TOOL FOR PREDICTING TRANSMISSION OF AIR-BORNE AND STRUCTURE-BORNE SOUND IN BUILDINGS

J. David Quirt, and John K. Dickinson
National Research Council, Institute for Research in Construction, Ottawa, K1A 0R6, Canada

1. INTRODUCTION

In recent years, the science and engineering for controlling sound transmission in buildings have shifted from a focus on individual assemblies such as walls or floors, to a focus on performance of the complete system. A calculation framework based on extensive experimental studies of lightweight wood-framed constructions has been developed, and a first design guide[1] was published in 2006. This paper presents an overview of the design context and the basic features of a new internet-based acoustical application intended to make the design process more effective.

For decades, North American building codes, have considered only the rating for the assembly separating adjacent dwellings—Sound Transmission Class (STC) for airborne sources—as if sound were transmitted only through the obvious separating assembly. In reality, the problem is more complex. An airborne sound source excites all the surfaces in the source space causing them to vibrate in response. Some of this vibration is transmitted across the surfaces abutting the separating assembly, through the junctions where these surfaces join the separating assembly, and into surfaces of the adjoining space, where part of the transferred energy is radiated as sound. Occupants of the adjacent space actually hear the combination of sound due to direct transmission through the separating assembly and any leaks, plus sound due to structure-borne flanking transmission involving all the other elements coupled to the separating assembly. For design or regulation, the terminology to describe the overall sound transmission including all paths is well established; the ASTM descriptor for system performance including flanking is Apparent Sound Transmission Class (ASTC). While measuring the ASTC in a building is quite straightforward, predicting the ASTC due to the set of transmission paths in a building is quite complex, and requires data on structure-borne transmission that is only gradually becoming available.

A model for air-borne and structure-borne transmission must account for all five factors indicated in Figure 1. Framed assemblies are anisotropic and highly damped – the vibration field exhibits a strong gradient that is different in the directions parallel and perpendicular to the joists. In general, this vibration field is a poor approximation of a diffuse field, which limits the applicability of simple SEA models. Not only are vibration levels strongly attenuated across the surface of the structural assembly, but also some added surface layers (such as concrete floor toppings) *change* the attenuation across the structural assembly, with different changes in the three orthogonal directions pertinent to direct and flanking transmission.

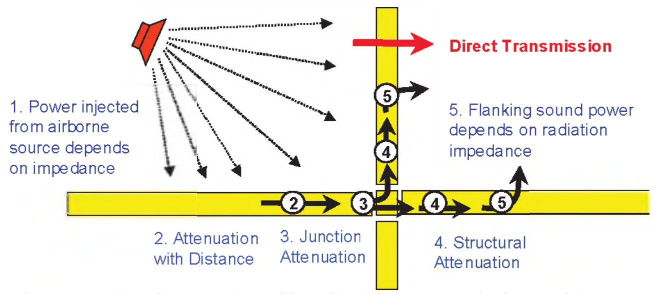

Figure 1: Five factors that affect flanking transmission, with an airborne source for the paths involving the floor surface in the source room. Similar factors apply for all other paths.

2. THE DESIGN GUIDE

A simplified guide for design of wood-framed buildings was developed[1], using a tabular approach to present alternative choices for all the surfaces likely to be significant to the overall sound transmission between adjacent spaces. It presents tables of ASTC and AIIC ratings for sound transmission between units that are side-by-side, or one above the other, for common constructions. These were based on results from a multi-year experimental study.

Separating wall:	Basic Wall (STC 52)	Better Wall (STC 57)	
Gypsum board on side walls:	Direct or resilient	Direct	resilient
Floor Topping:	(Apparent–STC)		
Basic OSB subfloor	43	43	43
Second layer of 19-mm OSB	48	50	50
•	•	•	•
•	•	•	•
38 mm gypsum concrete + resilient mat on subfloor	51	53	55

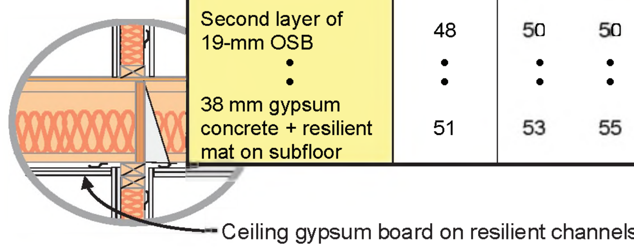

Figure 2: Simplified example from Guide[1] for adjacent one-level apartments. Sidewalls abutting the separating wall also transmit sound, but resilient channels supporting the gypsum board ceiling block transmission via the ceiling/ceiling path.

The tabular approach discussed above does show the effect of changes to the surfaces controlling sound transmission—both the separating assembly and the key flanking surfaces (hence indicating potential places to make improvements), and it also provides ASTC estimates for designers. Because tables are readily presented in conventional technical documents, distribution to builders and their generalist designers was effective. But there are obvious limitations:

- Each table (like Figure 2 above) applies to one specific combination of wall and floor constructions; therefore, many tables were required.
- Tabular form does not readily support comparison of different designs, or show relative strength of direct and flanking transmission paths in each case (to highlight which surfaces limit performance).
- A table can present only a few variants on possible elements such floor toppings, or floor coverings, or gypsum board type and attachment on flanking surfaces.

The obvious means to display more choices for each of the component materials—and to facilitate a more detailed analytic approach—is to implement the calculation framework in software, linked to a database of sound transmission data for each path, for the matrix of construction options that have been experimentally characterized. Implementing this as an internet-based tool (See Figure 3) should facilitate distribution, version control, and periodic updating and expansion of the database. A prototype screen image is shown in Figure 4, to illustrate the potential of such tools to provide acoustical performance estimates in an accessible form.

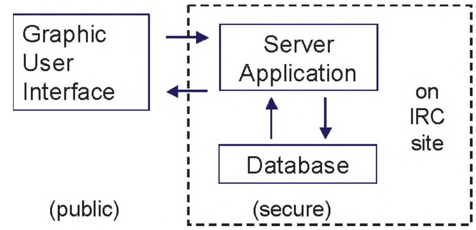

Figure 3: Conceptual structure for internet-based application

3. SUMMARY AND REFERENCES

This paper provides a terse overview of how experimental characterization of the direct and flanking sound transmission paths in wood-framed construction leads to a manageable set of path transmission terms (which depend on the specific construction details). By combining an interactive interface with a calculation framework, a new internet-based tool presents predicted energy transmitted via all paths in an intuitive and user-friendly form that supports informed design decisions.

We acknowledge collaboration with NRC for this extension of the flanking guide by FPI Forintek, Owens Corning, and Lauzon Floors, and also long term support for this activity by CMHC, Marriott International, Trus Joist, and USG.

1. J.D. Quirt, T.R.T. Nightingale, F. King, Guide for Sound Insulation in Wood Frame Construction, **RR219**, NRC-IRC Canada, (2006)

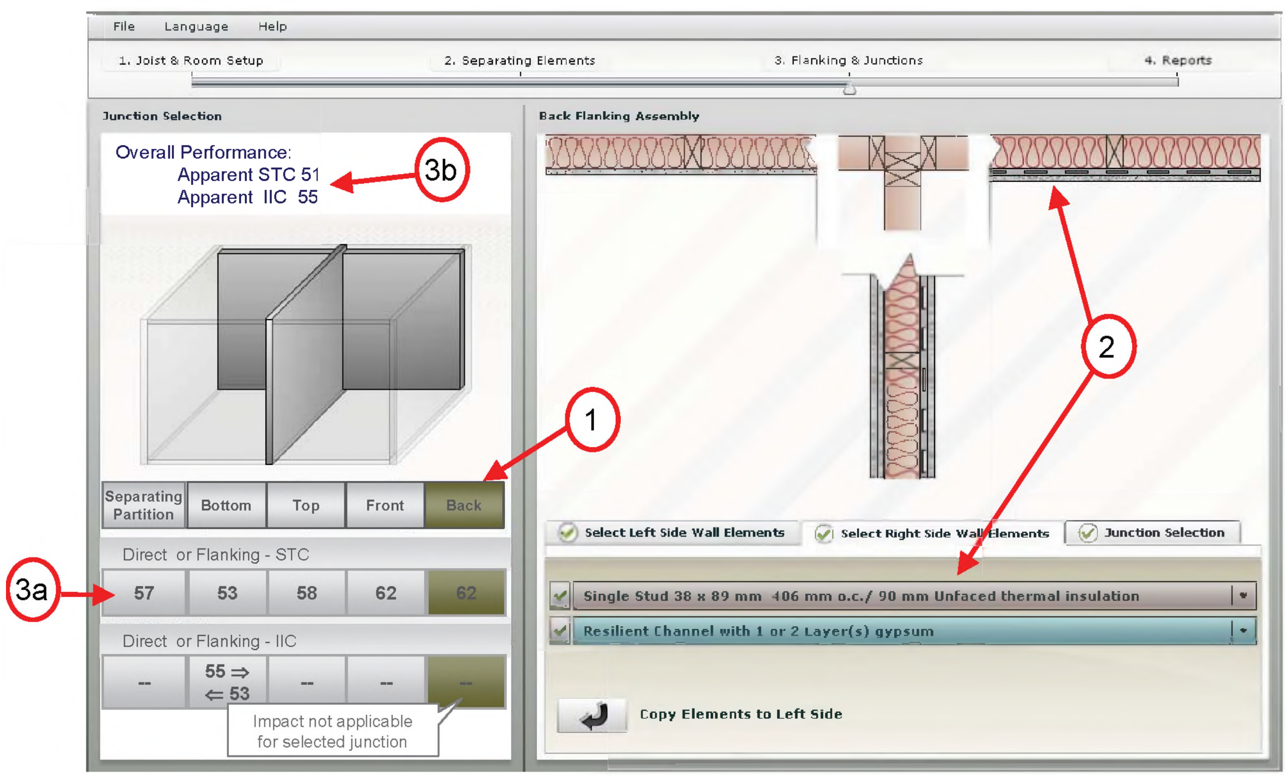

Figure 4: Example of user interface that displays sound transmission estimates for flanking and direct paths, to guide design decisions. Parts of the interface include: (1) buttons to select between the separating assembly or each of the four flanking junctions at its edges, (2) drop down menus to select details of framing and other components affecting transmission via the selected junction, (3a) calculated sound transmission ratings for each set of paths, (3b) calculated overall sound insulation estimate.