Sound insulation of solid wood constructions

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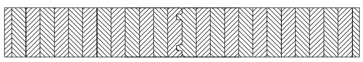
Introduction

Solid wood constructions have become the basis of many different building elements, like timber floors, walls and roofs. Despite the increased popularity of this building material the knowledge on the sound insulation of these elements is rather small. For that reason a research project on the sound insulation of solid wood constructions was initiated by German society for wood research (Deutsche Gesellschaft für Holzforschung DGfH e.V.) and financed through the Bavarian State Ministry of Food, Agriculture and Forestry. Acoustic measurements were performed at the LSW - Labor für Schall- und Wärmemesstechnik Ltd. and the results of a preliminary report [1] will be discussed in this paper.

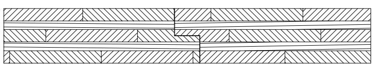
Definition

Within this paper the notion of a solid wood construction comprises a greater variety of different timber building elements:



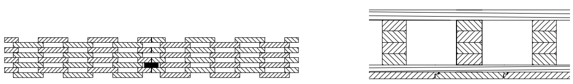
Laminated timber board walls and floors :

built of wooden boards oriented perpendicular to the building element



Cross laminated timber board walls and floors

built of wooden boards oriented parallel to the building element



„Case"-type-building elements

comprising a variety of construction principles, usually consisting of wooden boards and lathes

The thickness of the building elements depends on the structural demands :

50 - 80 mm for interior walls without load bearing function
80 - 110 mm for load bearing interior or external walls
110 - 300 mm for floors

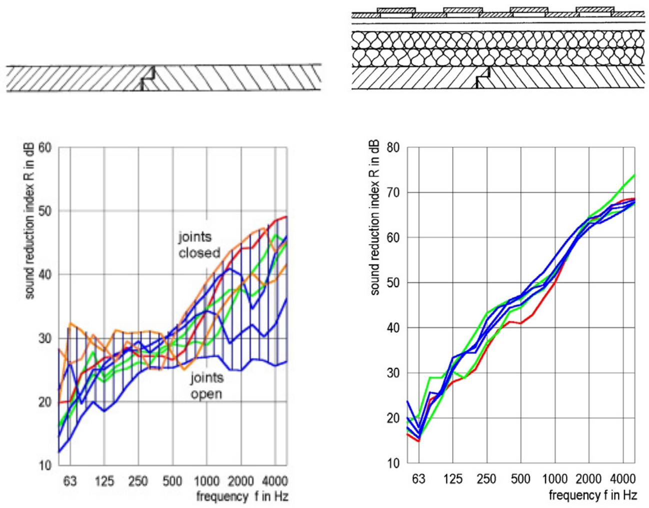
Experimental matters

The test elements were walls and floors with usual sizes of 10 m^2 (wall) and 20 m^2 (floors). The measurements were performed according to ISO 140 [2] in a test stand without flanking transmission. The impact sound pressure level was measured with the standard tapping machine (ISO 140-6). Results were evaluated in terms of R_w and $L_{n,w}$ according to ISO 717 [3].

Sound insulation of single leaf elements

Solid wood constructions are manufactured in single elements with sizes from approx. 40 cm up to several meters. The single elements are assembled through joints (e.g. groove and tongue). Depending on the quality of manufacturing and workmanship the joints are more or less open for sound transmission. The sound transmitted via these joints limits the maximum sound reduction index for the elements. This is displayed in figure 1 for the sound reduction of a great variety of different solid wood wall constructions with comparable mass. The large differences in the curves are mainly due to sound transmitted via the joints of the element.

a) b)



R_w = 26 - 35 dB R_w = 45 - 51 dB

Figure 1: sound reduction index of single leaf and external timber walls

a) 80 - 160 mm solid wood element (m' = 35 - 47 kg/m^2)
b) 80 - 160 mm solid wood element with 160 mm thermal insulation (wood fibre) as external cladding

Sound insulation of external walls

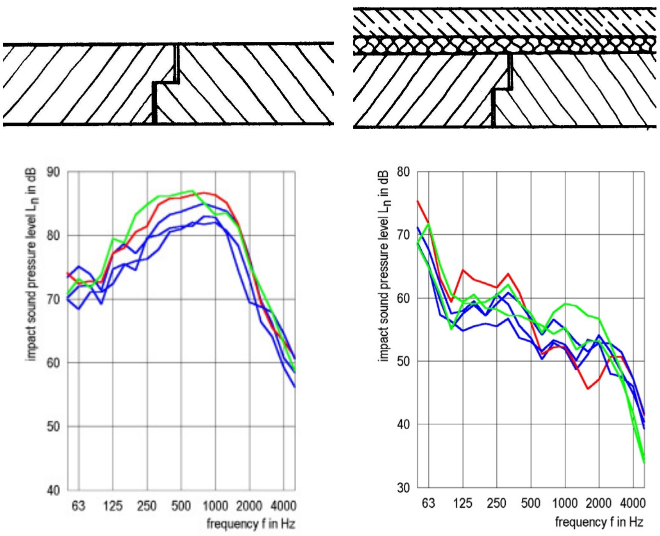
To reduce the thermal transmittance external timber wall constructions require an additional layer of thermal

thermal insulation the overall sound insulation increases. At the same time the differences of the results between the different timber constructions are reduced because of the suppressed sound transmission through the element joints, see figure 1. A further increase in sound insulation is achieved by an additional lining of plasterboard on lathes on the interior side (not shown in figure 1).

Impact sound insulation of floors

Results of measurements of impact sound insulation of solid wood floors are shown in figure 2 for the bare elements and for a floor with a cementbound floating screed.

a) b)



$L_{n,w}$ = 81 - 85 dB $L_{n,w}$ = 56 - 61 dB

Figure 2: impact sound pressure level of timber floors

a) 140 - 160 mm solid wood element (m’ = 45 - 73 kg/m^2)
b) 140 - 160 mm solid wood element with 80 mm floating screed (50 mm cement screed with 30 mm mineral wool - resilient layer)

By means of a common floating screed the impact sound pressure level of the element is reduced by the order of approx. 25 dB. As for the wall constructions the different timber construction elements display a very similar frequency dependence. For an application as separating floor between dwellings this construction needs further improvement measures e.g. by means of ballasting.

Empirical mass law

The sound insulation of flexurally rigid single leaf walls is usually described by an empirical mass law. For masonry and concrete the numbers have been layed down in German standard DIN 4109/Bbl.1:1989-11 [4]. Data on the sound reduction index for single leaf timber walls as a function of mass are found in various text books, see e.g. [5]. In figure 3 the literature values for the weighted sound reduction index are compared with the results of the current investigations (only results of measurements with closed element joints were taken into account). The results for the solid wood constructions fit in reasonably well to the well known literature data for timber constructions.

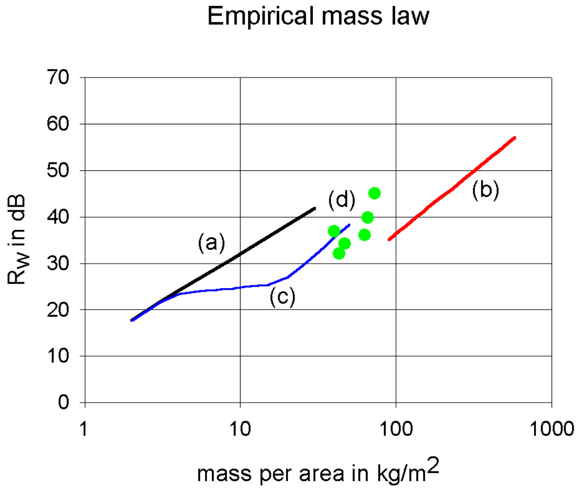


Figure 3: mass law for single leaf walls :

a) ideal flexible single wall
b) concrete and masonry according to DIN 4109/Bbl.1
c) timber walls according to Gösele [5]
d) data points from present measurements

Conclusions

Measurements on the airborne and impact sound insulation of many different solid wood elements have been performed.

The different solid wood construction elements showed a very similar behaviour with respect to the single number rating as well as to the general frequency dependence. For further research work it is therefore justified to classify the different constructions into 2 or 3 types of solid wood construction elements.

The results for single leaf elements fit in reasonably well with text book results for an empirical mass law.

Further research work needs to be done with regard to the flanking transmission, vibration reduction index and the application of the calculation models of EN 12354-1 [6].

References

[1] Holtz, F. et al., “Schalltechnische Kennwerte von Massivholzbauteilen”, DGfH- research report, 2002

[2] ISO 140 part 1 - 12, Acoustics - Measurements of sound insulation in buildings and of building elements, 1998

[3] ISO 717 part 1 - 2, Acoustics - Rating of sound insulation in buildings and of building elements, 1997

[4] DIN 4109, Bbl.1, Sound insulation in buildings - Construction examples and calculation methods, 1989

[5] Gösele, K. et al., „Schall, Wärme, Feuchte“ 10. Auflage, Bauverlag Wiesbaden (1997)

[6] EN 12354 part 1, Building acoustics - Estimation of acoustic performance of buildings - Airborne sound insulation between rooms, 2000