Feasibility Study
Building with Wood

Sound Insulation in the Low Frequency Range
Prospects and Recommendations to keep the Building with Wood Industry competitive

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Summary short report
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Content

The accomplishment of the study

Experts from different European countries were invited to work on this study. During a kick off meeting at TGM in Vienna January 2010 the experts decided to establish 8 working groups with a clear defined scope and a suitable time schedule[1]. A convenor and the members were nominated to each of the work packages.

To enlist the currently most reputable and distinguished experts of the building with wood sector as well as of the field of building acoustics for this joint research project was an extraordinary chance to get a profound prospect of the most important aspects to keep the building with wood industry on a competitive basis concerning the medium- and long-term perspective regarding the building acoustics requirements.

The experts, the title of the work packages, the convenors and the members are listed in alphabetical order below.

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WP 01: Legislation and Standardisation
convenor: KH, members: AS, AR, HF, MS, PL

WP 02: Noise related complaints concerning the low frequency problem in light weight buildings
convenor: HM, members: BÖ, KH, AS, AL, AR

WP 03: Sound insulation in timber construction considering the low frequency range: How to improve
convenor: OB, members: AS, KH, FD, AL, AR, HF, MS, PL

WP 04: Measurement methods and accuracy in light weight buildings
convenor: MS, members: BÖ, KH, HM

WP 05: Proposed European Actions and Strategies
convenor: BÖ, members: AS, AL, KH, OB

WP 06: Mode of construction, comparison
convenor: AR, members: KH, OB, FD, HF, PL

WP 07: Interdependencies and Side Effects with other Building Component Properties
convenor: AL, members: BÖ, OB, FD, AR

WP 08: Status and National Strategies
convenor: AS, members: BÖ, OB, AL, AR, MS

The work has been coordinated by the Federal Institute of Technology (TGM), Department of Acoustics and Building Physics, Wexstrasse 19-23, A-1200 Vienna. The Project managers are HR Prof. Ing. Mag. Mathias M. Stani mathias.stani@tgm.ac.at and Ing. Mag. Herbert Müllner herbert.muellner@tgm.ac.at.

[1] At the same time the TGM got the mandate to an "Inter-laboratory test Measurement of airborne and impact sound insulation of lightweight floors, focusing on the extended frequency range below 100 Hz" funded by the Austrian Federal Ministry of Economy, Family and Youth. First result showed that this theme will be extremely interesting to this study. It was decided to wait for the final result of this investigation.

Introduction

Complaints about acoustic comfort in buildings built in light weight mode of construction especially in multi-storey dwellings are increasing although the current requirement standards are met. The most disturbing is the low frequency 'thumping' noise, generated by footsteps but also by modern electronic sound systems. The noise issue has also received increasing attention from the World Health Organisation. In a large analysis of European housing coordinated by WHO, neighbour noise was identified as a health problem.

The aim of the study

The reason is that acoustical development is based on knowledge for heavy weight mode of construction. Because of this fact, the aim to consider the extended frequency range down to 50 Hz to become an established part of standards and legislations. The sound insulation properties between dwellings and between apartments are currently a vivid discussed topic in many European countries.

The study will deliver basics and proposals based on the conclusions of the state-of-the-art and the supposed future situation regarding the effect on the "building with wood sector" and actions which have to be taken into consideration to face the upcoming challenges well prepared and to keep the concerned industry sector competitive.

To avoid a loss of sympathy for light weight mode of construction and to keep the building with wood industry competitive action is needed.

A feasibility study should clarify the current situation, the intermediate as well as long term prospects to get a basic knowledge what actions have to be done, to keep the building with wood industry competitive. Experts from different European countries (already listed above) were invited to work on this study.

The results of the study in short are:

- Extend the frequency range for sound insulation in building acoustic down to 50 Hz.
- Use (as first step) the descriptors $D_{nT,w}+ C_{50-3150}$ for airborne and $L'_{nT,w} + C_{I,50-2500}$ for impact sound. Perhaps use only positive values of $C_{I,50-2500}$ in order to prevent future annoying high frequency sound.
- Develop constructions with higher values of R in the low frequency range with a good shaping of the R-curve (less steeps then the currently applied constructions show). The same is necessary for ceilings. A quite appropriate way seems to be to increase the distance and the mass of the plates, damp the resonance system and make the connection of the plates less pliable.
- Develop a better system to evaluate the sound reduction in the design stage.
- Work on the field of harmonization of descriptors to facilitate the exchange of experience and to reduce trade barriers in Europe (CEN, ISO, COST and national building requirements).
- Research is necessary to find a new evaluation procedure which correlate measured sound insulation and perceived acoustic quality. (we don't have sufficient experience with the proposed descriptors $C_{50-3150}$ and $C_{I,50-2500}$)
- Research is necessary to find a method to measure down to 50 Hz in real rooms with Volumes from 30 m^3 to 100 m^3. This is important regarding the situation in situ as well as in the laboratory. At this time it is not possible to measure the sound insulation down to 50 Hz with satisfying repeatability r and reproducibility R.
- Cooperation in R&D in Europe.

Results of the work packages (in short form)

For details see the results of the workgroups 1 to 8 in the paper “LowFreCon_long”.

Work package 01 “Legislation and Standardization”

Convenor: Hagberg, Klas

Members: Ferk, Heinz; Lavisci, Paolo; Rabold, Andreas; Saarinen, Ari; Stani, Mathias

This package gives comprises an overview about the regarding common goals in the legislation in the different European countries. It also describes and the situation in national and international standards and ongoing work also about in various additional actions in this field, for instance within like COST network. In all these work areas there is the common sense that the low frequency range has to be taken into account. This can happen in different ways, one possible good looking way could be a system of classification. Few countries already have mandatory a classification schemes mandatory, some work on such a system. A possible coordination across the European countries could be a big chance with positive effects for the industry. ISO and CEN have ongoing do a good work to form basis for common European single numbers which could be used in future classification schemes. Our hope is, that an agreement will be found soon and the new standards can be used also are available soon. The Work Package also gives an overview of the future development needs to further adapt acoustic requirements to light weight wooden structures.

Most of the experts came to the conclusion that new light weight structures with the focus on the low frequency range should be developed now to be prepared to meet the upcoming requirements.

The problem of the reproducibility of results of measurements in laboratory and in situ is announced (see WP 04).

Work package 02 “Noise related complaints concerning the low frequency problem in light weight buildings”

Convenor: Müllner, Herbert

Members: Östman, Birgit; Hagberg, Klas; Lüdemann, Arne**;** Rabold, Andreas; Saarinen, Ari

Complaints about acoustical comfort occur in light weight buildings although current requirement standards are met. The reasons are multifaceted. From the developers point of view new and more sophisticated constructions have to be conceived and designed to improve the sound insulation in the range of the resonant frequency. Beyond that, it is important to avoid the steep sound insulation characteristic.

The experts are of the opinion that the analysis of the acoustic properties of building elements, which were judged adequately by the occupants regarding the complex occurrence of sound event apperception, particularly concerning dominant low frequency sound events, should be conducted to establish a number of appropriate and applicable criteria as tools for the development engineers. This approach will lead to appropriate and reasonable target values as well as to supporting guidelines to design efficient building elements with sound insulation properties concerning the contemporary way of building and living.

Work package 03 “Sound insulation in timber construction considering the low frequency range: How to improve”

Convenor: Bartlomé, Olin

Members: Dolezal, Franz; Hagberg, Klas; Ferk, Heinz; Lavisci, Paolo; Lüdemann, Arne; Rabold, Andreas; Saarinen, Ari; Stani, Mathias

The acoustic quality in a lightweight building structure is perceived differently compared to a heavyweight building structure of the same R'_w: In lightweight structures the frequencies below 250 Hz often become very evident and disturbing: This commonly leads to inhabitants who complain about disturbances, although the legal acoustic requirements are met.

The most common disturbing noise in the low frequencies is the ‘thumping' noise, generated by footsteps. However, also the noise of modern electronic sound systems leads to complains.

A good way to have and find fulfilling constructions is a comprehensive catalogue with construction details (see also WP 06). However, due to the fact that the low frequency range is not being considered in most existing standards values given in such documents usually consider only frequencies above 100 Hz.

Beside the knowledge on how to build the elements themselves (e.g. from approved detail catalogues etc.) correctly also the flanking transmission and the effectiveness of joints and fixings are of great importance to achieve good sound insulation in buildings. Therefore investigations have been carried out on the flanking transmission in lightweight constructions with the focus on the low frequency range.

For intermediate floors the surface layer is important for the acoustic compliance of a floor. Further does a resilient layer change the shape of the force pulse and the amount of mechanical power introduced into the structure.

The final quality of the element/building must be guaranteed. Wooden constructions and other lightweight constructions can be controlled significantly in industrialised building systems. This is one major way to secure the final building quality for light weight structures.

Work package 04 “Measurement methods and accuracy in light weight buildings”

Convenor: Stani, Mathias

Members: Östman, Birgit; Hagberg, Klas; Müllner, Herbert

The intention of this contribution is to discuss the themes relating to the methods of acoustic measurements in lightweight buildings with the focus to the frequency range below 100 Hz.

In ISO 140-2 the basic formula for measurement of sound reduction R is defined: “sound reduction index R ten times the common logarithm of the ratio of the sound power, W_1, which is incident on the test element to the sound power, W_2, radiated by the test element. The measurement of the sound power is done by measurement of the sound pressure level in the room, in rooms with in situ and in labs usually volumes this is practically not possible for frequencies below 100 Hz.

Therefore, test results depend on the test facility even if the repeatability is not bad at low frequencies. However, reproducibility and comparability with results from other rooms may be very poor. This is the problem of the laboratories, because different labs give different results and the true values are unknown. In addition, the sound insulation in the real building depends on the room geometry. Currently we do not know the true value of the building element (different lab geometry), nor the sound reduction index of the element in the building (because of geometry, the flanking transmission is an additional factor). We have only different results from different labs. Research has to be done.

In work package 04 [9] you can find the short form of the results of the study “Inter-laboratory test Measurement of airborne and impact sound insulation of lightweight floors, focusing on the extended frequency range below 100 Hz“ funded by the Austrian Federal Ministry of Economy, Family and Youth. The result is, that the upcoming descriptors, which take the frequency range down to 50 Hz into account give very high values of repeatability r and reproducibility R. The situation is very unsatisfying, therefore work has to be done. In WP 05 are difficulties about differing result of measurements described. A partly explanation may be the unsatisfactory situation about repeatability r and reproducibility R.

Work package 05 “Proposed European Actions and Strategies”

Convenor: Östman, Birgit

Members: Bartlomé, Olin; Hagberg, Klas; Lüdemann, Arne; Saarinen, Ari

Acoustics is an important performance characteristic for building. Acoustics concern both sound and vibration. Because wooden constructions have low mass they may have poor sound insulation in the lower frequencies and are sensitive to the generation of vibration. Footsteps produce a high degree of noise disturbance, especially at low frequencies. In addition, the evaluation procedure is known to frequently fail to correlate measured sound insulation and perceived acoustic quality. In lightweight constructions there is always a risk of annoying floor vibrations and springiness due the human activities.

Methods for predicting sound insulation in lightweight buildings are today not really available. Change in minor details due the erection process further can affect the final result by several dB´s. A related problem is the large variations in sound insulation between ‘identical’ measurement places in the same building or other ones (but see also WP 04). New methods for predicting the sound insulation in the design stage for light weight buildings should be developed.

It is proposed to establish cooperation in Europe and to prepare an “acoustical” housing directive with a related strategy paper “Research for quieter European homes in 2020” in the same way as with European initiatives for environmental noise. The noise issue has also received increasing attention from WHO, World Health Organisation. In a large analysis of European housing coordinated by WHO, neighbour noise was identified as a health problem.

Very important is the harmonization of descriptors to facilitate exchange of experience and to reduce trade barriers in Europe.

European R&D cooperation should be started. Active participation in European and international standardisation, the harmonisation national building requirements and the use of the descriptors $D_{nT,w}+ C_{50-3150}$ for airborne sound and $L'_{nT,w} + C_{I,50-2500}$ for impact sound should be the topics of the future.

Work package 06 “Mode of construction, comparison”

Convenor: Rabold, Andreas

Members: Bartlomé, Olin; Dolezal, Franz; Ferk, Heinz; Hagberg, Klas; Lavisci, Paolo

Building elements, used in practice, are showing a wide range of construction principles, also among the lightweight constructions there are differences in terms of their construction principles and their acoustic properties. Lightweight floors shows very different impact sound levels in the mid and high-frequency range but their sound insulation in the low frequency range is very similar. The same effect can be observed for lightweight walls and roofs. The main reason for the small sound insulation properties of lightweight constructions in the low frequency range is the lower mass of these constructions and poor sound insulation in the lower frequencies, especially in the area of the resonance frequency. However, the use of additional mass counters the principles of prefabricated buildings.

The sound insulation in buildings depends not only from the properties of the element itself, but also from interaction with the room and flanking transmission.

There is a high need for a prediction model for lightweight construction because the EN 12354 works only for heavy weight systems. Up to now the common way to determine the sound insulation of a new building element is the measurement in a laboratory.

Research and development should look to the influence of room dimensions and element size (see also WP 04), flanking transmission in the low frequency range and a stronger an firmer integration of the prediction models into the planning process of multi-storey buildings with the object of a more efficient planning procedure.

Work package 07 "Interdependencies and Side Effects with other Building Component Properties"

Convenor: Lüdemann, Arne

Members: Östman, Birgit; Bartlomé, Olin; Dolezal, Franz; Rabold, Andreas

Building components have to fulfill many different requirements. Besides sound insulation structural properties, thermal insulation, moisture transport, air tightness, fire protection has to be considered. All these requirements show significant interaction. Sometimes measures to improve one property will help another, but sometimes it leads to deterioration. However, not only physical properties of building components are of high interest these days, also ecological evaluation and the sustainability of the whole construction have to be kept in mind.

The planning of the load bearing structure has an influence on the low frequency noise annoyance problem caused by the vibration behavior of lightweight constructions. Modern architecture requires wide spans. Bending stiffness and wide spans both need beams or panels with a high depth which are under today's economical aspects too expensive. The problems worsen if heavy-weight layers, which are needed for good sound insulation properties in today's constructions, are taken into consideration. During the last years, timber and concrete composite constructions have become more and more common since they have a high bending stiffness. That makes wide spans with quite low construction depths possible.

Increased thermal insulation improves in most cases the sound insulation. Nowadays in Central and Northern Europe it is common to have U-values in the range of 0.20 – 0.15 W/(m²K) in new built houses. The enhanced sound insulation of exteriors walls, roofs and also windows reduces the indoor noise level. The result is that a much greater importance is attached to sound insulation of intermediate floors, party- and interior walls.

Heavy-weight materials (with high heat capacities) for the indoor planking are helpful in lightweight construction mode to keep room temperatures low.

Basically it can be said that improved fire resistance properties also enhances the sound insulation properties of building components.

Work package 08 "Status and National Strategies"

Convenor: Saarinen, Ari

Members: Östman, Birgit; Bartlomé, Olin; Lüdemann, Arne; Rabold, Andreas; Stani, Mathias

New and renovated dwellings are expected to provide sufficient sound insulation to allow privacy and reasonable activities without disturbing neighbors. The external noise levels as well as noise from neighbors have not only increased they also contain strong low frequency components. That results that low frequency noise often become more audible and hence leads to increased annoyance.

The different European countries have very different requirements and regulations. Usually the fire protection rules and regulations limit the numbers of storey's for wooden buildings.

However, impact sound insulation is usually the most important factor to consider in light weight structures. Nevertheless the low frequency sound insulation requirements have usually not been taken into consideration in national building codes or national guidelines. An overview shows that

the different European countries deal differently with the low frequency problem. A few try to solve the low frequency problem with the concept of classification.

There seems to be potential for further expansion of wood as a building material especially in multi storey buildings. Main driving forces are the low weight in wooden constructions, environmental as well as ecological issues, industrialized building technique and finally a potential for future cost-effective use of wood. Guidelines or construction details to increase the quality of lightweight partition walls and floors are available for particular building elements. However, a lot of research work has recently been done (or are ongoing) in Europe, North America, Asia and Australia/New Zealand. A study or a European / International meeting with the aim to comprise a compilation of all this research would be very meaningful.

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http://www.tz-bau.at/
http://www.tz-bau.at/Seiten/Interlaboratorytest_LF_summary.pdf

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