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EFFECT OF SOME FLOOR-CEILING CONSTRUCTION CHANGES ON FLANKING TRANSMISSION

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1.

2. INTRODUCTION

A large systematic study was carried out by the National Research Council-Institute for Research in Construction (NRC-IRC) to evaluate a wide range of floor-ceiling designs to control transmission of airborne and impact sound between vertically adjacent rooms. As impact sources, the tapping machine according to ASTM E492 as well as the heavy sources, the ball and the "bang-machine", according to JIS A 1418-2 were used. The first part of the study was a parametric study. The direct sound transmission of a large series of floor-ceiling assemblies was measured systematically in the NRC-IRC Floor Transmission Facility to understand the complex interaction of the various structural components and to optimize noise control measures. The second part of the study was a flanking study. A number of floor-ceiling assemblies that achieved good direct sound insulation in the parametric study were selected and their system performance was measured in the NRC-IRC Flanking Transmission Facility. The system performance is determined by the apparent sound transmission which is the sum of the direct transmission and the flanking transmission via the floor to the walls below. This paper presents some findings from this flanking study. Only impact measurements with the tapping machine are presented in this paper.

3. MEASUREMENTS AND RESULTS

The parametric study shows that adding a floor topping or decoupling the ceiling from the floor assembly are both effective ways of controlling direct transmission. Two floor-ceiling assemblies with decoupled ceilings were selected to be studied in the Flanking Facility with and without topping. One objective was to investigate the contribution of flanking transmission to the apparent sound transmission.

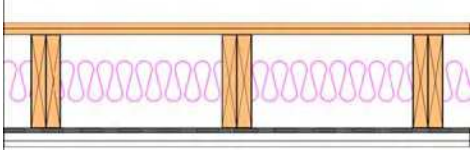

Figure 1: Floor ceiling assembly with resilient channels.

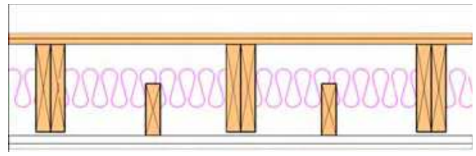

Figure 2: Floor ceiling assembly with separate joists.

The first assembly, shown in Figure 1, consisted of two layers of 16 mm plywood subfloor, scabbed 2X10 joists spaced 455 mm o/c, 100 mm glass fiber insulation, resilient channels spaced 455 mm o/c, and two layers of gypsum board (21 mm and 16 mm) for the ceiling. The second assembly, shown in Figure 2, was identical to the first except separate ceiling joists were used instead of resilient channels to decouple the ceiling. The walls in the room below the floor/ceiling assembly consisted of 2X6 wood studs spaced 455 mm o/c with a single layer of 13 mm gypsum board directly attached.

Five transmission paths contribute to the apparent sound transmission of vertically adjacent rooms:

1. One direct transmission path through the floor ceiling assembly,
2. Two floor-wall flanking paths via the floor-ceiling assembly and the load-bearing (LB) junctions, and
3. Two floor-wall flanking paths via the floor-ceiling assembly and the non-load bearing (NLB) junctions.

Figure 3 shows the direct impact sound pressure level and the flanking impact sound pressure level transmitted across the load bearing and non-load bearing junction for the two floor-ceiling assemblies. Direct transmission is reduced more effectively for the assembly with resilient channels (RC) than with separate joists (SJ) whereas flanking transmission across the load-bearing and non-load bearing junction is similar for the two assemblies. Figure 4 shows the percentage of contribution of the direct and flanking transmission to the total transmitted sound power for the two floor-ceiling assemblies. When the direct transmission is reduced effectively by decoupling the ceiling, flanking becomes more important and contributes more to the overall apparent transmission. Flanking transmission is more important for the load bearing wall than the non-load bearing wall for both assemblies. However, this relative importance could change as shown in the next part of the study.

Adding a floor treatment is a second method to improve impact sound insulation of a floor assembly. The parametric study had found a gypsum-plywood (21 mm and 15.5 gypsum and 15.5 mm plywood) floor topping to be effective in suppressing direct impact and airborne sound transmission. The gypsum-plywood topping was added to both floor-ceiling assemblies to examine its effect on flanking transmission. Figure 5 shows that the effectiveness of the topping is similar for both assemblies. However, it is different for direct and flanking transmission. Previous NRC-IRC studies[1] have shown that the floor topping reduces power injection by the impact source but also changes how the vibration energy travels across the floor. On a bare floor, the floor joists "channel" structure-borne sound towards the load bearing (LB) junction while they "block" wave propagation towards the non-load bearing (NLB) junction. When a topping is added, both the "channeling" and "blocking" effects are diminished. The floor appears more homogeneous and isotropic and the relative importance of the load-bearing to the non-load-bearing flanking transmission changes. Figure 6 shows the percentage of contribution of the direct and flanking transmission to the total transmitted sound power for the two floor-ceiling assemblies with the topping. With the topping added, the relative importance of non-load bearing flanking path has increased. With the resilient channel ceiling and the topping added, the non-load bearing flanking path contributes more than the direct path from 100 Hz to 1 KHz and more than the load-bearing flanking path in the 200 Hz and 250 Hz bands.

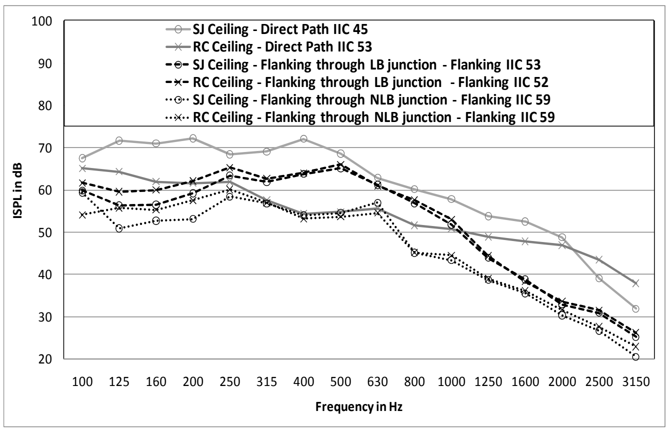

Figure 3: Direct and Flanking transmission paths across load-bearing (LB) and non-load bearing (NLB) junctions of two floor-ceiling assemblies.

4. CONCLUSIONS

The flanking study on two types of floor-ceiling assemblies with and without topping shows that both decoupling the ceiling and adding a topping are effective in reducing direct transmission. However, they affect flanking transmission differently. This changes the importance of direct and flanking transmission for the overall apparent transmission. When the ceiling is decoupled effectively and a topping is added, both the load bearing as well as the non-load bearing flanking paths are equally important and exceed the direct path in some frequency bands. Thus, it is necessary to examine the overall system performance when construction changes are made to floor-ceiling assemblies to improve sound insulation.

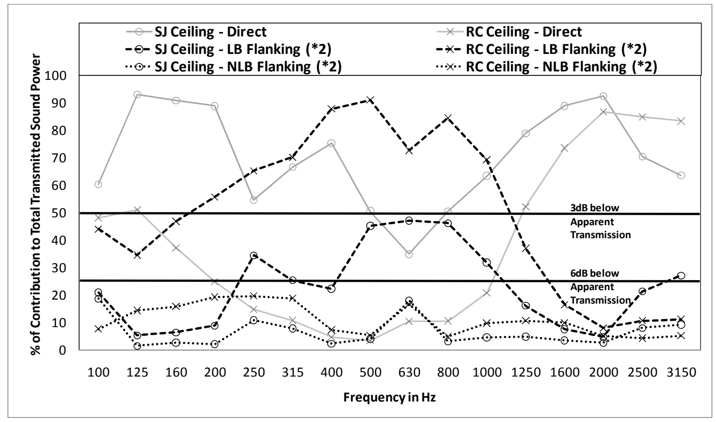

Figure 4: Relative contribution of direct and flanking transmission to total transmitted sound power for two floor-ceiling assemblies.

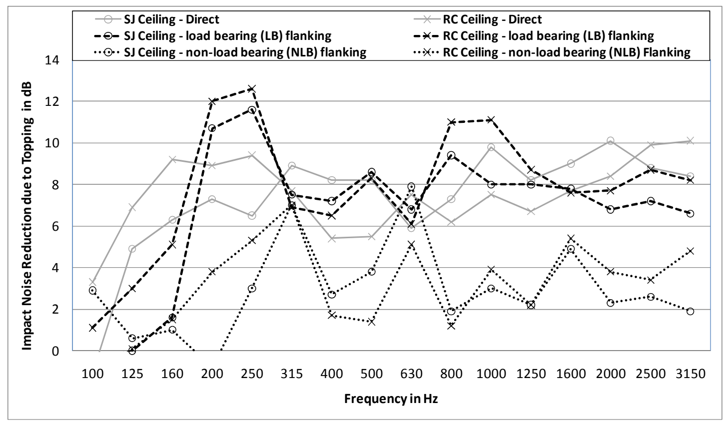

Figure 5: Impact noise reduction of two floor-ceiling assemblies with a topping.

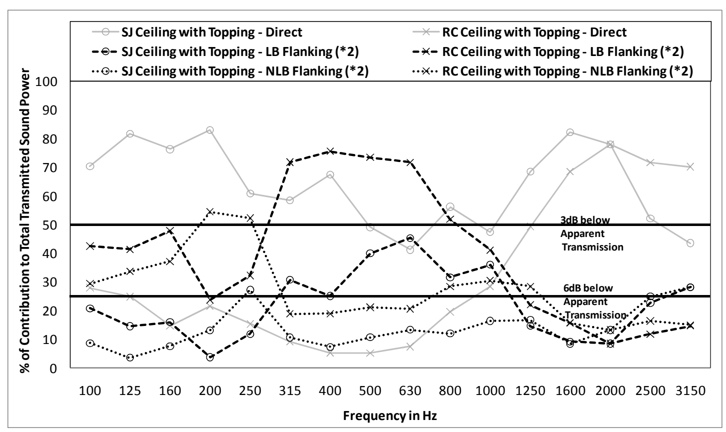

Figure 6: Relative contribution of direct and flanking transmission to total transmitted sound power for two floor-ceiling assemblies with a topping.

REFERENCES

[1]T.R.T. Nightingale "Controlling impact noise in wood-frame multi-unit buildings," Proceedings of 15th International Congress on Sound and Vibration, (Daejong, 2008).