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SOUND INSULATION PROPERTIES OF HOLLOW BOX TIMBER FLOORS: A SUMMARY

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ABSTRACT

Hollow-box timber floors are an efficient constructive option when long span is required. The industry has a strong interest in timber long span floors because they are a mean to make wooden constructions competitive in urban buildings and a wider range of building categories. Accurate knowledge of their acoustic properties is required to make these solutions attractive for the market and contribute to sustainable design choices. In the last years, we wrote several papers focusing on the sound insulation of hollow-box timber floors. Here we present a consolidated summary of these papers with the aim of making the knowledge more readily available for the practitioners and the industry. We provide an overview of the parameters governing airborne and impact sound insulation in hollow-box timber floors. We present examples of how the available information can be used to adapt and optimize assemblies to meet different requirements. We discuss the constructive consequences of different choices, looking in particular at space requirements and the acoustic performance of the different solutions.

Keywords: *hollow-box floors, airborne sound insulation, impact sound insulation*

1. INTRODUCTION

Between 2018 and 2022, we wrote several papers focusing on the acoustic properties of hollow-box timber floors. With the current paper we want to address the need of a summary that can serve the industry in finding and applying more readily the knowledge contained in those papers. The paper start with a section on the methods used (2) followed by a section highlighting the most applied results. We address the low frequency behaviour (3.1), the effect of cavity filling (3.2), the acoustic performance of different assemblies with the corresponding space requirement (3.3) and, the general trends for different floating floor categories (3.4). We refer to the original papers for the details.

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2. METHODS

The results in the papers were based on experimental activities in the laboratory and in the field, standardized measurements in the laboratory and the collection of data from our own database, the databases of partners and public databases. The approach was designed in advance and described in [1].

We used experimental modal analysis to determine the modal behaviour under different installation conditions. The results were documented in [2].

Under the same conditions we measured the radiated sound power level under impact excitation on a full size floor element with the integral transform method (ITM), which we implemented for the purpose. We described thoroughly the measurement method in [3], benchmarking it with other relevant methods.

With the ITM we studied the interaction between the vibration modes and the sound radiation as a function of span length, boundary conditions and cavity filling. The results were presented in [4].

We then conducted a measurement campaign on one floor element in a transmission suite according to the relevant

standards. We varied the cavity fillings and floating floor. This produced results comparable with data in the literature and indications on the performance of each modification. The results are described [5].
Eventually, we extended the analysis to a broader range of bare floor dimensions and floating floor solution. Since we collected data from different sources, the analysis can only show general trends but it is very useful in early stage design [6]. In addition, the analysis shows trends for improvements due to different floating floors as compared to the bare floor. Those results are not included in this paper.

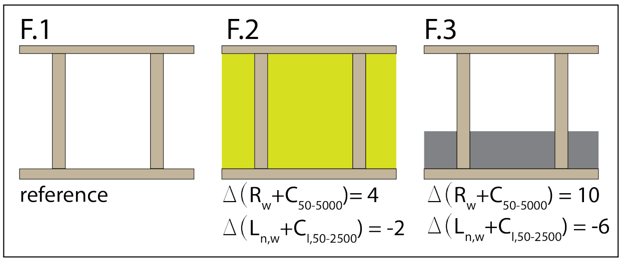

Figure 1. Effect of different cavity fillings on airborne and impact sound insulation. The reference case is the empty cavity. Re-elaborated from [5].

3. RESULTS AND DISCUSSION

3.1 Laboratory data and low-frequency behaviour

The acoustic properties of floors are often determined with laboratory measurements. Laboratories fulfilling the ISO10140-5 requirements have a size opening between 10 and 20 m^2 with a minimum width of 2.3 m resulting typically in a opening length of approx 4 to 6 m. Hollow-box floors are often used for longer span. In paper 1, we showed that this can lead to clear deviations between the laboratory and the field situation at low frequencies. The most accurate way to address this issue is to use more advanced measurement methods as suggested in the paper. However, one could use the simple formula for a one dimensional beam to calculate the eigenfrequencies distribution in the frequency range between 20 Hz and 100 Hz to obtain and indication in which direction the deviation will go.

3.2 Effect of the cavity filling

Figure 1 shows the effect of different cavity fillings on airborne and impact sound insulation. Three cases are shown: empty cavity, cavity filled with wood fibre (13 kg/m^2) and cavity filled with gravel (100 kg/m^2). The first case is taken as reference and the indicated values were calculated as difference between each case and the reference. The wood fibre filling is representative for a material which has low mass and high sound absorption. The gravel filling is representative for loose materials with high weight.

We observe a strong effect of the gravel filling and a rather limited effect of the sound absorbing filling.

3.3 Different assemblies

The comparison of the space requirements of different assemblies and the corresponding performance is often challenging. One of the major reason is that the height of the floor element will typically be determined by the structural engineer according to the span length. In figure 2, we give examples of the space required for different acoustic solutions and the corresponding improvement on the airborne and impact sound insulation ratings using as a reference the bare floor. The measurements were performed on a 509 mm height floor element filled with 100 kg/m^2 gravel and designed for 9 m span. We selected typical floating floor assemblies used in the Norwegian market; floating floor built with dry screed panels on a wood fibre continuous layer (s' $>$ 15 MN/m^3) (A.2), dry screed panels on a mineral wool continuous layer with dynamic stiffness s' $<$ 15 MN/m^3 (A.3), dry screed panels on point elastic supports (Sylodyn) (A.4). The floor covering with only vinyl (A.1) is included as a minimal solution that might fulfil the requirement for an office building. The values in the figure are the difference in airborne and impact sound insulation between each case and the reference. The differences are calculated including the spectral adaptation terms, i.e. using $R_w + C_{50-5000}$ and $L_{n,w} + C_{I,50-2500}$ respectively.

Solutions based on point elastic support turns out to be slightly more efficient than those based on continuous layer. As expected low dynamic stiffness give better performance. In terms of space requirements are hollow-box floors rather convenient since the cavity can be used to add the required extra weight, without affecting the total height.

3.4 Trends for dimensioning in early design stages

Rough estimates of material requirements are necessary in early project phases. The diagram presented in figure 3 can be used to estimate the total mass of a floor element required to fulfil given acoustic requirements. The

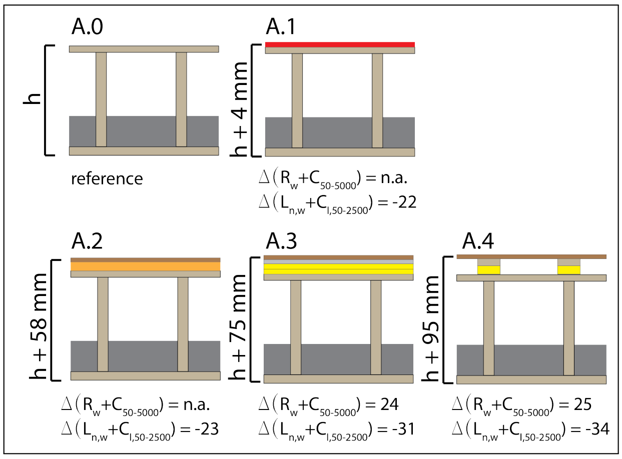

Figure 2. Typical floating floor assemblies on hollow-box element and related improvement. Re-elaborated from [5].

diagram is based on $L_{n,w}$ + $C_{I,50-2500}$ since experience shows that this is the acoustic quantity governing the material needs. The span length will typically be the main dimensioning factor for the floor height. Once that is set, it is possible to calculate the mass of the timber and by subtraction from the values in the diagram one can estimate the required additional weight. As described in the original paper, the trends are based on a limited number of objects and should be used carefully.

4. CONCLUSIONS

The acoustic properties of hollow-box floor element are well documented. In this paper, we presented a brief overview of a few main aspects that are most relevant for practitioners. The tools given here can be used in early design stages to roughly dimension acoustic solutions. We refer to the papers in the literature for detailed data and equations.

5. ACKNOWLEDGMENTS

This paper is based on the work we did to write the papers given in the literature. No external funding was received to write the current paper.

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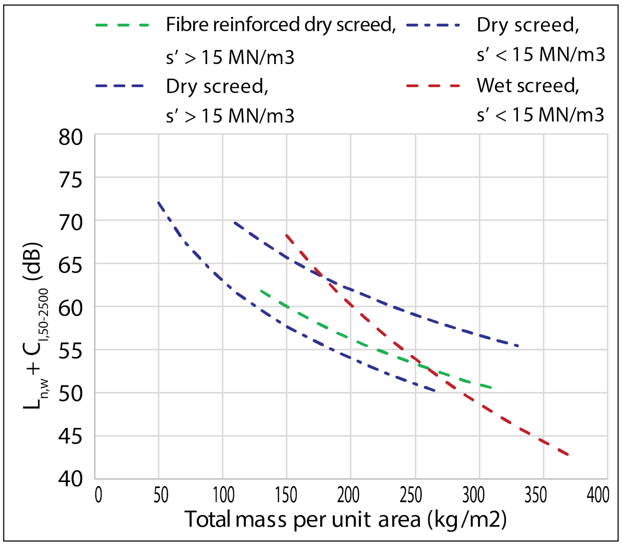

Figure 3. $L_{n,w}$ + $C_{I,50-2500}$ as a function of the total floor mass for floor assemblies categories based on hollow-box floors. Adapted from [6].