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Application of Passive Techniques to Achieve Thermal Comfort and Minimize Energy Consumption: A case of Office Building in Composite Climate, India

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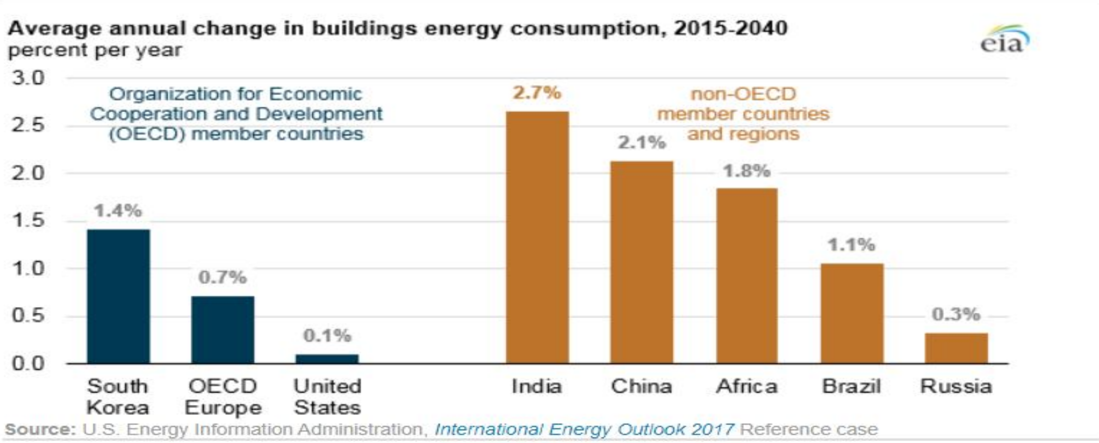
Abstract: Approximately 5% of India's total construction currently embraces sustainable design, indicating significant potential in the Indian market. The key to successful building design lies in the integration of both passive & active techniques. Emphasizing passive strategies are essential due to their cost-effectiveness & superior efficiency compared to active methods. For truly achieving sustainability it is imperative to prioritize passive strategies tailored to the local climate. Active techniques should function as supplementary elements rather than overshadowing passive approaches. The study concentrates on comprehending passive design strategies specific to India's composite climate by analyzing case studies of various office buildings. The investigation delves into passive strategies such as orientation, fenestration, shading devices, earth touch, roof gardens, water features & landscaping. The proper use of passive techniques promotes energy saving.
Keywords: Passive techniques, Thermal comfort, Composite Climate.

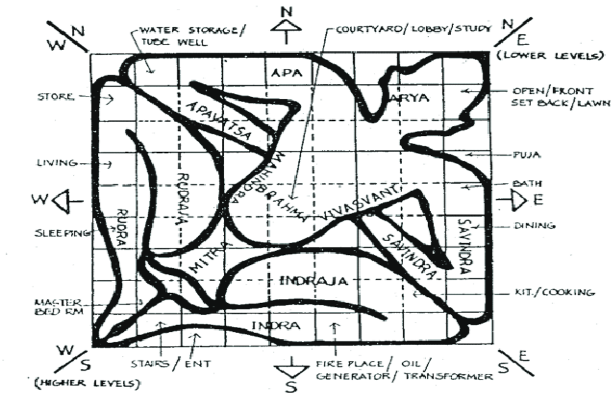
I. INTRODUCTION

Among all regions of the world, the fastest growth in building energy consumption through 2040 will occur in India (EIA's International Energy Outlook 2017). Energy consumption for residential & commercial buildings in India is expected to increase by an average of 2.7% per year between 2015 & 2040, more than twice the global average change.



Commercial buildings (Offices, hotels & shopping centres etc.) are the third largest consumers of energy after industry & agriculture. In the pursuit of sustainable & energy-efficient building design, the integration of passive techniques has emerged as pivotal approach to enhance thermal comfort & minimize energy consumption.

Use of Passive design is not new for India. It is being used from Vedic Era such as Mahabhuta (five basic elements of nature) i.e. Akash(space), Jal(water), Agni(fire), Prithvi(earth) & vayu(wind) for design of building. This technique is known as Vastu shastra.
Vastu Purush mandala was used for building design as per climate.



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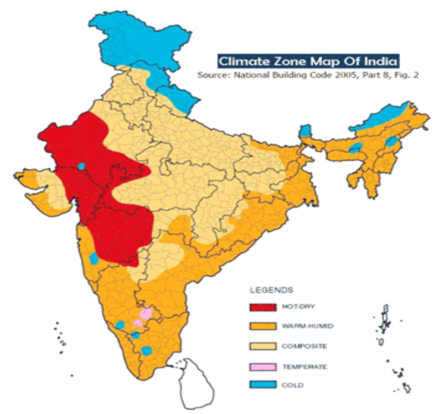
II. CLIMATIC ZONES OF INDIA

India is divided into five climatic zones as given below:

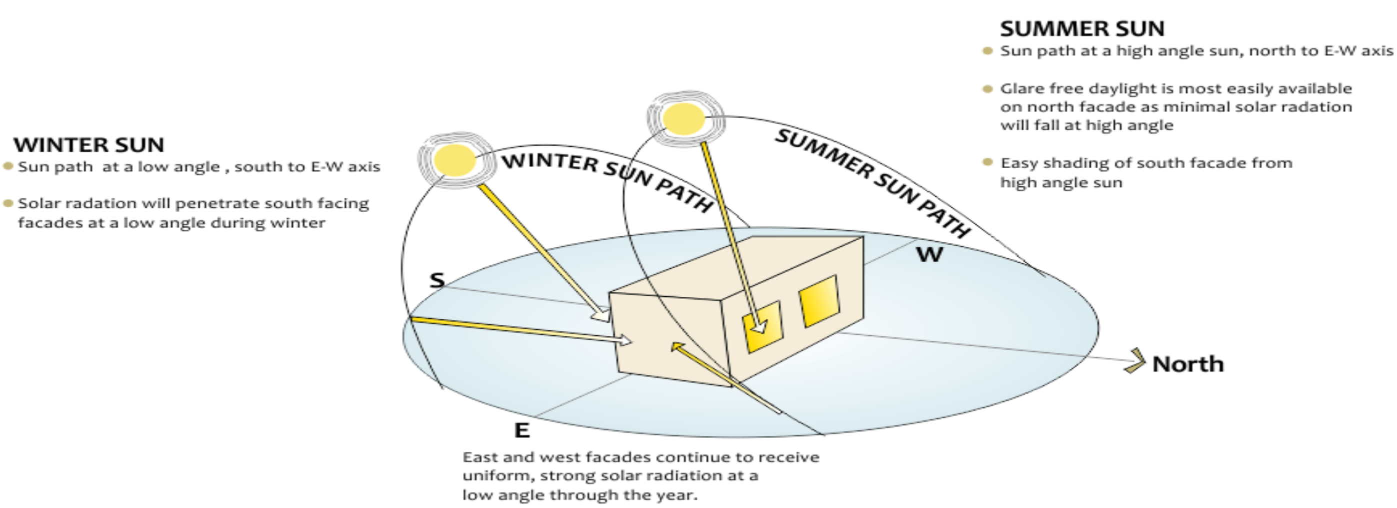
1) Moderate/ Temperate climate
2) Hot & Dry climate
3) Warm & Humid climate
4) Cold climate
5) Composite climate

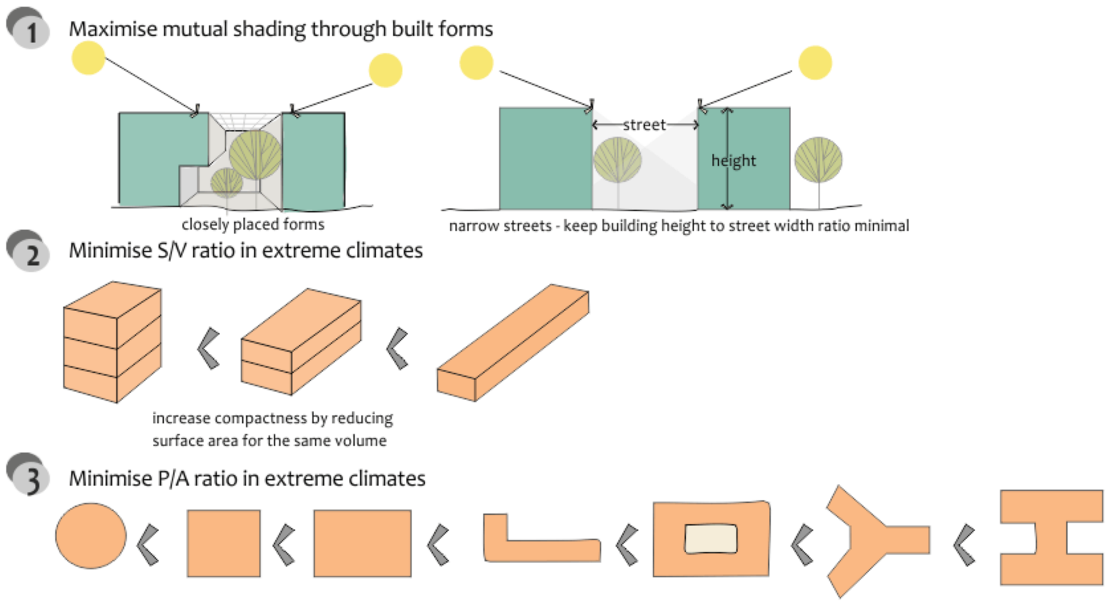


Source- http://high-performancebuildings.org/climate-zone.php

III. PASSIVE DESIGN STRATEGIES FOR COMPOSITE CLIMATE

1) *Form & Orientation*



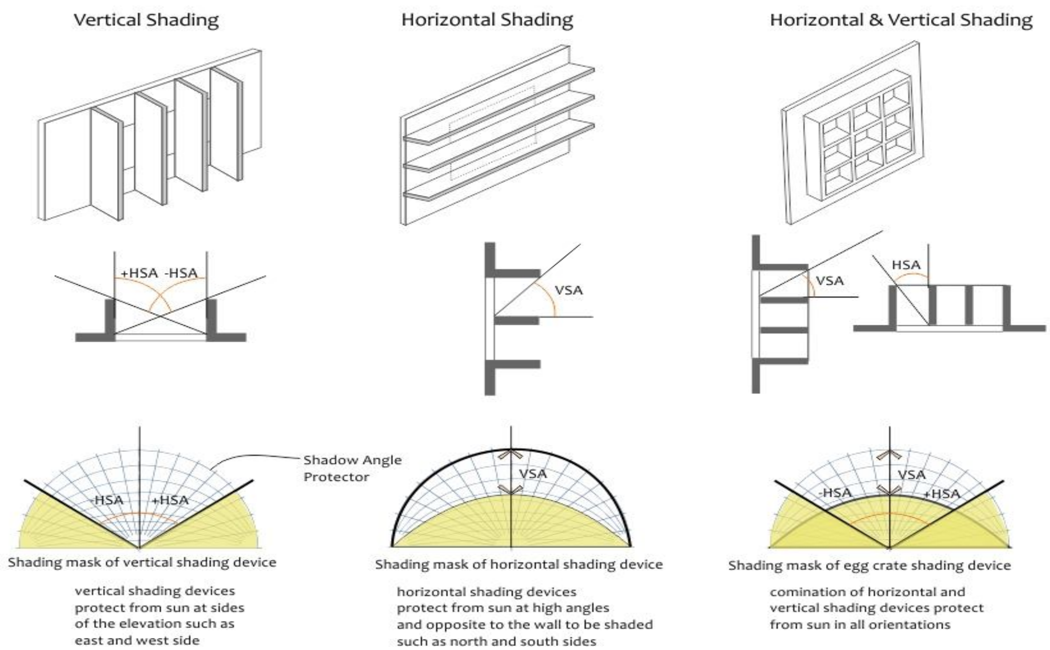


Source:https://nzeb.in/knowledge-centre/passive-design/form-orientation

Recommendation

a) Compact form with low S/V ratio
b) A square plan with a courtyard would be very effective
c) North-South orientation is preferable
d) East & West orientation should be protected by buffer spaces, shaded walls etc.

2) Shading



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Recommendation

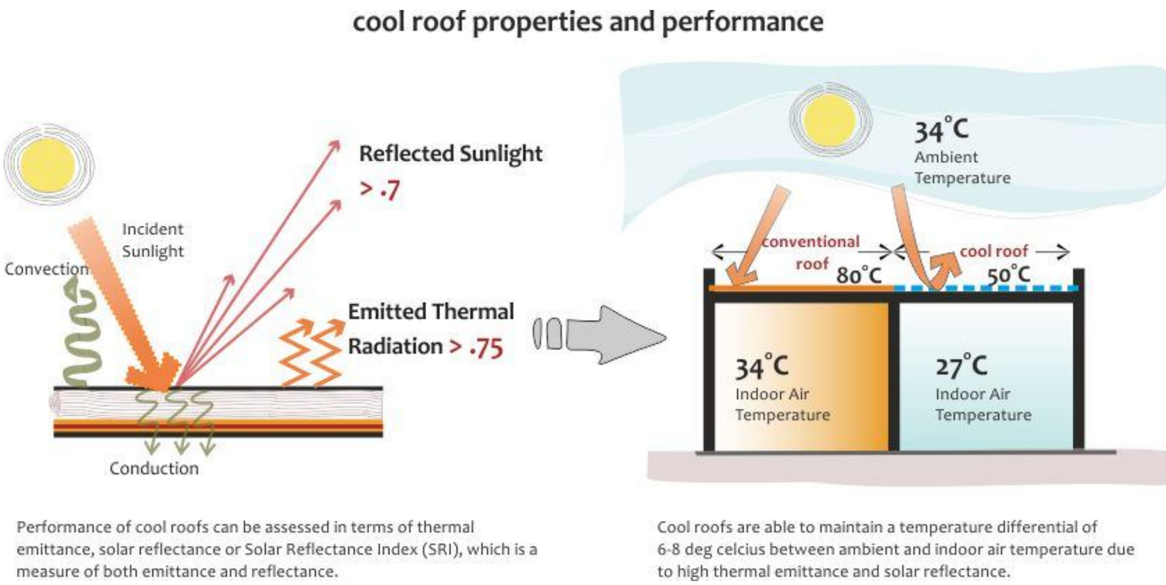
a) Overhangs on south oriented windows provide effective shading by blocking summer sun & admitting winter sun. 1m horizontal overhang is enough to reduce cooling loads substantially.

b) Shading is not required in north side. Internal blinds are enough for cutting the low evening summer sun.

c) Minimize the window opening in east & west side as they are harder to shade.

3) C ool Roof

Cool roof use solar-reflective surfaces to maintain lower roof temperatures. High reflective & light coloured roofs have now become an inclusive part of energy efficiency measure in a building.



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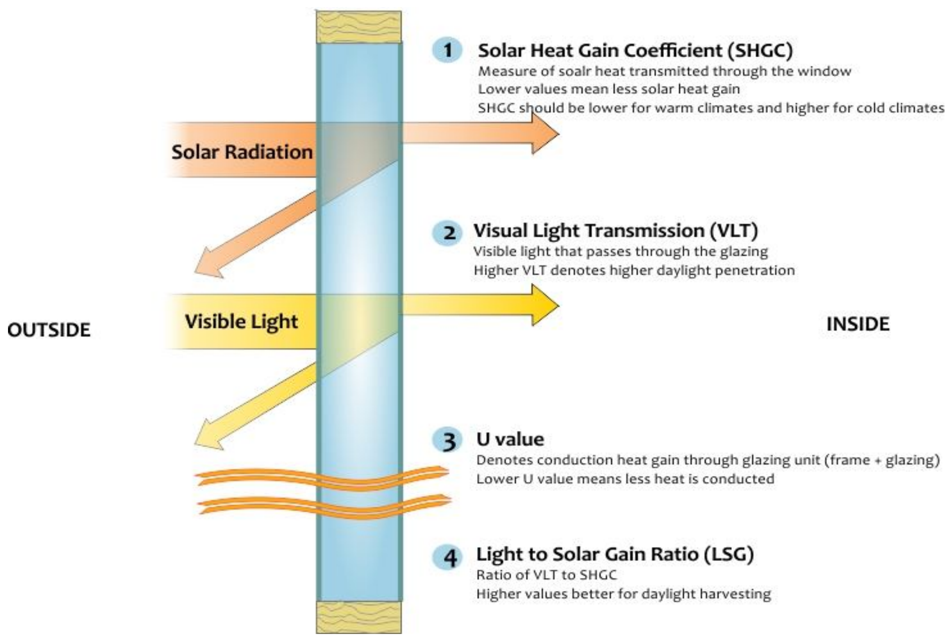
4) Fenestration

Fenestrations (windows, skylights & other openings in a building) allow daylight & the prevailing wind inside the building when needed.



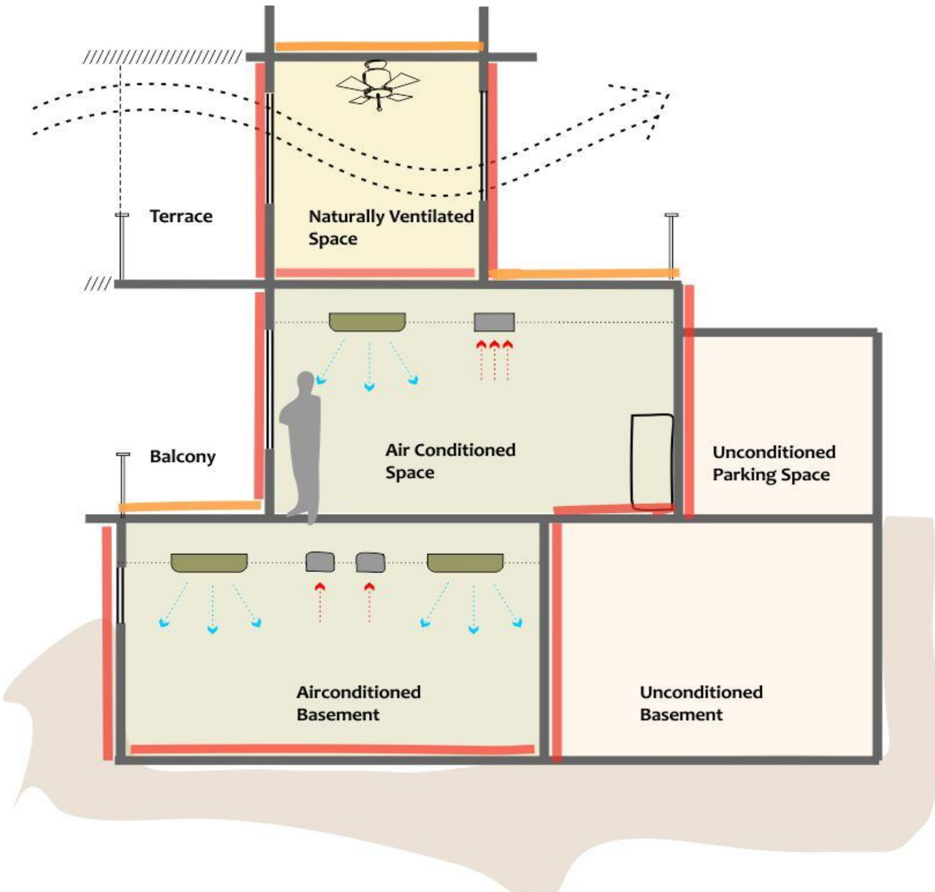
Source:https://nzeb.in/knowledge-centre/passive-design/form-orientation

Recommendations

a) Reduce Solar Heat Gain Coefficient (SHGC) as less heat will be transferred into the building.
b) Reduce the U-Value of glazing.

5) Insulation

a) Insulation should be placed at the hotter side of the surface (in case of summer cooling, insulation should be on outer side, while in case of heating the building, insulation should be placed on the internal side).
b) Thermal performance, lifetime time performance, fire safety, moisture , condensation, air filtration & environmental benefits must be consider at the of selection of insulation material.



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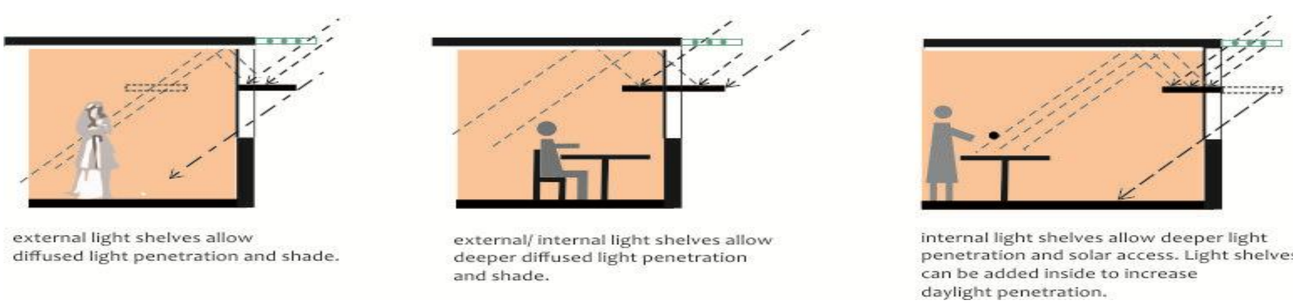
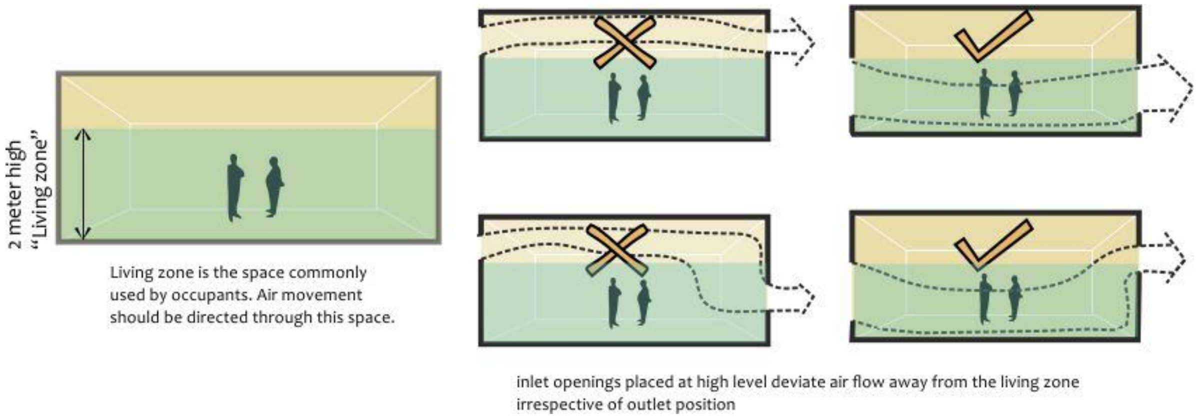
6) Day Lighting



Recommendations

a) Building must be longer on their East –West axis for better day lighting & visual comfort.
b) North facing windows provide consistent indirect light with minimal heat gains.
c) Use skylights & roof monitors to areas without easy access to windows.

7) Natural Ventilation



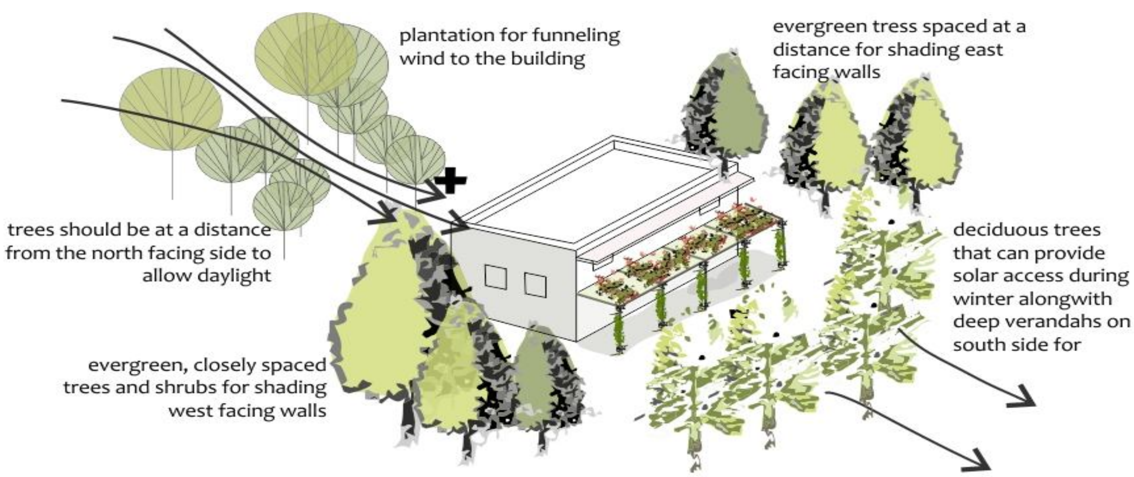
Recommendations

a) Total area of window opening should be minimum 30% of floor area.
b) Window -Wall –Ratio (WWR) should not be more than 60%.

8) Thermal Comfort

a) While designing a building for enhanced energy conservation, determine the time period in a year when mechanical means of cooling or heating can be ignored to maintain thermal comfort in spaces. This can be done either using software tools like climate consultant or through simple calculations using the psychometric chart.
b) Make provision for Post Occupancy Evaluation (POE) in buildings.POE involves systematic evaluation of opinion about buildings in use, from the perspective of people who use them.

9) Vegetation



Recommendations

a) Use of local species for vegetation is highly recommended as they could be better option to the variations in temperature, rainfall patterns & soil conditions for that region.

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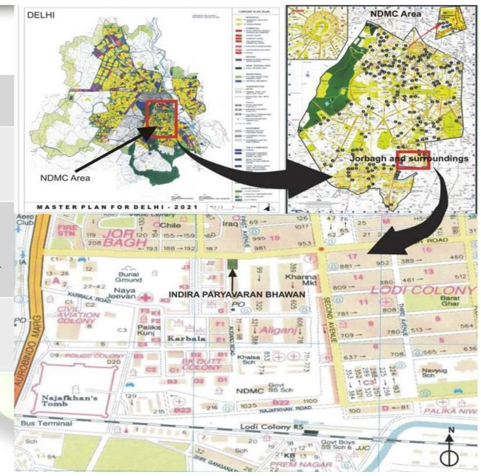
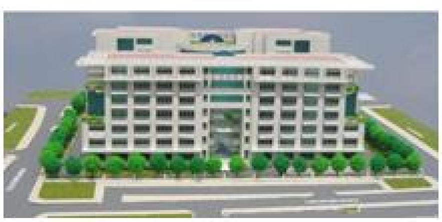
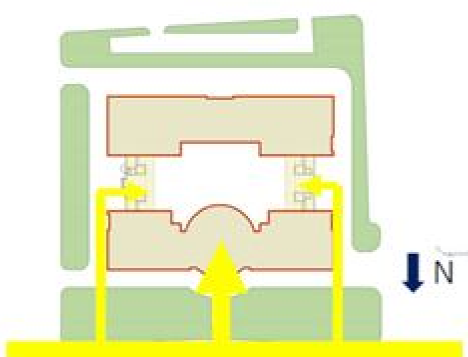
A. Case Study –I (Indira Paryawaran Bhawan, New Delhi)

Location- New Delhi
Geographical coordinates-28°N, 77°E
Occupancy Type- Office
Climate Type- Composite
Project Area- 9,565 m²

Nearest Highway	•NH-2 •NH-8	3.9 km 4.2 km
Nearest Metro Station	Jorbagh	0.5 km
Nearest Railway Station	•Lody Colony RS •Hazrat Nizamuddin	0.6 km 4.0 km
Nearest Airport	•Safdarjung Airport •IGI Airport	1.2 km 11 km

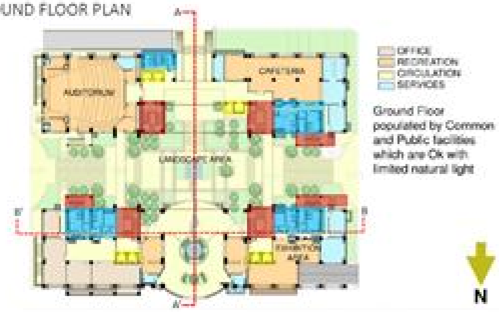






Plan developed for direct pedestrian axis to East, North & West

GROUND FLOOR PLAN



Courtyard also helps in air movement along with shaded interaction space

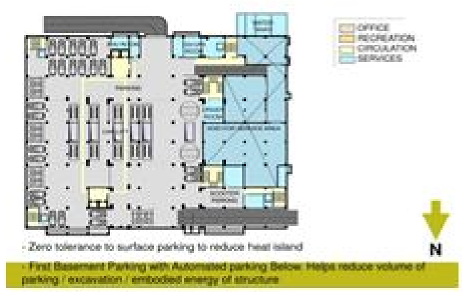
FIRST FLOOR PLAN

Keeping Service Areas, Staircases on low light areas. Efficient usage of the perimeter to maximize sunlit areas & views for the users

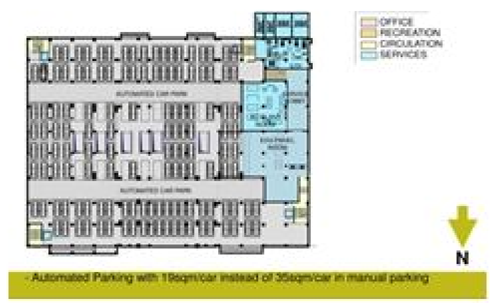
THIRD FLOOR

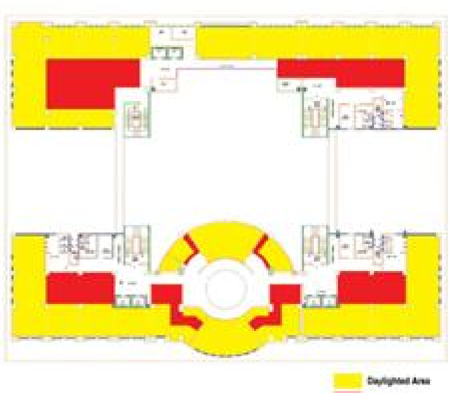
FORTH FLOOR

UPPER BASEMENT

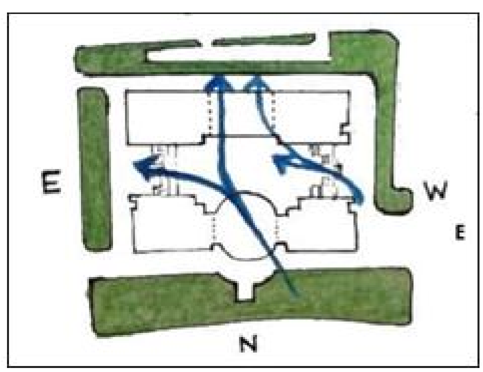


LOWER BASEMENT





The Building Envelope has been designed to receive 75% of natural daylight to reduce energy consumption.



Building is oriented in such a manner to utilize natural wind flow for cross ventilation

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CENTRAL COURTYARD

The building has the advantage of natural ventilation throughout happens due to stack effect, with a central courtyard between the North & South blocks.

An entrance atrium of four storey height has been made in the middle of the North block & in the entrance to the South block.

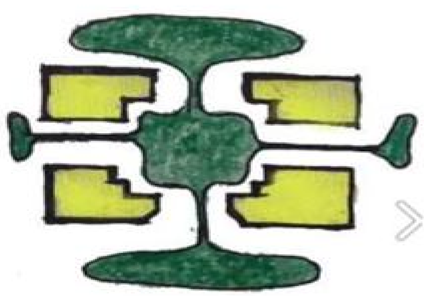
A shaded interaction space.

Covering of central court yard

BIODIVERSITY

Existing balance of nature to connect outdoor greens & the courtyard greens.

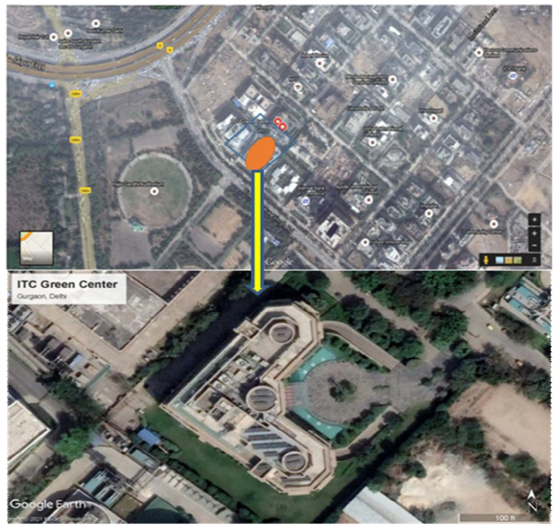
Deciduous trees plantation.



1) Building Envelope & Fenestration
Optimized building envelope- window assembly (U-value 0.049 W/m²K), VLT-0.59, SHGC-0.32
uPVC windows with sealed double glazed using low heat transmittance index glass
Rock wool insulation
High efficiency glass
Cool roofs: Use of high reflectance terrace tiles for heat ingress, high strength & hard bearing

2) Materials used
AAC block with fly ash
Fly ash based plaster & mortar
Stone & ferro cement jaalis
Local stone flooring
Bamboo jute composite doors, frames & flooring
High efficiency glass, high VLT, low U-value, optimized by appropriate shading
Light shelves for diffused sunlight

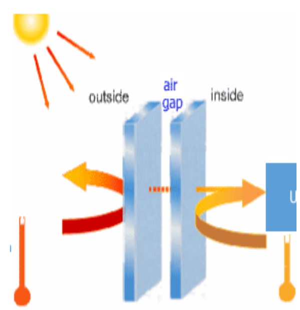
B. Case Study –II (ITC Green Centre, Gurgaon, India)



Iconic L shaped building is located in Sector 33, Gurgaon, India near Delhi-Jaipur Express way & the metro station.
Climate: Composite
Area: 15,799 m² (out of which 9294 m² - conditioned area, 6505 m² - non- conditioned area)
A LEED PLATINUM certified building
'L' shape design with main entrance towards north.
Longer axis along NE & NW directions
The L-shape blocking ensures that part of the façade is always shaded.
By 'L' shape configuration, the width of the floor plate is reduced for the same amount of floor plate area thereby allowing natural light to penetrate deep into the interior spaces.
The central atrium allows glare- free natural light to form in the heart of the building, thereby reducing the use of artificial light.
The atrium also connects the various parts of the building to each other, both horizontally & vertically, it encourages interaction between the various parts & more, it promotes sense of community.

Double glazing window

The glazing for the building has been designed to maximize the effect of natural light, largely eliminating the need for artificial light during day



The high performance window glass, while allowing light inside, does not allow heat & also keeps office cool during day time decreasing the load of HVAC.

Glass on north orientation has been designed to maximize natural day light with lighter light transmission.
Optimum WWR is less than ECBC standard (40%). It helps in reducing external solar heat gain.

1) Materials used in ITC Green Centre

High reflective roof coating
Autoclaved aerated Concrete (AAC) Block with 55% Flyash content
Ready mix concrete
Fly Ash
Medium density fiber board (MDF)
40% of the materials used in the construction was taken from within 80 km range, which not only cost effective but also offers easy renewal.
10% of construction material such as glass, ceramic tiles, steel & aluminium used in the building are recycled.

2) Inferences

a) Zero water discharge
b) 53% energy savings
c) 40% reduction of potable water use
d) Use of treated grey water for flushing & landscaping
e) Fly- ash bricks & concrete
f) Alternative transportation facilities
g) Storm water management system
h) Reflective high – albedo roof paint
i) 30% smaller carbon footprint with the use of sensible passive & active technologies

IV. CONCLUSION

1) The application of Passive Techniques demonstrated a significant positive impact on thermal comfort within the office building
2) Study has revealed a notable Reduction in energy consumption, affirming the effectiveness of the implemented passive strategies in minimizing the building's reliance on active heating & cooling systems.
3) The study aligns with & contributes to global sustainability goals by providing practical solutions for reducing consumption & enhancing the environmental performance of office buildings.

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