Innovative Façade Design Strategies

Case studies that highlight the significance of the various aspects of façade design, and convince you that a thoughtfully designed skin is capable of making a building ideal for its occupants as well as the environment.

The building envelope is a critical area of a building’s design. It is one of the most significant exterior elements for building functionality. Façades and building envelopes not only form the outer skin of buildings, but also project image and creative intent.

The façade plays a critical role in the energy performance and interior function of a building. It protects the occupants from wind and rain and the extremes of temperature and humidity. It is also an essential part of the building’s aesthetics, complementing the structural form and outlining its visual impact on the urban environment. As technology continues to improve, different options for improvement become available for incorporation into building facades. These elements are geared toward improvement of the performance of the building envelope.

Let us try and identify effective design strategies, through various case studies, that minimize building energy use while simultaneously enhancing the comfort and well-being of the building’s occupants.

Role of the facade

i) Reduces Energy Consumption: This is achieved by minimizing solar gain through the façade, which, in turn, reduces the cooling loads of the building.

ii) Ensures Natural Ventilation: Protection provided by the external skin, ensures that natural ventilation is achieved by various means like cavity skins and mechanized windows without compromising
occupant comfort during harsh climatic conditions such as wind, rain and snow.

iii) Provides Acoustic Insulation: A well-designed external skin provides a high degree of acoustical comfort for the occupants of a building, as compared to a conventional building façade while ensuring required ventilation, air exchange and visual connection with the exterior.

iv) Offers Comfort/Productivity: A well-designed building façade system allows occupants to control light penetration by various methods, such as louvers or shading devices and to regulate air movement and temperature with operable windows, thereby increasing the overall building comfort levels. The increased environmental control and comfort levels result in better work productivity.

v) Provides Additional Security: A well-designed façade system provides a relatively unobtrusive method of achieving building security by properly planning and treating the openings as opposed to the conventional system of bars and grills to protect such openings.

vi) Ensures Aesthetics: Aesthetics pertains to the appearance and image of building elements and spaces as well as the integrated design process. It dissects visual elements like proportion and line, as well as other formal qualities—auditory, tactile, olfactory, thermal, and even kinesthetic—that achieve beauty. In the case of architecture, these underlying concepts may include branding, image-ability, ideas about community, and the importance of technology. The standards of beauty vary according to time and culture.

**Day lighting**

Day lighting significantly impacts buildings and their occupants. Daylight can be used to counterbalance the use of electrical lighting and ensure a positive effect on not only the productivity of the occupants but also their mood. According to studies, in the absence of proper solar control, occupants tend to draw blinds when visual or thermal comfort thresholds are exceeded. These blinds are likely to remain closed for some time, negating the potential benefits of having the window in the first place.

At the Institut du Monde Arabe (1987) or The Arab World Institute (AWI), Paris, French architect, Jean Nouvel has realized a dynamic redesign of the vernacular Arabic screen. The amount of daylight entering the building is controlled by 27,000 light-sensitive diaphragms. The metallic brisesoleil on the south façade, with intricate and clear-cut details, quite similar to those of the traditional mashrabiya, is visible from a distance.

![Institut Du Monde Arabe, Paris, Jean Nouvel; SOURCE: www.parissecret.fr](image)

Fig. 1: Institut Du Monde Arabe, Paris, Jean Nouvel; SOURCE: www.parissecret.fr
The structure may initially appear to be an Arabic decoration, but its function is to filter the daylight dynamically, depending on the weather.

In Al Bahar Towers by Aedas, Abu Dhabi, the solar-responsive dynamic screen reduces the solar gain of the towers. The lightly tinted glass reduces the incoming daylight at all times and not only in situations when the temperature is critical. The towers have a protective skin comprising 2,000 umbrella-like modules per tower driven by photo voltaic panels. By attaching mashrabiya to the towers, the floors are prohibited from taking too much sunlight despite the transparency of the walls. Thus, the residents of the towers have no problem shading themselves from the sun's rays.

**Ventilation and Energy Conservation**

Proper designing of a double skin façade can not only improve the indoor climate but also reduce the use of energy in a building. There are several variations in the construction types for double skin facades. Therefore, it is necessary to evaluate and compare the merits of the various systems as well as the 'environmental success' of one building's skin versus another.

**Buffer System**

This system precedes insulating glass. In fact, it was invented to maintain daylight entering the buildings and at the same time increase insulation and sound properties of the wall system. This uses two layers of single glazing spaced 250 to 900 mm apart, sealed and allowing fresh air into the building through additional controlled means, that is, either a separate HVAC system or box type windows cutting through the overall double skin. Shading devices can be included in the cavity. A modern example of this type is the Occidental Chemical/Hooker Building at Niagara Falls, New York. This building allows fresh air intake at the base of the cavity and exhausts air at the top.
Extract-Air System
This system is used where natural ventilation is not possible, for example, in locations with high noise, wind or fumes. This comprises a second single layer of glazing located on the interior of a main façade of double-glazing. The air space between the two layers of glazing becomes part of the HVAC system. The heated ‘used’ air between the glazing layers is extracted through the cavity using fans. This tempers the inner layer of glazing while the outer layer of insulating glass minimizes heat-transmission loss. Fresh air is supplied by HVAC and prevents natural ventilation. The air contained within the system is used by the HVAC system. These systems tend not to reduce energy requirements as fresh air changes must be supplied mechanically. Occupants are prevented from adjusting the temperature of their individual spaces. Shading devices are often mounted in the cavity. The space between the layers of glass ranges from around 150 mm to 900 mm and is used to access the cavity for cleaning as well as the dimension of the shading devices.

Twin-Face System
This system may be distinguished from both buffer and extract-air systems, by the inclusion of openings in the skin to allow for natural ventilation. This system consists of a conventional curtain wall or thermal mass wall system within a single glazed building skin. The outer glazing may be safety or laminated glass or insulating glass. Such a system must have an interior space of at least 500 to 600 mm to permit cleaning. The single-glazed outer skin is used mainly to protect the air cavity contents (shading devices) from weather. In this system, the insulating properties of the internal skin minimize heat loss. The outer glass skin is used to block/slow the wind in high-rise situations and allow interior openings and access to fresh air without the associated noise or turbulence.

Hybrid System
This system combines various aspects of the systems discussed till now. In fact, it is a class that accommodates all the building systems that do not fit into a precise category. Such buildings may use a layer of screens or non-glazed materials on either the inside or outside of the primary environmental barrier. The Tjibaou Center in New Caledonia by Renzo Piano is an example of this type of Hybrid system.
KfWBankengruppe office building, in Frankfurt, has the world’s first ‘pressure ring’ facade. In the KfW tower, sensor-controlled ventilators on the outer skin open and close throughout the day in response to temperature, wind direction and speed, among other factors. This throws a ring of positive pressure around the building.
The air is drawn into offices through floor vents and windows along an inner facade workers control, and then exhausted into the building core. It provides a system of natural ventilation, which eradicates the need for AC and heat in the fall and spring.

**Aesthetics**

Aesthetically successful architecture can only result from an integrated approach. By correctly formulating a project’s purpose, seeking inspiration in programmatic requirements, and engaging in team-wide design reviews, an architect most effectively arrives at a solution that is not only visually pleasing but also cost-effective, secure/ safe, sustainable, accessible, and functional/ operational.

Let us look at some concepts of façade design:
Fig. 11: Rhythm & Dynamic - Dynamic Tower, Dubai (Source: arclickdesign.com)

Fig. 12: Abstract & Biomimicry - Guggenheim Museum, Bilbao (Source: www.flickr.com)

Fig. 13: Contrast - Gherkin building, London (Source: www.rgbstock.com)

Fig. 14: Advanced Green Façade
Safety and Security

There are many factors that building designers, whether they are architects or engineers, have to consider when planning a new building. The forces of nature acting on the building, such as gravity, wind and seismic loading, need to be assessed and resisted. Imposed loads associated with the function of the building must be considered. The façade of the building should be able to protect its occupants against wind and rain and the extremes of temperature and humidity. Keeping in mind the violent terrorist attacks on civilians around the world in recent years, protective measures are being included in the designs of increasing numbers of commercial and public buildings.
The most widespread cause of injuries and internal disruption from an external bomb blast is the fragmentation and inward projection of window glass. Plain annealed glass is the most hazardous type breaking easily into sharp dagger-like shards. Laminated glass is the most effective in providing protection against blasts. Even if cracked by blast pressures, the outer glass layers generally remain bonded to the inner plastic inter layer instead of forming free-flying shards. Structural silicone sealant can be used for maximum protective performance. This enables the cracked frames to behave as a membrane allowing it to bulge inwards while at the same time remaining attached to its frame due to the properties of the PVB inter layer.

Narrow recessed windows can be considered on external facades, as the amount of blast overpressure coming in the interior of the building is directly proportional to the window and opening area or size on the external façade. Sharp corners of sills intensify the blast overpressure. Thus, sloped sills should be used.

Laminated glass is the most effective in providing protection against blasts. Even if cracked by blast pressures, the outer glass layers generally remain bonded to the inner plastic inter layer instead of forming free-flying shards. Structural silicone sealant can be used for maximum protective performance. This enables the cracked frames to behave as a membrane allowing it to bulge inwards while at the same time remaining attached to its frame due to the properties of the PVB inter layer.

Narrow recessed windows can be considered on external facades, as the amount of blast overpressure coming in the interior of the building is directly proportional to the window and opening area or size on the external façade. Sharp corners of sills intensify the blast overpressure. Thus, sloped sills should be used.

Laminated glass is the most effective in providing protection against blasts. Even if cracked by blast pressures, the outer glass layers generally remain bonded to the inner plastic inter layer instead of forming free-flying shards. Structural silicone sealant can be used for maximum protective performance. This enables the cracked frames to behave as a membrane allowing it to bulge inwards while at the same time remaining attached to its frame due to the properties of the PVB inter layer.

Narrow recessed windows can be considered on external facades, as the amount of blast overpressure coming in the interior of the building is directly proportional to the window and opening area or size on the external façade. Sharp corners of sills intensify the blast overpressure. Thus, sloped sills should be used.

Laminated glass is the most effective in providing protection against blasts. Even if cracked by blast pressures, the outer glass layers generally remain bonded to the inner plastic inter layer instead of forming free-flying shards. Structural silicone sealant can be used for maximum protective performance. This enables the cracked frames to behave as a membrane allowing it to bulge inwards while at the same time remaining attached to its frame due to the properties of the PVB inter layer.

Narrow recessed windows can be considered on external facades, as the amount of blast overpressure coming in the interior of the building is directly proportional to the window and opening area or size on the external façade. Sharp corners of sills intensify the blast overpressure. Thus, sloped sills should be used.
Conclusion
A thoughtfully designed skin can make a new building work more effectively for its owners, occupants and environment. It can also transform the performance of an existing building. As the interface between interior space and exterior environment, a building's skin plays a crucial role in heat and light exchange. Its performance in that role affects occupant comfort and productivity, energy use and running costs.

Rather than serving as a static enclosure, the building skin has the potential to redirect and filter daylight, provide natural ventilation, manage heat transfer, enhance occupant well-being, and create visual and physical connections between the inside and the outside.

References

Fig. 21: Vertical load carrying elements of the building, like columns and structural walls, should not be exposed on the exterior façade

Fig. 22: Narrow and recessed windows with sloped sills

Fig. 23: Vertical load carrying elements of the building, like columns and structural walls, should not be exposed on the exterior façade

Ruchi Yadav, Architect at Dar Al Handasah, Pune; M.Arch (Architectural Measures for Terror Mitigation) - IIT, Roorkee; B.Arch, GCA, Lucknow
Jaideep Sarkar, Architect at Dar Al Handasah, Pune; M.Arch, IIT, Roorkee; B.Arch, NIT, Patna
Kartik P. Jadhav, Computational Design Specialist, Architect at Dar Al Handasah, Pune; MSc (Sustainable Architectural Studies)-University of Sheffield, United Kingdom

Photographs and Illustrations: Courtesy, authors.