

# Training Program on Innovative Construction Technologies & Thermal Comfort in Affordable Housing



**RACHNA for Officers on 07 June 2022, Tuesday**

**Venue:** Vermello I, Sarovar Premier, Jaipur

**Time:** 10:00 AM to 5:30 PM

‘RACHNA for Officers’ training program delivered in-depth knowledge on thermal comfort, its nuances, and its relationship with building physics. Moreover, it discussed design strategies, construction techniques, policy documents, building codes, international practices, and other aspects relevant to thermal comfort in affordable housing through a suite of case studies. Additionally, it familiarized participants with the evaluation process of thermal comfort, the statistics, and indicators involved as well as affordable cooling technologies and their applicability in various climates.

## Session proceedings

Thermal Comfort Training Module		
10h00 – 10h10	Address and Introduction	Shri Pradeep Garg, Project Director (Housing), RUDSICO
10h10 – 10h15	Introduction to Climate Smart Buildings Programme (IGEN – CSB) and overview of workshop	Anurag Verma, GIZ

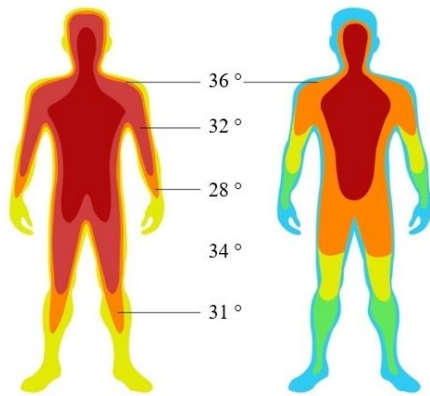
10h15 – 11h00

## Session 2 (Technical): Importance of Thermal Comfort

Dr. Yash Shukla

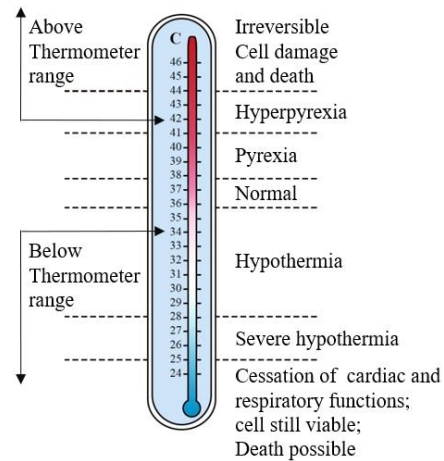
*This session established the importance of thermal comfort.*

### Importance of thermal comfort : Conditioning and Comfort



30 °C – Ambient temperature – 20 °C

Human Body Condition in two set of environment



Human Body Condition beyond comfort bands

*It provided an insight into the connections between comfort, physiology, health, and productivity.*

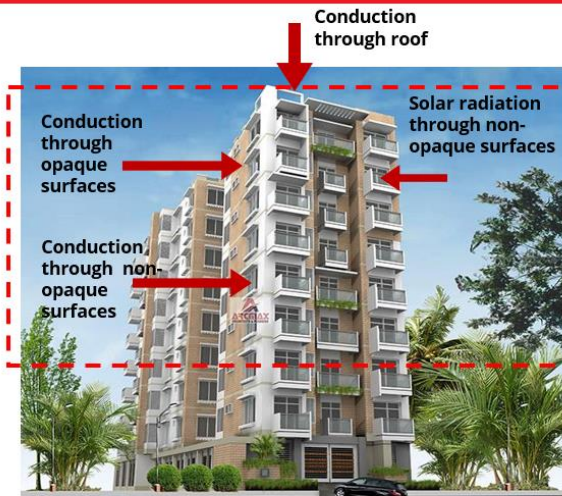
### Importance of thermal comfort : Conditioning and Comfort



- In ability to shed excess heat leads to rise in core body temperature.
- Increase heart rate
- Loss of concentration
- Irritation
- Sickness and Vomiting
- Unconsciousness
- Death

*It briefly exposed the audience to the connection between buildings and comfort.*

## ECO NIWAS Samhita: ECBC Residential



To limit the heat gain/loss from the building envelope, the code specifies:

**Maximum value of thermal transmittance of roof** ( $U_{\text{roof}} = 1.2$  W/m<sup>2</sup>.K) for all climate zones

**Maximum value of Residential Envelope Transmittance Value (RETV)** for building envelope (except roof)

*It provided overarching guidance about the ways and means to achieve comfort in buildings.*

## Importance of thermal comfort : Ways to achieve it



- Electrical – Mechanical Systems
- Change of Air
- Air Velocity
- Cooling
- Heating

*With the help of examples, the factors affecting thermal comfort were explained.*

## Factors Affecting Thermal Comfort: Others



Short term  
physiological  
adjustments



Long term physiological  
adjustments



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

- **Body shape and fat**



Age



Gender

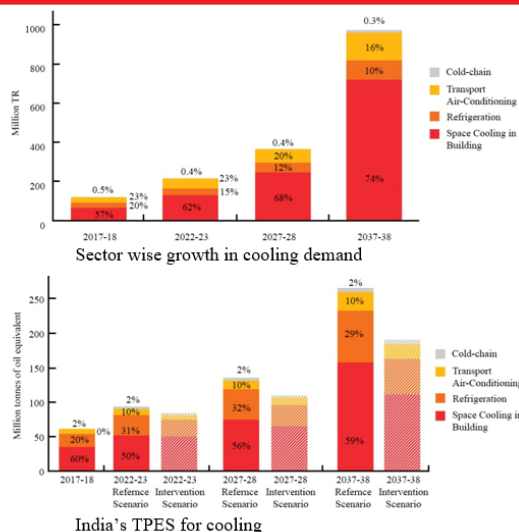


Health and Wellbeing

- **Age and gender**
- **Status of health**

The session ended with establishing a relation between comfort and associated energy consumption through cooling needs.

## Impact of need of Thermal Comfort: India Cooling Action Plan



### India's cooling demand

- 8 times by 2037-38
- 11 times for Building Sector compared to the baseline 2017-18
- India's Total Primary Energy Supply (TPES) for Cooling 4.5 times in 2037-38
- 30% reduction possible due to intervention – from better design and technology

Source: India Cooling Action Plan

11h00 – 11h10	Questions and Answers	
11h10 – 11h20	Health Break	
11h20 – 12h05	Session 3 (Technical): Affordable Housing Passive Design Strategies	Dr. Yash Shukla

*This session started with the introduction of passive design and its importance.*

## What is Passive Design?



- No universally accepted definition
- Use of building envelop components to ensure thermal comfort
  - Material Use
  - Spatial Configuration

*It provided a quick overview of various strategies that are important to be incorporated in affordable housing.*

## Passive Design Parameters : Spatial Configuration & Construction

**Radiation**

Orientation

**Convection**

Shading / Brise Solil

Space Volumes

Building Form – Form of Roof, Plan

**Conduction**

Material and construction

*The session provided insights into the site level design decisions as well as building-level design decisions.*



## Other Passive Design Strategies: Spatial Configuration



Optimizing Radiation

Wind Direction and Speed

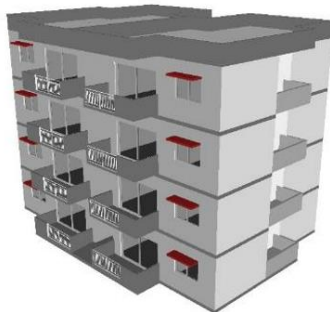
Rectangular Plan

Less 'tight' buildings

Orientation: Positive, Negative and Neutral

*It further provided a comparative understanding of appropriate orientation & use of building mass to reduce radiative heat gains in warm climates*

## Passive Design : Residential Envelop Transmittance Value (RETV) Use of Material



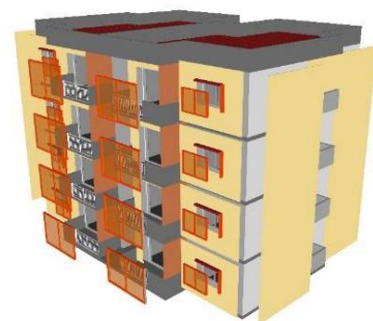
**RETV 21.0 W/m<sup>2</sup>**

Business As Usual Building Envelop



**RETV 18.0 W/m<sup>2</sup>**

Better Insulation on wall and roof (U value)  
Higher Solar Reflectance On the roof (SRI)



**RETV 15.0 W/m<sup>2</sup>**

Better Windows (U Value, SHGC, VLT)

*It will guide fenestration design, location, and shading design appropriate for affordable housing. The use of appropriate ventilation for comfort and well-being was also covered in this session.*

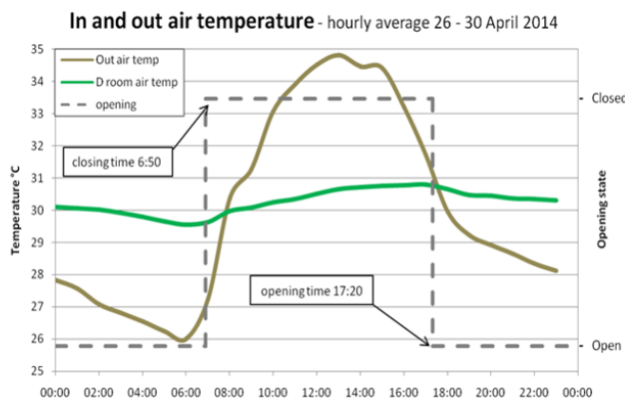
## Other Passive Design Strategies: Spatial Configuration



- E-W Longer Axis
- E-W Vertical ,
- S Horizontal
- Latitude
- *Climate Zone?*

The session also provided selected case studies that have adopted best practice approaches at the site and at the building level to implement passive design strategies.

## Blessings House: Auroville



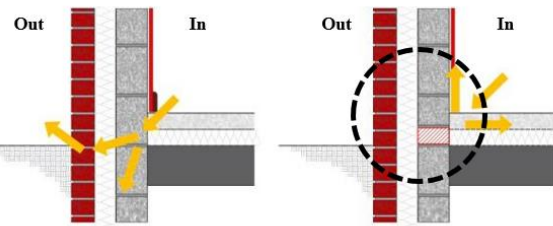
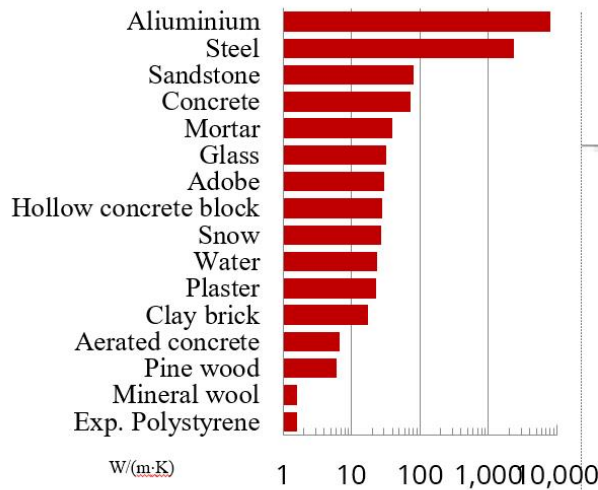
- Balancing Thermal Mass and Insulation
- NV operation with controlled Ventilation
- Warm Humid Climate

Day shutting and nighttime comfort strategy show good results in preventing excessive temperature rise in the building

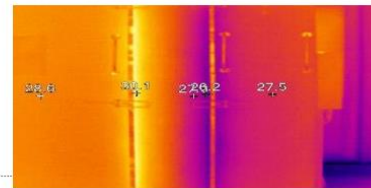
12h05 – 12h15	Questions and Answers	
12h15 – 13h15	Session 4 (Technical): Building Materials and Methods of Construction for Affordable Housing	Dr. Yash Shukla

This session started with the overview of affordable walling, roofing and fenestration materials and technologies.

## Walling Materials and Methods : Conductivity & Thermal Bridge



Air = 1  
0.0002 Sq mts of aluminium (2 Sq Cms) = 1 Sq mts of insulation



Information and Image Courtesy: Prof. Claude Roulet, EMPA, Switzerland, Indo Swiss BEEP project, BEE, India

It further detailed the appropriateness of materials and methods of the construction for housing and its applicability in various housing typologies.

## Nonhomogeneous Walling Technologies, Traditional

**Bamboo-Crete**  
U - VALUE (W/m<sup>2</sup> K)= 1.82



**Wattle and Daub**  
U - VALUE (W/m<sup>2</sup> K)= 2.09



**Stabilized Adobe**  
U - VALUE (W/m<sup>2</sup> K)= 1.50



**Laterite block wall**  
U - VALUE (W/m<sup>2</sup> K)= 1.61



**Unstabilized Adobe**  
U - VALUE (W/m<sup>2</sup> K)= 1.57



**Compressed Stabilized  
Earth block wall**  
U - VALUE (W/m<sup>2</sup> K)= 1.59



**Unstabilized Compressed  
Earth block wall**  
U - VALUE (W/m<sup>2</sup> K)= 1.42



**AAC block wall**  
U - VALUE (W/m<sup>2</sup> K)= 0.45



**Unstabilized Rammed Earth  
Wall assembly**  
U - VALUE (W/m<sup>2</sup> K)= 1.68



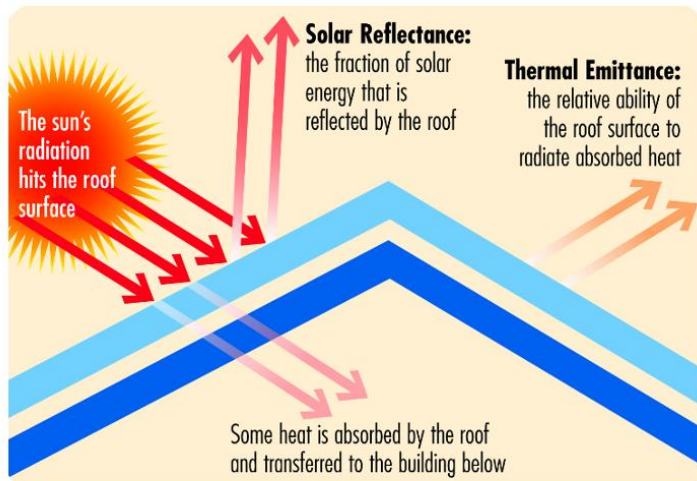
**Stabilized Rammed Earth  
Wall assembly**  
U - VALUE (W/m<sup>2</sup> K)=



The session further enhanced the understanding of the audience to adopt materials and methods according to the climate context.



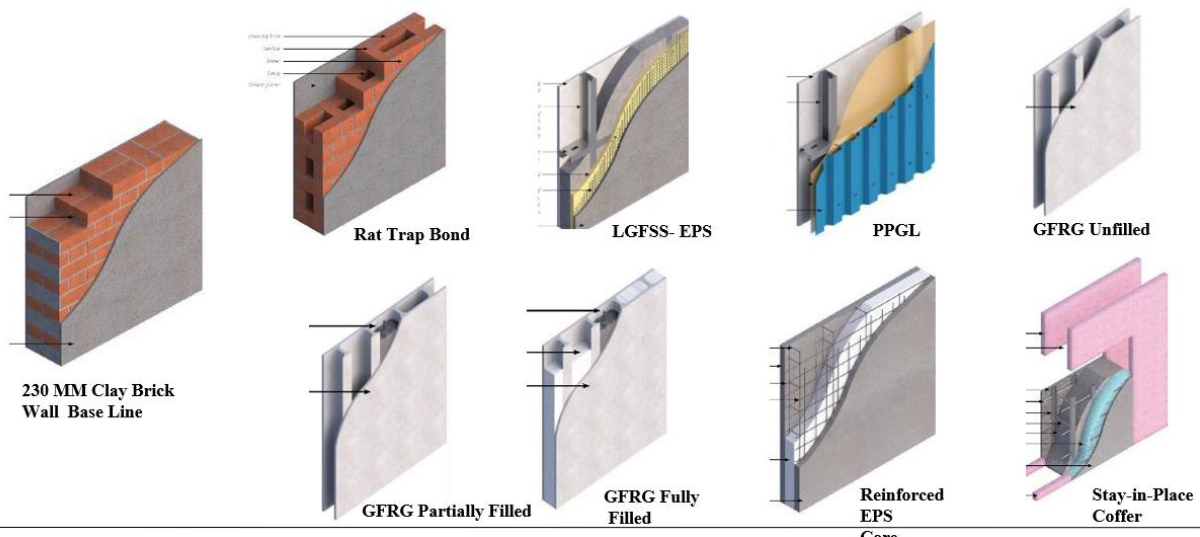
## Roofing Coating Material and Solar Reflectance Index



- Reflectance
- Thermal Emittance.
- Emissivity
- Solar Reflectance Index (SRI)

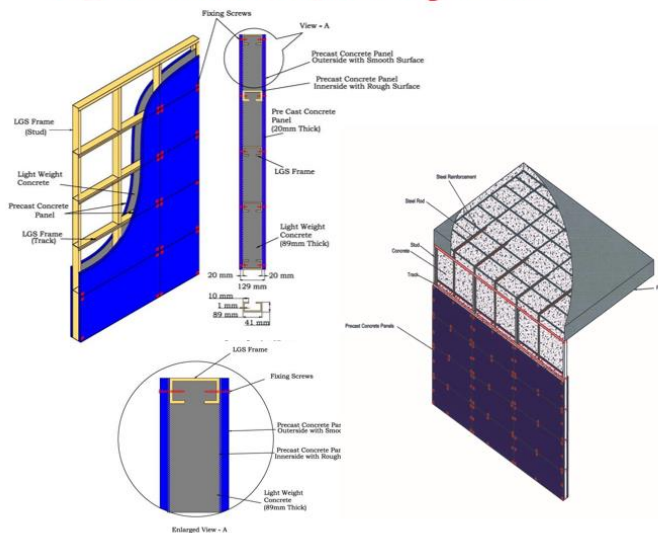
The focus was on alternative construction technologies, low embodied carbon materials, availability of material locally and economics of it.

## Nonhomogeneous Walling Technologies, Industrial



The session also provided selected case studies of construction technologies that have been adopted in LHPs.

## Light House Project: Agartala



- Light Gauge Steel Framed Structure with Infill Concrete Panels (LGSFS-ICP)
- Ground and 06 Floors
- Weight of the LGSFS-ICP building is about 20-30% lighter
- The LSG frames manufactured using numerically controlled roll forming machine using CAD design

## Light House Project: Lucknow

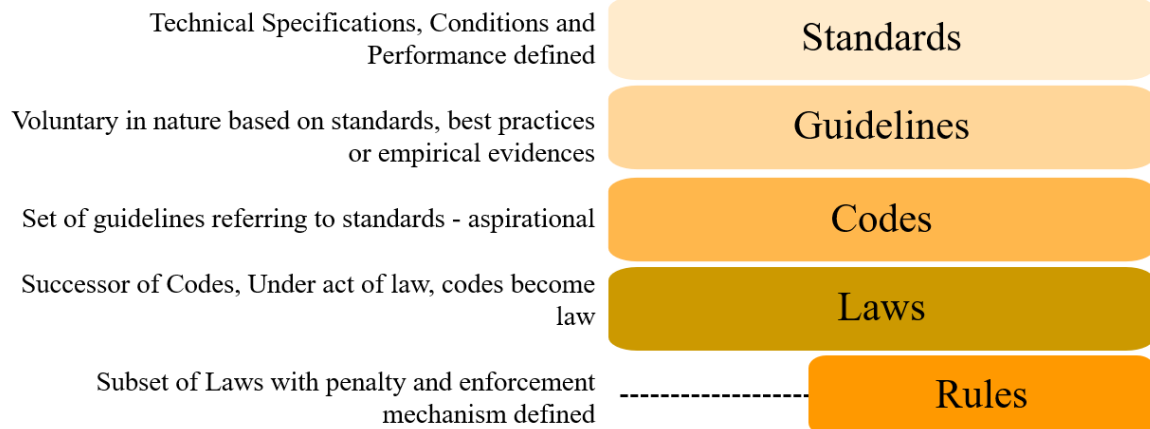


- PVC Stay in Place Formwork System
- S and 13 Floors
- Rigid poly-vinyl chloride (PVC) based form work system serve as a permanent stay-in-place durable finished form-work for concrete walls
- The PVC extrusions consist of the substrate (inner) and Modifier (outer). The two layers are co-extruded during the manufacturing process to create a solid profile.

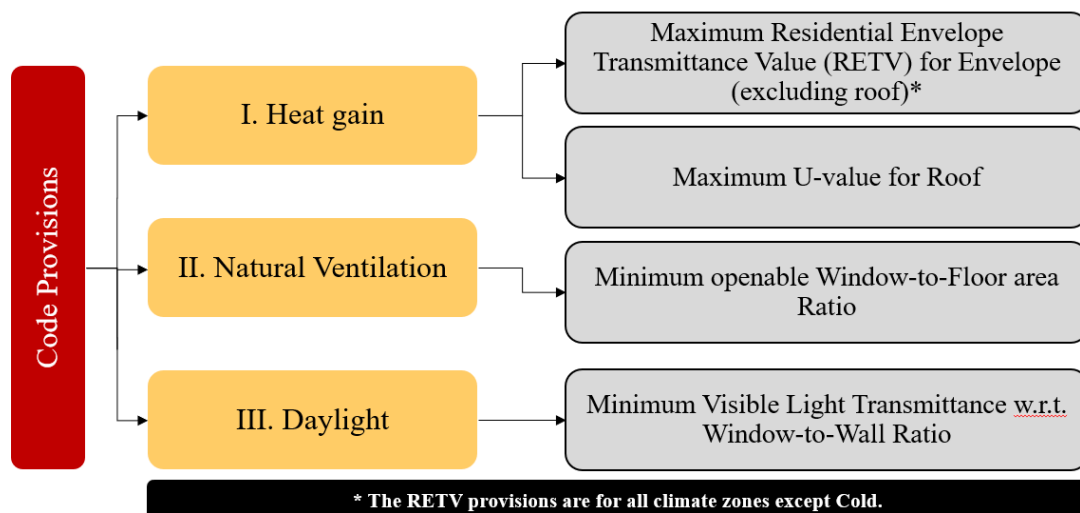
13h15 – 13h30	Questions and Answers	
13h30 – 14h30	Lunch Break	
14h30 – 15h15	Session 5 (Technical): Building Codes, Affordable Housing and Thermal Comfort	Dr. Yash Shukla

*This session provided an understanding of the provision of various thermal comfort-related clauses in the National Building Code, Eco Niwas Samhita, various guidelines provided by the government.*

## Standards, Guidelines, Codes, Laws, Rules.



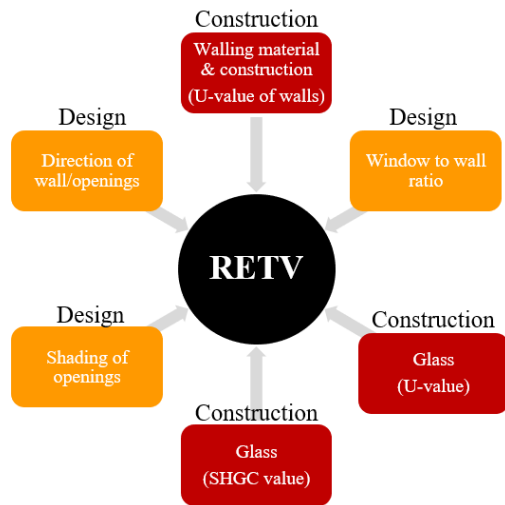
## Overview of Code Provisions



*It also provided insights into the implementation of policy. The audience was able to comprehend the process of implementing the code at the local level. It discussed the programming of code implementation, the economics of it as well as the benefits of the codes.*

*Further, this session outlined the implementation of codes through examples.*

## RETV: Influencing Factors, Design and Construction

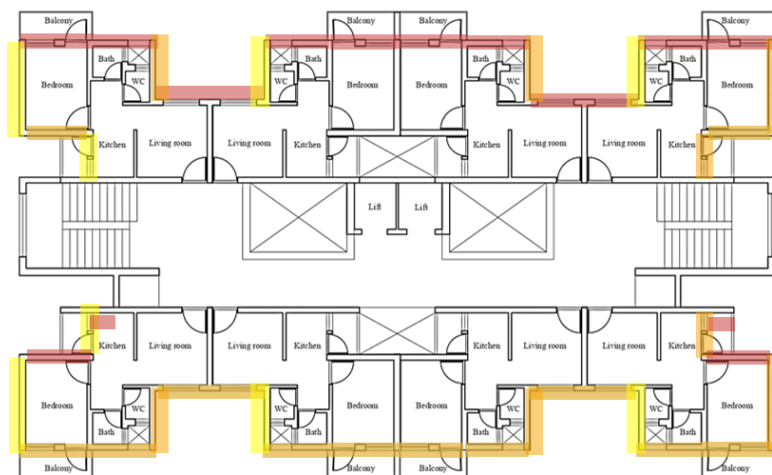


The net heat gain rate (over the cooling period)

through building envelope (excluding roof)

divided by the area of building envelope (excluding roof), measured in  $W/m^2$ .

## Wall Construction details



E  
W  
S  
N

### Construction:

- Outer: 25mm Cement plaster
- Layer 1: 200mm AAC block
- Inner: 25mm Cement plaster

15h15 – 15h30	Questions and Answers	
15h30 – 15h45	Health Break	
15h45 – 16h45	Session 6 (Technical): Application of Thermal Comfort in Affordable Housing- A Suite of Case Studies	Dr. Yash Shukla

*This session brought salient features of the projects that have demonstrated approaches to achieve thermal comfort in affordable housing. This session included the projects that were conceived using*



integrated design practices. The case studies in this session highlighted more than one aspect of the project that meets the objective of affordability and comfort. The on-site performance of the housing was also included to help the participants understand the methods of field performances.

## Case study: Shree Ram Nagar Co-operative Housing society

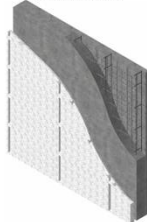
Walling Materials	Existing layout		Case 2: Re – oriented (Without cost)		Case 3: Re – oriented + Increased FSI (With Cost)		Calculations
	Case 1	Case 1A 2	Case 2	Case 2A 2	Case 3	Case 3A 2	
Monolithic RCC							Without Shading
							With Shading
Burnt Brick	Case 1B 1		Case 2B 1		Case 3B 1		Without Shading
	Case 1B 2		Case 2B 2		Case 3B 2		With Shading
Fly Ash Brick	Case 1C 1		Case 2C 1		Case 3C 1		Without Shading
	Case 1C 2		Case 2C 2		Case 3C 2		With Shading
AAC Block	Case 1D 1		Case 2D 1		Case 3D 1		Without Shading
	Case 1D 2		Case 2D 2		Case 3D 2		With Shading
Solid concrete block	Case 1E 1		Case 2E 1		Case 3E 1		Without Shading
	Case 1E 2		Case 2E 2		Case 3E 2		With Shading

Total Cases: 30

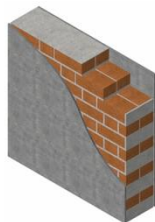
1. RETV  
2. EPI  
3. Comfort hours

## Case study : Existing Layout without Shading

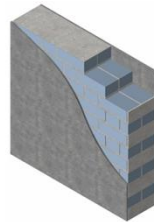
EXISTING RCC  
(MASCON)



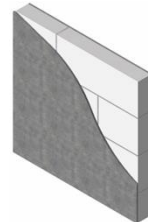
BURNT CLAY BRICK



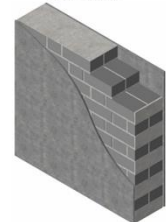
FLY ASH BRICK



AAC BLOCKS

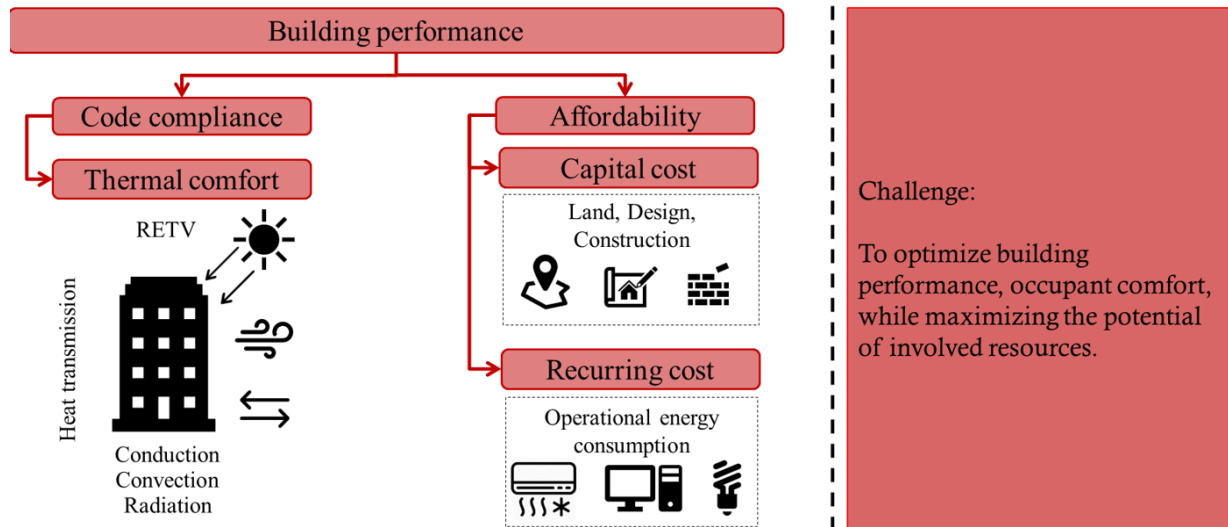


SOLID CONCRETE  
BLOCK



Case	Case 1	Case 1B 1	Case 1C 1	Case 1D 1	Case 1E 1
Shading	Without				
RETV	26.00	16.62	16.34	12.35	25.48
EPI	75.92	48.53	47.71	36.06	74.40
Comfort hours	4760 - 7627	4887-8599	4716-8608	1874-8760	4618-8009
Difference in cost	₹ -	₹ -79,50,926	₹ -66,03,988	₹ -76,08,377	₹ +61,12,630

## Case study : Code and Cost



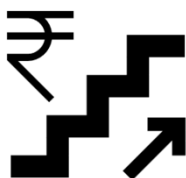
## Maximizing the potential of resources



Incentive to  
contractor



Land usage is  
optimized.  
Land value is  
achieved.



Profit increases.  
(even on a break-even  
regime, the contractor  
will benefit)



More dwelling  
units,  
accommodating  
more people.  
More comfortable  
homes.

16h45 – 16h55	Questions and Answers	
16h55 – 17h25	Session 7: Overview of Innovative construction technologies implemented in Light House Projects (LHPs)	Mr. Pankaj Gupta, Dy. Chief, BMTPC
17h25 – 17h30	Feedback and Concluding Remarks	Mr. Yash Shukla