Building With Wood Workshop - Acoustics and Vibration in Wood Construction, Stockholm 17-18 October 2011

Klas Hagberg

SP Technical Research Institute of Sweden

SP Trätek

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Abstract

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This report is a summary of the presentations, discussions and conclusions from an international workshop on “Acoustics and Vibration in Wood Construction”. The workshop was organised by Skogsindustrierna (Swedish Forest Industries Federation) in co-operation with CEI-Bois Building With Wood. The report has been compiled by Klas Hagberg, WSP. The report contains a short summary of the presentations held during the workshop as well as a summary of the group discussions. The report also concludes that, from the industry’s point of view, the topic “development of structural solutions” should have the highest priority in upcoming research calls and projects.

Key words: Acoustics, vibration, building with wood, light-weight construction, research needs

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Cover photo: The N building at Linnaeus University in Växjö, Sweden. Architect: Henrik Jais-Nielsen & Mats White Arkitekter AB. Photo: Ole Jais-Nielsen

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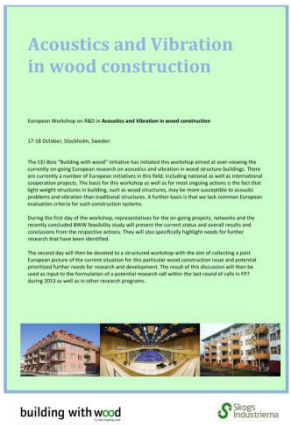
1 Summary and conclusions



The main conclusions from this workshop (regarding future research needs within wooden multi storey buildings) are summarized in the bullet points below. However for a full overview it is necessary to read the full report. The summary is divided into four parts according to the programme in the workshop. These four parts are mentioned below in the order that they appeared in the workshop. However, due to content of past and currently on-going projects, the main priority order concerning industrial needs, for upcoming calls and new projects should be

I. 2. Development of structural solutions
II. 3. Modelling and prediction
III. 1. Design criteria and 4. Measurement methods and techniques

1.1 Design criteria

Design criteria are developed currently in on-going projects. However, it is of interest to further develop some parts in this area after the completion of the projects

a. Study cultural differences within European countries – various acceptance in different countries due to cultural reasons.
b. Level of acceptance for different categories of habitants (Students, elderly et.c) to promote more optimized constructions
c. Develop methods in order to secure the final results – "Confidence in sound class rating" and "Understandable criteria for real disturbance"
d. Sound class rating. How many classes and which limits should fit?
e. Further investigations regarding frequencies below 50 Hz, in particular vibrations. Investigate heavy impact sources further if this, after all, might be an alternative to the impact machine and then, consider this in the criteria development (noise and vibration)
f. How do other technical aspects relate to acoustic criteria? Relation of (increased?) acoustic criteria to other aspects (cost, fire, energy, env.) for optimizing structural systems

1.2 Development of structural solutions

Once more knowledge in design criteria is available, an important step towards more wood in buildings is to develop solutions that exhibit resistance to vibrations and low frequencies. It should be done in different approaches

- Global solutions for the building (R&D)
    a. Concept study
    b. Study Statics, Acoustics, Fire, Earthquake and Wind stiffness
    c. Study the effect of combining various materials
    d. Possibilities for modelling and predictions

- Parametric Study (R&D)
    a. Study critical parameters and certain elements
    b. Study stiffness and mass and their mutual influence on the characteristics
    c. Include studies of
        i. element damping,
        ii. multilayer constructions,
        iii. loss factor
    d. In this context – optimize in order to avoid low frequency "thumbs"

1.3 Modelling and prediction

It is important to highlight potential problem in order to promote development and try to define "what is light". Create models from the knowledge regarding subjective response (design criteria).

- More knowledge regarding flanking transmission ("non" homogenous)
- Direct transmission including floating floors
- Involve potential various floor / building systems
- Consider multilayer constructions
- Consider radiation factor and loss factor
    - Study critical frequency

1.4 Measurement methods and techniques

Measurement technique in low or very low frequencies has to be further developed since the statistical methods are not valid in the low frequencies / structural vibrations. There is a need for "New way to think".

- Adapt to human perception of very low frequencies (sound and vibration)
- Carry out laboratory tests ➔ full scale tests
    - Perform variation studies
    - Coupling effects between rooms and structural parts
- Involve new/current impact methods in research (heavy ball for instance) further, if this after all might be an alternative to the standardized impact machine

2 Background

A two day workshop / seminar regarding acoustics in Light weight structures was held in Stockholm at the Swedish Forests Industries Federation. This report gives a summary of the content and also the main conclusions from the workshop discussions, day two.
The CEI-Bois “Building with wood” initiated the workshop, aimed at over-viewing the currently on-going European research on acoustics and vibration in wood structure buildings. There are currently a number of European initiatives in this field, including national as well as international cooperation projects. The basis for this workshop as well as for most on-going actions is the fact that light-weight structures in building, such as wood structures, may be more susceptible to acoustic problems and vibration than traditional structures. A further basis is that we lack common European evaluation criteria for such construction systems.

During the first day of the workshop, representatives for the on-going projects, networks and the recently concluded BWW feasibility study presented the current status and overall results and conclusions from the respective actions. Each representative specifically highlighted needs for further research that have been identified.
The second day was devoted to a structured workshop with the aim of collecting a joint European picture of the current situation for this particular wood construction issue and potential prioritized further needs for research and development. The result of this discussion is presented in this report and can be used as input to the formulation of a potential research call within the last round of calls in FP7 during 2013 as well as in other research programs.

3 On-Going activities and future needs – day one

In the following paragraphs, a short summary is given of the presentations during day 1. The full presentations can be downloaded from http://www.forestindustries.se/web/acousticsworkshop.aspx with reference to the name of the presenter/author.

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The workshop started with an over view of industrial needs. This presentation was held by Johan Åhlén at Moelven Töreboda in Sweden. Moelven Töreboda produces elements for wooden buildings in cross laminated timber. The system can be used in public buildings as well as multifamily buildings in several storeys. The main conclusion from his presentation is that the Swedish project AkuLite is very important to overcome the scepticism that is connected to light weight structures.

- AkuLite

AcuWood

The next presentation was given by Klas Hagberg and described the two projects AkuLite and AcuWood. The objectives and research contents of the projects are given in the presentation and the main conclusions are that the projects have to be followed by

  - Transfer of knowledge to industry, authorities, university students
  - Raised knowledge within calculation models
  - Minimizing failure during building process

- tgm

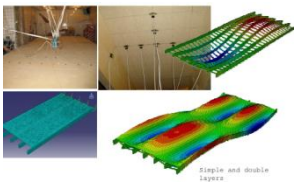
Herbert Muellner from TGM in Austria presented a recently finalized BWW Feasibility Study. The conclusions from this study is

  - How to overcome the very poor low frequency sound insulation problem in some light structures and need for more robust constructions adapted to future requirements
  - The urgent need for better prediction models
  - The need for raised knowledge regarding flanking transmission
  - Improvement of measurement procedures

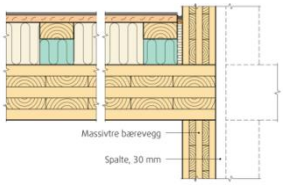
Olin Bartlomé from Lignum in Switzerland (corresponding to The Swedish Forest Industries Federation) presented the aim of a big national Swiss project, comprising in total thirteen "sub-projects". The project is doing research in a newly built "wooden" laboratory at EMPA in Zürich, but also setting up an on-line database comprising a large amount of data and combinations of different materials and building elements. It will promote more accurate design for builders and consultants.

Ari Saarinen gave a short overview of projects running in Finland and possible future research work. There is a lot of experience in developments projects in Finland since the middle of 1990. Currently there is an on-going unique project called "The wood city" comprising approximately 20000 m^2 of buildings. The challenges for future are:

- Lack of wood competence in the building sector
- Low frequency noise protection
  - Walking noise
- Flanking transmission
- Noise from installations
- Prediction and monitoring tools
- Subjective vs physical properties

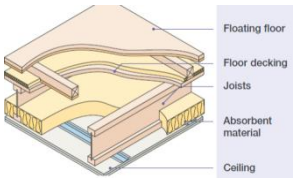


Delphine Bard at Lund University presented the outcome from the regional project "Silent Spaces". This project is an Interreg IV project started in 2010 and Professor Göran Sandberg as project manager. In this project there is focus on calculation models for vibrations and low frequencies. One important activity is to develop prediction models using FEM and to verify the models through measurements. The results could be very important input for future prediction model research. The project also involves production Technology and Harmonization of legal acoustic requirements in the region.



From Norway, Anders Homb from SINTEF in Trondheim, made a summary of current status in Norway, regarding recently finished projects, ongoing projects and future needs. The main focus in Norway is on Vibrations (comfort properties), design of floor constructions (CLT constructions), and calculation models of certain timber constructions. On-going projects are "wood joist floor constructions" using different variables to optimize floor structures, and development of CLT construction. The future needs are summarized as:

- Impact sound insulation, lack of safe design and performance
- "tighten" the gap between perception of impact sound insulation and requirements / measured values
  - In particular – low frequencies
- A lot still unknown regarding measurement methods and calculation models
- Cost effective and environmentally friendly solutions adapted to future modern requirements



UK, represented by Sean Smith at Napier University in Edinburgh, is the European country that currently builds the most multifamily housing units with wood structures. The presentation gave an overview of new regulations involving Robust Details and the improvement in acoustic quality this new system has implicated. The presentation also included brief information of a classification system, or rather different sustainability requirements for acoustics.

The main complaints are still in the region below 100 Hz and the main issues for the future are:

- Bridging the gap between 20-100 Hz
- Tackling Stiffness of core floor
- Achieving all-round good performance for 20-4000 Hz

COST Action TU0901

FP 0702

After the summary of on-going research in each country there were presentations from two on-going European COST actions TU0109 and FP0702. The first action is managed by Birgit Rasmussen in Denmark at SBI (Danish Building Research Institute) aiming at harmonizing sound insulation aspects within Europe. The second one is a COST action based on acoustics in wooden constructions managed by Michel Villot at CSTB in France. None of the COST action managers were present, however they were in both

cases presented by Eddy Gerretssen at TNO in the Netherlands. The conclusions from these actions so far are summarized below

- Need for good vibration descriptors and well defined measurement methods
- Need for perceptive studies in order to identify proper descriptors and frequency range (low frequencies)
- Collect relevant examples with performance data also for low frequencies and vibrations (collaboration between the COST actions)
- Proposals of preferred descriptors all over Europe to promote trade with building systems and products

➢ PTB

Finally the on-going revisions of two evaluation standards were presented by Werner Scholl. These standards are of great importance for the future development of wooden structures in multifamily houses. In the new standard proposals the quantity of single numbers are reduced significantly, and now comprise only four single numbers according to table below

new quantity		*old equivalent*
R_{living}	living noise sound reduction index	$R_w+C_{50\text{-}5000}$
$R_{traffic}$	traffic noise sound reduction index	$R_w+C_{tr,50\text{-}5000}$
R_{speech}	speech sound reduction index	R_w+C_{speech}
R_{impact}	impact sound reduction index	$L_{n,w}+C_{I,50\text{-}2500}$

This means that the frequency ranges will be fixed and all quantities are expressed in terms of sound reduction indexes. Old system and new system will work in parallel during some years period.

4 Need for future development/research – day two

Day two comprised structured group discussions in four different groups, each with one topic to discuss and to present certain needs for the future. The topics in the four groups were

1. Design Criteria
2. Development of structural solutions
3. Modelling and prediction
4. Measurements

The results from the workshops show the following primary needs for the future

4.1 Design Criteria

Design criteria are developed currently in on-going projects. However, it is of interest to further develop some parts in this area after the completion of the projects

Needs for research and development (R&D)

- Study cultural differences within European countries – various acceptance in different countries due to cultural reasons.
- Level of acceptance for different Categories of habitants (Students, elderly et.c) to promote more optimized constructions
- Develop methods in order to secure the final results – "Confidence in sound class rating" and "Understandable criteria for real disturbance"
- Sound class rating. How many classes and which limits should fit?
- Further investigations regarding frequencies below 50 Hz, in particular vibrations. Investigate heavy impact sources further if this, after all, might be an alternative to the impact machine and consider this in the design criteria development (noise and vibration)
- How do other technical aspects relate to acoustic criteria? Relation of (increased?) acoustic criteria to other aspects (cost, fire, energy, env.) for optimizing structural systems

Needs for engineering adaptation (Eng)

- Develop towards one common design criteria for light and heavy structures
- Standard development – Prove that the new sound reduction indices are fairly correct R_{living}/R_{impact} to convince users and building system developers
- Are the current proposal regarding R_{speech} spectrum in ISO 16717 correct enough?

4.2 Development of structural solutions

Once more knowledge in design criteria is available, one important step towards more wood in buildings is to develop structural solutions that exhibit resistance to vibrations and low frequencies. It should be done in different approaches

Global Solution (R&D)

- Concept study
    - Study Statics, Acoustics, Fire, Earthquake and Wind stiffness
    - Study the effect of combining various materials
    - Possibilities for modelling and predictions

Parametric Study (R&D)

- Study critical parameters and certain elements
  - Study stiffness and mass and their mutual influence on the characteristics
  - Include studies of
    - element damping,
    - multilayer constructions,
    - loss factor
  - In this context – optimize in order to avoid low frequency "thumbs"

Needs for guidelines (eng)

- A database with typical Solutions and principles
- Simple descriptions "Do and Don´t"
- Harmonizing regulations/recommendations for vibrations

4.3 Modelling and Predictions

It is important to highlight potential problem in order to promote development and try to define "what is light". Create models from the knowledge regarding subjective response (design criteria)

Needs for research and development (R&D)

- More knowledge regarding flanking transmission ("non" homogenous)
- Direct transmission including floating floors
- Involve potential various floor / building systems
- Consider multilayer constructions,
- Consider radiation factor and loss factor
  - Study critical frequency

Needs for design software (Eng)

- A useful tool that help designers to predict sound insulation and vibration behaviour – that also could be used to predict changes in construction

4.4 Measurement methods and Techniques

Measurement technique in low or very low frequencies has to be further developed since the statistical methods are not valid in the low frequencies / structural vibrations. There is a need for "New way to think".

Research and development in measurement technique (R&D)

Measurement technique in very low frequencies, below 50 Hz, adapted to wooden structural systems (light weight systems)

- Adapt to human perception of very low frequencies (sound and vibration)
- Carry out laboratory tests ➔ full scale tests
  - Perform variation studies
  - Coupling effects between rooms and structural parts
- Involve new/current impact methods in research (heavy ball for instance) further, if this after all might be an alternative to the standardized impact machine

Engineering methods (Eng)

- Develop standard vibration measurement procedure
- Describe low frequency measurement technique in building acoustics

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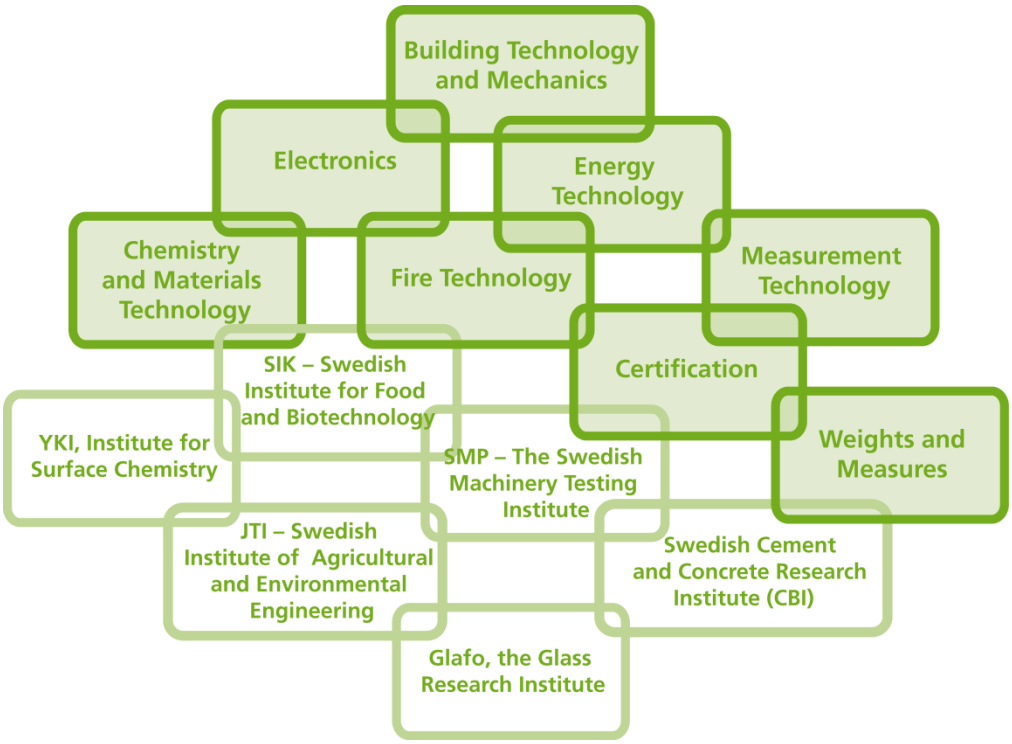

SP Technical Research Institute of Sweden
Box 857, SE-501 15 BORÅS, SWEDEN
Telephone: +46 10 516 50 00, Telefax: +46 33 13 55 02
E-mail: info@sp.se, Internet: www.sp.se
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