Impact Sound Insulation of Timber Floors; A Forest Research Project

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Non-refereed

Introduction.

Forest Research has committed itself to examining and researching the 'Built Environment', with an aim being to utilise and promote more wood products. One aspect of this research is multi-storey, multi-tenant residential constructions.

In general, timber is an excellent material to use for multi-storey constructions, both from a construction and end-use point of view. However, a significant problem in using timber and any lightweight construction material in such applications can be low-frequency (bass) sound insulation of neighbouring units.

This is particularly so for insulation of impact sounds from the floor above. The lesser mass of lightweight construction tends to result in more low-frequency sound being transmitted than heavyweight construction. On the other hand, the greater vibration energy absorbing characteristics of timber and its resilience results in less higher-frequency vibration being transmitted than concrete constructions.

Rating impact sound insulation of floors.

The problem of low-frequency impact sound transmission through timber floors is so significant that it can outweigh the benefits of timber as far as the end-users are concerned. This problem is also compounded by the fact that the inter-tenancy sound insulation aspect of the building code (section G6) currently does not completely address this problem, because it uses standards for rating the impact sound insulation of floors which don't consider all the low-frequencies which are a problem.

To elaborate, the Impact Insulation Class rating standard (ASTM E989) does not include sound below the 100Hz third-octave band, whereas people can hear sounds down to about 20Hz.

The result is a floor which meets the building code, but which doesn't necessarily meet the expectations of the occupants, especially if they can hear people simply walking about above them.

The appropriateness of rating methods for timber floors is a subject which has received some attention over the past decade or so. It is now generally accepted that IIC and $L_{n,w}$ (the ISO equivalent of IIC) are not good rating methods for all floors (particularly lightweight floors).

For example, one study [ref. 1] showed that, although the different floors in the study had very different IIC values (a range of 14dB), the occupants underneath rated the floors impact sound insulation performance as almost the same.

There are other rating methods which do take lower frequencies into account, but there seems to be no general consensus across countries on which rating method is most appropriate.

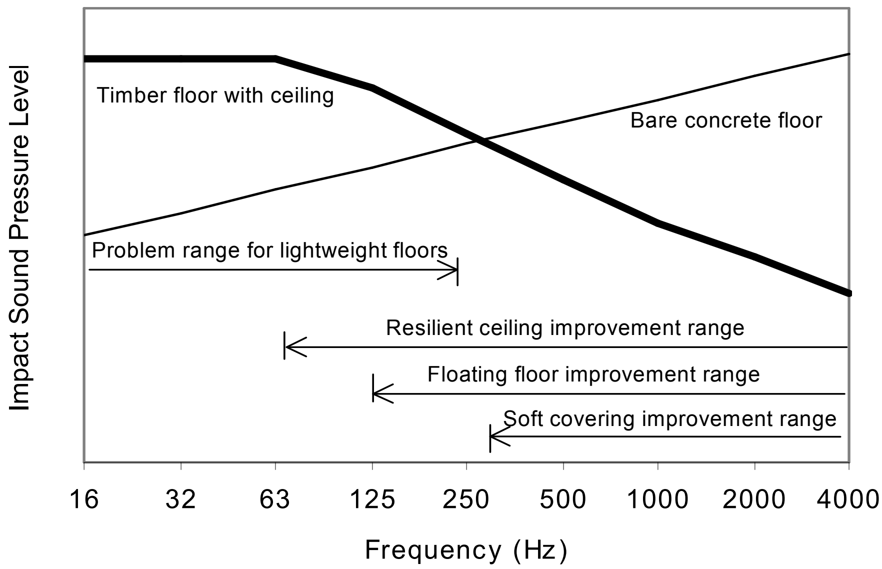

Figure 1. Impact sound insulation of a wooden floor compared to a concrete floor (after P. Sipari).

Resilient layers don't solve the problem.

When faced with a concrete floor which is has an impact insulation problem, resilient upper layers are commonly employed with good effect to reduce impact sound problems. Unfortunately, carpets or resilient layers on the upper surface *don't* improve the low-frequency impact sound insulation performance of floors.

Figure 1 illustrates the differences between the performance of a general timber floor and a general bare concrete floor, showing the problem frequency range for timber (and other lightweight) floors and the general frequency ranges which are improved by certain common acoustic treatments that use resilience.

While these treatments (resilient ceiling to joist attachments, floating floor on a resilient underlay and soft coverings such as carpet) work for the problem (higher) frequencies of concrete floors, they don't cover the frequency range which is a problem for timber floors. What is more, footfall impacts – probably the most common type of floor impact – generate most sound energy in the 20Hz to 200Hz frequency range.

The floor designs of some other countries.

A lot of work has been done in this area by researchers from all over the world, and although solutions have been found which can satisfy the occupiers of multi-storey timber buildings, they have a tendency to be complicated, difficult and possibly expensive to construct.

Recently, pilot building projects in Scandinavia [ref. 2] have shown that timber apartment buildings of 4 or 5 storeys that satisfy the sound insulation expectations of the occupiers can be constructed. It was, however, noted that the builders complained that the floor construction was a little too complicated, requiring multiple layers of materials in the floor upper as well as careful edge detailing.

Figure 2 shows a generalised floor from the projects; while no one floor looked exactly like this, it does show the important elements generally common to the floor designs used.

Although I particularly mention the Scandinavian projects, it should be noted that similar floor designs are now used elsewhere.

For example, the UK organisation TRADA have released a report [ref. 3] which assesses floors with a similar construction scheme to the generic floor shown in figure 2.

The Forest Research project.

The Forest Research impact sound project is concerned with the examination of the problem of impact sound insulation of timber floors, particularly the low frequencies which are the problem. The aim being to find usable impact sound control solutions which satisfy the occupiers and the constructors of multi-storey timber buildings.

That is to say, we wish to find solutions or paths to solutions which perform acoustically, are more cost-effective and are robust to small defects in construction.

Broadly, the research approach is to first discover how the parameters of a floor (stiffness, mass, damping, edge mounting conditions) and the room below affect the floor's performance for low-frequency impact sound insulation.

This can be achieved by developing a model of the floor whose parameters can be changed to see the effect. Once important results are found in the floor model, these can be tried out on an experimental floor.

To test experimental floors, a floor test rig has been set up at Forest Research, consisting of a frame into which a test floor can be built and a room below where the sound from the floor can be measured.

Figures 3 and 4 show the

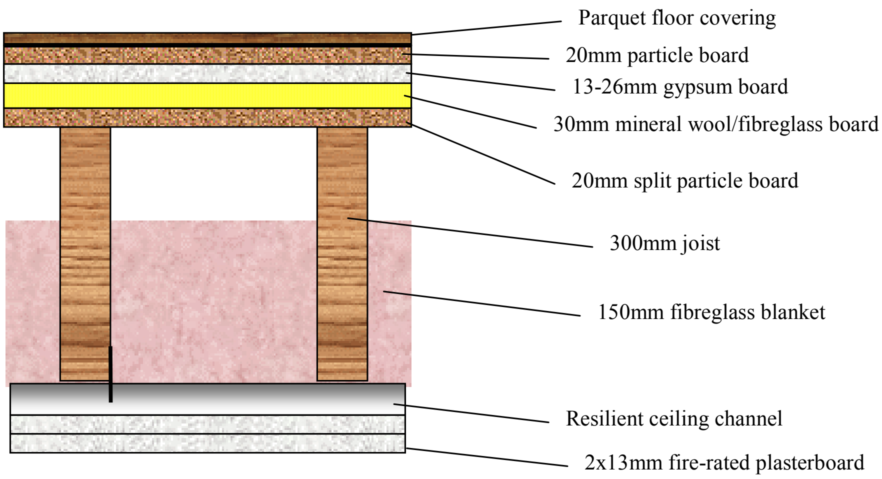

Figure 2. Generalised cross-section of floors used in pilot projects in Scandinavia. The floors used achieved IIC's of about 60–70dB.

exterior and the interior of the floor test rig. Measurement of the sound insulation and vibration characteristics of the floors is made by microphones and accelerometers. These transducers are attached to a 01dB-Stell 4 channel digital measurement system where the measurements are processed and analysed.

Figure 3. Exterior view of the facility for testing the impact insulation of floors at the Forest Research labs. The stairs lead up to the top of the floor. The floor frame and legs are made from glulam.

A parallel and important aspect of research into the performance of the impact insulation of floors is subjective analysis of the impact sounds heard by occupiers in the rooms below a particular floor. We need to know which impact sounds irritate people and to what degree.

Some overseas studies have been done on this problem, but these studies are by no means complete, and it may be important for us to examine the subjective response of New Zealanders, rather than relying on data for people from other cultures who may have different expectations.

Figure 4. Inside the acoustic floor test chamber at the Forest Research labs. The view here is looking up at the beginnings of a simple floor, which at the time had no ceiling. The door shown is an inner door of a bivalve acoustic door system.

References.

[1] **Sipari, P**., Sound Insulation of Multi-Storey Houses – A Summary of Finnish Impact Sound Insulation Results, Building Acoustics, 7 (1), p.15–30, 2000.

[2] **Nordic R&D** project "Multi-storey timber frame buildings": Hveem, S, Comparison of low frequency impact sound insulation of different Nordic lightweight floor constructions, Conference in Building Acoustics, Dublin, Ireland, 1998.

[3] **Pitts, G**, Acoustic performance of party floors and walls in timber framed buildings, TRADA Technology report 1/2000.