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Are energy consumptions decreased with the addition of a double-skin?

Elisabeth Gratia *, André De Herde

Université Catholique de Louvain, Architecture et Climat, Place du Levant 1, B-1348 Louvain-La-Neuve, Belgium

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Abstract

A recent architectural current, mainly carried by a desire of building transparency proposed completely glazed facades, released from their function bearing and reduced to the role of envelope. In this case, the only manner of limiting to the maximum the losses in an entirely glazed building is either to build an entirely glazed additional skin, or to use the most efficient possible glazing.

The argument justifying the overcost of an additional facade is very often that of the energy effectiveness of the double-skin facade and the improvement of the interior environment. However, this argument must be taken with many precautions. The efficiency of the double-skin depends indeed on many factors such as the type and the use of the building, the orientation, the level of insulation, the proportion of opaque and glazed surfaces of the inside skin, the operating mode of the double-skin, the type and the position of the shading devices, the quality and the dimension of double-skin openings towards outside and inside the building, the strategy of control of the equipment integrated into the facade, such as the opening of the windows or the use of the shading devices . . .

This study compares consumption of heating and of cooling in a building with or without double-skin when the heating and cooling natural strategies are or are not used, according to the level of insulation and the orientation of the double-skin.

Keywords: Double-skin facade; Thermal modelling; Office building; Natural ventilation; Shading devices; Cooling strategies

1. Introduction

The double-skin facade is an architectural phenomenon driven by an aesthetic desire for an all-glass facade.

Transparency is often seen as the main architectural reason for a double-skin facade, because it allows close contact with the surroundings. From the client's point of view, physical transparency may appear to indicate a transparent organisation with a large degree of openness [1].

This ‘‘emerging technology’’ of heavily glazed facades is also often associated with buildings whose design goals include energy efficiency, sustainability, and a ‘‘green’’ image.

So there has been an increase in the numbers of this type of building. The success of these facades also lies in the fact that they admit a large amount of daylight, exhibit a uniform exterior, and have attractive aesthetics.

The costs of double-skin facades are higher than those of normal facades, but claims of energy and productivity savings are used to justify some of these increased costs [2]. However, this argument must be taken with many precautions. The efficiency of the double-skin depends indeed on many factors.

The advent of computers and other electric office equipment has increased the internal heat gain in most offices. Highly glazed facades, often with poor shading, have become very common. This, together with the extra heat gain from the electric lighting made necessary by deep floor plans, and the widespread use of false ceilings, has increased the risk of overheating [3,4].

In the 1990s, concern about global warming resulted in a resurgence of interest in natural cooling strategies, including natural day and night ventilation and solar protections use [5–7].

There is also an increasing demand for high-quality office buildings. The occupants and developers of office buildings require healthy and stimulating working environments [8]. This is usually provided by an air conditioning system. But in many

* Corresponding author. Tel.: +32 10 47 22 23; fax: +32 10 47 21 50.
E-mail addresses: elisabeth.gratia@uclouvain.be (E. Gratia), deherde@arch.ucl.ac.be (A. De Herde).

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cases, with some effort to reduce internal heat gain (well chosen equipment), solar protection and natural ventilation may be sufficient to ensure good comfort levels for the buildings' occupants.

In that case, air conditioning system will not be necessary, which will result in considerable energy and cost savings. It will also indirectly reduce the burden on the environment, since the use of energy is always associated with the production of waste materials [9].

Double-skin facades are assuming an ever-greater importance in modern building practice. They are already a common feature in architectural competitions in Europe; but there are still relatively few buildings in which they have actually been used, and there is too little information on their behaviour in operation [10,11].

There are many unknowns: optical and thermal modelling of these systems is not routine and coupling heat transfer and air flows from an isolated facade system to the whole building is complex. A variety of thermal coupling strategies must be simulated [12–15].

Moreover, although subjective claims abound in the architectural literature, it is extremely difficult to find any objective data on the actual performance of buildings with double-skin facades.

Results of simulations show that heating loads are decreased in an office building with a double-skin facade. Indeed, the temperature of the air layer in the double-skin is more important than the outside temperature and so the cavity protects the building from the cold. Moreover, double-skin hot air can be recovered to heat the coldest zones of the building [16,17].

On the other hand, results of simulations show that cooling loads are increased in an office building with a double-skin facade. Indeed, the hot air layer becomes an obstacle with the cooling of the building. Application of natural cooling strategies becomes still more important in the building with double-skin than in building without double-skin [18–21].

To undertake the study, we chose an office building with various level of thermal insulation. We compare consumption of heating and of cooling in a building with or without double-skin when the heating and cooling natural strategies are or are not used, according to the level of insulation and the orientation of the double-skin.

Simulations were performed with the thermal program TAS.

2. Method

2.1. TAS program

TAS is a software package for the thermal analysis of buildings. It includes a 3D modeller, a thermal/energy analysis module, a systems/controls simulator and a 2D CFD package. There are also CAD links into the 3D modeller as well as report generation facilities. It is a complete solution for the thermal simulation of a building, and a powerful design tool in the optimisation of a building's environmental, energy and comfort performance [22].

2.2. The building

The simulations where undertaken using the building proposed in Subtask A of Task 27 (Performance of solar facade components) of the International Energy Agency, Solar Heating and Cooling Program. Some modifications were made to adapt this to Belgian practices. This is a medium-sized office building with office modules on two facades separated by a central corridor and staircase/service spaces at both ends of the building. It comprises 150 offices, distributed over 5 floors and 2 orientations: 15 offices on either side of the building per floor. Fig. 1 presents the geometrical data for the office building.

A vertical cross section of an office with its main measurements is shown in Fig. 2.

The internal wall between the office module and corridor has an openable window above the door to facilitate the air flow between northern and southern spaces (the false floor is not included in the drawing).

Each office has four windows (two top and two bottom) to allow natural day or night ventilation.

Each floor is divided into 5 zones; the building thus comprises 25 zones plus the double-skin space.

Orientation of the building:

We studied the building

- with a NORTH-SOUTH orientation
- with an EAST-WEST orientation.

Thermal characteristics:

Three levels of insulation were studied:

- a well-insulated building;
- a moderately insulated building;
- a not insulated building (building to renovate).

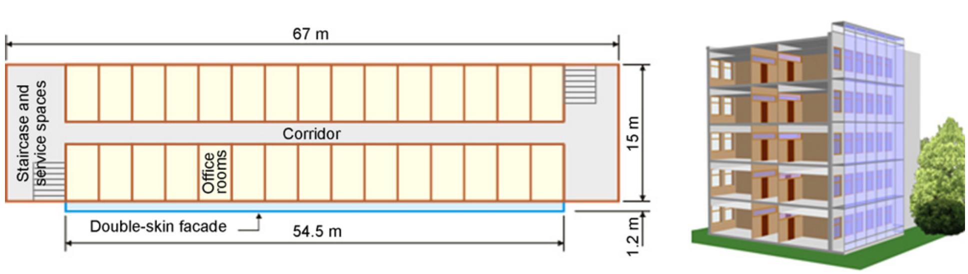

Fig. 1. View of the office building studied.