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Importance of Passive Architectural Illumination and Ventilation of buildings in Yenagoa, Bayelsa State, Nigeria

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Abstract
Studies Have shown that, though Passive Architectural Illumination and Ventilation are one of the basics of Architectural design to bring about comfort in interior places, modern Architects of today tend to forget their importance. Passive transcend looks, which is one of the major focus of today's architecture in most regions of Nigeria. This Article emphasizes on buildings / modern buildings in Yenagoa, it cuts across building designs in other regions of the world. The use of narrow trim windows in place of large wide windows to drive in daylight and air into a building interior is the order of the day, though this practice can be aesthetically pleasing, to some extent but it also gives the building large surface area to receive solar radiation gain which in turn generates heat in the interior spaces and destabilize thermal comfort. Illumination (daylighting) comes with solar radiation gain which this paper takes into consideration, the use of appropriate techniques to fend off unwanted solar ray and effectively introduces daylight into interior spaces. Yenagoa the capital city of Bayelsa state, like in other suburbs in Nigeria is dense with houses with poor ventilation and daylight there is also flooding issue that affect most low land areas of the state. This paper is to correct and throw light on measures Appling the Passive Architectural Approach to achieve daylighting and natural ventilation.

Keywords: *passive Architecture, Illumination, Ventilation, suburbs.*

1.0 INTRODUCTION

Traditional vernacular architecture has taught us the best of sustainable architecture and ecologically sensitive adaptation, using passive features ranging from building orientation and form, appropriately sized and oriented openings linked with vertical forms, the benefits of local materials and mass for night cooling, and the relationship of buildings in context to ensure effective air flows. Passive design lies at the foundation of Passive architecture; using the inherent conditions of the site as a design advantage. The different elements of passive design work together to provide indoor comfort and achieve energy efficiency, using construction technique that employs the natural flow of heat and air, passive solar gain and cooling to maintain a good internal comfort.

The primary aim of this research is to bring about a reawakening of the primary sustainability practices of old, that is now ignored by most Architects, simply because of their inability to create a balance between functionality and aesthetics.

The study is centered chiefly on Yenagoa, Bayelsa, which falls under a climatic zone that is situated in the rain forest region of the country; with high humid an1d generally tropical climate, with heavy erratic rainfall, dense cloud cover, relatively high solar radiation, which has the potential of causing discomfort in interior spaces, where passive architecture is not duly considered. This research highlights the ethos behind passive sustainability practices, reflecting the use of daylighting and natural ventilation, their benefits and measures set up to curb any adverse effect or impediments to comfortability, which is the essence of fine living

2.0 LITERATURE REVIEW

Passive design is a subset of environmentally sustainable design (ESD) that involves the use of natural sources such as natural ventilation and daylighting without the input of mechanical sources of energy, offering a solution for a more environmentally friendly building (S-H Loo et al 2021). Passive design ideas seek to maximize the use of natural sources of daylight, and ventilation to create comfortable conditions inside a building. Passive measures unlike Active Design measures do not involve mechanical or electrical systems as their major approach to illuminating and venting a space in a facility. Passive design is said to be a part of the sustainable design principles that aim to create a conducive indoor living as it reduces the energy output of the building (HMC Architects, 2018).

This principle is believed to have started as part of the indigenous architecture around the world, in vernacular forms such as tee-pees, igloos and cob houses which provided shelter while treading lightly on the land, with the most recent reawakening in the seventies as a response to the oil crisis, launching a movement concerned with all things solar energy and energy conservation. Passive design is a product of the sustainable design principles; the efforts made to ensure that the decisions made in building design presently do not harm the environment to avoid what McDonough (2002) described as "inter-generational tyranny" because the decisions and consequences we make today will be inherited by the innocent residents of the future. As Sim Van Der Ryn discussed in his book ecological design, "in many ways. the environmental crisis is a design crisis." this crisis is a result of the process of the design and construction process. The passive design looks to the design process to limit its hold and/or impact on the natural environment. Passive design as a subset of the sustainable design process can reduce the overall costs incurred, both environmental and financial.

Passive design implies the optimization of the building elements which are then re-evaluated for their inter-dependencies, optimized and integrated as part of a whole building solution. The accentuation of an optimized design is essential in almost every aspect of the building project right from the planning stages to design and construction. Take for instance the optimization of a building to use only natural ventilation will minimize cost over-run throughout its complete life-cycle and the impact on the environment, whilst maintaining quality and aesthetic (Loughborough University, 2004). For instance, the inter-relationships between the building and the site features; the wind direction and velocity, and the location and orientation of the building and elements such as windows have a significant impact on the quality and effectiveness of natural (passive) ventilation. These factors all come in when assessing a building's energy performance.

The Torrent Research Centre, Ahmadabad India, designed by Abhikram Architects uses wind catchers on a large scale based on Passive Downdraft Evaporative Cooling (PDEC) to achieve low energy consumption (A H Chohan and J Awad, 2022)

According to a 2007 Archidev article "Case Study II: The Torrent Research Center in Ahmedabad, by Abhikram" by Dushan Palacios, since its first occupation, the building has been under observation till date. The results were generally an indoor temperature of 31°C to 32°C as outside temperatures rose to 44°C. The use of the wind catchers proved to be economically viable, as civil work costs were cut by up to 13 per cent which saved approximately 200 metric tons of air conditioning, reflecting positively on the annual electricity consumption costs.

2 BUILDING DESIGN PROCESS AND OUTCOME

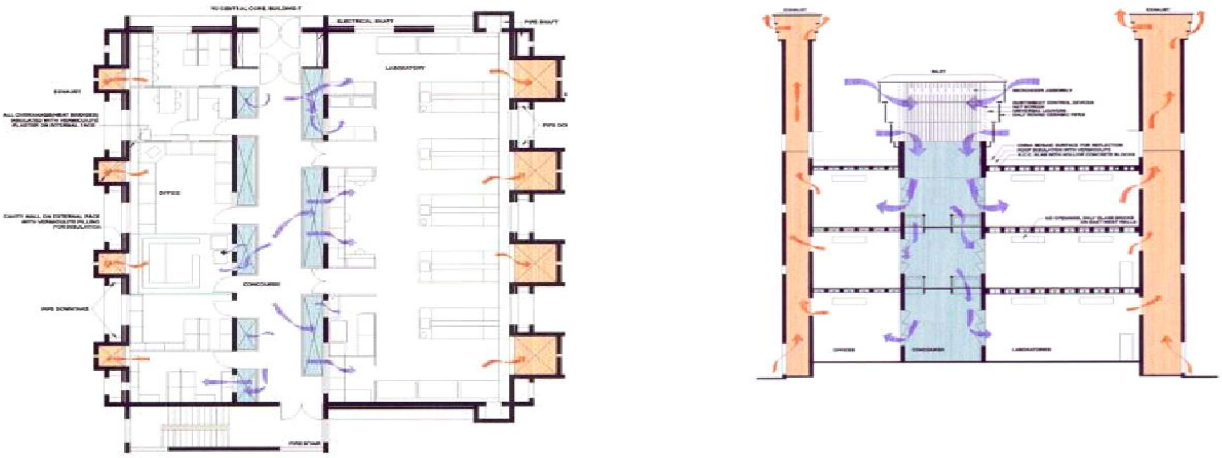


Figure 2.1: Floor plan and section Torrent Research Centre, Ahmadabad India
Source: https://www.archidev.org/spip.php?article1115 HYPERLINK "https://www.archidev.org/spip.php?article1115&lang=fr"lang=fr (2022)

Without considering these issues early on in the design process will result in a very inefficient building.

2.1 PASSIVE DESIGN STRATEGIES

The passive design has been included majorly through mass construction, wind towers, cooling system, roofing system, roof gardens, tremble walls, solar chimneys, light shelves, etc. The concepts of passive design in a mixed-use facility are simple and efficient but require some technical details and knowledge of the application. Some passive design strategies that will prove to be of benefit include the following:

2.1.1 LIGHTING

Providing light in spaces does not have to require electrical means at least during daylight hours. Daylighting involves design elements, such as windows, skylights, light shelves, and reflective surfaces, atrium and courtyards, to maximize the penetration and distribution of natural light.

Techniques for lighting during this period have been provided, some of which will include;

2.1.1.1 Atriums

As one of the passive design strategies for lighting, atria with a skylight are utilised because of the amount of light it brings into a space, which also doubles down as a source of ventilation.

Figure 2.2: Atrium for Daylighting
Source: https://www.architectmagazine.com/technology/lighting/5-surprising-daylighting-strategies

2.1.1.2 Sun Portal

Also known as Solar Tube, and Optic Solar Cable, the Sun Portal is a mechanism that works by collecting daylight through the aid of a convex glass and conveying it via a tube with reflective properties into the internal spaces.

Figure 2.3: *Sun Portal, use of Fiber Cable*
Source:*https://inhabitat.com/sunportal-uses-pipes-to-deliver-daylighting-anywhere-within-a-building/sunportal-daylighting-natural-daylight-solar-light-pipes-bender-relay/*

Controlling the intensity of daylight is another aspect of the passive daylighting technique that stresses the kind of materials used.

2.1.1.3 High-Performance Glazing

It is used to throw in light while minimizing the amount of heat gained thereby achieving a better solar heat gain coefficient in the building (H M Taleb, 2014)

Figure 2.4: High Performance Glazing
Source: https://passivehouseaccelerator.com/articles/five-principles-of-passive-house-design-and-construction

Different glazing can now be selected based on its performance capabilities to satisfy a variety of needs.

2.1.1.4 Light Shelves

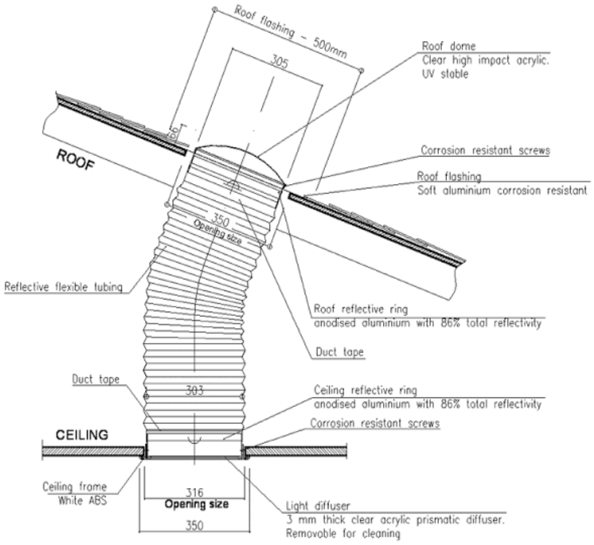
This has become an important iconic component in many green commercial buildings. It is constructed of metal, painted wood, or gyp-board and is located on the south on the walls of buildings separating a lower "vision-glass" from an "upper daylight glass".

Figure 2.5: Light Shelves
Source: *http://www.2030palette.org/intermediate-light-shelves/*

They are always white for reflective but some have mirrored tops. The purpose of the light shelf is to bounce the sunlight deeper into the space without causing glare, to reduce the difference in light levels at the front of the room and deep within the room, and to block heat gain from entering the main vision window during the cooling season on the external portion of the light shelf.

2.1.1.4 Solar tube

Solar Tubes and Light Pipes: These systems use reflective tubes or pipes to channel natural light from the roof into interior spaces, effectively illuminating areas without windows.



2.1.2 VENTILATION

Ventilation in this case is referred to the natural ventilation. The first step in designing for natural ventilation requires an understanding of the climate (wind direction and velocity) and building type.

2.1.2.1 Clerestory Windows

They are designed to allow for easy and efficient natural ventilation through the quick expulsion of used air in the building as a breeze comes in through the bottom vents on the leeward side of the house.

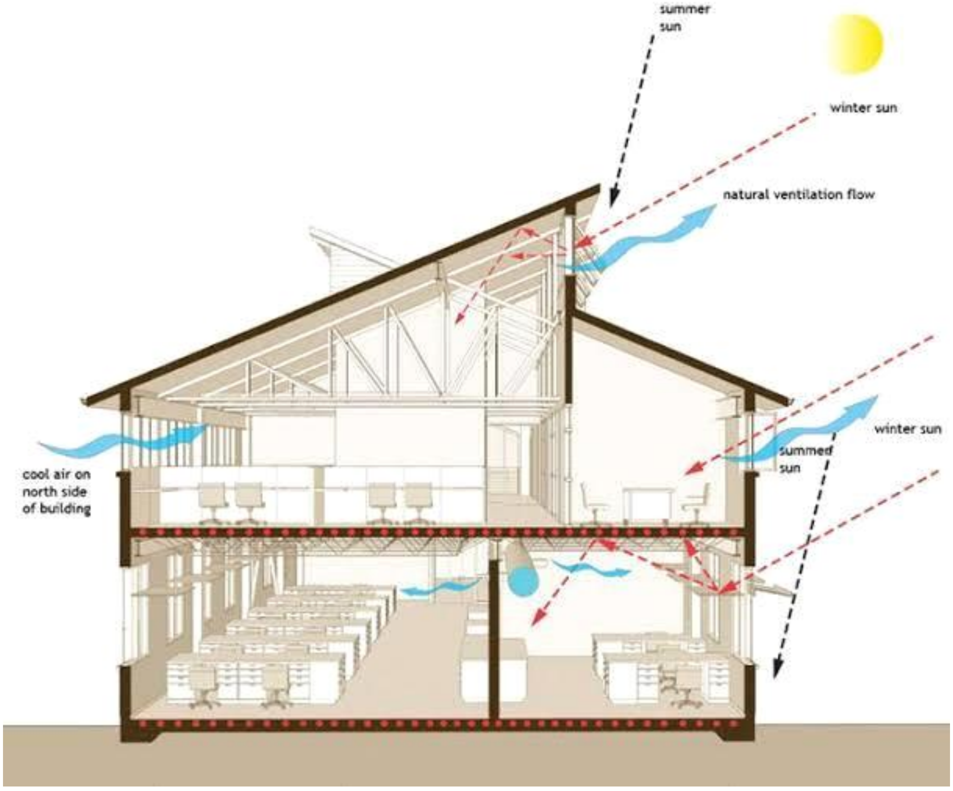


Figure 2.6: Clerestory Windows
Source: *http://engineeringfeed.com/winds-impact-construction*

2.1.2.2 Courtyards

The courtyard acts as an air conduit, releasing indoor air into the sky due to the difference in air density between indoor and outdoor and outdoor spaces.
Note: for an effective court Yard system, it has to be designed with a 1:2 ratio (where the aspect ratio, width of the court yard should be proportional to twice it' height), be course a well-designed court yard is crucial to the thermal comfort of both the exterior and interior surrounding spaces .

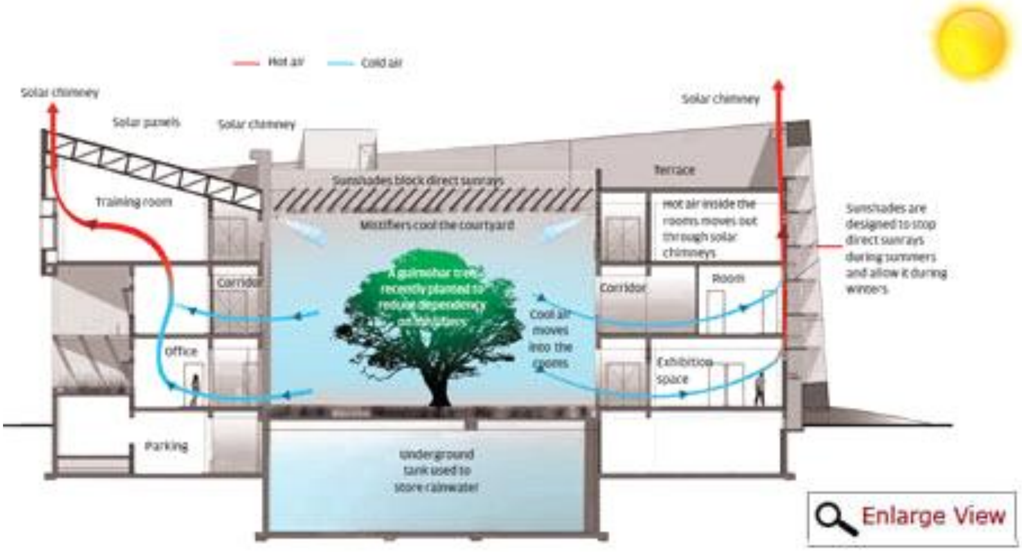


Figure 2.7: **Courtyards**
Source: *https://www.downtoearth.org.in/coverage/urbanisation/courtyard-as-cold-island-44966*

2.1.2.2 Wind Catchers

Wind catchers are passive cooling systems most common in Iranian architecture whose usage can reduce cooling loads in buildings and supply the necessary ventilation required for improved air quality (P K Sangdeh, 2020). The efficiency of the wind catcher is determined by parameters such as the number of openings, the height of the wind catcher, the wind approach, the wind speed, the configuration and cross-section, with the one-sided wind catcher being a better choice in regions with privileged wind direction (P.K. Sangdeh and N. Nasrollahi, 2022). Through several experiments, it was discovered that the performance of the wind catcher when compared with that of a window was a 300 per cent increase resulting from the increase in its pressure coefficient.

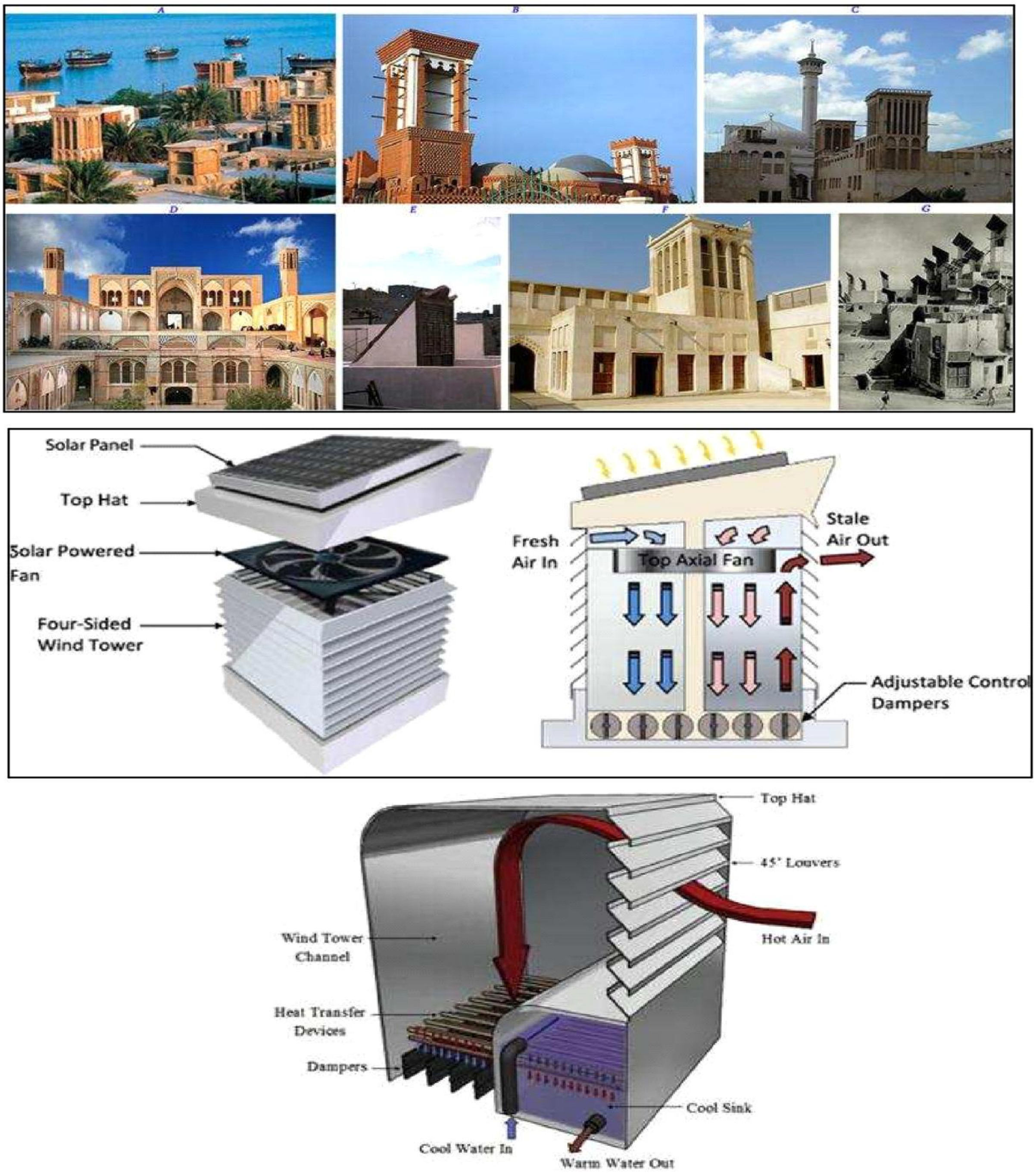


Figure 2.8: Commercial wind catcher for improved passive cooling and natural ventilation in buildings

SOURCE: *http://eprints.whiterose.ac.uk/112557/*

According to P.K. Sangdeh and N. Nasrollahi (2022) based on an investigation of the performance of a commercial wind catcher by Calautit et al, sufficient ventilation can be supplied even in velocities lower than 2m/s. It was also discovered that wind-catchers without other openings had a 17 per cent improvement in indoor air quality, and those with other openings had a 37 per cent improvement in indoor air quality. This, of course, is made possible through the use of heat control devices in the wind catchers.

2.1.3 Building Massing & Orientation

Massing and orientation are important design factors to consider. Proper building orientation will take into consideration the effects of the sun (heat gain and glare) as well as the degree of cooling needed through ventilation, which will ultimately impact the comfort levels of the entire building. The complex should be oriented to take full advantage of on-site features including climatic and weather. have proper definitions between the public and private areas with easily accessible entrances from the public sidewalks (H. Altan et al. 2016).

2.1.4 Landscaping

Landscaping elements play a critical role in defining the microclimate of a site. Elements like the amount of hard paving placement of water bodies, placement of shading trees, orientation and location of building blocks etc (H. Altan et al. 2016).

Figure 2.9: Landscaping Features
Source: https://www.firstinarchitecture.co.uk/what-is-an-architectural-site-plan/#:~:text=What%20is%20an,get%20in%20touch!

The amount of hard paving will affect the heat trapped around the building resulting in a heat island effect which will most likely increase the amount of cooling required in a building.

Moisture from water bodies cools the environment naturally with trees and other plants acting as natural buffers and shading devices.

3.0 RESEARCH METHODOLOGY

A descriptive case study research approach was used in studying and understanding the importance of Passive Architectural Illumination and Ventilation of buildings in Yenagoa, Bayelsa State, and how it can be achieved in interior design. This research approach goes beyond the documentation and description of the physical characteristics of the built environment (Oluigbo, 2010). Hence, the findings and results gotten have to be assessed based on specific approaches addressing the research question. This can be in the form of variables that seek to point out certain features of the research facility concerning Passive design approaches.

As such, the variables studied are on the bases of sustainable design principles by extension, passive design strategies with focus on lighting and ventilation techniques used in the design.

4.0 DATA ANALYSIS

Traditional architecture around the world reflects an understanding of local climates, resources, and environmental conditions, developed through centuries of experience and adaptation. Before the widespread use of modern HVAC and artificial lighting systems, architects relied on passive ventilation and lighting to naturally cool, heat, and illuminate buildings, reducing energy needs and creating comfortable indoor environments. These practices varied significantly by region, with unique adaptations reflecting specific climate challenges and resource availability.

Figure 4.1: Landscaping Features

Source: Author (2024)

In Yenagoa, Bayelsa State, these strategies were employed in buildings across different typologies, particularly the use of air vents just below the ceiling level, taking advantage of stack effect principles to cool the spaces. Perforated block walls was also used, which allowed for the maximum flow of cool air, facilitated by Venturi effect, and at the same time, filtered the intense light that entered the spaces throughout the day.

Figure 4.2: Landscaping Features
Source: Author (2024)

Over time, however, the architecture and construction industries became more focused on aesthetics, new materials, and mechanical systems, often sidelining the functional and sustainable benefits of passive design. This shift led to an over-reliance on artificial ventilation and lighting.

Figure 4.3: Landscaping Features
Source: Author (2024)
The decline in the use of passive ventilation and lighting strategies can be attributed to several interrelated factors, including a shift in architectural aesthetics, the rise of mechanical systems, and economic pressures within the construction industry.

Figure 4.4: Landscaping Features
Source: Author (2024)

4.1 AESTHETIC PRIORITIZATION

With the advent of modernist and international architectural styles in the mid-20th century, there was a distinct shift toward sleek, sealed structures featuring extensive glass facades. This design approach, which emphasized uniformity and visual impact, often disregarded climate and environmental context. Architects prioritized a clean, streamlined appearance that could be replicated globally, frequently ignoring regionally adaptive features such as operable windows, shading elements, and ventilation corridors that are vital for natural climate control. These design choices created buildings that looked impressive but required substantial energy inputs to maintain indoor comfort. For instance, the prevalence of glass facades—an iconic modernist feature—led to increased solar gain and glare, which in turn demanded higher energy consumption for cooling and artificial lighting.

4.2 AVAILABILITY OF MECHANICAL SYSTEMS

The widespread adoption of HVAC (heating, ventilation, and air conditioning) systems throughout the 20th century further contributed to the decline of passive design practices. HVAC systems provided a convenient way to regulate indoor environments, enabling architects to disregard natural ventilation, building orientation, and other climate-responsive design elements. This shift was compounded by advancements in artificial lighting technology, which allowed for deeper floor plans with minimal access to natural light. As a result, designers began to rely heavily on artificial lighting, creating interior spaces that were completely detached from outdoor conditions. While these technologies brought greater design flexibility, they also increased buildings' dependency on energy-intensive systems and neglected the potential benefits of passive design.

4.3 MARKET DEMANDS AND ECONOMIC FACTORS

Economic pressures within the construction industry also played a role in the decline of passive design. Rapid urbanization and the need for cost-effective construction solutions pushed developers toward standardized, quick-to-build designs that minimized project costs and timelines. Passive systems, which often require careful integration of building structure, orientation, and environmental analysis, were perceived as less efficient and more costly during the initial design phase. This short-term focus on reducing upfront costs and maximizing immediate profitability often sidelined passive design considerations that could offer long-term energy savings and enhanced occupant comfort. Consequently, buildings became more standardized and less responsive to local environmental conditions, resulting in higher operational costs and environmental impacts over their lifespans.

5.0 RESULT

Evidently, there are ways in which passive design strategies can be incorporated in modern building designs without compromising aethetics or functionality.

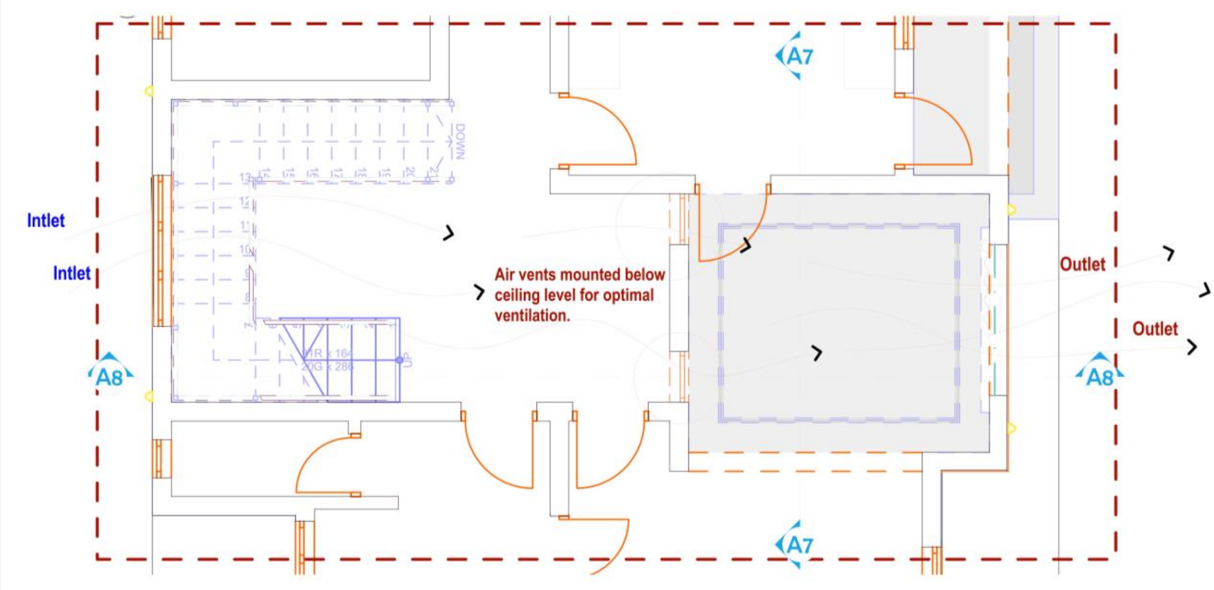


Figure 5.1: Landscaping Features
Source: Author (2024)

5.1 FACADE SHADING DEVICES AND AESTHETIC APPEAL

Modern buildings often times use shading devices on facades to control sunlight penetration, reducing heat gain and glare while enhancing visual appeal. These devices can take the form of louvers, brise-soleil, or perforated metal screens, which are both functional and architecturally striking.

The Brise-Soleil —external shading structures designed to block high-angle sunlight—for instance are popular for large buildings with glass facades, especially in hot climates.

5.2

NATURAL VENTILATION WITH HIGH-PERFORMANCE WINDOWS

Incorporating operable windows and high-performance glazing allows for natural ventilation and cooling in modern designs without sacrificing visual style. Advances in glass technology allow architects to use large windows and still maintain control over heat and light transmission.

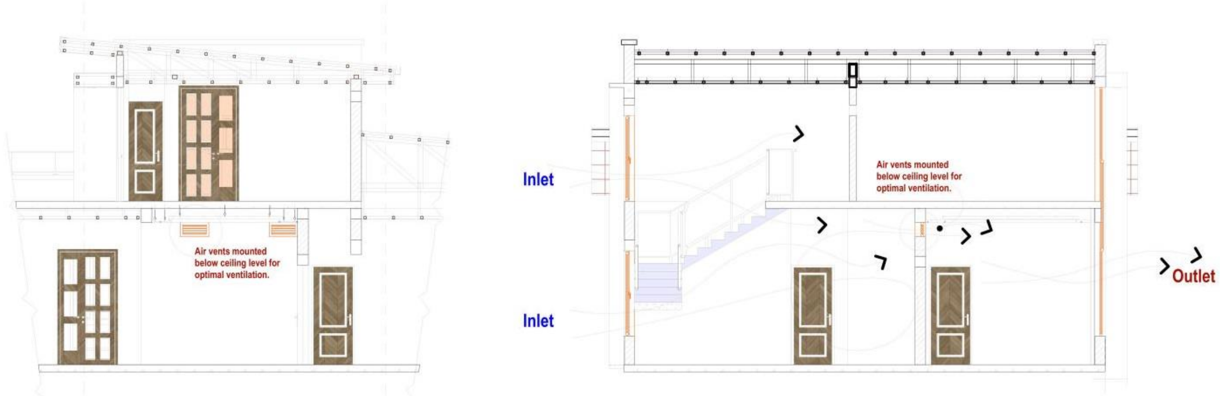


Figure 5.2: Landscaping Features
Source: Author (2024)

5.3 THERMAL MASS AND AESTHETIC INTEGRATION

The use of materials with high thermal mass, such as concrete or adobe, can help to regulate indoor temperatures by absorbing and releasing heat gradually. In modern buildings, concrete and masonry walls are not only functional but also add an industrial aesthetic that is popular in contemporary design.

By rethinking passive design strategies within a contemporary context, architects are able to integrate sustainable features without compromising the aesthetics or functionality in buildings in Bayelsa and other places with similar conditions, demonstrating that buildings can be beautiful, comfortable, at the same time, ecologically responsible.

6.0 CONCLUSION

This research underscores the critical role of passive design in sustainable architecture, illustrating that traditional methods rooted in vernacular architecture continue to provide valuable strategies for modern design. By aligning buildings with their natural environment, passive design utilizes factors like daylighting, natural ventilation, building orientation, and thermal mass to create comfortable, energy-efficient interiors. The study also highlights specific strategies such as façade shading, high-performance glazing, and thermal mass integration, which are viable solutions for architects aiming to balance sustainability, aesthetics, and functionality.

In the context of Yenagoa, Bayelsa, a region marked by high humidity and significant solar exposure, the adoption of passive design is particularly advantageous. The findings reveal that passive systems not only reduce energy consumption but also enhance indoor comfort by naturally regulating temperature and lighting conditions. Moreover, contemporary approaches to passive design, like façade shading devices and high-performance windows, demonstrate that environmentally responsible buildings can retain a modern aesthetic appeal.

In conclusion, reviving passive design principles within modern architecture can lead to buildings that are ecologically sound, visually appealing, and cost-effective over their lifespan. This research advocates for a harmonious balance between form, function, and sustainability, encouraging architects to integrate passive strategies from the earliest stages of the design process. This approach not only respects the environmental challenges but also aligns with the evolving standards of aesthetic and functional excellence in architecture.

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