Assessment of long-term and mid-term building airtightness durability: *field study of 61 French low energy single-family dwellings*

Bassam Moujalled*, Sylvain Berthault, Andrés Litvak, Valérie Leprince, and Gilles Frances

*bassam.moujalled@cerema.fr

Introduction

- The French research project **DURABILITAIR (2016-2019)**
  - ✓ *to improve our knowledge on the variation of buildings airtightness through **onsite measurement campaigns (Task 2)** and accelerated ageing in laboratory controlled conditions (Task 3)*
- Literature review (task 1) showed an important evolution over time of the air permeability in real buildings, especially in the first 3 years
- The second task of the project deals with the quantification and qualification of the durability of building airtightness of single detached houses through **field measurement** at:
  - ✓ *mid-term scale (MT)*
  - ✓ *long-term scale (LT)*

Methodology

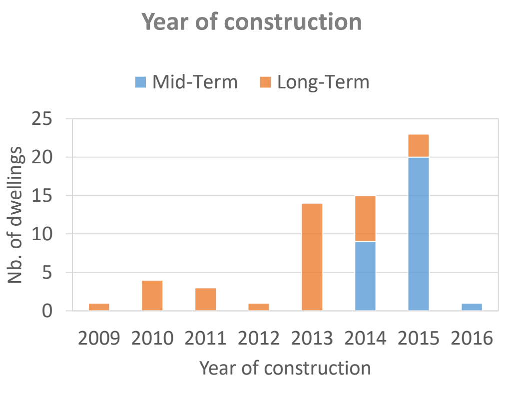
- MT and LT measurement campaigns based on two samples of single-detached low-energy dwellings:
  - ✓ *All dwellings measured upon completion* **[measurement n0]** *and treatment of airtightness well known*
- MT measurement campaign (1-3 years):
  - ✓ *Sample of 30 new single-detached dwellings*
  - ✓ *The airtightness of each dwelling was measured once per year over the 3-year period* **[measurements n1, n2 & n3]**
  - ✓ *Five dwellings were measured twice per year (impact of seasonal variations)*
  - ✓ *For six dwellings, the airtightness of an installed window was measured once per year over the 3-year period*

Methodology

- LT measurement campaign (5-10 years):
  - ✓ *Sample of 31 single-detached dwellings constructed during the last 10 years*
  - ✓ *The airtightness of each dwelling was measured once* **[measurement nx]**
- Measurement protocol based on ISO 9972 and its French implementation guide, with additional requirements:
  - ✓ *Measurements to be performed under the same conditions as the measurement upon completion both in pressurization and depressurization*
  - ✓ *Detailed qualitative leakage detection to be performed*
  - ✓ *Questionnaires for occupants to be filled at each measurement regarding the action of the occupants on building envelope*

RESULTS

Characteristics of buildings



Average timespan between measurements

MT sample:

n0-n1 : 1.7 yr (from 1.1 to 2.7)

n1-n2 : 0.7 yr (from 0.4 to 1.2)

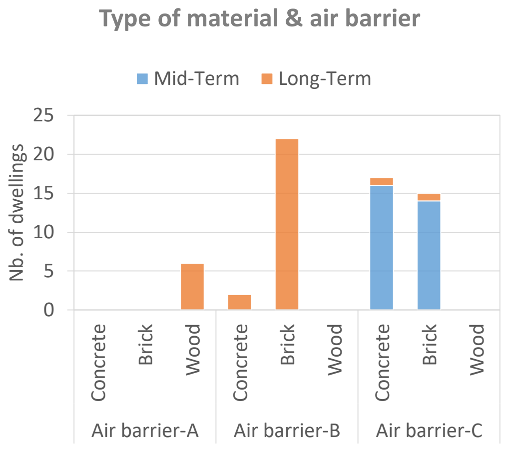
n2-n3 : 0.9 yr (from 0.4 to 1.7)

n0-n3 : 3.4 yr (from 2.8 to 4.2)

LT sample:

n0-nx : 4.6 yr (from 2.6 to 8)

Characteristics of buildings



MT sample:

Masonry walls with interior insulation: Airtightness by plasterboards and mastics at the inside facing of the walls (C)

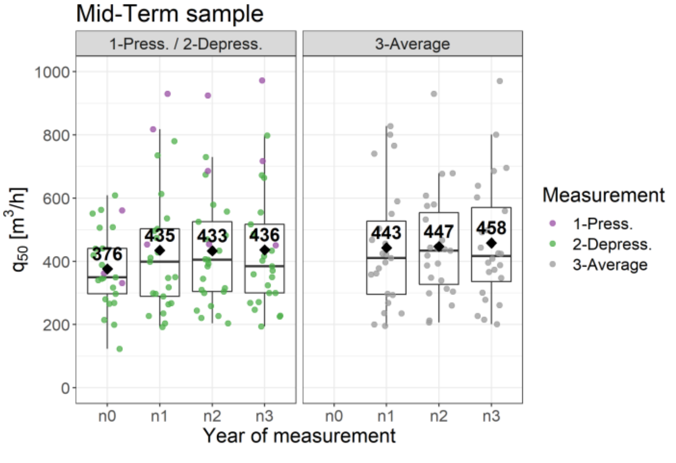
LT sample:

Masonry walls with interior insulation: Airtightness by coating on the masonry (B) or by plasterboards and mastics at the inside facing of the walls (C)

Wood frame houses with insulation between studs: Airtightness by the vapour barrier (A)

Evolution in q_{50}

MT sample



Evolution of mean q_{50}:

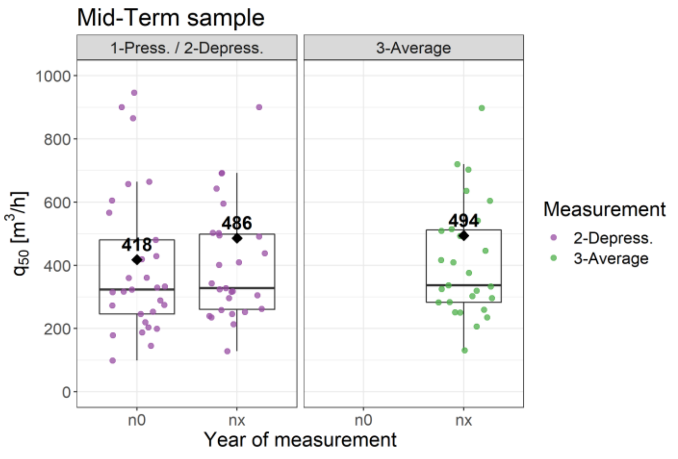
n0-n1: +58.9 $m^3.h^{-1}$ / +18%
(p-value = 0.037)
Timespan = 1.7 years

n0-n2: +57.2 $m^3.h^{-1}$ / +18%
(p-value = 0.026)
Timespan = 2.7 years

n0-n3: +60.4 $m^3.h^{-1}$ / +19%
(p-value = 0.037)
Timespan = 3.4 years

Evolution in q_{50}

LT sample



Evolution of mean q_{50}:

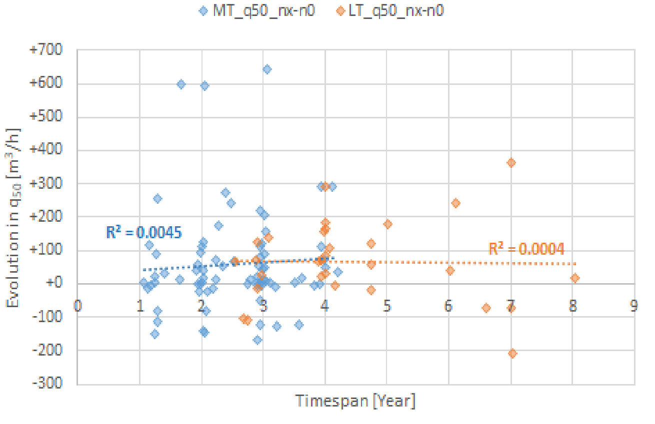
n0-nx: +67.7 m³.h⁻¹ / +20%

(p-value = 0.002)

Timespan = 4.6 years

Evolution in q_{50} vs. Timespan

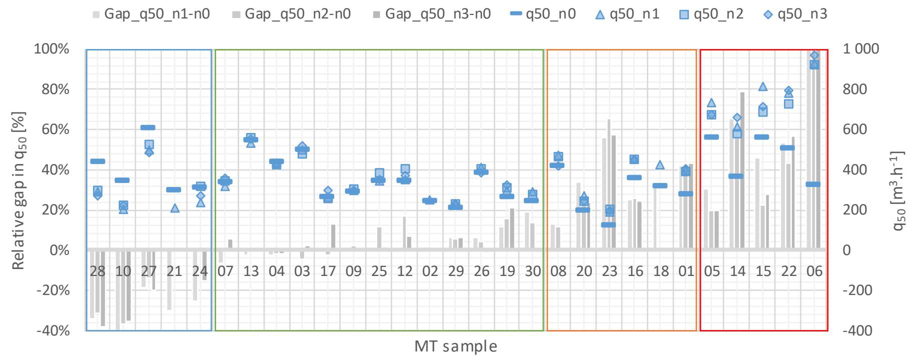
MT & LT samples



No correlation between the evolution in q_{50} and the age of the houses for both MT and LT samples

Analysis of explanatory factors

MT sample



Δq_{50}<-50m³.h⁻¹ — 5 houses

-50 <Δq_{50}<+50 — 13 houses

+50 <Δq_{50}<+150 — 6 houses

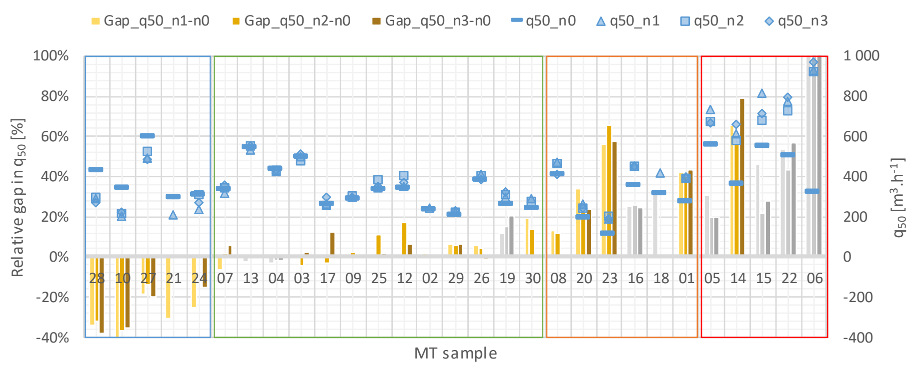
Δq_{50}>+150m³.h⁻¹ — 5 houses

Analysis of explanatory factors

Nb. Of levels (MT)

2-storey houses seems to deteriorate more than 1-storey houses
→ Structural movement?

1-storey (20)
2-storey (10)



Δq_{50}<-50m³.h⁻¹ — 5 houses

-50 <Δq_{50}<+50 — 13 houses

+50 <Δq_{50}<+150 — 6 houses

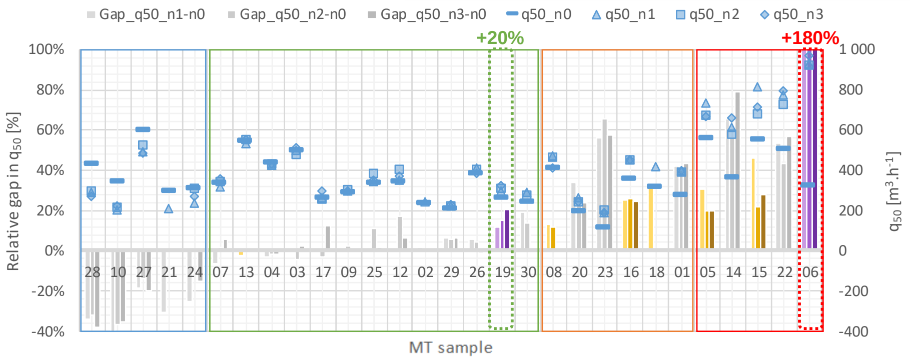
Δq_{50}>+150m³.h⁻¹ — 5 houses

Analysis of explanatory factors

Type of roof (MT)

Light frame (20)
Traditional wood frame (8)
Exposed Traditional wood frame (2)

2 exposed wood frame houses with same type of air barrier: +20% vs +180%
→ conditions of implementation?



Δq_{50}<-50m³.h⁻¹ — 5 houses

-50 <Δq_{50}<+50 — 13 houses

+50 <Δq_{50}<+150 — 6 houses

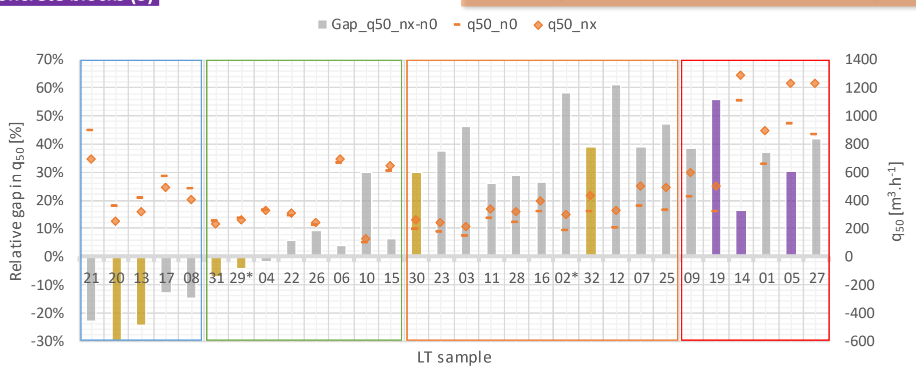
Δq_{50}>+150m³.h⁻¹ — 5 houses

Analysis of explanatory factors

Type of material (LT)

Wood frame (6)
Hollow bricks (21)
Concrete blocks (3)

Wood houses tend to stabilise or even improve over years
→ expansion of wood with humidity?



Δq_{50}<-50m³.h⁻¹ — 5 houses

-50 <Δq_{50}<+50 — 8 houses

+50 <Δq_{50}<+150 — 11 houses

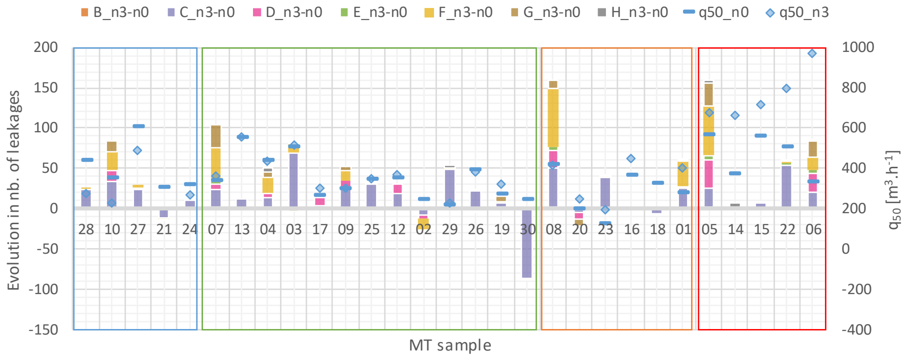
Δq_{50}>+150m³.h⁻¹ — 6 houses

Evolution of leakages

MT sample: n3-n0

Increase of leakages C, F, D & G
NO CORRELATION with the evolution in q_{50}

B: junctions wall/slab
C: doors and windows
D: penetration through envelope
E: trapdoor
F: electrical components
G: junctions wall/window
H: other leakages



$\Delta q_{50}<-50 m^3.h^{-1}$ $-50<\Delta q_{50}<+50$ $+50<\Delta q_{50}<+150$ $\Delta q_{50}>+150 m^3.h^{-1}$

CONCLUSIONS

Conclusions

- **Same evolution of airtightness at mid and long term**
  - ✓ Similar increase in q_{50} at mid and long-term (+18% and +20% respectively)
  - ✓ No correlation with the age of construction
  - ✓ Deterioration mainly during the first 2 years and then stabilisation
- **Significant increase in the number of leakages for:**
  - ✓ Doors and windows, electrical components, penetrations through envelope & junctions between walls and windows
  - ✓ But no correlation with the variation in q_{50}

Conclusions

- **Explanatory factors of the evolution of the airtightness:**
  - ✓ No impact for constructor, type of air-barrier, type of floor, type of heating, specific HVAC equipment
  - ✓ No impact for seasonal variation
  - ✓ The airtightness of wood houses tend to stabilise or even improve over years
  - ✓ 2-storey houses seems to deteriorate more than 1-storey ones
  - ✓ Studied factors unable to explain the variations:
    - ✓ **Other factors, such as conditions of implementation of the air-barrier, need to be explored**

Thanks…

Projet DURABILIT'AIR

https://www.durabilitair.com/

Lauréat de l'Appel à Projets de Recherche 2015 « vers des Bâtiments Responsables à l'Horizon 2020 »

Cerema PLEIAQ CETII RESCOLL Centre Technologique

avec le financement de ADEME