# FINAL DESIGN REPORT

April, 2022

Division :
Office Building


TEAMGLOBAL®
Taking business places

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# EXECUTIVE SUMMARY

*"Businesses, governments, and NGOs hold the key to this transformation, but they must commit to aggressive action. It is possible to create a world in which every single building produces zero carbon emissions, but we must start today."*

- Terri Wills, CEO of the World Green Building Council

The building sector, which is responsible for global emissions roughly equivalent to that of China, is in a dire need of transformation from its norm. We, the Team Ecocult as part of the Solar Decathlon India, have taken up this opportunity to try and design a net-zero-energy-water building for Team Global Logistics' new regional office in Chennai.

This project, SAT- PRANALI, is a G+4 story build-own/lease operate a commercial building, whose 3rd and 4th floors are going to be the office for Team Global, while the 1st and 2nd floors are planned to be rented out to their sister companies. Our aim was to provide the most cost-effective net-zero energy-water solution by integrating the various infrastructural needs of the project by working on various aspects of design, production, and execution.

With careful consideration of all the building science principles and affordability, by carrying out pre-design comfort & energy simulation we developed an optimized building massing having a huge potential for obtaining thermal comfort through natural lighting and operating the building on mixed-mode ventilation.

With a built-up area of **2486.12 sqm**, our final building design has been able to achieve an EPI of **45 kWh/sqm/year**, (a significant reduction of **56.5 %** from the GRIHA benchmark) achieving its net-zero target through solar PV generation **120485 kWh/day**. The design is also Net-zero water, combining efficient water consumption measures coupled with rainwater harvesting and wastewater recycling systems. Thus, the proposal is able to achieve a **62.8%** consumption reduction from the base case and Water Performance Index of **14.6Lpd** due to on-site rainwater and stormwater management and sewage treatment.

With each direction having its own constraints, the façade has been designed based on the requirement and with the thought of how it can cater to the indoor comfort need along with the appearance and aesthetic factors. By properly calculating Wall-Window Ratio (WWR), we have achieved IMAC mixed-mode ventilation with **30%** natural ventilation and **100%** comfortable operating hours.

Through the constant back and forth process, an initial search and exploration of all possible options, and setting the goals right, the focus has been to reduce not only energy & water consumption but also to address the well-being of users and the challenges of affordability & marketability, resulting to the proposal whose incremental construction cost is increased by **3.7%** from the base case, but in long run ,the proposal proves to be efficient than the base case.

# TEAM INTRODUCTION

TEAM NAME : ECO CULT

INSTITUTION(s) NAME : RV College of Architecture , RV College of Engineering

DIVISION : Office Building

TEAM MEMBERS :

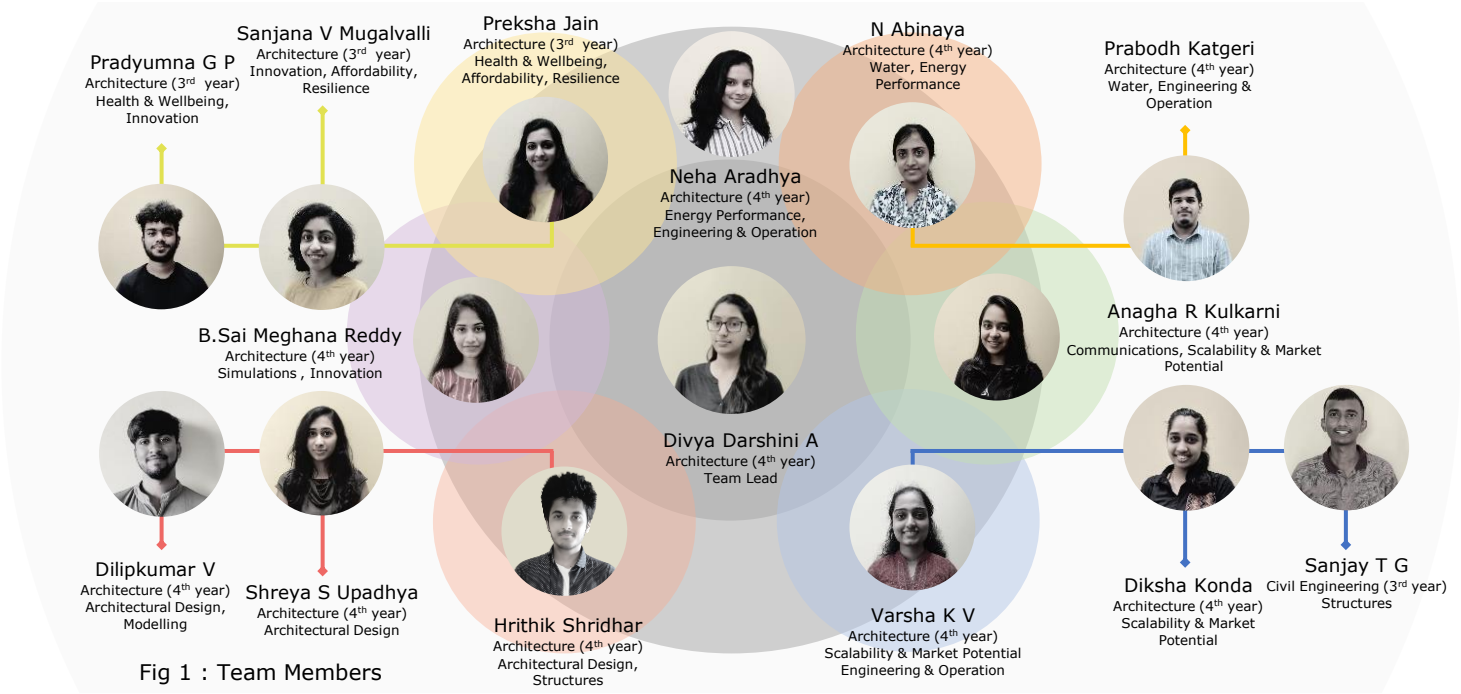



Fig 1 : Team Members

## APPROACH

Team Ecocult comprises student members with a diverse skillset. The approach to organizing the team involved introspecting and realizing each member's strengths and fields of interest. Roles and responsibilities were assigned in a flexible manner while simultaneously considering the 10 contests. The various topics were addressed as a team and decisions were made democratically. The plan was to approach the design head-on by establishing a robust understanding of the financially viable design options, along with the site context and climatic parameters to arrive at the design goals that conform to our aim of creating a comfortable, high-performance building.

## BACKGROUND OF LEAD INSTITUTE:

R.V. College of Architecture (RVCA), was established in 1992, as the Department of Architecture in R. V. College of Engineering (RVCE), Bengaluru. In 2014 they shifted to a new campus and function independently with a vision of being an architecture institute par excellence, nurturing academics, profession, and research for a sustainable contemporary society.

FACULTY LEAD:
Prof. Girish Ramanathan

FACULTY ADVISOR:
Ms. Anupriya Saxena

Fig 2 : Faculty Members

## INDUSTRY PARTNERS

Blue Star is India's leading air conditioning and commercial refrigeration company along with other businesses which include marketing and maintenance of imported professional electronics and industrial products and systems.

## DOCUMENTATION OF DESIGN PROCESS

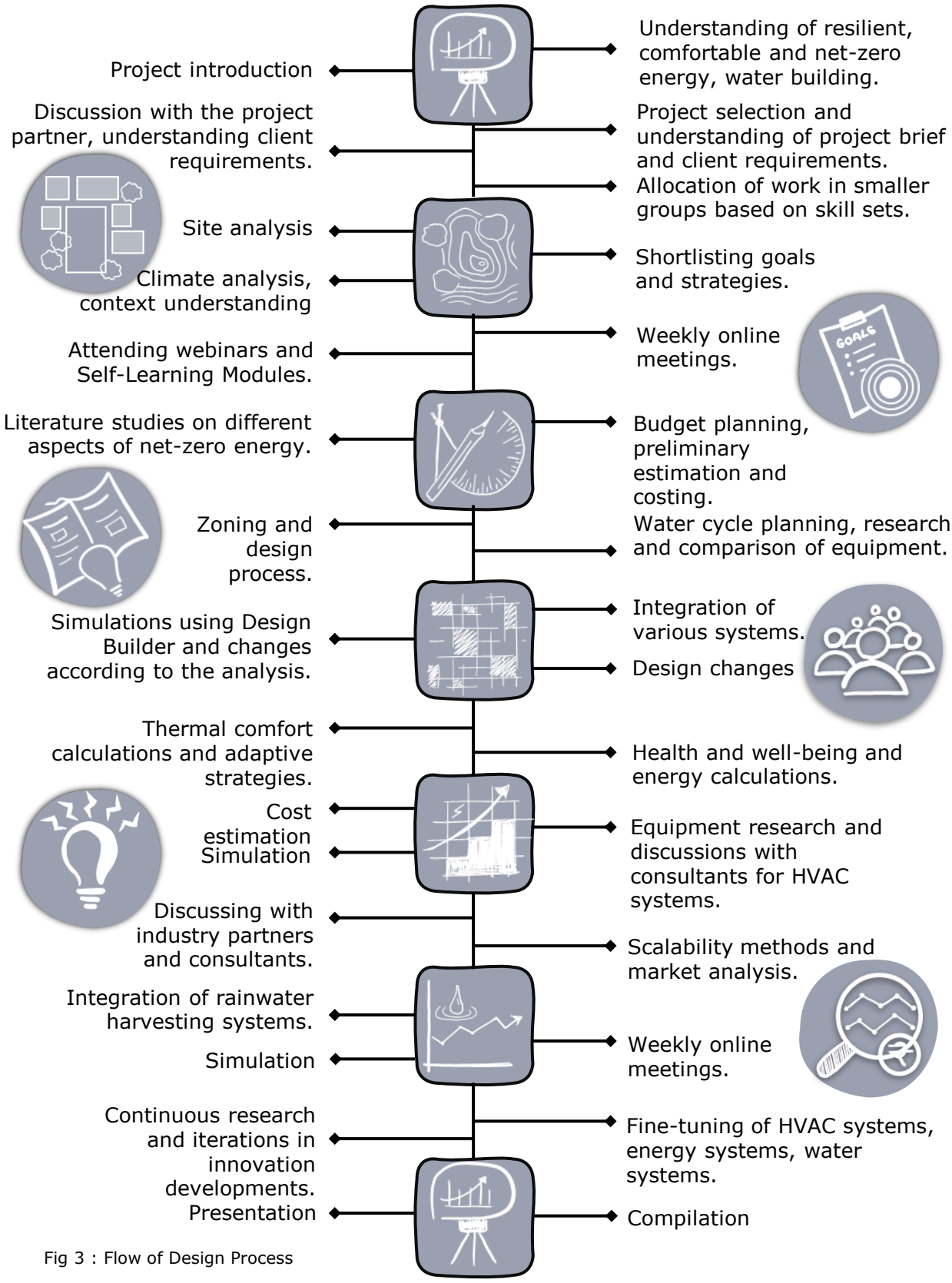
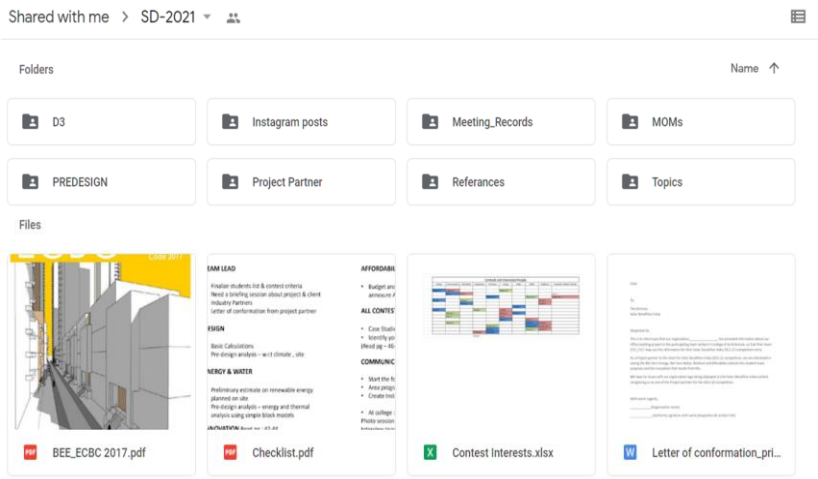



Fig 3 : Flow of Design Process

Team Ecocult followed an integrated design approach by establishing the goals of each contest and their interrelations. The design process started with understanding the site and its strengths through SWOT analysis. This was further integrated with a climate analysis and understanding of the micro-climate of Mylapore, Chennai.




Constant weekly meetings with the team were scheduled, to strengthen the process and achieve the goals. The minutes of meetings were recorded and proper planning of weekly goals and targets was done to avoid end delays. All the research done was added to the drive for future references.

TOOLS USED :

Fig 4 : Tools Used

## CHALLENGES FACED & APPROACH TAKEN TO OVERCOME:

The team faced constant difficulty in finalizing the best solution among the shortlisted options. Further meetings were scheduled with various specialists and consultants to guide us in the selection process of the best solution among the shortlisted possible solutions. Simulations were run regularly to compare base cases and shortlisted system efficiency to finalize one particular option. We would like to take this opportunity to thank **Ar. Indranil Bhattacharya** (BRAE Consulting Services Pvt. Ltd), **Mrs. Mini Sastry** (Consultant at IFC), Mr. **Suresh K Murthy** (Dean of RVCA) and **Mr. Saikat Banerjee** (Pinnacle Consulting Engineers) for providing guidance to the team in this journey.

# PROJECT BACKGROUND

PROJECT NAME: SAT-PRANALI

PROJECT PARTNER: TEAM GLOBAL

Team Global is an integrated Logistics services provider headquartered in Mumbai, India. They offer services in multiple segments of logistics Viz. Sea Freight, Airfreight, Project Cargo Transportation, Cargo Terminals and Coastal Shipping. Being a Non-govt company, incorporated on 25 Apr 2005; it has 18 offices in India, Bangladesh, Kenya and Tanzania. ( https://www.teamglobal.in/ )

NAME & DESIGNATION OF KEY INDIVIDUAL INVOLVED: Vivek Kele, Director at Team Global Logistics Pvt Ltd

BRIEF DESCRIPTION OF THE PROJECT:Team Global wanted to open its regional office in Chennai, for which they had acquired a plot of 8400 sq. ft in P.V Kovil Street. Their intent is to create an eco-sensitive building while availing maximum FSI. Being a build-own/lease-operate building, two floors will be utilized by the Team Global and the other floors are to be rented out to their sister companies.

LOCATION: Mylapore, Chennai
LATITUDE: 13° 2'33.77"N
LONGITUDE: 80°16'28.99"E
CLIMATE ZONE: Warm & Humid
PROFILE OF OCCUPANTS: White-collar workers
HOURS OF OCCUPATION: 9 am – 5 pm
CURRENT STATUS OF THE PROJECT: Waiting for approval (was on hold due to pandemic)


Fig 5 : Google Earth image of the site

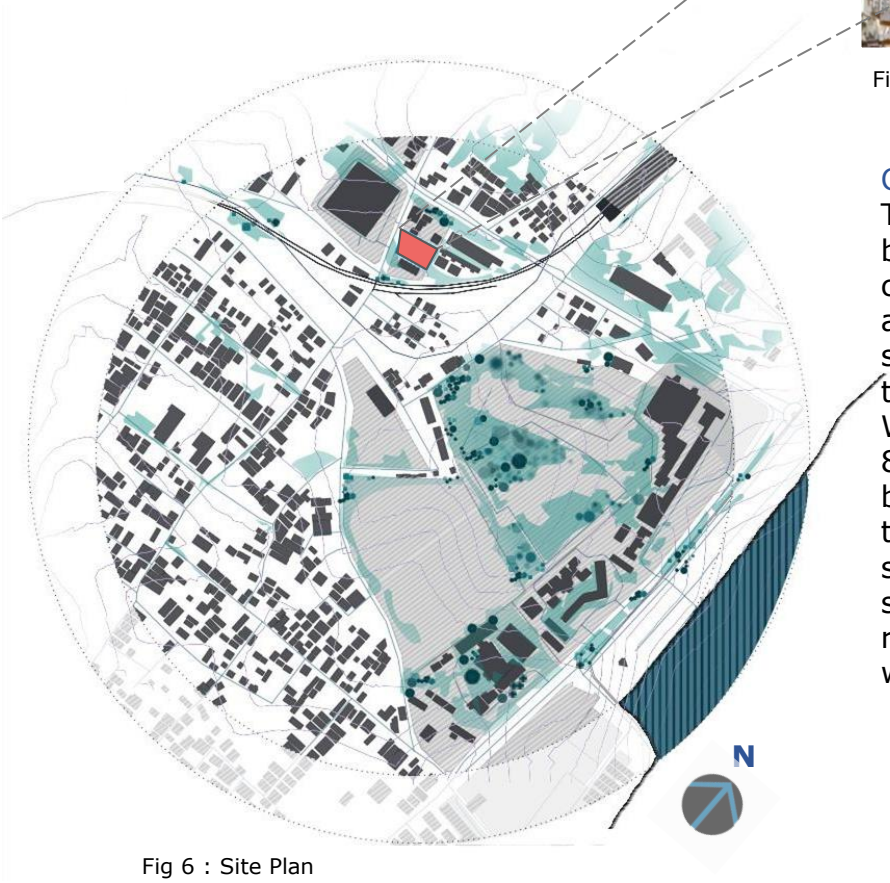



Fig 6 : Site Plan

CONTEXT

The site is located on a busy street with a city central mall (140m away) on the opposite side, and right next to the Mediscan building. While the shoreline is 815 m away, the Gandhi beach is just 582 m from the site on the eastern side. On the southern side of the site, there is a railway line and canal as well.

## SPECIAL REQUIREMENTS OF THE PROJECT PARTNER:

Since this building is designed to be the south zone regional office for Team Global, the client has requested for the logo to be displayed on the West side facing the road.

## AREA STATEMENT

As per Tamil Nadu combined development building rules, the site is classified under CBA, hence there are no side and rear setbacks. The front setback is left based on the road width. The maximum FSI allowed is 3.15

| | |
|---|---|
| SITE AREA | 780.67 sqm |
| PERMISSIBLE BUILT UP AREA | 2578.45 sqm |
| PROPOSED BUILT UP AREA | 2486.12 sqm |
| GROUND COVERAGE | 594.54 sqm |
| ROOF AREA | 516.67 sqm |

Air-conditioned area

Non- air-conditioned area

| SL NO | PARTICULARS | NOS. | AREA(sq.m) | TOTAL AREA(sq.m) |
|---|---|---|---|---|
| 1 | RECEPTION / WAITING AREA | 4 | 28.4 | 113.6 |
| 2 | TEAM HEADS CABIN | 4 | 18.3 | 73.2 |
| 3 | MEETING ROOM | 4 | 20 | 80 |
| 4 | MANAGER'S CABIN | 4 | 13.24 | 52.96 |
| 5 | ASST. MANAGER'S CABIN | 4 | 12.46 | 49.84 |
| 6 | WORKSTATIONS | | | |
| 6.1 | FIRST FLOOR | 1 | 186.4 | 186.4 |
| 6.2 | SECOND FLOOR | 1 | 186.36 | 186.36 |
| 6.3 | THIRD FLOOR | 1 | 175.25 | 175.25 |
| 6.4 | FOURTH FLOOR | 1 | 165.58 | 165.58 |
| 7 | BMS ROOM | 1 | 13 | 13 |
| 8 | SERVER ROOM | 4 | 10.76 | 43.04 |
| 10 | ELECTRICAL ROOM | 1 | 17 | 17 |
| 11 | STAIRCASE 1 | 5 | 21.9 | 109.5 |
| 12 | STAIRCASE 2 | 5 | 25.4 | 127 |
| 13 | LIFT | 5 | 4.6 | 23 |
| 14 | LIFT LOBBY | 5 | 9 | 45 |
| 15 | SHAFTS | | | 30 |
| 16 | TOILETS | 4 | 38 | 152 |
| 17 | PANTRY | 4 | 18.6 | 74.4 |
| 18 | PASSAGE | 4 | 14 | 56 |
| 19 | PARKING | 1 | 516.67 | 516.67 |
| 20 | STORAGE | 4 | 12.5 | 50 |
| TOTAL | | | | 2,486.12 |

Table 1 : Area Programme

## CONSTRUCTION BUDGET

| Project Summary | | | | | | |
|---|---|---|---|---|---|---|
| | | | Baseline Estimate (Project Partner / SOR basis) | | Proposed Design Estimate | |
| S.No. | Particulars | Definition | Amount (Rs Millions) | % | Amount (Rs Millions) | % |
| 1 | Land | Cost of land purchased or leased by the Project Partner | 68.84 | 46.70% | 68.84 | 46.70% |
| 2 | Civil Works | Refer Item A, Civil works in Cost of construction worksheet | 49.32 | 33.50% | 49.22 | 33.40% |
| 3 | Internal Works | Refer Item B, Civil works in Cost of construction worksheet | 5.71 | 3.90% | 5.93 | 4.00% |
| 4 | MEP Services | Refer Item C, Civil works in Cost of construction worksheet | 8.62 | 5.90% | 13.23 | 9.00% |
| 5 | Equipment & Furnishing | Refer Item D, Civil works in Cost of construction worksheet | 2.62 | 1.80% | 2.62 | 1.80% |
| 6 | Landscape & Site Development | Refer Item E, Civil works in Cost of construction worksheet | 0.17 | 0.10% | 0.63 | 0.40% |
| 7 | Contingency | Amount added to the total estimate for incidental and miscellaneous expenses. | 7.01 | 5.00% | 7.27 | 5.00% |
| | **TOTAL HARD COST** | | **142.29** | **96.90%** | **147.74** | **100.40%** |
| 8 | Pre Operative Expenses | Cost of Permits, Licenses, Market research, Advertising etc | 1.38 | 0.90% | 1.38 | 0.90% |
| 9 | Consultants | Consultant fees on a typical Project | 3.58 | 2.40% | 3.58 | 2.40% |
| 10 | Interest During Construction | Interest paid on loans related to the project during construction | - | 0.00% | - | 0.00% |
| | **TOTAL SOFT COST** | | **4.96** | **3.40%** | **4.96** | **3.40%** |
| | **TOTAL PROJECT COST** | | **147.25** | **100.00%** | **152.7** | **103.70%** |
| | **Total Project Cost per Sq.m of Built-up Area** | | **72,183** | | **74,853** | |

Table 2 : Base vs Proposed - Construction Budget

## PERFORMANCE SPECIFICATION

| | |
|---|---|
| **GENERAL** | |
| Built up Area | 2486.12 sqm |
| Electricity Rate | 8 INR/kWh |
| Average occupant density | 10m2/ person |
| Building Occupancy Hours | 9:00am - 5:00pm |
| **ENVELOPE** | |
| Wall assembly U value | 0.22 W/m2.K |
| Roof Assembly U value | 0.21 W/m2.K |
| Window U value | 2.2 W/m2.K |
| SHGC | 0.5 |
| VLT | 61% |
| Exterior Shading Device | Horizontal shading device with vertical fins and plantation boxes |
| **HVAC** | |
| System Type | Radiant Cooling System with DOAS |
| Mixed Mode Strategy | Windows are open when operative temperature lies within the IMAC thermal comfort band below 29 deg. This is possible during the months of November, December and January |
| Cooling Capacity | 37.23 TR |
| Operation Hours | 9:00am - 5:00pm |
| **LIGHTING** | |
| Interior Average Lighting Power Density | 0.71 W/ft2 |
| **RENEWABLE ENERGY** | |
| Type | Monocrystalline Photovoltaic Panels |
| Efficiency | 19.20% |
| Generation Capacity | 120485 kWh |
| Installed Capacity | 80.1 kW |
| **EPI** | |
| Proposed EPI | 45 kWh/ sqm per year |
| EPI Breakdown by use | |
| Cooling | 25.24kWh/ sqm per year |
| Lighting | 3.33kWh/ sqm per year |
| Equipments | 14.69kWh/ sqm per year |
| **WATER SYSTEM** | |
| Total Daily Consumption | 3368 Lpd |
| Domestic Requirement | 3277.064 Lpd |
| Flushing Requirement | 90.936 Lpd |
| Treated Black-water | 5,06,827 L/year |
| Treated Grey-water | 7,23,335 L/year |
| Total Treated Water | 12,30,162 L/year |

Table 3 : Performance Specification

## GOALS

### Architectural Design

To design a building that achieves a balance between form and function. **(Effective implementation of passive design strategies).** Efficient handling of the high humidity levels by wise use of air movement across the building. **(Achieved using Double skin on western façade and usage of shading devices on southern façade to reduce the heat gain).** An "irresistible staircase" provided for the health and well being of the employees as a buffer zone.

### Energy Performance

To achieve a net-zero energy building with a target EPI of 54 kWh/sqm/year(GRIHA benchmark = 108 kWh/sqm/yr)
**(Net site energy =1,24,997 kWh; Achieved EPI = 45 kWh/sqm/year)**

### Water Performance

To achieve a net-zero water building. Target Water Performance Index (WPI) < 45 Lpd (Base value –from NBC). **(Achieved WPI = 16.4 Lpd)**
To reuse and recycle greywater and treat black water efficiently on site. **(Greywater - evapotranspiration & infiltration; Blackwater - composting unit)**

### Resilience

To create a pandemic proof design, and have all the required backup prepared in case of any emergency.
**(The building can sustain with the energy produced through solar panels and has water backup for 17 days.)**

### Health & Wellbeing

To achieve 100% comfortable operating hours as per IMAC. **(Achieved)**
To provide an effective ventilation system and ensure good indoor air quality and provide visual comfort and well-being.**(Achieved)**

### Affordability

Adapting cost effective strategies to reduce the construction cost and decrease the life cycle cost by 30%.**(Achieved 34.6% reduction)**

### Communication

To create awareness among peers in the architecture and the general public about 'net'-zero-energy buildings and sustainable methodology.
**(Official Instagram - Team ECOCULT: Impressions - 7422 accounts; Reach – 3434 users; 107 accounts engaged )**

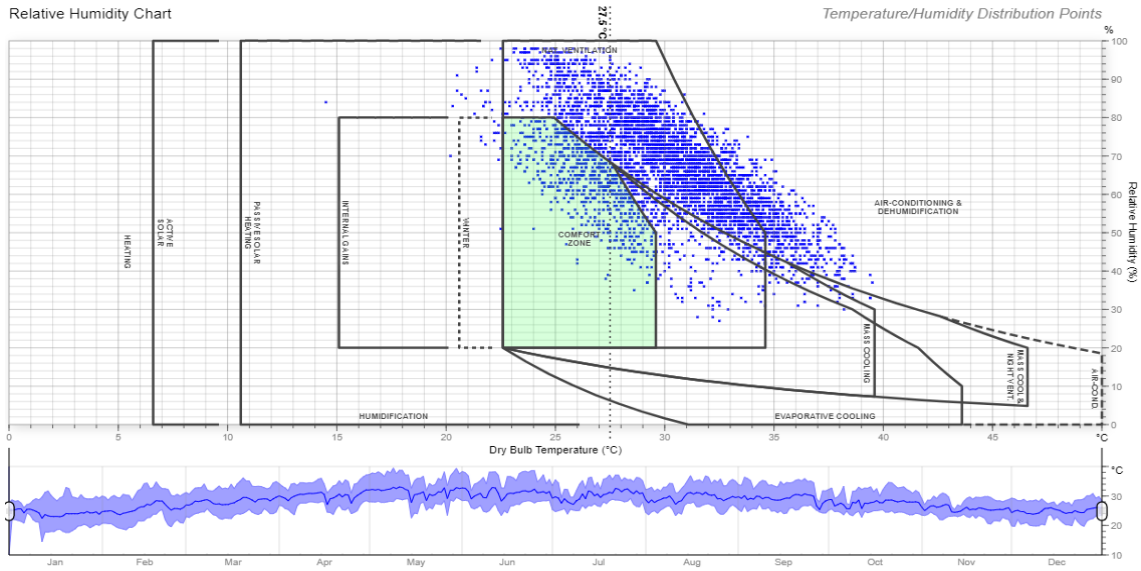
### Safety & Security

Physical protection of the assets and occupants of the office building from man made or natural accidents. **(Incorporation of fire protection system and placement of First aids for emergency usage)**

Fig 7 : Goals & Strategies

# PRE-DESIGN ANALYSIS

The location of the project is in Chennai. It is classified as Aw. Tropical wet and dry or savanna type according to Köppen– Geiger climate zone. A detailed climatic study was conducted to understand the combination of strategies that could be adopted to enhance the building's performance and achieve 100% comfortable operational hours. Considering the relative humidity levels to be >65% (monthly average), and the Cooling Degree days (CDD) for Chennai as 4108 hours, that is, 47% annually, cooling and dehumidification are considered very essential for this type of climate.




Source: Givoni Bioclimatic chart – AndrewMarsh.com for Chennai

Fig 8 : Psychrometric Chart

The IMAC (India Model for Adaptive Comfort) is developed based on thermal comfort surveys of office buildings across India. Climate analysis shows that there is a potential for utilizing favourable outdoor environmental conditions for about 7.5% of the operational period. And for about 49%, comfortable hours can be achieved through passive design strategies and natural ventilation. Hence the building is designed for a mixed-mode operation. According to IMAC, for mixed-mode buildings, the 90% accessibility is 3.5°C from the neutral temperature.

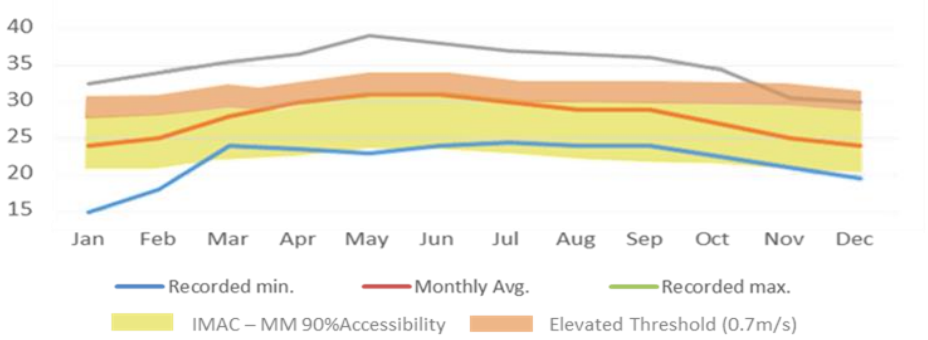
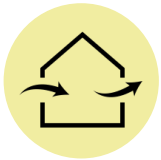


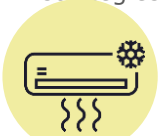

Fig 9 : Adaptive Comfort Band for Mixed mode office building as per IMAC , for Chennai



Natural Ventilation

Increased Air velocity at 0.7m/s

Passive design strategies



Cooling and dehumidificatio n

By introducing an elevated airspeed of 0.7m/s, the upper comfort threshold is further increased by 2.5°C as given by ASHRAE 55-2017. The increased airspeed is achieved through ceiling fans which allows them to adjust the temperature threshold by 2.5°C, providing comfortable hours during unconditioned times.
(Calculated using CBE Thermal comfort tool)
**Operative temperature = (0.25 x DBT (30-day running mean) +17.87**

# Thermal Comfort Analysis

The use of low thermal conductivity materials, envelope optimization, efficient WWR and natural ventilation helped in decreasing the internal heat gain by 70 % (from the base case).

Internal heat gains due to office equipment and human metabolism and solar heat gains lead to an increase in the operative temperature indoors by about 1-2.5 degrees Celsius. However, about 1000 operational hours lie under the comfort band with 90%acceptability as shown in Figure 11.

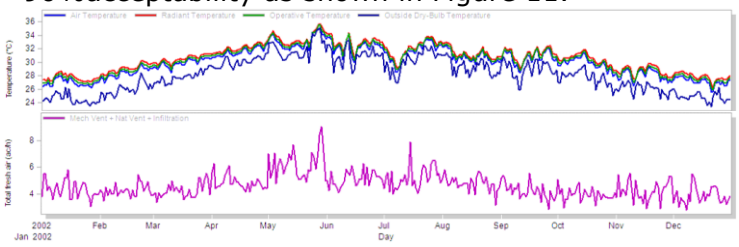



Figure 10: Thermal simulation (proposed case)

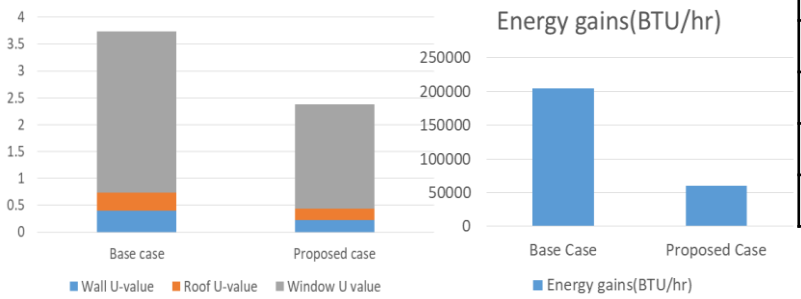



Table 5: Envelope optimization for thermal comfort

| Month | Mixed Mode buildings Max. Temp. \|Min. Temp. | | Thermostat set point |
|---|---|---|---|
| Jan | 28.36 | 21.44 | 28.2 |
| Feb | 28.69 | 21.44 | 28.1 |
| Mar | 29.13 | 22.21 | 29.4 |
| Apr | 29.69 | 22.77 | 29.6 |
| May | 30.31 | 23.39 | 30.1 |
| Jun | 30.53 | 23.61 | 30.3 |
| Jul | 30.00 | 23.08 | 29.8 |
| Aug | 29.75 | 22.83 | 29.6 |
| Sep | 29.66 | 22.74 | 29.7 |
| Oct | 29.41 | 22.49 | 30.0 |
| Nov | 29.01 | 22.09 | 29.7 |
| Dec | 28.63 | 21.71 | 28.6 |

Table 4: IMAC - MM 90% acceptability comfort bands

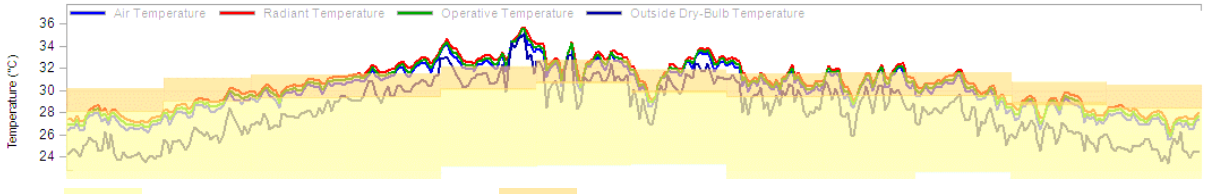



Fig 11: Adaptive Comfort Band overlay on Annual simulations graph

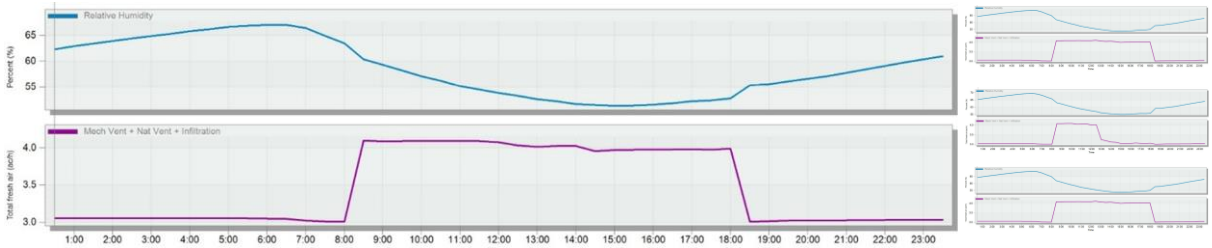



Fig 12: Relative Humidity graphs for 1st Jan, Feb, Nov and Dec

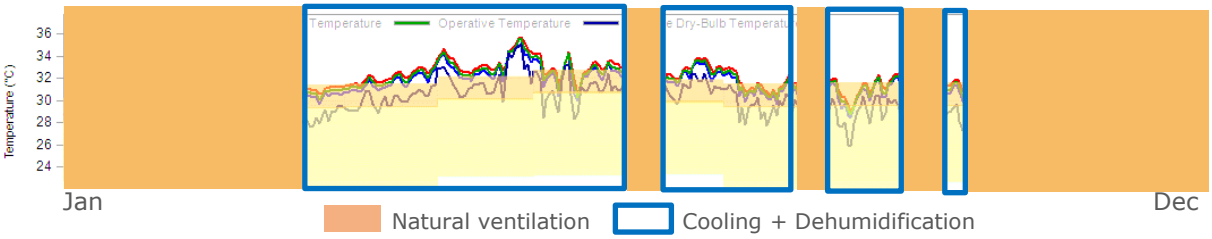



Fig 13: Modes of operation throughout the year

The simulations show that for about 30% of the year, the indoor temperatures lie under the comfortable bands and cooling + dehumidification is required for the rest of the year to achieve 100% comfortable hours.

# DESIGN DEVELOPMENT

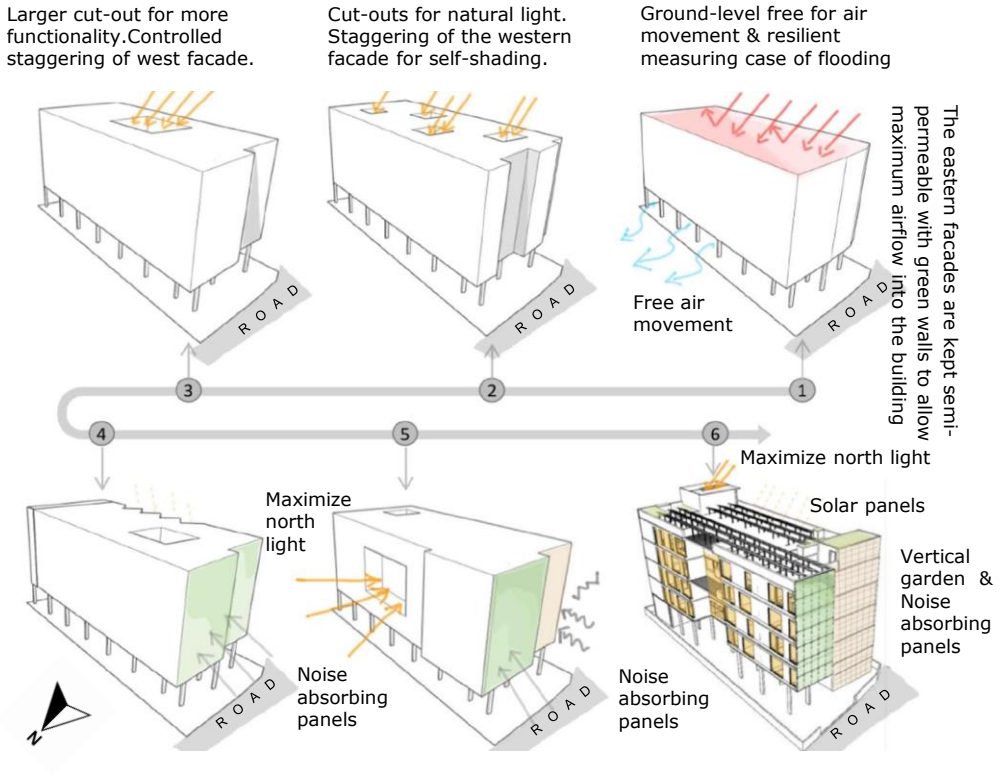



Fig 14 : Design development


Fig 15 : Zoning

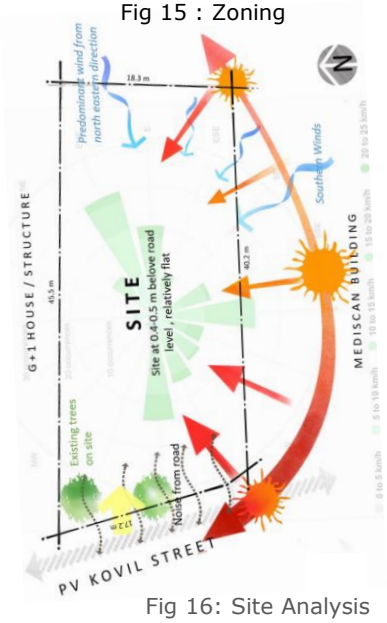



Fig 16: Site Analysis

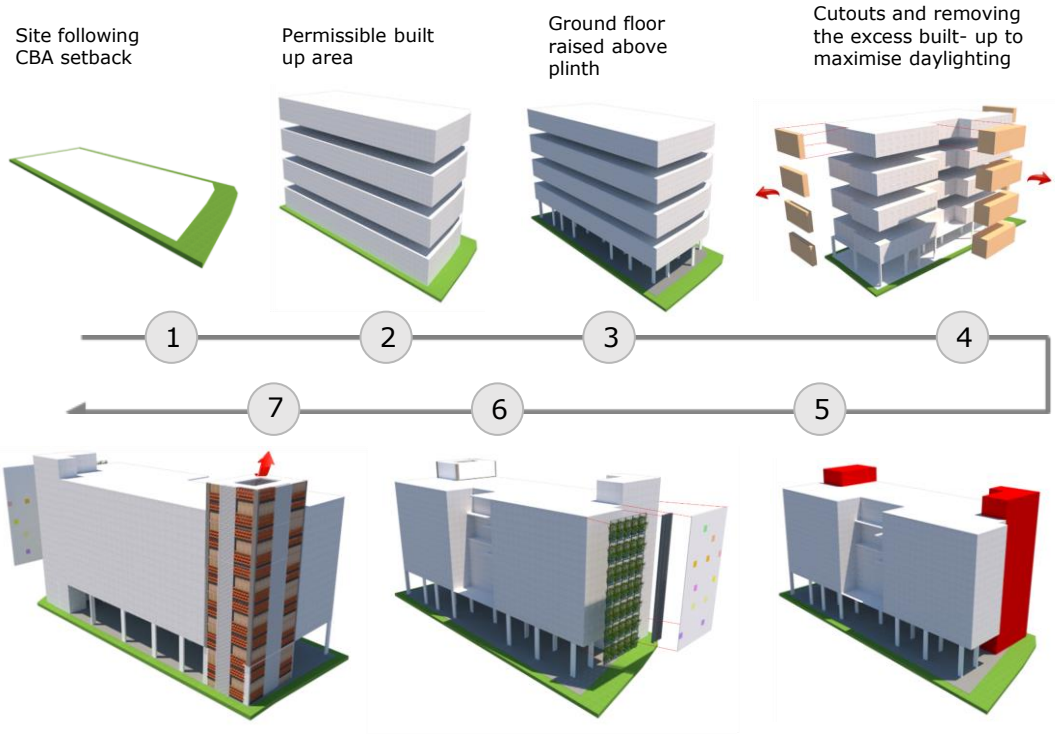



Fig 17: Form development

## Building Orientation

The orientation of the building is along the long axes in the east-west direction.

The longest façade faces north and south directions along with a short wall facing the east and west direction as per the climatic condition on the site.

## Plan at level 1 & 2


## Plan at level 3


LEGEND

1. Reception and lobby
2. Fire Staircase
3. Lift Lobby
4. Lift
5. BMS Room
6. Storage
7. Manager's cabin
8. Conference room
9. Assistant cabin
10. Open workstation
11. Cabin 1
12. Cabin 2
13. Washrooms
14. Irresistible staircase
15. Pantry
16. Balcony

Public

Private

Fig 18 : Floor Plans


Fig 19 : Longitudinal Section


Fig 20: Rendered exterior view

## DESIGN

**Northern Facade** - Maximizing daylight and allowing for cross ventilation.

**Southern facade** - Maximizing airflow into the building and controlled light without much thermal heat gain.

**Western facade** - Double skin with green wall facade and noise absorbing panels to generate electricity.

**Eastern facade** - Irresistible staircase with planter boxes to provide airflow into the building that reduces the heat gain into the building.

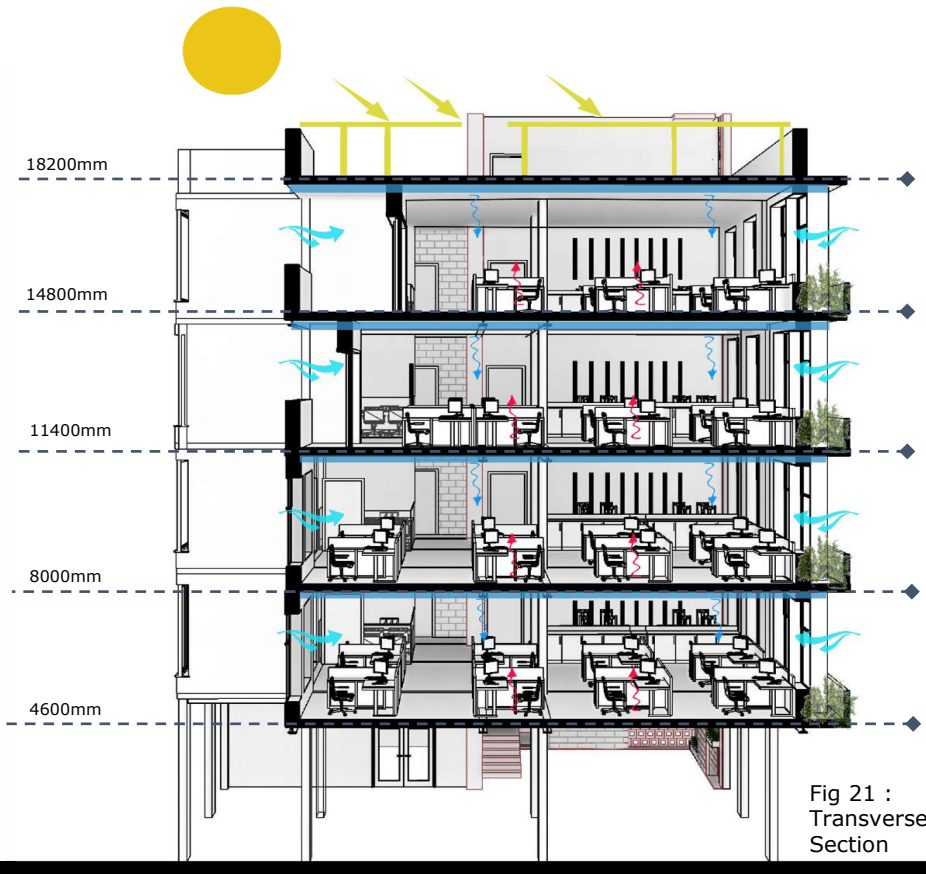
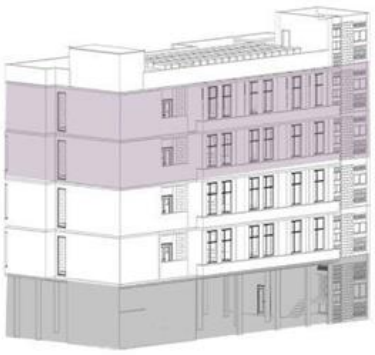


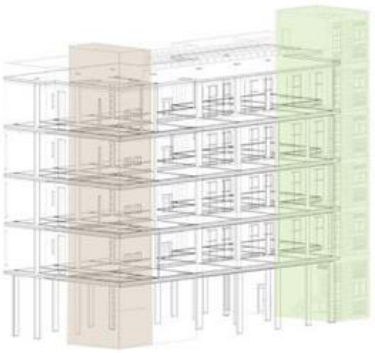

Fig 21 : Transverse Section

## DESIGN



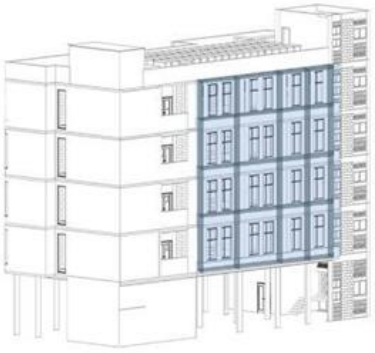
PROGRAM

- Team Global Office
- Other Rental Offices
- Parking



VERTICAL TRANSPORTATION

- Fire Tower : Staircase, Lift
- Irresistible Staircase



SHADING DEVICES

Horizontal shading device with vertical shades integrated with planter boxes

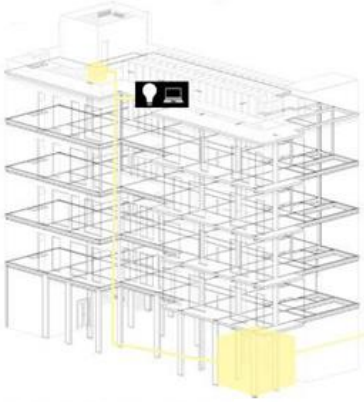
FRONT ELEVATION

Noise absorbing panels integrated on front facade that converts into electrical energy

## ENERGY

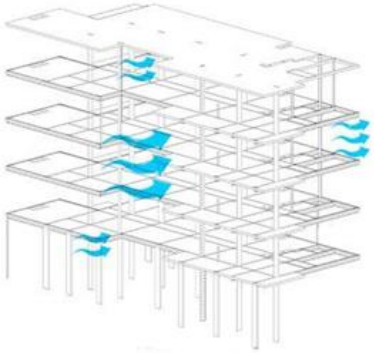
ENERGY POTENTIAL

25 year technology of monocrystalline solar panel



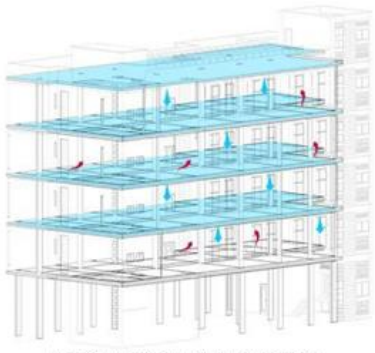
LIGHTING & EQUIPMENT

100% renewable energy on site is used



NATURAL VENTILATION

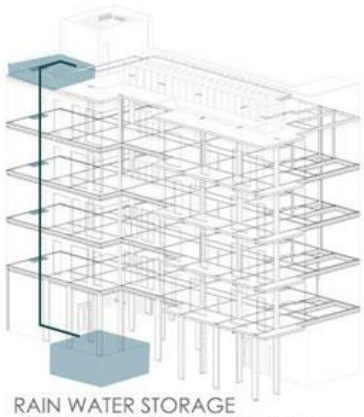
Cross flow openable windows & balconies



MECHANICAL VENTILATION

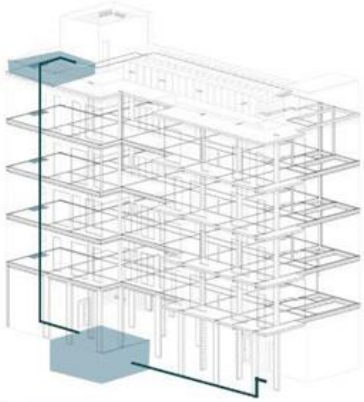
Radiant cooling system with DOAS system

## WATER



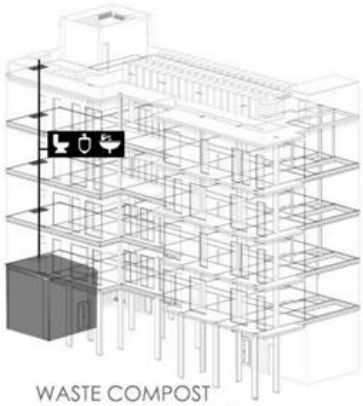
RAIN WATER STORAGE

Rain water on site is collected to meet the demands



FRESH WATER

Rest of the the demand is met by municipal supply, surface runoff & ground water



WASTE COMPOST

Composting units for treating black-water.

GREY WATER TREATMENT

100% treatment on site by Evapo-trapiration & Infiltration



Fig 22: Design Strategies

## ENERGY PERFORMANCE

### PASSIVE DESIGN

- Envelope Optimization
- Shading
- Irresistible Staircase to discourage elevator use
- Natural Ventilation

### Target Energy Performance Index

GRIHA benchmark for EPI = **108** kWh/sqm per year

Achieved EPI = **45** kWh/ sqm per year

### EFFICIENCY

- Maximize Daylighting
- Efficient equipment
- Efficient lighting fixtures

### OPERATION

- Radiant slab cooling with DOAS
- Mixed mode operation
- High-performance glass
- High-performance walls & roof

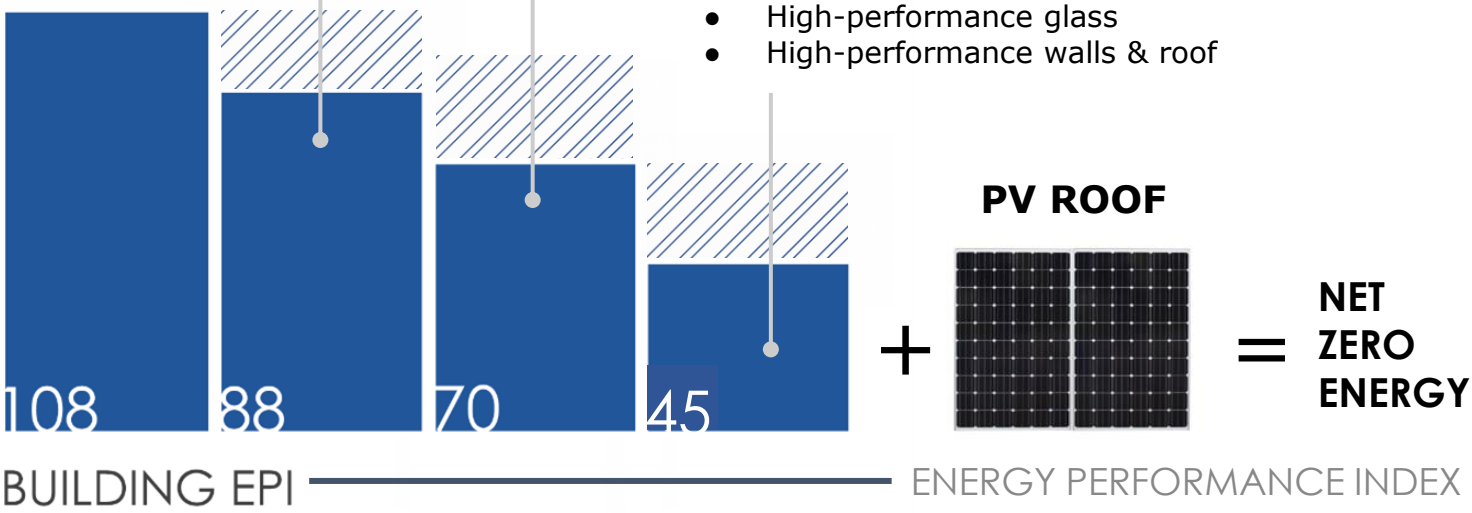



Fig 23: The path to net zero building

Building massing and orientation, as well as insulated walls, control heat gain. The building's windows face south and north to improve daylighting and solar control. Several simulations and analyses were done to get the final proposed design.

Our goal to achieve net-zero energy building is done by using several passive design strategies, efficient lighting fixtures and equipment and an optimized HVAC system

In targeting net-zero energy we calculated the amount of energy falling on-site from the sun and noise from the streets that is converted into electrical energy using high technology & innovative methods.

In the context of lying in a hot & humid climate, the major concern was to minimize heat gains in the building. This was achieved by using natural ventilation for passive cooling and a radiant cooling system with DOAS.

Simulation software made it easy to analyze the design to get better results. Daylight analysis also helped us in massing the project.

## Envelope Optimisation

Building massing and orientation, as well as insulated walls, control heat gain. The building's windows face south and north to improve daylighting and solar control. Several simulations and analyses were done to get the final proposed design.

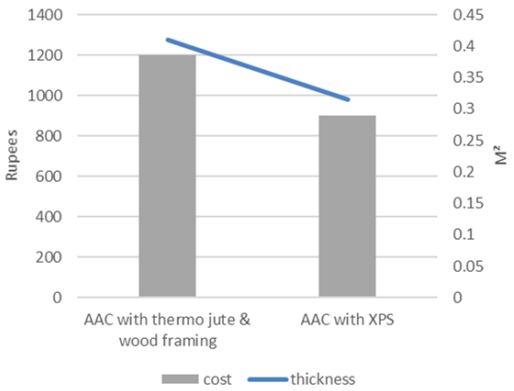
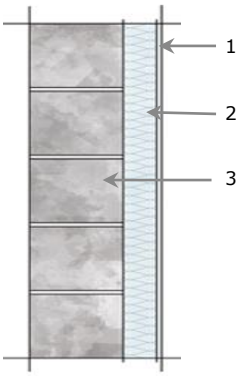
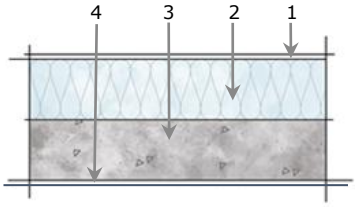



Fig 23: Comparison between AAC blocks with XPS and thermo-jute with wood framing




1. Outer Plaster
2. XPS
3. AAC
4. Inner Plaster

Fig 24 :Wall and Roof details

| Façade Direction | WWR |
|---|---|
| North | 40% |
| South | 25% |
| East | 10% |
| West | 4.5% |

| | WALL | ROOF | WINDOW |
|---|---|---|---|
| STANDARD DESIGN | Outer cement plaster 0.01m +XPS 0.07m+ brickwork 0.2m + inner cement 0.01m **U VALUE - 0.4** | Cement plaster 0.01m +XPS 0.00m+ RCC slab 0.15m + inner cement 0.01m **U VALUE - 0.33** | 6mm (solar control glass) - 12mm air gap - 6mm clear glass **U VALUE - 3** |
| PROPOSED DESIGN | Outer cement plaster with AAC 0.225m +XPS 0.08m+inner cement 0.012m **U VALUE - 0.22** | Outer cement plaster 0.01m +XPS 0.015m+ RCC slab 0.15m + inner cement 0.012m **U VALUE - 0.21** | Vertical sealed double glazed window - 20mm air gap - ordinary glass of medium coloured having SHGC 0.22 **U VALUE - 1.95** |

Table 6 : U- Values

## HVAC Optimisation

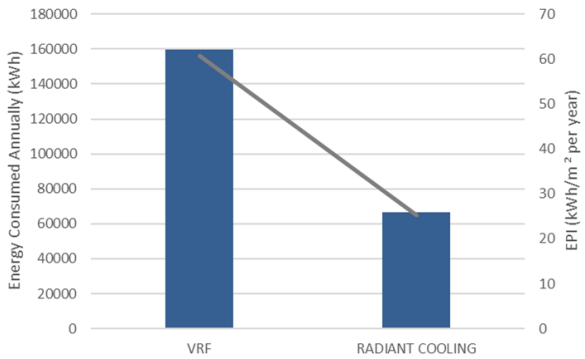
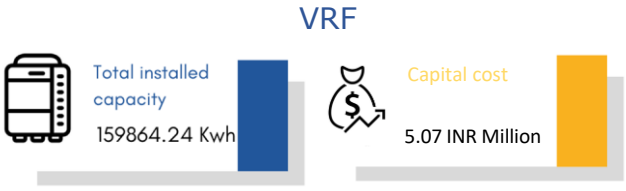
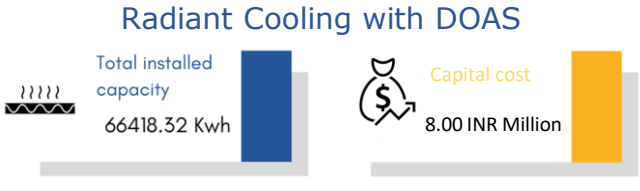



Fig 25: Comparison between VRF and Radiant Cooling with DOAS

HVAC optimization has been done with respect to the functionality in spaces which includes workstations, cabins, conference rooms, reception and manager and assistant cabins. Several analyses and simulations were done considering Baseline, VRF and Radiant Cooling with the DOAS system that helped in energy reduction.

DOAS- dedicated outdoor air system
VRF- Variable refrigerant flow



## Solar Potential

The site receives an average solar irradiance of 5.5kWh/sqm per day which promises a positive solar potential. The horizontal terrace receives maximum solar irradiance compared to the building facade. The solar panels are placed on the terrace as well as mumty to meet the demands of energy requirements. PVWatts was used to calculate the solar energy generated on the site. Along with a solar array, sound-absorbing panels on the west facade have the capacity to generate 3kW and energy savings of 4512kWh.

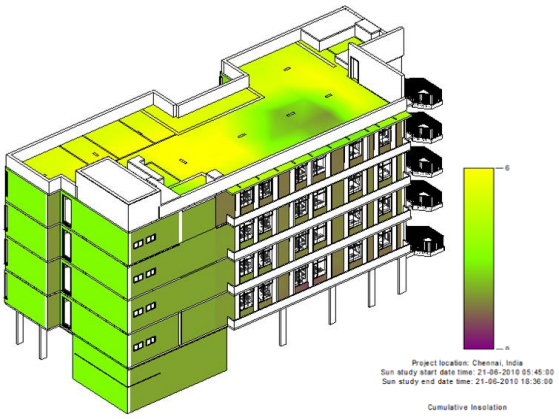
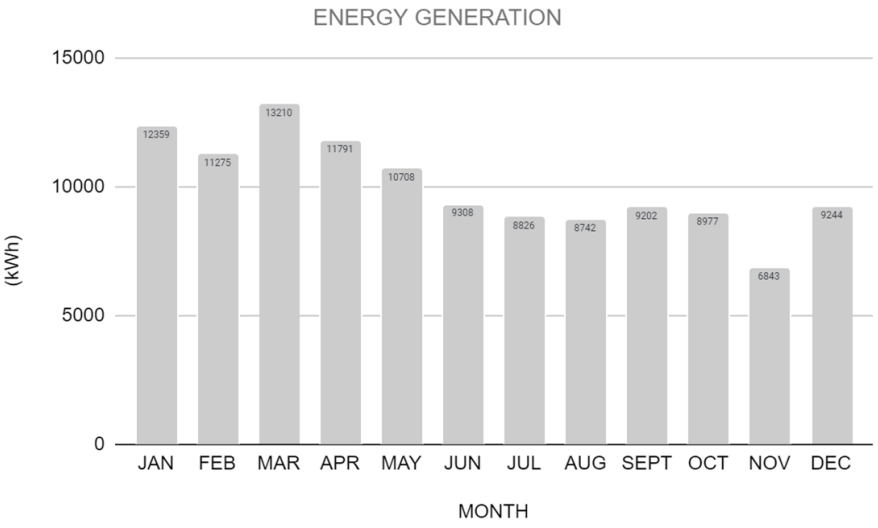


Fig 26: Solar Irradiance simulations



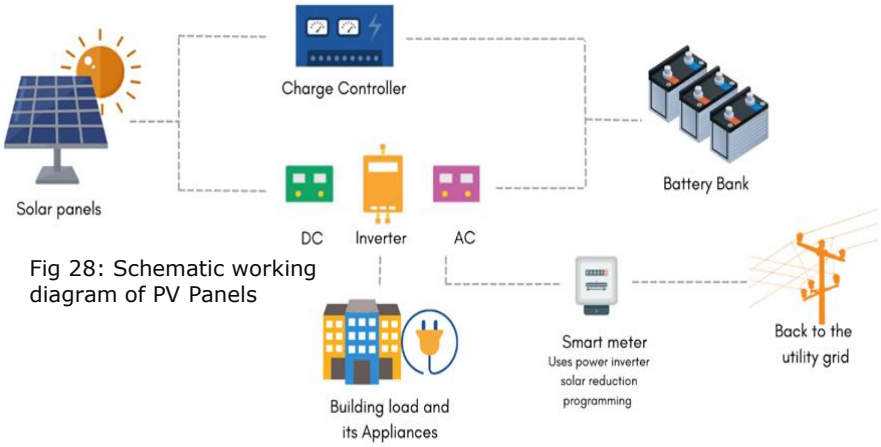




Fig 28: Schematic working diagram of PV Panels

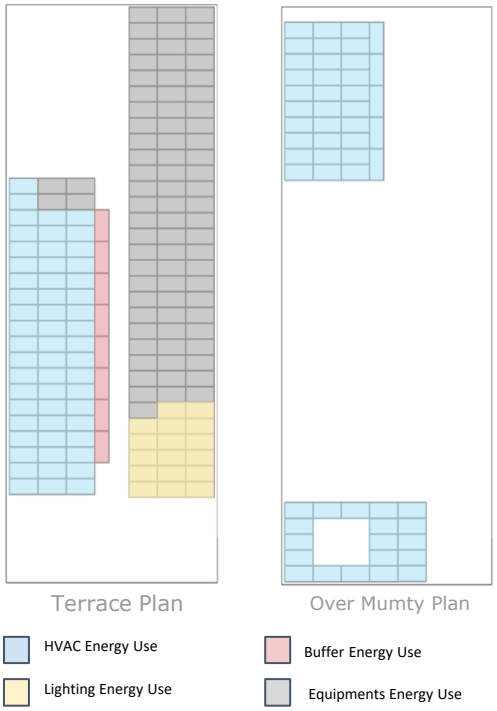
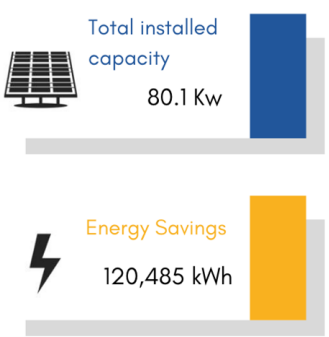



Fig 27: Solar PV Layout

### MODULE SPECIFICATIONS

### Loom Solar Panel

Size: 2131 x 1047 x 35 mm
Monocrystalline solar panel
Series: (12*6) * 2 of 144 cells
Module Efficiency : 19.2%
Output Power: 530 watts
Tilt angle: (13 * 0.87) + 3.1 = 15°
Number of panels: 216




| Month | Solar Radiation ( kWh/m2/day) | Electricity Generation (kWh) |
|---|---|---|
| JAN | 6.6 | 12359 |
| FEB | 6.75 | 11275 |
| MAR | 7.25 | 13210 |
| APR | 6.74 | 11791 |
| MAY | 5.85 | 10708 |
| JUN | 5.21 | 9308 |
| JUL | 4.74 | 8826 |
| AUG | 4.67 | 8742 |
| SEPT | 5.12 | 9202 |
| OCT | 4.87 | 8977 |
| NOV | 3.69 | 6843 |
| DEC | 4.84 | 9244 |
| **ANNUAL** | **5.53** | **120485** |

Table 7: Solar radiation and electricity generation

# WATER PERFORMANCE

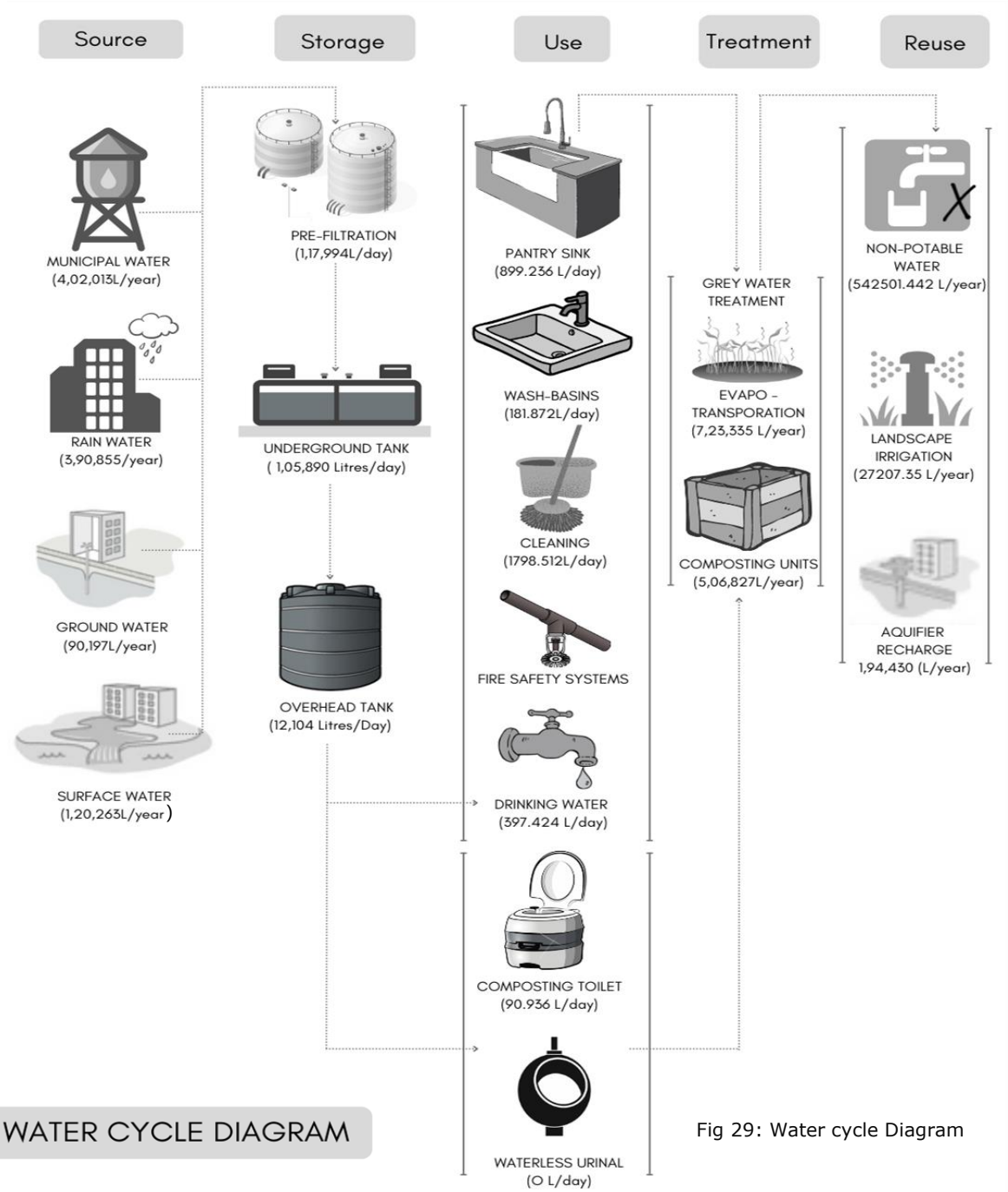



Fig 29: Water cycle Diagram

| Months | Days in month | Rainfall (mm) | Effective rain (mm) | Harvested water (l) | Municipality water supply (l) | Primary demand (l) | Grey water generated (l) | Irrigation seasonal factor (%) | Irrigation Water demand (l) | Unused grey water (l) | Total fresh water demand (l) | Storage (l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **October** | 31 | 223 | 218 | 137422 | 68758 | 104408 | 61392 | 10% | 604.5 | 51599.5 | 104408 | 120000 |
| **November** | 30 | 228 | 223 | 140574 | | 101040 | 59412 | 10% | 585 | 49935 | 101040 | 120000 |
| **December** | 31 | 113 | 108 | 68081 | | 104408 | 61392 | 20% | 1209 | 50995 | 104408 | 120000 |
| **January** | 31 | 17 | 12 | 7565 | 68758 | 104408 | 61392 | 20% | 1209 | 50995 | 104408 | 120000 |
| **February** | 28 | 9 | 4 | 2522 | 62659 | 95146 | 55946 | 50% | 2754.375 | 44818.625 | 95146 | 120000 |
| **March** | 31 | 11 | 6 | 3782 | 68758 | 104408 | 61392 | 50% | 3022.5 | 49181.5 | 104408 | 120000 |
| **April** | 30 | 18 | 13 | 8195 | 66540 | 101040 | 59412 | 50% | 2925 | 47595 | 101040 | 120000 |
| **May** | 31 | 48 | 43 | 27106 | 68758 | 104408 | 61392 | 100% | 6045 | 46159 | 104408 | 120000 |
| **June** | 30 | 68 | 63 | 39651 | 66540 | 101040 | 59412 | 100% | 5850 | 44670 | 101040 | 120000 |
| **July** | 31 | 70 | 65 | 40974 | | 104408 | 61392 | 20% | 1209 | 50995 | 104408 | 108770 |
| **August** | 31 | 99 | 94 | 59255 | | 104408 | 61392 | 20% | 1209 | 50995 | 104408 | 115822 |
| **September** | 30 | 110 | 105 | 66190 | | 101040 | 59412 | 10% | 585 | 49935 | 101040 | 120000 |

Table 8: Water balance

An effective water cycle has been developed to minimize daily fresh municipal demand. The usage of water-efficient fixtures has resulted in a 62.58% reduction from the base case. Rainwater harvesting was explored and implemented. This helped reduce the freshwater demand by more than 50%. Treated greywater is used as an alternate source of water for the non-potable purpose. In the monsoon months, extra grey water is used for ground recharge.

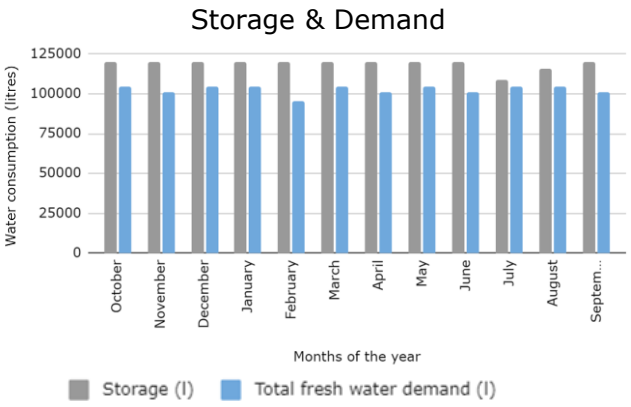



Fig 32 : Storage and Demand

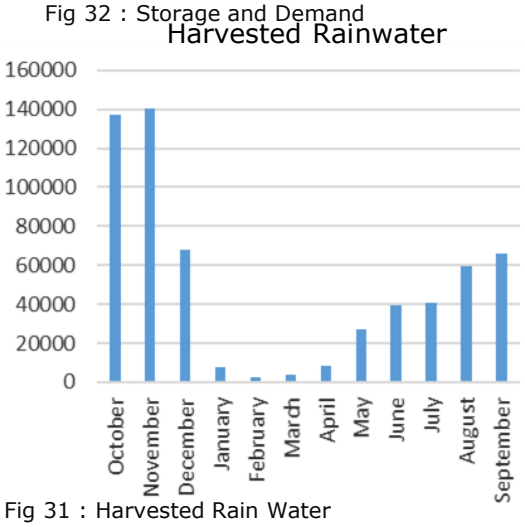



Fig 31 : Harvested Rain Water

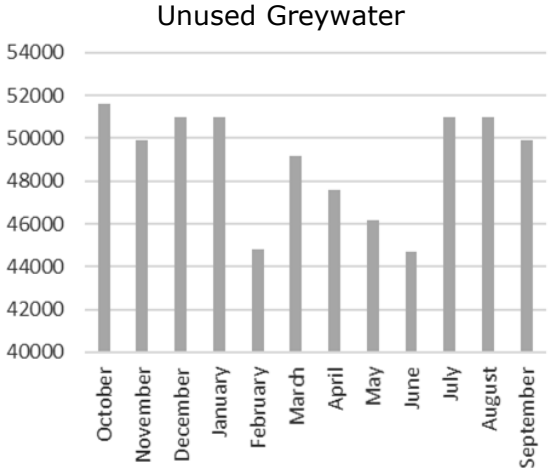



Fig 30: Unused Grey Water

| Per Capita daily consumption | Number of occupants | Total daily consumption | Grey water filter efficiency |
|---|---|---|---|
| 16.84 | 200 | 3368 | 75% |

Table 9: Per Capita Consumption

| Months | Days in month | Generated black water | Generated Grey water | Filtered grey water |
|---|---|---|---|---|
| Oct | 31 | 43016 | 61392 | 46043.928 |
| Nov | 30 | 41628 | 59412 | 44558.64 |
| Dec | 31 | 43016 | 61392 | 46043.928 |
| Jan | 31 | 43016 | 61392 | 46043.928 |
| Feb | 28 | 39200 | 55946 | 41959.386 |
| Mar | 31 | 43016 | 61392 | 46043.928 |
| Apr | 30 | 41628 | 59412 | 44558.64 |
| May | 31 | 43016 | 61392 | 46043.928 |
| Jun | 30 | 41628 | 59412 | 44558.64 |
| Jul | 31 | 43016 | 61392 | 46043.928 |
| Aug | 31 | 43016 | 61392 | 46043.928 |
| Sep | 30 | 41628 | 59412 | 44558.64 |
| Total : | | 506827 | 723335 | 542501.442 |

Table 10: Blackwater and greywater generated

| Water harvesting Sources | Area | Runoff coeff |
|---|---|---|
| Roof Surfaces | 548.09 | 0.85 |
| Hardscape areas | 170 | 0.7 |
| Softscape areas | 130 | 0.35 |
| **Effective catchment area :** | | **630.3765** |

Table 11: Water harvesting sources

| | |
|---|---|
| **Municipality water supply (l/day)** | 4,436 |
| **Storage size (l)** | 120,000 |

Table 12 : Municipal supply and storage size

| Water consumption point | Quantity | Liters/day |
|---|---|---|
| Occupants : {People x l/person} | 200 | 16.84 |
| Irrigation (max) : {m2 x l/m2} | 130 | 1.5 |
| Cooling tower (max) : {Ton x l/Ton} | 37.23 | 3 |

Table 13: Water consumption per day

**Note: Due to the usage of the radiant cooling system, water consumption would be minimal. Water required at the time of commissioning the system is 4000 Litres.**

| Base Case : | | | |
|---|---|---|---|
| **Per-capita consumption per day : 45 Lts** | | | |
| Activities | Domestic (Lts) | Percentage | **44.4% of 45 Litres** |
| Handwash | 4.5 | 10 | |
| Drinking | 1.98 | 4.4 | |
| Kitchen/pantry | 4.5 | 10 | |
| Cleaning | 9 | 20 | |
| Activities | Flushing (Lts) | Percentage | **55.6% of 45 Litres** |
| Urinal flushing | 13.5 | 30 | |
| WC flushing | 11.52 | 25.6 | |

Table 14: Base Case water consumption as per NBC

| Proposed Case : | | | |
|---|---|---|---|
| **Per-capita consumption per day : 16.84 Lts** | | | |
| Activities | Domestic (Lts) | Percentage | **97.3 % of 16.84 Litres** |
| Handwash | 0.9 | 5.3 | 80% reduction due to water efficient fixtures |
| Drinking | 1.98 | 11.8 | |
| Kitchen/pantry | 4.5 | 26.7 | |
| Cleaning | 9 | 53.4 | |
| Activities | Flushing (Lts) | Percentage | **2.7% of 16.84 Litres** |
| Urinal flushing | 0 | 0 | Zero water flush |
| WC flushing | 0.46 | 2.7 | Composting toilet :1 cup per flush |

Table 15: Proposed Case per-capita water consumption

| Occupant's Activity | Percent usage | Quantity | Grey water | Black water |
|---|---|---|---|---|
| Hand wash | 5.40% | 181.872 | 100% | 0% |
| Drinking | 11.80% | 397.424 | 0% | 100% |
| Kitchen/Pantry | 26.70% | 899.256 | 0% | 100% |
| Cleaning | 53.40% | 1798.512 | 100% | 0% |
| Urinal flushing | 0.00% | 0 | 0% | 100% |
| WC Flushing | 2.70% | 90.936 | 0% | 100% |

Table 16: Daily water consumption

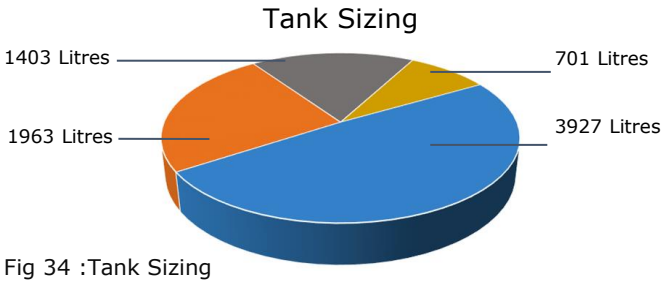



Fig 34 :Tank Sizing

**Overhead tanks**

- Freshwater ( Municipal + Treated rain water)
- Treated Water ( Recycled grey-water +Surface runoff rainwater) Fire water tank-10,000 Litres Tanks for HVAC: 2 X 1000 Litre tanks for Chillers

**Underground tanks**

- Freshwater (Municipal + Treated rain water)
- Treated Water (Recycled grey-water +Surface runoff rainwater)

Fire water tank-1,00,000 Litres

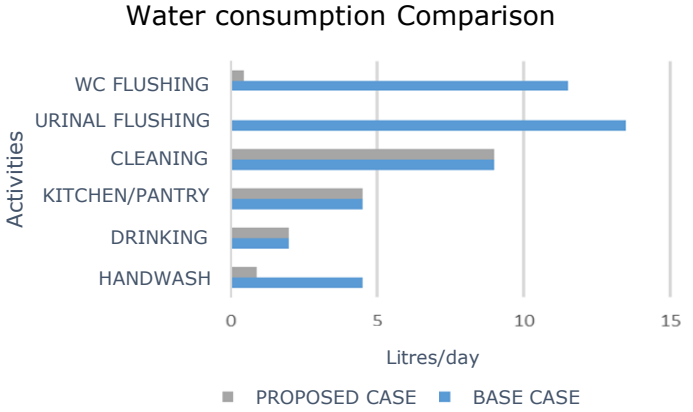



Fig 33 :Water Consumption Comparison

**Water saved in comparison to base case =62.58%**

| Image of the Sanitary fixture |  |  |  |  |  |
|---|---|---|---|---|---|
| Sanitary fixtures | Sensor faucet | Health faucet | Composting foam flush toilet | Aqua-free Waterless Urinal | Kitchen faucet |
| Baseline water usage LPM ( 1 BAR PRESSURE) | 4.31 | 8 | 6 | 2.2 | 8 |
| Benchmark water usage LPM ( 1 BAR PRESSURE) | 1.8 | 4 | 0.28 | 0 | 6 |
| Cost (INR) | 5500 | 1725 | 33,295 | 5900 | 2500 |
| Company | Jaquar | Jaquar | Clivus Multrum | Hindware | Jaquar |

Table 17: Flow rate of fixtures

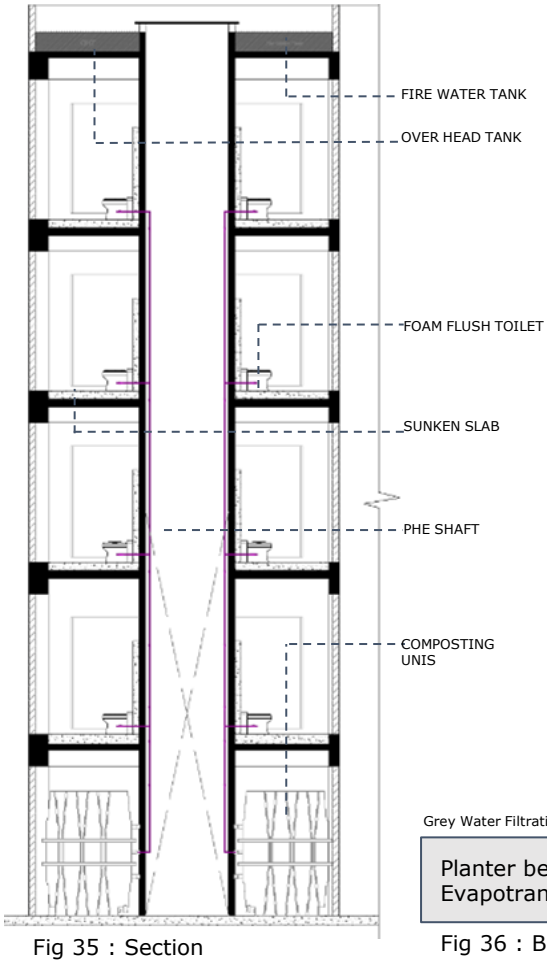



Fig 35 : Section

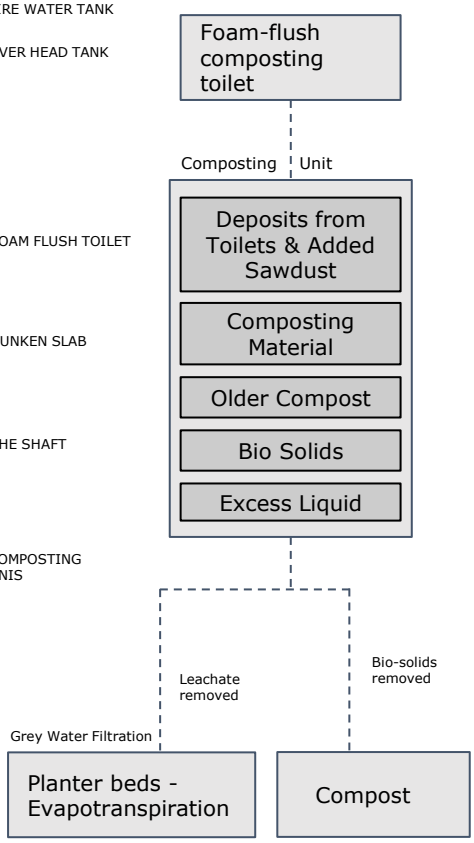



Fig 36 : Black water flow chart diagram

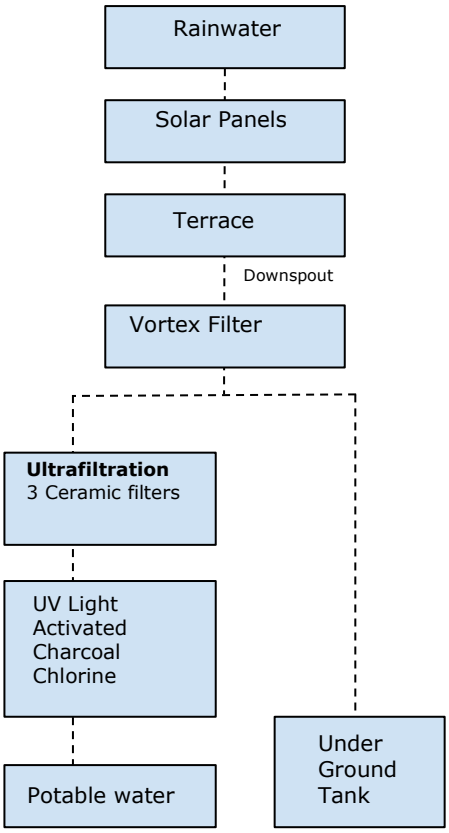
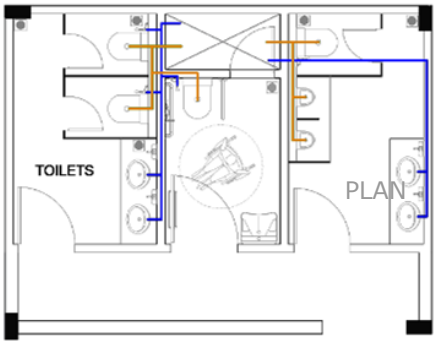
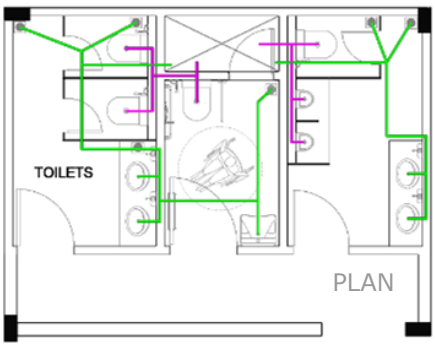



Fig 37 : Rain water flow chart diagram

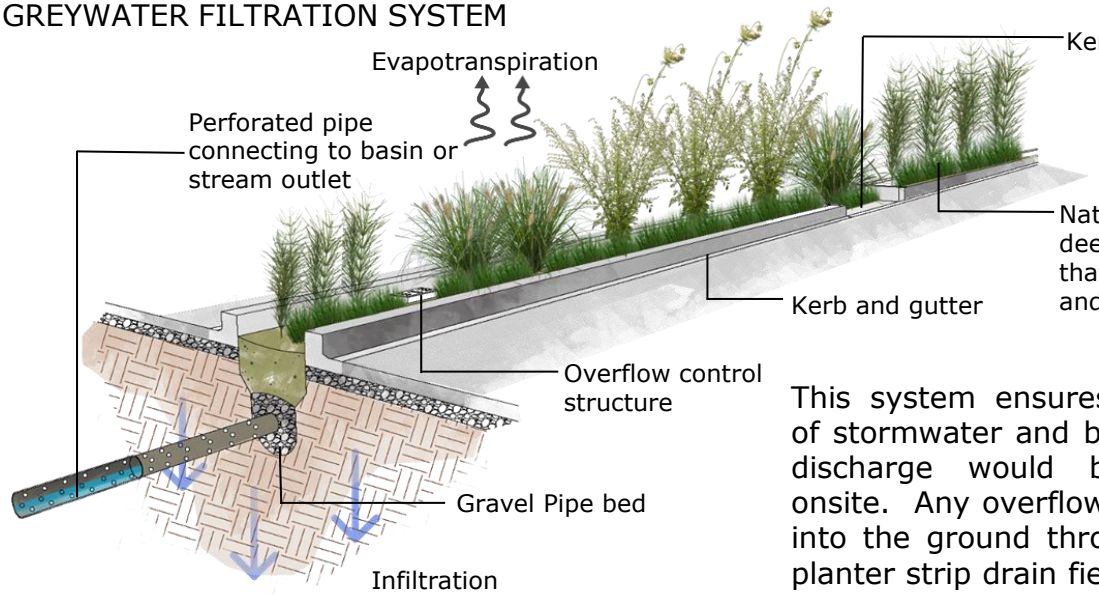



| LEGEND | |
|---|---|
| | 25mm dia. DOMESTIC WATER SUPPLY PIPE |
| | 32mm dia.FLUSHING WATER SUPPLY PIPE |
| | 110mm dia. SOIL CARRIER PIPE |
| | 70mm dia. WASTE CARRIER PIPE |

Fig 38 : Plan showing water fixtures

## GREYWATER FILTRATION SYSTEM




This system ensures that 100% of stormwater and building water discharge would be managed onsite. Any overflow is infiltrated into the ground through a green planter strip drain field.

Fig 39: Green planter strip drain field.

The Structural Design of the Team Global office division building has been done in compliance with the soil condition and the Earthquake loads of Chennai, using STAAD.Pro software. The Design is an IS-456 Code complaint and has been done for M-30 Grade of concrete and Fe-550 Reinforcement

The design employs 2 types of typical orthogonal footing and 2 types of typical column sections as 750mmX200mm and 600mmX200mm in the entire project.

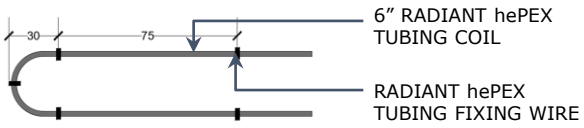



Fig 46 : Attachment detail of hePEX Tubing

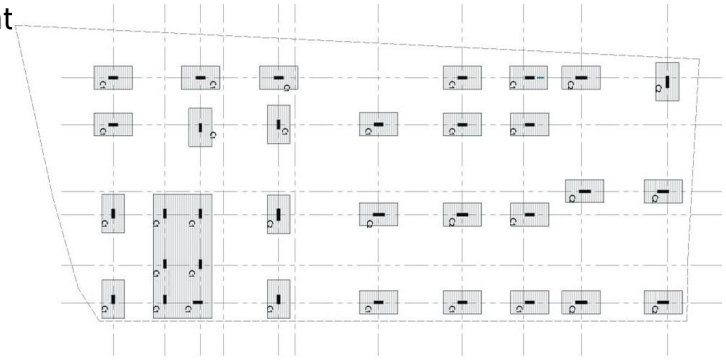


Fig 40 : Foundation footing and column layout

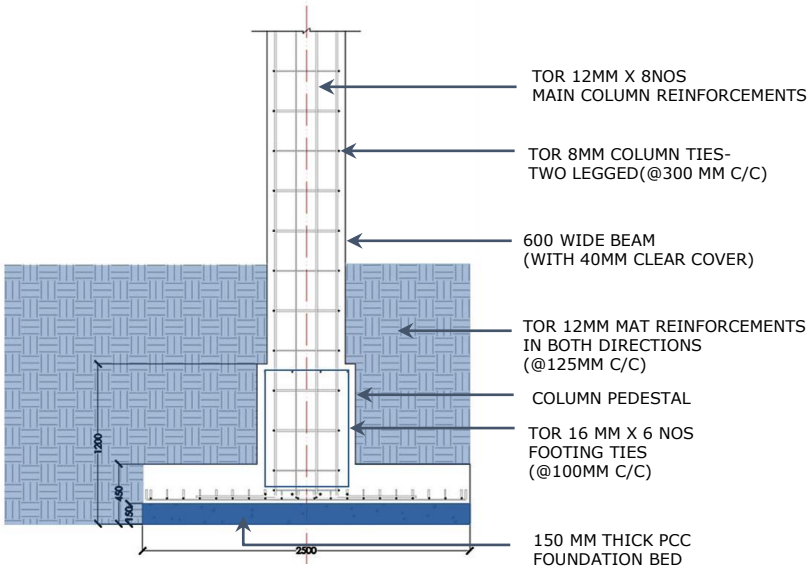



Fig 45 : Footing Detail

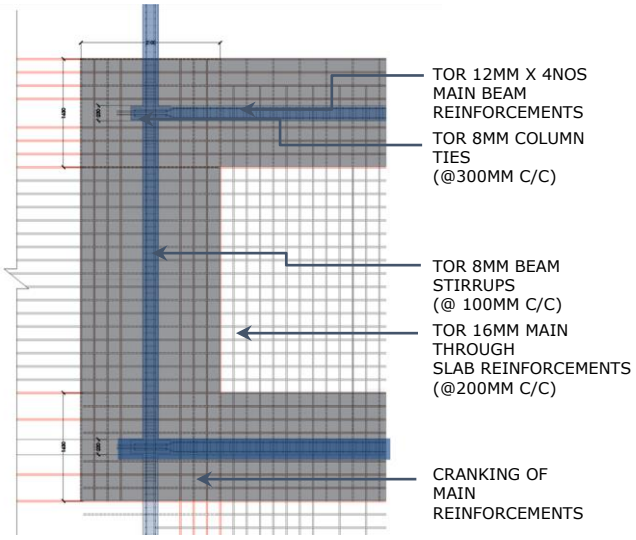



Fig 41 : Two way structural slab

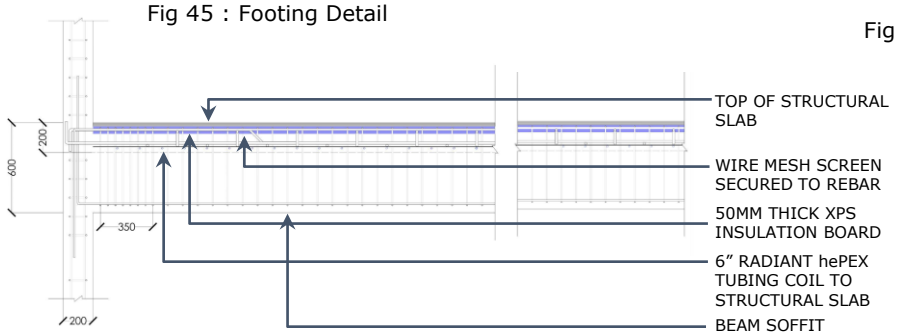
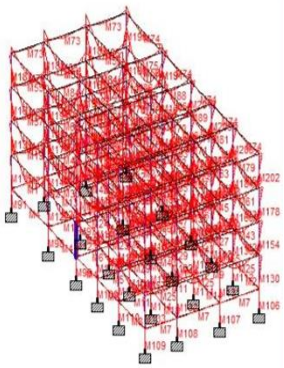



Fig 44 : Detail of Radiant Cooling integrated in Structural Slab



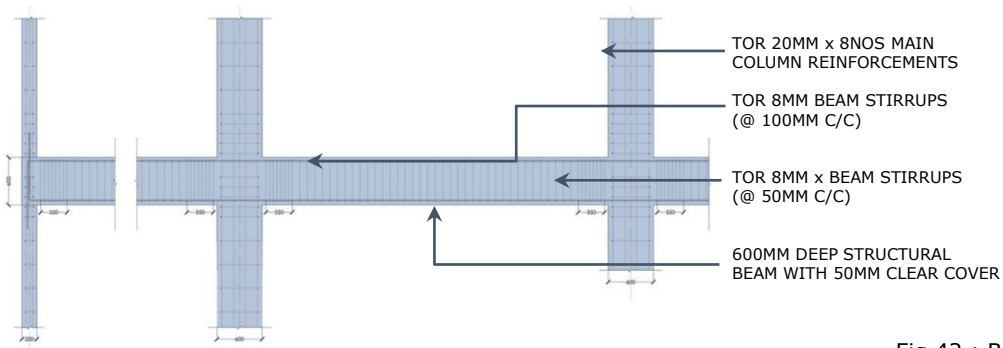



Fig 43 : Beam and Column Reinforcement detail

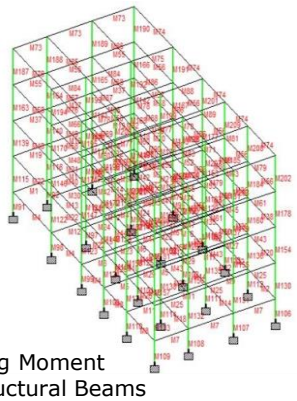


Fig 42 : Bending Moment analyses of Structural Beams and Columns

# Lighting Load Calculation

| Images of lighting fixtures |  |  |  |  |
|---|---|---|---|---|
| Type of lighting: | Suspended LED | Ceiling mounted LED(battens) | Ceiling downlight LED | Ceiling downlight LED 2 |
| Company: | Philips | Philips | Philips | Philips |
| Average lumen received: | 40000 | 20000 | 1000 | 2000 |
| Wattage(W): | 30 | 16 | 10.6 | 22 |

Table 18 : Rate of Lighting Fixtures

| Sl no. | Space Function | Target illuminance (lux) | Type of lighting | Company | Average lumen received | Watt (W) | Area | NOs. | Hrs per day | No. of days | Total hrs | Energy consumed annually (wh) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Reception/ waiting lobby | 200 | Ceiling downlight LED 2 | Philips | 2000 | 22 | 28.4 | 16 | 8 | 313 | 2504 | 869166.22 |
| 2 | cabins | 350 | Suspended LED | Philips | 4000 | 30 | 18.3 | 18 | 7 | 313 | 2191 | 1169446.25 |
| 3 | Workstations | 500 | Suspended LED | Philips | 4000 | 30 | 186.4 | 68 | 7 | 313 | 2191 | 4469640.00 |
| 4 | Staircase | 100 | Ceiling downlight LED 2 | Philips | 2000 | 22 | 48 | 16 | 8 | 313 | 2504 | 881408.00 |
| 5 | Lobby | 100 | Ceiling downlight LED 2 | Philips | 2000 | 22 | 9 | 4 | 8 | 313 | 2504 | 220352.00 |
| 6 | Toilets | 150 | Ceiling downlight LED | Philips | 1000 | 10.6 | 42 | 24 | 8 | 313 | 2504 | 637017.60 |
| 7 | Pantry | 200 | Ceiling mounted LED(battens) | Philips | 2000 | 14 | 18.6 | 4 | 1 | 313 | 313 | 17528.00 |
| 8 | Storage | 50 | Ceiling downlight LED | Philips | 1000 | 10.6 | 14 | 4 | 0.5 | 313 | 156.5 | 6635.60 |
| 9 | Meeting Room | 500 | Ceiling mounted LED(battens) | Philips | 2000 | 14 | 20 | 8 | 1 | 313 | 313 | 35056.00 |
| 10 | Server Room | 300 | Ceiling downlight LED | Philips | 1000 | 10.6 | 10.76 | 8 | 7 | 313 | 2191 | 185796.80 |
| 11 | Passage | 100 | Ceiling mounted LED(battens) | Philips | 2000 | 14 | 27 | 8 | 8 | 313 | 2504 | 280448.00 |

| **Total (Wh) :** | 8772494.47 | | **Total (kWh) :** | 8772.49 |
|---|---|---|---|---|

Table 19 : Lighting load calculation

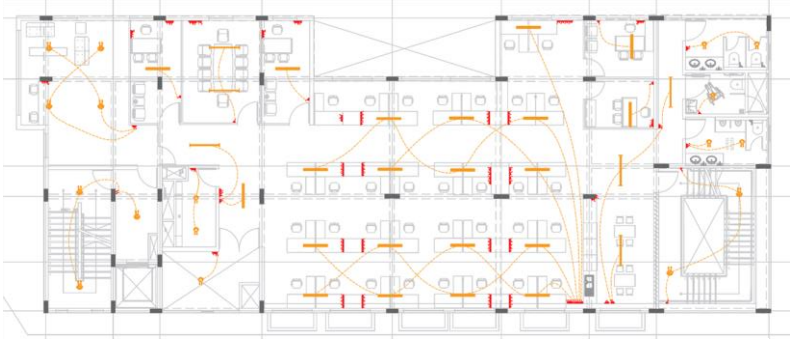
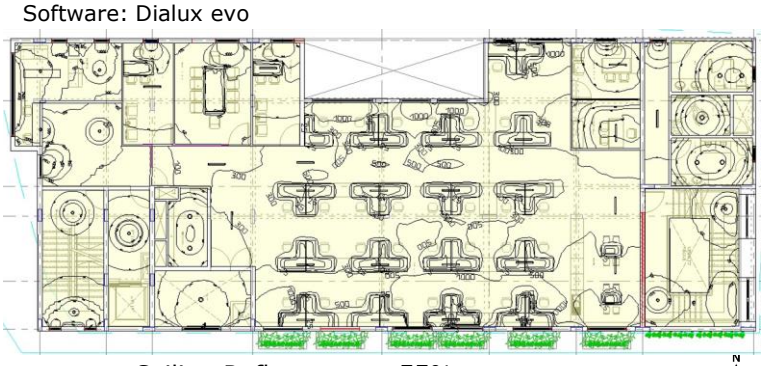



Fig 47 : Lighting Layout

Software: Dialux evo




Ceiling Reflectance = 55%
Floor Reflectance = 70%
Wall Reflectance = 80%
Ext. Wall Reflectance = 75%

Fig 48 : Analysis of Lighting Layout

# Equipment Load Calculation

| Appliances | Cost in rupees | Power | |
|---|---|---|---|
| Farberware Classic FMO07ABTWHA Microwave oven | 15,299 | 700 |  |
| Godrej 190 L 5 Star Inverter Direct-Cool Single Door Refrigerator | 16,990 | 285 |  |
| High Volume low Speed (HVLS) Fan HF-12 B5 | 20,000.00 | 750 |  |

| Appliances | Cost in rupees | Power | |
|---|---|---|---|
| Dell Latitude series laptop | 59,828 | 137 |  |
| Havells Exhaust fan (Ventil air) @200mm | 1290 | 32 |  |
| HP SMART TANK 750 WI FI DUPLEXER PRINTER | 23,020 | 0.1 watts (off); 1.10 watts (sleep) |  |

Table 20 : Rate of equipments used

| Sl No. | Appliances | Nos. | Wattage | No. of hours per day | No. of days | Energy consumed annually (kwh) |
|---|---|---|---|---|---|---|
| 1 | Laptop | 144 | 35 | 7 | 313 | 11042.64 |
| 2 | Printer (commercial)- Standby | 8 | 30 | 2 | 313 | 150.24 |
| 3 | Printer (commerciall) | 4 | 400 | 2 | 313 | 1001.6 |
| 4 | Microwave | 4 | 700 | 0.5 | 313 | 438.2 |
| 5 | Refrigerator | 4 | 285 | 24 | 313 | 8563.68 |
| 6 | Water purifier | 4 | 25 | 0.5 | 313 | 15.65 |
| 7 | Projector | 4 | 300 | 1 | 313 | 375.6 |
| 8 | Water Pump | 1 | 3000 | 8 | 313 | 7512 |
| 9 | Lift | 1 | 800 | 8 | 313 | 2003.2 |
| 10 | Fan | 16 | 750 | 7 | 90 | 7560 |
| | | | | | Total | 38662.81 |

Table 21 : Equipment load calculation

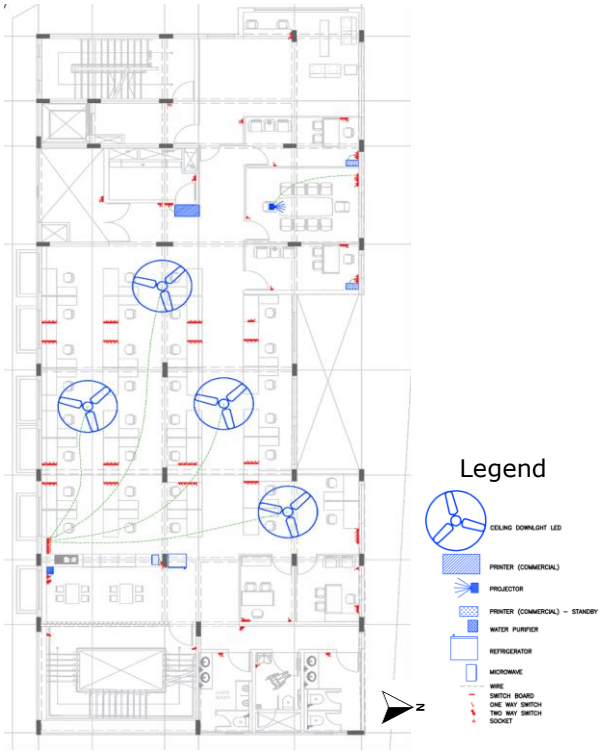



Fig 48 : Equipment Layout Plan

# HVAC Load Calculation

| FLOOR | COOLING LOAD IN BTU/H | | | TOTAL TR | No. of hours per day | No. of days | Energy consumed annually kWh) |
|---|---|---|---|---|---|---|---|
| | SENSIBLE LOAD | LATENT LOAD | TOTAL LOAD | | | | |
| 1F | 108105 | 21533 | 129639 | 10.8 | 8 | 223 | 19267.2 |
| 2F | 74231 | 21533 | 95764 | 7.98 | 8 | 223 | 14236.32 |
| 3F | 74231 | 21533 | 95764 | 7.98 | 8 | 223 | 14236.32 |
| 4F | 104067 | 21533 | 125601 | 10.47 | 8 | 223 | 18678.48 |
| **TOTAL** | **360634** | **86133** | **446768** | **37.23** | **Total** | | 66418.32 |

Table 22 : Cooling load calculation

| PARTICULARS | STANDARD DESIGN | EFFICIENT DESIGN |
|---|---|---|
| SENSIBLE LOAD IN TR | **45** | **30** |
| LATENT LOAD IN TR | **7** | **7** |
| TOTAL COOLING LOAD IN TR | **52** | **37** |
| **PLANT FOR SENSIBLE COOLING** | | |
| CHILLERS | 25 TR AIR COOLED SCROLL CHILLERS - 2 No.S | 18 TR AIR COOLED SCROLL CHILLERS - 2 No.S |
| CIRCULATION PUMPS | 251 LPM/20M HEAD - 3 NO.S (2 WORKING + 1 STANDBY) | 182 LPM/20M HEAD - 3 NO.S (2 WORKING + 1 STANDBY) |
| **PLANT FOR LATENT COOLING** | | |
| TREATED FRESH AIR UNIT WITH DX COIL | 2500 CFM X 1 NO. | 2500 CFM X 1 NO. |
| CONDENSING UNIT FOR TFA | 5.5 TR X 2 NO.S | 5.5 TR X 2 NO.S |

Table 23: HVAC Equipment

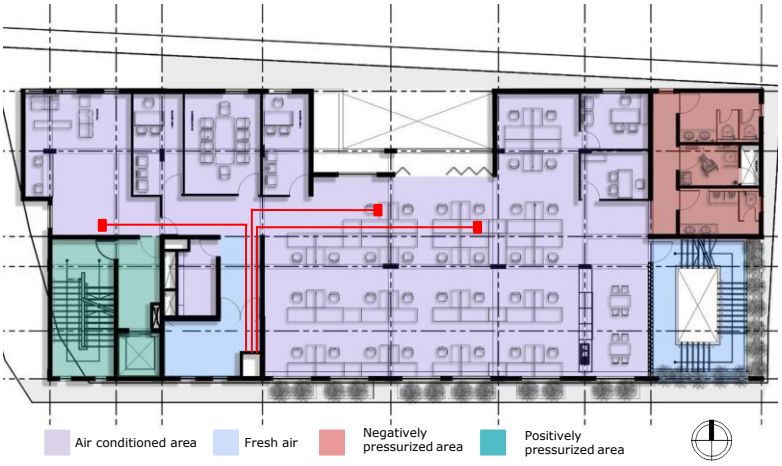
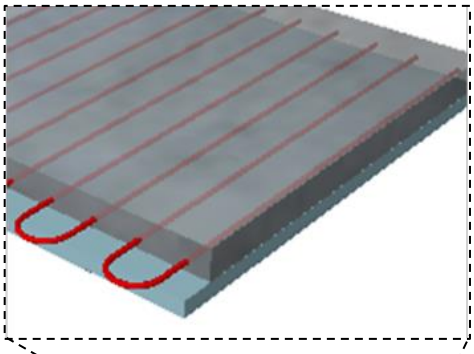



Fig 49: Operational Zones for Air-conditioning for typical office floor



1. Rautherm S pipe
2. Surface sensor
3. System controller
4.PRO-BALANCE® manifold
5. Chiller plant
6. Pump

Fig 52: Slab detail of radiant cooling

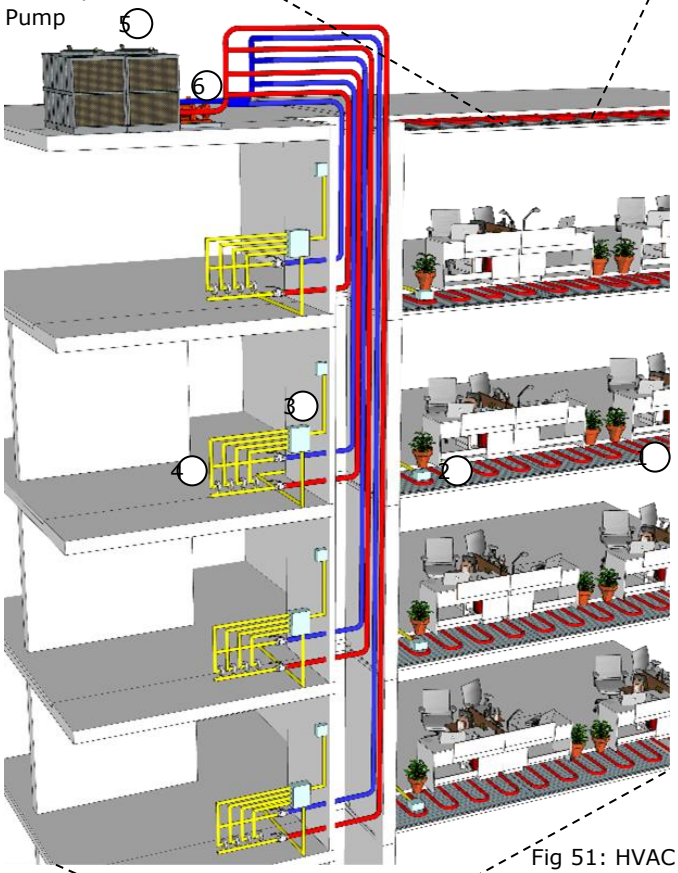



Fig 51: HVAC Detail


Fig 50 : Section: Air conditioning system

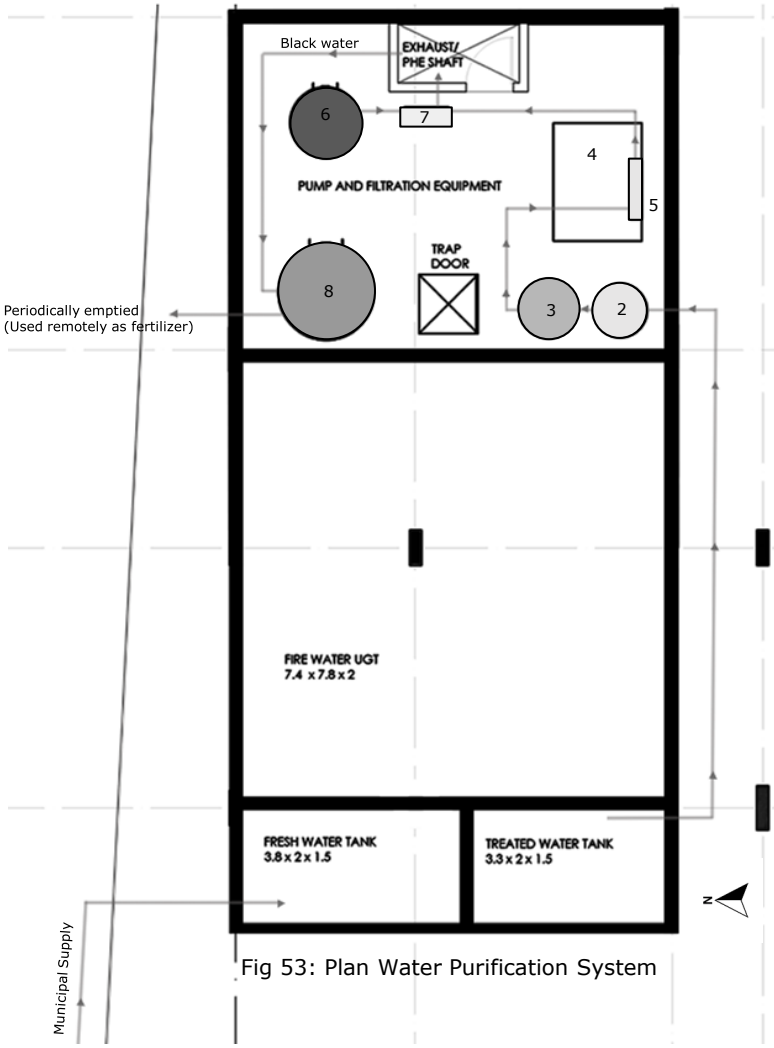



Fig 53: Plan Water Purification System

# Water Purification System

**Legend**

1.UnderGround Tank
2.Filters
3.Carbon Filter
4.Chlorine Tank
5.UV Light Disinfectant
6.Pressure tank
7.Pump
8.Leachate Tank
9.Composting Units
10.Waterless Urinals
11.Composting Foam Flush Toilet
12.Over Head Tank

## Wastewater treatment and reuse

It is estimated that 1387.6 litres of blackwater and 1980.3 litres of greywater are generated from the building every day. The wastewater is sent to the filtration room where greywater is passed through a series of water purification equipment. The surface runoff is infiltrated into the ground through a green planter strip drain field, which filters the water further through the process of evapotranspiration and infiltration, at the same time replenishing the groundwater.

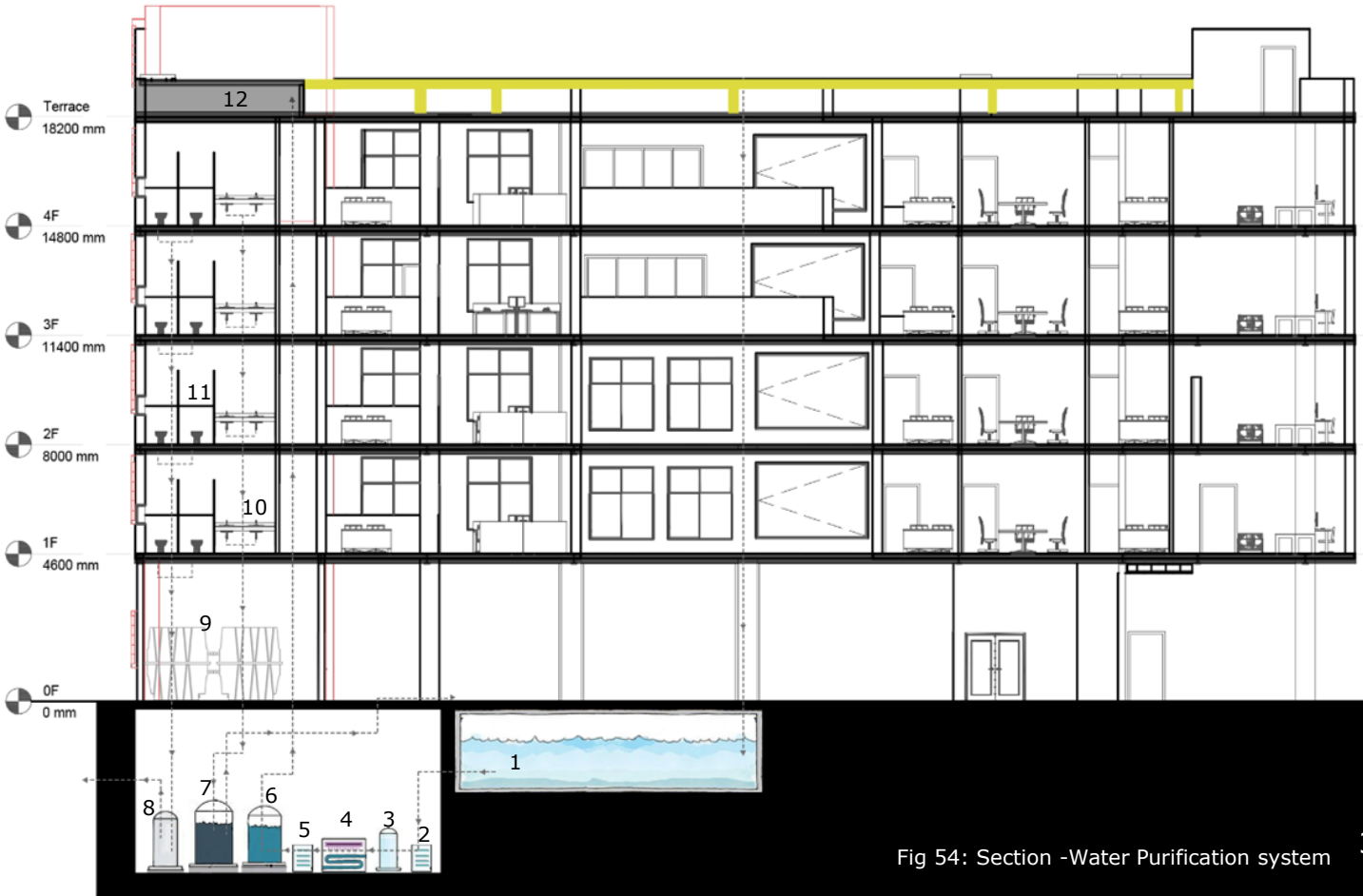



Fig 54: Section -Water Purification system

The building is designed for a mixed-mode operation. It is naturally ventilated for about 30% of the operational hours and air-conditioned for the rest. This helps in achieving 100% comfortable operating hours throughout the year.

Optimizing the layout, zoning and the building allowed for better cross-ventilation of spaces and helped in maximizing the daylit spaces.

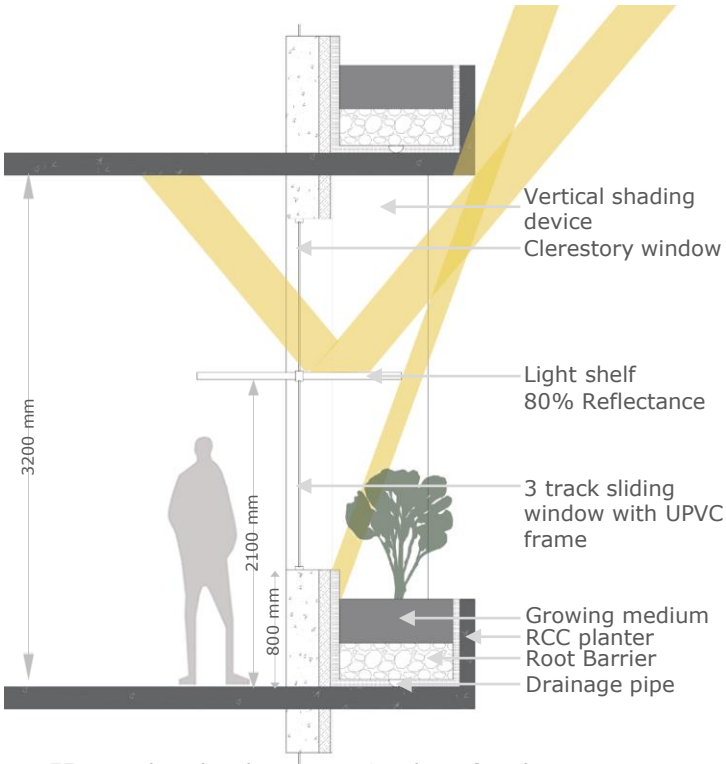



Fig 55 : Window detail section – Southern facade

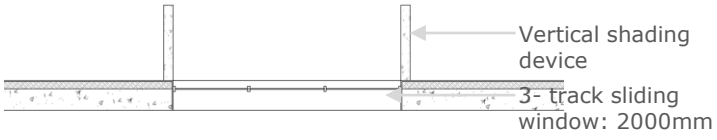



Fig 56 : Vertical shading device – Southern windows


Fig 57: Types of Plants used

| Façade Direction | WWR |
|---|---|
| North | 40% |
| South | 25% |
| East | 10% |
| West | 4.5% |

A popular 1989 study conducted by NASA concluded that plants are natural air purifiers. The study showed that through photosynthesis, the plants would convert the carbon dioxide we exhale into clean oxygen. Plants are also capable of removing toxins from the air we breathe like PM5 and PM10.

Hence, the window detail is integrated with planter boxes towards the southern side. The box has been designed such that it is visible from the work plane level, that is, at 750mm above FFL.

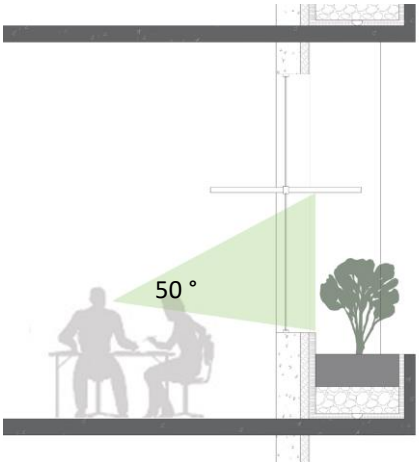


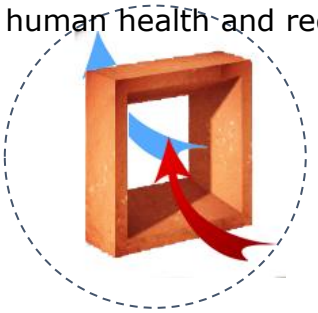

Fig 58: Assessment of sight angle of the occupant

Plant varieties like Areca Palm, Raphis Palm, Schefflera Venulosa, money plant, the peace lily, the weeping fig etc. are used both indoors and outdoors which help in improving the air quality as well as provides visual comfort to the occupants. Some of the above-mentioned plants also help in absorbing noise from the surroundings without affecting the humidity levels.

Fig 59: Interior View of workstation

## THE IRRESISTIBLE STAIRCASE:

For those occupants who are able, an "irresistible stair", with fresh air, connection with nature and a break time hangout area, promote stair use, and human health and reduces the usage of lifts.



Time of usage: 8 AM, break time, HVAC running seasons and 7 PM

The design of the staircase and the interiors enhance human senses like sight, touch, smell and hearing.

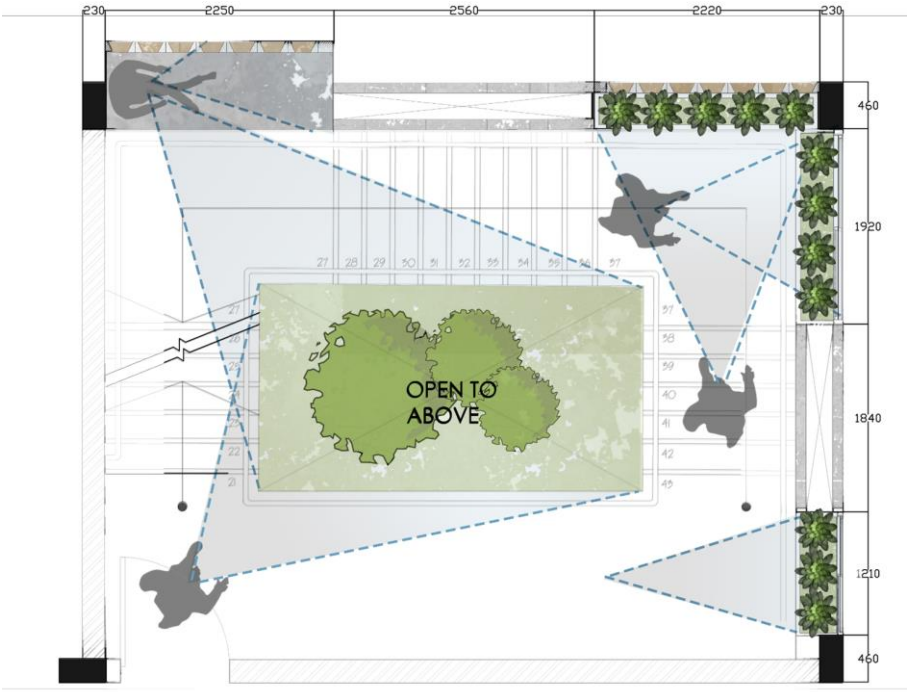
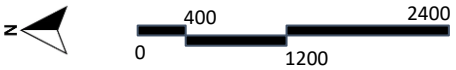



Fig 60: : Plan of the irresistible staircase




Mid landing is extended as a seating space of the staircase which acts as a pause point.

Planter boxes with plants (weeping fig) of low maintenance and a small tree in the center of the staircase well create a visual connection with nature on every floor.

The staircase to the east which is a little isolated from the workspace creates more like a buffer space for the employees of the office. The staircase design is intertwined with nature considering people's health and visual comfort.

For those occupants who are able, an “irresistible stair”, with fresh air, connection with nature and a break time hangout area, promote stair use, and human health and reduces the usage of lifts.

Silk Breathe Easy by Berger Paints eliminates lead, mercury and chromium from their paints and greatly reduced VOCs and the content of aromatics so that their products have no negative health impact. They are also anti-infection, anti-pollution and anti-bacterial and comes with a certified label by Singapore Green label.

Noise-Friendly Flooring: 1800mm high wall partitions help in separating the employees and reduce the overall noise to some extent as well.

LVT flooring is versatile alternatives thanks to its ease of maintenance and variety of design options. LVT flooring by itself boasts sound absorption qualities.

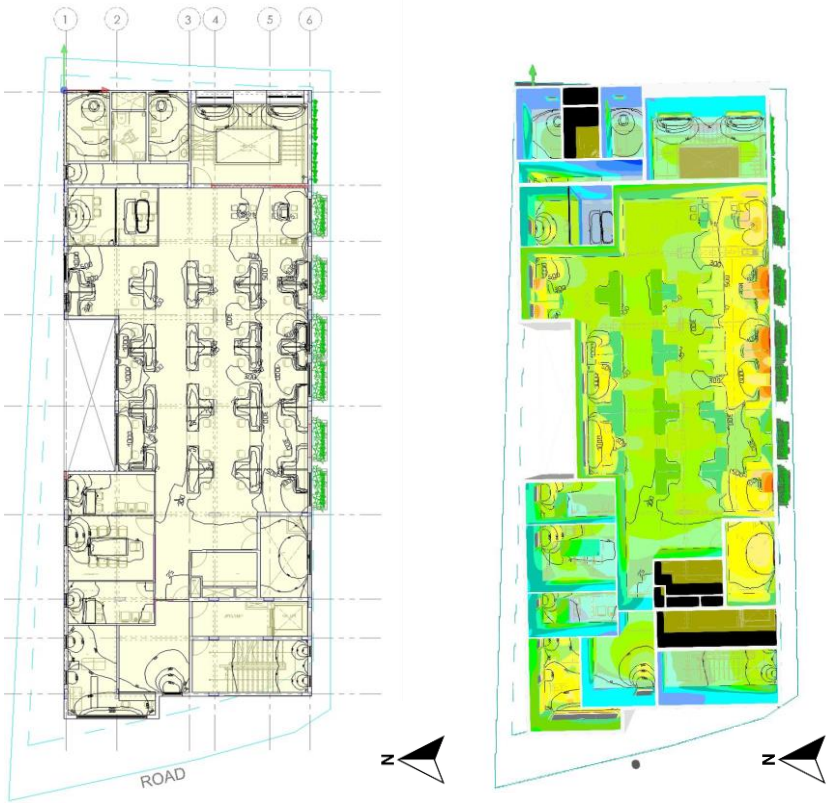



Fig 61: Daylight illuminance levels

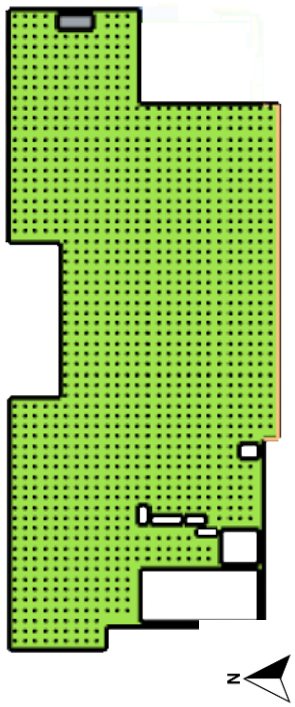


Fig 62: sDA Analysis

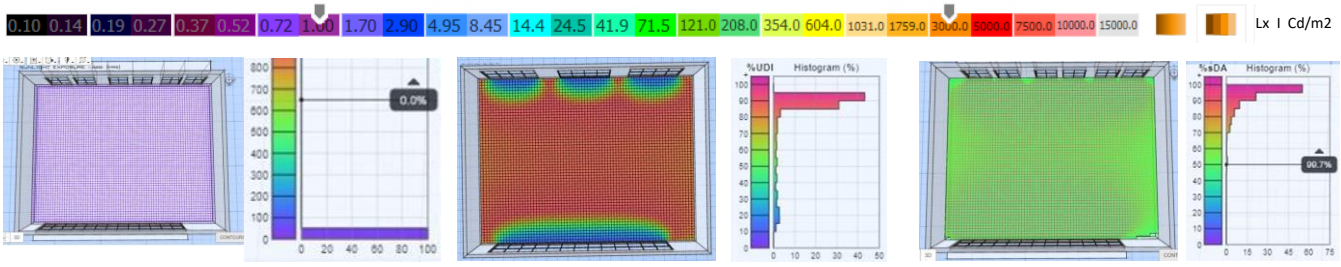



Fig 63: Annual Sunlight exposure, Useful daylight illuminance and daylight Autonomy Analysis (Initial analysis for workspace zone on AndrewMarsh)

# INNOVATION

## NOISE ABSORBING PANELS

With an aim to achieve net-zero energy, team Ecocult proposes the idea of making use of a renewable source of energy where we intend to produce our energy on-site as an addition to the grid.

The solution proposed is to make "NOISE BASED POWER BANKS" that make use of the sound, converting it into electrical energy which is used for lighting up the front facade and also acts as a backup option when stored in batteries. We tried to achieve this in two ways, one with the concept of a Piezoelectric system, that uses unique crystals to convert sound wave energy into electrical energy (which can be adapted in form of panels for facades once developed, but in our case used in the compound wall), second by using the circuit system method that uses speaker/mic/sound sensor to absorb sound.

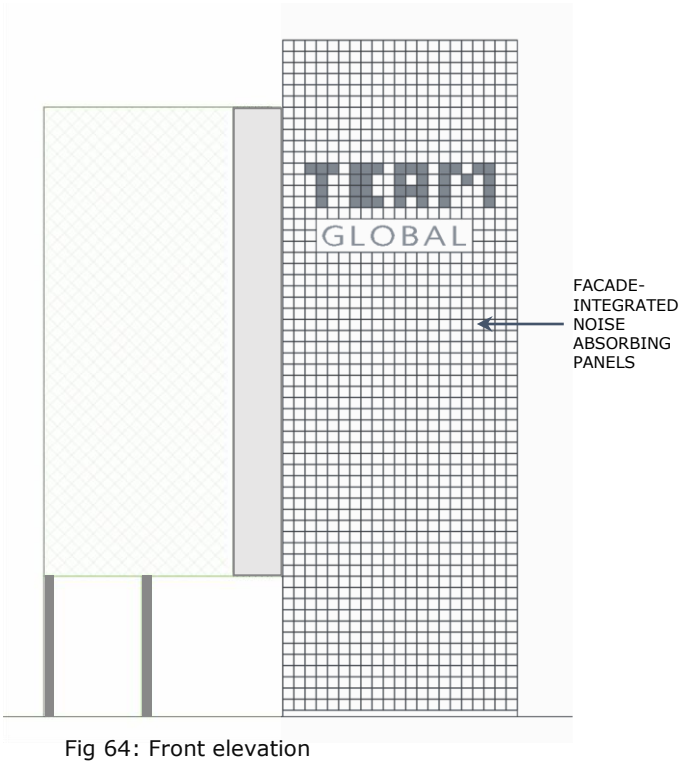



Fig 64: Front elevation

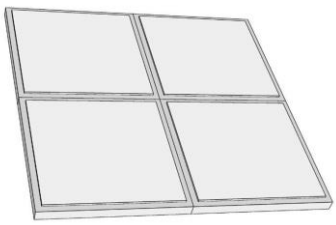


Figure 65.1: Sound absorbing panels

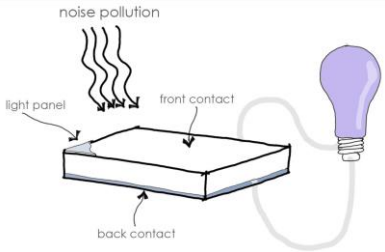



Figure 65.2: Energy conversion schematics

Size-**350mm x 350mm**
Voltage:12.5v
Amper :0.2A
Watts:**3kw**
Energy generated :**4512 KWH**

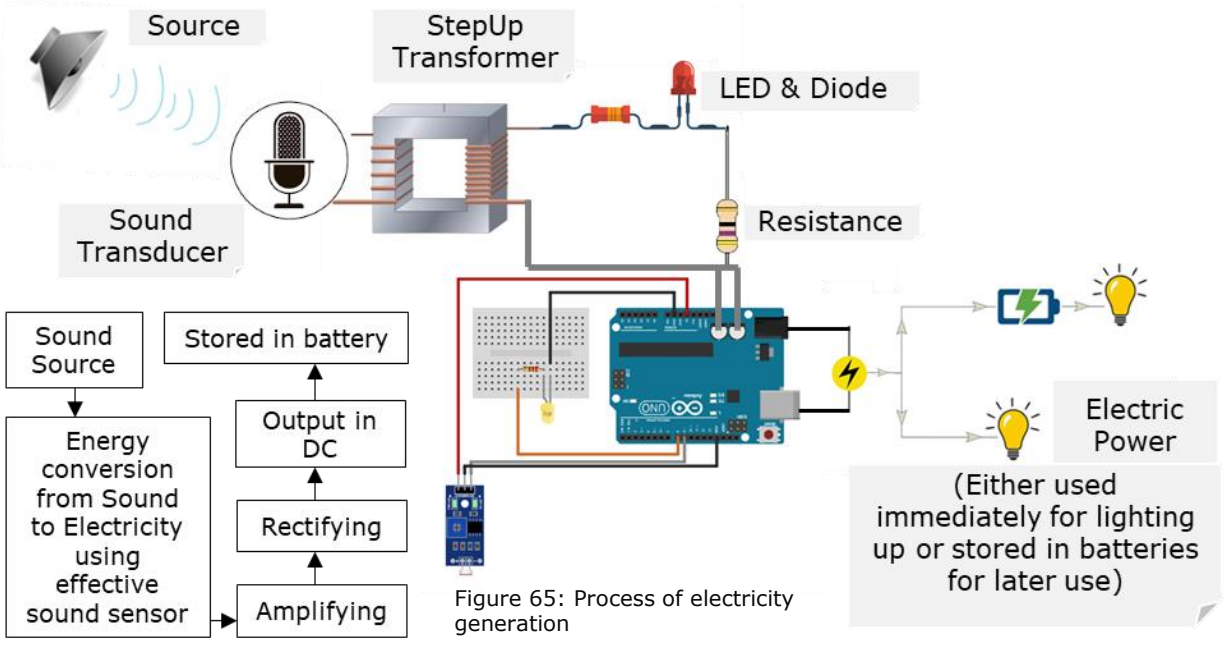



Figure 65: Process of electricity generation

## TERRACOTTA BLOCKS

The site (Mylapore, Chennai) is in a hot and humid climate, the main aim is to reduce the temperature and maximize airflow into the building. So the idea is to use the terracotta block (300mm x 300mm) which tapers into a 150mm x 150mm void to help reduce the air temperature which in turn reduces the cooling load.

This block is placed along the wind direction. It enables faster construction and adds character to the facade.

In addition, the nature-centric hangout area promotes the use of the 'irresistible staircase, improving human health and reducing the usage of lifts.

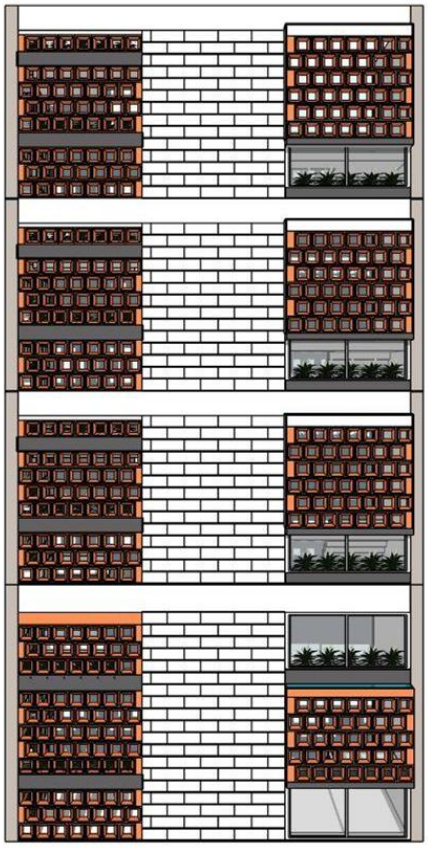


Fig 66: Irresistible Staircase elevation

- Flexibility of the block
- Reduction of the air temperature
- Promoting the natural material CLAY
- Installed in the direction of wind
- Less carbon footprint

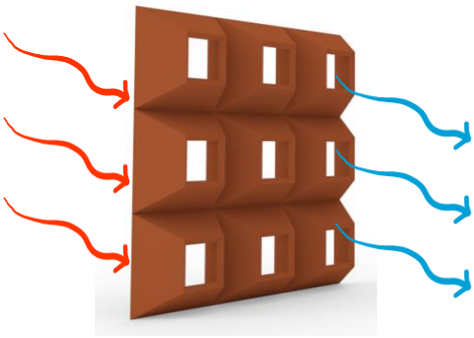
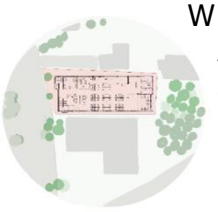


Fig 67: Terracotta Tile Block

Fig 68: Interior view of irresistible staircase

## RESILIENCE

According to the hazard maps of India provided by BMTPC, hazards due to wind, cyclones and heat waves need to be considered.
Even though the site has not experienced any floods yet, it is better to design the building for floods as a few surrounding areas are prone to floods.
The site has a basic wind speed of 50 m/s.

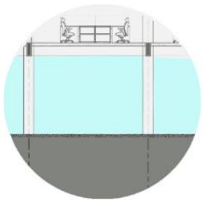


### Wind and Cyclone Hazard

Trees are not present close to the building. Hence uprooting trees will not damage the building.

### Fire Hazard

Emergency exits and fire-rated lifts are provided.



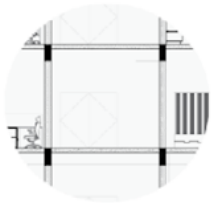
### Flood Hazard

Stilt floors are provided for parking. This ensures that the working spaces are safe from floods.



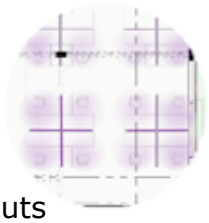
### Heat Waves

Roof and wall sections with reduced U-values are provided to reduce heat gain inside the building.



### Earthquake

Zone 3 – Moderate Damage Risk Zone Structure is designed according to IS 456.



### Adapting to the Pandemic

An open office plan is provided with partition walls in between for social distancing.

### Grid Disruptions and Blackouts

Solar power backup is provided. Natural lighting and ventilation through light shelves and courtyards are needed to save a backup in case of a long power cut.

### Social Resilience

Breakout spaces are provided. This will increase the efficiency of the occupants.

### Food Shortage

A roof garden is provided where garden crops can be grown.

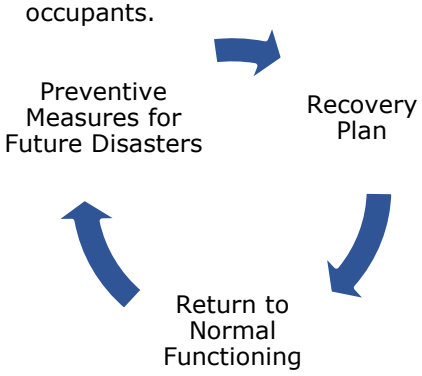



Fig 69 : Resilience strategies

### Sufficiency and Autonomy for critical functions

1. Water facility:

Water storage at a given point is **1,17,994 L**. Water consumption is **3,368 L/day** for working hours. Approximate, per day consumption = 3,368 *2 = **6,736 L/day**
(Critical storage + Main storage)/ per day consumption = Days of Autonomy
1,17,994 / 6,736 = **17.5 days of Autonomy**

2. Energy Efficiency:

Energy consumption per day is **1,13,853 kWh** which includes lighting, equipment and an HVAC system. The energy required is generated using Solar PV and sound-absorbing panels which are **1,20,485 kWh** from the PV array and **4512 kWh** from sound-absorbing panels.

## Preventive Measures

| Sl no. | Risk | Preventive Measures |
|---|---|---|
| 1 | Natural disasters | Preventive actions are considered for hazard resistant construction as mentioned earlier. |
| 2 | Slips and trips | All areas are well lit including stairs to prevent slips and trips. East-west clear central corridor helps with efficient circulation. |
| 3 | Stress and anxiety in working spaces | Open floor plan to make the working environment more transparent and democratic |
| 4 | Lack of preparation during a risk | • Installation of a warning system and required drills for its use.<br>• Prior training of staff for various tasks in the emergency. |

Table 24: Preventive Measures


Fig 70: Fire Escape Layout

## Fire Safety Requirements

| Sl no. | Types of Fire Protection | Description |
|---|---|---|
| 1 | Fire Extinguisher | 2 per floor with travel distance not more than 12 m. |
| 2 | Wet Riser | Provided at all floors. |
| 3 | Yard Hydrant | Provided all around the building |
| 4 | Automatic detection and Alarm System | For entire building |
| 5 | Automatic Sprinkler System | For entire building |
| 6 | Underground and overhead water tank | UGT – 1,00,000 litres<br>OHT – 10,000 litres |
| 7 | Fire shaft | 1 Fire rated lift and staircase |
| 8 | Emergency Lights | At staircase landing and exit routes. |

Table 25: Fire Safety Requirements

Address immediate well-being of occupants and provide necessary emergency services.

Examine the damage and provide solutions in decreasing order of priority

Provide safe and clean water supply obtained from critical and main water storage

Provide electrical supply from storage batteries for emergency services first and the remaining in the order of priority

Restore power supply by checking for damages in the distribution substations and supply lines

Clear obstructions on the western side (facing the main road) to permit transportation

Conduct repairs to restore communication and other utilities

## Recovery Plan

Fig 71: Recovery plan

## AFFORDABILITY

Construction affordability for Developing Countries is one of the main issues associated with sustainable construction and sustainable development.

Despite international awareness of sustainable construction, the cost rates for construction activities and resources have been continuously increasing. Due to these increases, the approaches to be used to achieve sustainable construction through efficient and affordable techniques can be difficult to determine but can prove to be effective in the long run.

Energy-efficient buildings involve lower financial risks, as they are economical in terms of the operational costs involved which increases the belief amongst the stakeholders.

Also, by addressing important issues such as thermal comfort, visual comfort and indoor environmental quality, there is an increased resale value, and rental value and hence the return on investment becomes much faster.

Green buildings also attract loans at a lower rate of interest and a faster sanctioning process. These factors play a major role in funding for the execution of the project.

Although the proposed cost of the project is more than the baseline cost, the total operational cost is much lesser than the baseline project. This has been achieved by improving the building's performance through various strategies mentioned below.The Proposed case total cost is 3.7% higher than that of the baseline cost.

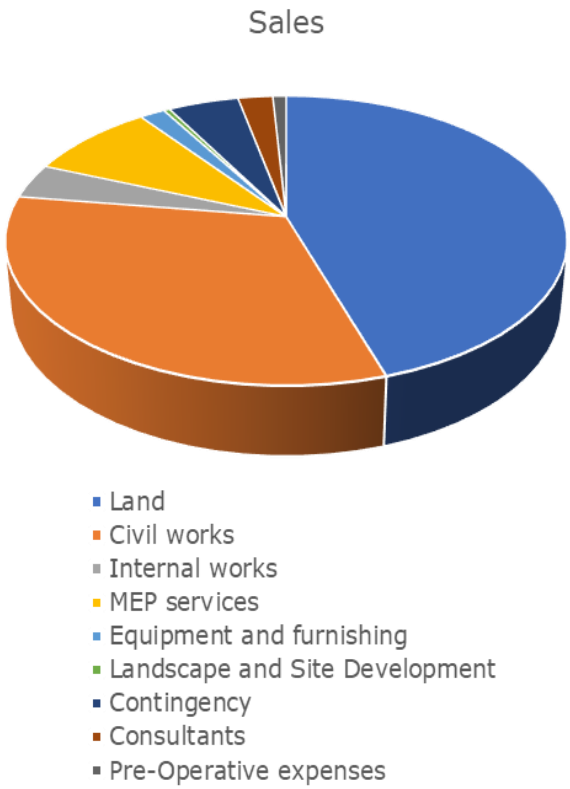



Fig 72: Operation costs and financial breakups

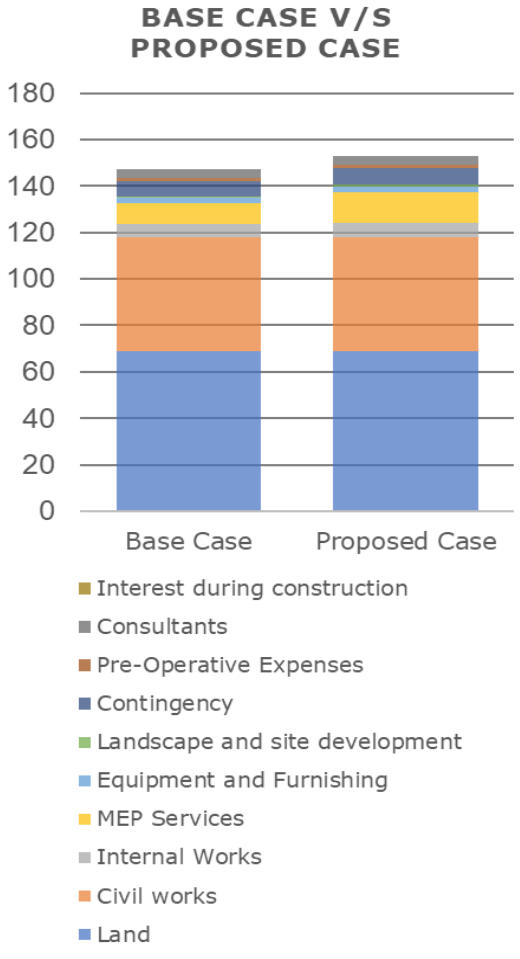



Fig 73: Comparison of baseline and proposed building

## Cost-effective strategies:

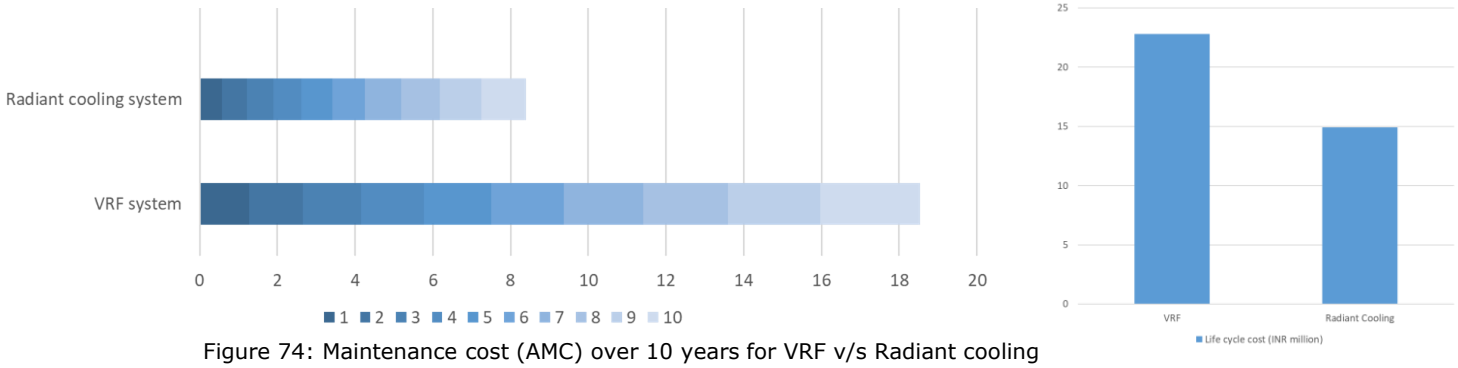
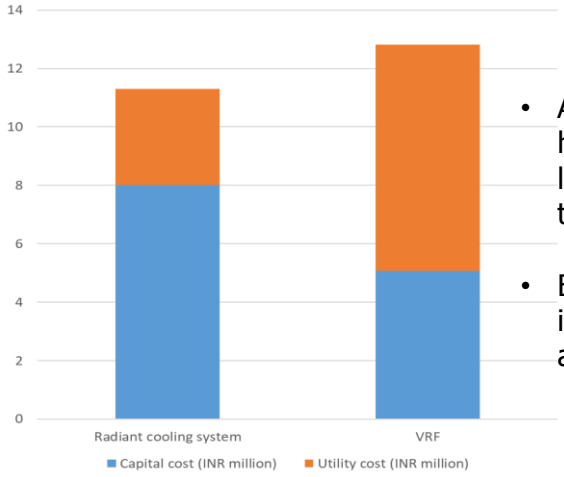



Figure 74: Maintenance cost (AMC) over 10 years for VRF v/s Radiant cooling




- Although the initial cost of radiant cooling is higher than VRF system, the maintenance cost is lesser by 54.6% and hence this helps in reducing the life cycle cost
- By using AAC blocks in the proposed case design instead of bricks, the dead load reduces by 58% and the cost per sqm. reduces by 39%

Figure 75: Radiant cooling v/s VRF

- Efficient planning to reduce circulation space by providing a single East-West corridor helps to increase the workspace area and in turn helps in the growth of the company.
- Since the service cores are limited to two corners, the functioning of the system is not disturbed.
- Healthier workspace with improved daylight facility and better indoor environmental quality reduces the cooling and lighting loads. Hence, the overall HVAC cost also reduces. This also, improves the productivity of the staff.

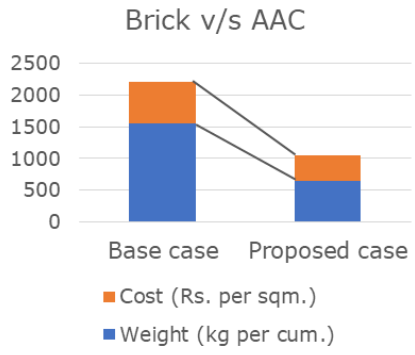



Fig 76: Comparison of Brick and AAC costing and weight

Fig 77: Corridors Layout

Main East-West corridor and secondary and tertiary corridors improve the circulation and communication in the workspace.

## SCALABILITY & MARKET POTENTIAL

Chennai is home to more green buildings than any other city in the country, 42 of the 212 structures in India that are certified as eco-friendly by the Indian Green Building Council (IGBC) are in Chennai. Mylapore neighbourhood of Chennai is the central part and the cultural hub of the city. The proximity to the railway line enables easy accessibility and an increased public footprint. Other office and commercial buildings in a hot and humid climate.

**Analysis of user/customer group -**

- Office employees (1:1 - Male: Female ratio) of parent company
- Office employees (1:1 - Male: Female ratio) of rental/ lease company
- Maintenance and service support

**Potential target market -**


Fig 78 : Potential Target Market

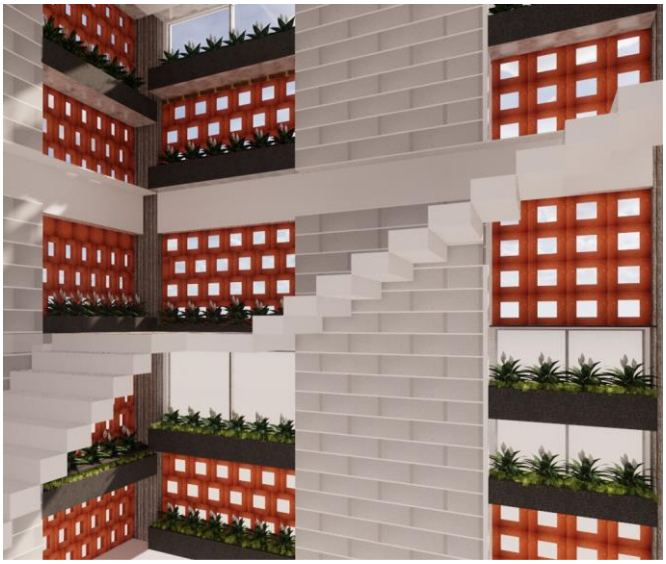


Fig 79 : Irresistible Staircase view

The current proposal has evolved through scrutinizing of the design iterations and simulations, with the potential to be the prototype model for an office building located at similar climatic region and context. The proposal caters to the current needs of the office space market & the needs of occupants at larger scale irrespective of being client specific.

By keeping this proposal as a prototype, with minimal changes as per the requirements, this building can be adapted to suit the needs of users in similar (Hot & Humid) climatic conditions, and scale irrespective of its typology due to the open floor plan proposal.

Apart from the building's potential to scale up, the two innovations proposed by the team- Terracotta modules, Noise Absorbing Panels have the potential to be market products.

## TERRACOTTA MODULES:

With the standard block size being 300mm X 300mm with a 150mm X 150mm puncture for airflow, the modules can be customized as 200mm X 200mm with 100mm X 100mm airflow punctures. The cost of these blocks ranges from Rs.50-80 based on the customized requirements.

With faster construction, these prefabricated blocks can be inbuilt into the 115mm thick walls, facing the direction of the wind, further adding aesthetically pleasing effects to the facade breaking the building's monotonous outlook.

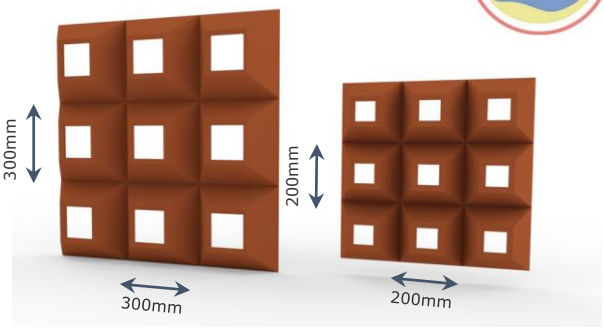



Fig 79 : Irresistible Staircase view

## NOISE ABSORBING MODULES`:

According to the 2018 report prepared by the Central Pollution Control Board (CPCB) of India, Chennai topped the list of noisiest metro cities in India. Chennai has an average noise level of 67.8dB during the day. Therefore, to combat this issue along with keeping Net-zero energy in mind we have developed a Modular product' that can be easily plugged onto any surface with incident noise energy across all climates and typologies of the structure are proposed by our team.


Fig 80: Exterior View

| Required Component | Cost/Piece |
|---|---|
| Control board - Arduino Uno | 270 |
| LCD | 220 |
| Speaker Mic | 100 |
| Step-up Transformer | 190 |
| LED | 90 |
| Diodes | 10 |
| LDR Sensor | 5 |
| Circuit Wire | 15 |
| Total Circuit Cost | 900 |

Table 26 : Cost analysis for circuit analysis

These modular products are designed in two modes - one as circuits and the other as panels for facades. The circuit system can be fixed at locations with noise potentials independent of buildings also. While the panels can be fixed on compound walls to light up the streets at night or incorporated into the building facades for aesthetics.

## PITCH TO PROJECT PARTNER

SAT- PRANALI is a net-zero-energy-water building for Team Global Logistics' new regional office in Chennai. The building provides tenants/owner-based office spaces for a lease with a total built-up area of 2289.80 sqm. The building is designed to achieve optimal comfort throughout the year by using various strategies to improve daylighting and indoor air quality.

The building has a cut-out for natural light with a self-shading staggered west facade, the building is stacked up one floor above the ground. thermal comfort is achieved by wedging of the southern facade and green facade towards west and east. northern side has a recess for maximum daylight, The eastern facades are kept semi-permeable with green walls to allow max. airflow into the building.

A detailed climatic study was conducted to understand the combination of strategies that could be adopted to enhance the building's performance and achieve 100% comfortable operational hours.


Fig 81 : Exterior View

The proposed cost of construction is **Rs. 7.16 Cr** which is **3.7%** greater than the base case cost of construction which is **Rs. 6.64 Cr**

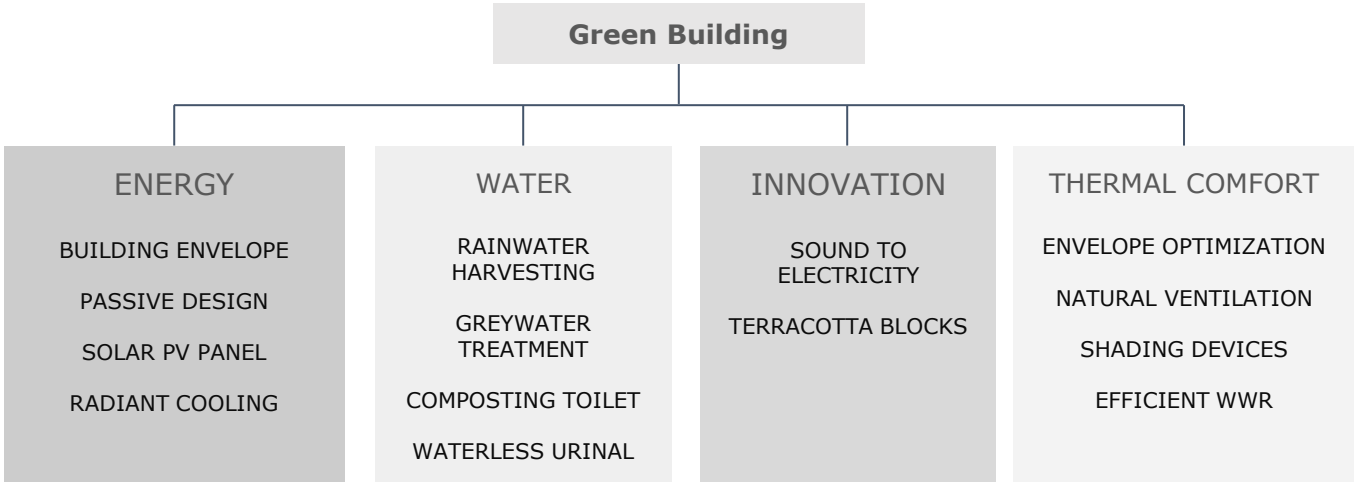
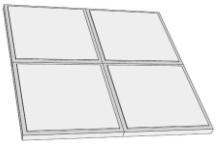



Fig 82: Flow chart of green building

Terracotta blocks that taper into a void help reduce the air temperature which in turn reduces the cooling load.These blocks are placed along the wind direction. It enables faster construction and adds character to the facade.



**Piezoelectric system**: **NOISE BASED POWER BANKS** are panels on facades that absorbs sound and converts it into electrical energy which can be used for various purposes during construction and post-construction and also can act as a backup option when stored in batteries.

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