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Publisher's version / Version de l'éditeur:

Canadian Acoustics = Acoustique Canadienne, 37, 3, pp. 54-55, 2009-10-14

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NRCC-51393

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October 2009

A version of this document is published in / Une version de ce document se trouve dans:
Acoustics Week in Canada 2009 (Annual Conference of the Canadian Acoustical Association), (Niagara-on-the-Lake, Ontario, Canada, October 14-16, 2009

EFFECTS OF STRUCTURAL LOAD AND JOIST TYPE ON FLANKING SOUND TRANSMISSION

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1. INTRODUCTION

It is well known that flanking sound transmission in lightweight wood frame construction is dependent on details around the junctions such as joist orientation and joist continuity[1]. In this paper (the fifth paper of a five part suite) two further parameters, namely structural load on the load bearing wall and joist type, are presented. They are both relevant for the building Codes and guides[2]. It is important to assess if laboratory measurements under- or over-predict the sound transmission in a real building and if construction elements such as joists can be treated as generic or not.

Measurements to assess the effect of these parameters were conducted at two NRC flanking facilities: the first generation four-room (two above two room), and second generation eight-room (four above four room) flanking facilities[3]. The later facility is unique in the world and has the capability of measuring flanking sound transmission of loaded partitions. The construction assemblies used in these studies are of common North American style wood frame construction[3]. The appropriate surfaces of the rooms are shielded to limit the sound transmission to the paths of interest[4].

2. EFFECT OF STRUCTURAL LOAD

This section on the effect of loading on flanking sound transmission is separated in two parts. The first part, an initial loading study, deals with the reproducibility of load and general tendency of the effect of loading. The second part deals with the effect of loading relative to joist orientation and continuity.

In the initial study the flanking sound transmission was investigated between two horizontally separated rooms, with discontinuous joists perpendicular to the separating wall; all sidewalls were shielded. Different loads were applied to the separating wall simulating no stories above, 0.5 stories above, and 0.7 stories above the rooms of interest. The apparent transmission loss (ATL) for the sum of these paths increases due to adding load to the party wall and tends to increase with frequency as shown in Figure 1. The effect of load stagnates at an extra load of 0.5 stories. This is a very important finding because it means that the same load can be used to assess the effect of load on buildings of different height, be they 2 stories or 4 stories tall. The second important finding is that the effect of load is reversible. After removing the load, the ATL returns to its original state. The same is true when reapplying the load. The very small variations seen are most likely due to the long duration between tests which was spread out over a period of weeks.

The second part of this loading study compares the effect of load relative to joist orientation and continuity. Single sound transmission paths were isolated to understand the effect of loading. It is to be noted that the partition wall is only loaded for the junction cases where the joists are perpendicular to the partition wall whereas it is the side walls which are loaded for the parallel case. Figure 2 shows the effect of loading for the horizontal floor-floor and ceiling-ceiling paths. Loading has a similar effect for both horizontal paths through the same junction. In general, loading improves both perpendicular cases while it causes a slight negative effect on the parallel paths. Very similar results were observed for the change of ISPL through floor-floor paths.

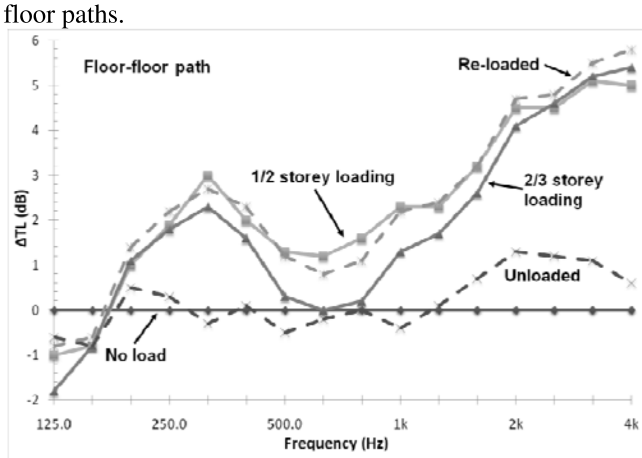

Figure 1: Change of ATL of horizontal room pairs due to loading, unloading, and reloading partition wall.

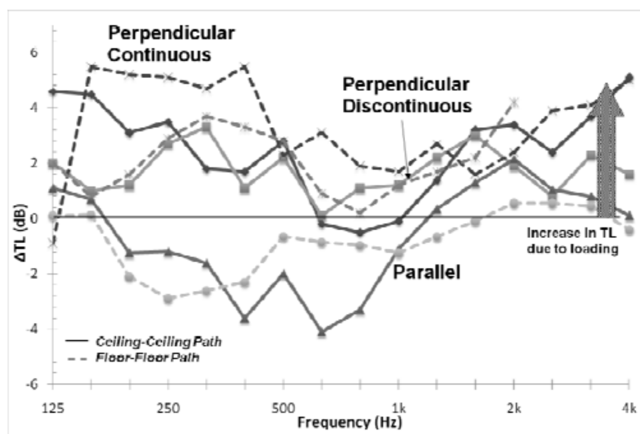

Figure 2: Effect of loading on ATL for different junction types for horizontal floor-floor and ceiling-ceiling flanking paths.

The fact that loading increases attenuation of sound transmission in cases where the joists are perpendicular and decreases attenuation slightly in parallel joist cases, can be explained by a recent study[5] using a laser vibrometer to capture the structural intensity. From this study, it has been shown that much of the flanking sound power is transported along the head- and soleplates of the wall into the receiver room. By loading the partition wall the contact between the floor and the soleplate of the wall becomes more rigid. Thereby more sound power from the floor is transmitted into and along the soleplate, and travels parallel to the load bearing junction instead of perpendicular to the junction through the floor causing the perpendicular paths to be attenuated more and the parallel path to be attenuated less.

Table 1: Summary of the effect of loading

Junction type	Direct Paths -vertical -horizontal	Horizontal Flanking Paths -floor-floor -ceiling-ceiling	Diagonal Flanking Paths -floor-ceiling
Perpendicular continuous	No significant change	Improvement (approx. 3 dB)	Improvement (approx. 2 dB)
Perpendicular discontinuous		Improvement (approx. 3-4 dB)	Improvement (approx. 1-2 dB)
Parallel discontinuous		No change or slight worsening	No change or slight worsening

3. EFFECT OF JOIST TYPE

The flanking sound transmission of assemblies constructed using three different types of joists is investigated here. The first comparison is between the ATL of specimens built with 2x10 lumber (Joist #1) and wood I-joists (Joist #2) measured at NRC's first generation flanking facility. The second comparison is between ATL using two different types of wood I-joists, both with OSB web. Joist #2 has a smaller laminated veneer lumber flange where as Joist #3 has a larger spruce-pine flange[3]. The latter assemblies to compare the effect of wood I-joist were constructed in different NRC flanking facilities; hence other parameters such as different room size, junction length, might have an influence on the results. Changing the joist type could affect many components of the transmission path – the power injected by the source, the structural attenuation, the junction attenuation, and radiation to the receiver room.

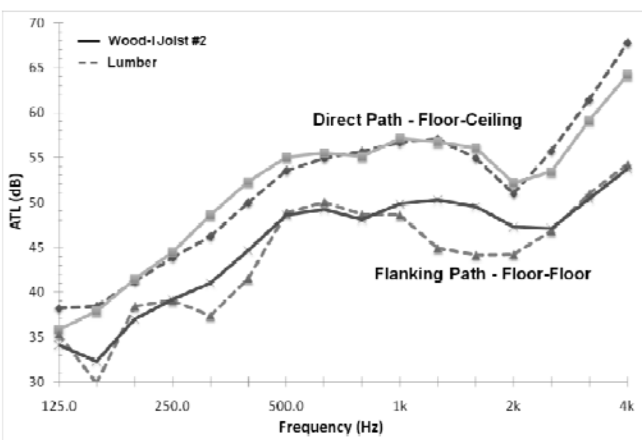

Figure 3: ATL difference for floor-floor paths due to joist types: 2x10 lumber vs. wood I-joists in same facility

A comparison of ATL between lumber and wood I-joists is shown in Figure 3 for the direct vertical and horizontal floor-floor cases. The joist type which performs better varies over the whole frequency range for the direct vertical path. For the floor-floor path however, the Wood-I joist #2 performs better throughout most of the frequency range. This order of performance changes for impact sound pressure levels though[1].

As expected, the largest difference due to different joist type is observed for floor-floor flanking transmission path. It is however difficult separate the effect due to the joist types and the room properties.

The comparison of Joist#2 and #3 can be seen in Figure 4, where the horizontal floor-floor, the direct vertical, diagonal floor-ceiling path are displayed for the parallel junction case. The differences for all paths are of similar magnitude. At high frequencies the floor-floor path difference is probably a reproducibility issue due to varied contact area between the floor and the head- and soleplate.

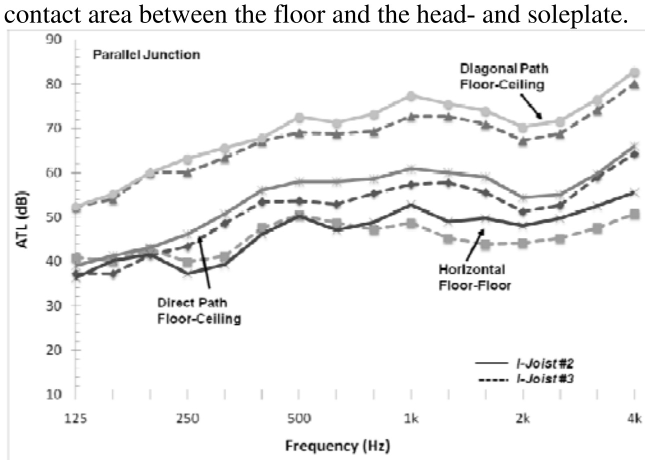

Figure 4: ATL for parallel floor-floor paths due to joist types – wood I-joists #1 vs. wood I-joist #2 in different facilities

4. CONCLUSION

Changes to the flanking sound transmission due to loading are small and might not be of any importance if the direct paths are dominant. Current estimates without loading are mostly conservative except for parallel cases. The load correction factor for relevant paths depends on the joist orientation and continuity.

Early data suggests that joists can be treated as generic, because the effect of the joist type is considered small relative to the influence of the joist orientation and continuity.

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