प्रधान मंत्री आवास योजना-शहरी
Pradhan Mantri Awas Yojana-Urban

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Ministry of Housing and Urban Affairs
Government of India

आज़ादी का अमृत महोत्सव

bmtpc

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

RACHNA 2.0

RESILIENT, AFFORDABLE AND COMFORTABLE HOUSING THROUGH NATIONAL ACTION

VOCATIONAL TRAINING

Innovative Construction Technologies for Affordable Housing

Climate Smart Buildings (CSB)

Cluster cell Rajkot, Gujarat under Global Housing Technology Challenge - India (GHTC-India)

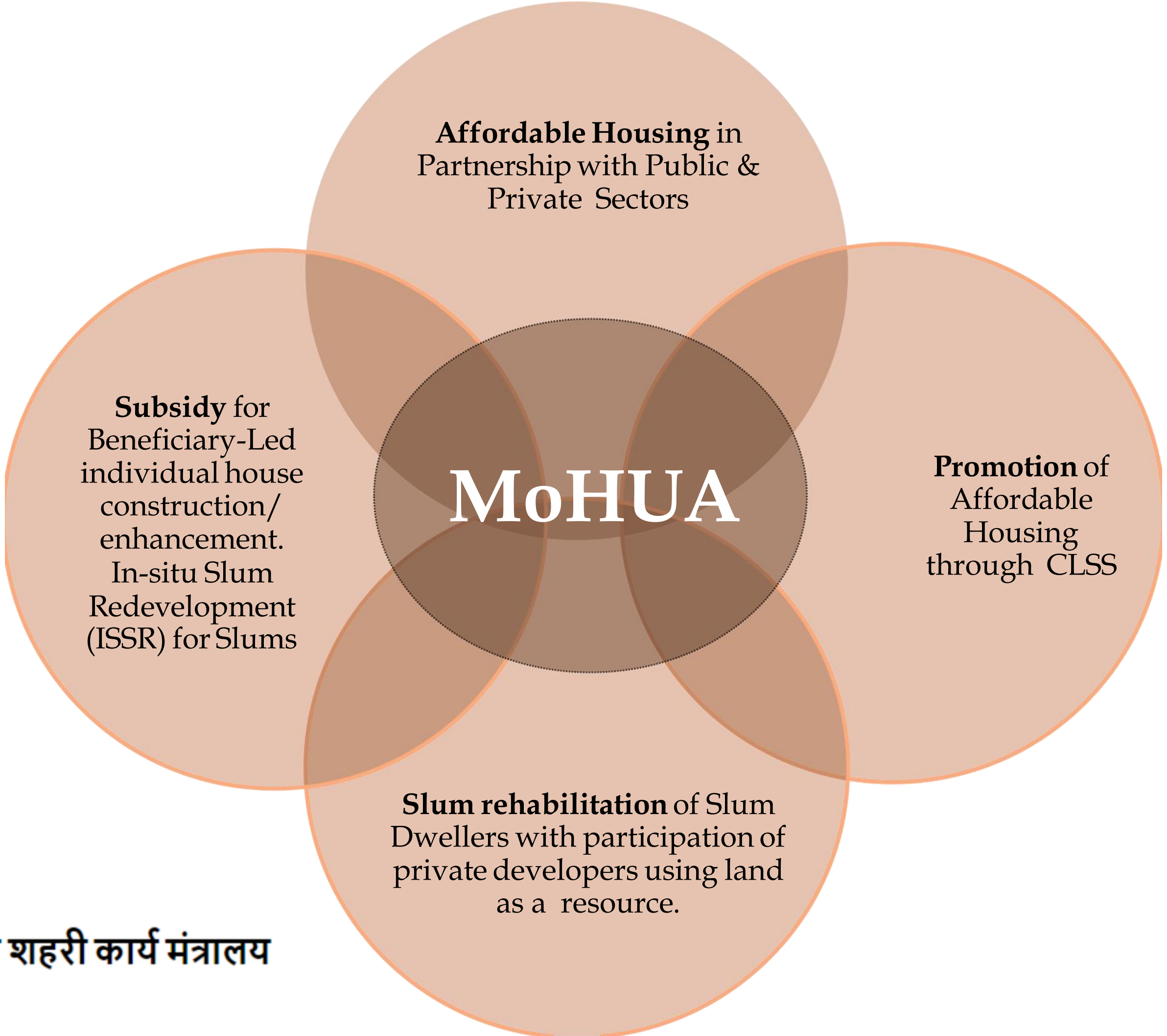
Introduction

INTRODUCTION - MoHUA

'Housing for All' by 2022.

Under the Mission, Ministry of Housing and Urban Affairs (MoHUA), provides Central Assistance to implementing agencies through States and Union Territories for providing houses to all eligible families/beneficiaries by 2022.

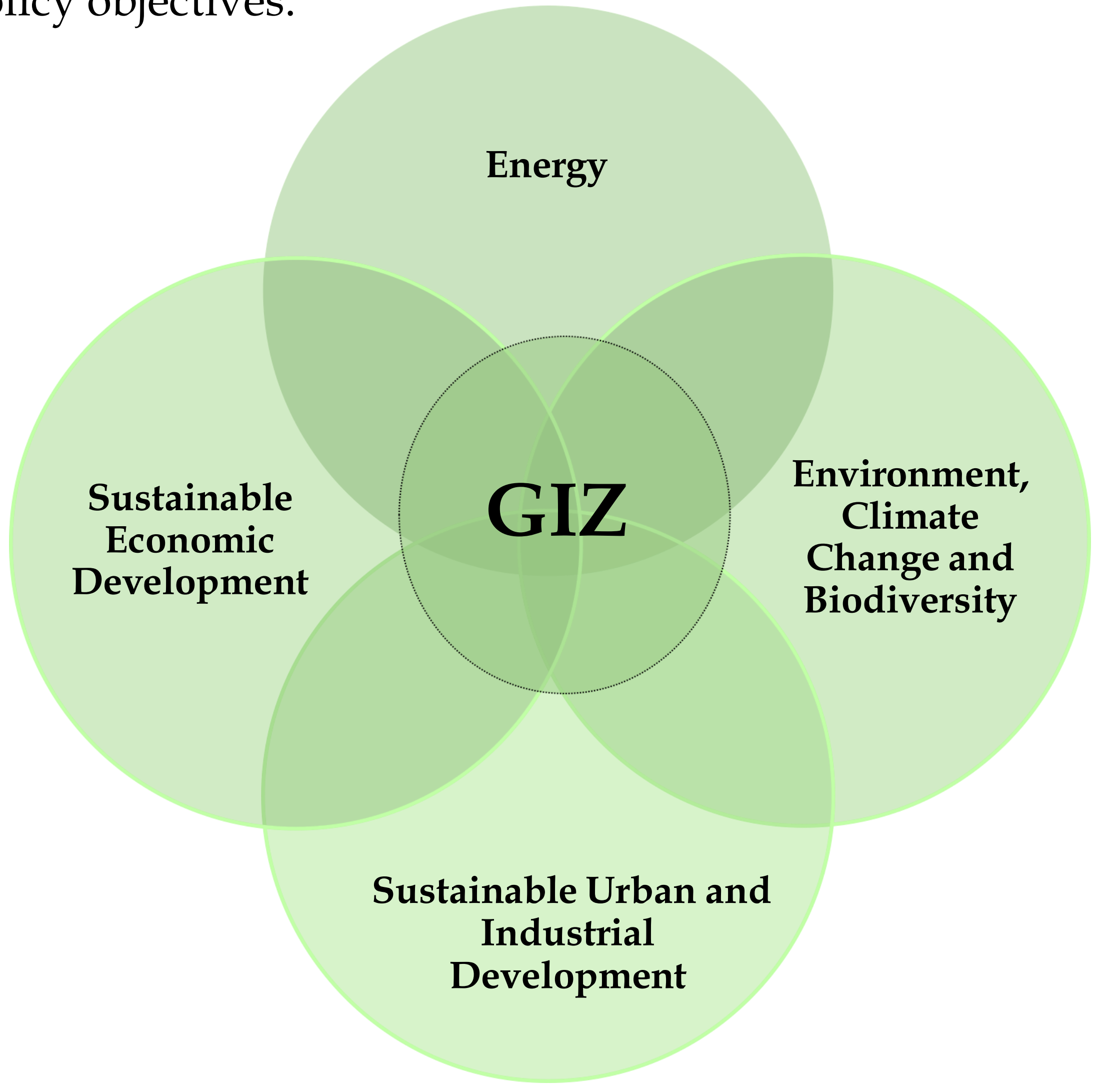
Addressing the affordable housing requirement in urban areas through:



भारत सरकार
आवासन और शहरी कार्य मंत्रालय
सत्यमेव जयते

INTRODUCTION - GIZ

- GIZ is an international cooperation enterprise for sustainable development which operates worldwide, on a public benefit basis.
- GIZ is fully owned by the German Federal Government, GIZ implement development programs in partner country on behalf of the German Government in achieving its development policy objectives.

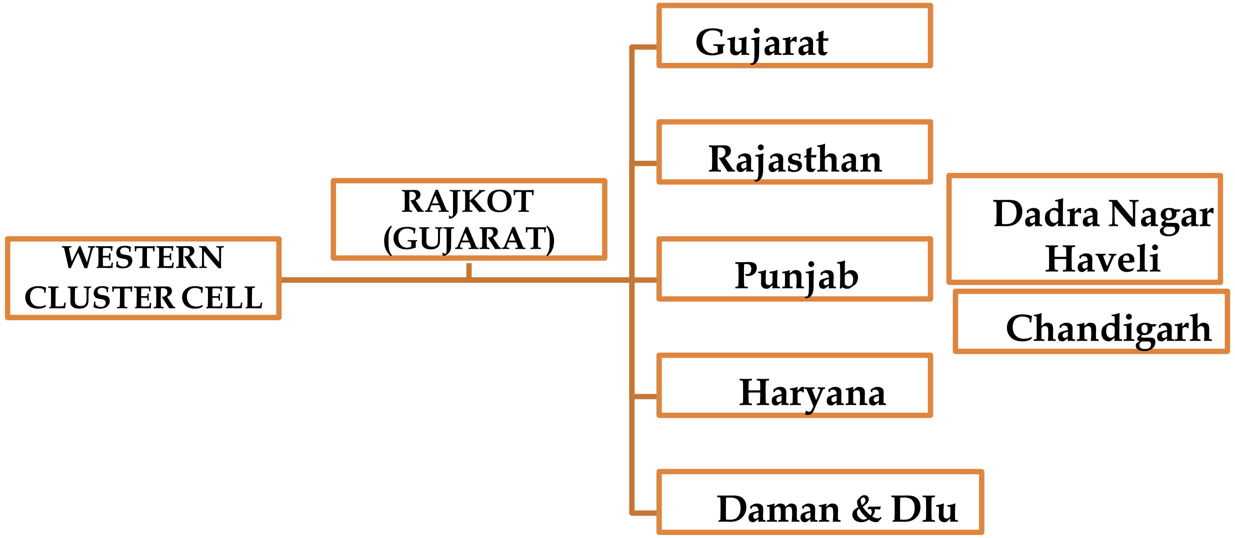


TASKS PLANNED WITH MoHUA

CLIMATE SMART BUILDING

- Technical assistance in developing thermal comfort action plan for climate resilience building for mass scale application in selected states for Affordable Housing
- Technical support in implementation of Global Housing Technology Challenge-India (GHTC-India)

States and UT's under central cluster cell established at Rajkot



भारत सरकार
आवासन और शहरी कार्य मंत्रालय
सत्यमेव जयते

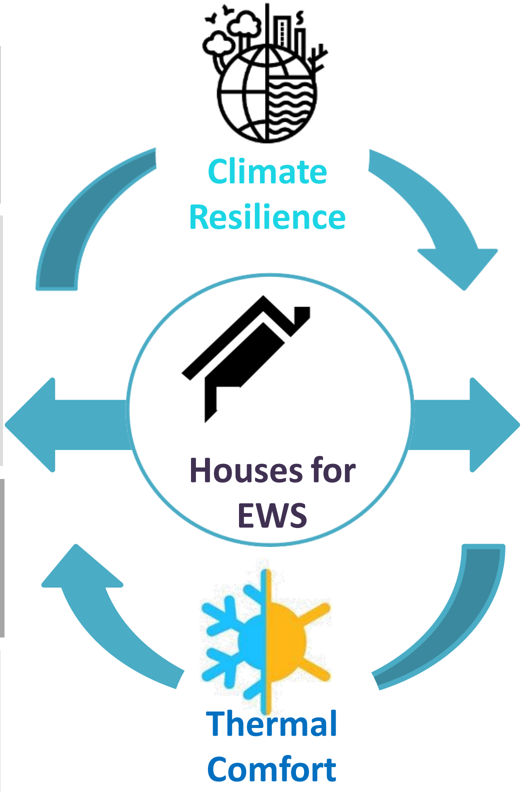
AIM & CONCEPT

7 AFFORDABLE AND CLEAN ENERGY
Ensure access to affordable, reliable, sustainable, and modern energy for all

9.INDUSTRY, INNOVATION AND INFRASTRUCTURE
Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation

11.SUSTAINABLE CITIES AND COMMUNITIES
Make cities and human settlements inclusive, safe, resilient, and sustainable

13. PROTECT THE PLANET
Take urgent action to combat climate change and its impacts



DESIGN
↓
CONSTRUCTION
↓
POST OCCUPANCY (O & M)

INTEGRATION IN BY-LAWS

Session 1

- LHP & its Construction Technology
- GHTC Brief on other LHP Construction Technologies (Video & Presentation)

LHP & its Construction Technology

LHP RAJKOT

Video on Construction Technology and Construction Process at LHP Rajkot

https://youtu.be/eGBCorzIf2w

Ministry of Housing and Urban Affairs
Government of India

- Have a look at the project brief:
  - 1144 houses will be constructed in Stilt+13 configuration.
  - The total plot area is around 39,600 Sqm and carpet area of each house is approximately 39.77 Sqm.
  - There are 11 residential blocks.
  - The project also includes Community Centre and Health Centre.

Typical floor plan

Block Plan

At each floor there are 08 dwelling units

Project Layout Plan

Typical Dwelling UnitPlan

Unit Plan

- Each dwelling unit comprises of one living room, one Bedroom, one study room, Kitchen and two toilets.
- The carpet area of each unit is 39.77 sq.mt. The sizes of individual rooms & service areas conform to NBC norms.
- **Other special features:**
- Green rating as per GRIHA
- Use of renewable resources:
  - Rain water harvesting
  - Solar lighting
- Solid waste management
- STP with recycling of waste water

Unit 3D View

Design Parameters

General Description:-

- Parking + 13 Above Floor + Stair cabin
- Height of Building from Ground =43.1 m (FGL to Parapet)
- Height of Typical Floor =2.950m
- Parking Height=3.550m
- Plan Area of Building = As per architectural layout

S.No.	DEAD LOAD	
1	Concrete	25 KN/m^3
2	Brick or Block – with plaster	9 KN/m^2
3	Floor finish	1.25 KN/m^2
4	Water proofing	2.25 KN/m^2

Design Parameters

S.No.	Details of Building	
1	Type of Building	Stilt + 13 – high rise building
2	Dimension of the Building	Width of Building -14.960m
3		Length of Building -38.920m
4	Floor Height	Height of Ground Floor -3.550m
		Height of Typical Floor -2.950m
5	Grade of Concrete used	M40 for all Wall, Slabs and Beam elements and M25 for footings.
6	Grade of Steel used	Fe-500
7	Live Load as per IS:875 2015 (Part 2)	For General -2KN/m^2
		Corridor -3KN/m^2
8	Wall Load as per IS:875 2015 (Part 1)	Masonry considered as Block wall and Applied load 1.6 KN/m^2 on Slab
9	Wall Size and loads Consider	External Wall -200 mm
		Internal Wall -150 mm
		Parapet Wall -100 mm
10	Water Tank Load	15 KN/m^2
11	Additional Lift load	12 KN/m^2

Prevalent Construction Systems

Technology being Used

Load bearing Structure

RCC Framed Structure

Monolithic Concrete Construction using Tunnel Formwork

Tunnel formwork
- Customized

Assembly of Formwork

Concreting after Placing formwork

Structure after removal of formwork
- Shear Wall Construction

Structural Elements

- Foundation
- Structural System – Monolithic Shear Wall and Slab
- A A C Block Masonry

GHTC Brief on other LHP Construction Technologies (Video & Presentation)

6 LHP ACROSS INDIA

Map showing six different LHP Locations

LHPs shall serve **as LIVE Laboratories** for different aspects of **Transfer of technologies**

1.Indore,Madhya Pradesh

- Prefabricated Sandwich Panel System

2.Rajkot,Gujarat

- Monolithic Concrete Construction using Tunnel Formwork

3.Chennai,Tamil Nadu

- Precast Concrete Construction System – Precast Components Assembled at Site

4.Ranchi,Jharkhand

- Precast Concrete Construction System – 3D Volumetric

5.Agartala,Tripura

- Light Gauge Steel Structural System & Pre-engineered Steel Structural System

6.Lucknow,Uttar Pradesh

- PVC Stay In Place Formwork System

Other 5 LHPs

https://youtu.be/_bl0P9gl0oo
https://youtu.be/DiGj3BOSfh4?t=14
https://youtu.be/ZTrUl--XnEU

https://youtu.be/GsmkfQA2rLE
https://youtu.be/5im2EeF_C1A

Technology of other 5 no. of LHPs explained via video

Summary of Light House Project (LHP)

LHP Location			Chennai (Tamil Nadu)	Rajkot (Gujarat)	Indore (Madhya Pradesh)	Ranchi (Jharkhand)	Agartala (Tripura)	Lucknow (Uttar Pradesh)
Sl. No.	Particulars	Units						
1	Name of Technology	Name	Precast Concrete Construction System- Precast Components	Monolithic Concrete Construction using Tunnel Formwork	Prefabricated Sandwich Panel System	Precast Concrete Construction System – 3D Volumetric	Light Gauge Steel Frame System (LGSF) with Pre-Engineered Steel Structural System	Stay in Place Formwork System
2	No. of Houses	No.	1,152	1,144	1,024	1,008	1,000	1,040
3	No. of Floors	No.	G+5	S+13	S+8	G+8	G+6	S+13
4	Plot Area	Sqm	33,596	39,599	41,920	31,160	24,000	20,000
5	Per House Carpet Area	Sqm	26.58	39.77	29.04	29.85	30.00	34.50
6	Project Cost	INR (in Cr)	116.27	118.90	128.00	134.00	162.50	130.90
7	Per House cost (with infrastructure)	INR (in Lakh)	10.09	10.39	12.50	13.29	16.25	12.58

Session 2

- Construction Process
- Basic of thermal Comfort and Passive design strategies for affordable housing

Construction Process

EXCAVATION

- The typical project starts with layout and excavation.
- After the layout at site, the excavation of each block is done using mechanical excavators upto the required depth offoundation.
- Hard rock was encountered during the excavation which required extra efforts and time to reach the required depth

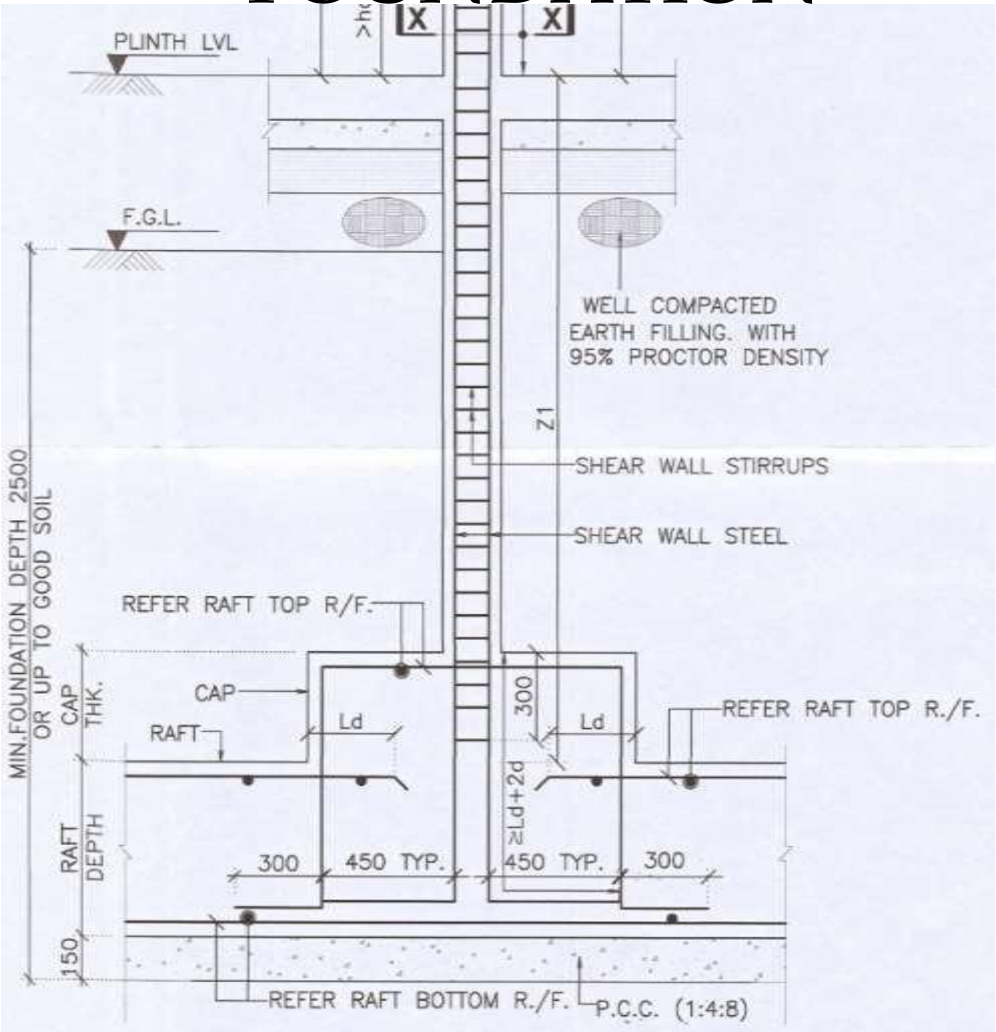
Foundation

- As per geo-technical investigations, bearing capacity, soil strata, water table, etc.
- Typical raft foundation of varying sizes depending on the load.

FOUNDATION

Concrete & Reinforcement Steel Specifications

- Raft foundation with Shear wall upto Plinth level has beenused.
- The raft foundation is designed for SBC of 25 T/m² as calculated in soil investigation report.
- After leveling of the ground 150 mm thick PCC is placed and depth of the raft footing is 750 to900mm.
- M25 grade of concrete has been used with cover of 50mm. reinforcement has been placed as per the drawings.
- Above raft footing, shear wall of 200mm thickness is designed upto Plinth level. Grade of concrete in shear walls is M40.
- Above shear wall, plinth beam of 230 x 600 mm is cast with M25 grade of concrete.



TYP.RAFT FOOTING DUCTILITY SECTION

Foundation

- Shear Wall up to Plinth level

FOUNDATION

- Plinth beam is constructed above the shear wall.

FOUNDATION

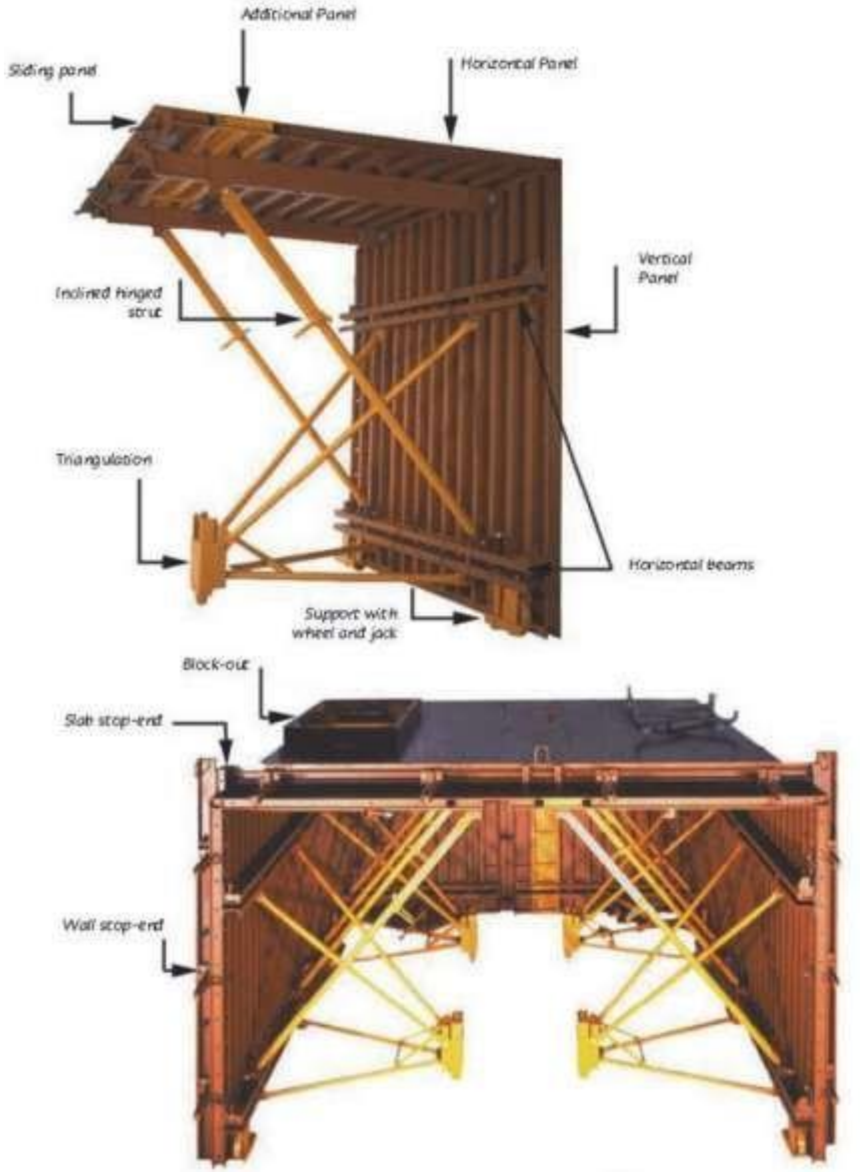
- Plinth beam is constructed above the shear wall.

Structural Elements

Structural System

- Tunnel formwork is customized engineering formwork based on two half shells which are placed together to form a room or cell. Several cells make an apartment.
- The construction of structure is divided into phases. Each phase consists of a section of the structure that will be cast in one day. The phasing is determined by the programme and the amount of floor area that can be poured in one day.
- The infill walls are of Autoclaved Aerated Concrete (AAC) blocks and being used for partition walls.

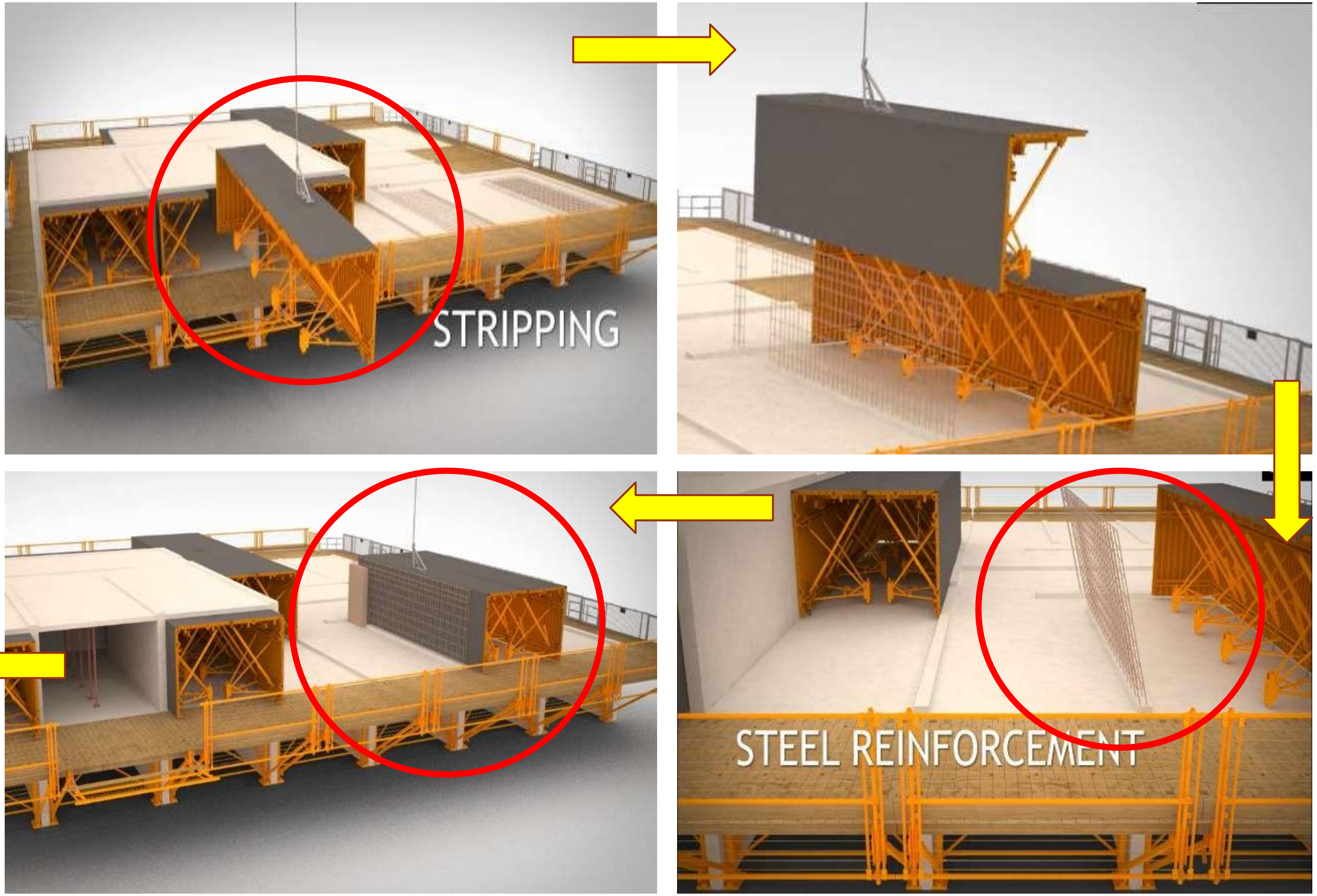
Assembly of Tunnel Formwork

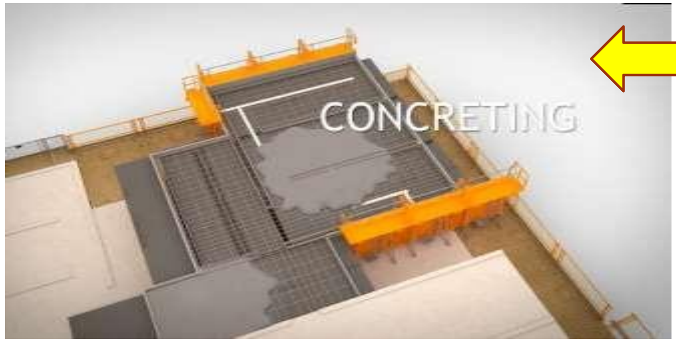


Work Cycle with Tunnel Formwork

The on-site implementation of 24 hour cycle is divided into following operations.

1. Stripping of the formwork from the previous day.
2. Positioning of the formwork for the current day's phase, with the installation of mechanical, electrical and plumbing services.
3. Installation of reinforcement in the walls and slabs.
4. Concreting.





Structural System

- Placement of tunnel formwork for slab and wall
- Concretingafter placement of reinforcement on slaband wall.

Structural System

- After placement of reinforcement, the slab is cast monolithically with the walls.

Placement and leveling of concrete

Structural Elements

- Finished Monolithic structure with shear wall and slab

Autoclaved Aerated Concrete (AAC) Blocks for Wall

- Autoclaved Aerated Concrete (AAC) blocks are lightweight, precast manufactured using foam concrete and suitable as masonry unit. These are non-load bearing infill walls.

Monolithic Concrete Construction using Tunnel Formwork

Advantages

- Facilitates rapid construction of multiple/ mass modular units (similar units)
- Results in durable structure with low maintenance requirement
- The precise finishing can be ensured with no plastering requirement
- The concrete can use industrial by-products such as Fly Ash, Ground granulated blast furnace slag (GGBFS), Micro silica etc. resulting in improved workability & durability, while also conserving natural resource
- Being Box type structure, highly suitable against horizontal forces (earthquake, cyclone etc.)
- The large number of modular units bring economy in construction

Monolithic Concrete Construction using Tunnel Formwork

Limitations

- A lead time of about 3 months is required for initiation of work, as the

  formwork are custom designed, manufactured and prototype

- Approved before manufacturing required number of sets of formwork
- Post construction alterations are difficult
- All the service lines are to be pre-planned in advance
- Economy in cost is achieved with large number of multi storied modular units.

Basics of Thermal Comfort and Passive Design strategies for Affordable Housing

Thermal comfort is a mental state that reflects happiness with the thermal environment and is measured by subjective assessment.

Importance of Thermal Comfort

1. You can increase morale and productivity while also enhancing health and safety by regulating thermal comfort. Because their capacity to make decisions and/or do manual tasks deteriorates in excessively hot and cold conditions, people are more prone to behave unsafely

2

People adjust their behavior to cope with their thermal environment, such as by adding or removing clothing, changing their posture unconsciously, selecting a heating source, moving closer to or farther away from cooling/heating sources, and so on.

3

When this option (removing a jacket or moving away from a heat source) is gone, issues develop since people are no longer able to adjust. People are unable to adapt to their environment in some cases because the environment in which they work is a product of the processes of the task they are doing.

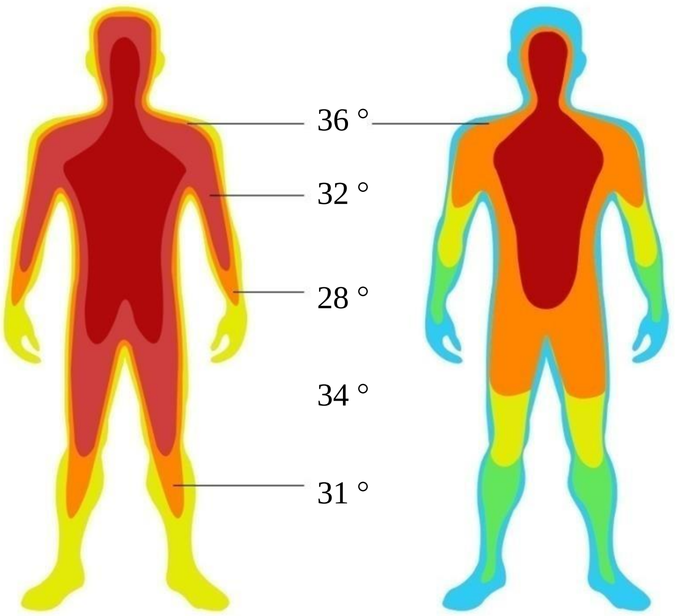
Importance of Thermal Comfort – Body Requirements

- Homo sapiens primate order of the class of mammals
- Body heat is a by-product of metabolism
- A normal core temperature of ~37° C and skin at ~34° C

Source: Sunil Kumar Singh. (2016). Alert to heatwaves [Image]. Retrieved 12 April 2022, from https://www.downtoearth.org.in/news/climate-change/alert-to-heat-waves-53459

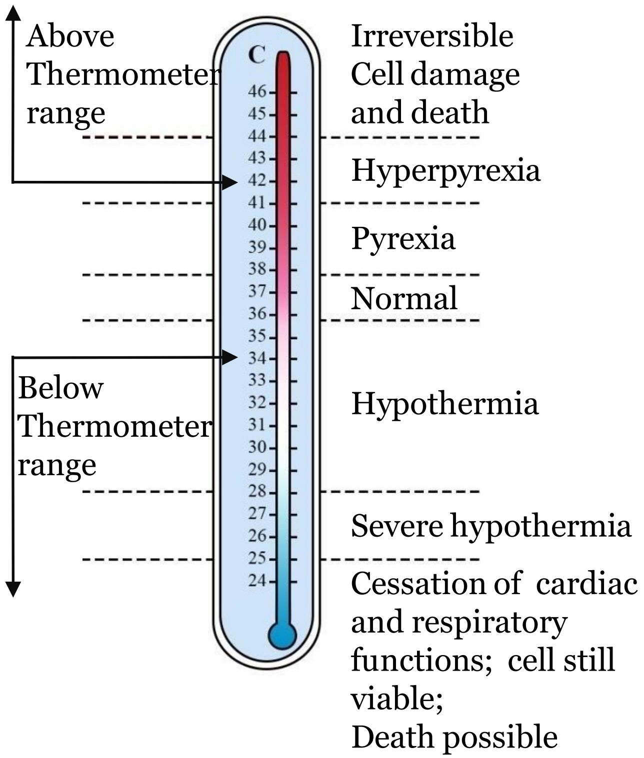
The Telegraph Online. (2020). Cold conditions continue in Delhi [Image]. Retrieved 12 April 2022, from https://www.telegraphindia.com/india/cold-conditions-continue-in-delhi/cid/1732019

Importance of Thermal Comfort – Conditioning & Comfort



30 °C – Ambient temperature – 20 ° C

Human Body Condition in two sets of environment



Human Body Condition beyond comfort bands

Factors affecting Thermal Comfort

PHYSIOLOGICAL FACTORS

When trying to maintain maximum thermal comfort in a building, are individualized in nature and impossible to manage

PHYSICAL FACTORS

Venus has a beautiful name and is the second planet from the Sun

PHYSICAL FACTORS

•01

•Air Temperature

•02

•Mean Radiant Temperature

•03

•Radiant Temperature Asymmetry

•04

Floor Surface Temperature

•05

•Relative Humidity

•06

•Air Speed

Factors affecting Thermal Comfort - Others

- **Acclimatization**
- Short-term physiological adjustments
- Long-term endocrine adjustments

- **Body shape and fat**

- **Age and gender**

- **Status of health**

Short term physiological adjustments

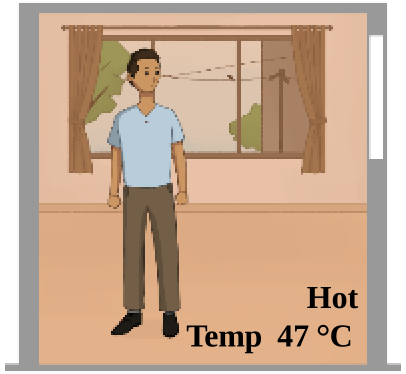
Long term physiological adjustments

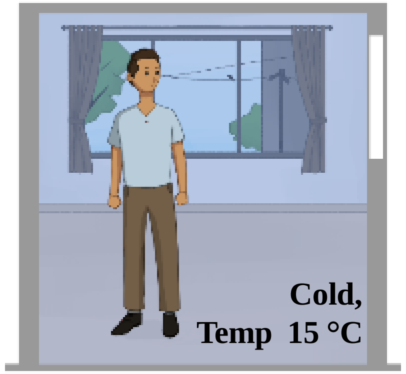
Age

Gender

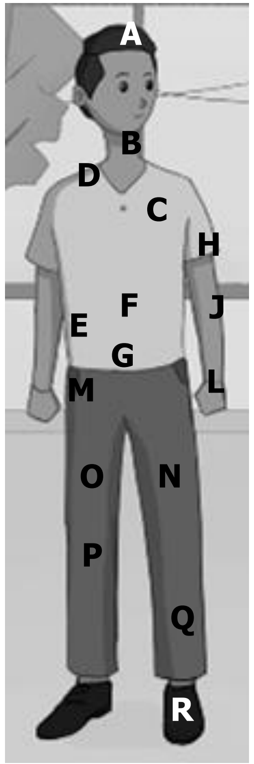
Health & Wellbeing

Thermal Comfort – Cold – Neutral - Warm



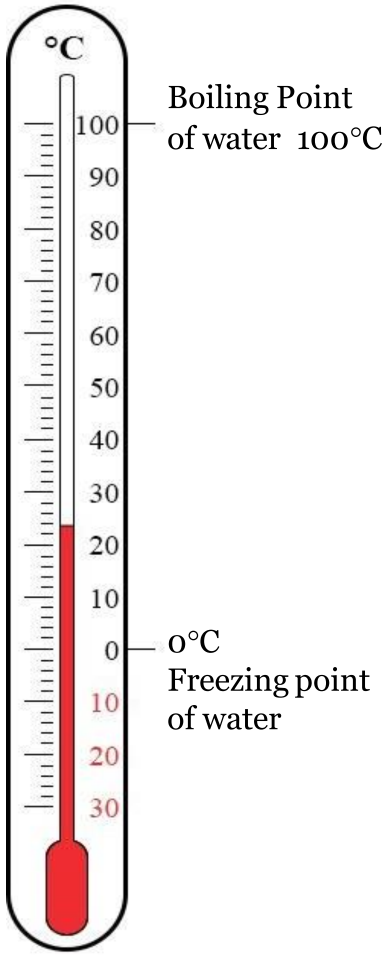


Air Temp 27 °C



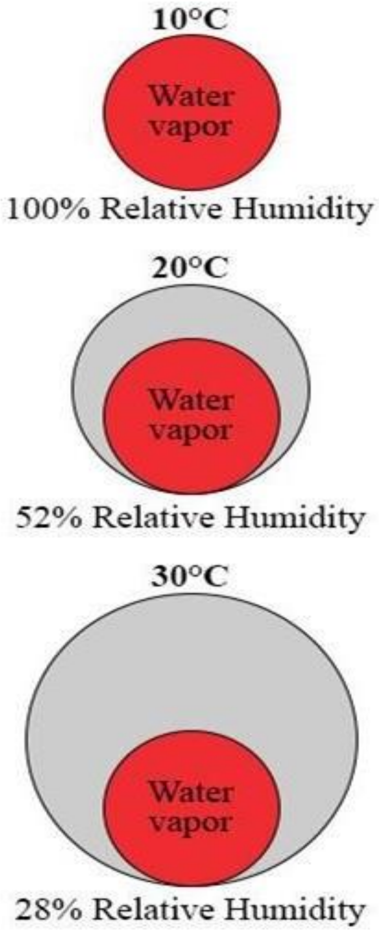
Body Part	Skin Location	Cold (15 °C)	Neutral (27°C)	Hot (47 °C)
A	Forehead	31.7	35.2	37
B	Back of Neck	31.2	35.1	36.1
C	Chest	30.1	34.4	35.8
D	Upper Back	30.7	34.4	36.3
E	Lower Back	29.2	33.7	36.6
F	Upper Abdomen	29	33.8	35.7
G	Lower Abdomen	29.2	34.8	36.2
H	Tricep	28	33.2	36.6
J	Forearm	26.9	34	37
L	Hand	23.7	33.8	36.7
M	Hip	26.5	32.2	36.8
N	Side thigh	27.3	33	36.5
O	Front thigh	29.4	33.7	36.7
P	Back thigh	25.5	32.2	36
Q	Calf	25.1	31.6	35.9
R	Foot	23.2	30.4	36.2

Factors Affecting Thermal Comfort – Air Temperature



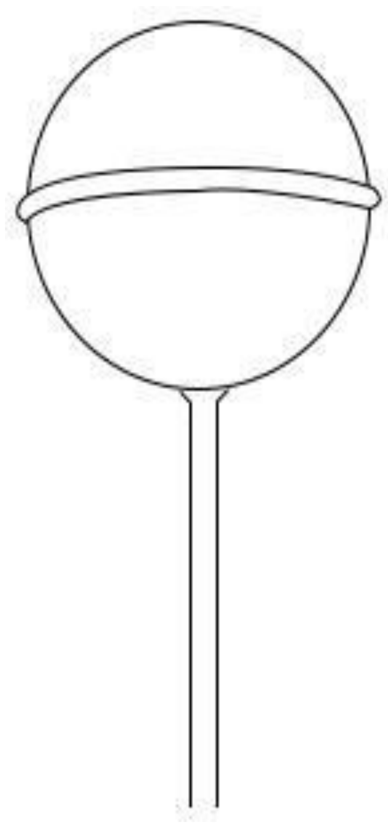
- Temperature of the air surrounding the body (Dry Bulb Temperature) – DBT)
- Temperature of air measured by a thermometer freely exposed to the air, but shielded from radiation and moisture.
- Degrees Celsius (°C)

Factors Affecting Thermal Comfort – Relative Humidity



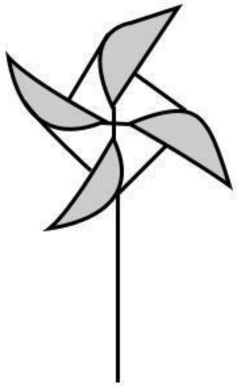
- Moisture Content of the air
- The amount of moisture in the air depends upon
- Air Pressure
- Air Temperature
- Percentage (%)

Factors Affecting Thermal Comfort – Mean Radiant Temperature



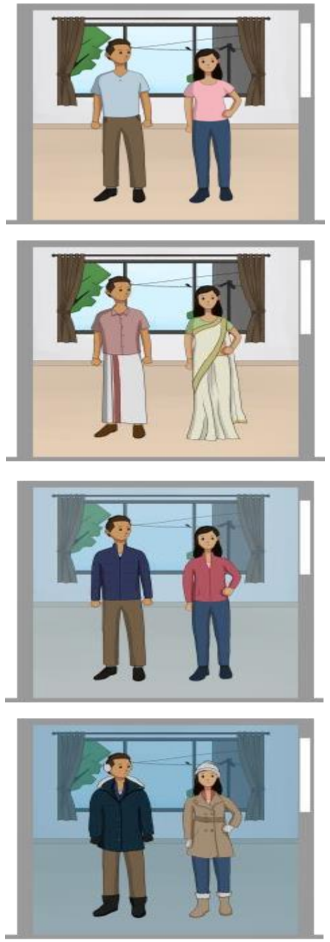
- Uniform temperature of an imaginary enclosure
- Measure of the effect of Radiant interchanges at a point in space
- Calculated using (T_g), (T_a) and air velocity

Factors Affecting Thermal Comfort – Air Speed



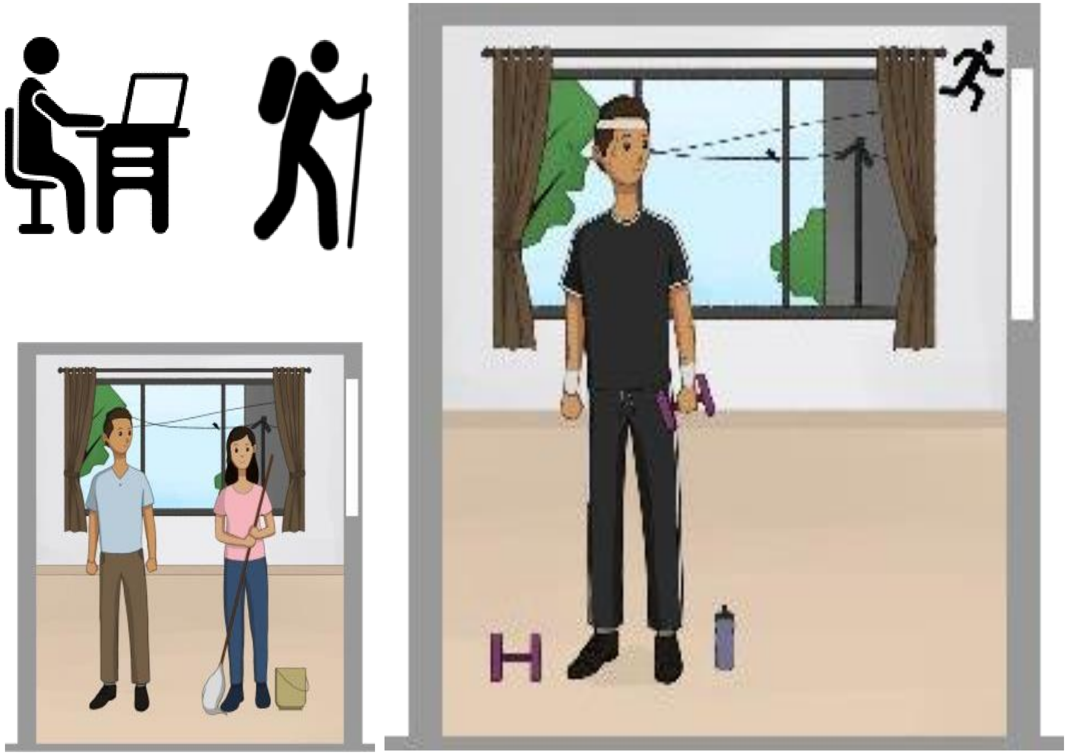
- Air Speed is the rate of air movement at a point, without regard to direction
- Average air speed, height and directions
- Calculated using (T_g), (T_a) and air velocity
- Meter per second (m/s)

Factors Affecting Thermal Comfort – Clothing Value



- The resistance to sensible heat transfer provided by clothing ensemble
- Clothing Insulation Value (clo - I_{cl})
- Impact of furniture such as chair and beddings

Factors Affecting Thermal Comfort – Metabolic Rates



- The rate at which metabolism occurs in a living organism.
- Rate of energy expenditure per unit time
- Average adult 1.8 square meter
- Energy per unit areas, watts per square meter (W/m^2)

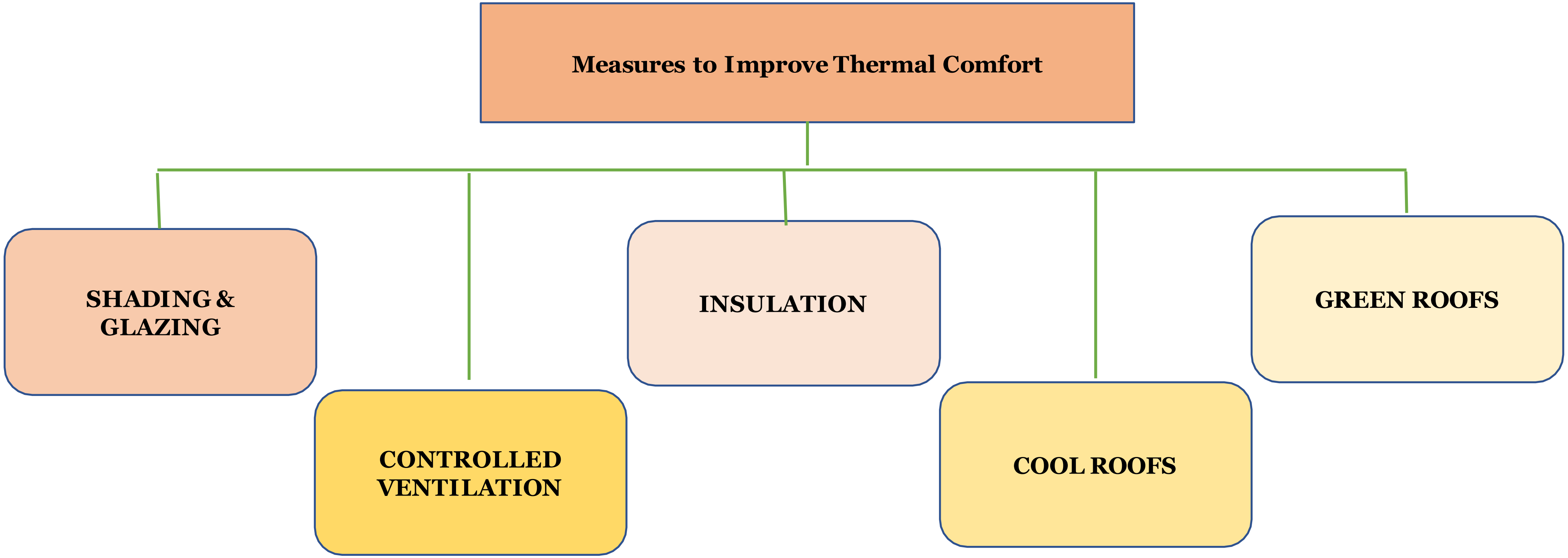
CLOTHING	Clo
T-shirts, shorts, Light socks, Sandals	0.30
Shirt, Trousers socks, Shoes	0.70
Jacket, Blouse, Long skirt, stockings	1.00
Trousers, Vest, Jacket Coat, Socks Shoes	1.50

CLOTHING LEVELS & INSULATION

ACTIVITY	Met
Seated, Relaxed	1.0
Sedentary Activity (office, dwelling, school, laboratory)	1.2
Standing, Light Activity (shopping, laboratory, light industry)	1.6
Standing, Medium activity (shop assistant, domestic work, machine work)	2.0

METABOLIC RATE

Measures to Improve Thermal Comfort



Shading & Glazing

Shading reduces internal heat gain through coincident radiation.

VARIOUS METHODS TO SHADE WINDOWS					
Overhangs	Awnings	Louvers	Vertical Fins	Light Shelves	Natural Vegetation

These can reduce cooling energy consumption by 10-20%

The shading mechanism can be fixed or movable (manually or automatically) for allowing varying levels of shading based on

1. **the sun's position and**
2. **movement in the sky**

Shading & Glazing

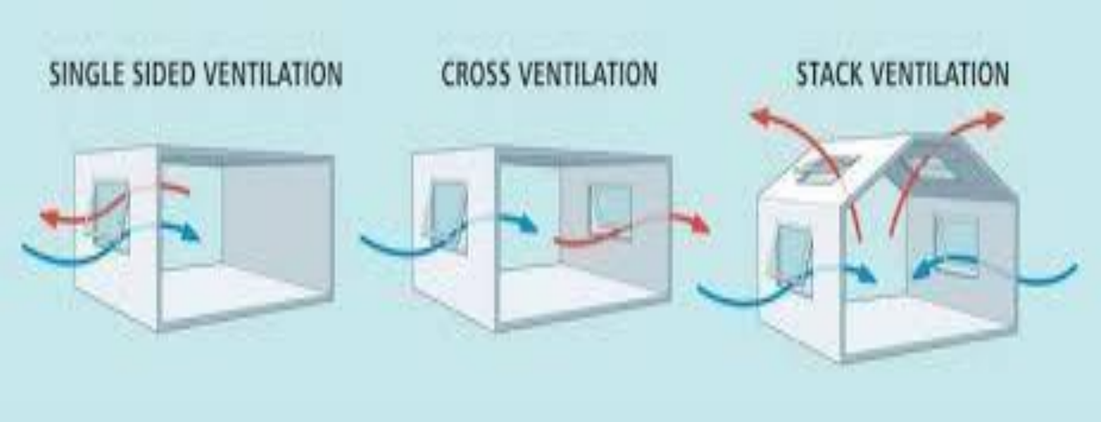
Thermal Comfort

- **SHADING** — In combination with high-performance glass with low solar heat gain coefficient (SHGC), can reduce energy consumption even further by cutting down or heat gain through radiation
- **GLAZING** — refers to the glass windowpanes that make up the building envelope. Conduction and radiation are the primary sources of heat gain via a window. radiation, which can be regulated by defining the parameters correctly. SHGC and U-value, respectively.

Controlled Ventilation

BUILDING CAN BE DESINED AS

- **CROSS VENTILATION**
- **STACK VENTILATION**
- **SINGLE-SIDED VENTILATION**



Controlled Ventilation

Designing windows and vents to dissipate warm air and allow the ingress of cool air can reduce cooling energy consumption by 10-30%

Air Velocity range between 0.5 to 1 m/s	Drops temperature at about 3 ^{O}C at 50% relative Humidity

AIR VELOCITY OF 1 m/s	
Office Environment	Too High
Home Environment	Acceptable (Especially if there is no resource to active air conditioning.)

Controlled Ventilation

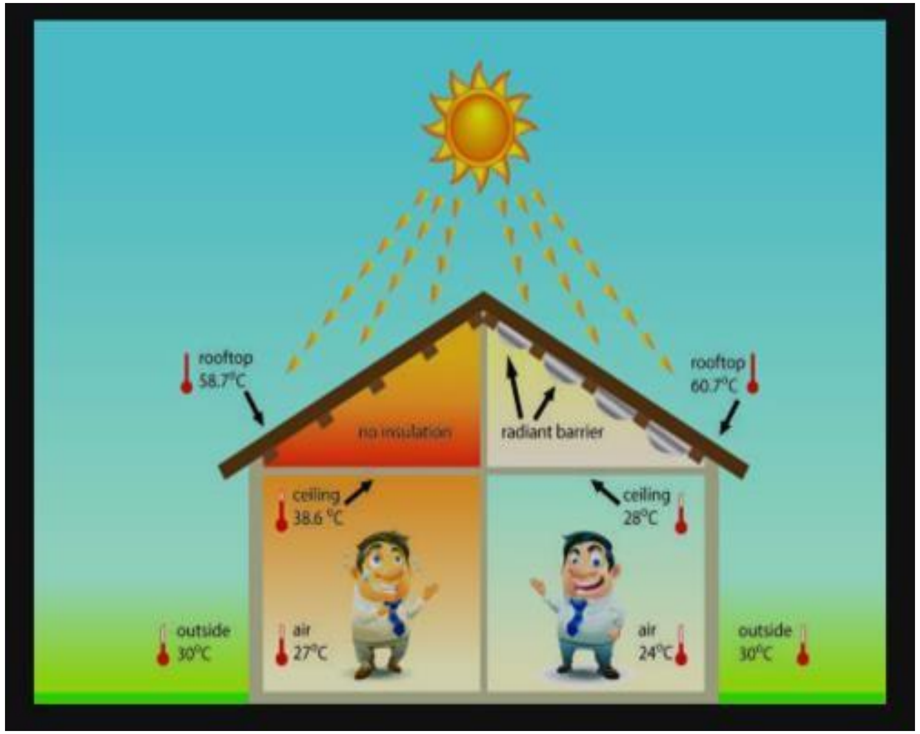
Natural ventilation takes advantage of the differences in air pressure between warm air and cool air, as well as convection currents, to remove warm air from an indoor space and allow fresh cooler air in.

This also has the added advantage of cooling the walls and roofs of the buildings that hold significant thermal mass, further enhancing the thermal comfort of the occupants

NATURAL VENTILATION	
With Breeze Air	Works Best
Absence of natural breeze	Fans can be used to improve the flow of cool air
Natural ventilation promotes the occupants' adaptation to external temperature, called adaptive thermal comfort	

Even in hot-dry and warm-humid climate zones where some air-conditioning may be required during peak Thermal Comfort for All summer, buildings can be designed to operate in a mixed mode to enable **night ventilation** and **natural ventilation** during cooler seasons

Insulation



Heat Conduction takes place through

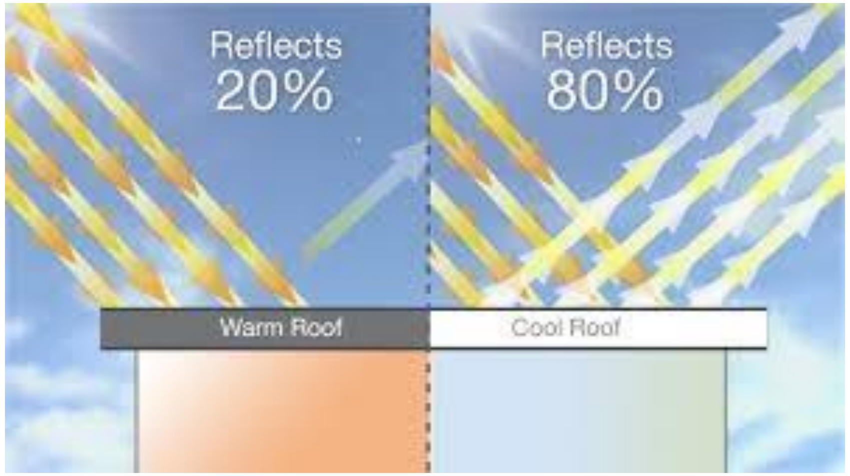
- Roof
- Walls
- Windows

An insulating material can resist heat transfer due to its low thermal conductivity. Insulating walls and the roof can reduce cooling energy loads by up to 8%

Cool Roofs

Cool roofs are one of the passive design options for reducing cooling loads in buildings. Cool roofs reflect most of the sunlight (about 80% on a clear day)

When sunlight is incident on a dark roof	When Sunlight is incident on a cool roof
38% heats the atmosphere	10% heats the environment
52% heats the city air	8% heats the city air
5% is reflected	80% is reflected
	1.5% heats the building



Cool Roofs

In the summer, a typical cool roof surface temperature keeps 25-35°C cooler than a conventional roof, lowering the internal air temperature by roughly 3-5°C and improving the thermal performance.

The comfort of the inhabitants is improved, and the roof's lifespan is extended.

Cool roofs increase the durability of the roof itself by reducing thermal expansion and contraction.

Apart from helping enhance the thermal comfort in the top floor and helping reduce air-conditioning load, cool or white roof or pavements also offer significant reduction in urban heat island effect

The cities of Jodhpur and Jaipur is the extremely hot state of Rajasthan, where most of the city homes are painted in light blue and light pink colours, are examples of practical application of this age-old traditional design style.

Green Roofs

A green roof is a roof of a building that is partially or completely covered with vegetation

GREEN ROOFS PURPOSE

- Absorbing Rain Water
- Providing Insulation
- Helping lower urban air temperatures
- Mitigating the urban heat island effect

Green Roofs

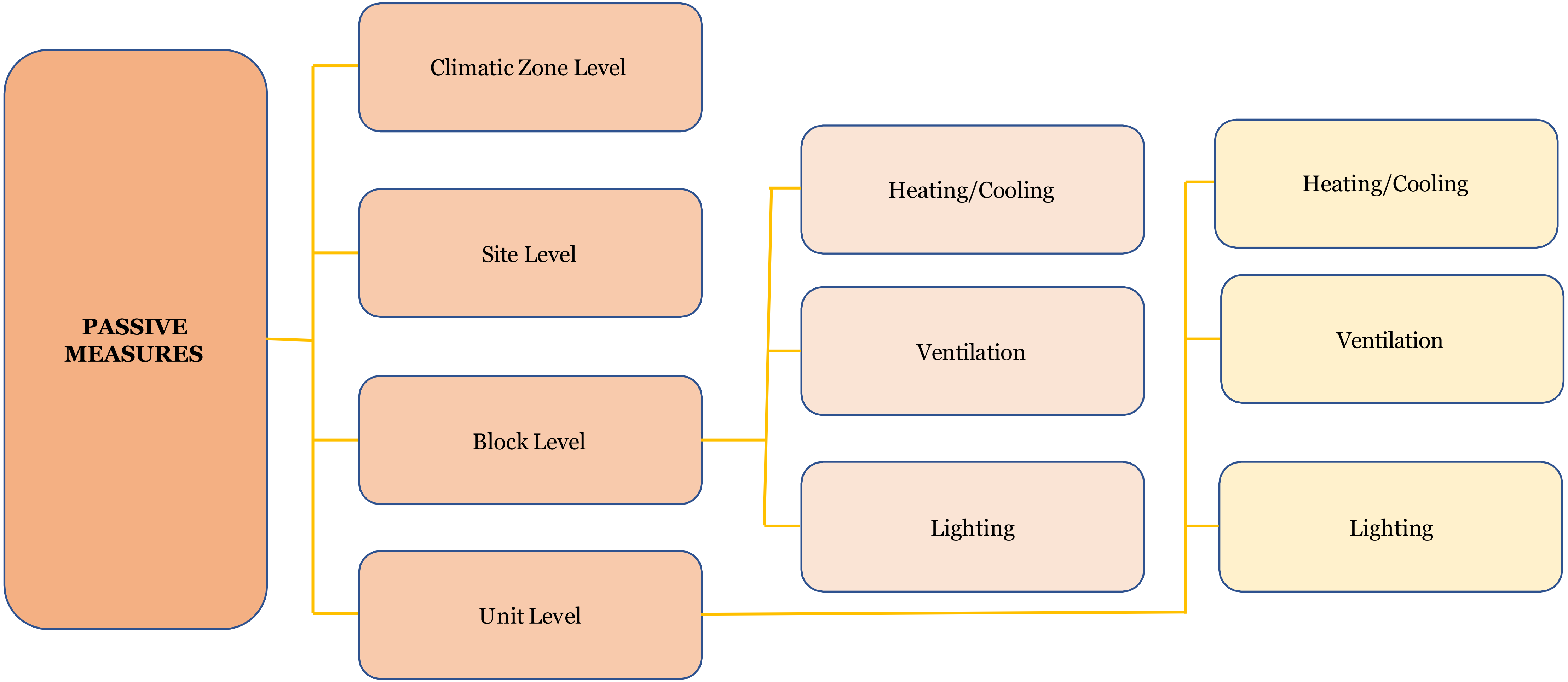
Reduction in Energy use is an important feature of Green Roofing

GREEN ROOFS IN BUILDINGS ALLOWS	
During cooler Winter Months	Retain their heat
During hotter Summer Months	Reflecting and absorbing solar radiations

Passive Strategies & Building Physics

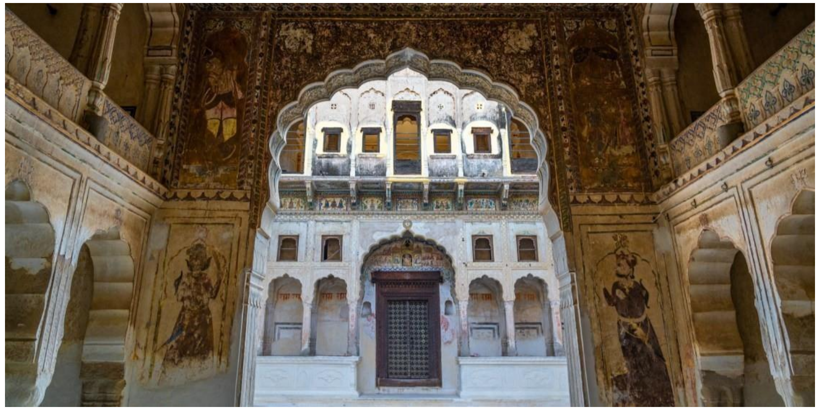
Passive Measures		Level of Response	
Climatic Zone Level	Temperature, rainfall, wind direction, sun radiation, humidity, and other environmental factors are taken into consideration when designing.	Block Level	Interaction of the block with its surroundings and plants to ensure that it has adequate heating, ventilation, and lighting.
Site Level	To take advantage of the positive aspects of the site and its microclimatic features while minimising the negative aspects.	Unit Level	Design solutions that influence heat, light, and ventilation based on climatic variables at the unit level.

Passive Strategies & Building Physics



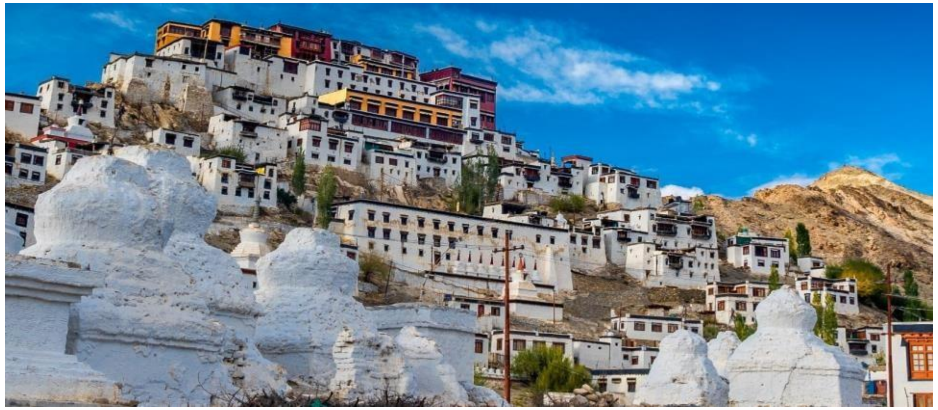
Passive Measures – Climatic Zone Level

Vernacular / traditional architectural typologies that respond to the region's distinct environment are best exemplified.



Example

- In Ladakh, earth architecture with thick walls and limited windows provides optimal insulation.
- In Rajasthan, courtyard havelis take advantage of pressure differences and reciprocal shading to provide natural cooling and ventilation.
- In Kerala, sloping roofs are used to guard against severe rains.



Passive Measures – Site Level

Reducing the 'heat island' effect with approaches like:

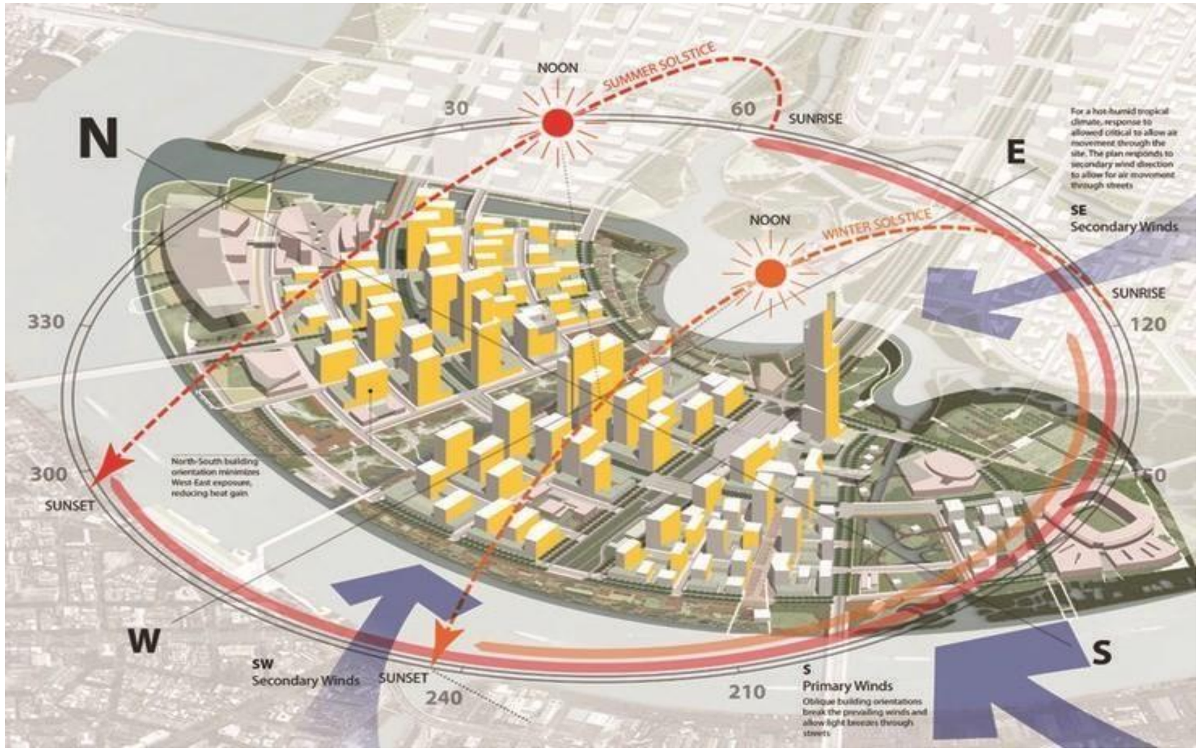
Courtyards / open courts are often surrounded by construction.

Taking advantage of block mutual shading

Using site massing to create wind passageways

lowering the amount of hard paving to allow for water absorption

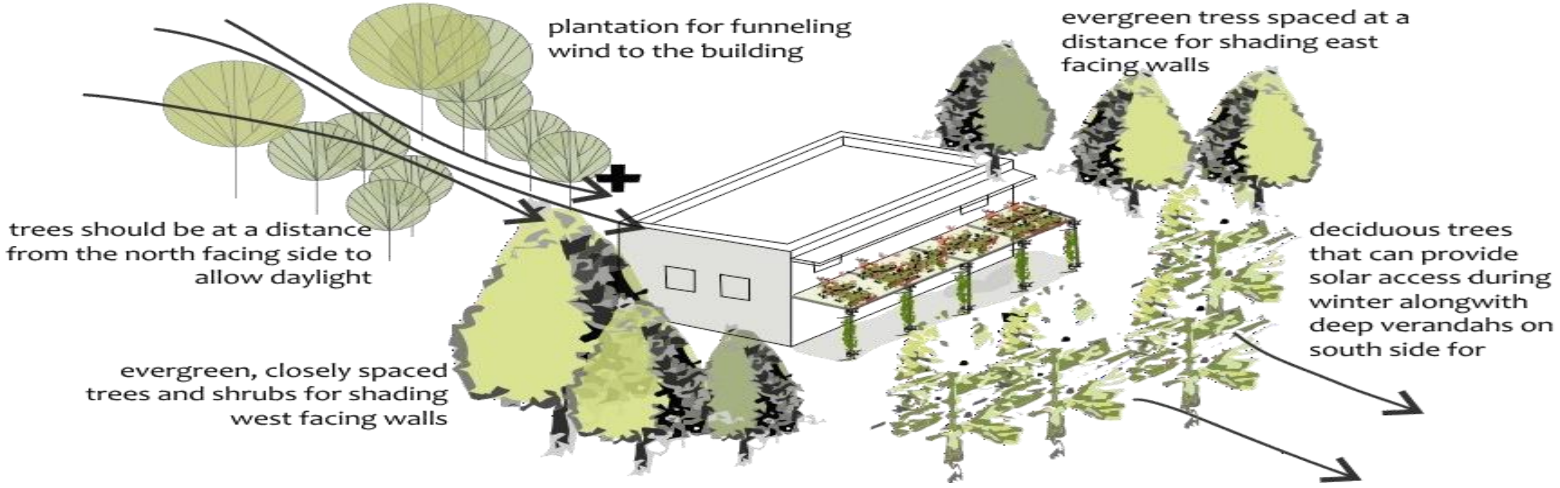
Using complementary vegetation to manage the amount of sunlight that gets through as the seasons change

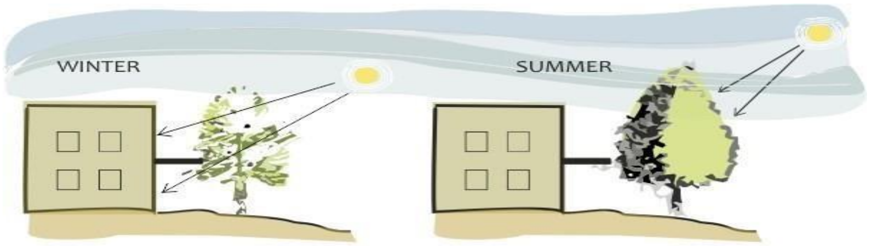


Passive Strategies & Building Physics

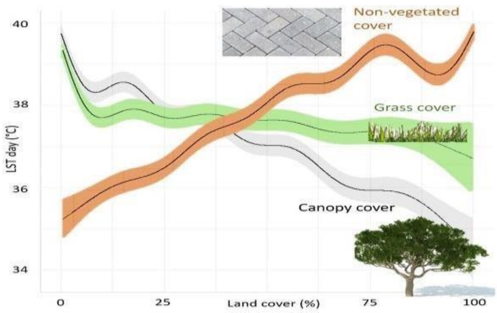
Passive Measures – Leveraging Plantation

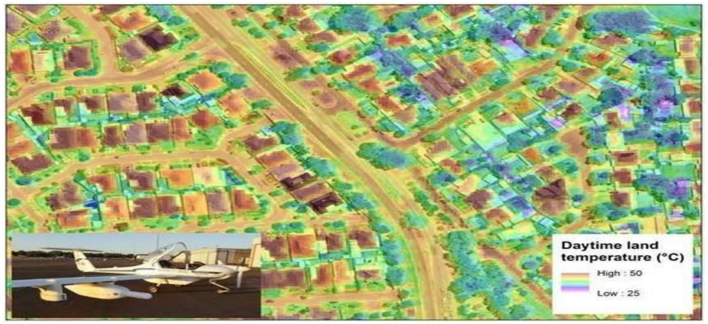
Planting trees in the right places to provide shade and ventilation can significantly reduce the severity of intense weather. During heatwaves in Adelaide, a research found that districts with more vegetation cover remained cooler by up to 6°C.





deciduous trees allow sun penetration in winter and block sun access during summer

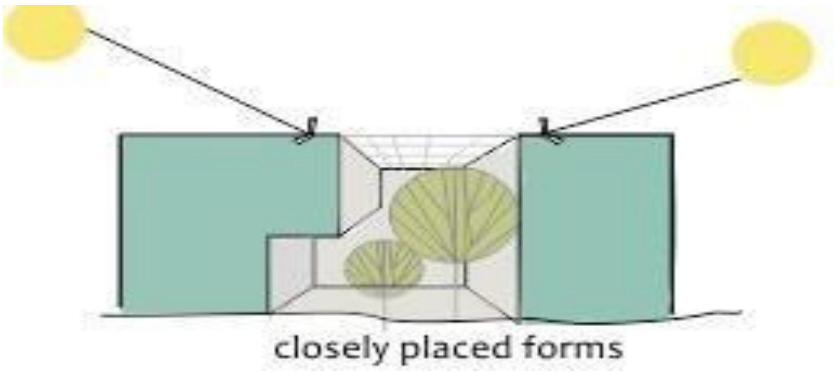


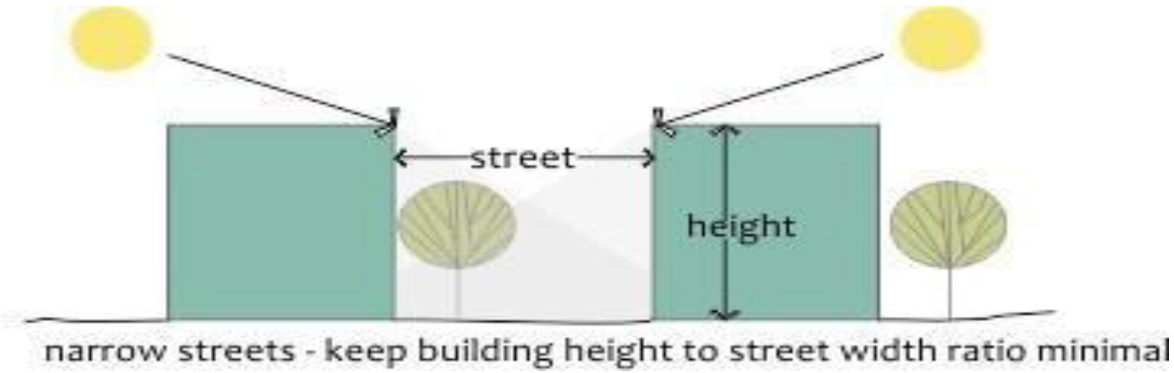


Passive Strategies & Building Physics

Block Level

Arrange the blocks so that mutual shade is obtained, avoiding solar heat buildup throughout the summer.





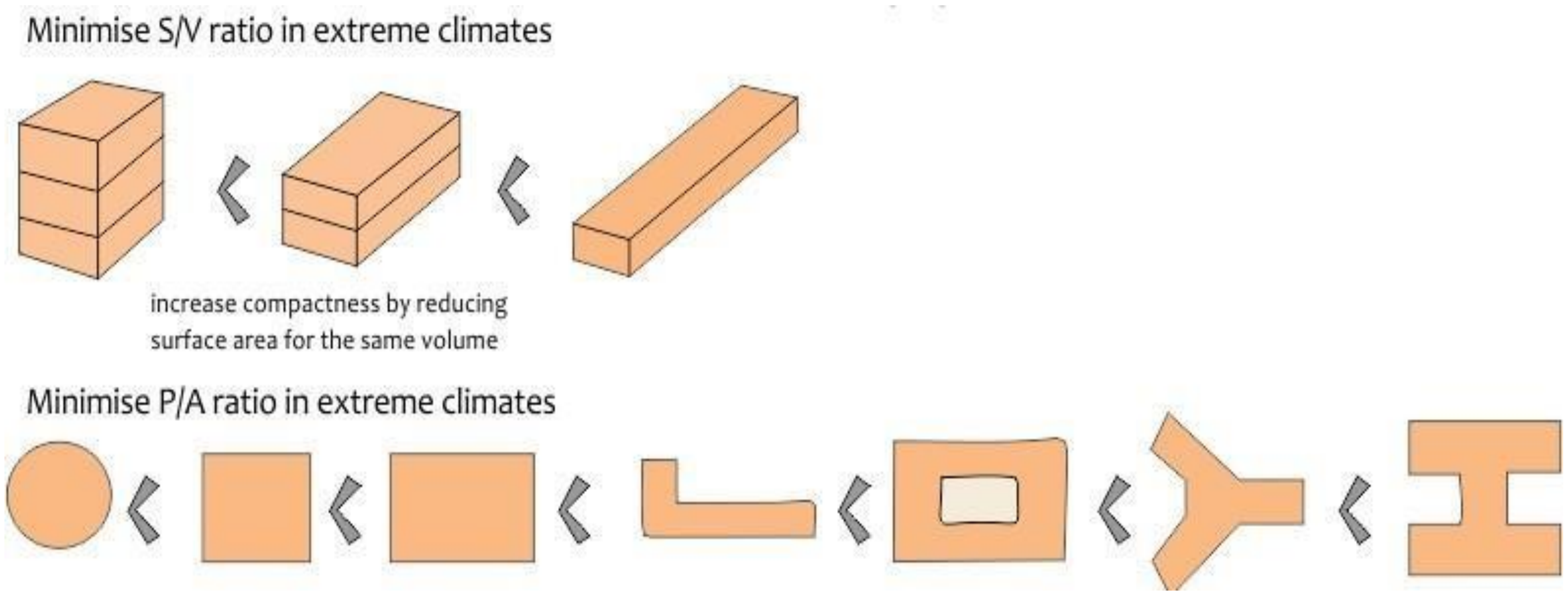
•

HEATING/ COOLING

Passive Strategies & Building Physics

Block Level

In harsh climate zones, reduce the surface area to building volume and perimeter to area ratios to reduce solar radiation exposure.

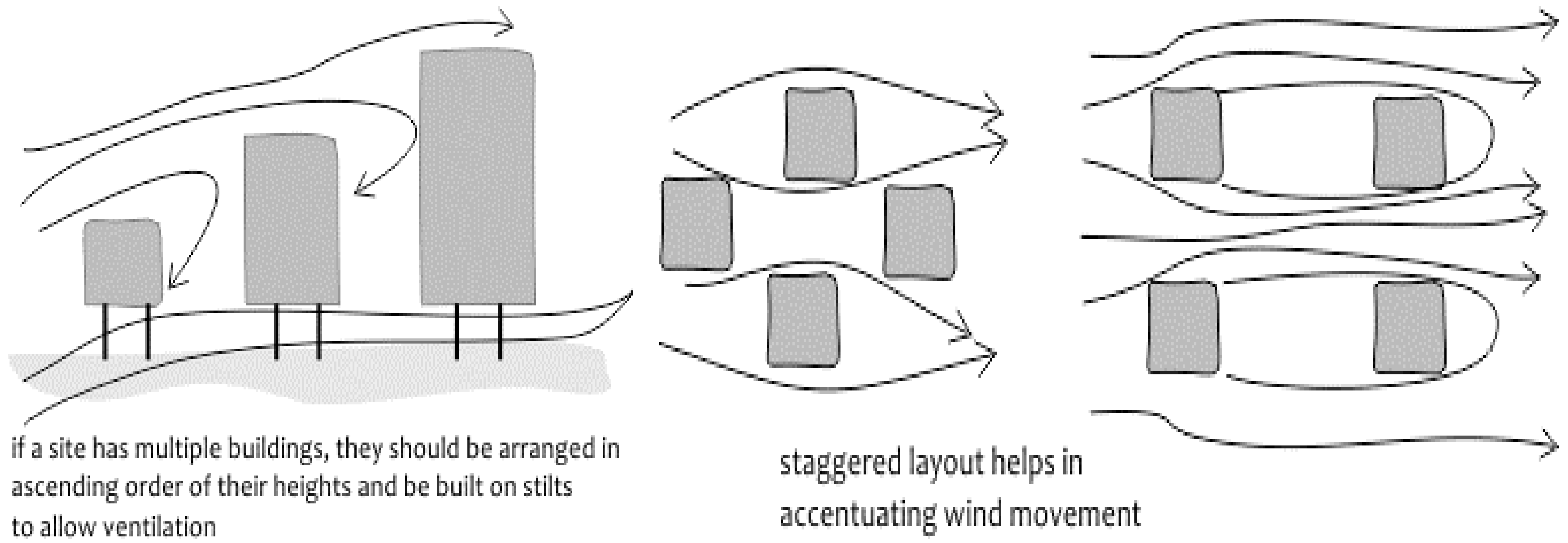


HEATING/
COOLING

Passive Strategies & Building Physics

Block Level

Wind shadows should be avoided by building orientation.

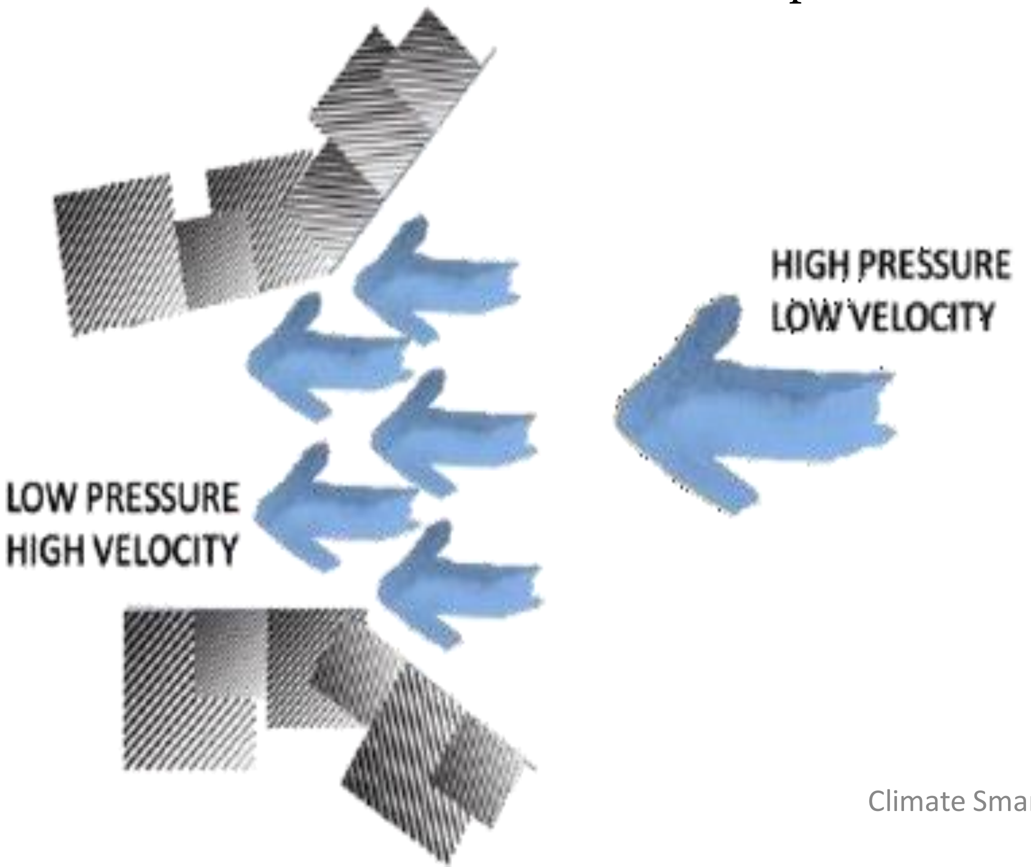


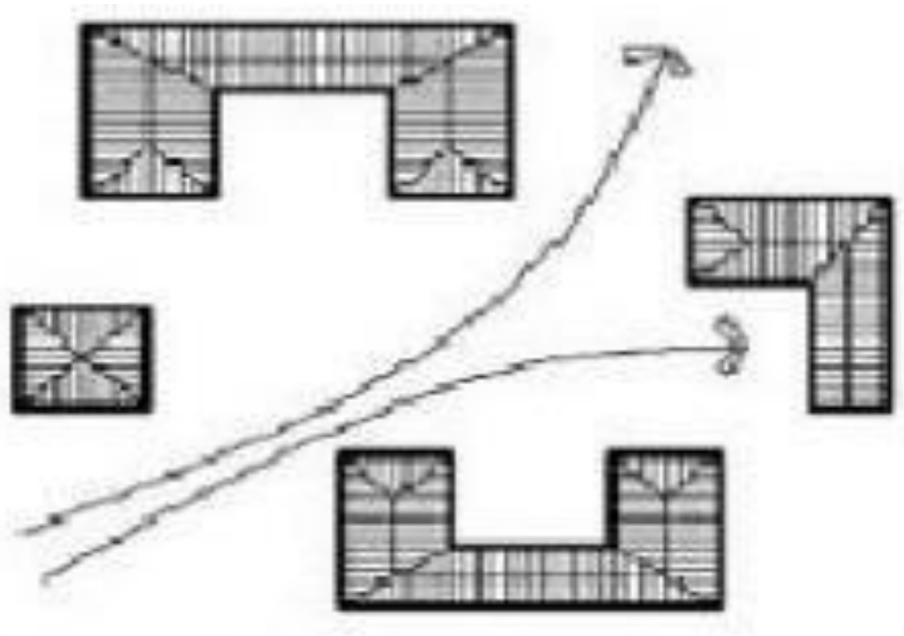
VENTILAT ION

Passive Strategies & Building Physics

Block Level

Wind flows can be harnessed by constructing courts and catchment zones of various sizes. This can help to improve airflow and provide a cooling effect for the blocks.





BUILDING SPACING SUCH THAT AIR FLOW IS PROMOTED

VENTILATION

Passive Strategies & Building Physics

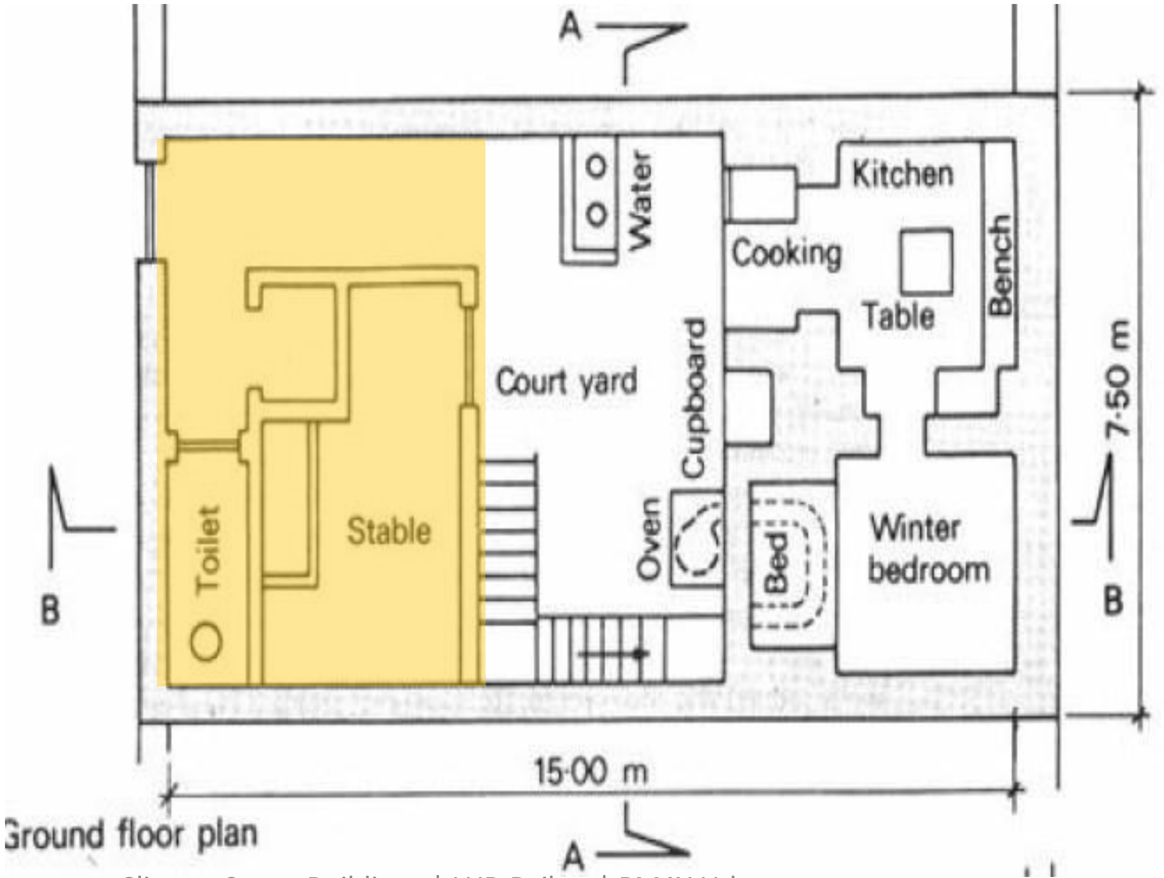
Unit Level

FORMS AND ORIENTATION:

Sun radiation penetration patterns and, as a result, heat uptake and loss in a building are affected by changes in solar route during different seasons.

Internal layout is of the courtyard type, which is rather compact. Reduced sun exposure on East-West external walls to reduce heat gain.

If planned and situated on the east and, especially, the west end of the structure, non-habitable rooms (stores, bathrooms, etc.) can be efficient thermal barriers.



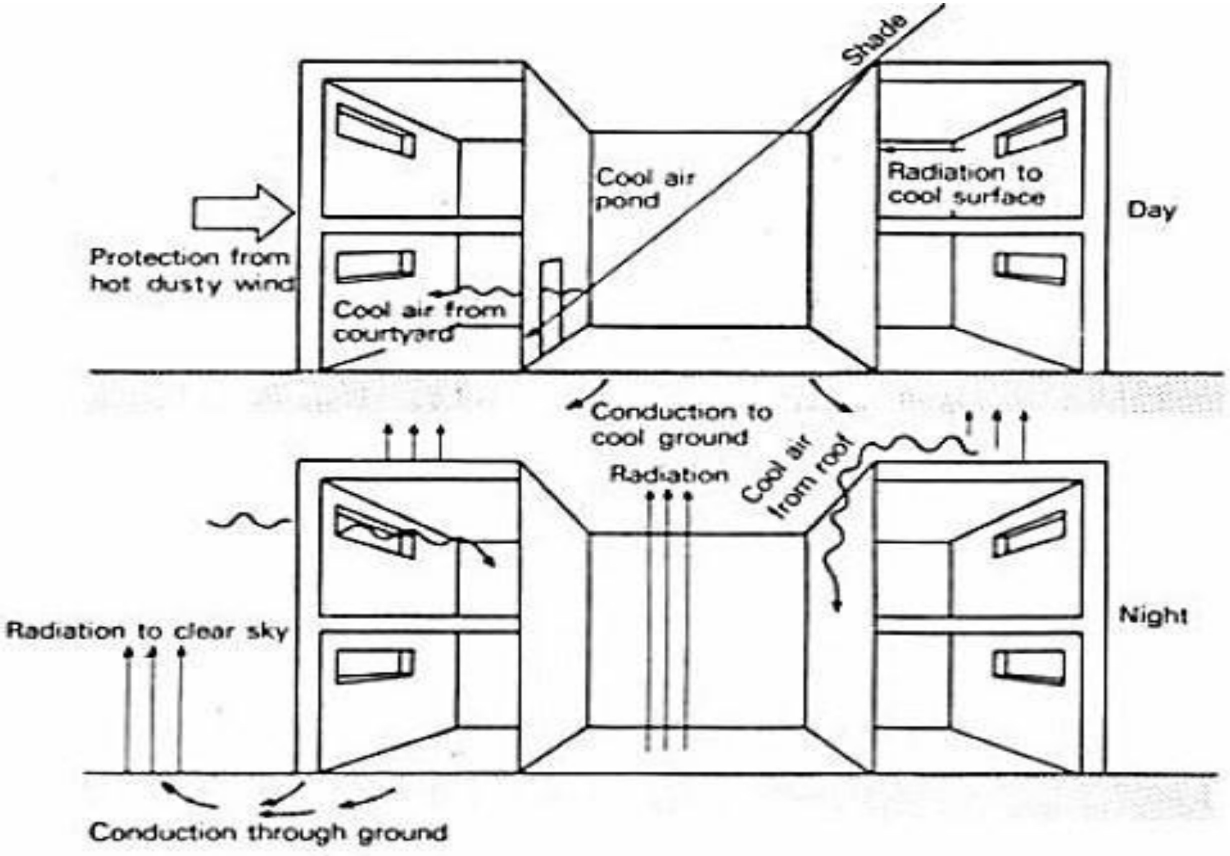
HEATING/ COOLING

Unit Level

FORMS AND ORIENTATION:

High walls block the sun, resulting in significant portions of the inner surfaces and courtyard floor being shaded during the day.

The dirt beneath the courtyard will extract heat from the surrounding places and remit it to the open sky during the night, resulting in cooler air and surfaces.



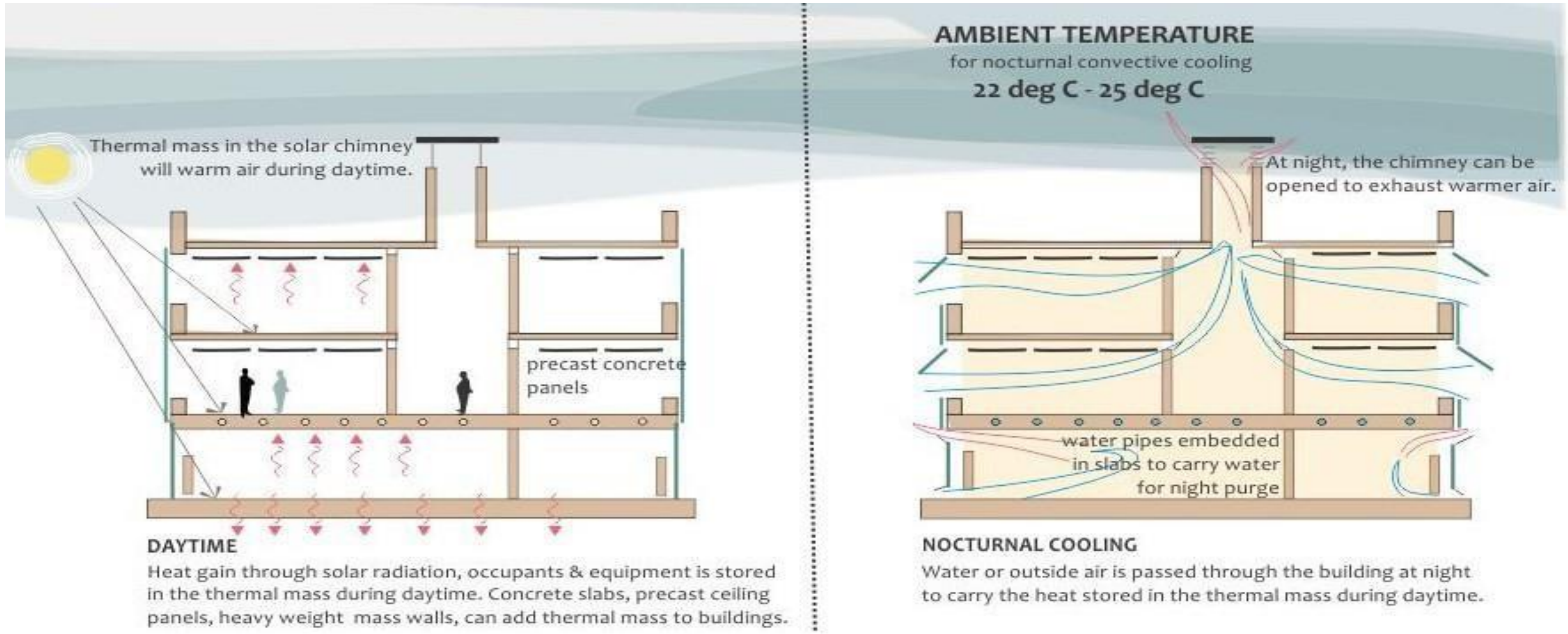
HEATING/ COOLING

Unit Level

THERMAL MASS:

Thermal mass can be combined with night-time convective cooling, sometimes known as "night cooling," to passively cool buildings.

Thermal mass as a passive cooling and heating approach requires a large diurnal swing.



HEATING/ COOLING

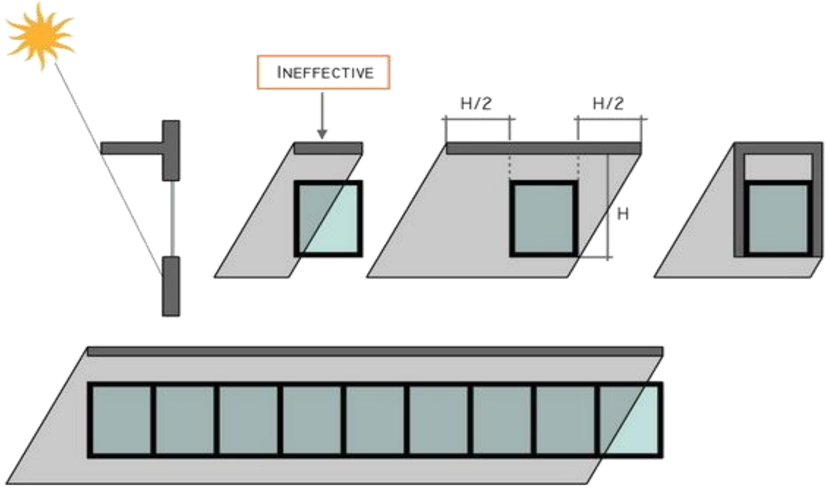
Passive Strategies & Building Physics

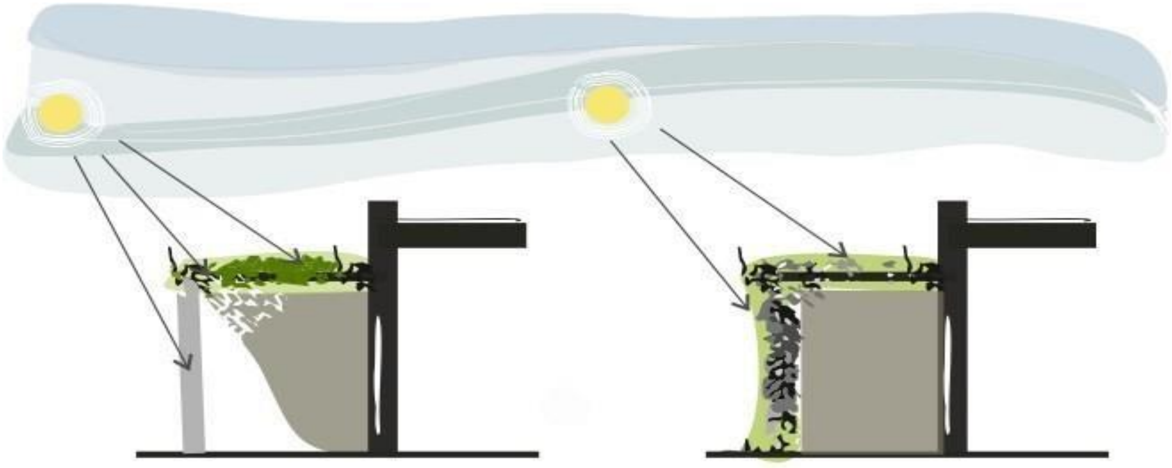
Unit Level

SHADING:

Shade-producing plants, such as creepers, can be used.

Fenestrations and shades/chajjas can be built to maximise solar radiation depending on the environment.





HEATING/ COOLING

Unit Level

ORIENTATION:

Buildings can be orientated in relation to the prevailing wind direction at angles ranging from 0° to 30°.

In buildings with a courtyard, positioning the courtyard 45 degrees from the prevailing wind maximises wind flow into the courtyard and improves cross ventilation in the building (in climates where cooling is required).

CREATING PRESSURE DIFFERENCES:

A 'squeeze point' occurs when wind enters through a smaller opening and escapes through a larger opening. This generates a natural vacuum, which speeds up the wind.

The total area of apertures should be at least 30% of the total floor space.

The window-to-wall-ratio (WWR) should not exceed 60%.

VENTILATION

CASE STUDIES

INFOSYS – POCHARAM CAMPUS

LOCATION	**HYDERABAD, TELANGANA**
COORDINATES	17° N, 78° E
OCCUPANCY TYPE	OFFICE
TYPOLOGY	NEW CONSTRUCTION
CLIMATE TYPE	HOT AND DRY
PROJECT AREA	27,870 m^2

Given the high-standards in terms of building design achieved at the SDB1 in Hyderabad, it has now been showcased in the 'Best Practices Guide for High Performance Indian Office Buildings' by Lawrence Berkeley National Lab, a U.S. Department of Energy (DoE) National Laboratory.

- The Indian Green Building Council (IGBC) has given Infosys, a worldwide consulting and technology firm, the LEED (Leadership in Energy and Environmental Design) India 'Platinum' designation for its Software Development Block 1 (SDB 1) at its Pocharam site in Hyderabad, India.
- The SDB 1 is the first commercial building in India to deploy unique Radiant-cooling technology, setting new norms for energy efficiency in building systems design.

It has been built keeping in mind a holistic approach to sustainability in five key areas

SUSTAINABLE SITE DEVELOPMENT

WATER SAVINGS

ENERGY EFFICIENCY

MATERIALS SELECTION

INDOOR ENVIRONMENT QUALITY

EPI – 75kWh/m²/yr

GODREJ PLANT 13 ANNEXE

LOCATION	**MUMBAI, MAHARASHTRA**
COORDINATES	19° N, 73° E
OCCUPANCY TYPE	OFFICE – PRIVATE
TYPOLOGY	NEW CONSTRUCTION
CLIMATE TYPE	WARM AND HUMID
PROJECT AREA	24,443 m^2

GODREJ PLANT 13 ANNEXE

The Plant 13 Annexe Building at Godrej & Boyce (G&B) in Mumbai has been designated as India's first CII-IGBC accredited Net Zero Energy Building. The structure is a mixed-use office/convention center (with office spaces, conference and meeting rooms, auditoriums (90 to 250 seats), banquet hall, 300-person eating facilities, and an industrial kitchen), making certification extremely difficult.

In 2015, the building received an IGBC Platinum grade in the EB (Existing Building) category, which was recertified in 2019. In 2016, it was also awarded the BEE 5 Star Rating. In 2019, he received the 'Energy Performance Award' for meticulous energy measuring and monitoring. At the CII National Energy Management Award event in 2020, it was named "Excellent Energy Efficient Unit."

EPI – 75kWh/m²/yr

INDIRA PARYAVARAN BHAWAN, MoEF

LOCATION	**NEW DELHI**
COORDINATES	29° N, 77° E
OCCUPANCY TYPE	OFFICE & EDUCATIONAL
TYPOLOGY	NEW CONSTRUCTION
CLIMATE TYPE	COMPOSITE
PROJECT AREA	9565 m^2

The Indira Paryavaran Bhawan is now India's most environmentally friendly structure. GRIHA 5 Star and LEED Platinum certifications were awarded to the project. The structure has already received accolades, including the MNRE's Adarsh/GRIHA Award for Outstanding Integration of Renewable Energy Technologies.

The new office building for the Ministry of Environment and Forest (MoEF), Indira Paryavaran Bhawan, is a significant departure from traditional architectural design

To reach net zero criterion, several energy saving measures were implemented to lower the building's energy loads, with the residual demand being satisfied by producing energy from on-site installed high efficiency solar panels.

The project team focused on measures for lowering energy demand, such as ample natural light, shade, landscape to reduce ambient temperature, and energy-efficient active building technologies

When compared to a conventional building, Indira Paryavaran Bhawan utilizes 70% less energy. The project used green building principles, such as water conservation and optimization through site waste water recycling.

EPI – 44kWh/m²/yr

Renewable Energy Integration 930 kW PV panels with a total area of 4650m² for on-site generation, tilted at 23° facing south to generate equivalent to 70kWh/m²/yr

JAQUAR HEADQUARTERS

LOCATION	**MANESAR HARYANA**
COORDINATES	28° N, 77° E
OCCUPANCY TYPE	CORPORATE AND MANUFACTURING
TYPOLOGY	NEW CONSTRUCTION
CLIMATE TYPE	COMPOSITE
PROJECT AREA	48000 m^2

JAQUAR HEADQUARTERS

The building is a perfect blend of modern design sensibilities, biophilic inspiration, and a brand ambition of soaring high.

The Jaguar Headquarters in Manesar is not only a stunning structure, but also a painstakingly constructed complex with cutting-edge technology that has resulted in a net zero campus with a LEED Platinum (USGBC) rating. This project is known for its complex organic design and space arrangement, making it a visual pleasure.

Through its characteristic wing-shaped architecture, the design redefines a business workplace by giving it a memorable experience. The spreading wings of a symbolic eagle, poised to take flight, are atop the horizontal glass edifice, suggesting a firm with worldwide ambitions.

ST. ANDREWS BOYS HOSTEL BLOCK, GURUGRAM

LOCATION	**GURUGRAM HARYANA**
COORDINATES	28° N, 76° E
OCCUPANCY TYPE	HOSTEL
TYPOLOGY	NEW CONSTRUCTION
CLIMATE TYPE	HOT AND DRY
PROJECT AREA	5574 m^2

ST. ANDREWS BOYS HOSTEL BLOCK, GURUGRAM

The goal of the design process was to increase student interaction within the indoor areas, which then spilled outdoors and interacted with the surrounding landscape.

On the south and north facades, the linear block was twisted to create a shaded entry (summer court) and an open terrace (winter court), respectively, to stimulate activities at all times of the day and season. The ramp serves as a buffer between the hot outdoors and the cooler interior, preventing kids from experiencing heat shock.

ST. ANDREWS GIRLS HOSTEL BLOCK, GURUGRAM

LOCATION	**GURUGRAM HARYANA**
COORDINATES	28° N, 76° E
OCCUPANCY TYPE	HOSTEL
TYPOLOGY	NEW CONSTRUCTION
CLIMATE TYPE	HOT AND DRY
PROJECT AREA	2322 m^2

ST. ANDREWS GIRLS HOSTEL BLOCK, GURUGRAM

Indoor and outdoor spaces that connect physically and aesthetically at different levels to encourage interactions and social activities are incorporated into the building's plan.

The entrance foyer and lobby were planned as outdoor spaces facing west and connected to the pantry so that students can enjoy their nights outside with a spill-out into the green landscape.

AKSHAY URJA BHAWAN HAREDA

LOCATION	**PANCHKULA HARYANA**
COORDINATES	30° N, 76° E
OCCUPANCY TYPE	OFFICE - PUBLIC
TYPOLOGY	NEW CONSTRUCTION
CLIMATE TYPE	COMPOSITE
PROJECT AREA	5100 m^2

AKSHAY URJA BHAWAN HAREDA

Mechanical air conditioning is used to guarantee thermal comfort in apical zones at all times.

Zones are created based on the intended temperature set points. 25 1 °C for apex offices, 25 3 °C for regulated office and public areas, and 25 5 °C for passive zones.

In the summer, controlled zones are cooled, and in the monsoon, they are chilled. In the summer, passive zones are cooled, while in the monsoon, they are aired. The centre atrium has a mist system for cooling the controlled and passive zones. Water that has been chilled to a temperature of 15°C.

Thank You