Short report of the research project
Impact Sound Insulation of Wooden Ceilings

Research Initiative "Zukunft Bau" of the Federal Institute for Research on Building, Urban Affairs and Spatial Development, Ref. no: SWD-10.08.18.7-14.12 / IBP-412376

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Title

Improvement of the impact sound insulation of wooden ceilings by optimized floor coverings

Motive / Starting point

Ceilings in wooden and lightweight construction can be found in many, both new and old, buildings. A general problem with this construction method is the often unsatisfactory impact sound insulation. The currently used improvement measures, that are mainly based on weighting the ceiling, have substantial disadvantages. Aim of the research project was therefore to develop alternative sound insulation measures suitable for wooden ceilings.

Subject of the research project

The investigations carried out within the frame of the research project focused especially on two subject areas which are of particular interest in building practice:

- Development of improved ceiling coverings for the redevelopment of old buildings, reaching a higher impact sound insulation with the same height than conventional dry screeds. The research activities were focused on the partial elastic bearing of the screed slab and its additional damping with vibration-reducing coverings.
- In practice, the weighting of wooden beam ceilings by bound fills is common. It was investigated how the fills can be optimized acoustically in order to save bulk material and to reduce the total mass of the ceiling. The investigations focused, on the one hand, on the binding agent used to fix the bulk material. On the other hand, alternative measures were tested, such as for example the elastic bedding of the fills.

The most important results of the investigations carried out can be summarized as follows:

- Compared to a full-surface installation on impact sound insulation panels with the same dynamic stiffness, the partial elastic bearing of the screed slab used for wooden ceilings provides no acoustic benefits. However, the partial bearing permits a significantly reduced resulting stiffness of the insulation layer, while maintaining the existing height. This leads to a reduction of the resonance frequency and thus usually to a decrease of the impact sound level.
- In contrast to the partial elastic bearing, the additional damping of the screed slab, for example by bonded bitumen coverings, presents an efficient measure to improve the impact sound insulation. However, this measure is applicable only with dry but not with mineral screeds.
- Having a considerable mass, the acoustic effect of damping coverings is due to a combination of damping and weighting. It has proved particularly useful to integrate the damping layer into the screed slab (sandwich construction of two stiff external layers and a soft damping center layer). With this construction and the external and center layers having approximately the same mass, a reduction of the weighted normalized impact sound level of approx. 7 dB was achieved. Yet, the improvement was achieved less in the problematic area of low frequencies but mainly in the area of medium and higher frequencies.

- By weighting wooden beam ceilings with fills, whether in loose or bound form, the impact sound insulation is always improved. However, depending on the construction of the ceiling and the type of fill, the improvement may vary significantly in individual cases.
- Commercial binders for fills differ only insignificantly with regard to acoustic aspects, provided that they ensure a sufficient elasticity of the fill. With one exception, this was the case for all investigated products. The noise control effect of elastically bound fills complies to a great extent with the effect of loose fills of the same mass.
- In contrast to elastic binders, cement-bound fills with a bulk forming a stiff vibratory slab are expected to have a significantly reduced acoustic effect. In this case, the normalized impact sound level can be about 5 - 7 dB lower compared to a loose fill.
- Most of the measures for the acoustic optimization of fills investigated in this research project, such as for example binders with increased internal damping, damping coverings or separation cuts, have proved to be inefficient. Yet, a considerable improvement of the impact sound insulation could be achieved by an additional elastic layer placed between the raw ceiling and the fill. With the layer used in the tests (commercial impact sound insulation plate made of stone wool, thickness: 12 mm, dynamic stiffness: ca. 40 MN/m³) lead to a reduction of the weighted normalized impact sound level of ca. 5 - 6 dB).

Conclusion

The research project provided numerous new insights serving to considerably extend the building acoustic know-how on wooden ceilings, floor coverings and fills. Furthermore, the developed noise protection measurements represent a valuable contribution to improve the impact sound insulation of wooden beam ceilings, both in the field of redevelopment and prefabricated buildings. Since the application in construction practice does not require any further development or planning steps, and since the costs and technical efforts are relatively low, there are no obstacles for manufacturers and construction companies to implement the developed measures directly into practice.

Basic data

Short title: Impact sound insulation of wooden ceilings
Scientist / Project Manager: Dr. Lutz Weber
Total cost: 125.600,00 €
Federal subsidy: 87.920,00 €
Project term: 18 months plus 7 months extension

Pictures / Drawings

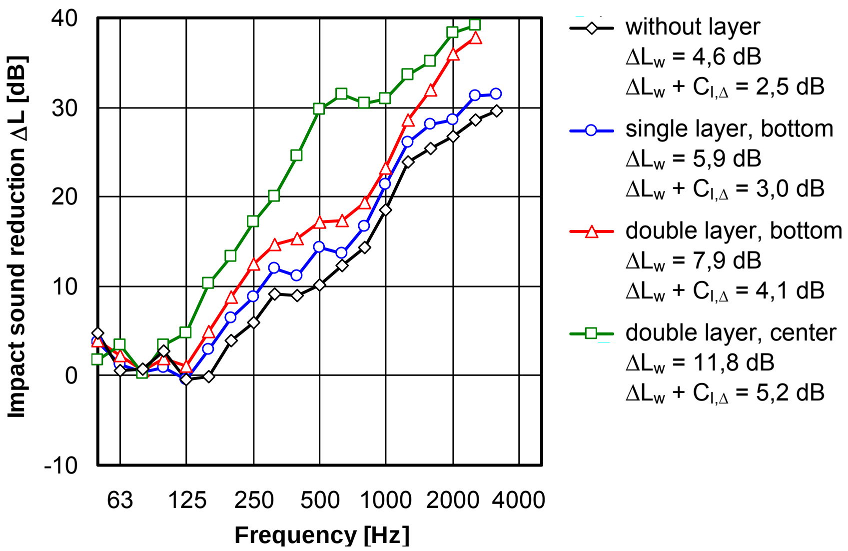

Fig. 1: Improvement of the impact sound reduction of a dry screed by damping the ground slab with bonded bitumen coverings. The green curve indicates the values of the coverings integrated in the center of the floor slab (sandwich construction).

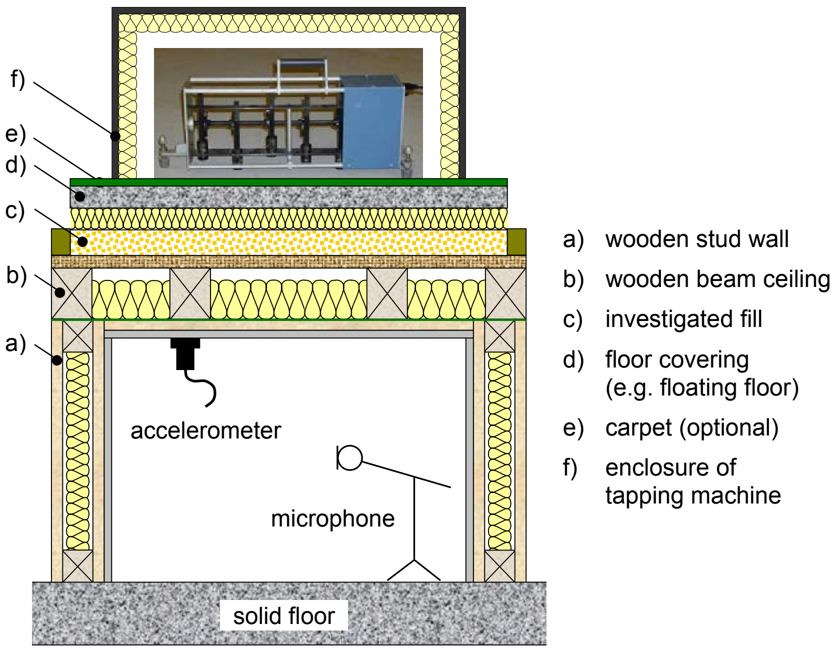

Fig. 2: Measurement setup for the investigation of the acoustic effect of wooden beam ceilings. The setup consisted of a section of a commercial wooden beam ceiling (dimensions: l x w = 1.5 m x 1.25 m), which was placed on four walls in timber-frame construction, with a small measuring chamber (volume: ca. 1.1 m³) underneath.

Fig. 3: Example of one of the investigated fills (side view of the ceiling covering). From top to bottom: cement screed (thickness: 43 mm), impact sound insulation slab made of mineral wool (thickness: 25 mm), basalt grit fill with a grain size of 5 – 8 mm (thickness: 60 mm).

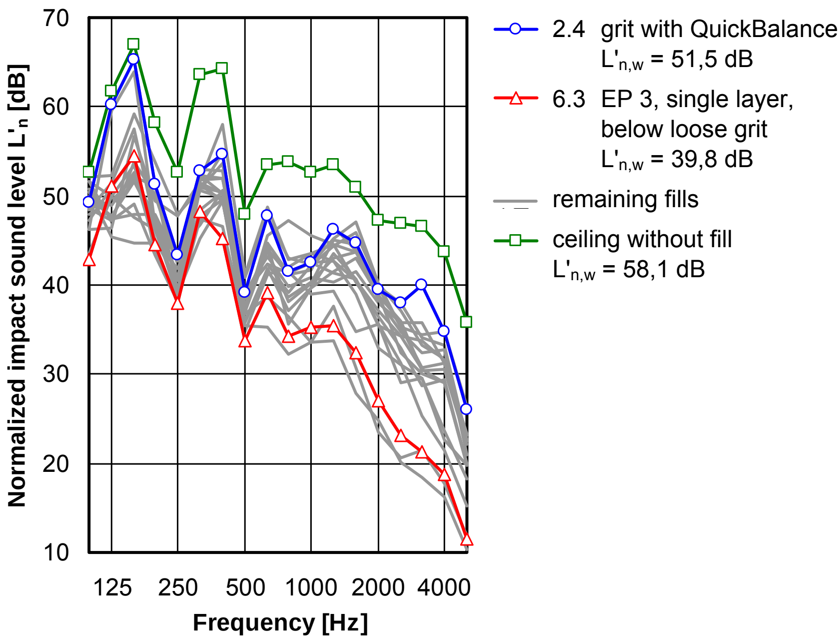

Fig. 4: Normalized impact sound pressure level of a wooden beam ceiling weighted with eighteen different fills. The measurements were performed in connection with a mineral floating floor. The bulk with the highest weighted normalized impact sound pressure level value $L'_{n,w}$ (hence the least favorable variant) is displayed as blue curve, the bulk with the lowest value is displayed as red curve. The curves for all other bulks are displayed as grey lines. In addition, the impact sound pressure level of the ceiling without bulk is displayed for comparative reasons (green curve).

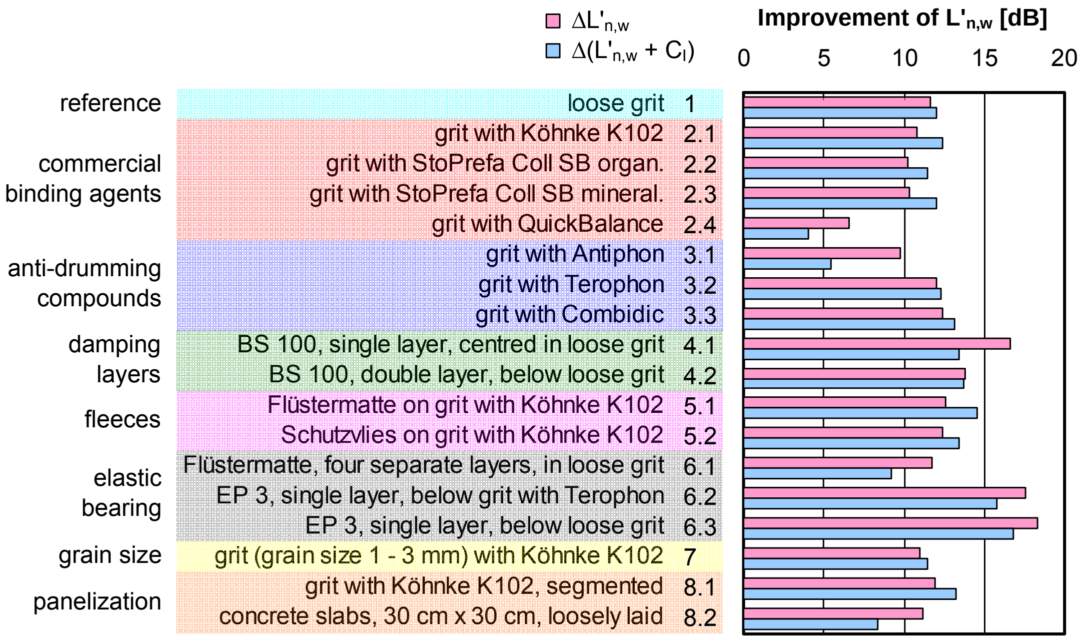

Fig. 5: Single values for the measurement curves displayed in Fig. 4. Besides the improvement of the weighted normalized impact sound pressure level due the bulk $\Delta L'_{n,w}$, also the improvement related to the sum $L'_{n,w} + C_I$ is presented (C_I identifies the spectrum adaptation value for the impact sound pressure level according to DIN EN ISO 717-2).