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Natural ventilation, some case studies in India

1) Natural ventilation in low and affordable housing multi-storey buildings
2) Design and testing of a very low energy ventilative cooling system for low wind availability
3) Natural ventilation with and without external shading in a residential tower

Indo-Swiss project on Building Energy Efficiency (BEEP)
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Greentech Team, Delhi, Dr. Sameer Maithel, Prashant Bhanware, Mohit Jain

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1) Thermally comfortable and climate friendly affordable housing in India: The Smart Ghar 3 project natural ventilation tests, in Rajkot, Gujarat

Background

- Generally, most of dwellings are not equipped with any active cooling system (80-90% in India today.

Resilience issues

- The building design has been developed with the main assumption that there would not be any active cooling at least for the next decade

Objectives

- Demonstrate passive natural ventilation efficacy to keep the temperature much below outdoor peak by night cooling in a hot climate

Features

- Very low heat gains envelope
- Good opaque envelope with AAC blocks
- Low window to wall ratio

Monitoring system

- CO_2 as tracer gas, cheap and simple solution, constant flow with a flow meter controller, measurement of the CO_2 concentration day and night, calculation of the AIR change
- Night and day constant flow, Guarded zone for the data acquisition → Avoid the CO_2 by human CO_2 production

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Monitoring methodology

Determine data monitoring period

5th May to 31st May 2019
(period when the maximum temperature would be consistently above 40°C)

Selection of test flat

Located on intermediate floor and should not have "first access" to wind

Determine parameters to be measured

Ambient DBT, RH, wind speed & direction;
Indoor (Bedroom & Living room) DBT, RH, CO_2 concentration (for ACH calculation)

Test set-up & operation

Data logging

Analysis (including calculation of ACH)

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Selection of test flat

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Measurement planning

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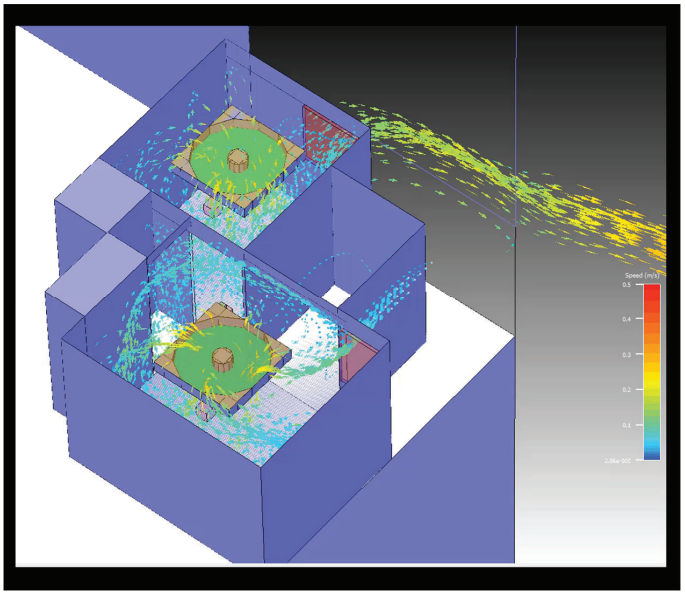
- Reverse flow due to the geometry of the recess (identified by CFD modelling and confirmed with smoke and velocity measurements)
- Analysis to locate the sensors for the best "averaged" values
  - CFD modelling to find the locations most representative of the average
    - Temperature
    - CO2 sensors



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Test of the CO2 decay with the bedroom "sealed"

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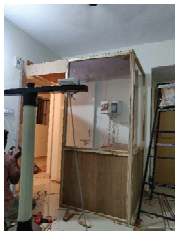
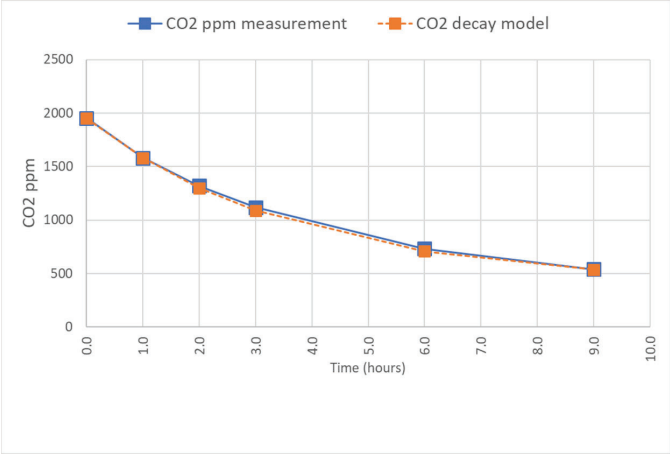
- Instead of use of tracer gas
  - Use of CO2 flow controlled
  - Use of CO2 sensors
  - Guarded zone for the data acquisition to avoid the human produced CO2



- In order to validate the method
  - Comparison between the measured CO2 concentration and a calibrated decay model
  - → ACH = 0.27 with the "sealed" bedroom



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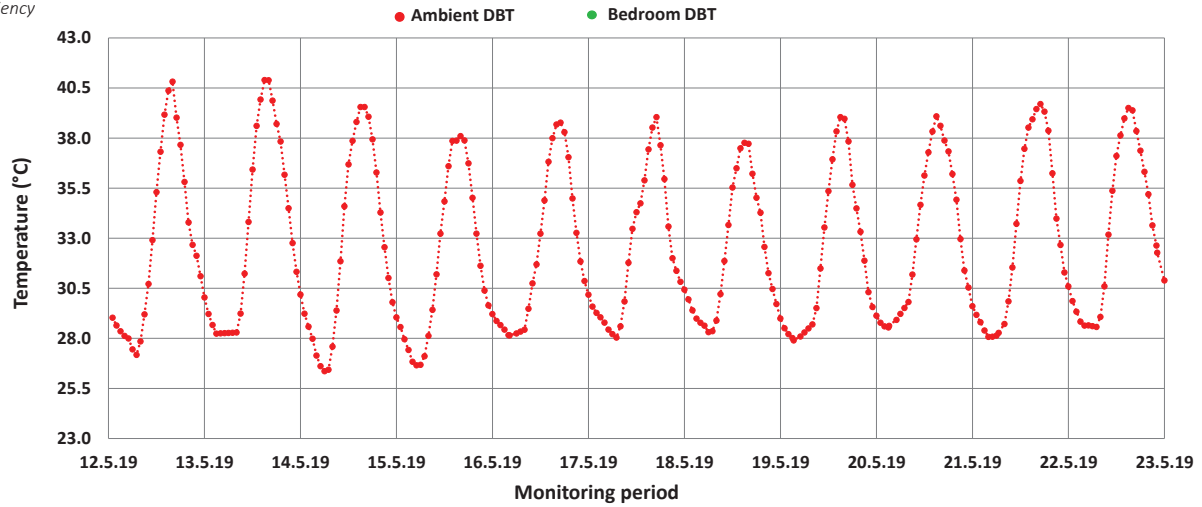
Monitored results: Outdooor temperature



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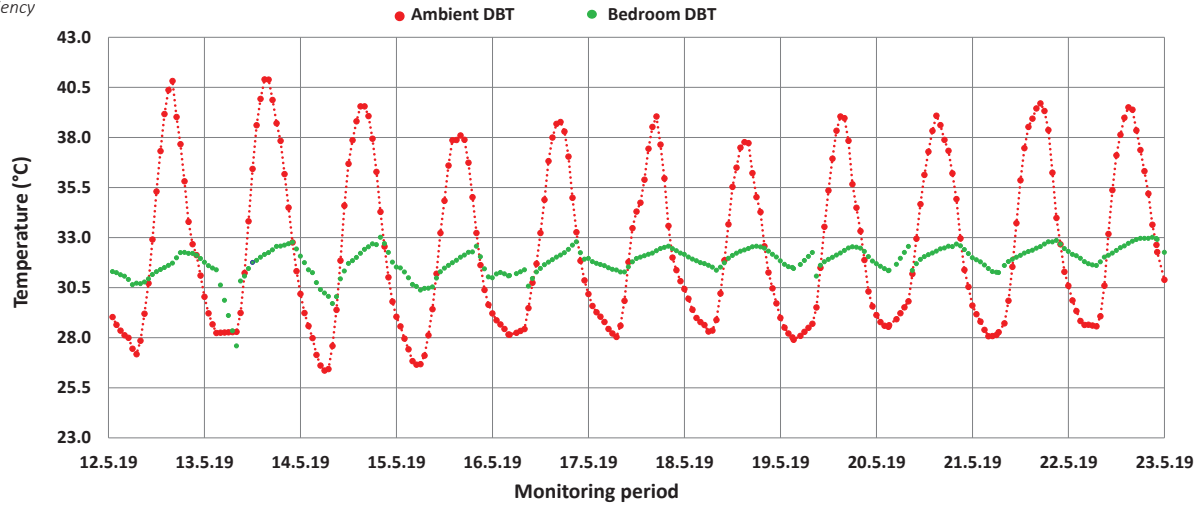
Monitored results: Indoor temperature



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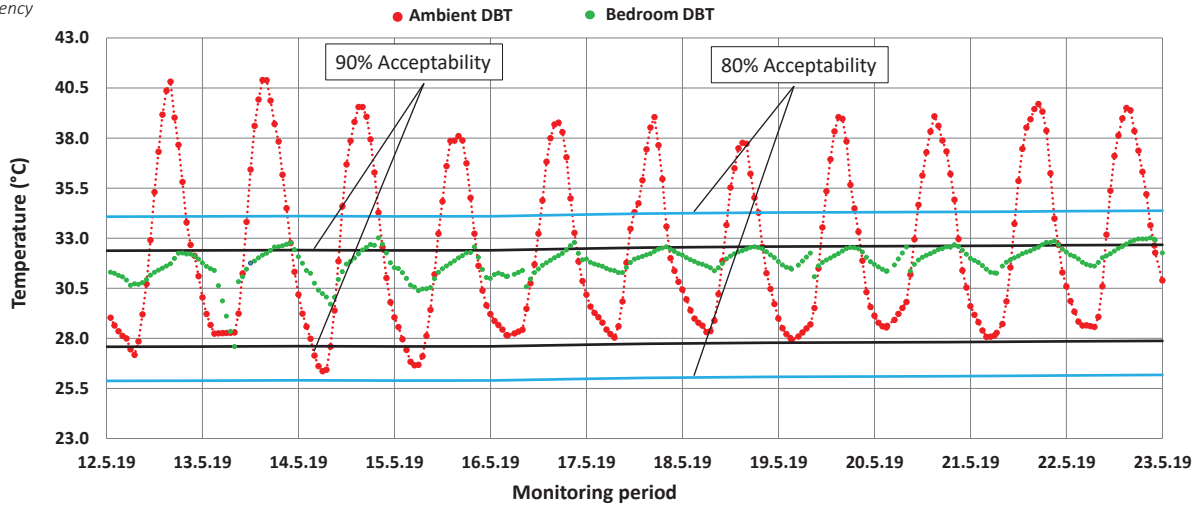
Monitored results: Indoor temperature



- Acceptability calculated using the IMAC (Indian Adaptive Thermal Comfort Model https://cept.ac.in/news/carbse-cept-thermal-comfort-research-included-in-national-building-code-2016)

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Conclusions for case 1)

- In affordable housings, it is possible to have an acceptable comfort level in residential non-AC at the same cost as business as usual with properly designed building envelope and natural ventilation openings
- Typically on hot days
  - Peak outside > 40 °C
  - Inside temperature < 33 °C
- This monitoring exercise shows measured quantification of the impact of building envelope on internal temperatures
- This resulted in a significant increase in comfortable hours duration and potential reduction in the need for air-conditioning

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2) Rajkot Smart Ghar III: assisted low energy ventilative cooling design and test

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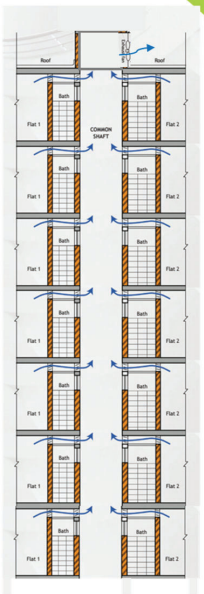

Background

- If the air movement between buildings is insufficient to generate 12-15 ACH, then very low energy ventilative cooling is a possible solution

Objectives

- Development of a balanced very low energy ventilative cooling system

Design options and development

- CFD comparison of different soluitions → no flow rate controller, constant resistance for balancing
- Mockup model testing
- Testing in real scale
- Balanced low negative pressure
- High performance fans

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Concept design, CFD development, lab scale mock-up testing

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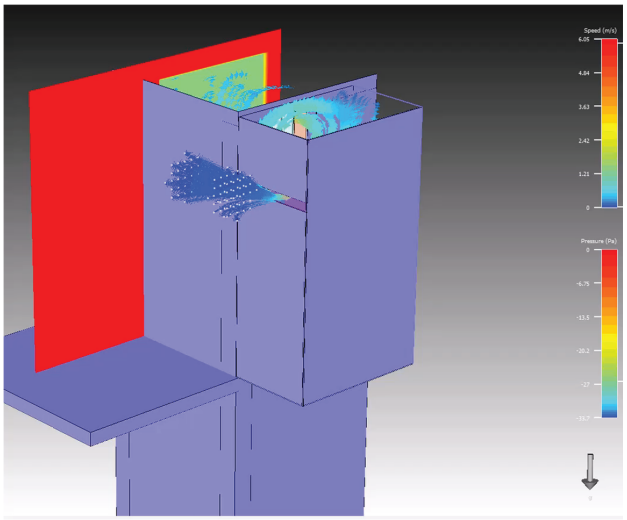

Set-up with the model scale 1:1

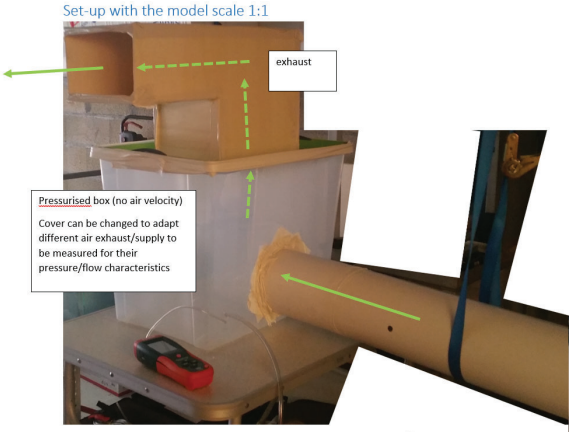

Figure 3 : View of the pressurised box with the sample 1 :1 exhaust for the bath room ot toilet

- Flow rate of 430 m3/h per exhaust
- Differential pressure of 30 Pa

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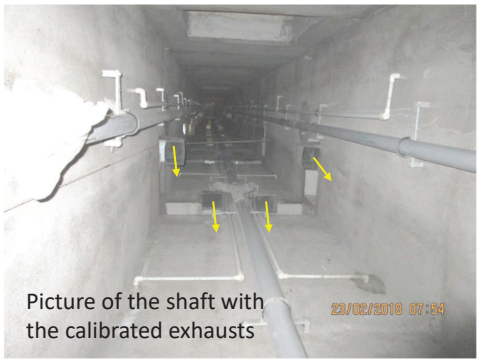
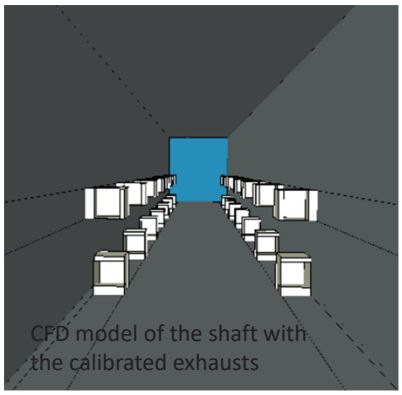
View of the balancing exhaust element

- The exhaust balancing elements (keeping the ~ same flow in all flats) are designed so that nothing can enter → downward physical opening, air blown downwards



Picture of the shaft with the calibrated exhausts


CFD model of the shaft with the calibrated exhausts

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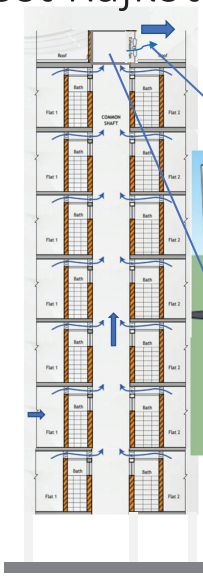
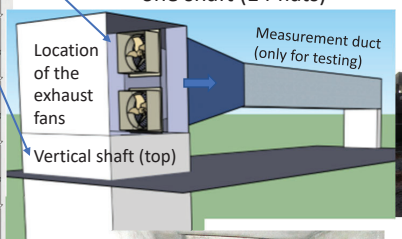
Low energy assisted ventilation for night cooling: testing of the aeraulic performances in the low cost Rajkot Smart Ghar III project

- Low energy assisted night cross-ventilation system
- Objectives: efficient night cooling
  - Test and confirm the design values of the overall system performance on one shaft (14 flats)





Vertical shaft on site (top) With extended duct for accuracy of air flow measurment


Exhaust fans inside the metallic top

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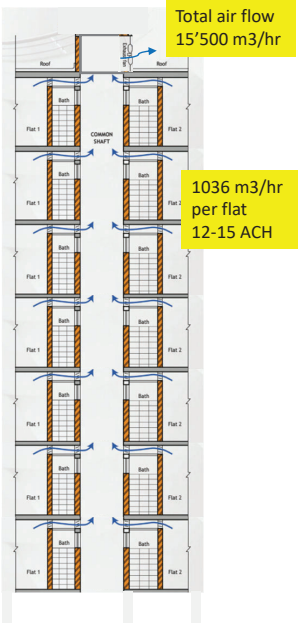
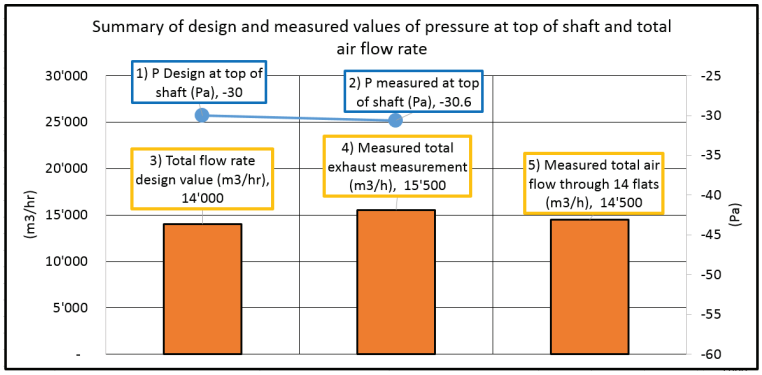
Results



- Measured values against design
  - Actual flow rate slightly > design values
  - The aeraulic concept is validated (optimal fan ~1.1 W/m^2 (floor area) at full flow)



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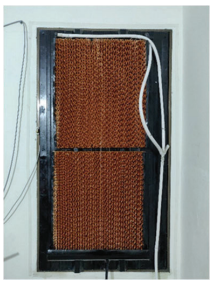
Conclusions for case 2

Low energy ventilative cooling

- If the air movement between buildings is insufficient to generate 12-15 ACH, then very low energy ventilative cooling is a possible solution
- Testing in real scale has demonstrated the aeraulic performance
- Balanced low negative pressure (30 Pa)
- High performance fans (efficiency of 27%)
- Specific power to ensure 12-15 ACH in 14 flats ~ 1.1 W/m2
- Potential to increase the comfort by adding evaporative cooling on the windows
  - Short test has shown that the balancing was hardly affected by a low differential pressure wet pad →



Global results		
negative pressure	30	Pa
flow rate	14000	m3/hr
flow rate	3.89	m3/sec
height	2.8	m
total volume	1097.6	m3
ACH	12.8	h-1
Aeraulic power	117	Watt
Fan efficiency	27%	
Electric power	432	Watt
Carpet area per flat	28	m2/flat
number of flats	14	
total carpet area	392	m2
specific power	1.10	W/m2

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3) Gurugram tower natural ventilation with and without external shading

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Gurugram tower natural ventilation with and without external shading

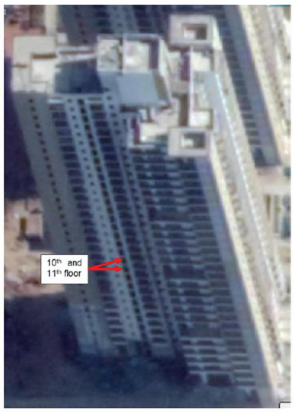
Background

- External movable shading used very rarely in India in new buildings

Objectives

- Quantify the impact of External shading and single sided natural ventilation on a typical modern building

- Development of the comparison methodology
  - Selection of two adjacent flats with exactly the same solar exposure
  - Checking the initial conditions (same temperature in non shaded mode)
  - Actual testing
  - Results obtained



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The building and its location in Gurugram (satellite city of Delhi)

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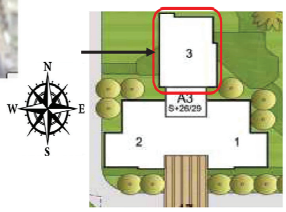
- Two flats at 10th and 11th floor, test room with west orientation



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The test room
A bedroom (normally the first room to have AC)

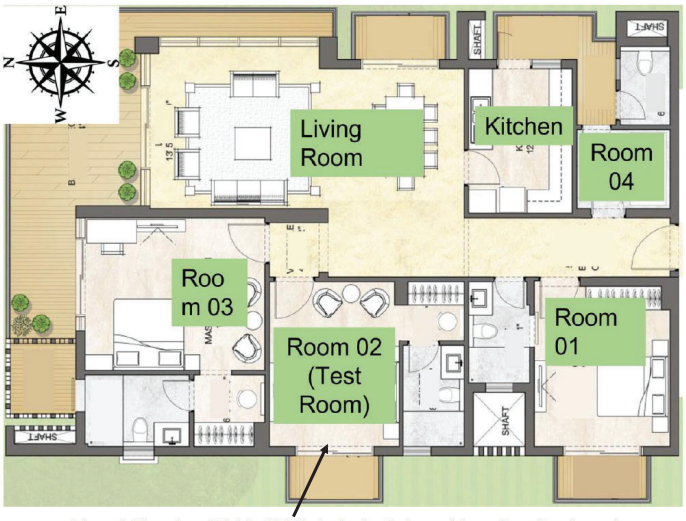

Figure 6: Floor plan of Unit 3 of A3 block showing test room (planned monitored space)

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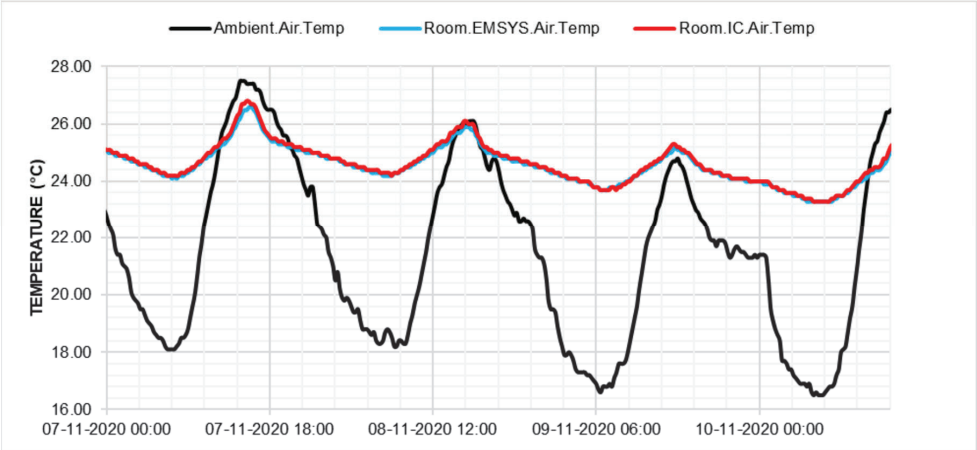
Checking the comparison procedure
→ checking if the same temperature in the two bedrooms with the same window system is obtained

- The temperature in both the bed rooms without any shading
  - Conditions good for the comparison



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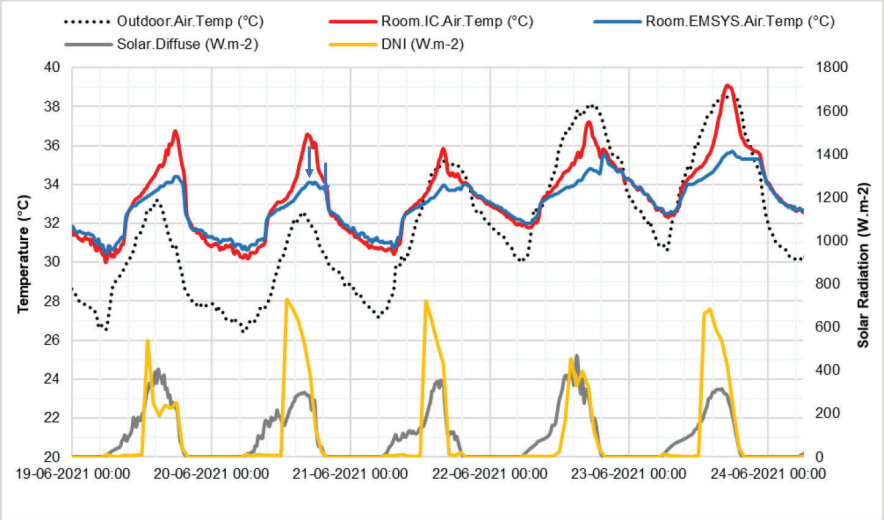
Testing in summer without AC, with natural ventilation (opening during the night)

- In red
  - Usual internal curtains
- In blue
  - With external movable shading (SHGC ~ 18% with glazing)



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Conclusions for case 3

- Natural ventilation is very efficient in tandem with external movable shading
- The peak temperature is reduced by 3-3.5 °C when using external movable shading → very signification reduction of the duration of discomfort (e.g. hours per years)
- This test confirms the relevance of external movable shading systems in the hot Indian Climates