AIRTIGHTNESS OF VERY LARGE VOLUME BUILDINGS: MEASURING METHOD AND FIRST RESULTS

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ABSTRACT

CETE de Lyon gives support to French administration for thermal regulation definition and enforcement. They must therefore work on measurements in order to set appropriate requirements and give advice to professionals about building methods.
Air-tightness of very large volume buildings is a growing issue in France, as performance levels are now required by low-energy labels and energy savings can be significant in those buildings. However, to measure airtightness one must be able to induce adequate airflow-rate to get sufficient differential pressure. A high-capacity fan called MEGAFAN was bought by CETE de Lyon in 2009 to measure very large volume buildings.
This article gives a presentation of this measuring tool and deals with the first measurements made on very large volume buildings and their results.

KEYWORDS

Airtightness, large buildings, retrofit

1 INTRODUCTION

In this article, airtightness measurements on very large volume buildings are considered. For this, common measurement devices such as blowing doors are inadequate because of their too low maximum air flow rate. In such cases, more powerful devices are required.
CETE de Lyon therefore bought a high capacity fan called MEGAFAN (CETE de Lyon, 2012). MEGAFAN is needed to measure the airtightness of full commercial buildings and collective housing because it can generate a maximum air flow rate of 300 000 m^3/h. Thus, sampling is not necessary which improves the measurement's precision. For example, MEGAFAN can measure commercial buildings with a volume of 50 000 m^3 and an n_{50} of 6 h^{-1} as well as collective housing with a volume of 75 000 m^3 and an n_{50} of 4 h^{-1}.
Today, French thermal regulation (JORF, 2010) does not require any airtightness level for commercial buildings. However, low-energy label Effinergie+ requires airtightness to be lower than 1.2 $m^3/h/m^2$ (with French indicator Q_{4Pa_surf} : air flow rate at 4 Pa divided by cold surface excluding ground floor surface) for buildings with floor space lower than 3 000 m^2. Considering collective housing, thermal regulation requires 1 $m^3/h/m^2$ (French indicator Q_{4Pa_surf}). In any case, measurements must be made in accordance with NF EN 13829 (AFNOR, 2001) and French application guide GA P50-784 (AFNOR, 2011).

For legal requirements to improve, one must be able to get a good knowledge of the existing buildings' performance, in order to conclude about what appropriate airtightness level can be required.
A presentation of MEGAFAN is proposed in this article as well as results obtained on tested buildings and recurring leakage points. As a conclusion, a comparison is made between measured airtighness and French thermal regulation default value for this type of buildings.

2 PRESENTATION OF MEGAFAN

MEGAFAN is composed of a 2-meter-diameter fan placed directly on the back of a truck. A flexible tube connects the fan to a false door which must be built on site to fit to the building's opening used for measurement (Figure 1). This opening must have dimensions of at least 2.10 m by 2.10 m as the flexible tube's diameter is identical to the fan's diameter.
Fan control and collection of data needed to quantify airtightness are carried out manually. Data processing is then done automatically via the associated operating software.

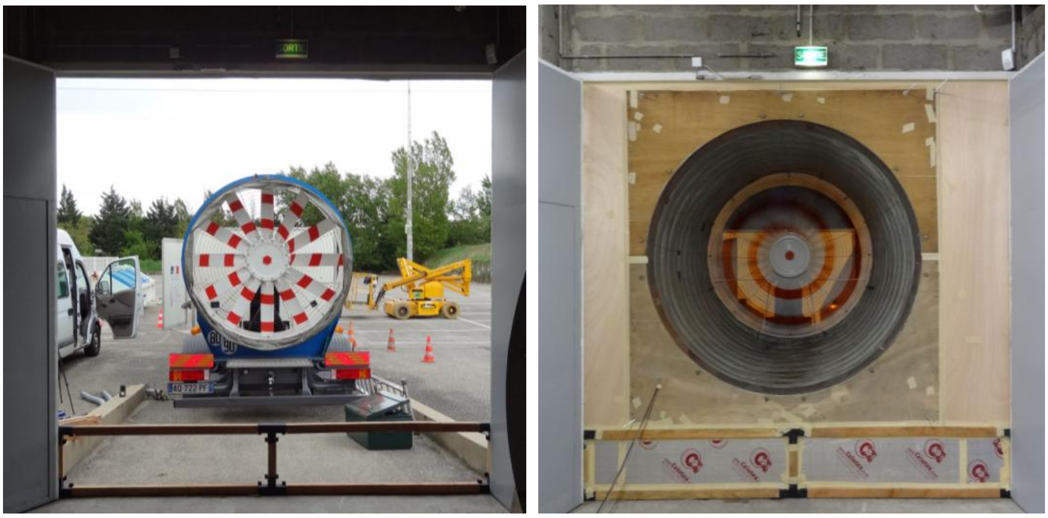

Figure 1: Interior view of MEGAFAN's connection to a commercial building's opening

MEGAFAN is a unique measurement device in France. CETE de Lyon is asked to measure large volume buildings with unusual architecture, large commercial buildings or exceptional projects (Figure 2). Customers are private and public organizations as well as local authorities.
Regarding the calibration of the equipment, a procedure in accordance with ISO 5801 (ISO) is implemented in CETE de Lyon to check MEGAFAN's reliability.

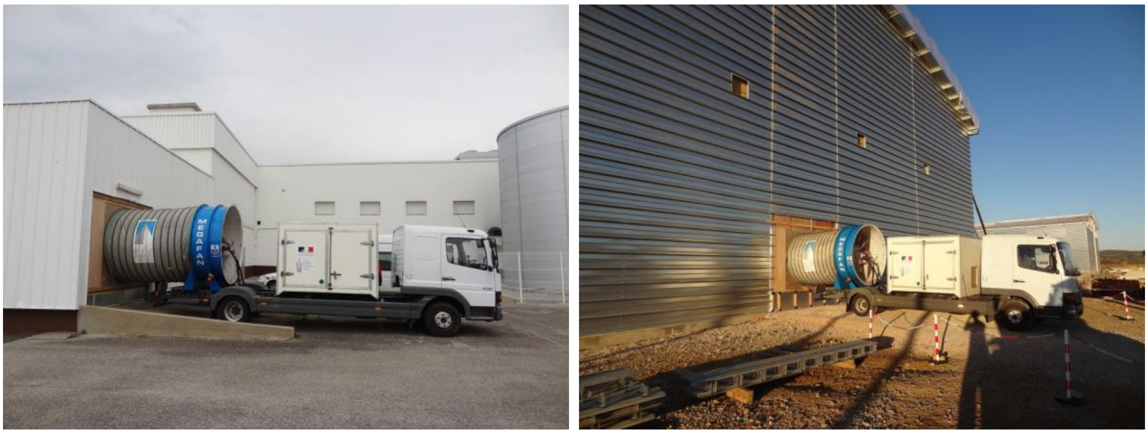

Figure 2: Airtightness measurement with MEGAFAN

3 RESULTS

The airtightness results obtained for the tested buildings and a description of the buildings' specifications for existing buildings are given in Table 1 and for new buildings in Table 2. Some of these buildings were measured for a project called ACIECO (CTICM, CETE de Lyon, CSTB, LEPTIAB, 2009) whose aim was to improve knowledge about actual airtightness levels and recurring leakage spots on steel-built buildings.

Table 1: Specifications of existing tested buildings and airtightness results

Type of building	**Volume (m^3)**	**Floor surface (m^2)**	**Cold surface except ground floor (m^2)**	**Main building materials**	**Year of construc-tion**	**Airtightness Q_{4Pa_surf} ($m^3/h/m^2$)**	**Airtightness n_{50} (h^{-1})**
Shop	14 061	3 544	2 484	Steel, concrete, double glaze	Approx. 1970	1.8	1.25
Shopping center	27 858	6 067	7 245	Steel, concrete, simple glaze	Approx. 1970	24.3	29.2
Gymnasium	7 408	1 133	1 705	Steel, concrete, simple and double glaze	Unknown	7.85	8.98
Industrial hangar	4 083	614	1 218	Steel	2007	4.47	7.87
Industrial hangar	3 430	560	1 088	Steel	2008	4.64	7.64

Main leaks were observed at pipe passages, rooflights, window and door jambs especially at emergency exits and damage due to aging on walls and ceilings. Less leaky spots were often found at connections between walls and ceilings.

Table 2: Specifications of new tested buildings and airtightness results

Type of building	**Volume (m^3)**	**Floor surface (m^2)**	**Cold surface except ground floor (m^2)**	**Main building materials**	**Year of construc-tion**	**Airtightness Q_{4Pa_surf} ($m^3/h/m^2$)**	**Airtightness n_{50} (h^{-1})**
Industrial hangar	53 000	3 774	7 331	Steel	2012	2.23	0.93
Industrial hangar	53 000	3 774	7 331	Steel	2012	2.51	0.91
Industrial hangar with offices	6 982	1 548	2 417	Steel	2010	0.18	0.28

Main leaks were observed on badly joint cladding pieces and window and door jambs.

4 CONCLUSIONS

In this article, 8 commercial building were presented. 3 of them were new buildings while 5 were existing buildings. The main building material was steel.

It was observed that airtightness was poor for the measured existing buildings, as only one of them was in accordance with French thermal regulation default value for this type of buildings: $Q_{4Pa\_surf} = 3\ m^3/h/m^2$. The other ones were 1.5 to 8 times higher than this default value.

In parallel, it is encouraging to see that today's new buildings, even with a very large volume, can be built with a good airtightness level. Indeed, all of the measured new buildings were lower than French thermal regulation default value.

Observations made on recurring leakage points in this study are very helpful to set recommendations for professionals on new construction and retrofitting procedures, which is a growing issue to reduce global energy consumption and CO_2 production.

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