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EXPLORING METHODS TO ACHIEVING THERMAL COMFORT IN SPAS AND FITNESS CENTRES IN AWKA.

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ABSTRACT

Humans spend the majority of their time indoors, so the quality of their indoor environment greatly affects their well-being. Thermal discomfort negatively impacts human effectiveness and well-being in indoor spaces, so buildings need to be designed to be thermally effective. This is even more so in the growing spa and fitness industry where the main essence is health and wellbeing. Fitness is increasingly becoming a recurring theme in today's society due to the mitigating sedentary lifestyle of many. Arising from the need to keep fit and healthy, well-being and wellness have become a theme in the fitness industry. With the growth of this theme has come an attendant growth in the number of fitness facilities. However, the challenge is that most of these are poorly designed, with little or no attention paid to thermal comfort. This is the situation today in Awka, a growing city with a teeming and increasing middle-class population. It is vital to achieve thermal comfort in these centres as this would go a long way in improving their core wellness services. Two key ways to achieve this are the passive methods that use building materials and natural strategies, and active methods that require appliances like air-conditioners and fans. However, active methods are energy-intensive and can be unreliable in areas with unstable electricity, like Nigeria. Therefore, architects should consider passive strategies for thermal comfort during the early design stages. The qualitative research method was employed with case studies and literature reviews to study the fitness industry and several thermal comfort indices and models, along with a review of Nigeria's climatological mapping, to determine Awka's bioclimatic condition and come up with the recommended strategies. From the findings, recommendations were made on passive strategies that should be adopted by architects in Awka in the design and planning of fitness centres.

Keywords: Health, fitness, well-being, thermal comfort, Bioclimatic, Passive design

Introduction

A building is a structure created for human habitation, work, or recreation. Buildings are crucial in creating the microclimate needed for human survival and for defining spaces for various activities. Buildings modify the microclimate by providing a space that isolates occupants from temperature and humidity fluctuations, wind, and precipitation while enhancing natural light. The indoor environment plays a crucial role in determining the quality of life of occupants. There are interactions between climate, behaviour, building design, and heating, cooling, and insulation technologies. Comfort is even more important in facilities developed for fitness and well-being, particularly in fitness centres.

In the past few years, there has been an increased awareness of the relevance of fitness clinics in the promotion of good health and physical fitness (Adeyeye, 2015). Evidence has shown a greater public awareness of the benefits of physical activity to human and social development. In response to the need to satisfy this growing awareness, there has cropped up series of services ranging from medical services through health and wellness-related services to traditional services. Among the services that have cropped up include the services of spas and fitness centres which are gradually taking up a whole new shape in response to new health and wellness paradigms. This recent increased awareness has given rise to the burgeoning growth of spas and fitness centres all over the world, in Africa and particularly in Nigeria today which is a positive step towards improving the health and fitness status of the populace (Agwubike and Ogbouma, 2010).

This growth however has led to the proliferation of poorly designed or not designed-for-purpose fitness centres with very little attention if any paid to the comfort of the users. This is as seen in a study conducted by Adeyeye (2015), where clients identified a number of issues with several centres including a lack of space in gyms and hazards created by clients, concern about the poor layout of fitness equipment in fitness facilities, specifically, space, overcrowding and ventilation issues. Along with ventilation issues, thermal discomfort is one of the issues that has plagued poorly designed fitness centres.

During hot weather, discomfort can result in lower emotional and physical health, including psychological distress, depression, anxiety, heart disease, insomnia, headache, fatigue, boredom, and poor arousal (Haruna et al, 2014). The impact of the indoor environment on physical and mental well-being cannot be ignored. The human body is exposed to various heat sinks and sources that operate at different rates of exchange. These heat exchanges can be controlled to ensure occupants of a building are thermally comfortable (Heerwagen, 2004). When occupants are dissatisfied with their thermal environment, it can be a potential health hazard and can impact their ability to function effectively and their satisfaction at these fitness centres.

There are two main methods for achieving thermal comfort in buildings: passive and active methods. Passive methods use building materials, finishes and strategies that reduce heat absorption and penetration, while active methods rely on appliances like air-conditioners and fans to control indoor temperature. However, active methods are energy-intensive, and therefore, when designing buildings in places like Awka, Nigeria, with poor and unstable electricity supply, architects should prioritize passive strategies for thermal comfort. This means considering these strategies during the initial sketch-design stage and making provisions to ensure effective levels of thermal comfort. Using passive design strategies to achieve thermal comfort and improve the health of the users, it is believed that some of these issues that have bedevilled the development of fitness centres in Awka can be remedied and ameliorated.

Aim of the Study

This research aims to explore the emergence of the fitness industry in Nigeria and propose a model for the application of indoor thermal comfort strategies in the development of spa and fitness centres in the hot-humid tropical climate of Awka to ensure the health and well-being of the users.

Research Methodology

The research methodology mainly used in this work is the qualitative research method. The qualitative research method is a scientific method of observation that seeks to interpret meaning from these data that help us understand social life through the study of targeted places or populations. It was used to compare the different common thermal comfort models, along with a review of Nigeria's climatological mapping, to determine Awka's bioclimatic condition to arrive at solutions to the issues observed from the case studies. Case studies were employed for the exploration of spa and fitness centres and the issues that face them. This consists of detailed investigations, with data obtained from defined cases to provide an analysis of the context and processes involved in it. Photographs, sketches, interviews, notes and journal articles as were employed to acquire relevant data for this study. Also, several pieces of literature were reviewed in coming up with solutions for the identified problem.

The Study Area

Awka, the capital of Anambra State in southeastern Nigeria, lies between latitudes 6.200N and 6.280N, and longitudes 7.000E and 7.060E. The town has experienced rapid population growth over the years. Its population grew from 11,243 in 1953 to 301,657 in 2006, with an estimated 375,000 persons in 2010.

Awka has a tropical wet and dry climate with distinct wet and dry seasons. The rainy season lasts for about eight of the twelve months of the year, while the dry season lasts for the other four. The region experiences two primary winds: the north-eastern dry winds from the Sahara desert and the south-western monsoon winds from the Atlantic Ocean. The dry season is characterized by a three-week period known as the harmattan, which is exceptionally dry and dusty. Although Awka is located within Nigeria's rainforest zone, pressure from agriculture and commerce has reduced the vegetation to mixed savanna which is now the predominant vegetation in the area.

Establishing Awka's Bioclimatic Condition

Because different climate regions exist, various climatic design criteria have been established by several researchers (Biket, 2006). In Nigeria, several researchers have studied the climate to create classifications used for agricultural and weather prediction purposes. Wladimir Köppen's vegetation-based and empirical climate classification system, known as the Köppen classification, is widely used, and it divides Nigeria into four climate divisions: warm desert climate (BWh), warm semi-arid climate (BSh), monsoon climate (Am), and tropical savanna climate (Aw) (Kottek et al, 2006). However, because this system is not suitable for architectural design, other attempts have been made to fill this gap. Ogunsote (2002) classified Nigeria into six zones for architectural design, while Komolafe's classification produced four climate divisions (Ajibola, 1997; Komolafe, 1988). In a 2020 study on vernacular architecture, Mobolade classified Nigeria into five climatic regions: hot-dry, temperate-dry, hot-humid,

temperate-humid, and temperate-dry with a cool climate. To arrive at these classifications, monthly statistical data were collected from cities across the thirty-six states of Nigeria for five years, and bioclimatic charts were created (Mobolade, 2020). These classifications can be seen in Figure 1.0.

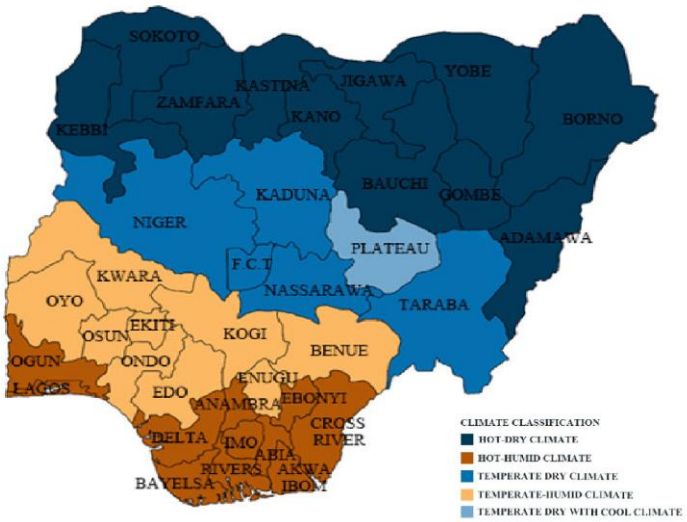


Figure 1.0: Nigeria Climate classification map showing five climatic regions. Mobolade (2020)

From Mobolade's 2020 study, Awka falls in the hot humid region and this is similar to its placement between the hot humid and warm humid zones in Komolafe's classification. Awka has prevalent temperature values of 23℃ and 27℃, and relative humidity between 59% and 90%.

Thermal Comfort Definition, Conditions and Parameters

ASHRAE (2010) and ISO (2005) defined thermal comfort as the state of mind which describes satisfaction towards the thermal environment. ASHRAE (2004) provides that 80% of the slightly active members of that environment under study must be thermally satisfied. The most influential environmental factors in the study of thermal comfort are air dry temperature, mean radiant temperature, air velocity and humidity (Odim 2008, Alozie 2014).

To ensure a healthy and efficient living space, it's important to meet certain comfort conditions that indicate the satisfaction of the user. There are no exact limits to these comfort conditions because it's influenced by various factors, including human dimensions, age, sex, nutrition, form of the body, subcutaneous fat, height and weight, activity, clothing, and personal differences. (Sözen, 2001; Sekhar, 2016). Parameters that affect thermal comfort generally can be divided into personal and environmental categories. Environmental parameters include ambient temperature, ambient relative humidity, ambient air speed, and average radiant temperature, while personal parameters consist of the person's metabolic activity level and clothing. (Bauman & Webster, 2001; Koenigsberger et al, 1973). It's important to consider all of these factors to create a comfortable living environment.

Thermal Comfort Models

Achieving thermally comfortable conditions depends primarily on being able to control all four principal environmental parameters, therefore, what is needed for creating and operating thermally comfortable buildings is some means for relating these four parameters examined. Alternatively, the relational devices that focus specifically on comfort normally indicate what combinations of the parameters will provide thermally comfortable conditions. These relational comfort devices often establish the parametric boundaries, that is, how high or low can the air temperature be; or, for some elevated activity rate, what clothing insulation is appropriate for some set of the four environmental parameters, etc.

Several thermal comfort indices and models have been developed to analyze indoor comfort conditions and to design ventilation systems. Only a few of these have been used to evaluate the satisfactory comfort range that must be achieved by the existing environmental conditions. Generally, the devices that consider only a few of the six parameters necessarily have limited accuracy, but are easier to use and understand. Instead the most comprehensive and, frequently, the most accurate methods are the most difficult and time-consuming to use (Heerwagen, 2004). Some of them mostly aim at defining comfort zones such as Fanger, Humphreys and Nicol, while others tried to define comfort zone and also give climatic design advice such as Olgyay, Givoni and Mahoney's. Five of the most common models are:

Fanger's Model: The Fanger comfort equation relates environment variables, clothing type, and activity levels to the heat balance of the human body (Fanger, 1970). It only applies when a person is in thermal equilibrium with the environment and it does not account for arbitrary climates where the variables may not satisfy the equation. Fanger used the equation to predict thermal sensation using experimental and published data. Fanger's model employs six entry data and gives comfort zone based on them. The entry data must be exact human and environmental factors. His model is not created to give design advice.

Humphrey's and Nicol's Adaptive Model: Humphreys and Nicol studied the thermal neutrality of the human body and found that it's the temperature at which a person feels comfortable. They used lab and field work to investigate different conditions and found that 95% of neutral temperature is linked to outdoor mean temperature (Nicol, 2004). They also created an adaptive model that calculates the neutral temperature for different months and provides a comfort zone for free-running buildings. It's easy to use but not designed to give design advice.

Olgyay's Bioclimatic Chart: Olgyay's chart integrates outdoor climate into building design. It outlines the zones of human comfort in relation to temperature, humidity, wind speed, solar radiation, and evaporative cooling. The comfort zone is in the centre, with winter and summer ranges indicated separately. His model gives up to six design advice, but it is not accurate in all climates. (Olgyay, 1963)

Givoni's Bioclimatic Chart: The Givoni model is a bioclimatic chart used to achieve human comfort in buildings (Givoni, 1992). It identifies 14 zones based on temperature and humidity levels. He gives architectural strategies that can be used to achieve the comfort zone if conditions are outside the comfort zone. Givoni's chart uses two data

entry points to make up to eight design recommendations. It is mostly used for climatic design advice.

Mahoney's Architectural Association Model: The Mahoney Model is a methodology for building design that considers climate in three stages: sketch, plan, and element design. It uses four climatic data points to offer 11 design suggestions and 24 comfort conditions. The model focuses on architecture and provides guidance for various stages of design.

Summary of the Different Models

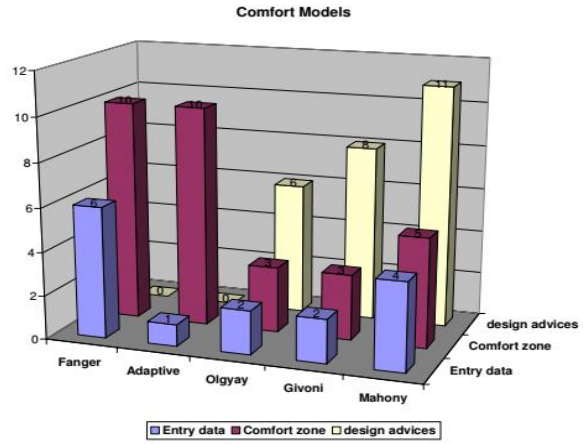


Figure 1.2: Results from all comfort models

Figure 1.2 summarizes the different models showing that Fanger and adaptive models, as they are designed, are very good for defining comfort zone, also the Mahoney model is the best for design advice. Givoni and Olgyay models are working with pictures rather than charts so more easily could be used by architects although they have very rough comfort zones.

Findings

From Mobolade's 2020 study seen earlier, Awka falls in the hot humid region and this is similar to its placement between the hot humid and warm humid zones in Komolafe's classification. Awka has prevalent temperature values of 23°C and 27°C, and relative humidity between 59% and 90%. Attendant to this, the strategies given by Givoni's bioclimatic model for achieving thermal comfort in the Hot Humid tropical climate is discussed below and would be adopted for ease of use with its entry data and design advice.

The Givoni Model Strategies for the Hot-Humid Climate

The Givoni diagram, shown in Figure 1.3, is a bioclimatic diagram that has been divided into different zones for which it is necessary to use strategies to achieve human comfort within a building.

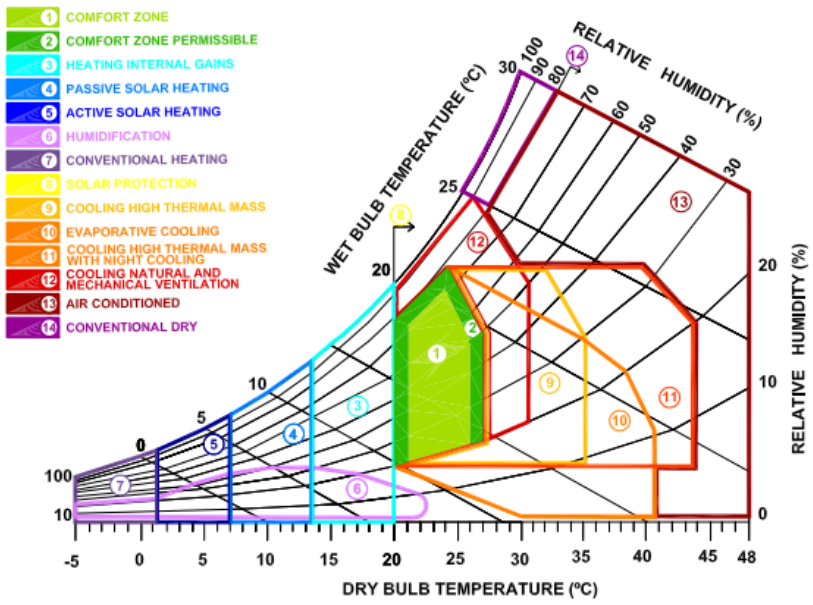


Figure 1.3: Givoni's bioclimatic chart showing the different comfort zones. (Givoni, 1992)

The x-axis represents the dry bulb temperature and the y-axis shows the fresh air humidity; psychrometric curves in the graph represent the relative humidity. As stated in the above-mentioned figure, 14 zones are defined based on previous definitions of bulb temperature and fresh air humidity. From there, zones 1 and 2 are the ideal comfort zones. Thus, we can define climatic conditions and the associated architectural strategies to shift the environmental conditions of the home into the comfort zone. To study the possible bioclimatic architectural strategies, we must first evaluate the conditions in which the home is located. The environmental conditions will place us within a zone in the Givoni diagram. If we are in the comfort zone, architecture will not have to perform any thermal corrections. If we are outside of the comfort zone, architectural strategies can be implemented to reach the comfort zone.

The climate of Awka (hot humid zone) falls within zone 12 in Givoni's chart and is outside the comfort zone and permissible comfort zones as shown in the chart (zones 1 and 2), therefore, architectural strategies are needed to move the bioclimatic conditions to the comfort zones for longer periods. Based on Givoni's model, the zone 12 strategy is cooling through natural and mechanical ventilation

The zone 12 is bound by temperature values between 20.1C and 31.5C, relative humidity between 95% and 20% and a dotted line that extends from an intersection at 31.5C and 50% relative humidity to another intersection at 26.5C and 95% relative humidity. Here, a greater thermal sensation is achieved while the indoor air is simultaneously cleaned. According to Givoni's design advice, thermal comfort here can be achieved naturally using cross-ventilation from north to south facades or dominant winds, the chimney effect, a solar chamber, subterranean ventilation,

wind towers, evaporative towers, vertical spaces within a building or patios. Additionally, this effect can be achieved mechanically using fans or blowers.

Going by this, passive architectural strategies are necessary to move to the comfort zone for longer periods.

Passive Design Strategies for Thermal Comfort in Awka

Passive design is design that takes advantage of the climate to maintain a comfortable temperature range in the home. Using passive design, building form and thermal performance of building elements (including architectural, structural, envelope and passive mechanical) are carefully considered and optimized for interaction with the local microclimate. Passive design aims to minimize or fully eliminate requirements for active mechanical systems (and associated fossil fuel-based energy consumption) and to maintain occupant comfort at all times. Even though the ultimate aim of passive design may not be achieved in every building, implementing the passive design approach to the fullest extent possible will lower building energy use. Thermal performance and efficiency of buildings should be measured through climate-responsive design. The use of site and climate for design with regard to thermal efficiency has further potential for reducing active energy which is the operational energy of the building.

Ways of moderating building bioclimatic conditions include the choice of proper site of the buildings, developing proper shape and size for the buildings, proper orientation of the buildings, providing good ventilation, providing adequate window sizes for natural ventilation, providing appropriate vegetation and selecting adequate building fabrics.

These strategies closely mirror the three basic approaches to passive cooling architecture given by Odim (2012). These approaches are:

- Solar control or protection,
- Heat dissipation, and
- Heat modulation.

In Awka (the hot humid climate), only solar protection and heat dissipation apply.

Solar Heat Gain Control

Solar heat gain control aims to avoid or significantly reduce direct solar heat gain using building enclosure features. Site design considerations, architectural forms and elements, and building fabrics all help with this. Building and landscaping features for consideration here include:

Building location and orientation on site: To minimize the impact of directly reflected or emitted solar radiation, it is recommended to position buildings on the northern slope of hilly or undulating areas. It is also advisable to avoid positioning buildings in valleys. To further reduce solar heat gains, it is best to orient the main axis of the building along the East-West compass axis line. This can be achieved by incorporating more envelope openings on the North and South elevations, reducing openings where possible, and using blank walls on the East-West elevations.

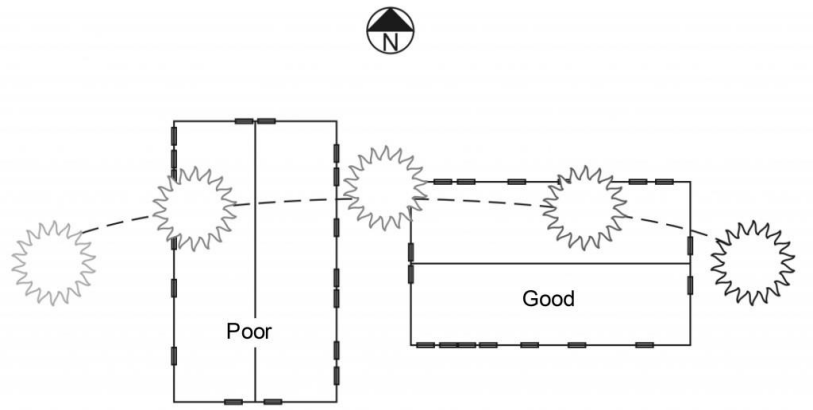


Figure 1.4: *Proper orientation and positioning of building on site. (Lurke, 2022)*

Site vegetation: To prevent direct radiation from entering a house through its walls, it's important to avoid West and East Low-angle rays. Planting trees on the west and east sides of a building can help minimize this type of radiation. Additionally, vegetation can help cool the air flowing into the building.

Site land massing: To ensure proper air circulation in humid conditions, it's recommended that buildings be situated away from perimeter walls and spaced out from each other.

Building form and layout: To improve the natural ventilation and cooling of occupants in the building, it's recommended to organize the floor plan in a single-banked layout. This design allows for easier air movement throughout the building with less resistance. Also where possible, central courtyards should be adopted too.

Roof overhangs: Provide covered walkways between buildings for protection from the sun: Due to the intense solar radiation on clear days, covered walkways will provide more comfort by shading. Create extensive overhangs beyond the planes of the vertical wall envelope. This will serve as a shade from solar heat gain in the building interior.

Shading: To minimize the heating effect of direct solar radiation entering the structure through big envelope openings, shading devices like window hoods, overhangs, internal blinds, curtains, and louvres, should be used. These shading options will help reduce solar heat gain while still allowing for airflow throughout the building. Also, wing walls and other vertical shading devices adjacent to envelope openings should be considered. These vertical devices are especially effective when the incident wind is not perpendicular to the window.



Figure 1.5: *Use vertical and horizontal shading devices to minimize direct solar radiation*

Type of materials and finishes: For the building's exterior surfaces, it is recommended to use finishes that are smooth and light-coloured. These surfaces can reflect solar radiation and absorb minimal amounts of it, resulting in less heat transfer through the building envelope. When selecting materials for floor assemblies, it's important to ensure that they are treated adequately to withstand the warm humid climate. This includes treating wood to prevent moisture, organic degradation, and insect attacks, and treating steel to prevent corrosion and rusting. It's also recommended to use concrete casting as slabs on grade for on-the-ground flooring.

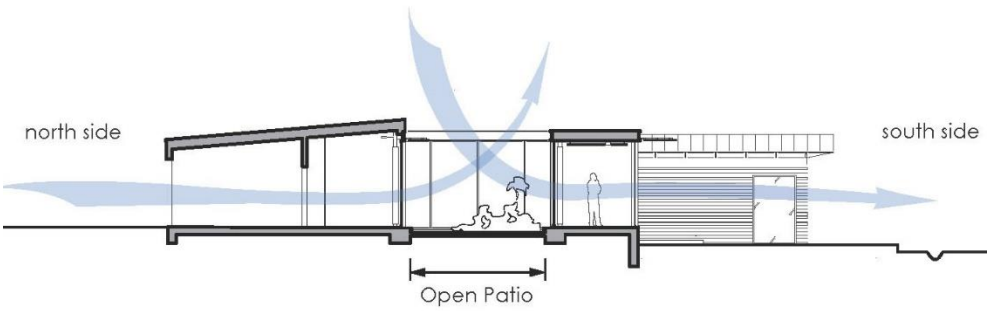
Heat Dissipation

Heat dissipation is aimed at evacuating or removing undesirable heat from building spaces or elements by:

Building forms: Building forms that lift the primary living and working areas off the ground are better for air movement in the hot humid climate. This is because the ground forms and objects close to the ground offer resistance to airflow. Raising the building on columns can achieve better natural ventilation. For open building envelopes that allow the passage of external airflow, large open areas should be deployed on the elevations into and from the prevailing winds and at wall heights suitable for encouraging airflow across the occupant - whether sitting or standing. For buildings in hot dry climates, smaller opening sizes are desirable.

Natural Ventilation: it's important to design spaces with cross ventilation. This means having both a windward and a leeward opening to ensure air movement across the space, which aids in convective and evaporative cooling. The size and position of these openings are also crucial for proper ventilation. It's important to direct the air movement at the body surface through the space that is mostly used by the occupant.

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Induced ventilation: When there is not enough wind at human occupational levels, induced ventilation can be considered with methods like stack-effect, solar chimneys, wind towers, wind scoops, greenhouse attachment, or thermosiphon systems.

- Stack-effect: This can be applied by employing stack ventilation for promoting air movement through building spaces in which wind-driven airflow is inadequate: Air with higher temperature is lighter and therefore less dense than air with lower temperature and higher Because the weight of heated air is less, therefore, it goes up and allows the space created to be occupied by denser air. The cooler air stays down and cools the occupants.
- Wind tower: A wind tower is a structure that extends from a building's interior and is open on all sides at the top to capture the wind. It has been used for hundreds of years to provide natural ventilation in buildings. Its purpose is to catch the cooler breeze found at higher levels and direct it into the building's interior.
- Solar Chimney: This is an interior vent in a building that extends from the roof and is designed to capture solar heat. It is typically narrow in section and black in colour to maximize heat absorption. The heated air in the vent rises, creating a temperature difference that causes air to flow out through the top openings and in through the bottom openings. This process, known as the stack effect, is influenced by the height of the openings. Stack pressure can therefore be employed to bring outside air into the building. By utilizing this pressure, fresh outside air can be brought into the building, aiding in the cooling of occupants and reducing heat gain in the building's envelope.

Evapotranspiration: Evapotranspiration is the process by which water vapour from land is released into the atmosphere through plant leaves. Plants strategically placed around buildings can cool the surrounding area through this process. The rate of evapotranspiration depends on the depth of roots, foliage characteristics, plant maturity, soil cover, solar radiation, humidity, temperature, and wind.

Evaporative cooling: Introducing water into a hot and dry space, in the form of pools, fountains, or swamp coolers, can increase the air's humidity and produce cooling effects through evaporation. Similarly, spraying water on roof decks can also create evaporative cooling for both the decks and the spaces underneath

Conclusion:

Exploring methods to achieve thermal comfort in spas and fitness centers in Awka through passive design offers sustainable and effective solutions. Passive design utilizes the natural elements and features of the building to regulate temperature, humidity, and air quality, creating a comfortable environment for occupants. This article delved into various passive design strategies that can be implemented in these facilities to enhance thermal comfort.

Passive design techniques use natural elements like orientation and insulation to maintain comfortable indoor conditions, reducing the need for mechanical heating and cooling, and saving energy. Building orientation is important for passive design. Maximizing exposure to natural light while minimizing heat gain can regulate indoor temperatures. North and south-facing spaces and minimal east and west-facing glazing can achieve this. Good insulation minimizes heat transfer, maintains stable temperatures, and improves thermal comfort. Walls, roofs, and floors must be insulated with high-quality materials to reduce heat loss and gain. Shading strategies are effective in preventing excessive solar radiation and heat gain. Installing shading devices, such as overhangs, awnings, or louvers, on windows and glazed areas can help block direct sunlight while allowing diffused light to enter the space. Strategic placement of operable windows, vents, or skylights allows for natural ventilation in passive design. Cross-ventilation can improve indoor air quality and regulate temperature by facilitating the movement of fresh air through openings on opposite sides of the building.

Recommendations

Based on the exploration of passive design methods to achieve thermal comfort in spas and fitness centres in Awka, the following recommendations are proposed:

1. Provide for solar heat gain control and protection measures during the design stage: These measures aim to avoid or reduce direct solar heat gain using architectural and site features. Adequate site design considerations, proper building placement and orientation on-site, use of architectural forms and elements like shading devices, and use of suitable building materials all help with this. For these to be properly employed, there should be a proper analysis of the proposed building site before the commencement of full design proposals.

2. Consider heat dissipation measures: These are measures aimed at removing or evacuating undesirable heat from building interiors. This is mostly achieved through provisions for natural ventilation and induced ventilation like the use of the stack effect. These measures are incorporated during the design stage and implemented during the construction of such facilities. This also should be prioritized.

3. Educate occupants and staff: Raise awareness among occupants and staff about the benefits of passive design and encourage their participation in energy-saving practices. Provide guidance on opening windows, adjusting blinds, and utilizing natural light to enhance comfort.

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