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Direct sound insulation of lightweight solid walls

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ABSTRACT

In many German buildings lightweight solid walls are used as separating walls between rooms in the same occupant unit. For this case no legal acoustical requirements on sound insulation exist and the suggested values are lower compared to separating walls between different occupant units. Due to this fact it is possible to use walls with a mass per unit area of about 100 kg/m², made of calcium silicate, porous concrete, brick or gypsum.
The flanking insulation of such lightweight solid walls can be improved by using an elastic interlayer to decouple the walls from the adjacent building elements. For decoupled walls a decreased sound insulation is expected due to the reduced energy flow to the adjacent building elements. However, the direct sound insulation of the lightweight gypsum walls increases by using said elastic interlayer. Several measurements have been conducted both in the laboratory and in buildings in order to investigate the acoustical behaviour of decoupled gypsum walls. The sound reduction index and the loss factor of gypsum walls decoupled by different elastic interlayer, for example polyethylene foam, cork and bitumen, were measured. Both depend on the kind of material of the elastic interlayer which is why the material characteristics of the different elastic interlayer were also investigated.

1. INTRODUCTION

In many multi-storey-buildings the separating walls between rooms in the same occupant unit are constructed by using lightweight solid stonework. In most cases these walls are non-supporting constructions, hence there are no static requirements for these walls. The acoustical requirements on the direct sound insulation are lower compared to separating walls between different occupant units. Due to these facts it is possible to use lightweight material, for example calcium silicate, porous concrete, brick or gypsum blocks to construct these separating walls. Typically the mass per unit area of such lightweight solid walls is about 100 kg/m².
Some of these lightweight internal walls are not connected rigidly to the adjacent building elements. They are decoupled by using an elastic interlayer. Lightweight walls made of gypsum blocks are a typical example for such decoupled constructions. Usually, the gypsum walls are decoupled on all edges by the elastic interlayer made of cork, polyethylene foam or bitumen, respectively. The primary reason for the decoupling is to avoid the crack formation between the different building elements. Additionally the decoupling has a significant influence on the direct and the flanking[1] insulation of the gypsum walls. Figure 1 shows the construction of such gypsum walls in buildings.

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Figure 1: construction of gypsum walls in buildings

Within a research project[2] at the Stuttgart University of Applied Sciences the acoustical behaviour of decoupled gypsum walls was investigated in detail. The aim of this research project was the implementation of the European standard EN 12354-1[3] regarding the prediction of sound insulation for constructions with gypsum blocks.

The decoupled gypsum walls have to be considered as a system consisting of gypsum blocks and elastic interlayer. To investigate the influence of the decoupling on the sound reduction index of lightweight gypsum walls was one part of the work. All results of the investigations discussed in this paper are related to gypsum walls with a thickness of 100 mm and a mass per unit area of 90 kg/m² (with mid density gypsum blocks) or 120 kg/m² (with high density gypsum blocks).

2. MEASUREMENTS IN THE LABORATORY

In a wall test facility for direct sound transmission the sound reduction index of different gypsum walls was determined according EN ISO 140-3[4]. In addition the loss factor of the gypsum walls was also measured according EN ISO 10848-1[5].

A. Sound reduction index

For decoupled building elements one usually expects a lower sound insulation because of the reduced energy flow to adjacent structures. Due to elastic interlayer one would expect that less energy can flow into the adjacent building elements. That means higher radiation losses and hence a lower sound insulation of the decoupled building elements is expected.

The most common materials for the elastic interlayer are cork, heavy polyethylene foam (density ≥ 120 kg/m²) and bitumen. The 3 mm to 5 mm thick elastic interlayer are fitted at all edges of the gypsum walls. Figure 2 shows a comparison of the sound reduction index of 100 mm thick gypsum walls with a mass per unit area of 90 kg/m² decoupled with three different kinds of elastic interlayer and with a rigid connection of the gypsum wall.

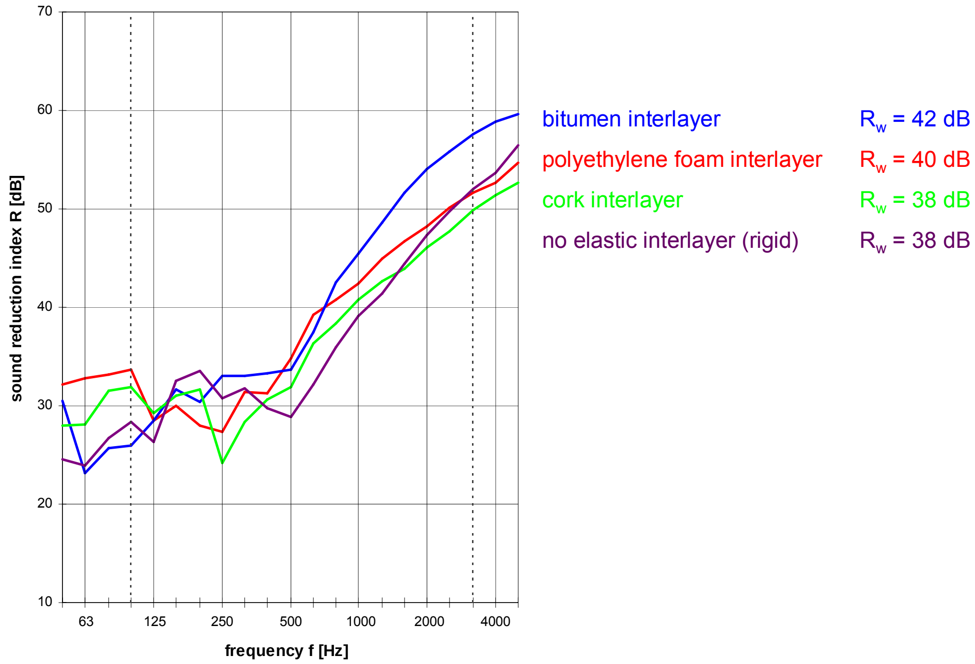

Figure 2: sound reduction index of gypsum walls - different elastic interlayer and rigid connection

The measurement results show that the application of some elastic interlayer can improve the sound reduction index of the gypsum walls significantly. The highest sound reduction index is attainable by using an elastic interlayer made of bitumen.
Figure 3 shows the influence of the gypsum blocks density on the sound reduction index of 100 mm thick gypsum walls which are decoupled by cork interlayer.

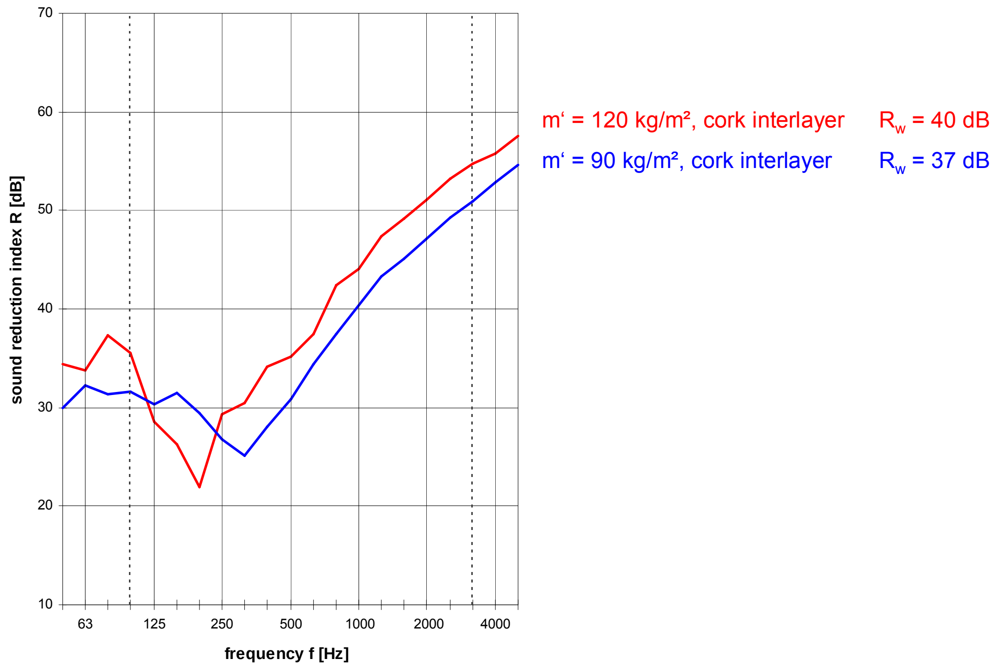

Figure 3: sound reduction index of 100 mm thick gypsum walls with m’ = 90 kg/m² (mid density) and m’ = 120 kg/m² (high density) - decoupled by cork interlayer

With a mass per unit area of 120 kg/m² for the gypsum wall the weighted sound reduction index increases by 3 dB compared to a gypsum wall with a mass per unit area of 90 kg/m² and the same cork interlayer. This improvement is independent of the kind of the elastic interlayer.

B. Loss factor

The loss factor of the different decoupled gypsum walls has been determined by measuring the structural reverberation time of the wall. In Figure 4 the loss factors of 100 mm thick gypsum walls with a mass per unit area of 90 kg/m² decoupled by the aforementioned three kinds of elastic interlayer cork, polyethylene foam and bitumen as well as a rigid connection of the gypsum wall are shown.

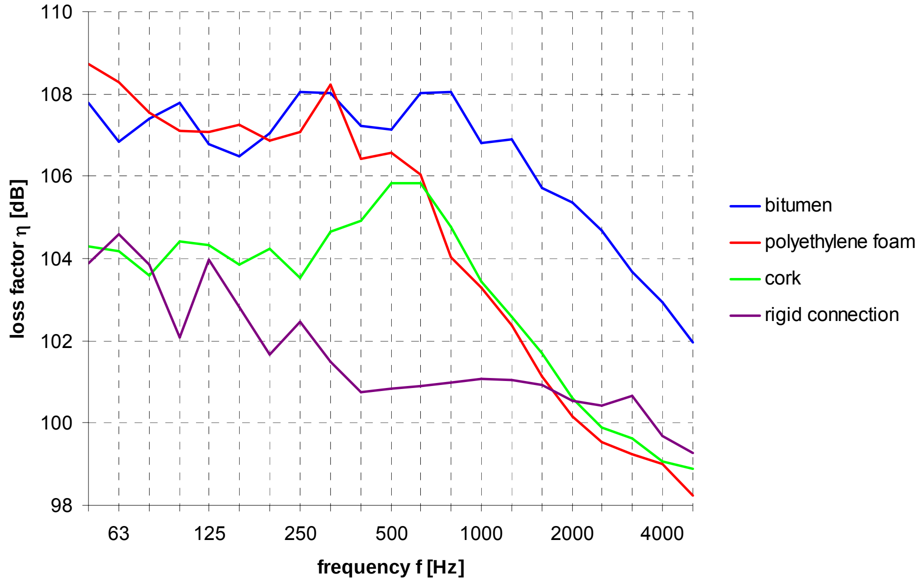

Figure 4: loss factors of gypsum walls - different elastic interlayer and rigid connection

The behaviour of the measured loss factors is analogue to the measured sound reduction indexes. That means the highest loss factor and hence the highest sound reduction index has been attained by the bitumen interlayer. An interesting fact is that the lowest loss factor was measured at the gypsum wall which was connected rigidly to the test facility. Normally one would expect a lower loss factor of a decoupled wall compared to a rigidly connected wall due to the reduced energy flow into the adjacent building elements. The measurements have shown that this in not applicable for the decoupled gypsum walls. Obviously the vibrations of the wall have been damped more by the elastic interlayer than by the energy flow in the adjacent building elements. Thereby the damping depends on the material characteristics of the used elastic interlayer.

3. MEASUREMENTS IN BUILDINGS

The sound reduction index of gypsum walls was also measured in different building situations, for example between a sleeping room and a living room in the same dwelling. Figure 5 shows the average sound reduction indexes measured in several building situations in comparison to the result of the laboratory measurement using the cork interlayer.

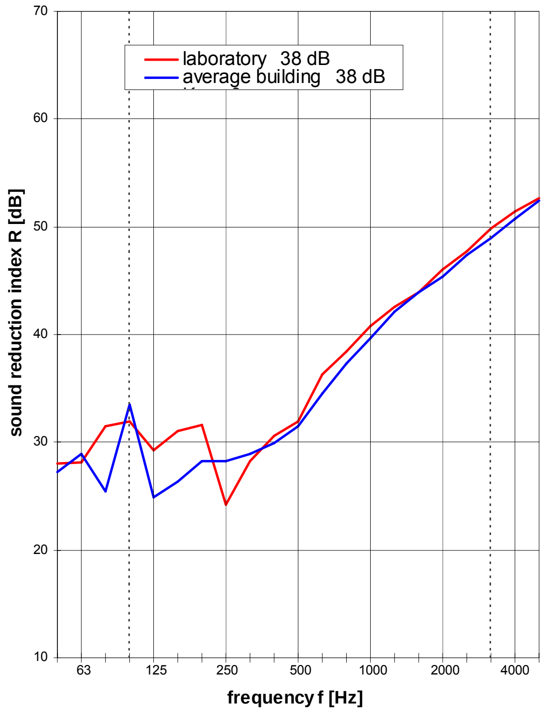

Figure 5: comparison of the sound reduction index, measured in the laboratory and in different buildings

The comparison between building and laboratory measurements of the sound reduction index shows similar results especially at frequencies higher than 315 Hz. In principle in building situations with decoupled gypsum walls similar sound reduction indexes can be measured comparable to those measured in the laboratory. The consequence for the sound reduction index is that no in-situ correction is necessary. The measurements of the loss factor in building and laboratory situations also support this fact. The loss factors measured in the buildings were quite similar to the loss factors which were measured in the test facility.

4. CONCLUSIONS

The use of decoupled gypsum walls as non-supporting internal walls in buildings has a couple of advantages. One of them is the improvement of the direct sound insulation by using elastic interlayer for the decoupling of the wall. Especially with bitumen but also with polyethylene foam interlayer the sound reduction index of the gypsum walls can be improved significantly. Due to the decoupling and the reduced energy conduction this would not be expected. Some of the elastic interlayer have damping material characteristics. This could be confirmed by the measurements of the loss factor.

The results of the sound reduction index from the building and laboratory measurements were quite similar so there is no in-situ correction necessary. The findings of the investigations can be used as input data for the calculation models of EN 12354-1. Suitable input data is proposed for the future German catalogue of building constructions within the standard DIN 4109[6]. The sound reduction index of the gypsum walls can be used directly according to the measurement results in a laboratory which are dependent on the kind of the elastic interlayer. Thereby an application of the in-situ correction is not necessary.

ACKNOWLEDGMENTS

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