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INTELLIGENT SYSTEMS IN ARCHITECTURE FAÇADE SYSTEMS

BY

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Abstract. Façade systems, and particularly glazing, most an intractable problem for designers. The façade is always bi-directional in that energy transfers in both directions simultaneously. Heat may be conducting to the outside while radiating to the interior, and light entering the building must be balanced with the view to the exterior. Intelligent application of advanced 'smart' façade technology in conjunction with innovative environmental systems can result in significant energy savings and, at the same time, improvement of indoor comfort.

Key words: façade; intelligent system; façade system.

1. Introduction

Façade systems, and particularly glazing, most an intractable problem for designers. The façade is always bi-directional because transfers energy in both directions simultaneously. Heat may be conducting to the outside while radiating to the interior, and light entering the building must be balanced with the view to the exterior. The problem of glazing did not emerge until the twentieth century, as it required the development of mechanical HVAC (Heating, Ventilation, and Air conditioning) systems to enable the use of lighter

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weight and transparent façades. At first, the façade systems, albeit lightweight and with an unprecedented amount of glazing, were more opaque than transparent.

Constant volume HVAC systems coupled with perimeter systems were more than adequate for mitigating the highly variable thermal loads of the façade, and simple shading devices were used to manage glare. The advent of the energy crisis in the 1970s marked the phasing out of the energy intensive HVAC systems and their replacement with Variable Air Volume systems (Addington, 2004). The energy penalty was removed, but at a cost to the thermal stability of the façade which began to loom as a problematic element in the building. Paradoxically, the demise of the CAV (Constant Air Volume) system was coupled with a rise in the percentage of glazing on the exterior, further exacerbating the thermal and optical swings of the façade. Compensatory mechanisms and approaches were developed and experimented with, and a host of new technologies were incorporated into the façade or enclosure systems. Glazing was coated with thin films, including low-emissivity, solar reflective, and non-reflective (on the interior faces). Automated louvers were installed in conjunction with energy management control systems to reject excess solar radiation, and elaborate double skin systems, which wrap the building twice in glazing, were encouraged for the dampening of the thermal swings. As a result, no other group in the architecture field has embraced smart materials as whole heartedly as have the designers and engineers responsible for façade and enclosure systems.

2. Function of Intelligent Façade System

Intelligent façade system is carried out many benefits in a building. There are many functions of intelligent façade system for a building such as enhancement of natural light, protection from glare, sound and noise insulation, provision of inside and outside view, enhacement of ventilation, heat or cold collection, protection from pollution, safety protection, protection from rain, solar gain, and solar protection.

2.1. Water Tightness

Façade should be tight in many ways. Rain and wind must not penetrate the façade from the outside, and moisture must not penetrate into the façade from the inside.

2.2. Fire

A façade should be generally made from non-combustible materials. Any smoke shutters/windows should be dimensioned according to the needs.

2.3. Ventilation

From confort ventilation, evacuation, or smoke ventilation inward or outward opening windows may be chosen, wich suit the function and the apparence of the façade in the best way. The numbers of windows in the façade is dimensioned according to the individual functions.

2.4. Sound Insulation

A façade should be dimensioned and designed with regard to existing noise sources and in a way wich limits the occurrence and propagation of disturbing noise. The factors which determine the overall sound insulation of a building from the environment, include the construction of the façade, the sound insulation properties of the windows, and the fitting and sealing of the window in the façade.

2.5. Sunshine Protection

High inside temperature, unwanted heat radiation from the sun, and the dazzling risk can be prevented/reduced if some form of sunshine protection is used. This can be, in principle, arranged on the outside of the façade, in the glass, or on the inside of the façade. The most convenient solution is to provide sunshine protection in the glass. If sunshine protection is required, it should be designed in connection with the façade.

2.6. Enhacement of Natural Lighting

Current knowledge for the office design should optimize natural lighting. One of the reasons is lighting always the largest single item of energy cost, particularly in open plan office. Another reason is that most of the occupants prefer natural light, especially since some of the artificial lighting have been implicated as the source of health problem.

3. Various Design of Façade System

3.1. Solar Shading

Solar Shading (Fig. 1) and Sun Screening systems are an integral part of the 21st century trend to design eco-friendly, habitable buildings for work or leisure. Modern sun shading systems are intelligently controlled and offer tremendous energy savings.

Correctly installed, these systems can reduce the energy required for heating. The usage of lighting and air-conditioning can be reduced by up to 40%.

Fig. 1 – Skyscraper with a solar shading system to prevent unnecessary heat gain.

The sun rises in the East and sets in the West. The sun travels in an arc, reaching its highest altitude in the South (for the Northern hemisphere).

An important requirement of the design process is to ensure the building is shaded from the sun for as many hours as possible throughout the whole day, during the course of the entire year. However a balance must be achieved in order to ensure that the level of natural light entering the building is not unacceptably reduced.

Controllable fins, unlike fixed, can hang vertically in front of a window and still optimize solar shading and visibility thanks to specially written computer software which controls the louvers to follow the path of the sun.

Fig. 2 – Extruded Aluminum Louver System.

Controllable solar shading systems (Fig. 2) enable the building to react to the changes in the weather and to the sun's position so as to optimize the flows of heat and light energy through the façade. This in turn may have a positive effect on reducing the heat load and glare, and enhancing the use of natural daylight, thereby reducing the operating costs of the building.

3.2. Double Skin Façade System

The Double Skin Façade (Fig. 3) is a system consisting of two skins placed in such a way that air flows in the intermediate cavity. The ventilation of the cavity can be natural, fan supported or mechanical. Apart from the type of the ventilation inside the cavity, the origin and destination of the air can differ depending mostly on climatic conditions, the use, the location, the occupational hours of the building and the HVAC strategy. The glass skins can be single or double glazing units with a distance from 20 cm up to 2 m. Often, for protection and heat extraction reasons during the cooling period, solar shading devices are placed inside the cavity.

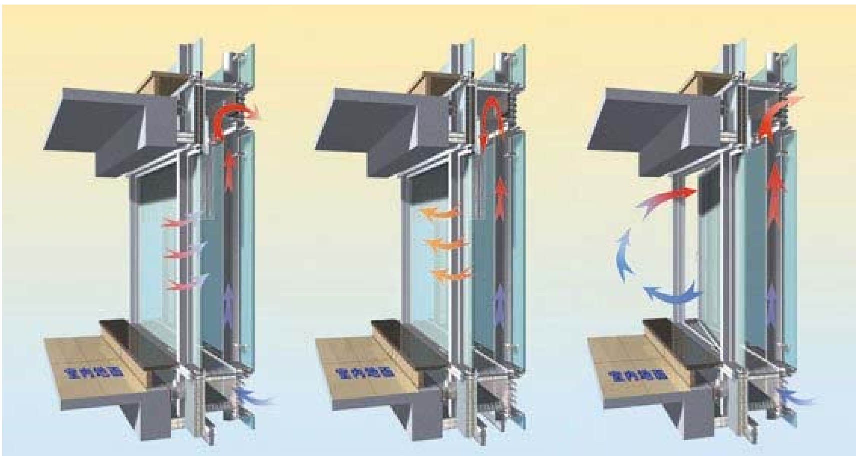

Fig. 3 – Double skin façade system.

The cavity between the two skins may be either naturally or mechanically ventilated. In cool climates the solar gain within the cavity may be circulated to the occupied space to offset heating requirements, while in hot climates the cavity may be vented out of the building to mitigate solar gain and decrease the cooling load. In each case the assumption is that a higher insulative value may be achieved by using this glazing configuration over a conventional glazing configuration. Recent studies showed that the energy performance of a building connected to a double-skin façade can be improved both in the cold and the warm season or in cold and warm climates by optimizing the ventilation strategy of the façade (Mingotti *et al*., 2010).

The advantages of double skin façades over conventional single skin facades is not clear-cut; similar insulative values may be obtained using conventional high performance, low-e windows. The cavity results in a decrease in usable floor space, and depending on the strategy for ventilating the cavity it may have problems with condensation, becoming soiled or introducing outside noise. The construction of a second skin may also present a significant increase in materials and design costs.

Building energy modeling of double skin façades is inherently more difficult because of varying heat transfer properties within the cavity, making the modeling of energy performance and the prediction of savings debatable.

3.3. Electrochromic Glazing

Electrochromic windows (Fig. 4) can block the glare of the sun with the flip of a switch. Electrochromic windows are part of a new generation of technologies called *switchable glazing*, or *smart* windows. Switchable glazing can change the light transmittance, transparency, or shading of windows in response to an environmental signal such as sunlight, temperature or an electrical control. Electrochromic windows change from transparent to tinted by

Fig. 4 – Electrochromic windows.

applying an electrical current. Potential uses for electrochromic technology include daylighting control, glare control, solar heat control, and fading protection in windows and skylights. By automatic controlling the amount of light and solar energy that can pass through the window, electrochromic windows can help save energy in residences.

3.4. Responsive Artificial Lightning

Daylight is regarded to be a very promising option when talking about the use of solar energy. On the one hand there is no need to store it because it is used when it is available and on the other hand light is very tolerant against losses because of the logarithmic sensitivity of the eye. A loss of 50% which would be prohibitive for solar energy conversion is hardly noticeable to the eye (Goetzberger, 1996).

There are many systems who promise to use daylight in an optimized way, but up to now only few measures have been established to assess either the possible energy savings or the visual performance of a given system.

More daylight in interior spaces only leads to electrical energy savings if the artificial lighting is switched or dimmed according to the amount of daylight penetrating the room. In the main there are two different ways of controlling the artificial light: feedback control (closed loop) and feedforward control (open loop). For a feedback control the sensor must not receive direct daylight and for a feedforward control the sensor must not receive artificial light (Rubinstein *et al*., 1989; Knoop *et al*., 1996).

Fig. 5 – Ambient light sensor.

The market for daylight responsive artificial lighting control systems can generally be subdivided into one section of simple stand-alone solutions with mostly one sensor per luminaire whose advantages are the low cost and the easy possibility to retrofit. The other section contains all products based on building management systems which are very flexible and offer the chance to create integral solutions for lighting and blind control.

4. Conclusions

New buildings, predominantly domestic housing, only add somewhere between 1% and 5% of the total building stock each year. The development of new façade solutions that can respond to the needs of the occupants of both new and refurbished buildings is, therefore, a key area for development. The facade of a building can account for between 15% and 40% of the total building budget. Furthermore over the life of the façade, maintenance can account for between five and ten times the initial costs of the installation.

In complex buildings the mechanical and electrical services can account for 30…40%, or more, of the total building budget. Intelligent application of advanced 'smart' façade technology in conjunction with innovative environmental systems can result in significant energy savings and – at the same time – improvement of indoor comfort. It has been shown that, when designed carefully, innovative systems do not represent additional initial building costs, running costs are lower and energy costs can be reduced by approximately 30% compared with conventional solutions. Although the performance requirements of a façade have a degree of common function in both the domestic and commercial building application, there are distinct differences. Workplaces such as offices have to provide a glare-free working environment to enable the use of computer screens and, owing to their location, are often subject to higher external noise levels than domestic buildings.

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SISTEME INTELIGENTE ÎN ARHITECTURĂ
Sisteme de faţadă

(Rezumat)

Sistemele de faţadă şi în special ferestrele, reprezintă o problemă greu de rezolvat pentru proiectanţi. Faţada este întotdeauna bi-direcţională, în sensul că transferul de energie se realizează în ambele direcţii simultan. Căldura poate fi condusă la exterior în timp ce radiază în interior, şi cantitatea de lumină care pătrunde în clădire trebuie să fie echilibrată cu vederea spre exterior.

Clădirile de locuit noi, predominant cele familiale, reprezintă undeva între 1% şi 5% din stocul total de construcţii realizate în fiecare an. Faţada unei clădiri poate reprezenta între 15% şi 40% din bugetul total al construcţiei. În plus, pe durata de viaţă a faţadei, costul de întreţinere poate reprezenta între cinci şi zece ori costul iniţial de instalare. Realizarea de soluţii noi pentru faţade, care pot să răspundă nevoilor ocupanţilor de clădiri noi cât şi renovate este, prin urmare, un domeniu cheie pentru dezvoltare.