Introduction to Passive-design Response in Increasing Resilient Thermal with Viable Solutions - PRiTHVi

A result of the Living Laboratory Experiments at Light House Projects

21st November 2023,
Bhubaneswar

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

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Ministry of Housing and Urban Affairs
Government of India

bmtpc

german cooperation
DEUTSCHE ZUSAMMENARBEIT

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Buildings have a very unique powerful characteristics – its has a capacity to define & identify.

Buildings will remain one of the important elements of our Identity and our

FUTURE

HOUSING FOR ALL – *More than a MISSION, it's a need*

India urban population is increasing, and so is the demand for residential buildings out of which most of them are in the 'affordable' category.

Demand

Overview of affordable housing sector

80 million
households in India are estimated to be living in slums

40 million
current housing shortage in Rural areas

20 million
current housing shortage in Urban areas

Supply

PMAY (U) Achievement

Construction of Houses (Nos in Millions)

11.89
Sanctioned

11.313
Grounded*

7.625
Completed/Delivered*

Source:

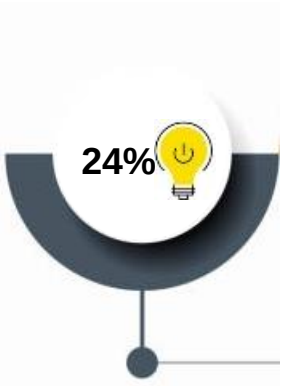
1. Affordable And Quality Housing Is Still A Dream For Many In India
2. Resilient and affordable housing for all: Lessons on house building from Kochi and Trivandrum, India, Coalition for Urban Transitions
3. Ministry of Home Affairs, Government of India. Population projection. Census of India. (2011). Retrieved 12 April 2022, from https://www.censusindia.gov.in/2011census/dchb/DCHB.html
http://nbo.nic.in/pdf/SLUMS_IN_INDIA_Slum_Compendium_2015_English.pdf
https://pmay-urban.gov.in/uploads/progress-pdfs/638581aea7c71-PMAY-U_Achievement_as_on_28th_Nov_2022-FOR-WEB.pdf

Housing for All

Ministry of Housing and Urban Affairs
Government of India

The Government of India has been implementing its flagship programme- Pradhan Mantri Awas Yojana- Urban (PMAY-U) since 2015 to fulfil the vision of 'Housing for All' by 2022.

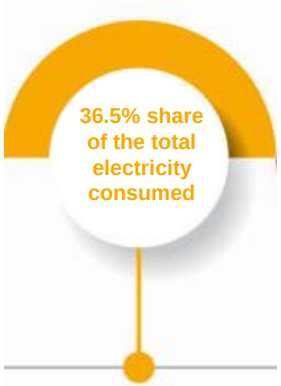
प्रधान मंत्री आवास योजना–शहरी
Pradhan Mantri Awas Yojana-Urban



Electricity Consumption from residential Building Sector

Country's building sector is expected to increase **5-fold** in three decades

Electricity consumption in residential buildings is expected to increase **7-fold** during the period 2020-2040



The residential sector will become the largest consumer of electricity in 2032

30 Mt CO2 mitigation potential in Affordable housing (PMAY-U) by 2047

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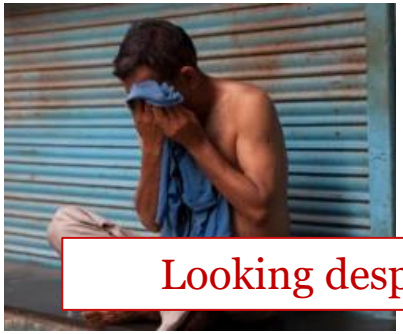
Innovative Construction Technologies for Affordable Housing

Global Housing Technology Challenge was launched in 2019 under which 6 Light House Projects were grounded to showcase new age technologies

Pursuit to provide Pucca House and solve many problems of the people living in slums.

Trapped with adverse thermal conditions



Looking desperately for solutions

Induced dependency on Active measures

& Thermal Comfort

Innovative Construction Technologies for Affordable Housing

Living Lab Experiments Vision to Prime Minister Modi at the 6 LHP sites

To Fast track construction with new age innovative technologies and to ensure sustainable tomorrow

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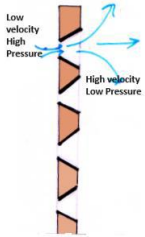
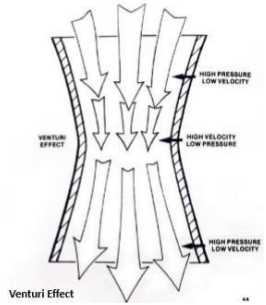
History is filled with great examples of successful case studies.

Vernacular Architecture

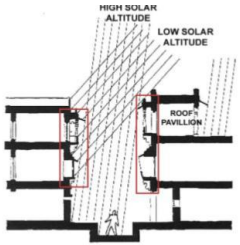
Design elements used: jharokha, jaali, red sandstone, stained glass



Jali section



venturi effect sketch



Jharokha

Hawa Mahal

Jharokha and Jali

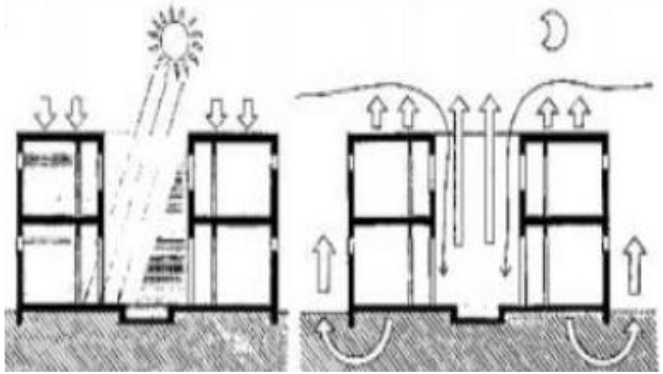
Source: Hawamahal the crown of Jaipur/amerjaipur.in/2016
https://thinkindiaquarterly.org/index.php/think-india/article/view/18458/13421

Vernacular Architecture

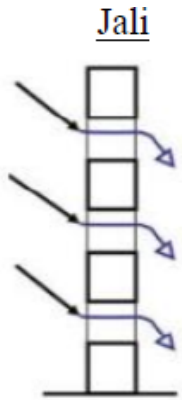
Gardens in the Amer fort

Design elements used: courtyards, red sandstone, jharokha, jali, geometrical patterns in gardens, pillared halls, central pool, fountains

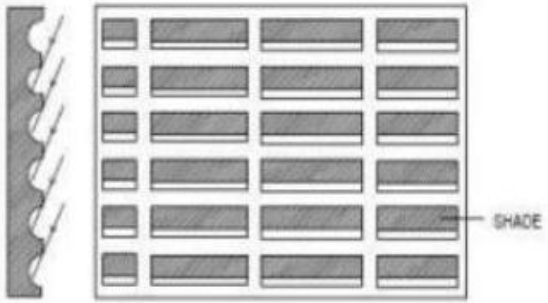
Gardens and water bodies are one of the most effective way in lowering the temperature inside the building. these not only enhance the microclimate of the building but also helps in adding royal and aesthetic look.

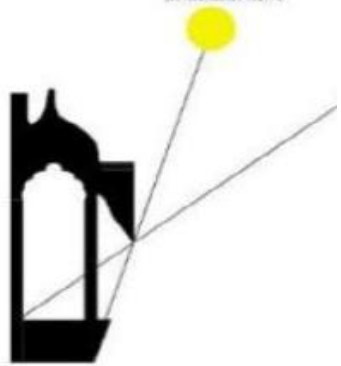


Shading by wall texture



Jharokha





Source: amerfortgardens/cpreecenvis.nic.in/2013
https://thinkindiaquarterly.org/index.php/think-india/article/view/18458/13421

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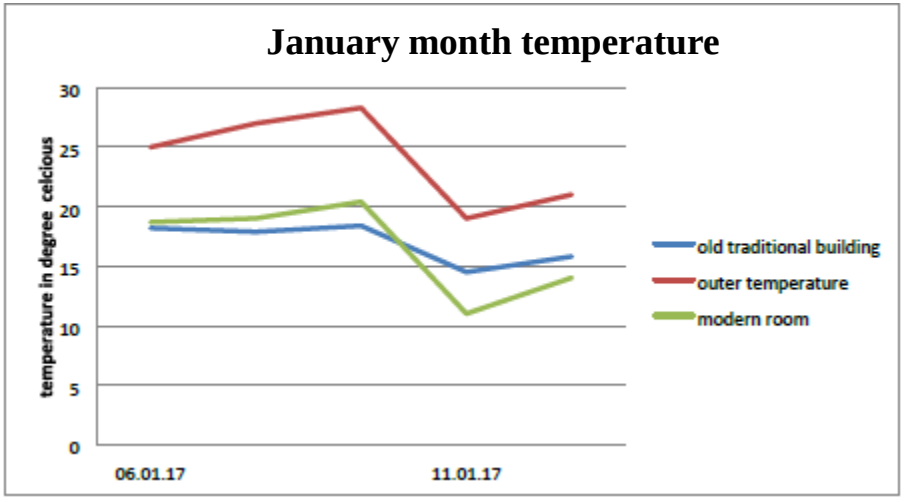
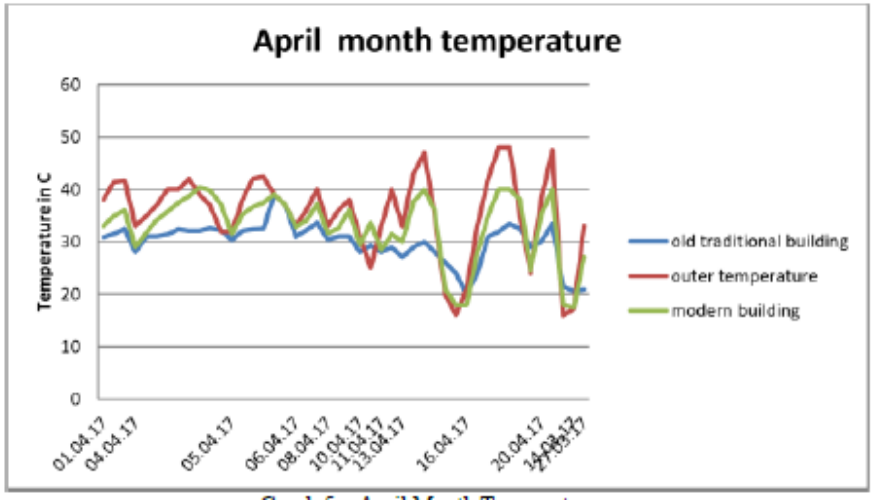
With Modernization & in fast moving pace world, we are getting trapped in thermally uncomfortable environment

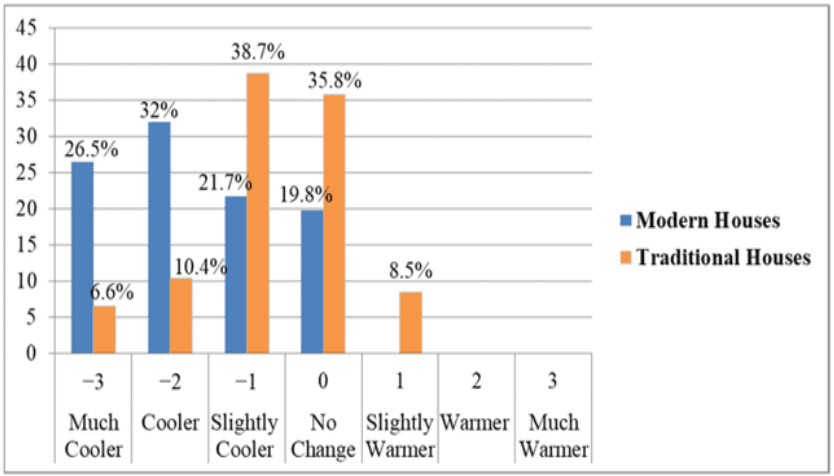




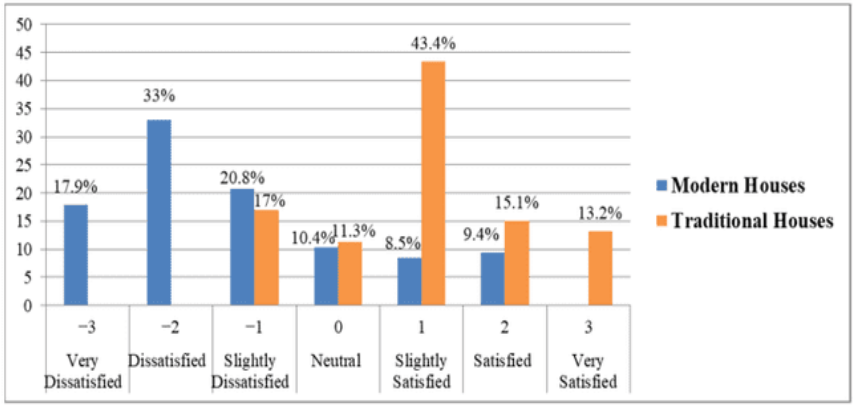
The experimental observations for temperature and humidity reveal that traditional building provided better thermal comfort with variation of 4-5^{0}C,
temperatures were higher in winters and lower in summers.

Source: http://heb-nic.in/cass/admin/freePDF/9y19bgg8gsqmriknkp79.pdf

Occupants of modern houses demands cooler indoor environment and remain dissatisfied with Thermal conditions in their home compared to traditional house occupants



Thermal preference scale for condominium and traditional house



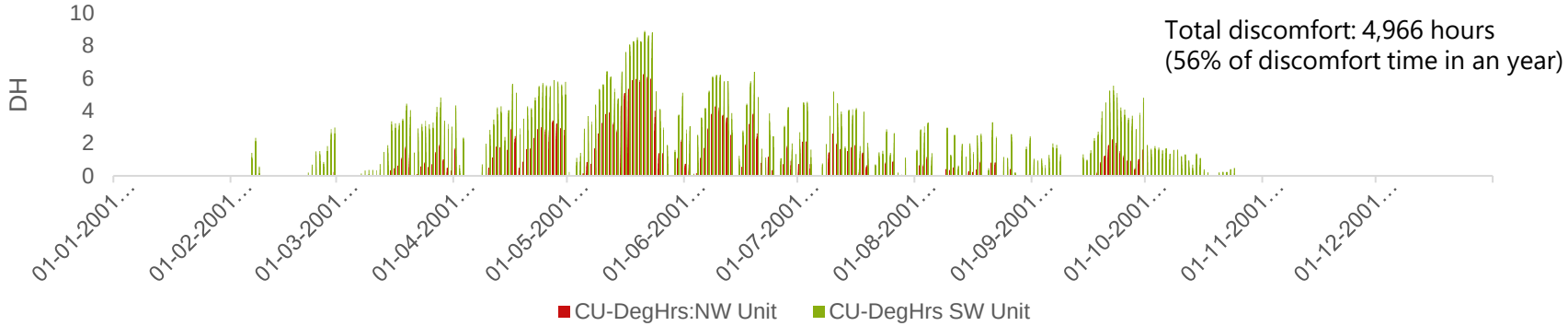
Thermal satisfaction scales for condominium and traditional houses.

Source: (PDF) Indoor Thermal Comfort Analysis: A Case Study of Modern and Traditional Buildings in Hot-Arid Climatic Region of Ethiopia (researchgate.net)

Discomfort Hours (DH - cooling)

Composite Climate – New Delhi

Typical unit discomfort hours around an year



Total discomfort: 4,966 hours
(56% of discomfort time in an year)

We are meeting this DH with Active Measures and we don't mind paying our bills.

But do we see the same future for occupants of affordable housing or we have alternatives?

Envelope RETV
18.5 to 12

Reduction in DH by
10-15%

Same is True for Temperate Climate Zone as well due to :

1) Climate Change
2) Urban Heat Island
3) Poor Ventilation
4) Many Technology which are not RETV compliant

SHGC reduction
0.8 to 0.3

Reduction in DH by
8 - 10%

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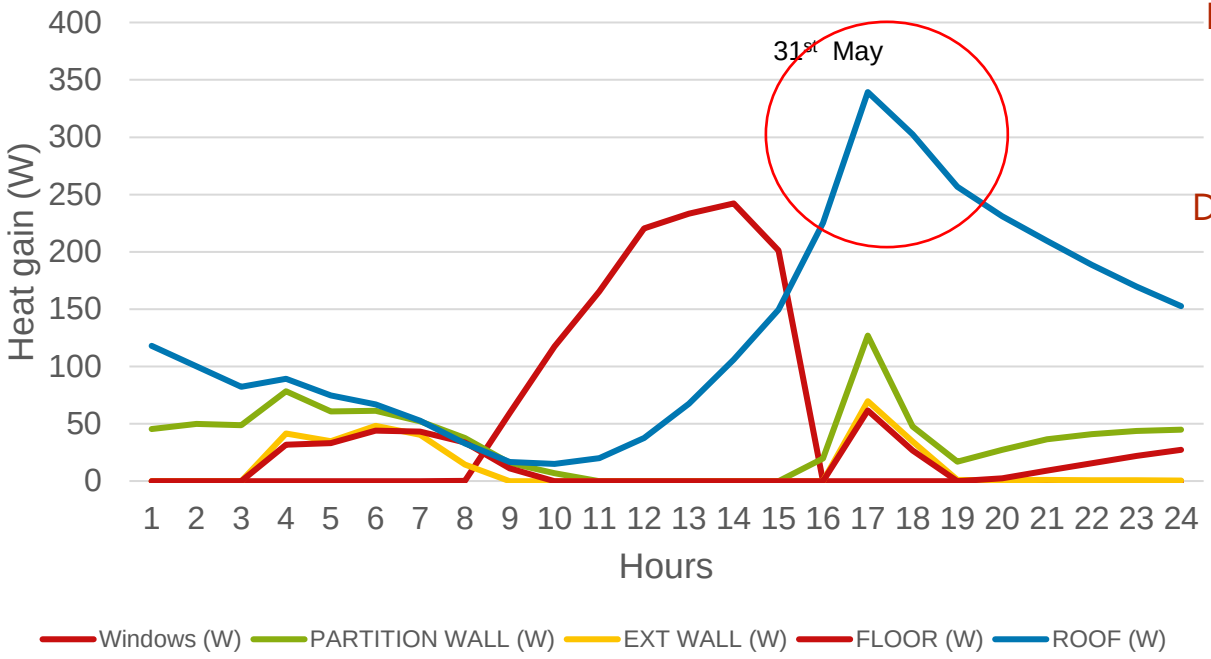
Peak day heat gain



Discomfort hours for top floor exceed the ground floor by more than 30%

Many places Top floor remain in Discomfort Zone by 70-90% of time in an year

Roof U value reduction by
2.1 W/m2K to 0.6 W/m2K

Reduction in DH at top level by
20-25%

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✓ **Current Situation:**

✓ **Fast Pace Construction to meet high demand in short period of time**

✓ **Relevance of other Standards in Affordable Housing?**

understood by a limited number of professionals and not implemented vigorously at ground level

✓ **Constraints – Cost | Time**

✓ **Pucca House is the need | Thermal Comfort is Necessity | How to fulfil the need & necessity together where one compliment the other?**

To make thermal comfort an important criteria to Design and Construct an affordable housing

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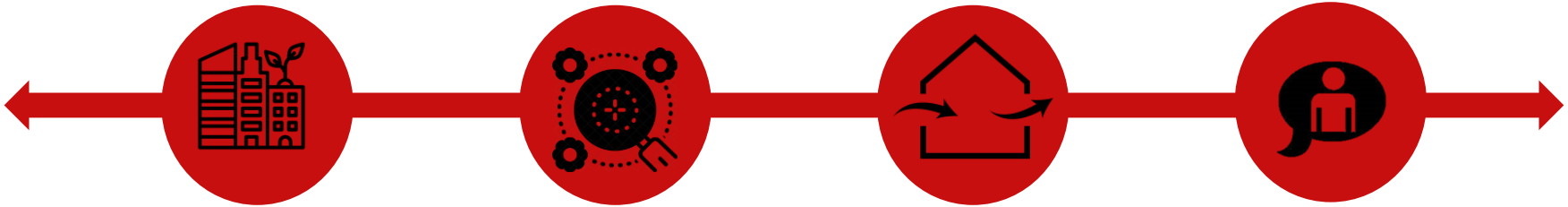
Become a TECHNOGRAHI – Register Today

Strategy – Climate Smart Buildings Programme to design a viable solution

STEP 1:

LHPs and Living Laboratory Experiments:



- Climate resilience testing through CSB cells at each LHPs
- Understanding new age tech w.r.t. thermal comfort
- Passive measures experimentation on LHPs

Simulation Analysis

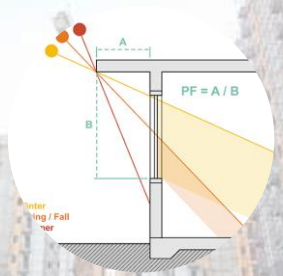
Data analysis through data loggers, lux meters

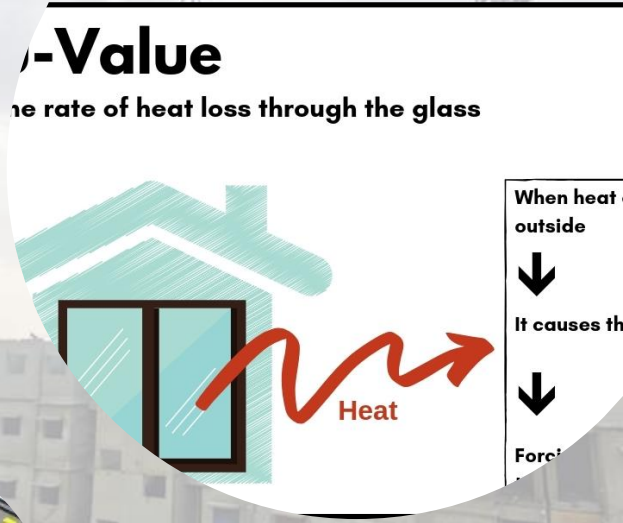
Alternative Design Recommendations

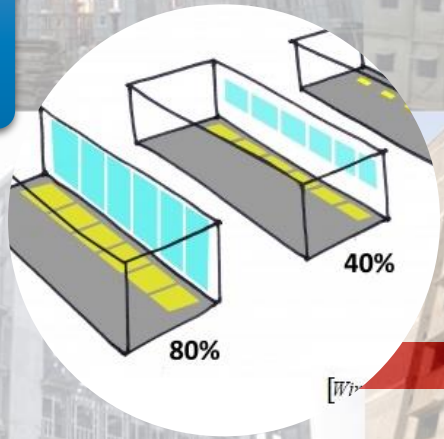
CSB Cells at each LHPs

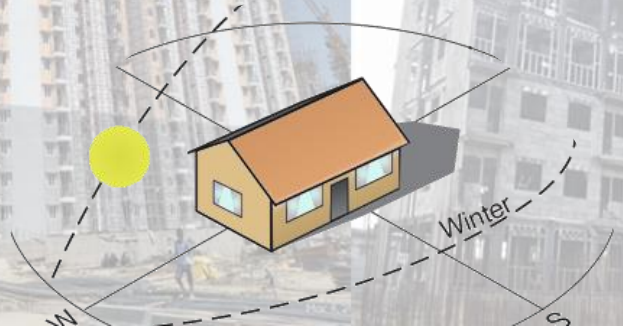
Living Lab Experiments @ all 6 LHPs

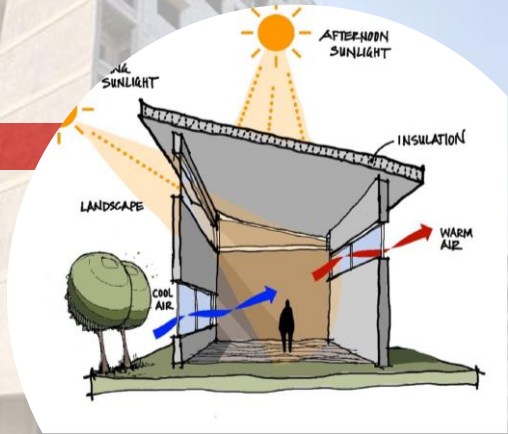
No Cost/ Low Cost Solutions

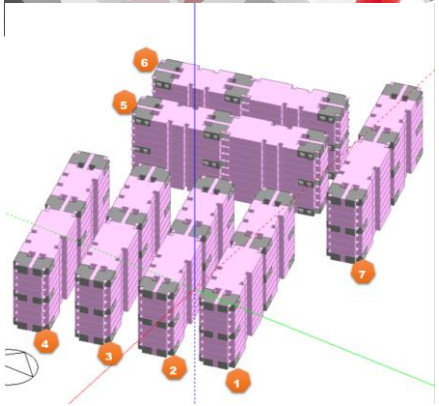


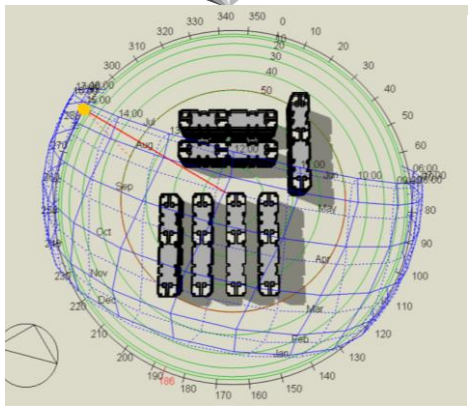


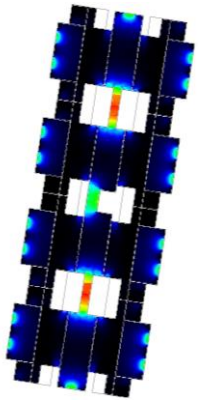


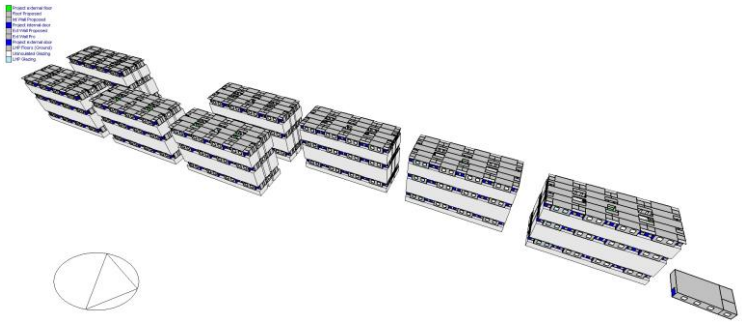





6
5
4
3
2
1
7








1003
Mode
testo 540

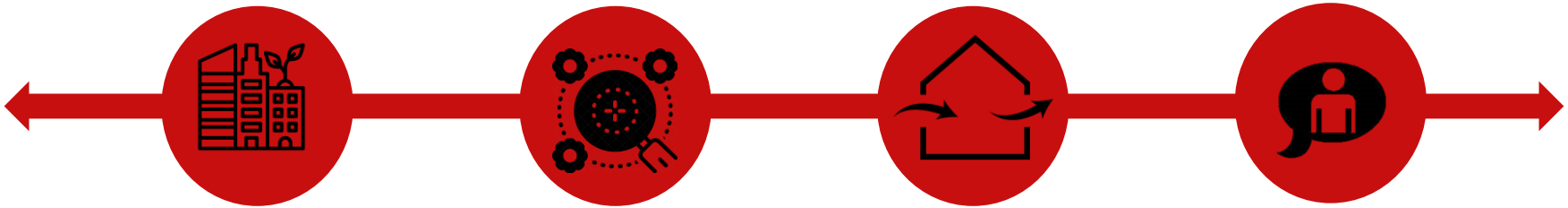

tempnote
TH32
OK
ALARM
START
STOP


42.3 %
22.3 °C
Hygrometer testo 608-H1
testo
MODE
SET

Strategy – Climate Smart Buildings Programme to design a viable solution

STEP 1:
LHPs and Living Laboratory Experiments:

STEP 2:
Extrapolation and Diversity of Projects:



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- Passive measures experimentation on LHPs

- Findings extrapolated to DHPs, AHPs, ARHCs, BLCs
- Broader scope: Applicable to Public and private projects.
- Applicable to new age and BAU construction

Demonstration Projects

6 LHPs	12 DHPs	15 AHPs	6 ARHCs
14 Private Projects	5 Climate Zones	75000+ units	Millions of Simulations

One objective – to understand the relevance of Passive-design Response in Increasing Thermal Comfort

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Passive-design Response in Increasing Thermal Comfort with Viable Solutions (PRiTHVi – Draft)

A result of the Living Laboratory Experiments at Light House Projects

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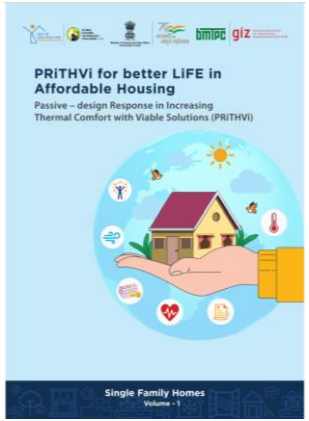
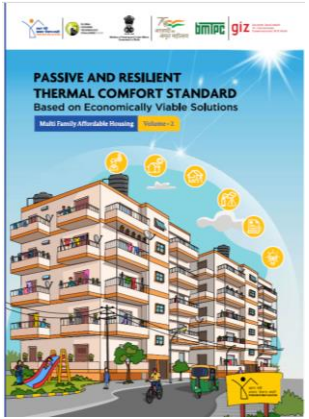


Vol 1 – Single Family Homes



Vol 2 – Multi Family Homes

Emphasis on Passive Design strategies for thermal comfort

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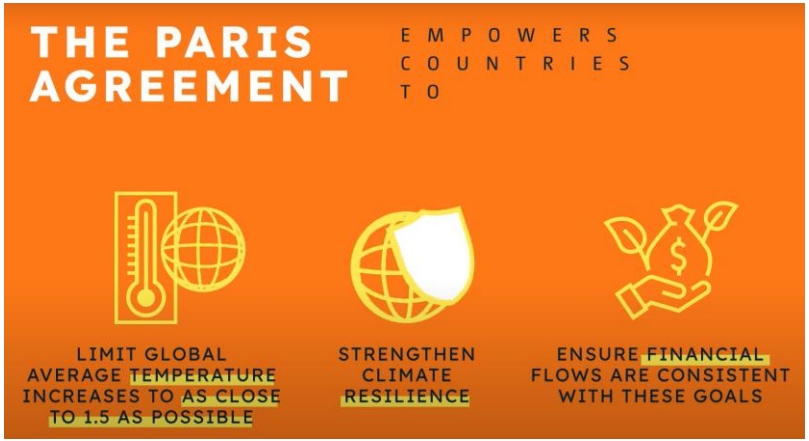
Results supported by CSB Cells of GIZ

Why PRiTHVi is the need of hour?

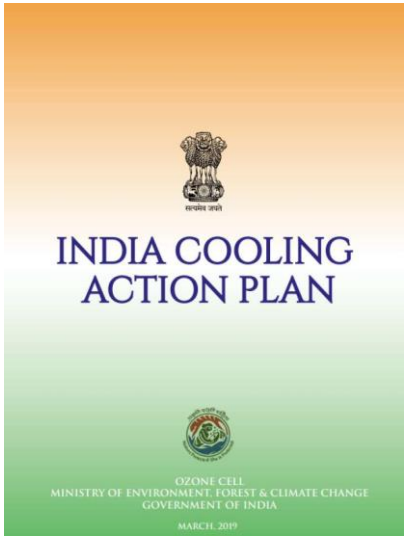
- Thermal Comfort is a **basic necessity** and demanded by all of us (without any discretion) since birth
- **Choice** - meet it via passive measures or active measures.
- Any house has to provide thermal comfort to its occupant **inevitably**
- The volume of PMAY is huge and more and more houses will be added in its portfolio for years to come putting **pressure on our infrastructure**
- Homes we build today needs to be future ready for the sake of our **PRiTHVi**
- **Passive** principles with simple and no cost solutions
- Adopted to provide one of the basic needs of humankind – **“Thermal Comfort”.**

PRiTHVi for Nationally Determined Contributions (NDCs) and Combating Climate Change



PRiTHVi for India Cooling Action Plan

- ICAP, The India Cooling Action Plan (ICAP)
- Address the challenges and opportunities related to space cooling and providing thermal comfort for all.
- Promotes sustainable approaches for:
  - Thermal comfort for all
  - Reduce green house gas emissions and enhance energy efficiency,
  - Provide access to cooling for all, while ensuring the well-being of the people and the environment.



Cool cities

Energy efficiency

Climate resilience

Renewable energy

Provide thermal comfort solutions for affordable housing through passive design approaches

Thermal Comfort Affordable Housing has the potential to contribute to India's commitment in COP27

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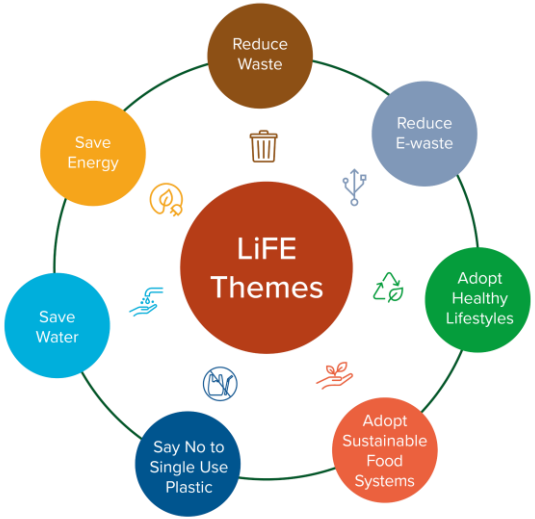
PRiTHVi for LiFE (Lifestyle for Environment)



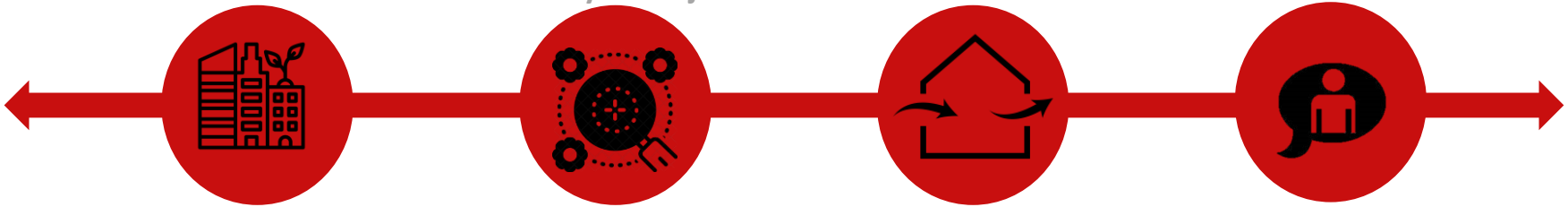
- LiFE Initiative: Launched by PM Narendra Modi at COP26 in Glasgow in Nov ‘21

- Aims to shift from destructive consumption to mindful utilization for environmental protection and preservation.

- Three themes aligned with climate smart affordable housing – **Save energy, Reduce Waste and Save Water**

LiFE
Lifestyle for Environment

Strategy – Climate Smart Buildings Programme to design a viable solution



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STEP 4: Stakeholder Consultation:

- 5 event across country
- To take wide stakeholder comments
- ONE Rule – Application from design phase

Objective of todays Stakeholder Consultation

Discuss the Finding of the entire development of **PRiTHVi**

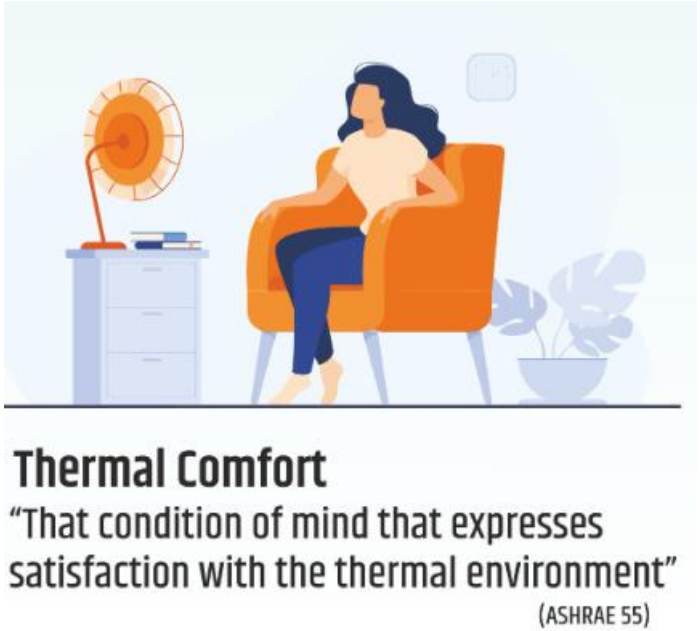
Discuss the relevance and ease of understanding for Affordable Housing

Collate suggestions and feedback

Interactive discussions to make **PRiTHVi** relevant for the industry

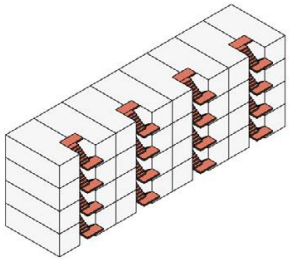
Scope for PRiTHVi

- Translates solar passive design principles into design requirements.
- This document is based on the adaptive comfort principles – IMAC-R
- Provides opportunity
  - Passively designed building in improving thermal comfort.
  - Based on no cost solutions widely available via nature or intelligent planning
  - which shall retain the affordability of an affordable housing.

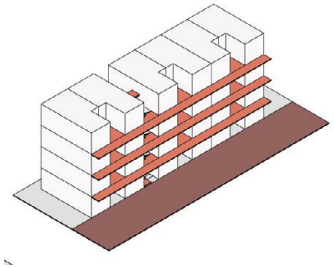


PRiTHVi for Multi family home

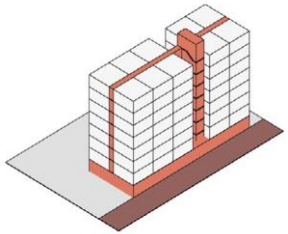
- Multi-family homes are usually developed in low rise (walk up apartments up to ground +4 storeys), mid-rise (up to 8 storeys) and high rise (beyond 8 storeys) formats. The various multi-family typologies are discussed below.



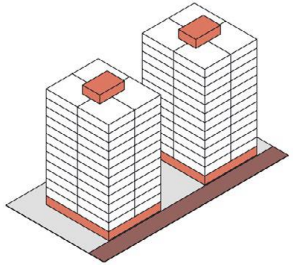
Row house Two side open



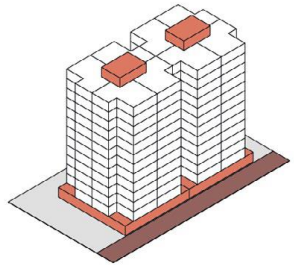
Singly loaded corridor



Doubly loaded corridor



Tower (stand-alone)



Tower (Connected)

5 Panchamrit for Passive-Design in PRiTHVi – Multi Family – what we think?

1. Orientation and Mutual Shading
2. Shading of glazed façade
3. Window sizes and Glass Specification
4. Natural and Cross Ventilation
5. Cool Roof

2 Levels of PRiTHVi Compliance

LEVEL 1:

PRiTHVi

(Minimum Thermal Comfort Performance Level)

- ✓ Easily achieved by passive measures.
- ✓ If adopted, the building will achieve the **acceptable level of thermaly comfortable** hours inside the building and reduce the need of active cooling or heating **considerably**.

Level 2:

Swarna PRiTHVi

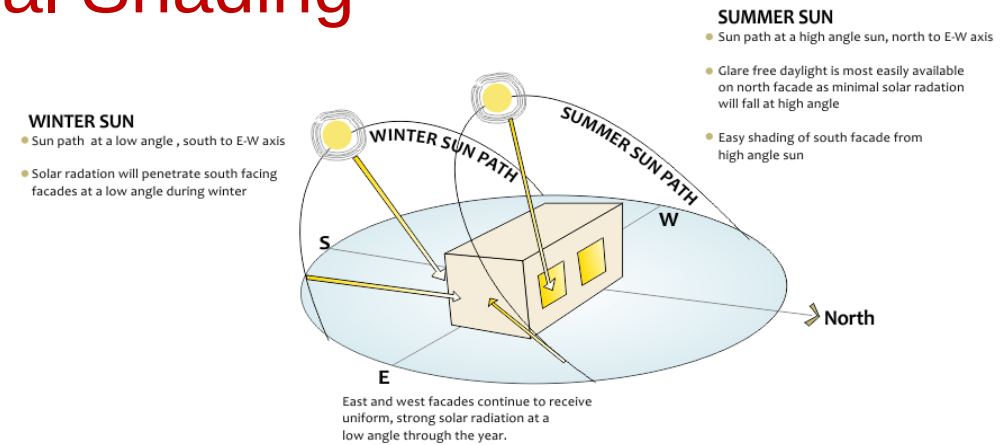
(Advance Thermal Comfort Performance Level)

- ✓ Adopting all recommendations of Level 1 bundled with additional advance measures,
- ✓ If adopted, will ensure a building will **maximize the thermal comfortable hours inside the building** and reduce the use of active cooling or heating **significantly**.

1 Orientation & Mutual Shading

Ideal orientation:

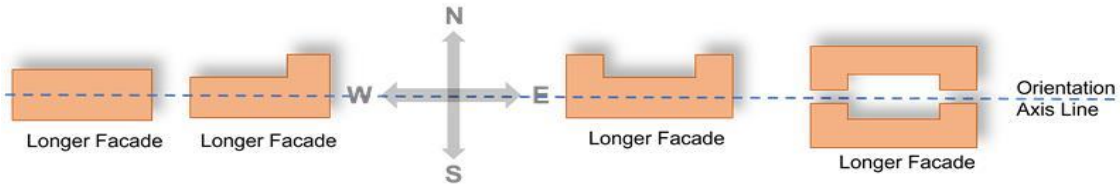
- allows for **minimizing solar radiation in summers** (or in hot climate zones)
- and **maximizing solar radiation in winters** (or cold regions).



Understanding the sun path for ideal orientation. source: https://nzebnew.pivotaldesign.biz/knowledge-centre/passive-design/form-orientation/#

For ideal orientation:

- the longer façade should face true north and south directions
- but on site sometimes achieving ideal orientation is not possible due to shape or other constraints



Understanding the longer and shorter facade of buildings.

1 Orientation & Mutual Shading

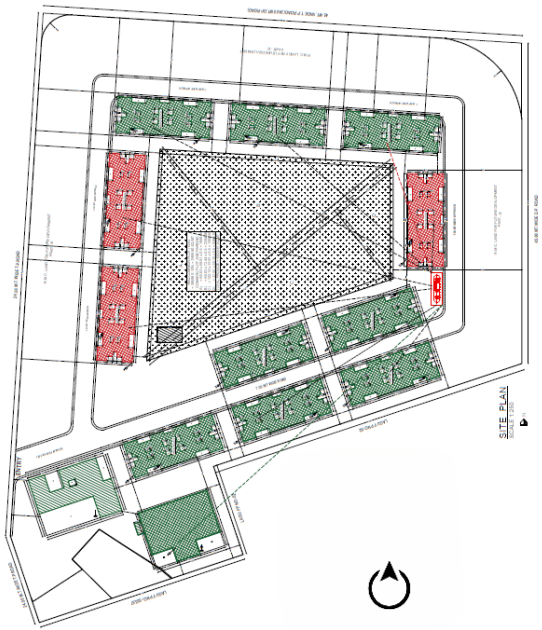
LHP Chennai

14° Tilt from North

N-S Oriented blocks = 66.67%

With Mutual Shading – 83%

LHP Rajkot



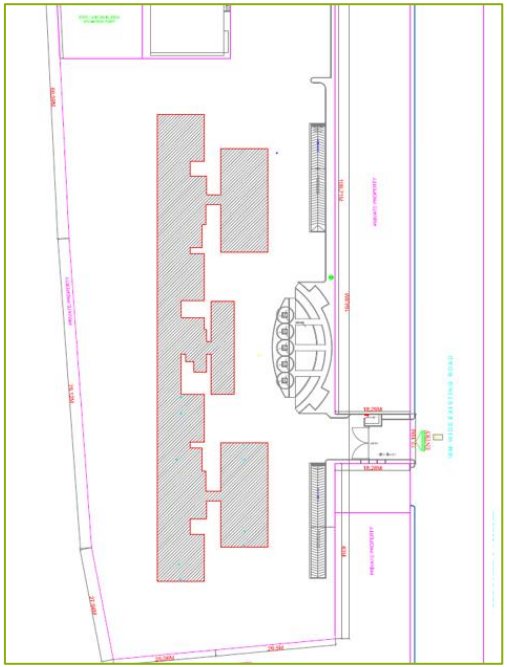
18° Tilt from E-W Axis

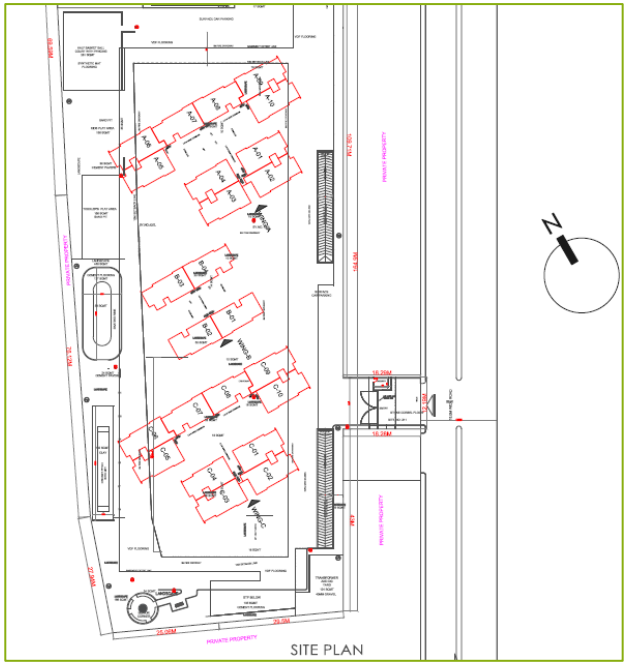
N-S Oriented blocks = 75%

Impact :
Proper orientation further enhanced the Thermal Comfort of these technologies by
10-12%

Examples - Greenfinch Habitat, Bengaluru

Impact in improving Thermal Comfort **21%**

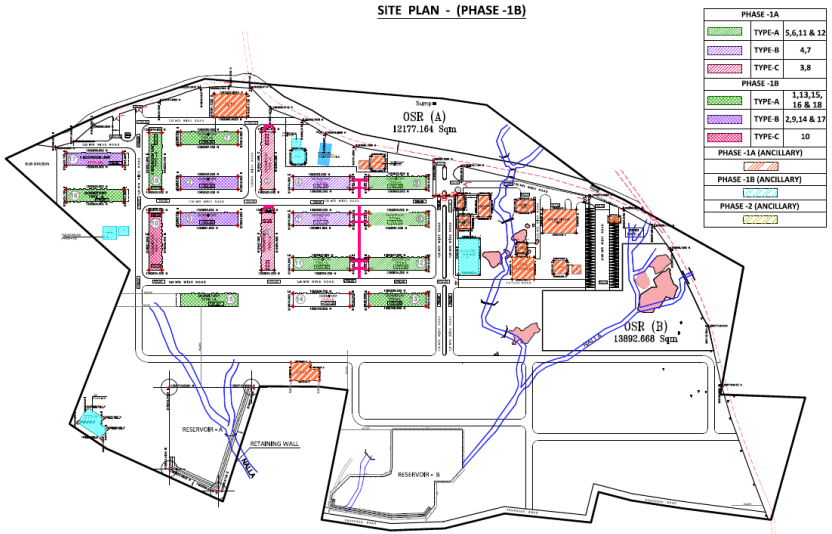


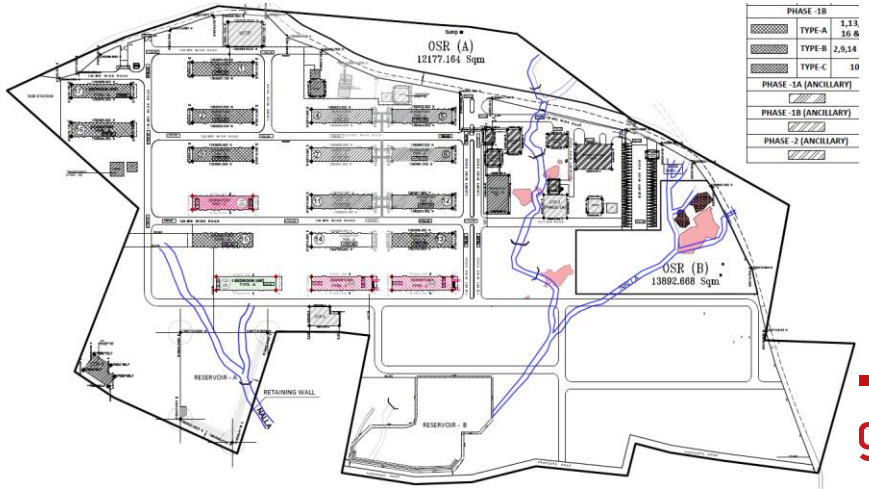


Proposed ECM plan – Actual & re-oriented site plan

Vidiyal Residency Private Limited
Hosur, Tamil Nadu

Impact of rotating only 4 blocks in improving Thermal Comfort
10%





The Question is – what's stopping us then?

Correct orientation and mutual shading

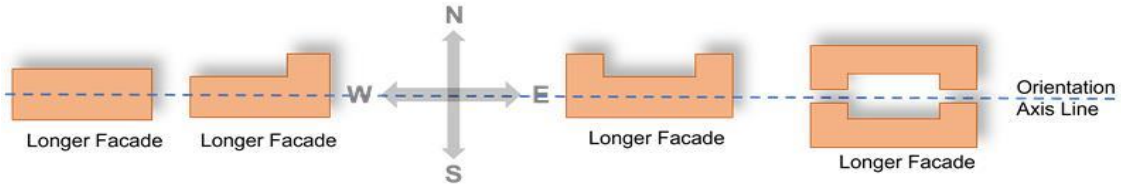
- is free of cost
- is possible
- is simple
- It has a SIGNIFICANT impact
- All it needs a due consideration during planning time

1 Orientation & Mutual Shading

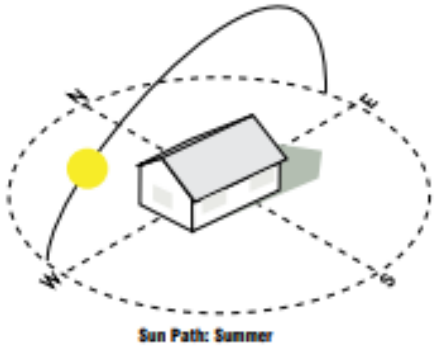
To do the same, the *Orientation Axis Line* of the building block shall

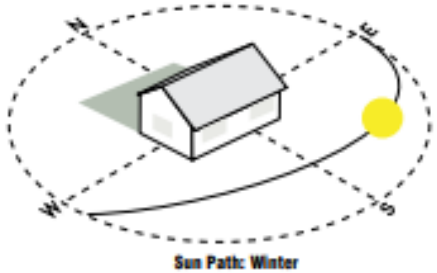
- be aligned with the True North with a maximum deviation of ± 22.5 degrees, or

- aligned between 45 degrees to 135 degrees from true North or 225 degrees to 335 degrees from true north and is Mutually Shaded from the adjacent block as per the criteria mentioned in section covering mutual shading requirement.

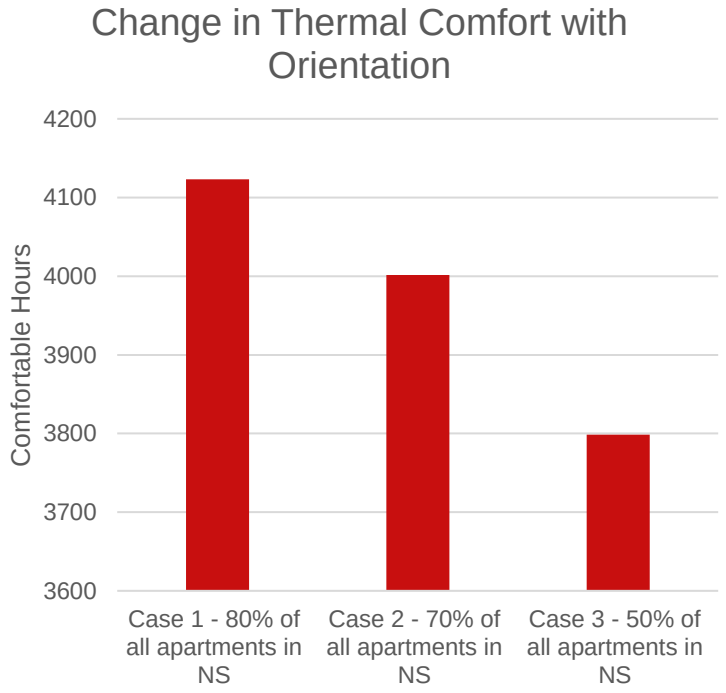


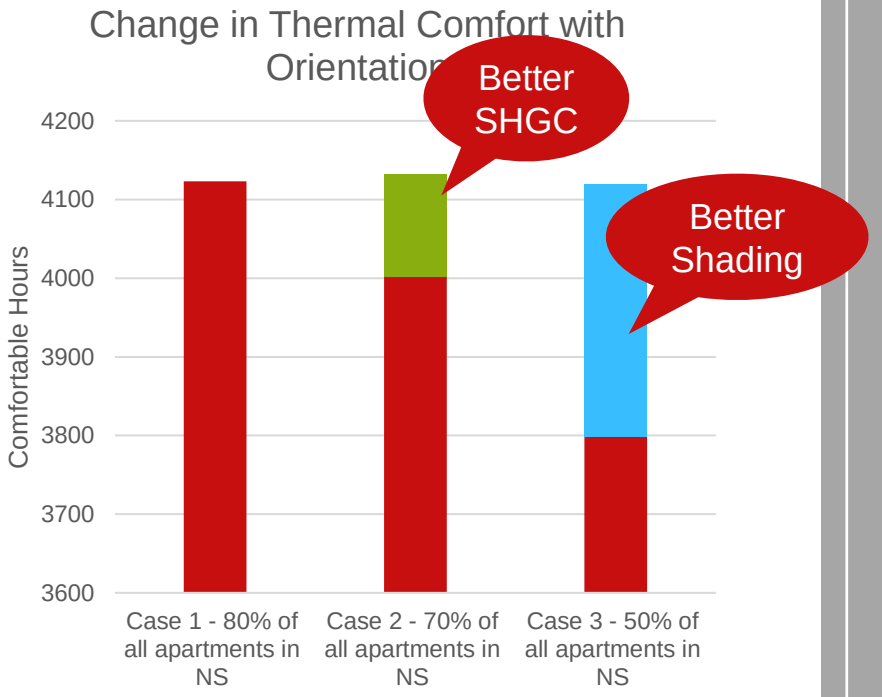
Understanding the longer and shorter facade of buildings.





Change in Thermal Comfort with Orientation





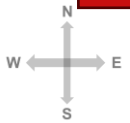
Compliance Requirement - Minimum threshold limit as per planning category

Ideal planning
if more than 80% of the blocks are oriented correctly

Orientation cum Mutual Shading correct for more than 80% blocks (as per area weightage)

No additional measures needed

Moderate planning
if 70 - 80% of the blocks are oriented correctly



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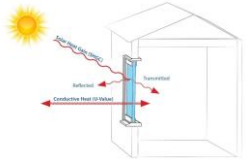
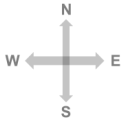


Orientation cum Mutual Shading correct for more than 70% of blocks and less than 80% of blocks (as per area weightage)

SHGC of all glasses to be maximum 0.7

Lenient planning
if 40 - 80% of the blocks are oriented correctly



+

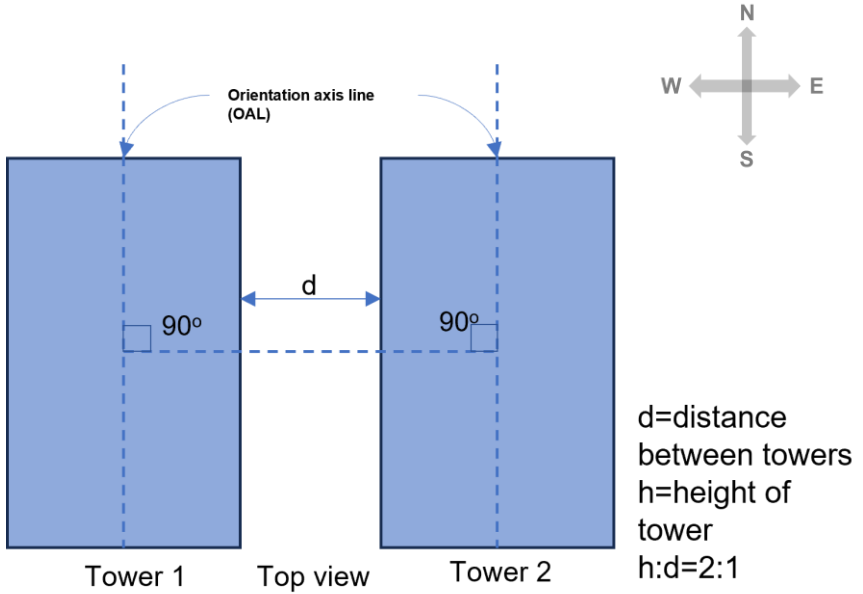
Orientation cum Mutual Shading correct for less than 70% blocks (as per area weightage)

Permanent box frame - external projections with projection factor = 0.55

Mandatory compliance to Swarna PRiTHVi
Level if 0 - 40% of the blocks are oriented correctly

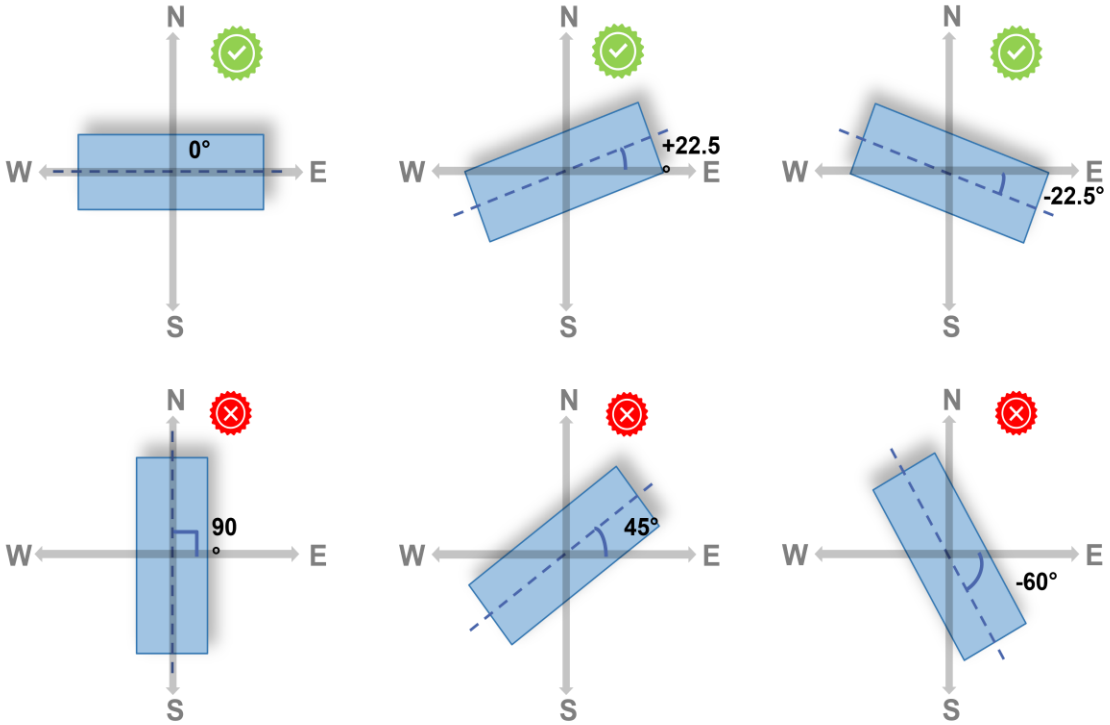
1 Orientation & Mutual Shading

- For mutual shading
  - same height and length.
  - parallel to each other
  - their edges are flushed
  - Only 50% of each building block ground coverage area shall which are mutually shaded are considered for final calculation.



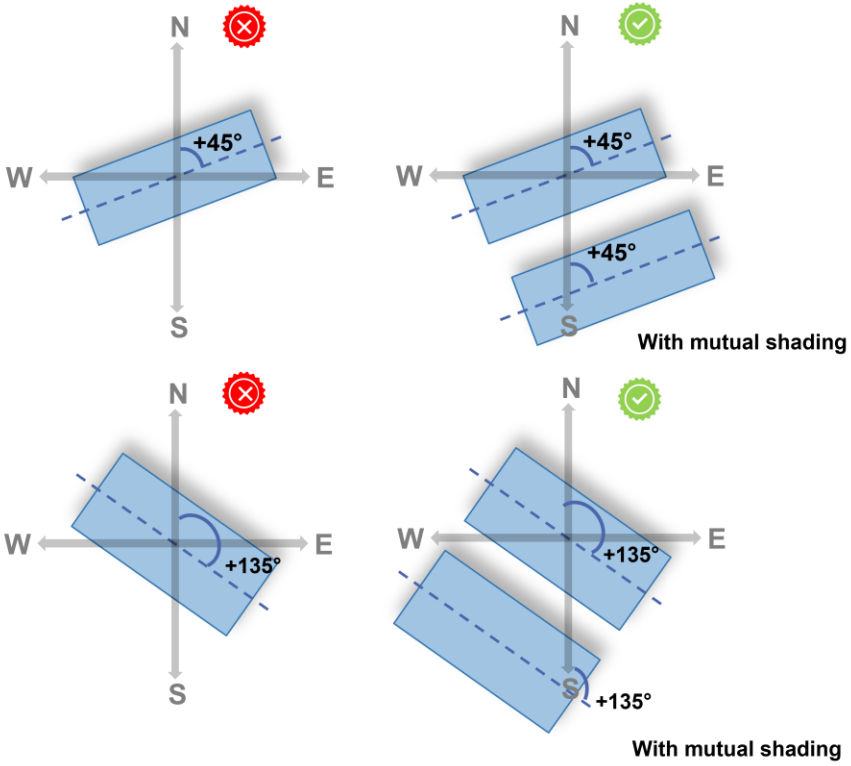
Requirements of orientation and Mutual Shading in PRiTHVi has been kept keeping the simplicity in mind and avoiding the need of simulation or complex calculations

Orientation



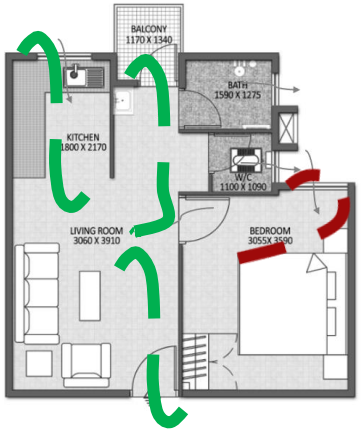
Acceptable limits of orientation of the longer facade

1 Orientation & Mutual Shading



2 Natural and Cross Ventilation

LUCKNOW



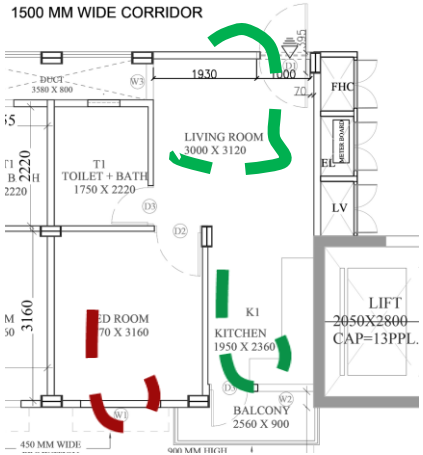
Cross Ventilation – Yes
Jaali Doors at entry & balcony

Impact :
Cross Ventilation enhanced the Thermal Comfort of these technologies by
10-15%

In Warm and Humid Climate Zone, the impact is **25-28%**

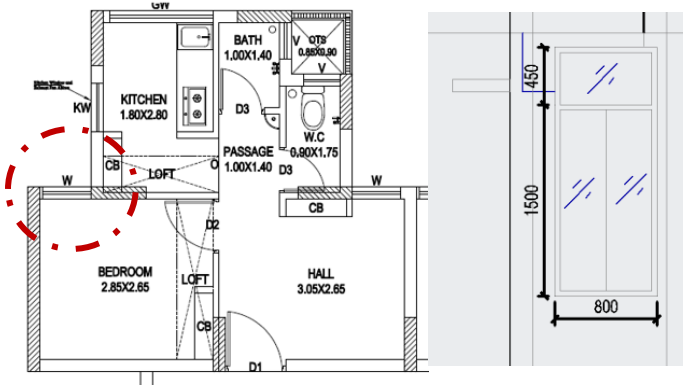
AGARTALA

Cross Ventilation – Yes
Jaali Doors on main door



giz

2 Natural and Cross Ventilation



Dr Thomas Road, Phase 1, Chennai

Casement Window

Sliding Window

Difference between DH of bedroom and living is around **20-25%**

Difference between DH of Casement and Sliding window **15-18%**

giz

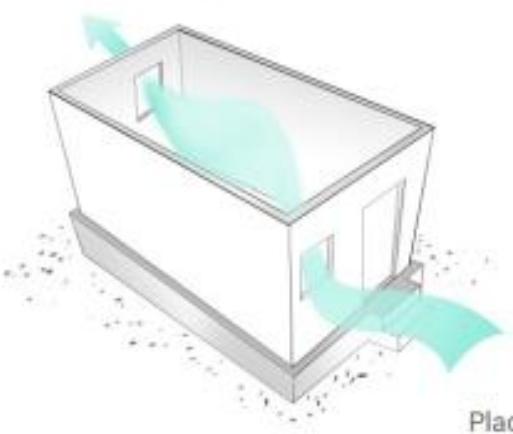
The Question is – what's stopping us then?

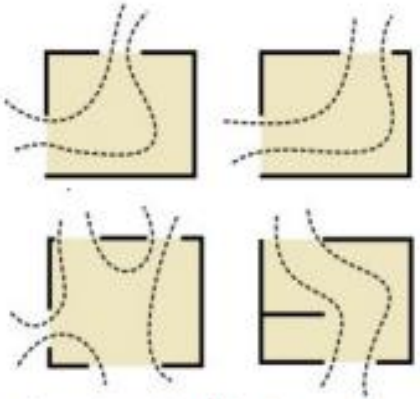
Natural and Cross Ventilation

- Source (wind) is naturally available
- Closing the building envelope hinders its flow inside
- is possible
- is simple
- It has a **SIGNIFICANT** impact
- Its even more needed due to smaller size units
- All it needs a due consideration during planning time

2 Compliance Requirement – Natural and Cross Ventilation

- *Main entrance door of all units in an affordable housing located in warm & humid and composite climate zone should have an additional full length Jaali door fitted at the entrance of the unit (entrance door) to allow cross ventilation.*
- *All windows in bedroom to be a casement window with 90% openable area..*
- *All windows in living room and kitchen having size less than 1.25 meters should be a casement window with 90% openable area.*





Placement of openings for effective cross-ventilation

3 Cool Roof

Impact of cool roof in improving Thermal Comfort **20-25%** in top floor

RAJKOT

40 KW on-grid solar PV
65% of Roof Area of Community center
Use of China Mosaic

RANCHI

152 KW on-grid solar PV Proposed
23% of Roof Area covered by PV use
China Mosaic on roof

LUCKNOW

140 KW on-grid solar PV
39% of Roof Area covered by PV
ACC blocks on roof

INDORE

Use of China Mosaic on roof

Similar impact range in all climate zone

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Again the same Question – what's stopping us then?

Cool roof

- It can be done via waste (china mosaic)
- Can help to generate energy (PV)
- Help in heat island effect
- is possible
- is simple
- It has a SIGNIFICANT impact
- All it needs a due consideration during exection time

3 Cool Roof

- The roof should have 7mm reflective white colored China Mosaic tiles on the entire Terrace floor with appropriate spacing over 50mm bedding cement mortar.

(or)

- Choose light-colored or reflective roofing materials that reflect sunlight. Apply special coatings (high SRI paints) that make your roof reflect sunlight and stay cooler.

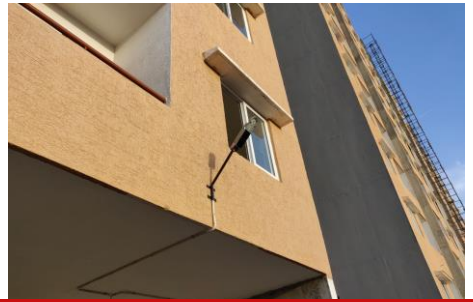
(or)

- Shade minimum 50% of the roof area with canopies/ shading structure/ green vegetation/ solar PV.

Consider having plants on your roof, as they provide natural shade and help cool down the building.

Remember to take care of your roof by keeping it clean and fixing any damage to maintain its cooling properties.

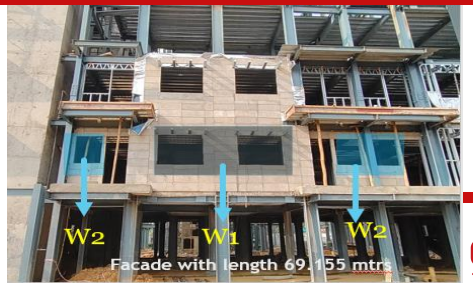
4 Shading



Correct design of Shading plays a very important role in cutting unwanted solar radiations in summer time and allowing solar radiations in winter time.

Generally all affordable housing is providing shading with depth of 300 mm to 450 mm

Proper shading can enhance thermal comfort by 7-8% from basecase. Having a rolling blinds in east and west façade improves ventilation by 20-25%



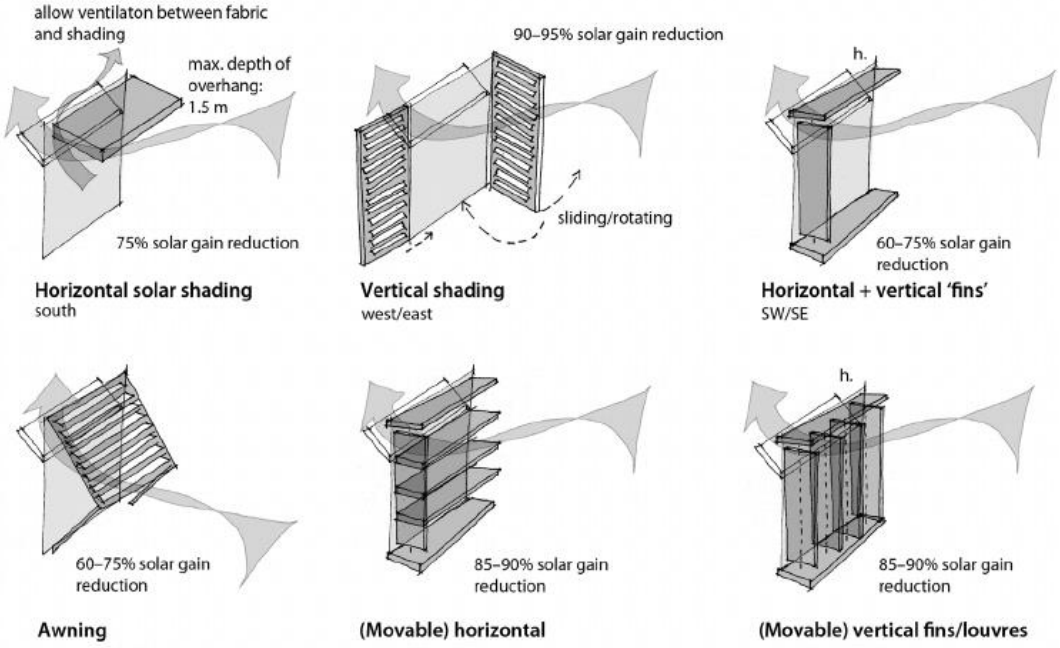
4 Shading

- A minimum projection factor of 0.55 is required for windows with permanent external projection, such as overhangs, side fins, box frames, verandas, balconies, and fixed canopies that offer continuous shade, except for the lenient planning category.

OR

- *A minimum depth of permanent external projection such as overhangs, side fins, box frames, verandas, balconies, and fixed canopies that offer continuous shade to be at least 600 mm*

Any consideration to be given to direction of façade ?



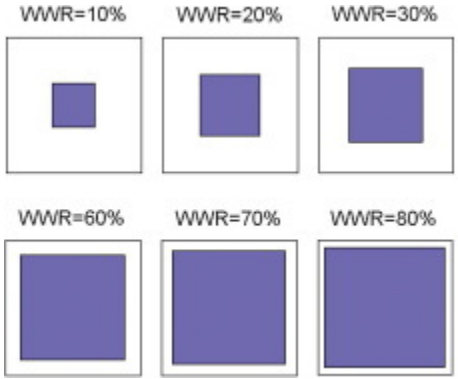
5 Window sizes and Glass Specification

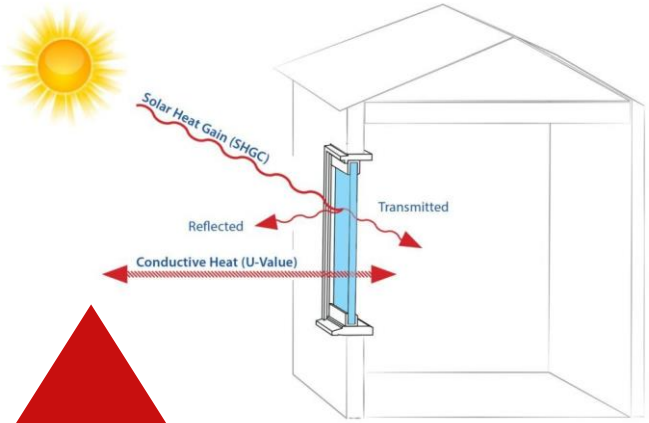
- Maximum allowable Window Wall Ratio (WWR) is 15% and minimum is 12%

- Vertical fenestration (glass only) shall comply with the maximum SHGC of 0.7.

Or

- Should we mention tinted glass?





Impact in improving Thermal Comfort **7-8%**

Summary of Recommendations

	Hot & Dry	Warm & Humid	Composite	Temperate	Cold
					
Orientation	Adopt the orientation and mutual shading concept as per Table no. 4				Optimize the building's orientation to maximize solar gain during the winter months. The living spaces and large windows should face south to capture the most sunlight.
Shading	PF = minimum 0.55 or Permanent projection of 600 mm				
WWR	Maximum allowable Window Wall Ratio (WWR) is 15% and minimum is 12%				Maximum allowable Window Wall Ratio (WWR) is 12%. Plan maximum no. of windows on South, West and East direction.
SHGC	Vertical fenestration (glass only) shall comply with the maximum SHGC of 0.7				
Ventilation/ WFR	All windows of size less than 1.5 meters should be a casement window with 90% openable area				

Summary of Recommendations

	Hot & Dry	Warm & Humid	Composite	Temperate	Cold
					
Roof	The roof should have 7mm reflective white colored China Mosaic tiles on the entire Terrace floor with appropriate spacing over 50mm bedding cement mortar. (or) Choose light-colored or reflective roofing materials that reflect sunlight. Apply special coatings (high SRI paints) that make your roof reflect sunlight and stay cooler. (or) Shade minimum 50% of the roof area with canopies/temporary shading structure/green vegetation/solar PV.				Insulate your roof to keep the heat outside and the coolness inside

Envelope Material (U value) for Swarna PRiTHVi

CHENNAI

U Value
Wall – 0.97 W/m².K

RETV Compliant

RAJKOT

U Value
Wall – 0.68 W/m².K

RETV Compliant

INDORE

U Value
Wall – 1.37 W/m².K

RETV Compliant

Impact in improving Thermal Comfort **15-18%**

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Swarna PRiTHVi

Though this standard focuses on the Passive approaches and natural remedies to attain optimum level of thermal comfort, it is important to mention the importance of building envelope design in attaining the thermal comfort inside a built environment.

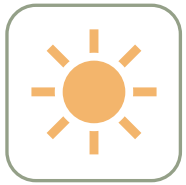
Thus, to further strengthen the impact on comfortable hours attained with the 5 passive measures stated in this standard, PriTHVI recommends:

- Opaque above grade external walls shall comply with the maximum assembly U-factors of 0.8 W/m2K
- And Thermal transmittance of roof shall comply with the maximum Uroof value of 1.2 W/m2.K.

for compliance with **Swarna PriTHVi** level of this standard.

Impact of Passive Strategies based on Climatic Zones

Hot & dry



Very High	Natural ventilation control, sunlight control, orientation
High	Wall surface area, Windows
Neutral	Material, Typology

Warm & Humid

Very High	Natural ventilation, sunlight control, orientation
High	Windows
Neutral	Material, Typology, Wall surface area

Temperate

Very High	sunlight control, orientation
High	Windows, Natural ventilation
Neutral	Material, Typology, Wall surface area

Impact of Passive Strategies based on Climatic Zones

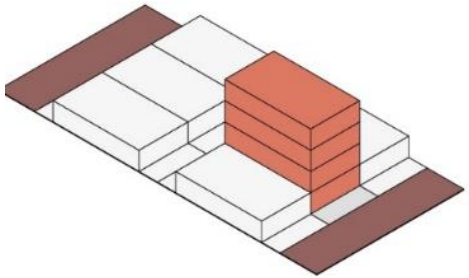
Cold

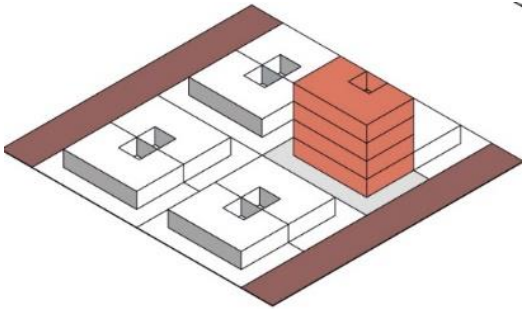
Very High	sunlight control, orientation, Material
High	Wall surface area, Windows, Natural ventilation
Neutral	Typology

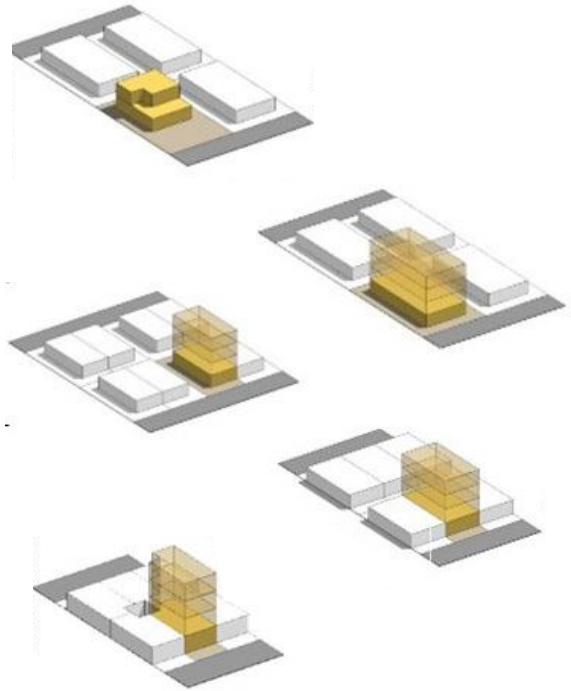
Composite

Very High	sunlight control, orientation, Natural ventilation
High	Wall surface area, Material, Windows
Neutral	Typology

PRiTHVi for Single Family Homes







Passive Design Approaches

- Small plot sizes
- Big Dreams, Bigger Constraints, PRiTHVi needs to contribute to make LiFE better
- Need to reach the ground level in Villages and Small Towns
- Simple Dos and Donts to make a Dream House Thermally Comfortable as well

5 Panchamrit for PRiTHVi – Single Family

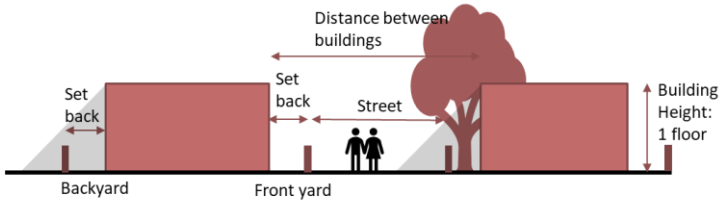
1. Site Planning
2. Built Form
3. Space Planning
4. Windows – Location, Cross Ventilation, & shading
5. Wall and Roof Design

1. Site planning

Minimise hard paved surfaces:

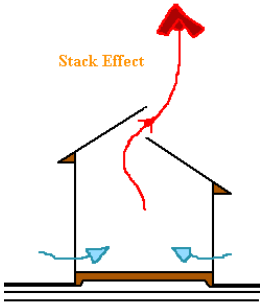
Maximise green area:

- For cold climates locations - allow maximum sunlight by enough space between buildings.
- For summer dominated location – plan enough shades to walls and ensure cool surroundings with vegetations, mutual shadings

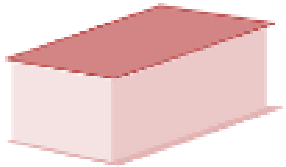


2. Built Form

Sloping roof for rain & snow



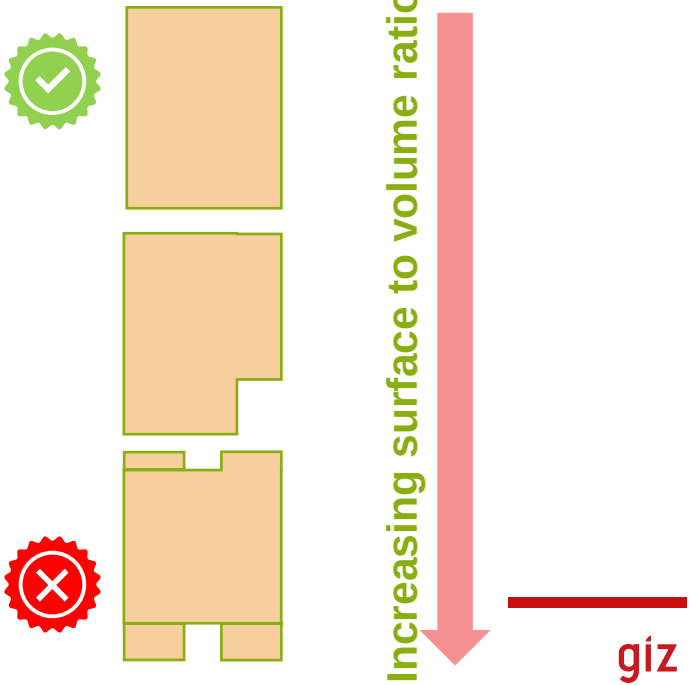
More height for ventilation in hot & Humid climate



Flat roof for composite climate & hot Dry

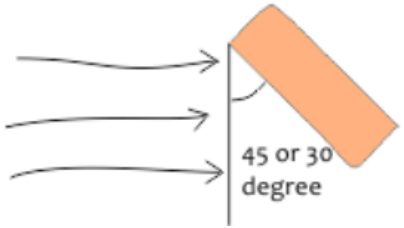
COMPACTNESS

Simple building form needs to be adopted where the external wall area is minimum.

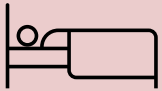
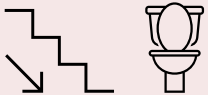


3. Space Planning – As per Solar Design

In warm and humid climates apart from orientation in relation to the sun, the direction of wind is also important

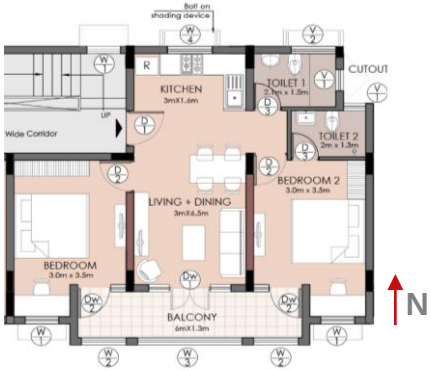


Recommendations for summer dominated locations

Direction	Response	Strategy	
South	Low angle of the sun in winter: ideal to allow sunlight. High angle of the sun in summer: can be shaded		Ideal to locate windows and living spaces of the house
North	Very little direct sun received, best for receiving uniform daylight		Ideal for cool spaces requiring uniform light such as a study
East	Receives morning sun at low angle.		Ideal for bedrooms to catch morning sun, windows can be shaded with side fins or louvers.
West	Maximum effect of the harsh evening sun specially in summers		Avoid windows, openings, ideal to locate staircase or utility areas Have least wall area facing west Shade wall with vegetation

3. Space Planning – As per Solar Design

Living areas are located facing South, East and West, Utility areas are located facing North



Sun balcony on south facade to trap maximum heat inside.

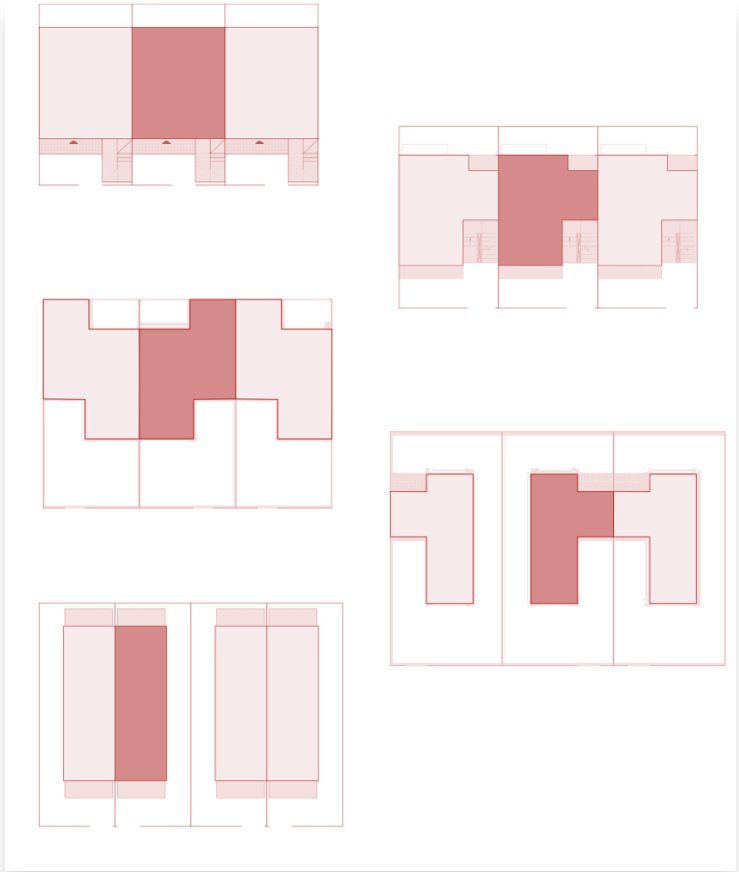
Recommendations for winters dominated locations

Direction	Response	Strategy
South	Receives maximum sunlight and warmth during the day	Ideal to locate sun balconies to capture warmth during the day and living spaces of the house
East	Receives morning sun at low angle.	Ideal for catching morning sun and keep areas warm during the day.
West	Receives evening sun	Ideal for catching evening sun and keeping areas warm during the night.
North	Very little direct sun received, best for receiving uniform daylight	Ideal for cool spaces requiring uniform light such as utility areas.

3. Space Planning – Internal Space

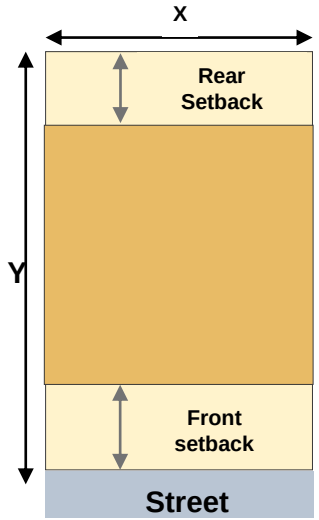
- Plots in India usually have a rectangular configuration with the shorted side facing the street and the depth being longer.

- As the city becomes more crowded and more expensive the plots tend to become long and narrow as street frontage and access becomes more prime.



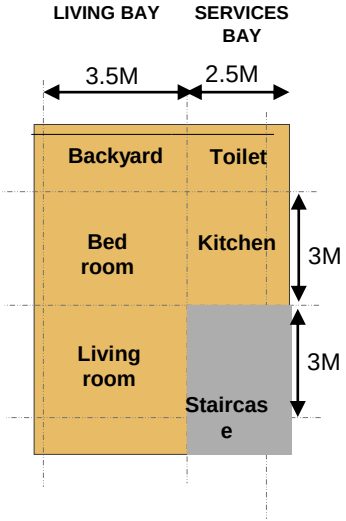
3. Space planning – Internal Spaces

Plot setbacks



Minimum setback range of 2-3m to ensure optimum light & ventilation. These may be superseded by local byelaws in each location.

Unit size & design



Unit with its typical 3.5m wide structural bay for living rooms and 2.5m wide bay for services gives optimum space and economy of structure.

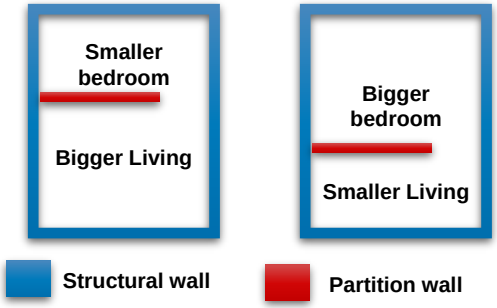
Unit plan

Unit with its typical 3.5m wide structural bay for living rooms and 2.5m wide bay for services gives optimum space and economy of structure.

3. Space Planning - Internal Flexibility

1 Structural walls vs partitions

- Keep internal walls flexible wherever possible to allow flexibility in space usage. If not structural these can be movable partitions with openings/ ventilators on top for air flow between rooms.



2 Storage and multi-purpose spaces

- In small homes storage needs to be maximized. Wall shelves and recesses help clear floor space. Cupboards can function as partitions. Recessed windows provide shade as well as storage above & below.

3. Space Planning - Internal Flexibility

3 Front & back open spaces for ventilation

- Open spaces in the front and back of the house are important for washing, drying, parking, socializing etc. Spaces like kitchen and washing area should connect to the outside for better ventilation & comfort.

4 Natural light

- With long narrow plots it is important to have light and ventilation through the back or through a courtyard or shaft in the middle to get light & ventilation in the back rooms.
- .

3. Space Planning - Future expansion

The building would also add upper floors as an extension of the home. Eventually, most buildings in such a colony will grow to four stories.

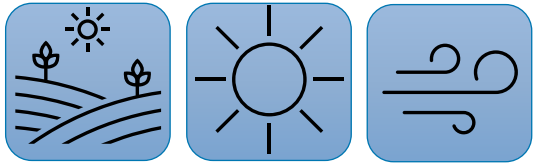
The design of the individual dwelling unit must, therefore, **anticipate extension and growth**. The patterns of extension and growth:

- **Need to be efficient & functional-** proper access, provision should be left on the ground floor to add a staircase for terrace access
- **Maintain adequate daylight & ventilation –** enough distance between buildings should be maintained and cut outs should be provided
- **Optimise passive strategies in buildings -** in order to maintain optimal thermal comfort.

These aspects of environmental performance must be assured through the processes of incremental growth of the buildings.

4. Windows - Windows – Location, Cross Ventilation, & shading

- ✓Adequate daylight
- ✓heat outside
- ✓natural ventilation



Views **Day light** **Ventilation**

Recommendation for different climates

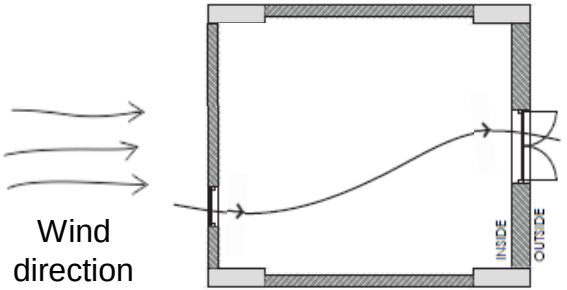
In **hot climates**, evenings and nights - open for cool air to flow through the rooms.
During the afternoon- keep windows close

In **warm and humid climates**, more cross-ventilation is needed. Larger window openings, with additional ventilators above, need to be provided.

In **cold climates**, prefer glass windows instead of open balconies or verandahs

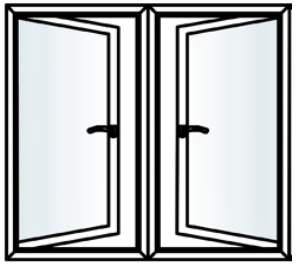
1 Location

- facing the natural wind direction - smaller windows
- opposite side - larger to encourage cross ventilation.

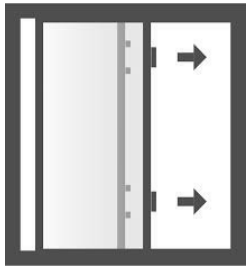


2 Window type

- Casement windows allow 90% of the window



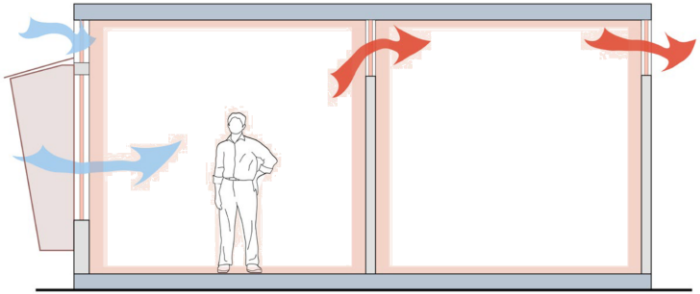
Casement window



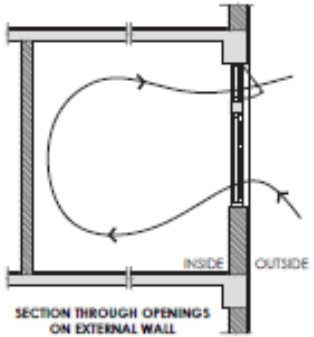
Sliding window

3 Window height

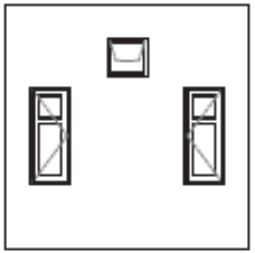
- Provide ventilators on top
- Provide ventilators between rooms

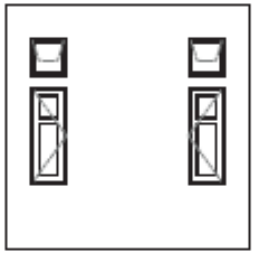


Here, ventilators are provided in 3 window design options for natural ventilation.



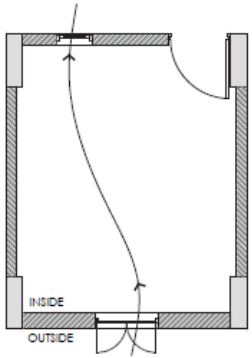

OUTSIDE ELEVATION

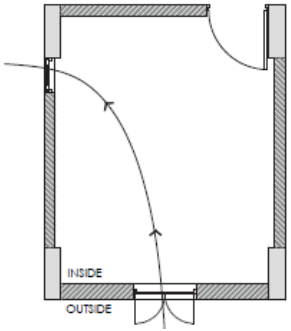

OUTSIDE ELEVATION


OUTSIDE ELEVATION

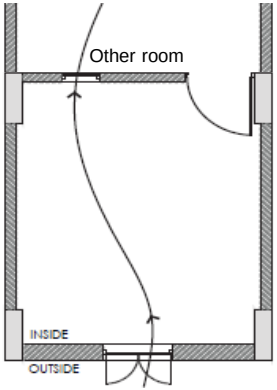
4. Windows - Windows – Location, Cross Ventilation, & shading

- Following are a few best practices to enhance the natural ventilation potential in affordable housing dwelling unit

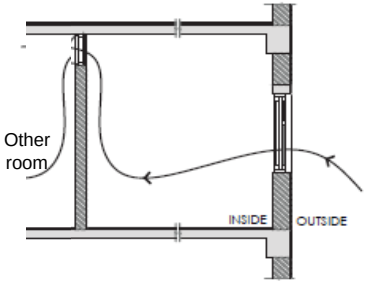




Openings on adjacent or opposite external walls for cross ventilation



Plan



Section

Openings on external wall and internal wall for cross ventilation

4. Windows - Windows – Location, Cross Ventilation, & shading

Recommendation for different climates

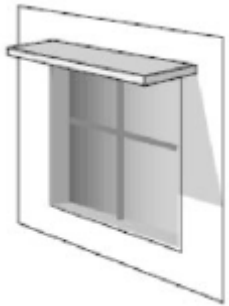
During warm and hot seasons, Minimum Chajja of 600 mm

In a cold climate, or during a cold winter, it is desirable to let the sun enter the room, while the glass window is closed. This will add warmth to the rooms.

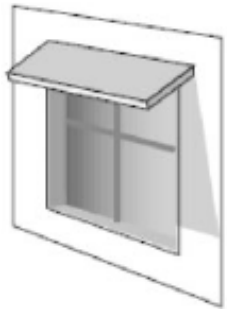
Recommendation for different directions

South

A chajja or overhang works best for windows in the south. This allows low winter sun while blocking the high summer sun.

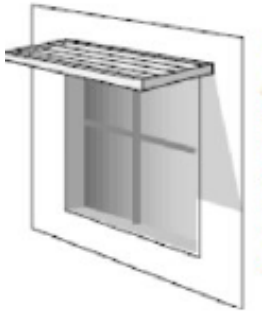


Standard horizontal overhang of 2 ft width

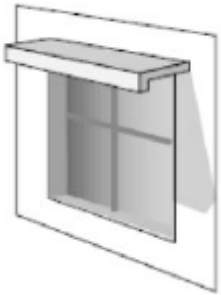


Slope it down for less projection

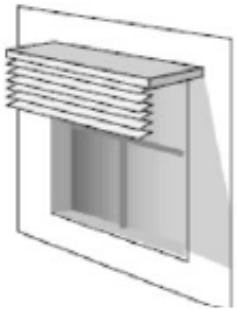
Other variations



Use louvers in place of solid overhang for more light while still shading



Drop the edge for less projection

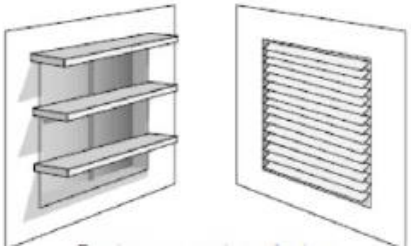


Substitute louvers for the solid dropped edge to let in more light

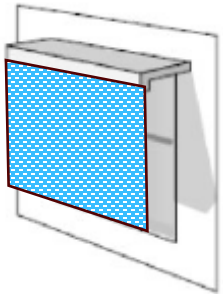
Recommendation for different directions

East & West

Shading is crucial if the window is facing toward East or West as the sun is low and harsher from these directions. This can lead to substantial heat gain.

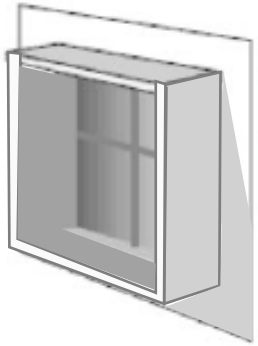


Louvers or fins to cut low Sun in the morning & evening

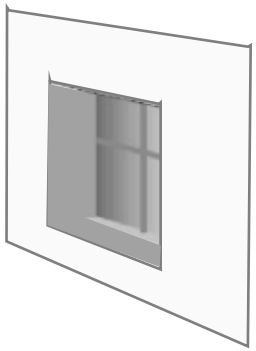


Adjustable shading works well – either roll-up and roll-down bamboo screens or louvres.

Other variations



Boxed windows with projection on all sides



Recessed window with storage above and below

5. Wall and Roof Design

Selection of building materials is significant as it affects the thermal comfort of the occupants and energy consumption.

Materials like metal sheets or dark colours should be avoided as they trap more heat.

AAC Block

Hollow brick

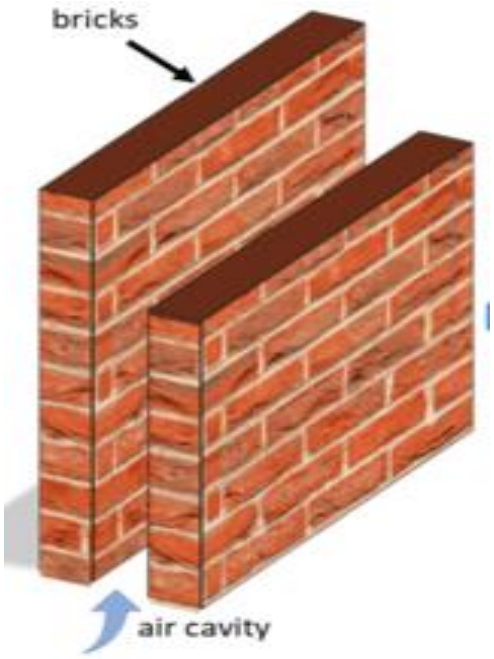
Mud Blocks

Flyash brick

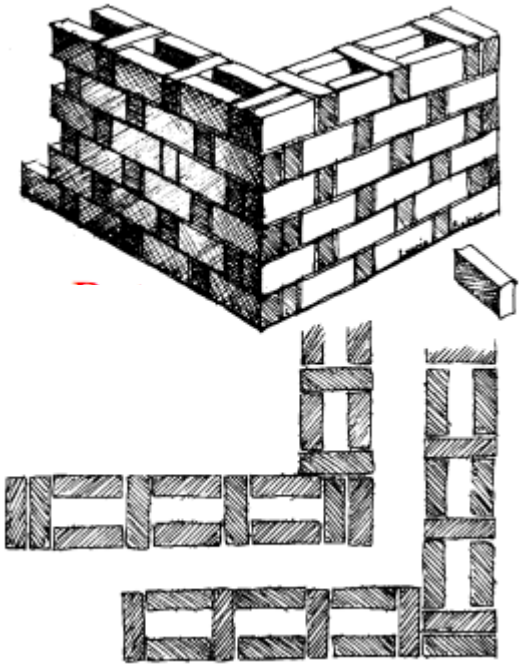
Materials like AAC blocks, Fly ash-based blocks or hollow blocks with light coloured finish help reduce heat transfer to the inside.

5. Wall and Roof Design

Cavity wall



Rat Trap Bonds



5. Wall and Roof Design

- The roof experiences maximum heat gain from the Sun’s direct rays. The hotter the surface of the roof the more heat will travel to the room below. .

1 Shade

- Shading the roof surface using light weight framed structures. Installing solar PV over the roof also helps shade the roof surface. Vegetation can also be used to cover the roof surface and protect from Sun’s rays

5. Wall and Roof Design

2 Reflect

- Reflect majority of the direct Sun rays falling on the surface. This can be achieved by using a light-colored roof finish such as China mosaic/ tiles, or limewash, or a heat reflective paint to reflect the sun's rays.

3 Insulate

- Use layers in the roof assembly that prevent heat transfer to the inside. Using insulation material such as Extruded polystyrene (XPS) or EPS insulation layer or mud phuska or air cavities created using inverted earthern pots are all ways of achieving insulation on the roof

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