Lab 2 – Measurement of impact sound insulation

1. Introduction

Problems of sound insulation have recently become more actual as a result of, for example, densification of cities where people live very close to each other as well as indoor and outdoor noise sources such as cars, appliances, Hi-Fi systems... Two types of sound transmission can be distinguished:

- Airborne sound is the type of transmission which takes place between source and receiver mainly by the air; for example, people talking or music.
- Impact sound (structure-borne sound) is the sound radiated to the adjacent room produced by objects striking directly on a floor, stairs etc. Everyday examples are: people walking, dropping objects…

In this laboratory, impact sound insulation measurements according to the current ISO norms will be performed.

2. Objective and method

The objective of this lab session is to plan, perform and evaluate a standard measurement of impact sound insulation on a wooden floor according to the current ISO standards.

3. Theory

Impact sound level L_n

Let the stepsound lab of LTH be described by the sketch presented in Figure 1; where the upper room (denoted hereafter as *sending room*) is placed on top of the so-called *receiving room*. The excitation source (i.e. the ISO tapping machine) is placed on top of the floor to be tested in the sending room, whereas a microphone is used to measure the impact sound level radiated into the lower, i.e. receiver, room. It should be noted that just direct transmission (i.e. through the floor to be tested) takes place, i.e. no flanking transmission should occur due to the lab-controlled conditions.

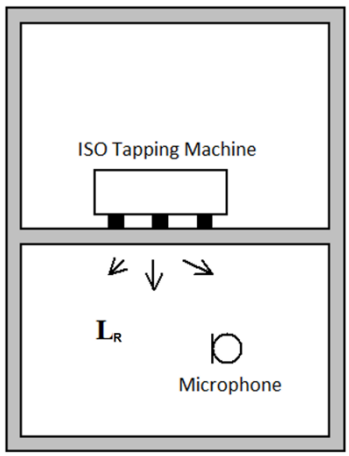

Figure 1. Impact sound transmission through a floor of surface S. L_R and A are the SPL and absorption area in the receiving room.

The ISO tapping machine is placed at different spots on the floor and as soon as it is turned on, it creates vibrations in the floor which propagate throughout and radiate to the room below. The sound pressure level $L_R(f)$ is measured in the receiving room at different positions with help of a sound level meter. The tapping machine positions as well as the microphone placement are defined in the standard ISO 717-2. The frequency dependent impact sound level $L_n(f)$ is calculated with the help of:

$$L_n(f) = L_R(f) + 10\log\frac{A(f)}{10}$$

The absorption area $A(f)$ is related to the reverberation time as described below.

Reverberation time

Each time the sound in a room hits a wall, it loses a percentage of its energy that is given by the absorption coefficient α. From the repeating wall hits, the total sound energy in a room decays exponentially with time, whereas the sound pressure level decays linearly with time. The time it takes for the sound pressure level to decrease 60 dB from the time a sound is turned off is called reverberation time, T_{60}.

When measuring reverberation time, one starts by emitting either pink noise (equally distributed energy in each octave band) or also an impulse excitation. One then simply measures the inclination (i.e. decay) of the SPL curve after the sound is turned off. If the sound level does not decrease by 60 dB, the reverberation time can be evaluated through the drop of the curve during the first 20 dB or 30 dB and then be extrapolated instead (T_{20} or T_{30}, respectively). Theoretically, the values of T_{60}, T_{20} and T_{30} should be the same; however one should be careful as there may be cases where the inclination is not linear with different results. This is often the case when measuring the reverberation time in a room with irregular geometries (e.g. one or two room dimensions much larger than another), such as in corridors and office landscapes.

Reverberation time can also be calculated by means of Sabine's formula, which gives us the relationship between the effective absorption area $A(f)$ in a room of volume V and the reverberation time $T_{60}(f)$, or $RT(f)$, according to:

$$T_{60}(f) = \frac{55.26}{c_0}\frac{V}{A(f)} = 0.16\frac{V}{\sum_i S_i\alpha_i(f)},$$

c_0 being the speed of sound in the air. The total effective absorption area of the room is calculated as $A(f) = \Sigma_i \alpha_i(f) \cdot S_i$, where α_i is the absorption coefficient of each surface involved and S_i its respective area.

The description of the decay of sound described above is based on a model of sound that assumes a diffuse sound field in the room (i.e. equal sound pressure level in every position of the room). The frequency above which a diffuse room model is valid is referred to as the Schroeder cut-off frequency, given by

$$f_S = 2000\sqrt{\frac{T_{60}}{V}}.$$

4. Preparations

Review from the lecture notes the process on how to perform an ISO impact sound insulation measurement; check the number of positions (microphone, tapping machine, loudspeaker…) one needs and put up a plan.

5. Measurement equipment

The measurement equipment is composed of:

- A Norsonic 140 sound level meter (with a microphone)
- Noise generator
- Amplifier
- Loudspeaker
- ISO tapping machine

NOTE: Wear ear protections at all times when performing measurements!

6. Execution

Before you start, make sure that you get familiar with the equipment and that you know how it works.

1. Measure the reverberation time $T_{60}(f)$ in the receiving room with help of the sound level meter using both methods: (i) impulse excitation (slam a book against the wall, clap…. Try different impulses and compare them) and (ii) interrupted noise. If the latter is used, send out noise of ca 80-90 dB, which can be done by adjusting the volume in the amplifier. The loudspeaker should be placed at least in two different positions (of which one must be a corner), with 2 measurements for each position being needed. Make sure that the lab door is closed at all times during the measurements.

2. Measure and record (for 15 seconds) the sound pressure level in the receiving room after having set on the tapping machine. Write down/take a photo of all sound pressure level values (although the teachers will also email the raw data files to you) for each third octave band and position. Measure in 2 different positions for each tapping machine position (total 4), making sure that you keep a distance of 1.5 m from the floor and the walls. Remember that the ISO tapping machine should be angled 45º respect the floor edges.

7. Lab report

Generally speaking, a lab report should contain:

- A brief introduction of the underlying theoretical background.
- A description of what you have done and how you did it.
- The results that have been arrived at.
- An explanation, discussion and/or reflection of the aforementioned results.
- A discussion on the accuracy of the measurements performed, including possible errors that could be encountered/present in the results.

NOTE: Read the *"Guidelines on how to write a technical report"* (available on the course website) as an orientation so as to learn how one should tackle a technical report.
The lab report should contain:

- Measured sound pressure levels in the receiver room for each position as well as the energetic average.

- Reverberation time for the different positions as well as the reverberation time.
  - A comparison between both methods employed should also be presented, discussing the differences (if any) between them.
- Calculated absorption area $A(f)$ in the receiving room.
- Impact sound level $L_n(f)$ calculated for every third octave band between 50–5000 Hz.
- Weighted impact sound level $L_{n,w}$ (single number quantity), and the spectrum adaptation term $C_{I,50\text{-}2500}$ calculated according to the procedures described in the international standard SS-ISO 717-2.

Try to discuss and explain the appearance of all plots you report. Do they comply well with the theory? If not, how and why do they differ? Please complete the report with pictures you should take during the lab session! The laboratory report must be computer-written, printed, stapled, and it should be handed in to Nikolas' tray on the floor +5 of the *V-huset* no later than one week after the laboratory session (you can also send the report via mail if you prefer). The laboratory report is either passed or returned for completion.