NRC-IRC FLANKING SOUND TRANSMISSION FACILITY

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1. INTRODUCTION

Walls and floors evaluated using ASTM laboratory test methods are built in structural isolation to evaluate direct transmission. However, in real buildings, junctions between walls, floors, enable structure borne vibration to be transmitted around the nominally separating element. This 'flanking' transmission reduces apparent the sound isolation effectiveness of walls and floors in real world settings but is not accounted for in the ASTM laboratory methods. National Research Council persons (T. Estabrooks, B. Fitzpatrick, R. Halliwell, F. King, D. MacMillan, T. Nightingale, and D. Quirt) recently designed and built a flanking facility to investigate how flanking paths affect the sound insulation performance of building systems (coupled wall and floor elements). This paper describes some of the key features of the facility that is unique to the world. This is the second paper in a suite of five that examine flanking.

2. FACILITY DESIGN

The research facility has 8 rooms, or more specifically, 8 walls, 4 floors and 6 junctions, enabling evaluation flanking of bearing and non-bearing wall/floor junctions, as well as wall/wall paths with a single specimen. To ensure the facility itself does not contribute to vibration transmission, fixed surfaces are massive and isolated from one another using resilient mountings and each surface has its own independent structural framing. Each room has a volume that differs by about 10% from adjacent rooms, to avoid modal matching, and follows the recommendation of ISO 140.

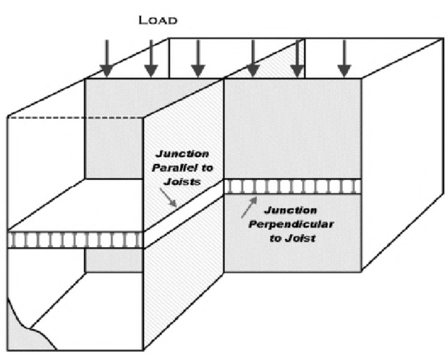

Figure 1: Cut-away sketch showing the bearing walls of the specimen to which a static load can be applied.

The entire facility is run by a computer system[1], which controls noise sources, robot movements and signal capture. In each room a pressure microphone is precisely moved to pre-determined positions by a computer-controlled robot having 4 degrees of freedom. The analogue signal from the microphones in all 8 rooms is sampled simultaneously, digitized, and saved to disc for later processing. This system enables measurements to be run after business-hours when the ambient environment is quietest, and virtually eliminates uncertainty due to measurement repeatability. This is the second generation of flanking facility built at the NRC. It has the enhancement of being able to simulate the static load using 6 hydraulic cylinders which distribute 4500lbs on each of the East and West loading beams (*Figure 1*) - the equivalent of a two story building. The effect of loading on flanking transmission in wood frame construction is discussed in a companion paper[2].

3. COMMISSIONING

There were three phases in commissioning the facility. First was to establish microphone locations. Second was to establish consistency of results from the first generation flanking facility. Third was to establish flanking limits.

<u>Selection of microphone positions</u> – Microphone positions must be selected such that their mean value approximates that of a very large population that samples the entire room volume. To accomplish this each room was divided into a grid of 5 x 5 x 5, and the 125 positions measured in each third octave band between 50 and 5000 Hz. All points met ASTM standards, namely, they were farther than 0.5 m from a room surface and 1 m from a noise source. The average of all 125 positions was then calculated. One position was then selected within the centre zone of the grid, and an algorithm was written to randomly select the remaining 8 microphone positions. None of the resulting 9 microphone positions were permitted to be no closer than in 0.5m of each other. This ensured that the microphones were spread throughout the volume of the room. After this process was completed for all eight rooms, measurements were conducted at the selected locations and then compared to the average of the 125 positions. Positions were deemed acceptable when the mean value of the 9 positions (plus/minus one standard deviation) equaled that of the larger set. Physical checks were conducted to ensure the automated system properly positioned the microphones. The robots were cycled though all 9-microphone positions many times, and positions confirmed by a measuring tape.

<u>Consistency of Results</u> – The first construction built in the new facility is shown in *Figure 2* and was one that had been thoroughly evaluated in the first generation facility. Full details of the construction details can be found elsewhere[3], which consisted of floors with 3/4" OSB, wood-I joists spaced 16" O.C, 6" batt insulation, resilient channels spaced 16" O.C., and two layers of 5/8" Type C gypsum board. Wall consisted of 2x4 wood studs 16" o.c. batt insulation,

resilient channels 16” o.c., and three layers of 5/8” Type C gypsum board. The joists used in the first generation facility were slightly different than those used in the new facility and are listed in Table 1.

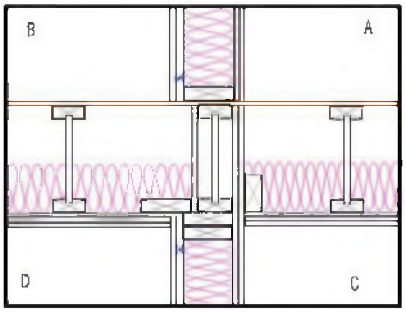

Figure 2: Sketch showing the specimen used in commissioning.

So any differences between results from the two facilities will then be the sum of two systematic effects and one random effect. Systematic effects are different joist flanges, and differences in room sizes, microphone positions, and measurement system. The random effect is the uncertainty introduced by rebuilding a (complex) specimen.

Table 1. Joist Properties.

Joist	Description	Web
#1	Solid Wood 2” x 10”	N/A
#2	Laminated veneer lumber 1-1/2”X1-1/2” flange	3/8” thick OSB
#3	Spruce-pine-fur 2-1/2”X1-1/2” flange	3/8” thick OSB

Figure 3 shows that despite differences in the joists, Apparent Transmission Loss (ATL) results from the two facilities are remarkably similar, especially considering the added uncertainty of completely rebuilding the complicated construction. Agreement between the apparent airborne and impact sound insulation between other room pairs was similar.

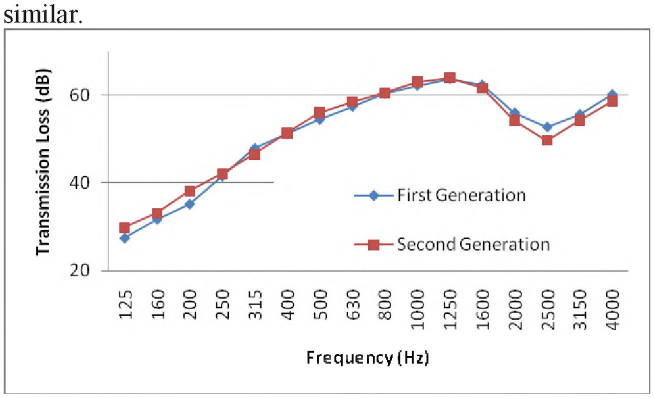

Figure 3: ATL for rooms separated by the floor-ceiling assembly in the first generation facility and the second generation facility.

Facility Flanking Limits – For the facility to be effective as a research facility to assess the various transmission paths in framed construction, transmission involving the facility (facility flanking) must be considerably less than that of the specimen under test. Establishing flanking limits is difficult and time consuming, and basically follows this approach. A specimen is installed whose sound insulation is systematically improved by adding some treatment (typically a topping for floors, and additional layers of the gypsum board for walls) and at each stage the change in sound insulation is compared to expected changes. When commissioning the new facility it was possible to install some of the “high sound insulation” assemblies form the first generation facility and compare results. In reality for any sound transmission facility there is no unique flanking limit because facility flanking changes with the type and construction details of the specimen installed.

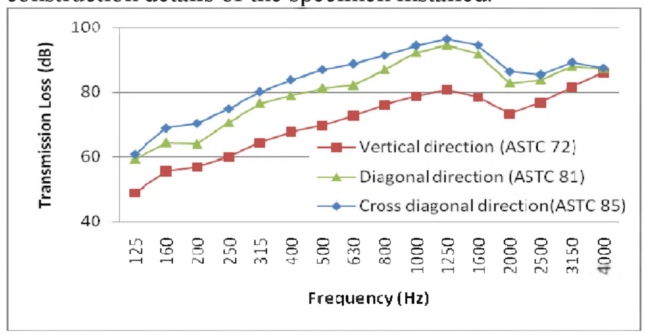

Figure 4: ATL between various room pairs indicating very sound insulation can be measured before the facility will affect results.

4. ESTIMATING SPECIFIC PATHS

The apparent sound insulation is the sum of all transmission paths between two rooms, and is what determines the subjective response of occupants. However, it is often very useful to obtain estimates of the sound insulation of particular paths in order to determine the most effective treatment to improve the apparent sound insulation. The NRC-IRC facility employs the ISO 10848 procedure with a minor variant[3].

Systematically, all wall surfaces are shielded, and for each shielding condition the airborne and impact sound insulation measured. The next paper in this suite, shows that by recognizing which transmission paths are active for each shielding condition it is possible to create a set of simultaneous equations, which can be solved for the various paths. Obviously, the effectiveness of this method is strongly dependent on the quality of the measurements – they must be highly repeatable – hence the need for computed controlled robotic measurement system.

REFERENCES

[1] Timothy Estabrooks, “NRC-IRC Computer Controlled Acoustic Measurement and Quality System,” *Canadian Acoustics*, V37 No.3, 2009

[2] Ivan Sabourin, Berndt Zeitler, and Frances King, ”Effects of Structural Load and Joist Type on Flanking Sound Transmission” ,*Canadian Acoustics*, V37 No.3, 2009.

[3] “Flanking Transmission in Multi-Family Dwellings: Phase IV”, NRC-IRC-RR-218, 01 March 2006.