ISSN PRINT 2319 1775 Online 2320 7876

*Research paper*  UGC CARE Listed (Group -I) Journal Volume 8, Issue 3, 2019

# Intelligent Building Facade for Office in Hot and Humid Climate (Vijayawada), India

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**Abstract.**

The purpose of the study is to meet optimum usage of day light and natural ventilation reduces the energy consumption and reduces the need for artificial lighting and ventilation. few countries are adopting new facade technologies for buildings to recuse energy consumption increase comfort of users depending on the functional purpose of a space and lighting systems may be controlled to provide 'comfort' in the sense of a relaxing or pleasant visual environment[1]. By adopting these new façade technologies make building more efficiency and reduce the energy consumption .In hot and humid climate ventilation is considered as a major problem by adopting these new façade systems achieve comfort in work place.

**Keywords:** Building facade, Day light, Intelligent Building, Hot humid climate.

## 1. Introduction

In this research focused on building facades in order to meet the functional performance and requirements on the environmental, social, and aesthetical aspects. Facades are one of those essential part of building and crucial to energy consumption and comfort in buildings. Incorporating intelligence techniques and solutions in building design is an effective way to achieve comfort condition for occupants. Facades are boundary between external and internal environment based on outdoor climatic conditions these facades adjust indoor environment and increase user comfort. Day light is one of the key factors in office buildings. To achieve optimum day light and ventilation into work space by adopting intelligent facade techniques and technologies.

Everyone agrees that light could be a fundamental ingredient of excellent design, but agreement on the quantity and quality of sunshine, both natural and artificial, that creates good design is a smaller amount easy to search out. Daylight is additionally a vital

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contributor to the reduction within the need for artificial lighting with its associated energy costs and contribution to heating loads[2]. This climate is also referred to as humid subtropical climate. It is mainly experienced generally around the equator belt extending to about and 15° north and south. The climate is characterized mainly by high rainfall and high humidity. The temperature range is relatively high ranging to about 35°C and is fairly even during the day and throughout the year. Due to minimal temperature differences, winds are light or may be non-existent for extended periods.

Façade design serves as the architectural face of a building, influencing both its aesthetic appeal and functional performance. Derived from the French word "façade," meaning "frontage" or "face," the façade represents the outer skin or envelope of a structure. Its significance lies in a multifaceted role, addressing various aspects of building functionality. One primary function involves the enhancement and maximization of natural daylight within the interior spaces, creating a harmonious blend of aesthetics and practicality. Additionally, façades play a pivotal role in providing protection, insulation, and ventilation, thereby ensuring the comfort and well-being of occupants. They act as dynamic interfaces with the external environment, adept at collecting and rejecting heat as needed. Modern façade design even extends its impact to energy generation, with some structures incorporating elements that harness solar power, exemplifying the evolving synergy between architectural innovation and sustainability. In essence, the façade emerges as a crucial element, seamlessly integrating form and function in the architectural tapestry of a building.

The concept of an intelligent facade represents a paradigm shift in building design, where the building envelope becomes a dynamic, responsive interface with the external environment. An intelligent facade is not merely a static shell but a system that adapts to varying external conditions, ensuring optimal comfort inside the building irrespective of external factors. This innovative approach integrates variable technologies that enable the facade to modify its properties in real-time.

Several types of intelligent facades exemplify this transformative trend in architecture:

*Double Skin Facade:* This design incorporates two layers of building envelope with a ventilated air cavity in between. The outer layer serves as a protective barrier against environmental elements, while the inner layer contributes to insulation and regulates thermal conditions. The cavity allows for controlled ventilation, contributing to energy efficiency[3].

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*Double Glazed Facade:*Double glazing involves the use of two layers of glass with a space in between, providing enhanced insulation and soundproofing. The gap between the glass layers can be filled with inert gases to improve thermal performance, making it an energy-efficient solution that contributes to maintaining a comfortable indoor environment.

*Kinetic Facade:* Kinetic facades are dynamic and responsive, capable of changing their configuration or orientation based on environmental conditions. This adaptability allows for the optimization of natural light, shade, and ventilation, contributing to energy conservation and occupant well-being.

*Solar Facade:* Solar facades integrate photovoltaic technology to harness solar energy for power generation. By seamlessly incorporating solar panels into the building's exterior, these facades contribute to sustainable energy practices and reduce the building's reliance on conventional power sources.

*Ventilated Facade:* Ventilated facades promote air circulation between the building envelope and the exterior, offering benefits such as improved thermal performance and moisture control. This design not only enhances energy efficiency but also contributes to the longevity of the building structure.

In essence, intelligent facades epitomize a holistic approach to building design, where technological innovations are seamlessly integrated to create environments that are responsive, energy-efficient, and conducive to occupant well-being. As the architectural landscape continues to evolve, intelligent facades represent a pivotal advancement in marrying aesthetics with sustainability and functionality.

A Double Skin Façade (DSF) represents a cutting-edge architectural approach, crafting building envelopes with two transparent "skins" separated by an air corridor. Notably, DSF stands as an active façade, seamlessly integrating passive design strategies, such as natural ventilation, daylighting, and solar energy harnessing. The DSF system comprises three essential components: an exterior wall, a ventilated cavity, and an interior wall.

The exterior wall serves as the first line of defense against external elements, while the ventilated cavity allows for controlled airflow, contributing to enhanced thermal performance and energy efficiency[4]. The interior wall completes the ensemble, providing an additional layer of insulation and creating a buffer zone that aids in maintaining a comfortable indoor environment.

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One of the notable advantages of DSFs lies in their sustainable design solutions. By integrating passive strategies, these facades contribute to increased energy efficiency in buildings. The ventilated cavity, a key component, serves as a dynamic thermal buffer, mitigating temperature fluctuations and reducing the building's reliance on mechanical heating and cooling systems. Moreover, DSFs leverage solar rays to preheat the air within the cavity, further optimizing energy conservation.

In essence, the DSF concept embodies a holistic approach to architectural design, seamlessly blending technological innovation with eco-conscious solutions. By effectively marrying active and passive design principles, Double Skin Façades emerge as not only aesthetically pleasing but also as a pragmatic and sustainable choice for modern building envelopes.

*Double Glazed Façades:* Double Glazed Façades represent a sophisticated architectural solution wherein the building envelope consists of two layers, typically made of glass, with an intermediate cavity through which air flows. This design serves both aesthetic and functional purposes, offering a sleek and modern appearance while providing practical benefits.

The two layers of glass in a double glazed façade create a barrier that enhances insulation and soundproofing within the building. The intermediate cavity acts as a thermal buffer, reducing heat transfer between the interior and exterior environments[5]. This design contributes significantly to the energy efficiency of buildings by minimizing the need for excessive heating or cooling.

Moreover, the airflow within the intermediate cavity can be regulated to further optimize thermal performance. The use of inert gases within this cavity enhances the façade's insulation properties, making double glazed facades an effective solution for maintaining a comfortable indoor environment.

**Case Study 1: Sustainable Design in Baghdad, Iraq**

*Location:* Baghdad, Iraq

*Designed by:* Iraqi National Engineering Consultations Center

*Constructed by:* Al-Mansour Contracting Co.

*Building Characteristics:* The architectural landscape of Baghdad welcomes a striking addition, a 10-floor structure with a basement and a versatile multi-purpose hall on the

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ground floor. Executed by Al-Mansour Contracting Co. and designed by the Iraqi National Engineering Consultations Center, this building stands out for its commitment to sustainable principles and the fusion of traditional architecture with cutting-edge technology.

*Architectural Design:* The façades of this architectural marvel are conceptualized as a single skin, featuring double glazing. The choice of materials is notably aluminum, ensuring both structural integrity and a sleek, modern aesthetic. Interestingly, the corners of the building deviate from the aluminum norm, incorporating concrete for added strength and resilience.


*Figure: showing the façade system*

*Sustainable Principles:* A standout feature of this building is its commitment to sustainability. In alignment with modern architectural trends, it goes beyond conventional design, opting for a holistic approach that minimizes environmental impact. The incorporation of double glazing in the façade serves dual purposes: enhancing insulation for energy efficiency and fostering a visually appealing aesthetic.

*Technological Integration:* Embracing innovation, this structure stands as a testament to the seamless integration of traditional architectural elements with state-of-the-art technology. By adopting new technologies, the building manages to upgrade and modernize the traditional architectural landscape of Baghdad.

*Comfortable Workspaces:* One of the primary objectives of the design is to provide comfortable and functional workspaces. The multi-purpose hall on the ground floor adds versatility to the structure, catering to various needs and enhancing the overall utility of the building.

*Extensive Use of Glass:* A notable design feature is the extensive use of glass throughout the façade, covering a significant portion of the building. This not only

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contributes to a contemporary and open aesthetic but also maximizes natural daylight penetration, creating well-lit and inviting interior spaces.

*Solar Radiation Control:* Recognizing the harsh climate of Baghdad, the façade is engineered to control solar radiation effectively. By mitigating the impact of solar heat, the building ensures that its interior spaces remain comfortable and conducive to work, despite external weather conditions[6].

In summary, this architectural masterpiece in Baghdad reflects a harmonious blend of sustainability, technology, and functionality. From the extensive use of glass to the adoption of sustainable principles and the integration of innovative technologies, this building stands as a beacon of modern design, enhancing the cityscape while prioritizing occupant well-being and environmental responsibility.

**Case Study 2: Modern Elegance at the Sunni Endowment Bureau, Baghdad, Iraq (2010-2014)**

*Location:* Baghdad, Iraq

*Architectural Feature:* Double Skin Façade

Nestled in the heart of Baghdad, the Sunni Endowment Bureau's building, constructed between 2010 and 2014, emerges as a testament to contemporary architectural finesse. The façades, distinguished by a double skin design, not only contribute to the building's aesthetic appeal but also embody a deliberate interaction with the surrounding environment.


*Figure: figure showing elevations*

*Design Principles:* Anchored in sustainability, the architectural blueprint of this structure adheres to eco-conscious principles. The integration of a double skin façade serves dual purposes, marrying visual elegance with functionality. This design choice facilitates an active engagement with the ambient environment, showcasing a commitment to harmonizing modernity with the local context.

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*Technological Advancements:* This architectural endeavor is more than a mere structure; it symbolizes the harmonious convergence of tradition and innovation. By embracing cutting-edge technology, the building not only upgrades traditional architectural norms but also establishes itself as a contemporary landmark in Baghdad.

*Comfortable Workspaces:* A primary focus of the design is the creation of comfortable and inviting workspaces. The double skin façade, with its thoughtful use of glass enveloping the entire building, maximizes natural light penetration. This design feature not only enhances the aesthetic allure but also ensures that the interior spaces are bathed in daylight, fostering an atmosphere conducive to productivity.

*Expansive Glass Integration:* The use of glass across the entire façade is a defining characteristic, contributing to an expansive and open ambiance[7]. This architectural choice not only provides panoramic views of the surroundings but also reflects a commitment to transparency and openness in design.

*Sustainable Design:* Aligned with global sustainability goals, the Sunni Endowment Bureau's building stands as a model of green architecture. The double skin façade, by nature, enhances energy efficiency by providing an additional layer of insulation. This sustainable design approach ensures that the building minimizes its environmental footprint while offering a comfortable working environment for its occupants.

In essence, the Sunni Endowment Bureau's building is a harmonious blend of tradition and innovation, sustainability and aesthetics. The double skin façade not only elevates the architectural language of the structure but also speaks to a conscientious approach to environmental impact and occupant well-being in the heart of Baghdad's urban landscape.

**Case Study 3: Sustainable Shading and Adaptive Design in Masdar, Abu Dhabi**

*Location:* Masdar, Abu Dhabi

In the unique context of Masdar, Abu Dhabi, the architectural focus extends beyond mere structure to address environmental efficiency and energy conservation. The design intricacies of the building's façade take advantage of the surrounding context, showcasing a thoughtful approach to sustainability.

*Façade Design for Energy Efficiency:* At the heart of the design philosophy lies a strategic exclusion of direct sunlight through the façade. By modeling the façade to limit glazed openings and strategically utilizing shading from adjoining buildings, the architects

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successfully minimize the impact of harsh sunlight on the building's interior spaces. This intentional design not only reduces the need for artificial lighting but also contributes to substantial savings in electricity bills and minimizes reliance on mechanical equipment.

*Harnessing Diffuse and Reflected Light:* A distinctive feature of the façade design is its ability to harness diffuse and reflected light. The architects have ingeniously crafted the building envelope to utilize natural light sources, reducing dependence on artificial lighting during daylight hours. This not only aligns with sustainable principles but also creates a well-lit and comfortable indoor environment for occupants.

*Integration of Traditional Techniques:* Drawing inspiration from traditional Arabic architecture, the design team has seamlessly integrated time-tested techniques into contemporary solutions. The façade design pays homage to traditional shading methods, adapting them to modern demands and the complex solar geometry of the region. This fusion of heritage and innovation stands as a testament to the adaptability of traditional architectural wisdom in crafting sustainable solutions.

*Solar Geometry Considerations:* Masdar's unique geographical location in Abu Dhabi presents solar geometry challenges that demand sophisticated design solutions. The façade's strategic orientation and modeling take into account the complex solar angles, ensuring optimal shading and light penetration. This meticulous consideration of solar geometry underscores the commitment to energy efficiency and sustainability.

In conclusion, Masdar's architectural narrative is a compelling case study in the delicate balance between tradition and innovation, sustainability and functionality. The façade design, with its emphasis on shading, light utilization, and adaptation of traditional techniques, not only addresses the region's specific challenges but also serves as a beacon for future sustainable urban development.

**Case Study 4: Sustainable Elegance at Abu Dhabi Investment Council Towers**

*Location:* Abu Dhabi

In the heart of Abu Dhabi, the Abu Dhabi Investment Council Towers stand tall, not just in stature but in their commitment to sustainable and innovative design practices. This case study explores the noteworthy features of these two 150-meter-tall office buildings, showcasing a harmonious blend of architectural grandeur and environmental responsibility.

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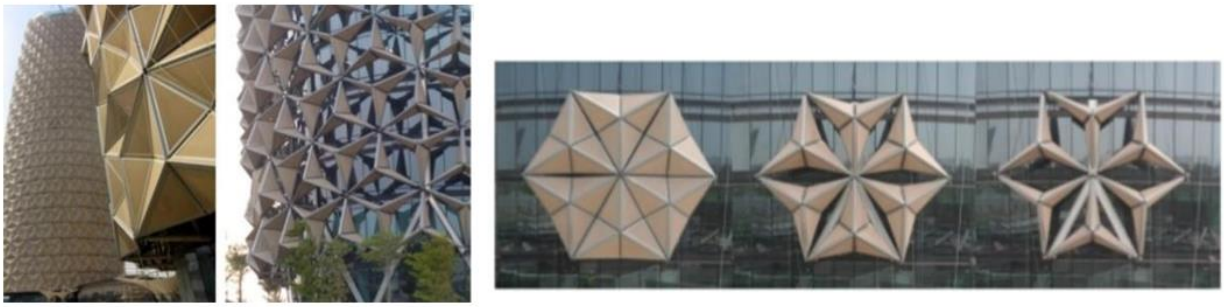

*Figure: dynamic façade system in Abu Dhabi investment council:*

*Automated Solar Shading:* One of the standout features of the Abu Dhabi Investment Council Towers is the integration of automated solar shading. The design incorporates a sophisticated system of automated "Umbrella" structures that open and close based on the path of the sun. This dynamic shading solution not only enhances the aesthetic appeal of the towers but also optimizes natural light penetration, contributing to energy efficiency and occupant comfort.

*Dynamic Façade with High-Performance Glass:* The façade of these towers goes beyond the conventional, featuring a dynamic design that responds intelligently to external conditions. High-performance glass is strategically employed to strike a balance between light transmission and energy efficiency. This not only creates a visually stunning exterior but also ensures that the interior spaces are bathed in natural light while mitigating the heat impact.

*Balancing Light Transmission:* The architectural vision for the Abu Dhabi Investment Council Towers places a strong emphasis on achieving a delicate equilibrium in light transmission. The design team has meticulously calibrated the façade elements to allow just the right amount of natural light into the building, minimizing the need for artificial lighting during daylight hours. This not only reduces energy consumption but also creates a pleasant and productive work environment.

*Integration of Sustainable Technologies:* Beyond the visual aesthetics, the towers incorporate cutting-edge sustainable technologies. The automated solar shading system, coupled with the dynamic façade and high-performance glass, represents a holistic approach to energy efficiency. These features not only contribute to a reduction in the building's carbon footprint but also result in tangible operational cost savings over time.

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In summary, the Abu Dhabi Investment Council Towers stand as a beacon of sustainable architecture, marrying technological innovation with a commitment to environmental responsibility. The automated solar shading, dynamic façade, and high-performance glass collectively redefine the skyline while embodying a conscientious approach to energy efficiency and occupant well-being. This case study serves as an inspiring example of how tall office buildings can be both visually striking and environmentally responsible in a rapidly evolving urban landscape.

**Case Study 5: Harmonizing Tradition and Innovation at Kings Place, London**

*Location:* Kings Place, London

*Architectural Firm:* Dixon Jones

*Façade Design:* Double Skin

Nestled in the vibrant landscape of London, Kings Place stands as a testament to the fusion of functionality and aesthetic grace. Designed by Dixon Jones, this five-story building hosts a dynamic array of spaces, including galleries, conference areas, a canal-side bar, and a restaurant beneath commercial offices, currently housing the Guardian newspaper among other occupants.

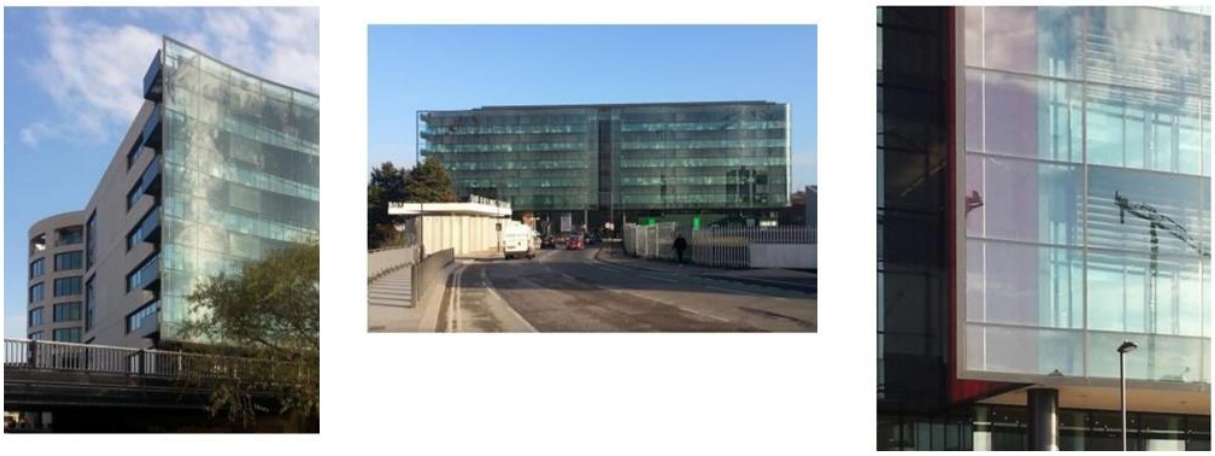

*Figure: Elevations of Kings Place, London, Dixon Jones*

*Double Skin Façade:* A distinctive feature of Kings Place is its double skin façade, meticulously designed to marry tradition with innovation. Dixon Jones has artfully composed a façade that not only pays homage to traditional design elements but also incorporates modern functionality. This design choice creates a visually appealing exterior while addressing practical considerations such as energy efficiency and acoustic comfort.

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*Glass Shield for Noise Reduction:* The façade incorporates a glass shield that serves a dual purpose. Not only does it contribute to the building's visual aesthetics, but it also functions as a shield against traffic noise. This strategic use of materials reflects a thoughtful approach to occupant well-being, creating a serene and focused environment within, shielded from the bustling urban surroundings.

*Thermally-Responsive Screen:* Innovatively, the building features a thermally-responsive screen at the front. This screen is designed to be thermally open at both the bottom and the top. The strategic design allows warm air to disperse naturally, leveraging the stack effect. This passive ventilation technique contributes to the overall energy efficiency of the building, showcasing a commitment to sustainable design principles.

*Punched Window Openings:* In a nod to more traditional architectural design, Kings Place features punched window openings arranged in a manner that aligns with conventional aesthetics. This compositional choice not only adds a touch of classic elegance to the building but also provides a balance between the traditional and the contemporary in façade design[8].

In summary, Kings Place exemplifies a thoughtful approach to architectural design, seamlessly blending traditional elements with innovative solutions. The double skin façade, glass shield for noise reduction, thermally-responsive screen, and traditional punched window openings collectively create a distinctive and harmonious architectural ensemble. Dixon Jones' design for Kings Place not only serves its functional purposes but also contributes to the rich architectural tapestry of London's urban landscape.

**Advancements in Façade Systems: Enhancing Environmental Responsiveness and Sustainability**

The evolution of façade systems in modern architecture has brought forth a range of advantages that extend beyond mere aesthetics. These innovative designs serve as integral components of building envelopes, providing numerous benefits to both the structure and its occupants.

*Advantages of Façade Systems:*

1. **Protection from Natural Elements:** Façade systems act as the first line of defense against external elements such as rain, wind, and harsh sunlight, preserving the integrity of the building structure.

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2. **Improved Energy Efficiency:** Innovative façade designs contribute to enhanced energy efficiency by regulating thermal conditions within the building, reducing reliance on mechanical heating and cooling systems.
3. **Light Penetration and Filtration:** Façade systems strategically control natural light penetration, fostering well-lit and comfortable interior spaces while minimizing glare and optimizing daylight.
4. **More Fresh Air:** The integration of ventilated façade systems facilitates improved air circulation, enhancing indoor air quality and creating a healthier environment for occupants.
5. **Noise Control:** Façade systems play a role in mitigating external noise, contributing to a quieter and more conducive indoor environment.

*Glass as a Sustainable Material:*

Glass, a prominent material in façade design, stands out for its sustainability. Its recyclability aligns with eco-conscious design practices, making it an environmentally responsible choice. Façade systems leveraging glass are often referred to as climatic-sensitive, as they respond dynamically to external climatic conditions.

1. **Increase Durability:** Glass façade systems contribute to the longevity of buildings, providing durable protection against environmental factors and maintaining their aesthetic appeal over time.
2. **Sustainable:** The recyclability of glass aligns with sustainable design principles, reducing the environmental impact associated with building materials.
3. **Provide Insulation:** Glass façade systems, when intelligently designed, contribute to thermal insulation, regulating interior temperatures and reducing the need for excessive heating or cooling.
4. **Aesthetic Appeal:** Beyond its functional benefits, glass façades add a touch of sophistication to architectural designs, enhancing the overall aesthetic appeal of buildings.

*IoT Integration and Energy Efficiency:*

Modern façade systems are evolving into integral components of the Internet of Things (IoT). These systems enable automatic adjustments in response to environmental changes, fulfilling the requirements of occupants in indoor spaces. By reducing energy

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consumption through intelligent, data-driven adjustments, façade systems contribute to sustainable building practices and occupant comfort.

In conclusion, the integration of advanced technologies, sustainable materials like glass, and a focus on occupant well-being mark a new era in façade system design. As buildings embrace these advancements, they not only achieve better performance but also contribute to the broader goals of environmental sustainability and enhanced living and working environments.

## 3. Results:

From the above study intelligent facades are increase the work productivity of occupant. Incorporating new façade system (intelligence ) in design is an effective way to achieve low energy consumption building. It is a sustainable design by making building intelligent. There are different façade systems incorporate them according to climatic condition. Double skin façade is used in hot and humid climates. The façade system performance is effective when it is oriented in certain direction.

## 4. Conclusion

Intelligent facades are mainly used for office buildings to increase the thermal comfort in indoors. These façade systems are used based on local climatic conditions. Intelligent façade increase building efficiency and durability. Light and ventilation are the problems in office buildings to achieve these intelligent facades are incorporated in design. In double skin façade system air movement is through the cavity between the facade skins. It has design considerations and limits. Glass is used most of the time in façade system it is recyclable material. Material specification is required in façade design. Glass is not preferred in some climatic conditions. Ventilation and natural light are achieved in double skin façade. Facades play a key role in achieving more sun light and ventilation. By incorporating these façade systems these are aesthetically pleasing also.

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