Comparison of airflow and acoustic measurements for evaluation of building air leakage paths in a laboratory test apparatus

AIVC Webinar – Better Quantifying and Locating Building Leakages

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Air Leakage in Building Envelopes

Uncontrolled airflow → increase consumption of heating and cooling energy

Measuring airtightness: Blower door test

1. Measuring air leakage in buildings
2. Comparing relative airtightness of different buildings
3. Determining reduction of air permeability

→ Leakage detection time-consuming and expensive
Why Acoustics?

Sound takes predominantly the same paths as air in fan pressurization method

Advantages:

- Can be applied while building is in use
- Independent from pressure or temperature differences
- Microphone arrays may localize leakage spots

→ Size quantification difficult

Is leakage size quantification possible?
Laboratory Test Apparatus

**Goal:** Simulation of realistic leakage scenarios on model scale

![Image of laboratory test apparatus]

2.5 m

0.6 m

Different wall configurations
Laboratory Test Apparatus

Airflow Measurements

Acoustic Measurements
Tested Leak Configurations

43 different wall configurations

Modified parameters:

- Variation of slit heights: 5, 1, 0.4, 0.25 mm
- Number of walls: Single wall or two walls with air gap
- Distance between double-wall constructions: 100 and 150 mm
- Measurements with/without insulating material
- Connection of slits at double wall with a channel
- Non-parallel leakage paths
- Blank walls without openings
Tested Leak Configurations

43 different wall configurations

Airflow Measurements – Setup
Airflow Measurements – Setup

Airflow Measurements – Results
Acoustic Measurements – Setup

Microphones in both chambers
Speaker in one chamber
Excitation signal: White noise
Frequency range: 0 – 40 kHz

Coherence

Describes the fraction of an output signal from an input signal at a specific frequency

\[ C_{xy}(f) = \frac{|G_{xy}(f)|^2}{G_{xx}(f) \cdot G_{yy}(f)} \]

- Measure of the linear dependency between two discrete time signals \( x[n] \) and \( y[n] \)

- \( 0 \leq C_{xy}(f) \leq 1 \)
Acoustic Measurements – Results

Airflow vs. Acoustic Measurements
Airflow vs. Acoustic Measurements

![Graph showing airflow vs. acoustic measurements](image_url)

Coherence Difference [-]

Airflow Rate $Q$ [m$^3$/h]

- $Q_{10}$
- $Q_{20}$
- $Q_3$

Evaluation of leakage paths

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Airflow vs. Acoustic Measurements

![Graph showing airflow vs. acoustic measurements](image_url)

Coherence Difference [-]

Airflow Rate $Q$ [m$^3$/h]

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Evaluation of leakage paths

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Conclusion and Outlook

• **Airflow** and **acoustic measurements** in the same **laboratory** environment

• **43 different leak configurations** were tested

• **Distinction** between different **leak sizes** possible

• **Weighting** of certain dominant **frequency bands**, instead of mean value may **increase** prediction **accuracy**

• More **complex** and **different leaks**

• Potential for **localization** of leaks using acoustics

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Thank you

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