WP 2: Vibration measurements

Net-Acoustics for timber based lightweight building and elements

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Content of the e-book

- Measurements of floor deflections: chapter 4
- How to measure floor vibrations: chapter 5
- Assessment of walking-induced floor vibrations according to the SBR Guideline: chapter 6
- References: all chapters
Presentation - overview

- Floor deflections
- Floor vibration, excitation principles
- Analysis and characterization of floor vibrations
- Damping measurements
- Methods specific for the assessment of floor vibrations
  - Eurocode 5
  - Canadian method
  - SBR Guideline
Floor deflection measurements

- **Principles**

- **Transducer mounting – separate from floor construction**

  When field measurements:
  - supported at load bearing positions
  - supported transversely if low transverse stiffness of the floor
Floor deflection measurements, contin.

- **Measurement of global deflection**
  both point load and transducers "down" to beams or stiff plate on beams
  necessary to "short-circuit" soft floor coverings, underlayer products
  or resilient floor products

- **Measurement at weakest position**
  Normally in center of the span width
Floor vibration measurements

Excitation principles

- **Impact sources**
  - **Modal hammer**
    - + simple
    - need statistical treatment
    - ÷ for field use
  - **Heel impact**
    - + simple
    - need statistical treatment
  - **Reproduceable impact**
    - + useable also in field
    - ÷ more complicated
Floor vibration measurements
Excitation principles, continued

• **Shaker excitation**
  - different excitations, for instance sine, random, broadband
  - require skilled operators, therefore most common studying complex structures

• **Both impact and shaker excitation applicable for floor vibration measurements**
Floor vibration measurements
Analysis & characterization

- **Fundamental frequency**
  - from FFT-spectra
  - from Frequency Response Function (FRF)
Floor vibration measurements
Analysis & characterization

• **Modal analysis**
  - FRF calculation and curve-fit
  - Mode shape
  - Modal damping

• **Example of experimental setup**

• **Experimental mode shapes**

mode 1  mode 2  mode 3  mode 4  mode 5
Floor vibration measurements
Analysis & characterization

- **Integrated parameter from the transfer function**
  according to SBR guideline method to determine the OS-RMS\(_{90}\) - value

- **Integration of acceleration level**
  (seldom used)

\[
a_{RMS} = \sqrt{\frac{1}{T} \int_0^T a^2(t) \, dt}
\]
Damping measurements, low frequencies

- **Impact excitation**
  - a) logarithmic decrement or envelope fitting: from time domain spectra
  - b) half-power bandwidth: from FFT spectra or FRF's
  - c) modal damping: from curve-fit of FRF's

- **Shaker excitation**
  - all methods based on FFT spectra or FRF's
Methods specific for the assessment of floor vibrations
Eurocode-5 parameters

- **Maximum impulse velocity response**, $v_{\text{max}}$
  measurement method not suggested – or verified

- **Fundamental frequency**, $f_o$
  according to page 8

- **Damping**
  only default value for calculations are given
  If measurements -according to page 11, accuracy?

- **Static deflection**, $\Delta$
  according to page 4 & 5
Methods specific for the assessment of floor vibrations
Canadian design-guide method

- **Fundamental frequency,** $f_0$
  according to page 8

- **Static deflection,** $\Delta$
  according to page 4 & 5

- **Criteria diagram example**
  - solid line = criteria curve
  - markers = measured floors
Methods specific for the assessment of floor vibrations
SBR Guideline

• OS-RMS$_{90}$ value
  transfer mobilities
  from point of excitation
  to point of observation
  convoluted with the walking load
  spectra, see also page 10

• Isograph, damping dependent
  suggested, but values not verified
  If measurements:
  according to page 11, accuracy?
Summary

- **Eurocode 5**
  - measurement method not suggested or verified
  - calculation method not verified with respect to human perception

- **Canadian method**
  - measurement methods verified
  - criteria verified with respect to human perception
  - damping not included

- **SBR Guideline method**
  - measurement method verified, sufficient accuracy (?)
  - damping, indirectly included but how to determine?
Further work

• Harmonization of methods
  - interesting or possible?

• Decision on quantities
  - depends on the method

• Damping properties
  - special need
  - validation of measurements & calculations