

HEADQUARTERS OF THE *COMISIÓN NACIONAL DEL MERCADO DE VALORES*. DOUBLE FAÇADE SIMULATION STUDY

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ABSTRACT

Nowadays, the use of translucent or transparent façades as lining of another façade is increasing. This is done with the purpose of creating a ventilated air chamber façade, or renovating the building appearance without giving up the vision of their original aspect or with the objective of incorporating sustainable approaches and bio-climatic improvements to the building.

This is the case of the Headquarters of the National Securities Market Commission, a very representative administrative building located in the centre of Madrid whose redevelopment will be carried out by the architecture office FERNANDEZ DEL CASTILLO ARQ, SL. The most significant and differentiating aspect in this redevelopment consists on the application of a ventilated double skin façade (VDSF) in the central atrium of the building in order to offer a more modern design and to help the entrance of daylight in the interior spaces.

In order to reduce the quantity of energy consumption in the building air conditioning system and to increase the interior thermal comfort it has been necessary to study and to optimize the design of the double ventilated façade, using for that the most innovative software simulation tools.

KEYWORDS

Building Simulation, Double Skin Façade, Glazing/Radiation analysis, Ventilation strategy.

INTRODUCTION

Reasons for the increasingly common use of translucent or clear facades to clad a building's existing surface include building a vented cavity façade, updating without sacrificing the original appearance, and incorporating sustainable criteria and bioclimatic improvements.

This is the case with the Headquarters of the Spanish Securities and Investment Board (*Comisión Nacional del Mercado de Valores*), a highly representative

administrative building located at Paseo de la Castellana 19, Madrid. With a surface area of 6,800 m², it is due to be rehabilitated by the architecture firm FERNANDEZ DEL CASTILLO ARQUITECTOS, SL.



Fig. 1. Proposal for rehabilitation of the Headquarters of the *Comisión Nacional del Mercado de Valores* (Madrid)

The most significant and differentiating aspect of the rehabilitation consists of the application of a double ventilated façade (DVF) to the building's central atrium to give it a more modern image and bring more natural light into interior offices.

The innovative façade system proposed has a double skin: an outer glass skin, an inner glass skin and a ventilated air cavity, a combined construction known as a Multistorey Façade (a type of double ventilated façade). This kind of façade gives the building a second skin, so providing greater protection from the elements. In spite of having openings in the outer skin for air input and output, it can still offer improved acoustic comfort within the building by maintaining excellent levels of acoustic insulation. In our increasingly dense cities, with rising levels of sound pollution, this is of growing importance.

Another of the main benefits of this innovative façade is energy-saving in the building's air

conditioning. The DVF acts as a screen against solar radiation in summer and sometimes as a thermal insulation layer in winter. The DVF also decreases the effects of cold or hot walls, so improving thermal comfort near the façade.

To optimise the design of the building's double ventilated façade, reducing the amount of energy used in its air conditioning and raising thermal comfort inside, a study was conducted of its thermal and energetic behaviour using the most innovative computer simulation tools.

These tools enabled energy exchange flows in the ventilated façade to be calculated, taking into account both vertical and horizontal thermal flows and the thermal conditions of both the indoor area and the air cavity. Results can be obtained by stationary methods or transient methods over a period of time.

With these IT tools, suitable data were obtained about enclosures and strategies of natural ventilation to validate the different DVF concepts, in order to assist in the proper design of the interior space installations in terms of thermal design and optimisation of resources.

SIMULATION

Simulation by TAS software

The simulation tool used, EDSL's TAS (Thermal Analysis Software), analysed the building's seasonal thermal behaviour, permitting its architectural and constructive design to be optimised.

The TAS software works solving the dynamic fluid equations at the studied building zones using hourly conditions during a whole year according to geographical location. The equations together describe mass transfer and thermal transmission on each of its process – conduction, convection and radiation. The software also takes into account internal loads like equipments (computers, printers, etc), artificial illumination and users of the building. It also considers infiltration through openings, ventilation and air exchange between zones

The building

Before embarking on the thermal and energetic analysis, the aims of the study had to be defined and the building described and modelled. In the case of the *Comisión Nacional del Mercado de Valores* headquarters, the study was intended as a thermal behaviour analysis of the building's central atrium and access corridors through consideration of the temperatures reached depending on types of glass used for the DVF.

A further objective of the study was to analyse the effect of these temperatures on the climatized office areas in direct contact with the central atrium, through examining their yearly cooling and heating energy demand.



Fig. 2. Interior view of the Central Atrium and offices from the open corridor on the top floor.
Source: Fernández del Castillo Arquitectos, SL.



Fig. 3. Interior view of the Central Atrium from the ground floor area of occupation.

Source: Fernández del Castillo Arquitectos, SL

Once the study's aims and strategy had been defined, the next step was for the simulation tool to construct

a 3D model of the building based on the architectures and design provided by the architects.

After the model had been constructed, the different areas of study had to be defined.

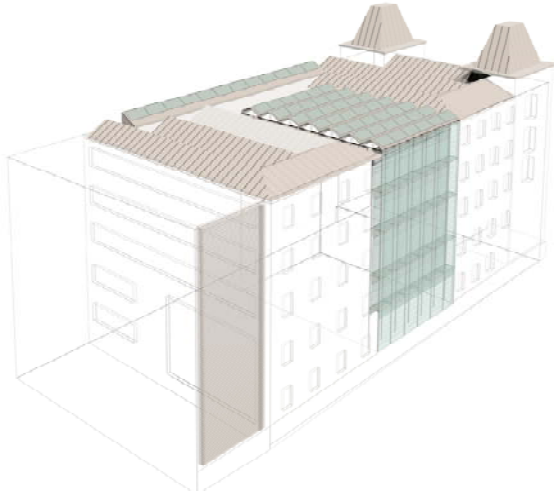


Fig. 3. Model provided by Fernandez del Castillo ArquitectosSL

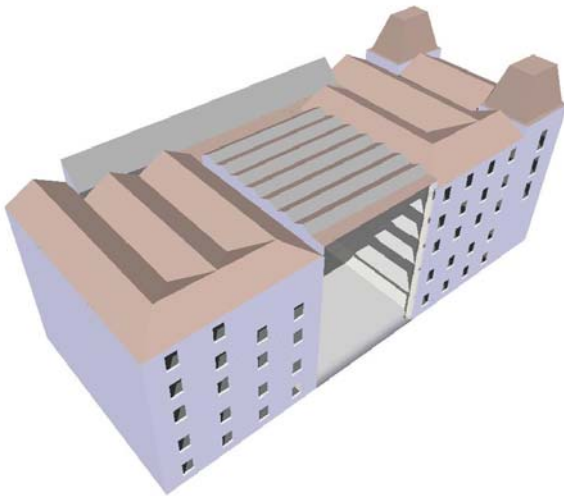


Fig. 4. Model created using TAS

Every floor of the modelled building was zoned according to occupation, functionality and applied thermal treatment:

- Central atrium enclosed by the DVF.
- Air conditioned offices in direct contact with the atrium.
- Open corridors.
- Interior area of the DVF.

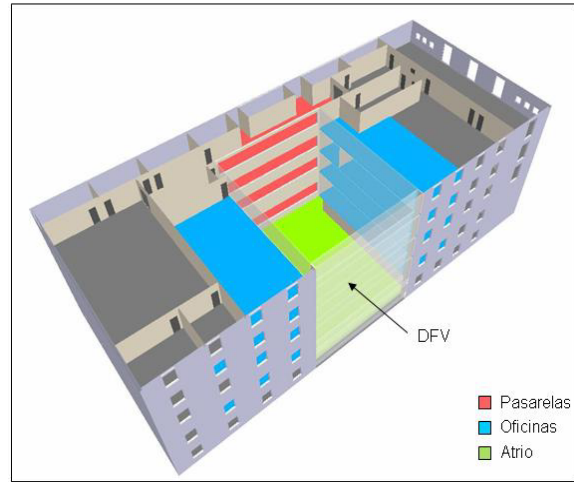


Fig. 5. Model zoning

Internal loads were applied to each area of study for occupation, lighting and electrical appliances, as well as some specific environmental conditions.

Glazing and radiation analysis

During the first stage of the simulation, the thermal behaviour of the areas studied was analysed for the different types of glass to be used for the DVF, to select the optimum composition of the DVF under thermal-comfort and energy-saving criteria.

Double façades are based on the ‘multi-layer’ principle: they consist of an outer glass skin, an inner glass skin and a ventilated air cavity. The outer skin serves basically as a shelter against the elements, to acoustically insulate against external noise, and as the first barrier protecting the building against the impact of solar radiation. Initially, the use of solar control glass in this outer layer of the DVF seemed advisable. The inner skin is intended to provide thermal insulation of the building’s indoor environment from the air cavity or inter-skin space, and the use of low thermal emission glass might be seen as beneficial.

The types of glass analysed for constructing the double façade are listed below:

Description	Thickness (mm)	Solar Factor	U (W/m ² C)
Monolithic clear glass	10	0.76	5.60
Double 6-4-6 glass	6-4-6	0.46	1.77
Solar control (20%) glass	6	0.20	5.73
Solar control (40%) glass	6	0.40	5.73

To assess the optimum constitution of the double façade, several thermal simulations were carried out with different combinations of glass:

V0. *Inner skin:* monolithic clear glass. *Outer skin:* monolithic clear glass

V1. *Inner skin:* double (6-4-6) low-emission glass. *Outer skin:* monolithic clear glass

V2. *Inner skin:* double (6-4-6) low-emission glass. *Outer skin:* solar factor 20 % glass

V3. *Inner skin:* double (6-4-6) low-emission glass. *Outer skin:* solar factor 40 % glass

V4. *Inner skin:* monolithic clear glass. *Outer skin:* solar factor 40 % glass

For each area of study, operative temperatures reached during the two most thermally critical days of the year - the warmest and the coldest day - were analysed.

The operative temperature is one of several parameters devised to measure the air's cooling effect upon a human body. Is the medium between the mean radiant temperature and the mean air temperature.

It could then be observed that operative temperatures reached in the central atrium and corridor areas were very high during summer and intermediate months but could be drastically reduced by the use of solar control glass on the outer face of the DVF. As a result, the use of a laminated glass with maximum solar factor of 40% was advised for the DVF's outer skin.

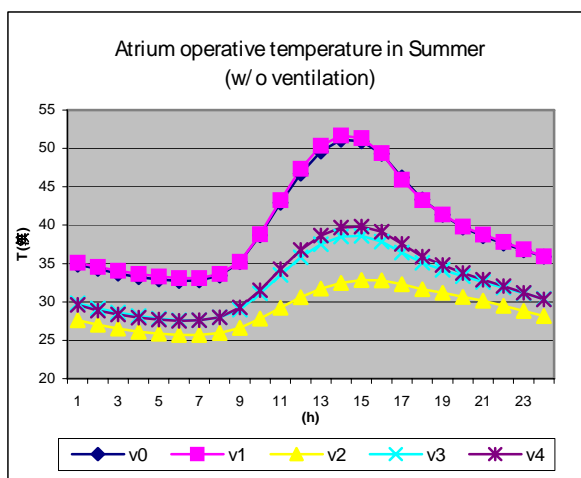


Fig. 6. Temperatures reached in the central atrium in summer for different types of glass

One alternative to a reflecting or solar-factor 40% absorbing glass could be a silk-screen glass. It would also be possible to stop solar radiation by fitting photovoltaic solar panels over the DVF's outer skin, or installing blinds or a solar protection device inside the air cavity, allowing the solar factor, light transmission, surface temperature and thermal transfer coefficient to be substantially varied at will.

It was also confirmed that laminated colourless glass was perfectly suitable for use in the DVF's inner skin, since other types of glass with higher thermal and light performance, such as solar control glass or low-emission glass, achieved no significant thermal variation.

Ventilation strategy analysis

The second stage of the analysis involved trying to reduce temperatures reached in the DVF and consequently in adjoining areas (atrium and corridors) in summer and intermediate months. A second simulation study was made to analyse different ventilation strategies for the central atrium area and the double ventilated façade.

Ventilated air cavities allow both the storage and extraction of heat by acting on air inputs and outputs. Ventilating the air in the cavity reduces the amount of thermal energy reaching the building's interior. This system is very versatile since it allows for different types of ventilation to improve its performance at different times of year.

In this case, it was proposed to ventilate the DVF in summer and intermediate periods by the natural convection produced by the 'chimney effect' caused by the heating of the air in the cavity, so expelling part of the energy absorbed by the outer skin.

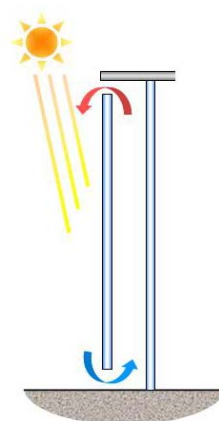


Fig. 7. Diagram of summer functioning Ventilation of Double Façade

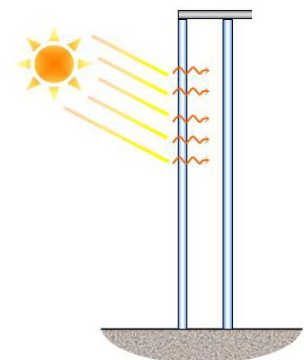


Fig. 8. Diagram of winter functioning Double Façade with thermal insulation

The chimney effect consists of an air current created within the cavity by pressure variations caused by increases in air temperature, which lower air density and make it tend to rise. The resulting rising force creates air input at the bottom and air output at the top. That is, colder air enters through the lower apertures in the double façade when there is enough suction force, and an equivalent amount of hotter air escapes from the upper apertures.

In this case, it is proposed to create an air current through the double ventilated façade by means of two 0.4 metre-high apertures right along its outer skin: an input aperture at the bottom, and an output aperture at the top.

To further reduce temperatures reached in the atrium and corridor areas during hotter months, it is proposed to also ventilate the central atrium through the aperture in the folding photovoltaic cover on the roof.

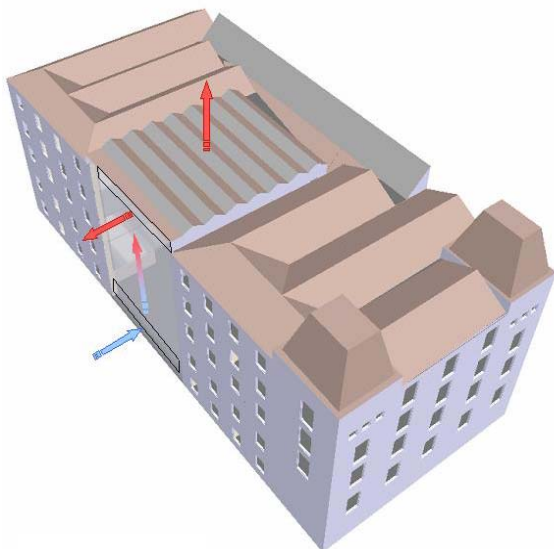


Fig. 9. Ventilation strategies for the DVF and central atrium

After simulations of different ventilation strategies, it was concluded that in the atrium area, the use of natural ventilation in the double façade and on the roof could significantly reduce temperatures reached in the warmer months, while in winter minimum temperatures would always be above 14 °C even without the use of air conditioning.

CONCLUSIONS

To sum up, the skin of any building is an energy interface. It can absorb or repel solar energy, conserve or dissipate energy from its air conditioning

system, help or hinder correct natural ventilation, all factors that influence the building's energy needs.

The design of its solar protection, the positioning of insulation, exploitation of its façades as heat collectors or accumulators, use of selective enclosures or enclosures fitted with solar filters and cooling mechanisms for natural ventilation of double facades, all help to reduce the building's global energy needs.

The great range of designs and functions that IT simulation tools can provide makes them extremely helpful when analysing the different options for conceptualising DVFs or other singular constructive elements.

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