INVESTIGATION OF FLANKING NOISE TRANSMISSION INTO A REVERBERATION ROOM

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1 Introduction

Testing facilities such as reverberation rooms or anechoic chambers are prone to flanking noise transmission problems. Flanking noise is the noise transmitted through indirect paths in buildings. These indirect paths, known as flanking paths, can be in the form of structural elements such as ducts, doors, ceilings, or floors of a building (structural-borne) or to be non-structural paths as air ducts, electricity outlets, and air leakage through holes or cracks in walls (air-borne). Flanking transmission can strongly affect the sound insulation between rooms in a building. Usually, the sound transmission through each flanking path is less than the direct transmission between two rooms. However, as there are many flanking paths, the overall flanking transmission is often important in sound transmission [1]. In buildings with masonry and concrete walls, around 50% of the sound transmission between two rooms is contributed by the flanking transmission and the rest is by the direct transmission through the common dividing partition [2]. If there is no common dividing partition between the source room and the receiver room, then all sound transmission is because of flanking paths [3].

Eliminating these paths requires a proper isolation of the room. However, in some cases leakage may occur despite the measures taken in their design and construction. Therefore, an accurate acoustical assessment is required to sort out the possible flanking paths and evaluate the main contributing paths to the leakage. In this work, detailed characterisation of flanking noise transmission into an industrial reverberation room is presented. Moreover, a mitigation technique was implemented to reduce/eliminate the flanking noise transmission into the reverberation room. The industrial reverberation room under consideration is located within a manufacturing facility.

2 Method

The characterization process inside the factory is done in two stages. First, acoustic noise measurements were performed inside and outside the reverberation room to characterise the acoustic field distribution in the facility and recognize the potential flanking noise paths. Second, a thoroughly examination of each flanking path is carried out to estimate its weighted contribution to the overall noise leakage.

The reverberation room under investigation has overall dimensions of 37 x 31 x 27 ft and separated from the rest of the facility by a separation wall composed of acoustic insulation filling sandwiched between two 10 gauge metallic sheets. The ceiling is a metal deck while the floor is made from concrete. The separation wall is equipped with air vents with integrated acoustic silencers to facilitate the introduction of air flow during the acoustic measurements. The reverberation room is connected via a duct to the acoustic source room. Free field microphones were used to measure and map the acoustic field inside the reverberation room and outside in the vicinity between the acoustic source room and the reverberation room. Precautions were considered in order to neutralize the effect of standing waves during the acoustic field measurements. Also, multiple accelerometers were used to measure the structural-borne flanking transmission at different locations. A special analyzing code was developed to match or to correlate the signals acquired from different measuring transducer, e.g. matching the signals of accelerometers and the microphones, to properly inspect the contribution of each flanking path. This matching process was based on the statistical correlation coefficient *R(f)*.

3 Results and discussion

3.1 Acoustic noise measurements

This stage was carried out at two times; during a regular working day and during a weekend day when the manufacturing facility is not operating. From comparing the measurements obtained from both days, it was evident that the outside noise leaks into the reverberation room at the low bands (f < 100 Hz). This leakage seemed to be not transmitting through the metallic separation wall as had been previously expected due to air vents. To investigate this further, white noise was introduced into the room, and the overall sound pressure levels (OSPL) inside and outside the room were measured as shown in Figure 1. It is clear that there is high leakage at frequencies less than 100 Hz which confirms the flanking transmission.

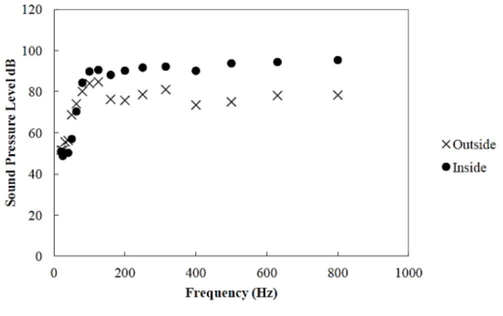

Figure 1 : Sound Pressure Level comparison between inside and outside the reverberation room.

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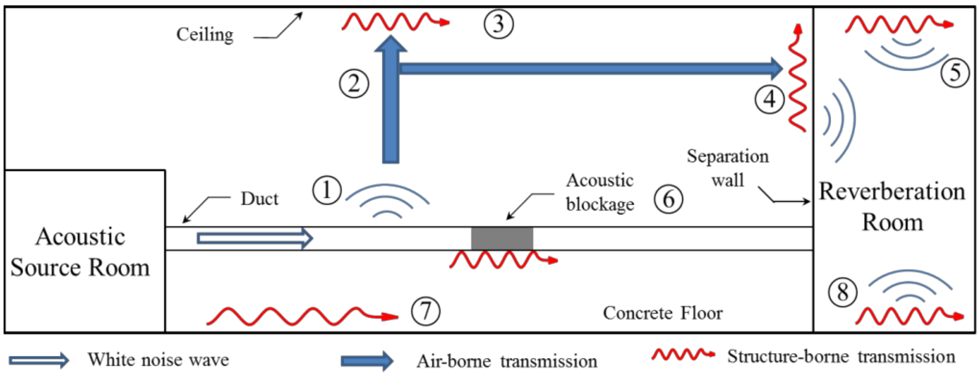

Figure 2 : Sketch of the elevation view with the expected flanking transmission paths for the reverberation room zone in the factory.

Another test was set by acoustically blocking the direct path of the white noise through the duct via acoustical insulating pads. This blockage forces the acoustical energy to pass through the flanking paths to the reverberation room. The OSPL inside the room was relatively at the same levels as without blockage while the OSPL outside the room was around 5 dB higher than the value inside at frequencies ≤50 Hz. This indicates that flanking transmission is the major contributor to this sound leakage at the mentioned frequency range.

The potential flanking transmission paths are illustrated in figure 2. There are three main structural flanking paths. First, the path along the duct body itself and crosses the two sides of the separation wall then to the room (1-6-4-room). Second, the path from the duct body to the outer separation wall then the ceiling and after that the room (1-6-4-5-room). Third, the flanking transmission through the floor from the source to the room (source-7-8-room). The paths which include air-borne transmission (paths 1-2-4 and 1-2-3) are considered as secondary flanking paths because of the high acoustic losses due the reflection of acoustic waves while transmitting through different mediums.

3.2 Structural vibration measurements

The structural vibration was measured via a set of accelerometers placed at different positions on the duct, separation wall, ceiling, and its supporting beams. The correlation coefficient of their signals and the microphone signals were calculated. Figure 3 plots such correlation from various transducers referenced to the signal from the accelerometer located at the outer side of the separation wall. High correlation values indicate better matching between the signals and they are more likely to be linked to each other. It can be seen that there is a weak correlation between the two accelerometers placed on both sides of the wall, hence the less likelihood of sound emission from the wall. This agrees with to what was found from the acoustic noise measurements. The high correlation value at 60Hz is due to the electrical noise. Other correlations were investigated. They revealed that ground flanking path (7-8) is not a main contributor. Surprisingly, a relation was found between the ceiling's supporting beams and the noise inside the room at frequencies ≤100 Hz even when the duct was disconnected which suggested that secondary path 1-2-3-5-room is the main flanking path. A solution was implemented to weaken this flanking path, and acoustic noise measurements were repeated. The repeated measurements showed that the flanking noise was successfully reduced by 10 dB at the frequency bands 25 Hz, 31.5 Hz, 40 Hz, and 50 Hz, and less reduction was obtained for higher bands.

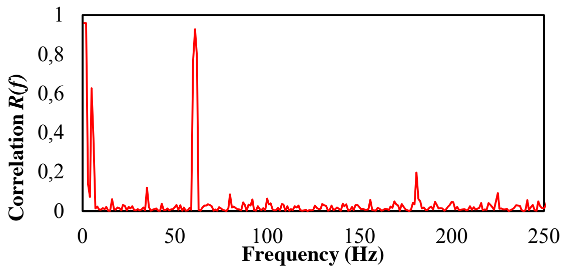

Figure 3 : Correlation between the signals of the accelerometers placed on the outer and inner side of separation wall.

4 Conclusion

A flanking noise investigation into an industrial reverberation room was carried out. It consisted of two stages. The first is an acoustic field mapping inside and outside the reverberation room to recognize the potential flanking transmission paths. The second is the detailed "Correlation" or "Matching" analysis to find out the relation strength between structural vibration and acoustic field at several points along the paths. The analysis revealed that the path 1-2-3-4-room is the major structural-borne flanking path. The propped solution showed a 10 dB reduction in the flanked transmission at frequencies less than 50 Hz.

References

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