Sustainable Architectural Design - The GRIHA Approach

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GRIHA Conference, Bangalore, 10-11 December, 2012

Content

- Defining Sustainable Architecture – from the eyes of a sustainable consultant
- What does GRIHA say to achieve sustainable architecture- Description of GRIHA Criterion
- Examples of Sustainable architecture – a few demonstration projects of TERI


Architectural design that provides comfort to occupants using nature's resources with minimal impact on the environment.

GRIHA - Sustainable Architecture

Criteria 4: Design To Include Existing Site Features

4.1 Commitment

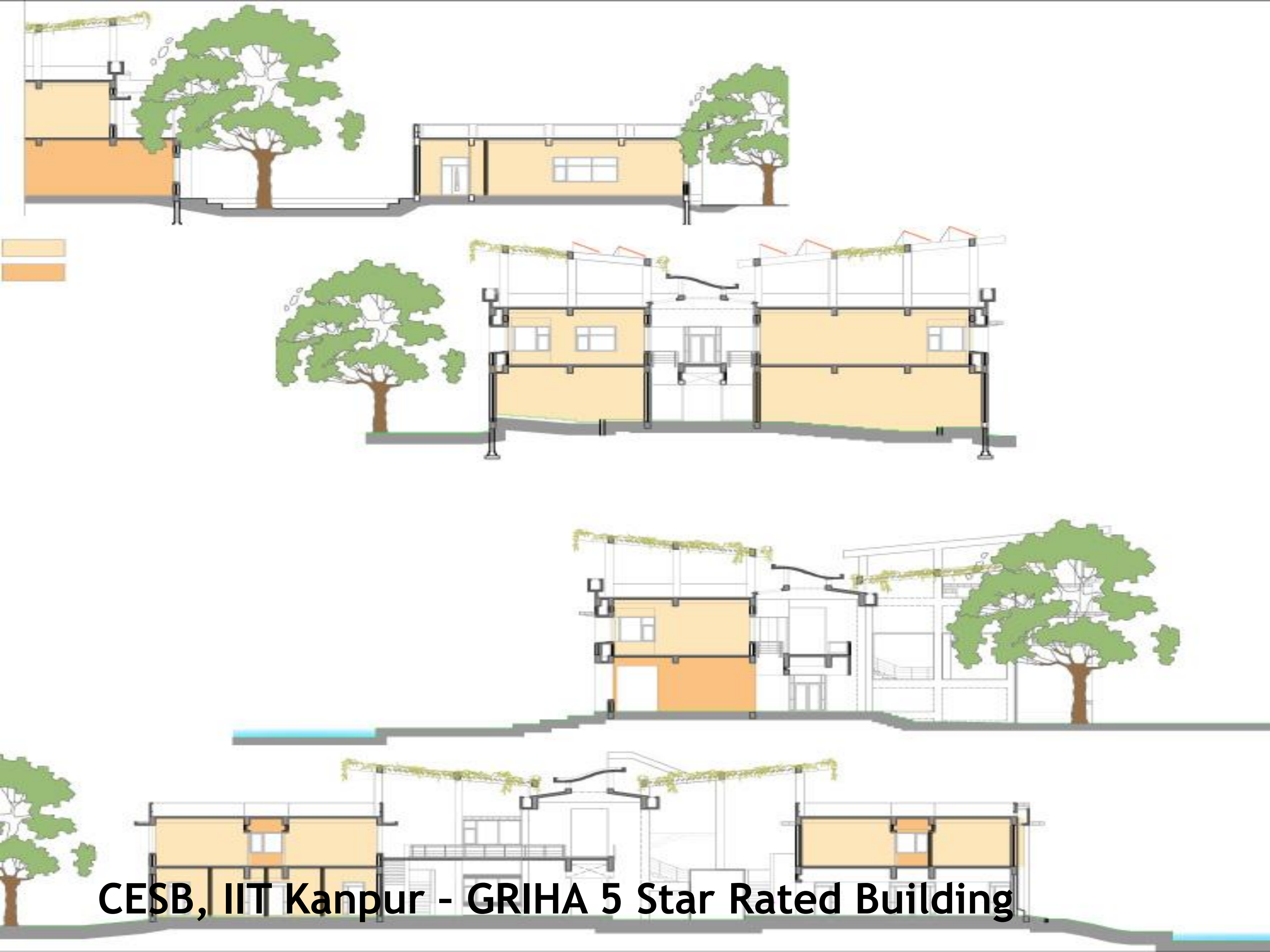
- 4.1.1 Carry out a comprehensive site analysis to identify site characteristics that can be used to harness natural resources (like solar energy, wind, and water)
- 4.1.2 Locate various activities of the scheme after careful site analysis and assessment so as to protect ecologically sensitive areas and reduce damage to the natural ecosystem.
- 4.1.3 Identify areas of the site that were damaged during construction and take steps to mitigate the harm and improve the natural site conditions.

Sustainable Habitats

http://www.tropicalisland.de/india/rajasthan/mandawa/images/DEL%20Mandawa%20in%20Shekawati%20region%20-%20hotel%20Mandawa%20Haveli%20outer%20courtyard%20with%20beautifully%20painted%20main%20facade%203008x2000.jpg

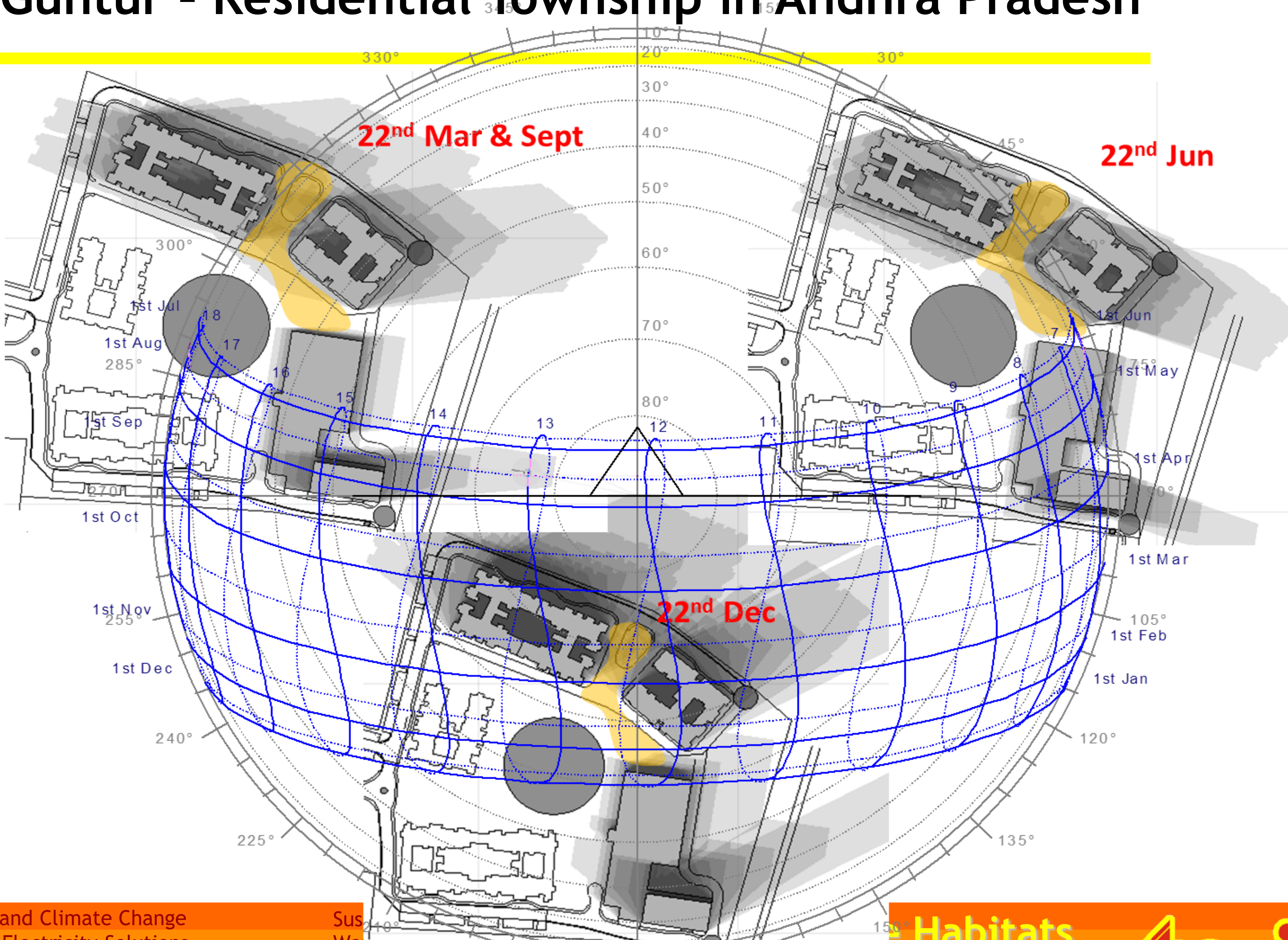
p://www.indiamike.com/photopost/data/500/kerala_06_213.jpg

CESB, IIT Kanpur – GRIHA 5 Star Rated Building

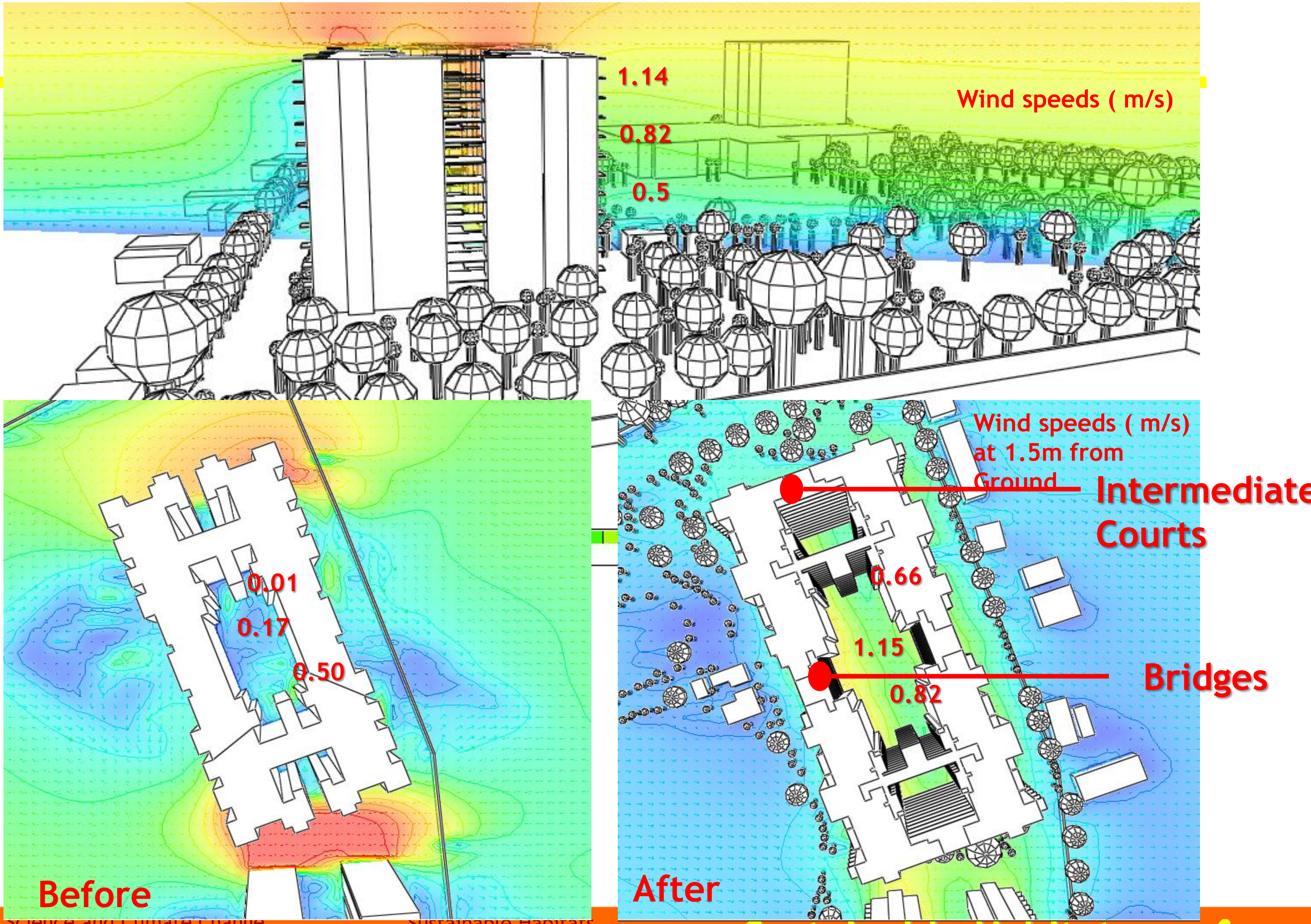


CESB, IIT Kanpur – GRIHA 5 Star Rated Building

ITC Guntur – Residential Township in Andhra Pradesh



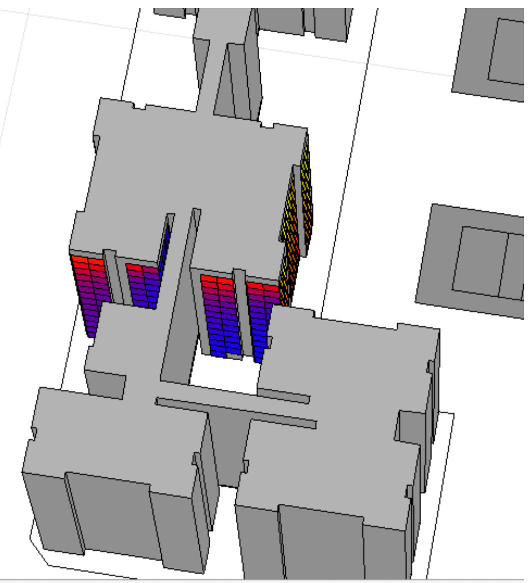
Out door Wind Flow analysis for High-rise structures

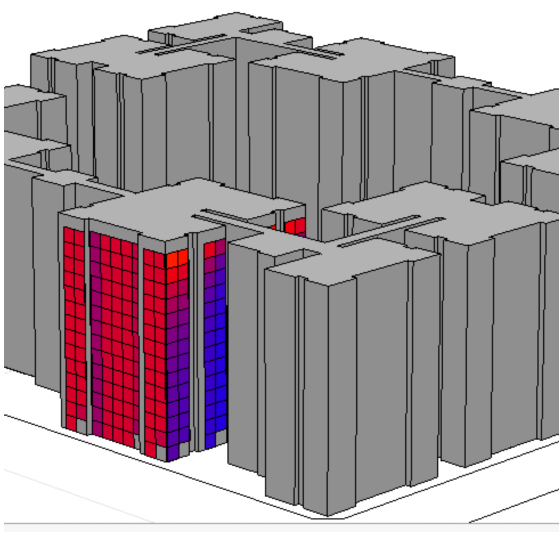


Higher wind speeds for better comfort in outdoor ,semi outdoor and courtyard spaces and by adding a stilt, bridges and intermediate courts and landscape elements

ITC Bhadrachalam - Residential Township

- Solar irradiation analysis – high rise dense development





GRIHA – Sustainable Architecture

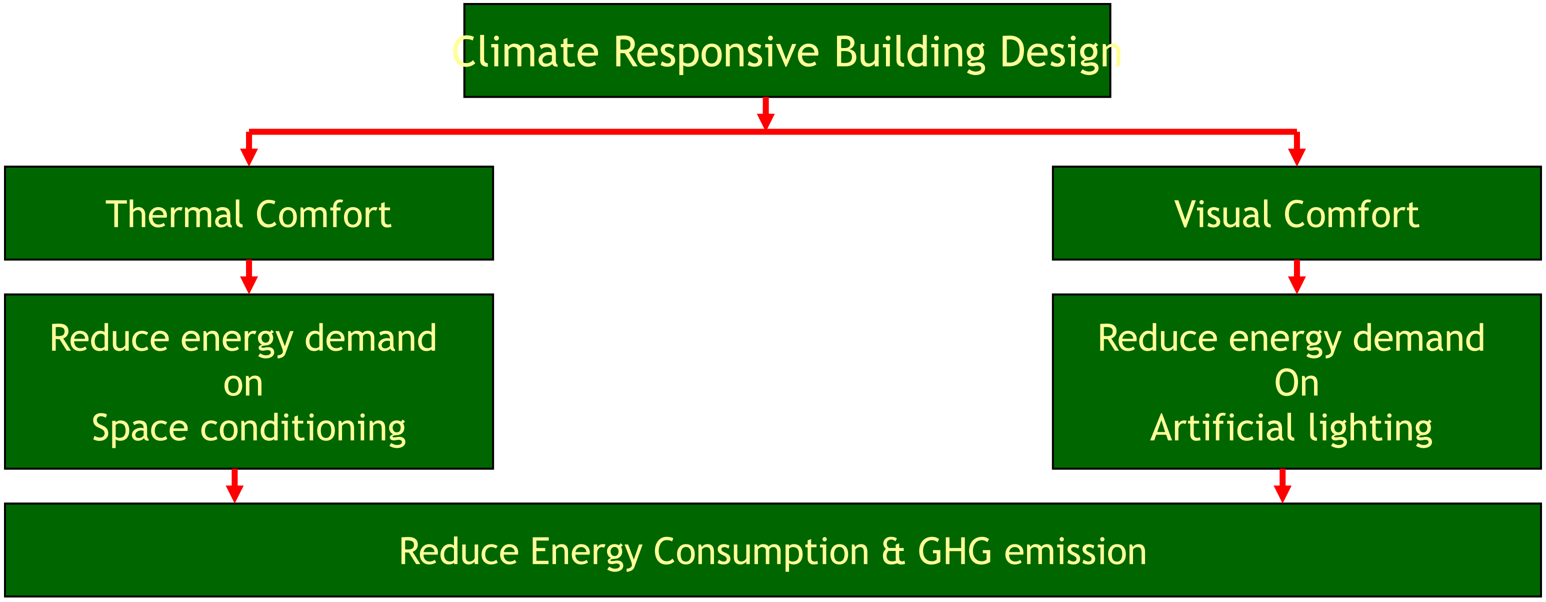
Criteria 13: Optimize Building Design to Reduce Conventional Energy Demand

13.1 Commitment

- 13.1.1 Appropriate climate responsive design strategies should be adopted such as: orientation, placement of fenestration and buffer zones, shading devices.
- 13.1.2 Window Wall Ratio (WWR) to be limited to maximum 60%, and Skylight Roof Ratio (SRR) to be limited to a max of 5%.
- 13.1.3 Demonstrate that the effective Solar Heat Gain Coefficient (SHGC) is compliant with the maximum SHGC prescribed by ECBC-2007.
- Ensure daylight area is ≥25%.Every 25% increase in daylight area – upto a maximum of 75%- shall fetch one additional point.

Objective of Criterion 13

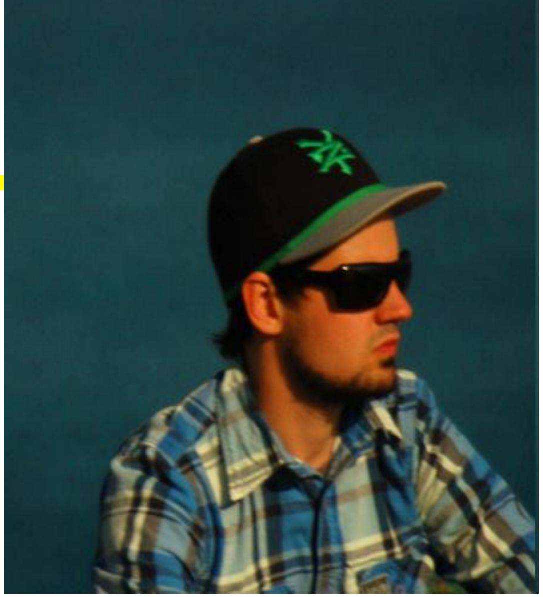
To apply climate responsive building design measures, including day-lighting and efficient artificial lighting design, in order to reduce the conventional energy demand.



Window Wall Ratio

- Window-Wall-Ratio (WWR) : The Window Wall Ratio refers to the ratio of the total fenestration area to the gross wall area.
- ECBC in a prescriptive approach recommends a maximum WWR of 60%.

The portion of the glazing which lets in light is same in both cases. This is why WWR is important. The rest of the glass does not contribute to daylight, only permits more heat inside.



/wwshop/images/ManMarinCap.jpg

http://u1.ipernity.com/u/2/3F/3A/604735.fef07a581.l.jpg

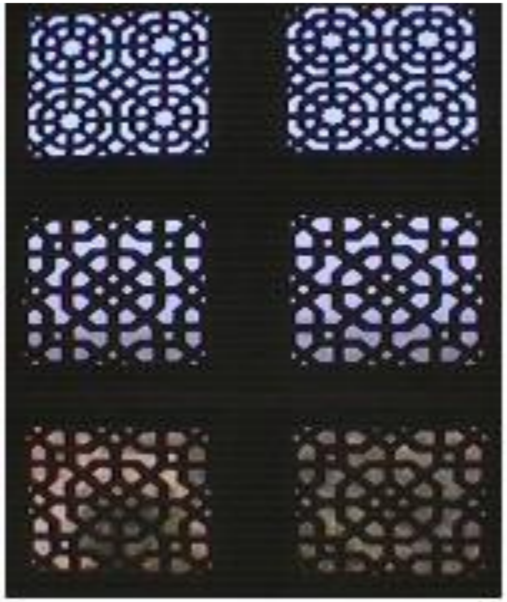
http://farm4.static.flickr.com/3102/2649874827_6fc6f36fe4.jpg?v=0

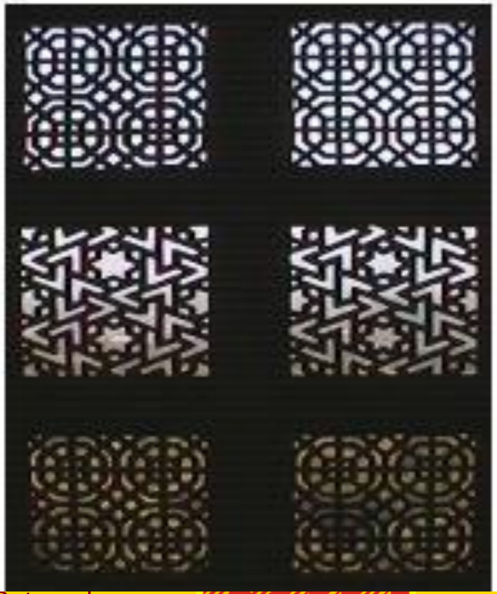
Sustainable Habitats

Earth Science and Climate Change
Decentralized Electricity Solutions
Environment Education & Youth Services
Energy Environment Technology Development
Environment & Industrial Bio-Technology

Sustainable Habitats
Water Resources
Bio-Technology & Bio-Resources
Resources Regulation & Global Security
Modeling & Economic Analysis

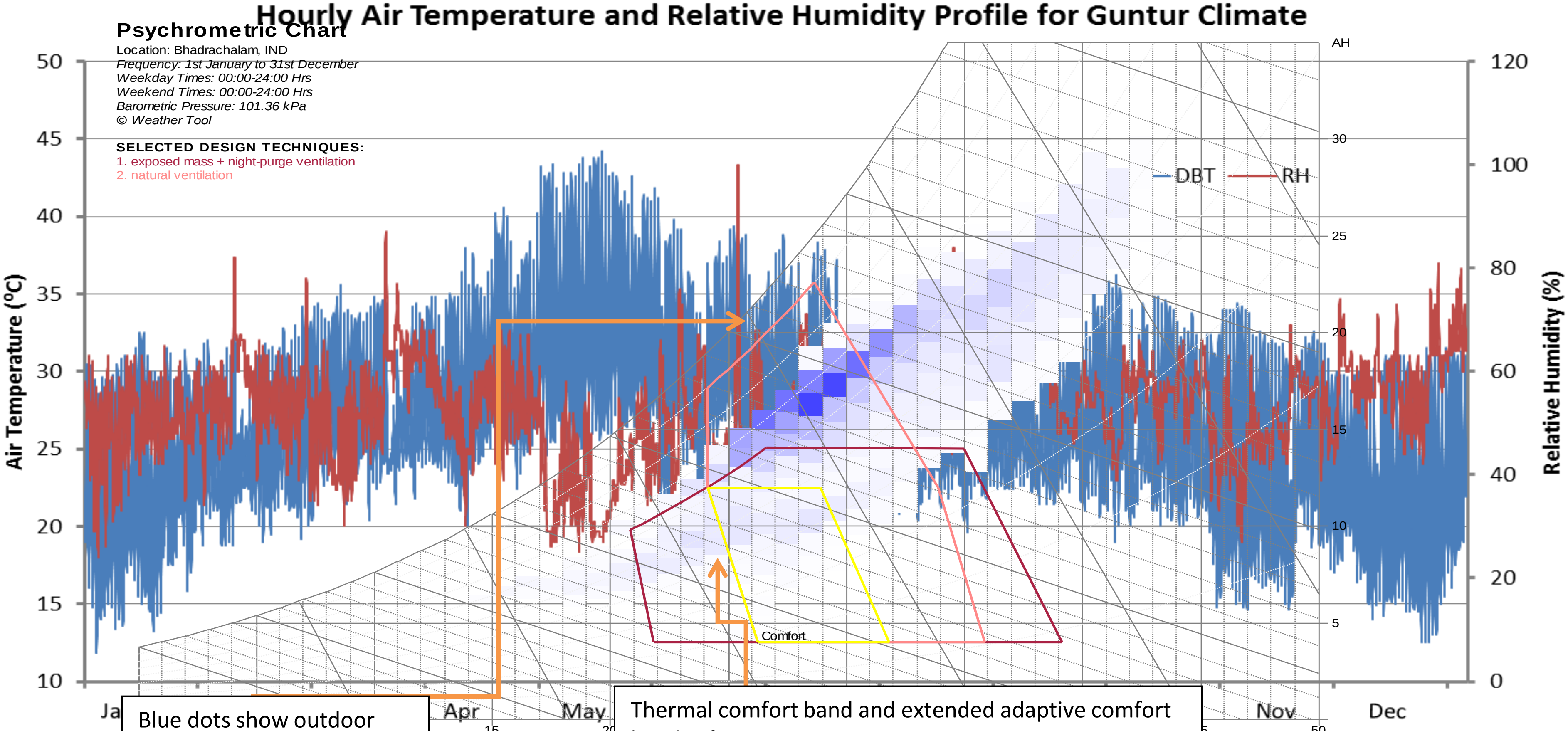
Industrial Energy Efficiency
Sustainable Development Outreach
Social Transformation





Climate Analysis

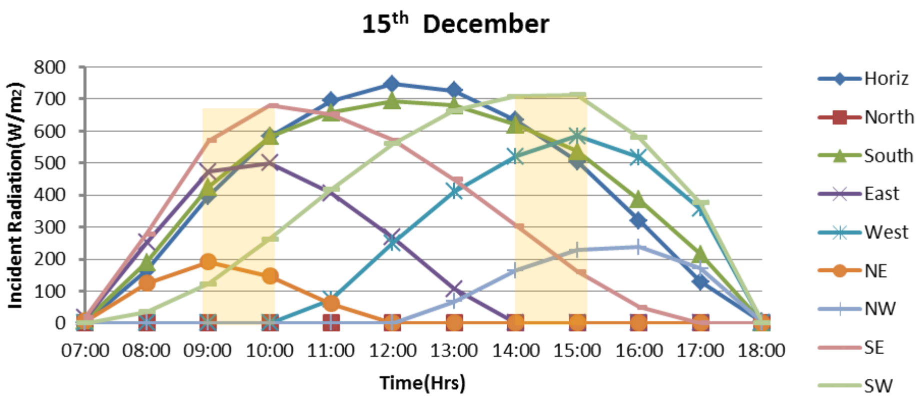
Hourly weather file processing from daily data acquired from meteorology department



Blue dots show outdoor climate of Bhadrachalam

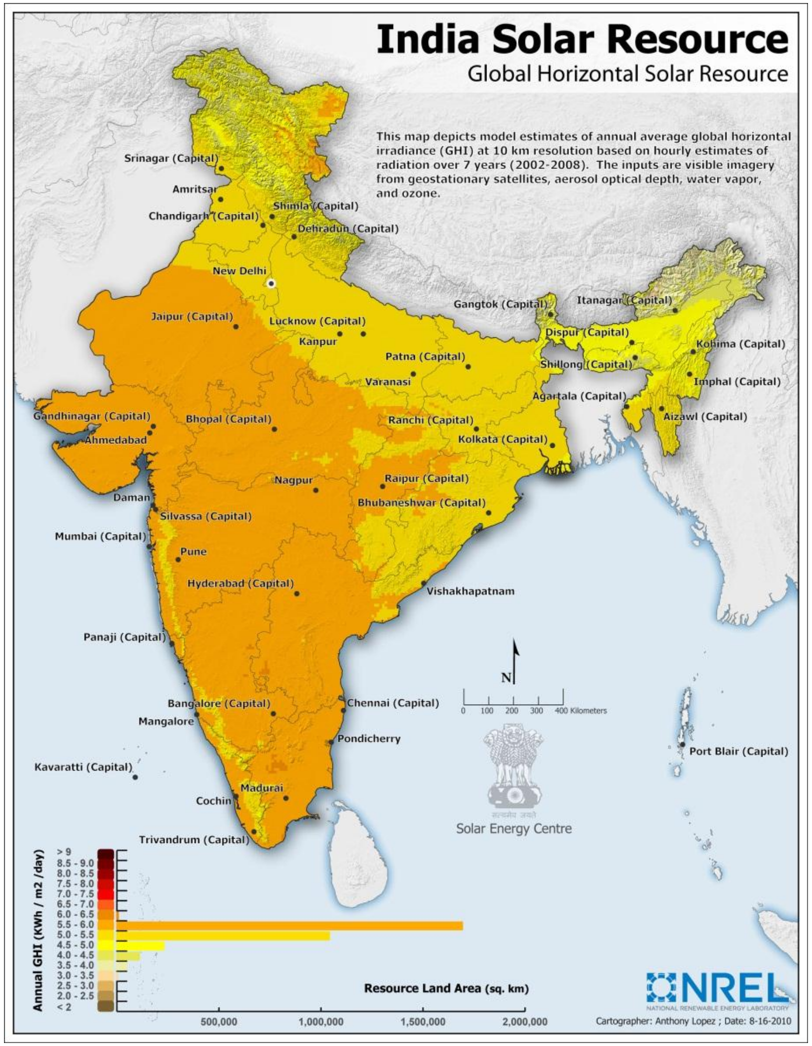
Thermal comfort band and extended adaptive comfort bands after integrating passive strategies

Solar Irradiation data



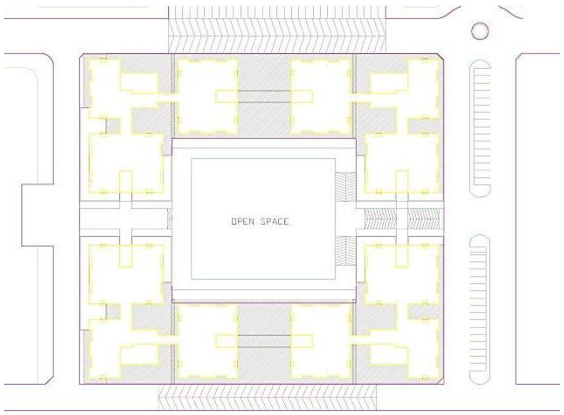
South

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
07:00	0	1.5	10	34	41.7	37	31	26	34	29	6.6	8.9
08:00	131	128	154	135	91.3	88	86	88	137	228	199	189
09:00	373	323	292	231	150	144	146	163	241	348	353	425
10:00	525	451	386	319	210	199	195	227	322	464	461	583
11:00	601	529	489	380	251	245	239	286	388	544	531	658
12:00	661	589	515	408	279	260	244	307	410	544	571	694
13:00	658	567	499	404	269	256	253	307	392	509	527	680
14:00	620	515	473	356	224	228	233	279	354	485	477	619
15:00	532	457	391	283	170	197	202	236	303	359	411	537
16:00	429	362	293	203	109	151	147	173	203	250	285	386
17:00	245	232	170	114	50.5	93	93	102	101	129	137	216
18:00	51	73	58	39	14.7	42	39	39	26	20	0	2.1

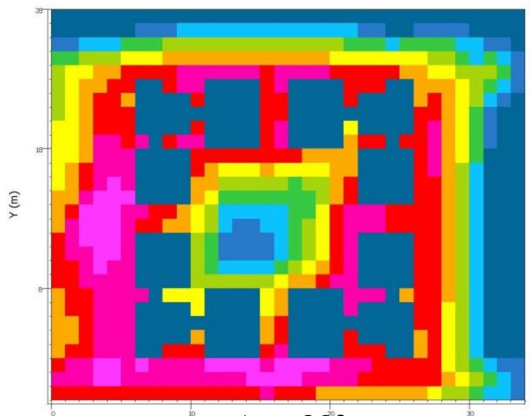


UHI Study- Air Temperature at 1.2m lvl on a typical day during March

Base Case- Asphalt Roads & Cement concrete paving

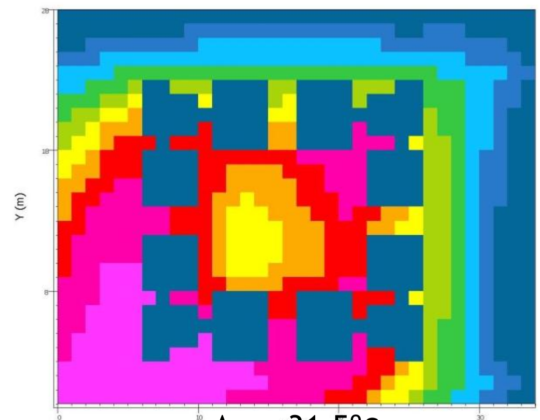


15:00hrs



Avg=39°C

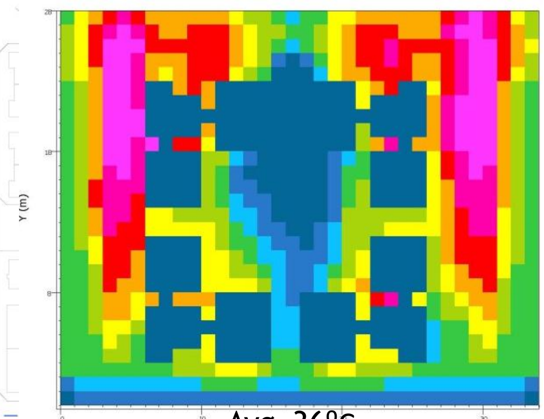
04:00hrs



Avg =31.5°C

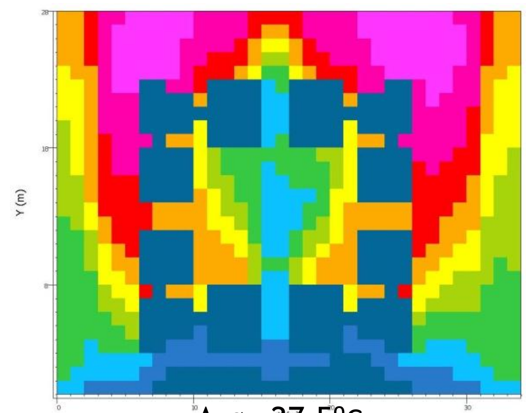
Design Case- with vegetation and landscape elements recommended

15:00hrs



Avg=36°C

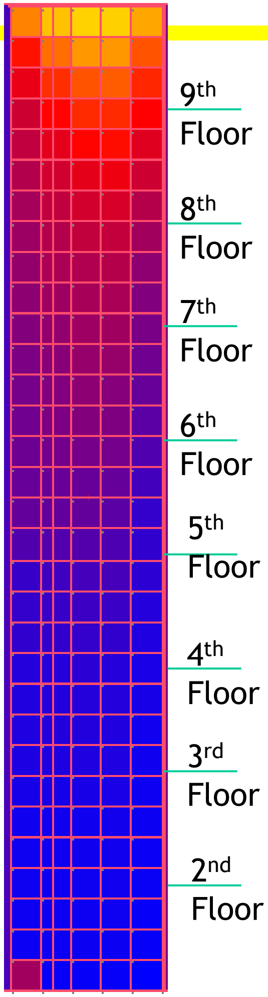
04:00hrs



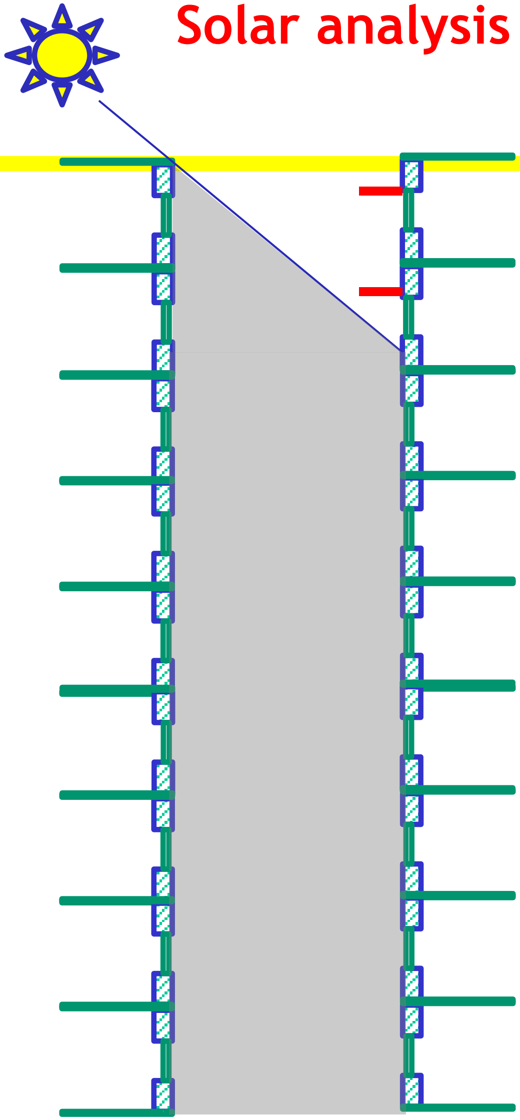
Avg =27.5°C

- Adding vegetation and landscape elements reduces air temperature by 3 to 4 deg C

Solar analysis for High-rise structures

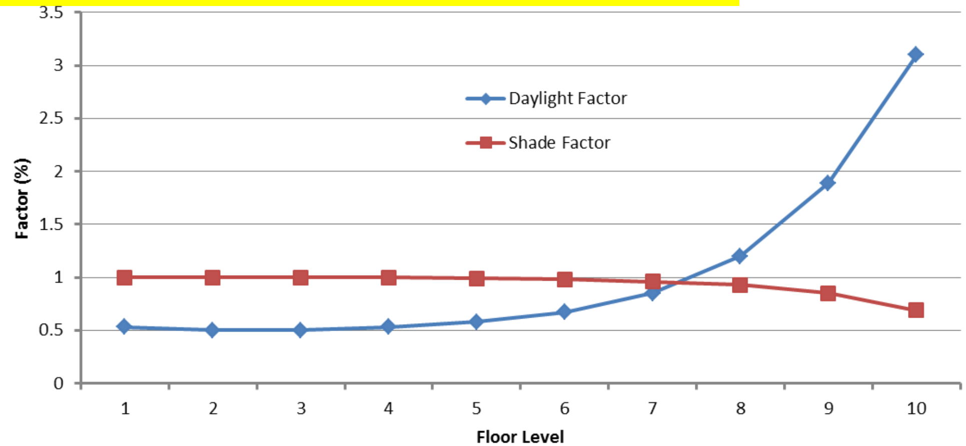


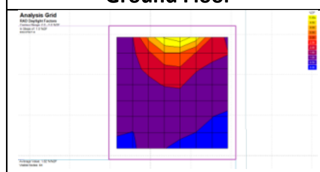
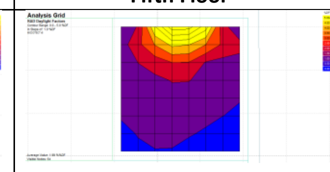
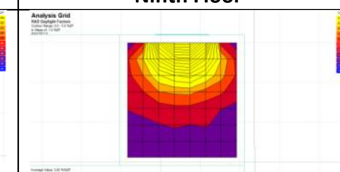
Solar Exposure



Schematic section showing shading design to respond to solar exposure

Daylight availability across the floors



Ground Floor	Fifth Floor	Ninth Floor
		
Average DF : 1.8	Average DF : 2.0	Average DF :3.8
Shading Factor: 1	Shading Factor: 0.83	Shading Factor :0.56

- Increase in daylight and decrease in shading factor especially in rooms facing inner courtyards - as we go up in dense developments
- No additional shading for lower floors and an optimized shading for upper floors is recommended to maintain uniform thermal and visual comfort conditions across the floors

Daylight Autonomy

It is essential to provide daylight in Kitchen, especially between 08:00hrs and 10:00hrs to reduce energy demand on artificial lighting.

Daylight Autonomy (DA) is calculated and found that 26.6% of the day time in a year, lighting level of 225 lux (with 60% VLT) is present in the space on the first floor.

Study of Daylight Glare Indices

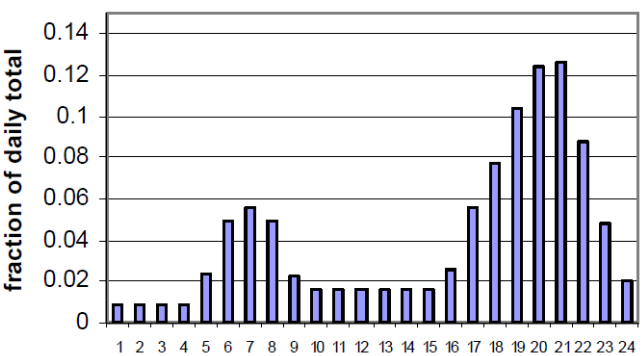
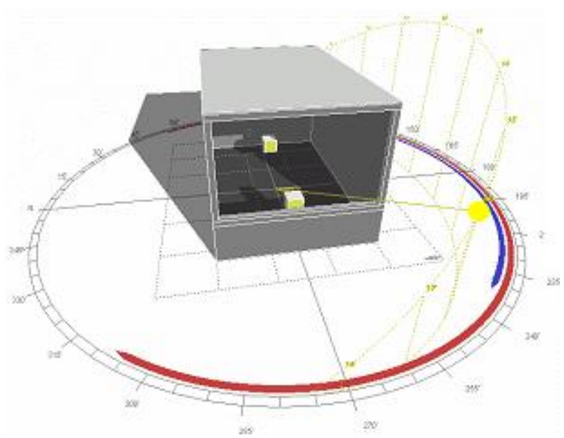
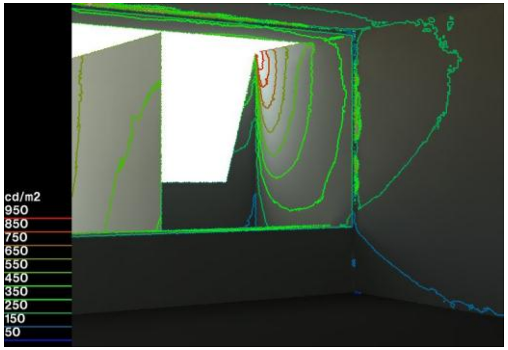
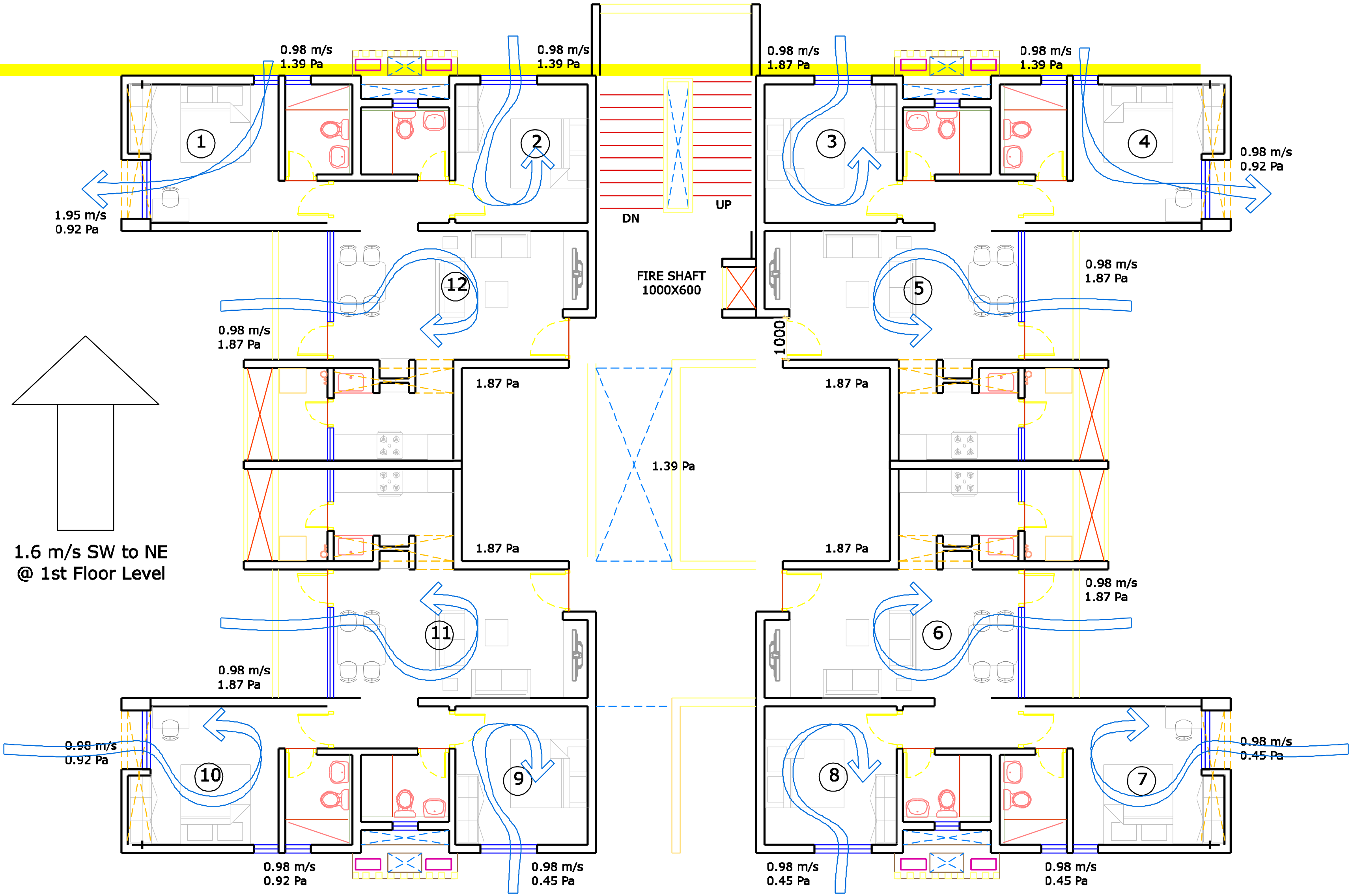


Figure 14. Interior lighting profile (Built up from detailed profiles)



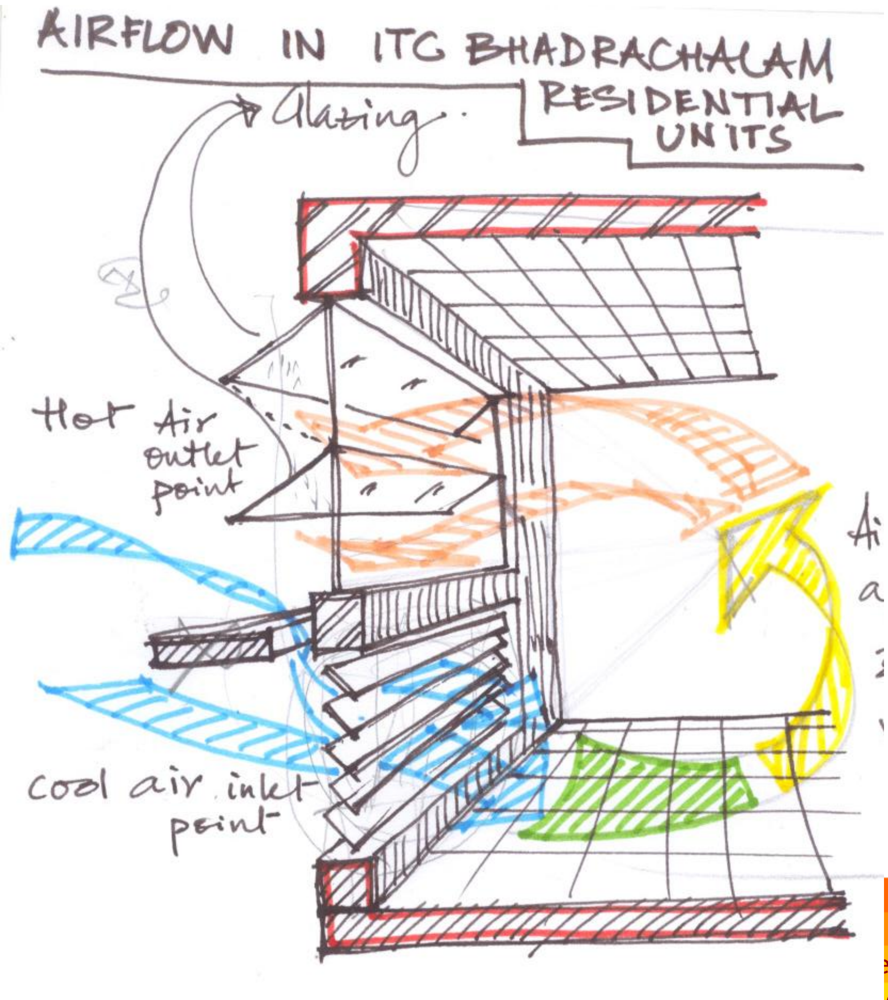


Indoor Air Movement in Employee Quarters

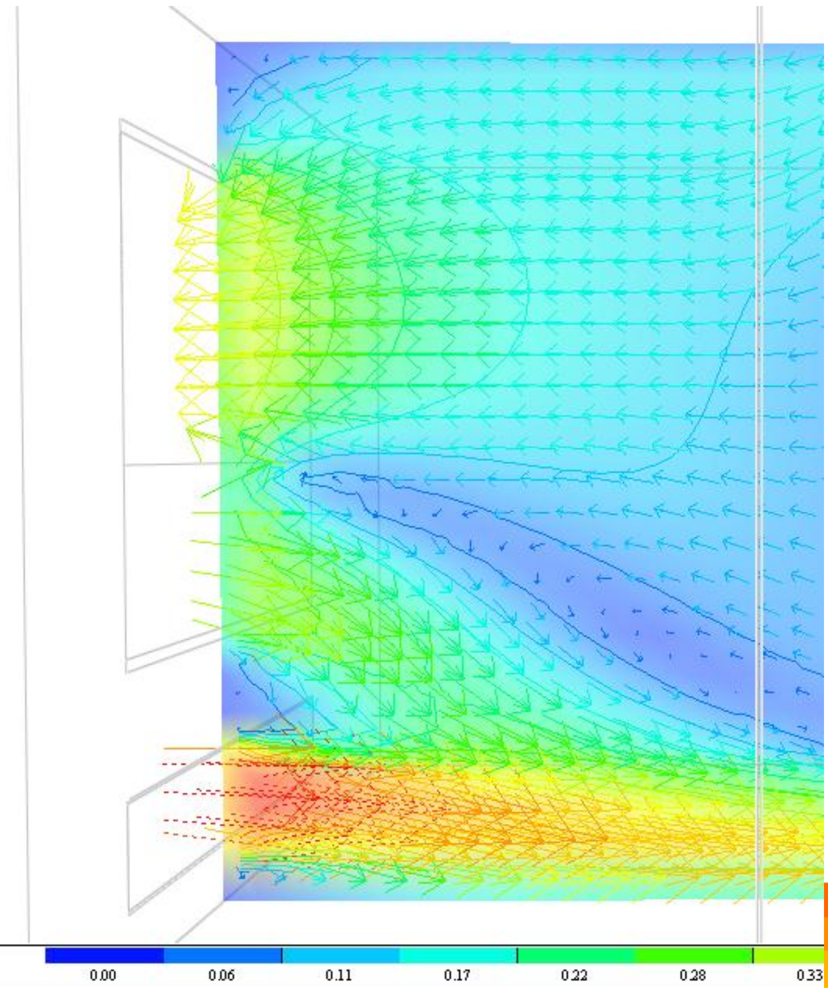


Conceptual Sketch and actual CFD model of Window System Proposed For Non Ventilated Spaces

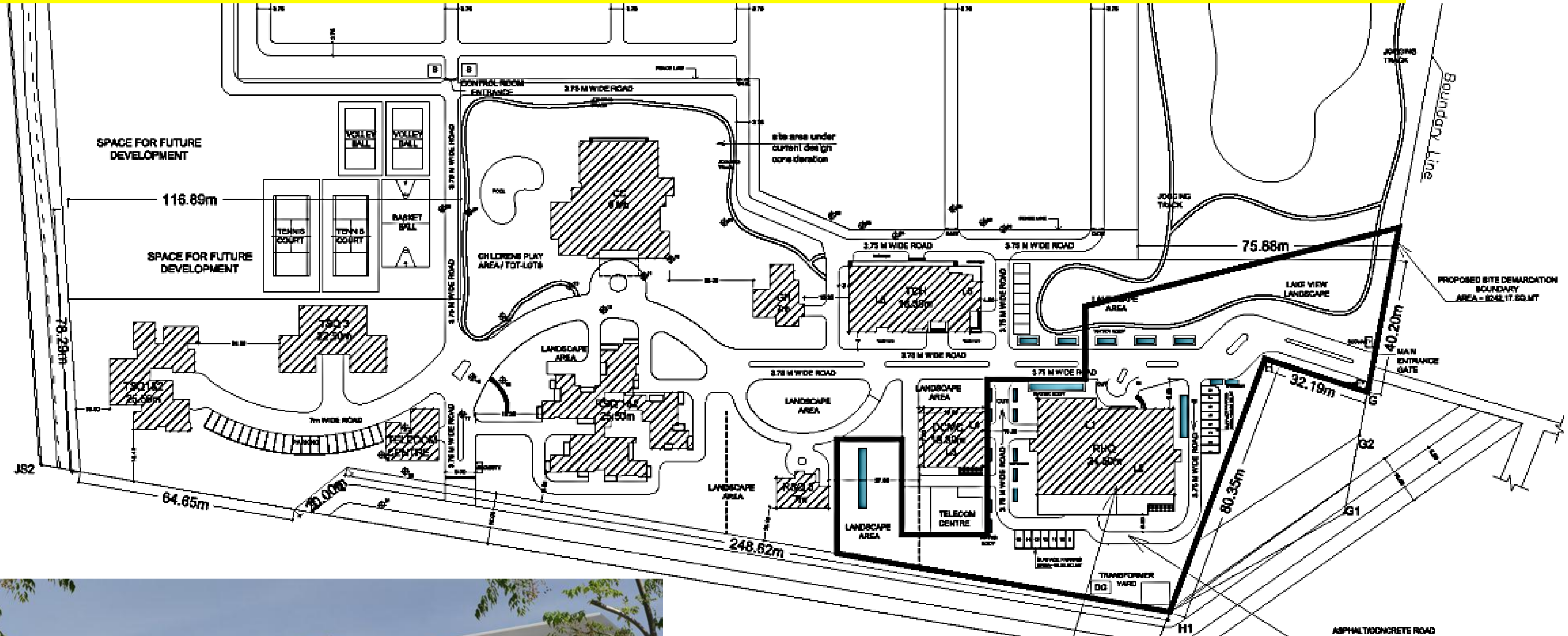
Conceptual sketch



CFD Model



Power Grid Corporation of India Limited Campus at Bangalore

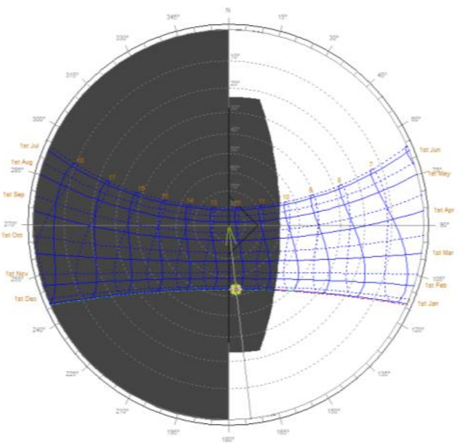


Courtesy: Klimart

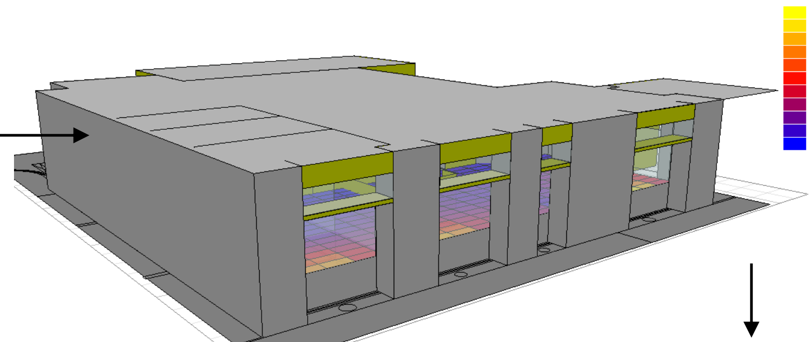
Project Details

Site Area	: 12 acres
Built-Up Area	: 17,305 Sq.m

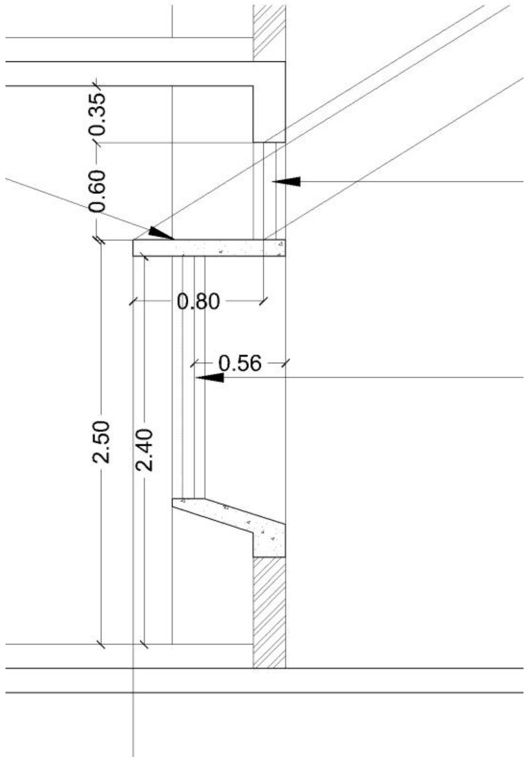
Solar analysis of PGCIL building for window optimization



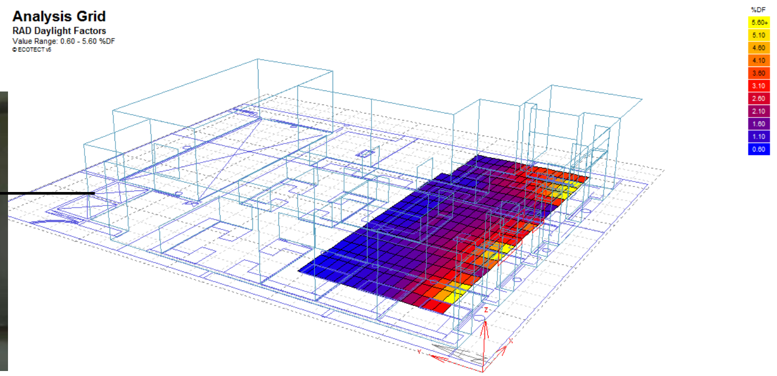
Solar Analysis and Daylight availability Studies



Window design optimization to respond to solar angles and achieve daylight



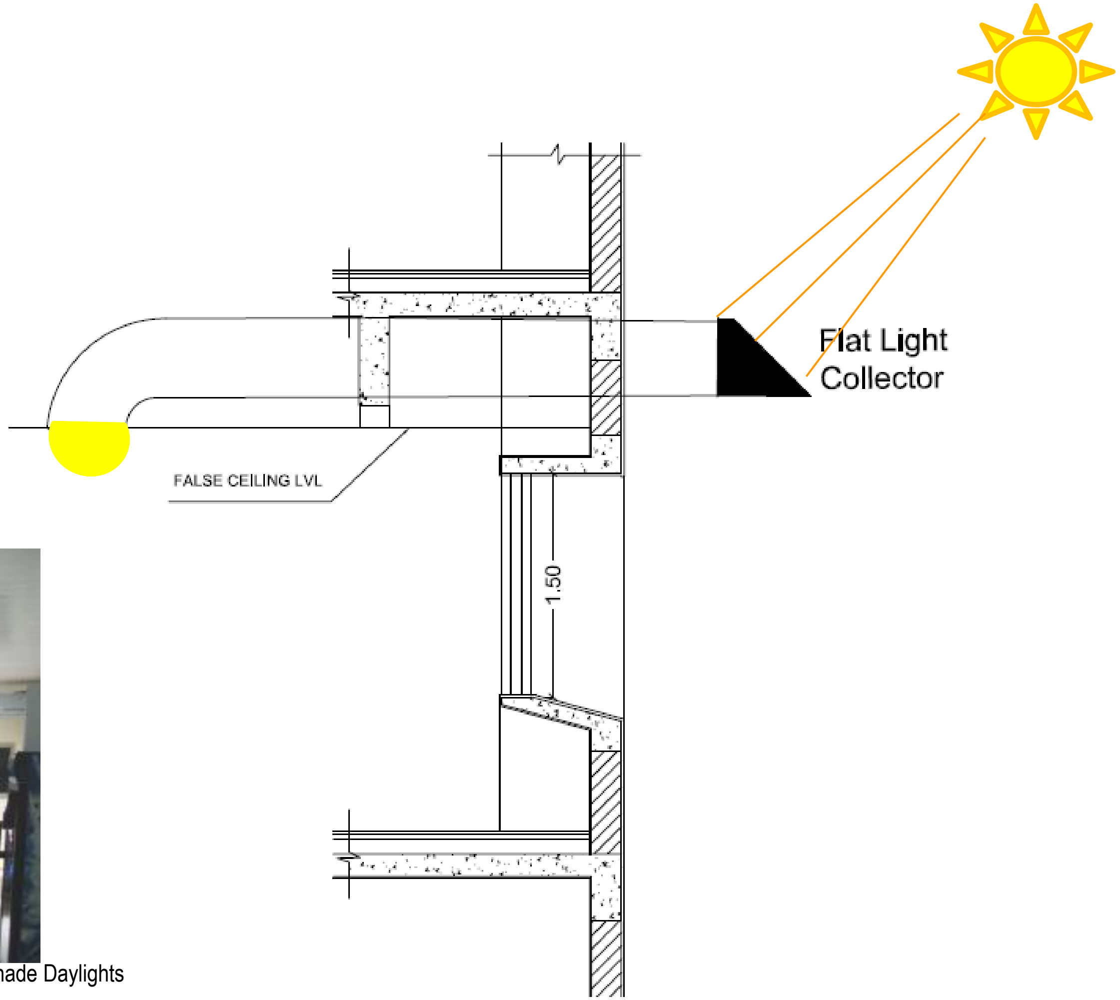
Optimize design to achieve glare free daylight with minimum external heat gains

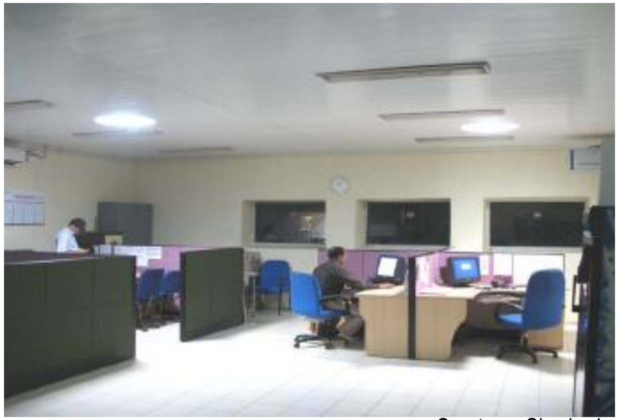


Daylight levels inside the work place.

Window design optimization for PGCIL Buildings, Bangalore

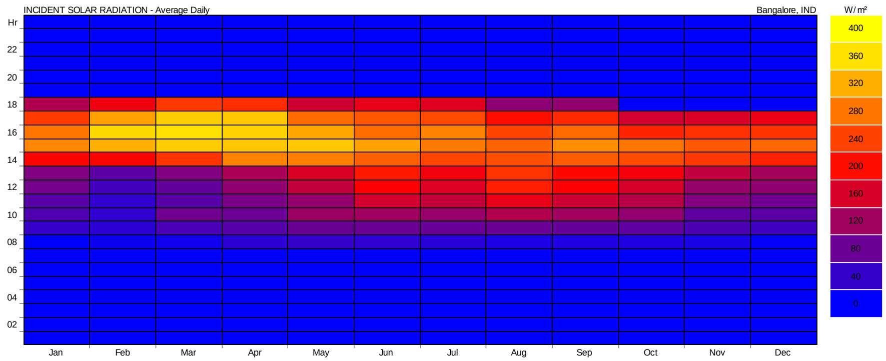
Integration of light pipes in PGCIL headquarters

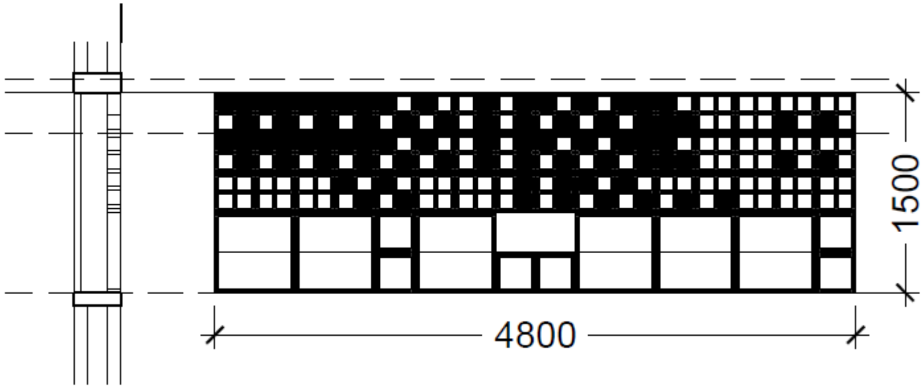


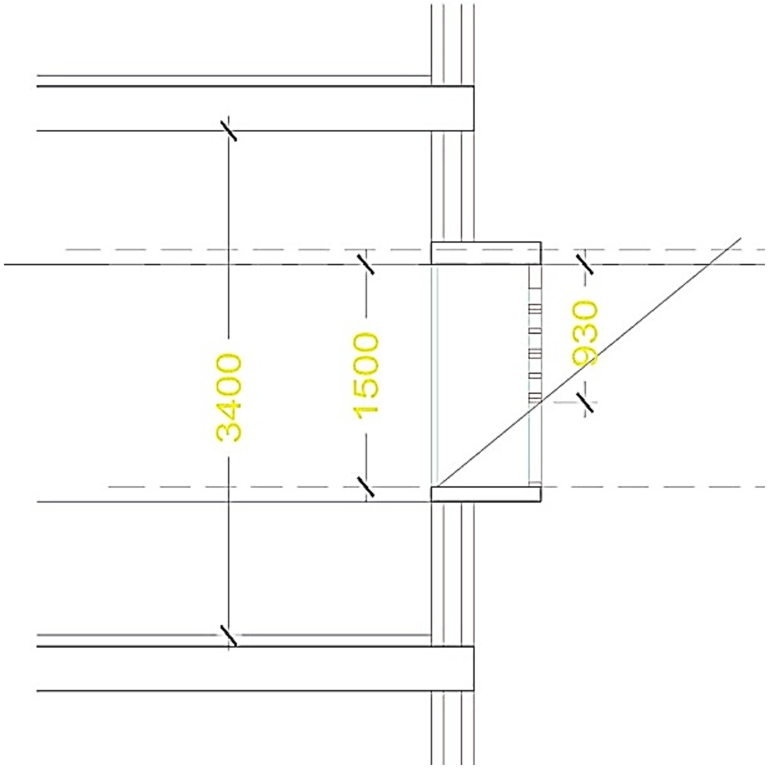


Courtesy: Skyshade Daylights

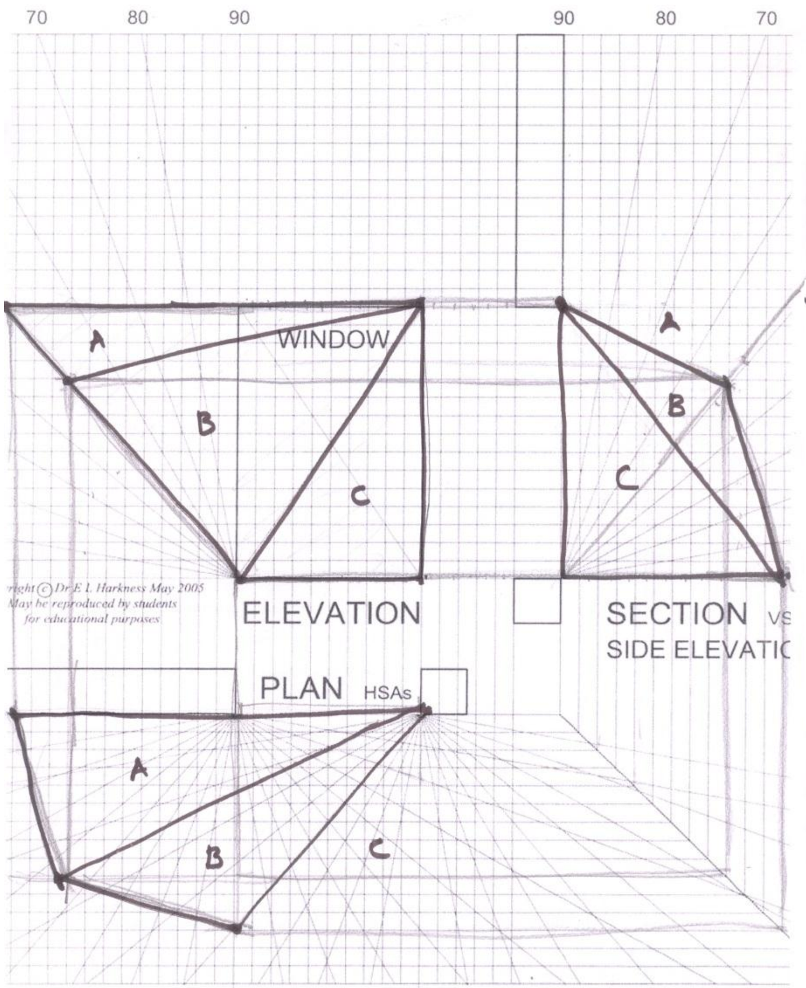
Solar radiation intensity analysis to design jallis for British School, Delhi

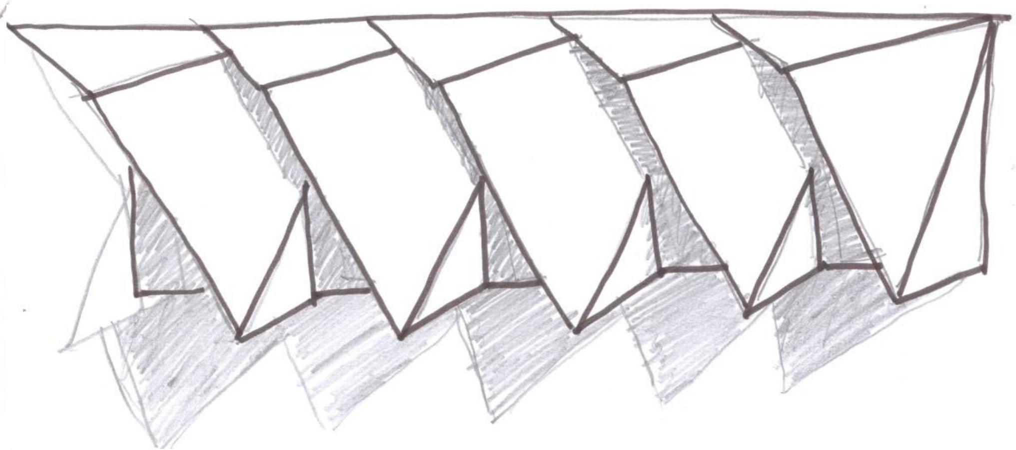






Shading Design- Option 2: Screen on West to cut the sun all round the year – EMPRI Project in Bangalore





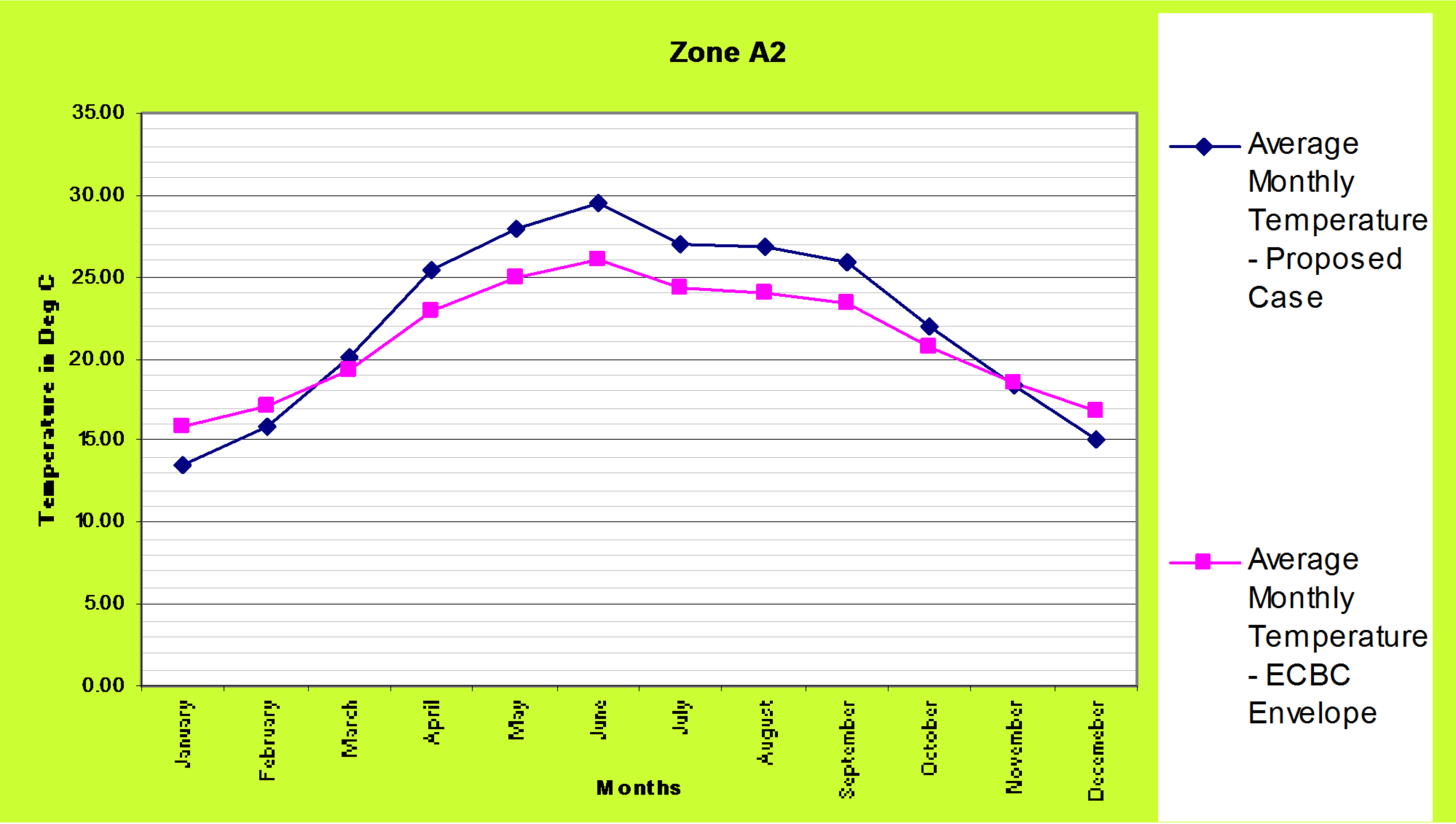
Schematic View

Criteria- 14: Optimize energy performance of building within specified comfort limits

Appraisal

14.3.1 Compliance with Energy Conservation Building Code as per clause 14.2.1(6 points).

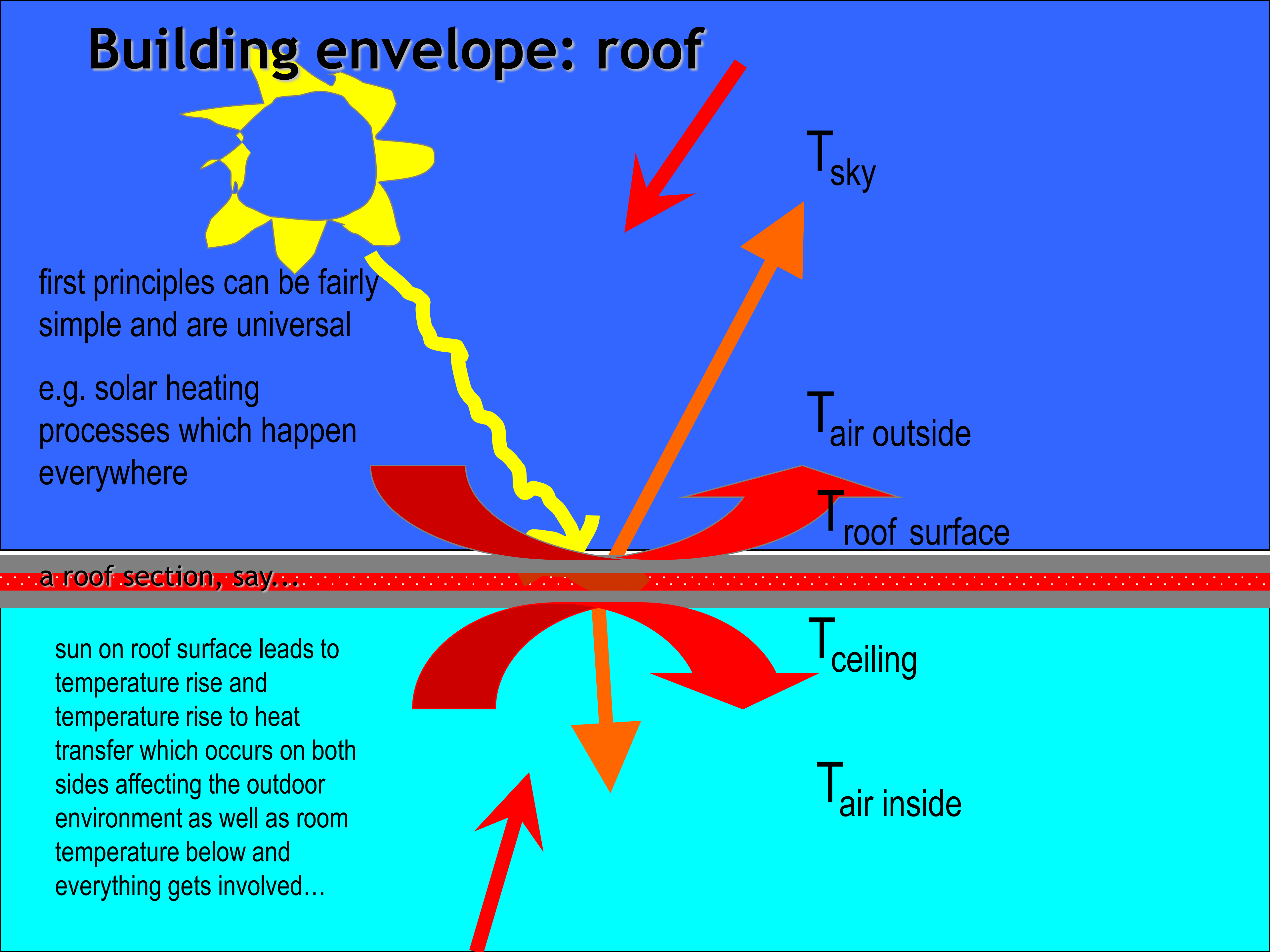
14.3.2 10% Reduction below the Energy Performance Index as in Table 14.1 to 14.2 and the thermal comfort criteria are fully met as per clause 14.1.7 and 14.1.8 (2-10 points). Achievement of benchmarked EPI shall fetch 2 points and every 10% reduction in EPI for respective cases shall fetch 2 additional points to a maximum of 10 points (50% reduction in EPI from the benchmark).



Zone A2
Temperature in Deg C
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
January
February
March
April
May
June
July
August
September
October
November
December
Months
Average Monthly Temperature - Proposed Case
Average Monthly Temperature - ECBC Envelope

Building envelope optimization for Air conditioned and Non Air conditioned spaces

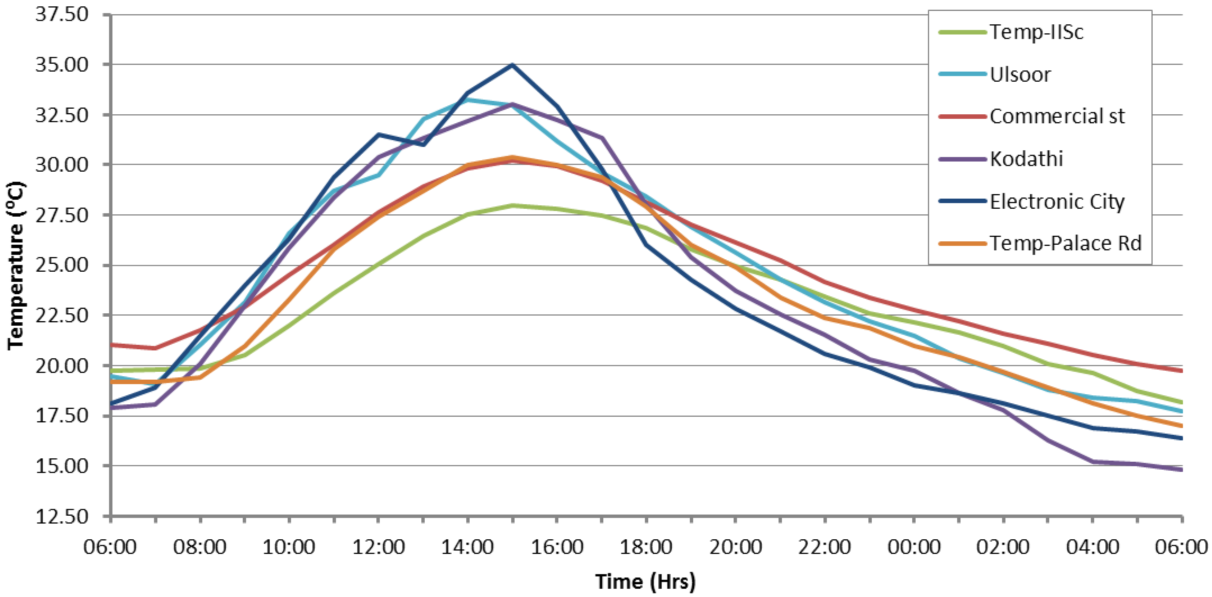
		Roof	Wall	Glazing_View Window			AC Spaces
	Alternative	U-Value	U-Value	U-Value	SHGC	VLT	Reduction in TR Load
		W/m2K	W/m2K	W/m2K			(%)
1	Base Case	2.49	3.17	6.17	0.815	0.88	
2	ECBC Roof Case_Over deck	0.36	3.17	6.17	0.815	0.88	1.76
3	ECBC Roof Case_Under deck	0.37	3.17	6.17	0.815	0.88	-0.18
4	Glazing optimised Case	2.49	3.17	1.59	0.28	0.4	4.20
5	Cumilative 1(Over Deck)	0.36	3.17	1.59	0.28	0.4	9.67
6	Cumilative2 (Under Deck)	0.37	3.17	1.59	0.28	0.4	7.93


Building envelope: roof
first principles can be fairly simple and are universal
e.g. solar heating processes which happen everywhere
T_{sky}
$T_{air\ outside}$
$T_{roof\ surface}$
a roof section, say…
$T_{ceiling}$
$T_{air\ inside}$
sun on roof surface leads to temperature rise and temperature rise to heat transfer which occurs on both sides affecting the outdoor environment as well as room temperature below and everything gets involved…

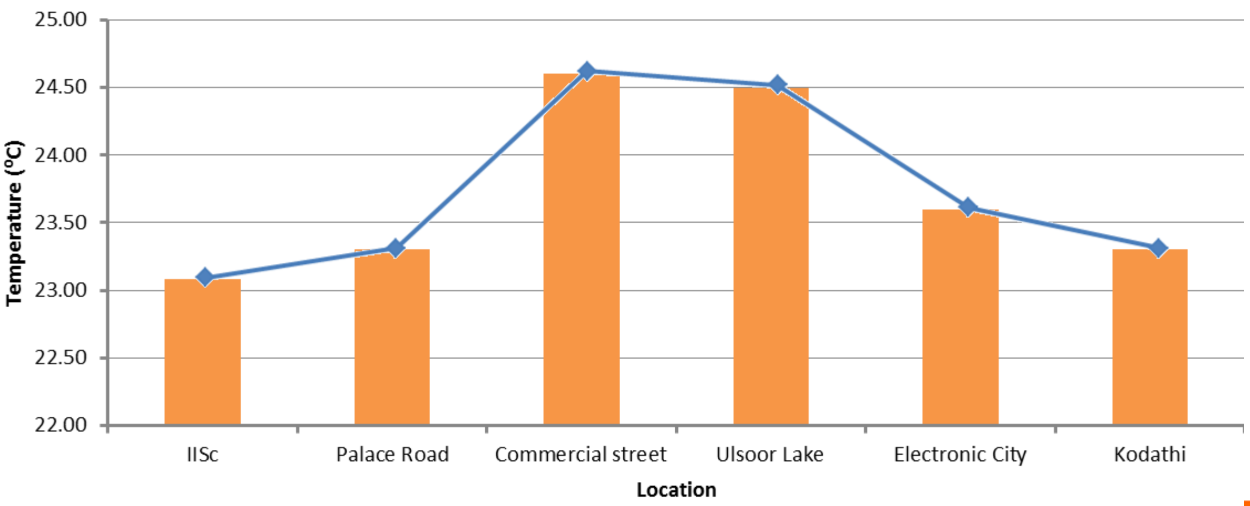
Sustainable Urban Development: Minimizing urban heat island effect and imperviousness factor

1.2 Hypotheses

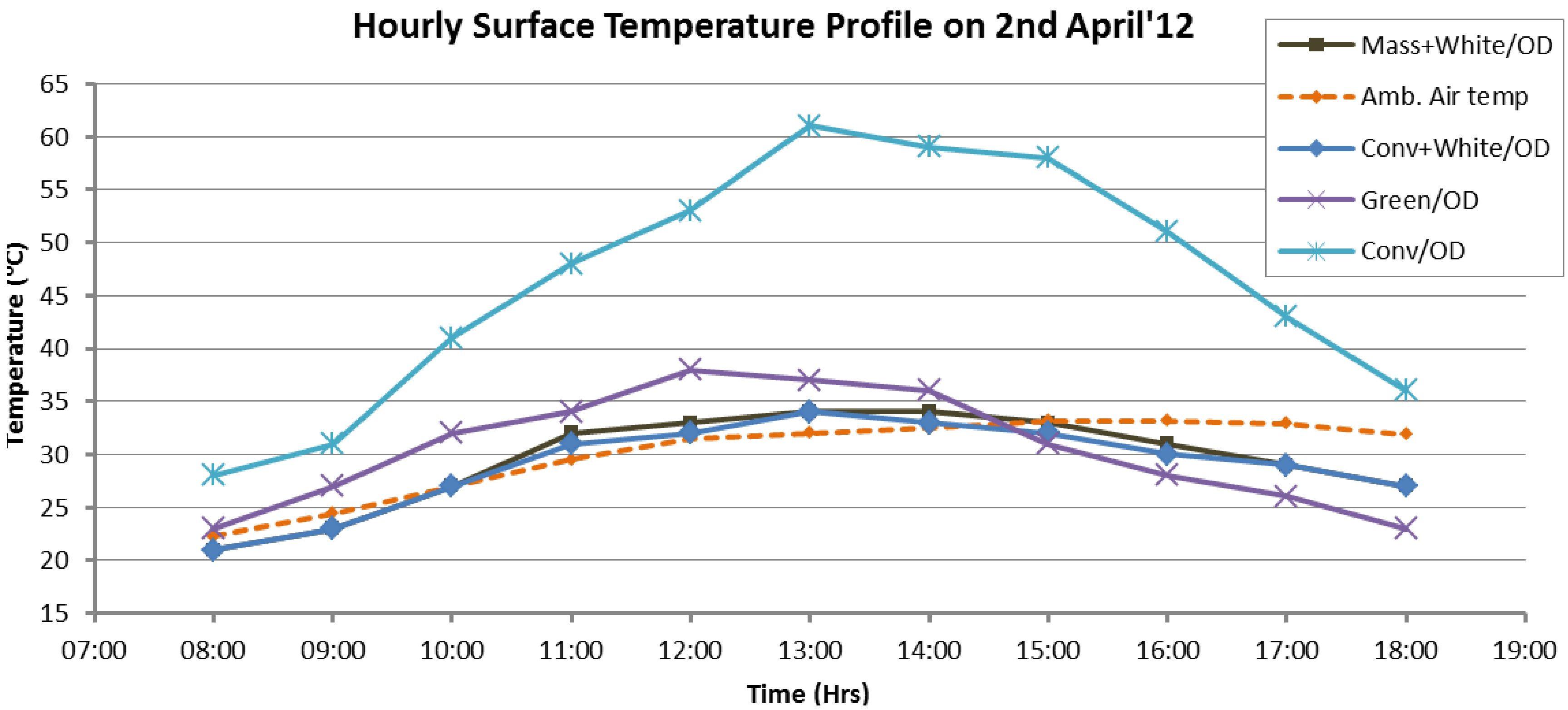
Implementation of Urban Heat Island (UHI) mitigation measures for various urban surfaces will reduce the ambient air temperatures. Energy savings in air conditioned buildings will possible due to improved micro climate around the buildings. Increased permeability of the urban surfaces will reduce the storm water runoff.



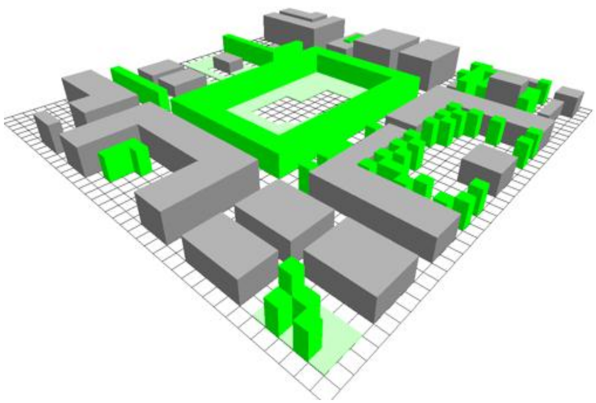
Hourly Mean Temperatures measured at different locations

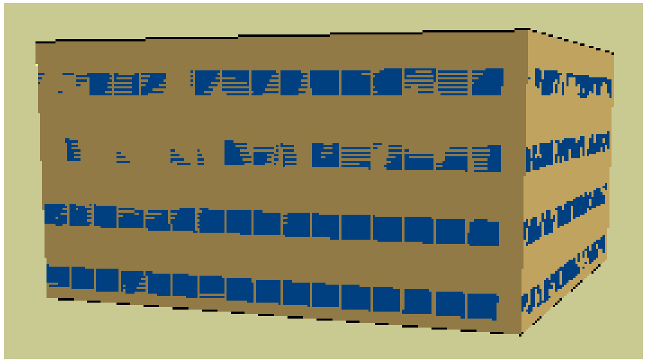


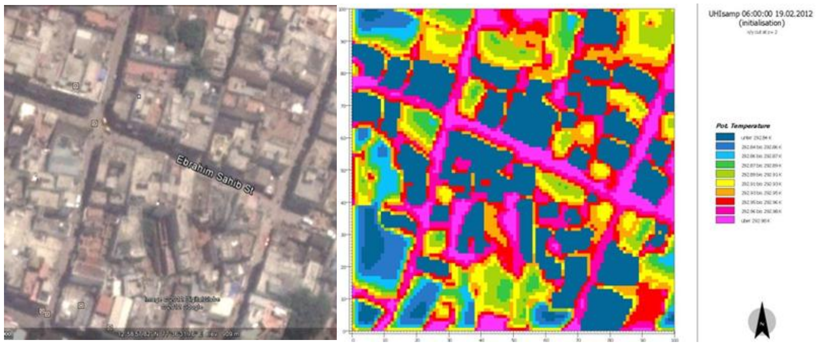
Sustainable Urban Development: Minimizing urban heat island effect and imperviousness factor

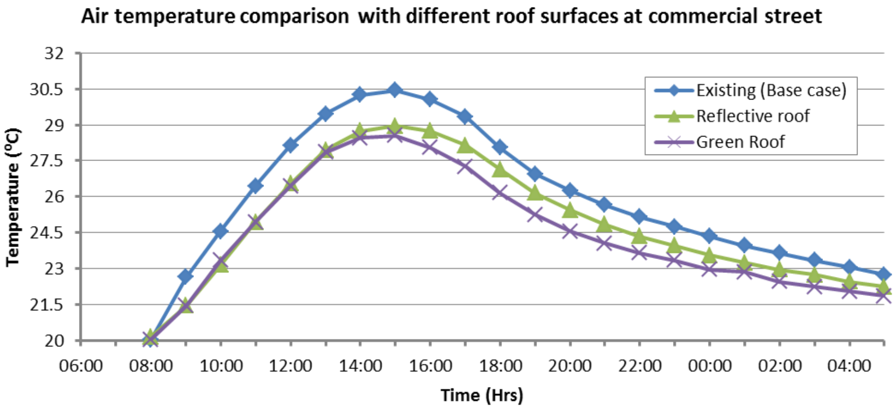


Sustainable Urban Development: Minimizing urban heat island effect and imperviousness factor



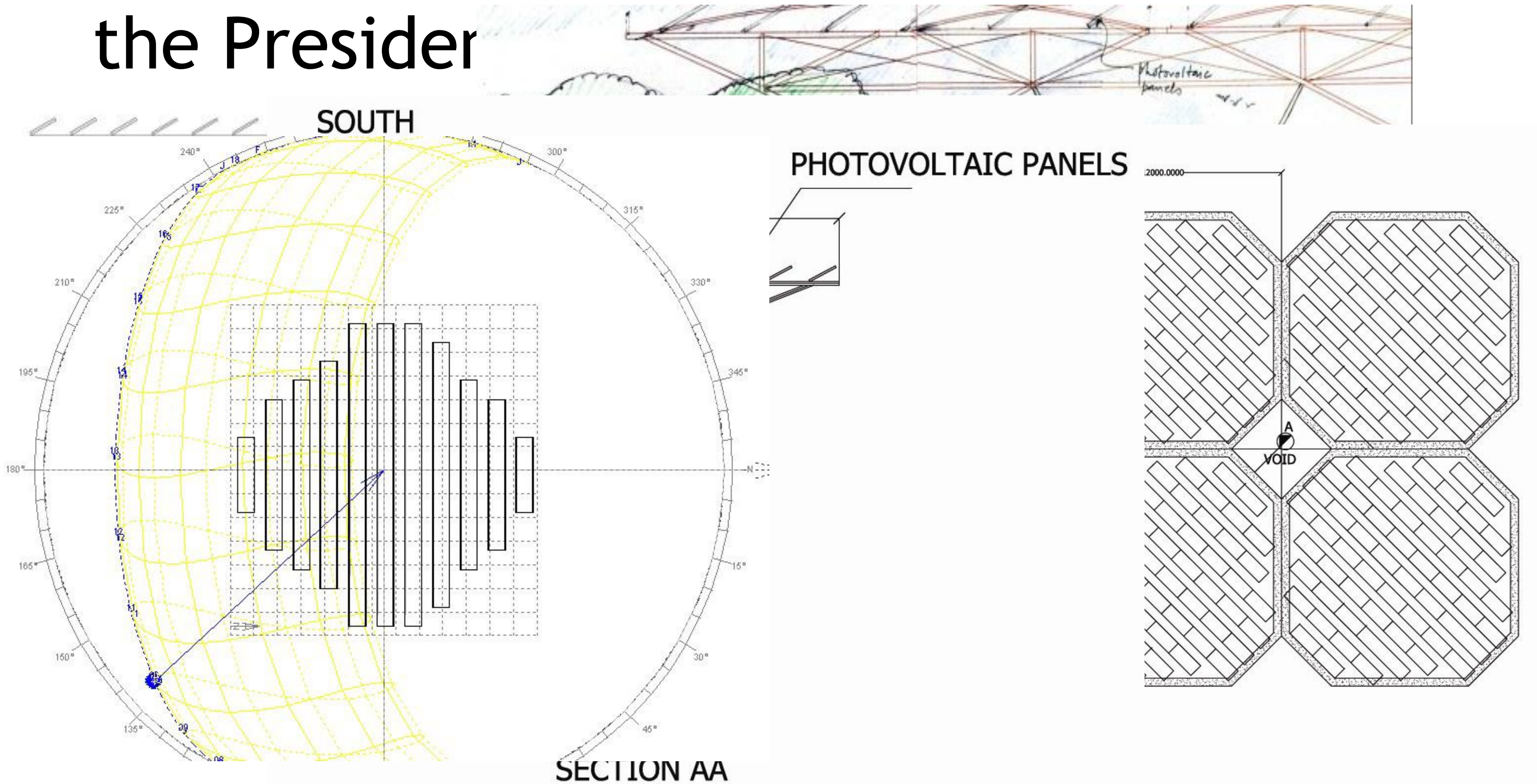






Integration of Renewable Energy

- 5MW Solar Photovoltaic system project for the Presider



Green interventions not limited to high end buildings…..

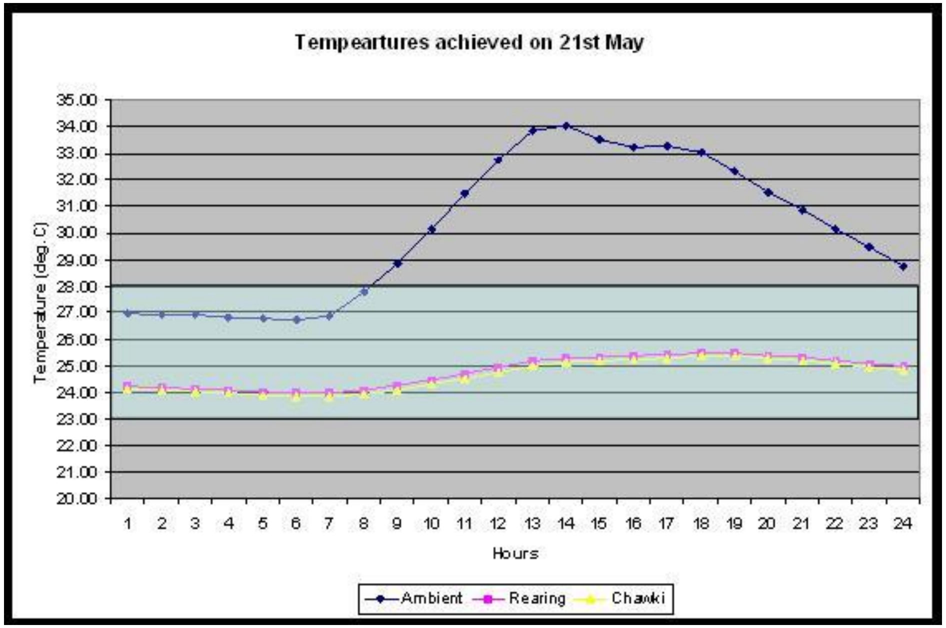
Solar Passive Silkworm rearing house, Bangalore

Thermal comfort requirement: Chawki room: 25 to 28 deg C with 70-90% RH

Rearing room: 23 to 25 deg C with 70-80% RH

Non uniform heating/cooling leads to loss in 50-70% of yield

Solar passive silkworm rearing house for enhanced productivity



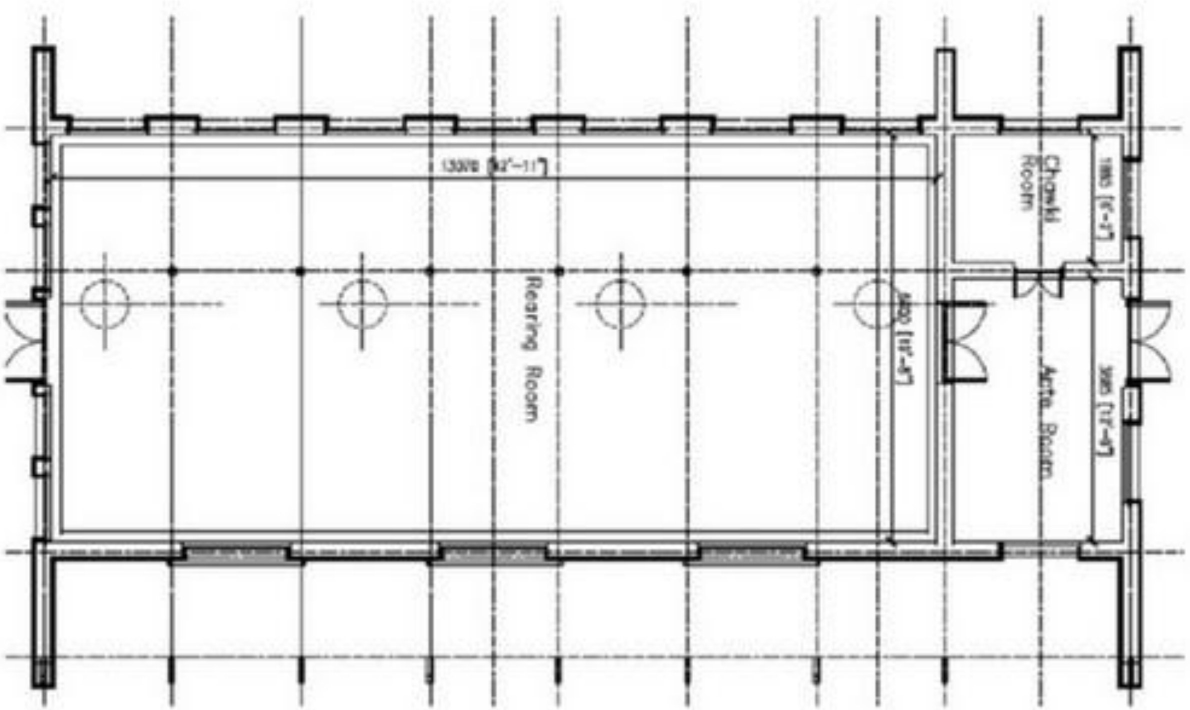
Strategies for summer:

Roof pond with insulation ;Insulated wall and roof; Wall shading

Solar chimney on south wall with adjustable vents (to improve ACH in the rearing room)

Air Inlet from north wall covered with wet gunny bags for added humidity

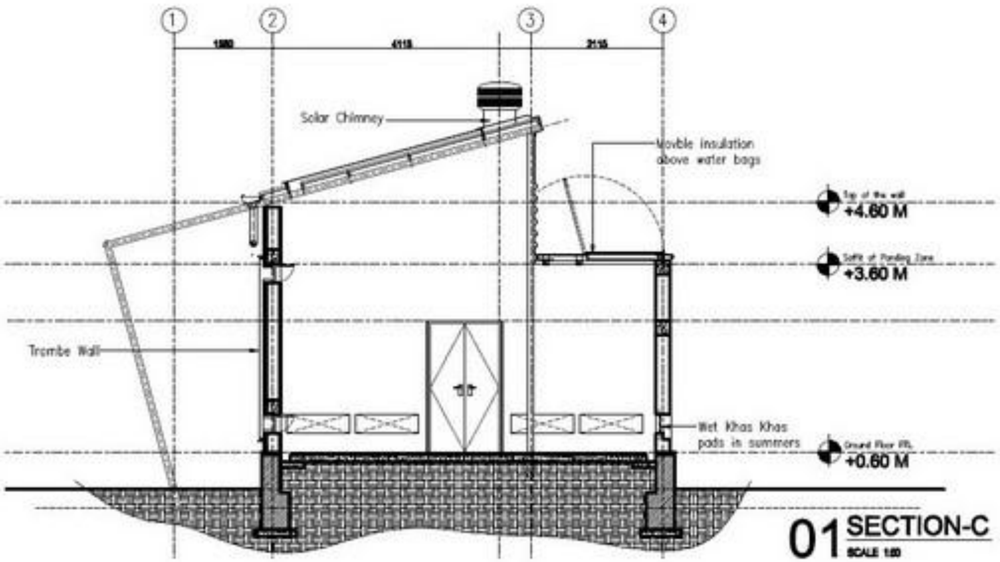
Details of the constructed solar passive silkworm rearing house



Floor plan for silkworm rearing house

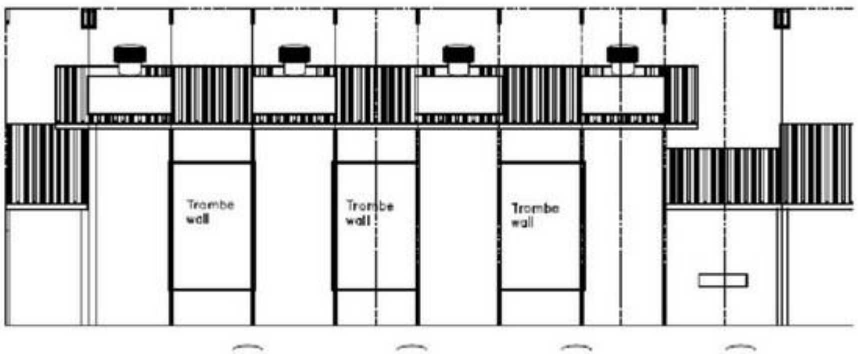
View of the constructed house at SSTL campus

Constructed solar passive silk worm rearing house



Building section for silkworm rearing house

Details of the constructed house



Thank you

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