma TL_l(f) =$	32.2	33.7	36.0	40.0	44.1	48.8	50.7	54.0	53.3	56.5	57.7	57.9	59.6	59.8	58.4	63.2	69.5
System effect:	$\chi_b(f) =$	-4.2	-1.3	-1.6	2.3	4.5	1.9	-0.4	1.1	3.4	0.5	1.5	0.7	0.8	2.3	4.9	4.4	2.9
Sum of system effect adjustments:	$\Sigma\delta_\chi(f) =$	-0.8	-0.2	0.7	0.6	0.2	0.2	1.1	1.0	0.1	-0.5	-1.0	0.5	0.8	0.3	-0.8	-1.1	-2.4
Estimated TL:	$TL_a(f) = \Sigma TL_l(f) + \chi_b(f) + \Sigma\delta_\chi(f) =$	27	32	35	43	49	51	51	56	57	56	58	59	61	62	63	67	70
Reference TL contour (ASTM E413):			-16	-13	-10	-7	-4	-1	0	1	2	3	4	4	4	4	4	4
Shifted reference contour:	**STC = 56**		40	43	46	49	52	55	56	57	58	59	60	60	60	60	60	60
Deficiencies:	Σ(deficiencies) = 28		**8**	**8**	3		1	4			2	1	1					

Figure 3.4.1 **Example 3: Estimated TL Contour with Corresponding Shifted Reference Contour and Deficiencies**



3.4.2 Estimation of IIC – Example 3

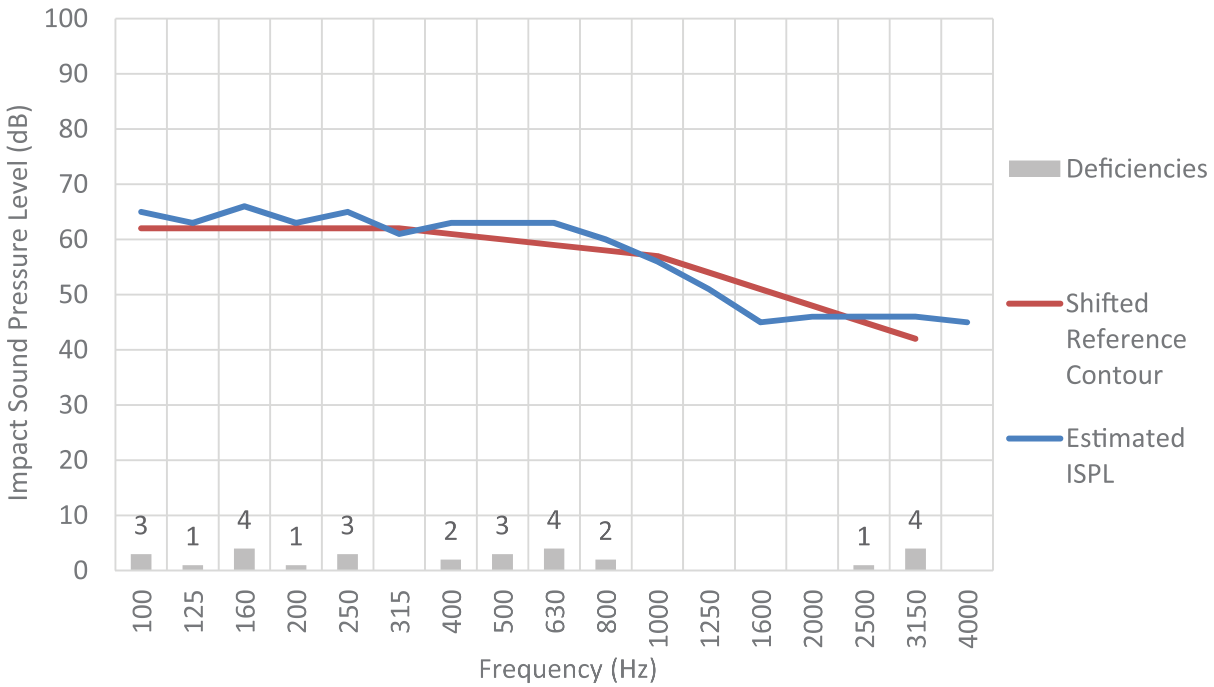
Individual values of TL_a and Δ_{ISPL} for Example 3 are tabulated in Table 3.4.2, along with the estimated ISPL values. Due to the fact that this example assembly is framed with wood trusses, the Δ_{ISPL} values shown in Table 3.4.2 have been adjusted by the values tabulated at the bottom of Table 1.3.5, in accordance with Section 1.3.5. The resulting contour of estimated $ISPL_a$ values for the example assembly is shown graphically in Figure 3.4.2, along with the shifted reference IIC contour fitted to the estimated $ISPL_a$ curve.

The estimated IIC for this assembly, which has a ceramic tile floor covering, is 50. This estimated IIC is controlled by the sum-of-deficiencies limit. Estimated deficiencies in this example are more evenly spread across the frequency spectrum than in Examples 1 and 2, and none of the deficiencies exceed 4 dB.

Table 3.4.2 **Example 3: Calculation of Estimated ISPL Values and IIC**

Example 3 (ISPL / IIC): Wood Trusses @ 24"; 2 Layers 1/2" GWB	Values (dB) at Frequency (f):																
	100 Hz	**125 Hz**	**160 Hz**	**200 Hz**	**250 Hz**	**315 Hz**	**400 Hz**	**500 Hz**	**630 Hz**	**800 Hz**	**1000 Hz**	**1250 Hz**	**1600 Hz**	**2000 Hz**	**2500 Hz**	**3150 Hz**	**4000 Hz**
Estimated TL: $TL_a(f) = \Sigma TL_I(f) + \chi_b(f) + \Sigma\delta_\chi(f) =$	27	32	35	43	49	51	51	56	57	56	58	59	61	62	63	67	70
ISPL adjustment: $\Delta_{ISPL}(f) =$	-18	-15	-9	-4	3	2	4	9	10	7	5	0	-4	-2	-2	3	5
Estimated ISPL: $ISPL_a(f) = 110 - TL_a(f) + \Delta_{ISPL}(f) =$	65	63	66	63	65	61	63	63	63	60	56	51	45	46	46	46	45
Reference ISPL contour (ASTM E989):	2	2	2	2	2	2	1	0	-1	-2	-3	-6	-9	-12	-15	-18	
Shifted reference contour: **IIC = 50**	62	62	62	62	62	62	61	60	59	58	57	54	51	48	45	42	
Deficiencies: Σ(deficiencies) = 28	3	1	4	1	3		2	3	4	2					1	4	

Figure 3.4.2 **Example 3: Estimated ISPL Contour with Corresponding Shifted Reference Contour and Deficiencies**



References

1. 2018 *International Building Code®*, International Code Council (ICC), Country Club Hills, IL.

2. “ASTM E90 – 09(2016): Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements,” ASTM International, Philadelphia, PA, 2016.

3. “ASTM E413 – 16: Classification for Rating Sound Insulation,” ASTM International, Philadelphia, PA, 2016.

4. “ASTM E492 – 09(2016)^{e1}: Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine,” ASTM International, Philadelphia, PA, 2016.

5. “ASTM E989 – 06(2012): Standard Classification for Determination of Impact Insulation Class (IIC),” ASTM International, Philadelphia, PA, 2012.

6. Warnock, A.C.C. & Birta, J.A., "Detailed Report for Consortium on Fire Resistance and Sound Insulation of Floors: Sound Transmission and Impact Insulation Data in 1/3 Octave Bands," IRC Internal Report IR-811, National Research Council Canada, Ottawa, Ontario, July 2000.

7. Warnock, A.C.C., "Summary Report for Consortium on Fire Resistance and Sound Insulation of Floors: Sound Transmission and Impact Insulation Data," IRC RR-169, National Research Council Canada, Ottawa, Ontario, January 2005.

8. Sabourin, Ivan, "Acoustic Testing of Two Floor Assemblies", Report A1-008919.1, National Research Council Canada, Ottawa, Ontario, June 2016.

9. Kruithof, Steven & Kashef, Ahmed, "Acoustic Testing of I-joist Floor Assemblies with Floor Coverings", Report No. A1-010726.1, National Research Council Canada, Ottawa, Ontario, December 2017.

American Wood Council
222 Catoctin Circle, SE, Suite 201
Leesburg, VA 20175
www.awc.org
info@awc.org