



Massive or lightweight? Sound Insulation Measurement Results of Austrian Residential Buildings

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ABSTRACT

in Austria, building with wood for multi-story residential buildings started in 1996. It was a big adventure at that time to meet the high Austrian sound insulation requirements with that new developed wood based building constructions. During the past 25 years a lot of different wood based multi-story residential buildings, lightweight and massive, have been built. The Styrian government performed a lot of quality measurements between the dwellings in these buildings. The results of this measurements were collected now in a database and an analysis was carried out. This talk shows some results for the different building constructions and gives an overview and a comparison of their sound insulation performance.

Keywords: *sound reduction performance, wood based residential buildings, multistory buildings, partition walls, separating ceilings*

1. INTRODUCTION

Austria is located in the heart of Europe and has a forest coverage of more than 46%. Until 1996 it was not allowed by building acts (there are 9 federal states with their own building requirements) to build multistory apartment buildings, although there exist a lot of historical multistory buildings with wood based ceilings. Styria was the first Austrian federal state to recognize the great importance of using wood as a building material also for multistory buildings. So, in the mid of the last decade of the last millennium the development of various new and innovative

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wood materials, such as “Kreuzlagenholz” (today called cross laminated timber, CLT), started, also to satisfy the demand for new building systems. Although it was a big adventure to meet all the requirements in statics and seismic, fire protection, moisture control, sound insulation, thermal insulation, and many others, the first examples of multistory apartment buildings could show, that this all is possible, together with appealing architecture. Other federal states followed and finally also in Vienna we could successfully erect the first five-story housing estate in 2004 and it lasted until 2019 to get an 24 floor 84 m tower as a wood-hybrid high-rise building. All these building fulfilled finally the relatively high sound insulation requirements is Austria of a $D_{nT,w} \geq 55$ dB and an $L_{nT,w} \leq 48$ dB between apartments. But what about the differences between massive and lightweight?

2. CONSTRUCTION SYSTEMS

There are two main building systems used for wood based multistory apartment houses:

- Building components based on solid wood as “Kreuzlagenholz”, CLT or board stack ceilings.
- Building components based on timber frame construction, wood beam ceilings.
- Wood based hybrid constructions, e.g. CLT based ceilings and timber frame walls.
- Hybrid constructions, e.g. Concrete slabs or hybrid slabs with wood based walls.

In most cases a) and b) are used.

As there are many different constructions, layers and materials were used, a few examples of typical wood based constructions are shown in Figure 1 and 2. You can find some more typical constructions and descriptions about Austrian wood based building systems in the “Dataholz”

database¹ and also some informative descriptions at “Proholz Austria”².

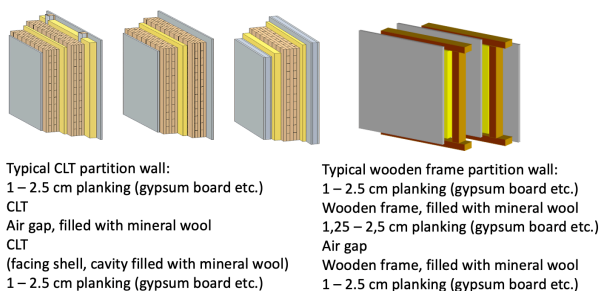


Figure 1. Examples for typical partition walls

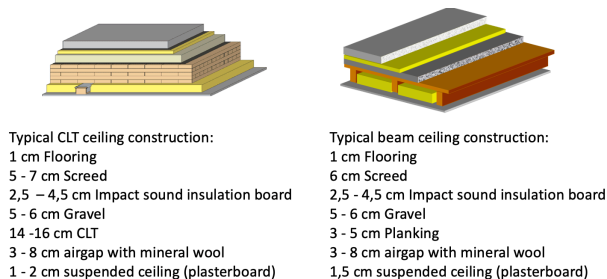


Figure 2. Examples for typical separating ceilings

3. OVERALL PERFORMANCE 1995 - 2020

Nowadays, more than 25 years of continuous quality measurements in subsidized housing in Styria provide the possibility to compare the sound insulation performance of the different constructions.

The following figure shows the Median of the results of quality-measurements of finished residential buildings for each year, starting from 1995, for an overview of all construction methods, including wood based constructions. There are about 4080 results for impact sound and 1550 for airborne sound insulation included.

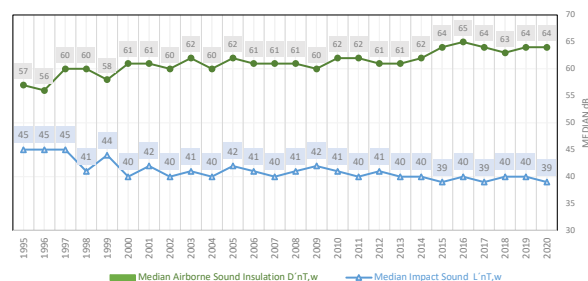


Figure 3. Median of the achieved performance of airborne sound insulation of residential partition walls and impact sound insulation of residential partition ceilings

As shown in Figure 1, the performance of the achieved sound insulation has increased since 1995 continuously, although the requirements for multistory apartment buildings did not change. Since 2000 the yearly median for airborne sound insulation was equal or higher than 60 dB and 2020, and for impact sound equal or less than 42 dB, which seems remarkable.

4. PERFORMANCE OF WOOD BASED MULTISTORY CONSTRUCTIONS 2012 - 2022

As construction methods change over time, the last ten years of woodbased constructions in particular will be considered in the following.

For multistory apartment houses with partition walls based on a timber frame construction 100 measurements could be evaluated.

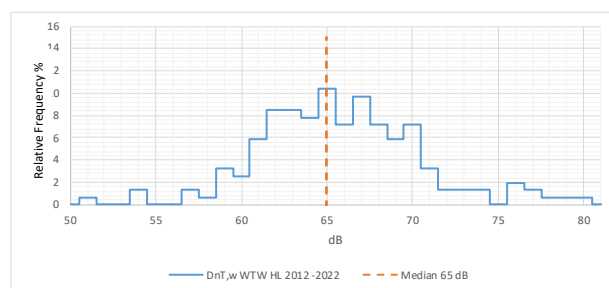


Figure 4. Relative Frequency in % results for airborne sound insulation ($D_{nT,w}$) for multistory apartment houses with timber frame partition walls. The Median here reached 65 dB.

¹ www.dataholz.eu

² www.proholz.at

Since constructions with beam ceilings still make up a smaller proportion than solid ceilings for multistory apartment buildings just 79 results for this construction system could be evaluated.

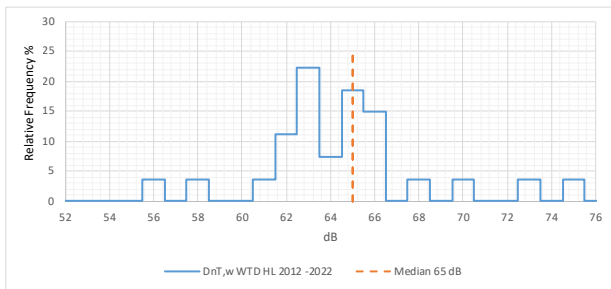


Figure 5. Relative Frequency in % results for airborne sound insulation ($D_{nT,w}$) for multistory apartment houses with timber joist ceilings. The Median reaches 65 dB.

As expected, the bigger challenge is impact sound for these lightweight constructions, but only 6% did not meet the requirements at the initial measurement, but only after execution errors had been corrected.

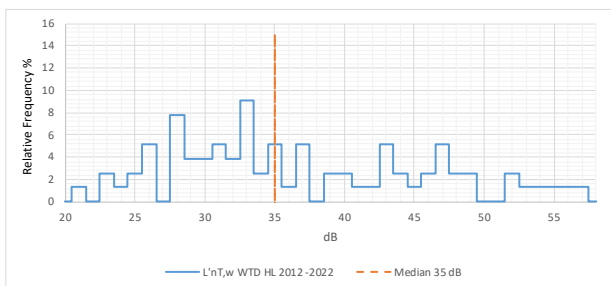


Figure 6. Relative Frequency in % results for impact sound ($L'_{nT,w}$) for multistory apartment houses with beam ceilings. The Median here reached 35 dB.

There are also results below 30 dB can be found, which is remarkable.

For CLT based partition walls 118 measurements were available. 9% did not meet the requirements at the initial measurement, but only after execution errors had been corrected. 33% showed a result for $D_{nT,w}$ higher than 70 dB, which is 15 dB higher than the legal requirement.

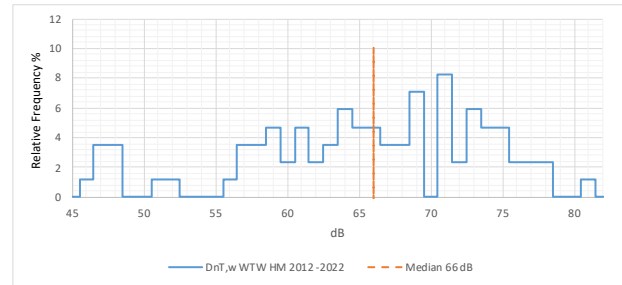


Figure 7. Relative Frequency in % results for airborne sound insulation ($D_{nT,w}$) for multistory apartment houses with CLT based partition walls. The Median here reached 66 dB.

Since constructions with timber joist ceilings still make up a smaller proportion than solid ceilings for multistory apartment buildings just 82 results with CLT-based partition slabs could be evaluated.

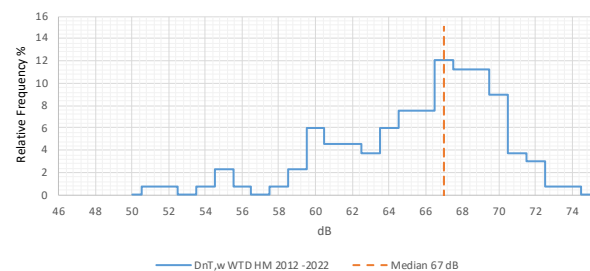


Figure 8. Results for airborne sound insulation ($D_{nT,w}$) for multistory apartment houses with CLT based partition slabs. The Median here reached 67 dB.

For CLT based partition slabs just 5% did not meet the requirements at the initial measurement, but only after execution errors had been corrected.

Here, too, the greater challenge is impact sound insulation. 103 measurement results could be evaluated here. About 12% did not meet the requirements at the initial quality measurement, but also all of them, as above, after correction of execution errors. But also here some examples show a really high impact sound insulation, with results for $L'_{nT,w}$ of less than 33 dB down to 24 dB, also a remarkable result.

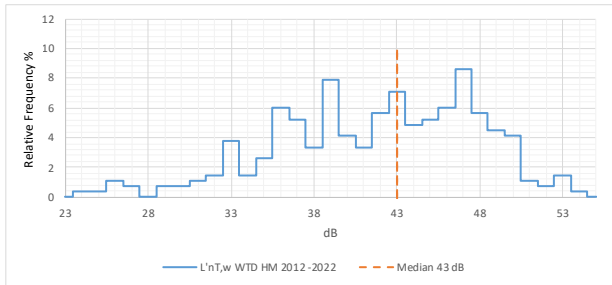


Figure 9. Results for impact sound ($L'_{nT,w}$) for multistory apartment houses with CLT based partition slabs. The Median here reached 43 dB.

5. CONCLUSIONS

The results show, that it is possible to fulfill high sound insulation requirements with wood based constructions, and, that in most cases, the archived sound insulation is much higher than the required values. For future it will be necessary not to increase the single-number values of the requirements, but to further improve the planning reliability and to better take into account the characteristic peculiarities of the sound insulation of wood-based constructions. The data and constructions used as basis for this short paper are still under further investigation. Some more laboratory measurement results for Austrian wood based constructions are provided in the bibliography, especially in the ongoing research project "Sound.Wood.Austria" [1], [2], [3], [4], [5], [6], [7]

6. ACKNOWLEDGMENTS

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