Box window double-skin façade. Experimental model in Brasov, Romania

GABRIEL NASTASE[a], ROBERT GAVRILIUC[b], ALEXANDRU SERBAN[a]
Building Services Department [a], Faculty of Building Services and Equipment [b]
Transylvania University of Brasov [a], Technical University of Civil Engineering [b]
Turnului Street, No. 5, Brasov [a], Pache Protopopescu Street, No. 66, Sector 2, Bucharest [b]
ROMANIA
traznasa@gmail.com http://www.unitbv.ro

Abstract: - This article describes the experimental model of a box window double-skin façade (DSF) developed in situ, on the ground floor of the Building Faculty in Brasov, part of Transylvania University from Brasov, on the south façade of the building. This model will serve as a basis for all the measurements to be made with the goal of modeling and then validate processes within the system and ultimately determine the impact of such façade on a building placed in Brasov, Romania. The experimental model is part of a PhD thesis and consists of a so called "box window" type double-skin façade, indoor air curtain, automatically controlled, forced air circulation in summer and venetian blinds shading system, placed inside the cavity, in the median area.

Key-Words: - glazed double-skin façade, box window, office building, energy, heat transfer, ventilation

1 Introduction

Energy efficiency in office buildings is the general framework in this paper and glass double-skin façade is a passive solar system, which is so to say, in a way, the successor to early ventilated facades, a good comparison example being Trombe wall system. The major difference between the two systems is that the massive wall from Trombe wall is replaced with a modern window that has good thermotechnical features. This cancels taking an extra space for access to natural light, as in the case of Trombe wall, allowing double glass facades to be used as an overall system, both with facade architectural role and the role of passive solar system plus all others benefits it brings which will be detailed in the next parts of this paper.

2 Experimental model

This experimental model is part of a doctoral dissertation in progress, where the doctoral student is Gabriel Nastase and the teacher is Professor Robert Gavriliuc, from Building Services Faculty, part of Technical University of Civil Engineering from Bucharest. The study was selected to illustrate the potential benefits of double-skin façade carefully combined with mechanical and natural ventilation technology and investigation of thermal performance of such system in order to reduce energy consumption in office buildings by exploiting solar contributions.

To realize the experimental model were collected a series of constructive/conceptual data, by viewing and evaluating several double-skin facades in few European Union countries.

It is vital to better understand the behavior of this system, which is complex, with different configurations, from several points of view. It further show a summary of the most important characteristics of the double-skin facades viewed on the spot by the first author, after several visits in Europe.

Thus, according to origin of the air flow in the intermediate space, most buildings have two-way airflow (6 of 16 buildings), or inside air curtain (3 of 16 buildings).

According to how air is circulated through the cavity, most visited buildings have mechanical ventilation (7 of 16 buildings) and the number of buildings with natural ventilation equals the number of buildings with hybrid ventilation (4 of 16 buildings for each type). This classification criterion is much influenced by the HVAC system installed inside the building and by the exterior climatic conditions, were the double-skin façade is installed.

Was not seen in any documentary visit a "trunk" double-skin façade, if we referrer to the system classification based on how the cavity is divided along the façade and most buildings have this system as a continuous façade (11 of 16 buildings), on the second and the third place are box window double-skin facades, with 3 of 16 buildings viewed and “corridor” double-skin facades with 2 of 16 buildings viewed.

The multitude of office buildings built with double-skin façade across Europe is a good example in respect with goals of use at maximum free resources, use of renewable energy and performant materials or systems, even if is still too little experience of their behavior globally and more so in Romania.

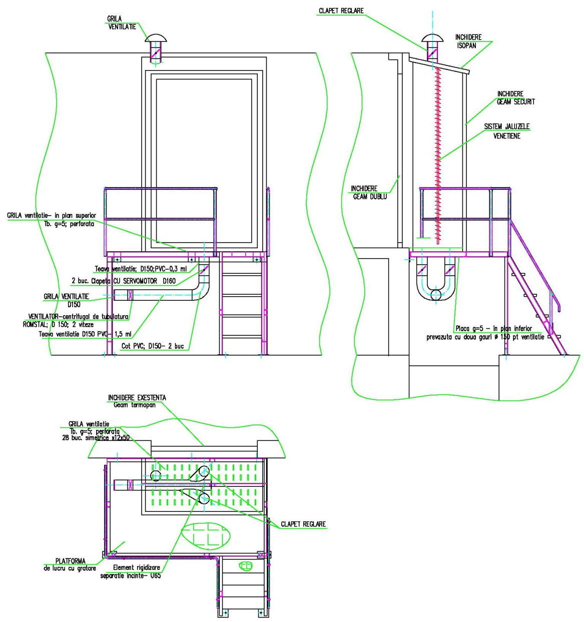

Fig. 1. Box window ventilated double-skin façade execution sketch for experimental model

The main advantage and what differentiates it from other models present in the technical literature is that the model is set on a real building, and the measurements can be made in real weather conditions, the key climatic factors cannot be controlled or can be controlled in slightly.

The model consist of a simple secure glass on the outside and a double pane insulated glass for the inside. Box window double-skin façade and experimental room dimensions are presented in table 1:

Table 1. Façade and experimental room dimensions

Area	Length	Width	Height
DSF	1500	1000	2500
Experimental room	3600	2000	3000

Because of the greenhouse effect inside the cavity mechanical ventilation was required in order to extract the solar heat and evaluate this hot air flow that can be used for other purposes. The mechanical ventilation is provided by a duct fan VENTS TT150, common to the two input fresh air circuits, in the cavity, one in front of the shading system and the other behind it, as can be seen in Figures 1 and 2.

Fig. 2. Exterior view of the experimental model

Air flow provided by duct fan DN150 inside cavity can have de minimum value of 595 m^3/h and maximum value of 680 m^3/h.

For controlling the natural light and solar contributions in the experimental room, exterior motorized venetian blinds with 80 mm sturdy roll formed slats with beaded edges are used inside the cavity. The slats of this system is made of special aluminum alloy UV and weather resistant. The system is electrically operated with electric motor (220/240 V, 50 Hz) enclosed within the head rail. The motor is thermally protected against overheating and splash proof (IP54). In this moment this shading system is controlled by a four channel radio remote control with scroll wheel, but as soon as full automated central data acquisition system will be installed the system will be operated by

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various controls, including solar sensors, anemometers, time switches and relays.

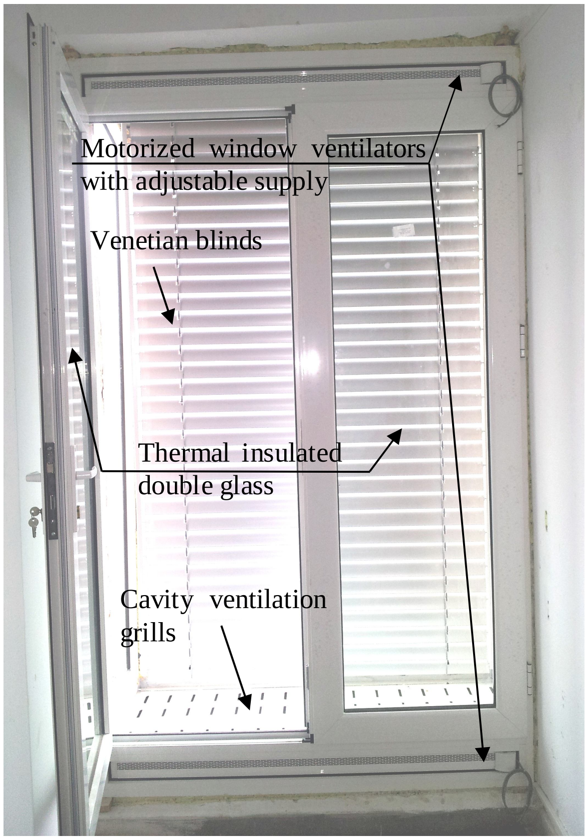

Fig. 3. Interior view of the experimental model

Inside glass is a double glass type window with thermal break aluminium joinery and two motorized window ventilators type THM90 with adjustable flow. In this moment the two ventilators are not electrically connected, but they are in full opened position. The THM90 is a thermally broken, non-self-regulating window vent for installation on 20, 24, 28 and 33 mm glazing thickness. In this experiment the inner glazing thickness is 24 mm and so is the THM90.

The closing flap is attached to the external profile: made of hard PVC, with 5 settings (open, closed and 3 intermediate positions) and a hollow design that admits the maximum amount of air when the flap is open.

Inside this closing flap, there is a pivoting flap that guarantees water tightness up to 20 Pa in open position. In closed position, the flap presses against a double EPDM lip seal. The more pressure on the flap, the tighter the seal, the better the water- and wind tightness

The extruded aluminium external profile is completely flush, this makes the THM90 perfect for installation in sliding doors. The external profiles exists of 1 profile with a 14.5 x 37 mm punching to guarantee the airflow.

Two PVC-profiles act as a thermal bridge and are clipped into the aluminium profiles, after these have been powder coated or anodised.

Two plastic end caps cover the ends of the profiles. These have connecting and water-excluding ribs to form a perfect seal between profiles, glass and window frames. Each end cap has a special foam to make the joint between the glass and the ventilator airtight. A glazing gasket is recommended to guarantee a perfect fit. The end caps also contain the control of the vent: on the left and on the right, indicating open (blue) or closed position (red).

A series of 2,7 x 18,5 mm perforations on the internal profile serve as an insect screen.

All system described above are controlled from a central control panel, respectively the shading system is controlled by a four channel radio remote control with scroll wheel. The two control units can be seen in Figure 4.

Fig. 4. Central control panel (left) and shading system remote control (right)

3 Some measurements

Besides the double-skin ventilated façade main systems, to make some measurements before installing the complex data acquisition system was purchased a professional wireless weather station Auriol type Z31055A-RX with radio sensor type Z31055A-TX. The weather station consists of a central unit for interior and a wireless temperature sensor to be placed outside. In this experiment the wireless temperature sensor was placed inside the cavity and the weather station inside experimental room.

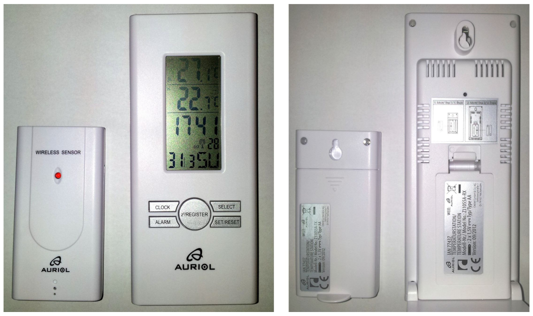

Fig. 5. Front and back view of wireless weather station Auriol type Z31055A-RX with radio sensor

Besides this, to measure exterior temperature, relative humidity and air velocity was used a multi-channel precision thermometer TM200. The TM 200 is a multi-channel instrument, compatible with Pt100 temperature probes, equipped with SMART PRO system, and with all thermocouple K temperature probes.

Fig. 6. Multi-channel precision thermometer TM200

Taking into account all described above two sets of measurements were made on the experimental model, in two separate days, one with overcast sky and the other with sunny clear sky. Both sets of measurements were carried out at approximate times, the first set, for overcast sky from 14:00 to 15:00 PM and the second set, for clear sunny sky starting from 14:30 up to 15:30 PM.

The two sets of measurements include air temperature in experimental room, air temperature in cavity, exterior temperature and relative humidity, an average value for relative humidity in experimental room and an average air velocity inside double-skin façade cavity.

In the first set of measurements, with overcast sky the average exterior relative humidity was 40,3 %, the average interior relative humidity was 27,1%, and the average air velocity in the cavity, with the back dumper open was 0,6 m/s. Temperature trends after starting the fan are shown in figure 7.

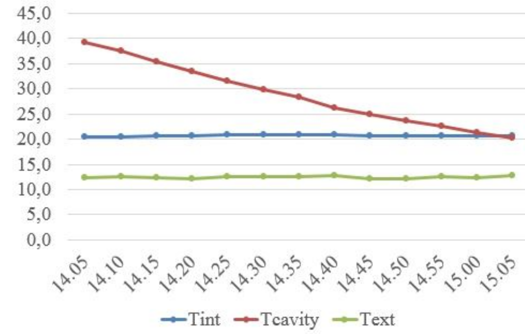

Fig. 7. Interior, cavity and exterior temperature as a function of time, in an overcast sky day

In the second set of measurements, with clear sunny sky the average exterior relative humidity was 34,6%, the average interior relative humidity was 33,4%, and the average air velocity in the cavity, with both front and back dumpers open was 1,7 m/s. Temperature trends after starting the fan are shown in figure 8.

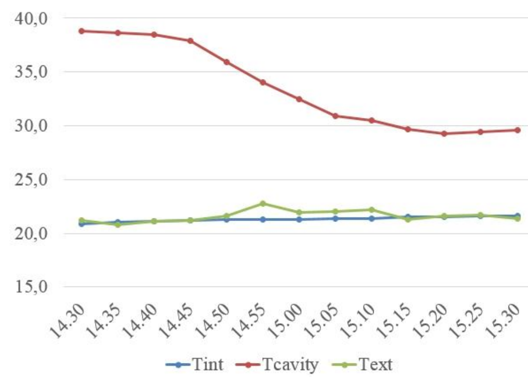

Fig. 8. Interior, cavity and exterior temperature as a function of time, in a clear sky sunny day

4 Conclusion

Since the concept of double-skin facade is complicated, and the use and operation of such a system affects internal parameters of the building (which often interact with each other, such as energy use, natural ventilation, lighting, indoor air quality, acoustics, environmental, visual and thermal comfort, etc.) the authors plan to study it from various views.

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