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Building Façade Design through Passive techniques to reduce Energy Consumption in Hot and Dry Climates

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Abstract : *This study has been undertaken to investigate Passive Façade Design for the reduction of Energy Consumption of a building in hot and dry climates. With the emerging energy crisis all over the world and the increasing construction industry , the associated rise in energy consumption can be solved by using sustainable Façade Design techniques. The paper elaborates different façade elements and the related passive design techniques associated with them. By studying the various elements of Façade and drawing a conclusion that elaborates various recommendations for different elements of façade design that can be implemented for the reduction of energy consumption.*

IndexTerms – Façade, Passive Design, Architecture, Energy Reduction.

1. Introduction

The façade provides diffused daylight, promotes natural ventilation, controls heat transfer, increases occupant productivity, visually connects the interior and exterior environments, and most importantly, the building has the ability to reduce the operating costs of The first is to identify some practical approaches that can be applied when designing building facades. The second is to identify some of the practical considerations that are relevant to successfully designing and implementing an advanced façade solution for your project. (Gupta, 2021).

Electricity consumption in buildings accounts for 55% of total electricity consumption in the world (Ian Hamilton, 2020). The result is a great opportunity to reduce overall energy consumption and address the global energy crisis.

HVAC and lighting loads can be reduced in a number of ways, including proper design and selection of building façades. One of the main contributors to building energy costs and important comfort parameters is the façade. This is also one of the most important things to consider when designing a structure.

2. Theoretical framework

Overview of different sustainable façade design, application of those façade elements that are relevant in hot and dry climate for the reduction of energy consumption. Through an intensive literature review of already published papers and various codes for sustainability draw a list of recommendations for the implementation of Façade design that would help in reduction of energy.

3. Literature Review

Facades contribute significantly to a building's energy costs and important comfort parameters. Variables that affect the energy performance of a building envelope can be design variables (such as exterior wall composition) or contextual design inputs depending on site conditions (such as outdoor areas). The building's internal and external environments are separated by the building's envelope. Building skins have a significant impact on a building's energy balance and can therefore make an important contribution to the transition to sustainable and energy-neutral buildings. A high-performance window system with excellent thermal and optical properties is important for determining both thermal comfort and illumination. Low-E coatings, insulated glass units, airgel void fills, and thermally broken frames have all made significant advances in glazing materials in recent years. (Gupta, 2021).

As a result of the rapid increase in global energy consumption (e.g. ozone depletion, global warming, climate change), there are already concerns about supply shortages, depletion of energy resources and severe environmental impacts. increase. Both residential and commercial buildings are steadily increasing their share of global energy consumption, ranging from 20% to 40% in developed countries.(Youcef Tamene, 2021).

Residential and commercial spaces consumed 32 percent of the country's total electricity consumption in 2016, according to the Government of India's (GoI) statistics.(Implementation, 2017). As India becomes more urbanized, this number is expected to increase. According to Niti Aayog's estimates, building power consumption will increase by about 860% (from 238 TWh/year to he 2,287 TWh/year) by 2047 in a "constant labor scenario"..(India Energy Security Scenarios, 2018).

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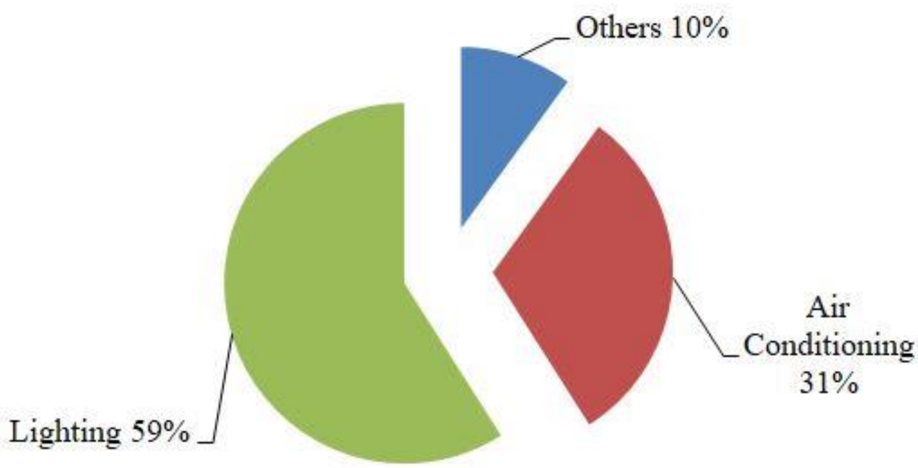

Figure 1 End use of electricity in commercial

Source : (BEE, 2002)

The design approach and choice of materials determine the amount of energy lost through the case. Window size and position are subject to design considerations that can be improved to reduce energy consumption. Choosing the right material is also important in determining energy efficiency.

3.1 Passive Techniques for Optimization of Façade

In hot and dry climates, the main objective of facade design is to maintain thermal comfort within a building by reducing the effects of adverse external conditions such as daytime sunlight and low nighttime temperatures. . Wind movement is only used after the indoor space has cooled and dusted. Surfaces exposed to sunlight should be minimized as much as possible.

3.1.2 Orientation

The east-west axis receives the most radiation. However, a north-south axis can be used to reduce solar heat gain. The thermal comfort of a building is affected by the north-south orientation of the long façade. The living space should face north because the position of the sun in the sky allows for full solar radiation in the winter. To let light and warmth into the house during the cold winter months, the main windows should face north.

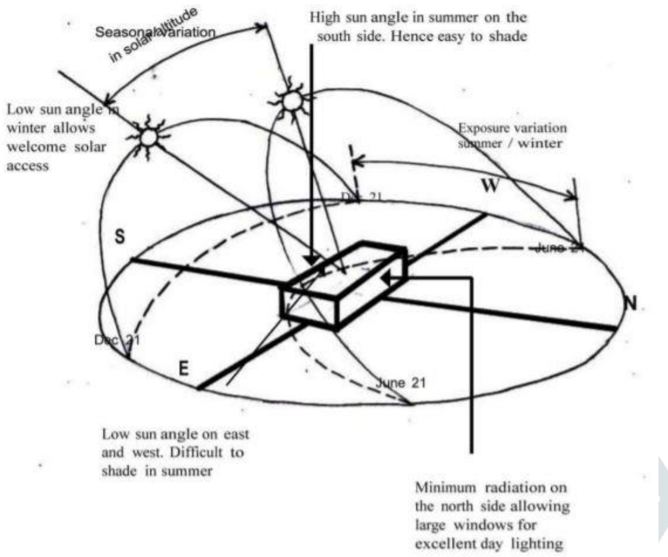

Figure 2N-S Orientation of Building

Source : (Veerakumar, 2005)

3.1.3 Building Form

A low P/A (perimeter to area) ratio results in less surface area being exposed to increased heat in hot, dry climates. If water bodies and vegetation can alter the building microclimate, plans can be implemented with higher P/A ratios. (Veerakumar, 2005)

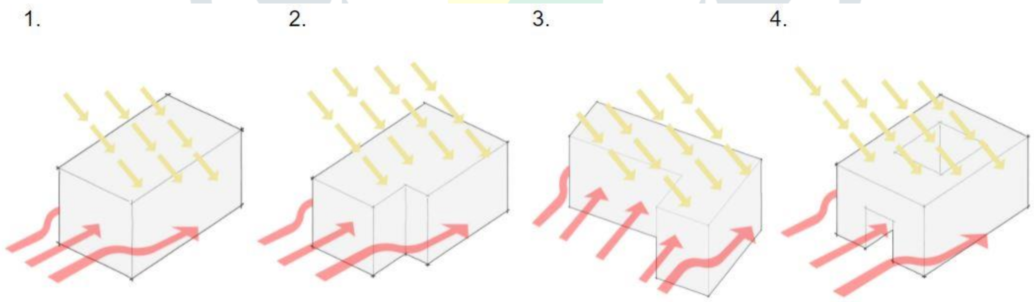

Figure 3 Building forms in ascending form of P/A ratio

Source : (Veerakumar, 2005)

3.1.4 External Wall

The development of walls, and thus their heat storage capacity and heat transfer properties, has a significant impact on both thermal comfort and cooling load in naturally ventilated and air-conditioned buildings. Thermal conductivity, thermal resistance, thermal absorption, emissivity, thermal reflectance, and heat capacity are the wall properties that determine heat transfer (NBC Approach to Sustainability, 2016). Using extruded polystyrene foam (XPS) can reduce energy consumption by 62%,(Ibrahim Motawa, 2021), but the optimal insulation thickness varies between 0.2 cm and 18.6 cm (BetulBektas Ekici, 2011).

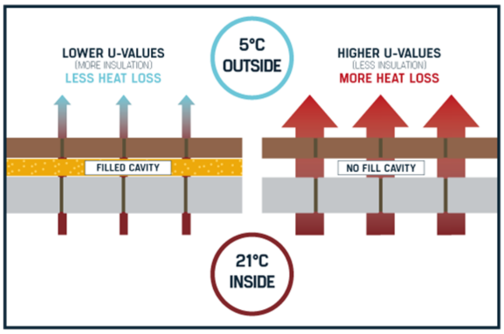

Figure 4 U-value for insulated and non-insulated wall

Source : (Premier Guarantee, 2016)

Thermal mass in walls allows the impact of the external environment on internal conditions to be delayed. Thermal mass is especially useful in hot, dry climates with a wide diurnal range. During the day, when the outside temperature is high, the building mass stores heat and releases it to the interior space at night, when the outside temperature is lower. Concrete, brick, and water, for example, have a high thermal storage capacity and can be used in this application. To allow for greater absorption, storage mass exposed to direct sunlight should be dark in colour. In general, thicker storage mass is more efficient than thinner storage mass. The ideal thickness ranges from 100 to 200 mm.(NBC Approach to Sustainability, 2016).

Figure 5 Thermal Mass for external walls in Hot and Dry climate

Source : (Sadler, 2020)

3.1.5 Fenestrations

While windows should allow natural light and air into the structure, light also brings in heat. The design of a solar passive building must consider window placement, size, detail, and shade shape. Size and placement of windows, glazing, frames and shading. With double glazed Low-E coated glass, the U value is as low as 1.77 and the VLT value is as high as 61%. This is ideal for reducing solar heat gain and maximizing building lighting..

3.1.6 Shading Devices

Direct sunlight can cause glare and therefore controls are necessary to allow diffused natural light. Curtain wall with horizontal and vertical shadings according to the VSA (Vertical Shading Angle) and HSA (Horizontal Shading Angle) has optimal performance with 18% decreased energy consumption to the baseline model (Aleksandra Krstić-Furundžić, 2019). Measures like vertical greening facade on an office building reduces the temperature and humidity of the building significantly. The three main ways of controlling direct sunlight are:

1. External shading and screens/Jalis,
2. Internal shading,
3. Use of solar control glass (spectrally selective)
4. Horizontal/vertical or angled louvers.

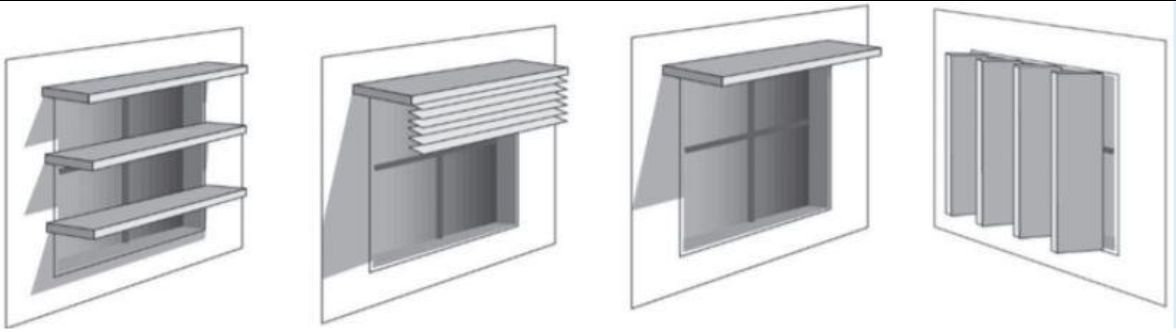

Figure 6 Commonly used shading devices

Source : (NBC Approach to Sustainability, 2016)

4. Conclusion

To reduce the increasing energy consumption of buildings with the change in climatic conditions the demand of heating and cooling load has increased. Climatically contextual façade designs can help in reducing the operational energy demand of buildings. The recommendations for designing a façade that can help in minimizing the heating and cooling load can be elaborated as the following elements of façade :

1. Building Form : A compact rectangular building form is recommended for an office building in hot and dry climate considering the Low P/A ratio of the building that helps in reduction of surface that is exposed to solar radiations during the day.
2. Orientation : Opening and longer side of the building should be aligned towards North to access diffused daylight in the office space and meet the Visual Transmittance% standards.
3. Fenestration : Double-glazed Low-e Coated Glazing will prove effective in protecting the building from solar heat gain and help in reducing the load of mechanical light inside the building.
4. Shading Devices : A building with a vertical and horizontal combination reduces the cooling load more than single type of shading devices.
5. External Wall Material & Thermal Properties: Because of their high thermal mass, RCC, Limestone, Dense Concrete, and Fly Ash Bricks are a few materials that can be used for external walls in hot and dry climates.
6. Surface Finish : Solar Control + Low E Coating is recommended for Hot and Dry Climates. Finishes with high reflectivity are recommended.

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