FINAL DESIGN REPORT
APRIL 2021

COLLEGE OF ENGINEERING, GUINDY.

TEAM - ANNIHILATORS

DIVISION - MULTI-FAMILY HOUSING

PROJECT PARTNER - SOBHA DEVELOPERS

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EXECUTIVE SUMMARY

Team Annihilators from College of Engineering Guindy working on Multi Family housing. Our team split into ten groups according to the ten contests given by Solar Decathlon India which focuses mainly on net-zero energy and net zero water, catered specifically to the hot-and-humid climate zone prevalent in India. Design is developed with multidisciplinary team members and technical support from faculty lead.

Our site is located in Poonamallee –15 miles from Chennai, Tamil Nadu, India, to demonstrate the applicability of our design. The developed prototype is a five-storey block comprising 30 apartments (2Bhk , 3Bhk and compact 3Bhk), while designating the ground floor for stilt parking. With careful consideration to all the building science principles and affordability carrying out pre design comfort & energy simulation we developed an optimized building massing having a huge potential for obtaining thermal comfort through natural ventilation and operating the building on mixed mode.

The aim was to not only reduce the energy consumption but also address to challenges of affordability and people's lifestyle, market forces and people's upgrading lifestyle. We have incorporated roof top Solar Photo-voltaic system, while generating 938100 Kwh successfully creating a Net-Positive energy building. Water efficiency measures coupled with wastewater recycling system reduces water demand by 50%. The design performance is tested for future weather scenarios up to 2025 using climate models. Providing a healthy environment for the occupants & maintaining thermal we proposed cooling as service through a Cooling system.

The Indian government has pledged to address this housing shortage with its Pradhan Mantri Awas Yojana (PMAY)-Housing for All scheme: which aims to build quickly and deliver homes to the needy while meeting affordability criteria. With a vision to contribute to this development, having net-zero energy & resource efficiency concepts at the core, we have designed & engineered a prototypical multifamily housing solution for the Hot & Humid climate zone (ICZ-0A), which occurs in almost 60% of Indian cities

DESIGN GOALS

- Achieving Net-Zero through
- Passive Design
- Efficient Technologies
- Renewable Energy
- Resource Efficiency

Fig – 1: Team Annihilators

Team Introduction:

Team name: Annihilators
Institutions names:

- College of Engineering, Guindy
- School of Architecture and Planning, Chennai
- MEASI Academy of Architecture, Chennai

Division: Multi-family housing

Approach:

Our Team Annihilators is split into ten groups according to the ten contests given by Solar Decathlon India. Each member will be taking part in 3 different contests apart from the individual roles assigned for them and thus contribute their part to the final design output. This ensures diversity, cross-membership and relevant skilled members in the respective groups. Also, this creates the development of the final design in a proper way without any future problems while working. Online meetings twice a week is a routine we stick to amidst the present pandemic situation, in order to set targets and discuss the work progress.

Background of the Lead Institution:

Located in the heart of city Chennai, Tamil Nadu with cutting edge infrastructure has been the foundation for many a successful engineer, scholar, and leader. The university offers 18 UG, 35 PG (Regular) and 34 PG Self- supporting courses. CEG has 16 Departments, 6 University Affiliated centers and 12 Research centers where research programs are offered. With close ties with the industry, excellent research practices and multiple extracurricular options, the institution advances the progression of the student's quest for knowledge.

Faculty Lead:

Prof. Dr. R. Velraj,

Professor & Director

Institute for Energy Studies (IES), CEG.

Has executed **32 consultancy projects as Principal Consultant** for various companies and Government organizations.
Research areas include:

- Energy Storage and its applications in building cooling, solar, microgrid and electronic cooling
- Distributed renewable energy source utilization.

Project Introduction :

a. **Project Name:** ***SOBHA ARBOUR***

b. **Project Partner:** ***SOBHA Developers***

- With three decades of glorious experience in creating interiors of palaces and masterpieces in the Middle-East, Mr. P.N.C. Menon founded SOBHA Limited in 1995.
- SOBHA has been honored with several prestigious awards by various institutions of repute such as CREDAI CARE award 2019 for CSR initiatives, 'Best Quality Construction of the Year – Chennai' and 'Best Architecture Plan of the Year' by FICCI Tamil Nadu State Council.
- Their Real Estate business involves development of Residential (Apartments, Villas, Row-Houses and Plots) Commercial projects and other Contractual Business services such as development of IT Parks etc.,

c. **Brief Description of the Project:** Sobha Arbour is a *Luxury Apartments Project* proposed by Sobha Developers at Ponamalle, Chennai. The site is just 200m away from the NH-45. The site with an area of nearly is to be developed as a low-rise luxury residential apartments with Indoor and Outdoor amenities such as Gym, Badminton court, Yoga room , Children's play area and swimming pools and more. They are aiming for *2BHK's and 3BHK's* targeting customers of 35-50 age group from Chennai, Bengaluru and some NRI's who would like to invest in their first and second homes. Sobha aims for the final hand-over of the property within in the first half of 2023. They are also aiming to get a ***LEED – Gold*** certification for this Residential Project.

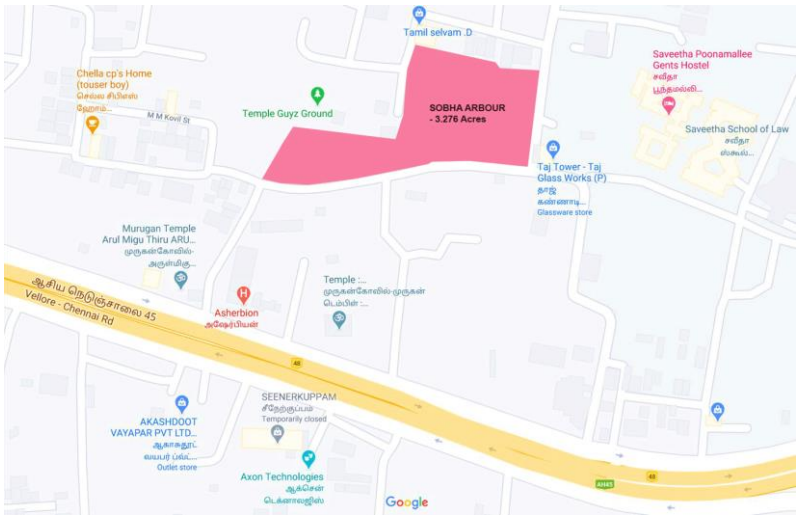


Fig – 2 : Site Location Map

- **Site Co-ordinates:** 13°03'27.1"N 80°07'15.2"E
- **Site Location :** Poonamallee, Chennai, Tamil Nadu
- **Climate Zone :** Warm and Humid Climate
- **Stage of the Project :** Yet to start.
- **Profile of Occupants:** Occupants include people of all age groups.
- **Operation Hours :** 24 hrs

Context and Market Analysis:

- The Project site is located just opposite to "The Pupil Saveetha School" which is spread across 3 acres and has Eco friendly Infrastructure. This is the first ever LEED certified school in Chennai, thus bringing our project to the context of Sustainability.
- The locality has only the School and another High-rise residential development other than workshops and small individual residences of the local workers. This will make our project Sobha – Arbour into a landmark site and good initiative development that would promote sustainability in the locality.
- The site will have no shortage for workers and water due to the close proximity to the local workers residences and just 500mts away from the Coovem River bed respectively.
- The roads are in a good condition to the site from the NH, for access and material transport to the site and also would not cause any block or hinder the traffic through those roads.
- Natural ventilation for the units and cross ventilation will be a factor to be considered in any Multifamily Residential Developments after this Co – Vid Pandemic, which is also considered as a prime element in our design.

Target Market & Market Potential:

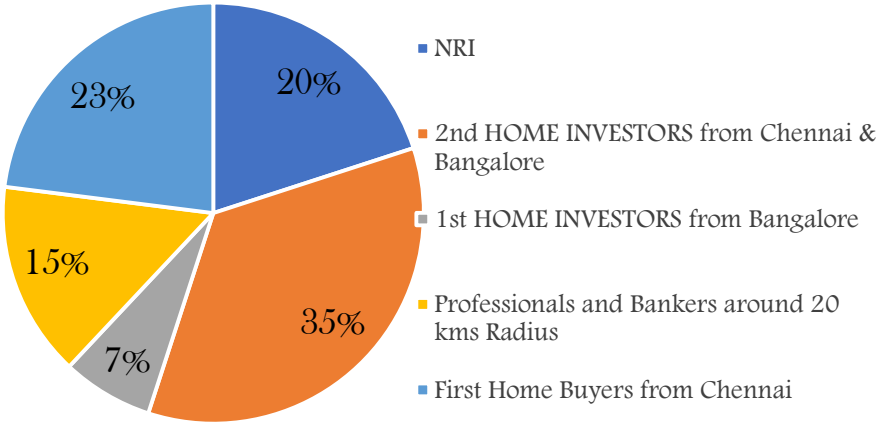


Fig – 4.0 : Primary market Survey – Investors Potential Survey

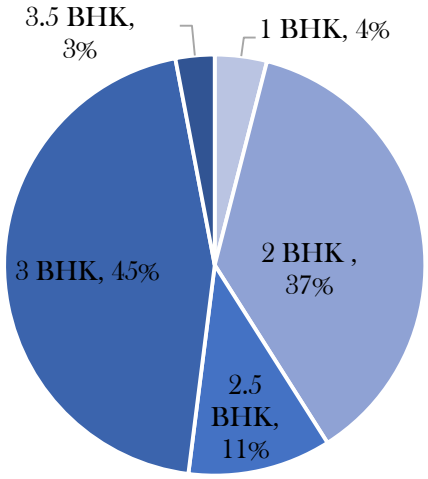


Fig – 4.1 : Primary market Survey – BHK Preference of the Investors

- Data from the 200 samples of the Online survey taken from the Target customers for our Project. They include IT professionals from Chennai who are working in Bangalore, Chennai based Professionals from around Poonamalle and Chennai based NRI's.

- 2nd Home Buyers from Chennai and Bangalore top the list and the most preferable are 3 BHK and 2BHK units which can have a difference in the carpet area size.

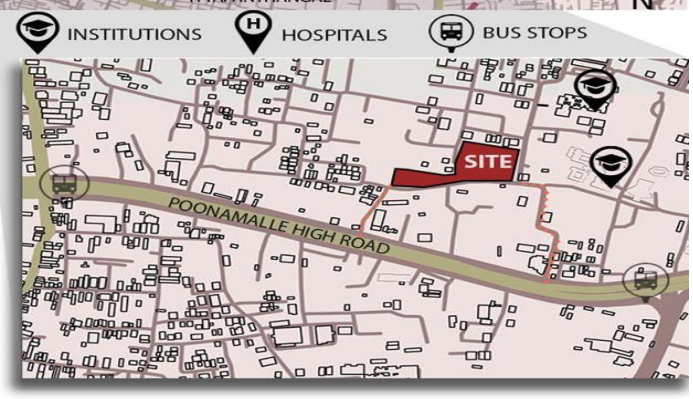
Detailed Building Area Program:

Site area	: 13,257.1 m^2	Mixed mode Operational area	: 6,448 m^2
Total estimated Built-up area	: 26,206 m^2	Unconditioned area	: 19,758 m^2
Ground coverage	: 9,942.8 m^2		
Landscape area	: 2,651 m^2		

SITE ANALYSIS

CONTEXT

SITE IMAGES



PROXIMITY TO THE NEARBY

Bus Stop - Sennerkuppam - 1.5 KM

Bus Stand - Poonamalle ..... 4.5 KM

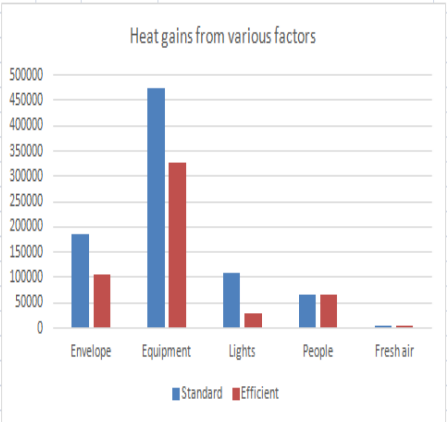
Railway Station - Koyambedu .... 9 KM

Airport - Meenambakkam -18.5 KM

Preliminary specification:

Total Room Sensible heat	500624
Total Room Latent heat	32852
Grand total heat, BTU/hr	533477
AIR CONDITIONING TONNAGE	44.46

	Standard	Efficient	% reduction
Envelope	185108	105597	43.0%
Equipment	473546	328553	30.6%
Lights	107974	30366	71.9%
People	65250	65250	0.0%
Fresh air	4166	3710	10.9%



HVAC load analysis, We come to know that the building consumes 0.085 tons of refrigeration per square meter for standard case by optimizing the parameters and orientation we can reduce HVAC load up to 0.055 tonnages per square meter. By including passive design we can efficiently reduce energy consumption.

Fig –9: Load calculation for 2BHK and 3BHK blocks

Total Room Sensible heat	518871
Total Room Latent heat	32852
Grand total heat, BTU/hr	551724
AIR CONDITIONING TONNAGE	45.98

	Standard	Efficient	% reduction
Envelope	216185	122975	43.1%
Equipment	475100	329422	30.7%
Lights	107974	30366	71.9%
People	65250	65250	0.0%
Fresh air	4166	3710	10.9%

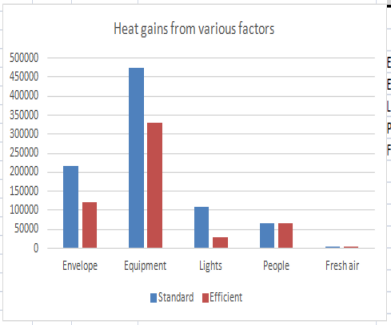


Fig – 10: Load calculation for 3BHK and Compact -3BHK blocks

Total Room Sensible heat	518860
Total Room Latent heat	33421
Grand total heat, BTU/hr	552280
AIR CONDITIONING TONNAGE	46.02

	Standard	Efficient	% reduction
Envelope	205930	122964	40.3%
Equipment	474587	329422	30.6%
Lights	107974	30366	71.9%
People	65250	65250	0.0%
Fresh air	4786	4279	10.6%

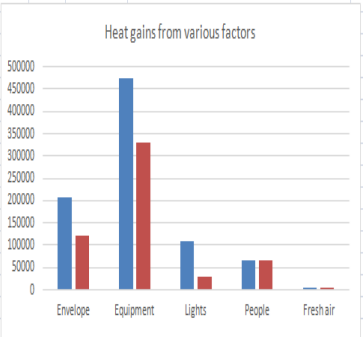


Fig –11: Load calculation for Elite 3BHK block

Lighting and Equipment Selection

Breakdown of Operational Schedules The appliance selection will help the residents minimize energy use. We use an alternative to Energy Star, which is the Star Labeling program by the Government of India's Bureau of Energy Efficiency (BEE). Appliances are rated on a scale of 1 star to 5 stars with one being least efficient and five being most efficient. We selected appliances that save energy, have minimal maintenance cost, a longer life.

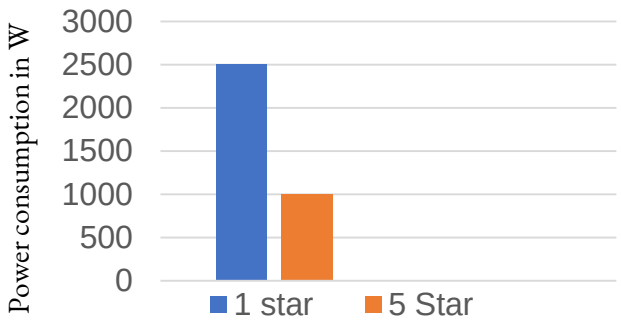


Fig – 12: Lighting and Equipment System Power consumption graph

GOALS:

ENERGY PERFORMANCE	▪ **A reduction of 50% energy used by common services like water pumps, common area lighting, cooling, security will be targeted.** ▪ **The performance of the building is monitored remotely hence improving the efficiency to at least 10%.** ▪ **To control and monitor the appliance conveniently with IOT and Smart sensors.**
WATER PERFORMANCE	▪ Overcoming water scarcity and saving water consumption by 50% ▪ Using an abandoned well in the site for ground water / aquifer recharge.
RESILIENCE	▪ Designing as disaster resilient design (to prevent the coastal cyclones and floods) ▪ Conserving or Replanting the Existing trees in the site.
AFFORDABILITY	▪ Incorporation of phase change materials and modular approach will be done to achieve the climate responsive design and affordability of the users and the developer. ▪ 28, 515 KWH energy will be generated using Building integrated photovoltaics (BIPV) Tiles. Which is more affordable.
INNOVATION	▪ Technologies and equipment are being controlled remotely to improve convenience by using IOT. ▪ The wastage of energy is minimized by using smart sensors and IOT, which enhances the performance of the building and is monitored remotely. ▪ Security equipment are installed and monitored with IOT.
SCALABILITY AND MARKET POTENTIAL	▪ Use of Pre-Fabricated material will reduce the construction time and increase the market potential within a short span of time, which will also be cost effective. ▪ Detail drawings for special structures in Pre-fab. ▪ This project as a Sustainable Building will become one of the Landmark along with the LEED Rated School nearby.
COMFORT AND ENVIRONMENTAL QUALITY	▪ Achieve 70% comfortable hours without air-conditioning and maintain acceptable indoor air quality. ▪ Humidity in the home is regulated and air is filtered to maintain the indoor air quality.
ENGINEERING DESIGN AND OPERATION	▪ To minimize the total environmental impact associated with all life-cycle stages of the building construction ▪ To reduce the waste generated during construction and reused.
ARCHITECTUAL DESIGN	▪ Achieving common Green spaces for 2 individual units in each floor, which can act as a terrace garden for vegetation. ▪ Trying to achieve 15% chargeable parking spaces for BS 6 Engine electric rechargeable cars in future. ▪ Achieve parking without going for any basement parking. ▪ To achieve a minimum 1 km Jogging Track around the site.
INDOOR AIR QUALITY	▪ To Meet WHO (World Health Organization) standards for PM 2.5 and PM10 to improve over ambient air quality in the city.

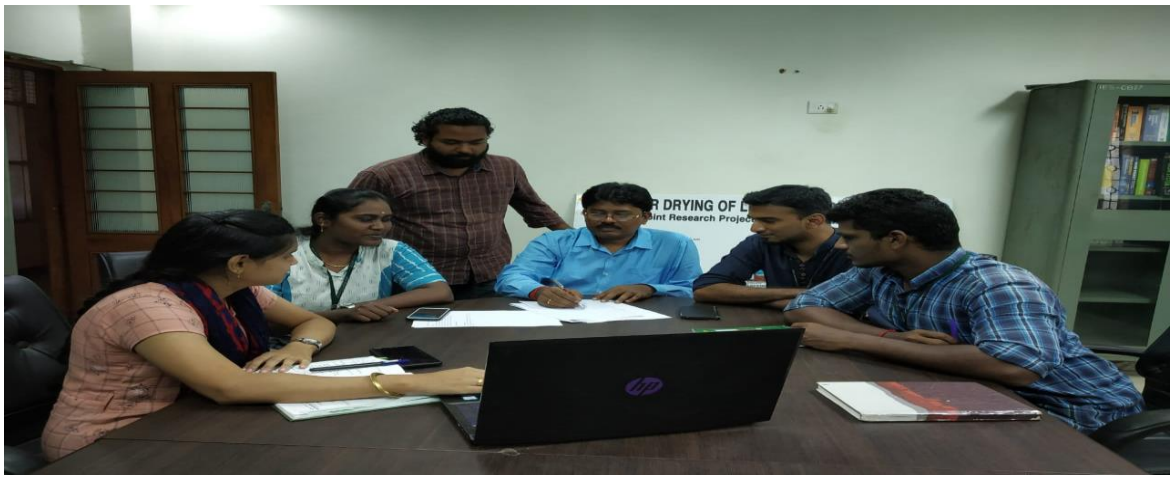
DOCUMENTATION OF DESIGN PROCESS

From the first, we assigned a role to each team member and we planned in such a way to complete the project earlier. we had continuous interaction with the faculty lead, industry partner, and project partner.

WEGOT is our industrial partner. They assist in the field of water conservation and attain net-zero water. WEGoT's Smart Water Meters manage real-time water consumption and quality with utmost ease, enabling to save up to 50% of water in residential.

Sobha Developer is our project partner. They assist us by providing inputs to us. As a team, we visited one of the Sobha projects which is nearby our site.

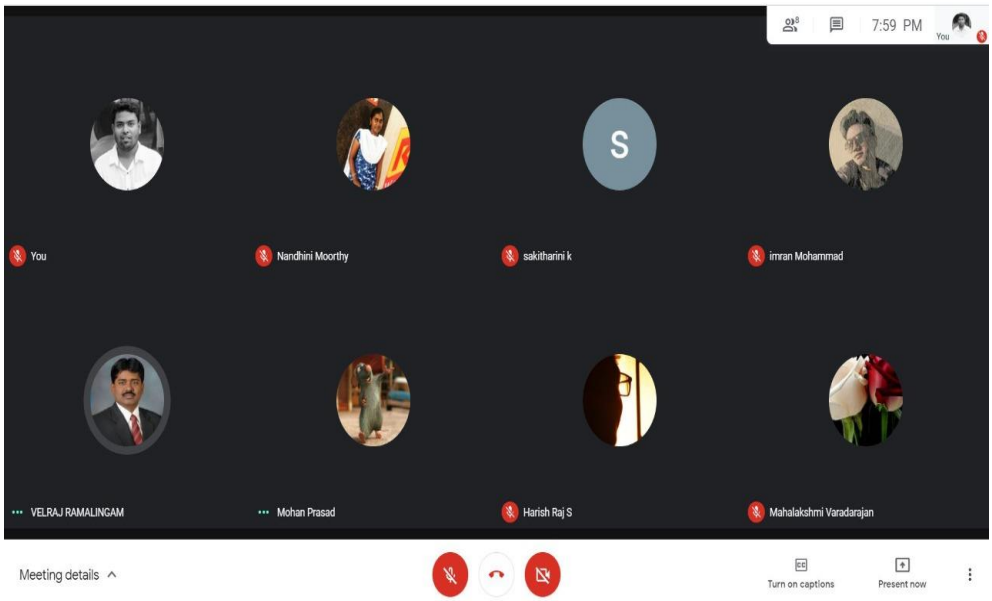
G-meet plays a vital role in our team discussion. Weekly twice we had a discussion through this platform. We had great interaction, we assigned proper roles to each one and present with other team members, that we come to streamlined work progress.



Team discussion with our faculty lead in College of Engineering Guindy campus. As a team, we meet our faculty once a month and clarify all the doubts and we start to proceed again. Meanwhile, faculty have an interactive session with team members

Challenges Faced:

COVID-19 is big challenge for all. Due to covid-19, everyone one of us suffered a lot. The virtual platform gives full support to the entire team. Likewise, we had a very challenging experience. All the challenges were overridden by the faculty lead. we had a consistent Conversation among the team with Gmeet.



Tools used

Autodesk AutoCAD
For Design development and detailing

Autodesk Revit Architecture
For 3D Modelling

3D - VISUALISATION AND RENDERING

Autodesk Insight
For Heat gain Analysis

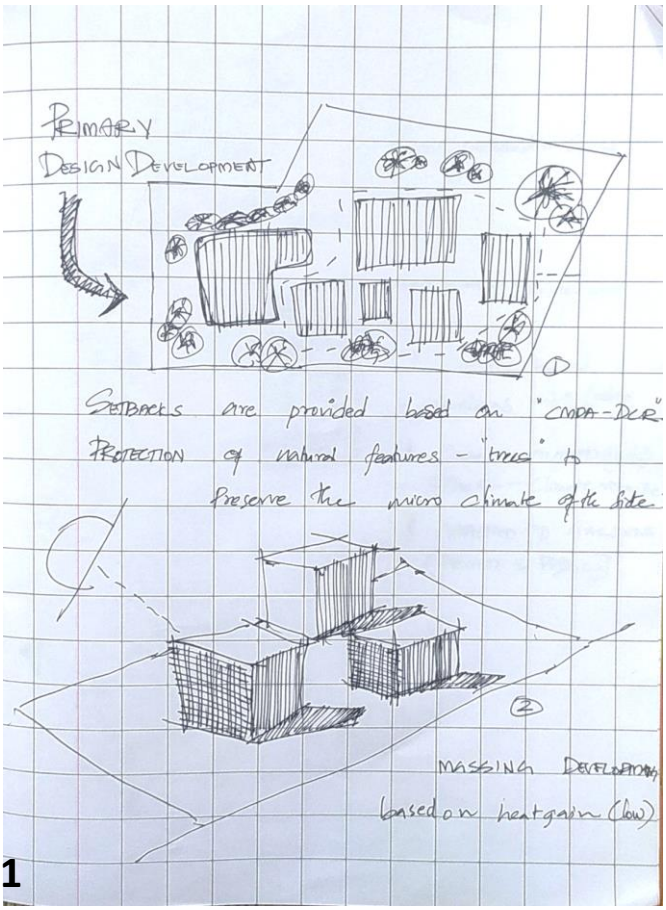
Climate Consultanat
Climate Analysis

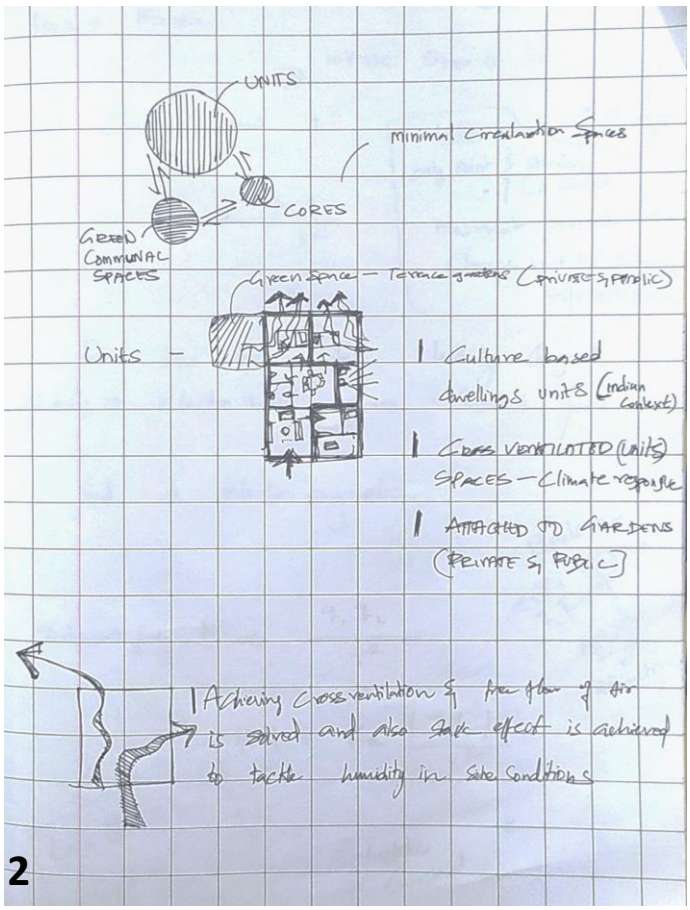
Climate Studio
Sun path and shadow analysis

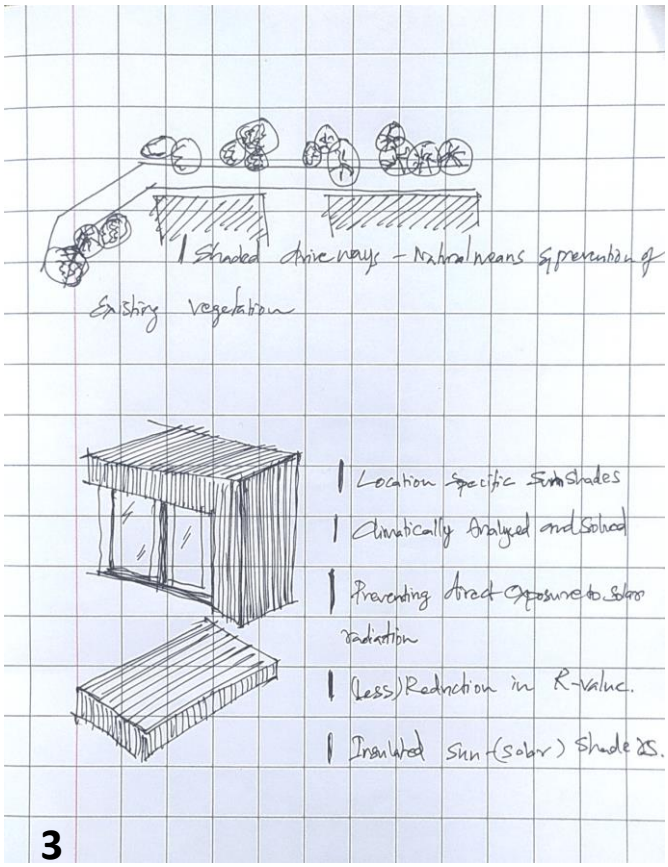
PV Syst
Solar Pv Analysis

Design Builder
Energy Stimulation
HVAC Design
Day lighting
Natural Ventilation

Design documentation







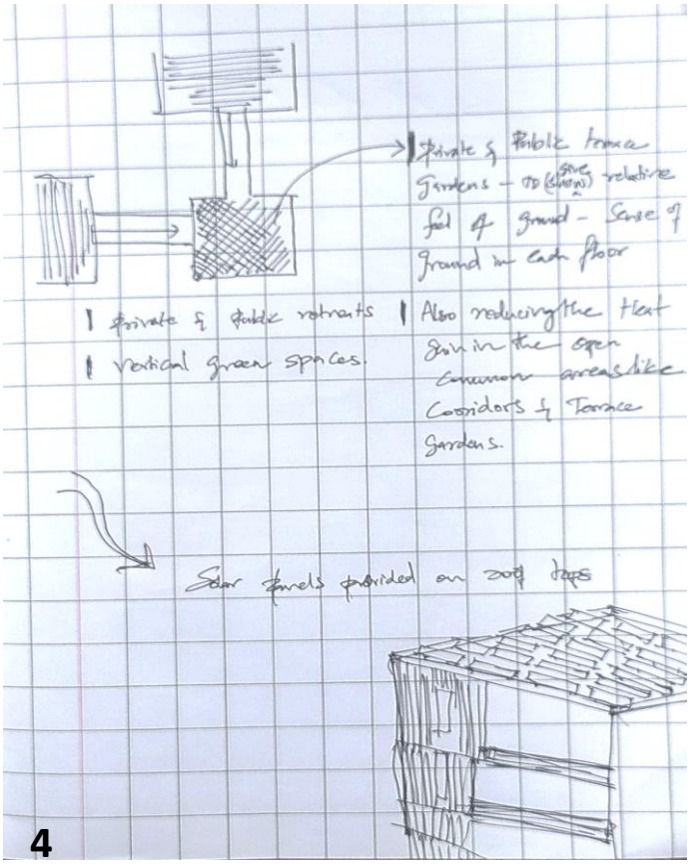


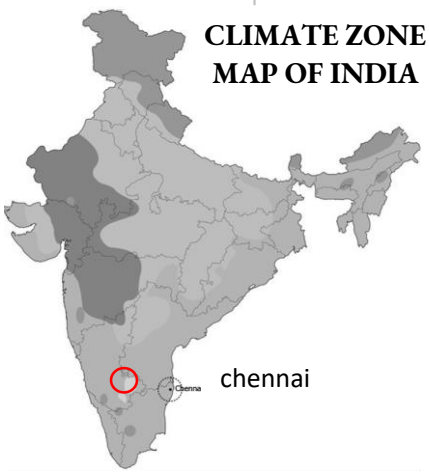
Figure: Detail Development sketches

DESIGN DEVELOPMENT

DESIGN DOCUMENTATION

a. CLIMATE ANALYSIS :

hennai falls under **Warm – humid climate zone** according to e Climate zone map of India – NBC 2005.



NALYTICAL ASSESSEMENT :

URCE : CLIMATE CONSULTANT & CLIMAPLUS
imate Analysis Model used : Ashrae standard 55 & current handbook of ndamentals model

TEMPERATURE RANGE

has been analyzed that corded temperature ange is **higher than mfort zone** during pril –October.

ecessary **cooling rategies** need to be corporated in order to aintain the thermal mfort.

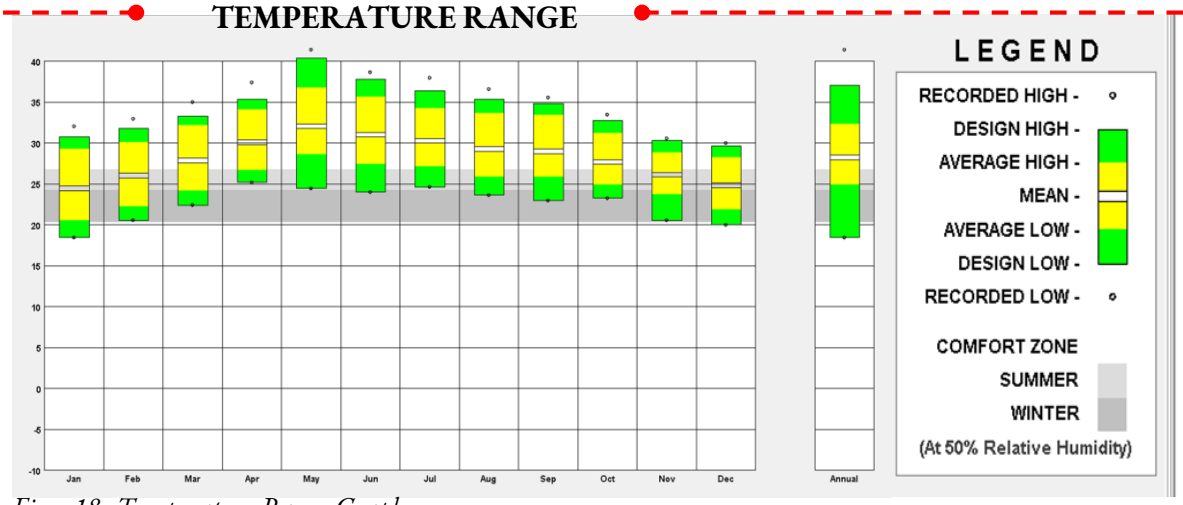


Fig – 18 : Temperature Range Graph

RADIATION RANGE

adiation range in chennai direct normal surface ffers between 650 to 0wh/sq.m, whereas 315 h/sq.m being the min posure where **shading eeds to be done**.

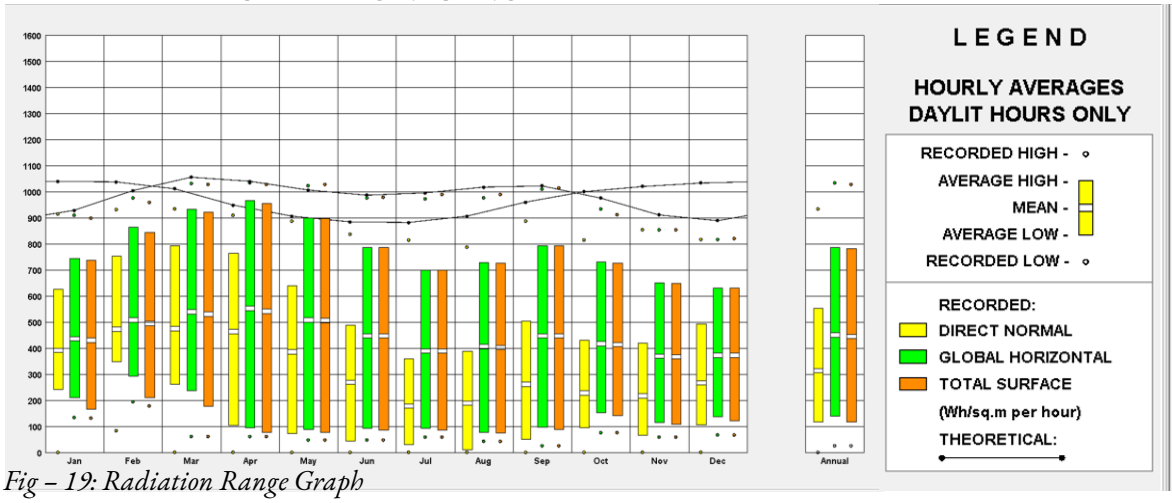


Fig – 19: Radiation Range Graph

SUN SHADING CHART

has been analyzed t all **fenestrations exposed to sun**, per shading must be ne.

oper fenestrations d ventilation must encouraged to tackle midity and focation.

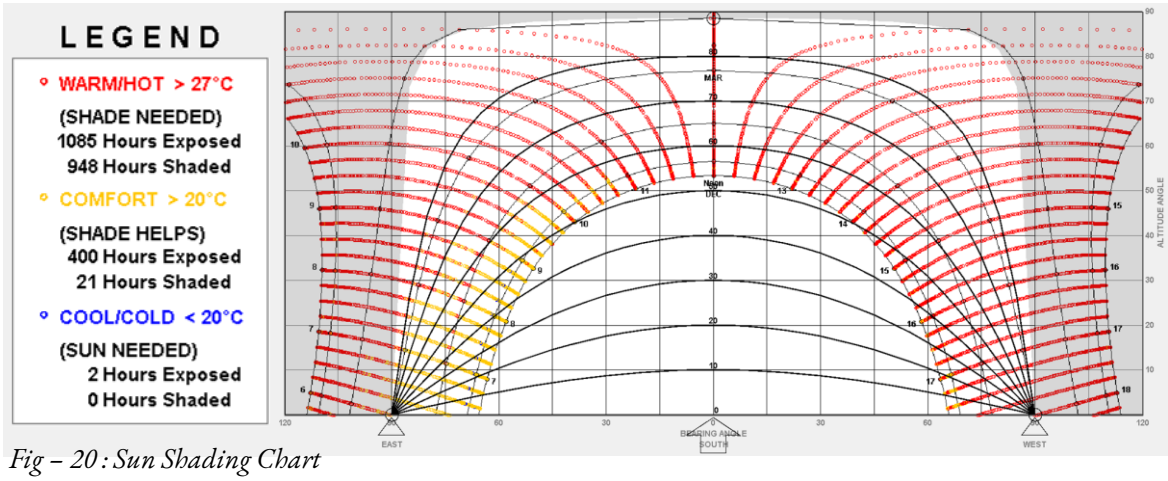
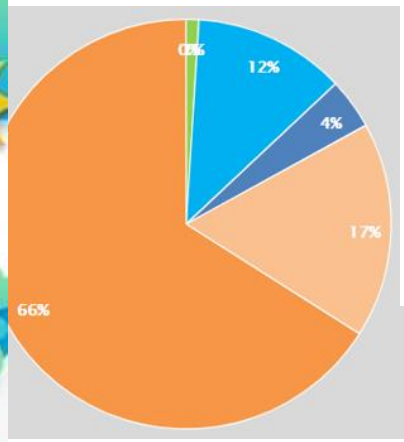


Fig – 20 : Sun Shading Chart

OPERATION MODES

Fig – 21: 24 hrs operation mode



It has been analyzed and estimated that Dehumidification and Cooling strategies need to be incorporated to maintain the thermal comfort of the space according to the climate of Chennai.

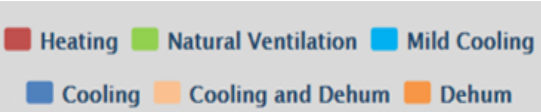
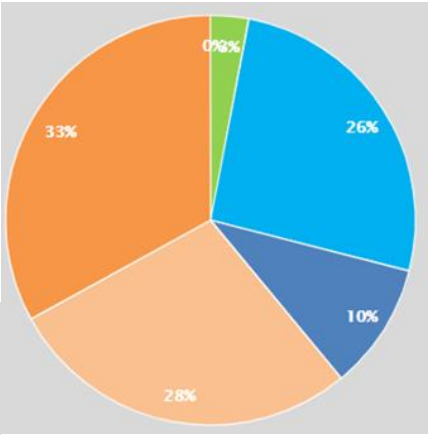
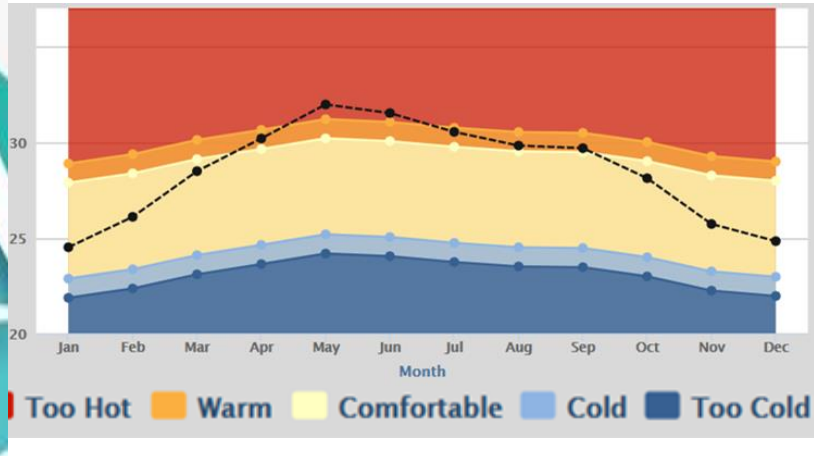


Fig – 22: Daytime operation mode



NATURAL VENTILATION



g – 23: Adaptive Comfort Zones for Naturally Ventilated Spaces in Chennai

od Natural Ventilation can reduce or eliminate air conditioning in rm weather, if windows are well shaded & oriented to prevailing eze.

Fig – 7.1.1 : 24 hrs NV

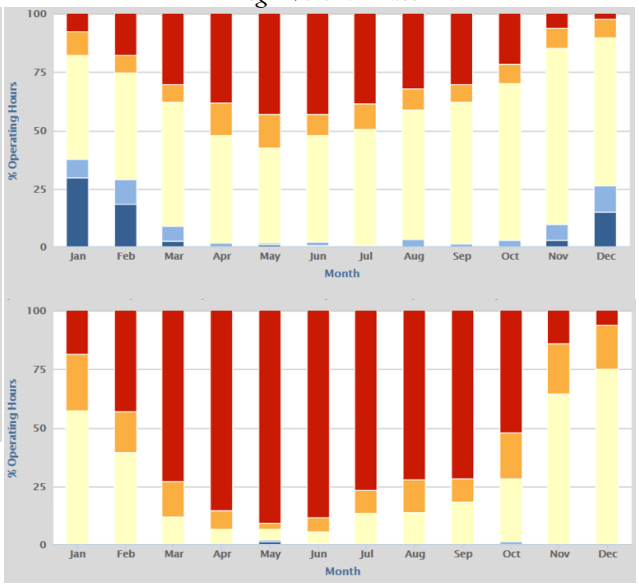
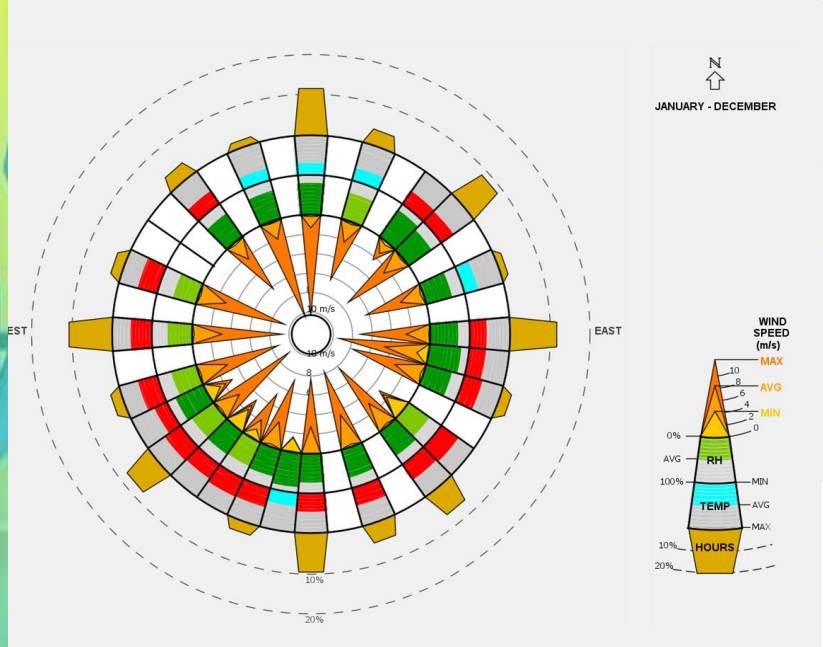


Fig – 24: Daytime NV

WIND WHEEL



– 25: Wind Wheel – Showing speed, temperature, hours and RH factors

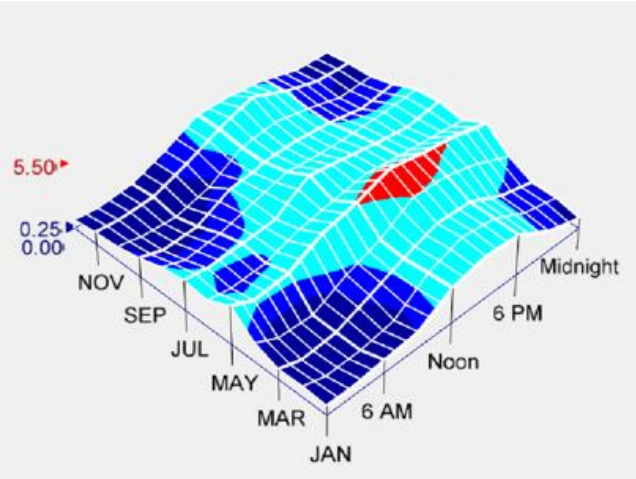


Fig – 27 : Wind flow graph in various months

It has been analyzed that recorded wind movement is along south west & north east, cold winds from north and wind velocity range recorded is 4 to 8m/s .

PSYCHROMETRIC CHART

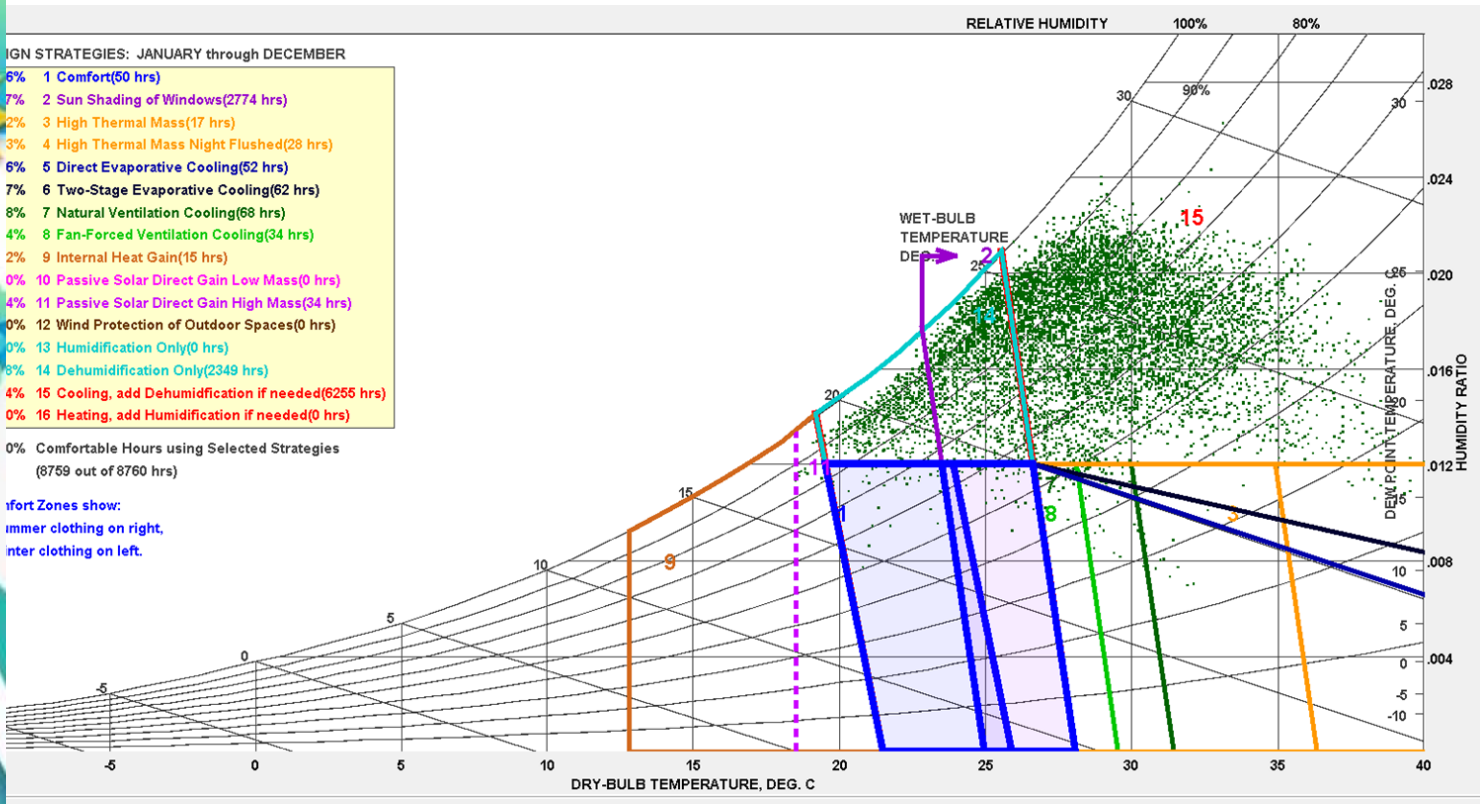


Fig – 8.0: Psychometric Chart

It has been inferred that proper shading and dehumidification strategies will improve the indoor comfort range.

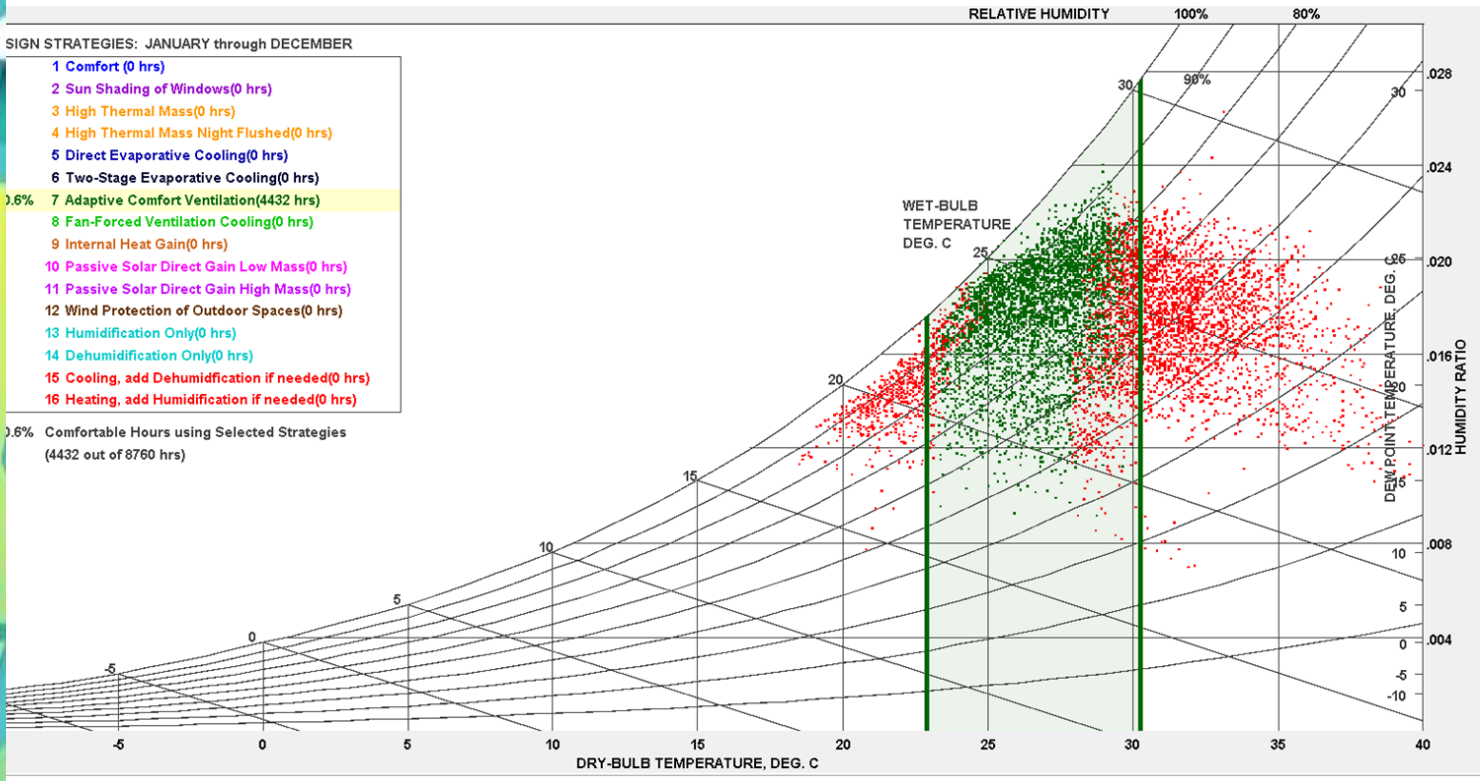
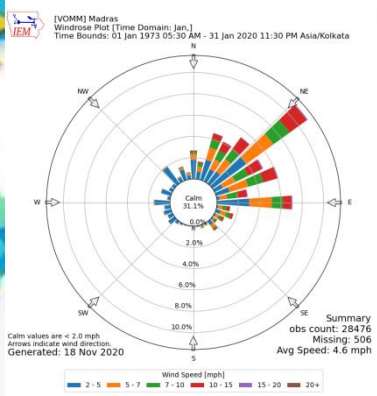
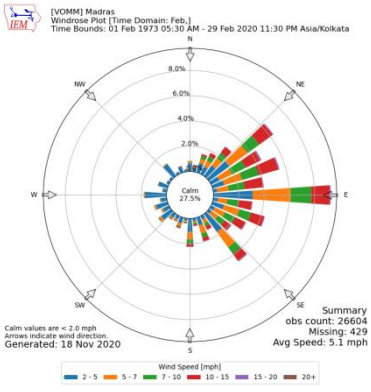


Fig – 8.1: Adaptive comfort

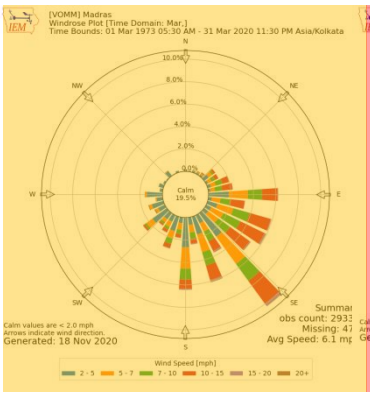
WIND ROSE DIAGRAM FOR CHENNAI - MONTHLY



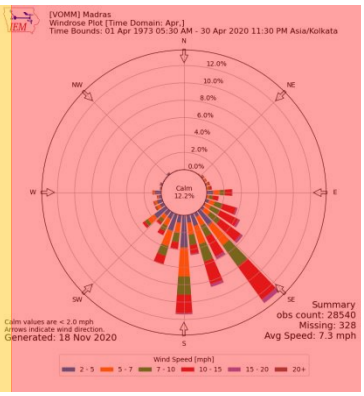
JANUARY



FEBRUARY



MARCH



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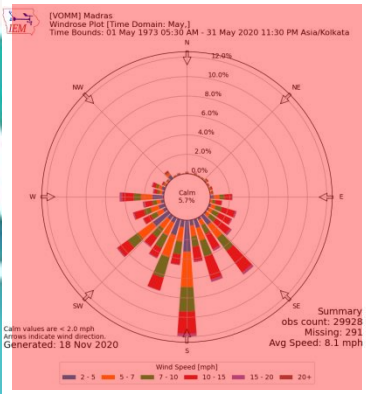

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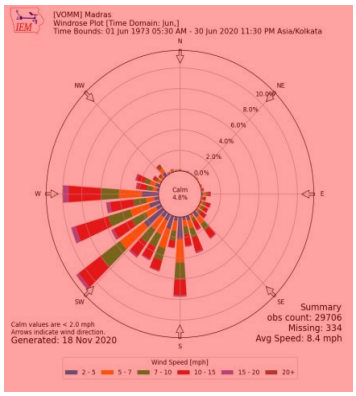

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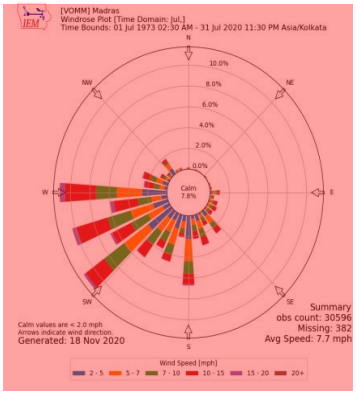

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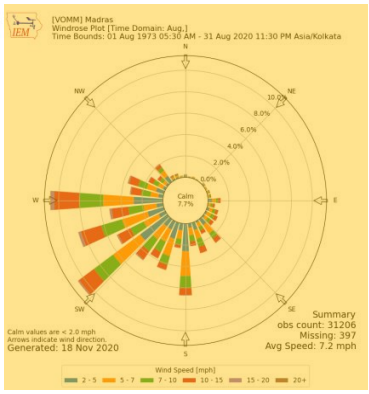

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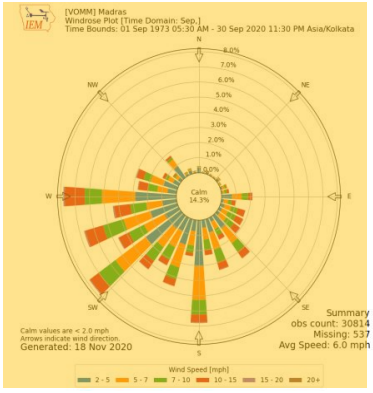

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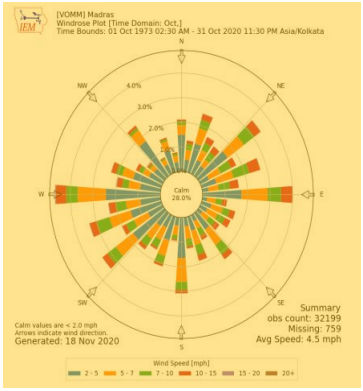

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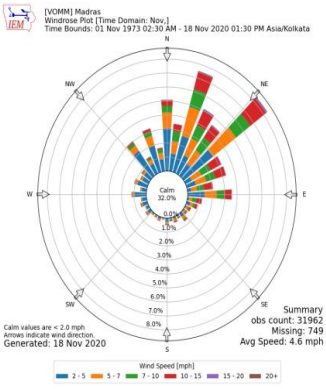

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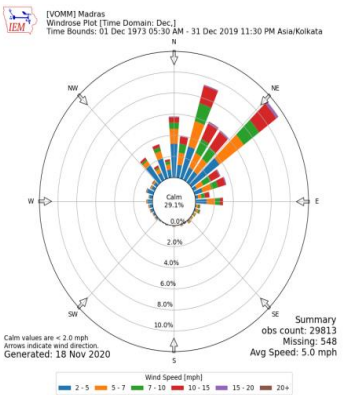


DECEMBER

Fig - 14 :Monthly wind rose with temperatures below monthly IMAC comfort band and wind speeds above 1ms-1

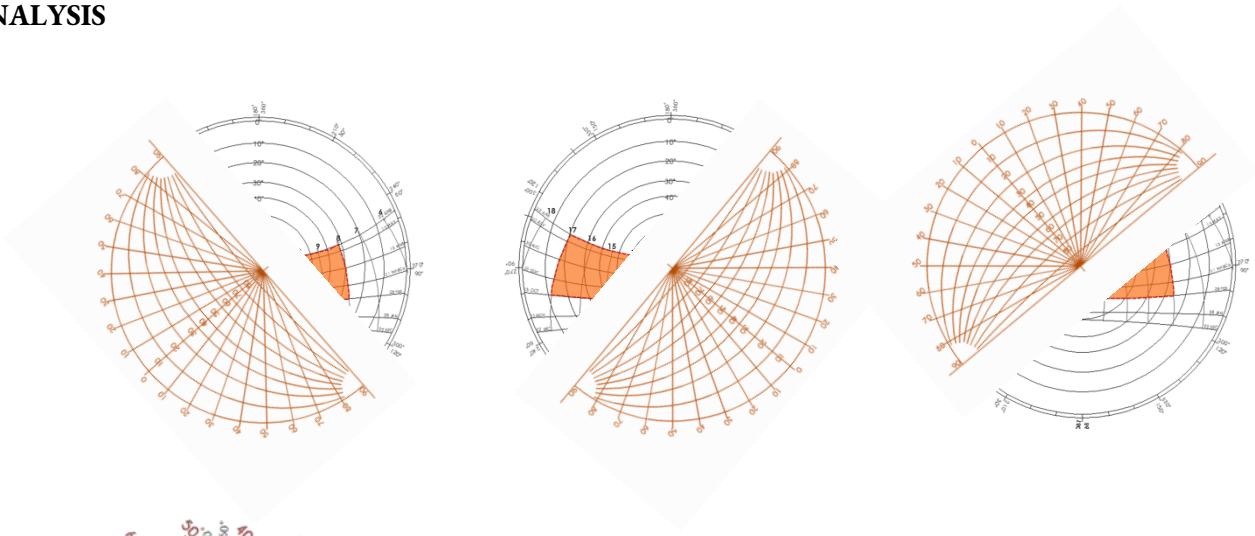
INFERENCE:

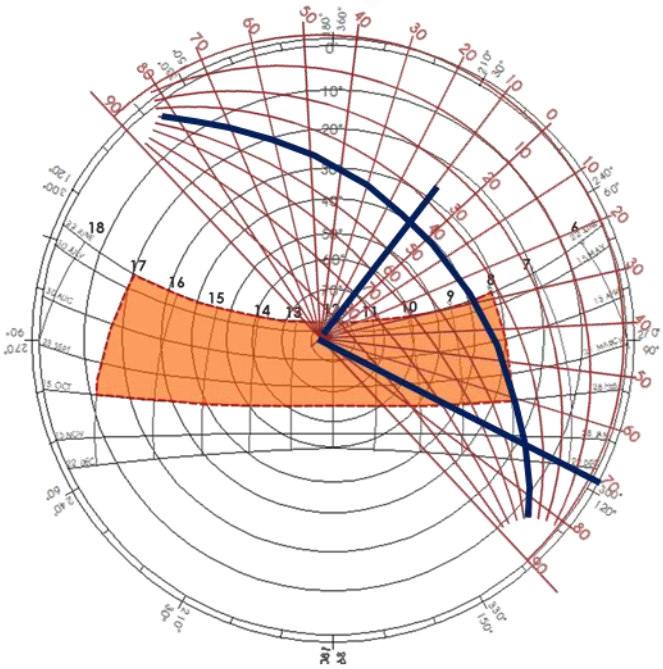
The months of **March, August, September** and **October** feels **slightly warm** while the months from **April to July are thermally Hot**.

According to SP 41: Handbook of Functional Requirements the **desirable wind speed for achieving comfort conditions during slightly Warm and hot conditions are >1.59m/s and >3.00** m/s respectively.

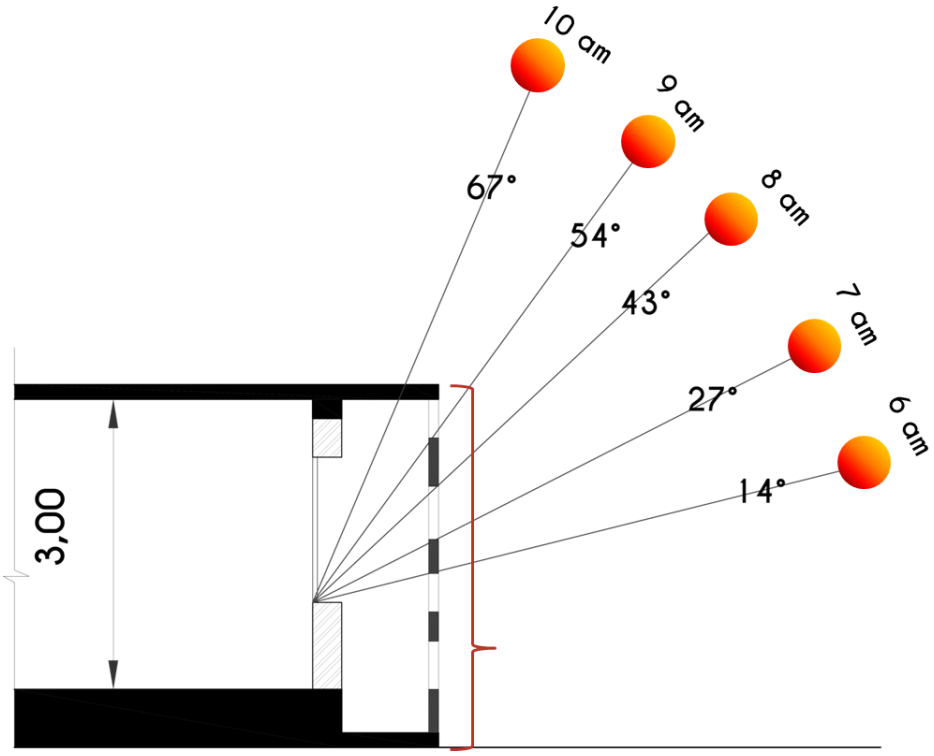
Thus the design consideration will have to **harness winds from SE, S and SW directions** for achieving comfort.

SHADING ANALYSIS





Since the major orientations are facing North East, South West, North West and South East Directions an Intricate shading device which can allow the wind movement but cut down the radiation as well is required. Thus an **Intermediate Jali facing parallel to the façade** at an allowable offset can satisfy the shading requirements.



South West is the prevailing wind directions. And these directions admits the lower angle sun .

Fig -15: Optimization of shading

Detail studying - Energy efficient building material

Roofing

One of the biggest influences on the energy efficiency of building is the type of roof that it has installed over it. Fundamentally, for a roof to be energy efficient, it needs to do a good job of blocking the heat out instead of absorbing it. When a roof absorbs heat, that warmth is transferred into the air inside the building radiantly, and pretty soon the entire interior has gotten much warmer.

Fibre Cement

Although fibre cement roofing resembles slate in most manners, it is considerably lightweight in comparison. This is made from a mixture of portland cement and special cellulose fibre. It is an efficient fire-retardant apart from being durable in all weathers.

Concrete Tiles

These tiles are made from Portland cement and rank quite low on the eco proof scale. However, their durability has led to them becoming remarkably popular in recent years. The weight is significantly heavier than others hence it has to be considered while designing the house.

Insulation

Insulation decreases the exchange of heat (both heat gain and heat loss) through the many surfaces in a building—walls, ducts, roof, etc. In a well-insulated building, less warm air escapes during the winter, and less cool air escapes during the summer, reducing the amount of energy needed for heating and cooling. Insulation can actually be one of the most practical and cost-effective ways to improve a building's energy efficiency: by improving the insulation in new and existing buildings, one can enjoy significant savings and reductions in energy usage.

Polyurethane insulation

Polyurethane insulation is used in many residential and commercial buildings. It is a solid, cellular polymer with a high thermal resistance. Polyurethane insulation comes in open or closed cell form, in varying densities. It is typically installed as insulation on the roofs, walls, floors and ceilings of new and retrofit buildings. It is also used to insulate appliances, pipes and a variety of other products. Polyurethane insulation is a sustainable material delivering real benefits to society facing escalating energy costs, diminishing fossil fuels and the negative environmental effects of climate change.

Polyurethane insulation is a sustainable material delivering real benefits to society facing escalating energy costs, diminishing fossil fuels and the negative environmental effects of climate change.

Spray Polyurethane Foam Insulation

Spray Polyurethane Foam (SPF) is an insulation product that is produced on-site and is typically applied by certified applicators. Two liquid components, polymeric MDI (A) and a polyol blend (B) are mixed at high or low pressure using a spray gun, and the reacting mix is sprayed onto the substrate. It expands and solidifies to form polyurethane foam that adheres well to the area it is applied to, providing a seamless seal. SPF insulation is ideal for roofs. It can also be sprayed into exterior wall cavities, or onto the exterior sheathing of commercial and residential buildings. SPF is compatible with many different wall types.

Waterproofing

Water proofing admixtures can be broadly grouped as permeability reducers and water repellents or hydrophobic (water hating) agents. Permeability reducers are pore filling and porosive reducing materials which can be further classified into very fine particulate matters, workability and air entering admixtures, accelerators.

Water Proofers

Water repellent coatings, which can be applied on the concrete surface to impart water proofing to the concrete structure. Thermoplastic PU has been used in the water proofing of below grade structures building foundation, basements, reservoirs, ponds, walkways, tunnels, earthen shelters, bridge, abutments, retaining walls, landfills and water canals. Acrylic compound polymer emulsion based additive for cement based coatings when mixed with cement gives excellent water proofing, excellent adhesion to concrete substrate, steel, asbestos, excellent resistance to ultra violet rays, excellent breathing properties and helps in reducing corrosion of reinforcement. Styrene butadiene co polymer emulsion have also been used as water proofing coating for concrete, which also increase adhesion strength, chemical resistance and abrasion resistance.

Windows

Windows also represent the major source of heat gain/loss, visual and thermal discomfort. In residential and commercial buildings, a considerable amount of energy has been used to compensate the unwanted heat gain/loss through windows. Windows have undergone a technological revolution in recent years. Energy-efficient window are now available that can dramatically cut building energy consumption. These high-performance windows feature multiple glazing, specialized transparent coatings, insulating gas in between glass panes and improved frame. All these features reduce heat transfer, thus able to cut energy burden due to the window openings.

Construction chemicals

Construction chemicals improve the quality and durability of the buildings. Commonly used as bonding agents, tile adhesives, expansion & crack joint filters, and plasticizers, these chemicals increase the overall life of the construction work along with providing protection against environmental perils. Apart from adding more strength to the buildings, these chemicals bring down the volume of water and cement used in the construction process at an excellent rate.

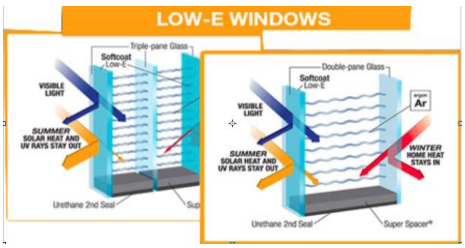
Another key reason behind the improved adoption of construction chemicals is that it improves the performance of emerging building technologies like new thermoset hotmelts, structural tapes, and multi-purpose adhesives. Construction chemicals are one of the best things to be initiated in the building construction industry. Its astute use is sure to change the face of the global green building market.

Low-e glass

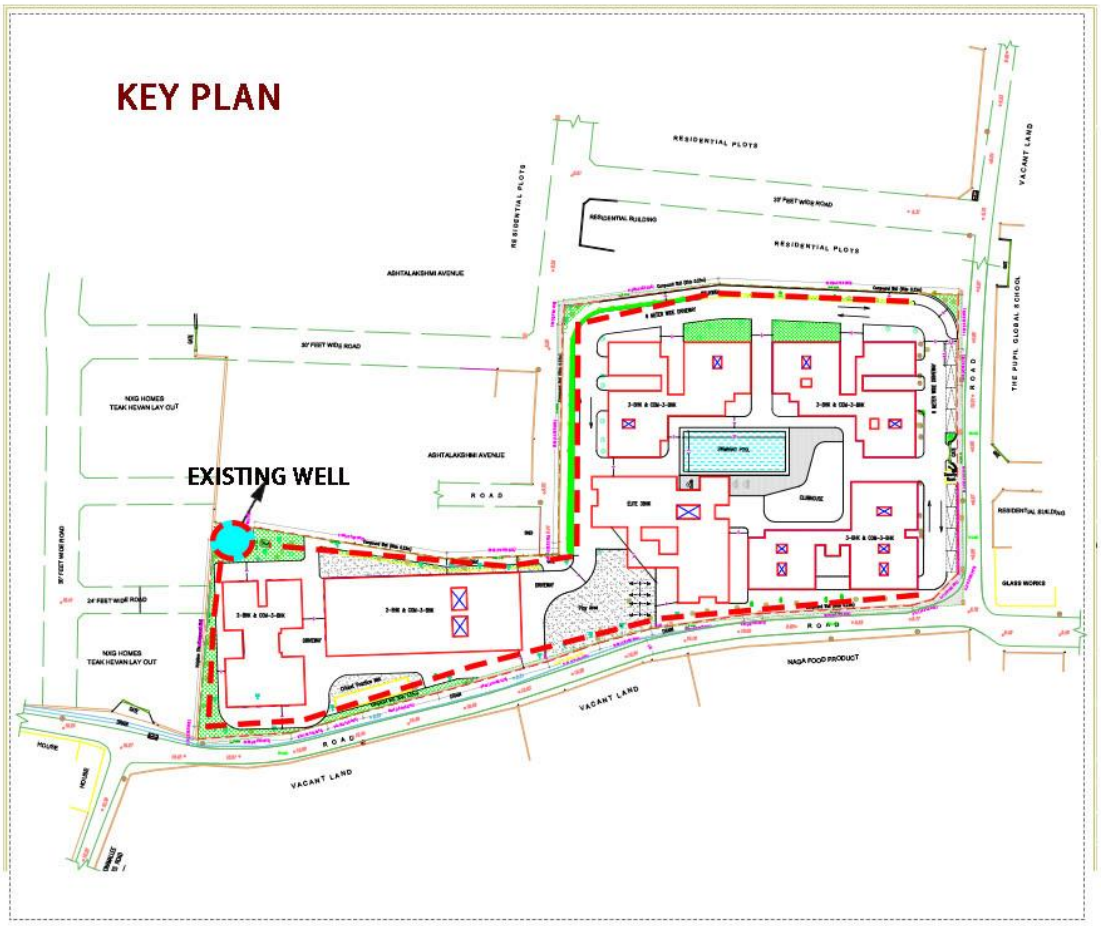
Low-e glass stands for low-emissivity glass. This type of glass has a special metal coating which able to reflect much of the infrared portion of the solar spectrum while transmitting most of the visible. The low-e glass manages the sun's heat by filtering the sun's short-wave radiation. This cuts down the amount of solar heat gain into the building. Therefore, the energy efficiency of low-e glass is higher than that of ordinary clear glass.

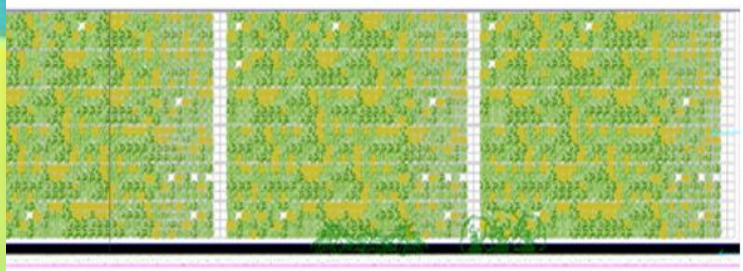
Double Glazed Glasses

Double glazing glasses are nothing but a combination of multiple glass panes mostly two in number and can be three at times, these panes are having a separation by a spacer and a still layer of vacuum or gas which reduces the heat transfer while forming a part of building envelope. The thermal resistance provided reduces the artificial heating required leading to a reduction in the overall cost and also the ecological footprint. These glasses are also called as insulation glasses and the manufacturing of the same comes in with a thickness ranging from 3mm to 12mm or more depending upon its application.



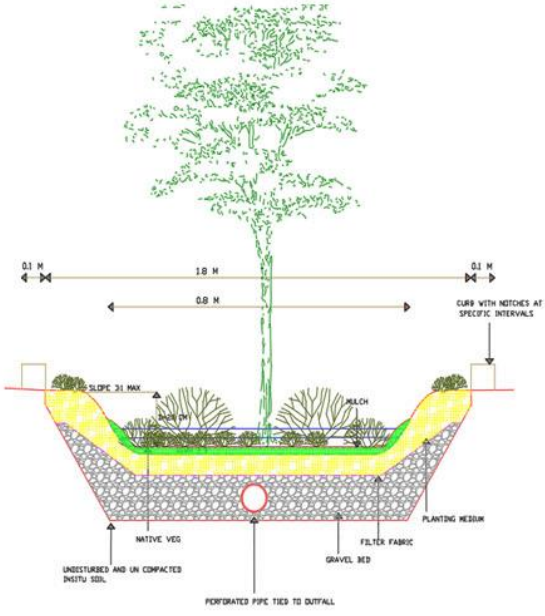
GREEN WALLS AND BIO SWALES

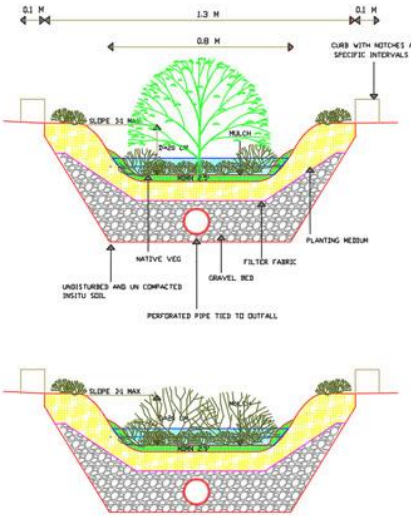




The selective regions of interior parts of the compound wall are treated as green walls.

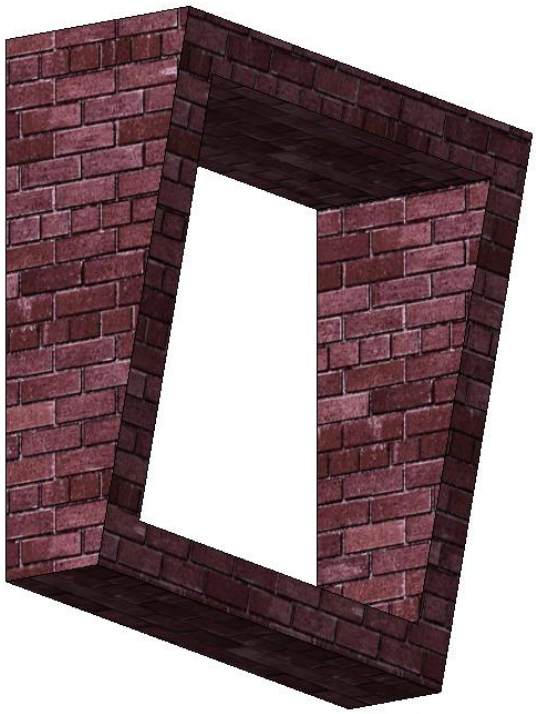
Bioswales along the periphery work to remove pollutants through vegetation and the soil. As the storm water runoff flows through the bioswale, the pollutants are captured and settled by the leaves and stems of the plants.
finally these water are collected to a pre-existing well at the end of our site as shown in the key plan. thus recharging the ground water.

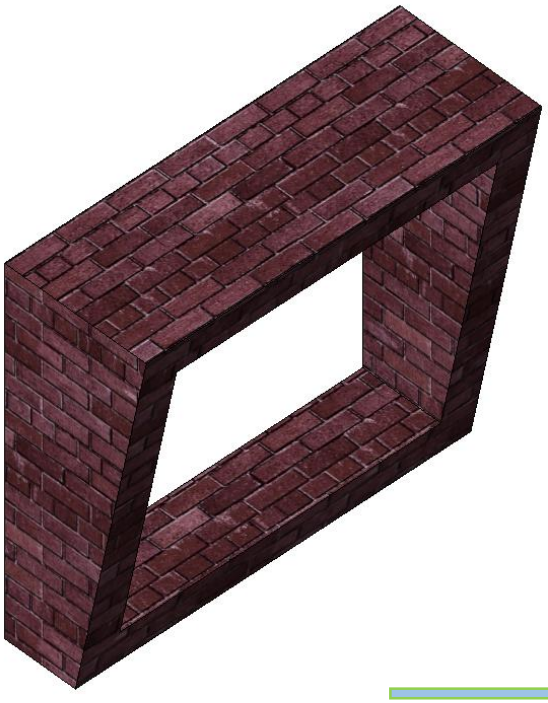




SUN SHADE

The sun shade is designed as such very less direct sunlight enter into the building, thus reducing the heat gain through windows





HVAC SYSTEM

Storage integrated Centralised chiller plant with Under floor radiant Cooling System

This system is completely powered by roof top solar photovoltaics to run the compressor during the sunshine hours.

There is a separate chiller plant located in two rooms with a total capacity of 500 Tons. The chille.d water produced is supplied to the underground storage tank

Each block is supported with four 32000 litre capacity chilled water storage tank buried under ground.

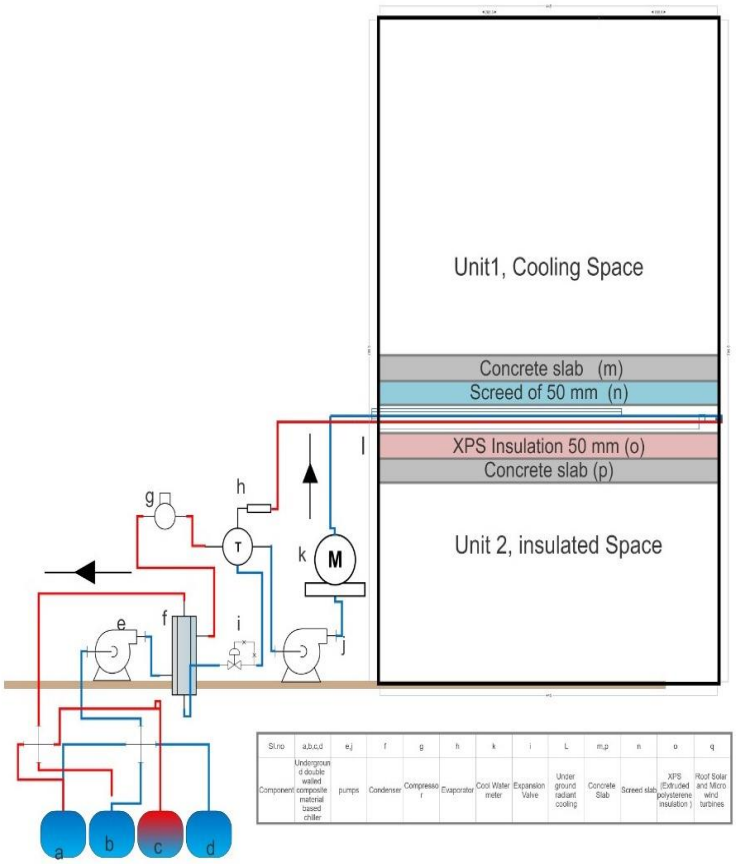
The chilled water is transferred to the individual dwellings through pipe lines sandwiched between the XPS (Extrude polystyrene) and Screed which hide under the two concrete slabs so that only the upper unit space only cools and the chilled water pipe lines are perfectly insulated with the XPS Foam.

Advantages of the system:

- The energy requirement for such a system is 40 % lesser than the normal air-conditione
- This storage system is centralized and underground which otherwise occupies the valuable space.
- Since the system is completely depends up on Solar PV the excess energy can be utilized for common utilities an other purposes.
- In winter seasons where there is less requirement of cooling the excess energy can be used for other purposes.

Under floor Radiant cooling System

The consumer decides which room to be installed with the radiant cooling system, accordingly the pipelines are to be laid.
Each dwelling is installed with a Chilled water meter to measure the consumption by the consumer.
The consumer is billed accordingly based on the usage



Sl.no	a,b,c,d	e,j	f	g	h	k	i	L	m,p	n	o	q
Component	Underground double walled composite material based chiller	pumps	Condenser	Compressor	Evaporator	Cool Water meter	Expansion Valve	Under ground radiant cooling	Concrete Slab	Screed slab	XPS (Extruded polystarene insulation)	Roof Solar and Micro wind turbines

Advantages of system:

This system is designed to reduce the energy consumption and better cooling performance.

- This system is responsible for reduction of 40% of heat load.

This system generates the revenue of 90 lakh rupees per year which covers the investment in 6 years, the payback period of 6 years is achieved by billing the consumers.

- Coal-based power plants emitted an average of 915 grams (32 ounces) of carbon dioxide (CO2) per kilowatt hour of electricity produced.

1250 kwh of energy is saved which extremely effects the reduction of carbon dioxide resulting 420T of carbon dioxide per year.

The water is circulated at 20 degree centigrade in the under floor radiative cooling system. The storage is done in three tanks with a cooling range of 4 to 12 degrees and one tank is mixed
The Centralized chilled water-based cooling system of 500T capacity is used where a double walled composite material based underground tank is used for storage of cooling water. The water is maintained between 4ºC and 12ºC This system is identified to reduce the losses in the storage tank as earth acts as an insulator.
The chilled water is transferred to each unit with the help pipes. A novel Cool water meter fitted in each unit measure the amount of chilled water consumed for cooling by determining the mass flow rate of the cool water. This system allows the users to pay accordingly

Selected Appliances for Multifamily housing

Company: Super Fan Q series
Power: 25W

Company: LG
Power: 159 W

Company: Onida
Power: 73w

Company: Samsung
Power: 2 units

Company: Preethi
Power: 505W

Company: crompton
power: 6 W

Energy Performance

SOLAR POTENTIAL

The site receives an average total horizontal radiation of 460 W/m^2 per day around 300 days in a year. This shows a huge potential of solar energy. We proposed a system which utilize half of the energy for HVAC cold storage during peak solar energy available (10 a.m. – 2 p.m.) time. The PV technical and Energy generation details is given below considering 5.5 sunshine hours.

Block	Annual potential(kWh)	Cost (Rs.)	Size of Power Plant (kW)
A (800 Sq.m)	114000	2789200	76.0
B(800 Sq.m)	114000	2789200	76.0
C (800 sq.m)	114000	2789200	76.0
D (680 sq.m)	96900	2356000	64.4
E 951 (sq.m)	135450	3332600	90.3
F 951 (sq.m)	135450	3332600	90.3
G 951 (sq.m)	135450	3332600	90.3
H 9280 (sq.ft)	122850	3013400	81.9
Total capacity	938100	23734800	

Table – 1: Power generated and cost estimation for solar energy

CALCULATION FOR SOLAR IRRADIANCE

- Co-Ordinates: Latitude: 13°03'27.1"N 80°07'15.2"E
- Geographical Site: Poonamallee, Chennai, Tamil Nadu
- Altitude : 16 m
- Time zone : UTC – 5.5
- Source – PVGIS TMY : (PVSYST SOFTWARE) & Climate Consultant

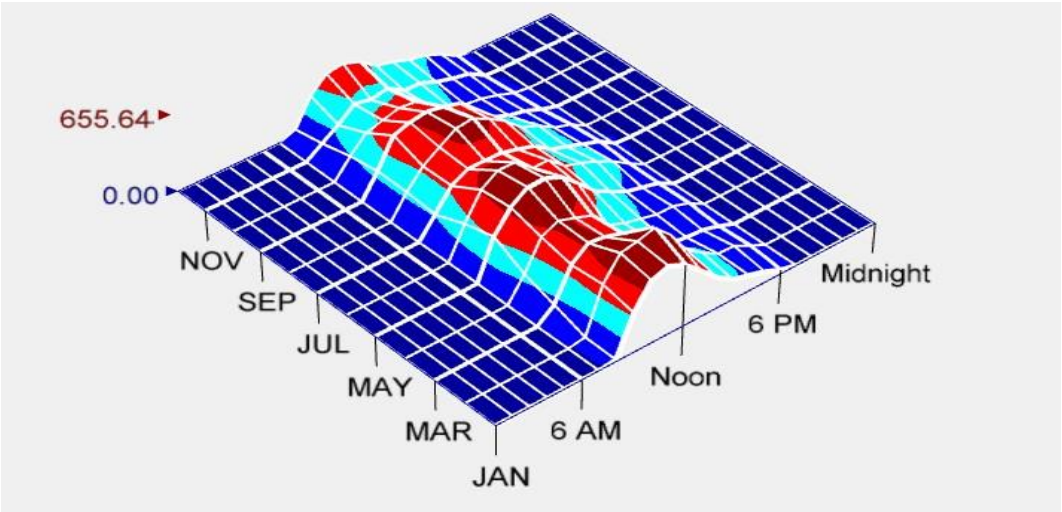
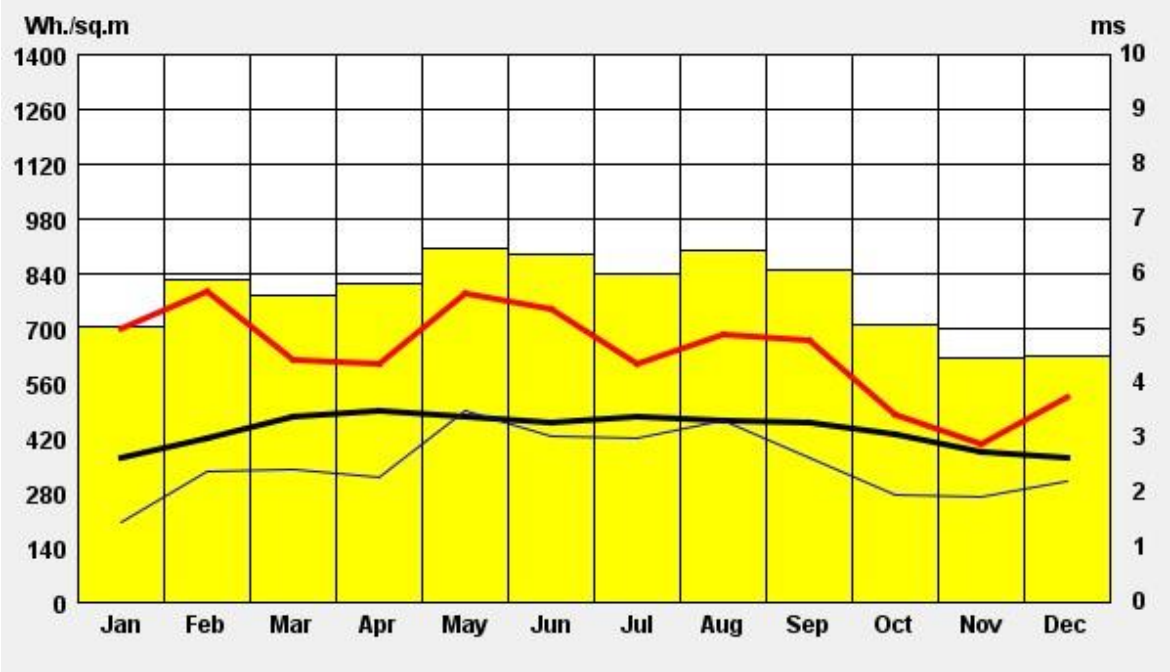


Fig-5 DIRECT NORMAL RADIATION (Wh/sq.m)

53%		Night Time
15%		4 - 158
13%		158 - 316
12%		316 - 474
7%		> 474



Total roof top PV Capacity is determined to be **500kw or 0.5MW**

Total of 3500kwh of energy is generated per day.

The PV is connected to a micro-grid system for supporting common facility arrangements like centralized cooling and Solar central street light system.

A novel system named as "Solar centralized street light system" is proposed which eliminates the shading problem which arises in the individual solar street light due to trees. There are 300 lights in the staircase and 100 lights in the street which are LED lamps of 20 w each connected.

The power generated from the PV in the sunshine hours is used for compressor of the chiller to cool the water where all four tanks of the cooling system of 32000-liter capacity are cooled and a battery of 12V and 10000 AH is used for supporting the Solar centralized street light system.

BUILDING INTEGRATED WIND TURBINES

Micro wind turbines are suitable for application at the building scale and are called 'Building Integrated Wind Turbines' or 'Vertical Axis Wind Turbines.' Vertical Axis Wind Turbines generators (200 W-10kW) can be used as stand-alone systems or as grid connected systems, and both can be paired with other energy conversion systems like photovoltaic system. Integrating wind turbine is not a widely used system because lack of technology and architecture design. But installing vertical axis turbine cause no harm to birds and produce less noise comparing to horizontal axis wind turbine.

PROPOSED SYSTEM

Gorlov Helical Wind Turbine Developed in the mid-1990s by Professor *Alexander M. Gorlov* of the *Northeastern University*, the helical rotor has become the popular choice of inventors of new Vertical Axis Wind Turbines. The design was originally designed for use in tidal and in-stream hydro applications. Nevertheless, the design has been frequently adapted for use in wind energy since the early to mid-2000s. One example is *Quiet Revolutio*n. The helical rotor design is reputed to reduce or eliminate the torque ripple encountered in traditional two-blade Darrieus or eggbeater turbines.

Because of its dramatic aesthetic appeal, the helical or Gorlov rotor has become the preferred wind turbine design by architects when adding architectural features to their buildings or development sites.

In the US, the addition of a wind turbine to a building or as part of a building's development gives the building design extra "points" toward its LEED certification. Architects seeking LEED platinum are notorious for adding small wind turbines—often helical—as an architectural element or kinetic sculpture.

Fig-6: Wind Turbine

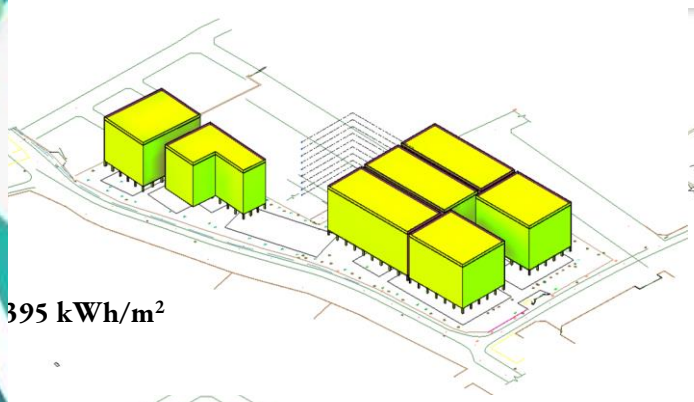
The example of transformation of the design and form of the building promoting concentration and the organization of the formed vortex streams increasing the volume of the developed energy is presented by the realized project also in London designed by the British bureau of the architectural projects "Waugh Thistleton". The building in the plan represents a sail which "collects" the air streams which are bending around construction and with acceleration directs them to the wind turbines located on all height on one side.

Fig - 7: Building integrated wind turbine

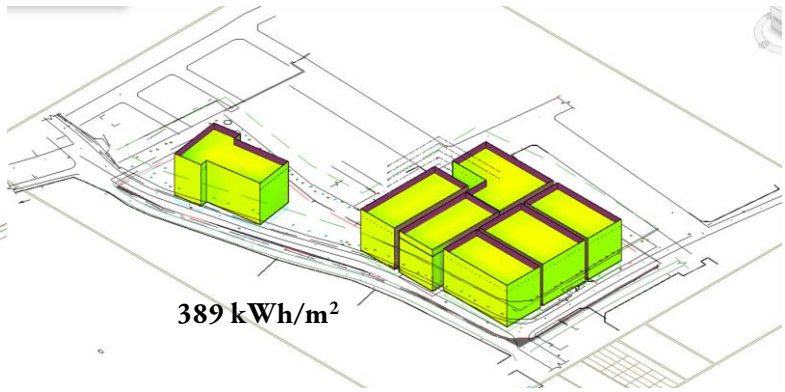
Total Wind capacity is 100kw

Energy Simulations:

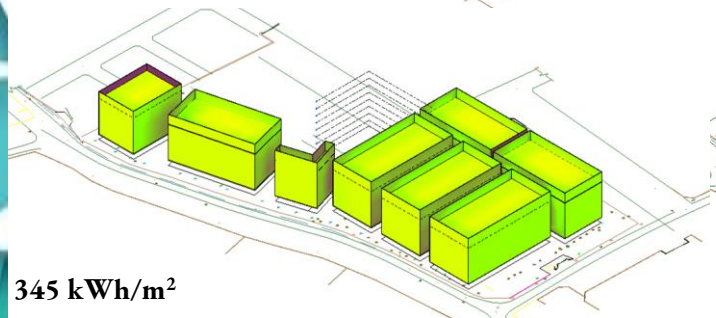
- Based on the requirements provided by our developer, we formulated different iterations in the unit mix with different views.
- After discussion, we shortlisted few options. From the shortlisted ones, different block models (shoebox model) have been developed and placed at different orientation.
- Solar Analysis has been done for all the models and the least heat gain ones from each iterations are as below.
- This simulation helped us to shortlist the modular iteration and find the best orientation of our design proposal.
- Solar heat gain is calculated from all the external surfaces and the output is as shown below.
- The lesser the heat gain, the lesser the energy spent for cooling and comfort equipment's.' Thus, this analysis helped us to reduce the energy requirement.



395 kWh/m²



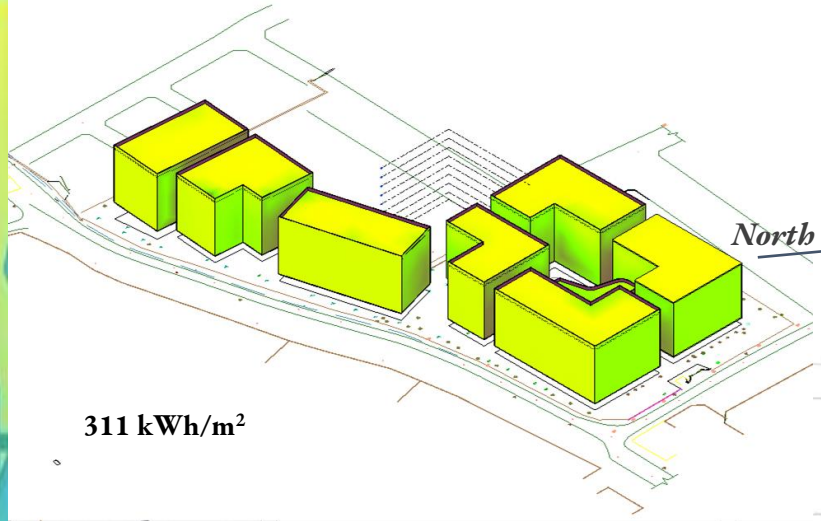
389 kWh/m²



345 kWh/m²

319kWh/m²

– 10.0 : Different Orientations of the Blocks and simulation



311 kWh/m²

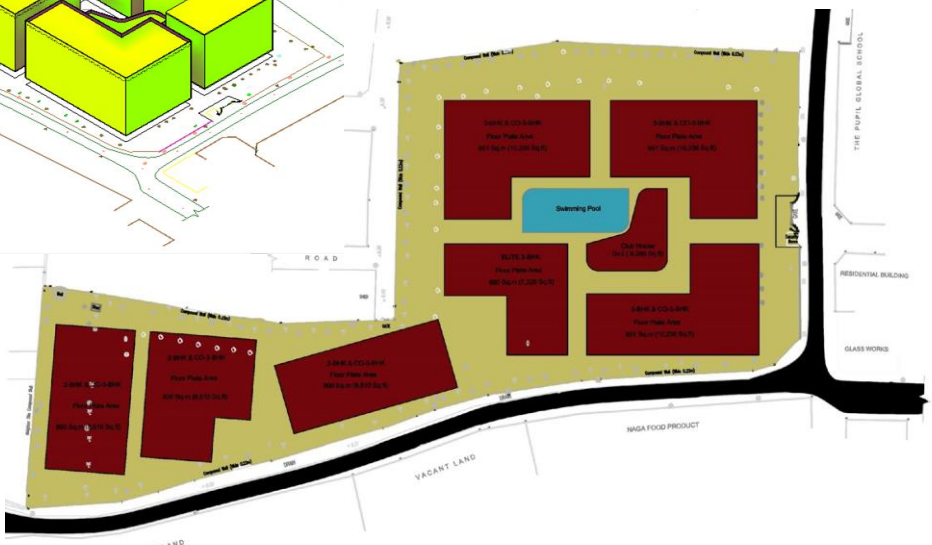


Fig – 17 : Finalized Block Orientation and Plan

Passive Techniques to reduce solar heat gain :

Wall material used is **AAC Blocks** (Autoclave Aerated Concrete). AAC is a ***highly thermally insulating concrete-based material*** used for both interior and exterior construction. Also the manufacturing processes gives away ***lesser carbon emissions*** compared to other materials used.
As per the climate in Chennai, the ***maximum heat gain is witnessed at the south and west facades***. Solar radiation directly hits on the southern walls around 8.5 months a year. And west side experiences more heat gain due to the *reradiation of the heat* from the earth surface around 4pm.
So, there should be extra insulation in the walls of south and west exterior walls.
So, we have chosen a ***50mm insulation of XPS*** (Extruded Polystyrene) along the outside of the wall.
These exterior walls will have a ***U value of 0.31*** while other walls have ***U value of 0.41***. This will eventually reduce the heat gain along the south and west facades.

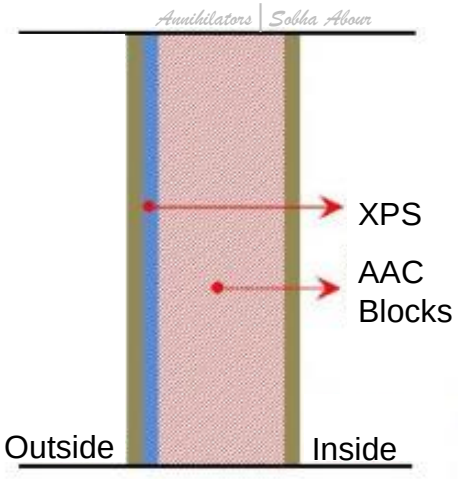


Fig – 19 : Wall Cross section
Insulation at west and south exterior walls

Benefits of using Passive Solar Techniques:

- Cost of Insulation along the west and south walls are around 2 Crores.
- Heat load is appreciably reduced by 40%
- This reduces the air conditioning requirement around 30% to 40%
- The chiller unit capacity is reduced giving away a saving of 3 crores.
- This eventually reduces the maintenance cost of 50 Lakhs per year giving a return on investment in 2 years.
- This also reduces the carbon emission around 50% compared to the conventional building of similar scale

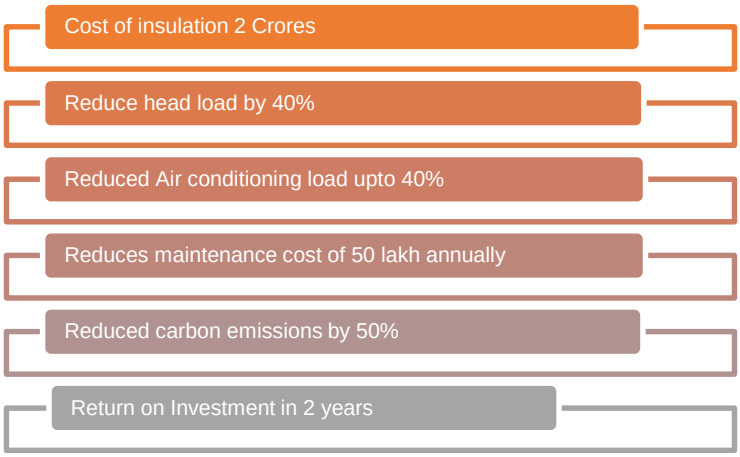


Fig – 20 : Heat gain analysis after implementing the passive solar techniques

WATER CYCLE DIAGRAM AND CONSUMPTION:

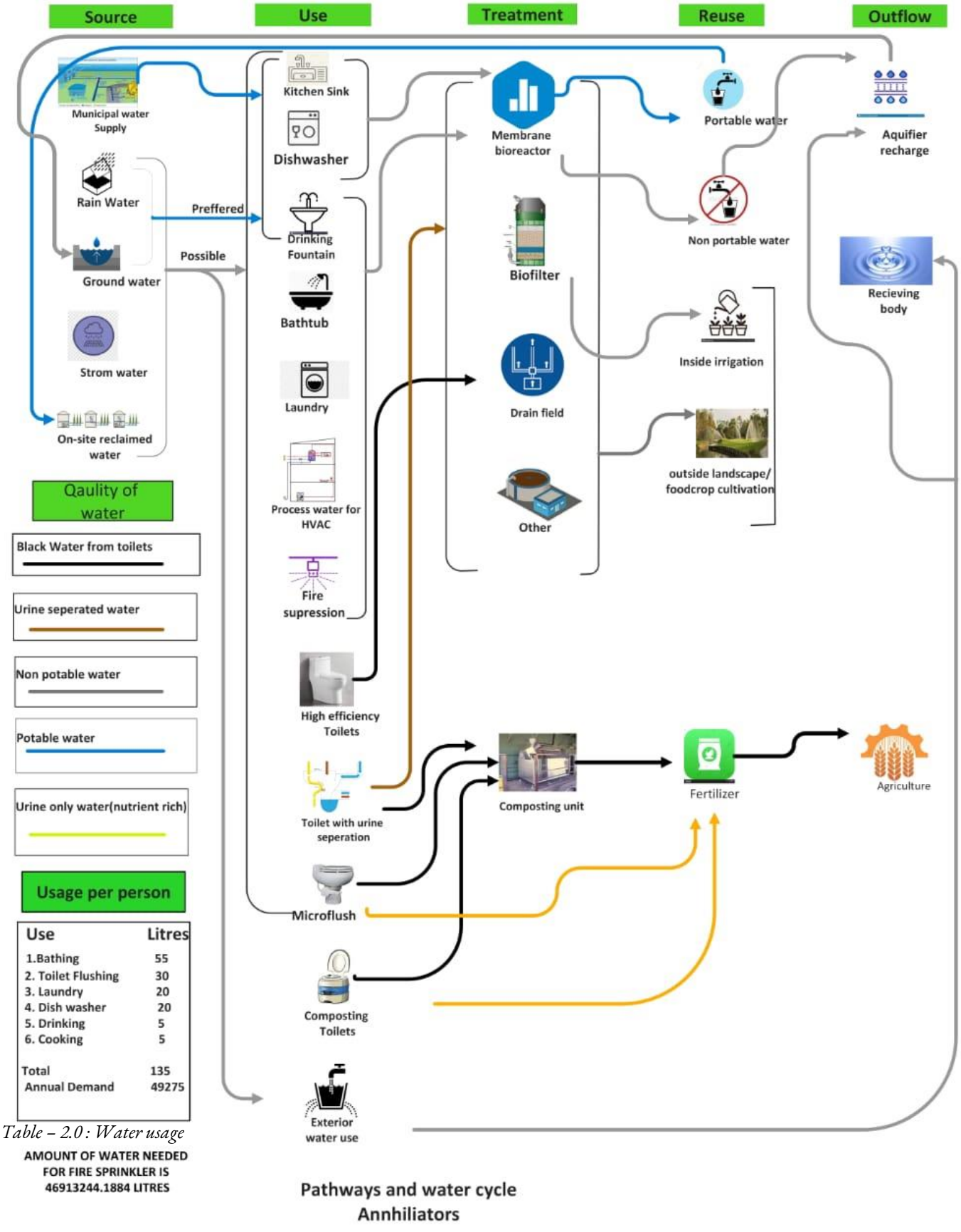


Table – 2.0 : Water usage

Fig – 16: Water Cycle Diagram – for Sobha Arbour

water management

An integrated or systematic approach to water system design gears all water-related activities to one another, thereby recognizing the interconnected nature of water and wastewater systems and allowing a concurrent evaluation of a whole system's potential costs and benefits. Augmenting existing resources through rainwater harvest, managing demand via fixture efficiencies and other conservation strategies, re-use of water prior to its release back into a larger system and on-site management of stormwater and other landscape concerns all need to be addressed in tandem, "as there is but a fine line of distinction between them."

Water Balance

The water balance is a crucial instrument to understand and manage water flows throughout the plant, to identify equipment with water-saving opportunities and to detect leaks".37 For a net zero water project, the amount of water entering and leaving a site should ideally reflect the natural hydrology of the site.

TREATMENT SYSTEM

Rainwater is typically treated after storage and before use. Treatment for non-potable uses, such as toilet flushing and irrigation, may only require filtration to prevent debris from obstructing conveyance pipes and pumps. Rainwater for potable use requires much higher levels of treatment to remove possible pathogens as well as organic and chemical compounds. These types of uses require filtration as well as disinfection

TECHNOLOGY

Best practices for designing rainwater harvesting systems utilize relatively simple, low technology methods for collection and storage of rainwater. Water should enter the cistern near the bottom of the tank where it is calmed by means of a U-tube or diffuser to avoid disturbing sediment in the tank. The supply outlet is typically located just below the water surface suspended by a float in order to avoid drawing in sediment. The tank is equipped with an overflow system so that the discharge does not cause flooding or damage to adjacent buildings and properties. The tanks require regular monitoring and cleaning and are best located in an area that is protected from light, debris and animals. In a well-functioning tank, a film layer develops on the interior surface, and beneficial micro-organisms in the sediment form an ecologic system that 'conditions' water in the tank. Care should be taken not to disturb these systems, which protect the tank walls and prevent the intrusion of harmful bacteria

common classifications of greywater light greywater:

water from bathroom sinks, shower, bathtub, laundry, drinking fountain, and equipment condensate dark greywater: water from kitchen sinks and dishwashers combined wastewater: co-mingled greywater and blackwater from toilets and urinals.

TECHNOLOGY	**DESCRIPTION**	**EXAMPLES**
Non-water discharging containment systems	Collection and processing of human wastes without the use of water	Composting toilets high efficiency toilets
Primary treatment systems	Pre-treatment and settling of particulate materials. Generally coupled with more advanced treatment technologies or with a drain field which relies on soil to filter, treat, and disperse effluent.	Septic tanks
Suspended growth	Treats water through active microorganisms suspended in aerated environments. Also known as activated sludge process	Sequencing batch reactors Membrane bioreactors
Attached growth	Treats water through active microorganisms attached to granule, organic or synthetic media. Also referred to as fixed-film processes	Recirculating biofilters Intermittent sand filters Fabric/synthetic filters
Hybrid	Utilize both suspended and attached growth processes to treat water.	Moving bed biofilm reactors

	FOOTPRINT	**OPERATING ENERGY**	**TECHNOLOGY**
Composting toilets	Small – Large	Zero – Low	Non-water discharging containment system Nutrient recovery
Recirculating biofilter	Medium	Low – Medium	Attached growth aerobic treatment
Membrane bioreactor	Small – Medium	High	Suspended growth aerobic treatment with synthetic membrane ultra-filtration.

Assumptions for water consumption:

Bathing	55litres
Toilet flushing	30litres
Laundry	20litres
Dish washer	20litres
Cooking	5litres
Drinking	5litres
Total	**135litres / person per day**
Per year 135 x 365	**49275litres / person per year**

FOR 196 UNITS:

	UNITS	PEOPLE PER UNIT	TOTAL NUMBER OF PEOPLE	WATER DEMAND 135LITRES / PERSON / DAY
2BHK	48	4	192	25920
3BHK	98	5	490	33750
COMPACT 3BHK	50	5	682	66150
TOTAL	196		1364	125820

Rain Water Harvesting

Rainfall Collection Equation

Total Harvested Rainwater = Rainfall Depth (in) x Catchment Area (ft^2) x 0.623 x System % Efficiency

Average annual rainfall in Chennai is 0.44 in

Total area exposed to rain water is 7746 m^2

Total catchment area is 70% of the total exposed area i.e., 58364.07 ft^2

System efficiency is 70% which is the ratio of catchment area and actual area.

Total Harvested Rainwater = 1119911.77 liters

Water saved

Low Flow High-Efficiency Faucet Aerators

A low-flow, high-efficiency faucet aerator lowers the fixture's water usage by about four percent. A standard faucet may be responsible for up to 15 percent of household water use. Making the switch could help us save more than **2273** litres of water every year.(445508 litres of water per 196 units)

Low Flow Water Efficient Showerheads

Standard showerheads use 11.36 litres of water per minute, meaning that a typical shower uses about 50 litres of water. A low-flow showerhead that uses 6.81 litres per minute or less can be replaced. In a home with four people who shower daily, you could save up to **3860** litres of water every year. (481760 litres of water per 196 units)

High Efficiency Toilets

Toilets use about 30% of water i.e., 40 litre per person

Usage of high efficiency toilets can reduce up to 50% of water i.e.,88 lakh litres per 196 units per year

Recycled water

Membrane bioreactors are used to recycle drinking and kitchen water and reused in toilets. Which saves 23 lakh liters of water per year per 196 units.

Total water saved= 13727268 liters of water per year per 196 units which is 29.8 percent of total water.

Rain water collected =1119911.77 liters

Total water required from municipal water and ground water is 31077120.23 liters of water.

Water Management service

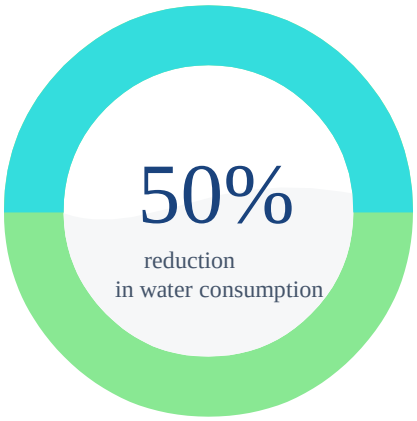
The Gold Standard in Water Meters

Solid Construction Ingress Protection 65

>98% accuracy
tested by Fluid Control Research Institute

Wireless Option with Long Range Capabilities

- Ultraprecise Metering to provide the most accurate water consumption data by excluding airflow and reverse flow.
- Ultrasonic Technology to track real-time water usage and ensure uninterrupted relay of data to our IoT-based Cloud.



6 BLOCKS
G+5 FLOORS
150 FLATS

INLET COUNT: INDIVIDUAL FLATS

PIPE TYPE	FLATS	SERIES	KIT	UTI	TOI	INLETS
25mm /CPVC	20	2 BHK	1	1	3	**100**
25mm /CPVC	130	3 BHK	1	1	3	**650**
	150	**FLATS**			**TOTAL**	**750**

INSTALLATION COST IN FLATS

BHK TYPE	PIPE TYPE/ SENSOR TYPE	PIPE SIZE/ SENSOR SIZE	SENSORS / APT	COST/ SENSOR	TOTAL COST/ APT	TOTAL SENSOR'S	NO. OF APTS	LINE TOTAL
2 BHK	CPVC/ Wired	25mm/ 33.3mm	5	3,000	15,000	100	20	**3,00,000**
3 BHK	CPVC/ Wired	25mm/ 33.3mm	5	3,000	15,000	650	130	**19,50,000**
						750	**150**	**22,50,000**

INSTALLATION COST

22,50,000

SUSCRIPTION

₹249/Home/Month

An App That Tracks Water Consumption

- **Monitor Consumption**
  At every inlet in the house
- **Track Supply**
  From every source
- **Leakage Alarms**
  Get instant app notifications
- **Shut Inlets**
  Remotely from the app
- **Pay Bills**
  Directly from the app
- **Tanker Lorry Management**
  Track supply & payments made to every vendor

STRATEGIES FOR RESILIENCE

The project addresses resilience to calamities and threats as follows:

Power back up during calamities & Design Measures for Risk Management and disruptions.

Rooftop Photo-Voltaic (PV) systems have the potential to supply electricity during grid disruptions resulting from extreme weather or other emergency situations. When in place, the Electricity System Resiliency will limit the consequences of a power disruption and specifically address protection of life and property.

Resilience to Cyclones & Heat Waves

Elevated plinth levels with essential equipment like back up pumps and generators on the raised plinth, anchoring the framing envelope, dense and tall trees, water retention areas in the landscape are some of the measures designed to mitigate the impact of cyclones and floods. Shaded rooftop areas, a more thermally resistant building envelope, and the standard provision of air-conditioned bedrooms for all units provide resiliency against heat waves.

Establishing early warning system & Communications (See Innovation App)

Smart-phone Application and feature-phone SMS provide notifications for early warning to alert residents on approaching natural disasters and recommend specific action to them. The App also provides a behavioral efficiency approach to optimize energy consumption and enable smart operation of windows based on the weather conditions

At the site level, CPVC piping and two 5-star rated submersible pumps (5.5 HP each) managed by a 3 Phase Control Panel with VFD ensure uniform water pressure. These pumps fill overhead tanks of 8KL on 24 individual towers in 4.5 hours. An extra pump provides redundancy. The pumps operate once a day to fill the overhead tanks (OHT) on each tower. The units are gravity fed from the OHT. The overall water requirement was reduced by 45% for residential uses