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# Facade for Futuristic Green Building

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**ABSTRACT:** In the Indian construction industry, a significant approach is emerging at the intersection of architecture and the environment, particularly in response to the energy crisis and climate change. Architects are developing new methods to meet energy demands in buildings, with façade greening gaining prominence over the last decade. Although not universally accepted as an energy-saving method, vertical greening can cool building surfaces, especially during hot summers, and positively impact indoor climates by preventing facade warming. This paper analyses the thermal effects of various facade systems and research about Low-E Glass, emphasizing their role in sustainable urban development. Façade engineering, a specialized discipline, integrates these principles, focusing on the design, construction, and maintenance of energy-efficient and aesthetically pleasing building facades.

**KEYWORDS:** Facade engineering, Low-e Glass, Energy efficient, Temperature Variation, Cost Difference.

## I.INTRODUCTION

In Indian construction industry is producing an important and interesting approach between architecture and the environment. This is taking place in forms and with different degrees of intensity. Within the challenges of energy crisis and climatic changes architects started to develop new approaches to address the quest of energy demands in buildings. One of these approaches is façade greening which started to take an important place in the last 10yrs however it has not been approved as an energy saving method for the built environment. Vertical greening can provide a cooling potential on the building surface, which is very important during summer periods in hot climates. The cooling effect of green facades has also an impact on the inner climate in the building by preventing warming up the façade. Within this quest, this paper is focused on the analysis of the effect of green facades systems on the building temperature and addressing different types of green facades systems and their thermal effect. In the challenge of development in dense urban areas and environmental preservation, sustainability is a significant requirement where green facade (vertical greening) is one of those approaches that flourished during the last decade although it is not a new concept. Hanging or vertical garden, vertical vegetable farms, balcony garden, container or planter box greening, green or eco building, green roof or rooftop garden, wall planter, Low- E glass and green envelop are all different aspects of this idea that demonstrate how wide this landscape can be. Greening the building envelope with vegetation can be used as a mean to restore the environmental conditions in dense urban areas. Designers can look for enhanced solutions where the façades are more than tinted glass barrier. Several researches have proven the environmental benefits of green facade on both new and existing buildings. They can be applied for mitigating the effect of urban heat island, increasing biodiversity and ecological value, insulating against environmental impact, outdoor and indoor comfort, social and psychological wellbeing and enhancement of air quality for city dwellers. This article discusses different systems of the green facade as a method of sustainable development.

Facade engineering is a specialized discipline within the field of architectural and structural engineering that focuses on the design, construction, and maintenance of building facades. With buildings increasingly becoming iconic symbols of modern architecture, facade engineering plays a crucial role in realizing architects' visions while ensuring structural integrity, energy efficiency, and aesthetic appeal. Facade engineers collaborate closely with architects, developers, and contractors from the conceptual design stage through construction and beyond. They are responsible for selecting appropriate materials, such as glass, aluminum, steel, or composite panels, based on factors like durability, aesthetics, and thermal performance. Advanced computational modelling and simulation techniques are utilized to analyse the facade's structural behavior under various environmental loads, including wind, snow, and seismic forces. Additionally, facade engineers integrate sustainable design principles into their work, optimizing energy performance through

strategies like thermal insulation, solar shading, and natural ventilation. Maintenance and lifecycle considerations are also paramount, with facade engineers designing systems that are durable, easy to maintain, and compliant with building codes and regulations. From curtain walls and cladding systems to green facades and historical preservation, facade engineering encompasses a diverse range of solutions tailored to meet the specific needs and objectives of each project. In essence, facade engineering is at the intersection of art and science, combining creativity with technical expertise to create buildings that are not only visually stunning but also efficient, resilient, and sustainable. There are several types of facades used in modern architecture, each with its own characteristics, advantages, and aesthetic appeal.

## II. LITERATURE SURVEY

In All case study, the performance of an Low-E glass was investigated in different parts of the different countries. This literature survey explores various approaches and studies on energy-efficient and sustainable building practices. It highlight the optimization of low-emissivity (Low-E) windows for residential buildings, demonstrating significant energy savings through innovations like CZO nanoparticles. This studies examine barriers and solutions to implementing green facades in urban areas, using Leipzig, Germany, as a case study. It compare energy consumption between Low-E and standard float glass . It discuss integrating Vertical Greenery Systems (VGS) into educational curricula to promote sustainability and climate literacy. It studied on PESTEL analysis to address the adoption of Low-E windows in Tehran, highlighting regulatory and economic barriers. It focuses on energy-efficient glass buildings in hot climates, emphasizing Low-E glass and double-skin facades. This investigate building orientation's impact on green facade performance in Barcelona, finding optimal orientations for energy savings. It discuss the benefits and threats of vertical greening in urban environments. This review green facades as a sustainable approach to combat climate change, emphasizing its role in climate adaptation and urban sustainability.

The review examines various approaches to enhancing energy efficiency and sustainability in urban environments, focusing on the use of low-emissivity (Low-E) windows and green facades. Low-E windows improve thermal insulation and reduce energy consumption in residential and commercial buildings. Green facades, involving building exteriors covered with greenery, offer benefits such as energy savings, improved air quality, and noise reduction. Despite implementation barriers, these innovations hold potential for sustainable architecture. Additionally, case studies from global cities highlight the positive impact of these technologies in addressing challenges like urban heat islands and promoting sustainable urban development.

## III. PROPOSED METHODOLOGY AND DISCUSSION

### 1) General Overview of ASTM C1363 and EN 673 Standards:

ASTM C1363, titled "Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus," provides a method to determine the steady-state thermal performance of building materials under various temperature conditions. This standard uses a hot box apparatus to measure parameters such as heat flux and temperature differences to assess the thermal resistance and conductance of insulation materials, walls, windows, doors, and other building envelope components. EN 673, "Glass in Building - Determination of Thermal Transmittance (U value) - Calculation Method," outlines a method for calculating the U-value of glazing units. This U-value measures the rate of heat loss through the material, incorporating factors like thermal conductance and the surface area of the glazing unit, making it essential for evaluating the thermal performance of windows and doors.

### 2) Principles and Technologies Behind Low Emissivity (Low-E) Glass:

Low-E glass technologies focus on enhancing energy efficiency in buildings by controlling solar heat gain and thermal transmittance. The Solar Heat Gain Coefficient (SHGC) measures the amount of solar radiation that enters a building as heat, with lower values indicating better performance in reducing heat gain. The U-value quantifies the rate of heat transfer through a material, where lower values signify better insulation. Relative Heat Gain (RHG) combines the effects of SHGC and U-value to provide an overall measure of heat gain in indoor spaces. Additionally, Ultraviolet (UV) transmittance indicates the amount of UV radiation passing through a material, with lower values offering better protection against UV damage. Sound transmission is another critical factor, with higher Sound Transmission Class (STC) ratings indicating better sound insulation. Visible Light Transmittance (VLT) measures the amount of visible light that passes through a material, influencing indoor lighting and energy efficiency.



### 3) Applications and Benefits of Advanced Glazing and Facade Technologies:

Advanced glazing technologies, including low-E coatings, play a crucial role in modern architecture by balancing natural light, thermal comfort, and energy efficiency. These technologies are essential for reducing cooling loads in warm climates and enhancing passive heating in cooler regions. The integration of green facades, which cover building exteriors with vegetation, further enhances sustainability by improving air quality, reducing noise, and contributing to energy savings. Despite challenges in implementation, such as regulatory and economic barriers, the benefits of these innovations are evident in case studies from global cities. These examples demonstrate the potential of low-E glass and green facades to mitigate urban heat islands, promote sustainable urban development, and improve the overall thermal performance of buildings.

#### Methodology:

1. Thermal Transmittance Test on Glass: For a heat transfer test on glass, a box with low-emissivity (low-E) glass is exposed to sunlight to measure its thermal performance. The procedure involves preparing the box with low thermal conductivity materials, securing the glass, and installing temperature sensors inside. The box is placed in direct sunlight, and internal temperature changes are recorded over time. Calibration of sensors and control of variables like position and environmental conditions are essential for accurate results. After exposure, data analysis includes comparing temperature changes, calculating heat transfer metrics, and compiling a report. This test evaluates the glass's insulating properties and ability to prevent heat gain from solar radiation.

2. Power Consumption Test with Cooling: The power consumption test assesses the thermal performance of low-E glass and the effectiveness of a cooling system. Initially, the box with low-E glass is exposed to sunlight for one hour, and internal temperatures are recorded. A fan powered by a DC power supply is then used to cool the box for another hour. Temperature changes are monitored, and power consumption of the fan is recorded. Data analysis involves comparing temperatures before and after cooling, evaluating the cooling system's effectiveness, and calculating energy efficiency. The results are compiled into a report, highlighting the glass's performance in regulating temperature and the cooling system's efficiency.

3. Light Absorption Test with Spectrophotometer: To test light absorption of glass using a spectrophotometer, the glass sample is cleaned and prepared. The spectrophotometer is calibrated, and the glass is placed inside it to measure transmittance or absorbance across the visible light spectrum (380 to 770 nanometers). Transmittance data is converted to absorbance to calculate optical density (OD). The OD is plotted against wavelength to visualize light absorption characteristics. Data analysis includes identifying significant absorption features and comparing results with industry standards. A test report is compiled, detailing the OD spectrum and assessing the glass's performance in terms of light absorption.

4. Estimation of Low-E Glass and Normal Glass for a Building: When estimating the impact of using low-E glass versus normal glass for a building, several factors are considered:

5. Energy Efficiency: Low-E glass significantly reduces heat transfer compared to normal glass. It helps keep buildings cooler in summer and warmer in winter, leading to lower energy consumption for heating and cooling. This can result in energy savings of up to 30% compared to buildings using normal glass.

6. Cost Analysis: While low-E glass is generally more expensive than normal glass, the initial investment can be offset by energy savings over time. The payback period can vary depending on the building size, local climate, and energy costs, typically ranging from 3 to 10 years.

7. Thermal Comfort: Low-E glass improves thermal comfort by reducing temperature fluctuations inside the building. It minimizes cold drafts near windows in winter and excessive heat in summer, enhancing occupant comfort.

8. UV Protection: Low-E glass blocks a significant portion of ultraviolet (UV) radiation, protecting interiors from fading and damage. Normal glass does not offer the same level of protection, leading to higher maintenance and replacement costs for furnishings and finishes.

## IV. RESULT

1. Thermal Transmittance Test on Glass: The U-value, also known as the thermal transmittance, is a measure of how much heat can pass through a material or assembly of materials, such as a window, wall, or roof, per unit area, per unit of temperature difference between the indoor and outdoor environments.

To calculate the U-value ( $U$ ) using the given thermal conductivity ( $k$ ) and thickness of the glass ( $t$ ), the simplified formula:

$$U = k / T$$

Where:

U = thermal transmittance in W/ (m<sup>2</sup>.k)

K = Thermal conductivity of the material W/mk

T = Thickness of material in meters

For Low-e Glass:

Given:

K =0.0265 W/mK

T =5 mm

First, convert the thickness from millimeters to meters:

$t = 5 \text{ mm}$

$=5 \times 10^{-3}\text{m}$

$t=5\text{mm}=5 \times 10^{-3}\text{m}$

Now, use the formula to calculate the U-value:

$U = 0.0265 / 0.005 \text{ W/m}^2\text{K}$

$U =5.3$

$U=5.3\text{W/m}^2\text{K}$

For Toughened transparent glass:

Given:

K =0.03 W/mK

T =4 mm

First, convert the thickness from millimeters to meters:

$t = 4 \text{ mm}$

$=4 \times 10^{-3}\text{m}$

$t=4\text{mm}=4 \times 10^{-3}\text{m}$

Now, use the formula to calculate the U-value:

$U = 0.03 / 0.004 \text{ W/m}^2\text{K}$

$U =7.5$

$U=7.5 \text{ W/m}^2\text{K}$

The goodness or quality of glass in terms of thermal transmission depends on the specific requirements of the application and the desired performance characteristics. In general:

**Lower U-value:** A lower U-value indicates better thermal insulation properties. Glass with a lower U-value will provide better resistance to heat flow, leading to reduced heat transfer between the indoor and outdoor environments. This is desirable for applications where energy efficiency is important, such as in windows and doors of buildings, to minimize heating or cooling costs and maintain comfortable indoor temperatures.

**Higher U-value:** A higher U-value indicates poorer thermal insulation properties. Glass with a higher U-value allows more heat to pass through, resulting in higher heat transfer between the indoor and outdoor environments. While higher U-values may be acceptable or even desirable in some specific applications, such as passive solar heating systems where maximizing solar gain is important, in most cases, higher U-values are associated with lower energy efficiency and increased heating or cooling costs.

## 2.Power Consumption Test with Cooling:

Conducting a power consumption test on low-e glass involves precise measurement and control of temperatures, calculation of heat transfer rates, and comparison against standard glass. This process helps determine the energy efficiency benefits of low-e glass.

In this test the sample is kept under the sun for 1 hour and after the temperature rises the cooling is done by using the mini fan the power required to the mini fan for cooling is calculated.

For Low-e Glass:

Time required for cooling = 45 minutes

Power: "power" refers to the rate at which energy is transferred or consumed in an electrical circuit. It is a measure of how quickly electrical energy is converted into other forms of energy, such as light, heat, or mechanical work. Power is a fundamental concept in electronics and is expressed in units of watts (W).

Power = voltage x current

Voltage: voltage also known as electric potential difference, is a measure of the electric potential energy per unit charge between two points in an electric field. It is the force that drives electric current through a circuit.

Current: is the flow of electric charge through a conductor or a circuit. It is a fundamental concept in the study of electricity and electronics. The unit of electric current is the ampere (A), named after the French physicist André-Marie Ampère.

Power:  $12 \times 0.05 = 0.6$  watt

Energy Consumption = Power Consumption x time  
 $= 0.6 \times 0.45$   
 $= 0.27$  watt/hour

For Toughened transparent glass:

Time required for cooling = 60 minutes

Power:  $12 \times 0.05 = 0.6$  watt

Energy Consumption = Power Consumption x time  
 $= 0.6 \times 1$   
 $= 0.6$  watt/hour

The low-e glass provides better insulation, resulting in lower heat transfer and reduced energy consumption for maintaining indoor temperatures. This improved thermal performance translates to energy savings and potentially lower heating (or cooling) costs, demonstrating the energy efficiency of low-e glass compared to normal glass.

### 3.Light Absorption Test with Spectrophotometer:

To find the optimal optical density at different wavelengths for low-e glass compared to standard glass.

Optimal Density: in the context of material science, particularly when discussing light absorption and transmission through glass, refers to the specific level of optical density that provides the best balance between transparency and insulation for a given application.

For Transperent Glass:

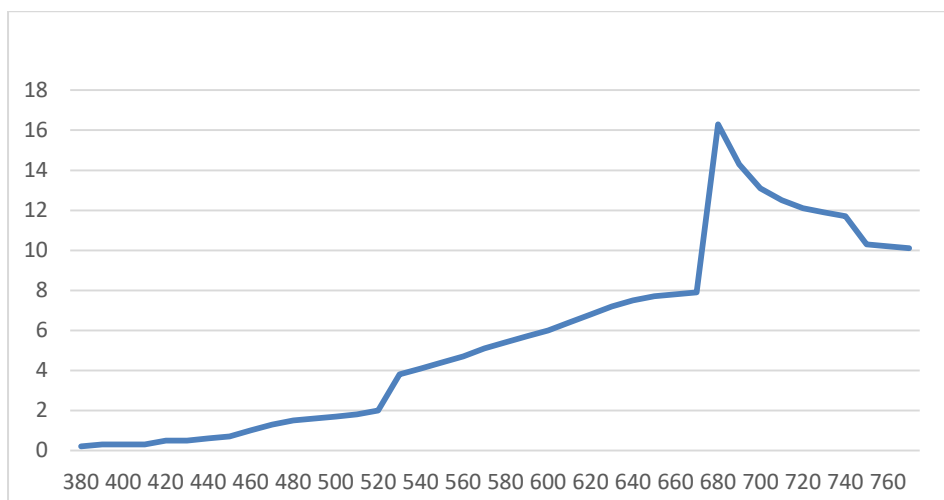


Fig. 1 Optimal Density at different wavelengths for Transperent Glass

For Low-E Glass:

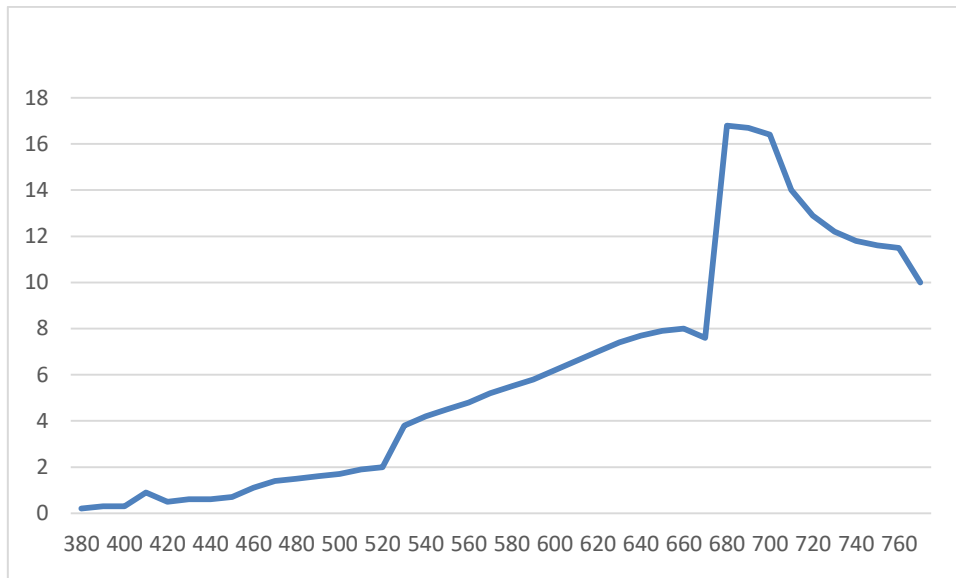


Fig. 2 Optimal Density at different wavelengths for Low e Glass

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