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A STUDY OF PASSIVE STRATEGIES FOR BUILDINGS TO ACHIEVE THERMAL COMFORT IN COMPOSITE CLIMATE

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Abstract: Presently architects are using many passive strategies to create sustainable buildings. Few buildings are designed with passive strategies in the composite climate of Lucknow. This paper is talking about passive strategies which can be used in the buildings in Lucknow. It also recommends various passive technologies to be preferred while designing any building in a composite climate to achieve lowering the temperature and provide thermal comfort within the building.

1.1. INTRODUCTION

The term "passive strategies" refers to techniques that use the climate and natural elements to maintain a comfortable temperature within a building while reducing or eliminating dependence on mechanical systems for heating, cooling, and lighting is called 'Passive strategies'. Climate and comfort are two factors that must be considered in order for the passive design to be beneficial and effective. The project's choice of passive design principles is heavily influenced by the local climate. Integration of these strategies aids in the transformation of building envelopes into live organic creations that can support human life.

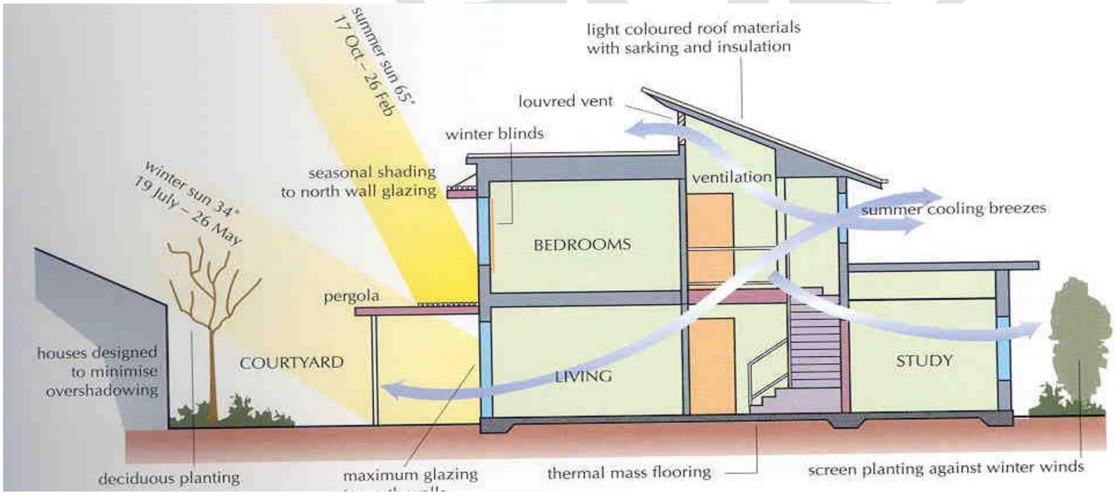

Figure 1 Passive design strategies are typically used in new construction
(Source: Green home technology center)

2.1 ANALYSIS OF CLIMATIC DATA OF LUCKNOW:
CLIMATE DATA OF LUCKNOW

Latitude and Longitude:

The capital of Uttar Pradesh is Lucknow, which is situated between 26.30 and 27.0 North and 80.30 and 81.13 East at a height of roughly 128 meters above sea level. Lucknow has a total size of 3,244 square kilometers.

2.1.1 TEMPERATURE RANGE

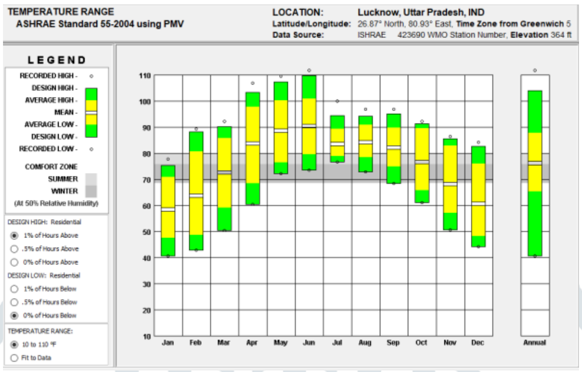

Figure 3: Temperature range chart

Source: Climatology and solar data for India

- The annual diurnal range of temperature is high i.e. 19.4 degrees Celsius a result days are hot and nights are comparatively cold.
- From mid-November to February, Lucknow has a composite climate with mild, dry winters with mean monthly minimum temperatures of 5 degrees Celsius and dry, hot summers with thunderstorms from late March to June, with mean monthly high temperatures of 45 degrees Celsius. Furthermore, there are approximately 4-6 days of heat waves in summer when the maximum temperature of a day rises to 4-6 degrees Celsius above normal values, and the temperature may fall to 3-4 degrees Celsius for a few days in winter when the cold winds from the Himalayan region make the winters chilly.

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2.1.2 PRECIPITATION CHART

- Therefore humidity is high in monsoon and low in summers.

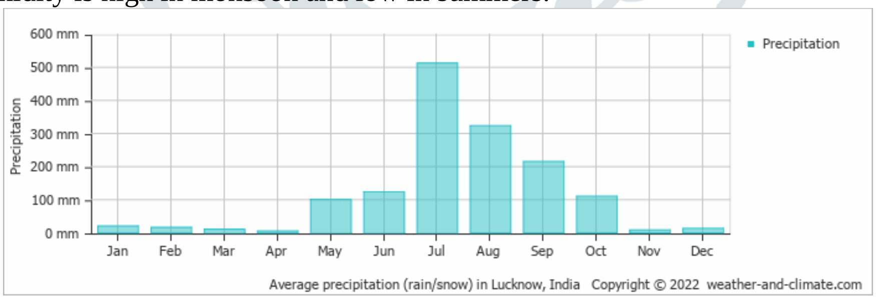

Figure 4-.Precipitation chart of Lucknow

Source: Weather and climate.com

- The months of May, June, July, August, September, and October see a lot of rain (rainy season).
- January, February, March, April, November, and December are all dry months in Lucknow.
- July is the wettest month on average, with 512.0 mm (20.16 inches) of rain.
- The average annual precipitation is 1450.0 millimeters (57.09 inches)

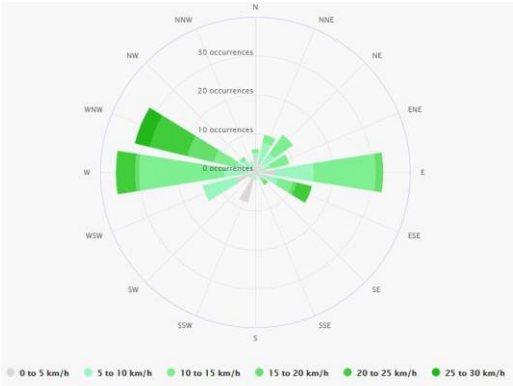

Figure 5. Wind graph of Lucknow

- The prevailing wind direction of Lucknow is westerly and the average wind speed is 1.87m/s.

2.1.3 BIOCLIMATIC CHART

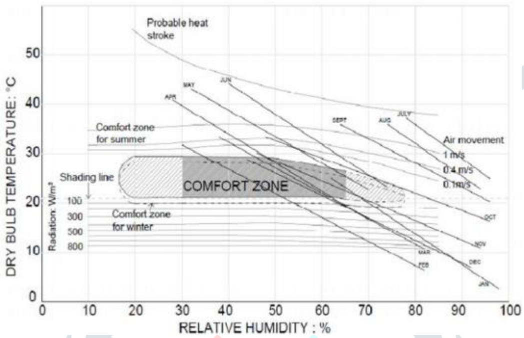

Figure 6-. Bioclimatic chart of Lucknow

INFERENCES

- The Chart shows that the days of April and May, as well as the nights of February, March, and November, are pleasant.
- Furthermore, wind speeds of 1 to 2 m/s and window shade could make the hotter months of May, June, July, August, September, and October more bearable.
- Colder months can also be made comfortable by absorbing solar radiation in January, February, November, and December.

2.1.4. SUN PATH AND SHADING DEVICES

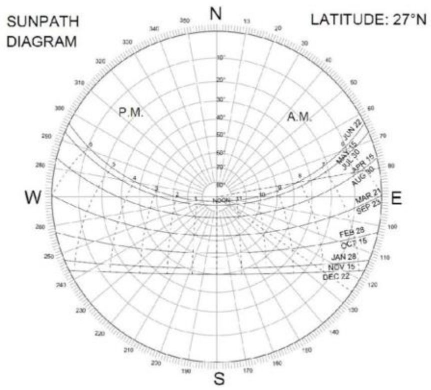

Figure 7- Solar Chart of Latitude 27 degrees North of Lucknow

INFERENCES

- We can retrieve horizontal and vertical shading angles from this shading mask.
- Only the morning and evening sun shines in the north, which can be shielded by 400mm vertical fins.
- Because the sun shines brightest in the south, a shading mask is developed to block the summer sun while allowing the winter sun to shine through. An overhang with little fins would work well for this purpose. The work of designing shade devices for east and west directions is particularly tough because the sun's rays are nearly vertical and the intensity of the radiation is also considerable.
- As a result, vertical fins suited for certain directions are parallel to the window.

3. PARAMETERS FOR CLIMATE RESPONSIVE BUILDING DESIGN

The goal of climatically responsive design is to keep the outside and inside environments as near to or as close to the comfort zone as possible. Because the prevailing climatic conditions are often harsh for much of the year, the necessity of building design in modifying the inside conditions to suit the occupants cannot be overstated. The difference between natural climatic conditions and a thermally comfortable built space can be mitigated by incorporating appropriate site planning, building form, envelope materials, opening, daylighting, and other factors into a climate-responsive building design, without relying on active measures.

The design begins with the context as the most significant parameter, with the geographical location as well as the local climate playing a critical role. The recommendations are likewise broad and not tailored to India's climate zones. (Arvind Krishan 2014)

4. PASSIVE DESIGN STRATEGIES FOR COMPOSITE CLIMATE

A set of climate-sensitive passive design characteristics, in addition to the passive design tactics mentioned in the preceding sections, can favorably contribute to a building's cooling or heating demands. The next section examines a variety of optimal design solutions for cooling and heating, as well as their applicability and benefits. In addition, the intangible benefits of passive design solutions to human comfort and wellbeing are highlighted in this section. (Hanan M. Taleb 2014)

4.1 EVAPORATIVE COOLING

The effect of evaporation as a natural heat sink is used in this traditional passive cooling approach. When hot, dry air comes into contact with water, it begins to evaporate due to the latent energy absorbed from the air. As a result, the air becomes cooler as the relative humidity ratio rises (Cuce and Riffat 2016). The climate suitability of this method is determined by the temperature and humidity levels in the area under consideration (Givoni 1994).

- Evaporative cooling reduces the temperature of interior air by evaporating water.
- As the surface area of water and air comes into contact with each other, the rate of evaporation increases.
- A water feature near the structure, such as a pond, lake, sea, or a fountain in a courtyard, might give a cooling effect.

4.2 COURTYARD EFFECT

The air in the courtyard becomes warmer and rises as a result of the incident solar radiation. Cool air from the ground level replaces it and creates the airflow through the room's louvered vents. The technique is inverted when it comes to during the night. As the warm roof surface cools from convection and radiation, it reaches a point where its surface temperature equals the ambient air's dry bulb temperature. Cooled air sinks into the court and enters the living space through low-level apertures and exits through higher-level openings if the roof surfaces are sloped towards an internal courtyard. In a hot and humid area, this approach could be quite useful. To create a draught through the interior, the courtyard must get sufficient radiation. A twin courtyard design, in which one courtyard is kept cool by shady trees/vegetation while the other courtyard is exposed to the sun, can maintain an airflow inside the room.

(greenepots.com)

4.3 LANDSCAPE DESIGN

When it comes to keeping neighborhoods and homes cool, the landscape is crucial. As climate changes and urban growth accelerate, its impact on controlling urban heat is becoming more widely recognized. Outdoor spaces around your house might serve as a source of heat. Roofs with green roofs might also benefit from additional insulation. Shaded regions near earth-coupled slabs can assist keep daytime surface ground temperatures lower while still allowing nighttime cooling. In many regions, poorly shaded surroundings can cause ground temperatures to surpass indoor comfort levels. An earth-coupled slab can become an energy burden in this situation.

4.4 JALI

The issue with building in hot-humid and composite climate climatic zone is to reduce cooling loads while increasing day lighting and glare management. External shading is a cost-effective passive design method for lowering energy needs while improving occupant thermal and visual comfort in hot conditions. According to previous studies, light wood screens with broad perforations (80-90 percent) would save the most energy in residential structures, saving up to 30%. However, this high penetration % is not suited for big veiled facades such as Jali stone or marble screens in commercial buildings, according to this study. It argues that vernacular examples with 30-50 percent perforations might give a better design that balances energy savings and comfort. On comparing the effects of different perforation ratios ranging from 30 to 50 percent in increments of ten percent on energy and indoor thermal and visual comfort. The 30% Jali screen perforation is best for hot-arid cities, while a 50% Jali perforation is better for hot-humid cities with the 40% perforation is ideal for hot-moderate cities. (Ihab M.K. Elzeyadi 2017)

4.5 EARTH AIR TUNNEL

This technique can work if the ground beneath it has a high thermal capacity, such as soil with sufficient water content. The following are the design fundamentals that are commonly followed (based on several existing systems) At a depth of roughly 4 m below ground, the temperature inside the earth is practically constant year-round and is nearly equivalent to the place's yearly average temperature. A tunnel in the form of a pipe or otherwise embedded at a depth of about 4 m below the ground will acquire the same temperature as the surrounding earth at its surface, and thus the ambient air ventilated through this tunnel will be cooled in summer and warmed in winter, and this air can be used for cooling in summer and heating in winter.This technique was employed in RETREAT in Gurgaon's composite climate. (yourhome.gov.au)

4.6. ORIENTATION FOR PASSIVE HEATING

Daytime living rooms should face north for the best passive heating efficacy. True north is the best direction, however, orientations up to 10 degrees west of north and 20 degrees east of north can still provide considerable passive solar gain. Where solar access is limited (for example, if the sun is blocked by surrounding houses or other buildings, as is common in urban areas), smart design can nevertheless result in an energy-efficient building. Alternative passive solutions can be used to boost comfort and minimize heating costs in homes that are poorly oriented or on narrow blocks with limited solar access. (yourhome.gov.au)

4.7. THERMAL MASS FOR PASSIVE HEATING AND COOLING

Thermal mass should be placed where it will be exposed to direct sun radiation or radiant heat sources (for example, near north-facing windows, or next to a heater). Because thermal mass absorbs both radiant heat and solar radiation, it's a good idea to place thermal mass walls between northern living spaces and southern sleeping areas. Through thermal lag, these will transmit daytime solar gains into sleeping rooms at night, as well as provide a noise barrier. Thermal mass is heated or cooled by air movement within the building. Place the mass away from cold draught sources (such as doors) and expose it to the building's convective warm air circulation. Insulate all slab edges and underside sections of the slab on the ground where the indoor surface is exposed to direct solar radiation in cold climes. In south-facing rooms, low thermal mass materials and high degrees of insulation should be used. (yourhome.gov.au)

5. CONCLUSIONS

The chapter presented a discussion of passive design methods in general, as well as the methodologies and benefits of employing them not just in building design. The key to creating a passive building is to make use of the local climate (microclimate), therefore climate characteristics and classification can aid in identifying approaches during site planning and analysis. As a result, the two most important factors to consider in passive design are climate and comfort. Passive design is an important aspect of environmental design, and it employs a variety of techniques and tactics to accomplish the sustainable design. Patterns of biophilic design are also used to improve health and well-being in the built environment.