

Augmenting Nature by Green Affordable New-habitat

# **ANGAN 2022**

Making the ZERO Carbon Transition in Buildings

#### **Thermal Comfort in Indian Residences:** India Model for Adaptive Comfort – Residential (IMAC-R)

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# **Indian population in various climate zone – urban land**



Population (Millions)

Area (in '000 sq. km.)

# **Background, and Recap: Comfort**



- The conscious mind appears to reach conclusions about thermal comfort and discomfort from
  - direct temperature and moisture sensations from the skin
  - deep body temperatures
  - efforts necessary to regulate body temperatures

Image Source: https://www.dreamstime.com/devices-thinking-mind-icon-image136580981

# **Background, and Recap: Comfort**



# **Background, and Recap:** Historic Approach (Heat Balance)

$$M - W = q_{sk} + q_{res} + S$$
  
= (C + R + E<sub>sk</sub>) + (C<sub>res</sub> + E<sub>res</sub>) + (S<sub>sk</sub> + S<sub>cr</sub>)

Where,

- M = rate of metabolic heat production, W/m<sup>2</sup>
- W = rate of mechanical work accomplished, W/m<sup>2</sup>
- $q_{sk}$  = total rate of heat loss from skin, W/m<sup>2</sup>
- $q_{res}$  = total rate of heat loss through respiration, W/m<sup>2</sup>
- C + R = sensible heat loss from skin, W/m<sup>2</sup>
- $E_{sk}$  = total rate of evaporative heat loss from skin, W/m<sup>2</sup>  $C_{res}$  = rate of convective heat loss from respiration, W/m<sup>2</sup>  $E_{res}$  = rate of evaporative heat loss from respiration, W/m<sup>2</sup>  $S_{sk}$  = rate of heat storage in skin compartment, W/m<sup>2</sup>  $S_{cr}$  = rate of heat storage in core compartment, W/m<sup>2</sup>

- Many standards of thermal comfort are based on a heat balance model of the human body.
- Derived from extensive experiments in climate chambers.
- Universally applicable across all building types, climates and populations.
- Strict reliance on laboratory based comfort standards ignores the important contextual influences that can attenuate responses to a given set of thermal conditions

# **Background, and Recap: Adaptive Model**



- People naturally adapt and make adjustments in order to reduce discomfort
- Important factor behind adaptive process: Outside weather conditions
- Voluntary Adjustments: altering activity, posture, clothing, opening or closing windows
- Involuntary Adjustments: shivering, sweating, blood flow

# **Background, and Recap: Indian Studies**





- British Scientist Dr Webb and M.R Sharma (1984-86) from CBRI Roorkee developed Tropical Summer Index, SP 41. NBC India
- India Model for Adaptive Thermal Comfort, (IMAC) by CEPT University (2014-16), based on Air Conditioned Buildings, Mixed Mode Buildings and Naturally Ventilated buildings
  - Three equations for three kind of commercial and Office Buildings
  - National Building Code 2016, ECBC 2017, Basis of ENS's RETV and other green building rating programs
  - ASHRAE Database 2, IMAC of the largest dataset in the world

#### Background, and Recap: Indian Studies based on Adaptive Approach & Residential



1. Around India 2. Kerala 3. Tezpur 4. Thanjavur 5. Chidambaram 6. Chennai 7. Sugganahalli 8. Bhopal 9. Hyderabad 10. Hyderabad 11. Jaipur 12. Jaipur 13. Chandigarh & Roorkee 14. Darjeeling 15. Cherrapunjee 16. Imphal 17. Ahmedabad

Sunil Kumar Sansaniwal, Jyotirmay Mathur, Vishal Garg & Rajat Gupta (2020) Review of studies on thermal comfort in Indian residential buildings, Science and Technology for the Built Environment, 26:6, 727-748, DOI: 10.1080/23744731.2020.1724734

## India Model for Adaptive Comfort – Residential (IMAC-R)

# **Methodology : IMAC - Residential**



Eight Cities

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- Four Climate Zones
  - Two Cities (*Locations*) per Climate Zones

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• 12+ Months
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**Data Collected** 









# **Indoor air temp vs RH – Binned**



#### **Strategic Decisions for the basis of the model development**



- National Model based on 30 days running mean (7 days, UTCI)
- Mixed Mode Operations (*Naturally ventilated, Air Conditioned*)
- Methodology in consistent with IMAC (G constant, ATHB)

# **India Model for Adaptive Comfort – Residential**



#### India Model for Adaptive Comfort – Residential, Comparison



# India Model for Adaptive Comfort – Residential, Comparison



# **India Model for Adaptive Comfort – Residential, Application**



# India Model for Adaptive Comfort – Residential, Application



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