Approach to Climate Responsive Built Environment

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Buildings- Context, Role and Importance

- Buildings-- integral part of human history, growth, development
- Buildings --continue to define future journey of human growth
- Buildings-- manmade environment
- Buildings-- vital for human growth
- Buildings – living organism
- Buildings – structures catering to all human activities
- Buildings --valuable - 80% human life spent in buildings
- Buildings- full of dualities and contradictions
- Buildings -- largest consumers of energy
- Buildings - largest consumers of resources
- Buildings – largest generators of waste
- Buildings- largest polluter of environment /ecology
- Buildings --- responsible for largest carbon footprints
- Buildings -- responsible for global warming
- Buildings -- major determinant of global sustainability

Buildings-Context, Role and Importance

- Buildings– provide optimum/worst living conditions
- Buildings -- make people healthy/sick
- Buildings -- vital to overcome human/ ecological concerns, global warming, reducing carbon footprints
- Making Buildings Sustainable-- essential to make value addition to -- resources, environment ,ecology
- Researches made/Studies carried out revealed —
- Green/sustainable buildings-- create win-win situation for owners, occupants & users

A Green School-makes learning easy & more meaningful

A Green House--makes people happy, healthy, productive

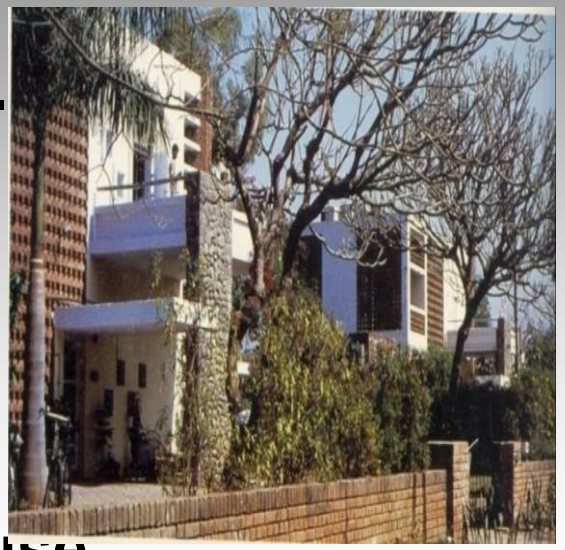
- A Green Hospital-- cures patients quickly
- A Green Shopping Mall-- increases sale / profits

Buildings- Built Environment

- Operational domain of Architects /Engineers revolves around:
- -- Siting,
- -- designing,
- --construction,
- --operation,
- -- maintenance
- --Demolition and
- -Reconstruction
- -creating state of art built environment.
- Architects-- have critical role/ responsibility to;--make value addition to resources ,environment ,ecology
- -- by creating sustainable built environment.
- Considering implications of Buildings-- resources, environment / ecology
- -- Going green-- a necessity
- – for sustainable tomorrow
- -Each building unique--requires different options for greening

BUILDINGS --AS CONSUMERS OF RESOURCES

- **Built environment– significantly impact environment /consumption of resources/generators of waste/climate change/rising temperature:**



  - **16% of world's fresh water withdrawal.**
  - **25% of wood harvested.**
  - **30% of consumption of raw material.**
  - **50% of global energy consumption.**
  - **35% of world's CO2 emission**
  - **40% of Municipal solid waste.**
  - **50% of Ozone depleting CFC's still in use.**
  - **30% of residents having sick building syndrome**
- --70% of global warming outcome of ;
- --built environment & transportation

-- Majority of existing buildings-

-- low concern for energy conservation

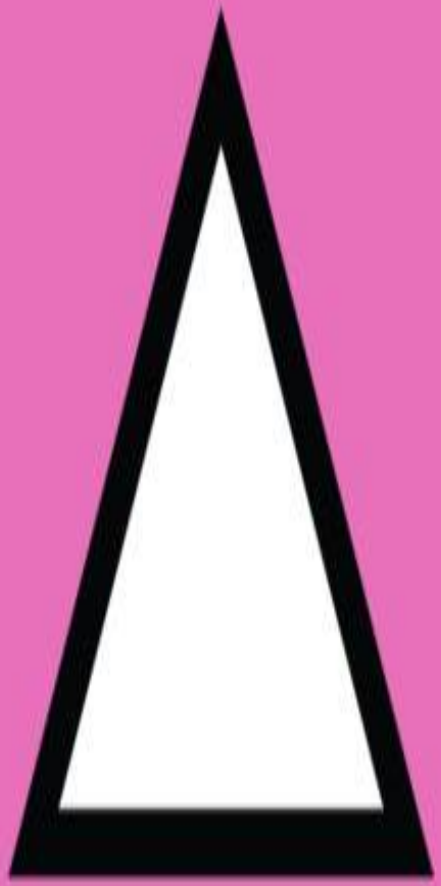
Implications of Built Environment

Aspects of Built Environment	Consumption	Environmental Effects	Ultimate Effects
• Siting • Design • Construction • Operation • Maintenance • Renovation • Deconstruction	• Energy • **Water** • Materials • Natural Resources	• Waste • Air pollution • Water pollution • Indoor pollution • Heat islands • **Stormwater runoff** • Noise	• Harm to Human Health • Environment Degradation • Loss of Resources

- ***Changing Context of Building Design-iii***

Vitruvius-Three Pillars of Architecture

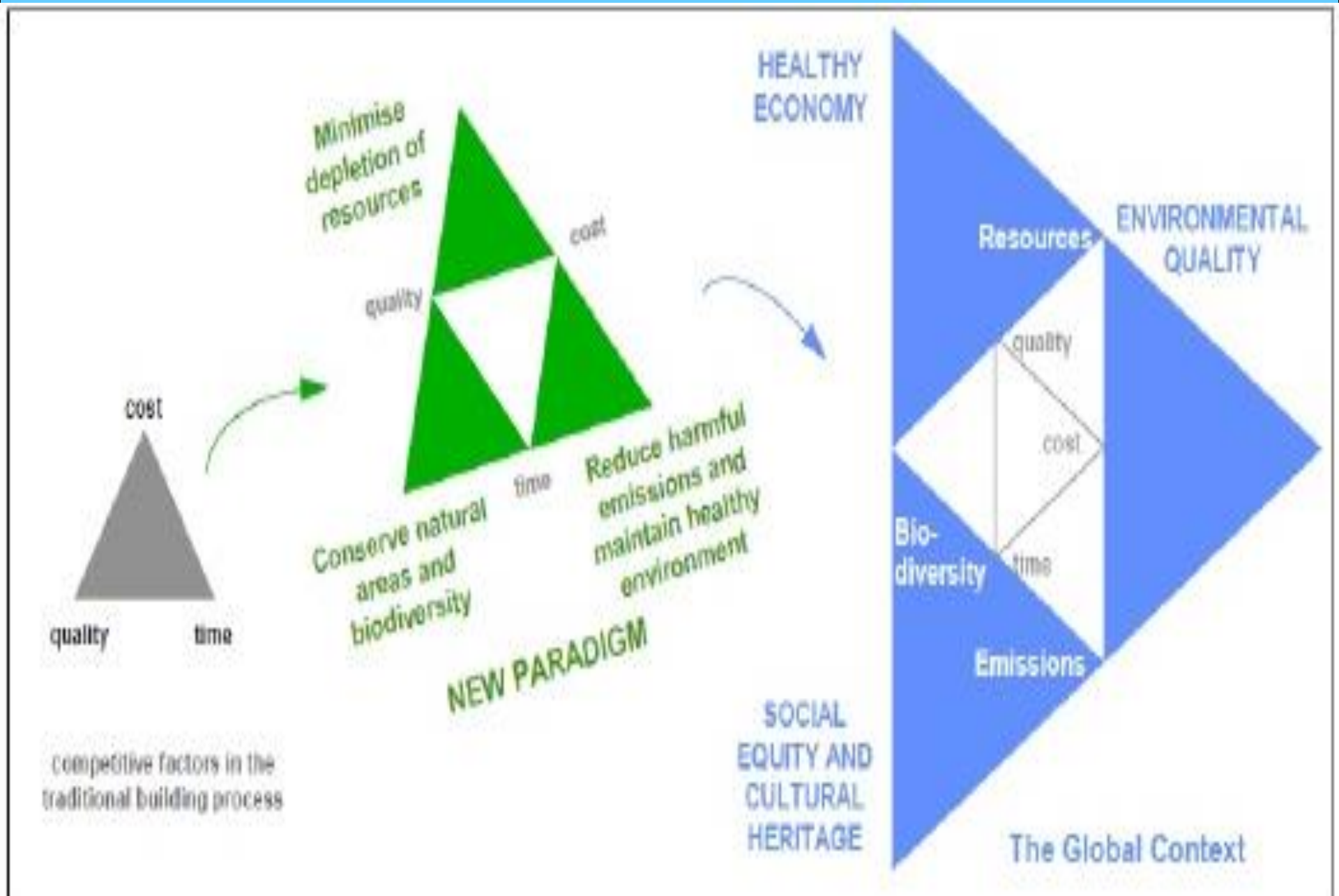
Firmitas - Durable



Utilitas - Useful

Venustas - Beautiful

Changing Context of Buildings



- ***Green Buildings-***
- ***Need , Definition& Advantages- iv***

Defining- Green Buildings

DEFINITION:

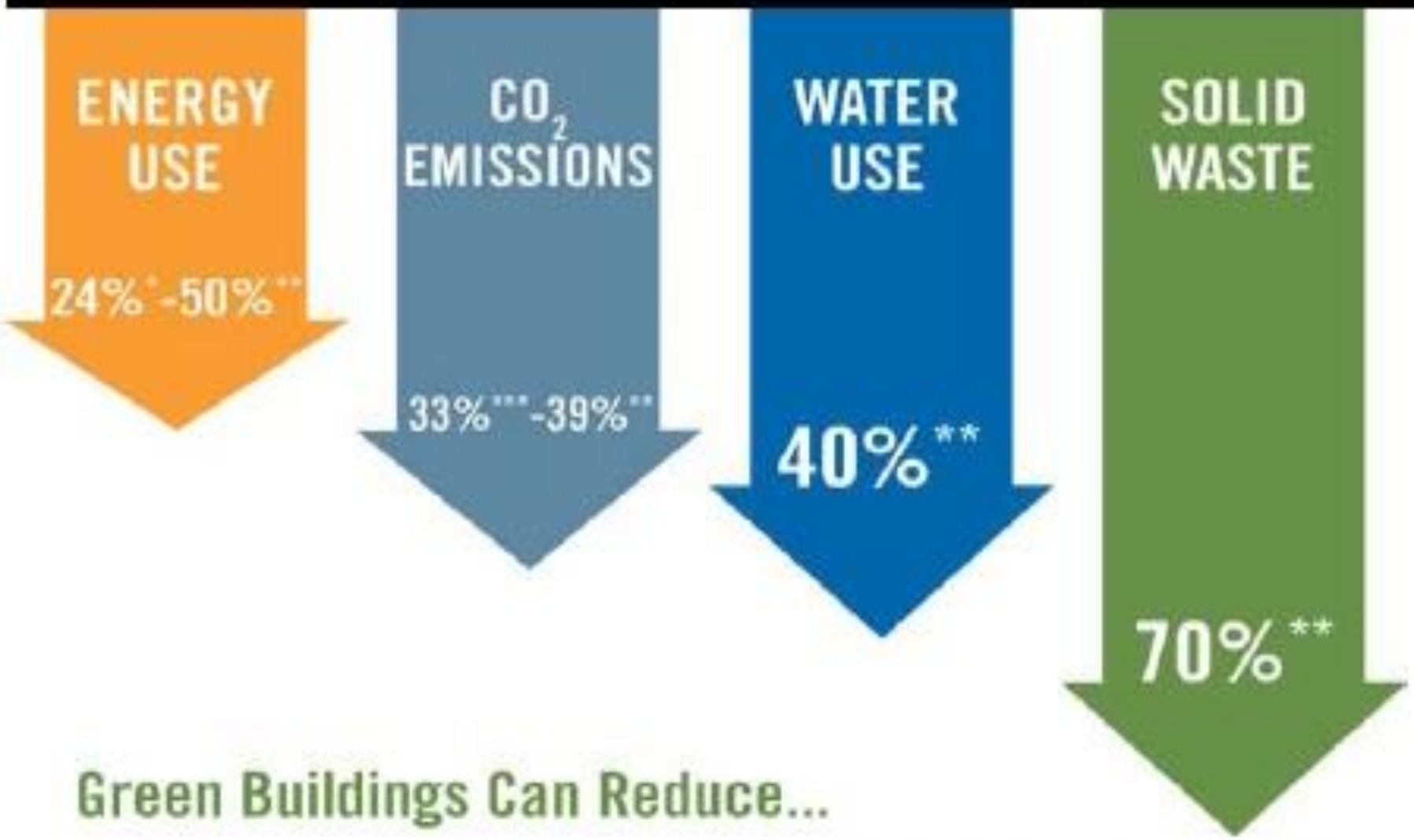
- "A green building is one which uses less water, optimises energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building."

SDG 11- Make cities / human settlements- inclusive ,safe, resilient and sustainable

Climate Responsive Building- Characteristics

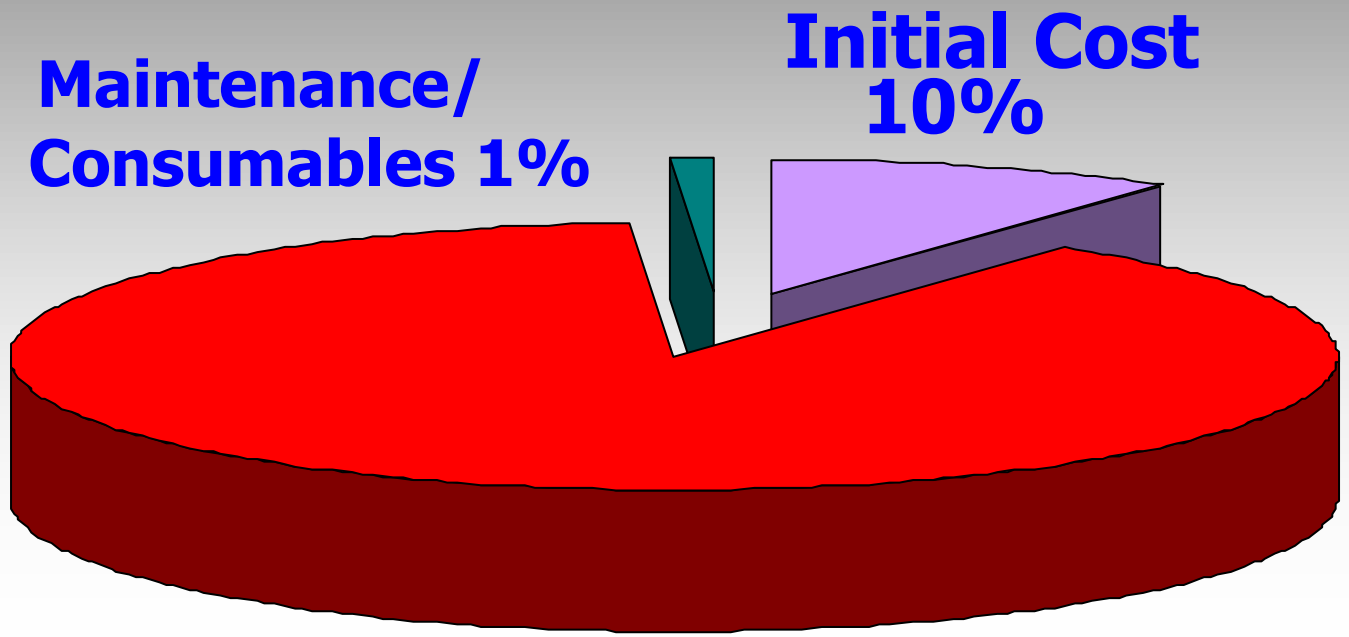
- **Energy focused**- Besides Consuming Energy- also produces Energy
- **Water focused**— focus on conserving water
- **Resource focused**—Ensures efficient use of Resources- renewable/non-renewable
- **Material focused** -Use minimum/eco-friendly materials having minimizes environmental impact .
- **Sustainability focused-** Designing buildings Using Construction processes -- environmentally sustainable.
- **Environment Focused-** minimizes adverse impact on environment.
- **Indoor air quality focused-** Provide best possible indoor air quality
- **Human focused-** promote good health for users
- **Site Focused-** Causing minimum disturbance to site
- **Durability focused-** Remains durable having longer life
- **Land Focused--** Remains Compact-saves/conserves land

Advantages of Green Buildings



* Turner, C. & Frankel, M. (2008). Energy performance of LEED for New Construction buildings. Final report.
** Kats, G. (2003). The Costs and Financial Benefits of Green Building: A Report to California's Sustainable Building Task Force.
*** GSA Public Buildings Service (2008). Assessing green building performance: A post occupancy evaluation of 12 GSA buildings.

Green Buildings- life cycle costs



Cost of Green Buildings-Indian Experience

Building	Year awarded	Built-in Area (sq.ft)	Rating Achieved	% Increase in cost	Payback (Yrs)
CII-Godrej GBC, Hyderabad	2003	20,000	Platinum	18 %	7 years
ITC Green Centre, Gurgaon	2004	1,70,000	Platinum	15 %	6 years
Wipro, Gurgaon	2005	1,75,000	Platinum	8 %	5 years
Technopolis, Kolkata	2006	72,000	Gold	6%	3 years
Spectral Services Consultants Office, Noida	2007	15,000	Platinum	8%	4 years
Kalpataru Square	2008	3,00,000	Platinum	2%	2 years
Suzlon One Earth, Pune	2010	8,00,000	Platinum	2%	2 years

- **Cost showing a decreasing trend over the years**
- **Incremental Cost lower-- if base design has already factored normal Green features**

- ***Designing Climate Responsive-Difference between Weather & Climate***

Weather and Climate

- ***Weather-*** *what you experience when you step outside on any day- at a particular location over short-term-* precipitation, temperature, humidity; wind direction, wind speed, windy, stormy, rainy, foggy, cold, hot, snowing atmospheric pressure- Sky Conditions-sunny, cloudy, …
- *Climate -average of Weather in a location over a longer period - 30 years or more.*
- ***Weather****- can change quickly- in time/ over short distances.*
- *Climate- changes slowly- Northeast cold /snowy in January and South hot /humid in July. doesn't vary over-short distances,*
- ***Weather-*** *what you get*
- *Climate - what you expect,*

Weather ***influences human activity- Sailors/ pilots to know about storm ; farmers to plan for plantation/ harvest crops.***

- **Climate-** *averages of daily weather conditions, -- temperature, precipitation, humidity, wind speed, --Long-term records --enable detection of climate patterns /trend.--input for computer models to help generate climate outlooks /weather forecasts.*

Weather and Climate

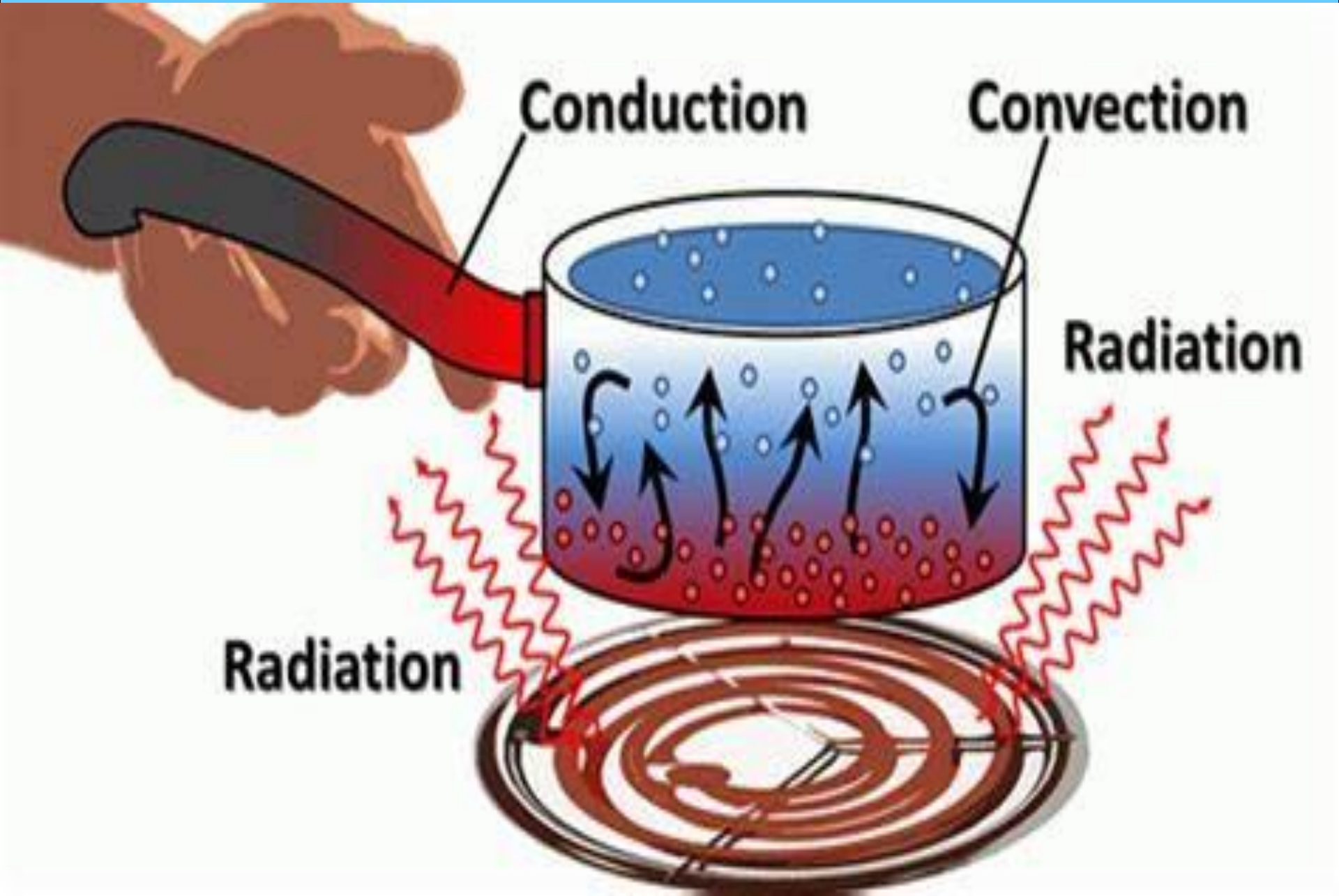
Despite differences- weather & climate interlinked.

- ***Climate - following weather- takes into account precipitation, wind speed, direction, humidity, temperature.***

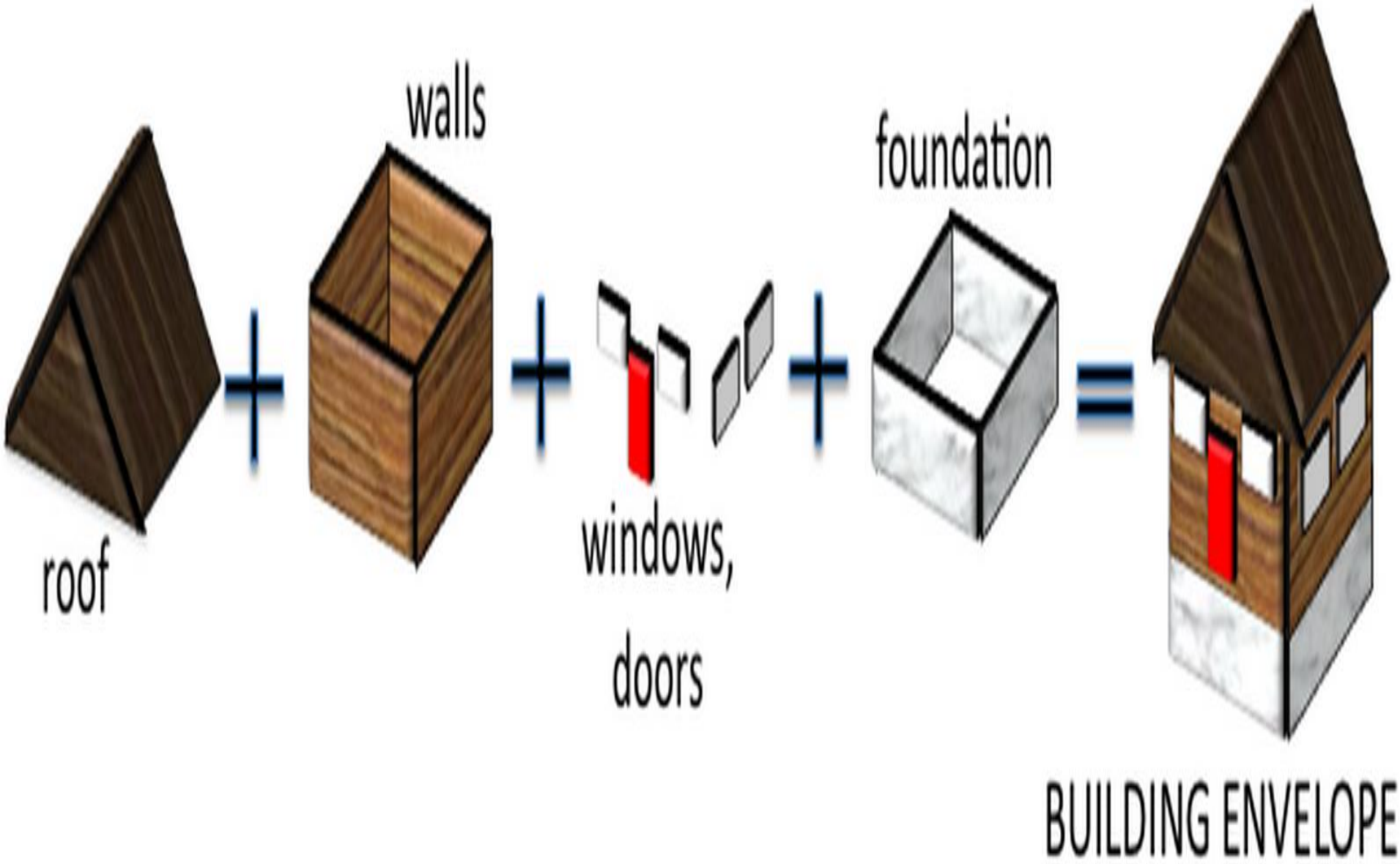
- ***climate - an average of weather conditions over time.***
- ***- change in climate can lead to changes in weather patterns.***
- ***Climate conditions—***
- ***- vary between different regions of world***
- ***--influence types of plants / animals that live there.***
- ***- Antarctic -has polar climate with subzero temperatures, violent winds, driest conditions on Earth.***
- ***- Organisms living -highly adapted to survive extreme environment.***
  - Amazon rainforest enjoys a tropical climate.
- ***- Temperatures consistently warm/ high humidity, plenty of rainfall, lack of clearly defined seasons.***
- ***- Stable conditions support- high diversity of plant /animal species,***
- ***- many – not found nowhere else in world.***

- ***3 -Modes of Heat Transfer into a Building***

Modes of Heat Transfer



Heat Transfer in Buildngs



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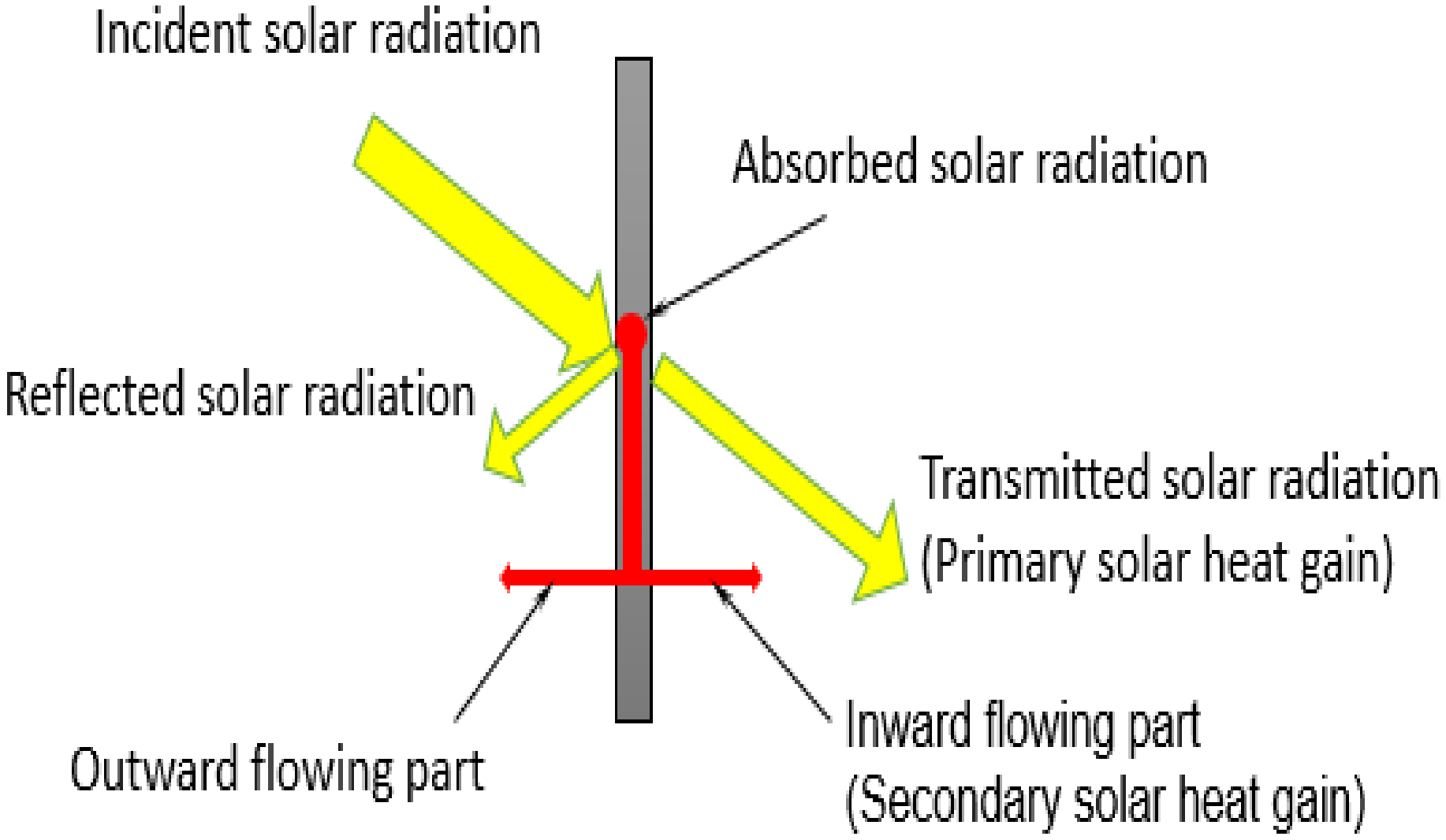
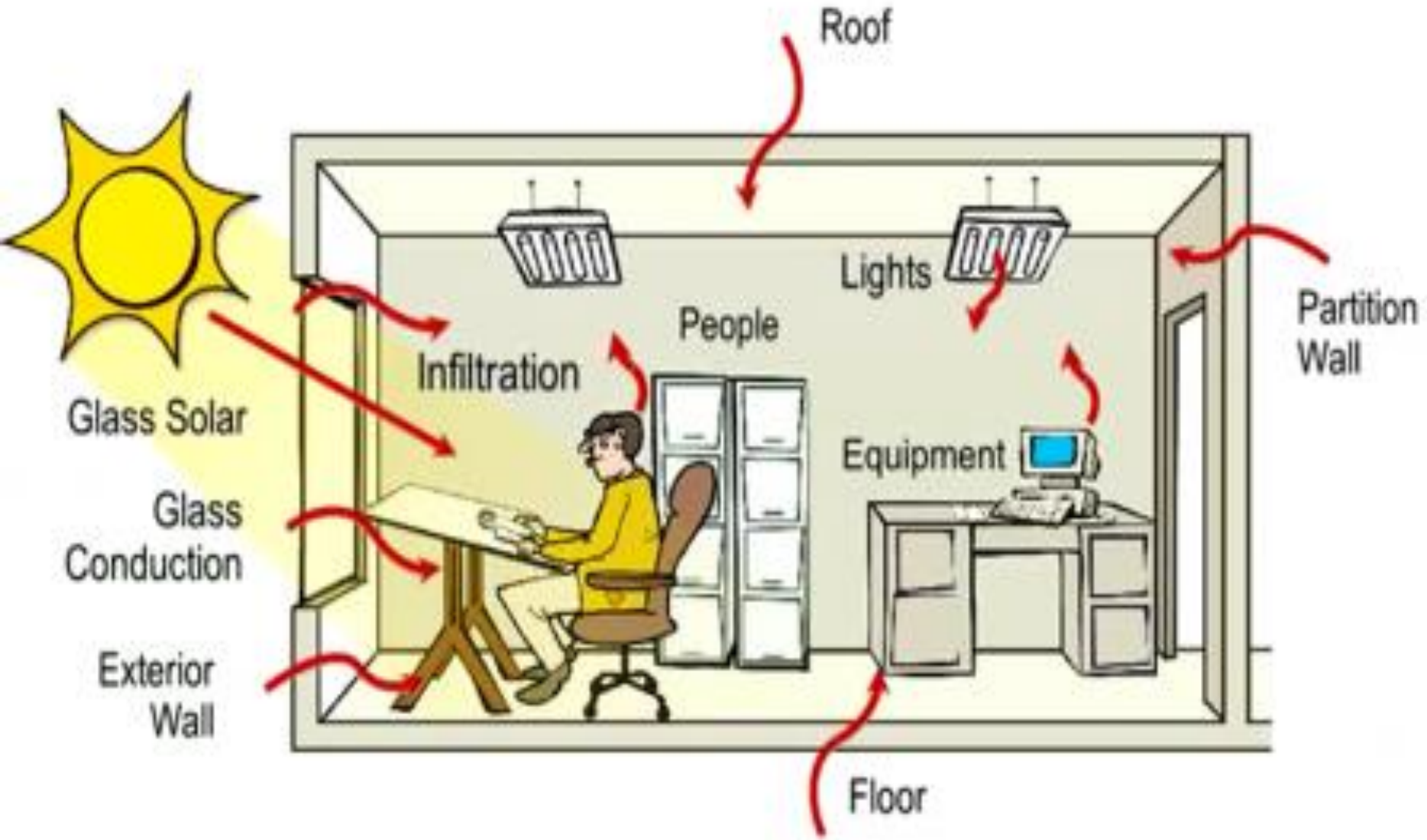


Heat Transfer in a Building



- ***Designing Climate Responsive Buildings – Managing Heat/Cold/Moisture***

Designing Green Buildings

- 1. **Adopting integrated approach to building design**
- 2. **Design based on Climate**
- **Macro Climate – Regional climate; Meso Climate– local climate**
- **Micro Climate--Site climate -- based on site characteristics,**
- 3. **Orientation -- to optimize light , heat gain/ heat loss**
- 4. **Sun movement-- to maximize use of free solar energy for heating /lighting**
- 5.**Wind direction--using air movement for ventilation/ cooling**
- 6. **Planning of Building-- optimize site potential, defining size, shape, planning spaces, allocating uses, placing rooms, circulation, promoting building efficiency, promoting natural sunlight, air / ventilation**
- 7.**Designing Building Envelop--– Mass – space relationships/ solids/voids, positioning –openings/projections, shading devices, height, shape of building, natural lighting and ventilations etc**
- 8. **Materials- low embodied energy; available locally ; using in natural form, lightweight; non-toxic/ sustainable materials**
- --

Designing Green Buildings

- 9 **Technology**- cost effective/material efficient/ speedier/ energy efficient
- **10. Indoor Air Quality-**Creating optimum living conditions for occupants
- 11. **Nature**-- making best use of nature; natural resources ; sun/wind energy

12. **Site**-Optimizing use of site potential

13 **Loads**--Minimising self/structural – live load

14 **Energy**--Generating on-site renewable energy.

15 **Planning**-- with energy as focus,

16 **Water**--Minimizing water consumption

17 **Environment** -Preserving/promoting environment in design, construction and operation

- 18 **Quality of life**-- for occupants in design, construction operation

19 **Reuse/ Recycling** -- Promoting re-use and recycling

Green Building practices expands/ complements

-- economy, -utility,

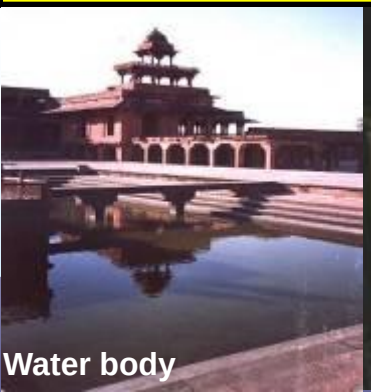
-durability, -comfort.

Integrated Approach: Green Buildings

Indian Way of approaching design

- **Rediscovery Indian ethos- Making optimum use of 5 elements of Nature (Panchabhutas)**

Prithvi (Earth)	**Sustainable Sites**
Jal (Water)	**Water Efficiency**
Agni (Energy)	**Energy Efficiency**
Vayu (Air)	**Indoor Environmental Quality**
Akash (Sky)	**Daylight**

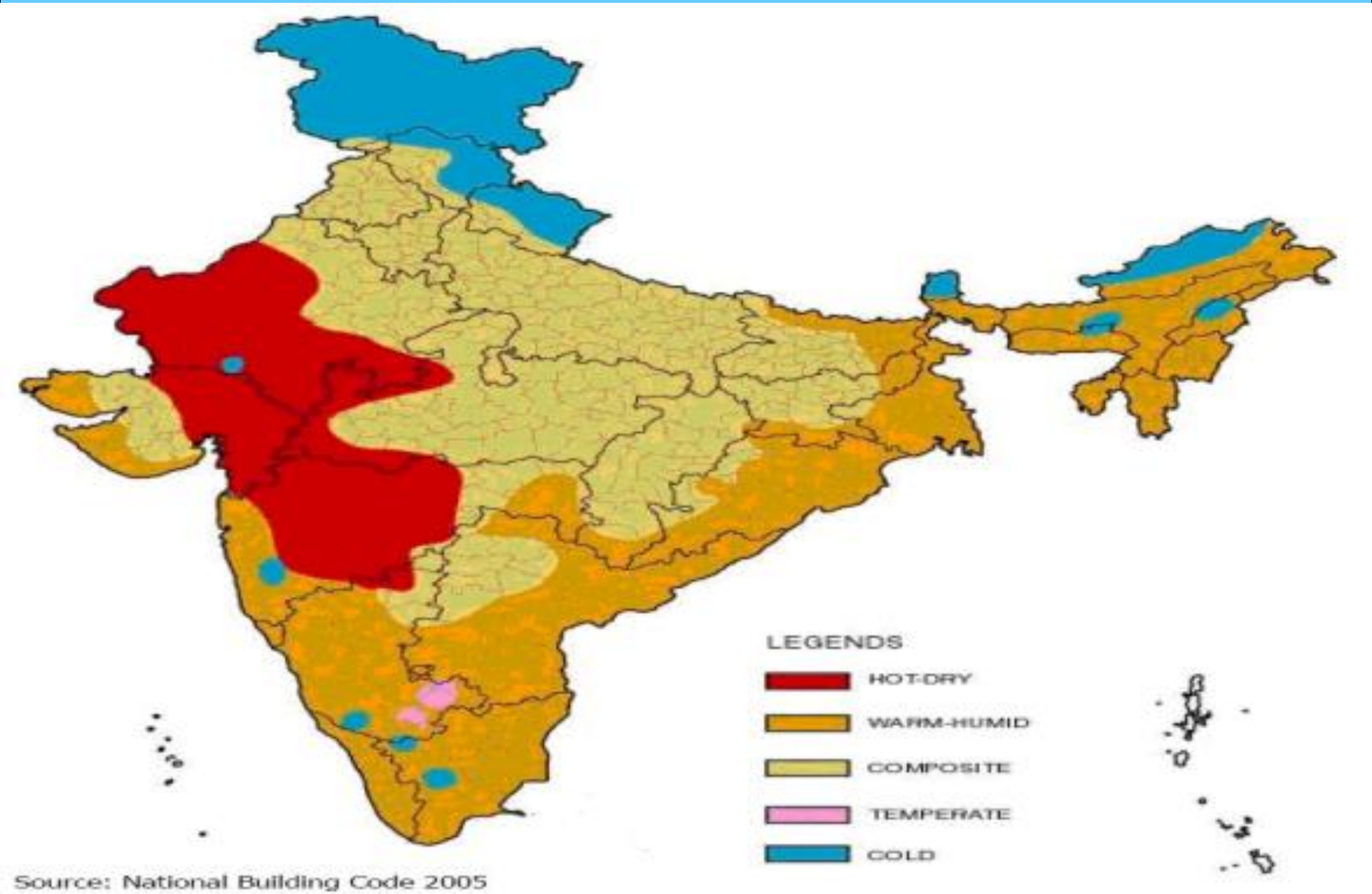

Water body


Local materials


Views


Daylighting

5 CLIMATIC ZONES IN INDIA



Source: National Building Code 2005

CLIMATIC ZONES AND THEIR CHARACTERISTICS

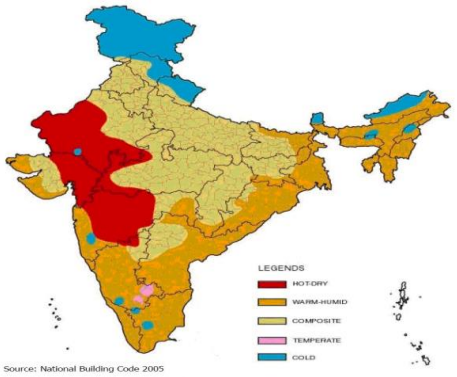
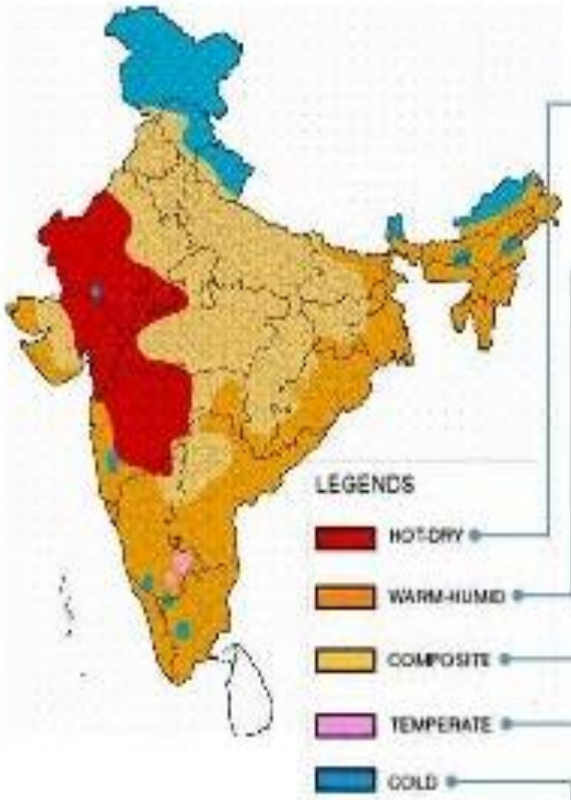


Table 2.1 Classification of Climates

Criteria of Bansal et al. [1]			Criteria of SP 7: 2005 [9]		
Climate	**Mean monthly temperature (°C)**	**Relative humidity (%)**	**Climate**	**Mean monthly maximum temperature(°C)**	**Relative humidity (%)**
Hot and dry	>30	<55	Hot and dry	>30	<55
Warm and humid	>30	>55	Warm and humid	>30 >25	>55 >75
Moderate	25-30	<75	Temperate	25-30	<75
Cold and cloudy	<25	>55	Cold	<25	All values
Cold and sunny	<25	<55			
Composite	This applies, when six months or more do not fall within any of the above categories		Composite	This applies, when six months or more do not fall within any of the above categories	

Climate Zones in India



High temperature • Low humidity and rainfall • Intense solar radiation and a generally clear sky • Hot winds during the day and cool winds at night

Temperature is moderately high during day and night • Very high humidity and rainfall • Diffused solar radiation if cloud cover is high and intense if sky is clear • Calm to very high winds from prevailing wind directions

This applies when 6 months or more do not fall within any of the other categories • High temperature in summer and cold in winter • Low humidity in summer and high in monsoons • High direct solar radiation in all seasons except monsoons high diffused radiation • Occasional hazy sky Hot winds in summer, cold winds in winter and strong wind in monsoons

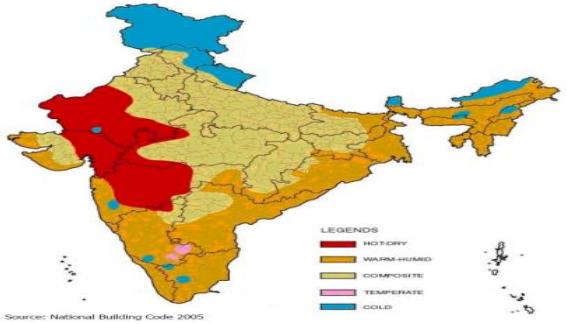
Moderate temperature • Moderate humidity and rainfall • Solar radiation same throughout the year and sky is generally clear • High winds during summer depending on topography

Moderate summer temperatures and very low in winter • Low humidity in cold/sunny and high humidity in cold/cloudy • Low precipitation in cold/sunny and high in cold/cloudy • High solar radiation in cold/sunny and low in cold/cloudy • Cold winds in winter

SOURCE: Bureau of Indian Standards, National Building Code of India 2005, Part 8 Building Services, Section 3 Air Conditioning, Heating and Mechanical Ventilation; Bansal, N. K. & G. Minke (1994), Climatic Zones and Rural Housing in India; Krishan, A., N. V. Baker & S. V. Szokolay (2001), Climate Responsive Architecture: A Design Handbook for Energy Efficient Buildings, Tata McGraw Hill

Hot and Dry Climate Zone-

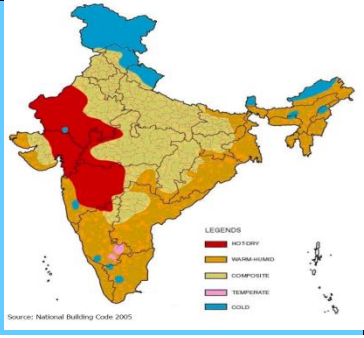
Comfort requirements and Physical manifestations in Buildings



Thermal Requirements	Physical Manife
Reduce Heat Gain	
Decrease exposed surface area	Orientation and shape of building
Increase thermal resistance	Insulation of building envelope/roof/walls
Increase thermal capacity (Time lag)	Massive structure
Decrease air exchange rate (ventilation during the day)	Smaller windows openings, night ventilation
Increase buffer spaces	Air locks/lobbies/balconies/verandahs
Increase shading	External surfaces protected-overhangs, fins, trees
Increase surface reflectivity	Pale color, glazed China mosaic tiles etc.
Reduce solar heat gain	Use glazing with lower Solar Heat Gain Co-efficient-SHGC and provide shading for windows. Minimize glazing in East and West
Promote Heat Loss	
Increase air exchange rate (ventilation during night-time)	Courtyards/wind tower/arrangement of openings
Increase humidity levels	Trees, water ponds, evaporative cooling

Hot and Dry Climate Zone-

Comfort requirements and Physical manifestations in Buildings



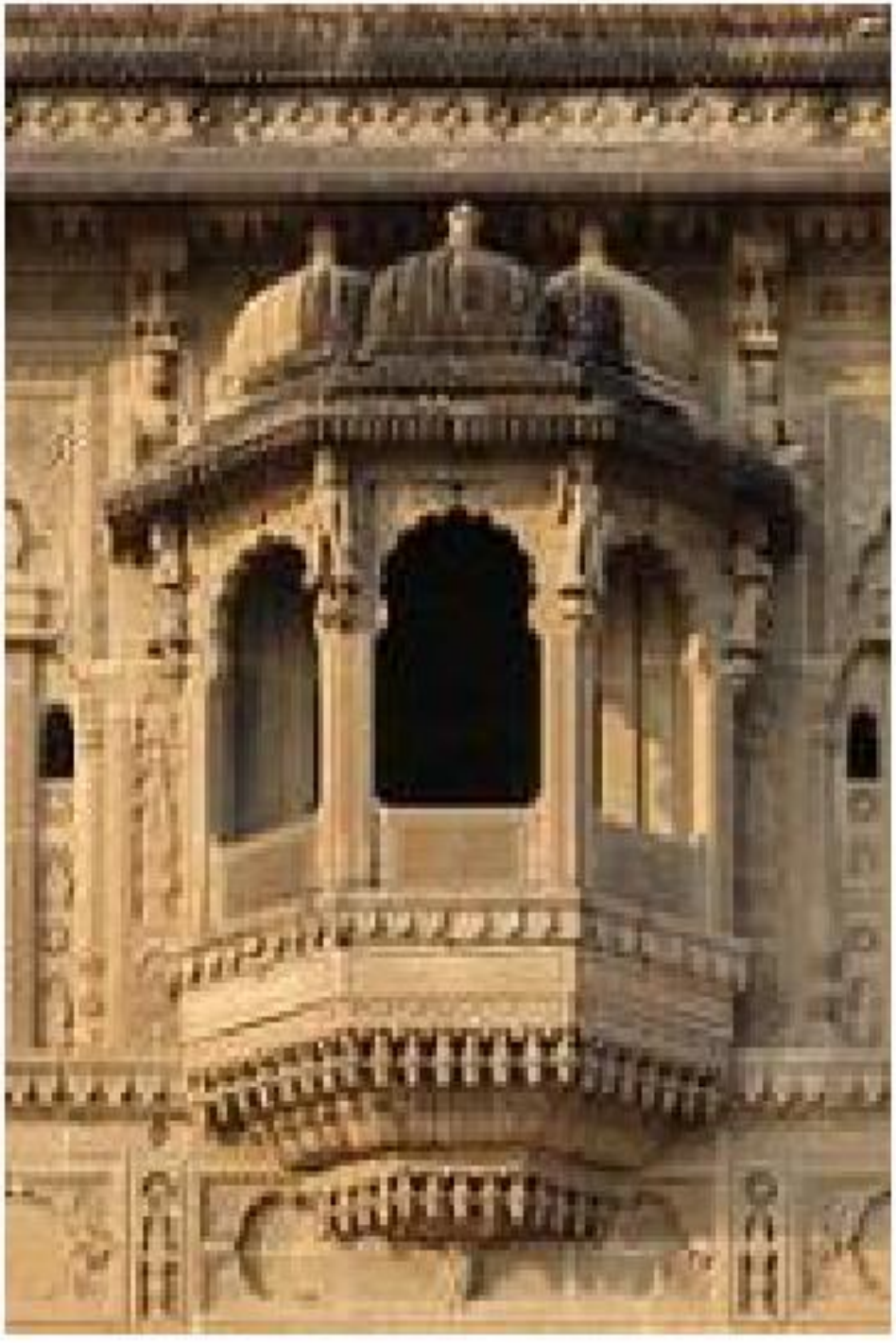
HOT

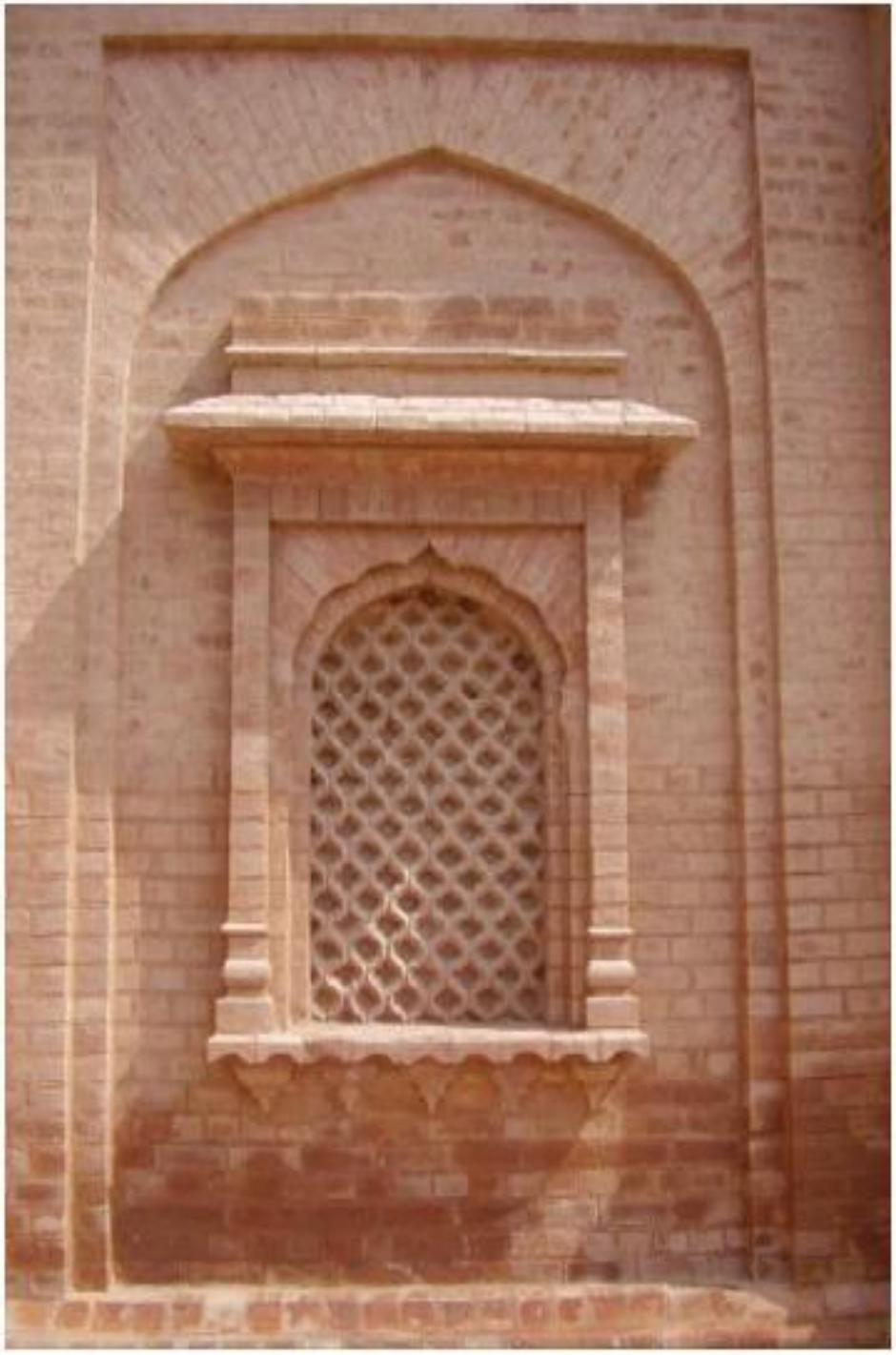
COOL

LIVING ROOM

EVAPORATIVE COOLER

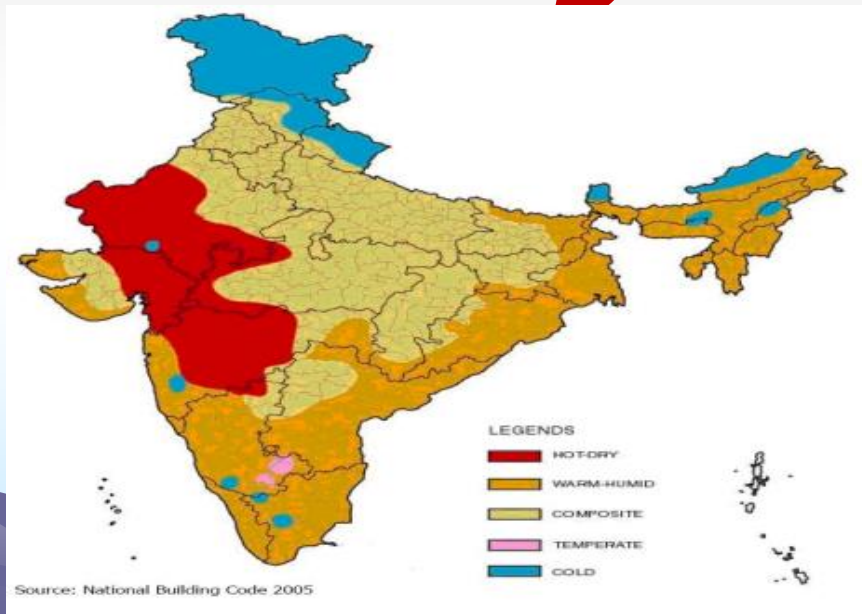
Cavity Walls





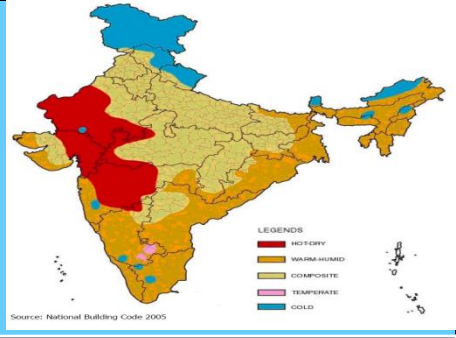
Cold-Cloudy/Sunny

- Climate



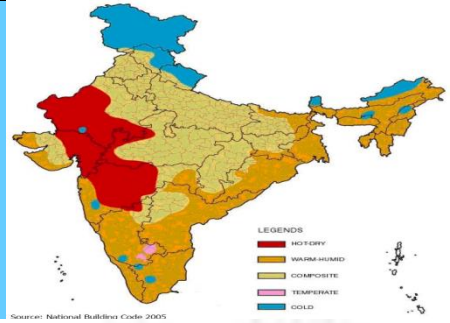
Source: National Building Code 2005

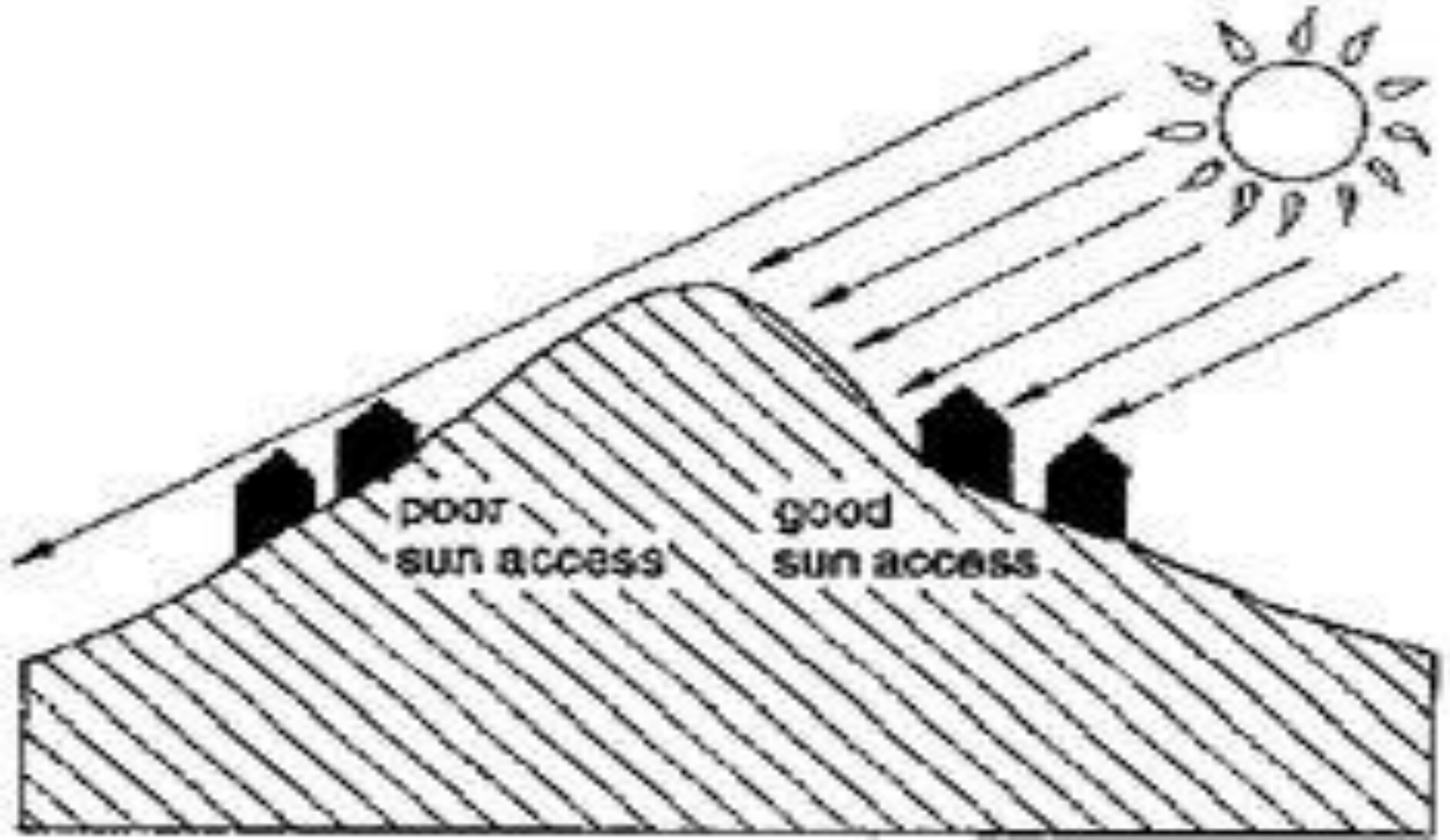
Cold (Cloudy/Sunny) Climate Zone- Comfort requirements and Physical manifestations in Buildings



Thermal Requirements	Physical Manifestation
Reduce Heat Loss	
Decrease exposed surface area	Orientation and shape of building. Use of trees as wind barriers.
Increase thermal resistance	Roof insulation, wall insulation and double glazing
Increase thermal capacity (Time Lag)	Thicker walls
Increase buffer spaces	Air locks/Lobbies
Decrease air exchange rate	Weather stripping and reducing air leakage.
Increase surface absorption	Darker colours
Promote Heat Gain	
Reduce shading	Wall and glass surfaces
Trapping heat	Sun spaces/green houses/trombe walls etc.

Cold (Cloudy/Sunny) Climate Zone- Comfort requirements and Physical manifestations in Buildings

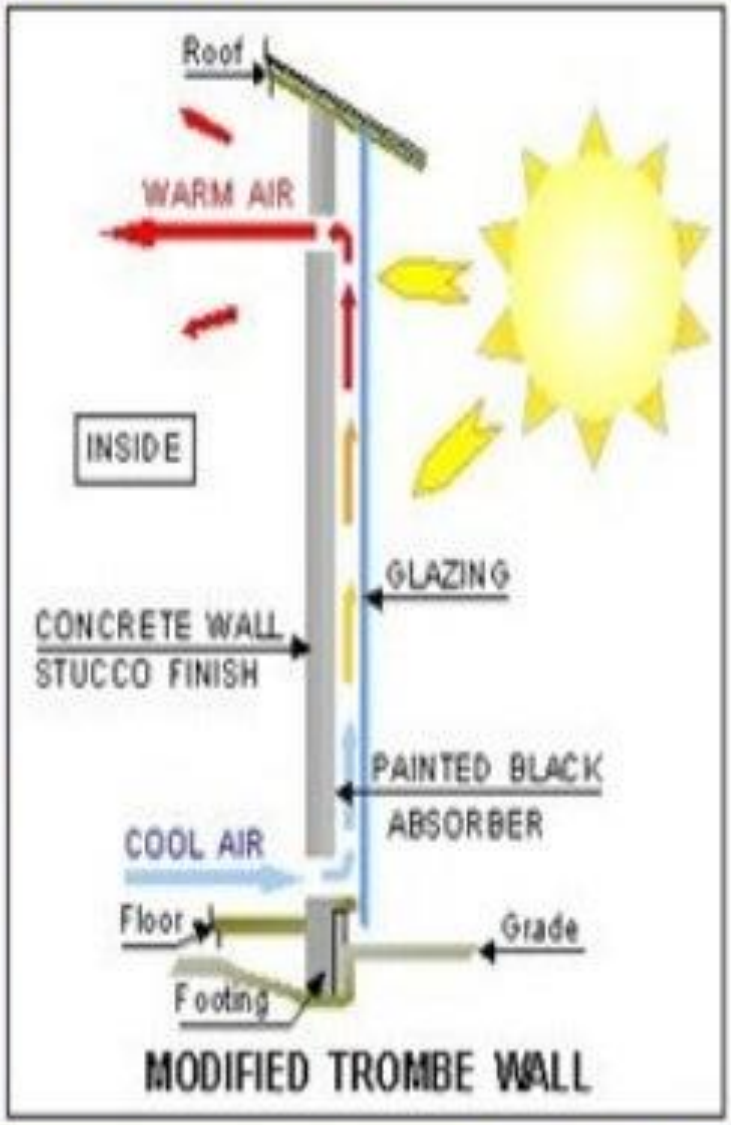




SOLARIUM

Design Strategies in Cold Climate

- Glazing windows up to 25% floor area
- Double glazing to avoid heat losses during winter nights.
- Adopt Trombe walls.
- Sunspaces



Cold (Cloudy/Sunny) Climate Zone

LOCATION OF CITY

Understanding Site

- Site Evaluation

-Site Analysis

-Site Planning

Site Analysis- Factors To be considered for Evaluating site

i) Location
ii) Understanding Site
iii) Orientation-*position of building in relation to east-west axis*.
iv Wind direction
v Soil conditions
vii Topography
viii Vegetation and Natural Features
ix Hydrology and Precipitation
x Infrastructures
xi Surrounding Land uses & Buildings
xii Vision / Visual Linkages

SITE ANALYSIS

SWOT

STRENGTH

- The site is near to the business and agriculture land of the place.
- It has good condition of accessibility through road.
- The area has enough water supply,power lines, telephones and communication lines are available.
-

WEAKNESSES

- There is a possible to deal with noise pollution.
- There are problems in heavy traffic during weekdays.

OPPORTUNITIES

- It can also provide job opportunities to the locals.
- The rich and the poor have the opportunity to socialize with one another.
- Can also provide opportunities for families with no sufficient income for the facilities to be built.
- All families have the opportunity to choose their residence to the best of their income.
- This project can also add to the development increase of the city.

THREATS

INTRODUCTION

Tanauan,Batangas has a tropical climate.The is a great deal of rainfall in Tanauan, even in the driest month.The Koppen-Geiger climate classification is Af.The avverage annual temperature is 27.0° C in Tanauan.The average annual rainfall is 2459 mm.

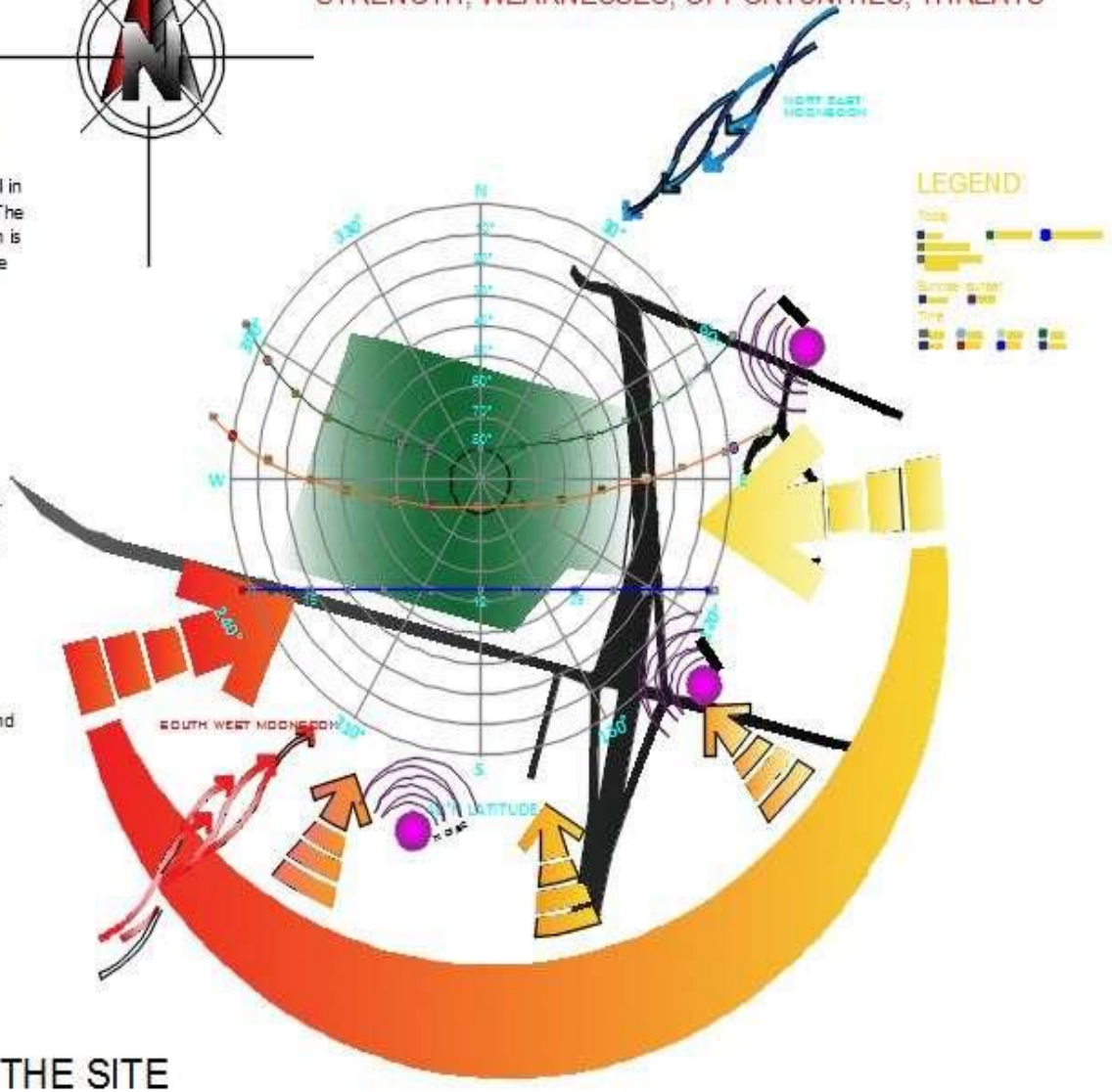
CLIMATOLOGY

The temperatures are highest on average in August, at around 27.8°C. The lowest average temperatures in the year occur in January, when it is around 25.9°C.

TOPOGRAPHY

The city of Tanauan covers a total land area of 10,716 hectares which represents 3.38% of the total land area of the province (316,581 ha).Majority of the areas in Tanauan City belong to 0 to 15 percent slope that are undulating to rolling.

STRENGTH, WEAKNESSES, OPPORTUNITIES, THREATS

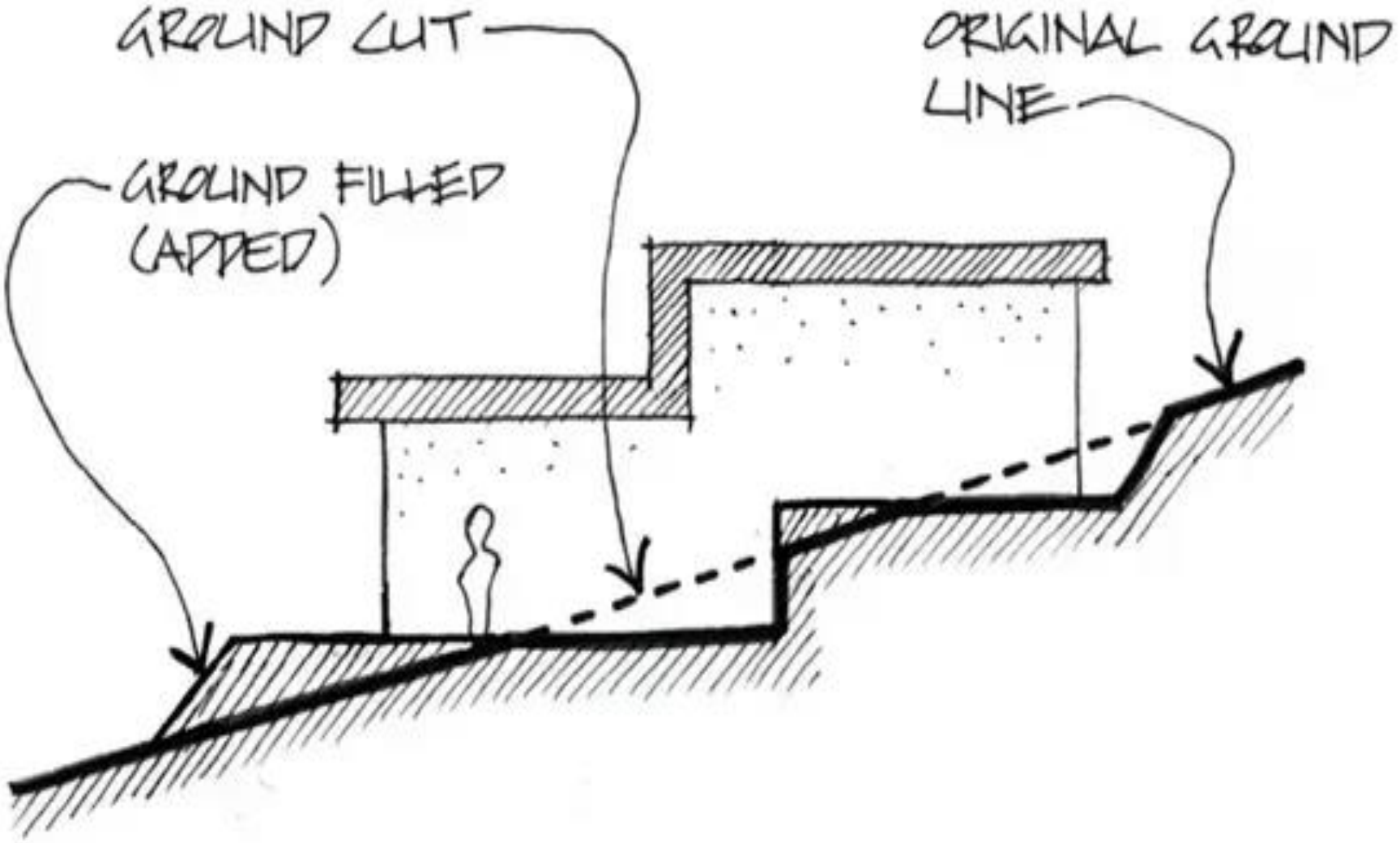


VIEWS FROM THE SITE

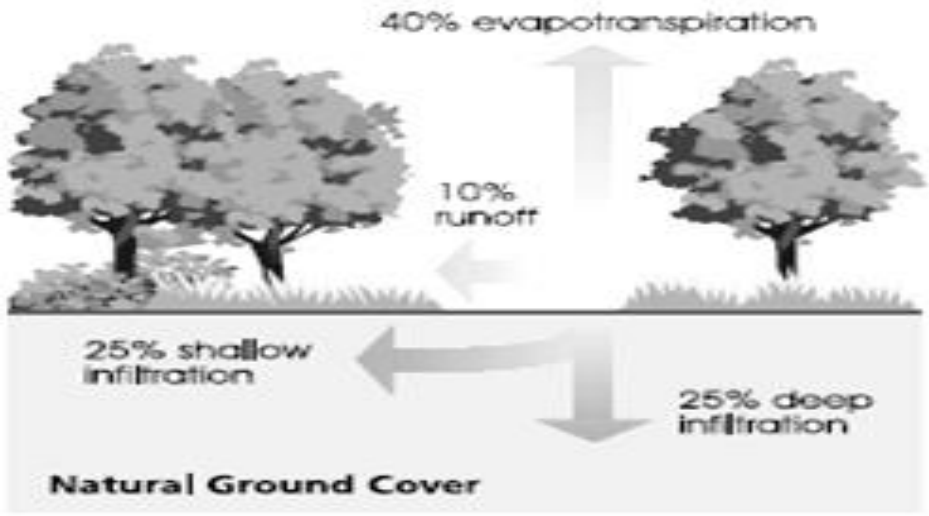
Site Planning Principles

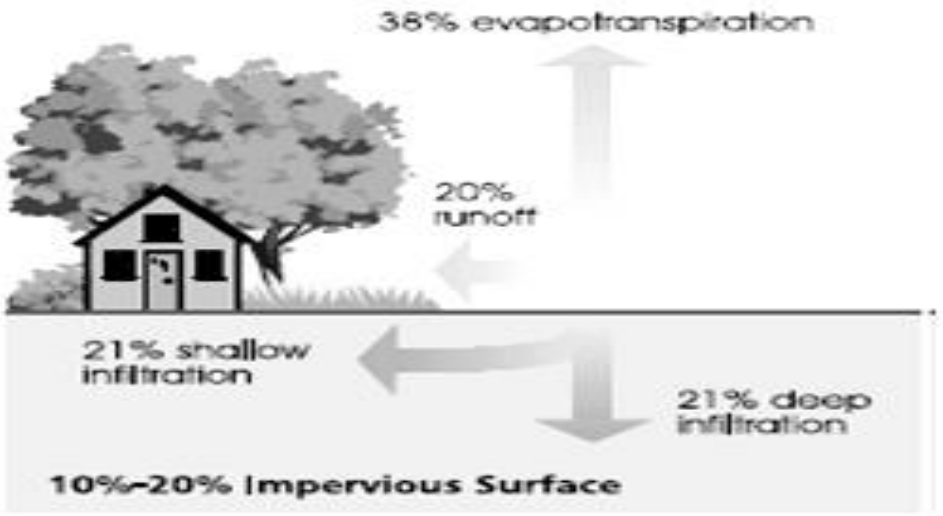
i) Neighbourhood Character
ii) Physical Characteristics
iii) Site and Slopes
iv) Minimum Fingerprints of Building
v) Minimum damage to site
vi) Design with Nature and local Culture
vii) Promoting Pedestrianization
viii) Using hierarchy of
-- Preservation,
-- Conservation and
-- Regeneration

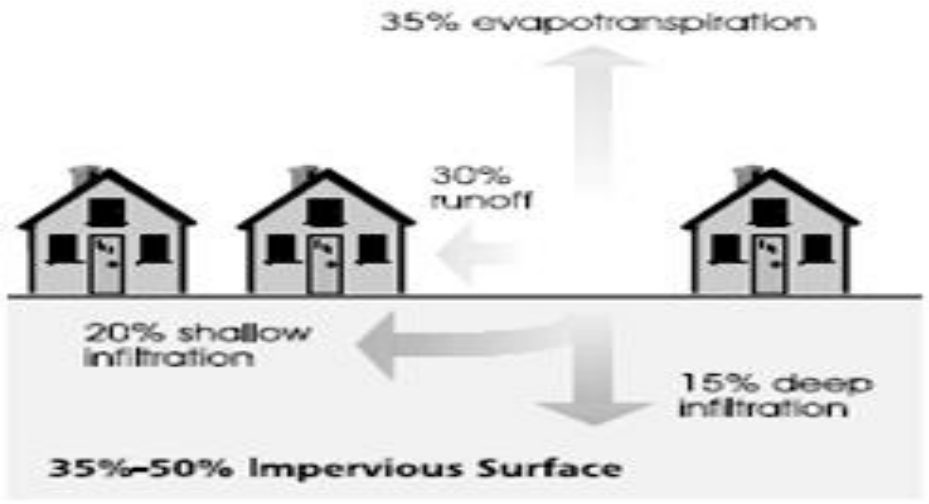
MANAGING SITE- MIN. CUTTING &FILLING

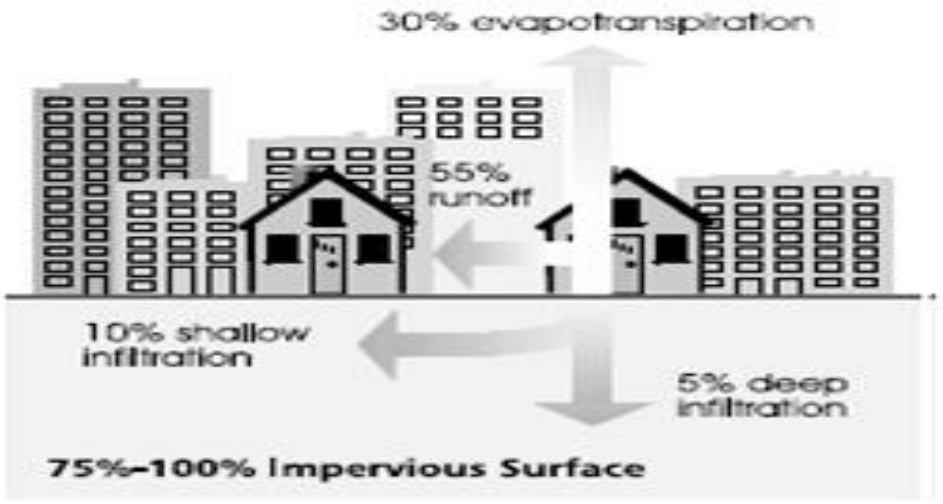


Impact of Buildings- minimising Building Footprints









Preserving & Protecting Green Areas

View from Site- sea

Understanding Orientation; Planning of Spaces; Building Envelop-v

Understanding/Valuing Sun

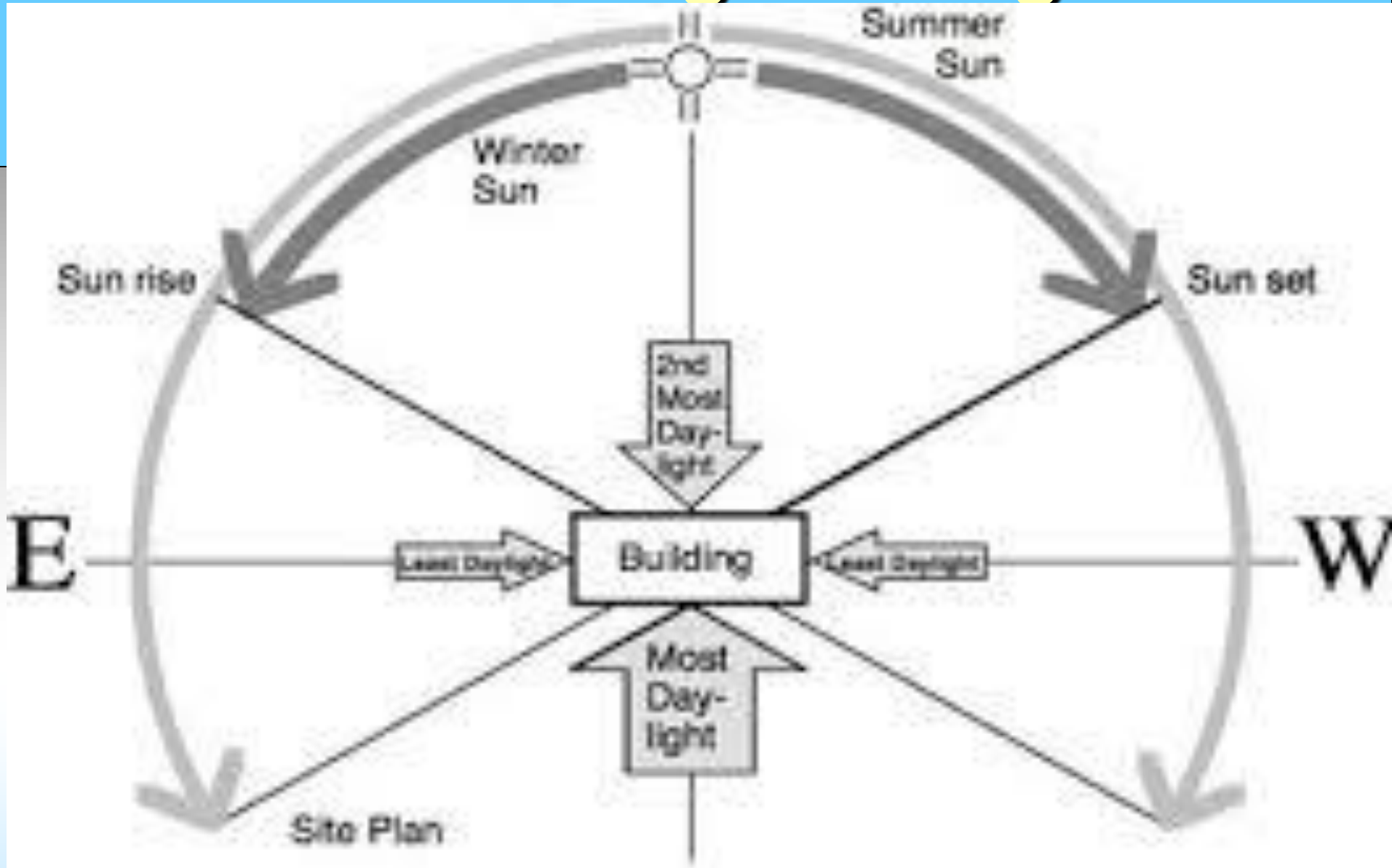


Figure 1

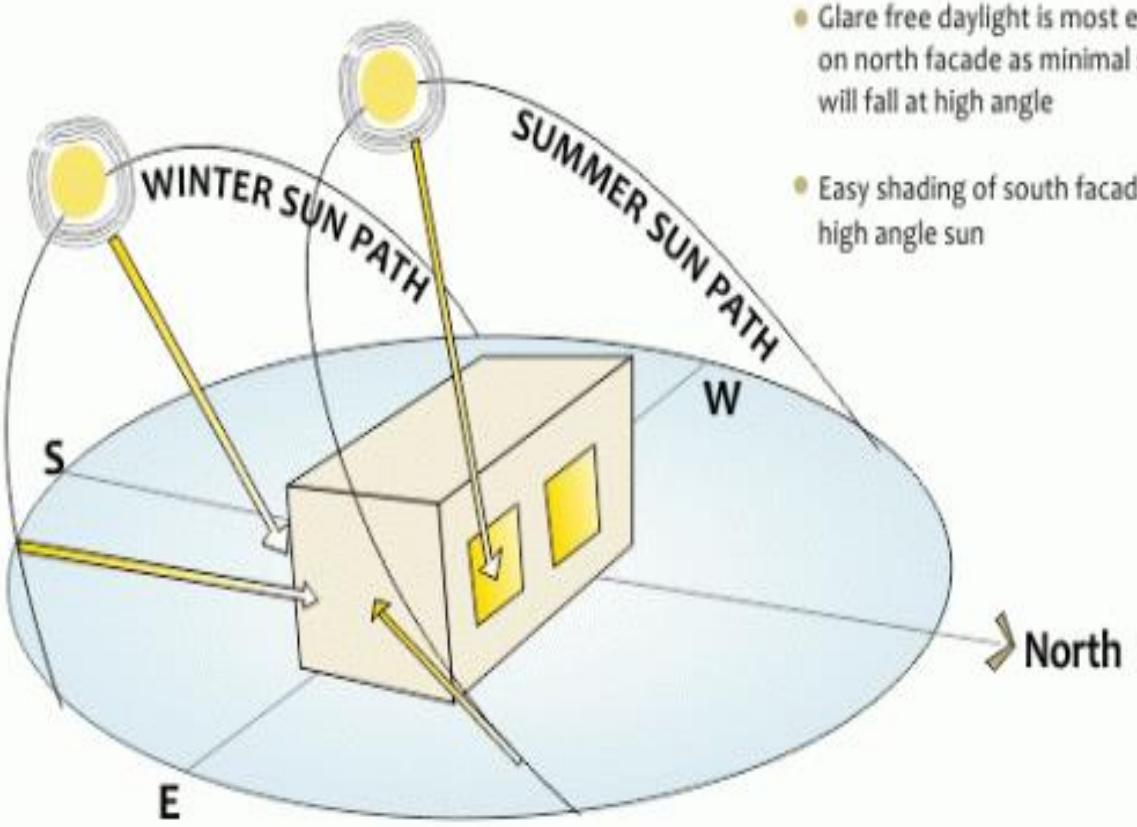
ORIENTATION

SUMMER SUN

- Sun path at a high angle sun, north to E-W axis
- Glare free daylight is most easily available on north facade as minimal solar radation will fall at high angle
- Easy shading of south facade from high angle sun

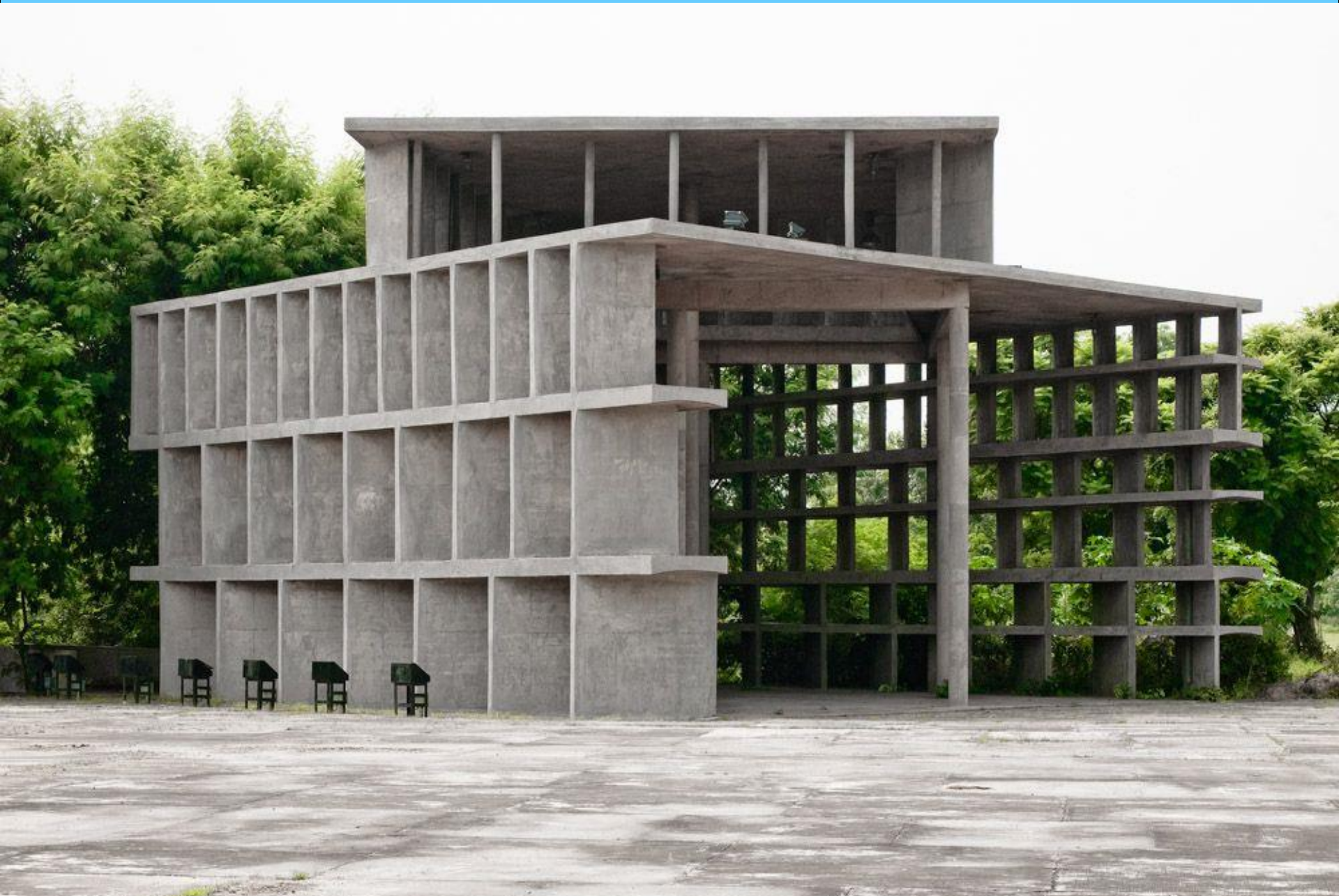
WINTER SUN

- Sun path at a low angle , south to E-W axis
- Solar radation will penetrate south facing facades at a low angle during winter

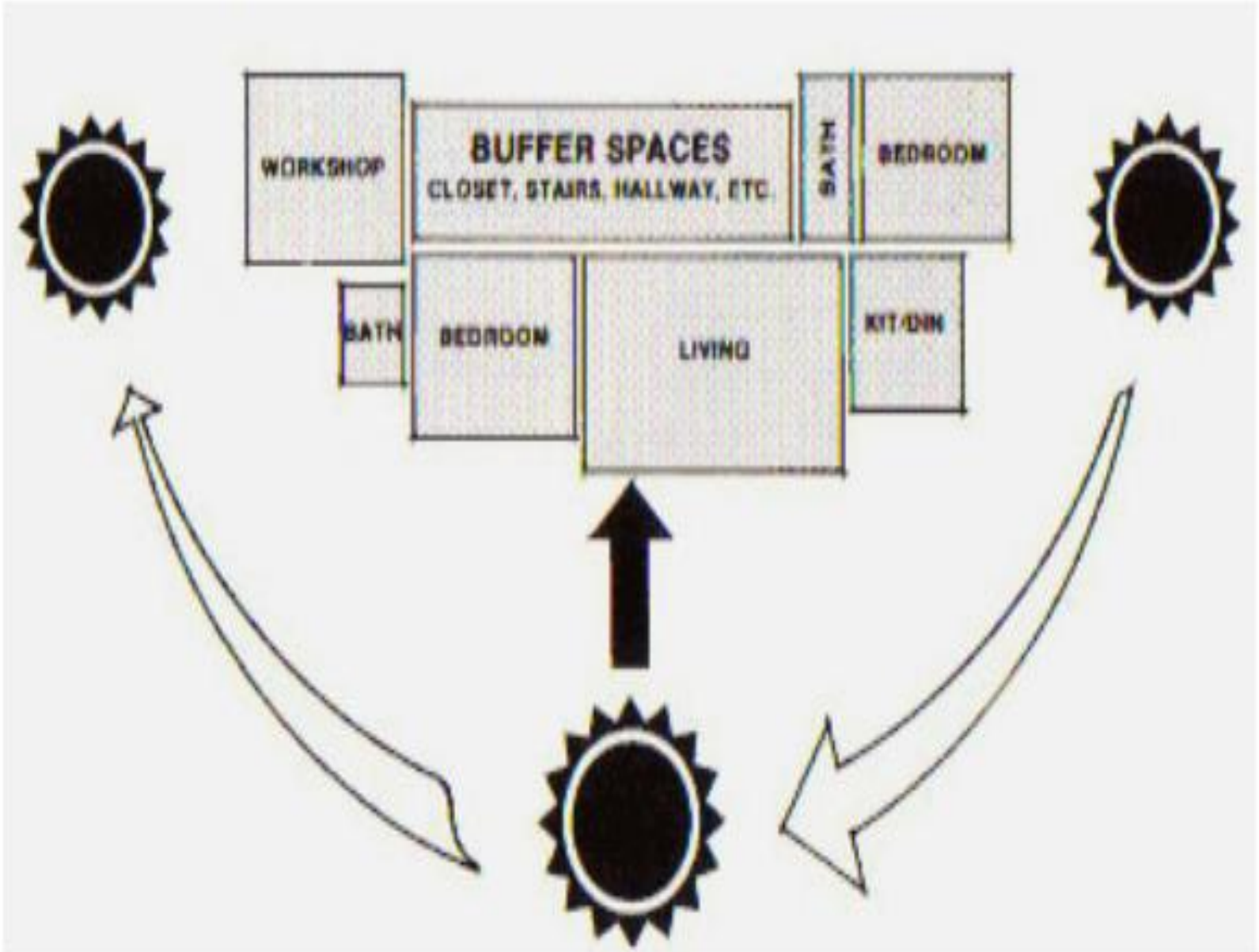


East and west facades continue to receive uniform, strong solar radiation at a low angle through the year.

Tower of Shadow- SunTemple;Chd



Planning for spaces in buildings



Building Envelope

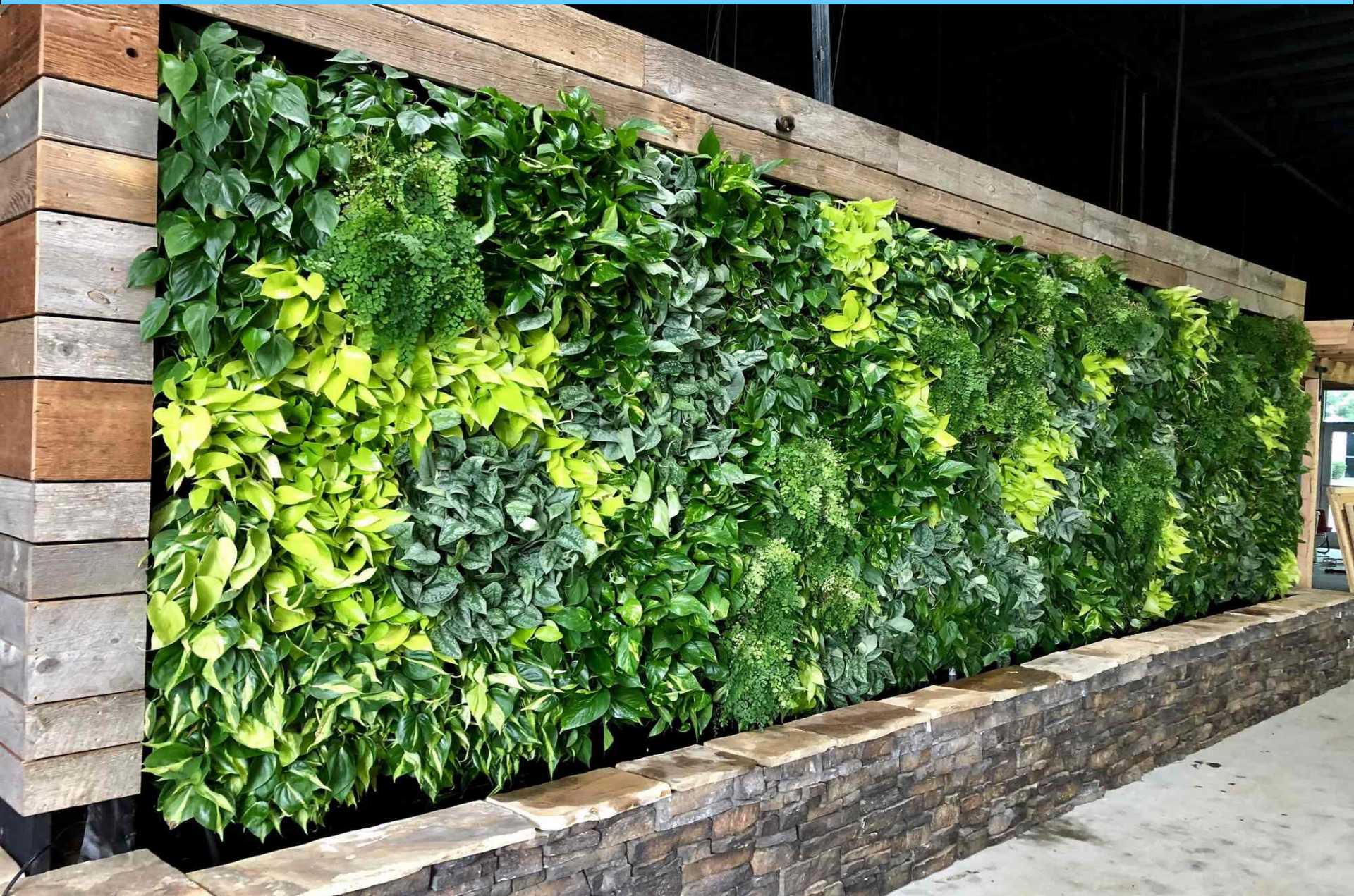
- *Building envelope;*
- *-Divides – natural / Manmade Environment*
- *-First line of defense- against natural forces – rain , heat, cold, storm*
- *Barrier-- between interior/exterior of a building*
- *Controls-- exchange of air/water/heating/ cooling in interior.*
- *Components constituting Envelope;-- Roof, Walls, Doors, Windows, Foundations, Projections, Recesses, Louvers; shading devices*
- *Envelop- Involves structural loads , air, heat, moisture loads.*
- *Colour/texture- contributes to heat gain/loss within building.*
- *- Tight Envelope -in cold climates- controls airflow in / out building.*
- *- Loose Envelop--in hot climates- lets air flow through building*

Making Roof White

Making Roof Green

Making Roof Garden

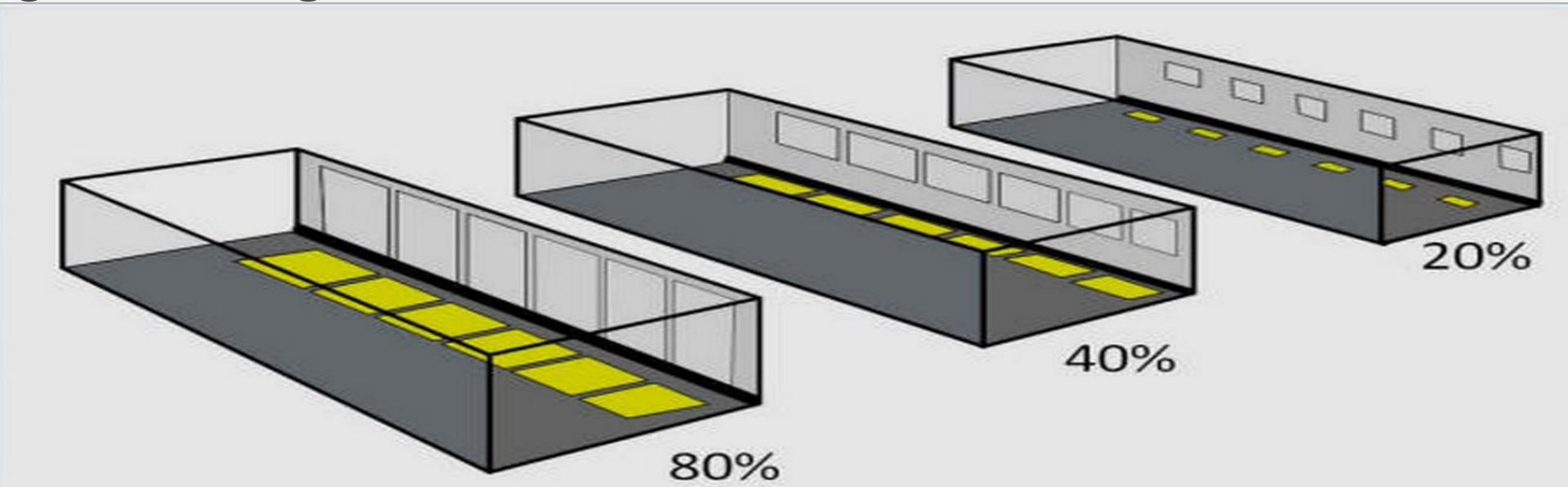
Making Walls Green



Landscaping- Interiors/Exteriors

Window-wall ratio (WWR)

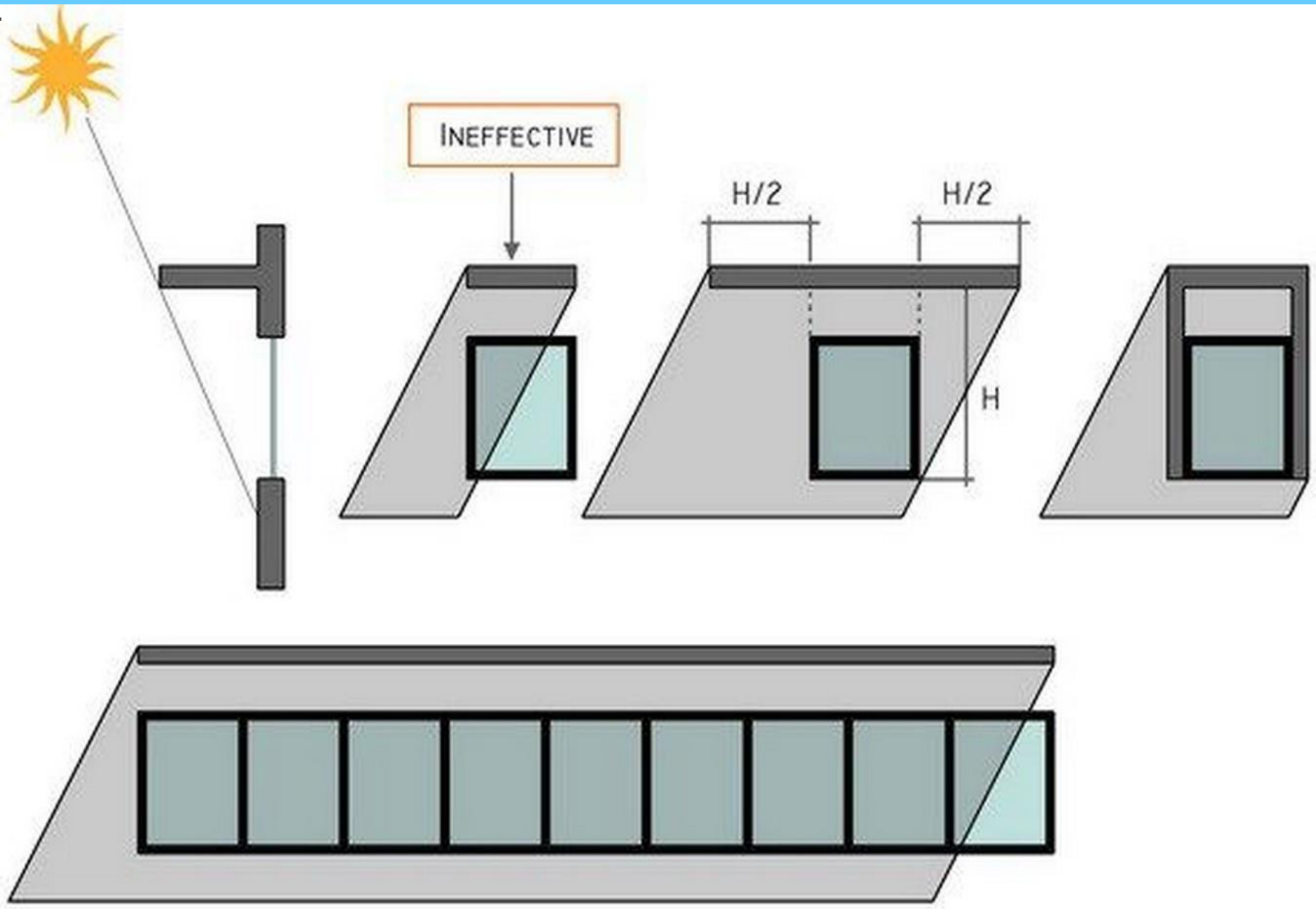
Window-wall ratio;-- ratio of window area to exterior wall -- important for determining energy performance of building.-- Windows -cause energy loss/gain- twice more than wall-impacts heating, cooling, lighting, ventilation.- Size/number of windows - designed according to climatic conditions. -- high-performance glazing - reduces solar heat gains through windows



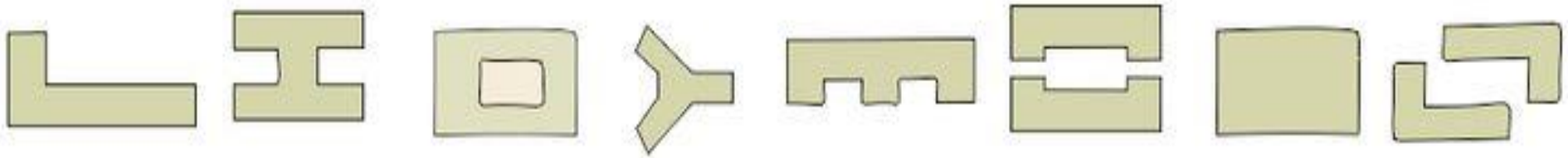
Solar Shading

- *Solar control / shading --directly impact -- energy efficiency*
- *--cooling load minimized to one-fourth of building's load.*
- *-Shading devices – fins/ chajjas (overhangs) designed*
- *--to get a minimum exposure of sun in summer*
- *-- while allowing winter sun inside the space.*
- *-- helps in regulating /reducing electrical load on building.*
- *-- Solar orientation important*
- *-- while designing an effective shading device.*
- *-- Some solar shading elements -- trees, hedges, overhangs, vertical fins, low-shading coefficient glass, blinds, and louvers*

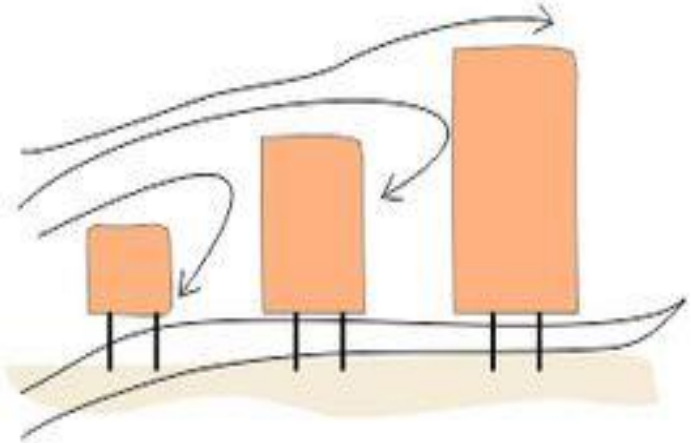
Solar shading



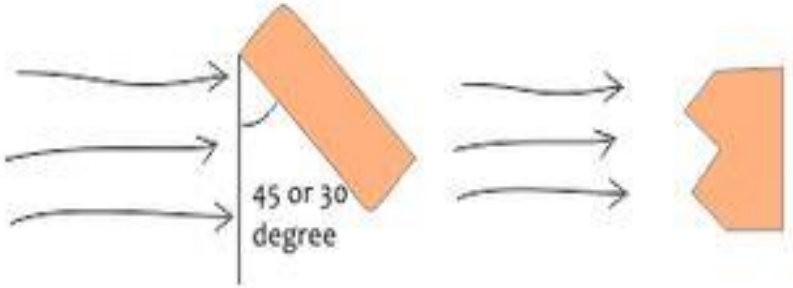
Planning with Cross-Ventilation-vi



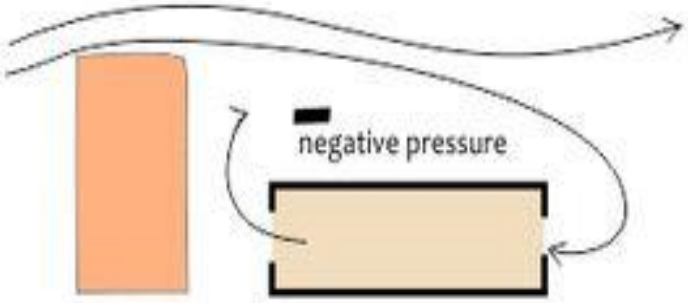
Orient longer facades along the north. This will provide glare free light in summer from north without shading and winter sun penetration from the south.



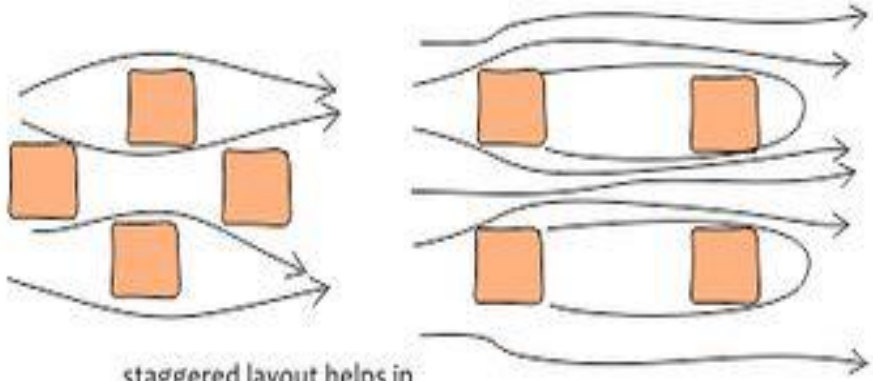
if a site has multiple buildings, they should be arranged in ascending order of their heights and be built on stilts to allow ventilation



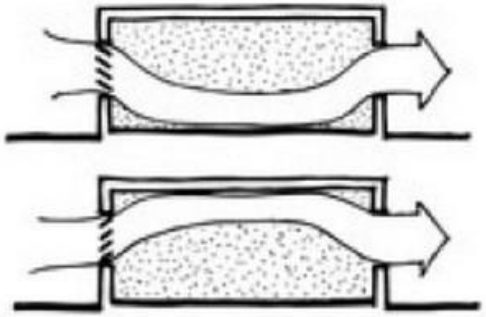
Place buildings at a 30 or 45 degree angle to the direction of wind for enhanced ventilation. Form can be staggered in the wind facing direction also to achieve the same result.



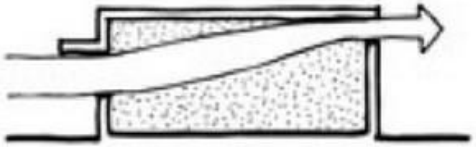
Taller forms in the wind direction of prevailing wind can alter the wind movement pattern for low lying buildings behind them



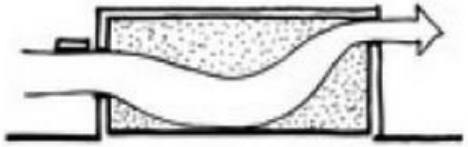
staggered layout helps in accentuating wind movement



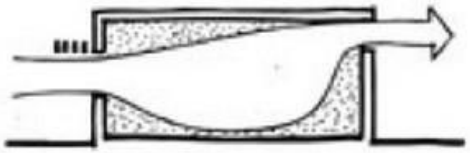
Louvres can direct airflow upward or downward.



A canopy over a window tends to direct air upward.



A gap between canopy and wall ensures a downward pressure.



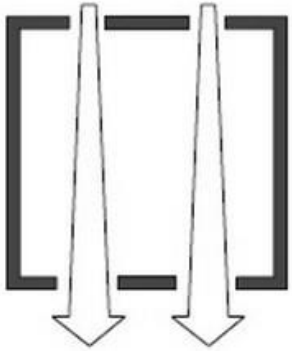
Downward pressure is improved further in the case of a louvered sunshade.

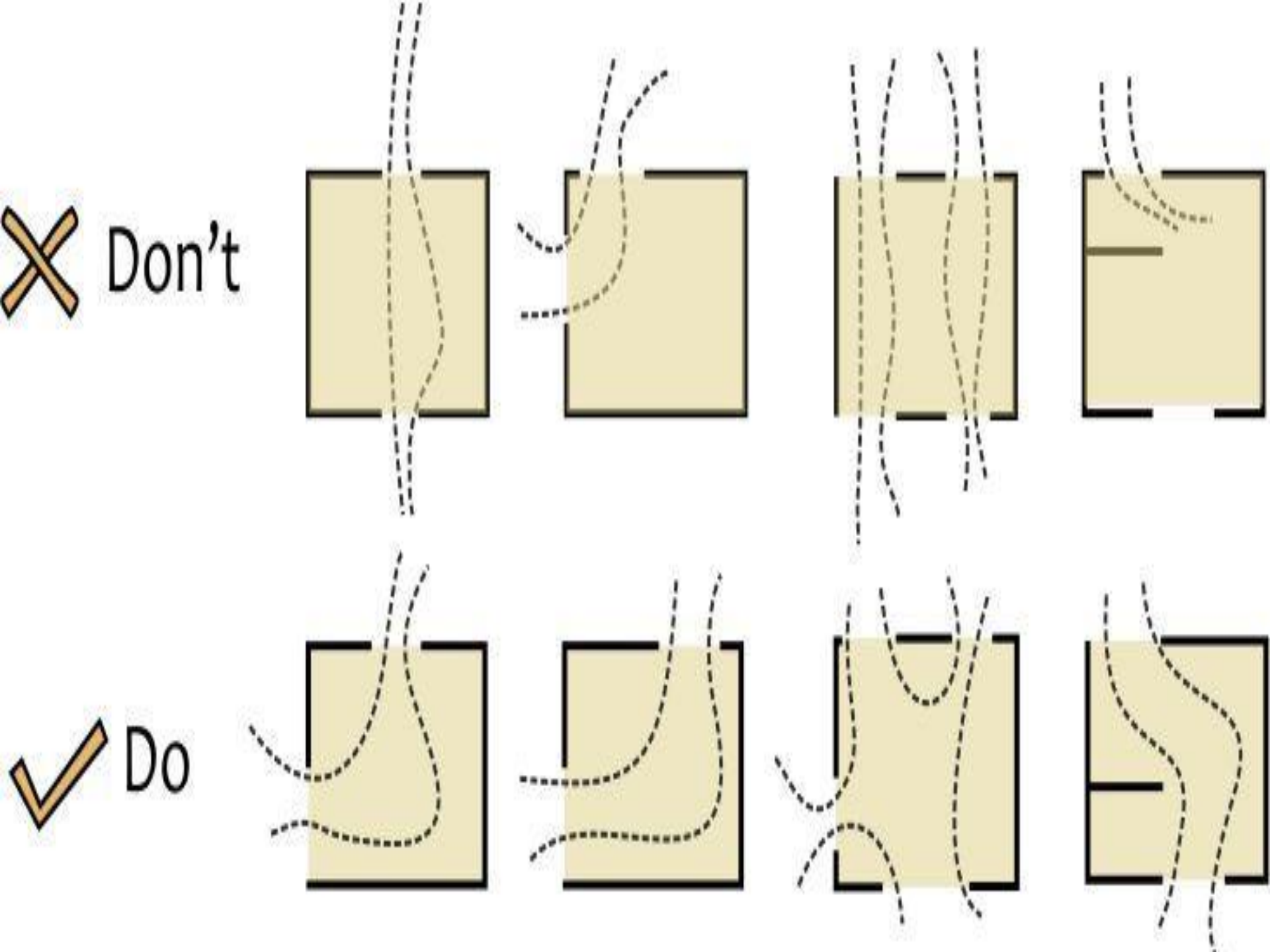
Steve Szokolay

_cross-ventilation

_higher up windows to allow hot air to escape

_smaller inlet windows facing prevailing winds and larger outlet windows on opposite side




Don't
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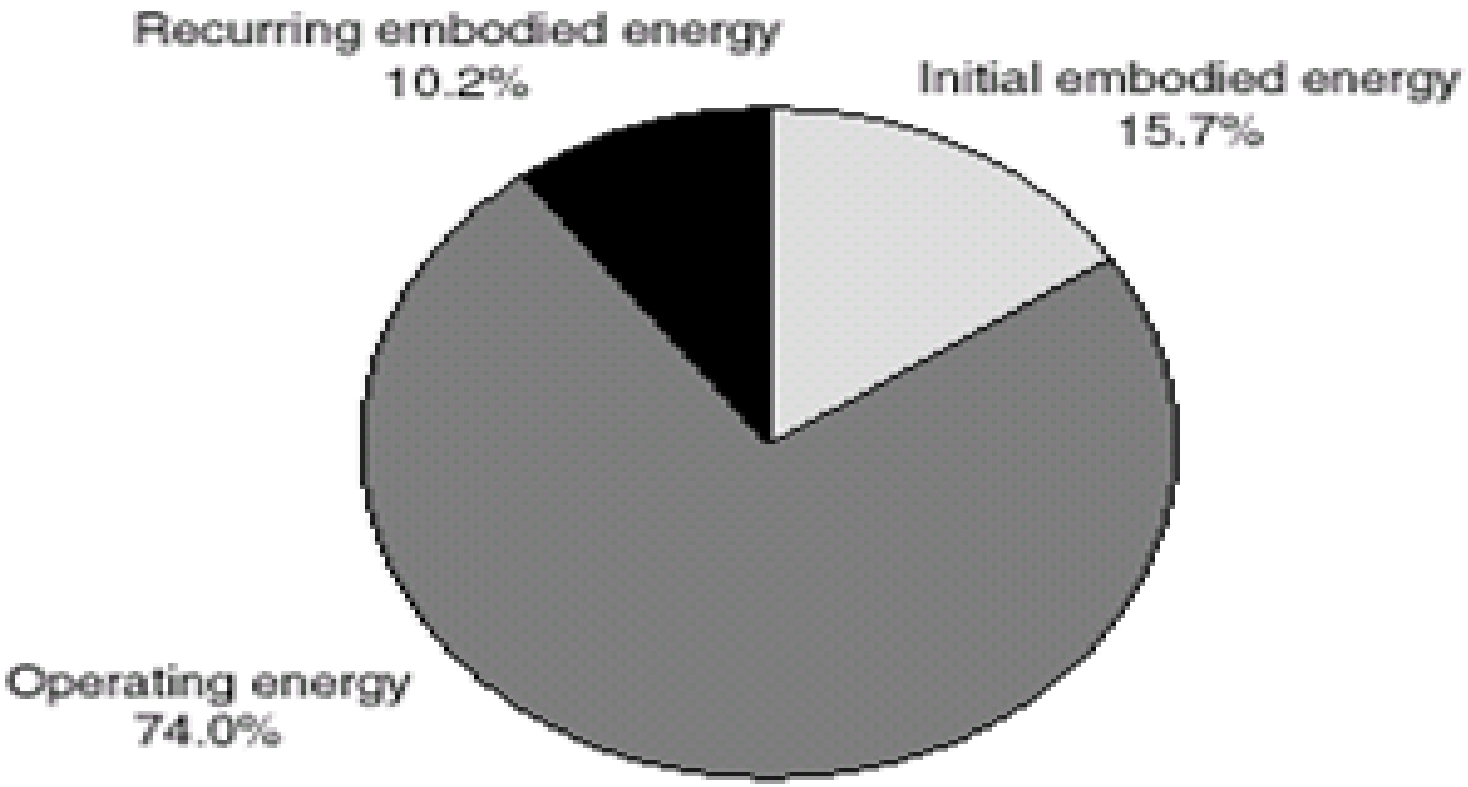
Understanding Energy implications& Achieving Energy Efficiency-vii

Figure 3: Distribution of Life-cycle Energy Consumption.



Energy Efficiency

- ***Green buildings reduce energy consumption in two ways-***
- **i. *Embodied energy-* extract, process, transport and install building materials and**
- **Ii. *Operating energy--* to provide services to make buildings operational-- such as heating, lighting, air conditioning, ventilation and power for equipment.**
- **High-performance buildings use less operating energy,**
- ***Embodied Energy importance* – upto 15.7 % of total energy consumption.**
- **Use local materials/ materials which consume less energy for manufacturing**
- **--buildings made of wood have lower embodied energy than steel/concrete**
- ***To reduce Operating energy –***
- **--reduce air leakage through building envelop**
- **--Specify high-performance windows**
- **--Provide extra insulation in walls, ceilings, and floors.**
- **-- use Passive solar building design**
- **-- Orient windows and walls rationally ,**
- **-- Use trees shade windows /roofs during summer for cutting sun- in hot areas/zones**
- **- while ensuring maximizing solar gain in winter- in cold areas**
- **-- effective window placement (day lighting)-- to provide more natural light /reduce need for electric lighting during day.**
- **-- Solar water heating reduces energy costs.**
- **--Onsite generation of renewable energy through solar power wind power, hydro power or biomass significantly reduce environmental impact Of building**

Energy efficiency- Embodied energy

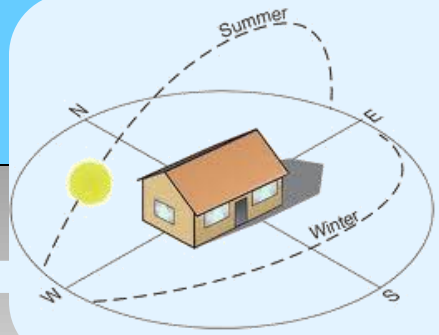
What is embodied energy?

The quantity of energy required to manufacture, and supply to the point of use including:

- Extraction
- Transportation
- Manufacturing
- Assembly
- Installation
- Some definitions also include: Disassembly & Removal

Cost effective strategy for energy efficiency

Reduce energy demand by **passive measures**



- Climate responsive architectural design
- Efficient building envelope
- Daylight harvesting
- Integration of natural sources for cooling & heating in building design.

Reduce energy demand by **active measures**

- Energy efficient equipment
  - Lights
  - Fans
  - Air- conditioners
- Efficient building Operation & Maintenance through BMS (Building Management System) & Smart Metering

Integration of **renewable energy**

Offset energy demand from the grid by installing on-site renewable energy

Least cost impact

Some cost impact

Highest cost impact

High Performance Envelope

Cavity Walls, Double Glazed Units, & Roof insulation

- Reduced heat gain by design
- Significant energy savings

Energy Efficiency

- Energy efficiency achieved through ;
- *Adopting Passive design strategies* -- through building shape , orientation, passive solar design, use of natural lighting.
- Planning and Designing Spaces- differentiating habitation/non-habitation
- Using natural light- positively impact on productivity /well being.
- Installing high-efficiency lighting systems-- with advanced lighting controls-- motion sensors / dimmable lighting controls.
- Using properly sized / energy-efficient heat/cooling system in a thermally efficient building shell.

Energy Efficiency

- Maximize- light/dark colours for roofing / wall finish materials in hot/cold regions;
- -- install high R-value wall/ ceiling insulation;
- - R-value -- measure of how well a two-dimensional barrier- layer of insulation/window/ complete wall/ceiling, resists conductive flow of heat
- -U-Value – measure of overall rate of heat transfer, by all mechanisms under standard conditions, through a particular section of construction.
- **R and U are inversely related – Higher R value and Low U value are good for managing heat transfer in hot areas**
- -- using minimal glass on east/ west exposures.
- -- Minimizing electric loads from lighting, equipment, appliances.
- --Involving alternative energy sources -- photovoltaic /fuel cells
- Computer modelling -- for optimizing design of electrical and mechanical systems and building shell.

Energy efficiency- Day Lighting

Rules of thumb to maximize day lighting without compromising thermal performance shall be:

- **Mark true north on all drawings.**
- **building placed with long axis running east-west.**
- **Minimize apertures on east and especially west**

. Low sun angles for these orientations makes shading difficult without blocking entire window.

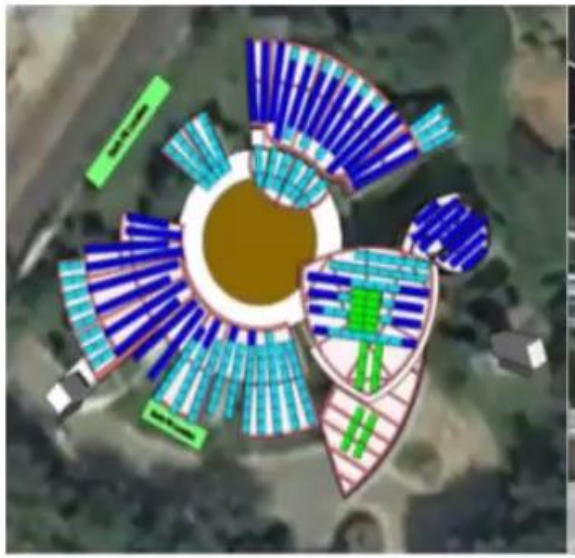
- **Keep window-to-wall ratio between 0.30 and 0.40.**
- **Higher Window to Wall Ratio will require careful handling.**

Day Lighting

Reduced lighting energy consumption through efficient use of skylight and light pipes

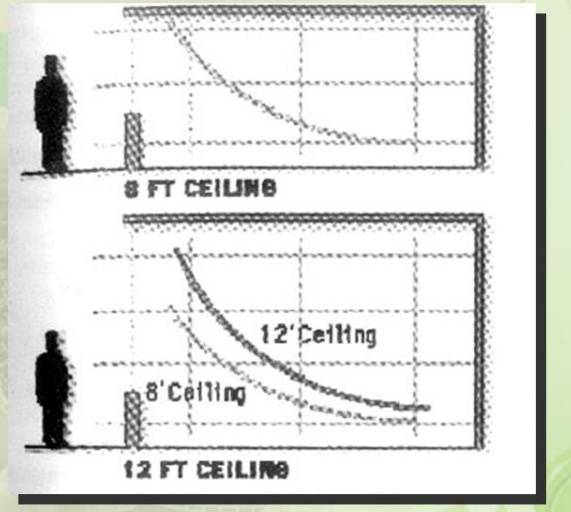
Bifacial Solar PV Modules

- ❖ Transparent & frameless
- ❖ Energy yield enhanced with higher reflectivity
  - ➢ PV module with all-round & undisturbed reflection will have potential of higher energy yield
  - ➢ 20-30% with an elevation of 1.5 m

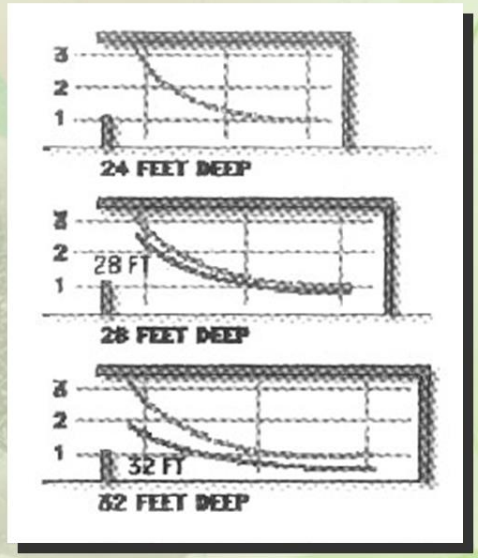


DAY LIGHTING

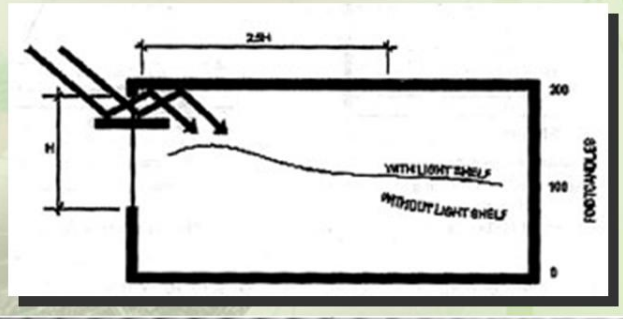
EFFECT OF CEILING HEIGHT

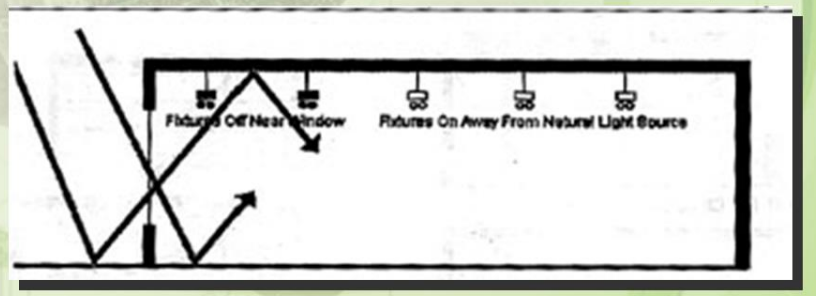


EFFECT OF ROOM DEPTH



INTELLIGENT LIGHTING CONTROLE





Using Green Building Materials-ix

Green Materials

Structure design efficiency

Building / construction sector accounts for;

-- Half of total Energy usage

- Consumption of 1/3rd of raw material

- *- Causing depletion of natural resources*
- *Need to - Optimization / selecting*
- *-- innovative green materials/ structural systems*
- *– which help minimizing weight of structure-*
- *Reducing self load/dead load of buildings*
- *-for minimizing consumption of natural resources.— different Structure varieties having- typical shapes/ cross-sections -- being developed to optimize use of Materials.*

Green Material

- ***Building materials considered 'green' include***:

-- rapidly renewable plant materials -- bamboo and straw,

- ***stone, recycled stone, recycled metal ,***

--- Non-toxic, reusable, renewable, and/or recyclable Products include--

- ***- Recycled industrial goods--.***
- ***-- Coal combustion products, foundry sand,***

-- Demolished debris in construction projects

Green materials are:

- ***Made up of recycled content***
- ***Containing natural/ renewable content***
- ***Available Locally***
- ***Reduced transportation.***
- ***Salvaged/refurbished or remanufactured***
- ***Reusable or recycled***
- ***Durable - last longer than their conventional counterparts***
- ***Materials assessed on the basis of--***
- ***-- Life Cycle Analysis (LCA) --***
- ***embodied energy,***
- ***durability,***
- ***recycled content,***
- ***waste minimisation, and***
- ***-- ability to be reused /recycled.***

- .

Building Material choices

- *Materials also help in modulating temperature within Building*

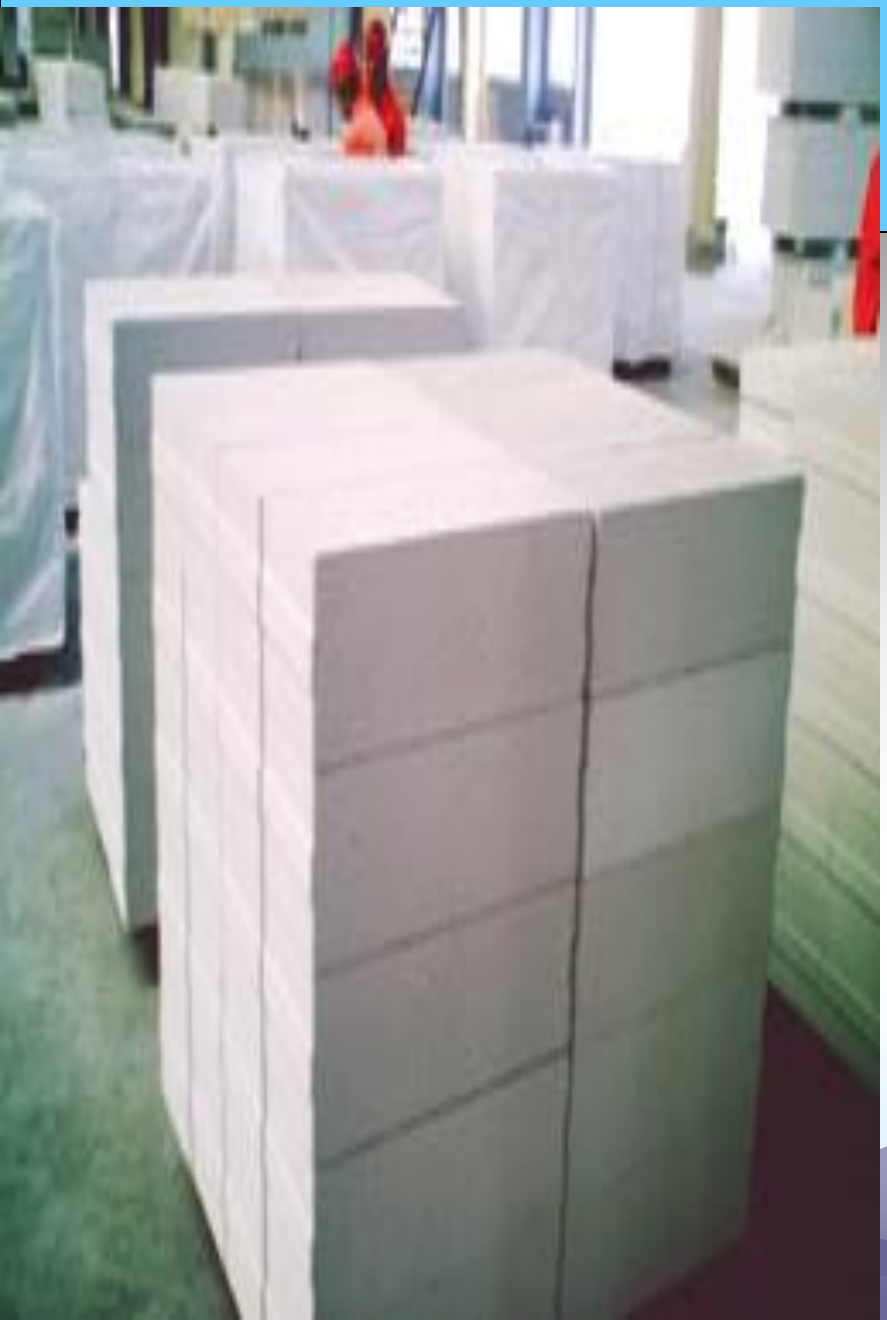
- *Using UV reflective paints -on exterior walls-- reduce heat gain of the building.*
- *Using;*
- *-- light color material including*
- *--China mosaic white finish,*
- *-- vermiculite concrete,*
- *-- polystyrene insulation –*
- *as a roofing material*
- *-- minimises heat gain*
- *-- into building*

Green Material - Fly Ash Bricks

Fly Ash Bricks- Advantages

- ***Reduced Embodied Energy*****: using Fly ash- lime- Gypsum bricks-- 40% reduction** in embodied energy of masonry.
- • ***Environment Friendly*****: Fly ash brick uses unfired Fly Ash technology --** CO_2 emissions in manufacturing process limited..
- • ***Excellent Thermal Insulation*****: Buildings using fly ash bricks -- cool in summers and warm in winters**.
- • ***Fire Resistance: very high-*****--** as these bricks composed of fly ash as its major constituents, which is un-burnt residue of the coal fired in a thermal power plant.
- • ***No Efflorescence*****: Fly ash bricks resist salt and other sulphate attack, ensuring no** efflorescence in structure.

Autoclaved Aerated Concrete



Autoclaved aerated concrete

- **(**sand, calcined gypsum, lime (mineral), cement, water and Aluminium powder,)
- **-- versatile**
- **- lightweight construction material**
- **used as blocks which are:**

- Lightweight
- low density with
--excellent insulation properties.
-- good acoustic properties
-- durable
--- good resistance to sulphate attack
---- damage by fire /frost.
-- used as inner leaf of a cavity wall.
-- also used in outer leaf,
-- when rendered in foundations.
Autoclaved aerated concrete
-- easily cut to any required shape.

UPVC(Unplastisized Polyvinyl chloride) **doors and Windows**

The Vinyl windows

--- excellent insulators :

--Reduce heating / cooling loads by:

- preventing thermal loss through frame / sash material

-- not affected by -

-weather/ air pollution / salt, acid rain/ industrial pollution ,pesticides ,smog, discoloration/ structural damage .

- **user friendly**
- **Eco- Friendly**
- **,-- readily accepted and safe**

Bamboo

i. ***Strength at par with hard wood***

--- Bamboo extremely strong natural fibre, on par with hardwoods-- when cultivated, harvested, prepared and stored properly

-- Bamboo, like true wood, is a natural composite material with a high strength-to-weight ratio useful for structures.

--***Bamboo has higher compressive strength than wood, brick or concrete and a tensile strength that rivals steel***

- ii ***High Flexibility*** - Bamboo highly flexible--during growth trained to grow in unconventional shapes.

-- After harvest, may be bent /utilized in archways / curved areas.

iii. ***Earthquake-resistance*** - Great capacity for shock absorption, -- makes it useful in earthquake- prone areas.

iv. ***Lightweight*** - Bamboo extremely lightweight.

- -- Building with bamboo can be accomplished faster with simple tools than building with other materials.

-Cranes /other heavy machinery rarely required.

- v. ***Cost-effective*** – Economical
- --- especially in areas where cultivated/ readily available.
- --Transporting cost also much lesser.
- -- Helps achieve cost effective construction.

Bamboo

vi**. vi.** ***Durable*** - Long-lasting --as its wooden correlates, when properly harvested and maintained.

- ·vii. ***Fast Growing-***--Bamboo fast growing species / renewable resource which can be cultivated in most types of soil. ·
- viii. ***Simple designing-*** **D**esigns of Bamboo components being simple, there is no need of highly skilled labour.
- ·ix ***Reducing use of wood-***-- Dependency on natural forests for wood reduced thus contributing to the protection of the environment.
- ·x ***Eco- friendly-***-- As it can grow in many types of soil, bamboo cultivation is suitable for rehabilitation of degraded forests and other waste lands thus converting them into fertile lands
- xi ***Promoting Employment*****–** Creating employment opportunities especially for rural people --as Bamboo manually woven before making them into Bamboo Mat / Boards, Bamboo Mat Veneer Composites and Bamboo Mat Corrugated Sheets.
- ·**xii** ***Promoting Welfare of society/poor-*** **Promotes** overall welfare of the society, particularly of economically weaker section.
- xiii ***Reducing GLOBAL warming-*** Captures 17 mts CO_2 per hectare per year- more than any specie
- xiv ***Improves indoor air Quality-*** **By** removing carbon and adding oxygen when used as Indoor plant

India Pavilion made of Bamboo at Shanghai expo 2010

Containerwerk's 'tiny houses' made from upcycled shipping containers

Construction Technologies-

On Site- Off Site

Pre- fabrication- x

Pre- fabrication Construction/Advantages

- **Green Construction**
- -Modular buildings require less power consumption compared to traditional constructions,
- ---lower life cycle energy implications as compared to on-site construction
- -- have minimum requirement of water due to absence of onsite watering of brick/concrete
- -- Energy efficiency achieved through using recycled materials
- -- Resource efficient greener construction process-- due to reduced material waste/ use of recycled materials
- **Flexibility**
- Flexibility --based on easy dismantling /Relocation of buildings to different sites,
- being made of numerous individual parts-- also permit flexibility in building structure/ design by changing design of specific prefab component.

Crystal Palace London

Promoting health and wellbeing

- **Promoting health and wellbeing by;**
- **Bringing fresh air inside/ Delivering good indoor air quality-- through ventilation-- avoiding materials / chemicals -- creating harmful /toxic emissions.**
- **Incorporating natural light / views--to ensure building users' comfort /enjoyment of surroundings/ reducing lighting energy needs .**
- **Designing for ears/ eyes – through Acoustics /sound insulation-- for promoting concentration, recuperation/ peaceful enjoyment of a building-- in educational, health /residential buildings.**
- **Ensuring Environment comfort --through right indoor temperature**
- **Adopting Passive design**

Using sustainable building materials-- like wood/recycled glass/renewable materials like rubber / bamboo.

Choose interior finish products with Zero or low VOC emissions

Using Indoor plants

Eliminating dampness

Avoiding Carpeting

Improving Indoor Air Quality through Plants – Air Purifiers

Areca Palm

Best air purifying plants for general air cleanliness

Snake Plant

Removes Nitrogen Oxides & absorbs formaldehydes

Money Plant

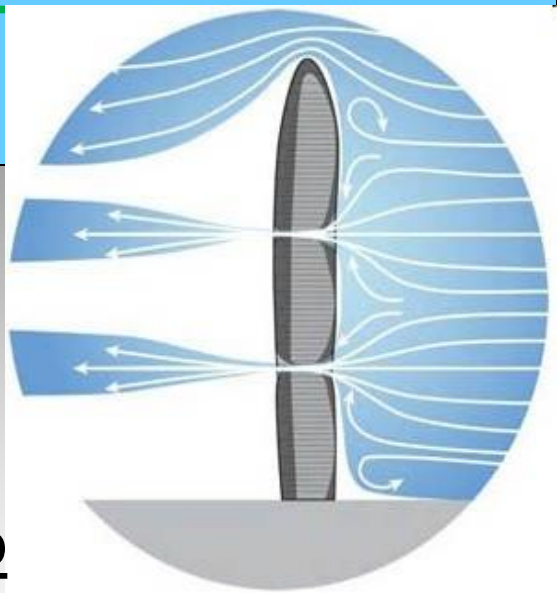
Best Air Purifier

PEARL RIVER TOWER- GUANGZHOU, CHINA
NET ZERO ENERGY BUILDING

YEAR OF COMPLETION- 2011
SITE AREA-10635SQ.M.
PROJECT AREA- 214,100SQ.M. (2.3MILLION SQ.FT.)
NO. OF STORIES- 71
HEIGHT OF BUILDING-309 M

ENERGY EFFICIENCY ACHIEVED THROUGH

--SOLAR PANELS/ PHOTO VOLTAIC CELLS
-- WIND TURBINES
-- DAY LIGHT HARVESTING
-DOUBLE SKIN CURTAIN WALLS
--CHILLED CEILING WATER UNDER FLOOR VENTILATION



Bahrain World Trade Center - Bahrain

- Generating 15% energy from windmills
- Two 240 meter twin sky scrapers joined by three windmill--, each 3 meters wide, attached to walkways
- ;designed/ built by Atkins in city of Manama.

Conclusion- Green Buildings

- **United Nations Framework– Convention on Climate Change states that:**

---Urban areas responsible for 70% of global energy consumption and CO_2 emission

--By 2030—82 billion sqm (900 billion sqft)

- an area equal to 60% of total stock of world will be built

--by 2050 building sector --must phase out CO_2 (Zero carbon built environment)

- **--Buildings critical-- to address ecological concern**
- **--Going green -- necessity/ imperative to ensure sustainable tomorrow**
- **- Let us make green as**
- **-- way of life,**
- **-- make integral part of professional learning/education and**
- **-- way of professional practice**
- **--Together we can and we shall make difference**

'A Green building makes you

Happy, Healthy and More Productive

-Provides highest quality of indoor environment

-Optimizes Resources, , Reduces Waste,

- Reduces Carbon Footprints

-makes building operations, cost effective and energy efficient-

create win-win situation for owner; occupant; users; tenant

– 'Natural Capitalism'