Making Building-Green & Sustainable

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Buildings- Role and Importance

- Buildings-- part of history, growth /development of humanity since inception
- Buildings -- shall continue to define future journey of human growth
- Buildings-- constitute manmade environment
- Buildings-- remain vital for human growth, development
- Buildings – are living organism
- Buildings – cater to all human activities
- 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- Role and Importance

- Buildings– providers of optimum/ worst living conditions
- Buildings – known to make people -- healthy & sick
- Buildings –critical for human living - accounting for 80% human life span
- Buildings-- vital to overcome human/ ecological concerns
- Making Buildings Sustainable- essential to make value addition to -- Resources, Environment ,Ecology
- Studies revealed —
- A Green School--makes learning easy & more meaningful
- A Green House--- makes people happy & healthy
- A Green Hospital-- cures patients quickly
- A Green Shopping Mall-- can increase sale / profits

Buildings- Built Environment

- Operational domain of professions of Architecture/ Engineering revolves around –Designing/constructing/maintaining/managing state of art built environment, involving;
- --Siting
- -- planning/ designing,
- --construction,
- --operation,
- -- maintenance
- --Demolition and
- -Reconstruction
- Architects/ Engineers -- have critical role & responsibility

-- for making value addition to

-resources ,

--environment

--ecology

-- by creating sustainable built environment.

-- Going green –necessity --to ensure sustainable tomorrow

-Each building unique --requires different options to make it green

- ***Demographical, Environmental, Energy, Resources Context of Buildings***

The World's 20 LARGEST CITIES by Population Size

Which global cities have the largest populations?

Here's a look at the top 20. ▸

The largest city, Tokyo, has nearly 3x the amount of people than the 20th largest city Tianjin, China ▸

No European cities make the list ▸

Four cities on this list are concentrated in China, three are in India, and two are in Japan ◂

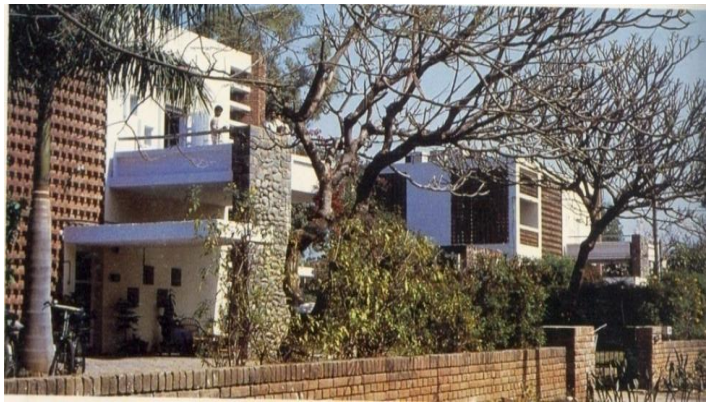
SOURCE: MACRO TRENDS

Population Scenario- India-2011

- Population of India reached
- 1210 million in 2011
- 2050- Indian population- 1600 mil. -- 50% in Urban India.
- During last 100 years, India witnessed—
  - -Urbanization level going up -- 3 times
  - Urban settlements growing merely- 4 times
  - Total Population multiplying-- 5 times
  - -Urban population increasing --15 times
  - -Rural population increasing --3.5 times
- Increased population requires
- More cities,
- More Buildings
- More housing,
- More educational/ healthcare/ institutions
- Space to be added- 700-900 m sqm annually

BUILDINGS AS CONSUMERS OF RESOURCES

- Built environment impact environment / consumption of resources:
  - 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 CO_2 emission
  - 40% of Municipal Solid Waste.
  - 50% of Ozone depleting CFC's still in use.
  - 30% of residents having sick building syndrome



(Roodman and Lenssen, 1995)

- 70% global warming--outcome of buildings / transportation
- Existing buildings--low concern for energy conservation.
- Considering annual addition of- 700-900msqmts-
- -- energy/ environment implications will be critical.
- Buildings need to be;
- -- designed /constructed / operated /maintained
- --with utmost care /considerations for
- -- energy/ sustainability/resources

ENERGY CONSUMPTION PATTERN

- Globally, developed world - major consumer of energy.
- Energy consumption in developing world low.

Category	Population	Energy Used
Developed world	22%	70%
Developing world	78%	30%

- Energy Consumption in developing world increasing rapidly due to-
- - Industrialization , Urbanization
- Prosperity, & Globalization

China/USA consume-

3.5/13 times energy/ capita--compared to India(832 KWH/ann/per)

- 40-50% energy consumed by buildings.
- -- Construction consumes 5-10% whereas
- -35--40%- energy used for operations/ maintenance
- Building energy component largest
- --Possibility of reduction --50% to 70%

Designing 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

- ***Need for Making Buildings Sustainable***

Need for Green Buildings

- **Looking at implications of built environment**
- **-- buildings need to be made –Green Sustainable/Energy efficient/Eco-friendly/ Water efficient/Zero-Energy/Zero Waste**
- **Reduction of Energy/Water/ Waste/Resources/ Green house gas emission possible by;**
  - ***Adopting integrated approach to creating built environment.***
  - ***Evolving climatic responsive building designs***
  - ***Using Energy efficient/low energy--Materials / Equipment/ Technologies.***
  - ***Retro fitting of existing buildings.***
  - **For making buildings sustainable –**
  - **"Green Building Concept-- gaining momentum**
- **Sustainable Dev Goals also calls for;**
- **-- Support least developed countries**, through financial and technical assistance, **in building sustainable and resilient buildings utilizing local materials**
- **- -Promoting Energy efficient buildings,**
- **-Net Zero energy buildings and**
- **- Green Rated Buildings**

SDG 11-Make cities/human settlements, inclusiv ,safe, resilient and sustainable- 10 targets and 15 indicators

SDG--10 targets and 15 indicators

- 11.1. **By 2030--** ensure access for all to **adequate, safe and affordable housing** and basic services and upgrade slums
- 11.2.-- **By 2030--** provide access to **safe, affordable, accessible and sustainable transport systems** for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons
- 11.3. **By 2030,-- enhance inclusive and sustainable urbanization** and capacity for participatory, integrated and sustainable human settlement planning and management in all countries
- 11.4. Strengthen efforts to protect and safeguard the **world's cultural and natural heritage**
- 11.5. **By 2030**, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused **by disasters, including water-related**

SDG--10 targets and 15 indicators

- 11.6. **By 2030-- reduce the adverse per capita environmental impact of cities**, including by paying special attention to air quality and municipal and other waste management
- **1.7. By 2030-- provide universal access to safe, inclusive and accessible, green and public spaces,** in particular for women and children, older persons and persons with disabilities
- **11.a. Support positive economic, social and environmental links** between urban, per-urban and rural areas by strengthening **national and regional development planning**
- **11.b. By 2020,--** substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards **inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement,** in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels

2018 EMISSIONS BY SECTOR

BUILDINGS & ENERGY
- COMMERCIAL 70%
- RESIDENTIAL 30%

TRANSPORTATION
- PASSENGER VEHICLES 83%
- TRUCKS & BUSES 10%
- TRANSIT 7%

WASTE
- LANDFILL 55%
- COMBUSTION 36%
- WASTEWATER 8%

- ***Defining Green Buildings, Benefits, Cost***

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."

Green Buildings

- Green' Building are buildings which;
- --in design, construction /operation,
- -- reduces / eliminates-- negative impacts &
- -- creates positive impacts-- on our climate/ natural environment.
- -- preserves precious natural resources
- --improves quality of life.
- 'Green' Building features include:
- -Efficient use of energy, water/other resources
- --Use of renewable energy,-- such as solar energy
- -- Reducing pollution
- -- waste reduction--re-use and recycling
- -- Making buildings **low cost – during constructing , operationally, functionally**
- - provides Good indoor environmental air quality
- --Use non-toxic, sustainable materials in construction
- Focusing in design/ construction/ operation on
- -- Environment
- -- Quality of life of occupants

BENEFITS OF GREEN BUILDINGS

- *i. Green Building helps in* :
- ii. Saving Up to 50% in Energy
- iii. Saving Up to 40% in Water consumption
- iv. 35% Reduction in carbon emission
- v Reducing 8000-12000 Tons Co2 / million Sq. ft. of building
- vi Reducing 3 MW in connected electric load / million Sq ft building
- vii Reducing 70% waste to facilitate easy handling
- viii Reduced load on municipal water/waste water handling plants
- ix Enhance brand image--attracting national / international companies
- x Better returns due to higher rents
- Provide Financial benefits, Environmental benefits, Social benefits

Benefits to State :

- Reduction of electric demand– Reduced production capacity

Saving addition of-21000- 27000 MW power for new construction

- Reduction in solid waste- less waste to be carried/dumped
- Reduction in water requirement- less water sourced/supplied
- smaller service network-lower development cost/Reduced waste water

Tangible Benefits

- Reduce operating costs
- Optimize life cycle economic performance
  - Sustained savings

HPCL-Admin Building, Vizag

- ❖ Energy savings: up to 50 %
- ❖ Water savings: up to 40 %

In-tangible Benefits of Green Design

- **Environmental benefits**
  - **Reduce impact on environment-- Reduce destruction of natural areas, natural habitats, biodiversity**
- **Health and Safety benefits**
  - **Enhance occupant comfort-- Improve Productivity of occupants**

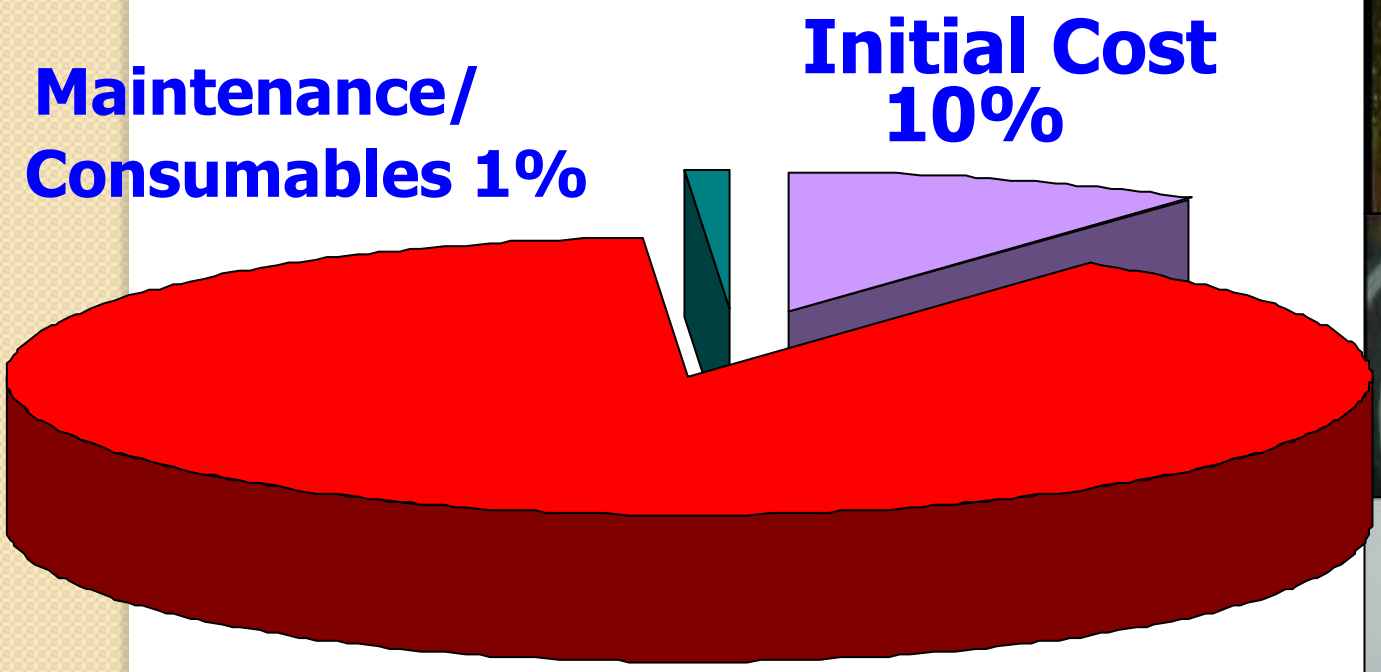
ISRO-NRSC, Shadnagar, Hyderabad

Cost of Green Buildings over the Years

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
Keyges Eternity	2014	1,31,000	Gold	1.5%	3 years
BIEC Hall 4	2017	1,76,250	Gold	1.1%	2.5 Years

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

Green Buildings- life cycle costs



Why Green Buildings

- A Green building ;
- -- may cost more up-front
- -- but promotes saving- through lower operating costs over useful life of building.
- -- cost savings optimised- when used at conceptual design phase
- –assisted by team of professionals.
- -- Integrated approach to building ensures
- -- building designed as one system
- -- rather than a collection of stand-alone systems.
- - Improves occupant health, comfort, productivity,
- -- Reduces pollution
- -- Green building -- yield large savings
- --Financial benefits of improving indoor environments- exceed costs by a factor of 8 and 14

Designing Green Buildings

i **Decision to build Green - taken at earliest in design process for:** :

- --Maximizing green potential
- --Minimizing re-design
- --Assuring overall success and
- --Achieving economic viability of Green Building Project
- Ii. **Setting Green Goals/ Objectives for:**
- -Energy Efficiency
- --Water consumption
- --On site treatment of rain/storm water
- —Material/ Resource management
- -Construction waste Management
- Iii. **Building a Green Team-**
- --Hiring a design team of Architect, Engineering Consultants with expertise, knowledge, experience, understanding of Green Concept
- Iv **Adopting an Integrated Approach to Design-**
- v **Adopting Key Principles/Strategies-**
- i Sustainability in built environment,
- Ii Water/waste management ,
- Iii Energy Management,
- Iv Material/ Resource Management and V Indoor air Quality

- ***Designing Green/Sustainable Buildings- Nature, Climate, Orientation, Sun, Wind***

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.Understanding Orientation -- to optimize natural light and heat gain/heat loss

4– Studying Sun movement-- to maximizes use of free solar energy for heating /lighting

5.—Finding Wind direction---using movement of air for ventilation/ cooling

6. --Planning Building-- to optimize site, shape of building, planning spaces, allocating uses, placing of rooms, circulation, promoting building efficiency, promoting natural sunlight, air &ventilation

7. --Designing Building Envelop-–positioning of openings / projections, planning for shading devices, determining height/ shape of building, natural lighting, ventilations etc

8. Specifying Materials- for buildings- low embodied materials locally available, in natural form, lightweight – to reduce self load

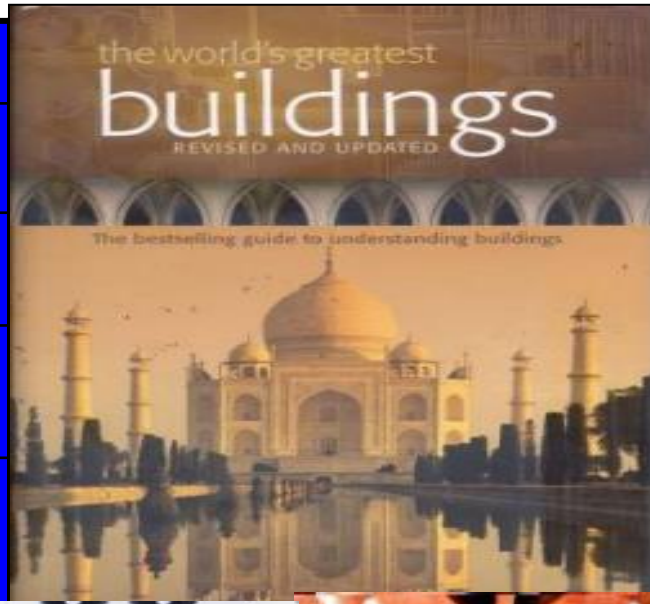
9. Using Technology- cost- effective, material efficient, speedier construction, energy efficient

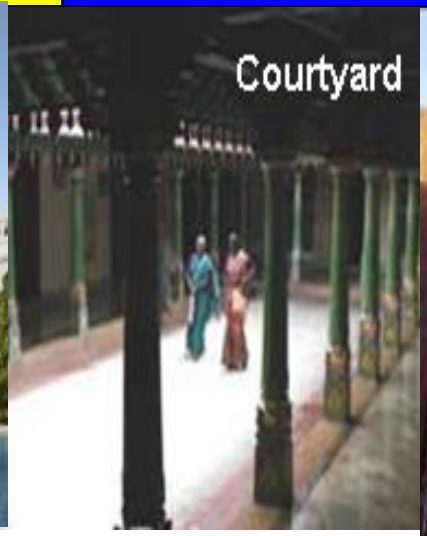
10.-Improving Indoor Air Quality- Creating optimum living conditions for residents

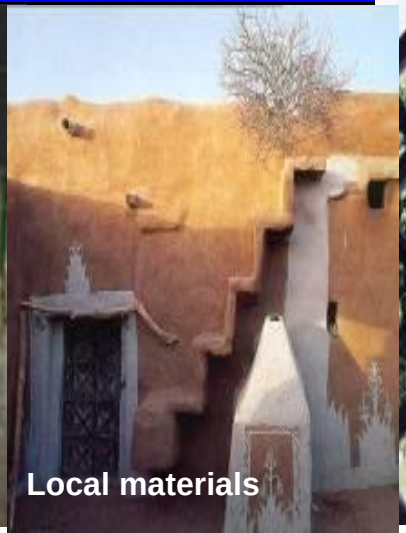
Rediscovery of the Indian ethos

- 5 elements of Nature (Panchabhutas)

Prithvi (Earth)	**Site Selection and Planning**
Jal (Water)	**Water Conservation**
Agni (Fire)	**Energy Efficiency**
Vayu (Air)	**Indoor Environmental Quality**
Akash (Sky)	**Daylight, Night Sky Pollution**







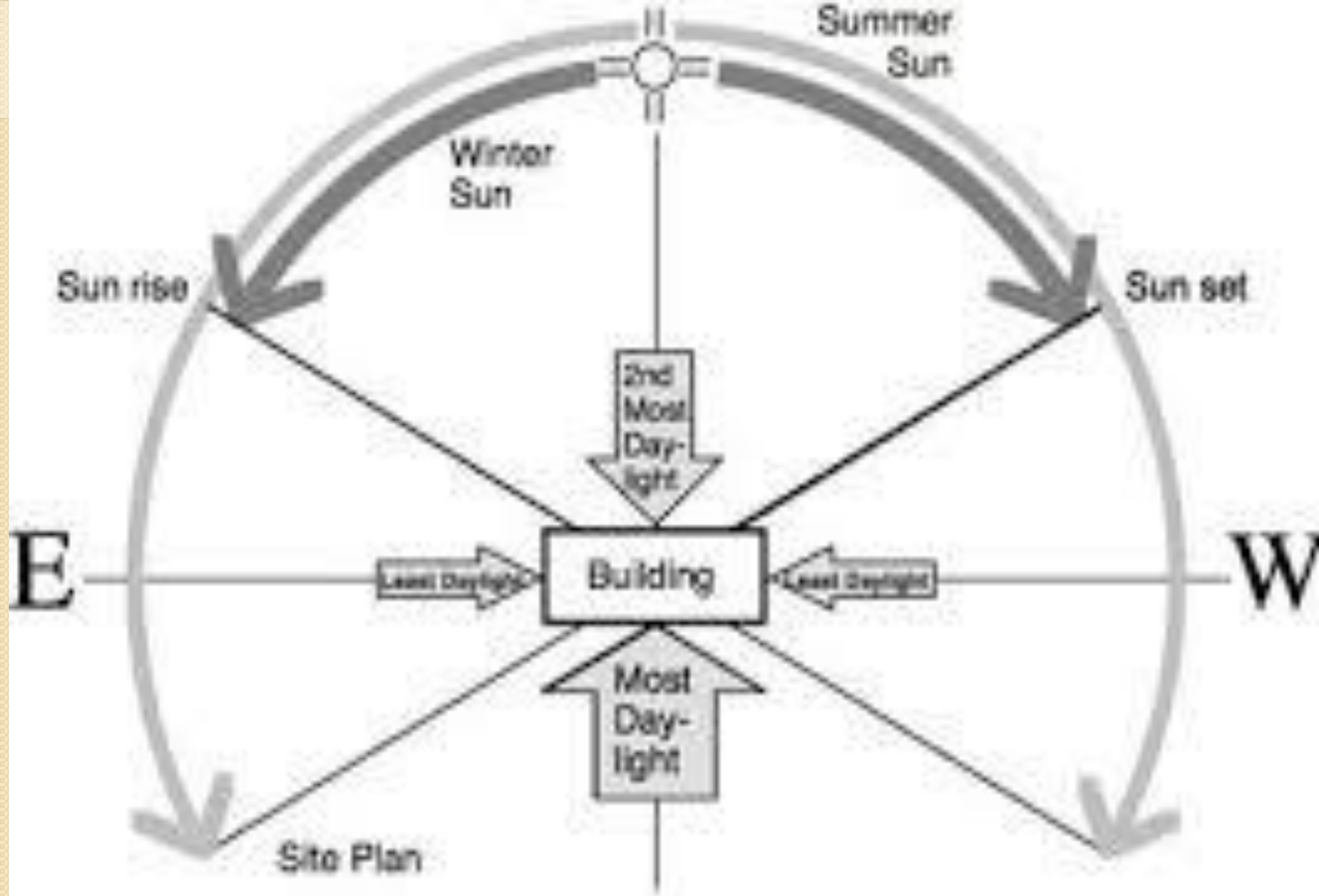
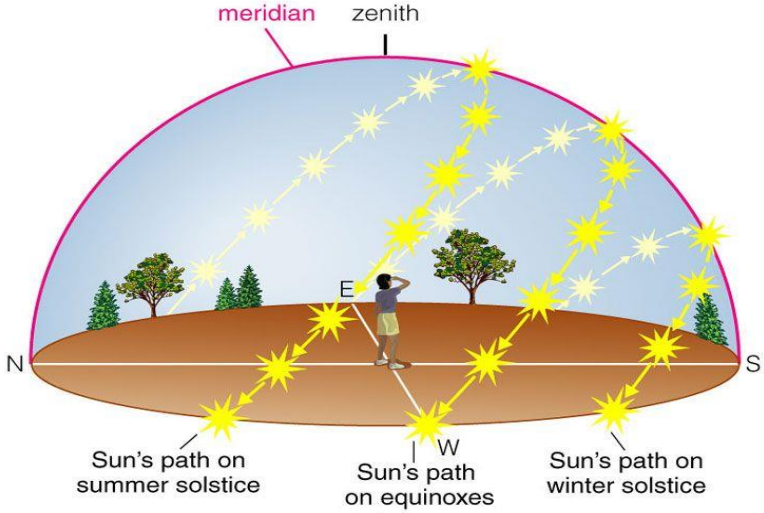

Summer
Sun
Winter
Sun
Sun rise
Sun set
2nd
Most
Day-
light
E
Least Daylight
Building
Least Daylight
W
Most
Day-
light
Site Plan

Figure 1

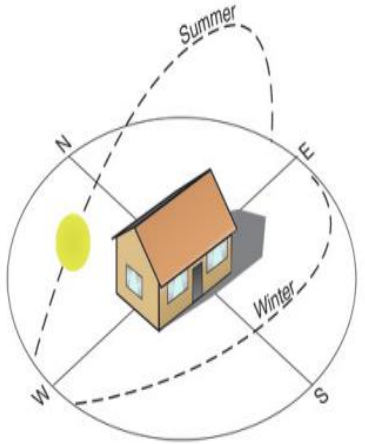
Movement of Sun



Building Orientation-

5. **Building Orientation and Shading**

5.1 The building shall be oriented with the long sides facing north and south whenever the site and location permit such orientation.



- Sun – only original source of heat and light
- Sun -- provides natural daylight into home
- Sun remains lower in sky in winter than in summer
- -- allows us to plan/construct buildings—
- -- which captures free heat in winter and
- -- reject heat in summer
- **Solar temperature and radiation**
- -- Solar radiation intensity depends on direction of sun rays.
- --building's temperature/interior temperature increases /decreases based on sun radiation.
- -- sunrays enters buildings through ---openings / radiation coming indirectly through roofs/ walls --by absorbing heat of sun.
- For comfort-- best orientation –get maximum sun's rays during winter and
- -- minimize sun's rays during summer.
- -- in cold climate-- provide more openings on Southern side - can be closed by curtains/ projections during summer
- For Minimizing solar heat reflected from ground – Provide grassy patch in front of south façade.
- Western /Eastern facades receive equal amount of light.
- -- But Sun on western side raises temperature outside/inside -- provide green walls/ trees/sunshades

Building Orientation-

- -- Building orientation refers to;
- --planning/positioning buildings related to sun path.
- -- to maximize solar gain in cold climate and
- --to minimize solar gain in a hot climate.
- Best orientation increases;
- -- energy efficiency in building--- by making living more comfortable
- --making buildings cheaper to run due to –
- -- low energy consumption
- --saving lot on energy - heating, lighting / cooling
- - creating a mental uplift --natural light / maximum ventilation
- -- Saving from negative effects of inclement weather.
- -- prevents hot winds from entering building
- -- Orientation must be made part of your building design..
- --Good orientation helps designing good building
- --Buildings, constructed according to sun / wind orientation--also known as Passive Solar Buildings.

Building Orientation- Aim

- Aim of best orientation in housing is to provide;
- -- physically/psychologically comfortable living inside building &
- -- good health / happiness -- to user in a secure way.
- Orient frequently used rooms during day in-- East/ North – cooler side
- -Orient rooms used mostly during night to– South/West-- which are hotter directions.
- Plan your house windows/doors in East
- --to allow Sun's UV rays to penetrate into house in mornings.
- --Orientation kitchen -- towards east to allow UV rays
- -- to destroy germs which multiply in moisture / food.
- - design-- all rooms to get maximum benefit of sunlight
- --When deciding building orientation
- -- consider location of landscape feature -- trees, planters, etc
- -- which affect building depending on sun direction /sun path
- Water bodies kept in north-east – for morning UV rays of sunlight-- to destroy germs /bacteria before using it.

Building Orientation

- South orientation receives maximum solar radiation during summers/winters
- --Sun remains vertical in summer
- --Sun remains horizontal in winter
- -Small overhang /curtains on south openings-- -- --- can cut direct solar penetration in summer&
- -- allows sun inside building during winter.
- This advantage -- not available on any other direction
- --East / west receive maximum solar radiation during summer.
- --West remains crucial/adverse orientation because
- -- high intensity of solar radiation received in evening hours- when internal gains are also at its peak.
- -- Deep verandahs/ sunshades in
- -- south & west facades would effectively exclude strong evening rays.

Building Orientation

- **In northern India, where winters are cold --South facing house advantageous** because -- interiors will get more hours of sunlight,- keeping house warmer at night. -- However, in summer interiors get overheated,-- essential to have a protective cover over house in hotter months-- to bring down energy costs for cooling house.
- **House facing North** don't get too much sunheat during day-- making best orientation for houses in south Indian states-- to keep interiors cool naturally, -- saving on energy costs.-- placing bedrooms facing south, will keep them warm, when weather turns cooler.
- **Surroundings have critical role** in deciding orientation.
- -- tall building on south can cast a shadow--Reducing amount of sunlight received.
- **When house built on a steep slope inclining from north to south**,-- effect of afternoon sun might reduce considerably.

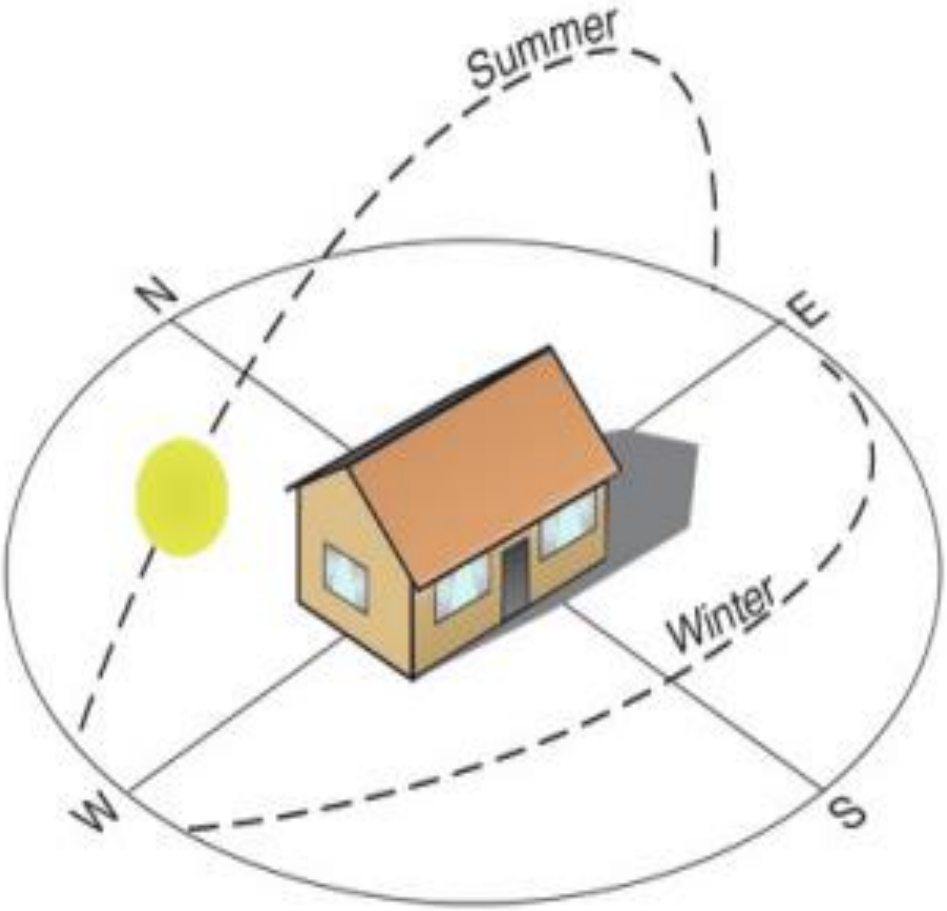
Site Micro-Climate

- **Each site has microclimate**-- more pronounced than neighbor's property
- **Spring arrives earlier on sloped sites** facing south in Hill areas--. Because of solar radiation /optimal sun angle-- they will be warmer, and snow will melt faster.
- **In summer-- these sites cooler than flat sites** when sun is directly overhead/closer to 90 degrees a site to sun,-- warmer it will be.
- **Trees are also a big factor--**Trees blocking sun help keeps homes cooler-- Fir trees provide shade year round,
- **Deciduous trees block heat in summer**, but without shade of its leaves ---will warm house in the winter.
- **Trees can also provide wind breaks from cold winter winds.**
- Trees /tall shrubs -- planted towards south / west – provide protection from afternoon heat & provide oxygen
- **Land near large Water bodies--oceans** / big lakes typically have smaller temperature variations than inland locations both yearly/ daily.
- **House next to a pond /pool**-- also moderate temperatures.
- **Softer soil** with more air pockets-- freezes more often
- -- **Hard soil can moderate --** surrounding air temperatures similar to concrete.

BUILDING ORIENTATION AND SHADING

5. Building Orientation and Shading

5.1 The building shall be oriented with the long sides facing north and south whenever the site and location permit such orientation.

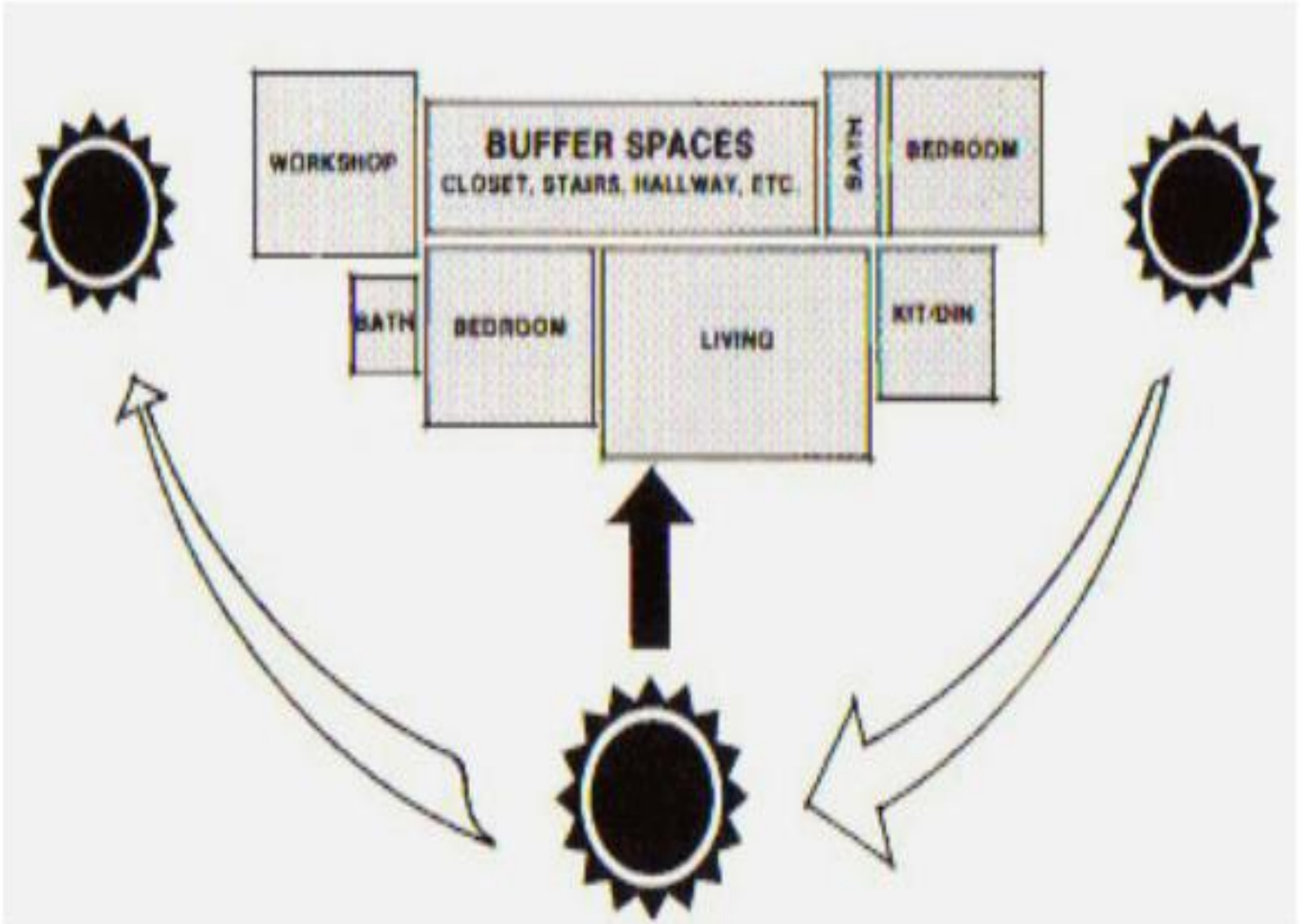


Sun Orientation – Angle of Building

- Houses facing South optimal for facades with more windows-- With large overhangs -- cooler in summer/warmer in winter.
- **Houses facing little more to the Southeast --are more efficient than facing southwest, --** more solar radiation gained in morning Vs warmer afternoons.
- -- **Homes in all climates** -- more efficient when elongated along **east/west axis**-- than **north/south** axis. .
- -- Views/ other factors may remain important to most owners.
- – While selecting site of house --make sure there exists no danger of other buildings/now/ future, -- blocking your views of sun.

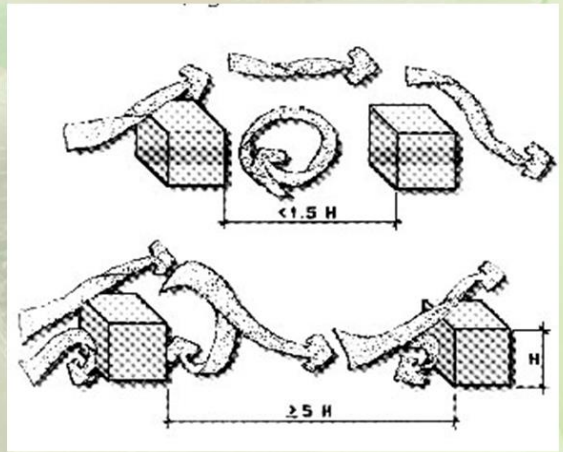
Tower of Shadow- Chandigarh

Planning for spaces in buildings

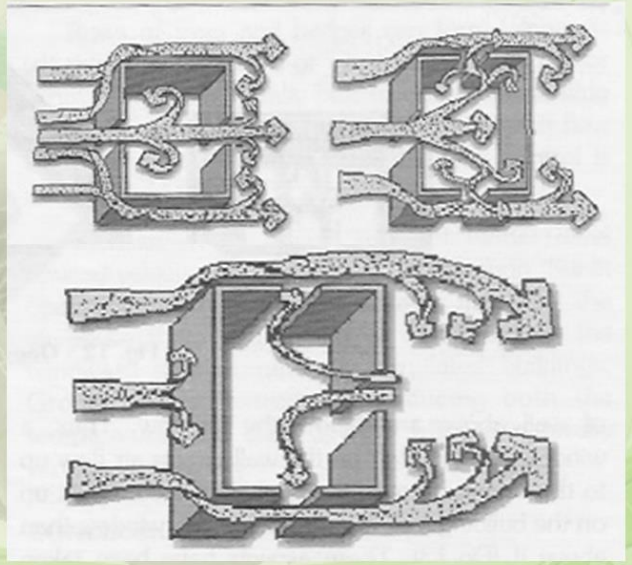


Natural Ventilation

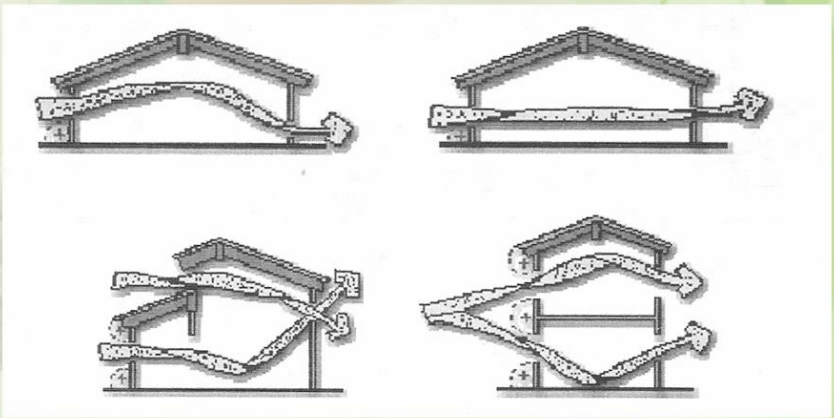
Building Spacing



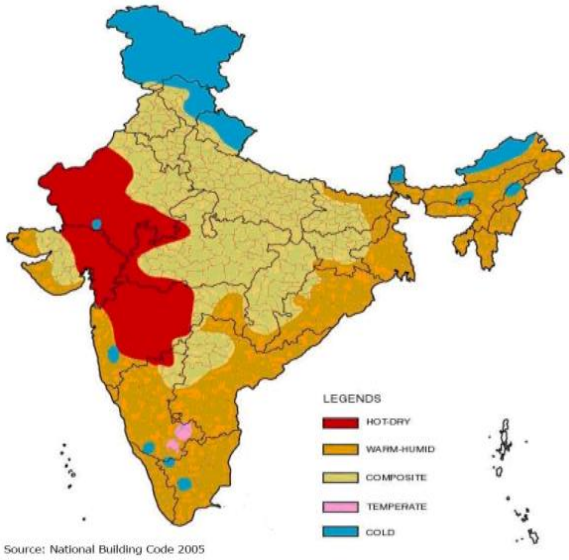
Cross Ventilation



Height & Shape of the inlet Window



Integrated Design Process



- **Five Climatic Zones In India-**
- **Hot and Dry**
- **Warm and Humid**
- **Moderate / Temperate**
- **Cold (Cloudy/Sunny)**
- **Composite**
- **All green buildings cannot be same**

All zones have specific requirements regarding:

--lighting,

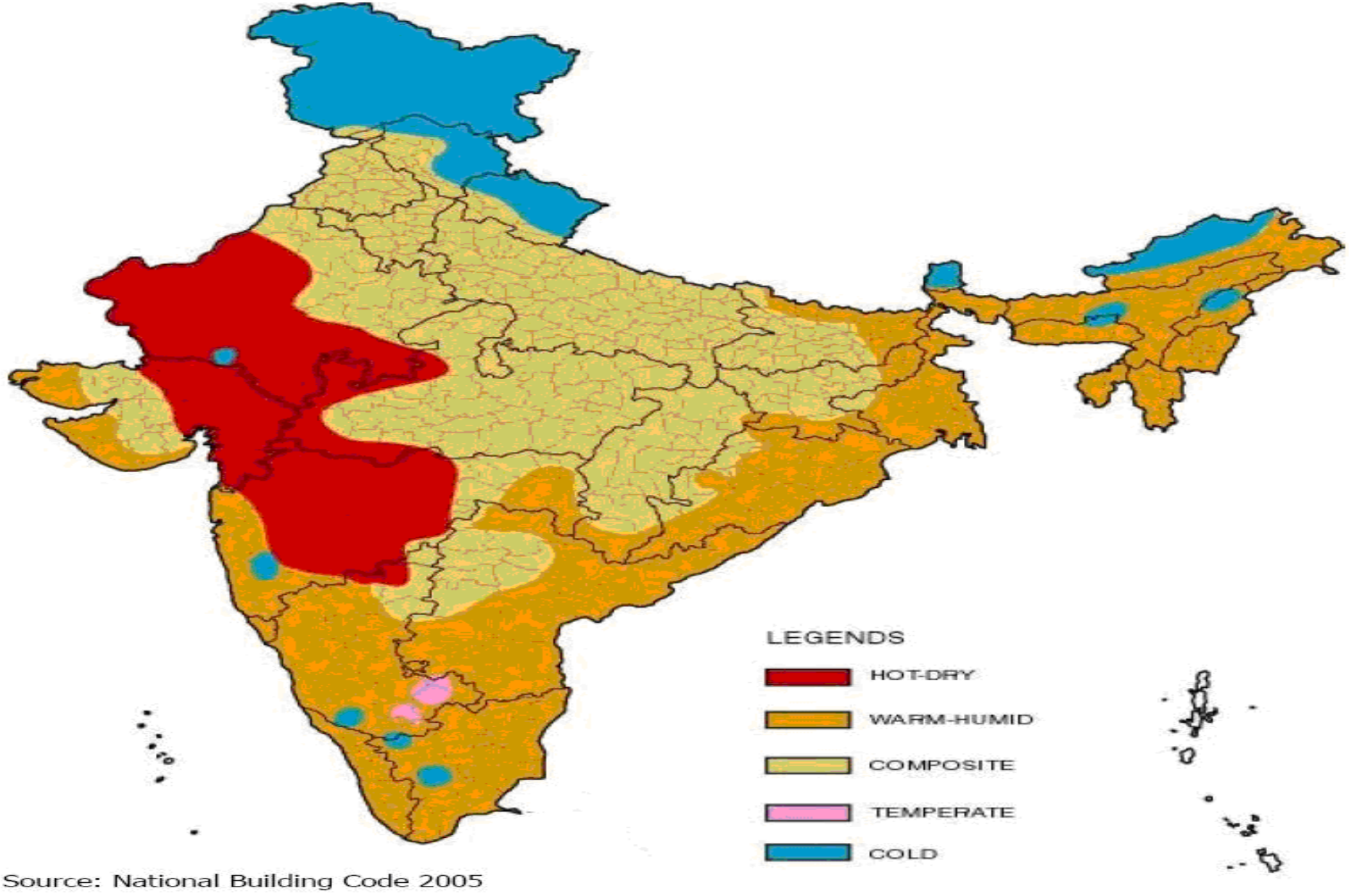
--heating,

--ventilation and

--thermal comfort

- **Different zones require different design strategies regarding ;**
- **---building envelop,**
- **--HVAC,**
- **-- lighting ,**
- **-- fenestration,**
- **-- performance standards**

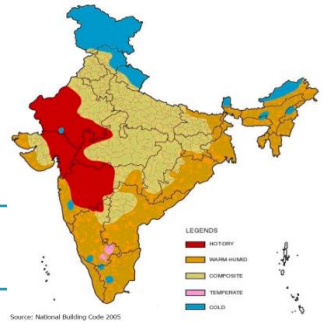
INDIAN CLIMATIC ZONES



Source: National Building Code 2005

Hot and Dry Climate Zone-

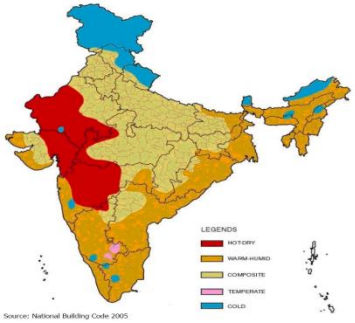
Comfort requirements and Physical manifestations in Buildings

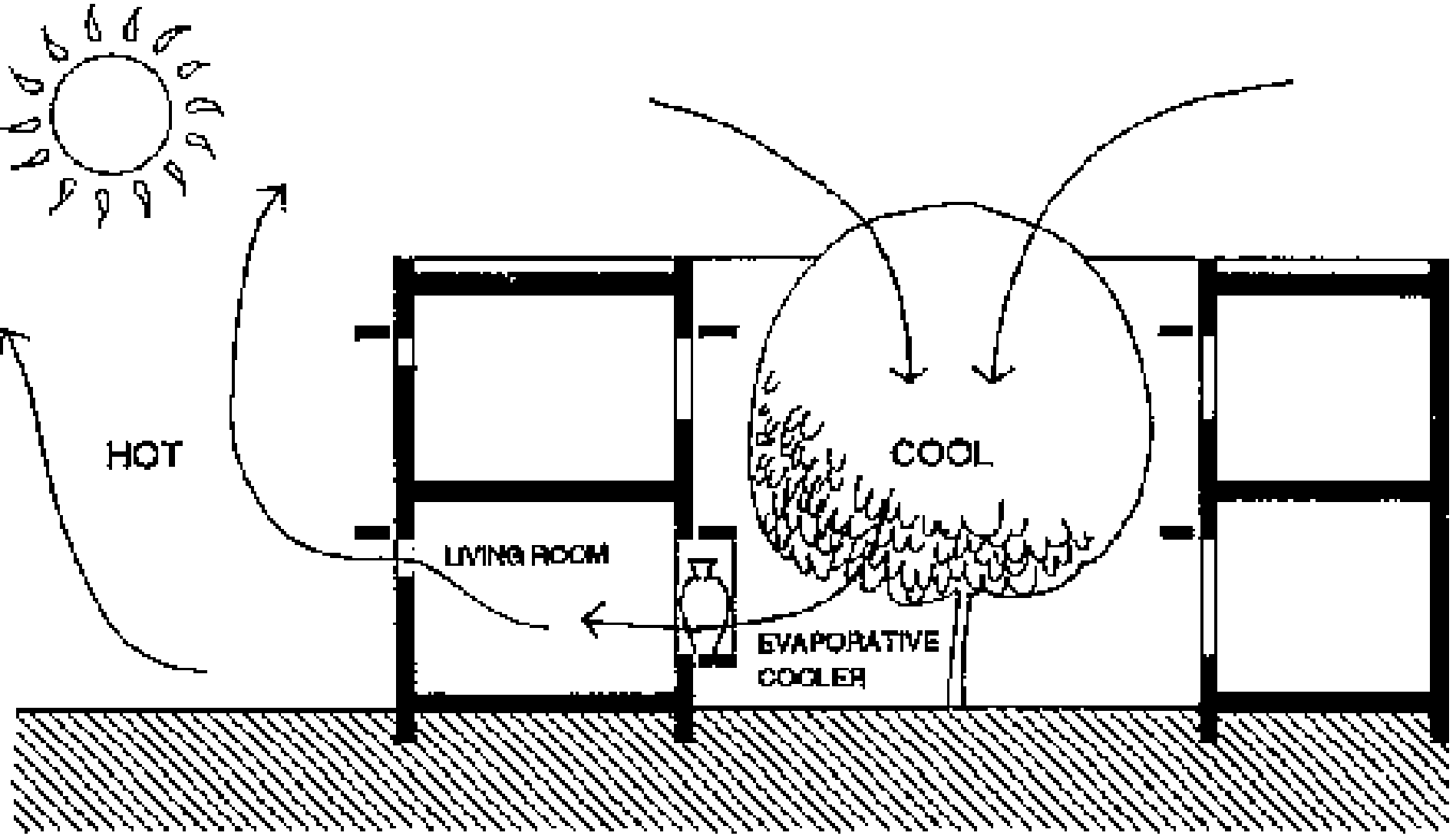


Thermal Requirements	Physical Manifestation
Reduce Heat Gain	
Decrease exposed surface area	Orientation and shape of building
Increase thermal resistance	Insulation of building envelope/roof/walls
Increase thermal capacity (Time lag)	Massive structure
Decrease air exchange rate (ventilation during the day)	Smaller windows openings, night ventilation
Increase buffer spaces	Create Air locks/lobbies/balconies/verandahs
Increase shading	Protect External surfaces by- Overhangs, Fins and Trees
Increase surface reflectivity	Use Pale Colour, 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

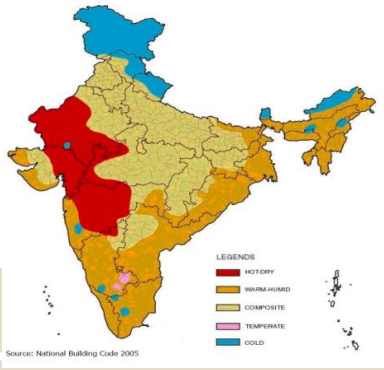




Cavity Walls

Warm and Humid Climate Zone

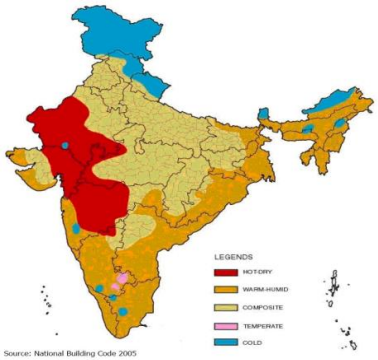
Comfort requirements and Physical manifestations in Buildings

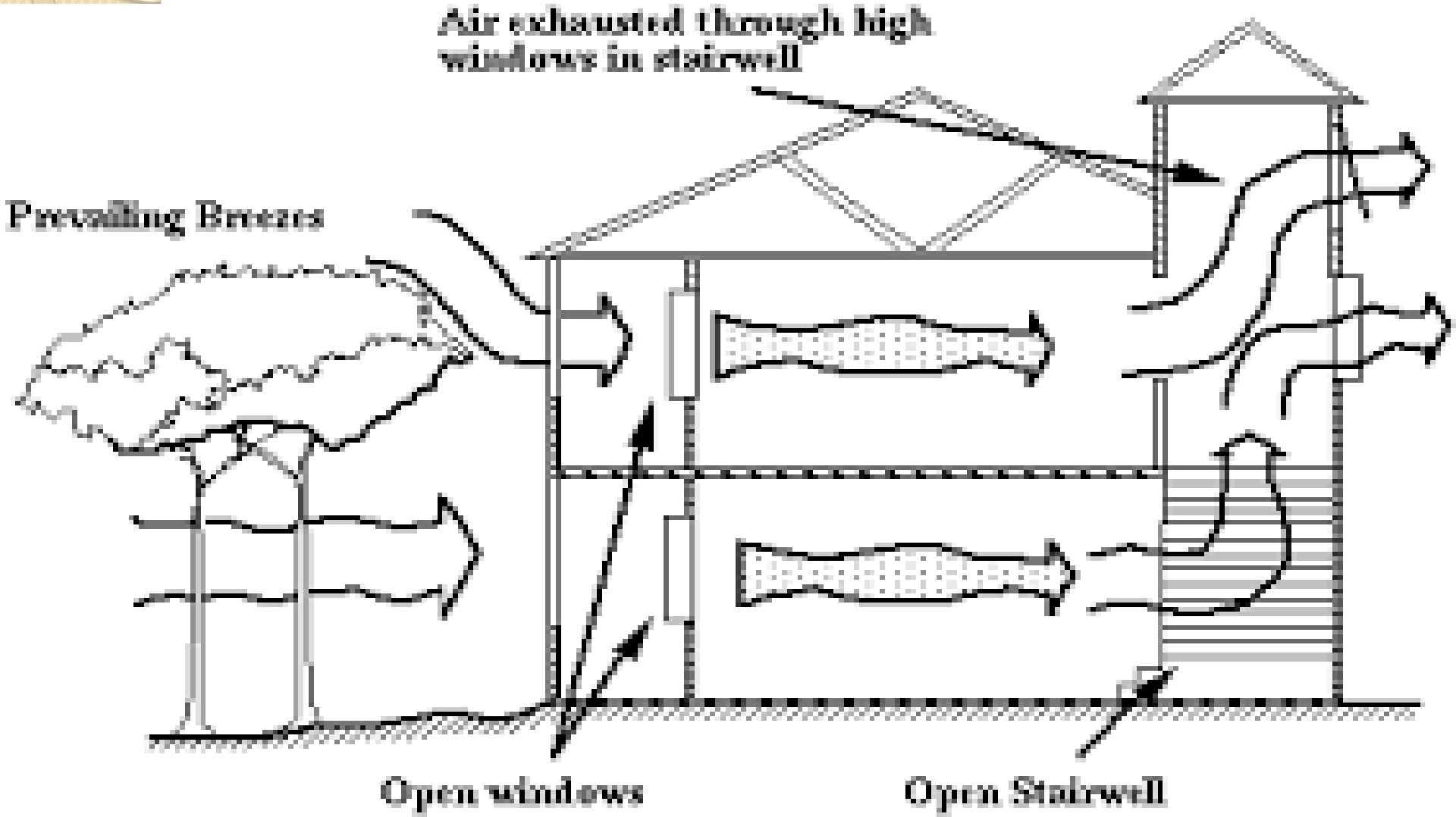


Thermal Requirements	Physical Manifestation
Reduce Heat Gain	
Decrease exposed surface area	**Orientation and shape of building**
Increase thermal resistance	**insulation of Roof and wall**
	Reflective surface of roof
Increase buffer spaces	**Balconies and verandahs**
Increase shading	**Walls, glass surfaces protected by overhangs, fins and trees**
Increase surface reflectivity	**Pale colour, glazed china mosaic tiles etc.**
Reduce solar heat gain	**Use glazing with Lower SHGC and provide shading for windows. Minimize glazing in East and West**
Promote Heat Loss	
Increase air exchange rate (ventilation during night-time)	**Ventilated roof construction, courtyards/ wind tower and arrangement of openings**
Decrease humidity levels	**Dehumidifiers/desiccant cooling**

Warm and Humid Climate Zone

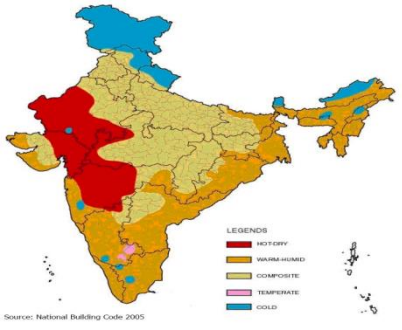
Comfort requirements and Physical manifestations in Buildings





Moderate/Temperate Climate Zone

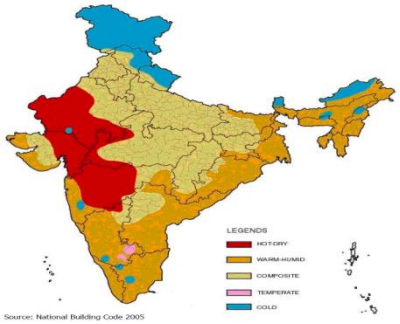
Comfort requirements and Physical manifestations in Buildings

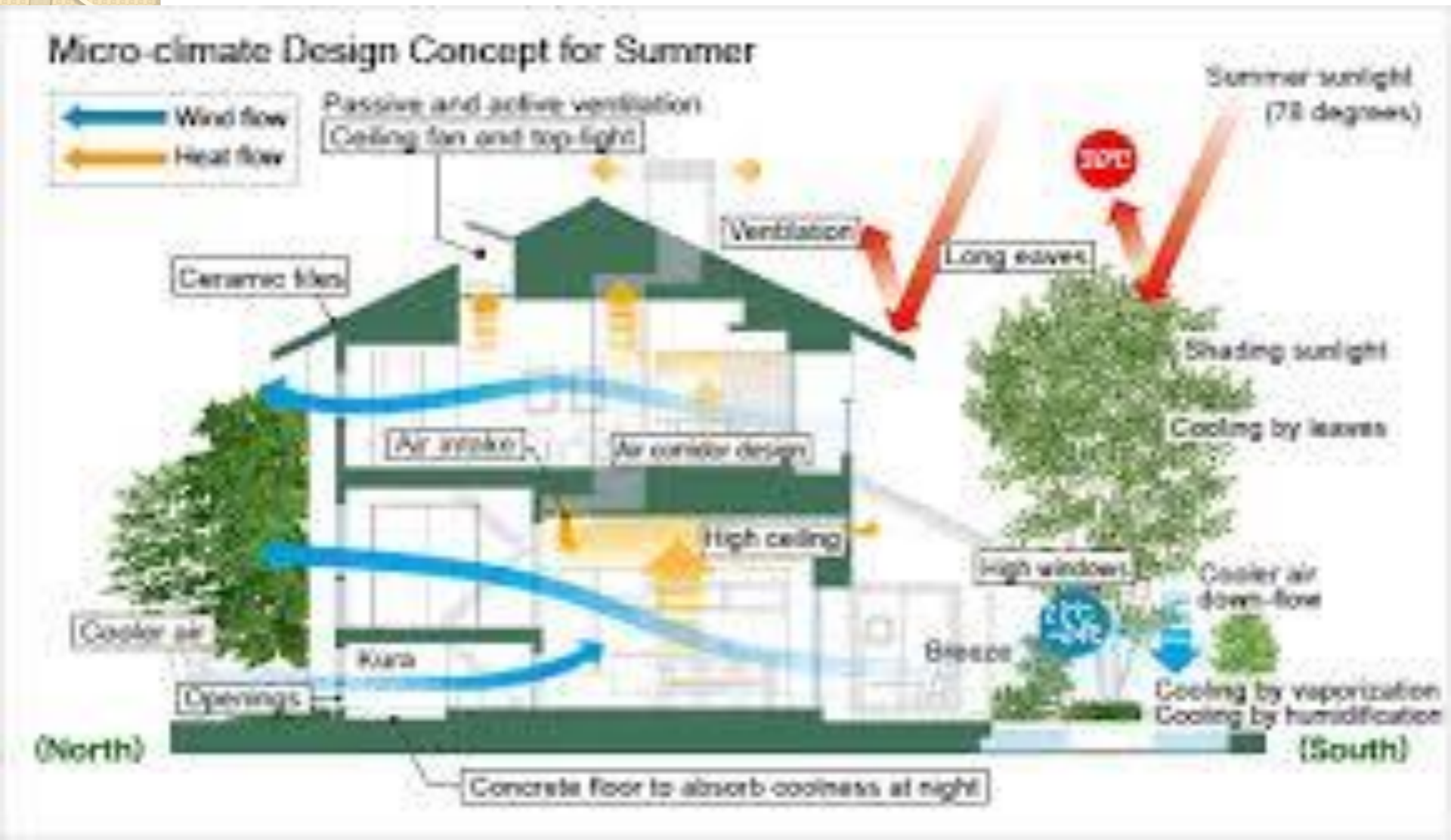


Thermal Requirements	Physical Manifestation
Reduce Heat Gain	
Decrease exposed surface area	Orientation and shape of building
Increase thermal resistance	Roof insulation and East and West wall insulation
Increase shading	East and West Walls, glass surfaces protected by overhangs, fins and trees
Increase surface reflectivity	Pale colour, glazed china mosaic tiles etc.
Promote Heat Loss	
Increase air exchange rate (ventilation)	Courtyards and arrangement of openings

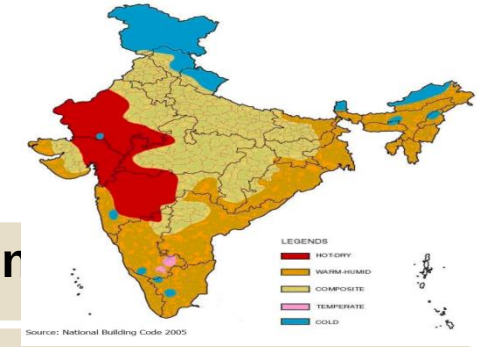
Moderate/Temperate Climate Zone

Comfort requirements and Physical manifestations in Buildings



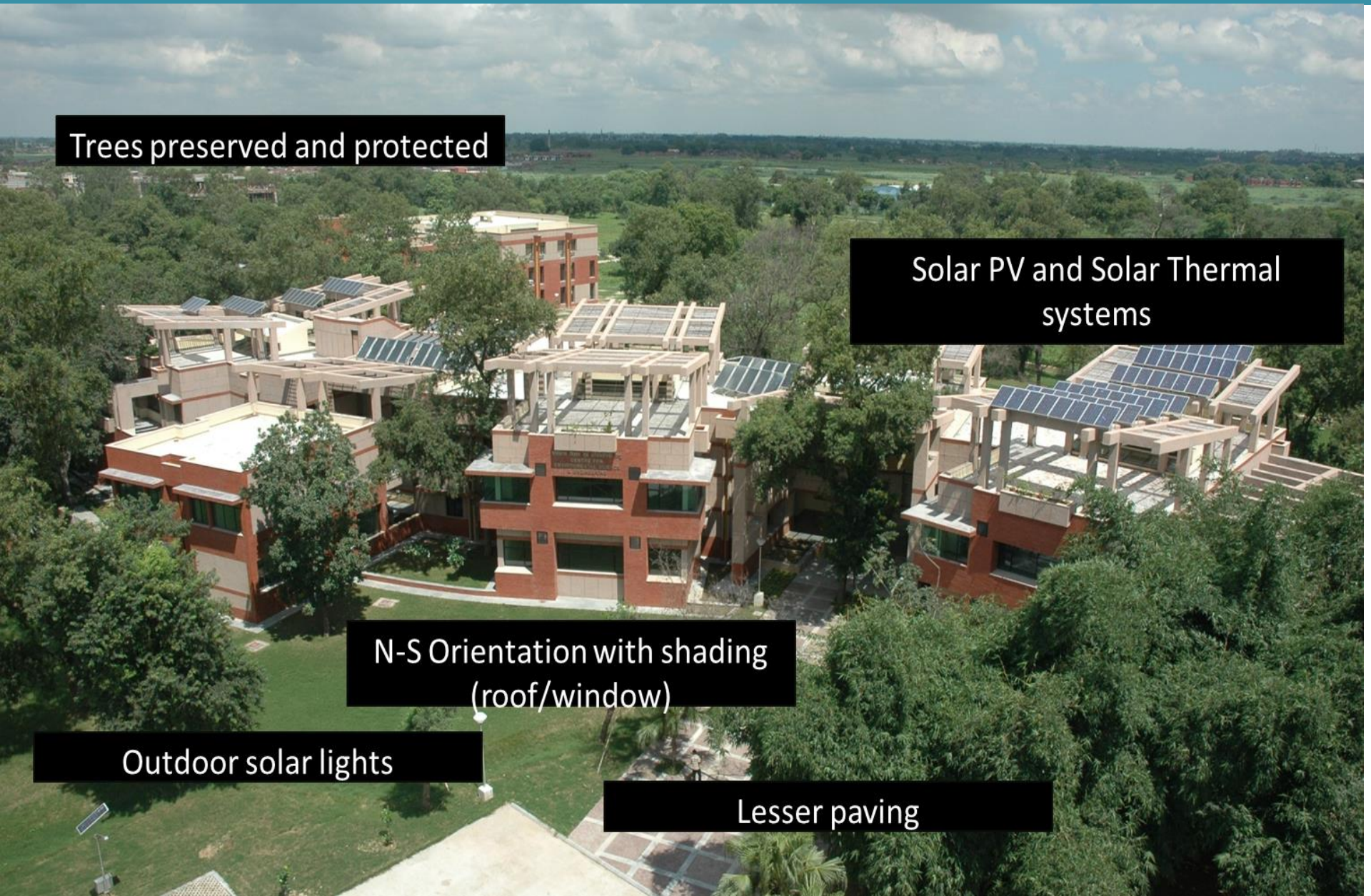


Composite Climate Zone-

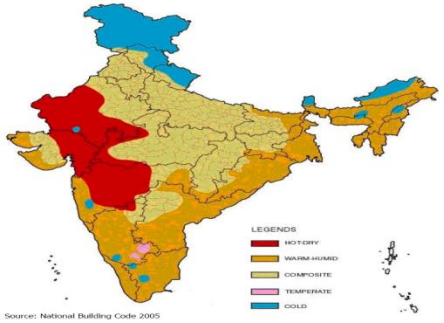


Thermal Requirements	Physical Manifestation
Reduce Heat Gain in Summer and Reduce Heat Loss in Winter	
Decrease exposed surface area	Orientation and shape of building. Use of trees as wind barriers.
Increase thermal resistance	Roof insulation, wall insulation
Increase thermal capacity (Time Lag)	Thicker walls
Increase buffer spaces	Air locks/Balconies
Decrease air exchange rate	Weather stripping (
Increase shading	Walls, glass surfaces protected by overhangs, fins and trees
Increase surface reflectivity	Pale color, glazed chins mosaic tiles, etc.
Reduce solar heat gain	Use glazing with Lower SHGC and provide shading for windows. Minimize glazing in East and West
Promote Heat Loss in Summer/Monsoon	
Increase air exchange rate (Ventilation)	Courtyards/wind towers/arrangement of openings
Increase humidity levels in dry summer	Trees and water ponds for evaporative cooling
Decrease humidity in monsoon	Dehumidifiers/desiccant cooling

Low Impact Design

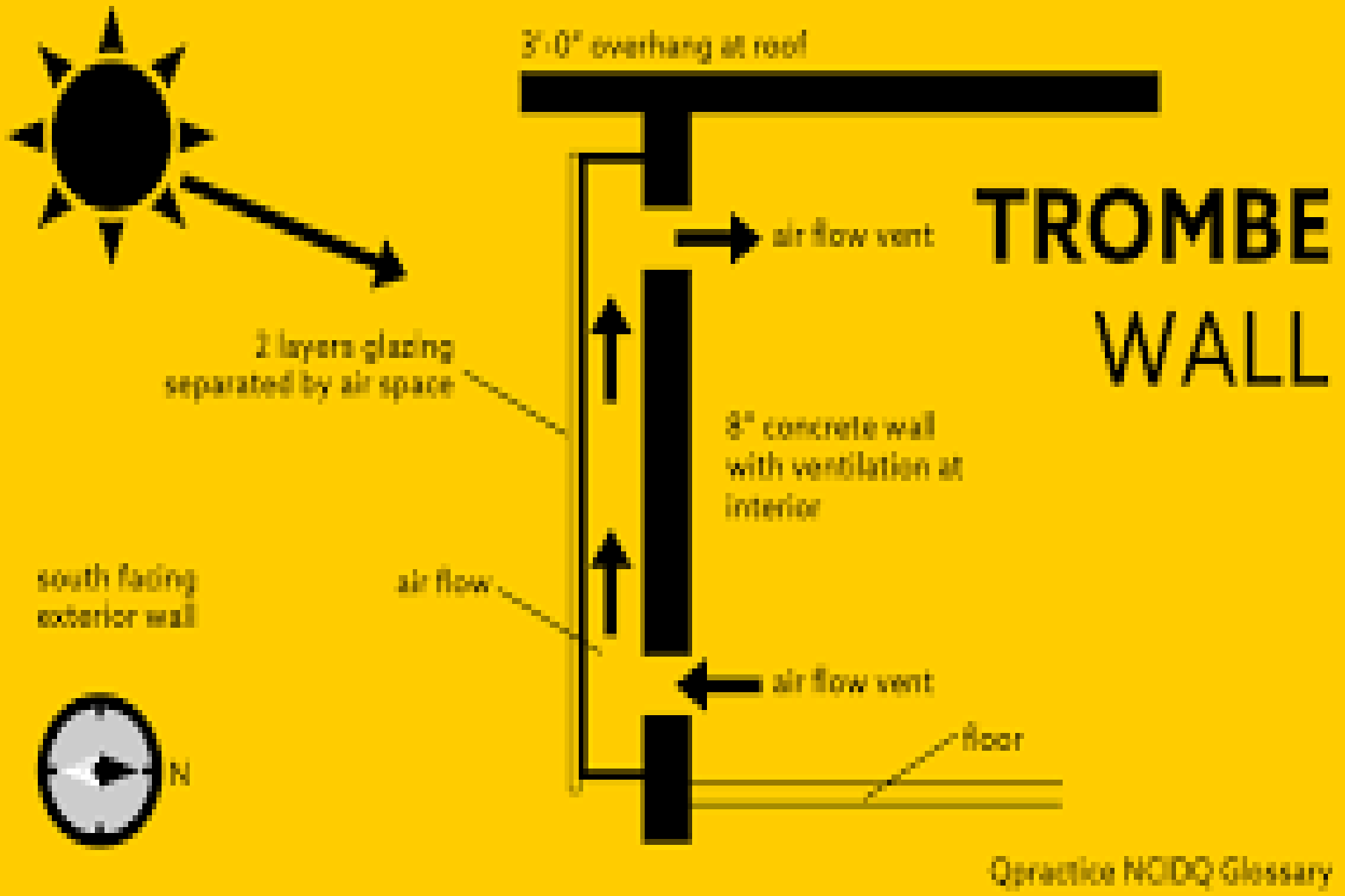


Cold (Cloudy/Sunny) Climate Zone- Comfort requirements and Physical manifestations in Buildings



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.

TROMBE WALL


3'-0" overhang at roof
air flow vent
TROMBE
WALL
2 layers glazing
separated by air space
8" concrete wall
with ventilation at
interior
south facing
exterior wall
air flow
air flow vent
floor
N
Qpractice NCIDQ Glossary

Solarium

Site Analysis- Factors considered

-Context of Site in Green Buildings—

Understanding Site; --

i) Size, shape, boundaries, area

ii) Location

iii) Orientation

iv) Wind direction

v) Soil conditions

vi) Topography

vii)Vegetation and Natural Features

viii) Hydrology and Precipitation

ix) Infrastructures

x) Surrounding Land uses & Buildings

xi) Vision / Visual Linkages

Site Planning Principles

Site Planning to be based on;

i) Neighbourhood Character

ii) Characteristics of site-Vegetation, flora , fauna, structures, electric wires, services

Site topography - Levels and Slopes

iii) Minimum Fingerprints of Building

iv) Minimum damage to site

v) Design with Nature and local Culture

vi) Promoting Pedestrianisation

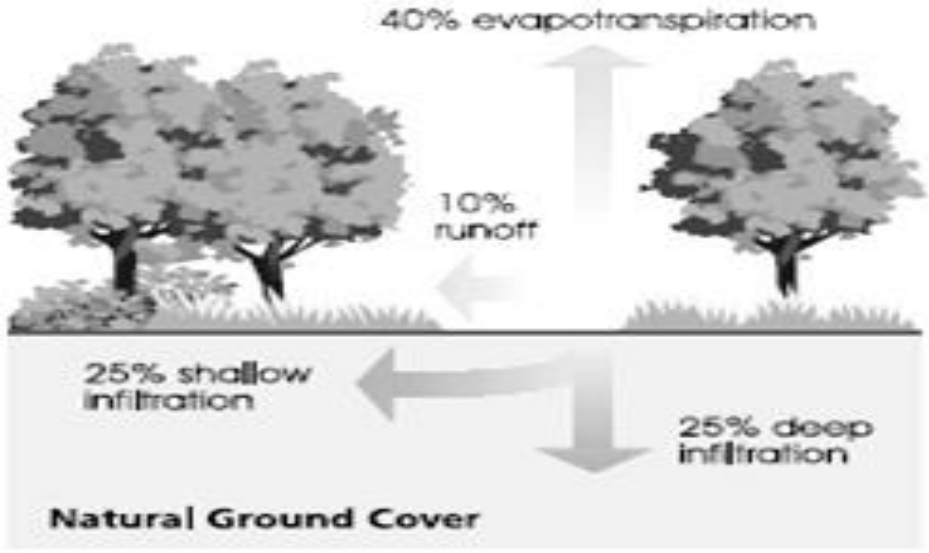
vii) Using hierarchy of

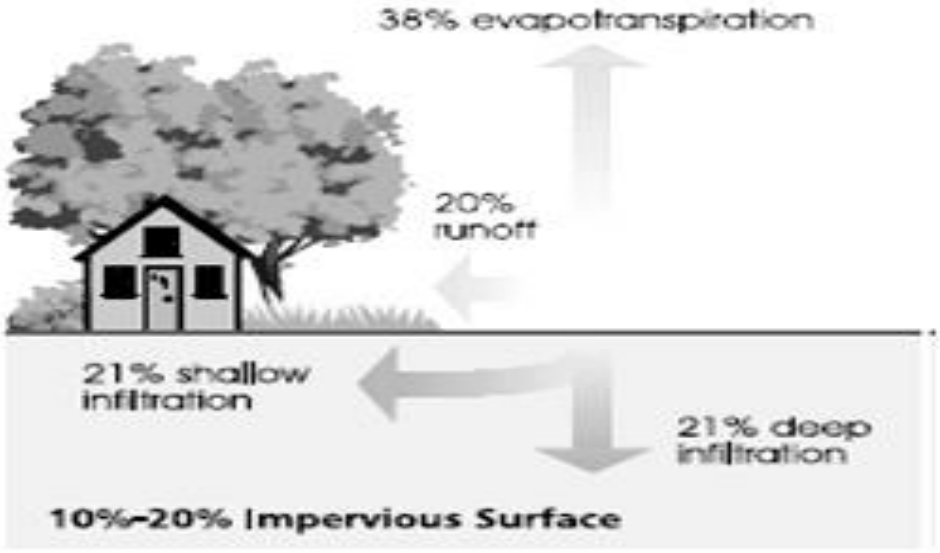
-- Preservation,

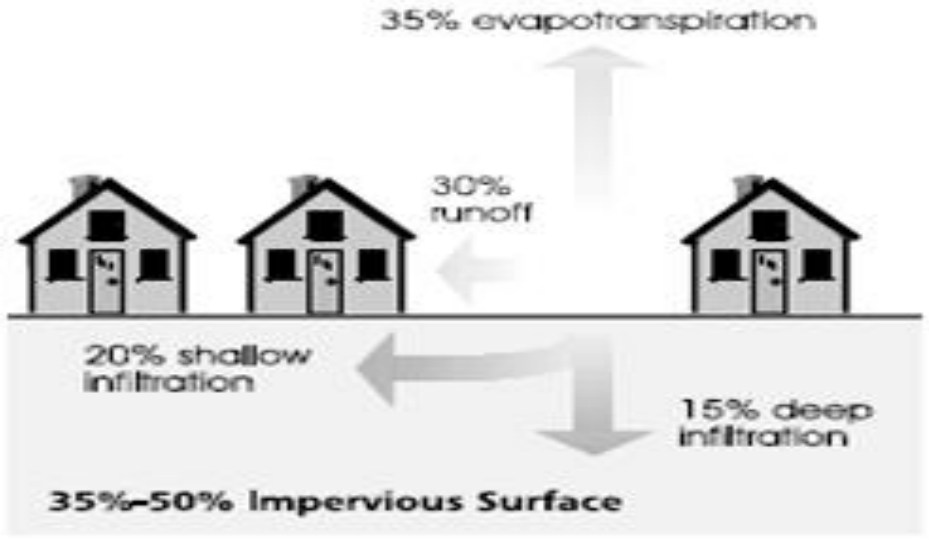
-- Conservation and

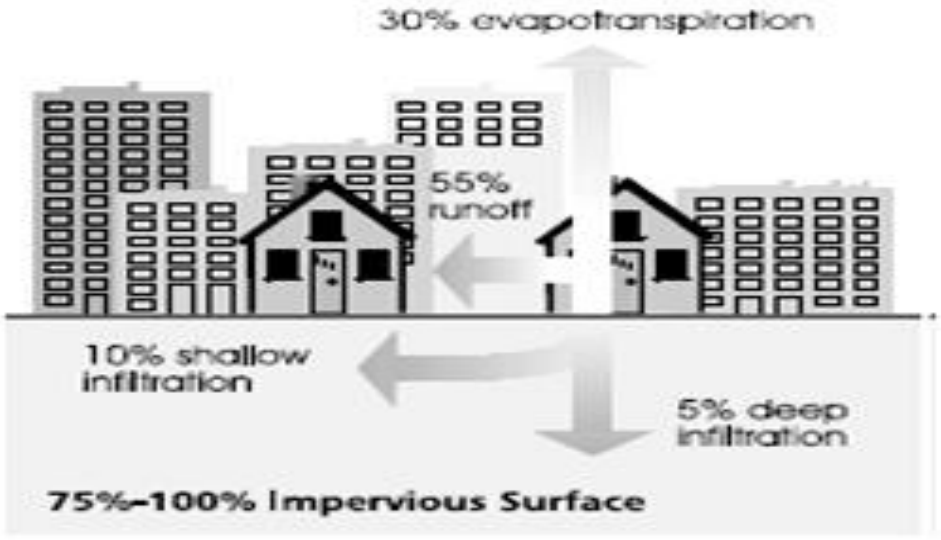
-- Regeneration

Impact of Buildings- minimizing Building Footprints

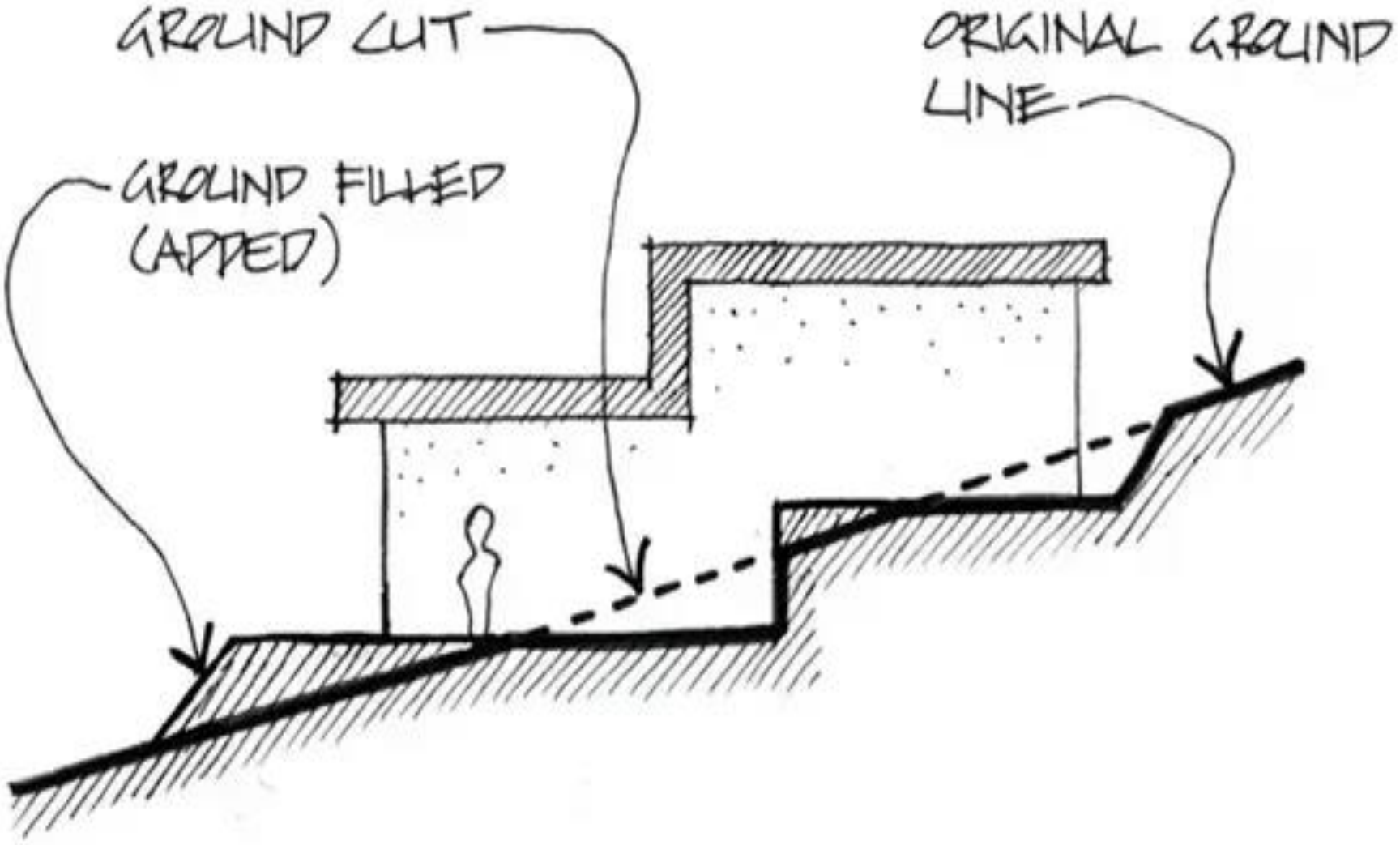




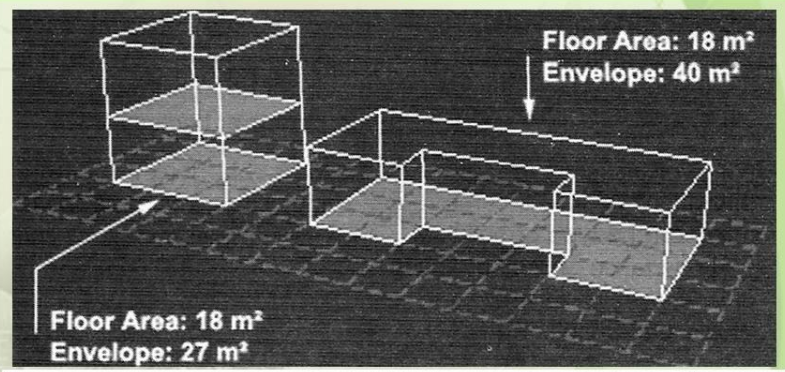


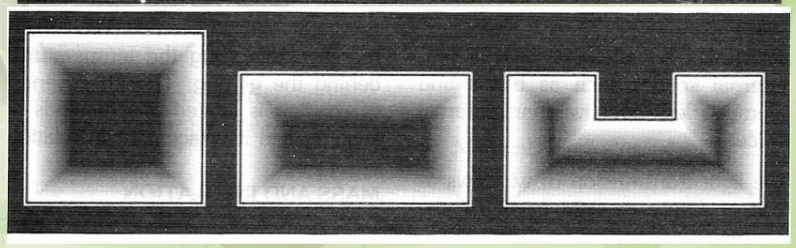


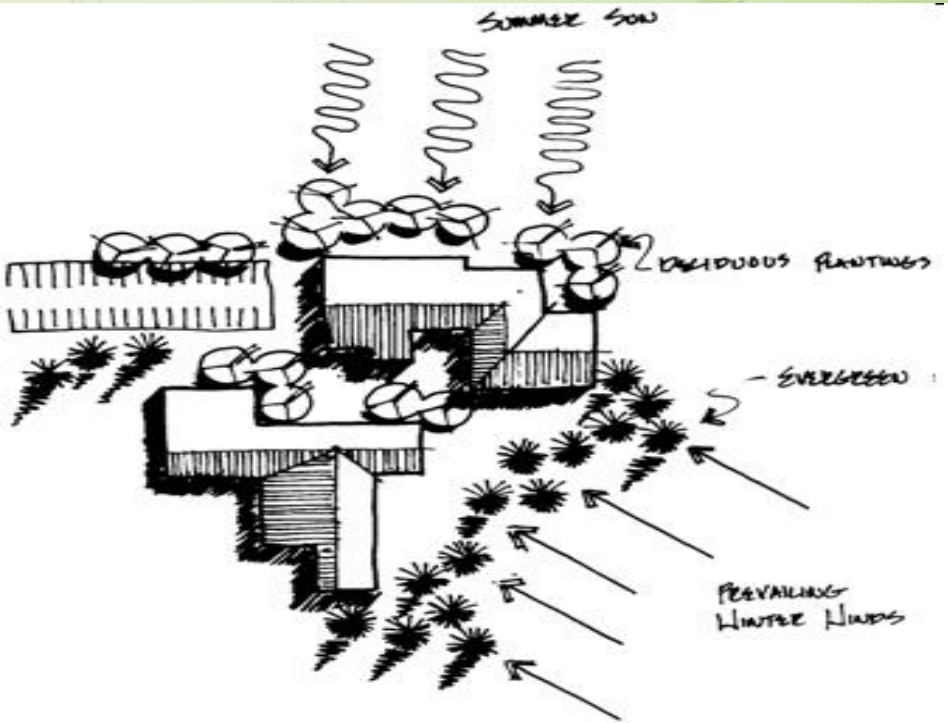
MANAGING SITE- MIN. CUTTING &FILLING

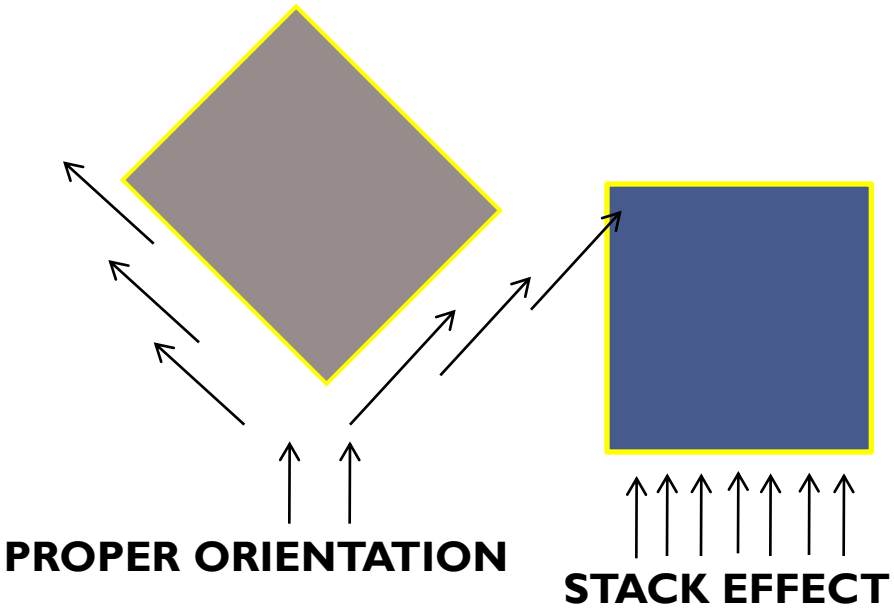


Shape


Floor Area: 18 m²
Envelope: 40 m²
Floor Area: 18 m²
Envelope: 27 m²




SUMMER SUN
DECIDUOUS PLANTINGS
EVERGREEN
PREVAILING WINTER WINDS


PROPER ORIENTATION
STACK EFFECT

SHAPING BUILDINGS- ROUND BUILDINGS

Round buildings are known to be more ;

-- comfortable,

-- safe,

--energy efficient --than other shaped structures.

-- have high resistance against natural disasters.

-- can withstand well-heavy winds/ tsunami waves - in sheer contrast to square/ rectangle buildings --- which obstruct path of water/ eventually water breaks corners of building.

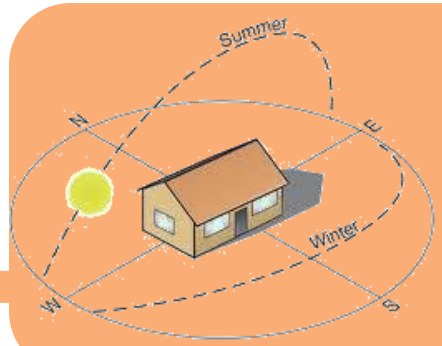
- a round structure has numerous interconnecting points -- that keep building intact in natural disasters.

- **using a center radial steel ring, steel brackets, bolts, seismic/ hurricane ties/ steel cables work as connecting agents**
- **--make round homes a safer option when facing conditions/ designing against natural disasters.**

- ***Promoting Energy Efficiency,***
- ***Day Lighting, Building Envelop***

Cost effective strategy for energy efficiency

Reduce energy demand by **passive measures**

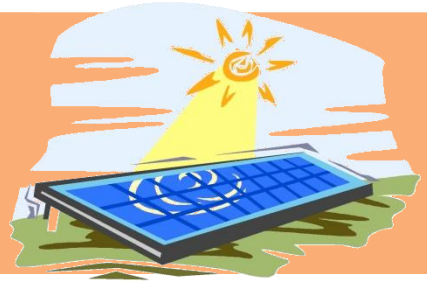


- Climate responsive architectural design
- Efficient building envelope
- Daylight harvesting
- Integration of natural sources for cooling & heating in building design.

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

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, cool roof
- 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;
- -- using minimal glass on east/ west exposures.
- -- Minimizing electric loads from lighting, equipment, appliances.
- --Involving alternative energy sources -- photovoltaic /fuel cells
- Promting BMS /BAS -- computer-based control system installed in buildings - to controls/ monitors building's mechanical/ electrical equipment -- ventilation, lighting, power systems, fire systems/ security systems.

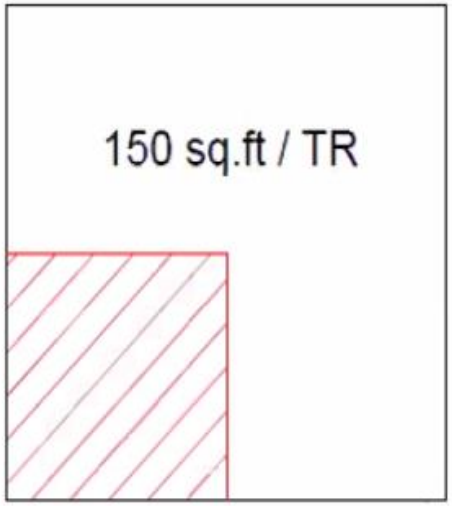
High Performance Envelope

Cavity Walls, Double Glazed Units, & Roof insulation

- Reduced heat gain by design
- Significant energy savings

What Green Buildings did differently

Air-conditioning Design



Conventional Buildings

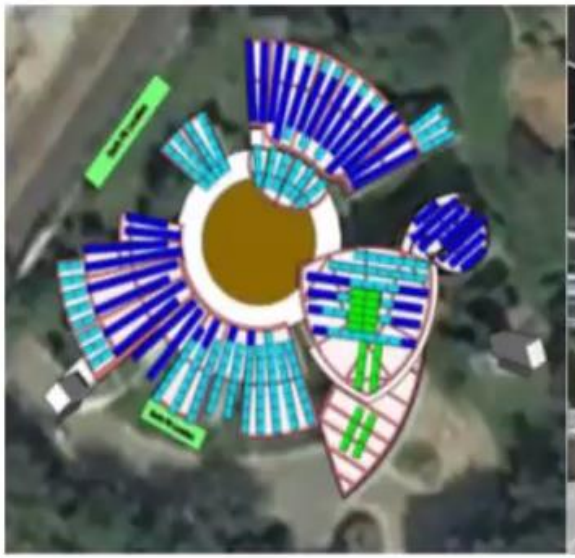
Green Buildings

Day Lighting

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

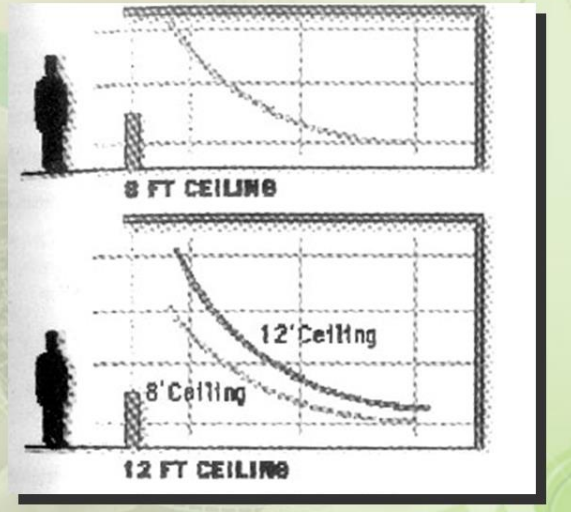
Bifacial Solar PV Modules

- 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

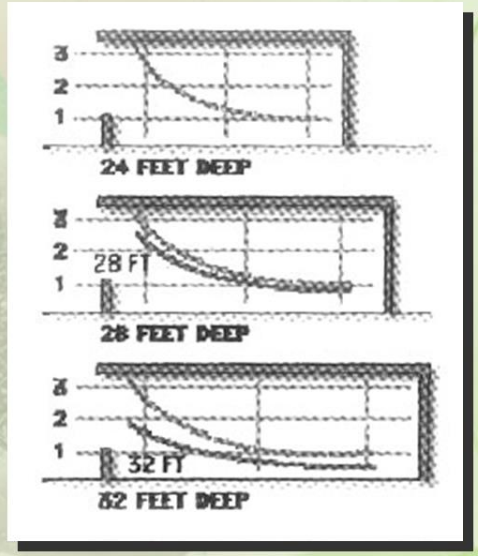


DAY LIGHTING

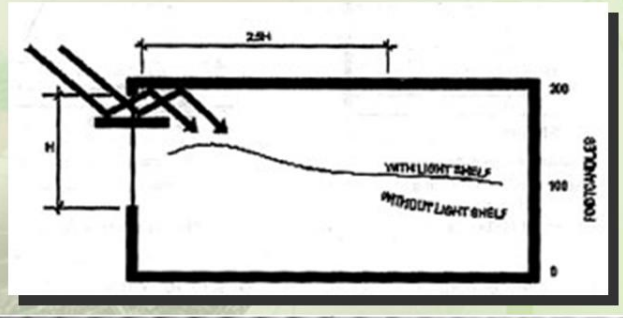
EFFECT OF CEILING HEIGHT

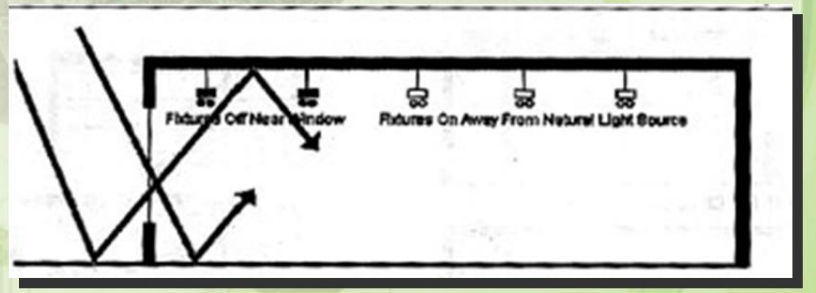


EFFECT OF ROOM DEPTH



INTELLIGENT LIGHTING CONTROLE



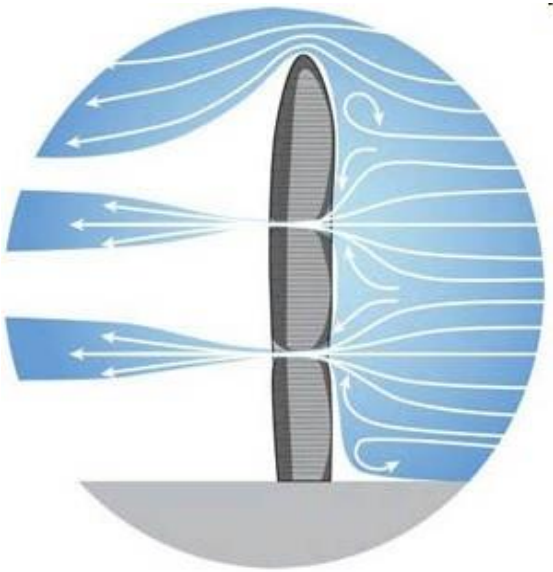


Sun pipe- Day Light Harvesting

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



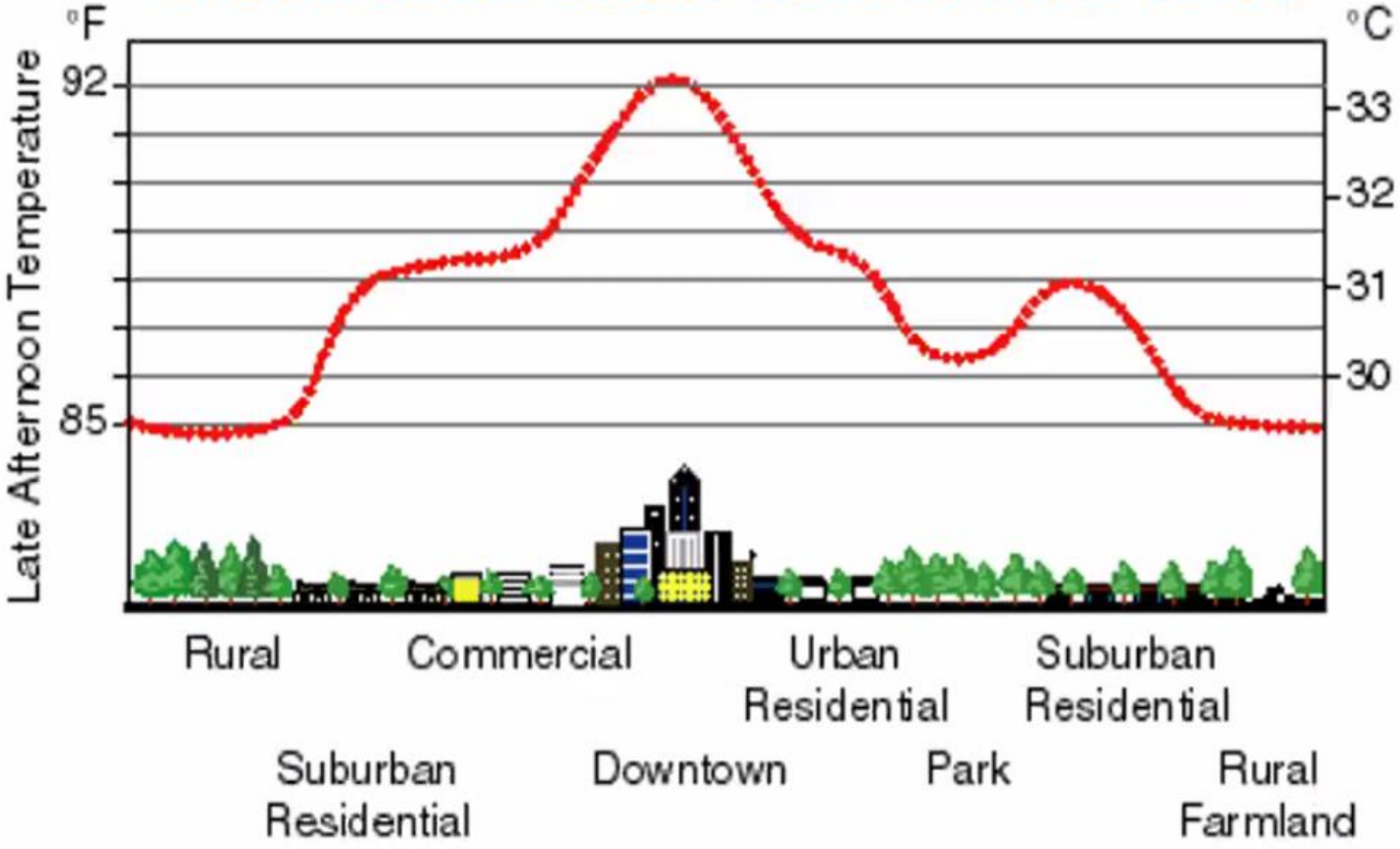
ENERGY EFFICIENCY ACHIEVED THROUGH

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

Present Cities- Concrete Jungle !! ??

Urban Roofs : Heat Islands

Sketch of an Urban Heat-Island Profile



Present Best Practices
Green Roofs & Walls

Please
USE WATER
WISELY

EVERY
DROP
COUNTS

- *Promoting Water efficiency;*
- *Rain Water Harvesting,*
- *Ground water Recharging,*
- *Water Efficient Plumbing,*
- *Water Metering*
- *Multiple- use of Water*
- *Recycling,*
- *Phyto-remediation*
- *Water Efficient Landscaping*

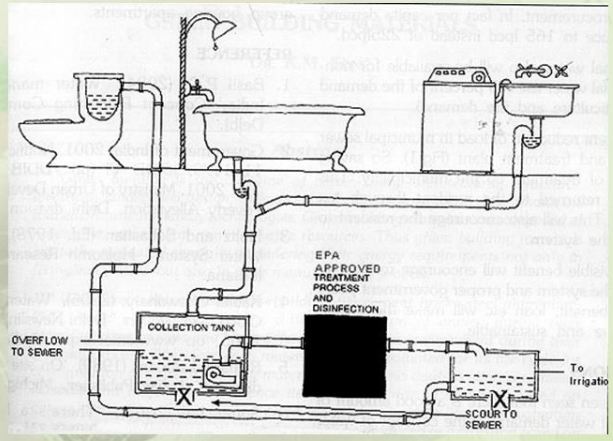
Water Efficiency- 4Rs- Refuse, Reduce, Recycle, Reuse

- **Adopt Strategies for –**
- **-- Slow the flow/ breaking water /water conservation/RW Harvesting/Ground water charging/ multiple use of water**
- **Design for dual plumbing-**
- **- using recycled water for toilet flushing**
- **-using grey water/ rainwater/other non-potable water-- for site irrigation.**
- **Using water efficient fixtures– to Minimize wastewater-**
- **- using ultra low-flush toilets,-- low-flow shower heads-- water conserving fixtures.**
- **Use Re-circulating systems**
- **-- for centralized hot water distribution.**
- **Installing point-of-use hot water heating systems-- for more distant locations.**
- **Metering water use – both for domestic/ landscape separately**
- **-- Promote micro-irrigation /sprinklers / high-pressure sprayer-- to supply water in non-turf areas.**
- **Involving communities --Through education /incentives**
- **Promoting Green Buildings as a Brand**

Water Efficiency

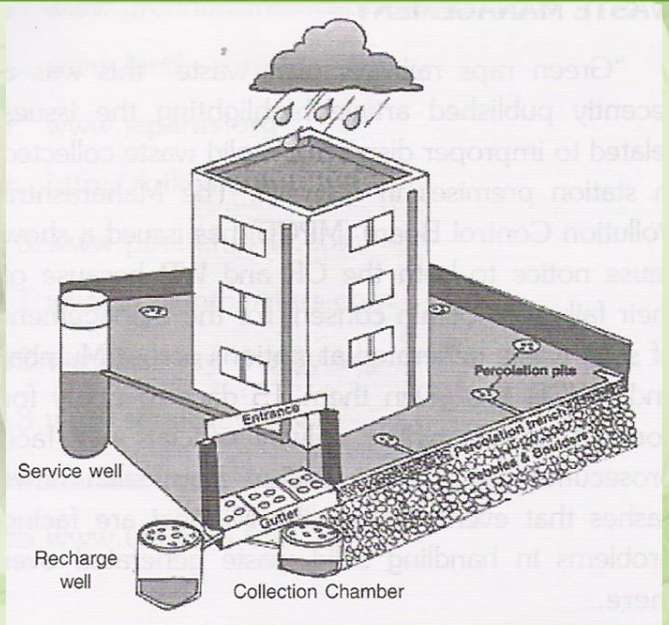
Use of low – flush toilets,
water less urinals,
sensors control taps for washbasin
and
water conserving system to
minimize the waste of water

Recycling of grey water



The dual plumbing system in which used water can be recycled for flushing of toilets and drain water can be used for irrigation and gardening purposes.

Rain Water Harvesting



Wastewater Treatment through Plants

- **Phytoremediation**
  - Natural system - Aesthetically pleasing and gives picturesque garden like appearance
  - Low capital cost – no usage of chemicals
  - Treated water - reused or recycled or recharged & meets CPCB Norms




Phytoremediation – Nature at its Best!

- Implemented at CII – Godrej GBC, Hyderabad
- Investment Rs 50,000 per m^3 per day
- No operating cost
- Payback: 3 to 5 yrs
- Application
  - ✓ Domestic sewage

Green Building Materials

Green Materials

- Fly ash Bricks,
- Aeriated Cement Concrete Block
- Hollow Concrete Blocks
- Bamboos
- C&D Waste

Green Materials

- Materials --for green buildings include materials ;
- --obtained from natural, renewable sources
- --managed / harvested in a sustainable way;
- -- obtained locally-- to reduce embedded energy costs of transportation;
- -- salvaged from reclaimed materials.
- -- Materials assessed using green specifications
- -- looking at Life Cycle Analysis (LCA)
- --- embodied energy, durability, recycled contents , waste minimisation, and
- ---their ability to be reused/ recycled.

Sustainable Building Materials

❖ Focus Areas:

i. Building Reuse/

ii. Reuse of salvaged Material

iii.Material with Recycled Content

iv. Local Material/ Regional Material

v. Wood Based Materials

Handling of Waste Material, During Construction

- **Segregation of construction & demolition waste at source**
  - To encourage reuse or recycling of materials, thereby avoiding waste being sent to land-fills

Wood Waste

Brick Waste

Metal waste

Segregation of metal

Green Material - Fly Ash Bricks

Green Material- Fly Ash Bricks-

- **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 –** limited CO2 emissions in manufacturing process
- **Excellent Thermal Insulation: The buildings using fly ash bricks -- cool in summers and warm in winters**.
- High **Fire Resistance: --** 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.

Green Material - Autoclaved Aerated Concrete

Advantages

- AAC has been produced for more than 70 years, and it offers several significant advantages over other cement construction materials, one of the most important being its lower environmental impact.
- * *Improved thermal efficiency reduces the heating and cooling load in buildings.*
- * *Workability allows accurate cutting, which minimizes the generation of solid waste during use.*
- * *Resource efficiency gives it lower environmental impact in all phases of its life cycle, from processing of raw materials to the disposal of waste.*
- * *Light weight saves cost & energy in transportation.*
- * *Light weight saves labor expenses.*
- * *Light weight increases chances of survival during seismic activity.*

Green Material--UPVC(Unplastisized Polyvinyl chloride) **doors and Windows**

The Vinyl windows
--Excellent insulators :
--Reduced heating /cooling loads
- Prevent thermal loss
through frame / sash material .
-- Not impacted by;
weather/
-air pollution / salt,
-- acid rain
--- industrial pollution
--- pesticides
---smog,
--- discoloration and
- structural damage .
-User friendly
- Eco- Friendly ,
-- Readily accepted
-- Safe .

Bamboo- Advantages

- Bamboo-- Higher Compressive
- Bamboo -- High Tensile Strength
- Earthquake Resistance –
- Lightweight -.
- Cost-effective
- Durable -
- Fast Growing
- Simple designing-
- Reducing use of wood
- Eco- friendly
- Promoting Employment
- Promoting Welfare of society/poor-
- Reduced Global warming-
- Improved indoor air Quality-

- ***Indoor Air Quality***

Indoor Air Quality

Good Indoor air quality essential for work places for ;

•--fostering better health

-- Creating good indoor environmental quality–

-- reducing- respiratory disease, allergy, asthma,

- Reducing Sick Building Symptoms

- **Reducing Covid 19**

-- Enhancing worker's performance.

• When people themselves main source of emission then--

---Carbon dioxide concentration -- ASHRAE , recommends CO2 level in buildings not > 700 parts per million (ppm) above outdoor air. Since outdoor air is approximately 400ppm, indoor CO2 levels should be no more than 1,100 ppm.

indoor air quality in interiors - indicate indoor air is bad/good

• Poor indoor air quality leads to

--tiredness-- lack of concentration

---- can even bring about illnesses.

Causes of Poor indoor air Quality

i. Poor ventilation
ii. Outdoor air quality/impurities
iii. Poorly insulated Building Envelop
iv. Smoking
v. Use of toxic building material
vi. Use of High VOC compound based paints for walls
vii. Dampness/water intrusion- microbial contamination
viii. Use of VOC based cleaning agents
ix. Poor Lighting
x. Furniture
xi. Floor Coverings- Carpets, Carpeting of floor
xii. Poor pollution controls-- during construction
xiii. Damaging existing vegetation/trees
xiv. Poor site planning/management
xv. Using pesticides

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
- Passive design/ using plants
- Building management and monitoring systems

Improving Indoor Air Quality through Plants – Air Purifiers

Best air purifying plants for general air cleanliness

Removes Nitrogen Oxides & absorbs formaldehydes

Best Air Purifier

- ***Greening-Retrofitting Existing Buildings***

Greening Existing building

- Greening existing building helps to;

-- reduce environmental impact ;

-without making major structural changes by ;

--managing use of water & energy by Buildings

--improving carbon footprint -- Cutting utility bills

- Start with small changes, for a big impact.

Energy--Update building's lighting to uses energy efficiently.

--Replacing existing light bulbs for compact fluorescent bulbs-using 75 % less power

-- Put lights on a timer to automatically shut off at night/ when you are away

--Make sure your building is well insulated

-- stop wasting energy on heating or cooling.

-- Insulate pipes passing through cold spaces not to lose heat.

--Plug groups of appliances into a smart power strip-using a timer to turn them all off at a certain time.

-- Set computers to turn off after being inactive for a certain time to eliminate screen savers,

Greening Existing building,

-- switches off power to non--essential systems each night.

-Turn down your heating /cooling /water heater system when building not occupied

-- maintain regularly - to use energy efficiently/ last longer.

- **Reduce amount of water used for building.**

--Fix leakages

--replace existing plumbing fixtures with low-flow options--- low-flow shower heads save over 7 gallons per minute

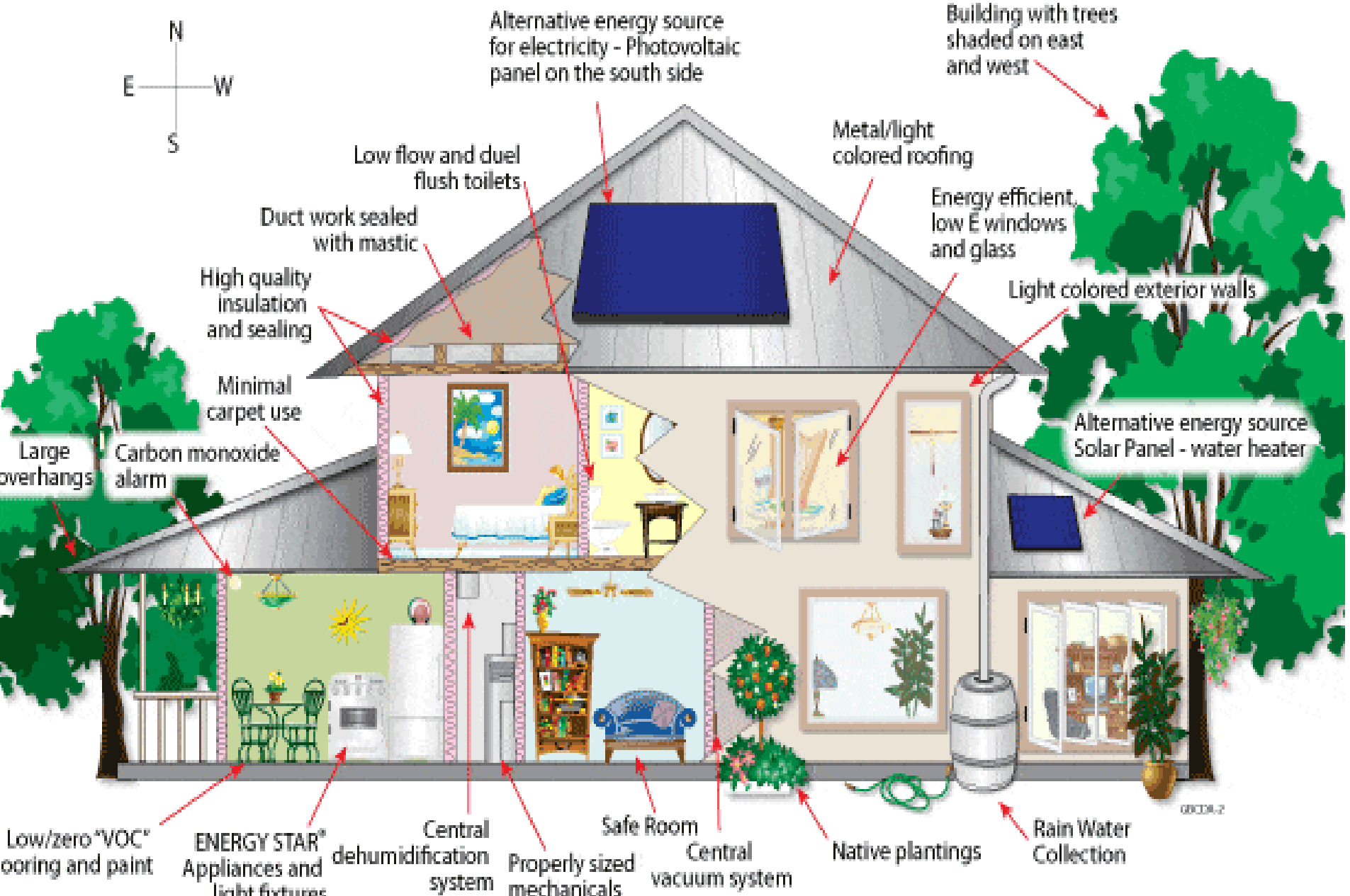
- **Promote rain water harvesting**
- **Promote recycling/reuse of water**
- **Promote multiple use of water**
- **use dual-flush systems/toilets**
- **Use gray water for irrigation/landscaping**
- **Plant native trees**
- **Provide soft surfaces for ground water re-charging**

- **Conclusion-**
- **What makes ane how to make Buildings Green**

What makes a Building Green:

- Building design
- Orientation
- Building insulation
- Window Sizing
- Window Shading (fixed overhangs)
- Glass Selection
- Building Envelope efficiency-- contributing 12% savings over base case
- System Design
- Energy efficient lighting
- Daylight sensing-- (90% lighting energy savings)
- Efficient Chillers, Variable air volume systems.
- Wind Towers for --pre cooling of fresh air.
- Efficient Lighting -- 15% savings
- HVAC efficiency -- 20% savings .

What makes a Building Green



'A Green building makes you

Happy, Healthy and More Productive

- ***Provides highest quality of indoor environment***
- ***Optimizes Resources, , Reduces Waste,***
- ***Minimizes Carbon Footprints***
- ***Makes building operations cost effective and Energy efficient***