

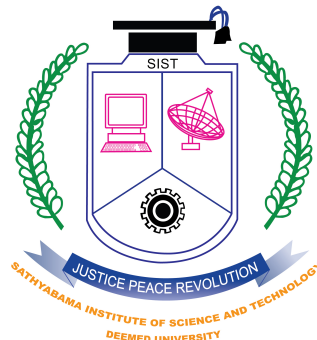
ACHIEVING WELLNESS AND THERMAL COMFORT IN AN OFFICE BUILDING - A DESIGN POST COVID 19

A Thesis

Submitted in partial fulfillment of the requirements for the award of
Master of Architecture degree in Sustainable Architecture

by

SEETHA VISALAKSHI K (39890015)



**DEPARTMENT OF ARCHITECTURE
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

MAY 2021



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DEPARTMENT OF ARCHITECTURE

BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **SEETHA VISALAKSHI K (39890015)** who carried out the Thesis entitled "**ACHIEVING WELLNESS AND THERMAL COMFORT IN AN OFFICE BUILDING - A DESIGN POST COVID 19**" under our supervision from January 2021 to May 2021.

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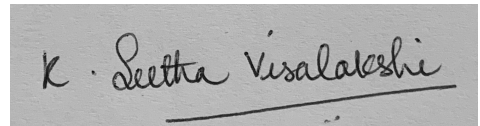
External Examiner

DECLARATION

I **SEETHA VISALAKSHI K** hereby declare that the Thesis Report entitled “**ACHIEVING WELLNESS AND THERMAL COMFORT IN AN OFFICE BUILDING - A DESIGN POST COVID 19**” done by me under the guidance of **Dr. Arulmalar Ramaraj** (Internal) and **Ar. P.S. GANESH, Principal Architect – GREENVIRON** (External) at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Master of Architecture degree in Sustainable Architecture.

DATE: 29/05/2021

PLACE: Chennai

A rectangular box containing a handwritten signature in black ink. The signature reads "K. Seetha Visalakshi" in a cursive script, with a horizontal line drawn underneath the name.

SIGNATURE OF THE CANDIDATE

ACKNOWLEDGEMENT

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ABSTRACT

Wellness is an important parameter which will have to be addressed in the future built environments. As the man kind spends 90% of their life indoors and the indoor air quality is low compared to the outdoor air quality, the first of question of Wellness starts with here. Keeping this fact in mind, the importance of Wellness in Built environment post pandemic situation is alarming and achieving the same is a challenge. The current COVID 19 pandemic situation have taught the human kind knowingly or unknowingly to live a Sustainable life, at the same time it has brought challenges for users' wellness inside the built environment. As people spend most of their time indoors for work, the post pandemic Office spaces are going to be challenging in achieving the users' wellness, at the same time maintaining thermal comfort for them.

The aim is to study, understand and achieve the key factors of Wellness, Thermal Comfort and Passive design approach in designing an Office space which can respond in Pandemic conditions. The study will be carried out by understanding the guidelines of WELL Building Standard by the International Well Building Institute and Green Building rating system to achieve the mentioned key factors.

An Exploratory analysis will be done to research, study and understand the parameters influencing the Built environment during pandemic situations.

The findings of the research and the studied principles of Wellness and thermal comfort guidelines will channelize and incorporated in the design of an office building which can respond in any Pandemic situation.

Key words: Pandemic, Wellness, Thermal comfort, Passive design, Office, Built environment.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The past Pandemic diseases in the history were due to respiratory infections which were airborne and also spread through social culture. The quality of indoor air also played a key role in the spread of such diseases. This is put the man kind to rethink their design and planning of built environment.

The Past & the present Pandemic situations have similar properties with respect to the nature and spread of the pathogens in the human community and this may prevail in future too.

Initially, the spread of the virus happened in poor ventilated spaces, spaces with HVAC and in colder areas. After few months of COVID 19 outbreak the pathogen started its evolution and taking a new life from the initial phase.

The entire planet is fighting against the virus in various ways and strategies.

Air is the primary medium of transmission of the virus and thus the indoor air plays an important role in the spread and transmission. The current COVID 19 pandemic situations have put 90% of our life to be spent in indoors.

Why Office space in particular to Pandemic

The one third of a day's time is spent at work and the indoor environmental quality is given a secondary concern in most of the developing and under developed countries. Thus, achieving wellness for the occupants in work place is challenging. The aim of the study is to achieve wellness and thermal comfort for the occupants in an Office, which can perform well even during future pandemics.

The necessary of Green or Sustainable building is not to satisfy the thermal comfort parameters alone, the wellbeing of the users should also be taken into account. The role of Indoor Air Quality in any Green building is an important factor, but not a mandatory parameter. A study says that the indoor air is polluted 5 times more than the outdoor air. Thus, indoor air quality needs to be addressed as a prime factor in a built environment.

The indoor air quality in an office helps in occupant's productivity, lesser sickness levels, less numbers of absenteeism. The quality indoor air is a non-legal right for all living being on the Planet.

The theoretical studies convey that proper ventilation, design of necessary open spaces, connection to nature in a built environment, more numbers in air changes will rejuvenate the indoor spaces helping to fight the pathogens.

How to achieve in the Design

The experimental studies prove that use of indoor plants as Green house or Phyto filters helps in cleaning the indoor contaminated air.

The Well Building Standard by the International Well Building Institute nurtures 10 criteria in which the wellness of the human being is given priority and to be achieved in a Sustainable approach. The importance of wellness and achieving in a sustainable approach is going to be the future of built environment. Thus, IGBC and WBS will be incorporated in achieving the Wellness and thermal comfort of occupants in an Office design.

1.2 AIM

To study, understand and achieve the key factors of Wellness, Thermal Comfort and Passive design approach in designing an Office space which can respond to Pandemic conditions.

1.3 NEED FOR THE STUDY

The study focuses on the wellbeing and thermal comfort of the occupants and passive design approach in an office space. This is the need of the hour in the current and future pandemic situations.

1.4 SCOPE AND LIMITATIONS FOR THE STUDY

The key factor of the study is wellness and thermal comfort and various methods in achieving both will be studied from literature in detail.

1.5 RESEARCH QUESTIONS

- How wellness can be incorporated in the Built environment?
- How the current Pandemic situation is going to influence the built environment?
- How the offices will function Post Pandemics?
- What are the indoor plants to maintain the indoor air quality?
- How can wellness and thermal comfort go hand in hand in the future built environments?
- How open spaces can be incorporated in designing a built environment which can act as breathing space in a building?

CHAPTER 2 CASE STUDY

2.1 CASE STUDY 1 – TRANSPORT CORPORATION OF INDIA, GURGAON

The Architect have attempted to minimize energy consumption and particularly for air conditioning through various strategies in the design of the building fabric :

- EXPOSURE – Compact shape and Compact height
- INSOLATION - the amount of solar radiation reaching a given area
 - a. support framework for shading screens (Retract/ remove in winter, stretch in summer)
 - b. forecourt, fountain court and garden terrace
 - c. trees and plants
 - d. control window area
 - e. venetian blinds in sandwich windows & external glass is tinted
 - f. self shading for small windows

- HEAT TRANSFER

External wall area badly exposed to low morning/ afternoon sun. therefore, heat transfer through walls is controlled

U - VALUE OF EXTERNAL WALL

Large window (11% of wall area) - 2.8 watts/sqm K
 Small window (5% of wall area) - 6.42 watts/sqm K
 Opaque area (81% of wall area) - 0.75 watts/sqm K
 Effective (average) "U" value - 1.35 watts/sqm K

HEAT TRANSFER THROUGH ROOF

Reflective Roof Surface U - VALUE OF ROOF - 0.6 watts/sqm K

- INFILTRATION

- a. Tight windows
- b. Air lock lobby at entrance

- INTERNAL MICROCLIMATE

FOUNTAIN COURT

- Evaporative cooling
- Psychological comfort in seeing and hearing the play of water
- ILLUMINATION

Design for daylight, reduce electric lighting

- Adequate daylighting throughout from courtyard from high window
- Glazed partitions to cabins

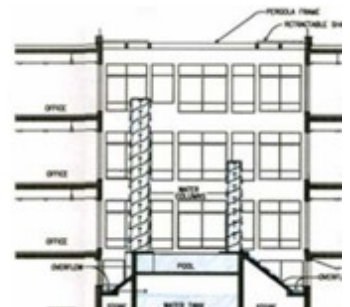


Figure 2.1. – Transport Corporation of India, Gurgaon

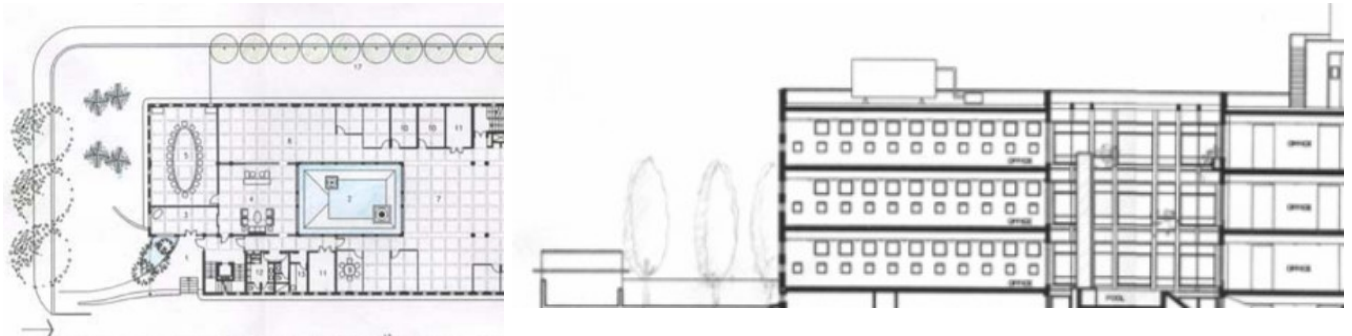


Figure 2.2 – Plan and Section of Transport Corporation of India, Gurgaon

RADIATION AND DAYLIGHTING ANALYSIS:

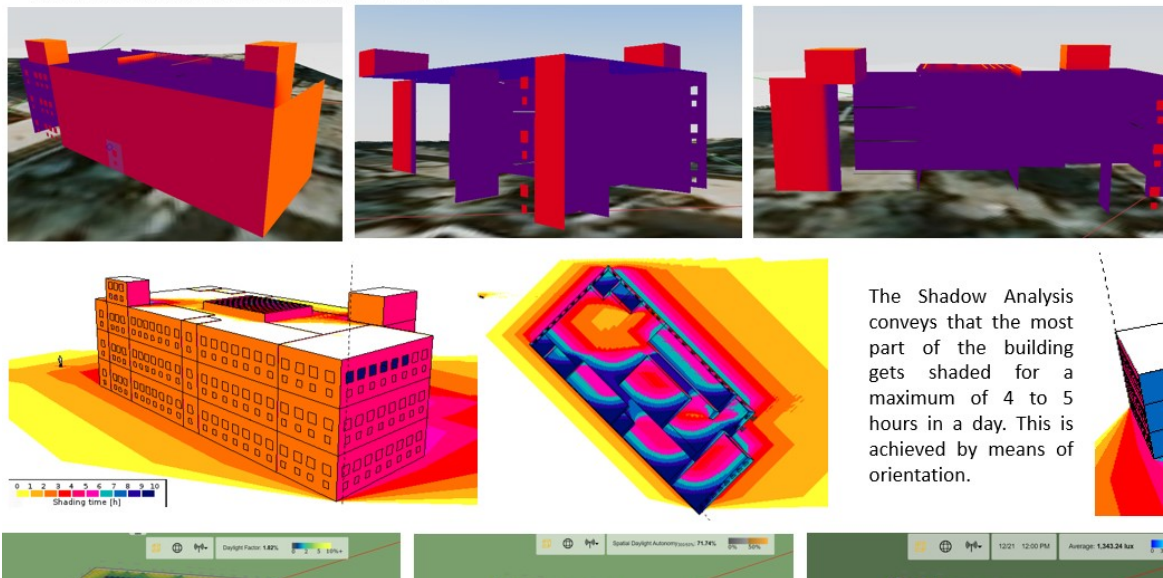


Figure 2.3 – Radiation and Daylighting Simulation, TCI, Gurgaon

WIND FLOW ANALYSIS:

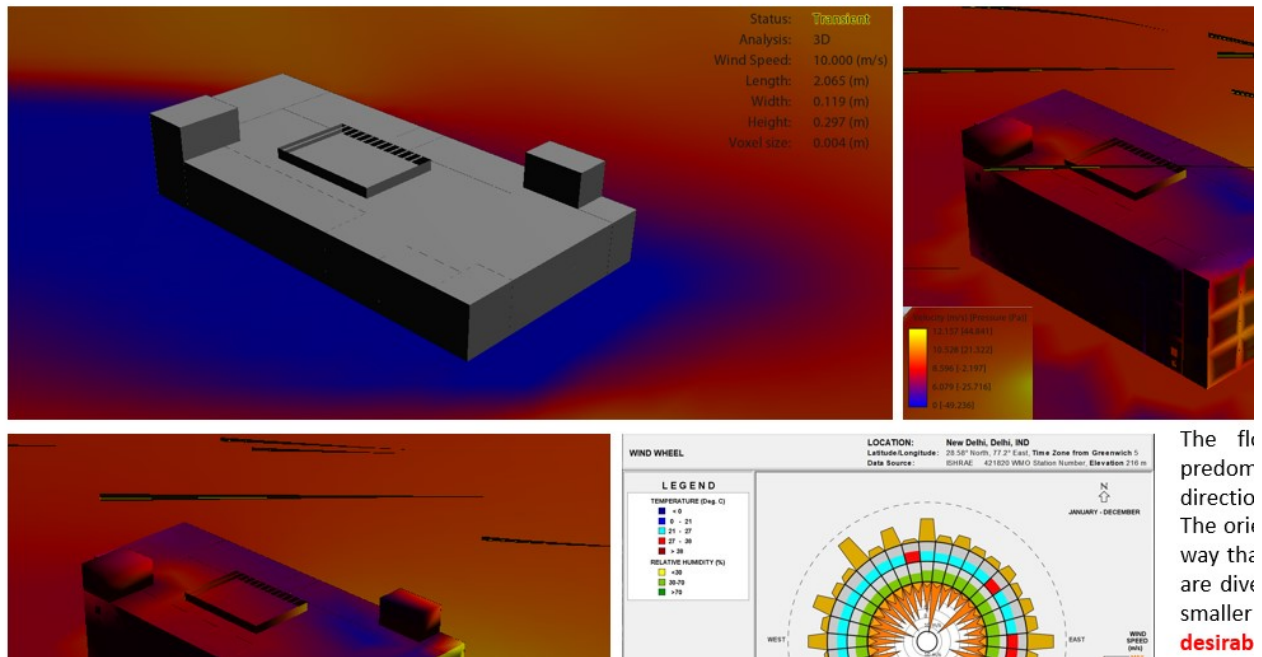


Figure 2.4 – Wind flow Simulation, TCI, Gurgaon

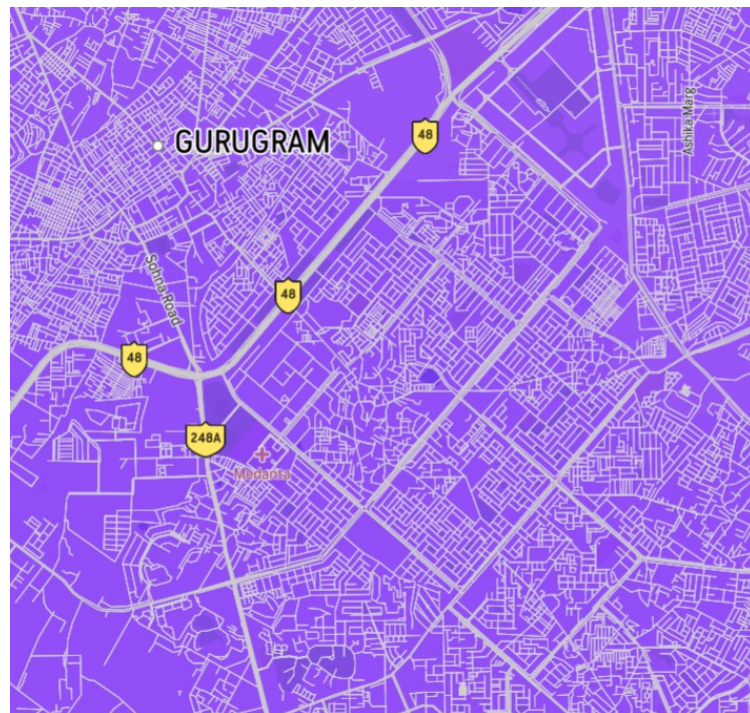


Figure 2.5 – Air quality, Gurgaon

The Air quality of Gurgaon is dangerous and unhealthy for the people to live in as it is in the range of dangerous.

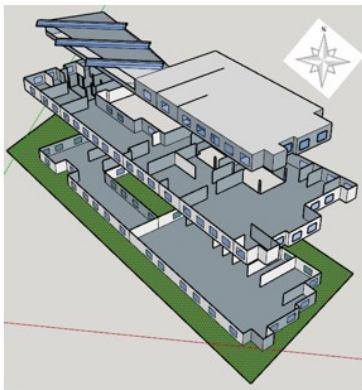
The office building designed with passive strategies and sustainable techniques might help in maintaining the indoor air quality.

The air quality of the indoors is not measured and proven, but the passive strategies adopted may help to an extent compared to any conventional building.

2.2 CASE STUDY 2 – TERI SRC, BANGALORE

Study III: TERI South regional Head Quarters, Bangalore

- **Orientation**

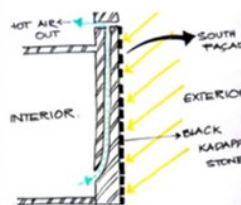
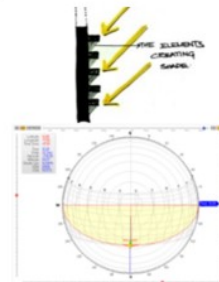


The building is oriented such a way that it does not receive direct solar radiation on the East and West

- **Daylighting**



- **Envelope Treatment**



The south façade has cavity with high thermal mass.

- **Renewable Energy**



2kWp Solar PV panels



The photo voltaic solar panels also generate electricity for the building.

The energy efficient light fitting

The rainwater harvesting system is used for sustainable approach

- **Rainwater Harvesting and**



Figure 2.6 – Passive Design Strategies, TERI SRC, Bangalore

RADIATION AND DAYLIGHTING ANALYSIS:

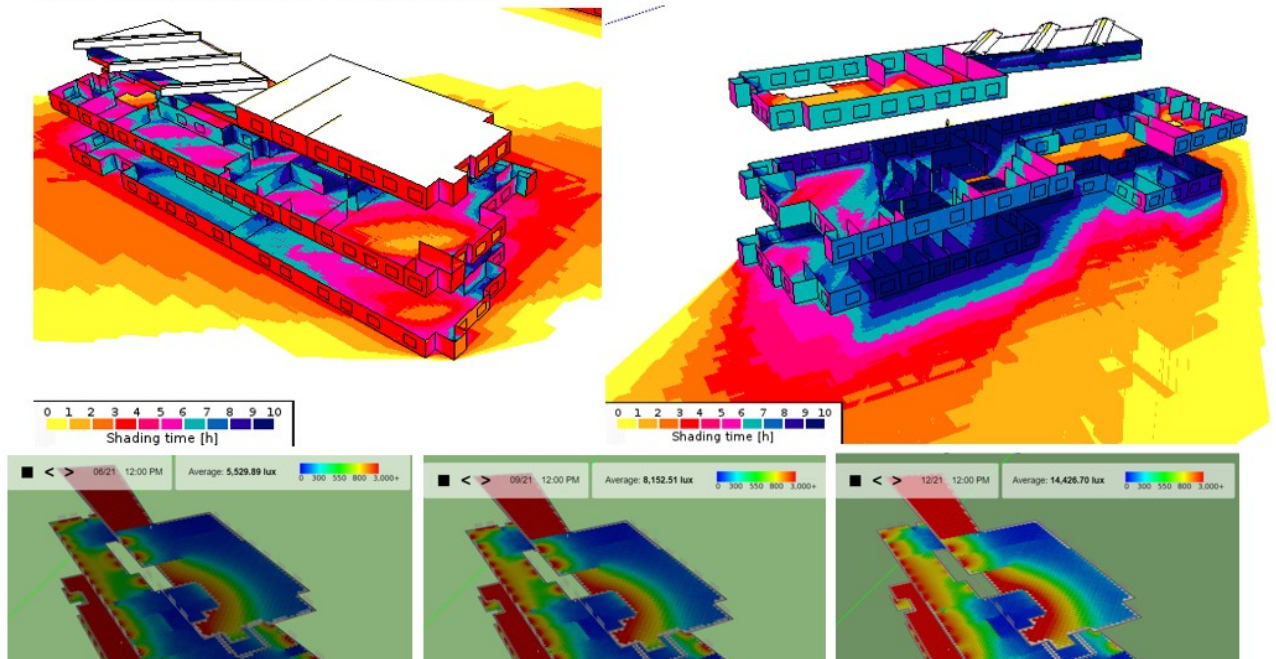


Figure 2.7 – Radiation and Daylighting Simulation, TERI SRC, Bangalore

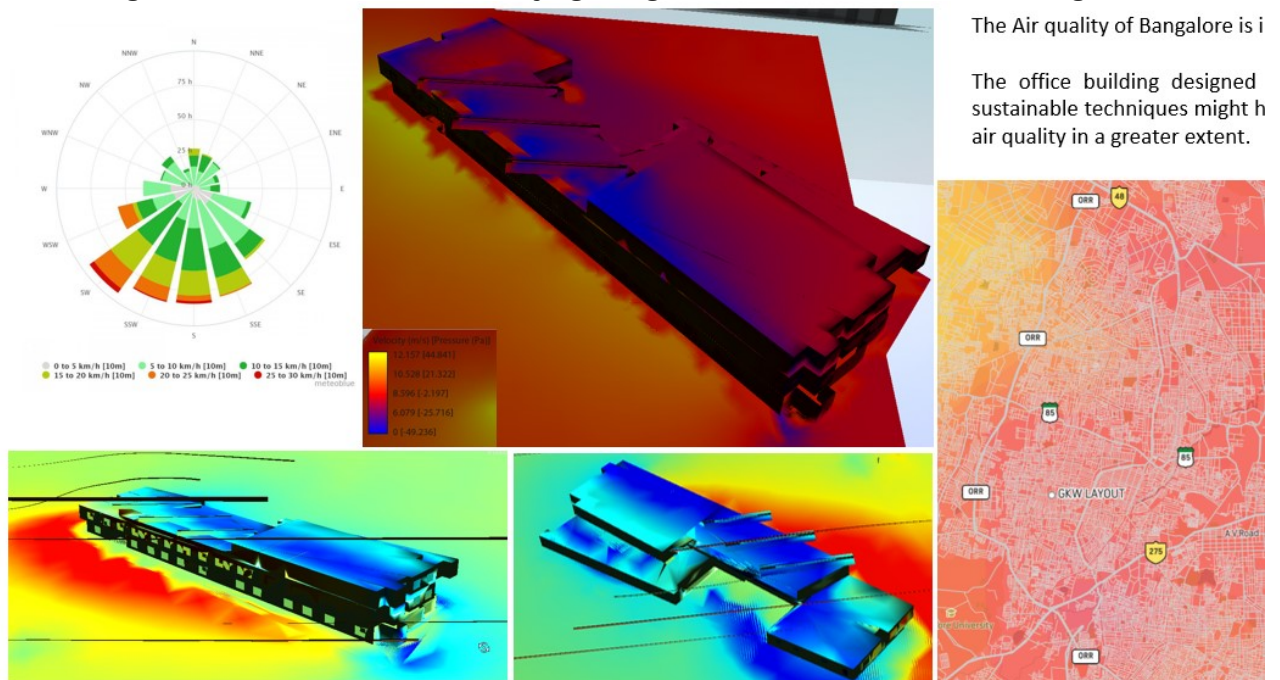
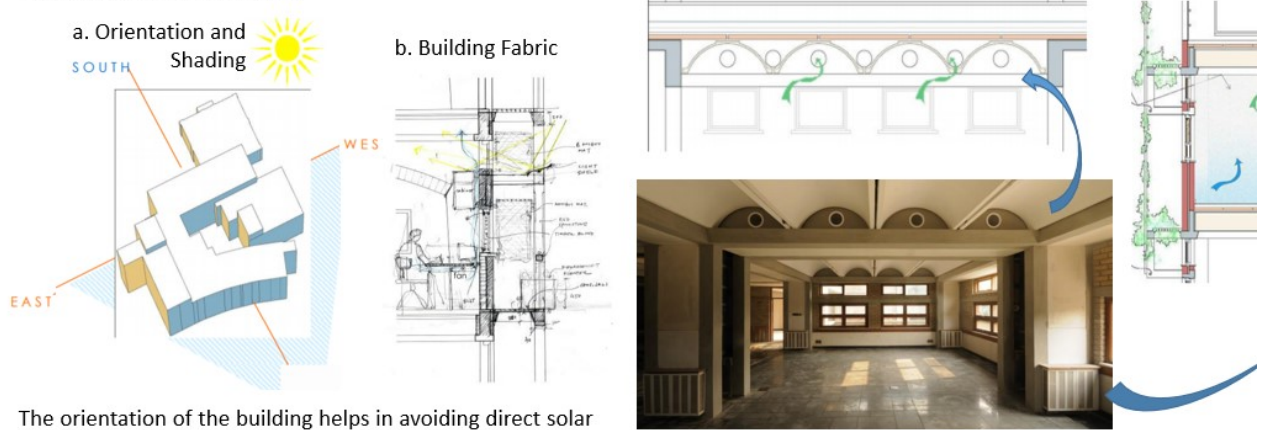


Figure 2.8 – Wind flow Simulation and Air quality, TERI SRC, Bangalore

2.3 CASE STUDY 3 – DEVELOPMENT ALTERNATIVE WORLD HEADQUARTERS, DELHI

Study II: Development Alternatives World Headquarters, New Delhi

Environmental Performance



The orientation of the building helps in avoiding direct solar heat gain which is a predominant parameter to be addressed in a Composite climate condition.



Figure 2.9 – Passive Design Strategies – DAWHQ, Delhi



The shading devices for the windows on the sides which experiences harsh solar radiation is designed in a way that it is shaded for extreme summers and openable during the winter as Gurgaon experiences composite climate.

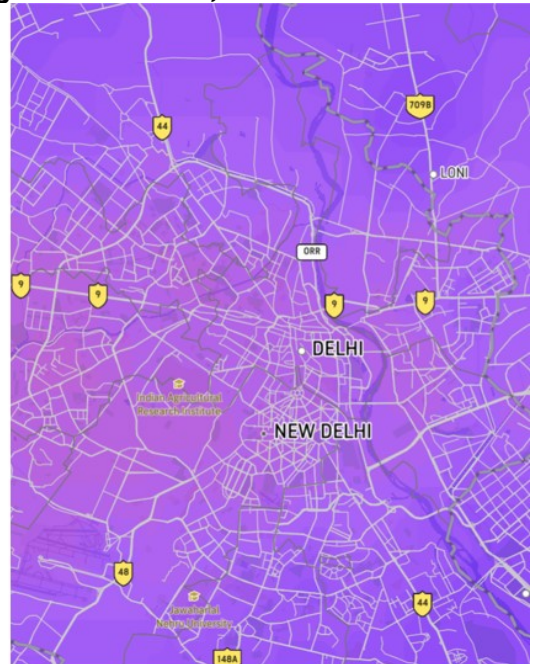
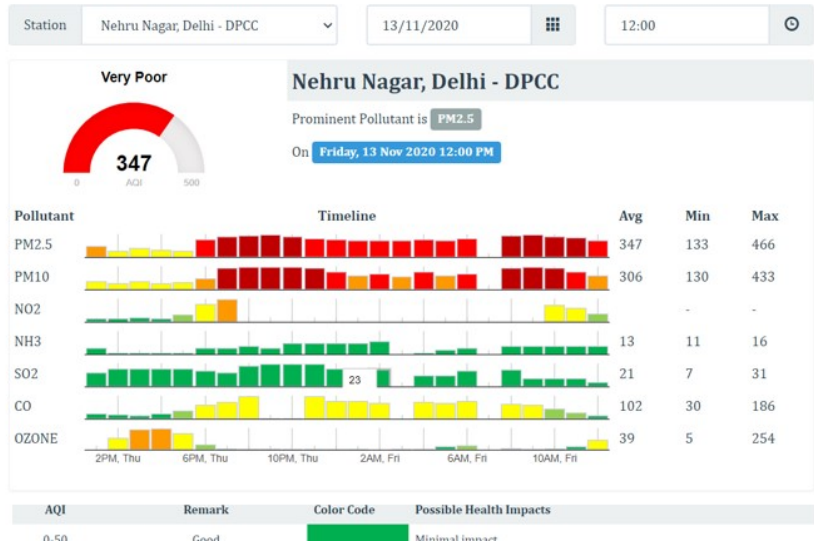


Figure 2.10 – Passive Design Strategies and Air Quality – DAWHQ, Delhi

2.4 SPECIAL STUDY – PAHARPUR BUSINESS CENTER, DELHI

SPECIAL STUDY – PAHARPUR BUSINESS CENTRE, NEW DELHI

PAHARPUR BUSINESS CENTRE (PBC) Is a Living Example of a Building which has been retrofitted with various technologies to enhance Work Experience – **PEOPLE FIRST**



Indoor Air Quality
We use green plants to remove toxins and harmful gases from indoor air.

IAQ PARAMETER	13-NOV-20	12-NOV
PM10 in Paharpur Business Centre (microgram/m3)	9	8
PM10 in Outdoor Delhi (microgram/m3)	152	102
CO2 in Paharpur Business Centre (ppm)	546	544
CO2 in Outdoor Delhi (ppm)	401	394
PM2.5 in Paharpur Business Centre (microgram/m3)	8	7
PM2.5 in Outdoor Delhi (microgram/m3)	136	95

- **LEED Platinum building with LEED monitor of building performance**
- **BEE 5-Star building with AAhEPI of 2**
- **ISO 9001, 14001, 22000, 50001, OHS**
- **NABERS Certified Building (for Indoor Air Quality)**
- **CETEC 5 Palm Rating (for Health Building)**

This building has been experimented to protect the occupants from health problems, according to the **Chittaranjan National Cancer Institute** and **Control Board**.



Figure 2.11 – Sheet 1 – Paharpur Business Center, Delhi

The study compared **94 nonsmokers working there with nonsmokers employed elsewhere in Delhi**. It is found that the former had fewer cases of **eye irritation, headaches, hypertension, and respiratory problems**.

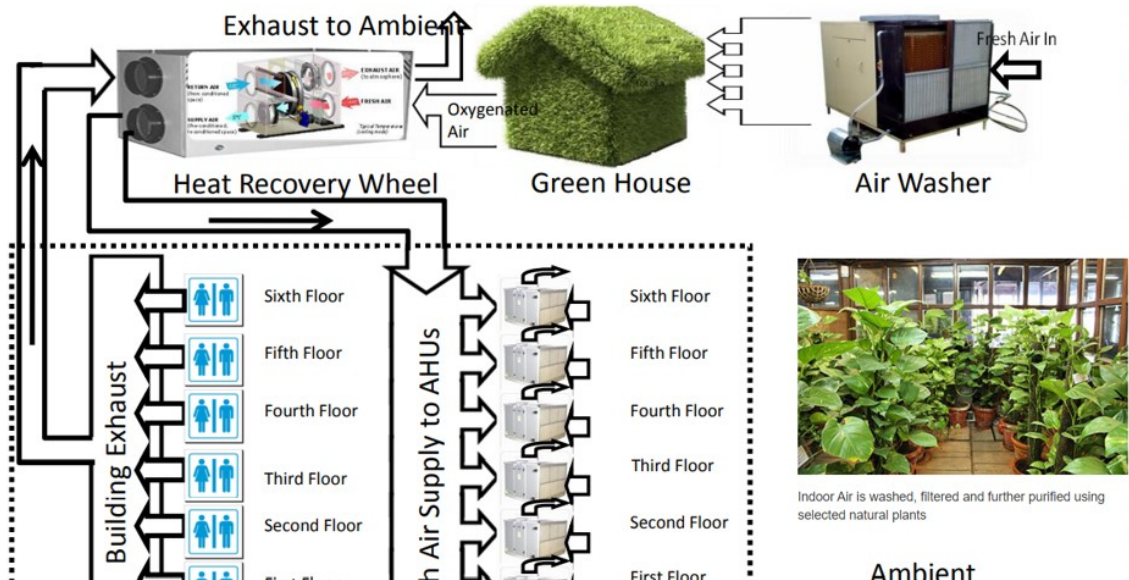


Figure 2.12 – Innovation in IAQ system in PBC, Delhi

2.5 SPECIAL STUDY – PLANTS HELP IN PURIFYING INDOOR AIR BY NASA



The following ALCA plants were screened:

Table 3. Formaldehyde Removal by Houseplants and

“The plants were mainly acting as a transport mechanism while the root microbes were performing most of the air purifying work”
Wolverton, 1989

Common Name	Scientific Name
Bamboo palm	<i>Chamaedorea seifritzii</i>
Chinese evergreen	<i>Aglaonema modestum</i>
English ivy	<i>Hedera helix</i>
Ficus	<i>Ficus benjamina</i>
Gerbera daisy	<i>Gerbera jamesonii</i>
Janet Craig	<i>Dracaena deremensis</i> “Janet Craig”
Marginata	<i>Dracaena marginata</i>
Mass cane/Corn cane	<i>Dracaena massangeana</i>
Mother-in-law's tongue	<i>Sansevieria laurentii</i>
Peace lily	<i>Spathiphyllum</i> “Mauna Loa”
Pot mum	<i>Chrysanthemum morifolium</i>
Warneckei	<i>Dracaena deremensis</i> “Warneckei”

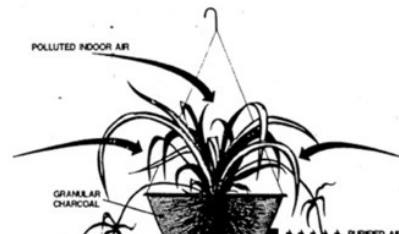


Figure 2.13 – Indoor plants help purifying indoor air by NASA

SPECIAL STUDY – PHYTOFILTER by WBDG AND NASA'S GREEN SOLUTION FOR UNHEALTHY AIR



A phytofilter is a plant filter (“phyto” being the Greek word for plant) which removes **airborne contaminants from indoor air**. It is composed of:

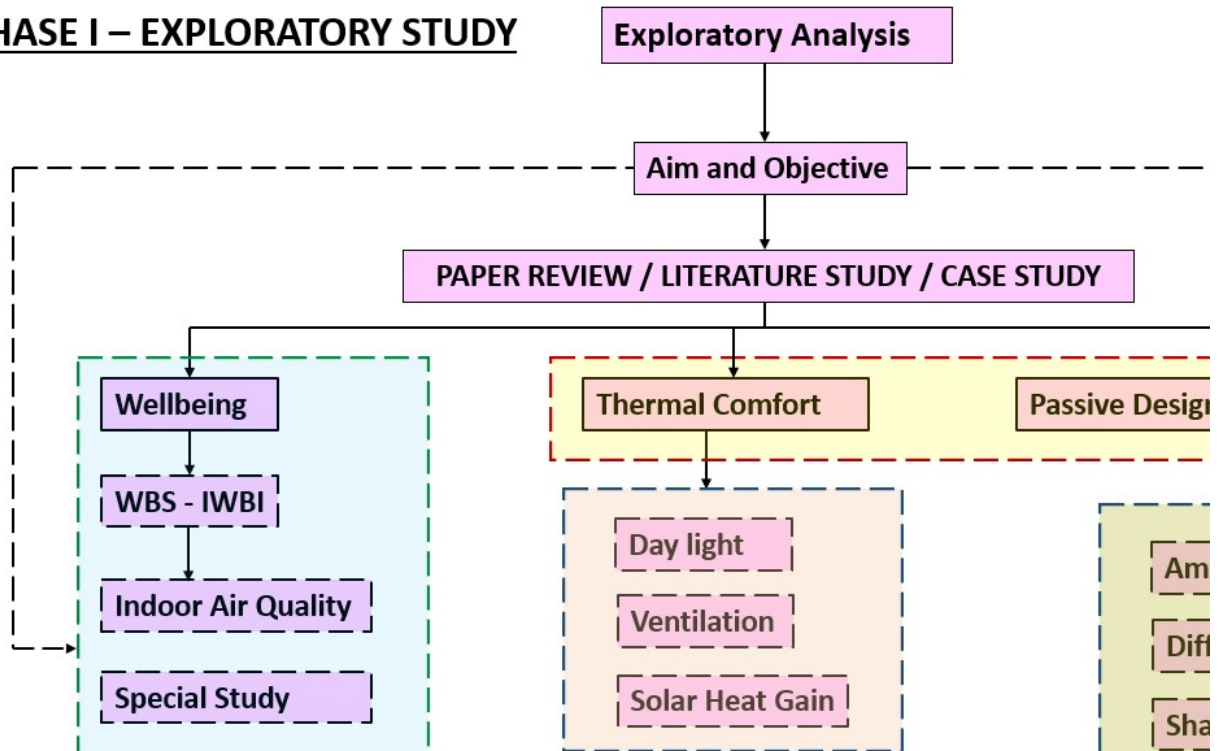
- a filter in which plants and root microbes grow,
- a porous artificial soil (usually composed of activated carbon and expanded shale or clay)
- an induction fan and,
- a moisturizing system which keeps the filter damp so it can act as a wet scrubber.



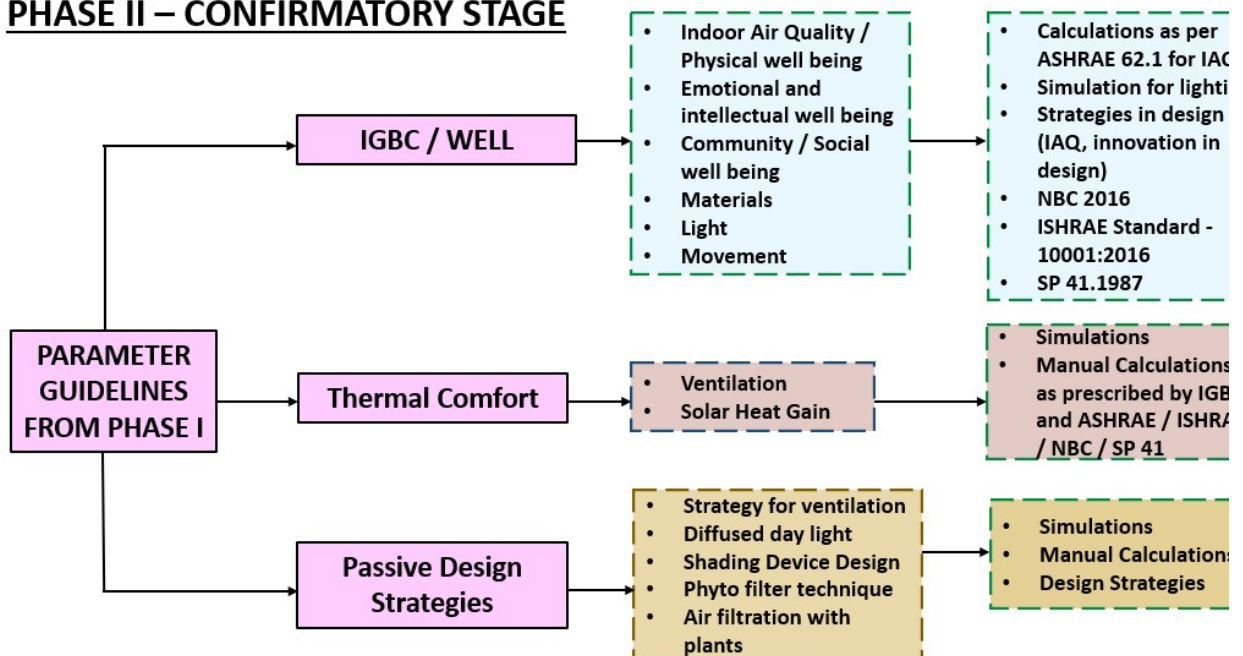
Figure 2.14 – Phytofilter technique by NASA

CHAPTER 3 METHODOLOGY

PHASE I – EXPLORATORY STUDY



PHASE II – CONFIRMATORY STAGE



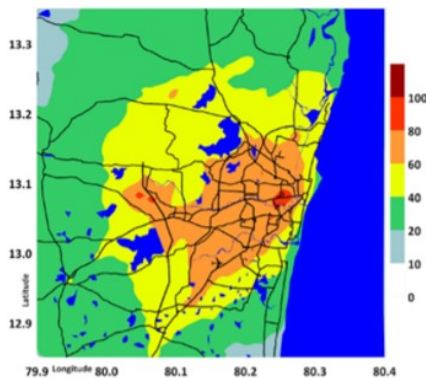
CHAPTER 4 ANALYSIS AND RESULTS

GUIDELINES AND PARAMETERS TO BE TAKEN TO DESIGN			
PASSIVE / GREEN STRATEGY	WELL BUILDING STANDARD / IGBC HEALTH AND WELL BEING	PANDEMIC GUIDELINES	CUMULATIVE ST
CROSS VENTILATION	INDOOR AIR QUALITY TO BE ACHIEVED	HIGHLY VENTILATED SPACE WITH MORE AIR EXCHANGES HELPS TO PREVENT TRANSMISSION OF PATHOGENS	1. CROSS VENTILATION HELPS TO PREVENT TRANSMISSION OF PATHOGENS
INDOOR PLANTS HELPS IN AIR PURIFICATION AND REMOVAL OF TOXINS PRESENT IN THE AIR	WATER QUALITY TO BE ACHIEVED	WATER QUALITY TO BE ENSURED FOR THE ZERO PERCENT CONTAMINANTS WITH A PH VALUE IN BETWEEN 6.5 AND 8.5 (BY EPA)	2. NATIVE INDOOR PLANTS HELPS IN AIR PURIFICATION AND REMOVAL OF TOXINS PRESENT IN THE AIR
DAYLIGHTING THROUGH DIFFUSED MEANS TO AVOID GLARE	LIGHTING COMFORT SHOULD BE ADDRESSED	BIPOLAR IONIZER HELPS IN TAKING THE PATHOGENS PRESENT IN THE INDOOR ENVIRONMENT	3. DAYLIGHTING THROUGH DIFFUSED MEANS TO AVOID GLARE
SELECTION OF TREES FOR PURIFICATION OF AIR. EG: NEEM, SACRED FIG (FICUS RELIGIOSA), ETC	ACTIVITY FOR OCCUPANTS SHOULD BE A PART OF DESIGN	AIR WASHER AND FILTERS HELPS IN REDUCTION OF CONTAMINATED AIR INTO THE INDOORS. UV LAMPS IN THE AC DUCTS CAN DESTROY THE MICROBES PRESENT IN INDOOR AIR	4. AIR PURIFICATION THROUGH DIFFUSED MEANS TO AVOID GLARE
MATERIALS SELECTION BASED ON REGIONALITY / LOCALLY AVAILABLE MATERIALS THAT CAN HELP IN THERMAL COMFORT	THERMAL COMFORT SHOULD BE ACHIEVED	SMART TECHNOLOGIES HELPS IN AVOIDING PHYSICAL CONTACT OF THE OCCUPANTS	5. MATERIALS SELECTION BASED ON REGIONALITY / LOCALLY AVAILABLE MATERIALS THAT CAN HELP IN THERMAL COMFORT
ORIENTATION OF THE BUILDING TO RESPOND THE CLIMATE	IMPORTANCE TO GIVEN FOR SOUND COMFORT	HIGHER THE RELATIVE HUMIDITY, THE PATHOGENS CANNOT LIVE FOR MORE DURATION	6. ORIENTATION OF THE BUILDING TO RESPOND THE CLIMATE
OPEN SPACES / CONNECTIVITY TO NATURE	NON MICROBIAL MATERIALS TO BE USED	SOCIAL DISTANCING	7. POSITIVE SPACES FOR OCCUPANTS
			8. SOCIAL SUSTAINABLE OCCUPANTS. BUILDING

Table 4.1 – Guidelines from the Study

4.1 – SITE SELECTION

Modeled annual average PM_{2.5} concentration (2015) µg/m³



For urban Chennai, average PM_{2.5} concentration was $57.5 \pm 16.8 \mu\text{g}/\text{m}^3$. This is much higher than the national standard (40) and more than 5 times the WHO guideline (10).

Air monitoring infrastructure

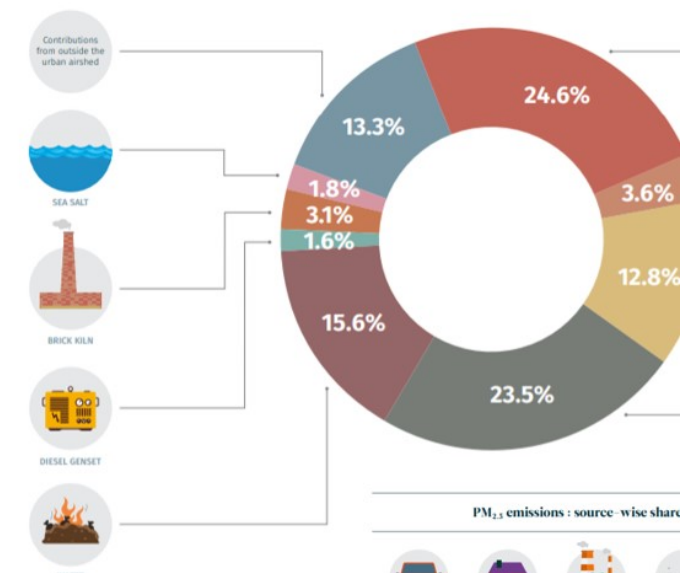
Chennai has 3 Continuous Air Monitoring Station (CAMS) reporting data for all the criteria pollutants and 11 manual stations reporting data on PM₁₀, SO₂, and NO₂. There should be at least 38 CAMS in the city for efficient reporting.

Annual averages from the national ambient monitoring

Figure 4.1 – Air quality study of Chennai

CHENNAI – AIR QUALITY

PM_{2.5} concentration : source-wise percentage share



PM_{2.5} emissions : source-wise share

Chennai Air Pollution: Real-time Air Quality Index (AQI)

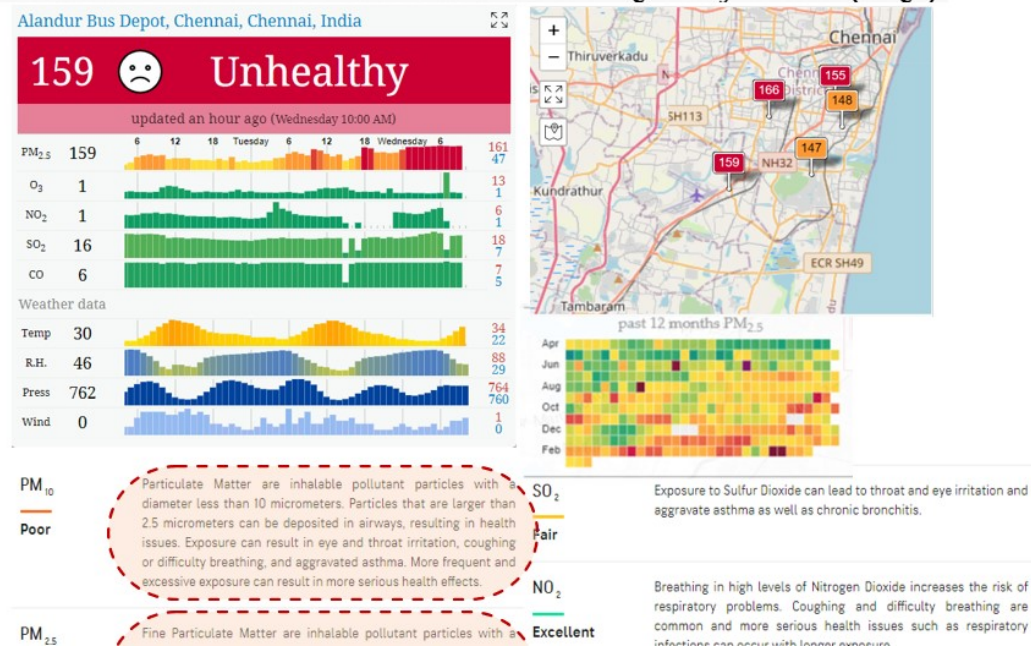


Figure 4.2 – AQI of Chennai



Figure 4.3 – Master Plan of Mahindra World City, Paranur, Tamilnadu

Mahindra World City is an Infra structure developed by the Mahindra group in a Sustainable approach. MWC have automobile companies and research valley for automobile industry. SAMEEEKSHA (Small And Medium Enterprises: Energy Efficiency Knowledge Sharing, A Platform for promoting Energy Efficiency in SMEs) is a collaborative platform with TERI and MSME, which promotes and provides best operating practices with energy efficiency approach for the SME industry. Thus, MWC would be a right choice of having an organization similar to SAMEEEKSHA / TERI, where the training center cum administrative office building would be designed to benefit the present automobile companies in the locality

MWC Chennai is home to companies such as BASF Catalysts, BMW India, Capgemini, Force Motors, Fujitec India, Infosys, Lear Corporation, Mahindra & Mahindra, NCR, Renault-Nissan, Timken India and TVS Group, among others.

MWC Chennai is India's first IGBC Gold Certified "green township." MWC Chennai is promoted in a PPP between Mahindra Group and Tamil Nadu Industrial Development Corporation Ltd (TIDCO).

4.2 CLIMATE ANALYSIS

CLIMATE ANALYSIS:

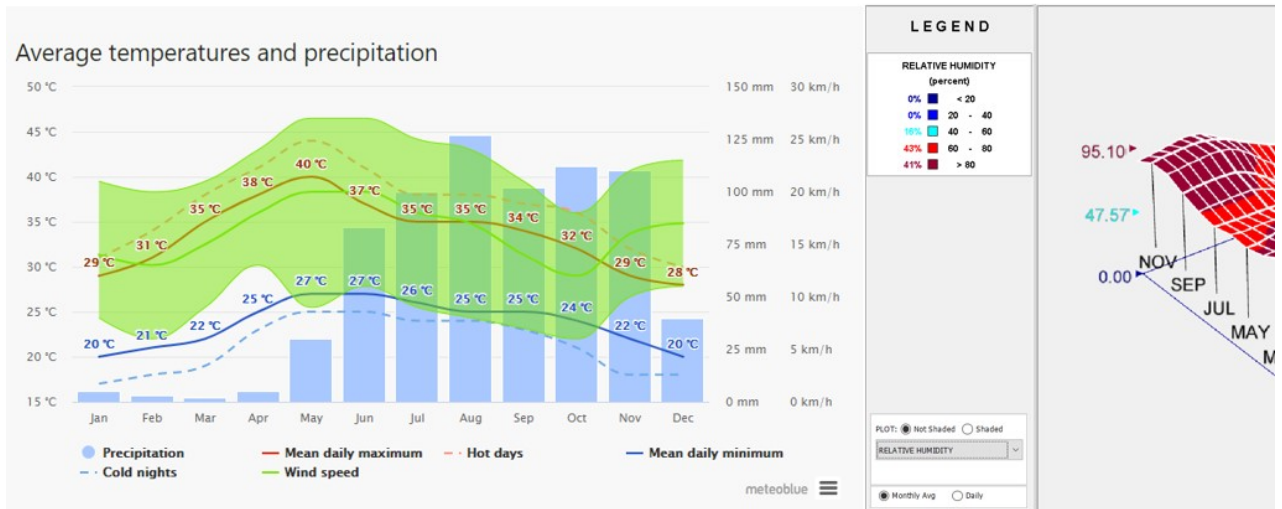
As per ECBC, Chennai comes under Warm – Humid climate zone. Chennai experiences hotter weather and high humidity because of the coastal region. Passive strategies can be adopted to maintain the

WEATHER DATA SUMMARY												LOCATION: Chennai-Madras, Tamil Nadu, IND	
												Latitude/Longitude: 13.0° North, 80.18° East, Time Zone from Greenwich 5	
												Data Source: ISHRAE 432790 WMO Station Number, Elevation 16 m	
MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	357	418	400	422	450	448	426	450	428	359	317	331	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	275	320	230	239	308	309	248	286	268	190	168	218	Wh/sq.m
Diffuse Radiation (Avg Hourly)	181	195	235	247	217	215	236	225	225	225	206	195	Wh/sq.m
Global Horiz Radiation (Max Hourly)	936	984	962	954	1058	1050	985	1104	1092	870	763	778	Wh/sq.m
Direct Normal Radiation (Max Hourly)	1399	1021	965	948	1017	999	843	990	974	812	698	892	Wh/sq.m
Diffuse Radiation (Max Hourly)	405	455	497	510	508	501	504	509	504	480	425	385	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	4053	4834	4786	5199	5678	5722	5402	5592	5177	4207	3620	3728	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	3117	3700	2754	2940	3889	3946	3143	3551	3242	2226	1919	2458	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	2054	2262	2814	3048	2744	2747	2998	2800	2715	2638	2353	2193	Wh/sq.m
Global Horiz Illumination (Avg Hourly)													lux
Direct Normal Illumination (Avg Hourly)													lux
Dry Bulb Temperature (Avg Monthly)	24	25	28	30	31	31	30	29	29	27	25	24	degrees C

Start	January		2000	
Max. Temperature				
Jan	Feb	Mar	Apr	
30.1	31.8	34.0	36.1	
99	99	98	99	
Jul	Aug	Sep	Oct	
35.8	34.9	34.3	32.7	
99	99	99	98	
Averaged Value (Jan)				
Temperature				
Max. Temperature				
Min. Temperature				
Frost Days				
Ice Days				
Precipitation				
Days with Precipitation				

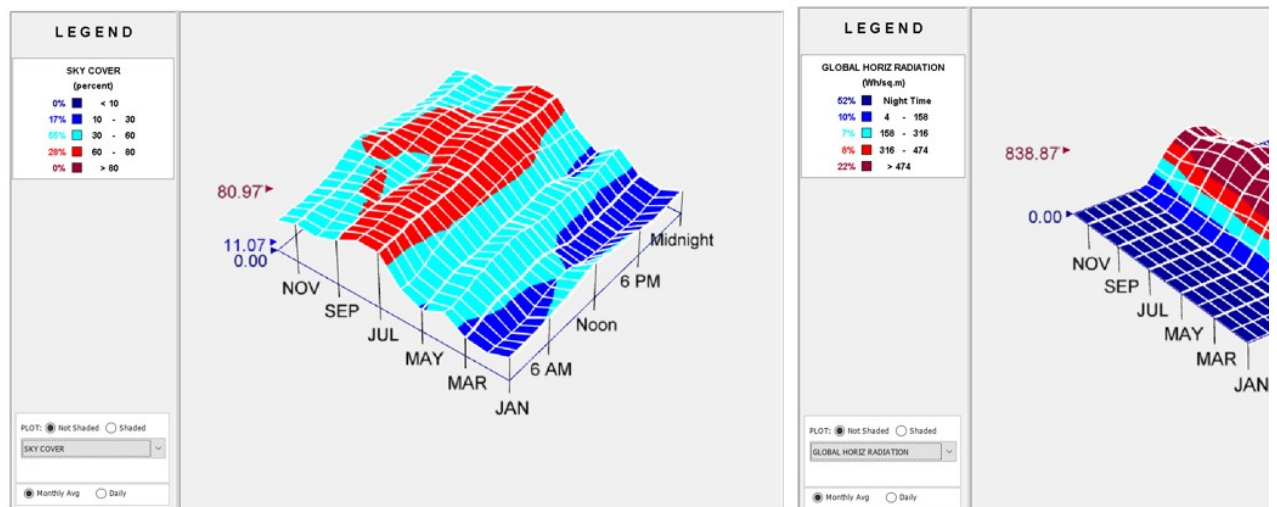
As we can see
than 65% whi

Figure 4.4 – Annual Climatic parameters for Chennai



The temperature of the **hotter days in the month of May** is nearing **45° C** which can be taken as design high temperature. The temperature of the **colder days in the month of January** which is **17 ° C**. The wind speed is **high during the hotter days**, which means **hotter** if the **movement is in the southern / western side** (need to check with Wind rose diagram). Even during the **cooler days** the **coast will be comfortable** which will be easterly (need to check with Wind rose diagram)

Figure 4.5 – Relative Humidity graph for Chennai



The maximum percentage of sky cover is seen in the rainy months (**July, August, September, October and November**). The maximum radiation is experienced between

Figure 4.6 – Sky cover and Global Horizon radiation for Chennai

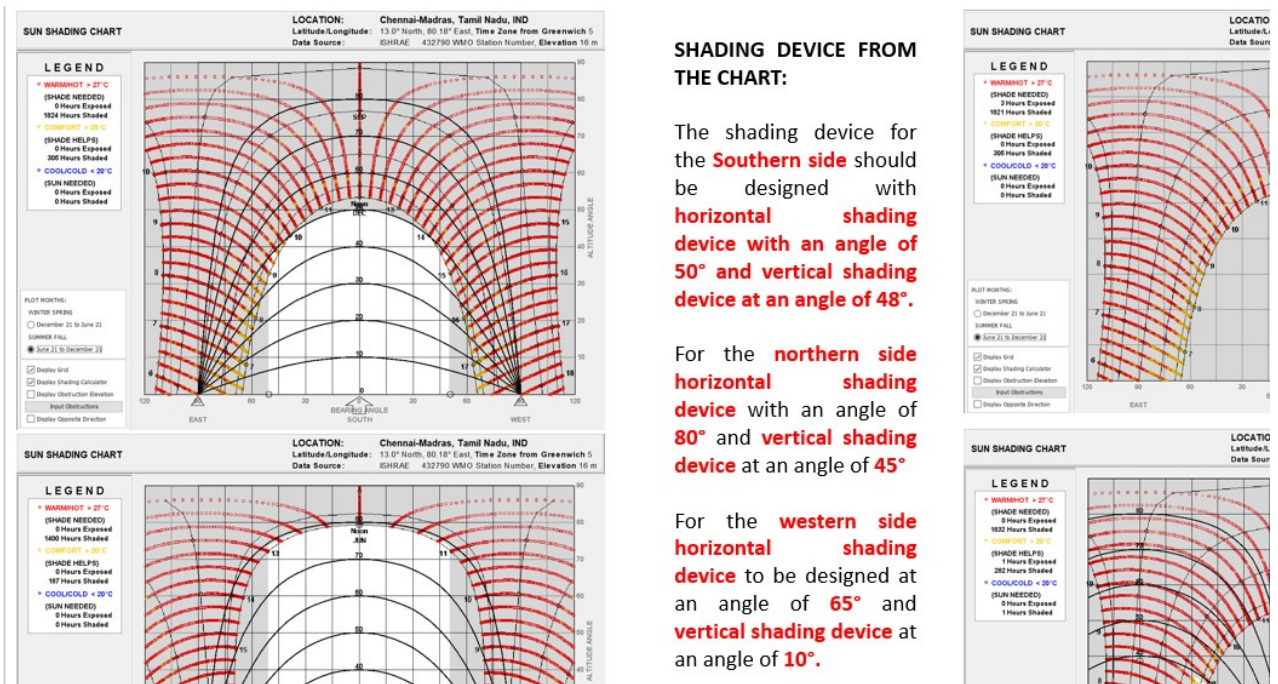


Figure 4.7 – Solar Shading Chart for Chennai

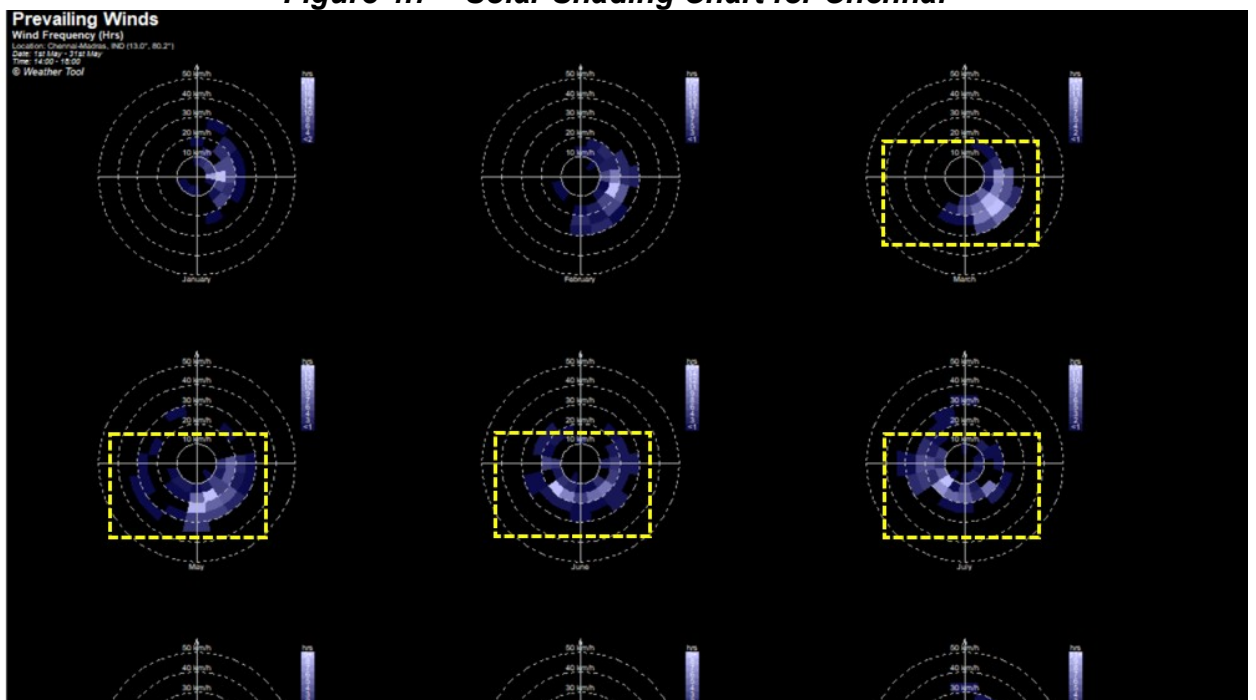


Figure 4.8 – Prevailing winds – monthly for Chennai

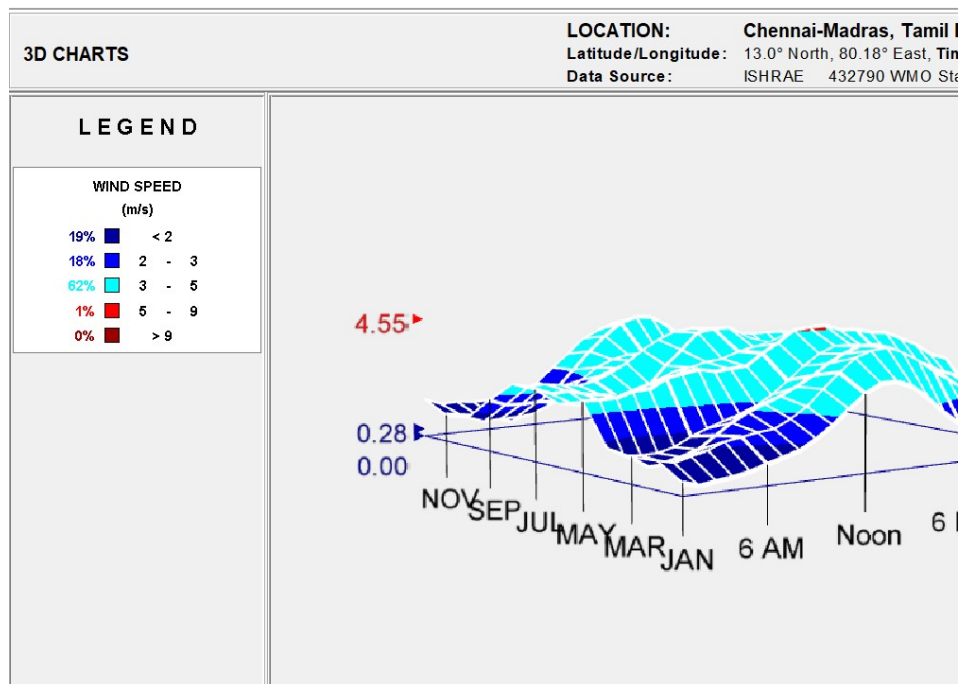


Figure 4.9 – Wind Speed for Chennai

The wind movement observed in the hotter months like March, April and May are predominantly E-SE winds.

The wind direction during the months of June and July are W – SW as the SW monsoon starts during these months.

The wind direction during the months of August and September are more or less equally experienced in westerly as well as easterly directions. Since these months experience rains in the city, the winds will not be with extreme temperature.

The wind direction during the rest of the months experience E – SE – NE as the NE monsoon is experienced in the October and November months.

Thus, Chennai's wind movement is complementary and can be well addressed in design to achieve the passive strategy.

The Psychrometric Chart conveys the following strategies to be incorporated to achieve the thermally comfortable design:

1. Sun shading of windows
2. Natural ventilation for cooling
3. Fan forced ventilation for cooling
4. Dehumidification needed
5. Cooling strategies

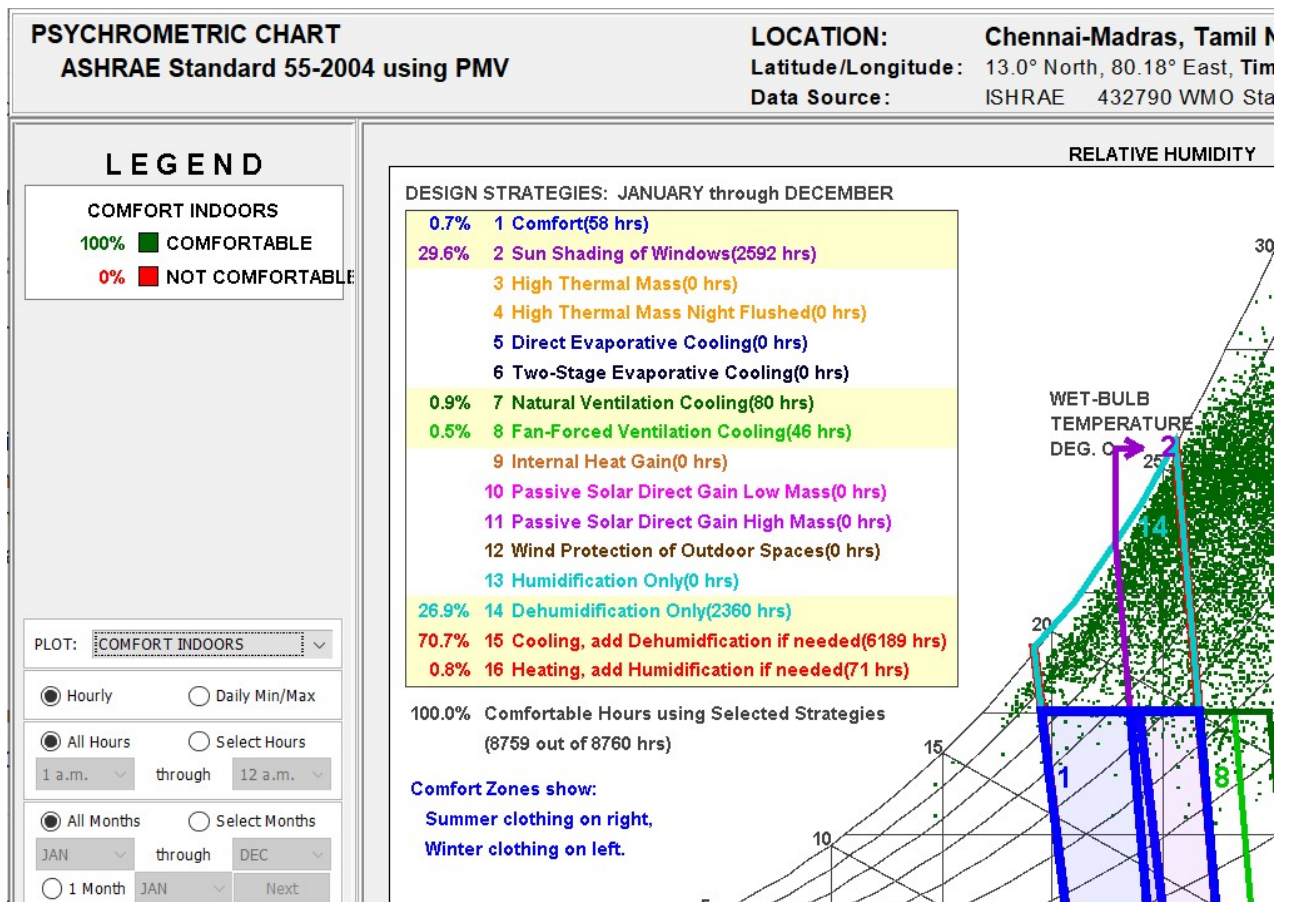


Figure 4.10 – Psychrometric Chart for Chennai

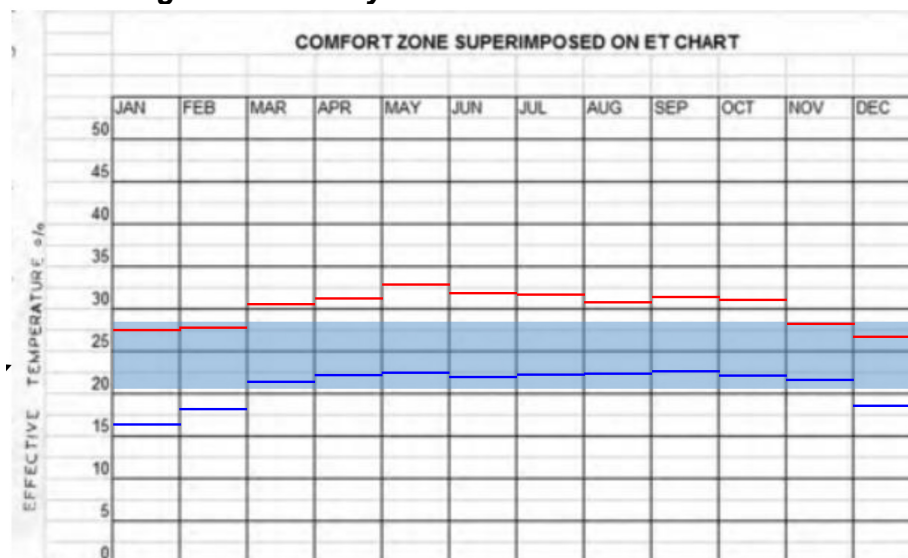


Figure 4.11 – Comfort Band for Chennai

$T_{cc} = (AMT + 4) / 17.2 = 25.2^{\circ}\text{C}$, for the AMR 20°C , the comfort zone range is 4.0, thus the comfort band's maximum temperature is 29.2°C and minimum temperature is 21.2°C . The comfort band for Chennai is shown and most of the months (8 months) experiences increased in ET (Effective temperature) and does not fall inside the comfort zone. Strategies to be adopted to maintain the air temperature that can make the occupants at comfort.

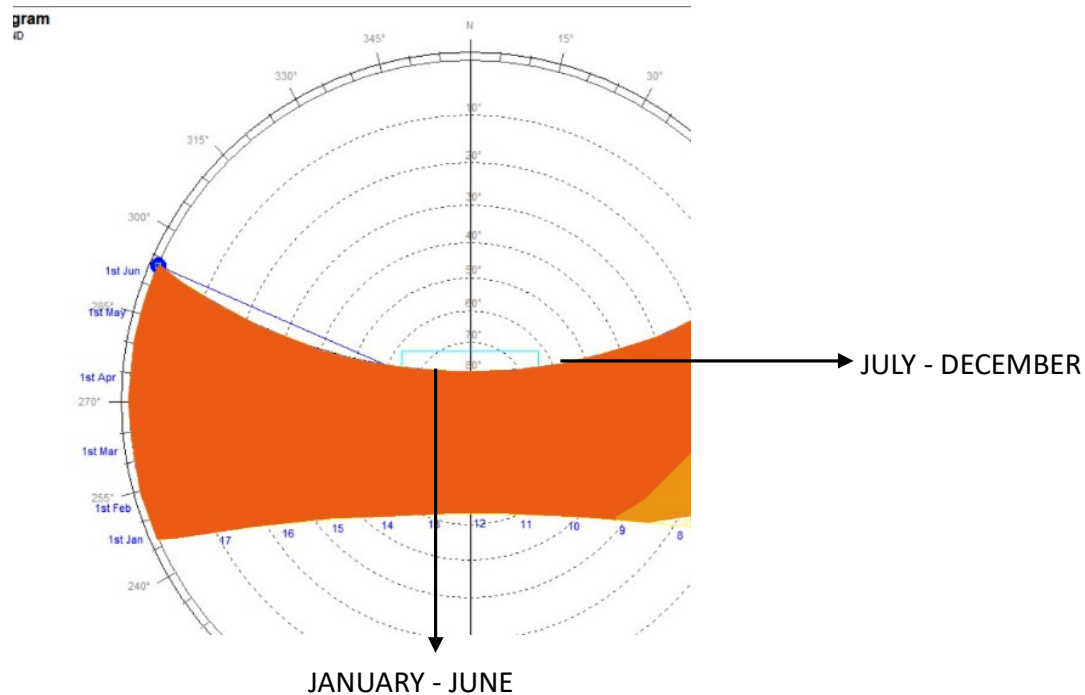


Figure 4.12 – Over Heated Period for Chennai

The over heated period for Chennai could be observed in maximum part of the year and design of shading device is very important to give a solution for the same.

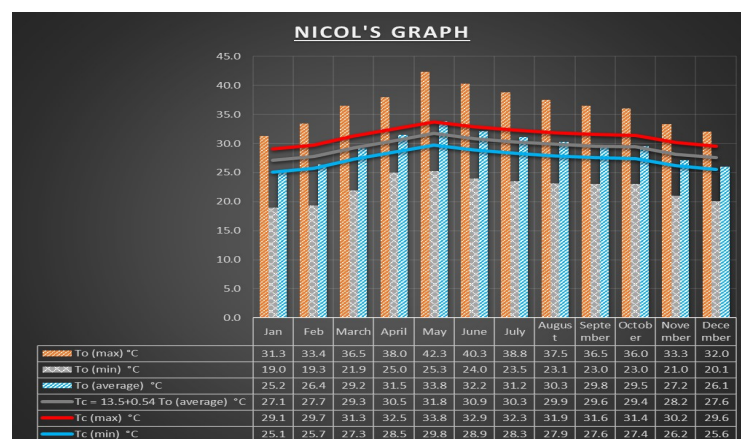


Figure 4.13 – Nicol's Graph for Chennai

The Nicol's graph indicates the comfortable temperature in the month of May is 31.8° C which is experienced as the hotter month in a year, the coldest month is January and the comfortable temperature for this month is 27.1° C

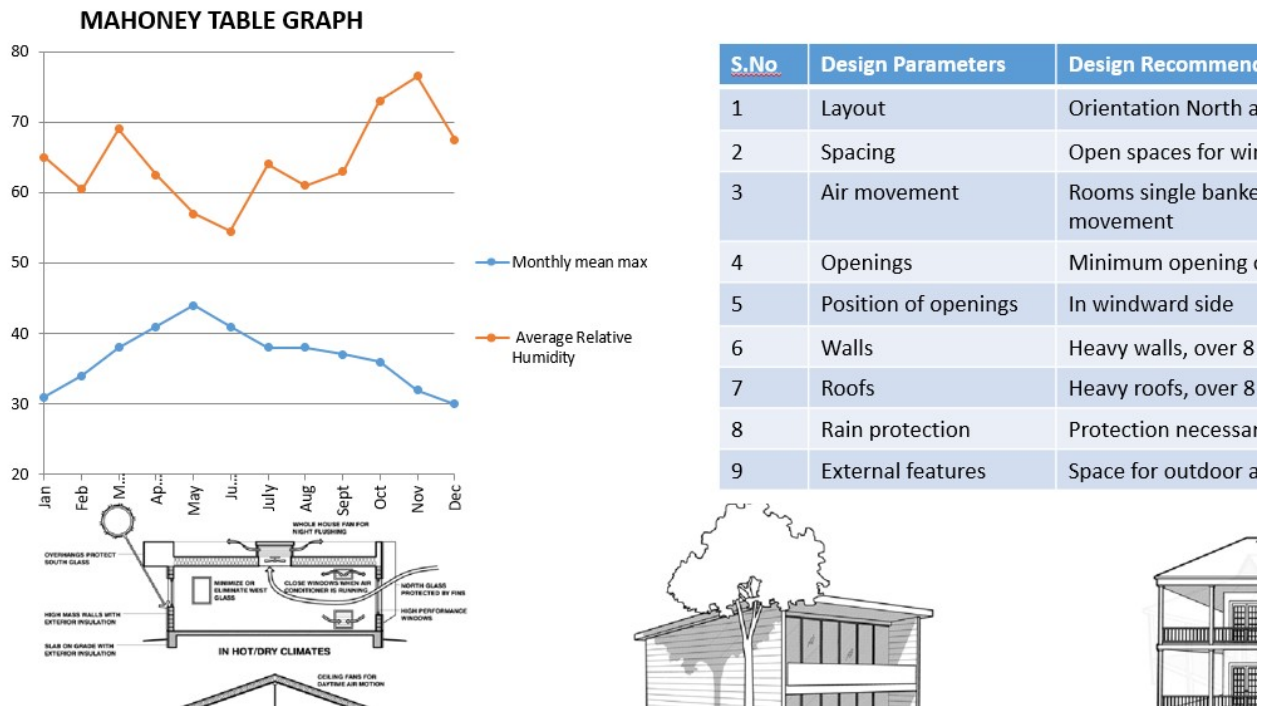


Figure 4.14 – Mahoney Table and Passive Strategies for Chennai

ORIENTATION:

A building elongated in the east-west direction exposes the shorter east and west sides to maximum solar heat gain and high afternoon temperatures during warm months.

The building have to be designed in taking advantage of natural site energy flows by minimizing solar heat gain and allowing naturally occurring air currents to cool indoor spaces.

Shape a building so that it:

- Is elongated in the east-west direction; and
- Has a narrow floor plate for incorporating cross or stack ventilation.

Shade east and west walls and all glazed openings during the summer – all year in hot climates – and make the roof a light color.

In hot-humid climates, create forms that shed water and shade both exterior walls and outdoor living spaces.

During warm summer months, overhangs block unwanted direct sunlight from solar glazing, reducing cooling loads.

Exterior horizontal louvers can also be used to shade south glazing.

VEGETATION:

Trees and vegetation shade buildings and surfaces, while water evaporating through their leaves lowers nearby air temperatures.

Locate:

- Trees on the east, west, southeast, and southwest sides of a building
- Ground cover and shrubs around buildings to lower air temperatures and reduce reflected sunlight.
- Trees in courtyards, parking areas, and adjacent to walkways.

Vegetated pergolas and trees with a high canopy provide shade and allow in beneficial winds.

SHADING DEVICES:

External shading devices can reduce solar heat gain through glazing by up to 80%.

Incorporate the following shading strategies:

- Horizontal overhangs or louvers for solar orientations and
- Vertical fins and egg-crate designs for other orientations.

Adjustable shading devices can be repositioned to allow for seasonal temperature variations or user control during unusually warm or cool periods. Additional shading strategies include recessing glazed openings, and incorporating porches, balconies, and mature vegetation to shade east and west walls as well as outdoor areas.

Buildings can be ventilated and/or cooled by taking advantage of naturally occurring wind currents.

Window openings located perpendicular to prevailing winds, and coupled with openings on the opposite side of a space or building, will provide natural ventilation for fresh air and/or space cooling. Adequate cross ventilation will remove heat from a space or building and maintain indoor air temperatures lesser than the outdoor air temperatures.

Guidelines for cross ventilation:

- Locate inlet openings perpendicular to (or at most $\pm 45^\circ$ from) the prevailing winds.
- Locate outlet openings on the opposite side of inlet openings, and make them equal to, or greater in size than, the inlet openings.

Maintain an unobstructed path between inlet and outlet openings for adequate airflow.

In hot climates, a light colored roof reflects sunlight, remains cooler, offsets CO₂ warming, and reduces the amount of heat transferred to the interior of a building.

Cool roofs have surfaces that reflect sunlight and emit or discharge heat efficiently, keeping them cooler on sunny days. The two surface properties that determine a roof's temperature are solar reflectance and thermal emittance, which range on a scale from 0 to 1. The larger the two values are, the cooler the roof will be.

Make the roof surface a light color and chose a roofing material that has a surface:

- Solar Reflectance (SR) of > 0.7 ; and
- Thermal Emittance (TE) of > 0.75 .

In hot climates, cool roofs can help mitigate urban heat islands



Figure 4.15 – Passive Strategies for roof, Chennai

TRAINING CENTER (100 Persons)		OFFICE SPACE (30 Persons)	
Meeting Rooms (2 Nos)	400 Sq.m.	Admin office	120 Sq.m.
Training Rooms (5 Nos)	400 Sq.m	Conference facilities	50 Sq.m
Lounges	100 Sq.m	Lounges	50 Sq.m
Trainer Lounges	50 Sq.m	Toilets	50 Sq.m
Accommodation rooms (30 Nos)	120 Sq.m	Services	50 Sq.m
Library		200 Sq.m.	
Laboratory		200 Sq.m	
Recreational facilities		100 Sq.m.	
Kitchen & Dining facilities		300 Sq.m	
Site area – 9800 Sq.m (2.42 Acres) (32292 Sq.ft)		Total built up area – 3000 Sq.m	

Table 4.2 – Area requirements for Design

4.3 SITE ANALYSIS

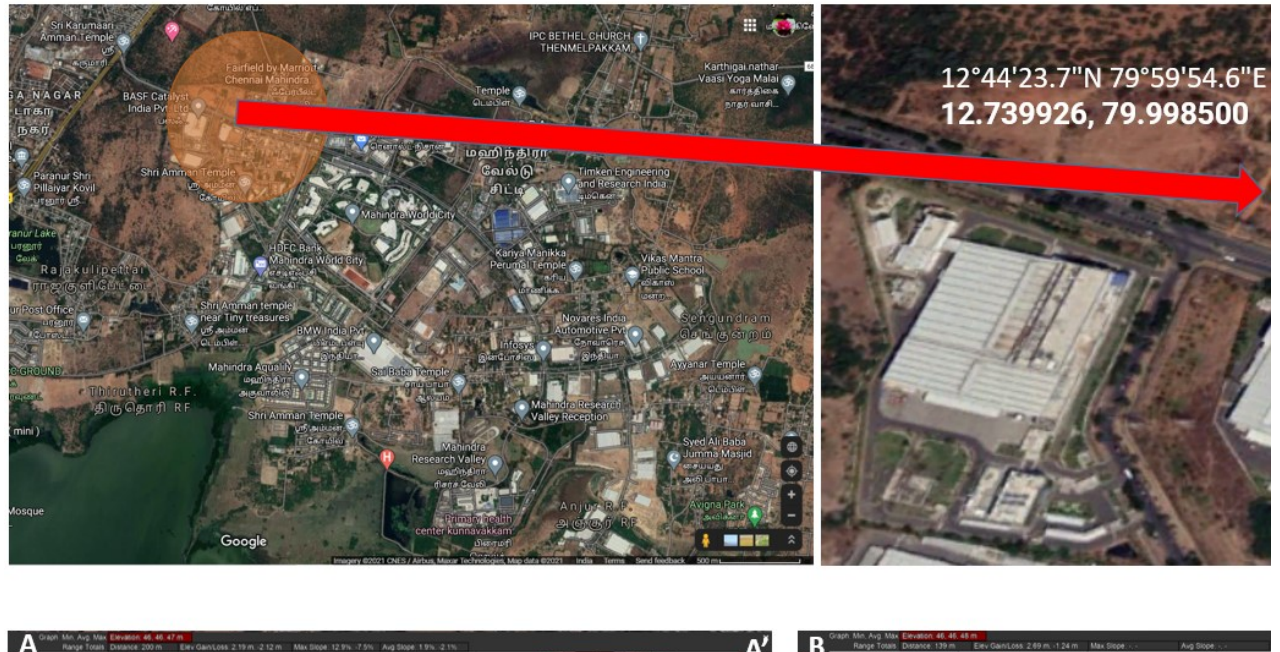


Figure 4.16 – Site Demarcation with the Topography Section



Figure 4.17 – Chronology of the Site

The chronology of the site shows the development made to create the Satellite town. Since the Sustainable concept is maintained the City have maintained to retain the landscape undisturbed. The design will also lessen the impact to the environment through various Sustainable approaches.

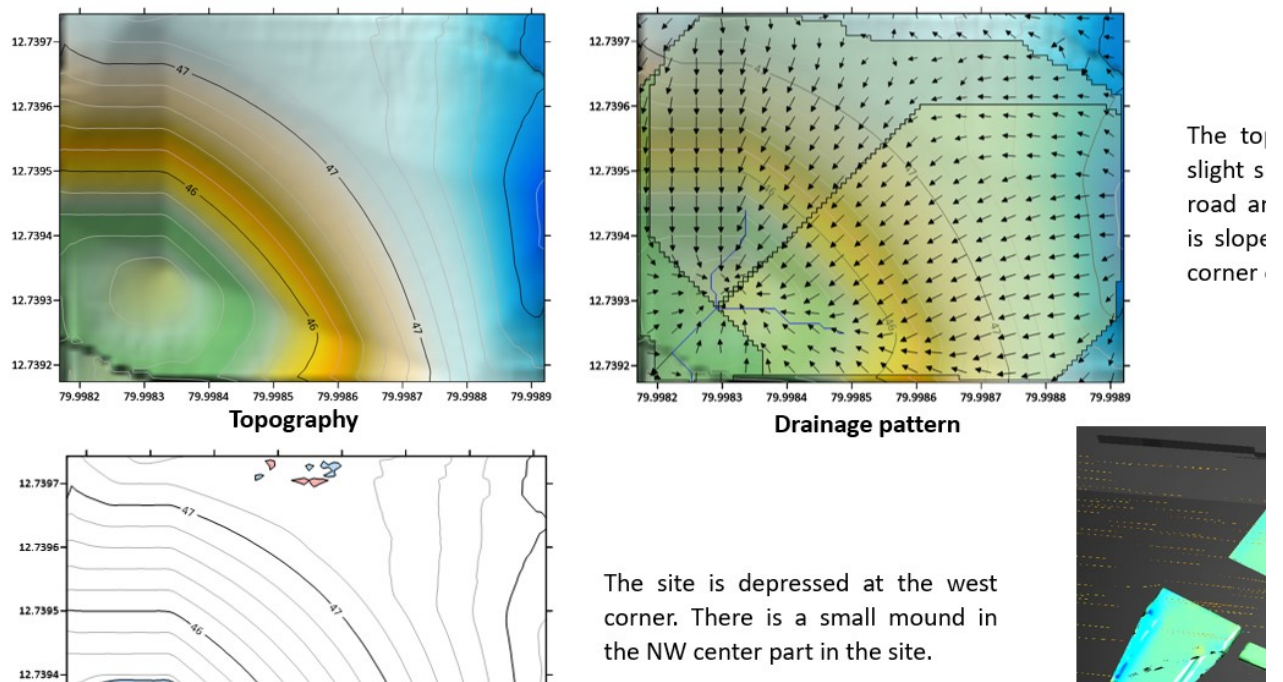
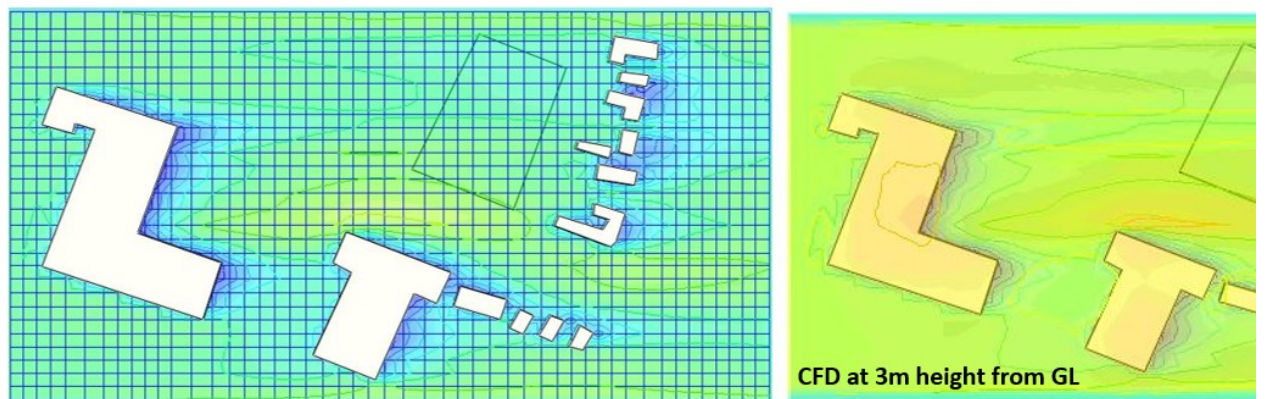


Figure 4.18 – Site Topography and Drainage Pattern



CFD at ground level

The CFD shows the air flow at the average speed of 4 to 5m/s

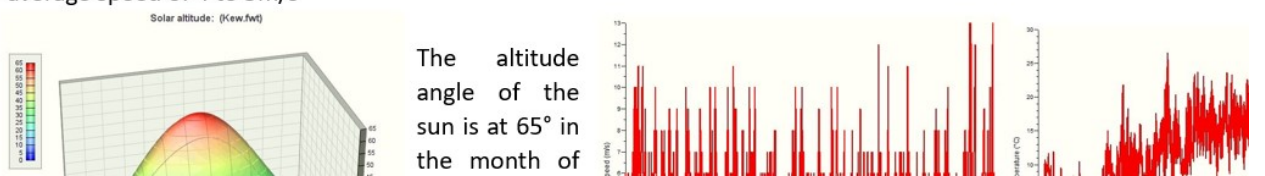


Figure 4.19 – Wind analysis in IES VE software

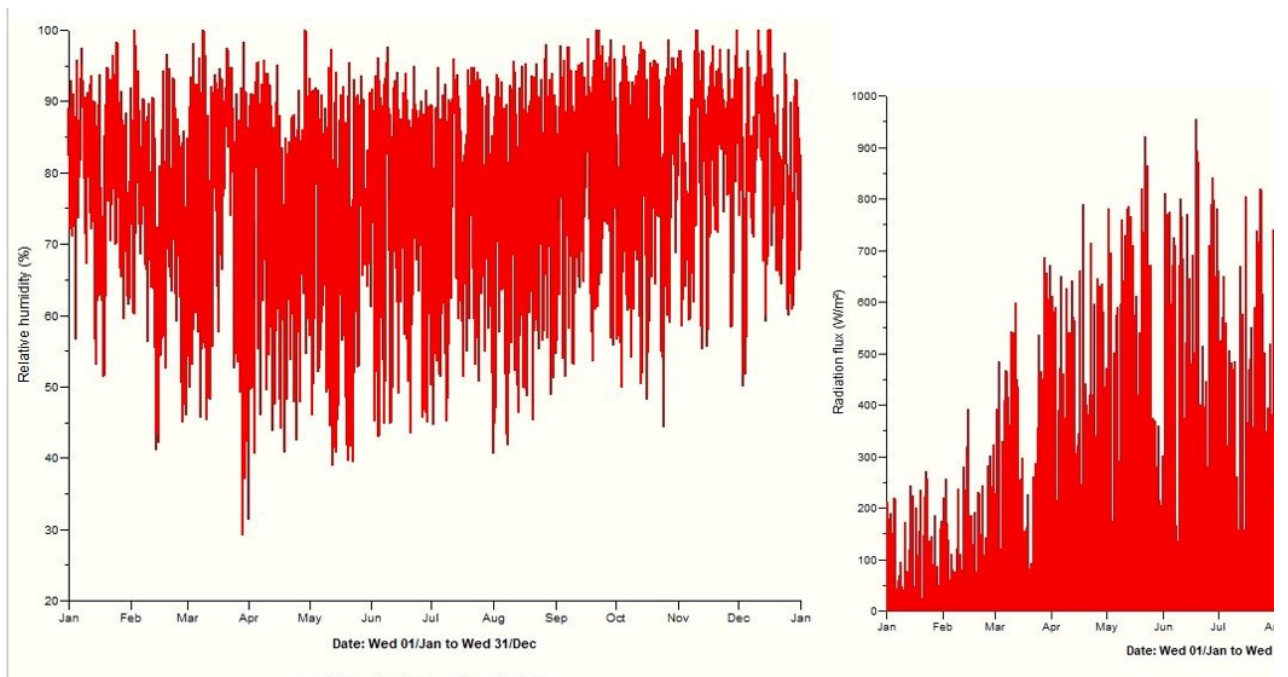


Figure 4.20 – Radiation Analysis in IES VE software

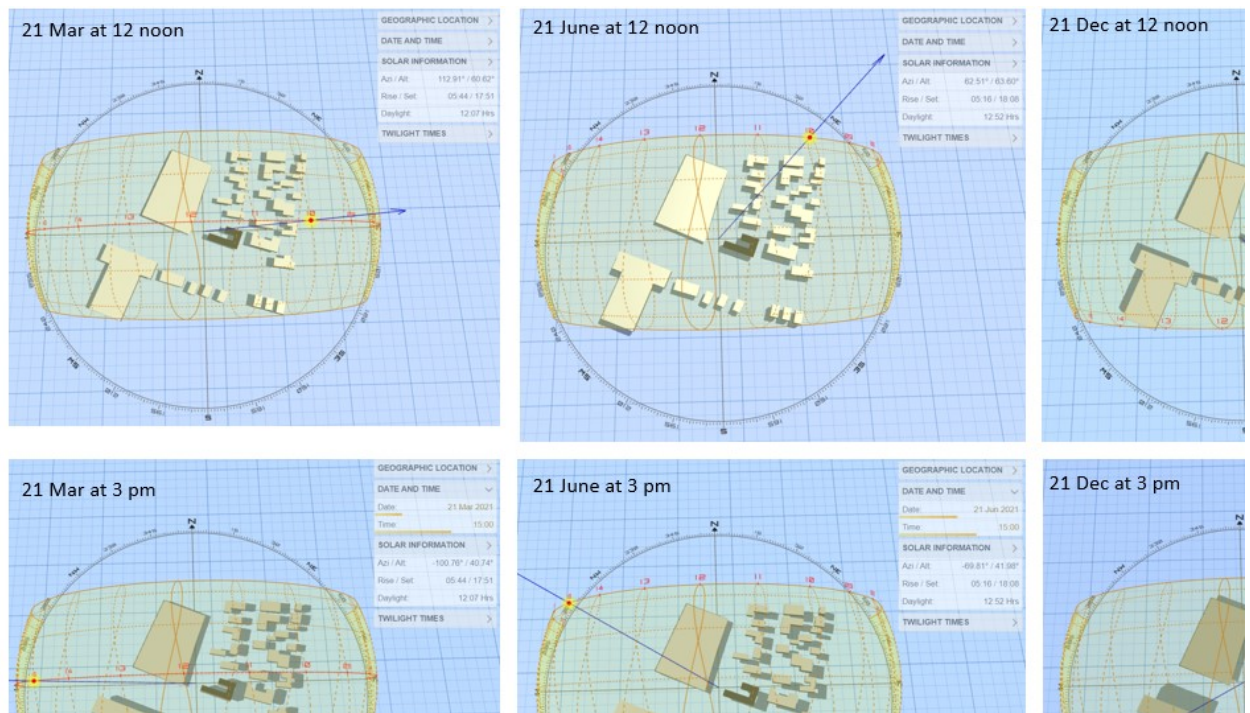


Figure 4.21 – Shadow Analysis in Andrew Marsh software

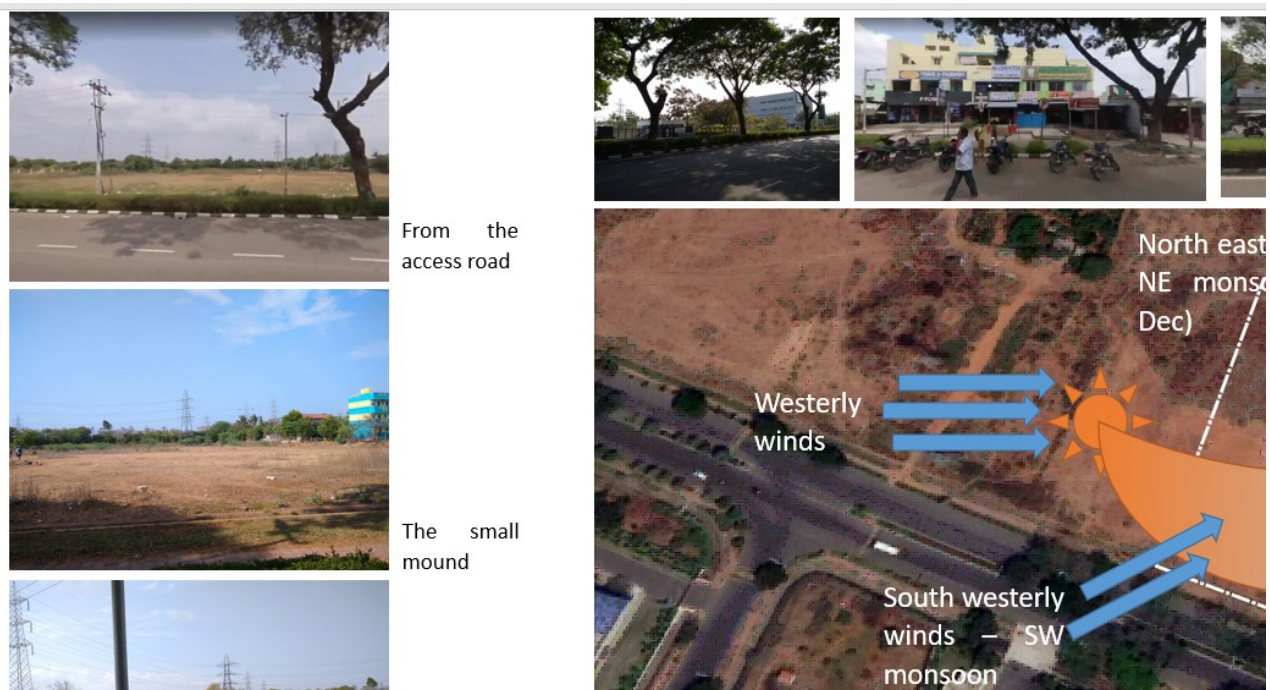


Figure 4.21 – Onsite and Off site factors

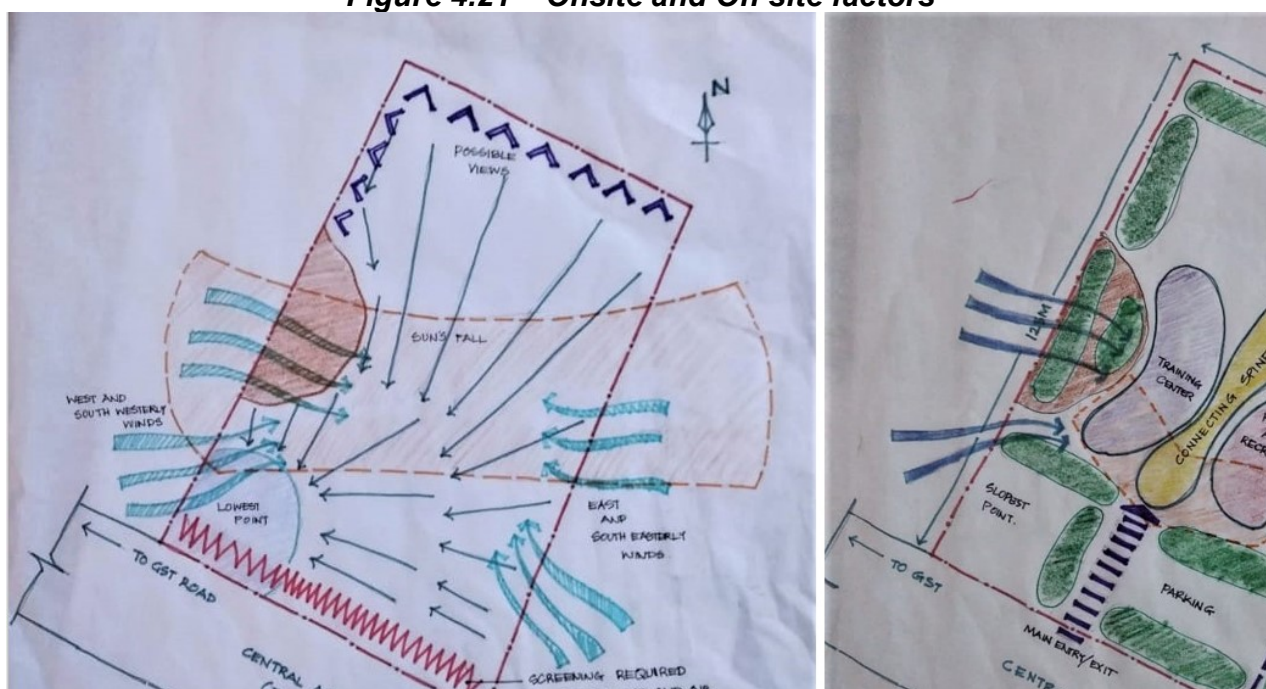


Figure 4.22 – Site Zoning

4.4 DESIGN RESULTS:

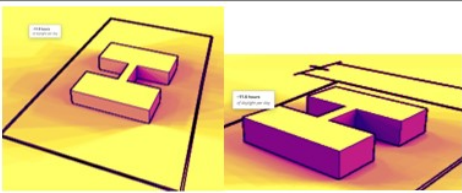
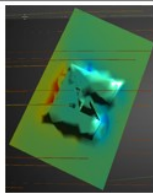
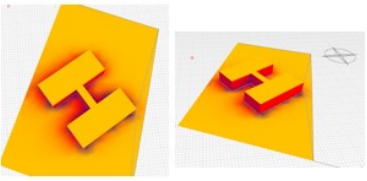
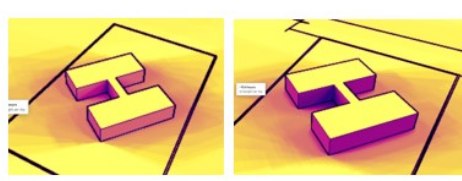
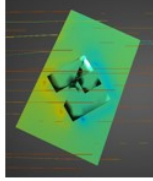
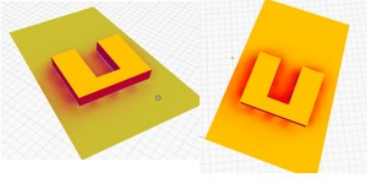
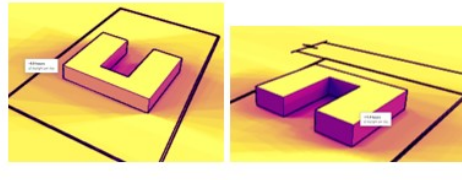
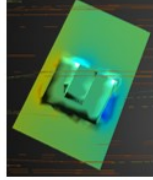
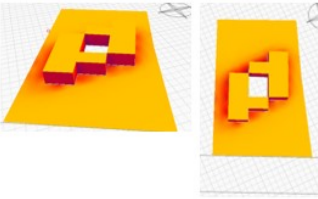
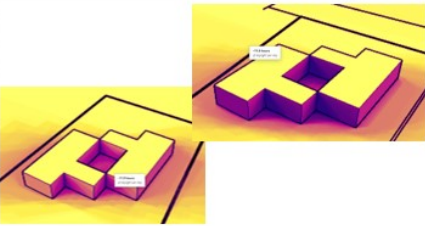
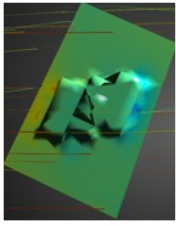
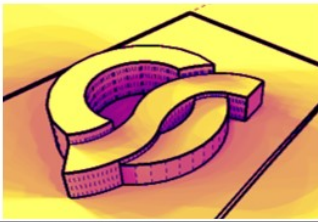
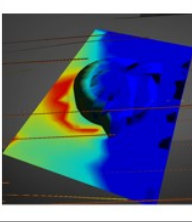
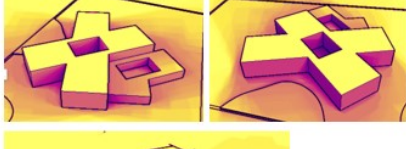
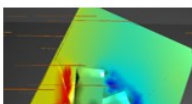
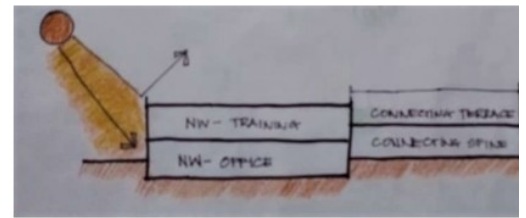
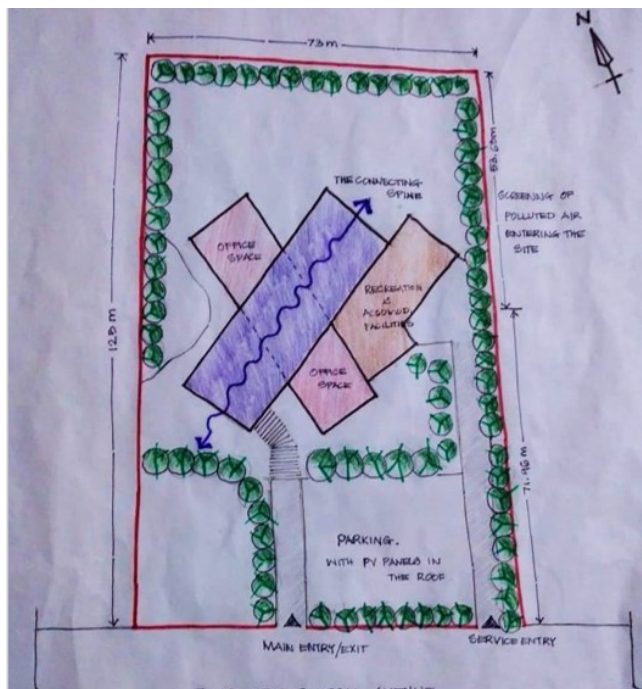
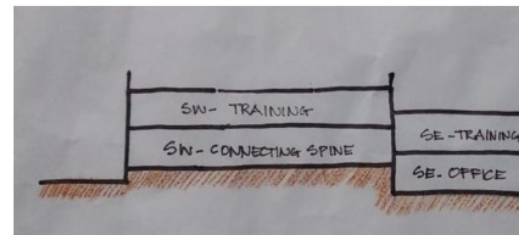
OPTIONS	FORMIT ANALYSIS	SHADE DAT ANALYSIS	FLOW DESIGN	INFERENCE
1				The building is oriented to the north and south. The analysis shows high radiation on the surface and envelopes.
2				The tilted orientation from the iteration could be observed with little difference in radiation on the surface.
3				The inverted courtyard can achieve mutual shading.
4				This iteration
OPTIONS	FORMIT ANALYSIS	SHADE DAT ANALYSIS	FLOW DESIGN	INFERENCE
5				The building is oriented such a way that the southern exposure is broken in three small sides and the introverted courtyard helps in shading.
6				The built form is completely done with curved lines to cut off high radiation and achieving mutual shading through the use of courtyards.
7				The concept of having a connecting spine which separates the two main activities (Training and Hostel) at the same time, keeping the radiative heat above the courtyard.

Table 4.3 – Iterations for form evolution



SECTION THROUGH THE CONNECTI



SECTION TAKEN FROM THE ENTRANCE THROUGH THE CONNECTING SP

From the above iteration analysis, orienting the building with a north-south orientation. Also the proposed layout will be selected.

Figure 4.23 – Schematic plan and Section

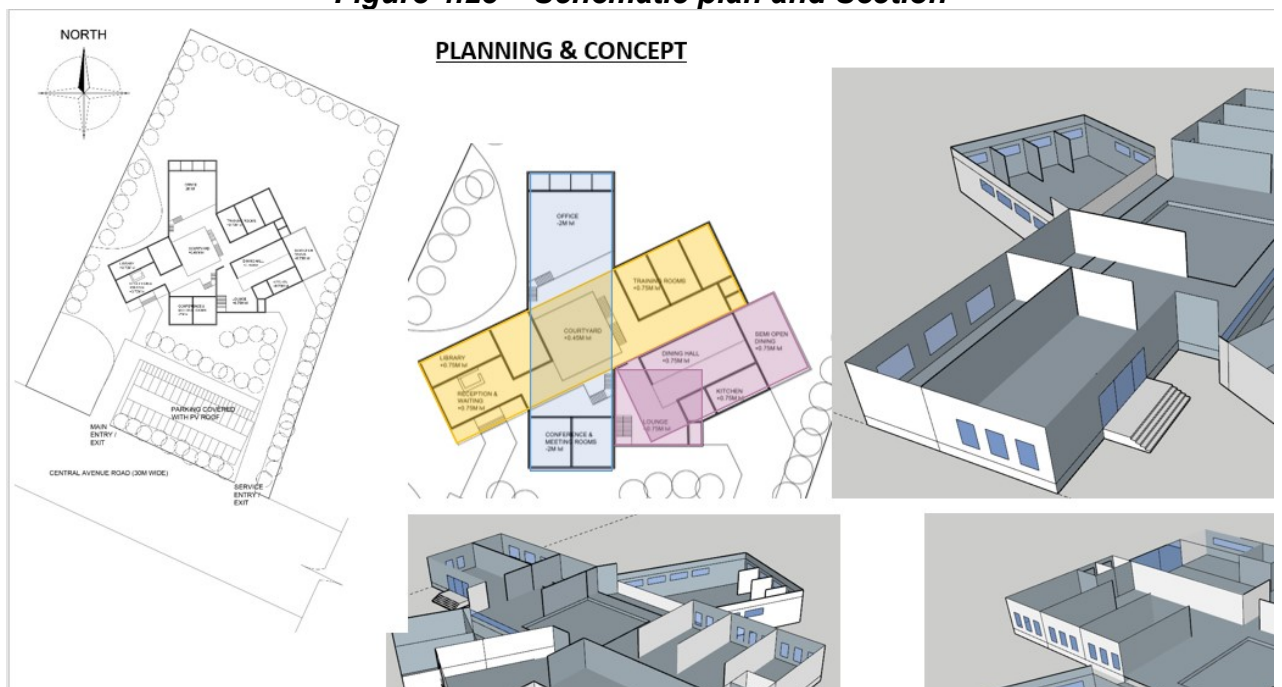


Figure 4.24 – Form generation and space arrangement

SECTION

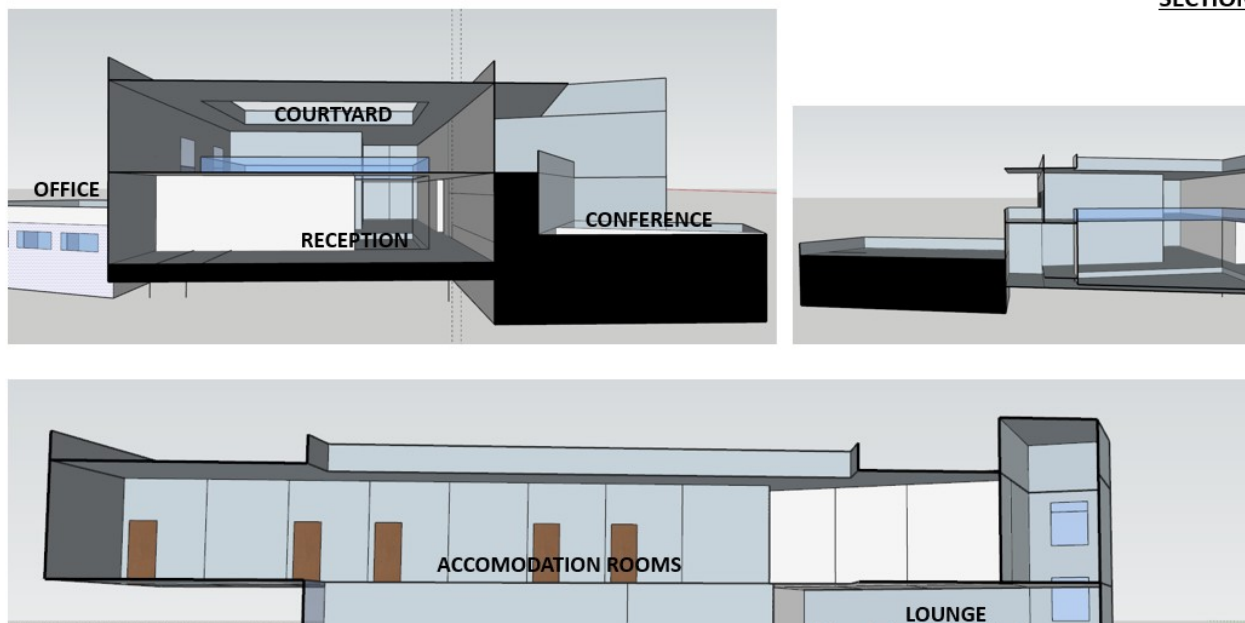


Figure 4.25 – Schematic Section in the model

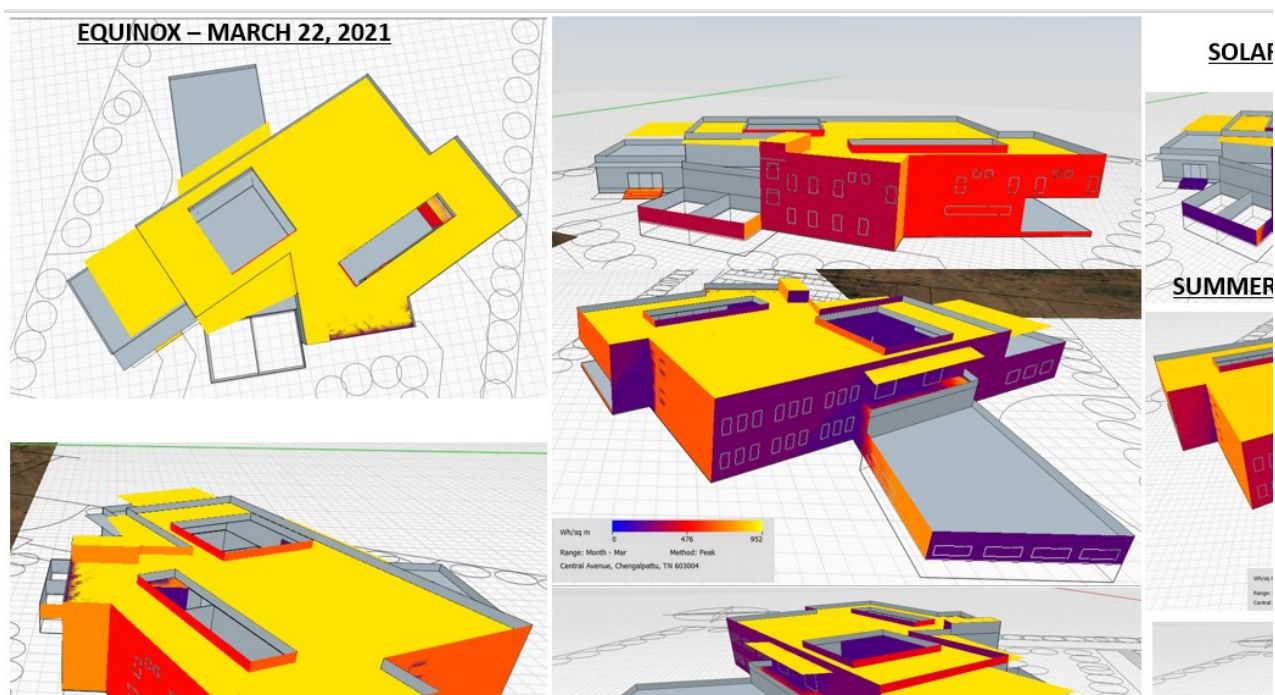


Figure 4.26 – Initial Stages of Radiation Analysis

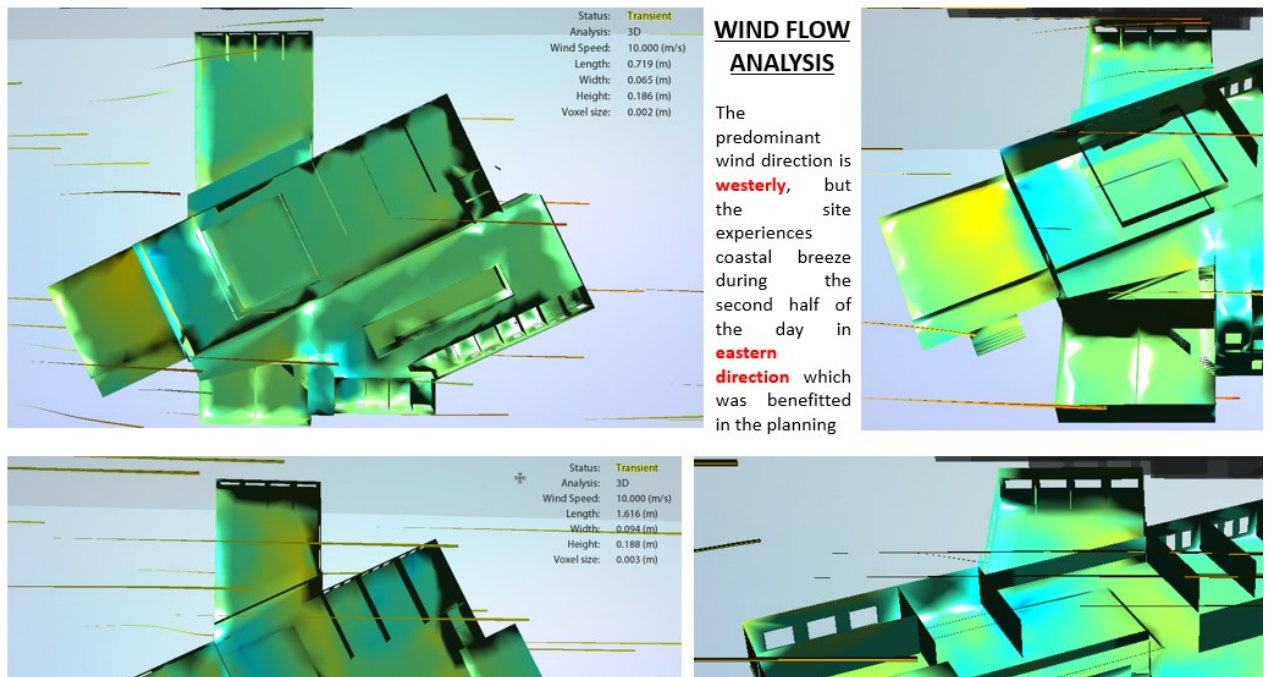


Figure 4.27 – Wind flow analysis

SECTION & LEVELS

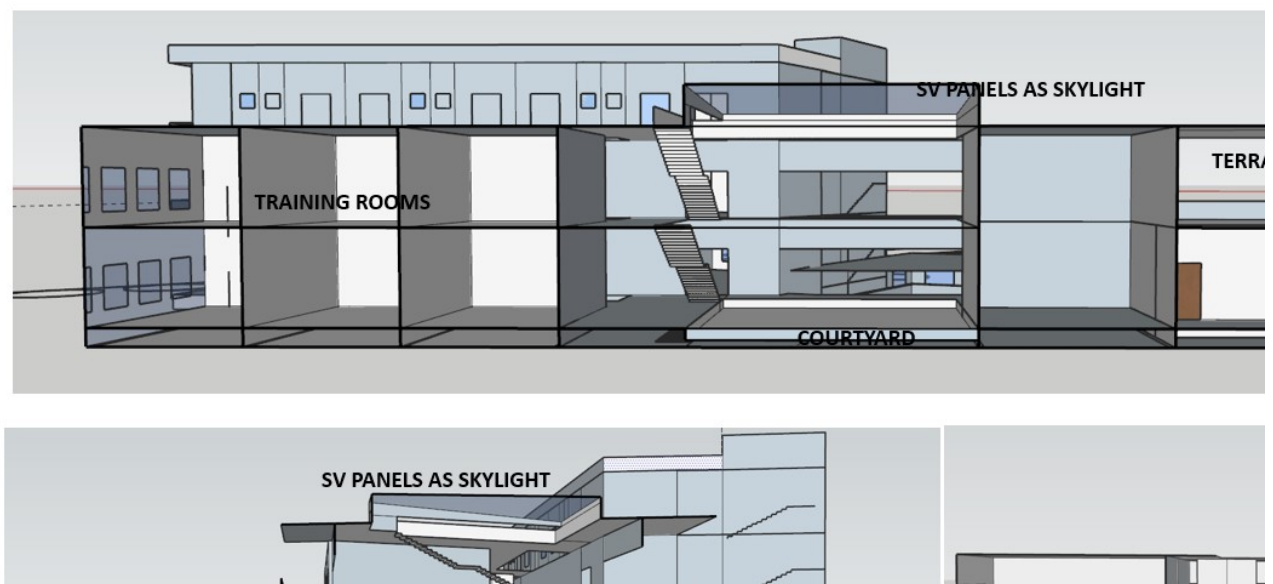


Figure 4.28 – Development in the Section

Parameters	WBS	IGBC	A
Air	Fundamental Air quality, Enhanced Ventilation, Operable windows, VOC control	Minimum fresh air ventilation standards, indoor air quality, openable area – 12% of carpet area	Operable windows, indoor air quality, openable area – 12% of carpet area
Water	Water quality, Rainwater Harvesting	Quality of drinking water and its accessibility, quality of recycled water	Rainwater harvesting, quality of recycled water
Nourishment	Food production, Food / Nutrition Policy	Fitness and Nutritional choices – Fitness facilities and nutritional choices	Food production, Fitness facilities and nutritional choices
Light	Window area is not less than 10% of the floor area. Visible light transmittance (VLT) of transparent glazing is greater than 40%	Visual comfort	Daylight, Visual comfort, 300 lux in spaces, 100 lux in areas

Parameters	WBS	IGBC	A
Thermal Comfort	Thermal performance, Humidity – between 30% and 60%, operable windows, choice of materials	Thermal comfort	Passive thermal performance, operable windows, choice of materials
Sound	Noise levels for various areas, sound barriers, sound absorption	Acoustic comfort	Acoustic comfort, sound barriers, sound absorption
Materials	No VOC materials	Health and sanitation - Harm free chemicals, control of outdoor dust pollutants.	Choice of materials, VOC materials, outdoor dust pollutants.
Mind	Mental support, connectivity to nature	Emotional and Intellectual well being - Exterior connectivity to occupants	Emotional and Intellectual well being - Exterior connectivity to occupants
Community	Social sustainability, support	Social well being -	Recreation, Social well being -

Table 4.3 – Guidelines and Standards

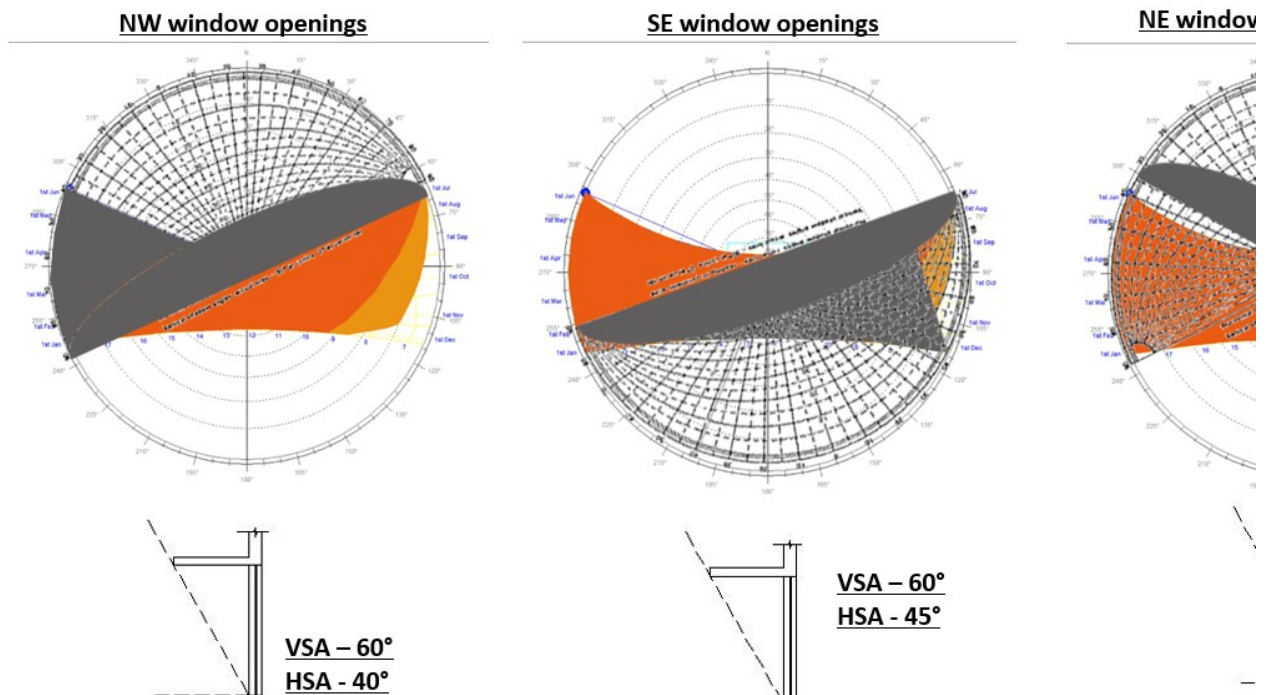


Figure 4.29 – Shading device Calculation



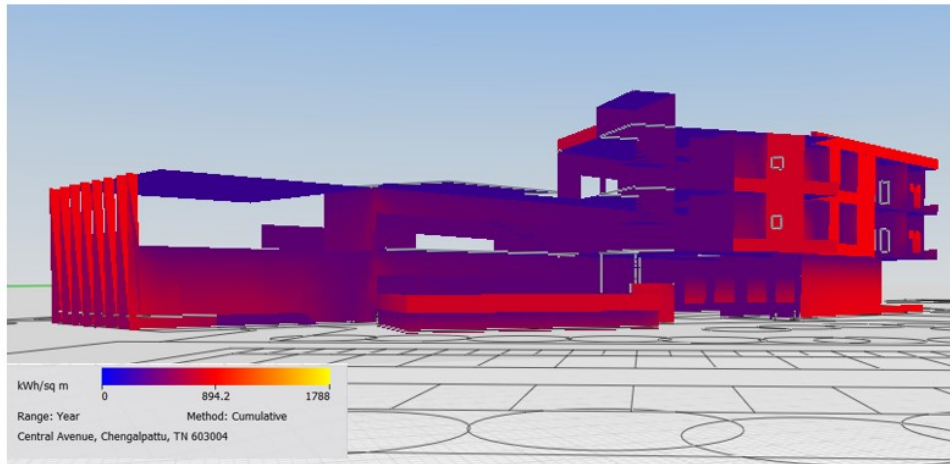
Figure 4.30 – Site plan with features



Figure 4.31 – Ground and First Floor Plans with the features



Figure 4.32 – Second floor plan and Sections with features



SOLAR RADIATION

The presence of Shading (vertical) helps in reducing solar radiation extent.

The simulation shown here indicates the solar radiation which is reduced by means of shading.

The roofing will be insulated to achieve thermal comfort and reduce production of heat.

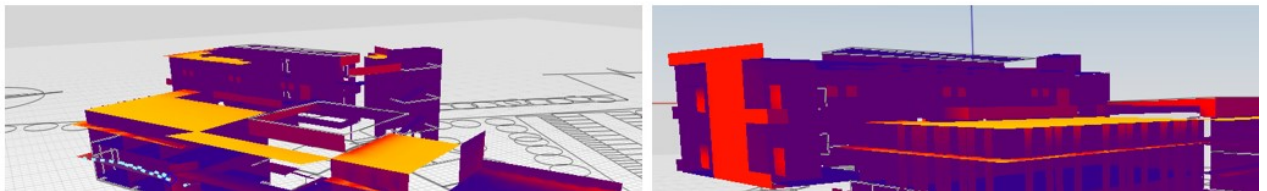
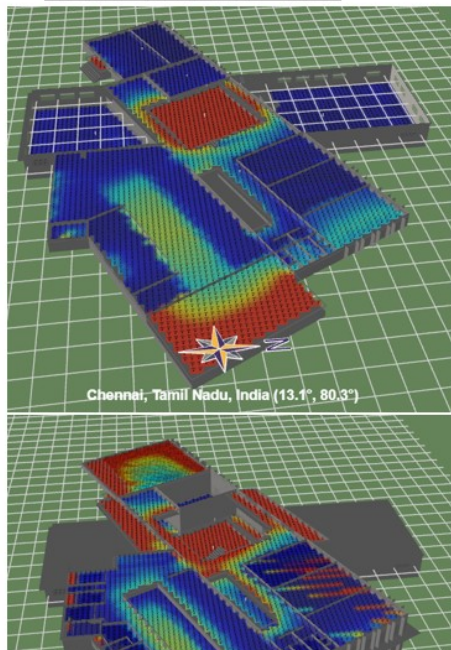
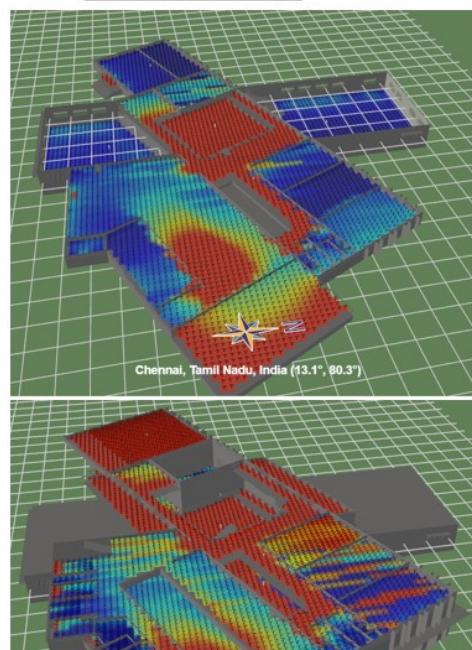


Figure 4.33 – Final design with Solar radiation results

SUMMER SOLSTICE – JUNE



EQUINOX – MARCH



WINTER SOLSTICE – DECEMBER

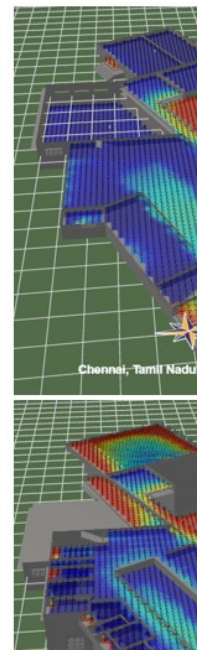


Figure 4.34 – Daylighting simulation results

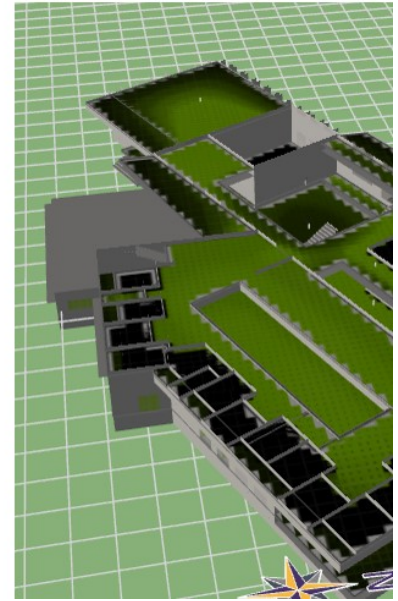
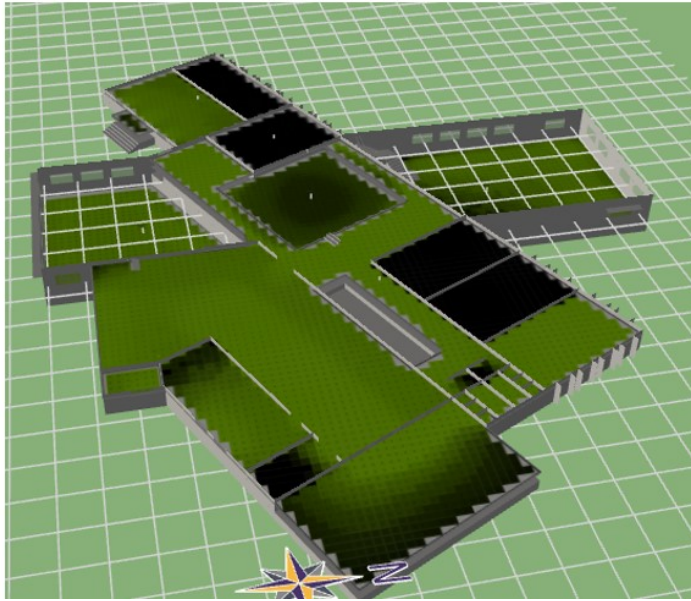


Figure 4.35 – Daylighting simulation results with UDI

The Daylighting Simulation could be observed with achieving the 300 lux levels in working areas and more than 300 lux levels in the common areas. The UDI is also achieved **at 58%** where the threshold is met.

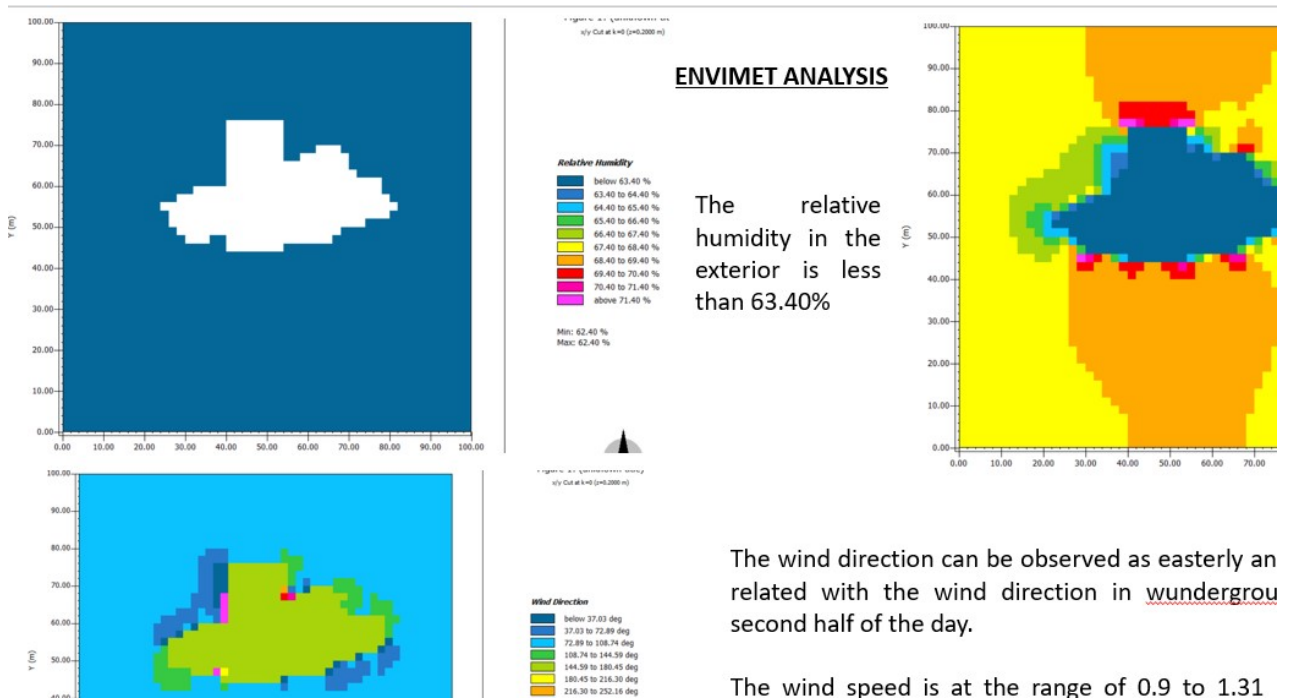


Figure 4.36 – Envimet Analysis for RH and Wind

ENVIMET ANALYSIS

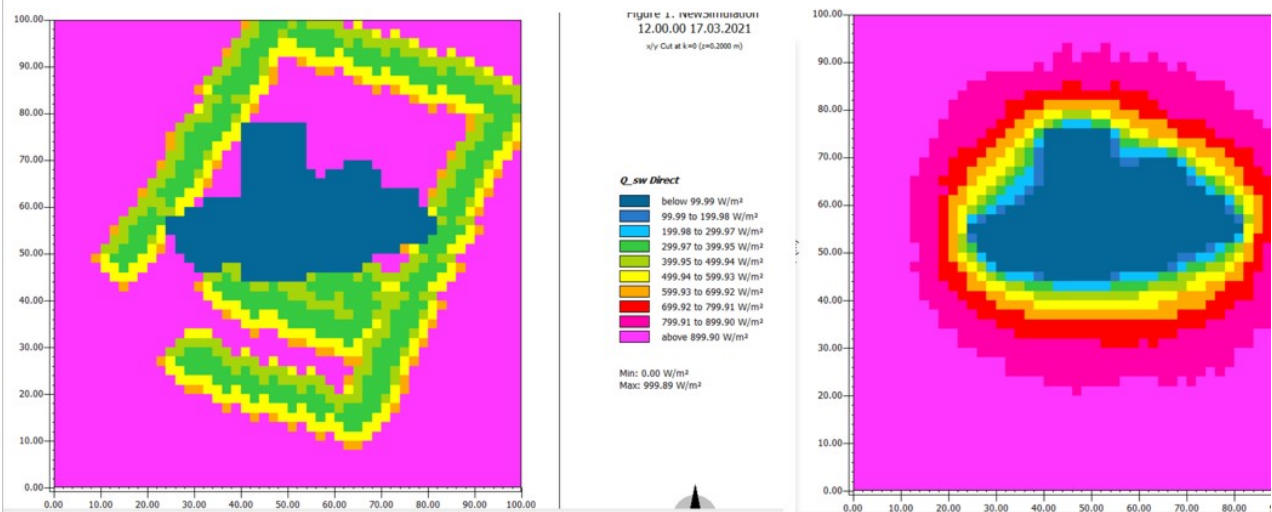


Figure 4.37 – Envimet Analysis for Radiation

ENVIMET ANALYSIS

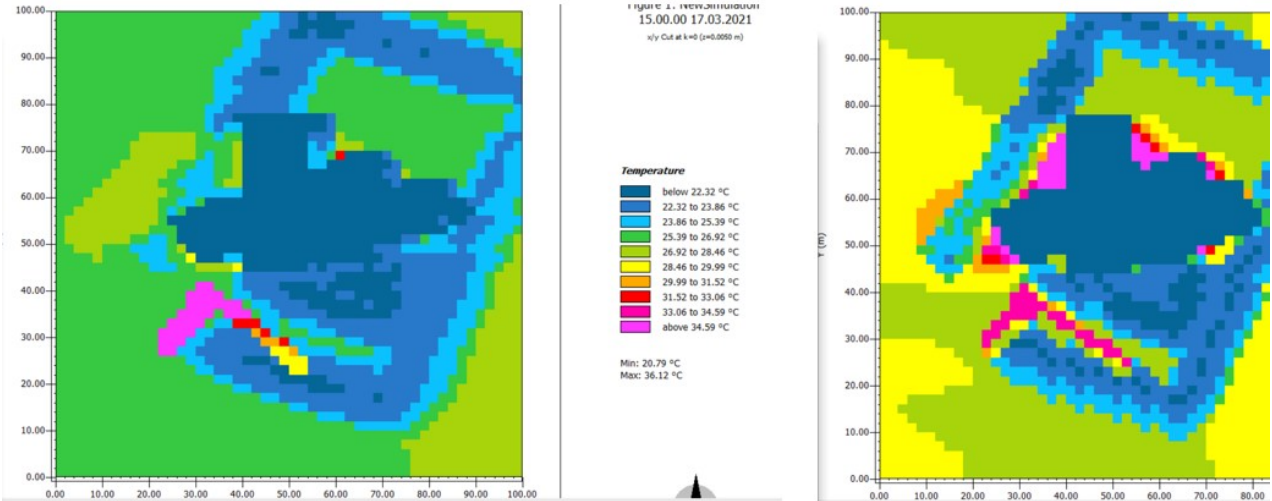


Figure 4.38 – Envimet Analysis for Temperature

<u>Rainwater Harvesting Calculations</u>		
Surface Type	Surface run off (in Liters)	
Roof	= 3000 X 1200 X 0.7	25,20,000
Non Roof (Road and Pavement)	= 500 X 1200 X 0.95	5,70,000
Non Roof (Open grid grass / Parking)	= 1000 X 1200 X 0.5	6,00,000
Vegetation on Ground	= 4500 X 1200 X 0.2	10,80,000

Table 4.4 – Rainwater Harvesting Calculation

Per Capita Water requirement Calculation

Population: 30 + 30 + 40

Per Capita for office: 45 lphd + 135 lphd

No of days: 365 days

Water Demand for the school = $(30 \times 45 \times 365) + (40 \times 135 \times 365)$

Electrical Load Calculation:

1- The total gross area of the building = 3000 Sq.m = 32,292 Sq ft

2- The building type/usage is Office

3- From ASHRAE and IEEE tables, the load densities will be as follows:

- Lighting = 1.81 W/SF
- Small appliances = 1 VA/SF
- Air conditioning = 6 VA/SF

4- The subtotals estimated electrical loads will be as follows:

- Lighting = $1.81 \text{ W/SF} \times 32292 = 58,448 \text{ Watt}$
- Small appliances = $1 \text{ VA/SF} \times 32292 = 32,292 \text{ Watt}$

Solar PV Panels Calculation

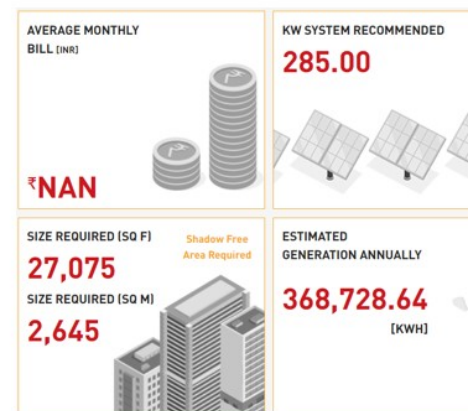


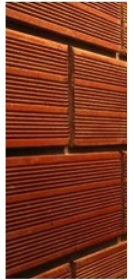
Figure 4.39 – Electricity and Solar Panel Calculation

4.5 MATERIALS:

1. Porotherm Bricks - Fired clay is a dry material that has a natural propensity to absorb and release humidity from the atmosphere to help keep humidity at a required 40-60 per cent level for healthy living

Porotherm Thermobrick - Product Parameters

	Length	Width	Height	Weight	Density	Compressive Strength	Water Absorption	Efflorescence	U-Value	Sound Insulation	Fire Resistance
	MM	MM	MM	Kg.	Kg/m ³	N/mm ²	%		W/m ² ·K	Rw (db)	min
Porotherm Thermobrick	400	200	200	11.7	731	≥3.5	~15	Slight	0.6	44.65	240



2. Planitherm glass for windows and ventilators – **U-value – 1.6W/m². K**

SAINT-GOBAIN GLASS EXPOSIUM

PLANITHERM series
Energy efficient glass for comfortable places

BETTER PLACE FOR PEOPLE

As the principal component in a window, glass is a key lever for comfort and beauty. Our glass solutions for windows ensure the

PROCESSING

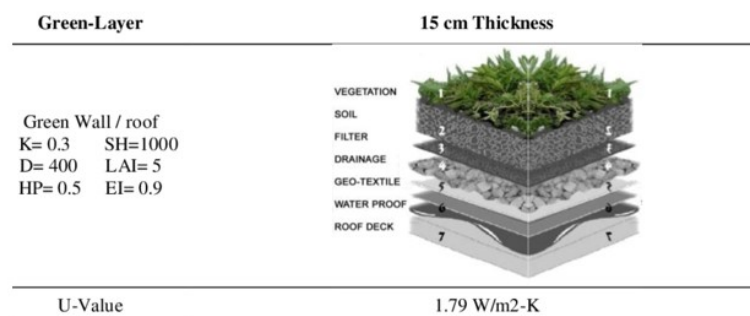
Available in two versions:
annealed or to be tempered

PERFORMANCES

Standard thicknesses : 4-6 mm (other on request) - Dimensions : Jumbos, split size:
Average performance values of DGU (6+12+6 mm) with coating on surface #3', according to the standards ISO 9050 m1 / EN

Figure 4.40 – Walling and Glazing materials

3. Green Roof



5. Bamboo flooring

Bamboo is a fast-growing grass that requires no fertilizers. Bamboo plantations provide a sustainable source of flooring and have a turnaround time of 5 years for harvesting.



6. Linoleum / Marmoleum Floor

Linoleums can be made from natural materials including solidified linseed oil, dust, wood chips and burlap. Linoleum floors are natural, anti-allergenic, and durable.



4. Safe Eco-friendly Paint

Figure 4.41 – Roofing and finishing materials

CHAPTER 5 CONCLUSION

The role of indoor air quality is very important in keeping the occupants healthy and wellness. Maintaining the indoor air quality involves various parameters such as thermal control, foul control, acoustic control, humidity control, light control. Thus, all these parameters are achieved in the design and the results are proven through manual calculations and software simulations.

The findings from the various study were incorporated in the design and the strategies and guidelines can be adopted in creating work environment that can respond during pandemics.

As Sustainability is the key criterion, the same can be achieved with the Well building Standards, IGBC rating system for Health and Well being and Passive design strategies and can be adopted in achieving the design of office space which can respond to pandemic situations.

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Guidelines / Standards:

1. Well Building Standard Q2 2020 version by the International Well Building Institute
2. IGBC for Health and Well Being

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