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

RACHNA
RESILIENT, AFFORDABLE AND COMFORTABLE HOUSING THROUGH NATIONAL ACTION

RACHNA for Officers on **15th June 2022, Wednesday**

Venue: Imperial-3 (Second Floor), Le Lac Sarovar Portico, Ranchi
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.

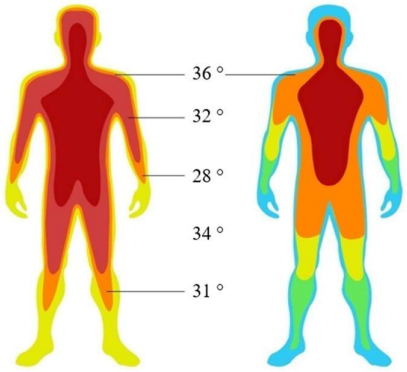
Session proceedings

Thermal Comfort Training Module		
10h00 – 10h10	**Welcome Address and Introduction to PMAY-U**	**MoHUA**
10h10 – 10h15	**Introduction to Climate Smart Buildings Programme (IGEN – CSB) and overview of workshop**	**GIZ**

10h15 – 11h00	**Session 2 (Technical): Importance of Thermal Comfort**	**Dr. Rajan Rawal**

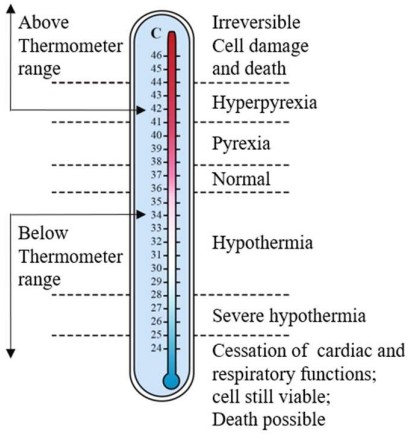
This session established the importance of thermal comfort.

Importance of thermal comfort : Conditioning and Comfort



30 °C – Ambient temperature – 20 ° C

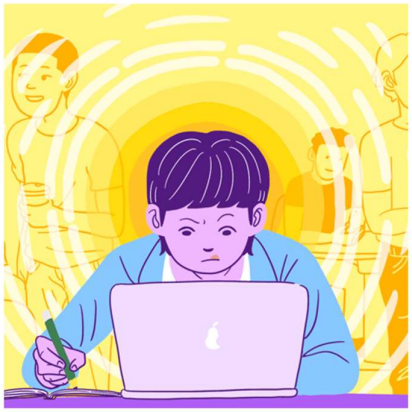
Human Body Condition in two set of environment



Human Body Condition beyond comfort bands

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

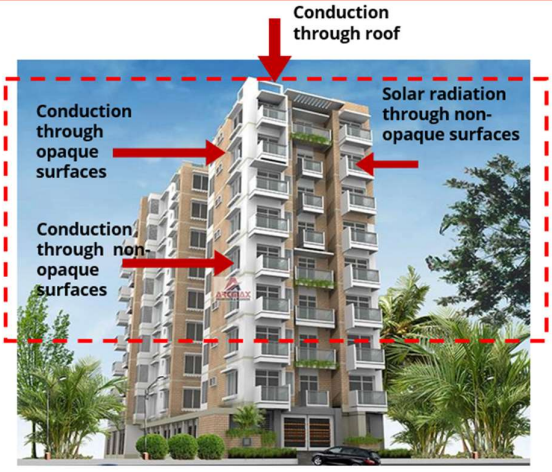
Importance of thermal comfort : Conditioning and Comfort



- 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_{roof}= 1.2 W/m^2.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

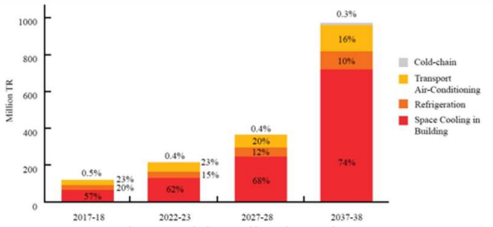
Gender

Health and Wellbeing

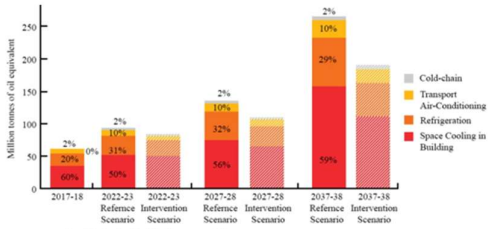
- **Age and gender**
- **Status of health**

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



Sector wise growth in cooling demand



India's TPES for cooling

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. Rajan Rawal**

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
	Shading / Brise Solil
Convection	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

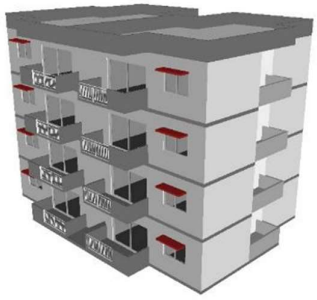
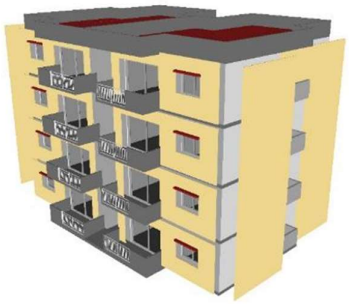
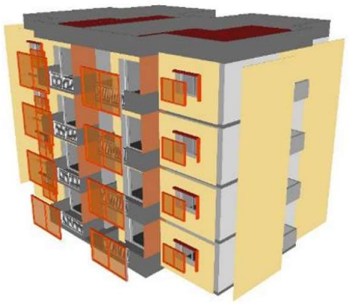
Wind Direction and Speed

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

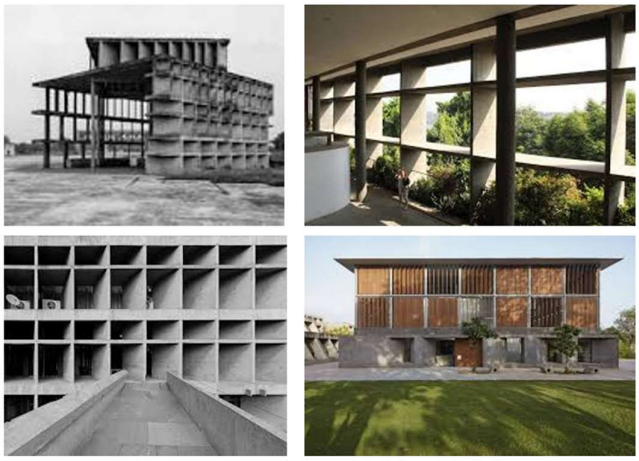
Passive Design : Residential Envelop Transmittance Value (RETV) Use of Material

RETV 21.0 W/m²	**RETV 18.0 W/m²**	**RETV 15.0 W/m²**
Business As Usual Building Envelop	Better Insulation on wall and roof (U value) Higher Solar Reflectance On the roof (SRI)	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.

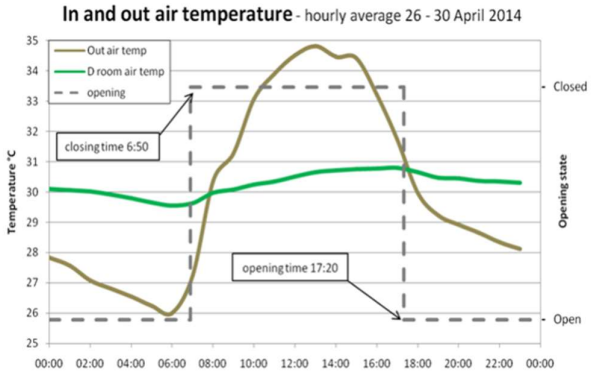
Other Passive Design Strategies: Spatial Configuration



- 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

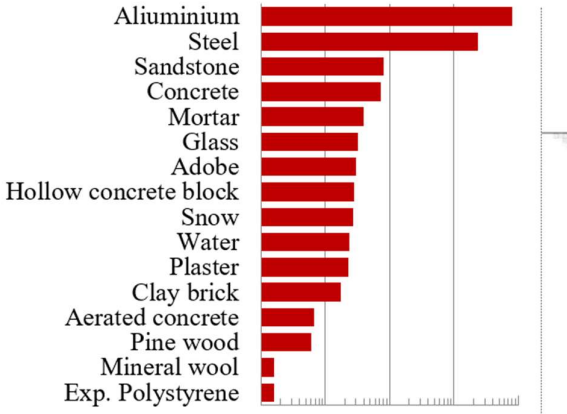


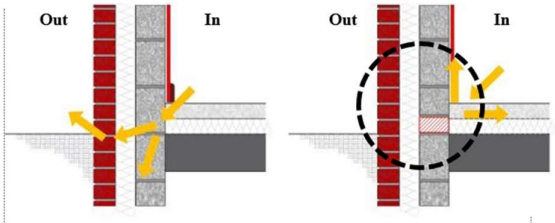
- Balancing Thermal Mass and Insulation
- NV operation with controlled Ventilation
- Warm Humid Climate

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

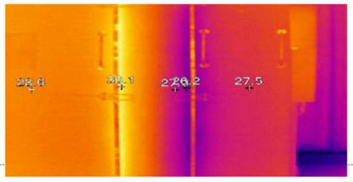
12h05 – 12h15	**Questions and Answers**	
12h15 – 13h15	**Session 4 (Technical): Building Materials and Methods of Construction for Affordable Housing**	**Dr. Rajan Rawal**
This session started with the overview of affordable walling, roofing and fenestration materials and technologies.		

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. Cloude Roulet, EMPA, Switzerland, Indo Swiss BEEP project, BEE, India

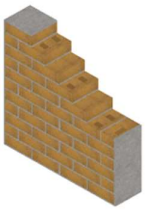
It further detailed the appropriateness of materials and methods of the construction for housing and its applicability in various housing typologies.

Nonhomogeneous Walling Technologies, Traditional

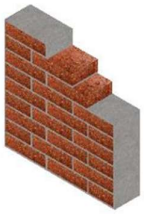
Bamboo-Crete
U - VALUE (W/m² K)= 1.82

Wattle and Daub
U - VALUE (W/m² K)= 2.09

Stabilized Adobe
U - VALUE (W/m² K)= 1.50



Laterite block wall
U - VALUE (W/m² K)= 1.61

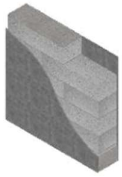


Unstabilized Adobe
U - VALUE (W/m² K)= 1.57

Compressed Stabilized Earth block wall
U - VALUE (W/m² K)= 1.59

Unstabilized Compressed Earth block wall
U - VALUE (W/m² K)= 1.42

AAC block wall
U - VALUE (W/m² K)= 0.45

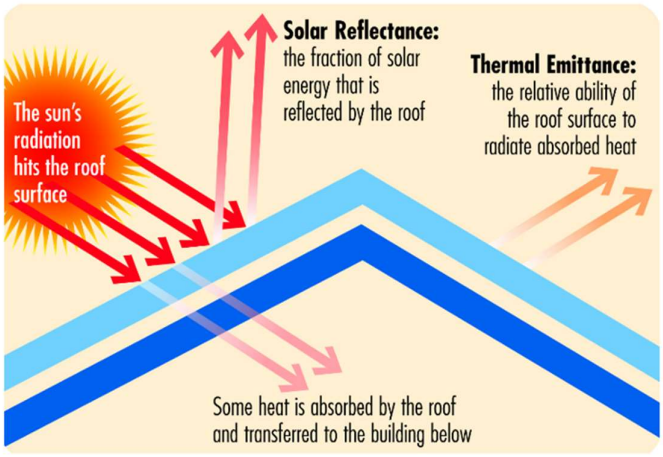


Unstabilized Rammed Earth Wall assembly
U - VALUE (W/m² K)= 1.68

Stabilized Rammed Earth Wall assembly
U - VALUE (W/m² K)=

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

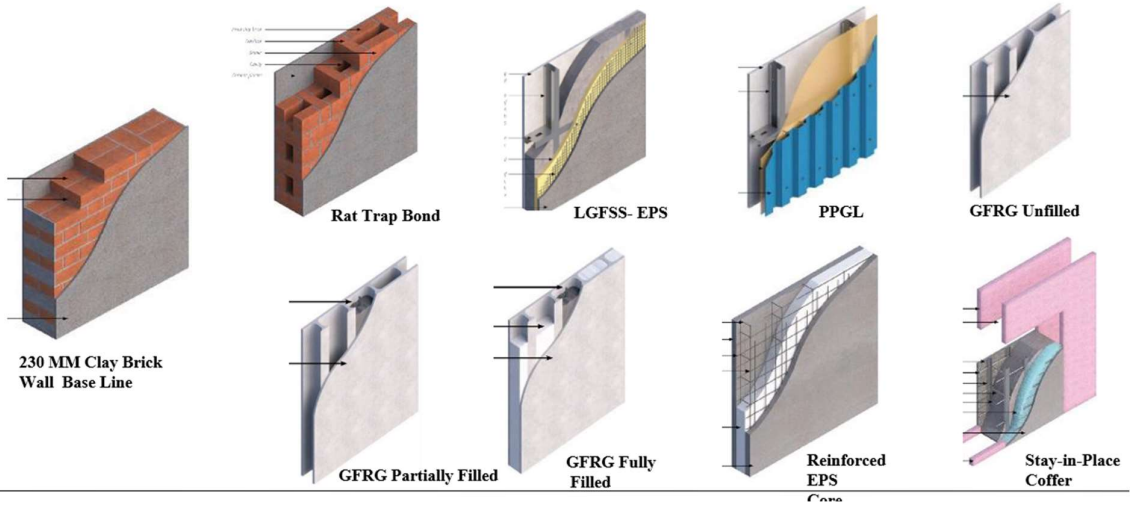
Roofing Coating Material and Solar Reflectance Index



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

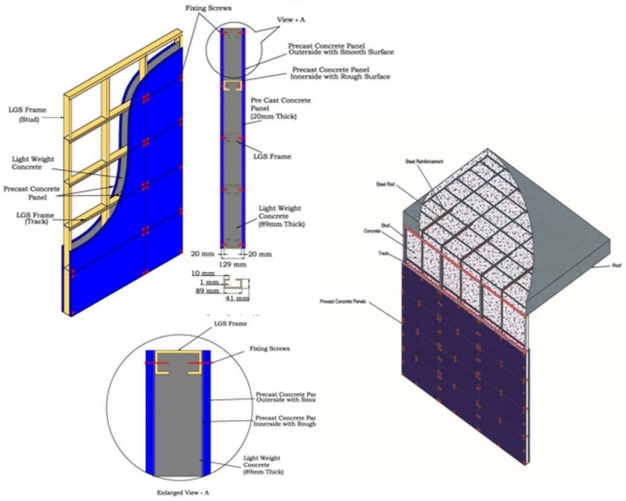
The focus was on alternative construction technologies, low embodied carbon materials, availability of material locally and economics of it.

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

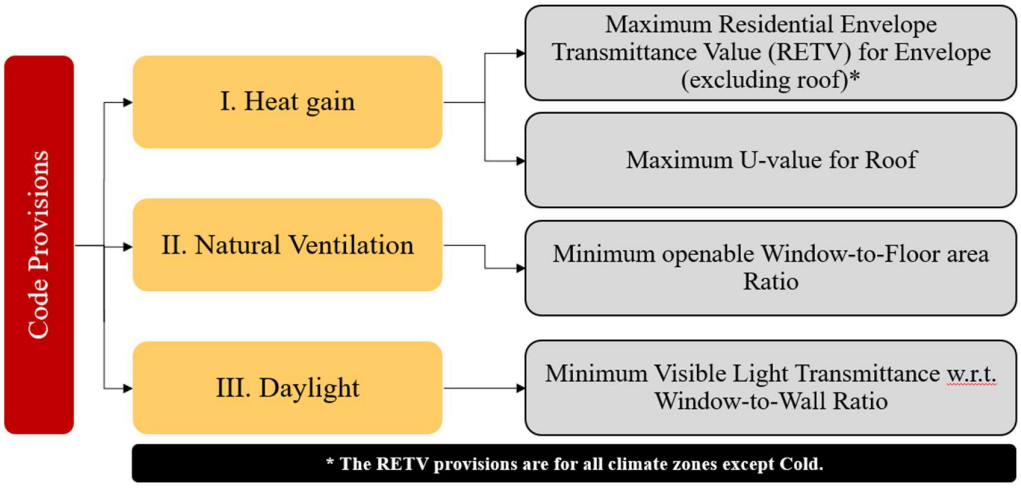
- PVC Stay in Place Formwork System
- S and 13 Floors
- Rigid poly-vinyl chloride (PVC) based form work system serve as a permanent stay-in-place durable finished form-work for concrete walls
- The PVC extrusions consist of the substrate (inner) and Modifier (outer). The two layers are co- extruded during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

Technical Specifications, Conditions and Performance defined	Standards
Voluntary in nature based on standards, best practices or empirical evidences	Guidelines
Set of guidelines referring to standards - aspirational	Codes
Successor of Codes, Under act of law, codes become law	Laws
Subset of Laws with penalty and enforcement mechanism defined	Rules

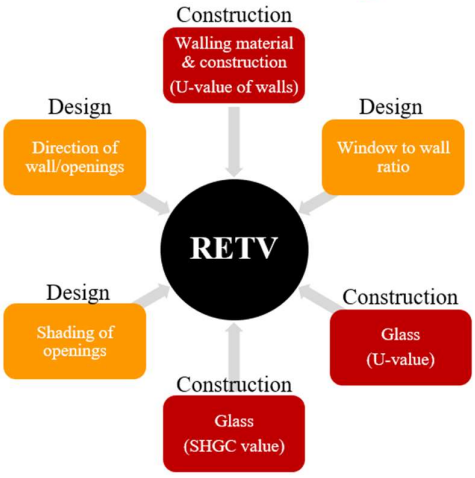
Overview of Code Provisions



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

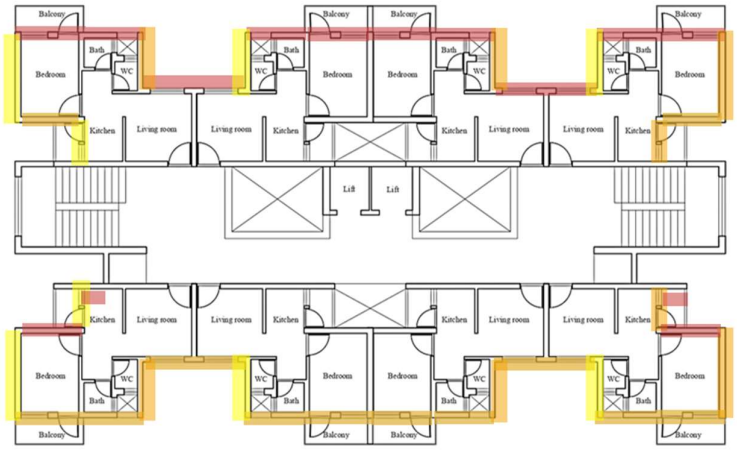


The net heat gain rate (over the cooling period)

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

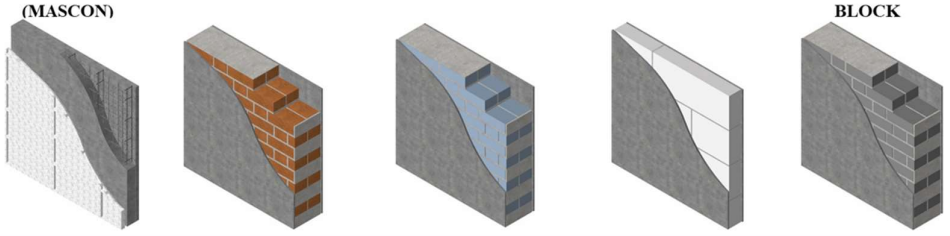
Construction:
- Outer: 25mm Cement plaster
- Layer 1: 200mm AAC block
- Inner: 25mm Cement plaster

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. Rajan Rawal**
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.

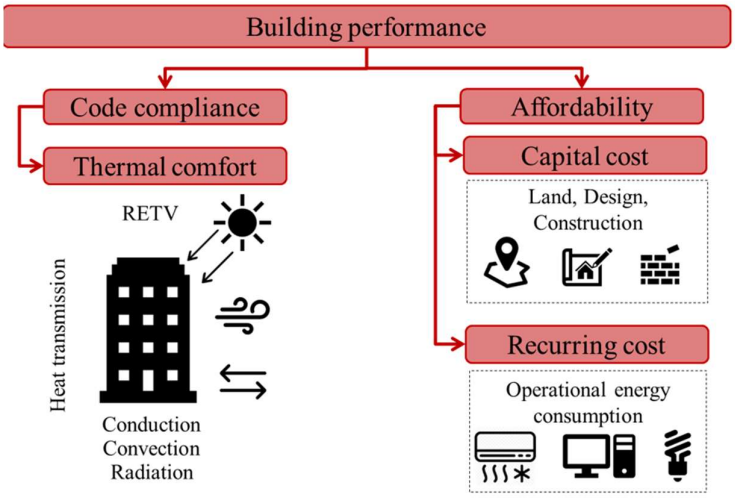
Case study: Shree Ram Nagar Co-operative Housing society

Case study : Existing Layout without Shading



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



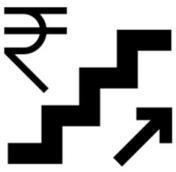
Challenge:

To optimize building performance, occupant comfort, while maximizing the potential of involved resources.

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. C N Jha, Dy. Chief, BMTPC**
17h25 – 17h30	**Feedback and Concluding Remarks**	**Dr. Rajan Rawal**