

# AWARENESS “B” WORKSHOP ON INNOVATIVE CONSTRUCTION TECHNOLOGIES AND THERMAL COMFORT FOR AFFORDABLE HOUSING



# INTRODUCTION

- 1. Introduction of Ministry of Housing and Urban Affairs**
- 2. Introduction of Global Housing Technology Challenge**
- 3. Introduction of GIZ**
- 4. Introduction of Climate Smart Building Cell**

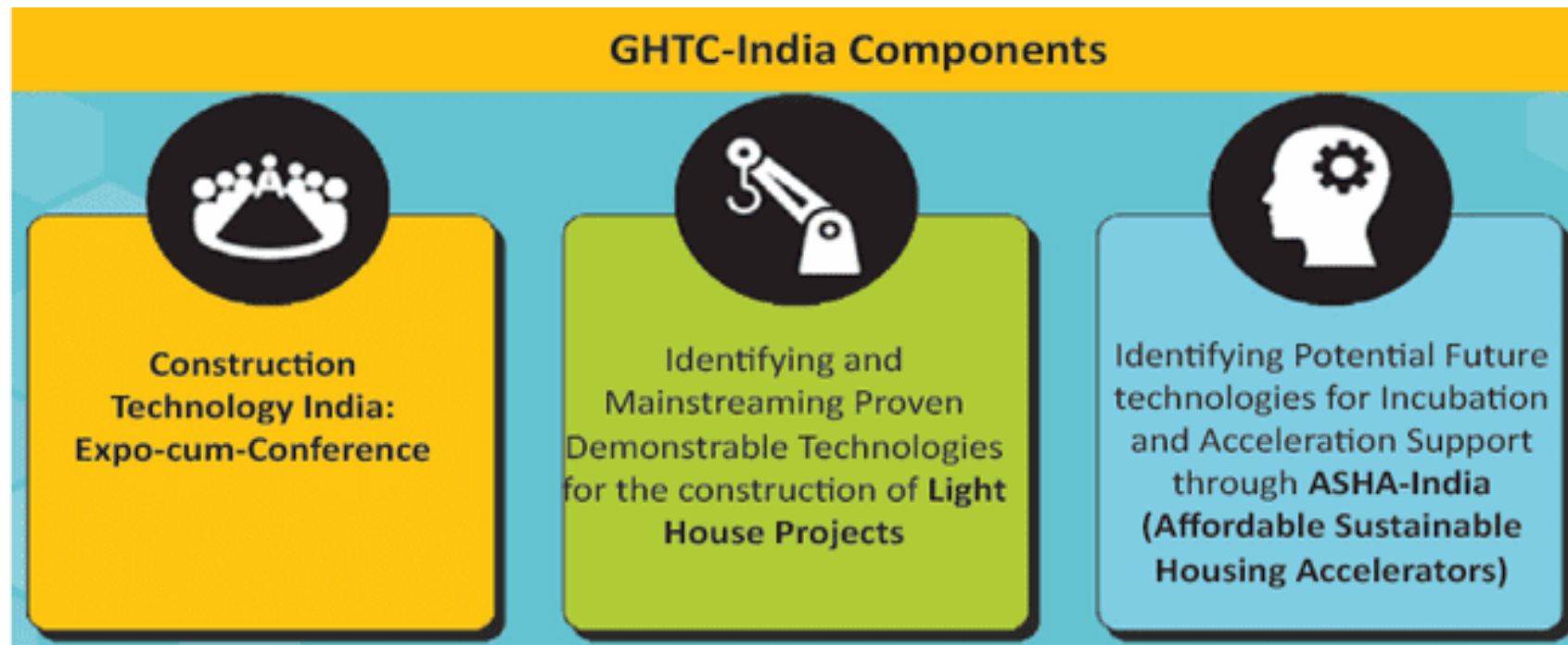
# INTRODUCTION – Ministry of Housing & Urban Affairs (MoHUA)

- **Ministry of Housing and Urban Affairs (MoHUA)** is the supreme authority of the Government of India to formulate and monitor all the programmes concerning the housing and urban affairs of the country.
- MoHUA's flagship mission **Pradhan Mantri Awas Yojana-Urban (PMAY-U)** ensures a pucca house for all eligible urban households by the year 2022.



# INTRODUCTION- Global Housing Technology Challenge (GHTC-INDIA)

- Due to the need for sustainable technological solutions for faster and cost-effective constructions suited to geo-climatic and hazard conditions of the country, **MoHUA** initiated the **Global Housing Technology Challenge (GHTC)-India** to identify and mainstream a basket of innovative housing technologies across the globe.
- 54 proven technologies were shortlisted suiting different climatic zone conditions in the CTI conference in 2019.



## INTRODUCTION – GIZ AND IGEN (INDO GERMAN ENERGY PROGRAM)

- The Government of the Republic of India and the Federal Republic of Germany under the Indo-German Technical Cooperation, agreed to jointly promote the “Indo-German Energy Programme” (**IGEN**) with the aim to foster sustainability in the built environment.
- Deutsche Gesellschaft für Internationale Zusammenarbeit (**GIZ**) GmbH has been working jointly with the Government of India for over 60 years, for sustainable economic, ecological, and social development.
- GIZ is an international cooperation enterprise for sustainable development which operates worldwide, on a public benefit basis.

## INTRODUCTION – CLIMATE SMART BUILDINGS (CSB CELL)

- Ministry of Housing and Urban Affairs (MoHUA) aims to enhance climate resilience and thermal comfort in the affordable housing segment through IGEN's programme, **Climate Smart Buildings (CSB)**.
- It will be achieved by adopting sustainable and low-impact design, materials, and the best available construction technologies.
- The intent is to demonstrate the use of innovative technologies to provide desired thermal comfort for mass replication.

# CSB CELL OBJECTIVES AND ACTIVITIES

- 1. Light House Projects in India**
- 2. Concept of DHPS & AHRCs**
- 3. Integration of Thermal comfort standards into Building Byelaws**

## OBJECTIVES AND ACTIVITIES – CLIMATE SMART BUILDINGS (CSB)- CELL

S.N	Objectives and Activities
1	Enhance climate resilience and thermal comfort in buildings.
2	Technical support in the implementation of Global Housing Technology Challenge (GHTC)-India
3	Provide technical assistance to promote thermal comfort in LHPs.
4	Technical assistance to enhance thermal comfort in upcoming Demonstration Housing Projects (DHPs) and Affordable rental housing complexes (ARHCs).
5	Inclusion of climate resilience and thermal comfort requirements in Building Bye laws in North Cluster.
6	Capacity development of Govt officials and private stakeholders on thermal comfort in the North Cluster.



## AIM FOR THE INCEPTION OF LIGHT HOUSE PROJECTS

- **Light House Projects** have been conceptualized as part of **Global Housing Technology Challenge – India (GHTC-India)**
- Ministry of Housing and Urban Affairs Under **PMAY(U)**, set up a **Technology Sub-Mission (TSM)** to provide:
  - Alternative sustainable technological solutions.
  - Better, Faster & cost-effective construction methodologies.
  - Houses suiting to geo-climatic and hazard conditions of the country.
- Construction of six **LHPs** with allied infrastructure and six categories of globally proven innovative technologies were envisaged in six different states.

## CONCEPT OF LHP PROJECTS

The fundamental concept of the Light-House Projects is to encourage large-scale participation of the people of India for mainstreaming the proven technologies.

- Serve as **live laboratories** for the transfer of technology to the field by, planning, design, production of components, construction practices, and testing.

Live Lab for :

- ✓ *Students,*
- ✓ *Faculties,*
- ✓ *Builder,*
- ✓ *Professionals of Public and Private sectors, and other stakeholders, to create technical awareness for on-site learning.*



## THE LIGHT-HOUSE PROJECTS- INDIA

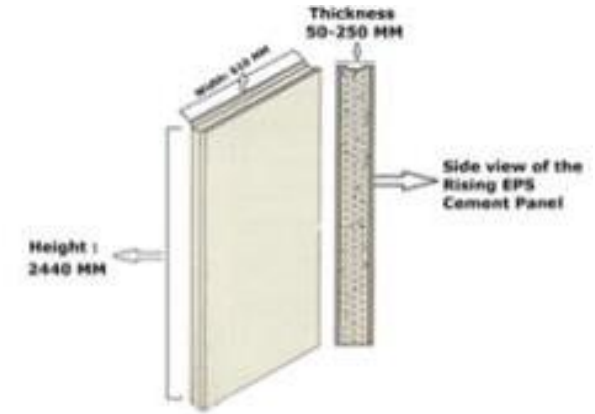
Hon'ble Prime Minister Shri Narendra Modi laid the foundation stone of six Light House Projects (LHPs) each consisting of approx. 1000 houses on January 1, 2021, in six cities :

- **Indore** (Prefab Sandwich panel)
- **Rajkot** (Monolithic concrete construction using tunnel formwork)
- **Chennai** (Precast concrete construction system assembled at the site)
- **Ranchi** (Precast concrete construction system- 3d volumetric)
- **Agartala** (Light gauge steel and PEB)
- **Lucknow** (Stay in place formwork and PEB)

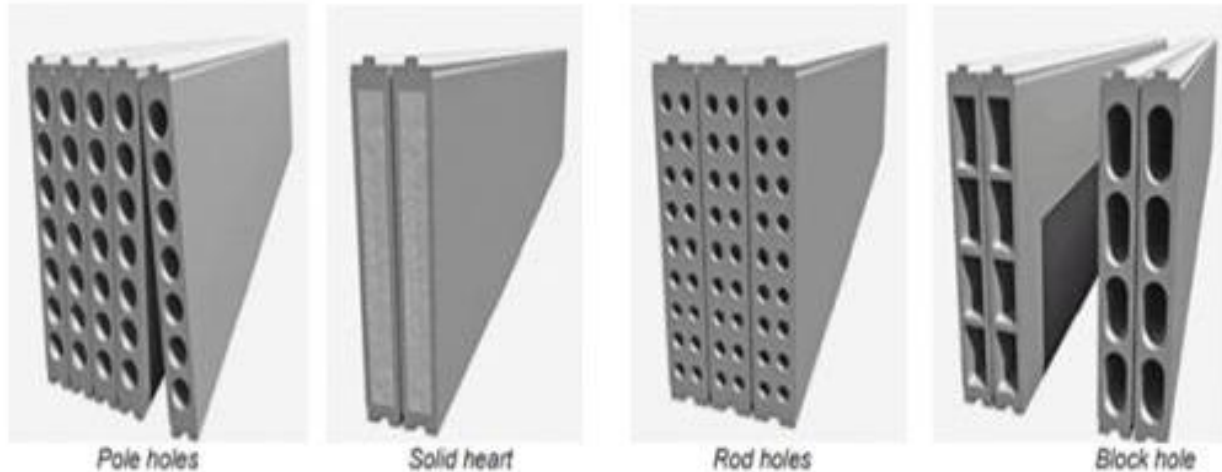


## LHP Indore-Prefabricated Sandwich Panel System

- Lightweight composite wall, floor and roof sandwich panels made of thin fibre cement or calcium silicate board as face covered boards.
- Core material is EPS granule balls, adhesive, cement, sand, fly ash and other bonding materials in mortar form.
- The core material in slurry state is pushed under pressure into pre-set moulds.
- Once set, it shall be moved for curing and ready for use with steel support structure beams and columns.



Prefabricated EPS Sandwich Panel



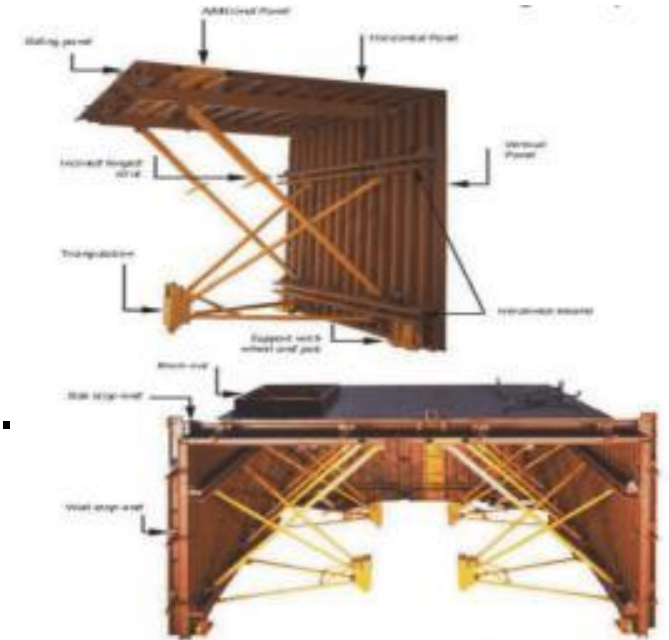
Types of Prefabricated Sandwich Panels



Steel Structure Prefabricated EPS Panel

# LHP Rajkot- Monolithic Concrete Construction using Tunnel Formwork

- Customized engineering formwork replacing conventional steel or plywood shuttering systems.
- Mechanized system for cellular structures.
- Two half shells which are placed together to form a room or cell.
- Walls and slab are cast in a single day.
- The formwork is stripped the next day for subsequent phase.



Tunnel Formwork



Box out of door and windows



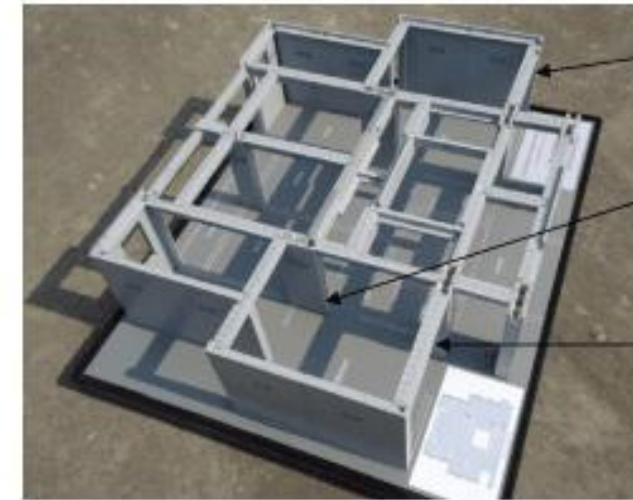
Kicker form of tunnel formwork panel



Monolithic Tunnel Formwork Panel

# LHP Chennai-Precast Concrete Construction System Assembled at Site

- Precast dense reinforced cement concrete hollow core columns and RCC shear walls is being used as structure .
- AAC blocks in partition walls are being used.
- Dowel bars, continuity reinforcement placed at connections.
- Self-compacting concrete is being used in hollow cores of columns.



Precast RCC shear wall.

'3-S' precast RCC column -  
core concreted using self-  
compacting concrete.

'3-S' precast RCC beams - top  
part concreted using self-  
compacting concrete.



Installation of panels



Precast concrete wall (Panels)



Precast rebar lattice girder  
composite slabs, having reinforced  
concrete topping.

## LHP Ranchi- Precast Concrete Construction System – 3D Volumetric

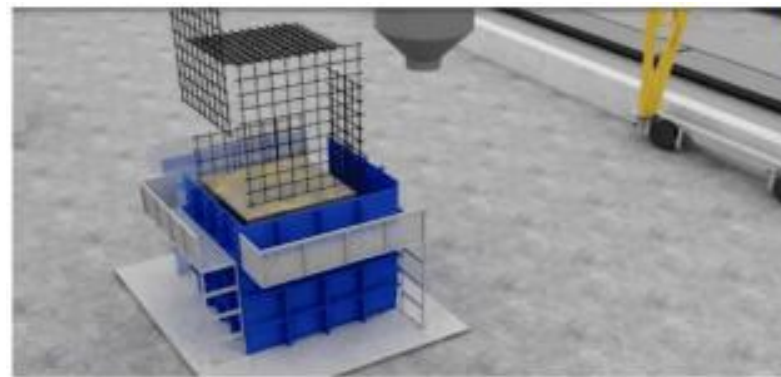
- Components like room, Bathroom, Kitchen etc are cast monolithically in Plant or Casting yard in a controlled condition.
- Magic Pods (Precast Components) are transported, erected & installed using cranes .
- Prestressed slabs are installed as flooring elements.
- Consecutive floors are built in similar manner to complete the structure.



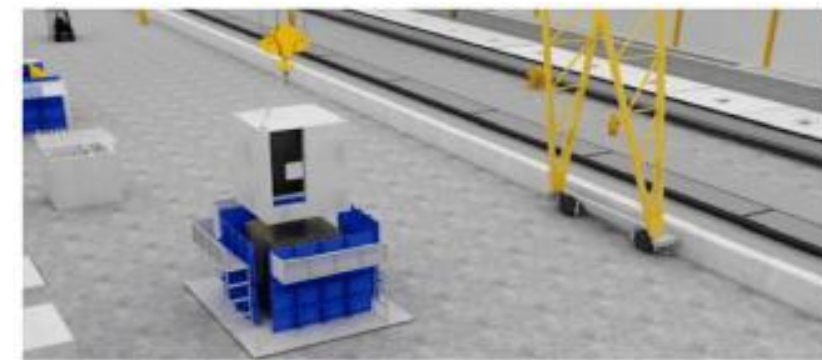
Transportation of Magic Pods



Construction and installation



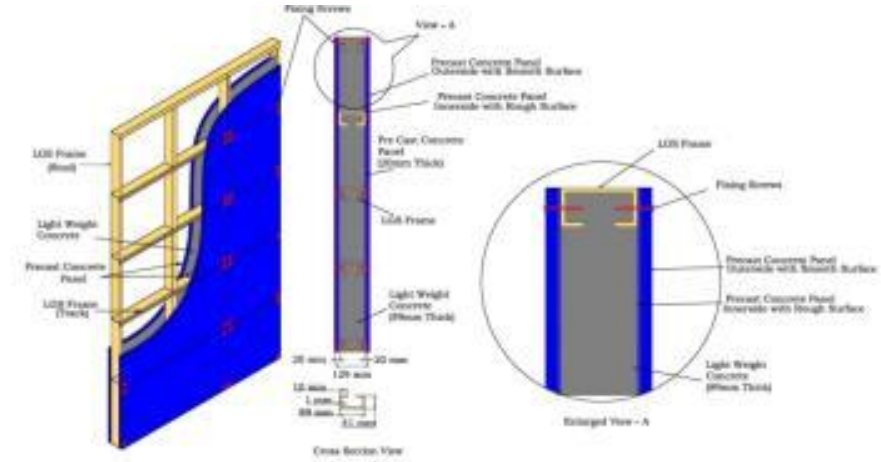
Pre Casting of building modules



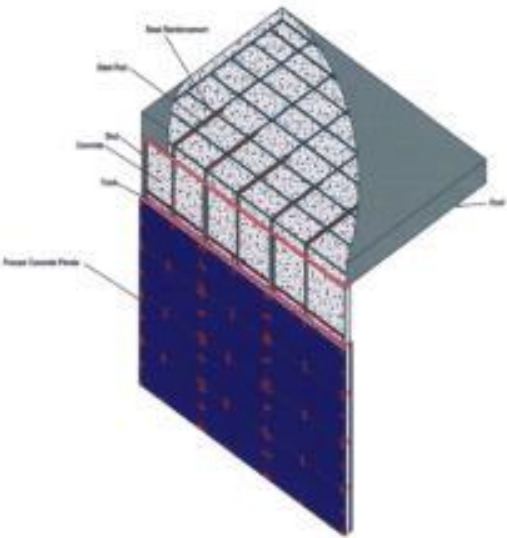
Pre Casting of building modules

# LHP Agartala- Light Gauge Steel Framed Structure with Infill Concrete Panels (LGSFS-ICP)

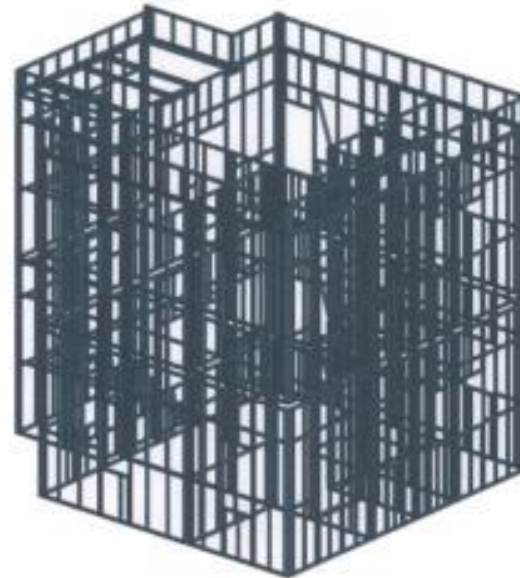
- Light Gauge Steel Framed Structure with Infill Concrete Panels (LGSFS-ICP) Technology.
- Factory made Light Gauge Steel Framed Structure (LGSFS), light weight concrete and precast panels are being used.



Structural Details of LGSFS-Infill Concrete Wall



Precast concrete panels



Light Gauge Steel Frame Structure



Assembly of LGS Frames and Construction of Wall



# LHP LUCKNOW- PROJECT OVERVIEW

Project Brief	
Location of Project	Avadh Vihar, Lucknow, U.P.
No. of DUs	1,040 (S+13)
Plot area	20,036 sq.mt.
Carpet area of each DU	34.51 sq.mt.
Total built up area	48,702 sq.mt.
Technology being used	Stay In Place Formwork System with pre-engineered steel structural system
Other provisions	Community Centre, Shops
Broad Specifications	
Foundation	RCC raft foundation
Structural Frame	Pre-engineered steel structural frame
Walling	Stay In Place PVC Formwork System
Floor Slabs/Roofing	Cast in-situ deck slab

# LHP LUCKNOW-PROJECT PLAN



SITE PLAN



TYPICAL FLOOR PLAN



3D- BIRD EYE VIEW

## LHP Lucknow- Stay in Place Formwork

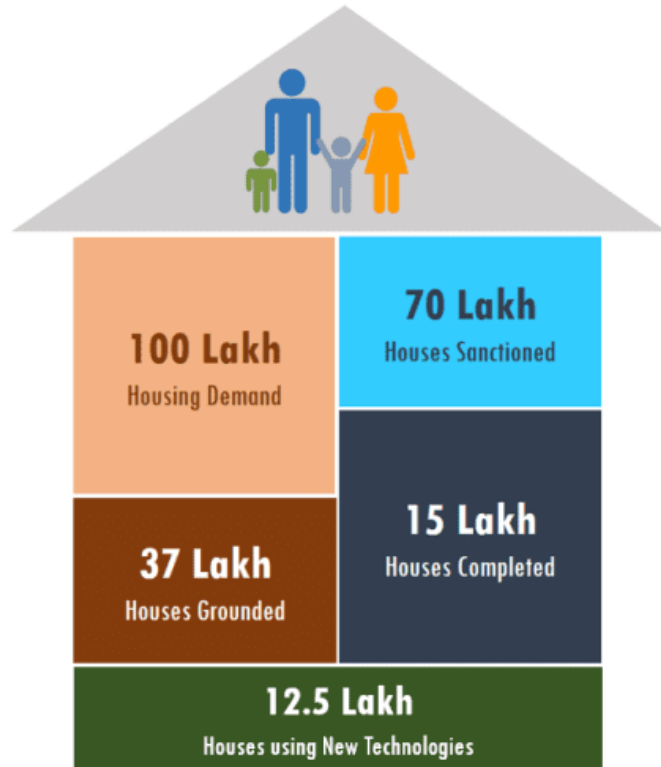
- SIP formwork is an advanced hybrid construction technology consisting of rigid polyvinyl chloride-based polymer panel infilled with self-compacting concrete in a building envelope.
- In this wall system PVC panel is used as a permanent stay-in-place finished formwork instead of concrete walls.
- Hot rolled Pre-Engineered building steel sections act as a structural framework of the building.
- SIP formwork works as a partition of building walls.



# SESSION-1

- 1. Introduction to Affordable Housing**
- 2. Challenges and Future Concerns**
- 3. Need for Thermal Comfort in Affordable Housing**
- 4. Thermal Comfort (*Indices, Thermal comfort in Affordable Housing, Passive Architectural*)**

# INTRODUCTION OF AFFORDABLE HOUSING



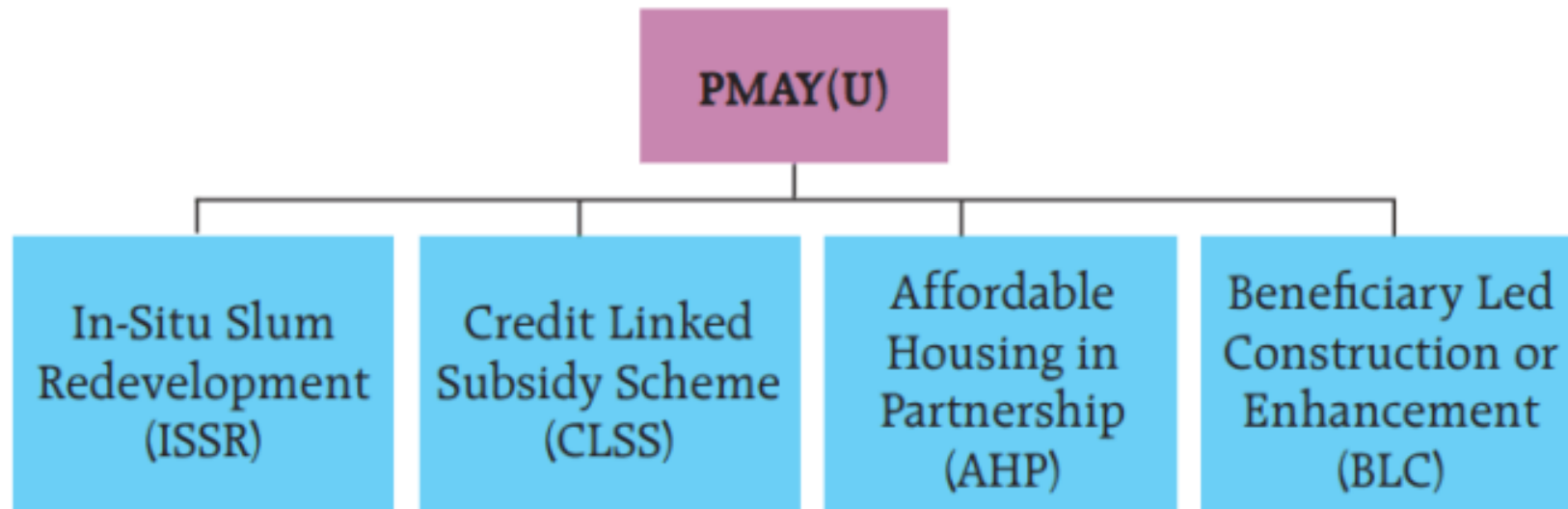
BLC*	39 Lakh
AHP*	23 Lakh
ISSR*	4.5 Lakh
CLSS*	3.5 Lakh

- **Affordable housing** refers to housing units that are affordable by that section of society whose income is below the median household income.
- **Rapid increase in urbanization** and believing it as an opportunity to reduce poverty.
- For addressing the huge housing demand in the Affordable Sector, Govt. of India launched **Pradhan Mantri Awas Yojana-Urban** in June 2015.
- Nearly 10 Million affordable houses are to be delivered by 2022.

\* Beneficiary Led Construction. Affordable Housing in Partnership. In-Situ Slum Redevelopment. Credit Linked Subsidy Scheme

## PMAY- AFFORDABLE HOUSING SCHEME

The *Pradhan Mantri Awas Yojana (PMAY)* launched in 2015 provides a fresh impetus – the PMAY-Urban (PMAY-U) subsumes all the previous urban housing schemes and aims at ‘Housing for All’ to be achieved by the year 2022. The total housing shortage envisaged to be addressed through the PMAY-U is 20 million. The mission has four components:



- **In-Situ Slum Redevelopment(ISSR).**
- **Credit Linked Subsidy Scheme(CLSS).**
- **Affordable Housing in Partnership(AHP).**
- **Beneficiary Led Construction(BLC).**

## CHALLENGES AND CONCERN

While the efforts of the Government has boosted affordable housing which has generated positive outcome. There are various factors affecting the pace of affordable housing development in India:

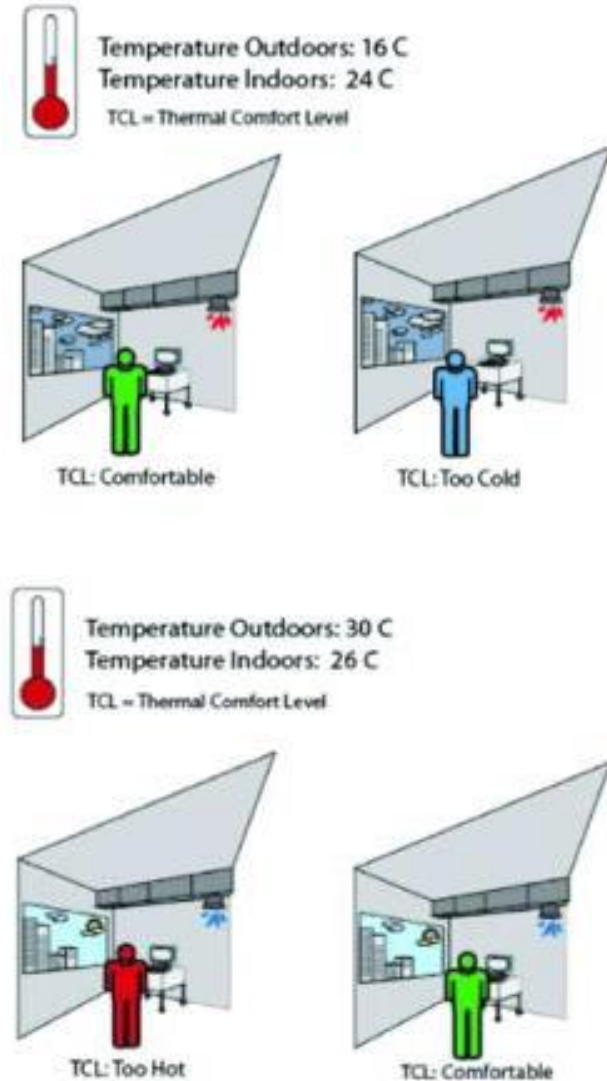
- ***Lack of suitable low-cost land within the city limits.***
- ***Lengthy statutory clearance and approval process.***
- ***Shortcomings in development norms, planning, and project design.***
- ***Lack of participation of large organized real estate players due to low-profit margins.***
- ***The high cost of funds for construction finance makes the projects unviable.***

# NEED FOR THERMAL COMFORT IN AFFORDABLE HOUSING

*A lack of thermal comfort makes us feel stressed, annoyed and distracted if it is too cold and it can make us feel sleepy, tired, and lacking concentration if it is too hot.*

**The need for thermal comfort is as follows:**

- Thermal Comfort Increases Productivity and Performance.
- Provides insulation from harsh outside weather conditions.
- Provide better radiant and ambient temperature within the envelope of the building.
- Reduces high energy demands and conserve extra energy for future use.
- Promote sustainability to the design and surrounding environment.





## WHAT IS THERMAL COMFORT?

**Thermal comfort is “the state of mind that expresses satisfaction within the thermal environment” and generally assessed subjectively (ASHRAE, 2004).**

Human thermal comfort cannot be expressed in degrees and can't be defined by an average range of temperatures.

It is a very personal experience and a function of many criteria, which differs from person to person in the same environmental space.



THERMAL COMFORT IS THE OUTCOME OF A WELL-BALANCED COMBINATION OF BUILDING SYSTEMS ADAPTED TO THE LOCAL CLIMATE & THE TYPE OF ACTIVITY PERFORMED.

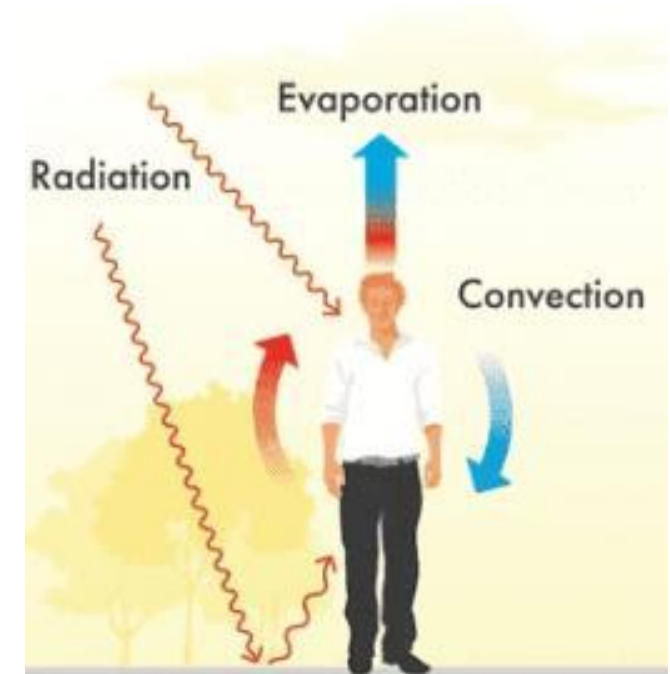
# TRANSFER OF HEAT IN BUILDING ENVELOPE

## Mode of Transfer of Heat

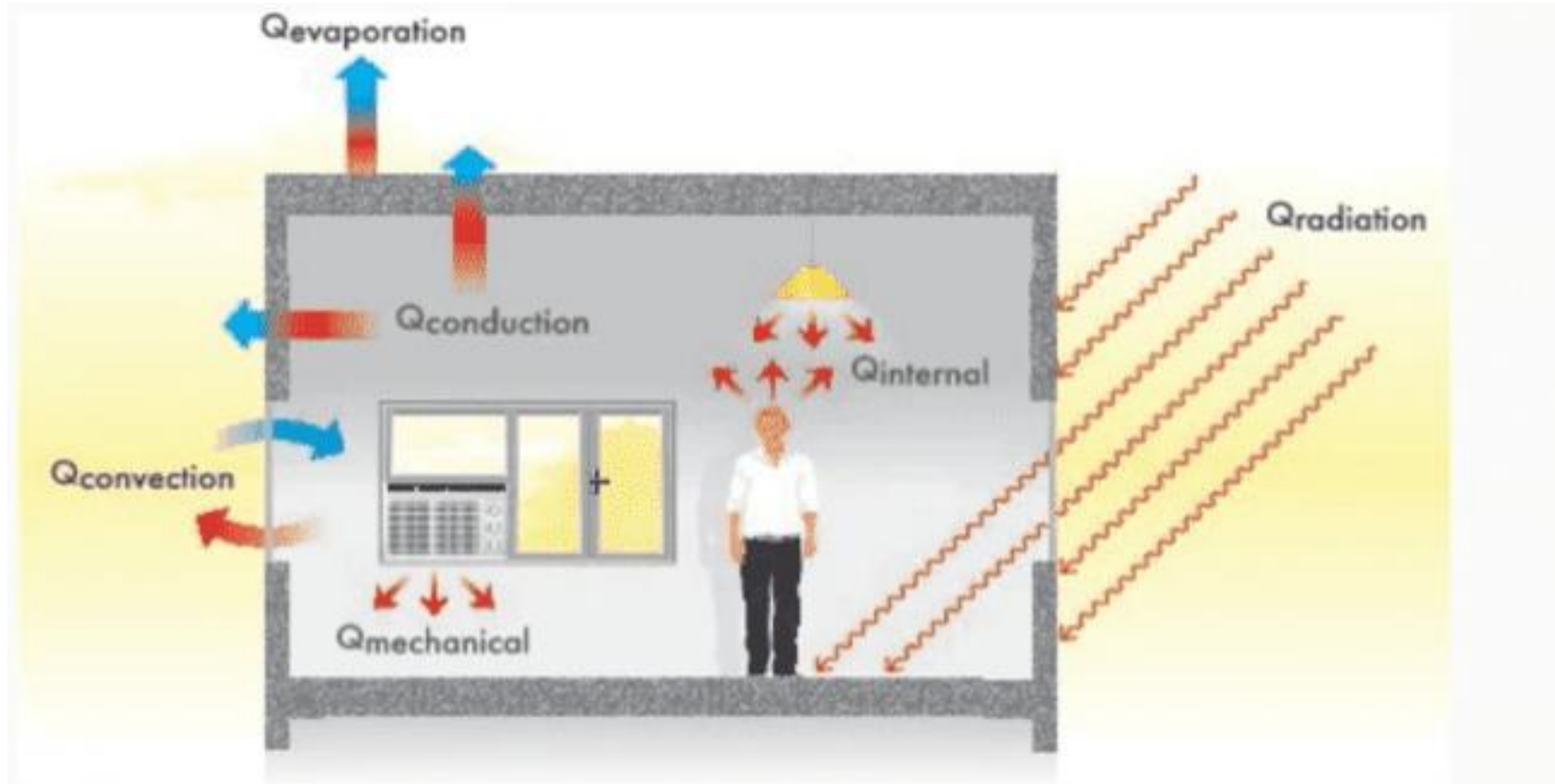
What affects the **Thermal indoor environment**?

- The heat exchange between the human body and its environment occurs mainly in three ways
  - Conduction
  - Convection
  - Radiation

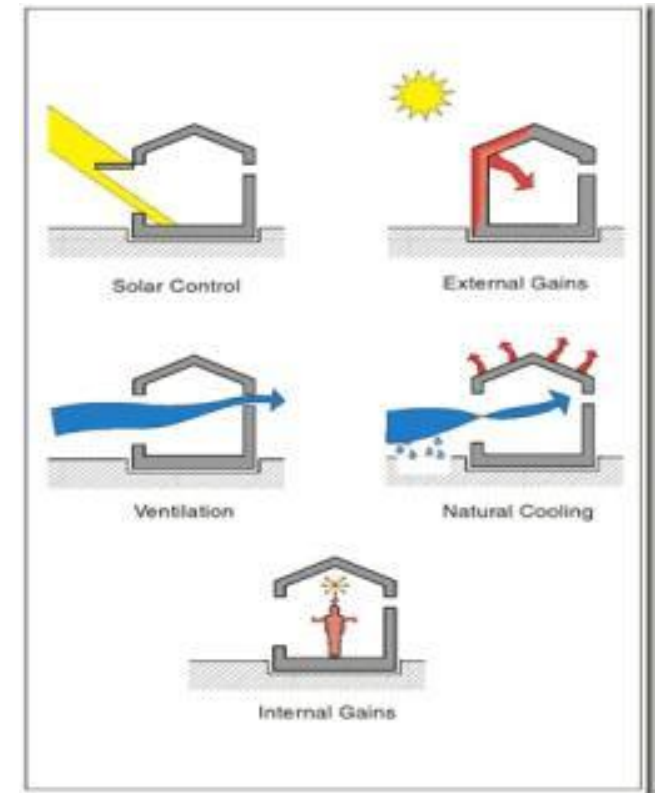
Thermal indoor environment is affected by both internal and external sources.



# HUMAN BODY PERCEPTION TOWARDS THERMAL COMFORT



*Thermal comfort refers to the perceived feeling on the human body as the result of the effect of heat and cold sources in the environment.*



**Heat Mechanism And Human Body Perception Towards Thermal Comfort**

# METABOLIC RATE FOR HUMAN ACTIVITY AND OCCUPANCY

**Table 3.1**  
Metabolic Rate  $M$  for Various Activities

$$1 \text{ M} = 1 \text{ met} = 58.2 \text{ W/m}^2 = 18.4 \text{ Btu/h.ft}^2$$

Activity	met	W/m <sup>2</sup>	Btu/(h • ft <sup>2</sup> )
Sleeping	0.7	40	13
Reclining	0.8	45	15
Seated, quiet	1.0	60	18
Standing, relaxed	1.2	70	22
Walking (0.9 m/s, 3.2 km/hr, 2.0 mph)	2.0	115	37
Walking (1.8 m/s, 6.8 km/h, 4.2 mph)	3.8	220	70
Office- reading, seated	1.0	55	18
Office, walking about	1.7	100	31
House cleaning	2.0-3.4	115-200	37-63
Pick and shovel work	4.0-4.8	235-280	74-88
Dancing, social	2.4-4.4	140-255	44-81
Heavy machine work	4.0	235	74

Source: Courtesy of ASHRAE, **Standard 55-2013**: *Thermal Environmental Conditions for Human Occupancy*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA, 2010. With permission.

- **Thermal comfort is maintained by heat mass transfer.**
- **Human body generates heat about 100w under sedentary conditions with a body area of 1.5 to 2 sqm.**
- **More layers of clothing = more insulation = less heat loss**

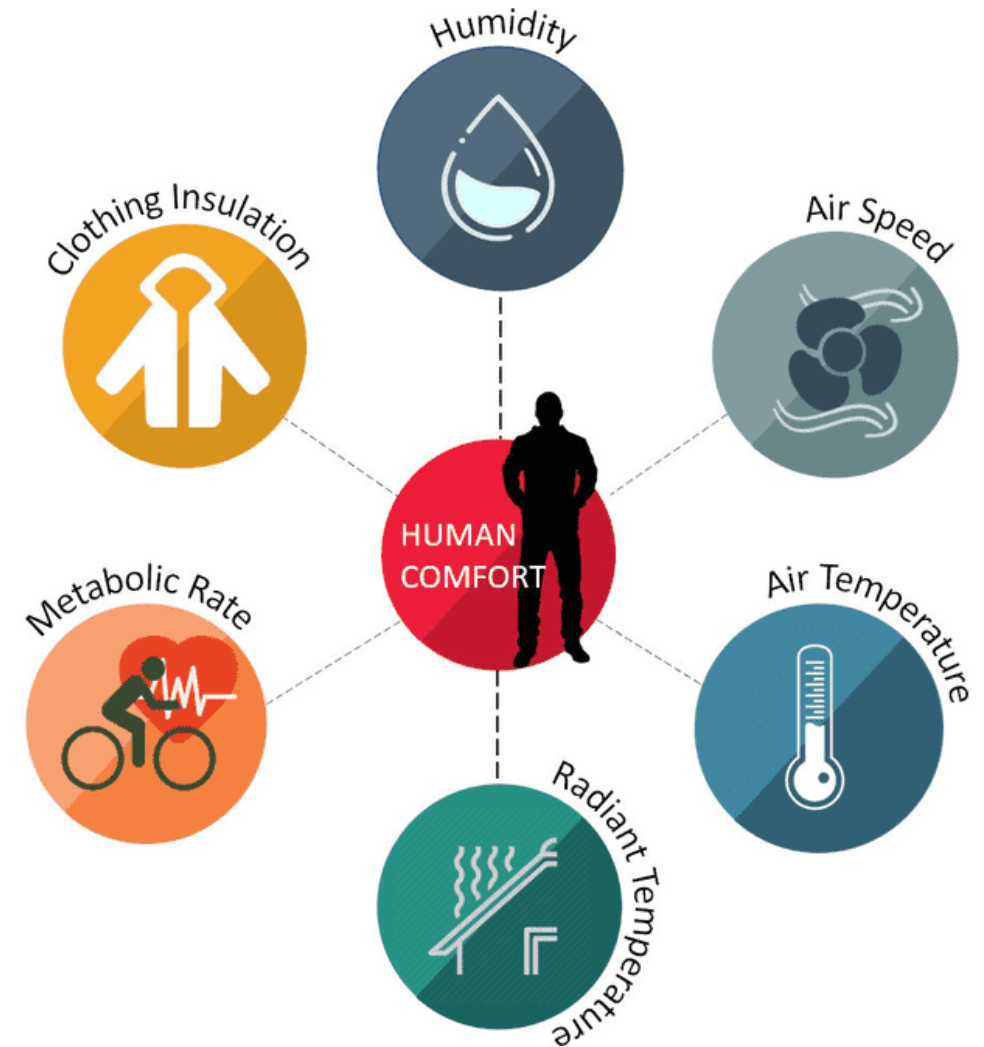
# FACTORS AND INDICES AFFECTING THERMAL COMFORT

## Environmental Parameters/Factors

- Air Temperature
- Mean Radiant Temperature
- Air Velocity
- Humidity

## Personal Parameters/Factors

- Clothing Level
- Physical Activity



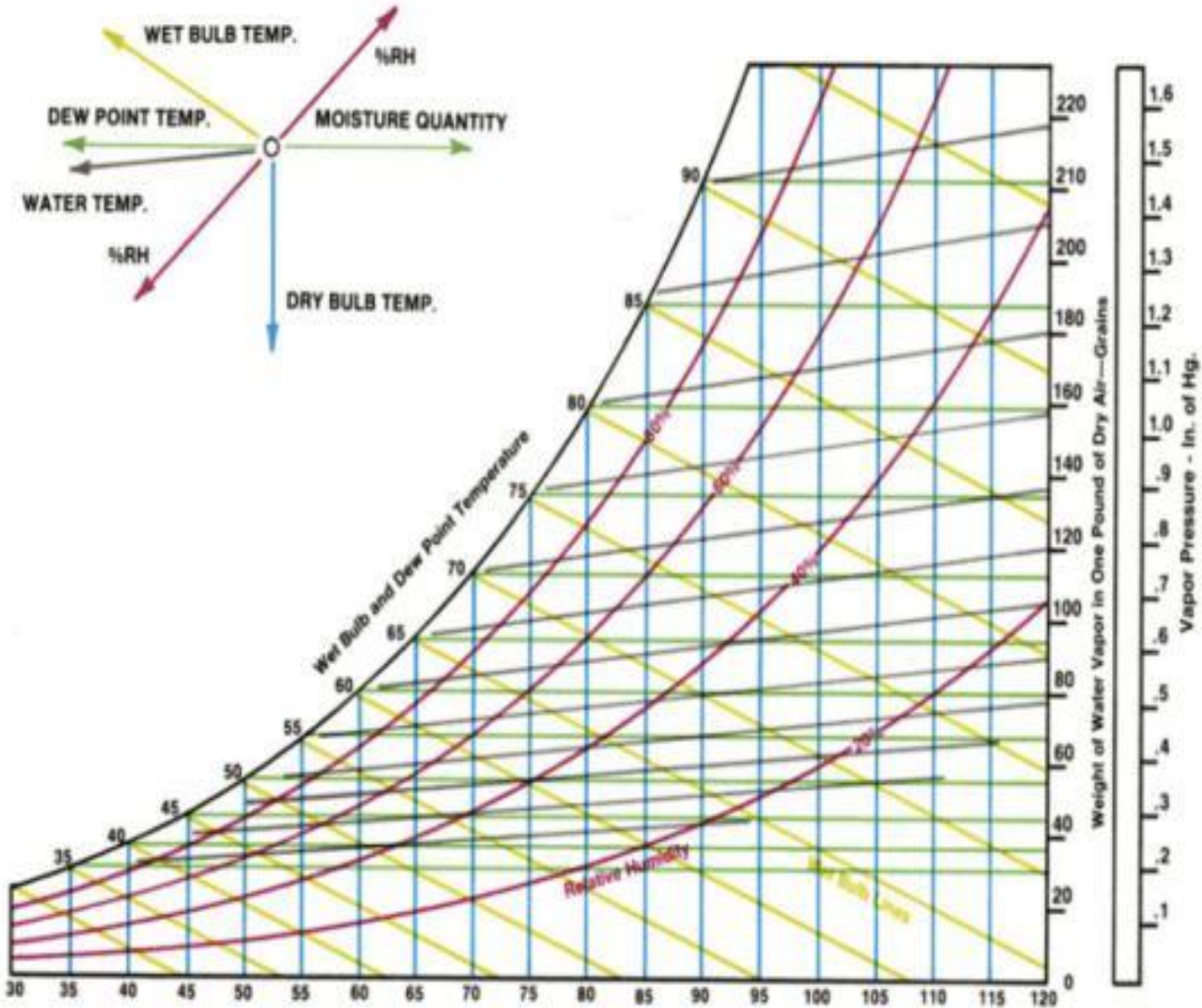
# FACTORS AND INDICES AFFECTING THERMAL COMFORT

<b>Air Temperature</b>	It can easily be influenced with passive and mechanical heating and cooling.
<b>Mean Radiant Temperature</b>	It allows defining the operative temperature which is the most essential component of thermal comfort.
<b>Air Velocity</b>	Quantifies the speed and direction of the air movements in the room. Rapid air velocity fluctuations might result in draught complaints.
<b>Humidity</b>	The moisture content of the air. Too high or too low humidity levels may induce discomfort.
<b>Clothing Level</b>	The amount of insulation added to the human body. Higher clothing levels will reduce the heat lost through the skin and lower the environment's temperature perceived as comfortable.
<b>Physical Activity</b>	The amount of heat produced by the human body and therefore also in the perception of a hot or cold environment.

# FACTORS AND INDICES AFFECTING THERMAL COMFORT

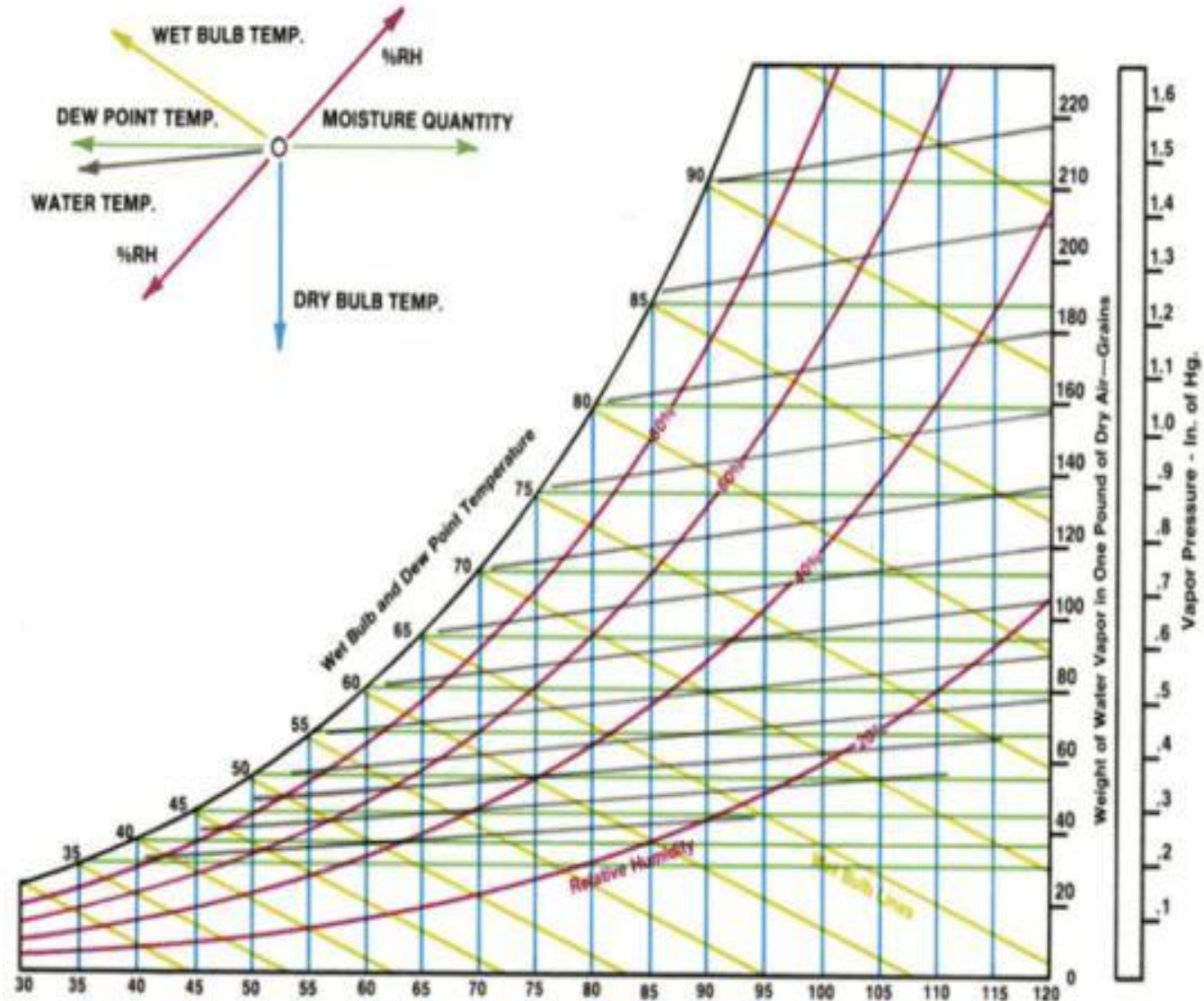
## Direct Parameters For Measuring Thermal Comfort

- 1. Dry Bulb Temperature:** Single most important index, especially influential when Relative Humidity is in the range of 40 to 60%.
- 2. Moisture:** Three measures.
  - **Dew point temperature:** The temperature below which the water vapor in a volume of air at constant pressure will condense into liquid water. It is the temperature at which the air is saturated with moisture.



# FACTORS AND INDICES AFFECTING THERMAL COMFORT

- Wet bulb temperature:** The wet-bulb temperature is the lowest temperature that can be reached under current ambient conditions by the evaporation of water only. use full for describing thermal comfort in the region of high temperature.





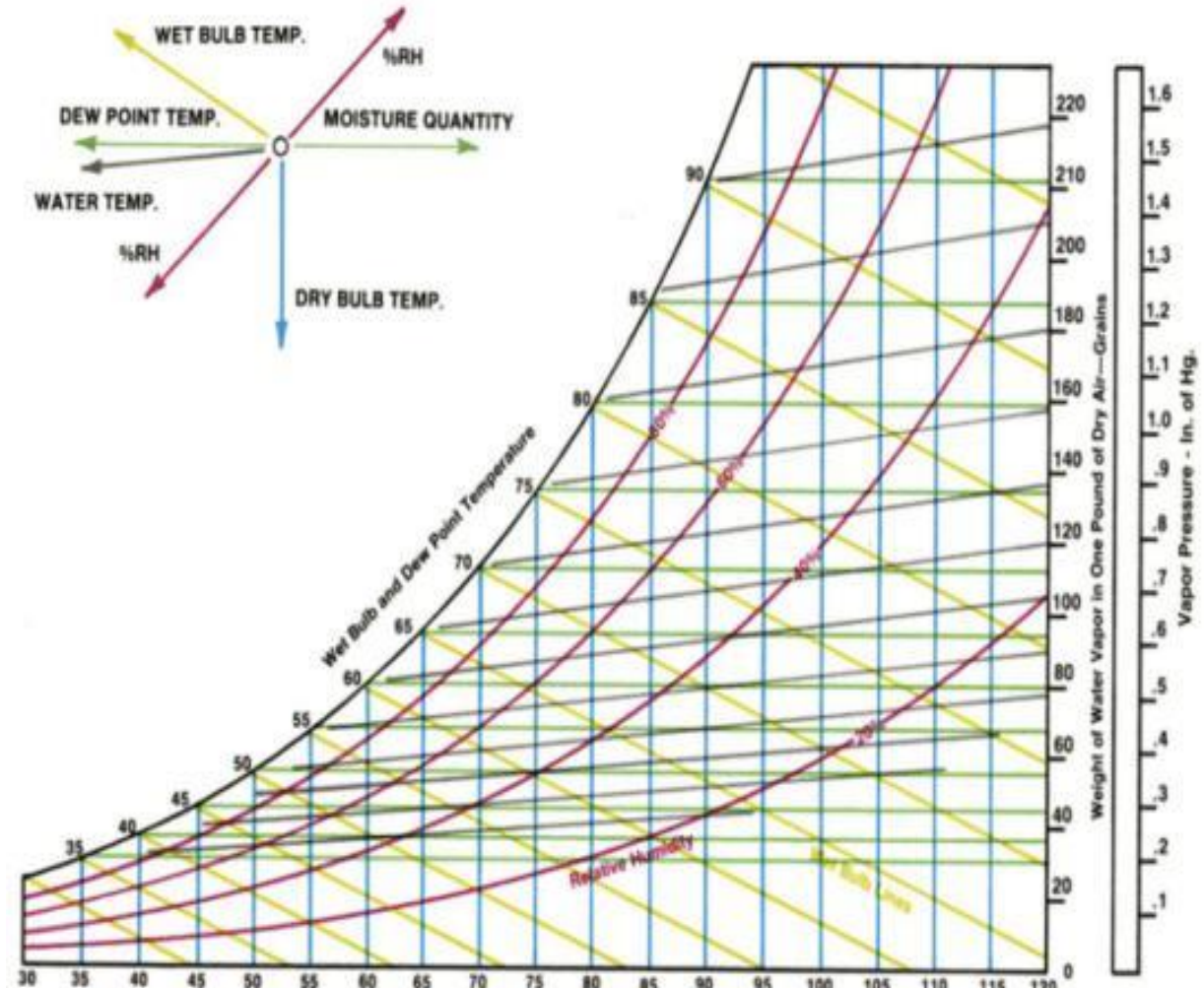
# FACTORS AND INDICES AFFECTING THERMAL COMFORT

- **Relative humidity:** Relative Humidity (RH) is a measure of the water vapor content of air.

“It is the amount of water vapor present in air expressed as a percentage (%RH) of the amount needed to achieve saturation at the same temperature”.

Very low and very high values are associated with thermal comfort.

3. **Air movement:** Most difficult of direct indices to describe, it affects only convective heat exchanges from body and surroundings within envelope.



# FACTORS AND INDICES AFFECTING THERMAL COMFORT

## Derived Parameters For Measuring Thermal Comfort

- **Mean Radiant temperature:** The mean radiant temperature ( $^{\circ}\text{C}$ ) is a numerical representation of how human beings experience radiation.
- **Operative temperature:** Operative temperature is defined as a uniform temperature of a radiantly black enclosure in which an occupant would exchange the same amount of heat by radiation plus convection as in the actual non-uniform environment. Numerically it is close to the average of indoor dry bulbs and MRT.
- **Effective temperature:** Combination of 50% relative humidity with the operative temperature that causes the same sensible plus latent heat exchanges as in the actual environment. It is an experimentally determined index of the various combinations of dry-bulb temperature, humidity, radiant conditions (MRT), and air movement.

## FACTORS AND INDICES AFFECTING THERMAL COMFORT

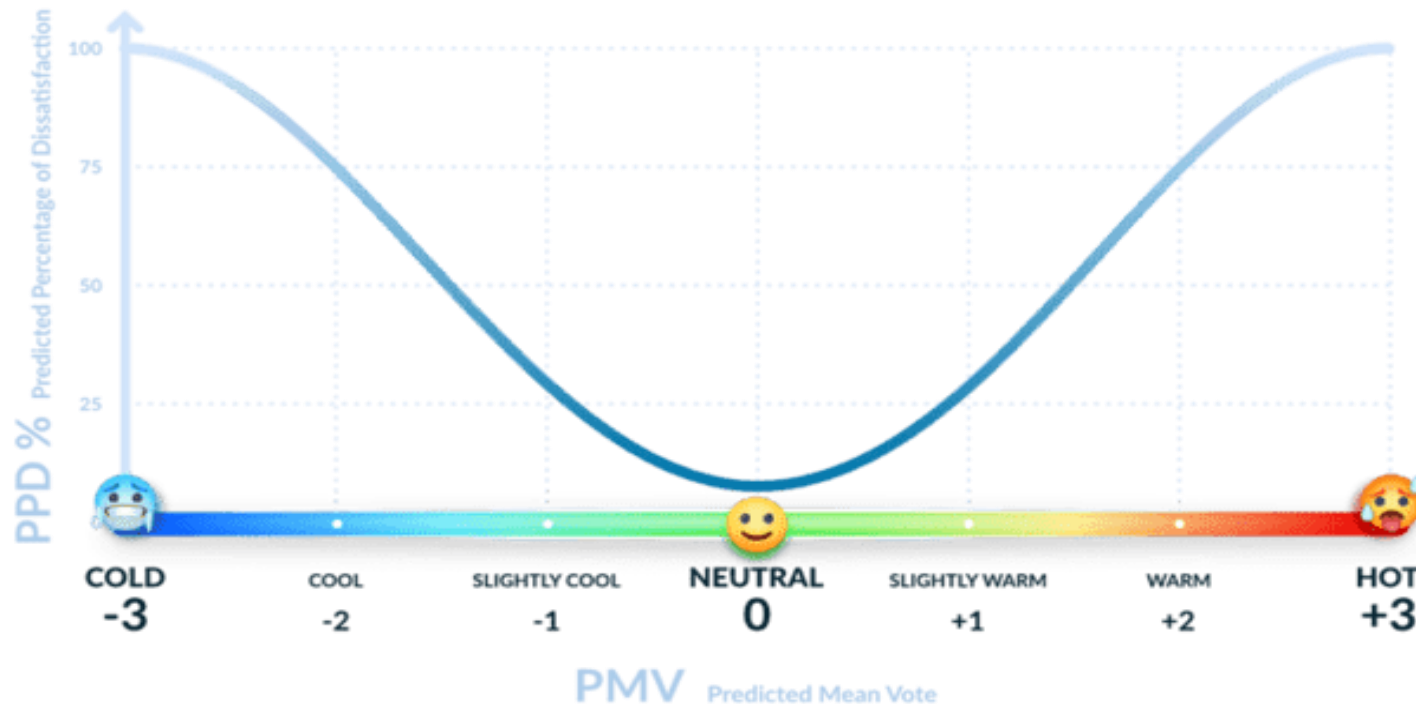
Thermal comfort limits can be expressed by the Predicted mean vote (**PMV**) and the Percentage People Dissatisfied (**PPD**) indices on the basis of the above direct and derived parameters.

**PMV** is an index that aims to predict the mean value of votes of a group of occupants on a seven-point thermal sensation scale. The thermal sensation is generally perceived as better when occupants of space have control over indoor temperature (i.e., natural ventilation through an opening or closing windows).



## FACTORS AND INDICES AFFECTING THERMAL COMFORT

**(PPD)** Predicted percentage dissatisfied essentially gives the percentage of people predicted to experience local discomfort. The main factors causing local discomfort are unwanted cooling or heating of an occupant's body.



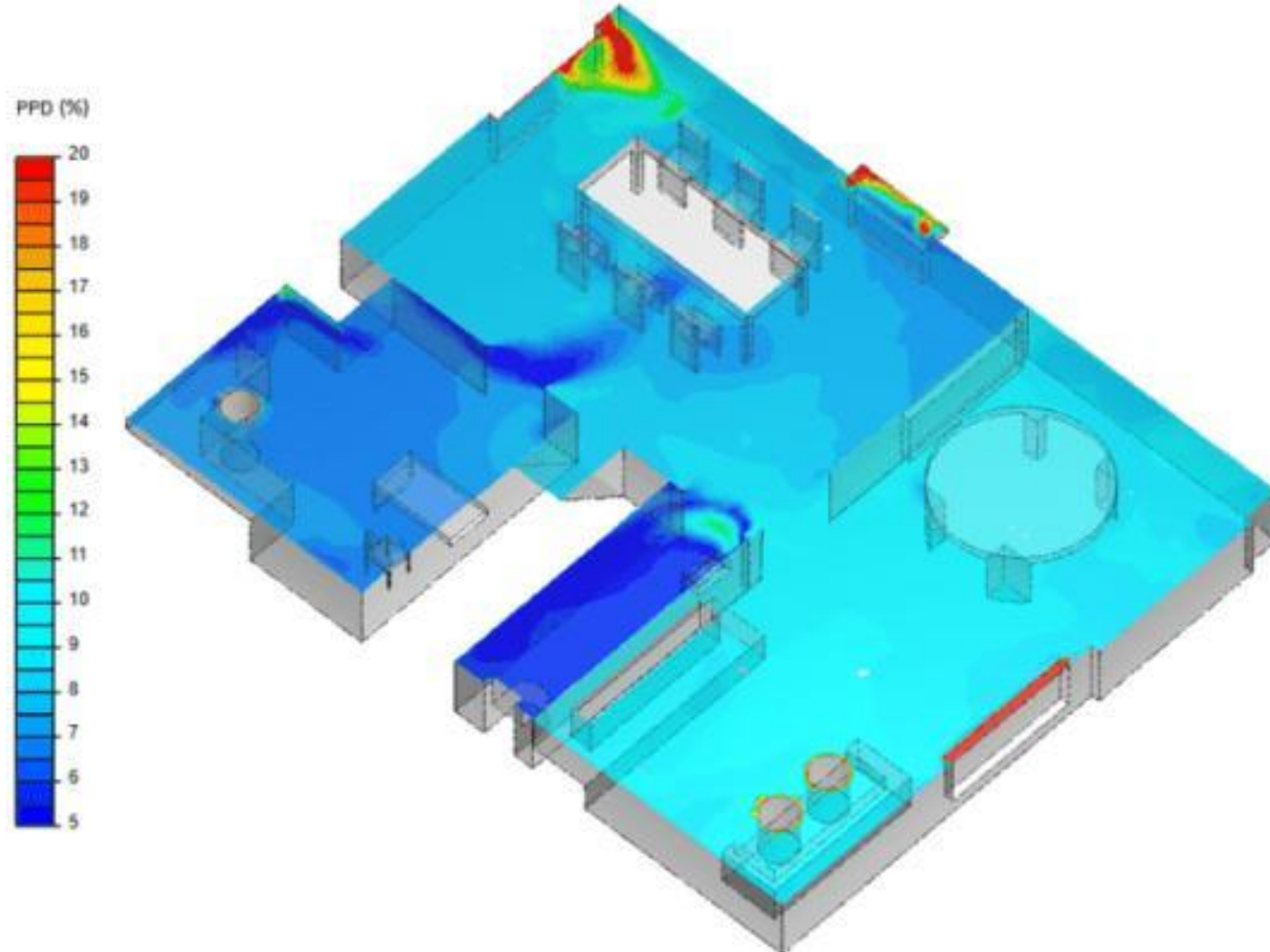
# FACTORS AND INDICES AFFECTING THERMAL COMFORT

## Acceptable PMV and PPD Ranges

Using both of these indices, ASHRAE 55 dictates that thermal comfort can be achieved based on 80% occupant satisfaction rate or more.

- In order to comply with ASHRAE 55, the recommended thermal limit on the 7-point scale of PMV is between -0.5 and 0.5.
- The PPD can range from 5% to 100%, depending on the calculated PMV. In order for comfort ranges to comply with standards, no occupied point in space should be above 20% PPD.

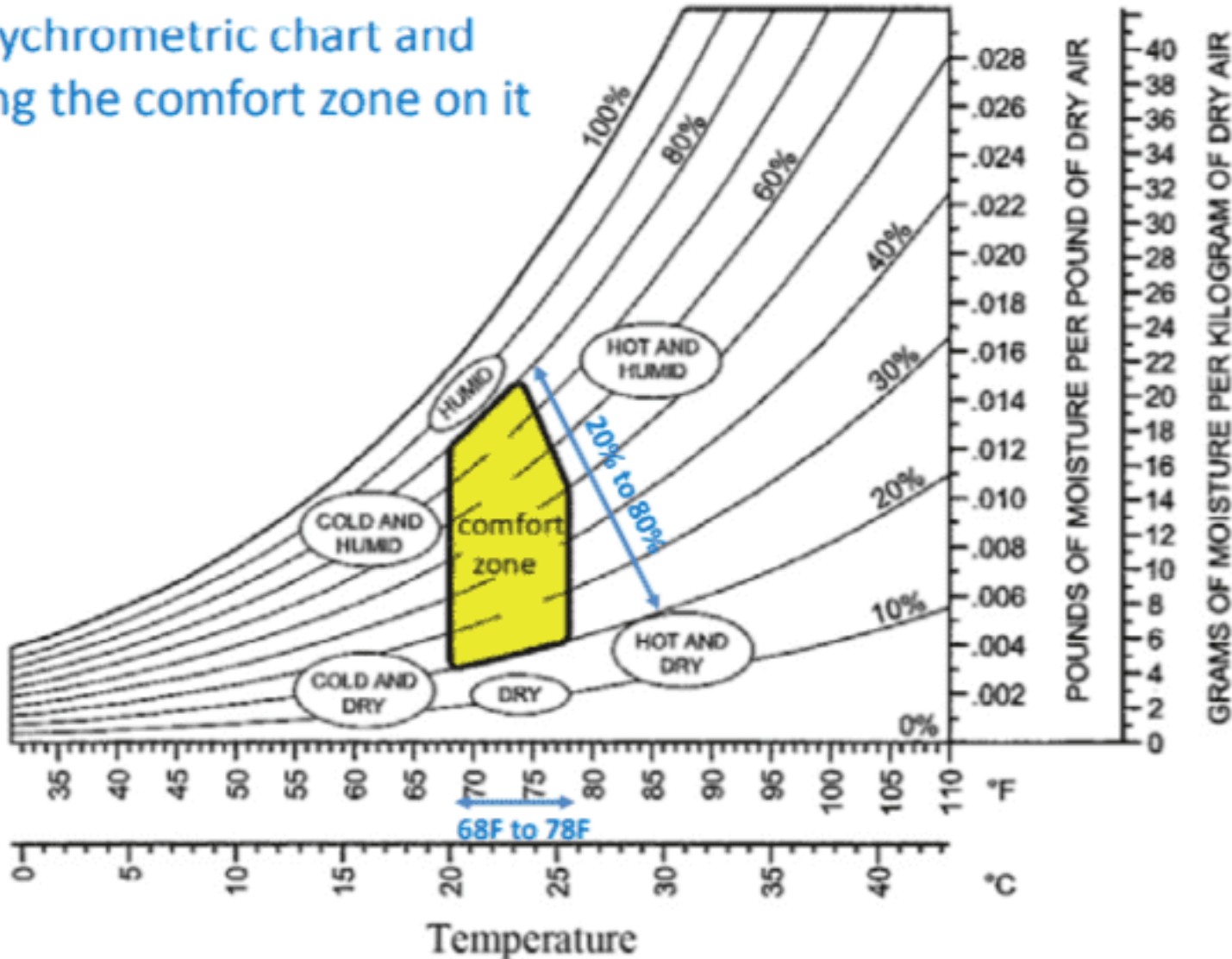
# FACTORS AND INDICES AFFECTING THERMAL COMFORT



- The predicted percentage of **dissatisfied (PPD)** index provides an estimate of how many occupants in space would feel dissatisfied by the thermal conditions.
- All occupied areas in a space should be kept below **20% PPD** in order to ensure thermal comfort according to the known standards (ASHRAE 55)

# USE OF PSYCHROMETRIC CHART FOR THERMAL COMFORT

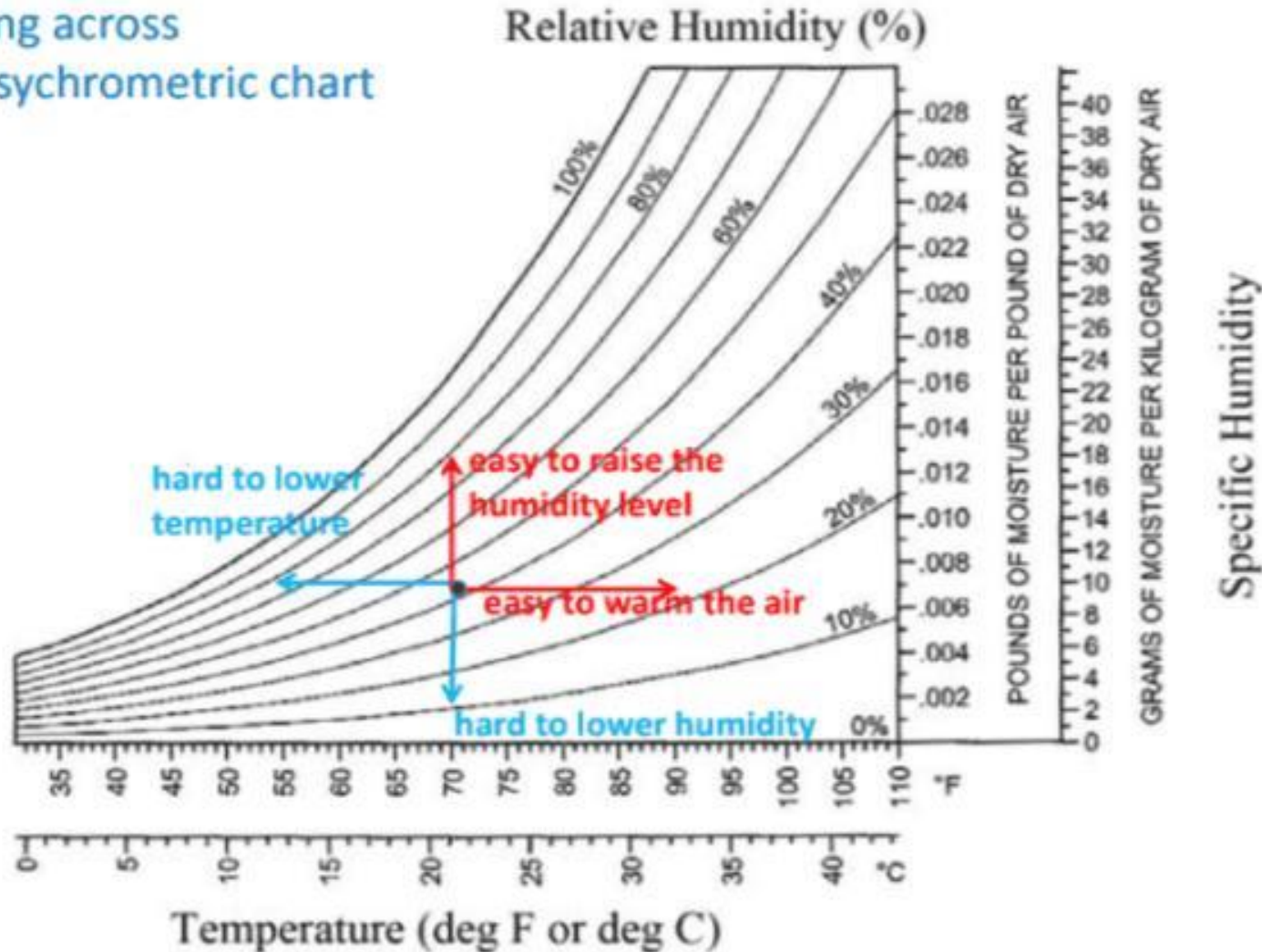
The psychrometric chart and Defining the comfort zone on it



- The Comfort Zone And Various Types Of Discomfort Outside The Zone As Shown In This Psychrometric Chart.

# USE OF PSYCHROMETRIC CHART FOR THERMAL COMFORT

Moving across  
the psychrometric chart

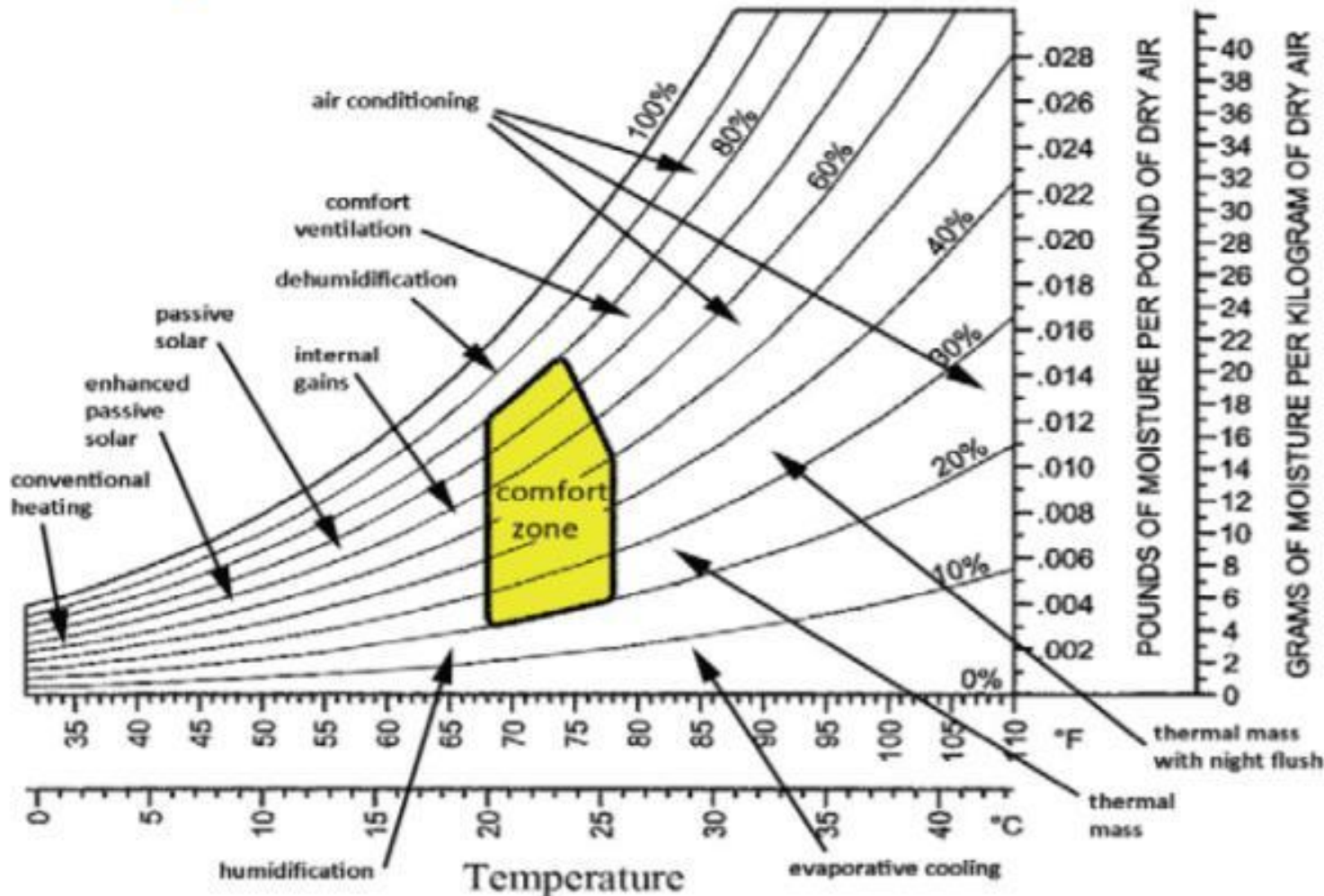


- How To Change The Humidity, Temperature While Moving To The Chart.



# USE OF PSYCHROMETRIC CHART FOR THERMAL COMFORT

Various methods and technologies  
to bring indoor air conditions into the comfort zone

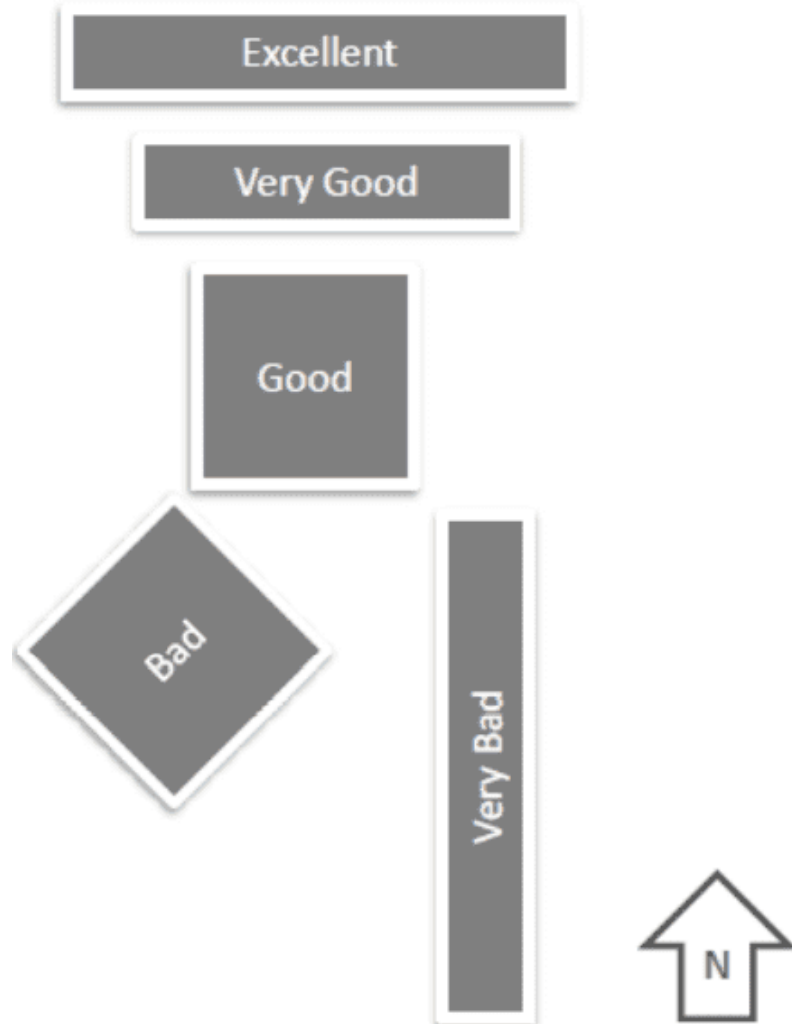


Incorporate To Achieve Thermal

Comfort Within Building:

- Comfort Ventilation.
- Internal And External Gains.
- Thermal Mass With Night Flush.
- Enhanced Passive Solar Technology.
- Conventional And Low Energy Heating And Cooling.

# PASSIVE STRATEGIES FOR THERMAL COMFORT IN AFFORDABLE HOUSING

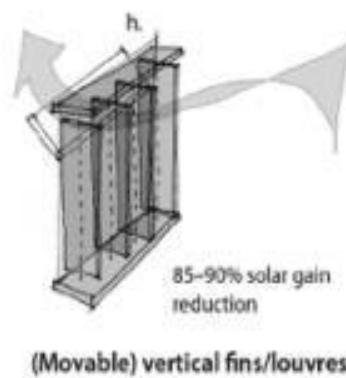
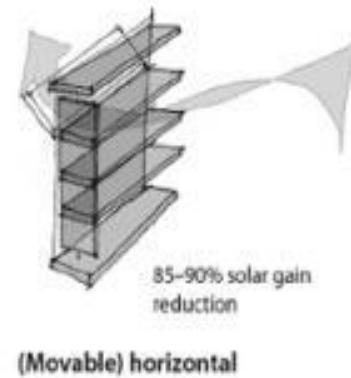
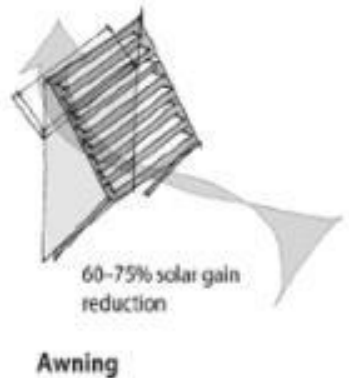
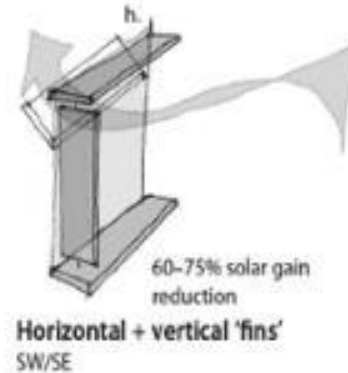
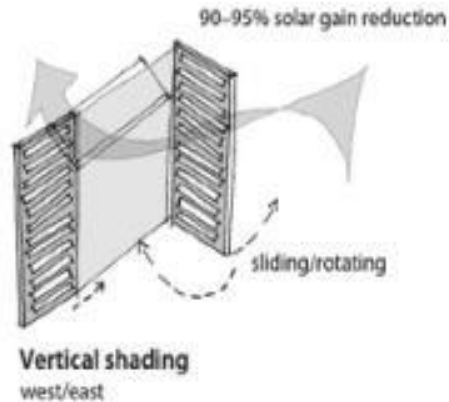
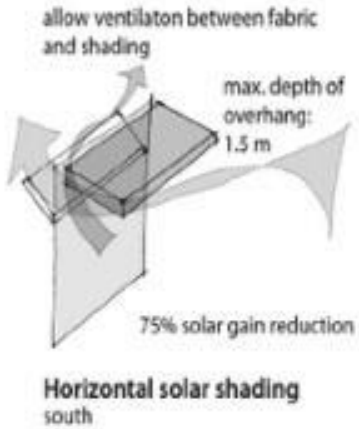


## Appropriate orientation of the building

- Daylight penetration and fenestration design have implications on heat gain/loss through the building envelope.
- Careful orientation of fenestration can help achieve thermal and visual comfort
- Daylight harvesting from the north and south facade should be maximized with proper orientation of the building.

# PASSIVE STRATEGIES FOR THERMAL COMFORT IN AFFORDABLE HOUSING

## Most effective shading



Bottom three shading devices are suitable for all orientations if movable shading fins. They are effective solar shading, but reduce daylighting and winter solar gain so use with care.

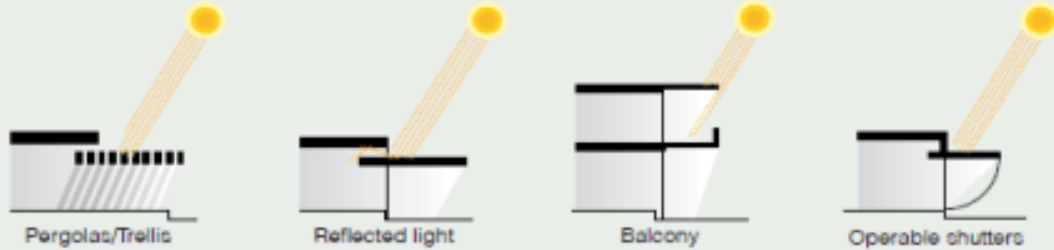
Design sliding/inward-opening windows, which do not impede natural ventilation. Design top inward-opening 'hopper' windows for night cooling (h.).

## Shading Devices

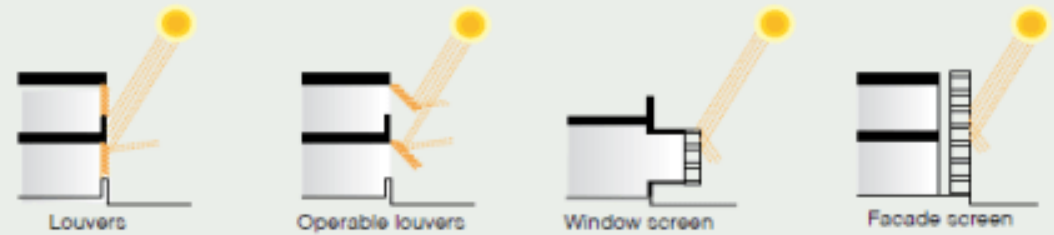
- Reduce heat gain and cooling energy use of the building.
- To prevent summer overheating and glare, a good shading device strategy should be used with glazed openings.
- Well designed sun shading devices will help keep the building cool and comfortable

# PASSIVE STRATEGIES FOR THERMAL COMFORT IN AFFORDABLE HOUSING

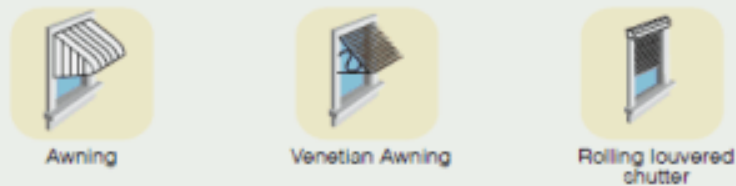
## EXTERIOR SHADING DEVICES



DIFFERENT TYPES OF OVER HANGINGS



DIFFERENT TYPES OF SCREENS



DIFFERENT TYPES OF WINDOW SHADINGS

- Awnings provide flexibility to span without need of extra support.
- Properly installed awnings can reduce heat gain by 66% from south and 77% from east.
- Adjustable louvers can control the sunlight entering into the building.
- Least cost solution for cutting heat gain into the building.

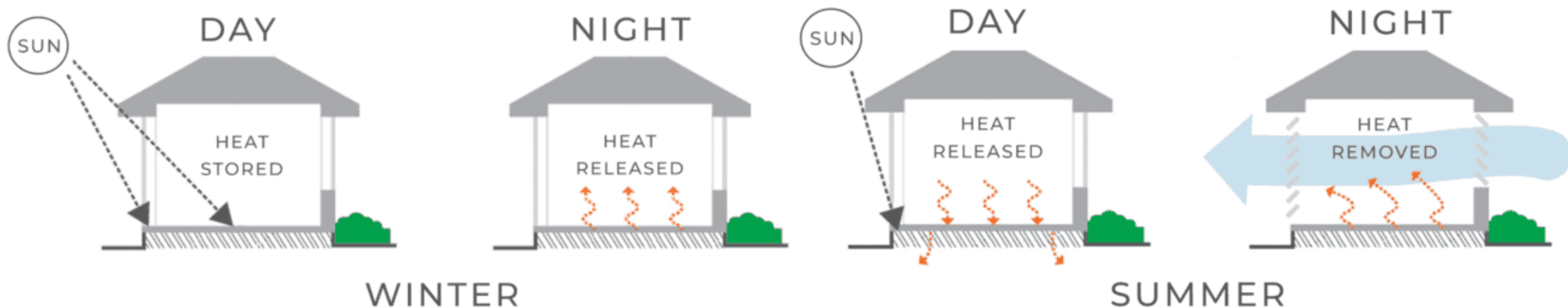
- Exterior shading devices can be provided in a variety of materials and designs, sunshades, awnings, louvers, bamboo screens, jaali, and green cover through vines.
- These can be implemented with minimal cost implications and have the most favorable cost-benefit relation with respect to thermal comfort.

# PASSIVE STRATEGIES FOR THERMAL COMFORT IN AFFORDABLE HOUSING

'**Thermal mass**' describes a material's capacity to absorb, store and release heat.

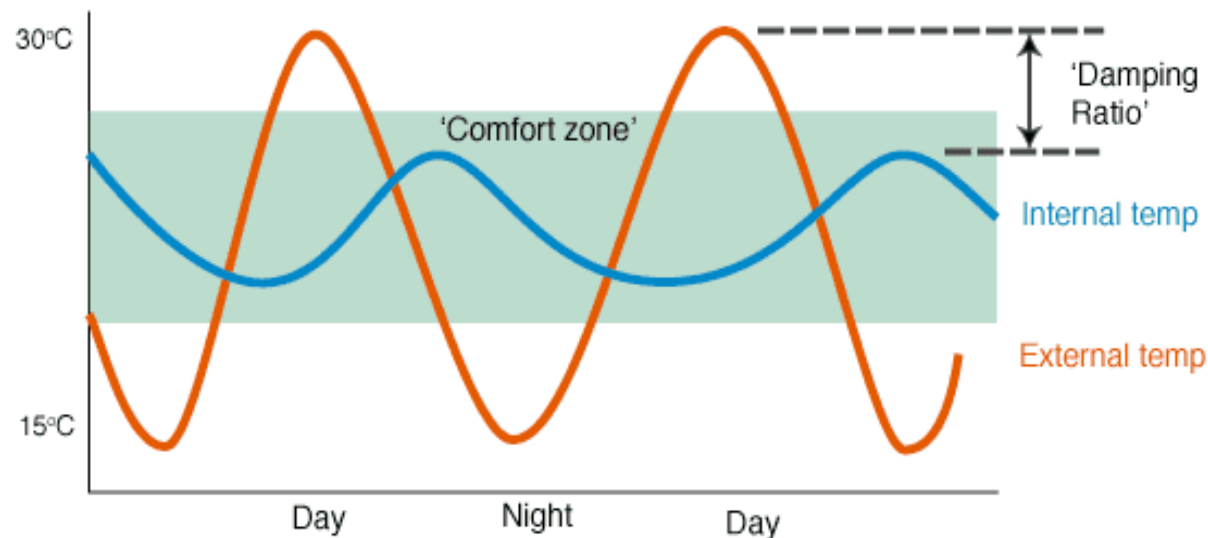
A common analogy is thermal mass as a kind of thermal battery.

- When heat is applied (to a limit) by radiation or warmer adjoining air, the battery charges up until which time it becomes fully charged.
- It discharges when heat starts to flow out as the adjoining air space becomes relatively cooler.

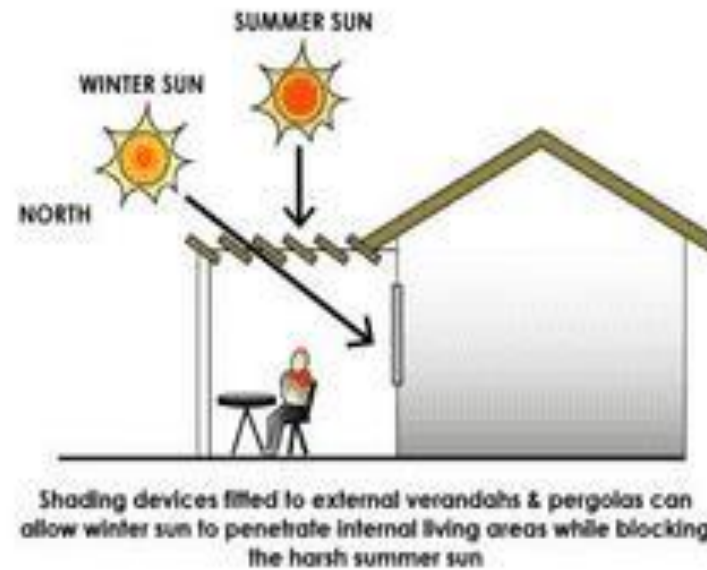
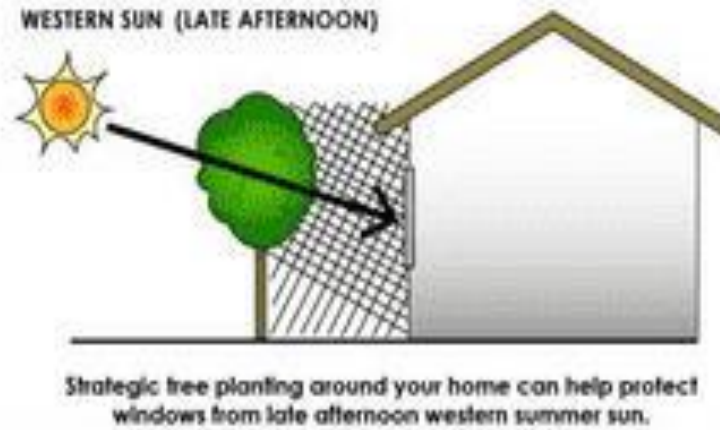
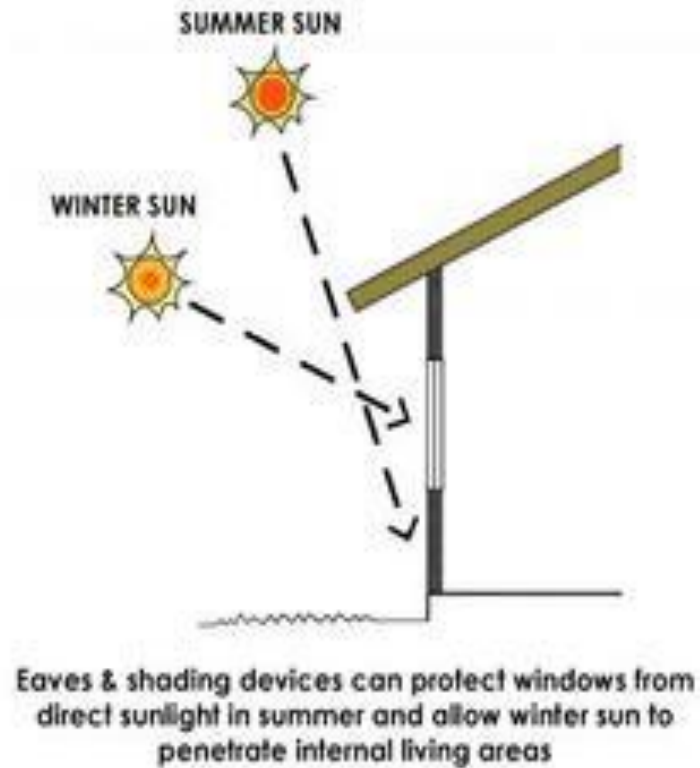


## PASSIVE STRATEGIES FOR THERMAL COMFORT IN AFFORDABLE HOUSING

- Denser thermal mass materials are more effective passive solar materials. Thus, denser the material the better it stores and releases heat.
- Integrate thermal mass with an efficient passive solar design, by considering the placement of added mass.
- Do not substitute thermal mass for insulation. It should be used in conjunction with insulation.



# PASSIVE STRATEGIES FOR THERMAL COMFORT IN AFFORDABLE HOUSING



## CROSS - VENTILATION



Strategically locating doors & windows during the design phase of your home can promote good conditions for cross - ventilation

# PASSIVE STRATEGIES FOR THERMAL COMFORT IN AFFORDABLE HOUSING

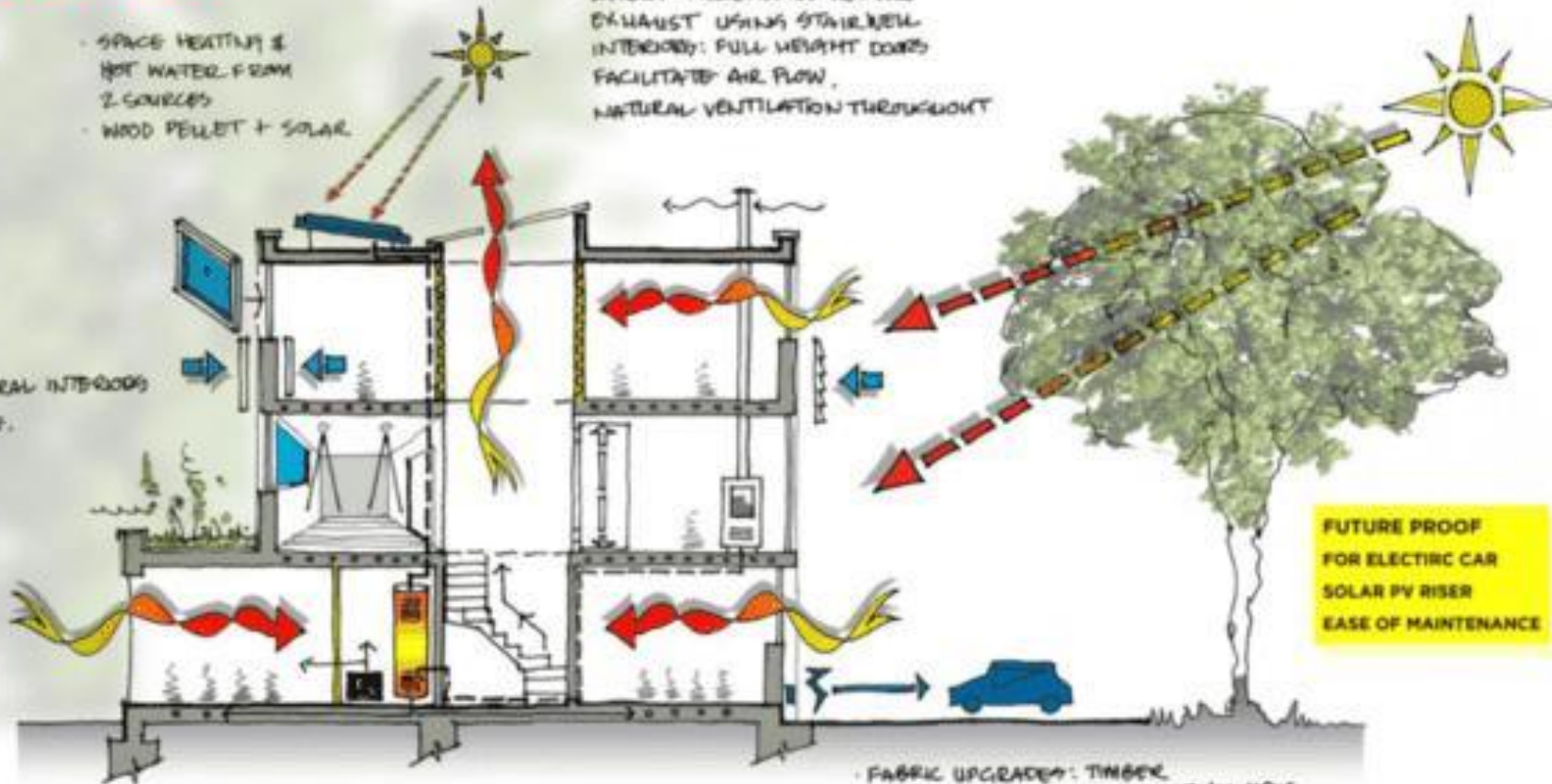
## PASSIVE COOLING

- SPACE HEATING & HOT WATER FROM 2 SOURCES
- WOOD PELLET + SOLAR

- LAYOUT FACILITATES HOT AIR EXHAUST USING STAIRWELL
- INTERIORS: FULL HEIGHT DOORS FACILITATE AIR FLOW, NATURAL VENTILATION THROUGHOUT

- SITE LOCATION - TREES LIMIT SUN PATH.

- SIMPLE, NATURAL INTERIORS / ALREADY BUILT.



- WATER PLAN: LOW USE APPLIANCES; + NEW SUPPLY; METERED SEPTIC ADDED.

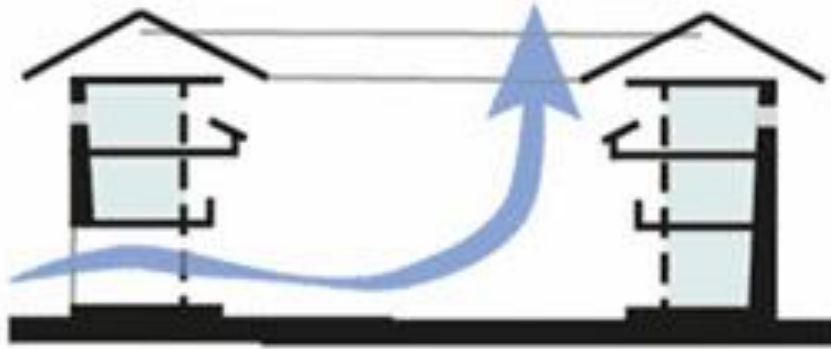
- FABRIC UPGRADES: TIMBER STEP OUT ALL UPVC ADD MIN 100MM INSULATION TO ALL SURFACES

- Layout facilitates hot air exhaust using stairwell.
- Airflow facilitation and natural ventilation.
- Use of trees to limit sun path.
- High thermal mass materials in envelope.

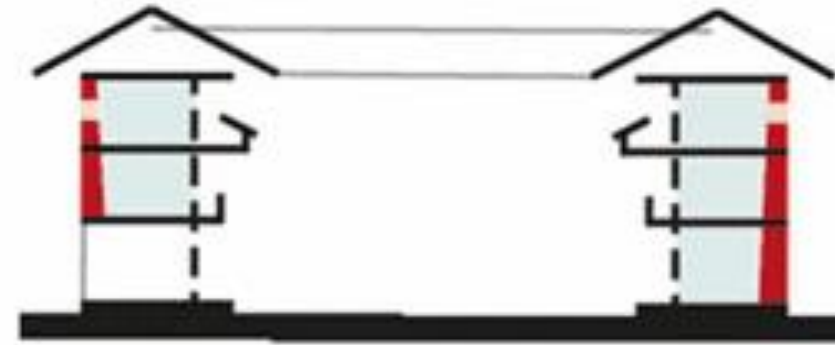


# PASSIVE STRATEGIES FOR THERMAL COMFORT IN AFFORDABLE HOUSING

## Courtyard configuration



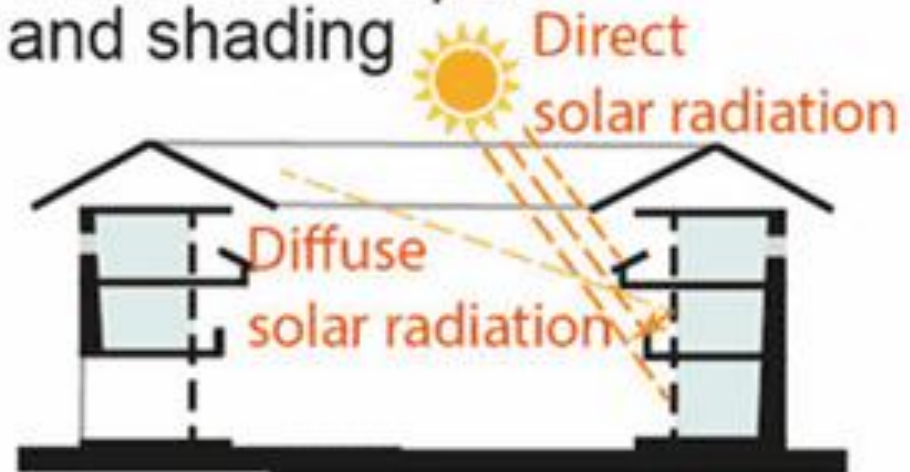
## Thermal mass



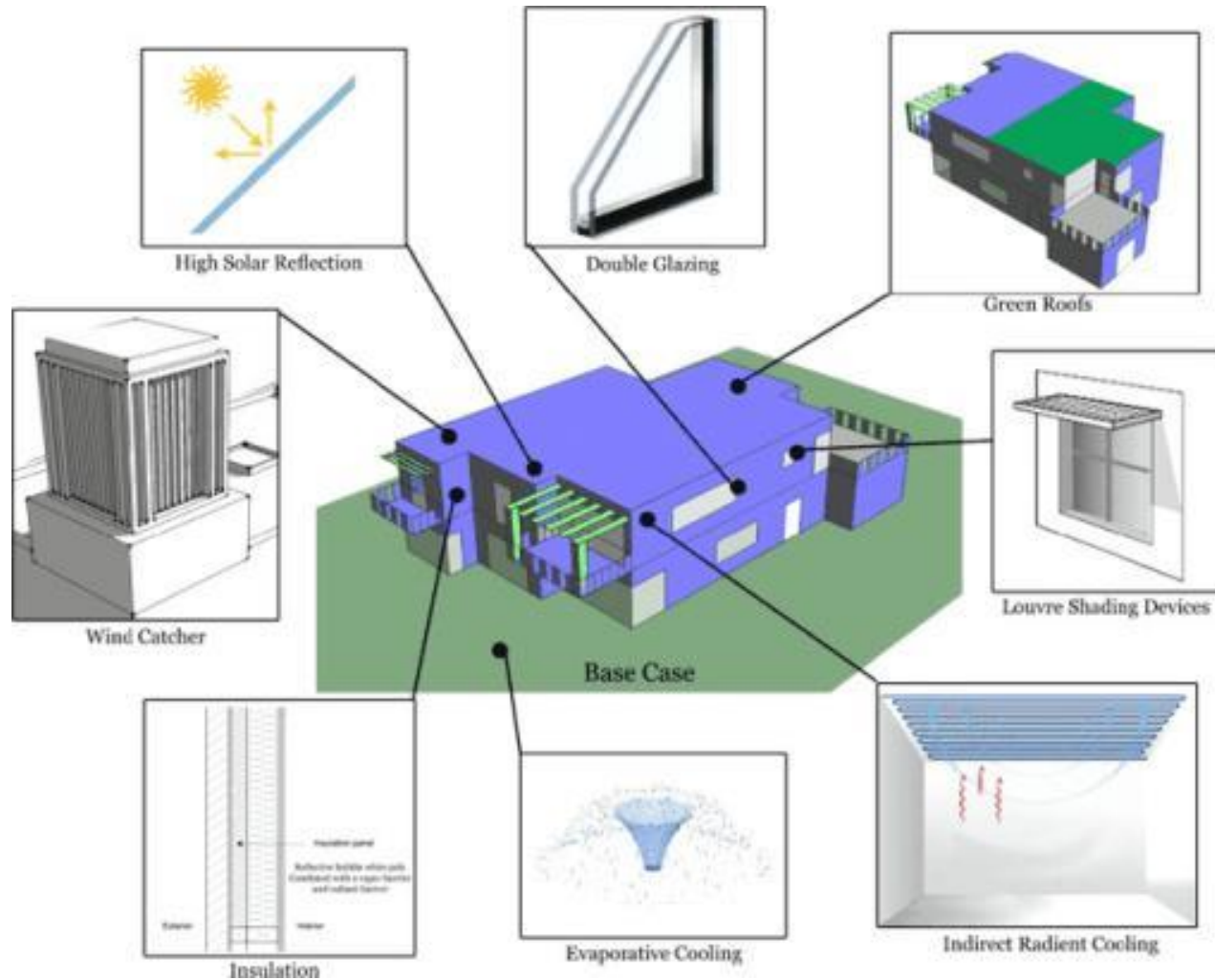
## Ventilated roof



## Transitional space and shading



# PASSIVE STRATEGIES FOR THERMAL COMFORT IN AFFORDABLE HOUSING



- Green roofs.
- Louvre and shading devices.
- Insulation
- Low energy cooling techniques.
- Wind catchment and ventilation.
- Double glazed glass.
- High solar reflective surface.

# SESSION-1 (Contd.)

- 1. Thermal Comfort Standards (*IMAC,ASHRAE*)**
- 2. Effect of Building Material Properties on Thermal Comfort**
- 3. Low Energy Comfort Cooling and Case studies**

# IMAC (INDIA MODEL FOR ADAPTIVE THERMAL COMFORT)

**India**

Standard of adaptive thermal comfort based on Indian specific model guideline (currently for office / commercial buildings),

**Model for**

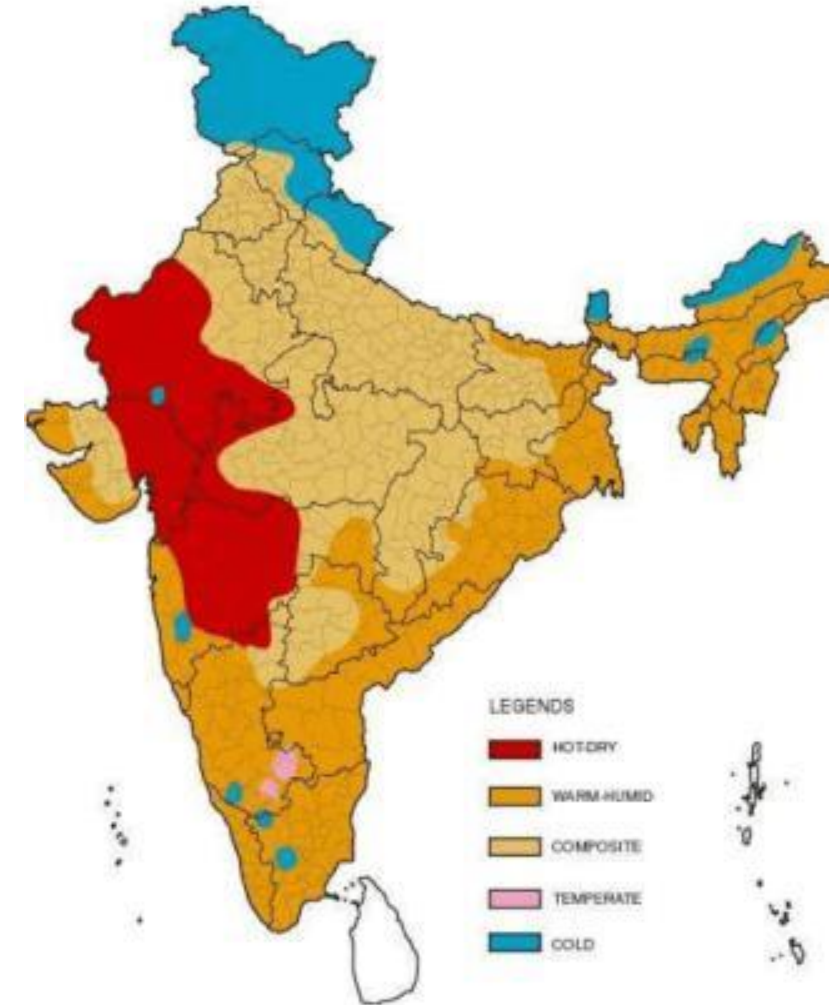
Applicable for air conditioned, naturally ventilated and mixed-mode buildings,

**Adaptive**

Includes the wide temperature ranges in all Indian climate zones,

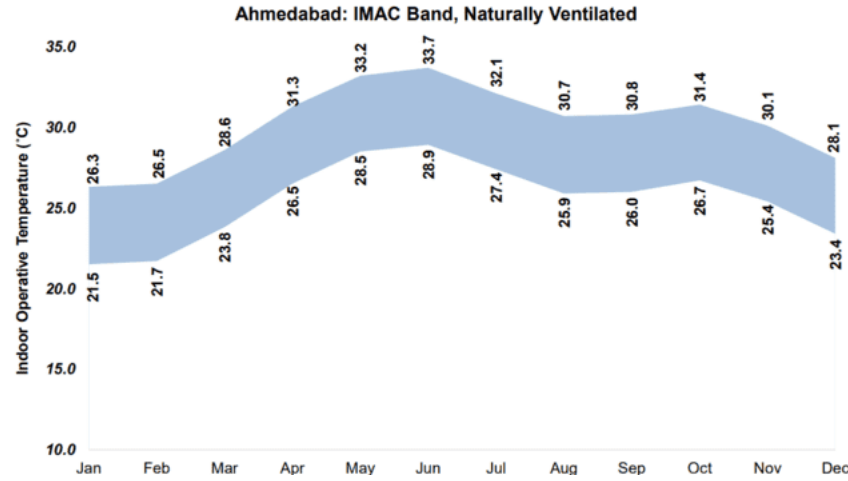
**Comfort**

Shows 90% and 80% acceptability bands.

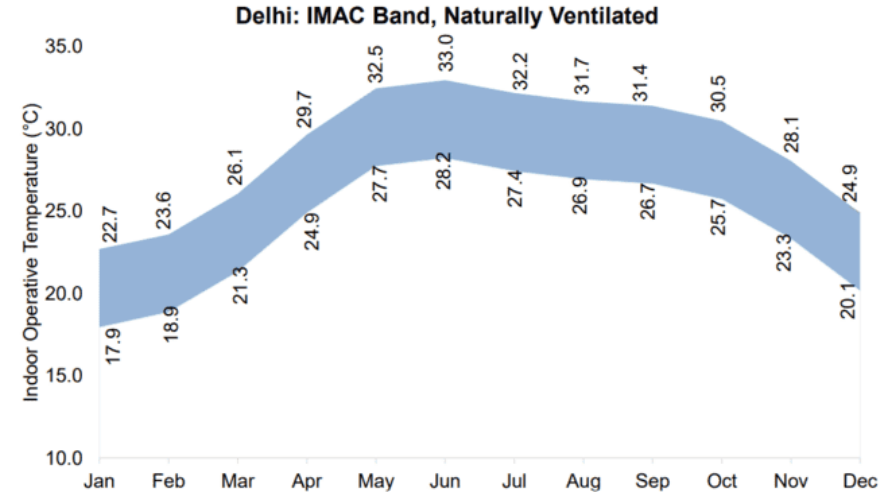


# IMAC (INDIA MODEL FOR ADAPTIVE THERMAL COMFORT)

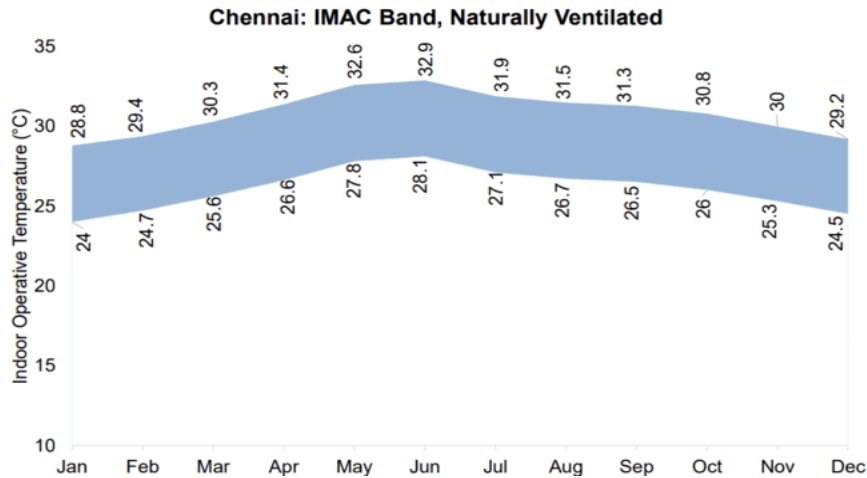
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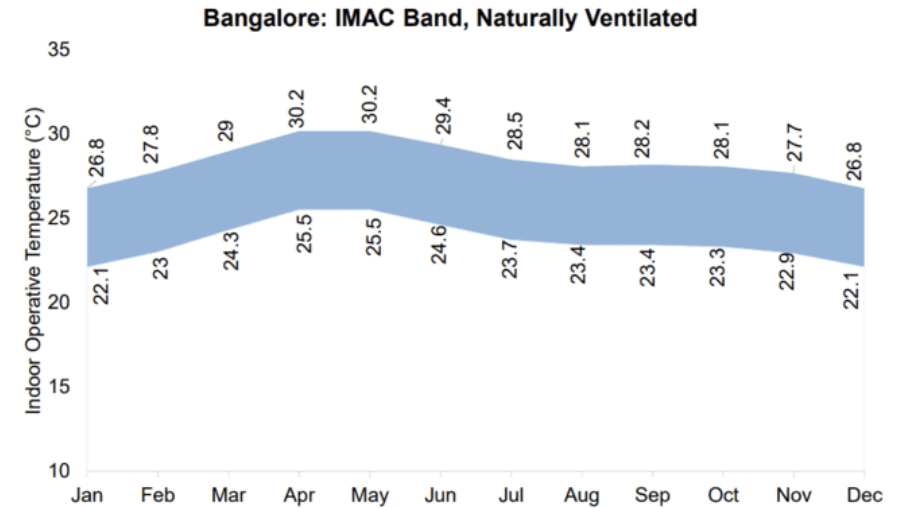
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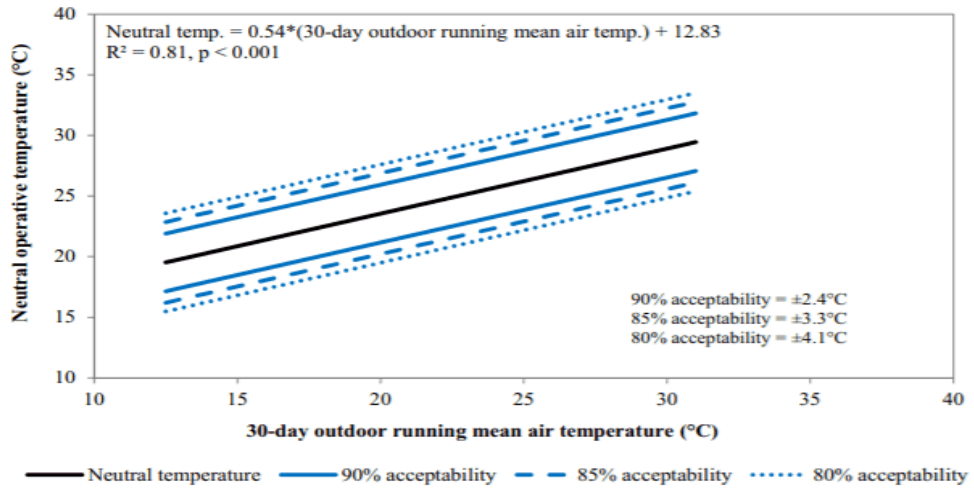
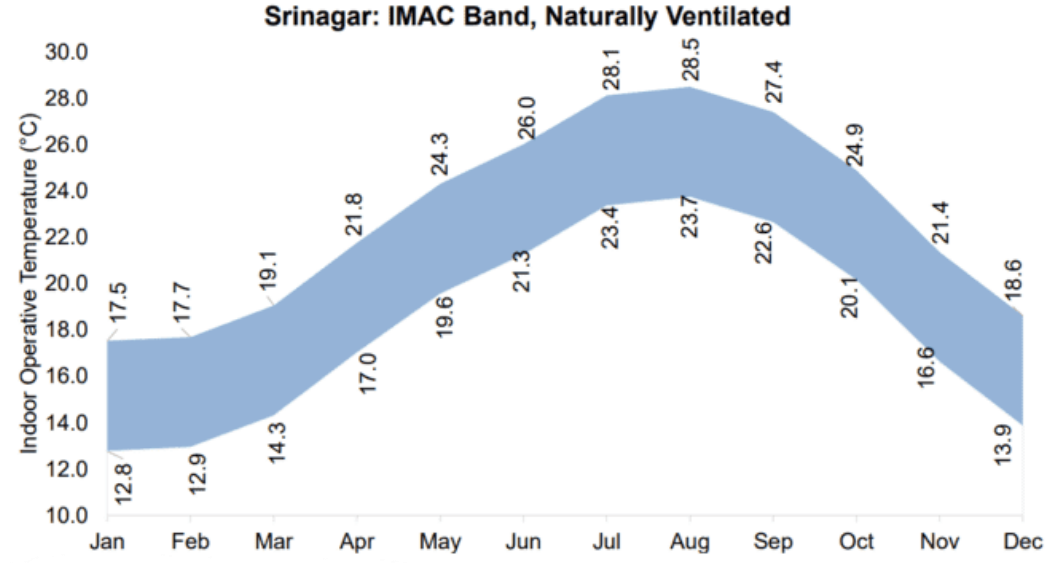


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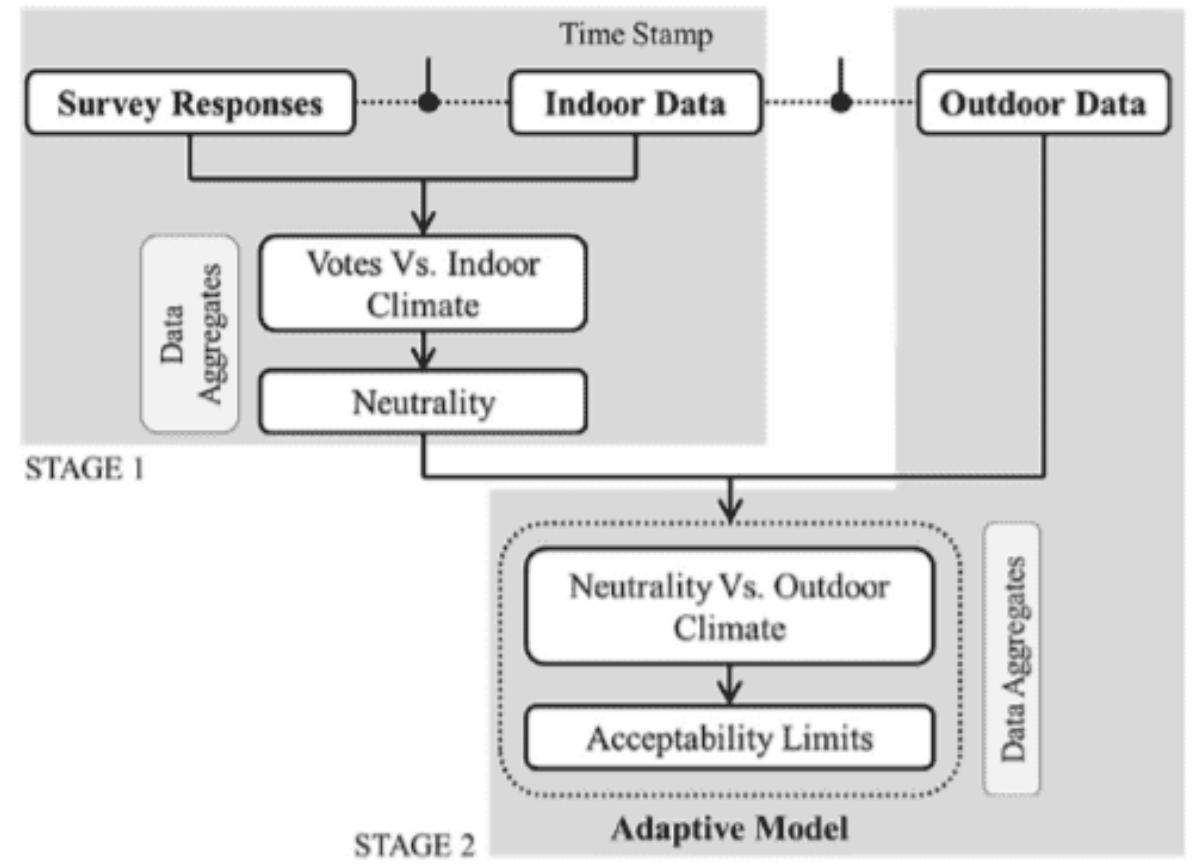
# IMAC (INDIA MODEL FOR ADAPTIVE THERMAL COMFORT)

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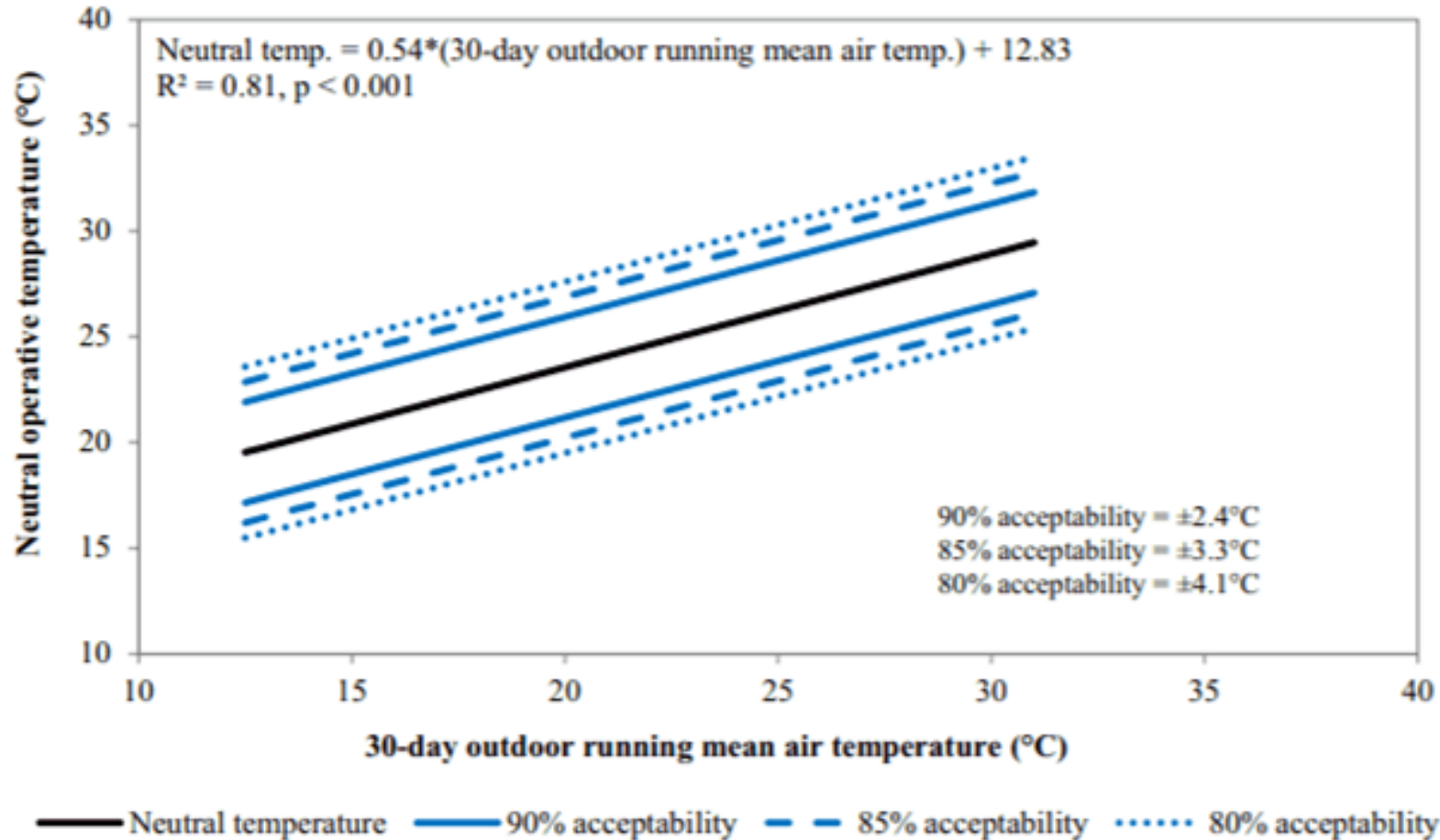


IMAC model for naturally ventilated buildings.

## IMAC ANALYSIS STEPS



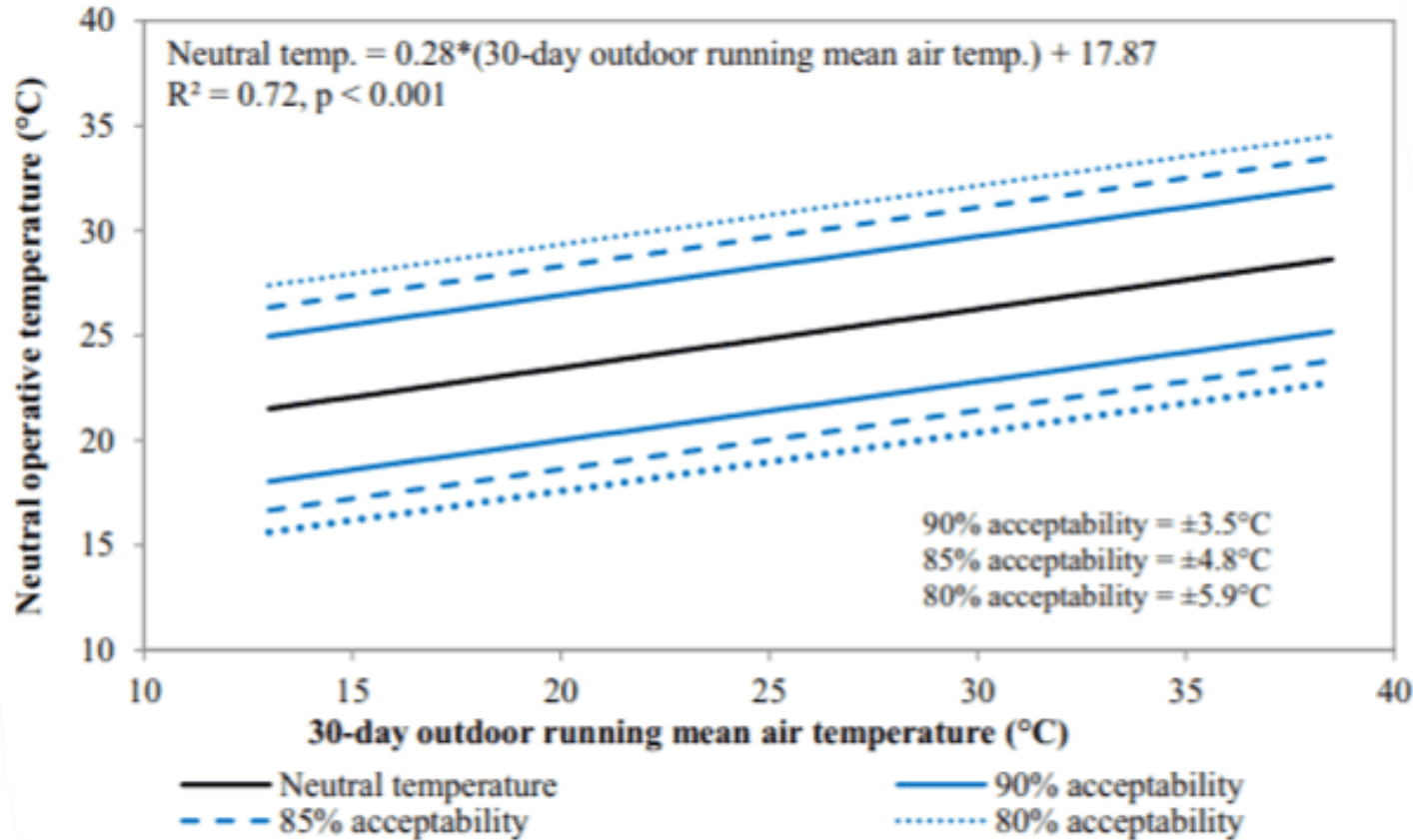
# IMAC (INDIA MODEL FOR ADAPTIVE THERMAL COMFORT)



The model indicates that occupants in NV buildings thermally adapt to the outdoor temperature of their location and the neutral temperature varies from 19.6 to 28.5 C for the above outdoor limits.

IMAC model for naturally ventilated buildings.

# IMAC (INDIA MODEL FOR ADAPTIVE THERMAL COMFORT)



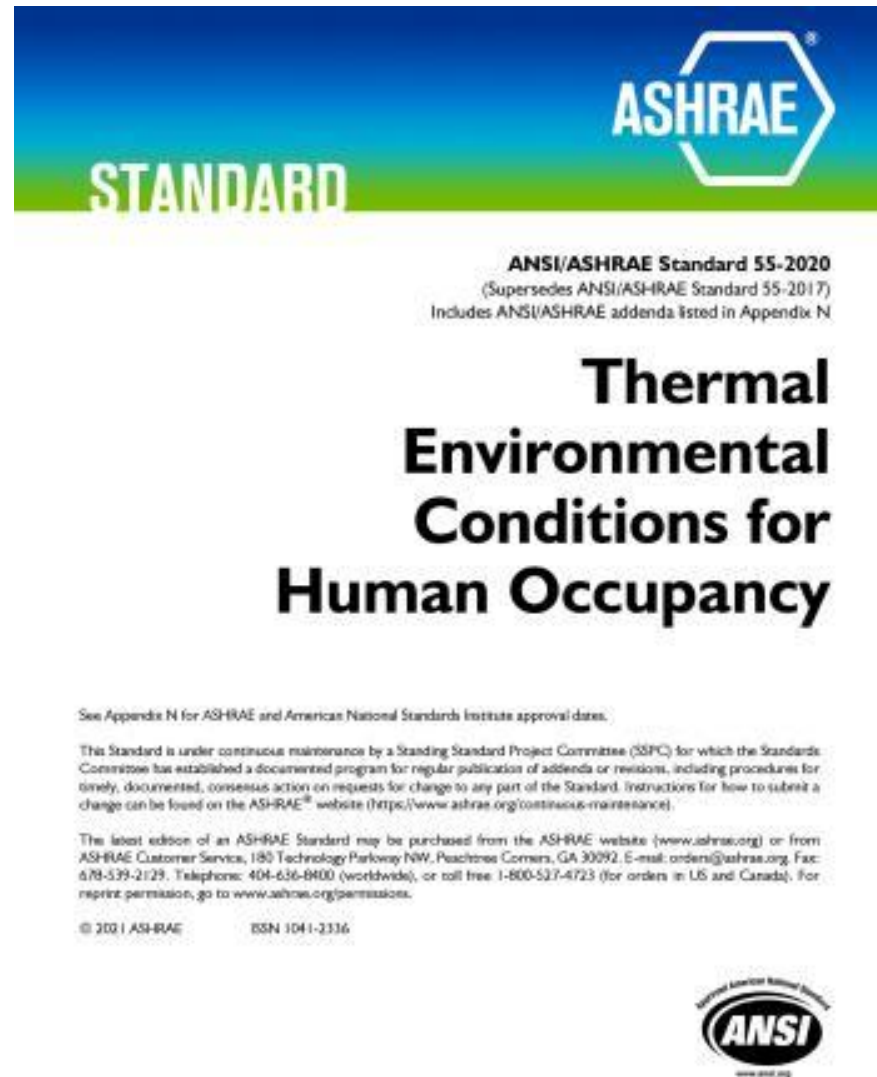
IMAC model for mixed mode buildings.

The acceptability limits derived from the IMAC data are wider for MM buildings model than NV.

This may be a result of the occupants knowing that the required comfort systems exist and will be operational when the external conditions are extreme.



# ASHRAE 55-2020 (THERMAL COMFORT STANDARD)



**ASHRAE** (*American Society of Heating and Refrigeration Engineering*) Standard 55 specifies conditions for acceptable thermal environments and is intended for use in the design, operation, and commissioning of buildings and other occupied spaces.

*ASHRAE 55 defines thermal comfort as “that condition of mind that expresses satisfaction with the thermal environment”.*

## ASHRAE 55-2020 (THERMAL COMFORT STANDARD)

The standard was primarily designed for thermal comfort in spaces where occupants are in sedentary states (i.e., office work). However, it can also be employed to cover other types of indoor environments like residential and commercial spaces.

This standard is based upon four pillars:

- The six environmental and personal factors taken into account are ***temperature, thermal radiation, humidity, airspeed, activity level (metabolic rate), and occupant clothing*** (degree of insulation). In order to comply with ASHRAE 55, all of these factors must be accounted for in combination.
- The thermal conditions that ASHRAE-55 aims to achieve are applicable to healthy adult occupants, up to an altitude of 3K meters, where occupancy time must surpass 15 minutes.
- This standard does not take into consideration factors including air quality, acoustics, illumination, or contamination.

## ASHRAE 55-2020 (THERMAL COMFORT STANDARD)

### ASHRAE-55 Optional Method for Determining Acceptable Thermal Conditions in Naturally Conditioned Spaces.

- In order to apply the adaptive model, there should be no mechanical cooling system for the space; occupants should be engaged in sedentary activities with metabolic rates of 1–1.3 met; and a prevailing mean temperature greater than 10°C and less than 33.5°C.

Adaptive comfort model as per ASHRAE 55	$T_{\text{comf}} = 0.31T_{\text{pma}} + 17.8$
80% Acceptability Upper limit (Eq + 3.5)	$T_{\text{comf}} = 0.31T_{\text{pma}} + 21.3$
80% Acceptability Lower limit (Eq - 2.5)	$T_{\text{comf}} = 0.31T_{\text{pma}} + 14.3$
90% Acceptability Upper limit (Eq + 2.5)	$T_{\text{comf}} = 0.31T_{\text{pma}} + 20.3$
90% Acceptability Lower limit (Eq - 2.5)	$T_{\text{comf}} = 0.31T_{\text{pma}} + 15.3$

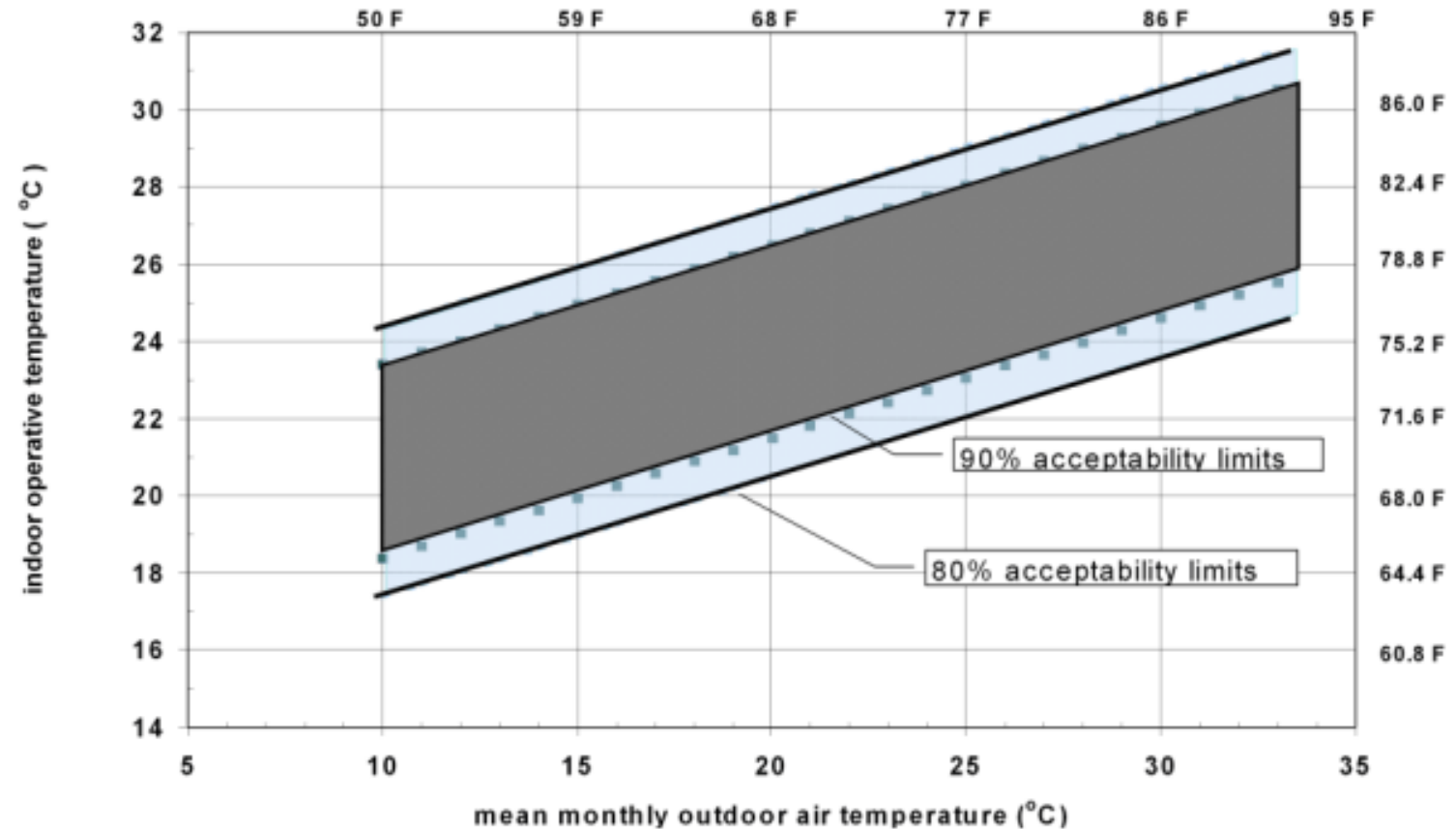
$T_{\text{comf}}$ : Indoor comfort temperature corresponds to acceptable operative temperature

$T_{\text{pma}}$ : Prevailing mean outdoor air temperature

## ASHRAE 55-2020 (THERMAL COMFORT STANDARD)

### ASHRAE-55 Optional Method for Determining Acceptable Thermal Conditions in Naturally Conditioned Spaces.

- In order for this optional method to apply, the space in question must be equipped with operable windows that are open to the outdoors and can be readily opened and adjusted by the occupants of the space.
- PMV and PPD are used to determine these acceptability ranges

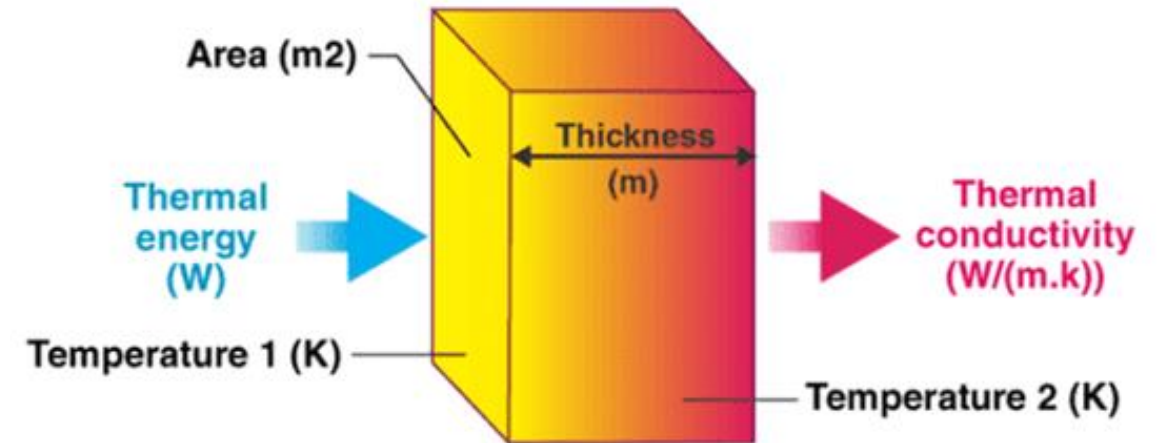


*Acceptable operative temperature ranges for naturally conditioned spaces*

# EFFECT OF BUILDING MATERIAL PROPERTIES ON THERMAL COMFORT

Materials has a direct impact on the achievement of the required thermal properties of a building due to their different thermal properties.

**1. Thermal Conductivity:** The amount of heat transferred through unit area of specimen with unit thickness in unit time is termed as thermal conductivity. it is measured in  $W/(m.K)$ . The lower the thermal conductivity of a material, the better the thermal performance.



# EFFECT OF BUILDING MATERIAL PROPERTIES ON THERMAL COMFORT

**2. Specific Heat:** Specific heat is the quantity of heat in kilo-joule required to heat 1Kg by 1 kelvin/celcius. Specific heat is useful when we use the material in high-temperature areas. Unit is **kJ/kg.K or kJ/kg.C.**

$$c = \frac{\Delta E}{m\Delta\theta}$$

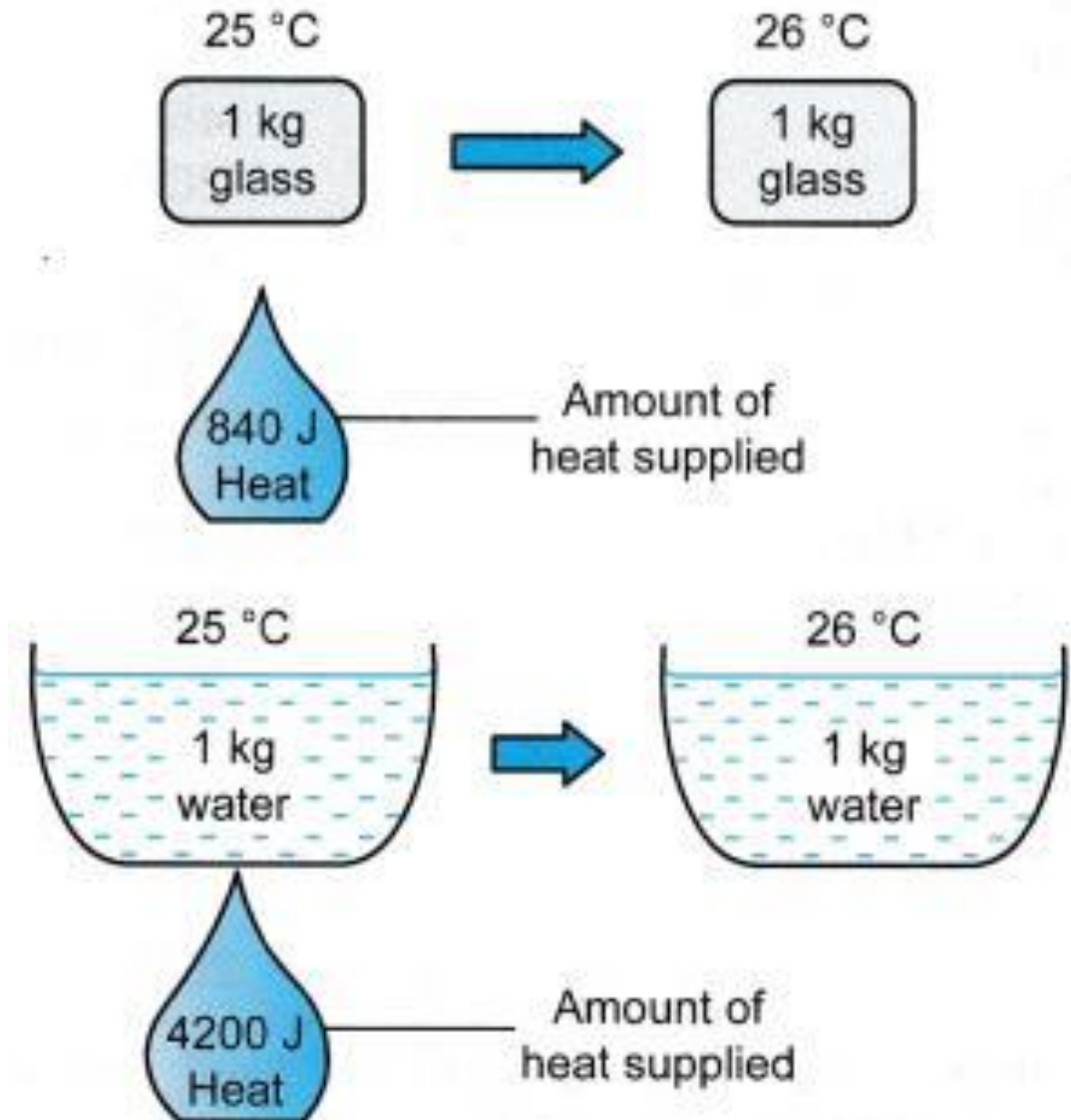
$$\Delta E = mc\Delta\theta$$

$m$  = mass (kg)

$c$  = specific heat capacity (J/kg°C)

$\Delta E$  = change in thermal energy (J)

$\Delta\theta$  = change in temperature (°C)



# EFFECT OF BUILDING MATERIAL PROPERTIES ON THERMAL COMFORT

**3. Thermal Mass:** Thermal mass is the ability of a material to absorb, store and release heat.

Thermal lag is the rate at which a material releases stored heat. For most common building materials, the higher the thermal mass, the longer the thermal lag.

It is calculated by multiplying the specific heat capacity by the density of a material. The unit of thermal mass is  **$\text{kJ}/\text{m}^3.\text{K}$**

**4. Density of material:** Density is the weight per unit volume of a material (i.e. how much a cubic meter the material weighs). Unit is  **$\text{Kg}/\text{m}^3$**

## THERMAL TRANSMITTANCE (U-VALUE)

The U-value is a measure of how much heat is lost through a given thickness of a particular material but includes the three major ways in which heat loss occurs: conduction, convection and radiation.

it is the inverse of resistance value R. Unit of U value is  $W/m^2.K$ .

The general formula for calculating the U-Value is:

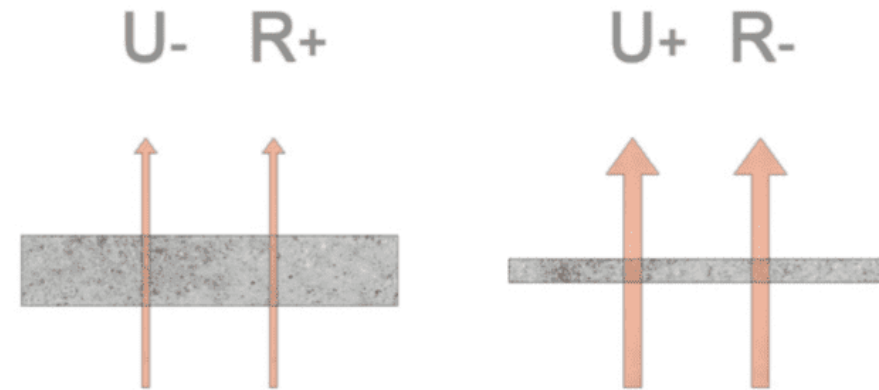
$$U=1/Rt$$

Where R is total Thermal Resistance of the element composed of layers in  $m^2.K/W$ .

$$Rt=R1+R2+R3.....Rn$$

$R1, R2, R3, Rn$  = Thermal Resistance of each layer, which is obtained according to:

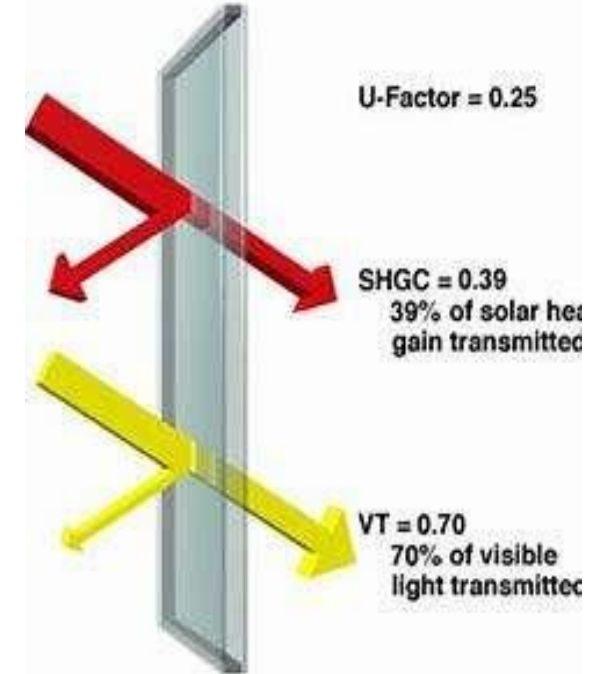
$R=d/K$ , where K is thermal conductivity. d is thickness.





# GUIDANCE ON U- VALUE, SHGC AND VLT FOR FENESTRATIONS

- 1. U-Factor:** Heat transmittance through the window. A lower number indicates less transmittance through the window.
- 2. SHGC (Solar heat gain coefficient):** Blocking the sun's radiant heat. Lower SHGC means less radiant solar heat gain through the window.
- 3. VLT Visible light Transmittance:** Visible light passed through the window. VLT is rated between 0 and 1. A higher number indicates more light is transmitted.



Glazing Assembly	U-Factor	R-Value	SHGC	VT
Single Glass	1.1	0.9	0.87	0.90
Double pane, insul. glass	0.50	2.0	0.76	0.81
High-SHGC, low-e, insul. glass	0.30	3.3	0.74	0.76
Medium-SHGC, low-e, insul. glass	0.26	3.8	0.58	0.78
Low-SHGC, low-e, insul. glass	0.29	3.4	0.35	0.65
Triple-glazed, 2 low-e coatings	0.12	8.3	0.5	0.65

# GUIDANCE ON U- VALUE, SHGC AND VLT FOR FENESTRATIONS

## Design Factors that impact on U-value, SHGC, VLT Etc.

**Climate Analysis :** To select type of glazing as different weather impacts differently.

**Optimum Orientation of Building:** Before selecting any glazing material, study of building orientation is must, if rightly oriented, we may get energy efficiency without using high performance glass. (according to Indian context, South-West orientation is responsible for maximum heat gain).

**Shadow Analysis:** Shadow of the building as well as surrounding also impacts heat ingress (direct & defused), hence changes the glazing requirement.

**Daylight Analysis :** Study of available lux level, window size and other passive design should be considered before defining the required VLT of a glass.

# GUIDANCE ON U- VALUE, SHGC AND VLT FOR FENESTRATIONS

## Dos in Indian climatic Context

- Choose products with least SHGC and U value and optimum VLT.
- Determine an optimum set of values for U-value, solar heat gain coefficient, and visible transmittance.
- Add overhead shading, use dark tinted glass at visible height and clear at higher levels. For shaded windows, products with lower U values perform better.

## Don't in Indian climatic Context

- Do not use glass with very low U value and moderate SHGC.
- Do not assume dark tinted glass brings solar control
- Do not use un-insulated frames

**Note:** Remember that same fenestration product behaves differently w.r.t. the specific design. It should not be assumed that products with Low U-value and SHGC are best and universal solution.

## SOME SUSTAINABLE BUILDING MATERIAL FOR THERMAL COMFORT

Some promising sustainable materials for better thermal comfort are:

1. Fly Ash sand-lime gypsum bricks
2. Compressed earth
3. Solid/ hollow concrete blocks
4. Coir polymer composite boards and ply
5. Ferro cement and Aerocon panels



# SOME SUSTAINABLE BUILDING MATERIAL ON THERMAL COMFORT

## Some properties of alternative materials

Sr No	Properties	Bamboo	Concrete Blocks	Ferrocement and Aerocon panels	Fiber-Cement composites	Fly ash bricks	Mud Blocks (compressed)	Rice husk	Straw bale (with bricks)
1.	Structural	Works better with moisture in shear forces; have high Flexibility than steel and lower young's modulus.	Can be given strength as per required; less mortar joint as size bigger which increases stability	Lightweight and requires no wet plastering (aerocon); high strength ,low density and high crack resistance of mortar (Ferrocement)	The light weight, high strength to weight ratio, corrosion resistance, crack resistance, flexibility, lightness	Reduce pollution, save energy, reduce mercury pollution and cost 20% less than traditional clay brick manufacturing, high strength, lower water penetration,	Economic and energy efficient	Pozzoloanic, economical , corrosion resistance increases, light weight final product	Stable and high load bearing power
2.	Thermal	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Moderate	Moderate
3.	Temperature and water resistance	Moderate	Excellent	Excellent	Moderate	Excellent	Excellent	Depends on composition as it is used as admixture	Also depends on brick composition as it is mixed with the brick and with mud
4.	Buildability	Moderate	Excellent	Excellent	Excellent	Excellent	Excellent	Moderate	Moderate

# SOME SUSTAINABLE BUILDING MATERIAL ON THERMAL COMFORT

## Locally available natural fiber and its use in building construction

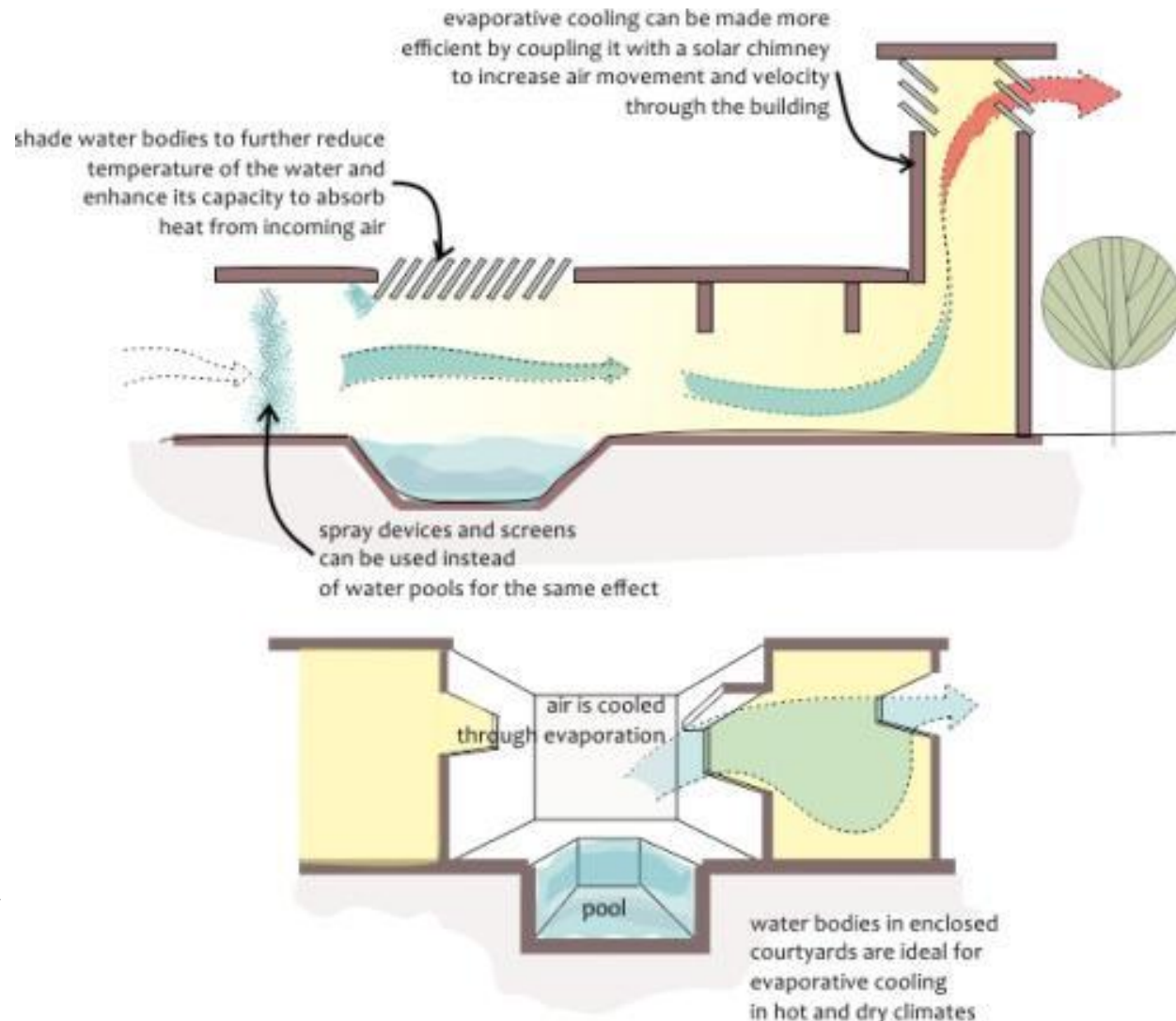
Item	Source	Application in building material
Rice husk	Rice mills	As fuel, for manufacturing building materials and products
Banana leaves/stalk	Banana plants	In the manufacture of building boards, fire resistance fibre board
Coconut husk	Coir fibre industry	In the manufacture of building boards, roofing sheets, insulation boards, building panels, as a lightweight aggregate, coir fibre reinforced composite boards
Groundnut shell	Groundnut oil mills	In the manufacture of buildings panels, building blocks, for making chip boards, roofing sheets, particle boards
Jute fibre	Jute industry	For making chip boards, roofing sheets, door shutter
Rice/wheat straw	Agricultural farm	Manufacture of roofing units and walls panels/boards
Saw mill waste	Saw mills/wood	Manufacture of cement bonded wood chips, blocks, boards, particle boards, insulation boards, briquettes
Sisal fibres	Sisal plantation	For plastering of walls and for making roofing sheets, composite board with rice husk, cement roofing sheet, roofing tiles, manufacturing of paper and pulp
Cotton stalk	Cotton plantation	Fibre boards, panel, door shutters, roofing sheets, autoclaved cement composite, paper, plastering of walls

## LOW ENERGY COMFORT SYSTEM

### Evaporative cooling (Direct/Indirect)

Evaporative cooling is based on the principle that water evaporates by absorbing heat from the surroundings. When air is passed over a water surface, evaporation results in the cooling of the air stream.

- ✓ When hot outdoor air is passed through the cooling medium, sensible heat from the air is extracted to evaporate the water flowing through it.
- ✓ Water passing through the cooling media evaporates into the air, reducing its temperature and producing a cooling effect and increasing the air's humidity.
- ✓ Evaporative cooling is most effective in hot and dry climates where water easily evaporates.



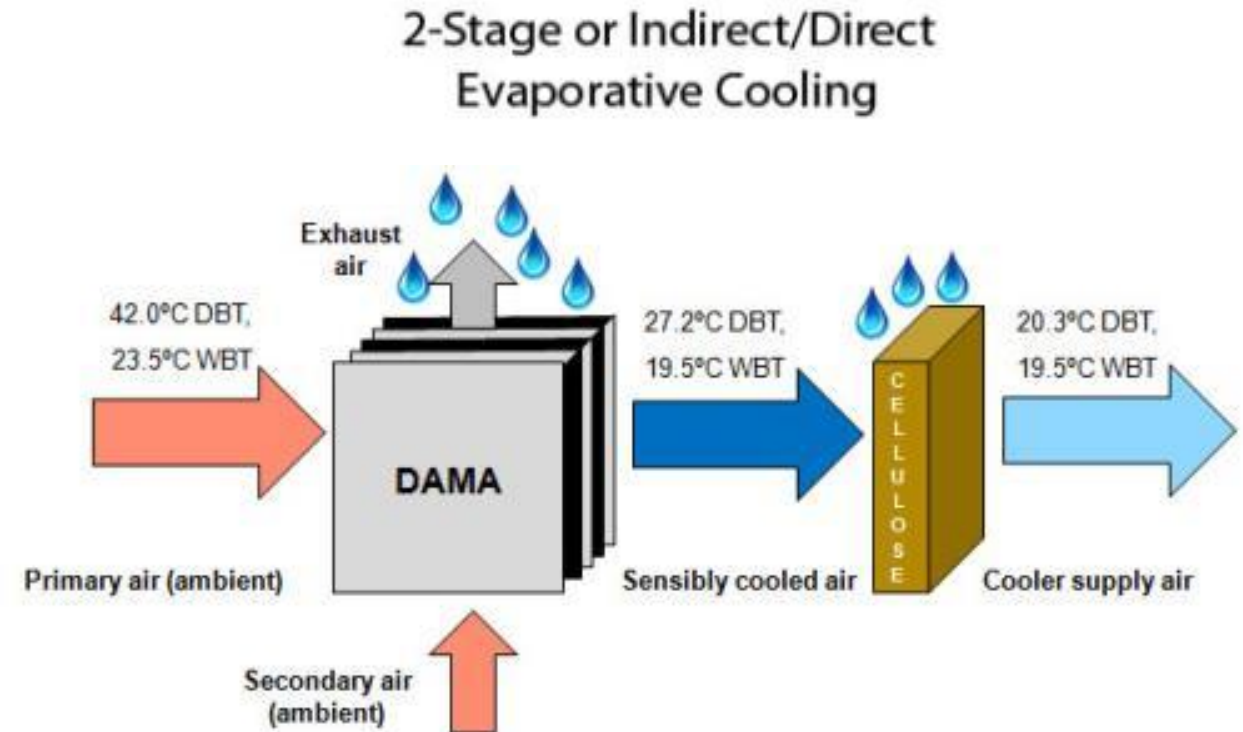
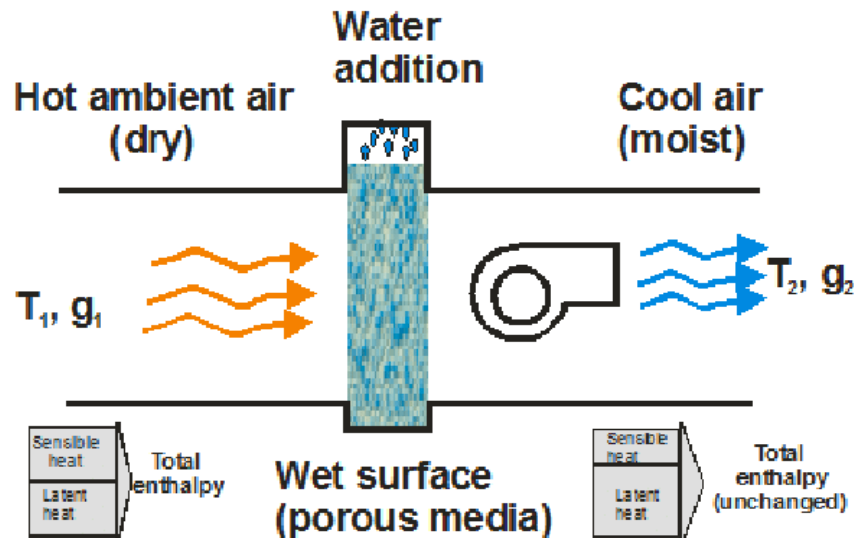
## LOW ENERGY COMFORT SYSTEM

### Evaporative cooling (Direct/Indirect)

The performance of an evaporative cooling system is dependent on several critical parameters:

1. Difference in dry-bulb and wet-bulb temperature of outdoor air
2. Efficiency of the cooling media
3. Flow rate of air through system

- ✓ In composite climates evaporative cooling systems can be used to reduce HVAC system use during early summer months when the temperatures are high and humidity is low.

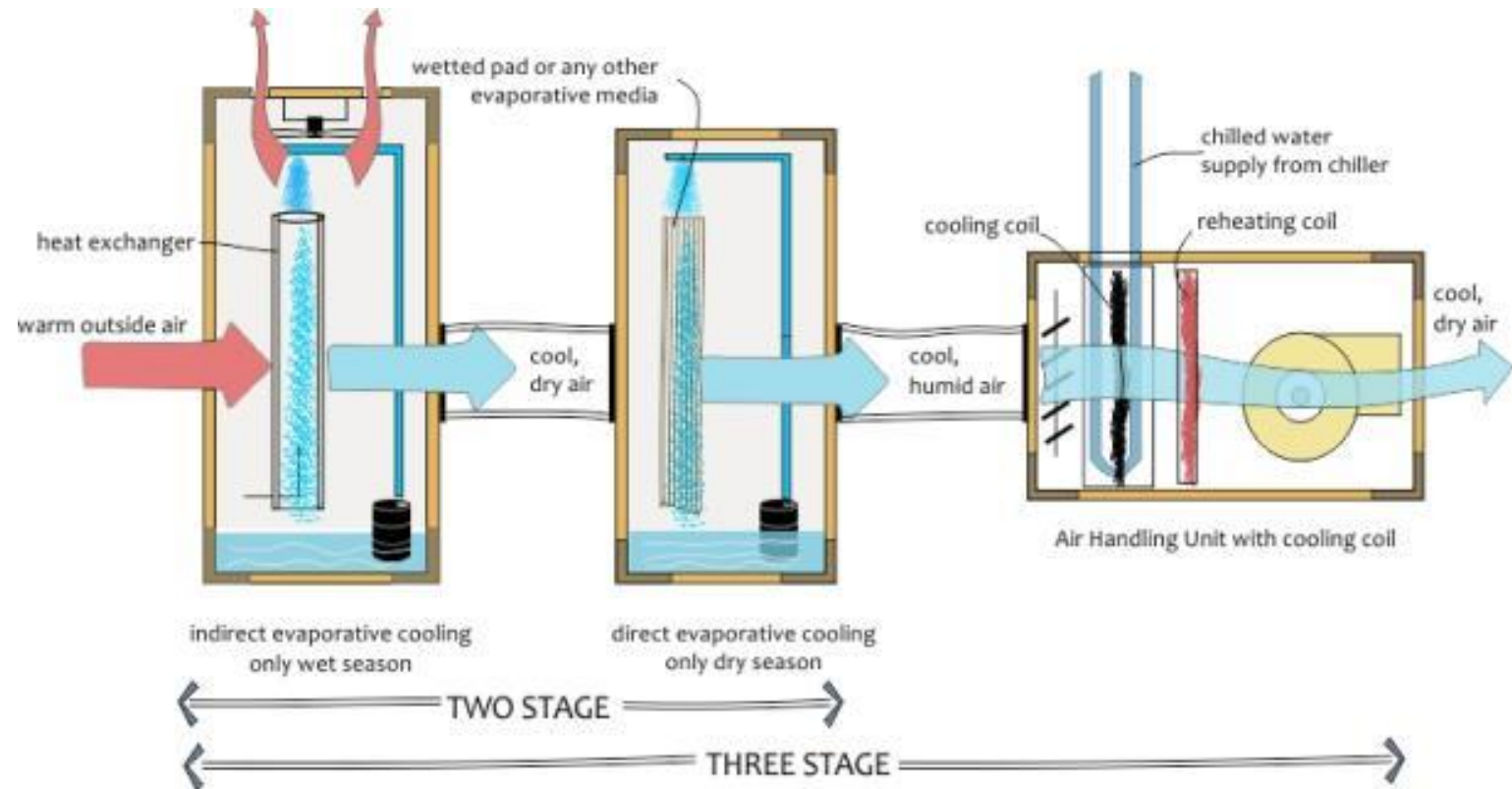




## LOW ENERGY COMFORT SYSTEM

### Evaporative cooling (Direct/Indirect)

- ✓ The direct system could be functional during the dry season, when humidification of air is required, and indirect system can be used when air primarily needs to be cooled.



- ✓ The addition of cooling coils (chilled water or refrigerants) is helpful in monsoon season when the humidity level is high and dehumidification is required. Fresh air passed through the coils controls both sensible and latent heat requirements. The coils are also useful in winter season when some heating is also required.

## LOW ENERGY COMFORT SYSTEM

### Case Study ST Mary School Pune

The school sought a low-cost, low-energy and low-noise solution to provide thermal comfort inside a 500m<sup>2</sup> auditorium being added to the existing structure. Conventional air-conditioning solutions required high capital investment and higher operational cost.

Hence, the school decided to install an IDEC system with a total capacity of 44,000CFM providing 100% fresh air to the space.

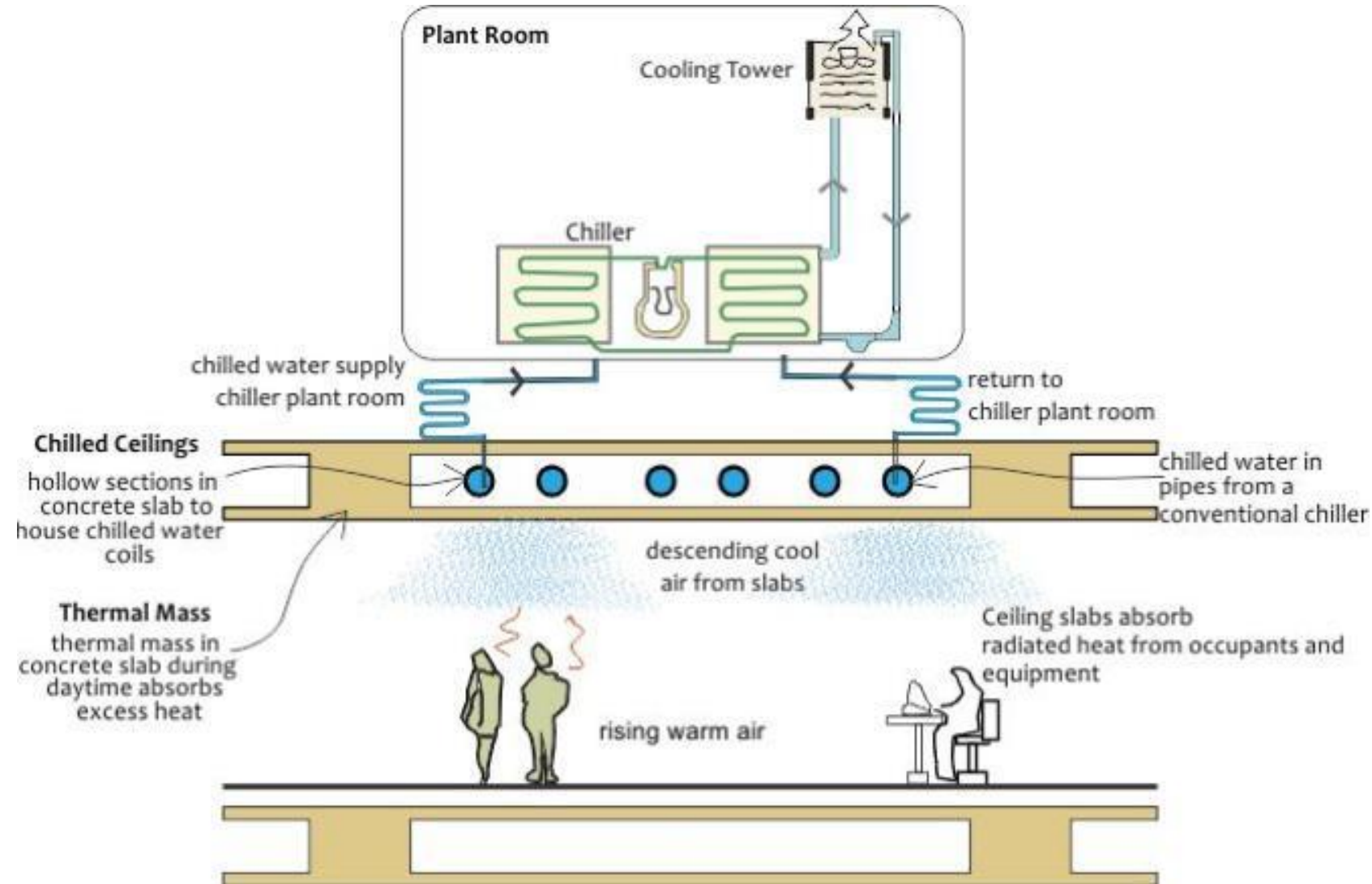
- ✓ The system was able to maintain 26 degree Celsius during its commissioning in peak summer when the outdoor dry-bulb temperature was 36 degree Celsius.
- ✓ The system consumes less than half the energy consumed by a conventional air-conditioning system. Post-occupancy evaluation of the auditorium revealed high levels of satisfaction towards thermal comfort and indoor air quality.



## LOW ENERGY COMFORT SYSTEM

### Radiant and Structure Cooling

- ✓ Radiant Cooling is based on the physical principle, that bodies with varying temperatures exchange thermal radiation until an equilibrium is achieved.
- ✓ Radiant cooling systems work by circulating chilled water through a network of polymer pipes installed on floors, walls, or ceilings.



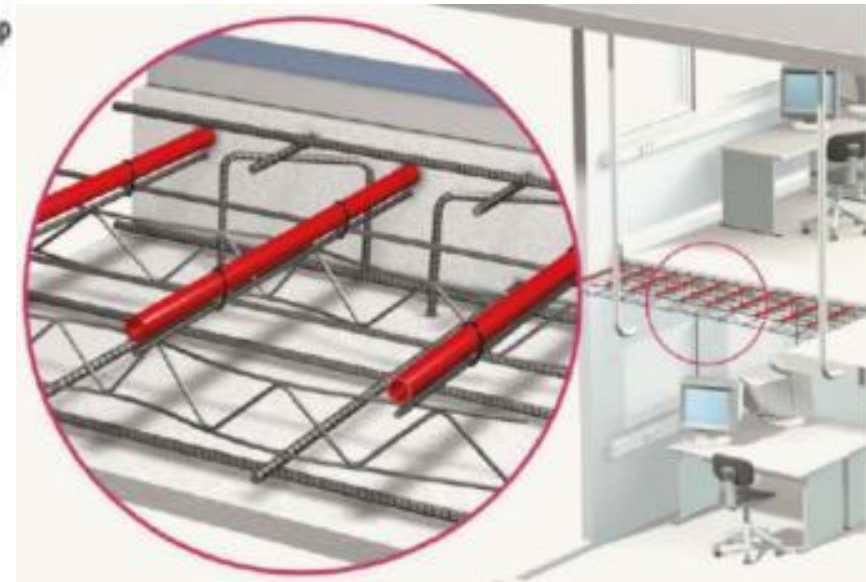
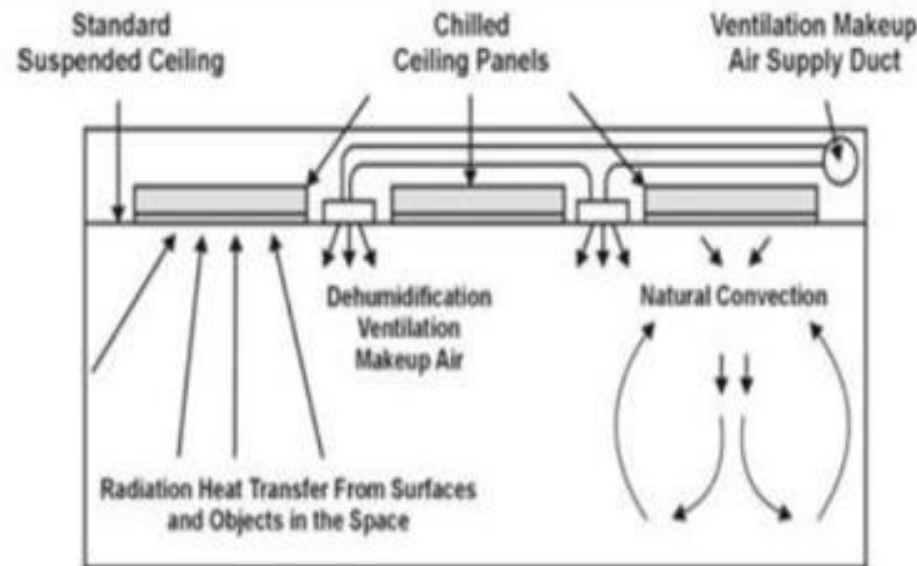
# LOW ENERGY COMFORT SYSTEM

## Radiant and Structure Cooling

Types of radiant cooling:

1. **Chilled slabs:** These deliver cooling through the building structure, usually slab, and are also known as thermally activated building systems.
2. **Ceiling panels:** These deliver cooling through specialized panels.

✓ Systems using concrete slabs are generally cheaper than panel systems and offer the advantage of thermal mass while panel systems offer faster temperature control and flexibility.



Chilled ceiling suspended panels and Structure cooling

## LOW ENERGY COMFORT SYSTEM

### Case Study School of Architecture, Vellore Institute of Technology, Vellore

The VIT School of Architecture sought a low-energy solution to meet its cooling requirement.

- ✓ Its 10,000m<sup>2</sup> area would have required an air-conditioning installation of at least 500TR, but the school adopted structure cooling instead.
- ✓ The Network of pipes was embedded in the concrete structure; these were connected to a two-stage cooling tower rather than a chiller.
- ✓ The system provides an internal temperature range of 26-30°C.
- ✓ The building is naturally ventilated and ceiling fans enhance thermal comfort.
- ✓ The structure cooling used here yielded > 80% energy savings and paid for itself within one year.

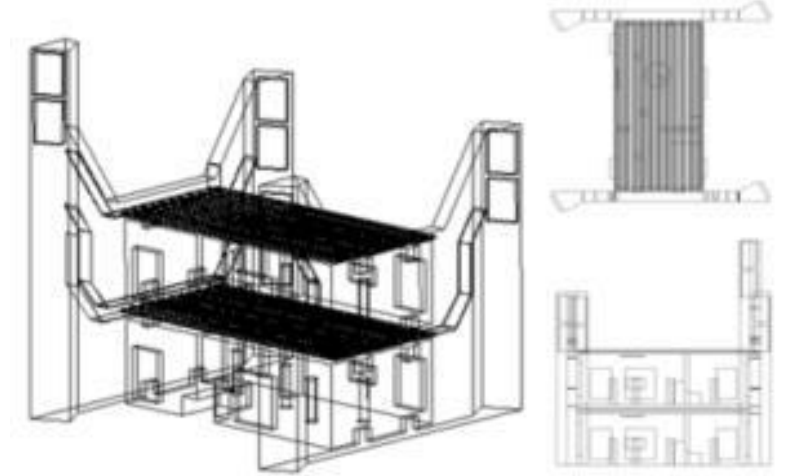


# CASE STUDY- LOW ENERGY HOUSING

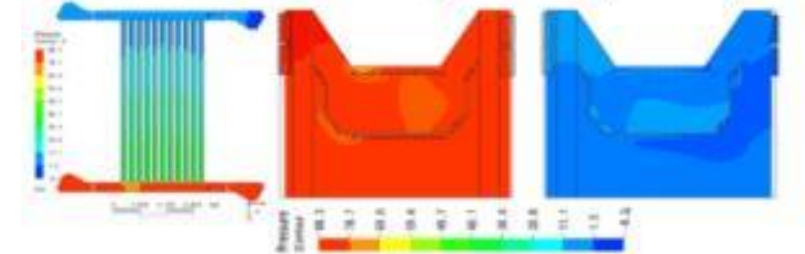
## Scope & Objective:

A prototype of large number of low-cost mass housing project was to be built with the owner’s mandate of using natural as well as external wind-based ventilation that create an efficient as well as comfortable living environment within the units. Further study includes.

1. Options of slab air cooling by concrete piping.
2. Estimates of how well the air changes are able to dissipate the internal heat load with slab cooling.
3. Use wind catchers as well as tower to enhance the air flow due to thermal stratification.
4. Estimate, if sufficient air changes are happening and what kind of temperatures will prevail inside the occupant spaces.



Snapshots below depicts the pressure drops in air path



Run	Run Description	Range DBT-WBT In (°C)	Mass Flow Achieved In (Kg/s)	Temp. and Enthalpy Drop		ACH Total Volume of Geometry is 385 m <sup>3</sup>	Ton of Cooling
1	DBT= 34 WBT= 26	8	1.01969 kg/s	In=2C/70%	H1=63.7 KJ/Kg	7.7	7.66
				Out =31.2C/80%	H2=90.1 KJ/Kg		
2	DBT= 40 WBT= 25	15	0.956495 kg/s	In =25C/70%	H1=60.4 KJ/Kg	7.2	7.84
				Out =31.0/80%	H2=89.2 KJ/Kg		
3	DBT= 31 WBT= 21	10	0.569413 kg/s	In = 21C/70%	H1=48.6 KJ/Kg	4.3	4.73
				Out = 28.3C/80%	H2=77.8 KJ/Kg		
4	DBT= 28 WBT= 24	4	1.00588 kg/s	In =24C/70%	H1=57.3 KJ/Kg	7.6	5.09
				Out =27.5/80%	H2=75.1 KJ/Kg		

## SESSION-2

1. **Eco Niwas Samhita (*ENS-2018, Building Envelope*)**
2. **Eco Niwas Samhita (*ENS-2021, Electro-Mechanical and Renewable Energy Systems*)**

## ENS 2018- INTRODUCTION

### Why Eco-Niwas Samhita has been created?

- ❑ **Built Up Area** - India will add 3 Billion m<sup>2</sup> by 2030 of New residential building w.r.t Year 2018
- ❑ **Energy Demand** - There is a 4 times increase in energy demand for residential units from 1996 – 2016
- ❑ Projections show energy demand will be approximately between 630 TWh and 940 TWh by 2032

### What is Eco-Niwas Samhita 2018?

- ❑ ECO-Niwas Samhita 2018 - an Energy Conservation Building Code for Residential Buildings.
- ❑ Launched on National Energy Conservation Day in 2018.
- ❑ Applicable to all residential units with plot area  $\geq 500\text{m}^2$
- ❑ (However, states and municipal bodies may reduce the plot area so that maximum residential buildings fall in the category of ENS compliance )



## ENS 2018- INTRODUCTION

### Why Eco-Niwas Samhita has been created?

- **Climate Responsive Building Design**
- **Efficient Building Envelope Design**
- **Energy Efficient Appliances (5 Star A/C, Fridge, LED Lights Etc)**
- **Proper Maintenance of Electrical Appliances**

**To Address The Above Factors  
Eco Niwas Samhita Was Created**

## ENS 2018- POLICIES FOR RESIDENTIAL BUILDINGS

### Policies & Regulations-Residential

- Eco-Niwas Samhita (ECBC-R) Part -1
- Star Rating for Buildings (Building Label)
- Supporting Government Initiatives
  
- Replicable Design Catalogue of EE Homes
- Energy Efficient Building Materials Directory
  
- ECONIWAS Web-Portal
- Smart Home Program
  
- Eco-Niwas Samhita (ECBC-R) Part -II



## ENS 2018- LAUNCH

**Eco-Niwas Samhita 2018** (Part I: Building Envelope) is the New ECBC for Residential Buildings, launched by Ministry of Power (MoP) on 14 December 2018.



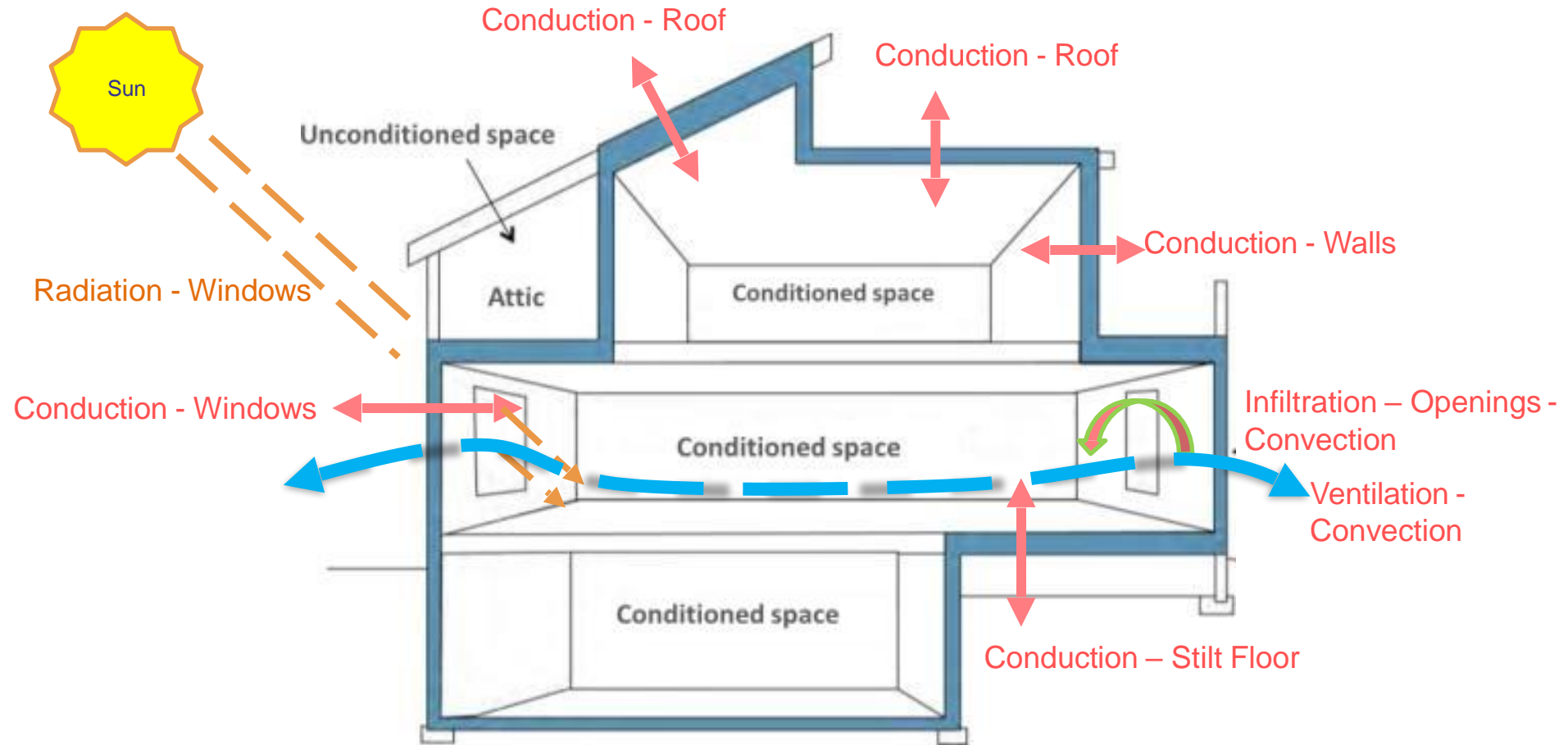
## ENS 2018- IMPACT ASSESMENT OF PART-1



- ✓ Estimated Savings 2018 – 2030
- ✓ 20% Cooling Energy
- ✓ 25 billion kWh Electricity
- ✓ 100 million Tons of CO<sub>2</sub> Equivalent

## ENS 2018-BUILDING ENVELOPE PHYSICS

### Building Envelope-Building Physics & Concepts



Building Envelope Design Is The Key Of Energy Efficient Residential Buildings

## ENS 2018-BUILDING ENVELOPE PHYSICS

### WHAT IS – U VALUE?

The lower the **U-value**, the lower the heat gain/loss in the building.

Definition:

**Thermal transmittance** is the rate of heat transfer through materials

Unit of U-Value :  $W/(m^2K)$

$$U\text{-Value} = \frac{1}{\text{Thermal Resistance of a material (R)}}$$

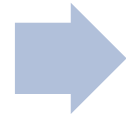
$$\text{Where } R = \frac{\text{Thickness of material (t)}}{\text{Conductivity (k)}}$$

Conductivity (k) is the rate at which heat travels through 1 meter thick material. It is a property of a material

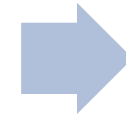
## ENS 2018-BUILDING ENVELOPE PHYSICS

### TYPES OF WALL AND THEIR U-VALUE

150 mm RCC  
(No plaster)  
U Value 3.77  
W/m<sup>2</sup>K

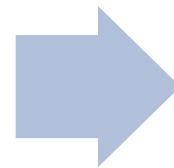


Block with 15  
mm plaster  
on both sides  
—



with 15 mm  
plaster on  
both sides  
U Value 1.72

200 mm Autoclaved  
Aerated Concrete  
(AAC) with 15 mm  
plaster on both side  
U Value 0.77 W/m<sup>2</sup>K



300 mm Autoclaved  
Aerated Concrete  
(AAC) with 15 mm  
plaster on both sides  
U Value 0.54 W/m<sup>2</sup>K

## ENS 2018-BUILDING ENVELOPE PHYSICS

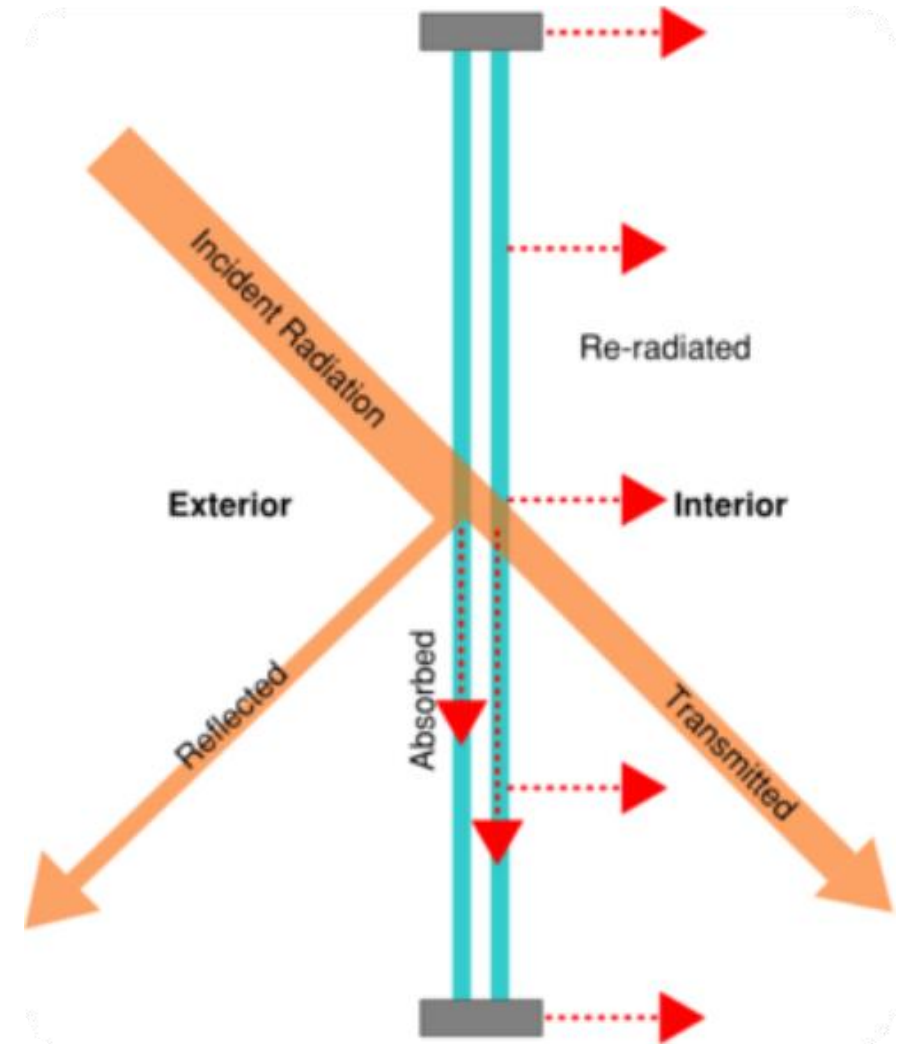
### SHGC

### Solar Heat Gain Coefficient

#### Definition:

SHGC is the fraction of incident solar radiation admitted through a window, both directly transmitted and absorbed and subsequently released inward.

The value of SHGC varies from 0 - 1

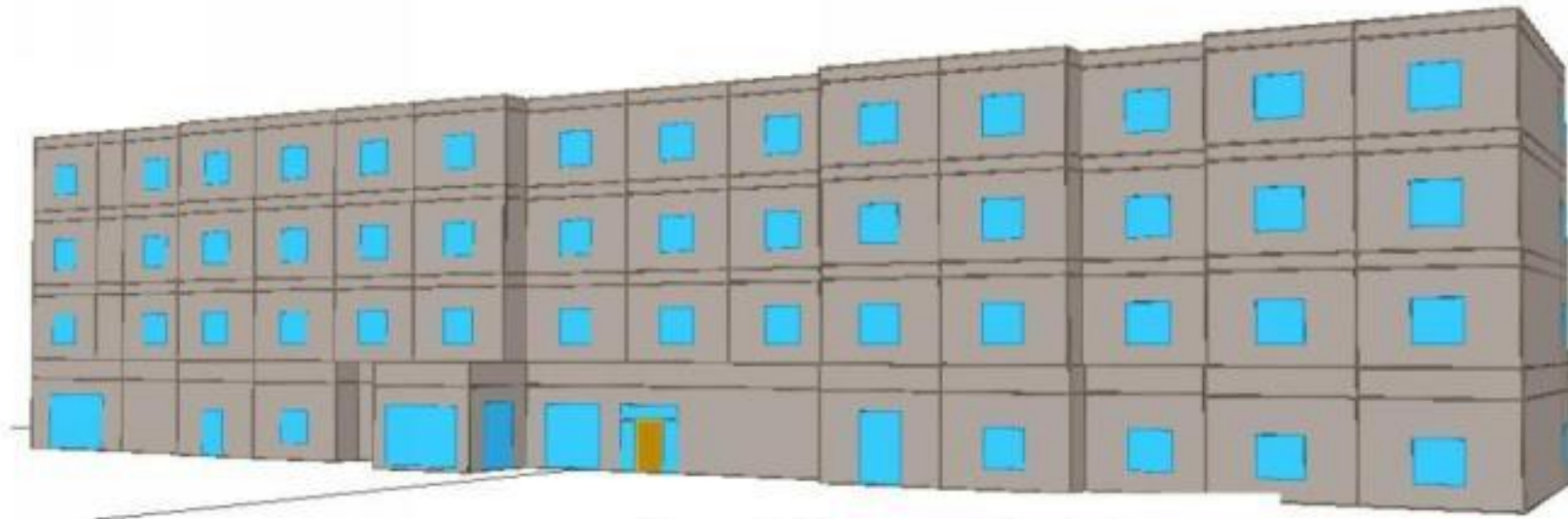




## ENS 2018-BUILDING ENVELOPE PHYSICS

### WINDOW TO WALL AREA RATIO (WWR)

$$WWR = \frac{\text{Area of Non - Opaque Windows \& Openings}}{\text{Total Area of Exterior Walls Including Windows \& Openings}}$$



## ENS 2018-BUILDING ENVELOPE PHYSICS

### WINDOW TO WALL AREA RATIO (WWR)



$$WWR = \frac{30 + 30}{40 + 30 + 30}$$

$$WWR = \frac{60}{100}$$

$$WWR = 0.6$$

$$= 60\%$$

## ENS 2018-BUILDING ENVELOPE PHYSICS

### VISIBLE LIGHT TRANSMITTANCE (VLT)

VLT is **V**isual **L**ight **T**ransmittance

Definition:

The amount of light in the visible portion of the spectrum that passes through a glazed material.

5%      15%      20%      30%      35%      50%      75%



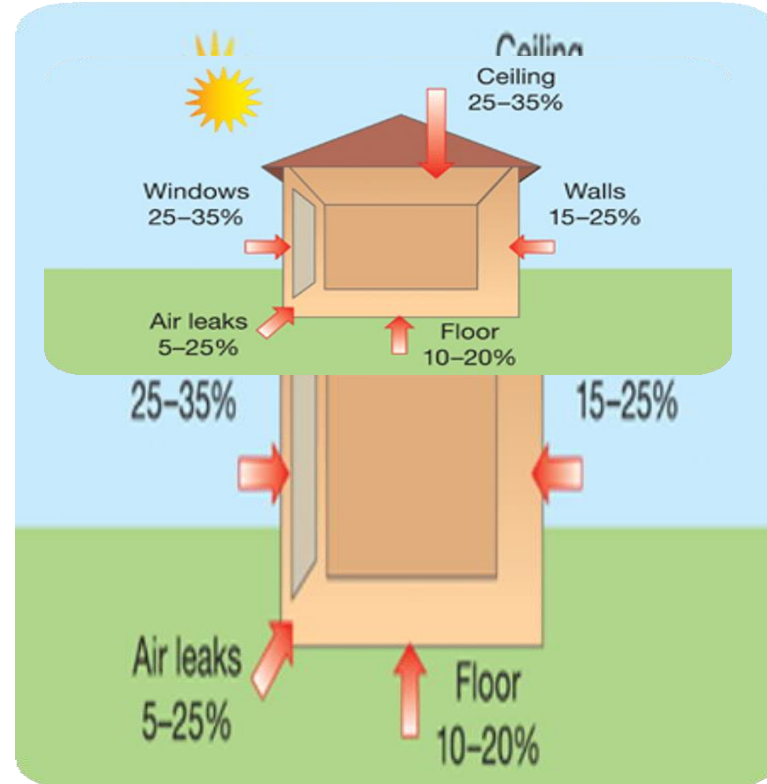
The higher the VLT, the more is the daylight received inside the building through glass.

# ENS 2018-BUILDING ENVELOPE COMPLIANCE REQUIREMENTS



## Transparency

1. Window to Wall Ratio
2. Visual Light Transmittance



## Heat transfer

3. U-Value of Walls
4. Solar Heat Gain Coefficient
5. U-Value of Roofs



## Ventilation

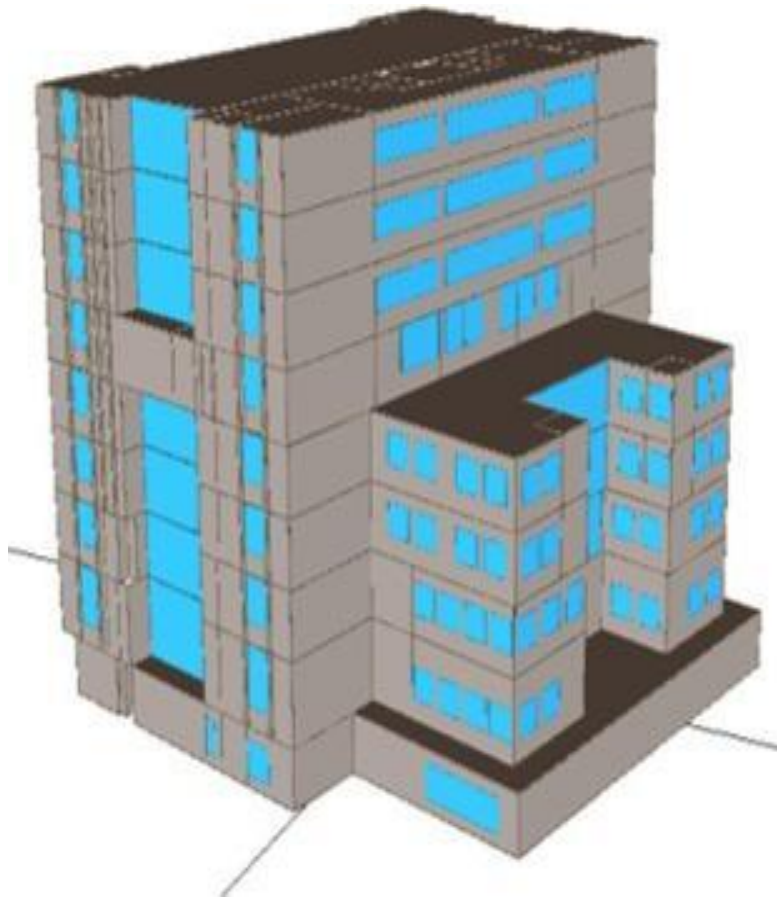
6. Window to Floor Area Ratio

## ENS 2018-BUILDING ENVELOPE VLT AND WWR

**Minimum VLT shall not be less than the values given in the Table below:-**

Window-to-wall ratio (WWR)	Minimum VLT
0-0.30	0.27
0.31-0.40	0.20
0.41-0.50	0.16
0.51-0.60	0.13
0.61-0.70	0.11

## THERMAL TRANSMITTANCE U-VALUE ROOF



Thermal Transmittance  
of Roof ( $U_{roof}$ )

Thermal transmittance ( $U_{roof}$ ) characterizes the thermal performance of the roof of a building.

Maximum  $U_{roof}$ : **1.2 W/m<sup>2</sup>K.**

## RETV-RESIDENTIAL ENVELOPE TRANSMITTANCE VALUE

**RETV** can be calculated by using the following formula:-

$$RETV = \frac{1}{A_{envelope}} \times \left[ \begin{array}{l} \left\{ a \times \sum_{i=1}^n \left( A_{opaque_i} \times U_{opaque_i} \times \omega_i \right) \right\} \\ + \left\{ b \times \sum_{i=1}^n \left( A_{non-opaque_i} \times U_{non-opaque_i} \times \omega_i \right) \right\} \\ + \left\{ c \times \sum_{i=1}^n \left( A_{non-opaque_i} \times SHGC_{eq_i} \times \omega_i \right) \right\} \end{array} \right]$$

Wall Conductive Heat Gains  
Window Conductive Heat Gain  
Window Radiation Heat Gain

- The RETV of the building envelope (except roof) for four climate zones, namely, Composite Climate, Hot- Dry Climate, Warm-Humid Climate, and Temperate Climate, shall comply with the maximum **RETV of 15 W/m<sup>2</sup>**

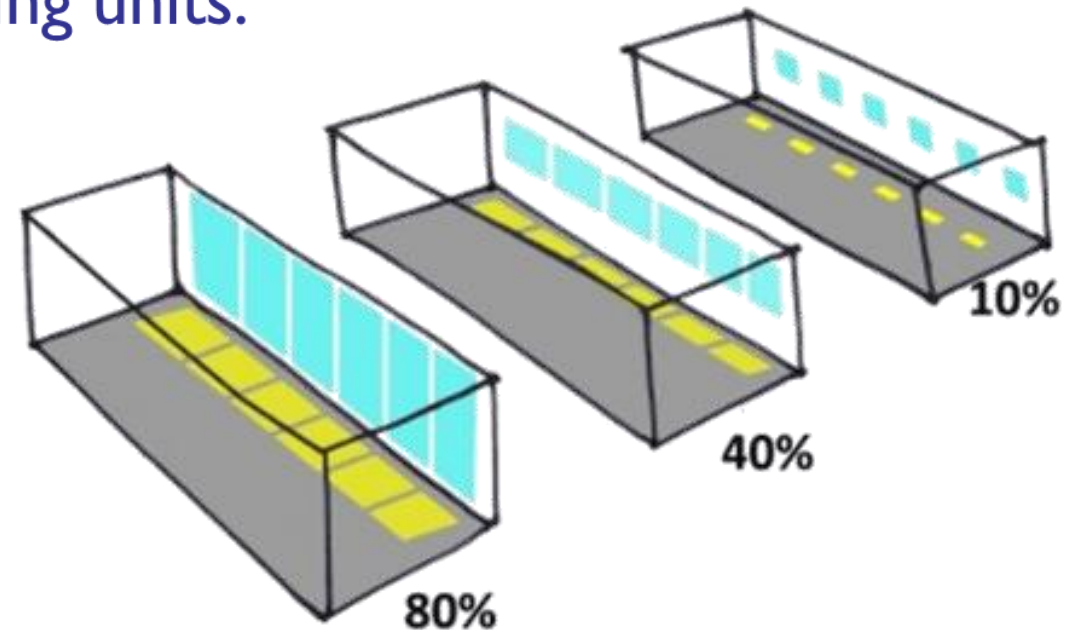
## WINDOW TO FLOOR AREA RATIO

$WFR_{OP}$  is Openable Window to Floor Area Ratio

Definition:

The openable window-to-floor area ratio ( $WFR_{op}$ ) is the ratio of openable area to the carpet area of dwelling units.

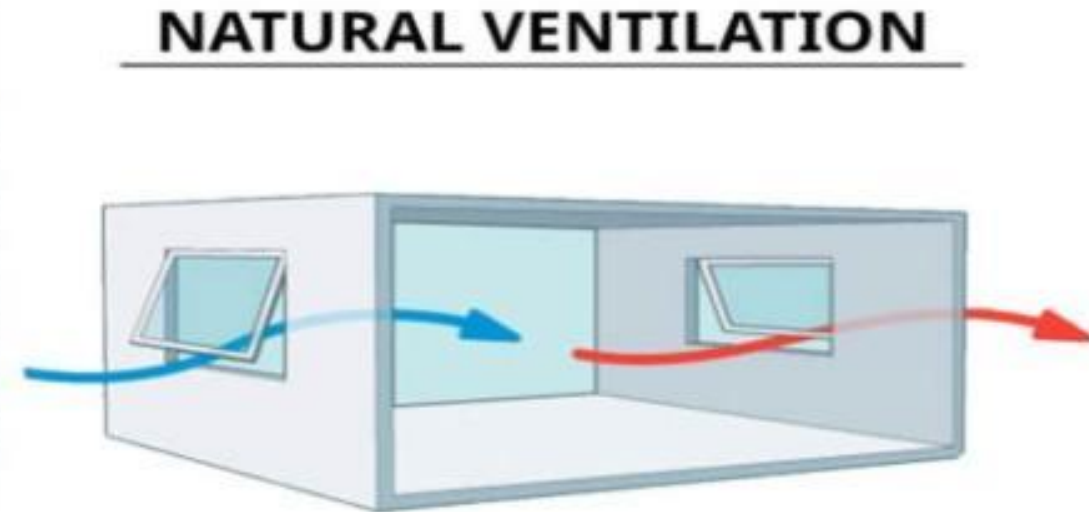
$$WFR_{op} = \frac{A_{openable}}{A_{Carpet}}$$





## WINDOW TO FLOOR AREA RATIO

- ✓ Higher  $WFR_{op}$  helps in enhancement in
- ✓ Natural Ventilation
- ✓ Thermal comfort
- ✓ Cooling Energy Savings



## WINDOW TO FLOOR AREA RATIO CALCULATION



Floor Area 100m<sup>2</sup>

Calculation:

$$\text{WFR} = \frac{54}{100}$$

$$\begin{aligned}\text{WFR} &= 0.54 \\ &= 54\%\end{aligned}$$

## WINDOW TO FLOOR AREA RATIO REQUIREMENT

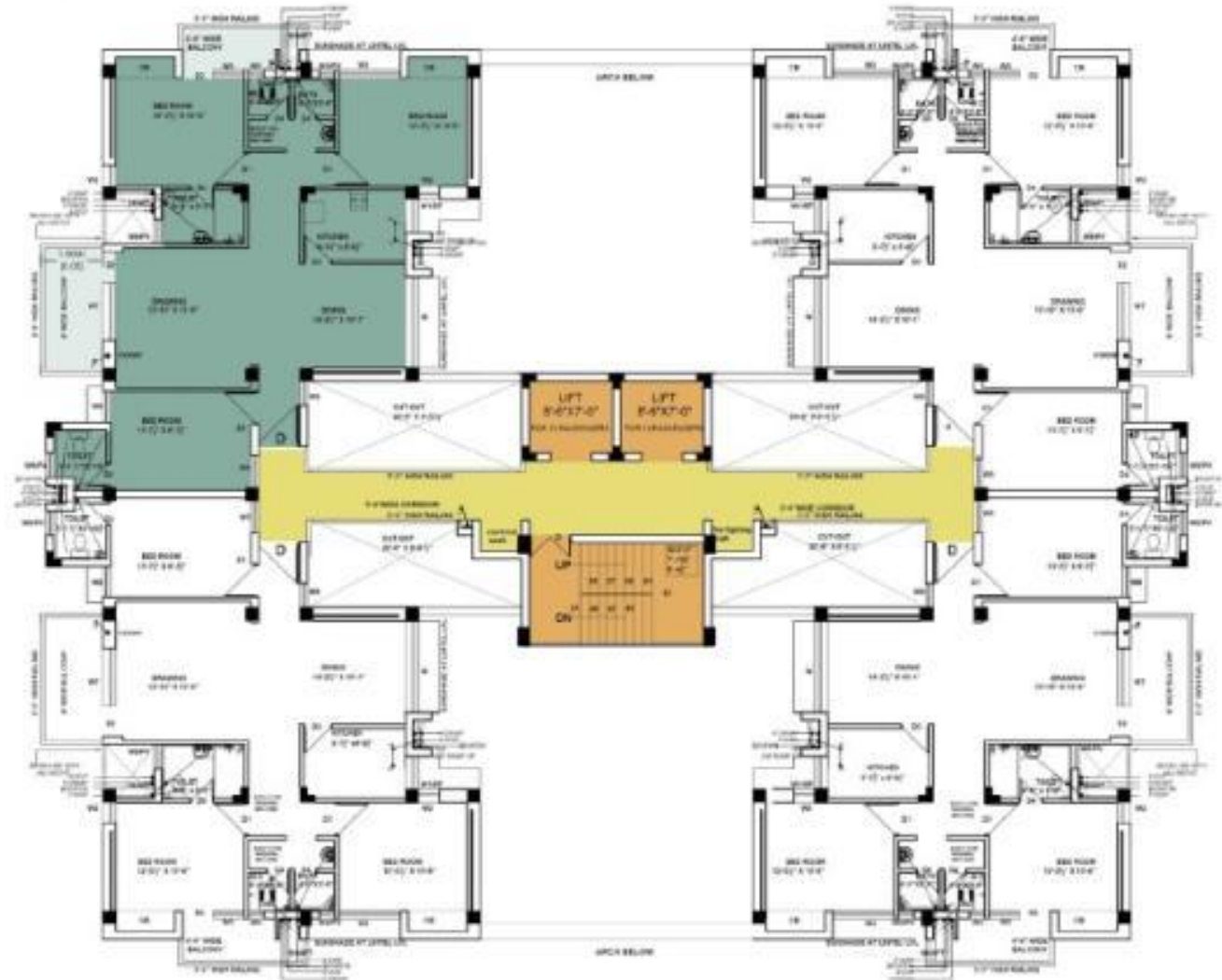
Climatic Zone	Minimum percentage (%) of $WFR_{op}$
Composite	12.50
Hot-Dry	10.00
Warm - Humid	16.66
Temperate	12.50
Cold	8.33

## ENS CASE STUDY RESIDENTIAL QUARTER NABARD

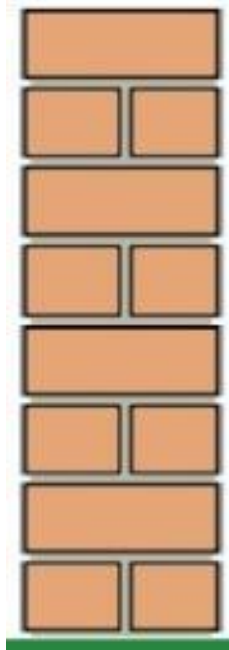
- Residential quarters built for the **NABARD** (*National Bank For Agriculture & Rural Development*) staff at Mohali.
- The climate type is composite and is similar to that of Chandigarh.

**No. of dwelling units in Block II  
(DU): 20 (all 2 BHK) Stilt + 5  
storeys**

***PLAN OF RESIDENTIAL QUARTER***



## Case I: 230 mm brick wall + Normal WWR + Single Clear Glazing + No Shading of Windows

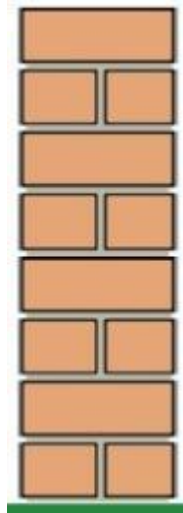


	RETV Wall conduction	RETV Window conduction	RETV Window Radiation	RETV (TOTAL)
Case.1 • Brick Wall • No Shading • Single clear glazing • WWR: ~14%	10.1	1.8	9.6	<b>21.5</b>

230mm Normal  
Brick wall with U  
value – 2 w/m<sup>2</sup>k

- **RETV: 21.5 W/m<sup>2</sup> higher than 15 W/m<sup>2</sup> (Non compliant)**
- Heat conduction through wall is high and high heat gain through windows with no shading

## Case II: Case I + Proper Shading of Windows



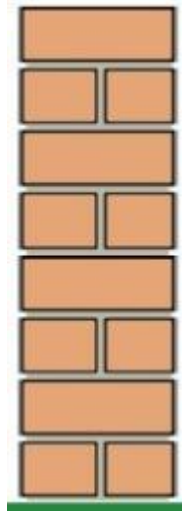
230mm Normal  
Brick wall with U  
value – 2 w/m<sup>2</sup>k



	RETV Wall conduction	RETV Window conduction	RETV Window Radiation	RETV (TOTAL)
Case.2 • Brick Wall • <b>Shading with overhang &amp; Fins</b> • Single clear glazing • WWR: ~14%	10.1	1.8	<b>6.7</b>	<b>18.6</b>

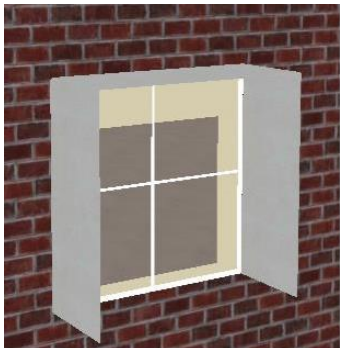
- **RETV = 18.6 W/m<sup>2</sup>**
- **Shading helps in reducing heat gain through windows**

## Case III: Case II+ Single reflective glass



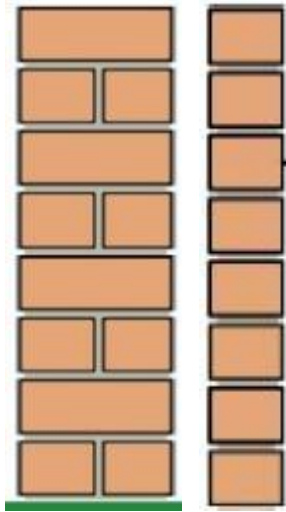
230mm Normal  
Brick wall with U  
value – 2 w/m<sup>2</sup>k

	RETV Wall conduction	RETV Window conduction	RETV Window Radiation	RETV (TOTAL)
Case.3 • Brick Wall • Shading with overhang & Fins • <b>Single                      reflective                      glazing</b> • WWR: ~14%	10.1	1.8	<b>4.5</b>	<b>16.3</b>



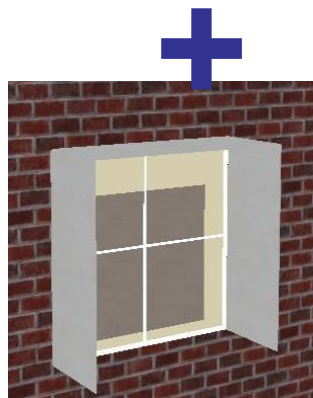
- **RETV = 16.3 W/m<sup>2</sup>**
- High Reflective Glass also helps in reducing heat gain through windows

# Case IV: (Final Design Constructed) Brick cavity wall+ Shading+ Single reflective glass



230 mm + 40 mm cavity +115 mm brick with U value – 1.1 w/ m<sup>2</sup>k

	RETV Wall conduction	RETV Window conduction	RETV Window Radiation	RETV (TOTAL)
Case.4 <ul style="list-style-type: none"> <li>• <b>Brick Cavity Wall</b></li> <li>• Shading with overhang &amp; Fins</li> <li>• Single reflective glazing</li> <li>• WWR: ~14%</li> </ul>	<b>6.6</b>	1.8	4.5	<b>12.8</b>



- **RETV = 12.8 W/m<sup>2</sup>**
- **Cavity in Brick reduces the conduction heat gain**



	RETV Wall conduction	RETV Window conduction	RETV Window Radiation	RETV (TOTAL)
<b>Case.1</b> <ul style="list-style-type: none"> <li>Brick Wall</li> <li>No Shading</li> <li>Single clear glazing</li> <li>WWR: ~14%</li> </ul>	10.1	1.8	9.6	<b>21.5</b>
<b>Case.2</b> <ul style="list-style-type: none"> <li>Brick Wall</li> <li><b>Shading with overhang &amp; Fins</b></li> <li>Single clear glazing</li> <li>WWR: ~14%</li> </ul>	10.1	1.8	<b>6.7</b>	<b>18.6</b>
<b>Case.3</b> <ul style="list-style-type: none"> <li>Brick Wall</li> <li>Shading with overhang &amp; Fins</li> <li><b>Single reflective glazing</b></li> <li>WWR: ~14%</li> </ul>	10.1	1.8	<b>4.5</b>	<b>16.3</b>
<b>Case.4</b> <ul style="list-style-type: none"> <li><b>Cavity Brick Wall</b></li> <li>Shading with overhang &amp; Fins</li> <li>Single reflective glazing</li> <li>WWR: ~14%</li> </ul>	<b>6.6</b>	1.8	4.5	<b>12.8</b>
<b>Case.5</b> <ul style="list-style-type: none"> <li><b>AAC Block</b></li> <li>Shading with overhang &amp; Fins</li> <li>Single reflective glazing</li> <li>WWR: ~14%</li> </ul>	<b>4.7</b>	1.8	4.5	<b>10.9</b>

# ENS(ECO NIWAS SAMHITA 2021 PART-2

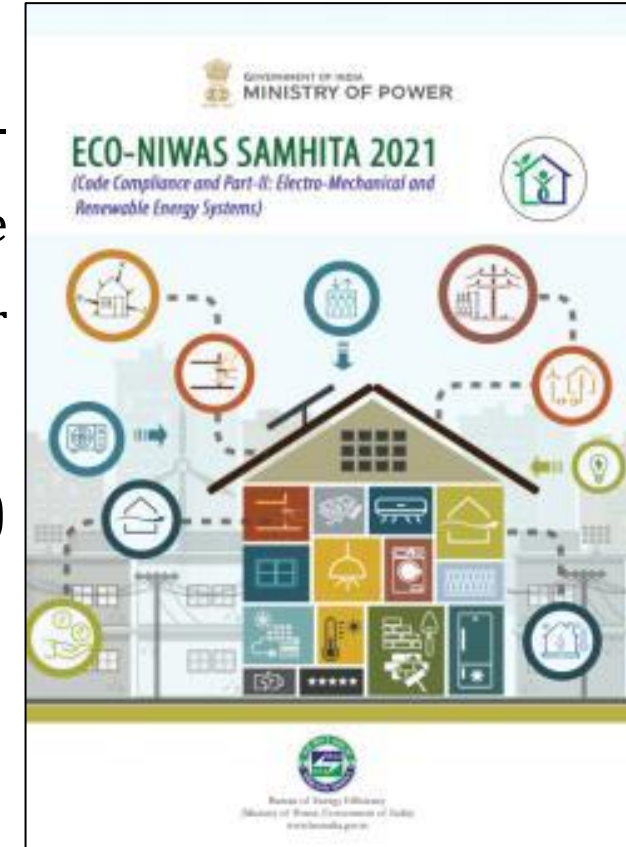
## Introduction

The **Eco Niwas Samhita 2021** (Code Compliance and Part-II: Electro-Mechanical and Renewable Energy Systems) is a code specifying code compliance approaches and minimum energy performance requirements for building services, indoor electrical end-use and renewable energy system.

ENS 2021 is for code compliance and to provide the minimum requirement(s) for:

1. ***Building services***
2. ***Electro-mechanical***
3. ***Renewable energy systems for new residential buildings.***

**Note:-**The code sets minimum requirement for all building envelope parameters as mentioned in Eco Niwas Samhita 2018 (Part I: Building Envelope).



**PART-2: Building Services, Indoor Electrical Use, Renewable Energy Systems (launched in 2021)**

## ENS(ECO NIWAS SAMHITA 2021 PART-2

### ENS-Part 2 Applicability

The **ECO NIWAS SAMHITA 2021** (based on the category of project) applies to the following essential design elements of a building:

- **Building envelope** (minimum performance requirements for RETV, Roof thermal Conductance, Window to floor area ratio and Visible Light Transmittance)
- **Building Services** (minimum performance criteria for common area lighting, lifts, pumps, DG Sets, Transformers, Car Parking etc)
- **Indoor Electrical Use** (maximum interior lighting power density allowance, minimum performance requirements for ceiling fans and cooling systems)
- **Renewable energy systems** (mandatory provisions for renewable systems in design).



# ENS(ECO NIWAS SAMHITA 2021 PART-2

## Mandatory Requirements

- 1. Building Envelope**-All requirements for building envelope under mandatory section as mentioned in Chapter 4 of ENS Part I.
  - Openable window to floor area ratio ( $WFR_{op}$ )
  - Visible light Transmittance( $VLT$ )
  - Thermal Transmittance of roof or U-Value of roof
  - Residential Envelope transmittance Value( $RETV$ )
- 2. Power Factor Correction**
- 3. Energy Monitoring**
- 4. Electric Vehicle Charging System**
- 5. Electrical Systems**

# ENS(ECO NIWAS SAMHITA 2021 PART-2

## Prescriptive Requirements

**1. Building Envelope-**All requirements for building envelope under mandatory section as mentioned in Chapter 4 of ENS Part I. The Residential Envelope Transmittance Value (RETV) for the building envelope (except roof) for four climate zones shall comply with the maximum RETV of 12 W/m<sup>2</sup> . Thermal transmittance of building envelope for cold climate shall comply with the maximum U value of 1.3 W/m<sup>2</sup> ·K.

- Openable window to floor area ratio ( $WFR_{op}$ )
- Visible light Transmittance( $VLT$ )
- Thermal Transmittance of roof or U-Value of roof
- Residential Envelope transmittance Value( $RETV$ )

## 2. Common Area and Exterior Lighting

Common Areas	Maximum LPD (W/m <sup>2</sup> )	Minimum luminous efficacy (lm/W)
Corridor lighting & Stilt Parking	3.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 105 lumens per Watt
Basement Lighting	1.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 105 lumens per Watt
Exterior Lighting Areas		Maximum LPD (in W/m <sup>2</sup> )
Driveways and parking (open/ external)		1.6
Pedestrian walkways		2.0
Stairways		10.0
Landscaping		0.5
Outdoor sales area		9.0

# ENS(ECO NIWAS SAMHITA 2021 PART-2

## Prescriptive Requirements

### 3. Elevators if Applicable

The Elevators installed in the ENS compliant building shall meet the following requirements:

- i. Install high efficacy lamps for lift car lighting having minimum luminous efficacy of 85 lm/W
- ii. Install automatic switch-off controls for lighting and fan inside the lift car when are not occupied
- iii. Install minimum class IE 4 high efficiency motors
- iv. Installing the variable voltage and variable frequency drives
- v. Installing regenerative drives.
- vi. Group automatic operation of two or more elevators coordinated by supervisory control

### 4. Pumps if Applicable

Either hydro-pneumatic pumps having minimum mechanical efficiency of 70% or BEE 5 star rated Pumps shall be installed in the ENS building.

# ENS(ECO NIWAS SAMHITA 2021 PART-2

## Prescriptive Requirements

### 5. Electrical Systems

Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating. The permissible loss shall not exceed the values listed in Table 6 for dry type transformers and BEE 5-star rating in Table 7 for oil type transformers.

## ENS(ECO NIWAS SAMHITA 2021 PART-2

### Openable Window-to-Floor Area Ratio (WFR<sub>op</sub>)

- Openable **window-to-floor area ratio** (WFR<sub>op</sub>) indicates the potential of using external air for ventilation.
- Ensuring minimum WFR<sub>op</sub> helps in ventilation, improvement in thermal comfort, and reduction in cooling energy.
- The openable window-to-floor area ratio (WFR<sub>op</sub>) is the **ratio of openable area to the carpet area of dwelling units.**

$$WFR_{op} = \frac{A_{openable}}{A_{carpet}}$$

#### **Note:**

**$A_{openable}$**  : **Openable area (m<sup>2</sup>)**; it includes the openable area of all windows and ventilators, opening directly to the external air, an open balcony, 'verandah', corridor or shaft; and the openable area of the doors opening directly into an open balcony.

*Exclusions: All doors opening into corridors. External doors on ground floor, for example, ground-floor entrance doors or back-yard doors.*

**$A_{carpet}$**  : **Carpet area of dwelling units (m<sup>2</sup>)**; it is the net usable floor area of a dwelling unit, excluding the area covered by the external walls, areas under services shafts, exclusive balcony or verandah area and exclusive open terrace area, but includes the area covered by the internal partition walls of the dwelling unit



## ENS(ECO NIWAS SAMHITA 2021 PART-2

### Openable Window-to-Floor Area Ratio (WFR<sub>op</sub>)

$$WFR_{op} = \frac{A_{openable}}{A_{carpet}}$$

**TABLE 1** Minimum requirement of window-to-floor area ratio (WFR<sub>op</sub>)

Climatic zone	Minimum WFR <sub>op</sub> (%)
Composite	12.50
Hot-Dry	10.00
Warm-Humid	16.66
Temperate	12.50
Cold	8.33

**SOURCE** Adapted from Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.

## ENS(ECO NIWAS SAMHITA 2021 PART-2

### Visible light transmittance(VLT)

- **Visible light transmittance (VLT)** of non-opaque building envelope components (transparent/translucent panels in windows, doors, ventilators, etc.), indicates the potential of using daylight.
- Ensuring minimum VLT helps in improving daylighting, thereby reducing the energy required for artificial lighting
- The VLT requirement is applicable as per the window-to-wall ratio (WWR) of the building.
- WWR is the ratio of the area of non-opaque building envelope components of dwelling units to the envelope area (excluding roof) of dwelling units.

$$WWR = \frac{A_{non-opaque}}{A_{envelope}}$$

TABLE 2 Minimum visible light transmittance (VLT) requirement<sup>15</sup>

Window-to-wall ratio (WWR) <sup>16</sup>	Minimum VLT <sup>17</sup>
0–0.30	0.27
0.31–0.40	0.20
0.41–0.50	0.16
0.51–0.60	0.13
0.61–0.70	0.11

SOURCE Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.

## ENS(ECO NIWAS SAMHITA 2021 PART-2

### Thermal transmittance Roof

- **Thermal transmittance (U-roof)** characterizes the thermal performance of the roof assembly of a building.
- Limiting the Uroof helps in reducing heat gains or losses from the roof, thereby improving the thermal comfort and reducing the energy required for cooling or heating.
- Thermal transmittance of roof shall comply with the maximum U-roof value of 1.2 W/m<sup>2</sup>.K

$$U_{roof} = \frac{1}{A_{roof}} \left[ \sum_{i=1}^n (U_i \times A_i) \right]$$

where,

$U_{roof}$  : thermal transmittance of roof (W/m<sup>2</sup>.K)

$A_{roof}$  : total area of the roof (m<sup>2</sup>)

$U_i$  : thermal transmittance values of different roof constructions (W/m<sup>2</sup>.K)

$A_i$  : areas of different roof constructions (m<sup>2</sup>)

## ENS(ECO NIWAS SAMHITA 2021 PART-2

### Residential envelope transmittance value (RETV)

- Applicable for building envelope (except roof) for four climate zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperate Climate.
- **Residential envelope heat transmittance (RETV)** is the net heat gain rate (over the cooling period) through the building envelope (excluding roof) of the dwelling units divided by the area of the building envelope (excluding roof) of the dwelling units.
- Its unit is  $W/m^2$
- RETV characterizes the thermal performance of the building envelope (except roof).
- Limiting the RETV value helps in reducing heat gains from the building envelope, thereby improving the thermal comfort and reducing the electricity required for cooling.

## ENS(ECO NIWAS SAMHITA 2021 PART-2

### Residential envelope transmittance value (RETV)

RETV formula takes into account the following:

- Heat conduction through opaque building envelope components (wall, opaque panels in doors, windows, ventilators, etc.),
- Heat conduction through non-opaque building envelope components (transparent/ translucent panels of windows, doors, ventilators, etc.),
- Solar radiation through non-opaque building envelope components (transparent/translucent panels of windows, doors, ventilators, etc.)
- The RETV for the building envelope (except roof) for four climate zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperate Climate, shall comply with the maximum RETV\* of 15 W/m<sup>2</sup>.

*\*BEE plans to improve the RETV norm to 12 W/m<sup>2</sup> in the near future and the building industry and regulating agencies are encouraged to aim for it.*

## ENS(ECO NIWAS SAMHITA 2021 PART-2

### Residential envelope transmittance value (RETV)

$$RETV = \frac{1}{A_{envelope}} \times \left[ \begin{aligned} & \left\{ a \times \sum_{i=1}^n (A_{opaque_i} \times U_{opaque_i} \times \omega_i) \right\} \\ & + \left\{ b \times \sum_{i=1}^n (A_{non-opaque_i} \times U_{non-opaque_i} \times \omega_i) \right\} \\ & + \left\{ c \times \sum_{i=1}^n (A_{non-opaque_i} \times SHGC_{eq_i} \times \omega_i) \right\} \end{aligned} \right]$$

where,

$A_{envelope}$  : envelope area (excluding roof) of dwelling units (m<sup>2</sup>). It is the gross external wall area (includes the area of the walls and the openings such as windows and doors).

$A_{opaque}$  : areas of different opaque building envelope components (m<sup>2</sup>)

$U_{opaque}$  : thermal transmittance values of different opaque building envelope components (W/m<sup>2</sup>.K)

$A_{non-opaque}$  : areas of different non-opaque building envelope components (m<sup>2</sup>)

$U_{non-opaque}$  : thermal transmittance values of different non-opaque building envelope components (W/m<sup>2</sup>.K)

$SHGC_{eq_i}$  : equivalent solar heat gain coefficient values of different non-opaque building envelope components

$\omega_i$  : orientation factor of respective opaque and non-opaque building envelope components; it is a measure of the amount of direct and diffused solar radiation that is received on the vertical surface in a specific orientation

# ENS(ECO NIWAS SAMHITA 2021 PART-2

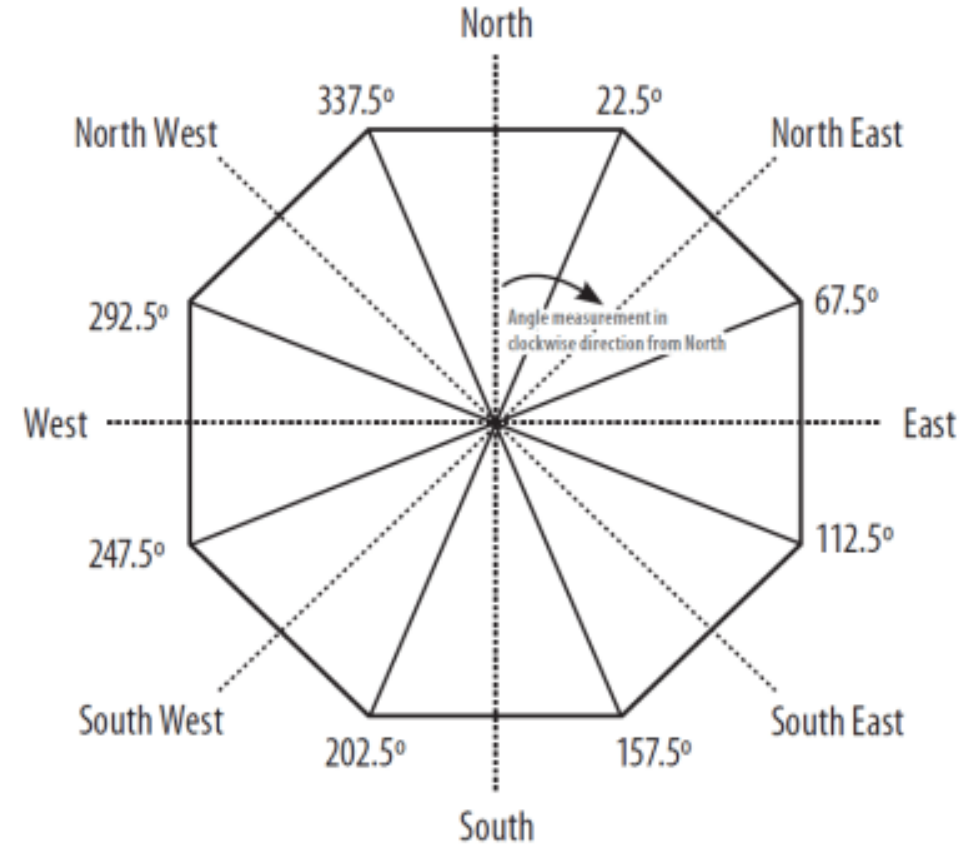
## Residential envelope transmittance value (RETV)

Coefficients (a, b, and c) for RETV formula

Climate zone	a	b	c
Composite	6.06	1.85	68.99
Hot-Dry	6.06	1.85	68.99
Warm-Humid	5.15	1.31	65.21
Temperate	3.38	0.37	63.69
Cold	Not applicable (Refer Section 3.5)		

Orientation factor ( $\omega$ ) for different orientations

Orientation	Orientation factor ( $\omega$ )	
	Latitudes $\geq 23.5^\circ\text{N}$	Latitudes $< 23.5^\circ\text{N}$
North ( $337.6^\circ$ – $22.5^\circ$ )	0.550	0.659
North-east ( $22.6^\circ$ – $67.5^\circ$ )	0.829	0.906
East ( $67.6^\circ$ – $112.5^\circ$ )	1.155	1.155
South-east ( $112.6^\circ$ – $157.5^\circ$ )	1.211	1.125
South ( $157.6^\circ$ – $202.5^\circ$ )	1.089	0.966
South-west ( $202.6^\circ$ – $247.5^\circ$ )	1.202	1.124
West ( $247.6^\circ$ – $292.5^\circ$ )	1.143	1.156
North-west ( $292.6^\circ$ – $337.5^\circ$ )	0.821	0.908



## ENS(ECO NIWAS SAMHITA 2021 PART-2

### Thermal Transmittance of building envelope (except roof) for cold climate (U<sub>envelope,cold</sub>)

- Thermal transmittance ( $U_{envelope,cold}$ ) characterizes the thermal performance of the building envelope (except roof). Limiting the  $U_{envelope,cold}$  helps in reducing heat losses from the building envelope, thereby improving the thermal comfort and reducing the energy required for heating
- Thermal transmittance of the building envelope (except roof) for cold climate shall comply with **the maximum of 1.8 W/m<sup>2</sup>.K.**

$$U_{envelope,cold} = \frac{1}{A_{envelope}} \left[ \sum_{i=1}^n (U_i \times A_i) \right] \quad \dots(5)$$

where,

$U_{envelope,cold}$  : thermal transmittance of building envelope (except roof) for cold climate (W/m<sup>2</sup>.K)

$A_{envelope}$  : envelope area (excluding roof) of dwelling units (m<sup>2</sup>). It is the gross external wall area (includes the area of the walls and the openings such as windows and doors)

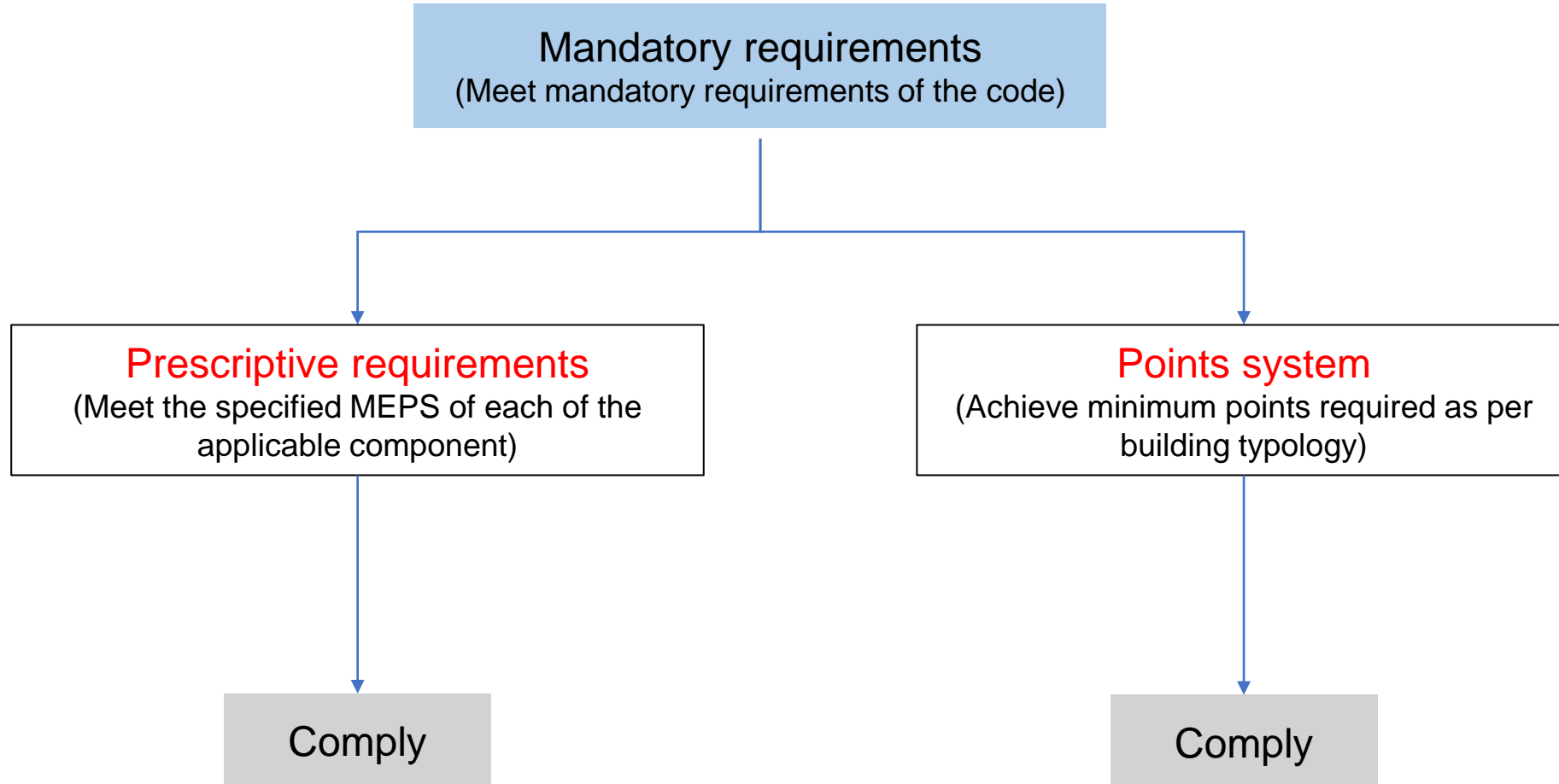
$U_i$  : thermal transmittance of different opaque and non-opaque building envelope components (W/m<sup>2</sup>.K)

$A_i$  : area of different opaque and non-opaque opaque building envelope components (m<sup>2</sup>)



# ENS(ECO NIWAS SAMHITA 2021 PART-2

## Code Compliance



# ENS(ECO NIWAS SAMHITA 2021 PART-2

## Applicable components as per compliance method

- In order to demonstrate compliance with the code through the **Prescriptive Method**, the ENS building shall meet mandatory requirements specified along with prescriptive requirements.
- In order to demonstrate compliance with the code through the **Point System Method**, the ENS building shall meet all applicable mandatory requirements along with point system requirements.

		Mandatory	Prescriptive	Point System
<b>1</b>	<b>Envelope</b>			
1.1	RETV		✓	✓
1.2	Building Envelope Cold (Uenvelope)		✓	✓
1.3	U-value Roof		✓	✓
1.4	WFRop	✓		
1.5	VLT	✓		
<b>2</b>	<b>Building Services</b>			
2.1	Common area & Exterior Lighting			
2.1.1	Outdoor Lighting		✓	✓
2.1.2	Corridor Lighting		✓	✓
2.1.3	Basement Lighting		✓	✓
2.2	Lifts		✓	✓
2.3	Pumps		✓	✓
2.4	DG Set	✓		
2.5	PD Losses	✓		
2.5	Transformer		✓	✓
2.6	Power Factor Correction	✓		
2.7	Electric Vehicle Supply Equipment	✓		
2.8	Energy Monitoring	✓		
<b>3</b>	<b>Indoor Electrical End Use</b>			
3.1	Indoor Lighting			✓
3.3	Comfort Systems			
3.3.1	Ceiling Fans			✓
3.3.2	AC			✓
3.3.3	VRF			✓
3.3.4	Centralised Air-Conditioning System			✓
<b>4</b>	<b>Renewable Energy System</b>			
4.1	Solar HW			✓
4.2	Solar PV			✓

## ENS(ECO NIWAS SAMHITA 2021 PART-2

### Different scores based on the project types and typologies

In order to demonstrate compliance with the code, the ENS building shall comply with all applicable mandatory requirements and shall achieve a minimum ENS Score by following either the prescriptive method or the point system method. The table below gives the minimum ENS score required to be obtained as per eligible project category:

Project Category	Minimum ENS Score
Affordable high-rise housing	70
Low-rise buildings*	47
Other High-rise buildings	100

\*Low-rise buildings should only meet envelope requirements to show ENS compliance

**Affordable housing:** Housing projects where 35% of the houses are constructed for EWS category (PMAY Definition)

**Low rise buildings:** A building equal or below 4 stories, and/or a building up to 15 meters in height (without stilt) and up to 17.5 meters (including stilt).

**High rise buildings:** A building above 4 stories, and/or a building exceeding 15 meters or more in height (without stilt) and 17.5 meters (including stilt).

# ENS(ECO NIWAS SAMHITA 2021 PART-2

## ENS-Part 2 Component wise score distribution for compliance

Components	Minimum Points	Additional Points	Maximum Points
Building Envelope			
Building Envelope	47	40	87
Building Services			
Common area & exterior lighting	3	6	9
Elevators	13	9	22
Pumps	6	8	14
Electrical Systems	1	5	6
Indoor Electrical End-Use			
Indoor Lighting		12	12
Comfort Systems		50	50
ENS Score	70	130	200

Renewable Energy Systems Components	Minimum Points	Additional Points	Maximum Points
Solar Hot Water Systems		10	10
Solar Photo Voltaic		10	10
Additional ENS Score		20	20

- **Minimum points:** are the set of points which are compulsory to achieve for each component to show compliance for ENS
- **Additional Points:** are the set of points which are awarded for adopting additional or better energy efficiency measures in a respective component. These points are trade able with other components to achieve the total score mentioned in section 3.1.2 for ENS compliance.
- **Maximum points** are the total points available for each component.

# ENS(ECO NIWAS SAMHITA 2021 PART-2




## Final Point System

- Envelope
- Building Services
- Indoor Electrical End Use
- Renewable Energy System

		Always Applicable/Elective	Minimum Points	Essential Points	Additional Points	Maximum
<b>1</b>	<b>Envelope</b>					<b>87</b>
1.1	RETV or Building Envelope Cold	Applicable	44	44	36	80
1.2	U-value Roof	Applicable	3	3	4	7
1.3	WFRop	Applicable				
1.4	VLT	Applicable				
<b>2</b>	<b>Building Services</b>					<b>51</b>
2.1	Common area Lighting	Applicable	3	3	6	9
2.1.1	Outdoor Lighting	Meet minimum requirements, as applicable				
2.1.2	Corridor Lighting	Meet minimum requirements, as applicable				
2.1.3	Basement Lighting	Meet minimum requirements, as applicable				
2.2	Lifts	Applicable	13	13	9	22
2.3	Pumps	Applicable	6	6	8	14
2.4	Transformer	Applicable	1	1	5	6
<b>3</b>	<b>Indoor Electrical End Use</b>					<b>62</b>
3.1	Indoor Lighting	Meet minimum requirements, as applicable	4		8	12
3.2	Comfort Systems	Meet minimum requirements, as applicable	26		24	50
<b>TOTAL</b>						<b>200</b>
<b>4</b>	<b>Renewable Energy System</b>					<b>20</b>
4.1	Solar HW	Meet minimum requirements, as applicable				10
4.2	Solar PV	Meet minimum requirements, as applicable				10

# ECO NIWAS SAMHITA-2018, CODE COMPLIANCE EXAMPLE POINT SYSTEM

Category	Requirement	Minimum Points	Additional Points	Minimum, if opted
Building Envelope	Uroof	3	4	
	RETV	44	36	
	Ucold	44	36	
Building Services	CA Lighting	1	2	
	CAL>Corridor	1	2	
	CAL>Outdoor	1	2	
	CAL>Basement	1	2	
	Lifts	13	9	
	Pumps	6	8	
	Electrical Sys	1	5	
Indoor End Use	Ind Lighting	4	8	
	Comfort Sys	6	3	
	CS>Fans	20	21	
	CS>Central AC	20	21	
RE Systems	Solar HW	5	5	
	Solar PV	5	5	

 Minimum Points  
 Additional Points  
 Minimum, if opted

# ECO NIWAS SAMHITA, CODE COMPLIANCE EXAMPLE POINT SYSTEM

Point System - A building opting for all 3 sections and getting 100 points

Building Envelope	Uroof		3	4	3	U - 1.2 W/m <sup>2</sup> .K	47
	RETV		44	36	44	RETV: 15 W/m <sup>2</sup>	
Building Services	CA Lighting	CAL>Corridor	1	2	1	3.0 W/m <sup>2</sup> LPD & at least 85 lumens/W	23
		CAL>Outdoor	1	2	1	LPD as per table & at least 85 lumens/W	
		CAL>Basement	1	2	1	1.0 W/m <sup>2</sup> LPD & at least 85 lumens/W	
	Lifts	13	9	13	85 lumen/watt, Automatic, class IE 3 motors, Sequencing		
	Pumps	6	8	6	BEE 4 star rated/Hydropneumatic 60% eff		
	Electrical Sys	1	5	1	Max PD Loss 3% , Transformer: BEE 3 star rated		
Indoor End Use	Ind Lighting		4	8	4	Luminous efficacy of minimum 85 lm/W	30
		Comfort Sys	6	3	6	BEE 3 star rated	
	CS>Central AC	CS>Fans	20	21	20	BEE 3 star rated	
		CS>AC	20	21			
RE Systems	Solar HW		5	5			
	Solar PV		5	5			

**Total 100 points**

# ECO NIWAS SAMHITA, CODE COMPLIANCE EXAMPLE POINT SYSTEM

Point System - A building opting for 2 sections only (Building envelope and Services) w/o RE

Building Envelope	Uroof		44	36	3	2	U – 0.74 W/m2.K	} 49
	RETV				44		RETV: 15 W/m2	
Building Services	CA Lighting	CAL>Corridor	1	2	1	2	2.5 W/m2 best LPD, 105 best LE	} 51
		CAL>Outdoor	1	2	1	2	0.75 W/m2 LPD, 105 best LE	
		CAL>Basement	1	2	1	2	installing controls	
	Lifts		13	9	13	9	85 lumen/watt, Automatic, class IE 5 motors, Sequencing, VVVF, Regenerative drive	
	Pumps		6	8	6	8	BEE 5 star rated, Low flow fixtures	
Electrical Sys		1	5	1	5	Max PD Loss 3% , Transformer: BEE 5 star rated		
Indoor End Use	Ind Lighting		4	8				
	Comfort Sys	CS>Fans	6	3				
		CS>AC	20	21				
		CS>Central AC	20	21				
RE Systems	Solar HW		5	5				
	Solar PV		5	5				

**Total 100 points**



# ECO NIWAS SAMHITA, CODE COMPLIANCE EXAMPLE POINT SYSTEM

Point System - A building opting for 2 sections only (Building envelope and Services) with RE.

Building Envelope	Uroof		3	4	3		U - 1.2 W/m2.K	47
	RETV		44	36	44		RETV: 15 W/m2	
Building Services	CA Lighting	CAL>Corridor	1	2	1	2	2.5 W/m2 best LPD, 105 best LE	43
		CAL>Outdoor	1	2	1	2	0.75 W/m2 LPD, 105 best LE	
		CAL>Basement	1	2	1		1.0 W/m2 LPD & at least 85 lumens/W	
	Lifts		13	9	13	9	85 lumen/watt, Automatic, class IE 5 motors, Sequencing, VVVF, Regen drive	
	Pumps		6	8	6	8	BEE 5 star rated, Low flow fixtures	
	Electrical Sys		1	5	1		Max PD Loss 3%, Transformer: BEE 3 star	
Indoor End Use	Ind Lighting		4	8				Total 100 points
		Comfort Sys	6	3				
	CS>Central AC	CS>Fans	20	21				
		CS>AC	20	21				
RE Systems	Solar HW		5	5	5	5	meeting 100% hot water demand of 2 floor	10
	Solar PV		5	5				

# ECO NIWAS SAMHITA, CODE COMPLIANCE EXAMPLE POINT SYSTEM

## Point System - A building opting for all 3 sections with RE

Building Envelope	Uroof		3	4	3	U - 1.2 W/m2.K	47
	RETV		44	36	44	RETV: 15 W/m2	
Building Services	CA Lighting	CAL>Corridor	1	2	1	3.0 W/m2 LPD & at least 85 lumens/W	23
		CAL>Outdoor	1	2	1	LPD as per table & at least 85 lumens/W	
		CAL>Basement	1	2	1	1.0 W/m2 LPD & at least 85 lumens/W	
	Lifts	13	9	13	85 lumen/watt, Automatic, class IE 3 motors, Sequencing		
	Pumps	6	8	6	BEE 4 star rated/Hydropneumatic 60% eff		
	Electrical Sys	1	5	1	Max PD Loss 3% , Transformer: BEE 3 star rated		
Indoor End Use	Ind Lighting		4	8		30	
		Comfort Sys	6	3			
	CS>AC		20	21	20		BEE 3-star AC
		CS>Central AC	20	21			
RE Systems	Solar HW		5	5	5	meeting 100% hot water demand of 2 floor	10
	Solar PV		5	5	5	PV on 10% roof area	

Total 100 points

## SESSION-2 (Contd.)

- 1. BEE Star Labelling (*Residential Buildings*)**
- 2. ENS Compliance Tool**
- 3. *Recommendations to Enhance Thermal Comfort in Residential Buildings***

# BUREAU OF ENERGY EFFICIENCY (BEE) AND STAR LABELLING

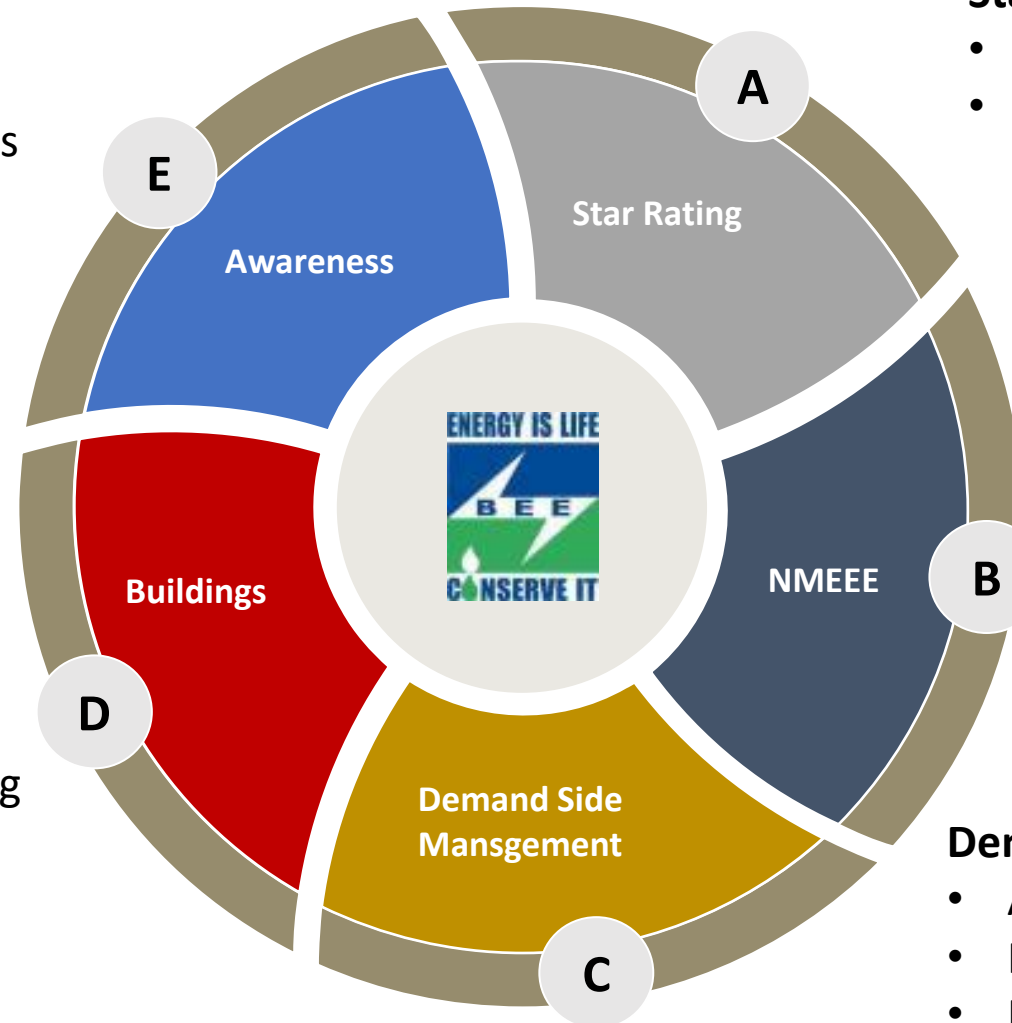
## BEE PORTFOLIO

### Awareness

- Energy Conservation Awards
- Painting Competition
- State Designated Agencies

### Buildings

- Energy Conservation Building Codes
- Retrofit in old buildings
- Residential Building Guidelines



### Star Rating of Appliances

- 8 Mandatory Labelled Appliances
- 13 Voluntary Labelled Appliances

### National Mission for Enhanced Energy Efficiency

- Perform, Achieve & Trade (PAT)
- Market Transformation for Energy Efficiency (MTEE)
- Framework for Energy Efficient Economic Development (FEEED)
- Energy Efficiency Financing Platform (EEFP)

### Demand Side Management

- Agriculture DSM
- Municipal DSM
- Energy Efficiency in SMEs

# BEE STAR LABELLING FOR RESIDENTIAL BUILDING

## About the Program

The program aims to develop a national energy efficiency label for residential buildings to enhance energy efficiency in the residential sector.

## Objective of the Program

The objective of the program is to provide:-

- Information to consumers on the energy efficiency standard of the Homes.
- Facilitation in the implementation of Eco-Niwas Samhita 2018 and 2021
- A consumer-driven market transformation business model solution for Energy Efficiency in the housing sector
- Steering the construction activities of India towards international best practices norms



# BEE STAR LABELLING FOR RESIDENTIAL BUILDING

## Benefits from the Labelling Program

Cumulative saving of 388 billion units of electricity by 2030

- Reduction of carbon emission by 3 billion tones by 2030
- Increased uptake of energy-efficient construction in India
- Facilitate energy-efficient materials and technologies market supporting the “Make in India” initiative
- Improve environmental resilience and energy security
- Sustainable living standards

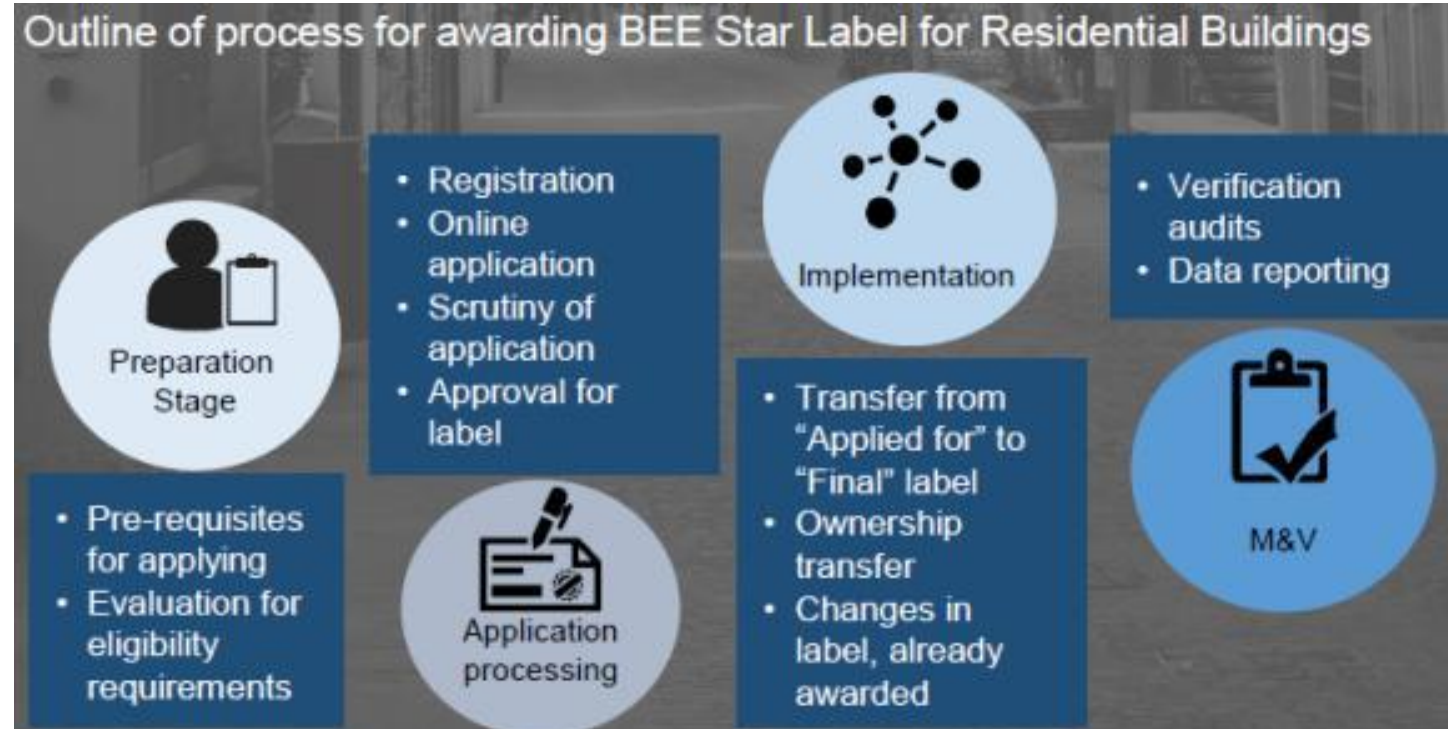


# BEE STAR LABELLING FOR RESIDENTIAL BUILDING

## Labelling types



## Labelling Process



# SIMULATION TOOL



## ***ECO NIWAS SAMHITA*** *Compliance Tool*



# INTRODUCTION

- Quick design and compliance checks
- benchmarks of ECONI WAS SAMHITA.
- 5 key features in consideration:
  1. User-friendliness
  2. Responsiveness
  3. Adaptability
  4. Dynamism
  5. Resourcefulness.



- Compliance for Both Prescriptive and Points Based Systems.
- Categories included:
  - High rise
  - Affordable
  - Low Rise
  - Mixed Use

## ECO NIWAS SAMHITA COMPLIANCE TOOL: KEY FEATURES

Project Name	Demo Building	State	New Delhi
City	New Delhi	Climate	COMPOSITE
Latitude	$\geq 23.5^\circ \text{ N}$		
Project Construction Type	New Building	Housing Category	Affordable ...
Plot Area (m <sup>2</sup> )	10000	Total no. of Residential Blocks	10
Compliance Method Used	<input checked="" type="radio"/> Points System <input type="radio"/> Prescriptive System		

- Easy project definition.
- Provisions for point system as well as prescriptive system approach for compliance evaluation.

## ECO NIWAS SAMHITA COMPLIANCE TOOL: KEY FEATURES

S.No.	Housing Category	Plot Area (m <sup>2</sup> )	Total Residential Block
1	Affordable High-Rise	10000	10
2	Low Rise	1000	1
3	High Rise	1500	5
Total No. of Block			16

# ECO NIWAS SAMHITA COMPLIANCE TOOL: KEY FEATURES

ECO-NIWAS SAMHITA COMPLIANCE TOOL

Ministry of Power  
Government of India

File Help

ECO-NIWAS SAMHITA COMPLIANCE TOOL

IMB Compliance

HELP 1

Climate zones of India

Project Construction type for compliance check

Orientation	Range (°) being north and 90° being east
North	337.5° - 22.5°
North-east	22.5° - 67.5°
East	67.5° - 112.5°
South-east	112.5° - 157.5°
South	157.5° - 202.5°
South-west	202.5° - 247.5°
West	247.5° - 292.5°
North-west	292.5° - 337.5°

North

North West 337.5° North East 22.5° 67.5° East 112.5° South East 157.5° South 202.5° South West 247.5° West 292.5°

IMB Code Purpose & Applicability

Project Construction Type

IMB Compliance Criteria

Plot Area

Housing Category

Total no. of Residential Blocks

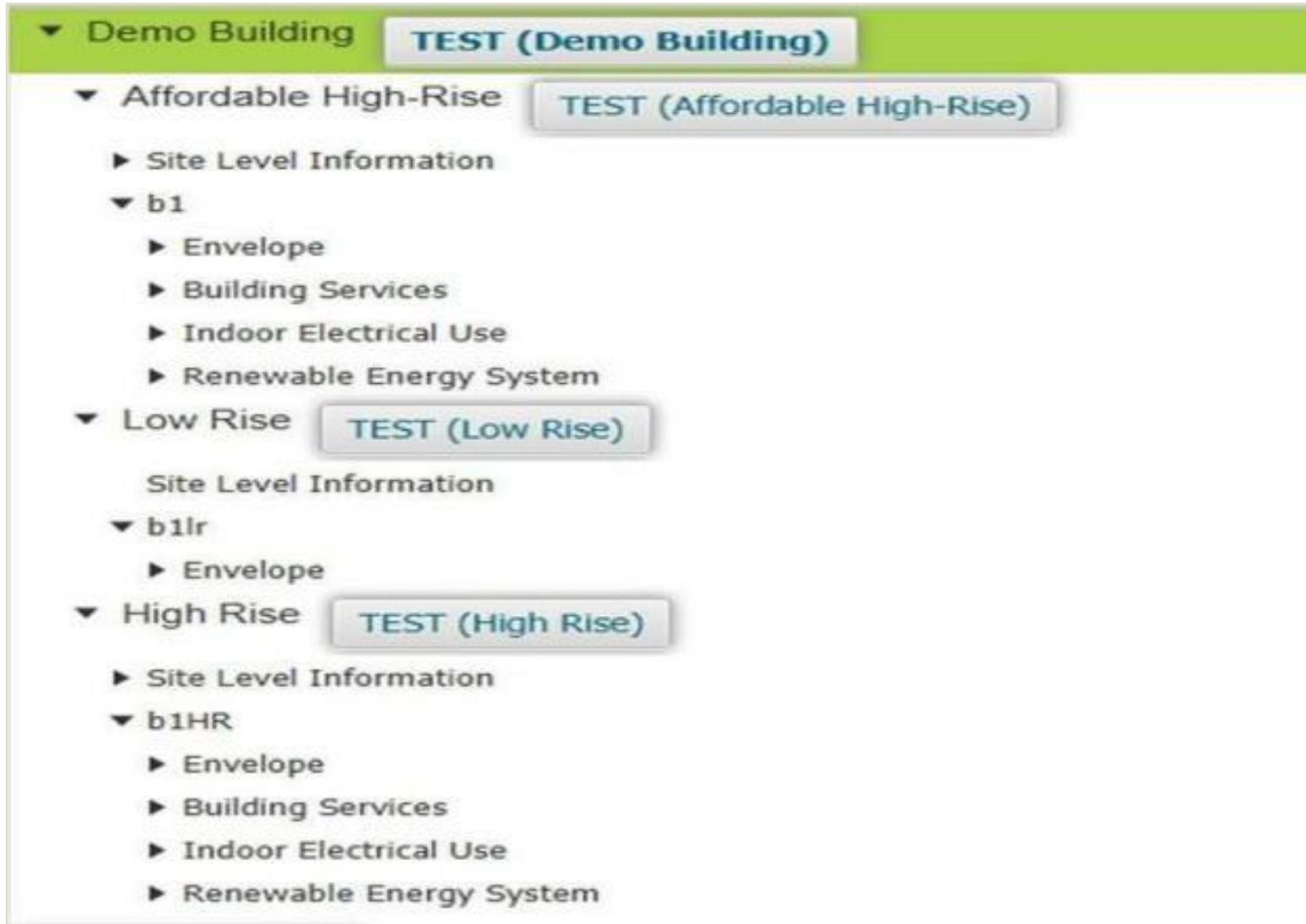
Project Name: Demo Building  
State: Chandigarh  
City: Chandigarh  
Latitude: 11° 23.5' N  
Project Construction Type: New Building  
Housing Category: High Rise  
Plot Area (sqft): 11500  
Total no. of Residential Blocks: 5  
Compliance Method Used:  Points System  Prescriptive System

Add Category Project Relocate

S.No	Housing Category	Plot Area (sqft)	Total Residential
1	Affordable High-Rise	10000	10
2	Low Rise	1000	1
3	High Rise	11500	5

Total No. of Blocks: 16

## ECO NIWAS SAMHITA COMPLIANCE TOOL: KEY FEATURES



- *Easy to navigate tree-view structure*

# ECO NIWAS SAMHITA COMPLIANCE TOOL: KEY FEATURES

Project Name	Demo Building	State	New Delhi
City	New Delhi	Climate	COMPOSITE
Latitude	>= 23.5° N		
Project Construction Type	New Building	Housing Category	Affordable ...
Plot Area (m <sup>2</sup> )	10000	Total no. of Residential Blocks	10
Compliance Method Used	<input checked="" type="radio"/> Points System	<input type="radio"/> Prescriptive System	
	<input type="button" value="Add Category"/>	<input type="button" value="Project Relocate"/>	

- Project relocation feature for multiple domain use

# ECO NIWAS SAMHITA COMPLIANCE TOOL: KEY FEATURES

▼ Demo Building **TEST (Demo Building)**

▼ Affordable High-Rise **TEST (Affordable High-Rise)**

▼ Site Level Information

- Basement Lighting
- Exterior Lighting
- Pumps
- Diesel Generator Set
- Power Factor
- Energy Monitoring
- EV Supply Equipment
- Transformer
- Power Distribution Loss
- Solar Photovoltaic System

▼ b1

- Envelope
- Building Services
- Indoor Electrical Use
- Renewable Energy System

► Low Rise **TEST (Low Rise)**

► High Rise **TEST (High Rise)**

**HELP !**

► Climate zones of India

▼ Project Construction type for compliance check

Orientation	Range (0° being north and 90° being east)
North	337.6° – 22.5°
North-east	22.6° – 67.5°
East	67.6° – 112.5°
South-east	112.6° – 157.5°
South	157.6° – 202.5°
South-west	202.6° – 247.5°
West	247.6° – 292.5°
North-west	292.6° – 337.5°

► ENS Code Purpose & Applicability

► Project Construction Type

► ENS Compliance Criteria

► Plot Area

► Housing Category

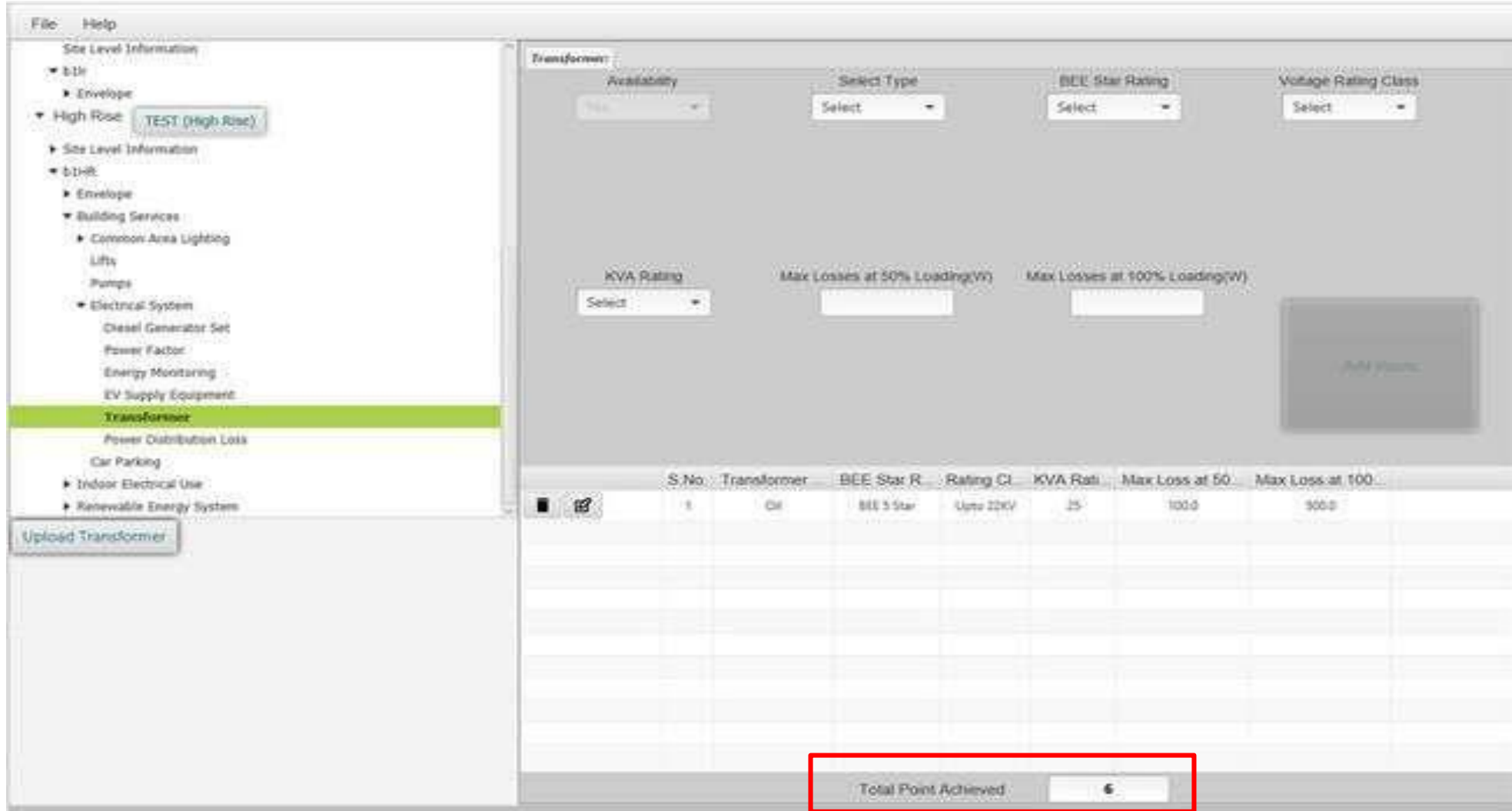
► Total no. of Residential Blocks

- Segregated site level & block level inputs for ease in information flow





# ECO NIWAS SAMHITA COMPLIANCE TOOL: KEY FEATURES



The screenshot displays the software interface for configuring a transformer. On the left, a navigation tree shows the 'Transformer' option selected under the 'Electrical System' category. The main panel contains several configuration fields:

- Transformer:** Availability (Yes), Select Type (Select), BEE Star Rating (Select), Voltage Rating Class (Select).
- Transformer Details:** KVA Rating (Select), Max Losses at 50% Loading (W) (input field), Max Losses at 100% Loading (W) (input field), and an Add Items button.
- Table:** A table with columns: S.No., Transformer, BEE Star R., Rating Cl., KVA Rati., Max Loss at 50., and Max Loss at 100.. The first row contains: 1, Oil, BEE 5 Star, Up to 22kV, 25, 1000, 9000.
- Total Point Achieved:** A red box highlights the 'Total Point Achieved' field, which shows a value of 6.

# ECO NIWAS SAMHITA COMPLIANCE TOOL: KEY FEATURES

The screenshot displays the 'Eco-Niwas Samhita Compliance Result' tool interface. It features a navigation menu with tabs for 'Affordable High-Rise', 'Low Rise', and 'High Rise', and sub-tabs for 'Envelope', 'Building Services', 'Indoor Electrical Use', 'Renewable Energy', and 'Final Result'. The main content area is divided into a table of scores and a summary section.

	Point Achieved	Total Points
Building Envelope	50	87
Building Services	47	51
Indoor Electric Use	47	62
Renewable Energy System	12	20

Summary Section:

- Total Points Achieved: 156
- Total Maximum Points: 226
- Compliance Status: **Compliant**

A 'Generate Report' button is located at the bottom right of the interface.

- Consolidated result display for individual housing category at project level & housing category level including compliance status

# ECO NIWAS SAMHITA COMPLIANCE TOOL: KEY FEATURES

**Total Points Achieved**  
156

**Total Maximum Points**  
220

**Compliant**

[Generate Report](#)

### Eco-Niwas Samhita: Compliance Check Report

## ECO-NIWAS SAMHITA (ENS) COMPLIANCE EVALUATION REPORT

#### Project Information

Project Name	Demo Building
State	Chandigarh
City	Chandigarh
Climate	COMPOSITE
Latitude	>= 23.5° N
Building Constructed Type	New Building
Compliance Method Used	Point System

#### Housing Category Information

Housing Category	Plot Area(m <sup>2</sup> )	Total No. of Residential Units	Total Basement Area(m <sup>2</sup> )	Total Exterior Light Area(m <sup>2</sup> )	Total Roof Area(m <sup>2</sup> )
Affordable High-Rise	10000	10	1000.0	1000.0	1000.0
Low Rise	1000	1	1000.0	1000.0	1000.0
High Rise	1500	5	100.0	100.0	100.0

### Eco-Niwas Samhita: Compliance Check Report

#### 1. Affordable High-Rise : Compliance Result

##### 1.1. Building Envelope:

S.No.	Component	Mandatory Requirements	Calculated value	Points Achieved	Maximum Points
1	RET/(000m <sup>2</sup> .K)	NA	14.59	44	80
2	U-Value Roof/(W/m <sup>2</sup> .K)	NA	0.53	6	7
3	W/F Htg.	Achieved	32.0	NA	NA
4	VLT %	Achieved	60.0	NA	NA

##### 1.2. Building Services:

S.No.	Component	Mandatory Requirements	Calculated value	Points Achieved	Maximum Points
1	Exterior Lighting	NA	--	3	3
2	Basement Lighting	NA	--	2	3
3	Corridor Lighting	NA	--	3	3
4	Lift	NA	--	22	22
5	Pump	NA	--	11	14
6	Diesel Generator Sets	Achieved	--	NA	NA
7	Power Factor Correction	Achieved	--	NA	NA
8	Energy Monitoring System	Achieved	--	NA	NA
9	Electric Vehicle Supply Equipment	Achieved	--	NA	NA
10	Transformer	NA	--	6	6
11	Power Distribution Loss	Achieved	--	NA	NA
12	Car Parking Basement Ventilation	Achieved	--	NA	NA

##### 1.3. Indoor Electrical End Use:

S.No.	Component	Mandatory Requirements	Calculated value	Points Achieved	Maximum Points
1	Indoor Lighting	NA	--	12	12
2	Ceiling Fan	NA	--	7	9
3	Cooling Equipment	NA	--	20	41

##### 1.4. Renewable Energy System:

S.No.	Component	Mandatory Requirements	Calculated value	Points Achieved	Maximum Points
1	Solar Hot Water Requirements	NA	--	7	10
2	Solar Photovoltaic System	NA	--	5	10

### Eco-Niwas Samhita: Compliance Check Report

#### Consolidated Compliance Status of the Project:

S.No.	Housing Categories	Total Points	Maximum Points	Minimum Points	Compliance Status
1	Affordable High-Rise	156	220	70	Compliant
2	Low Rise	63	87	47	Compliant
3	High Rise	82	220	100	Non Compliant

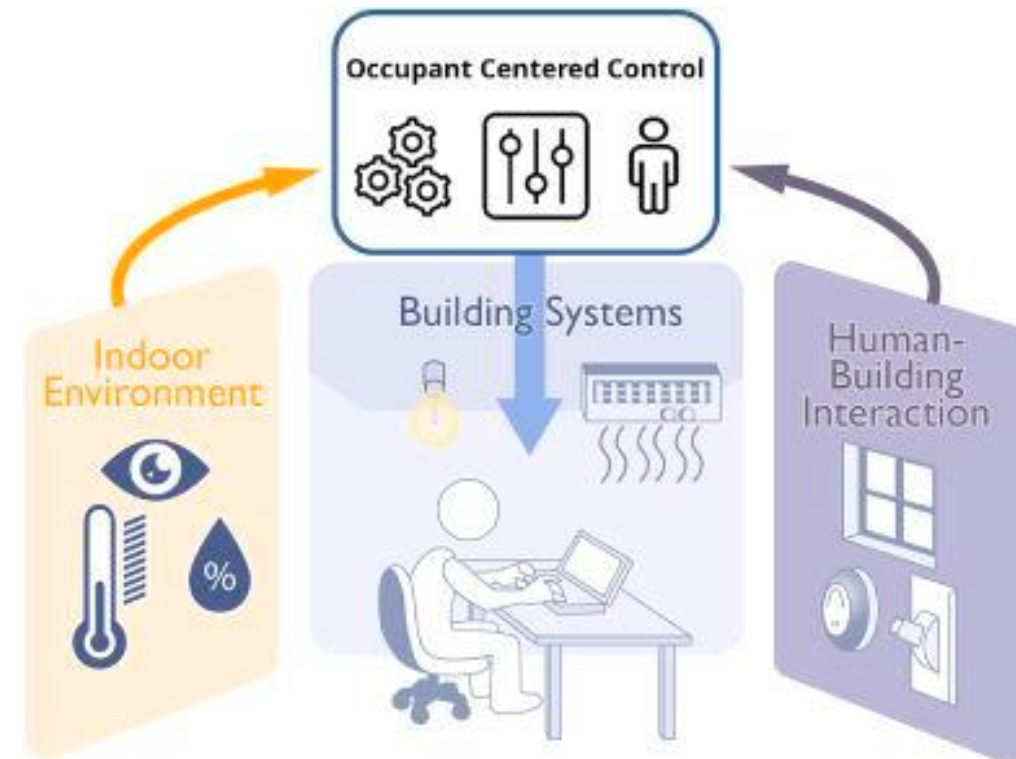
- Provisions for PDF output reporting for each input and corresponding output

# RECOMMENDATIONS TO ENHANCE THERMAL COMFORT IN RESIDENTIAL BUILDINGS

## Design and build for occupant control

Lower the energy load, Also allow occupants to more precisely control their environment as they desire.

- Orientation of building.
- Allowing access to the operable windows and blinds.
- Designing the building to maximize the potential use of natural ventilation and radiation from sun.
- In composite climate zones, seasonally adjusting temperature control by windows and ventilators to maintain thermal comfort.



# RECOMMENDATIONS TO ENHANCE THERMAL COMFORT IN RESIDENTIAL BUILDINGS

## **Regulation of Mean Radiant Temperature (MRT) and operative temperatures through envelope design and selection**

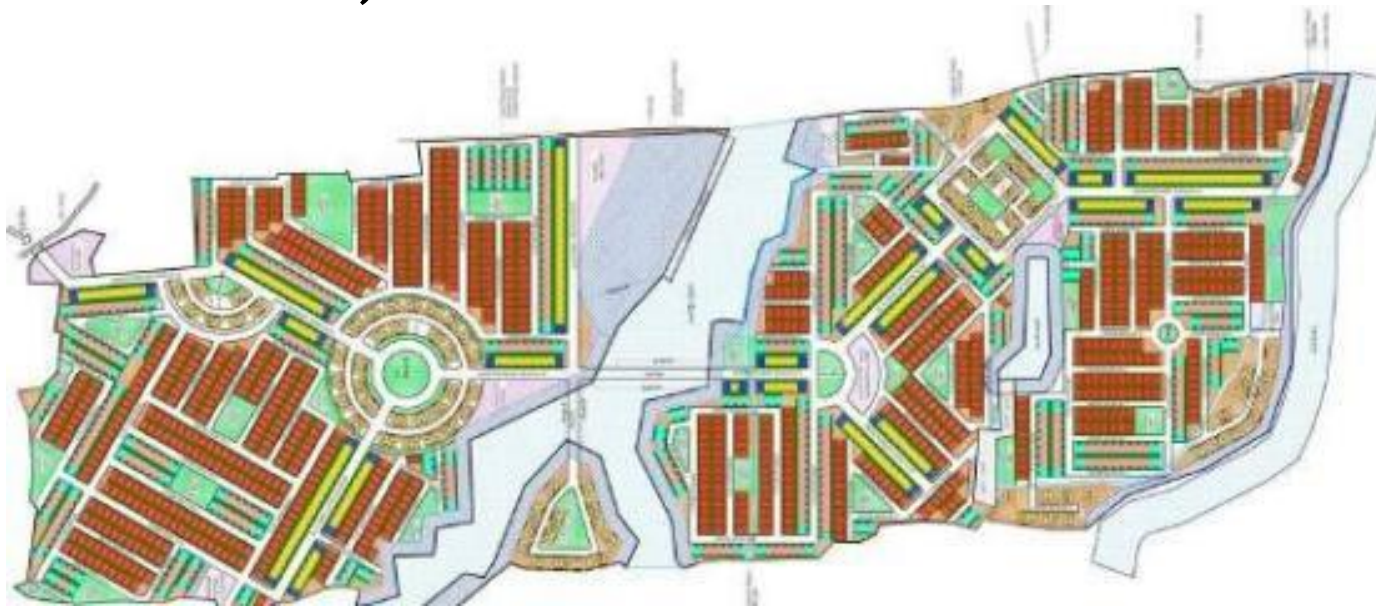
MRT and operative temperature are highly important to human thermal comfort, the best way to achieve a comfortable temperature within an enclosure is to use technology in envelope material which have greater resistance value and low transmittance value.

## **Minimize leakage in building envelope**

If there is leakage in the building envelope and air is transferring in and out of the building other than through the ventilator or windows only for required time, IEQ will be lowered. Thus, reducing the thermal balance of the indoor environment.

## CASE STUDY- MASS HOUSING, INNO GEOCITY, CHENNAI 500 HOUSES

### INNO GEO CITY, CHENNAI



### TECHNOLOGY USED

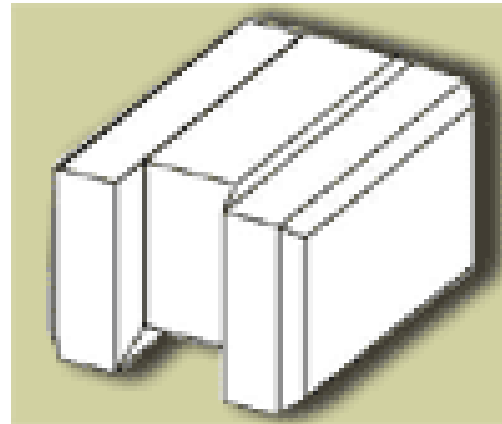
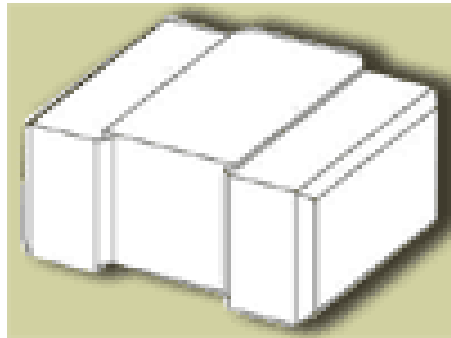
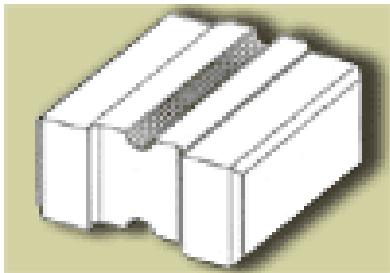
- Hydraform interlocking block walls,
- Precast RC Planks & Joists Roof
- Stone Block masonry in the foundation
- Precast Boundary wall



## CASE STUDY- AFFORDABLE MASS HOUSING, INNO GEOCITY, CHENNAI 500 HOUSES

### TECHNOLOGY HYDRAFORM BUILDING SYSTEM

- An alternate to conventional bricks & mortar for building envelope
- Male/Female Interlocking – Vertical / Horizontal Shear keys
- Suitable for Load/Framed Structures Compatible to incorporate Vertical/Horizontal reinforcements
- Suitable for Seismic structures
- Speedier construction



## CASE STUDY- AFFORDABLE MASS HOUSING, INNO GEOCITY, CHENNAI 500 HOUSES

### TECHNOLOGY HYDRAFORM BUILDING SYSTEM GREEN RATING

- Hydra-form creates high-quality bricks, created with nothing more than 10 percent addition of building cement and soil/fly ash, formed in a machine under hydraulic pressure.
- Hydra-form blocks are not in need of firing, they only require curing.
- The soil block also has the added benefit of preserving energy thanks to its incredible thermal properties.
- Also fulfilling the criteria 15,16 and 22 of TERI GRIHA , and LEED

#### **LEED :**

- » MRCredit : 4.1,4.2 – Use of Recycled Contents.(1-2 points)
- » MR Credit : 5.1,5.2 – Maximum use of Local and Regional material.(1-2 points)
- » MR Credit : 6.0 - Use of rapidly renewable building materials & products.(1 point)

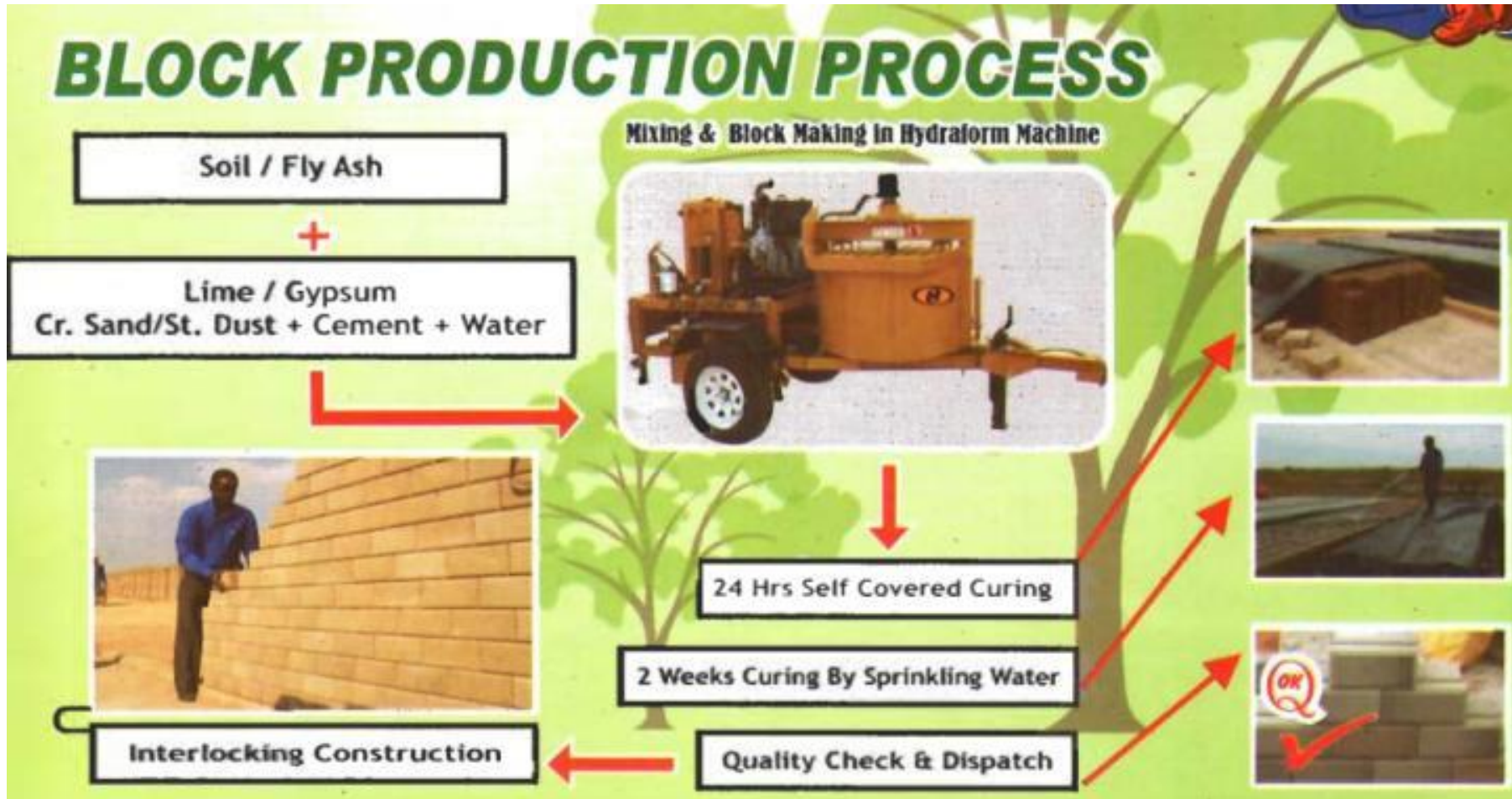
#### **TERI-GRIHA:**

- » Criteria 15 - Utilization of flyash in building & structure.(6points)
- » Criteria 16 - Reduce volume, weight and construction time by adopting efficient technologies [4 pts.]
- » Criteria 22 - Minimum 5% reduction in Embodied Energy compared with equivalent products. (1pt.)



# CASE STUDY- AFFORDABLE MASS HOUSING, INNO GEOCITY, CHENNAI 500 HOUSES

## Block Production On-site



**Stage 1:**  
Soil/Fly ash.

**Stage 2:** Lime/Gypsum  
Coarse sand/Stone Dust,  
Cement, and Water.

**Stage 3:**  
Mixing and block Making  
in Hydra-Form machine.

**Stage 4:**  
24Hrs Self covered Curing  
and 2 weeks curing by  
sprinkler. Quality check  
and dispatch.

# CASE STUDY- AFFORDABLE MASS HOUSING, INNO GEOCITY, CHENNAI 500 HOUSES

## Quality Check/Quality Control

PROBLEM	CAUSE	REMEDY
1. Rough surface on blocks	Mix too dry	Add more water to mix
	Rough plates	Inspect plates and change if necessary
	Soil build up in joints or on wear plates	Clean excess soil or fly ash from joints and plates
2. Cracking on blocks	Too much water in mix	Use less water in mix. Add cement to mix already made to dry out
A. Horizontal cracks seen as block ejected from chamber	Compression pressure too high	Reduce pressure
B. Cracks developing during 7 day curing period	Blocks losing too much water, too fast during curing	Cover blocks properly with plastic and water twice daily as per Hydraform recommendations
	High clay content	Add coarse sand to mix Add more cement
3. Blocks being damaged and broken during stacking and storage	Careless handling of blocks	Closer supervision of stacking
	Blocks too weak	Check production process and/or add more cement to mix
4. Blocks shorter than chosen length	Too much water in mix	Use less water in mix
	Compression pressure too high	Reduce pressure
5. Blocks longer than chosen length	Mix too dry	Add more water to mix
	Compression pressure too low	Increase pressure
6. Block length changing continuously	Water content changing continuously	Keep water in mix constant. Check water content by checking length of block with ruler
	Soil properties changing continuously	Use same soil source for all production

### NOTE:

*Since raw materials change from site to site, please consult Hydraform specialized engineers for proper raw material and mix design, block making process, and quality control procedure.*



THANK YOU!