LOW FREQUENCY IMPACT SOUND IN TIMBER BUILDINGS

– Transmission Measurements and Simulations

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ABSTRACT

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An increased share of multi-story buildings that have timber structures entail potential in terms of increased sustainability as well as human-friendly manufacturing and habitation. Timber buildings taller than two stories were prohibited in Europe until the 1990s due to fire regulations. In 1994, this prohibition was removed in Sweden. Thus, being a rather new sector, the multi-story timber building sector lags behind in maturity compared to the multi-story concrete sector.

The low frequency range down to 20 Hz has been shown to be important for the perception of the impact of sound in multi-story apartments with lightweight floors. This frequency range is lower than the one that has traditionally been measured according to standards and regulations. In small rooms, the measurement conditions tend to go from diffuse fields above 100 Hz to modal sound fields dominated by few resonances, below 100 Hz. These conditions lead to new challenges and to new possibilities for measurements and modelling.

In the present research, a frequency response functions (FRFs) strategy aimed to simplify simulations and correlations between the simulations and test results was used. Measurements made indicate that, in the low frequencies, the highest sound pressures occur at the floor level opposite the ceiling / floor that is excited. By having an iterative measurement strategy with several microphones and making measurements until a required standard error is achieved, it is possible to gain information about the statistical distribution of both the sound fields and floor insulation performance. It was also found that, depending on the excitation source, the FRF from an excitation point on the floor above to the sound pressure at a microphone position in the room below may differ. This indicates that non-linearities in sound transmissions are present. Thus, the excitation source used in a test should be similar in force levels and characteristics to the real excitation stemming, for instance, from a human foot fall to achieve reliable measurement results. The ISO rubber ball is an excitation source that is close to fulfilling this need. In order to obtain an FRF, the impact force must be known. A rig that enables the impact force from a rubber ball to be measured was developed and manufactured. The results show that the force spectra are the same up to about 55 Hz, regardless of the point impedances of the floors excited in the tests. Similar results have been found by others in tests with human excitations. This means that FRFs up to about 55Hz can be achieved without actually measuring the excitation force.

On the calculation side, finite element simulations based on FRFs may offer advantages. FRFs combined with the actual excitation force spectra of interest give the sound transmission. In higher frequencies, it is more important to extract the point mobilities of the floors and relate them to the excitation forces. By using an infinite shaft, sound transmission can be studied without involving reverberation time. The calculation methodology is used in the present research to evaluate different floor designs using FE models.

Keywords: Timber floors, FE-simulations, Light weight floors, Frequency response functions, Building acoustics.