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FIELD MEASUREMENTS OF 170 NOMINALLY IDENTICAL TIMBER FLOORS - A STATISTICAL ANALYSIS

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ABSTRACT
172 timber floors have been investigated concerning the impact sound insulation. The houses were built during a period of about one year i.e. during four seasons, and the measurements were carried out immediately after each house was completed. Construction and material are identical for all floors. The only difference was the size, dependent on different room size. The curves from all impact sound measurements follow a very similar pattern, well collected between 200 Hz to 1250 Hz. Above and below this frequency range, the curves show a dispersion more than 15 dB. These phenomena, dispersion at low and high frequencies, could be seen for all dimensions of floor. This sequence of measurements on nominally identical constructions demonstrates the uncertainty to guarantee that all constructions behaviors are alike. The reasons behind these differences will be discussed in the article.

1 - INTRODUCTION
How far is it possible to predict the sound insulation of timber floors in situ from laboratory results?
A timber floor (apartment-separation), mounted in a large number of houses, has earlier became assuredly tested and approved in the laboratory. The conditions in the laboratory were exactly the same at all measurements and the test curves showed also the same results. Normally you have to calculate with a deterioration of the sound insulation results between a floor measured in a laboratory and measured when mounted in a real building. This is depending on a lot of factors, alone or combined, that will change the condition in many ways. Usually these are very difficult to control. In order to examine the construction behavior in real buildings, a large number of measurements have been performed in houses of the same design of floors. In all about 170 floors have been tested, with regard to impact sound- and airborne sound insulation. This paper reports only from the impact sound measurements. The analyses are made on measurement data from 100 Hz to 3.15 kHz.

2 - THE TIMBER FLOORS
The houses were built in the north of Sweden during a period of about one year i.e. during four seasons, and the measurements were carried out immediately after each house was completed. Each house contains four apartments, two above the other two, and are identical i vertical direction. They varied in size from one room and kitchen to four rooms and kitchen.
Construction and material are identical for all floors. Measurements were carried out in two rooms from each apartment. One of the rooms has plastic carpet and the second room has parquet floor. The team of building workers have all the time been the same, so even the measuring-team.

3 - MEASUREMENT AND RESULTS
The curves from all impact sound measurements follow a very similar pattern, well collected between 200 Hz to 1000 Hz, figure 1. Above and below this frequency range, the curves show a dispersion up to 15 dB for the lower frequency range and up to 19 dB for higher frequencies. These phenomena, dispersion at low and high frequencies, could be seen more or less for all dimensions of floors. However all these

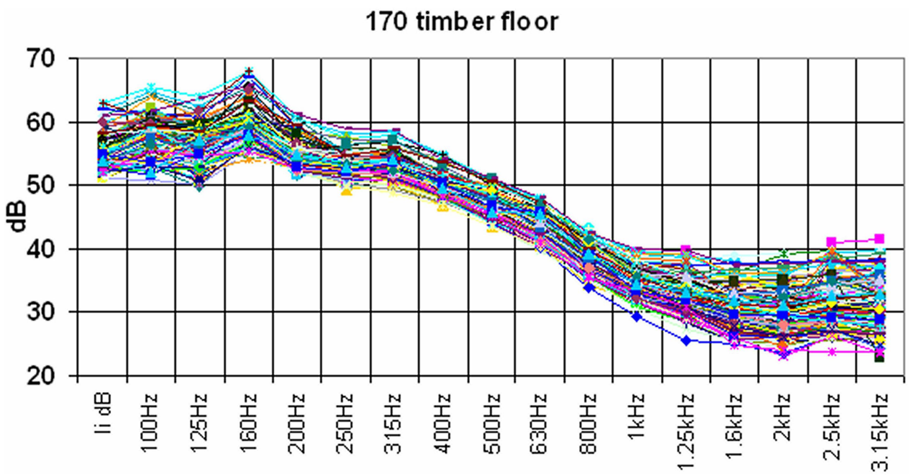

Figure 1: Impact sound level and index for 170 floors.

constructions have been carried out with good margin regarding to sound insulation based on the ISO Standard [1,2].
A serious concern also to be taken into account is whether the floors, with respect to annoyance and sound comfort i.e. psychological and physical aspects, are accepted by the housings.
The measurements comprise eight groups of rooms. In the analysis, the grouping was done with respect to differences in design, volume and floor area and floor covering.
Four of the groups have parquet and four have plastic carpet as floor cover. The room volume varies from 25 cubic metre to 66 cubic metre and the floor area from 10 square metre to 28 square metre.
The room shapes vary between rectangular, l-shape and u-shape, especially for rooms with parquet floor, but within each group the room's shape is exactly the same. The timber floors vary of course in size, but the construction is the same for all apartments.
The standard deviations for the sound level spectra for the total numbers of floors, figure 2, varied from 0.8 dB to 5 dB/oct band. For six of the groups the deviations lie between 0.7 dB to 2.2 dB. The remaining two have higher deviation, 2.7 respective 3.7 dB. These two groups of room have larger dispersion both at low and high frequency than the others.
Different parameters that were relatively easy to control have been included in the investigation, like the significance of different floor covers, effect of size and shape of the room, reverberation time and effect of source position.
The evaluation showed no clear connection between different floor cover and dispersion, as dispersion is found in all groups. Neither did the room volume and floor size alone seem to explain the dispersion, even if rooms from the smallest apartments showed more dispersion both at low and high frequency than from the others.
The notation in figure 2 means; 1L- 4L are groups of living rooms with parquet floor, 1K stands for kitchen with plastic carpet and 2b-4b for bedrooms with plastic carpet.

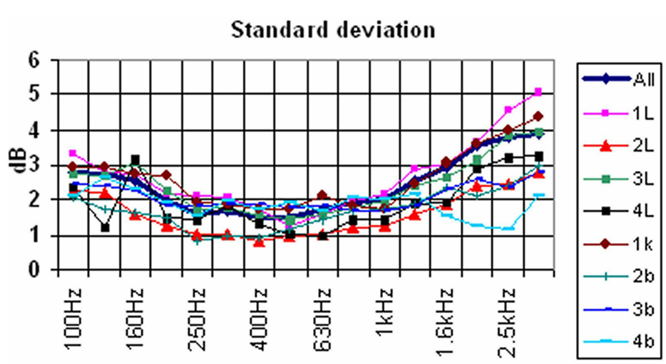

Figure 2: Standard deviation for all groups of rooms.

A comparison between the median (red line) and individual spectra for all groups of floors are shown in figures 3a−3d and 4a-4b.

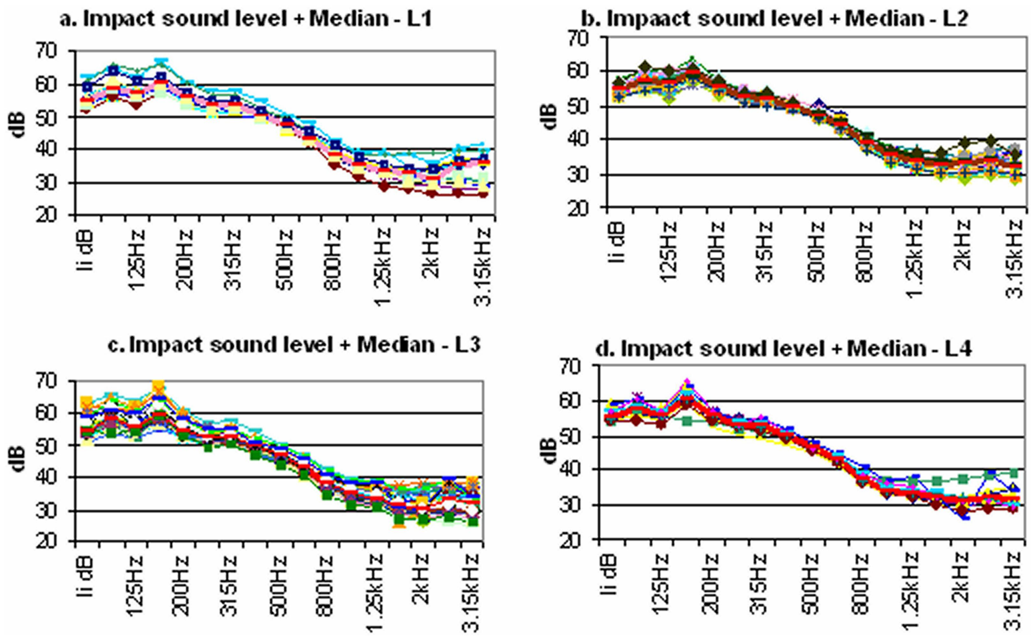

Figure 3: Impact sound level for living rooms.

Source and microphone position: A point under consideration is the source position, especially because these floors are anisotropic. Very important is that the hammer machine, as much as possible, has the same positions for all floors in the same group. For these measurements, efforts were made to always place the hammer machine in the same position for each group of floors. It is the same with microphone positions.
Reverberation time: The reverberation time seems to vary in a moderate way. Usually the value varied between 0.1 sec and 0.4 sec. The two largest values of reverberation time were 0.6 sec and 0.8 sec. The calculation of impact sound level from formula $L_{10} = L_m + 10 \log A_m/10$, gives about 4 dB higher sound level for an increase of 0.4 second for rooms with this volume. However these values cannot explain the relatively large dispersion.

4 - CONCLUSIONS

The dispersion lies in frequency ranges, which are important for the experience of annoyance. An assessment of the sound comfort for every house can only be carried out in situ and from case to case.
So far, it has not been possible to find accurate explanations of the causes behind the dispersions by looking at room volume, floor size, design and measurement method as the dispersion exist more or less in all groups of rooms. The dispersions may be caused by other reasons that are more difficult to check, like errors in measurements, small mistakes during the building etc., or by multiple coherence of many causes.
Whatever the reason for the dispersion is, the same results in field as in laboratory can according to this investigation only be guaranteed within a ± 5-7 dB range.

REFERENCES

1. *International Standard ISO 140/VI, ISO 140/VII*

2. *International Standard ISO 717-2*

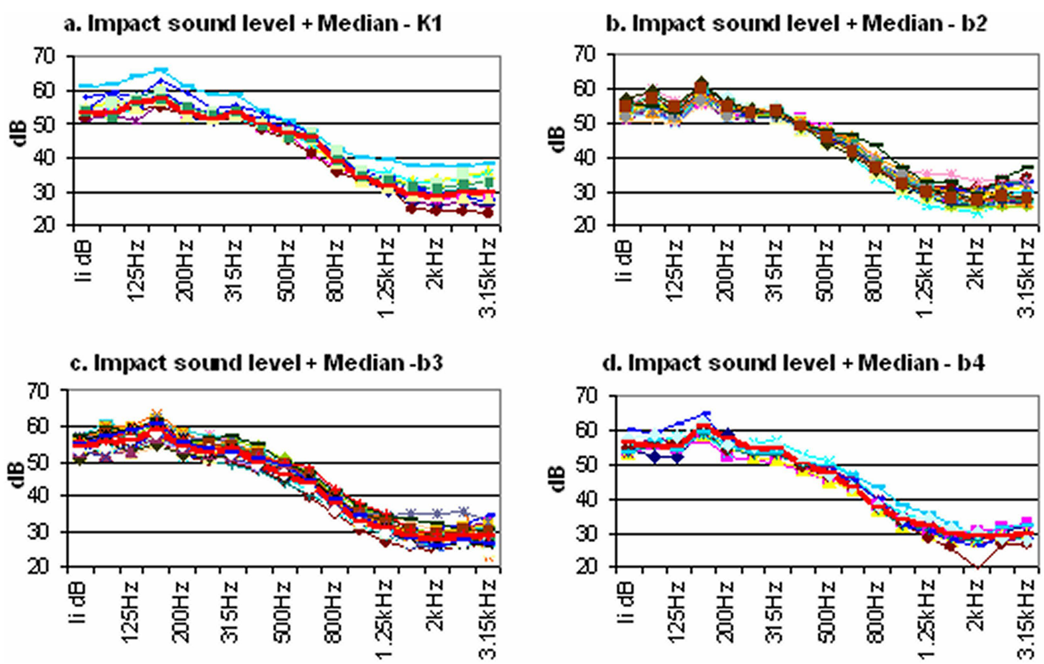

Figure 4: Impact sound level for three bedrooms and one kitchen.