Trends in building and ductwork airtightness in Japan

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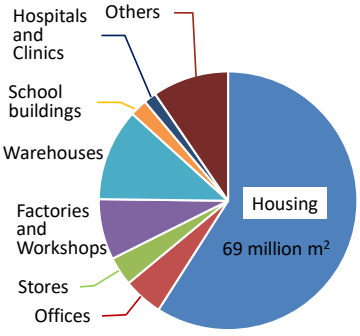
General introduction

- Japan is a country with currently about 123 million inhabitants.
- The total construction area in 2022 is approximately 119.5 million m^2.
- New housing starts totaled approximately 0.86 million units.



The area of construction started in Japan (2022)

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Building airtightness 1. Introduction

- In Japan in 1992, as a standard in cold regions, a house with $ELA_{F9.8}$ of 5.0 cm^2/m^2 or less (approximately $q_{E50} \leq 8.5$ $m^3/h/m^2$, $ACH_{50} \leq 7.7$ h^{-1}) was defined as an airtight house.
- In 1999 revised notification, the $ELA_{F9.8}$ was divided into areas with 2.0 cm^2/m^2 (approximately $q_{E50} = 3.4$ $m^3/h/m^2$, $ACH_{50} = 3.1$ h^{-1}) or less and areas with 5.0 cm^2/m^2, and became nationwide specifications.
- In 2003, "JIS A 2201 Test method for performance of building airtightness by fan pressurization" was enacted, and revisions to the Building Standards Law mandated the installation of mechanical ventilation equipment as a countermeasure against sick house syndrome.
- In 2009, the standard value for building airtightness was deleted based on the judgment that the airtightness of housing was widely known and construction was being carried out.
- However, in 2020s, some local governments began to establish and certify standards for building airtightness.

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2. Airtightness indicator

- The airtightness indicator used in Japan standards is effective (or equivalent) leakage area per the floor area at 9.8 Pa (1 mmAq originally used) pressure difference ($ELA_{F9.8}$).
- The effective leakage area at the reference pressure difference (ELA_{pr}) is calculated at the test reference pressure differences across the building envelope.
- As defined in ISO 9972 the specific effective leakage area is an effective leakage area per the envelope area (ELA_{Epr}) or per the floor area (ELA_{Fpr}) at the reference pressure difference (pr).

✓ $q = C(\Delta p)^n$ (eq. 1)

✓ $q = \frac{3\,600}{10\,000} ELA_{pr} \sqrt{\frac{2}{\rho}\Delta p}$ (eq. 2)

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Unit conversion for building airtightness

$ELA_{F9.8}$ [cm^2/m^2]	q_{E50} [$m^3/(h.m^2)$]	ACH_{50} [h^{-1}]
Detached houses (2 stories building, floor area of 125.9 m^2, height of 5.0 m, envelope area of 285.1 m^2, internal volume of 314.7 m^3, air flow exponent *n* of 0.6)		
0.5	0.9	0.8
1	1.7	1.5
2	3.4	3.1
5	8.5	7.7
Apartment buildings (Dwelling unit, floor area of 46.9 m^2, height of 2.4 m, envelope area of 159.56 m^2, internal volume of 112.56 m^3, air flow exponent *n* of 0.6)		
0.2	0.2	0.3
0.5	0.6	0.8
1	1.1	1.6
2	2.3	3.2
3	3.4	4.8
5	5.7	8.1
8	9.1	12.9

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3. Requirements and drivers

Building airtightness requirements in the regulation

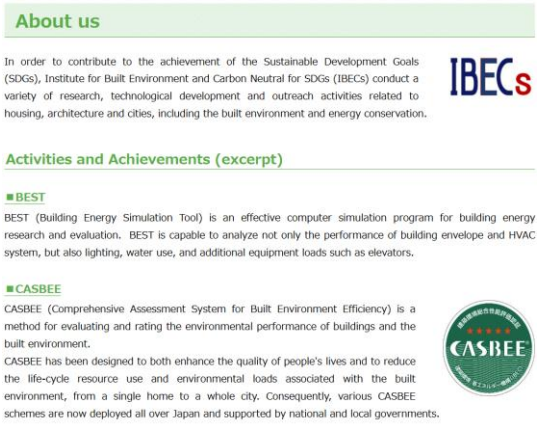
- Currently in Japan, there are no national building airtightness requirements in the regulation.
- On the other hand, local governments are making efforts to improve airtightness.

Sapporo City	Yamagata Prefecture	Nagano Prefecture	Tottori Prefecture
$3500 \leq HDD_{18\text{-}18} < 4500$	$2000 \leq HDD_{18\text{-}18} < 3500$	$2000 \leq HDD_{18\text{-}18} < 3500$	$2000 \leq HDD_{18\text{-}18} < 3000$
Starting Apr. 1, 2023	Revised Apr. 1, 2022	Starting Apr. 15, 2023	Starting Jul. 1, 2020
New construction: $ELA_{F9.8} \leq 0.5\ cm^2/m^2$ (Approximately $q_{E50} \leq 0.9\ m^3/(h.m^2)$) Refurbishment: $ELA_{F9.8} \leq 1.0\ cm^2/m^2$ (Approximately $q_{E50} \leq 1.7\ m^3/(h.m^2)$)	$ELA_{F9.8} \leq 1.0\ cm^2/m^2$ (Approximately $q_{E50} \leq 1.7\ m^3/(h.m^2)$)	New construction: $ELA_{F9.8} \leq 1.0\ cm^2/m^2$ (Approximately $q_{E50} \leq 1.7\ m^3/(h.m^2)$)	$ELA_{F9.8} \leq 1.0\ cm^2/m^2$ (Approximately $q_{E50} \leq 1.7\ m^3/(h.m^2)$) Refurbishment housings are recommended value
Common standards for detached houses and apartment buildings	Applies to newly built dwellings and existing dwellings with overall thermal insulation refurbishment	New detached wooden houses are eligible	Energy-saving standards for building detached houses

Incentive for Building airtightness

Building airtightness justifications

- Local governments set standards for building airtightness in addition to standards for insulation, etc., and partially subsidize construction costs.
- Airtightness tests are not mandatory, but it must be done in accordance with JIS A 2201 in order to receive subsidies for construction costs from local governments.
- Airtightness measurements are performed by airtightness measurement technicians registered by IBECs (Institute for Built Environment and Carbon Neutral for SDGs).
- Airtightness tests are not compulsory, so there is no penalty.



About us

In order to contribute to the achievement of the Sustainable Development Goals (SDGs), Institute for Built Environment and Carbon Neutral for SDGs (IBECs) conduct a variety of research, technological development and outreach activities related to housing, architecture and cities, including the built environment and energy conservation.

IBECs

Activities and Achievements (excerpt)

■BEST

BEST (Building Energy Simulation Tool) is an effective computer simulation program for building energy research and evaluation. BEST is capable to analyze not only the performance of building envelope and HVAC system, but also lighting, water use, and additional equipment loads such as elevators.

■CASBEE

CASBEE (Comprehensive Assessment System for Built Environment Efficiency) is a method for evaluating and rating the environmental performance of buildings and the built environment.
CASBEE has been designed to both enhance the quality of people's lives and to reduce the life-cycle resource use and environmental loads associated with the built environment, from a single home to a whole city. Consequently, various CASBEE schemes are now deployed all over Japan and supported by national and local governments.

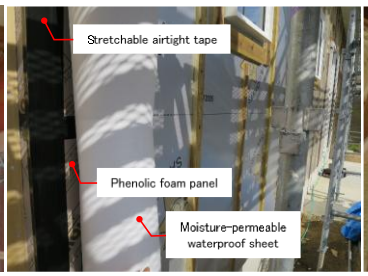
CASBEE

https://www.ibecs.or.jp/english/index.html

4. Building airtightness in the energy performance calculation

- In Japan, there is an evaluation program for energy efficiency and conservation standards for residential and non-residential buildings, but there is no input item for building airtightness.
- This is based on the judgment that the airtightness of houses is well known nationwide and that construction is being carried out.

Filling insulation



Outside insulation walls

Urethane foam insulation

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5. Building airtightness test protocol

- IBECs is conducting a training project for building airtightness measurement technicians for houses, etc.
- Those who have mastered the measurement methods based on JIS A 2201 are considered airtight measurement technicians.
- After taking the course, those who have passed the written examination can apply for airtightness measurement technician.
- About 500 people pass the exam every year.

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6. Building airtightness tests performed

- Tested buildings
  - There is no official data available of buildings airtightness tested.
  - In Japan, it is common to measure the building airtightness of houses, and non-residential airtightness measurements are rarely performed except for special buildings.

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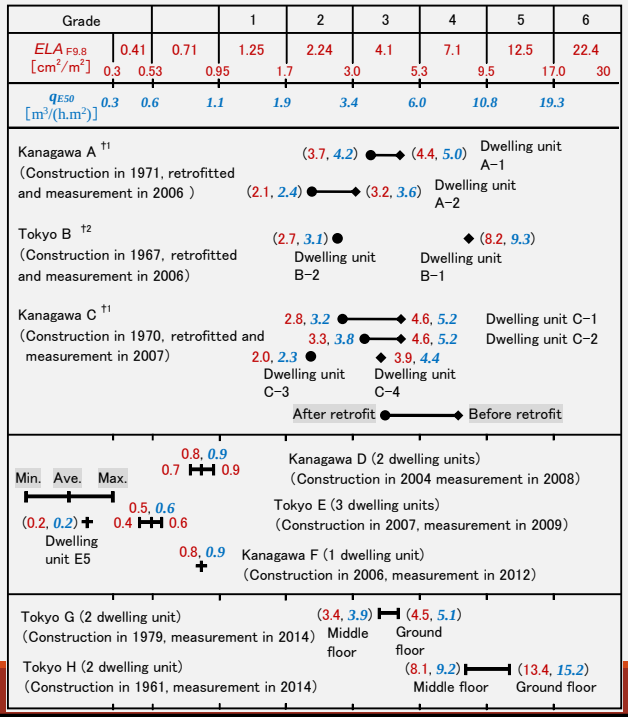
- Database
  - Figure shows changes in the building airtightness of dwelling units in housing complexes by the authors.
  - ✓The q_{E50} of dwelling units around 1970 is about 5 $m^3/h/m^2$ (approximately ACH_{50} = 8 h^{-1}).
  - ✓The q_{E50} of dwelling units after 2000 is less 1 $m^3/h/m^2$ (approximately ACH_{50} = 1.5 h^{-1}).
  - ✓On the other hand, airtight retrofitting of stock buildings will be around openings., and the q_{E50} are improved to about 3.5 $m^3/h/m^2$ (approximately ACH_{50} = 4.8 h^{-1}).



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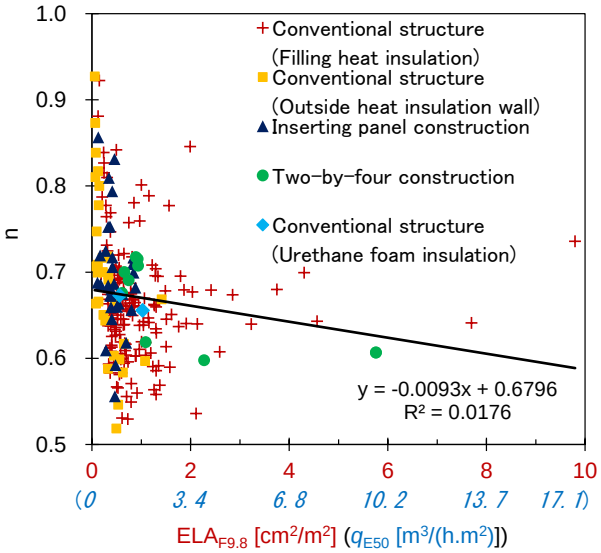
Database

- Figure shows the relationship between building airtightness and the air flow exponent *n* for 233 detached houses from 2015 to 2020.

✓Over 75% of detached houses have q_{E50} of 1.7 $m^3/h/m^2$ (approximately ACH_{50} = 1.5 h^{-1}) or less.



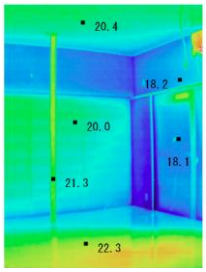
Airtight retrofit work

Sash retrofit of reinforced concrete housing complexes

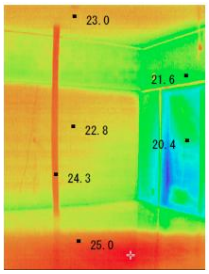
Airtight retrofit of a detached house by spraying urethane foam insulation

7. Guidelines to build airtight

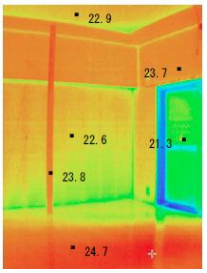
- AIJ (Architectural Institute of Japan) is currently formulating academic standards to improve building airtightness of houses.
- In addition, a consortium study group on building airtightness of non-residential buildings has been established.



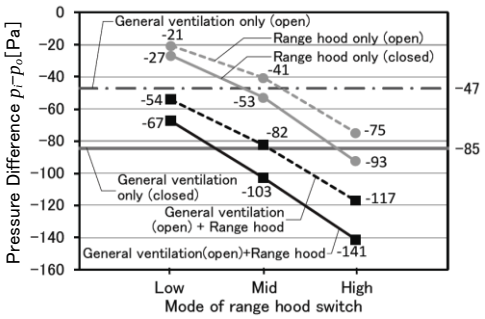
Not renovated



Airtight renovation



Insulation and airtight renovation



AIJES (Architectural Institute of Japan Environmental Standards) Standard for Building Airtightness

- An example of table of contents

✓Building airtightness performance standards

✓Planned ventilation and building airtightness

✓Improvement of thermal environment and heating/cooling energy consumption through building airtightness retrofit

✓Required building airtightness and achievable airtightness standards

✓Building airtightness and gap (openings) evaluation methods

✓Methods of measuring building airtightness performance

✓Installation position of air barrier and condensation inside the wall

✓Building airtightness and problems

✓Etc.,

8. Conclusions

- Japanese buildings ensure a certain degree of building airtightness.
- The awareness on building airtightness in Japan is growing again but there are still very few non-residential buildings that are tested.
- This is probably because airtightness testing of non-residential building is difficult.
- However, research consortiums have started up, and it is expected that interest in building airtightness for non-residential buildings will increase in the future, and databases will be created.
- In the case of housing, local governments are setting standards for building airtightness in some cases, and the number of airtightness testers is also increasing.

Ductwork airtightness

- In Japan, the ductwork airtightness has not been really considered so far.
- There is no national regulation nor guideline on this subject, so there is no requirement on the airtightness level of ductworks.
- Ductwork airtightness is important for ventilation and energy saving.
- But, there are only rare cases in which clients request a ductwork airtightness test.

Thank you for your attendance

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