Field measurement of the durability of building airtightness- review and analysis of existing studies

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Tightvent Webinar 2020

Durabilit’air project

• 1st task of the Durabilit’air project

• Objectives of the project:
  • State of the art of major international research findings
  • Characterizing the evolution over time in mid and long term scales by on-site measurement campaigns
  • Developing a laboratory controlled method in order to test the accelerated ageing of airtightness systems;
  • Disseminating the main results of this work to promote best practices.
Objective of the state of the art

- Learn from previous studies
- Improve the protocol for the other tasks of the project
  - Field measurements
  - Laboratory testing

Durability tested on site

- In situ measurement
- Measurement uncertainty, seasonal variation
IN SITU MEASUREMENTS

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- Chan & Sherman, 2014
- Chan & Sherman, 2014
- Hansen & Ylmén, 2012
- Prowski, 1998
- ADEME, 2016
- Feist, Ebel, et al., 2016
- Phillips, Rogers, et al., 2011
### Difference due to structure movements in new buildings?

<table>
<thead>
<tr>
<th>Year</th>
<th>Flowrate</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>6 ACH</td>
<td>+15%</td>
</tr>
<tr>
<td>2007</td>
<td>10 ACH</td>
<td>0%</td>
</tr>
<tr>
<td>Chan &amp; Sherman, 2014</td>
<td>Chan &amp; Sherman, 2014</td>
<td></td>
</tr>
</tbody>
</table>

### Building virtually identical (same craftsmen, same materials) => difference due to occupants behaviour?

<table>
<thead>
<tr>
<th>Year</th>
<th>Flowrate</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>0.6 ACH</td>
<td>+36%</td>
</tr>
<tr>
<td>2016</td>
<td>1.5 ACH</td>
<td>-3%</td>
</tr>
<tr>
<td>Chan &amp; Sherman, 2014</td>
<td>Chan &amp; Sherman, 2014</td>
<td></td>
</tr>
</tbody>
</table>

**Very low flowrate difference, measurement uncertainty?**
Half have increased, half have decreased, correlation neither with construction changes nor with age of the building.

Extended leakage detection: leaks appear at:
- Penetrations of the air barrier;
- Electrical appliances;
- New non-airtight appliances (hood, recessed lighting, etc.).

Chan & Sherman, 2014
Chan & Sherman, 2014
Hansen & Ylmén, 2012

Feist, Ebel, et al., 2016
Philips, Rogers, et al., 2011
ADEME, 2016
Prowski, 1998
Acrylic mastics, set on backer rod, have not deteriorated at all.
Windows and doors gaskets (on the openings) have deteriorated => changed for the new test.

Timber frame dwellings showed the largest change in airtightness compared to plastered masonry.
Shrinking of mastic when heated for the first time?
Performance improvement
Installation of carpets and floor finishes after the original test?
Conclusion on site ageing

• Seems that the airtightness decreases in the first years after completion and then stabilises.
• Explanation factors:
  • Heating houses for the first time may induce the shrink of mastics
  • Mastic shrinking when backer rod are not used
  • Structure movements and packing may induce cracking in the junctions between air barrier and penetrations
  • Occupants behaviour: Envelope drilling (lot in the first years), etc.
  • Unsuitable implementation conditions for adhesives and mastic (cold and/or dusty conditions).

Impact on the testing protocol

• Questionnaires to occupants to find out drillings made in the air barrier.
• Leakage detection and visual inspection at visible assemblies of air barrier with specific care on:
  • mastics,
  • penetrations of building structure inside the air barrier (ex. carpentry).
• Information about:
  • Products used for the air barrier (use of backer road, compatibility of products)
  • Construction details
  • Period when the air-barrier was layed-out (heating period or not)?
  • Air-barrier heated prior to the first test?
## Measurement Uncertainty and Seasonal Variations

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### Measurement Uncertainty:

- **Reference Pressure of Indicator**
  - 4 Pa
    - Repeatability: 3.5%
    - Reproducibility: 5.9%
    - Wind impact (10m/s): Max 60%
  - 50 Pa
    - Repeatability: 1.4%
    - Reproducibility: 2.4%
    - Wind impact (10m/s): Max 12%

Sources: Delmotte_2011, Carrié_2014, Bracke_2014

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Measurement uncertainty: seasonal variation

- Impact of indoor humidity?

<table>
<thead>
<tr>
<th>Winter</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wahlgren_2012</td>
<td>-10%</td>
</tr>
<tr>
<td>Brennan_2013</td>
<td>-10%</td>
</tr>
<tr>
<td>Bracke_2013</td>
<td>-20%</td>
</tr>
<tr>
<td>Kim_1986</td>
<td>-20%</td>
</tr>
<tr>
<td>Borsboom_2012</td>
<td>-40%</td>
</tr>
<tr>
<td>Bailly_2016</td>
<td>+20%</td>
</tr>
</tbody>
</table>

\[ \frac{Q_{50}}{Q_{50}} = 0.991 \cdot \left( \frac{W_i}{W_i} \right) \]

Impact on the testing protocol

- Reduce measurement uncertainty
  - Same qualified tester perform tests;
  - Reports precisely describe building preparation including locked and unlocked external doors.
  - Measurement devices calibrated according ISO 9972.
  - Measurements in low wind conditions.
  - Airtightness compared at 50Pa rather than 4 or 10 Pa.
    - In flowrate at 50 Pa rather than ratio (n50 or q50) take into account uncertainty
  - Average of pressurisation and depressurisation test
  - Better to perform test at the same season.
Conclusions

Airtightness changes through years
- Seems to decrease in the first years and then stabilise
- On site analysis required to explain measurement results

Low uncertainty required for interpretation
- 50 Pa indicator more reliable
- Test at same season if feasible

Thank you for your attention!

Source: AIVC 2017 –Nottingham:
Publication available on Airbase
https://www.aivc.org/resource/durability-building-airtightness-review-and-analysis-existing-studies