Solar Decathlon India™

TEAM FOOT-PRINTERS

We work

OFFICE BUILDING

PRELIMINARY REPORT

RACHANA SANSAD ACADEMY OF ARCHITECTURE

SARDAR PATEL COLLEGE OF ENGINEERING

DY PATIL COLLEGE OF ENGINEERING

VERMATA JIJABAI TECHNOLOGICAL INSTITUTE

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DESIGN PROCESS -

Initially, the group was formed with 12 people, and eventually by deliverable 3 the group was reduced to 7 people, but keeping the attitude of not giving up and hunger to learn more we powered through and overcame all the obstacles to reach the finals.

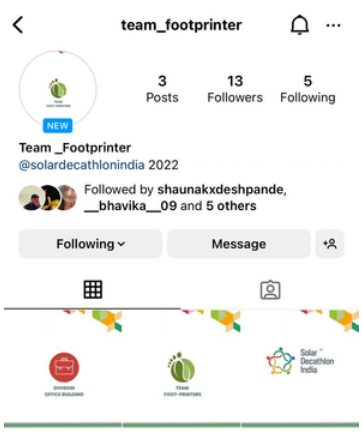
We initally started the process by doing a site visit and understanding the pros and cons of the exisitng building. We conducted online and offline meets discussing about the design, trying different methods to build net zero building

An instagram page was built up to communicate and make people aware about sustainabilty.

SOFTWARES USED -

AUTOCAD SketchUp Ps Canva DesignBuilder SOFTWARE Excel

TEAM-



1. TEAM SUMMARY

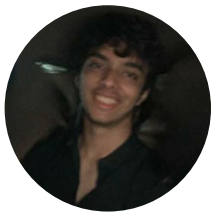
A.TEAM NAME: TEAM FOOTPRINT-ERS

B. INSTITUTION NAME: i. Rachana Sansad (Academy of Architecture), Mumbai
ii. Sardar Patel College of Engineering ,Mumbai
iii. VJTI Engineering ,Mumbai
iv. DY Patil College of Engineering, Pune

DIVISION: Office Building

TEAM APPROACH :

TEAM MEMBERS:



Aditya Srivastava
TEAM LEADER
Health and Wellbeing
3rd Yr B.Arch (UG)

Bhavika Jakhotiya
Arch.Design &Visualisation
Resilience
3rd Yr B.Arch (UG)

Janhavi Jadhav
Communication
Water Performance
3rd Yr B.Arch (UG)

Navya Malu
Innovations
Research and Documentation
3rd Yr B.Arch (UG)

Neha Malani
Innovations
Affordability and Scalability
3rd Yr B.Arch (UG)

Manasi Solanki
Constructions and Operation
3rd yr B.Tech. Civil

Shaunak Deshpande
Structure and Engineering
3rd yr B.Tech. Civil

Shriya Riana
Energy Solutions
3rd yr B.Tech. Electrical

1.2 INSTITUTIONS

LEAD: Rachana Sansad's Academy of Architecture, Mumbai
Established in 1955, Academy is a leading architecture institution in India continuing its 66 year old legacy to promote creativity and innovation in the fields of design and architecture. It is the founding department of Rachana Sansad in 1960, which has since then emerged as a premier institution for art and design education in Mumbai. 9 Students studying in 3rd year of B.Arch. have partnered with the institutions below to form a team of 12 students.

Dr. D.Y.Patil ,Pune
Established in 1998, is a private institute affiliated with SPPU, Pune, and is approved by AICTE, New Delhi. It is the oldest campus of the Dr. D.Y. Patil Group of Institutions.

Bharatiya Vidya Bhavan's Sardar Patel College of Engineering , Mumbai
It was established in 1962 as a Government Aided Engineering College. It started with three conventional courses: viz., Civil, Electrical, and Mechanical. The institute is permanently affiliated with University of Mumbai.

Veermata Jijabai Technological Institute (VJTI),Mumbai
Established in 1887, VJTI played a key role in fostering industrial growth across united India before independence and has established India's ecosystem for engineering training, research and education.

FACULTY GUIDES

Ar. Rajesh Shelke(Faculty Lead)

Architectural Building Construction Faculty at Rachana Sansad's Academy Of Architecture. He is an alumnus of AOA. He completed a course on Sustainable built environment and Technology in IGL 2019 (Indian Green League 2019), He received IGBC-AP in 2019. Worked with Conserve Consultants to create awareness and business opportunities in the West zone on Sustainable and Green building environments.

2. RESPONSE TO REVIEWER'S COMMENT

REVIEWER'S COMMENT	RESPONSE
energy performance	EPI calculation have been reached and necessary references have been provided in the appendix for proof of results along with heat and light simulation results presented as graphs
water performance - Consumption and reduction values need to be justified. Also mentioning the quantitative calculation of water saving.	A base case study on the water utilisation on the site has been done and varous methods and technologies have been provided to reuse,recyle water on the site. All the calculations have been provided
Embodied Carbon - Calculation for the base case and percentage reduction was missing	All the calculations For Embodied Carbon have been calculated and the conclusion has been withdrawn.
Resilence - Explaining the feasibility in proposed design.	Considering all the threats to the building, the design has been done and all the calculations and sizes of the DGU unit and Water tank have been mentioned.
Innovation How the idea is getting implemented on the site.	A well developed idea has been stated and how it can be implemented on the site.
Engineering and operation - Explaining the euipment section in more detail and mentioning the reason of selection	A more detailed study of each and every material has been done. Listed down with the reason of selection and providing its cost and brand
Affordiablity	Return on investment has been recalculated and the cost estimation sheet iwas reworked on after consulting experts and consultants in respective areas

Table 1

3. PROJECT SUMMARY

PROJECT PARTNER : WE WORK

PROJECT NAME: NET ZERO OFFICE

WeWork was founded in 2010 with the vision to create environments where people and companies come together and do their best work. It was opened first in New York City, and grown into a global flexible space provider committed to delivering technology-driven flexible solutions, inspiring spaces, and community experiences. Today, they constantly reimagining **how the workplace can help everyone**, from freelancers to Fortune 500s, be more motivated, productive, and connected.

It is a global company, where start-up companies or any individual who wish to start a new idea, and wants a space to work, this company offers a space on a rent basis to work.
Philosophy - Strive To Be Better, Together. We've always believed that we are better together. We must operate with a shared purpose to constantly improve and grow and become better as individuals, teams, and a company.

PROJECT DESCRIPTION

Our current site is located in BKC. It's a 16-tower building providing various options in spaces for a user to work. With the office culture, many recreational areas have been provided for events and many other purposes.
Looking at the current site and structure there is much scope for making the structure sustainable. Currently, on the daily basis, there is the use of an air conditioner for a minimum of 12 hours. There is no track on the use of water. Apart from this, being a such huge building the maintenance cost is high.

ESTIMATED TOTAL BUILT UP AREA :- 24800 sqm
TARGET EPI :- 52 KWP/SQM

REQUIREMENT OF THE PROJECT PARTNER

The requirements given by our project partner were,

- A space where the maintenance cost is less
- Space should provide multi options of seating arrangement and multiple usages.
- Making the building sustainable and user-friendly.
- Use existing resources available on the site can be used to its maximum potential.
- Reduction in energy consumption.

4. EXECUTIVE SUMMARY

The selected project WeWork is an international firm that rents shared coworking spaces and office spaces for people to work. The intention behind selecting the project is we can make the existing building self-efficient. So we initially started by analyzing and understanding the requirements of our project partner.
After this, we decoded the site in the following terms: climate, socioeconomic background, and physical features of the site. Knowing that the building requires flexibility in terms of space and acknowledging people coming from different backgrounds we have designed our building in a modular system. With this, we have tried to ensure that the building is self-efficient in terms of working. We have kept in mind future changes, in case expansion is required. We have tried to create a center that is special and appealing to invite people. The design has been done keeping physical and mental health as a priority and providing a space with an energetic and positive vibe.

Initially, we studied the existing structures of WeWork, to know about their working and operation. And drawing the pros and cons of existing building and understanding the project partner requirements.

With a **24800** sq.m. of built-up area, The main goal of the project was to design an office with a minimum EPI value, maximize renewable energy, make use of green materials, and use different techniques of water conservation. For reducing the EPI we have tried to implement an evaporative cooling system, cutting down on HVAC use, maximize sunlight, and provide the building with a self-generating electricity system which has helped us reduce the EPI to 38.6kWh per sq.m.
We have tried to include innovation in materials and to maximize the use of local materials. We have located suppliers and manufacturers close to site.

As we are **redesigning the existing building**, we have tried saving costs by reusing materials from the existing building. The concrete from the existing structure can be used as aggregate while reconstruction. The existing foundation can also be reused as the steel can be lapped. This also reduces excavation costs deeply,

As an office building requires a lot of equipment and HVAC of large tonnage, our primary concern was to reduce by at least 30% from the standard target of 71kWh/year.
Our main goal was to see how we can enhance pre-existing functions in the offices. As HVAC is absolutely necessary in our area of construction, we have looked at the addition of adiabatic cooling, to drastically reduce the HVAC requirements.
This approach is great keeping in mind global warming and our increasing dependence on HVAC.

5. CONTEXT AND APPROACH

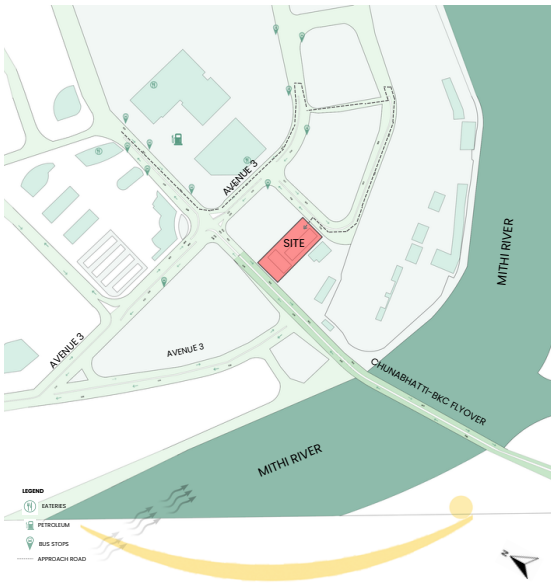


Figure 1 - Site Plan

- **LOCATION**: C20, G BLOCK, BANDRA KURLA COMPLEX, MUMBAI
- **SITE AREA**: 92M X 40M =3680 SQ.M

- **HISTORY OF SITE** - BKC has been created by landfilling 620 acres into rivers, wetlands, and mangroves. That area was an integral part of a river estuary, reclaimed and utilised to create a business hub.

- **USER PROFILE**

Occupation- Job,Students,Service providers

Timings- 8 AM to 8 PM

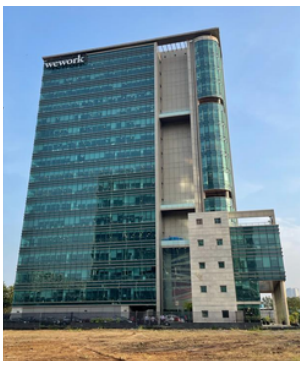


Figure 2 We Work Building

- **NATURAL PHYSICAL FEATURES NEAR THE SITE**

Mithi river
Barren lands-Micro climate created near the site
Playground

- **MANMADE FEATURES-**

Road Networks-Two way lane road, highways, Flyover
High rise buildings
Petrol pumps
Recreation spaces (dinning zones)

- **MICRO CONTEXT:**

It is a commercial area surrounded by modern buildings. Because it is commercial, it attracts a large number of working people, and many restaurants have sprung up to capitalize on this opportunity.
BKC is a central business district, which has some of the highest property rates in Mumbai.

- **TECHNOLOGIES AND MATERIALS**

Materials such as terracotta pots can be sourced from within Mumbai.

- **ENVIRONMENTAL ISSUES**

Overall BKC faces similar problems as the rest of Mumbai. Air pollution is at the top of the list- with pollutant levels approximately 6 times above recommended WHO levels. The mangroves, which are located close to the site, are a dying resource of Mumbai. A large quantity of e-waste is generated here, which can cause health and environmental problems if not managed well.

- **MARKET ANALYSIS AND TARGET POPULATION**

The project is designed keeping in mind the shared coworking space typology. The majority of people visiting this office are from within city limits. The employees' mode of transportation is mainly private 2-wheelers and 4-wheelers, followed by bus transport(public and cityflo)

6. GOALS

HEALTH AND WELLBEING

Aim: to reduce employee stress, absenteeism and Improve employee satisfaction, health, performance, and productivity, and Improve air quality within the building

INNOVATION

Provide flexible and multifunctional workspaces.
Ensuring a good ventilation system,
Increase thermal insulation to reduce HVAC load.
Inbuilt electricity generation.
Providing co-living and co-working space.

RESILIENCE

To resist and survive during natural disasters and successfully adapt to adverse events in future

AFFORDABILITY

To reduce the material used in the conventional way of construction. Strategic use of Locally available materials. To reduce the initial construction cost and provide a high return on investment to the employers

ENERGY PERFORMANCE -

The aim is to reduce annual EPI by 30% minimum from the mentioned target of 71kWh/m2 for energy-efficient office buildings here we have tried to use an adiabatic cooling system with HVAC and photovoltaic cells which have to reduce the energy performances of the building.

ARCHITECTURAL DESIGN

1. Office building to transcend conventions
2. Ensuring Accessibility and Inclusivity
3. Creating a network of open spaces within the built volume, spaces that provide a healthy working environment.

ENGINEERING AND OPERATION

Selecting eco-friendly materials. Also, using existing foundations and reusing the existing materials available on-site for constructing a new building. The energy appliances used for ventilation should minimize the wastage of energy. This building can cool itself without needing many energy appliances.

COMMUNICATION

AIM:-To encourage clients to work towards achieving and maintaining net-zero efficiency in the office building.

LANDSCAPE

To create a diverse landscape that has a positive impact on the surrounding environment.

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WATER-

The goal is to achieve Net-Zero Water by reducing and tracking consumption and utilizing harvested water, using water-efficient fixtures, and planning root-zone treatment for sustainable reuse of greywater.

SCALABILITY AND MARKET POTENTIAL

Make future expansions more easily.
Using green and affordable materials.
Making the building self-sustainable.

7. BUILDING AREA PROGRAMME

The area statement provided contains area of only 1 module of the design. According to the clients need and future expansion the module of 3 floors can be repeated above giving verticality to the structure.

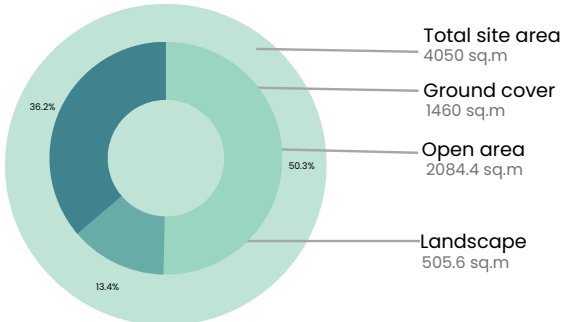
SITE AREA	4000 SQM
ROOF AREA	550 SQM
GROUND COVERAGE	550 SQM
PROPOSED BUILT UP AREA	96192 SQM

Table 2

SR.NO	SPACES	NO. OF UNITS	AREA (sq.m)	TOTAL AREA (sq.m)	HAVAC PROVISION
1	RECEPTION	1	50	50	Conditioned
2	ADMIN	1	200	200	Conditioned
3	WORKSTATIONS	12	2200	26400	Conditioned
4	MEETING ROOM	12	721	8652	Conditioned
5	WAITING AREA	12	400	4800	Conditioned
6	LOUNGE	12	960	11520	Conditioned
7	TOILET	16	600	9600	Unconditioned
8	PANTRY	12	200	2400	Conditioned
9	SLEEPING PODS	1	74.2	74	Conditioned
10	GALLERY	13	200	2600	Unconditioned
11	PHONE BOOTH	12	350	4200	Conditioned
12	COMMUNITY CENTRE	1	500	500	Conditioned
13	LIFT	16	300	4800	Unconditioned
14	SHAFT	16	36	576	Unconditioned
15	AHU	16	90	1440	Unconditioned
16	Store room	16	50	800	Unconditioned
17	FIRESTAIRCSE	16	230	3680	Unconditioned
18	STAIRCASE	16	600	9600	Unconditioned
19	OPEN SPACE	1	800	800	Unconditioned
20	Multipurpose	1	300	300	Conditioned
21	PARKING	2	1600	3200	Unconditioned
	TOTAL			96192	

Table 3 Proposed area programming with division of spaces

AREA SUMMARY



Total Site area	4050
Proposed Ground	1460
Coverage Open space	2084.4
Derived Landscape area	505.6
Proposed FAR	3.02
Permissible FAR	5
Proposed Built up Area	12262.6

Table 4 Area summary

8. PRE-DESIGN ANALYSIS

8.1 .Climate Analysis

- Mumbai has a **tropical climate**. The average annual temperature is **26.4 °C | 79.6 °F** in Mumbai.
- In Mumbai, the wet season is oppressive, windy, and overcast; the dry season is muggy and mostly clear; and it is **hot year** round.
- In a year, the rainfall is **2012 mm** | 79.2 inch. When compared with winter, the summers have much more rainfall.
- The month with the highest relative humidity is **July (88.99 %).** The month with the lowest relative humidity is **December (57.22 %).**
- The month with the highest number of rainy days is July (28.97 days). The month with the lowest number of rainy days is April (0.13 days)

MONTH	CLIMATIC SEGMENT	DESIGN GUIDELINE	
		PASSIVE COOLING STRATEGIES	ACTIVE COOLING STRATEGIES
JANUARY	Cool	narrow form, longer axis towards N-S, self shading,internal heat gain, Natural Ventilation	Cooling and dehumidification, Fans
FEBRUARY	Warm and Hot	narrow form, longer axis towards N-S, self shading,internal heat gain, Natural Ventilation	Solar AC, Geothermal heat pump, Cooling and dehumidification, Fans, evaporation system
MARCH	Warm and Hot		
APRIL	Hot	narrow form, longer axis towards N-S, self shading,internal heat gain, Natural Ventilation, Wind and Stack Ventilation, Night purge Ventilation, Shading of roof and window, Earthen pot cooling system	Solar AC, Geothermal heat pump, Cooling and dehumidification, Fans, evaporation system
MAY			
JUNE	Hot and Muggy	narrow form, longer axis towards N-S, self shading,internal heat gain, Natural Ventilation, Wind and Stack Ventilation, Night purge Ventilation, Shading of roof and window, Earthen pot cooling system	Solar AC, Geothermal heat pump, Cooling and dehumidification, Fans, evaporation system
JULY			
AUGUST			
SEPTEMBER			
OCTOBER	Hot	narrow form, longer axis towards N-S, self shading,internal heat gain, long elongated form, Natural Ventilation, Wind and Stack Ventilation, Night purge Ventilation, Shading of roof and window, Earthen pot cooling system	Solar AC, Geothermal heat pump, Cooling and dehumidification, Fans, evaporation system
NOVEMBER			
DECEMBER	Warm and Hot	narrow form, longer axis towards N-S, self shading,internal heat gain, Natural Ventilation,passive solar gain	Cooling and dehumidification, Fans

Table 5: Active and Passive cooling strategies based on the months

8.2.SITE ANALYSIS

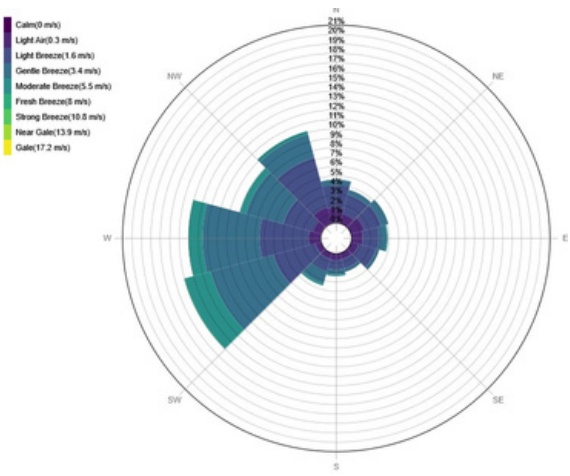


Figure 3: Wind Speed

The wind flows from west side at speed of 5.5 m/s

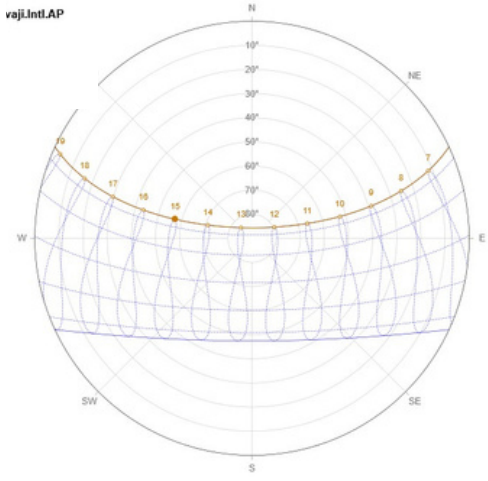


Figure 4: Sun Path

Sunpath on Summer solstice

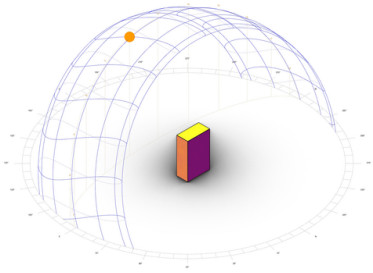


Figure 5: Spring Equinox

March 22, spring equinox 12.00pm

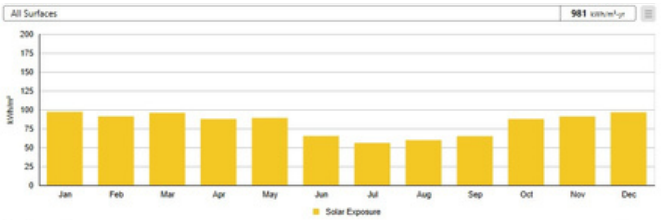


Table 6 Annual Solar Exposure

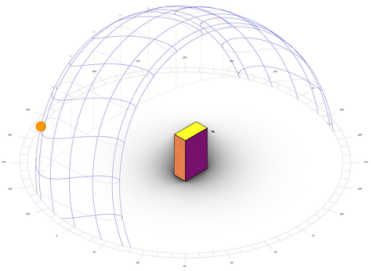


Figure 6: Winter Equinox

Dec 21, Winter solstice 9.00am

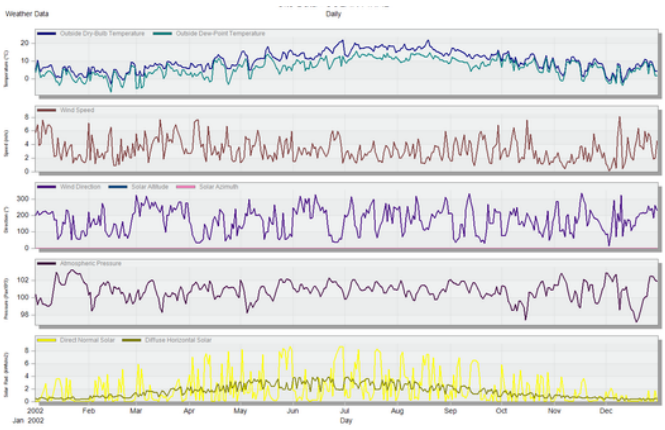


Table 7: Site Data

	Total	North (315 to 45 deg)	East (45 to 135 deg)	South (135 to 225 deg)	West (225 to 315 deg)
Gross Wall Area [m2]	7031.00	2157.59	1364.98	2153.45	1354.98
Above Ground Wall Area [m2]	7031.00	2157.59	1364.98	2153.45	1354.98
Window Opening Area [m2]	3269.82	1034.33	639.14	962.43	633.92
Gross Window-Wall Ratio [%]	46.51	47.94	46.82	44.69	46.78
Above Ground Window-Wall Ratio [%]	46.51	47.94	46.82	44.69	46.78

Table 8: Window to wall ratio for unconditioned facade

	Total	North (315 to 45 deg)	East (45 to 135 deg)	South (135 to 225 deg)	West (225 to 315 deg)
Gross Wall Area [m2]	7031.00	2157.59	1364.98	2153.45	1354.98
Above Ground Wall Area [m2]	7031.00	2157.59	1364.98	2153.45	1354.98
Window Opening Area [m2]	3269.82	1034.33	639.14	962.43	633.92
Gross Window-Wall Ratio [%]	46.51	47.94	46.82	44.69	46.78
Above Ground Window-Wall Ratio [%]	46.51	47.94	46.82	44.69	46.78

Table 9: Window to wall ratio for conditioned facade

8.3.DESIGN IDEA

A. ZONING

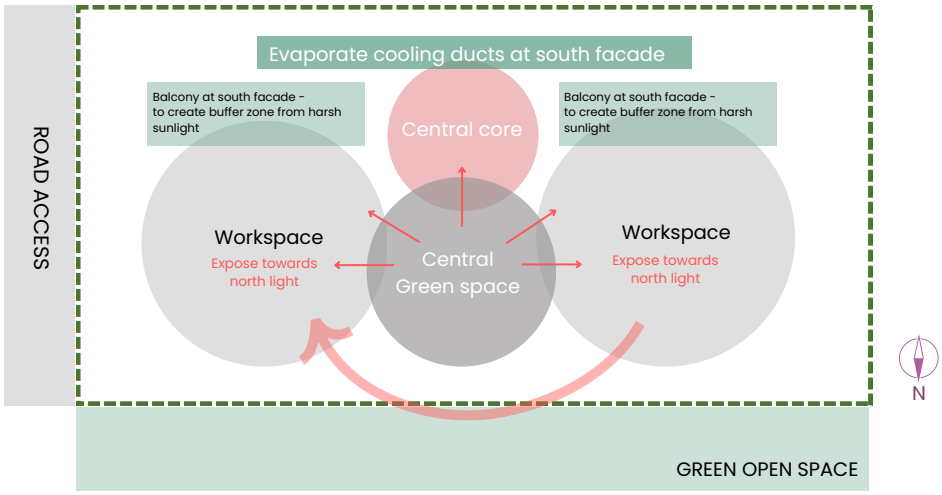


Figure 7 - Zoning

B. FORM DEVELOPMENT

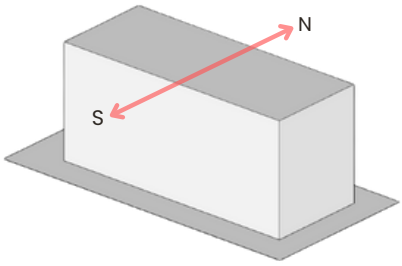


Figure 8

The office is aligned in such a way that the longer side is facing north south direction.

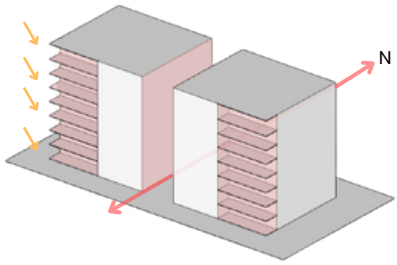


Figure 9

The form is divided into two entities forming a courtyard in the middle.

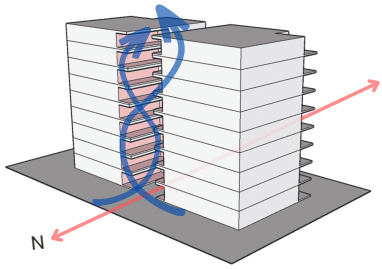


Figure 10

Substraction of the masses is done to regulate the air flow throught out the building.

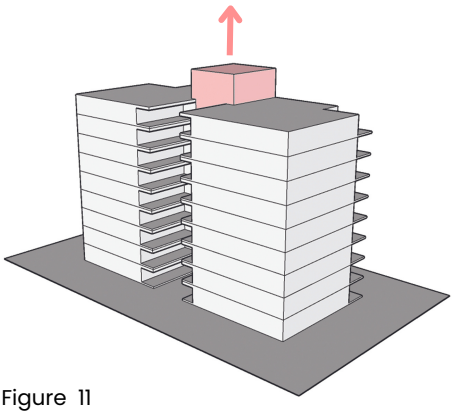


Figure 11

Chajjas are added for weather protection and shading. A central staircase is added connecting two spaces

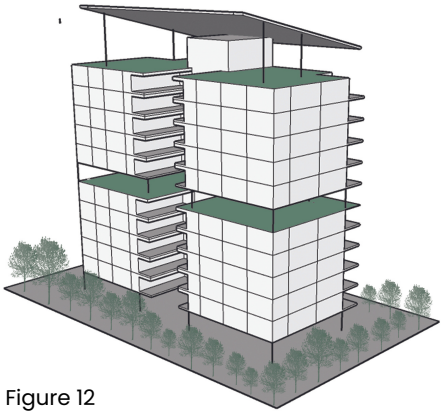


Figure 12

Roof is tilted in the southern direction for the solar panels to trap maximum sunlight .

8.4.DESIGN DOCUMENTATION

The office has been designed in such a manner that it can easily accommodate future changes. Using the concept of co-living and co-working the space has been executed.
With the increase of work culture and the effects of pandemic in recent years, this office is designed in a completely self-sustainable manner, where one floor has been dedicated to sleeping pods and community spaces. And rest of the spaces are dedicated to the work.
Keeping in mind the intense of work culture, physical as well as mental health has been given priority while designing the office.

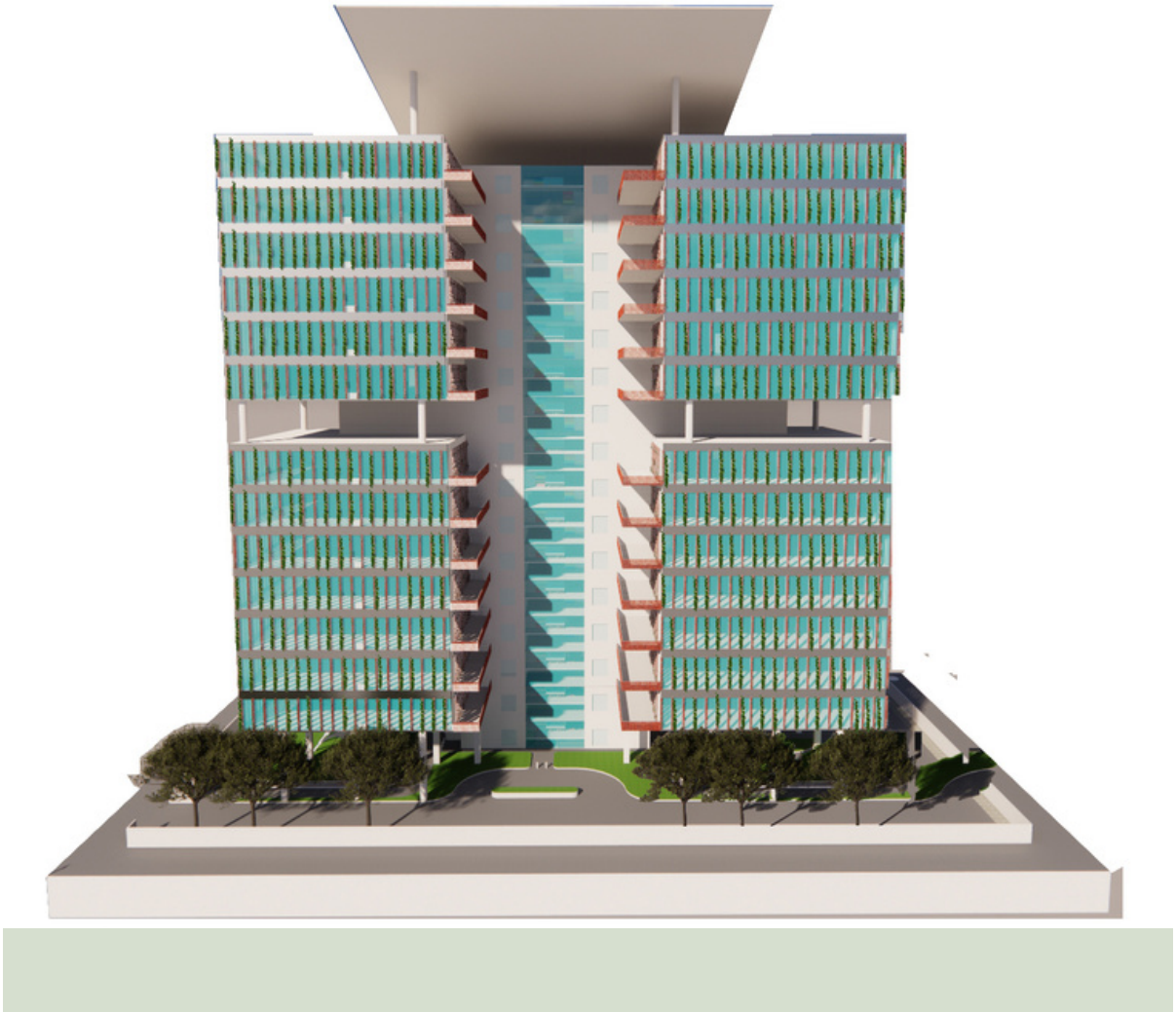


Figure 13 Elevation of the building

If we broaden our view of how our employees use the office, we have a greater chance of getting people back in the office and getting more out of the spaces and places that have been underutilized these past couple of years. So, make your office spaces and places something special and be willing to make them the center of your employee community rather than just a place where work can get done, which, of course, is still important, too.

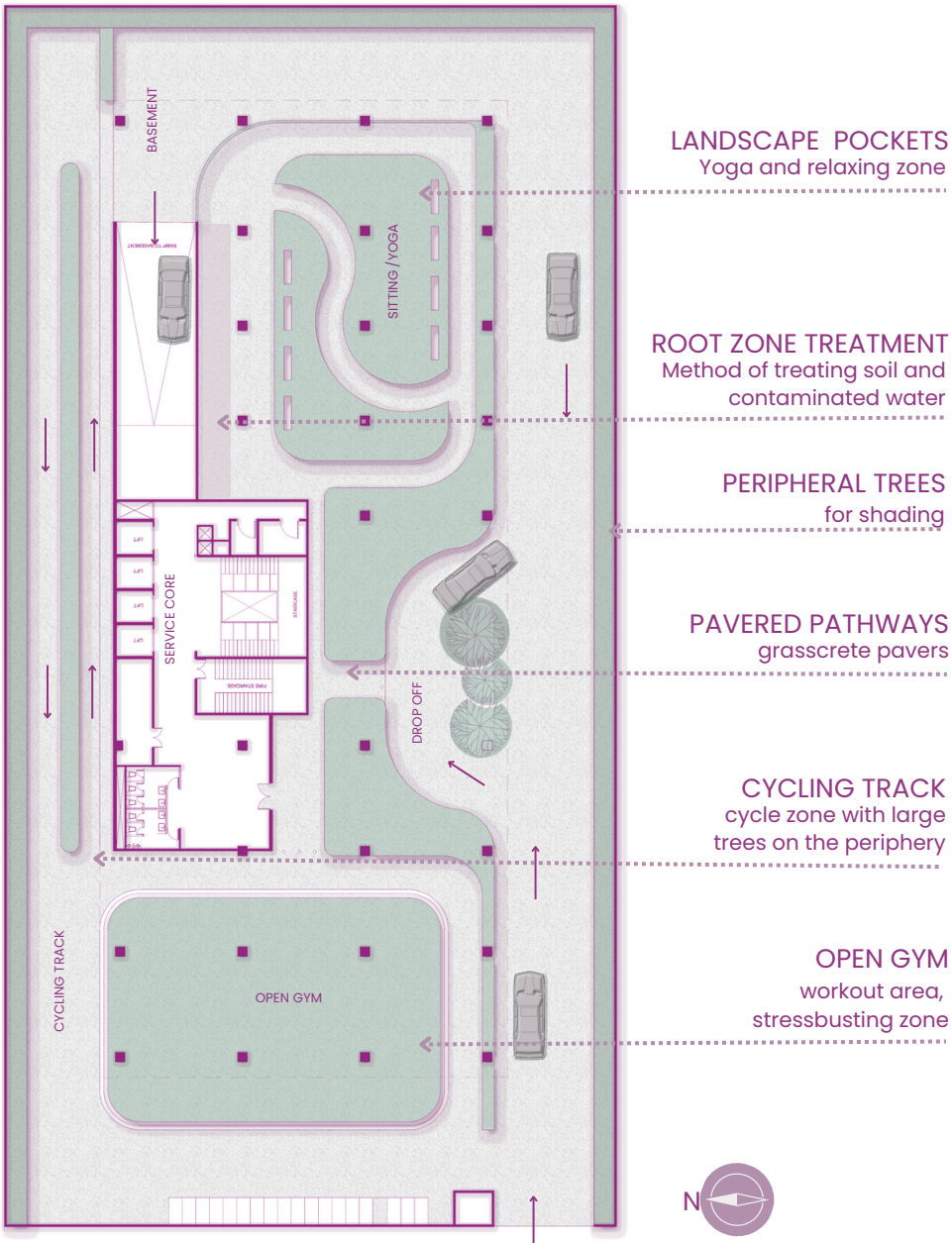


Figure 14

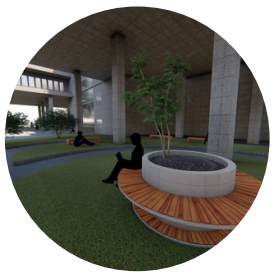
The ground floor is provided competely with green space with 8m high space. Here a cycling track, an open gym, walking track, place dedicated for yoga, etc has been provided which can be used by the people working here during their recreational time which will promote the healthy lifestyle among people.

The plants provided here are air filtering plant which try providing a good quality of air for the humans using this space so that they dont feel fatigue.

Figure 15

CYCLING TRACK

Figure 16



GREEN POCKETS

Figure 17

DROP OFF

Figure 18

OPEN GYM

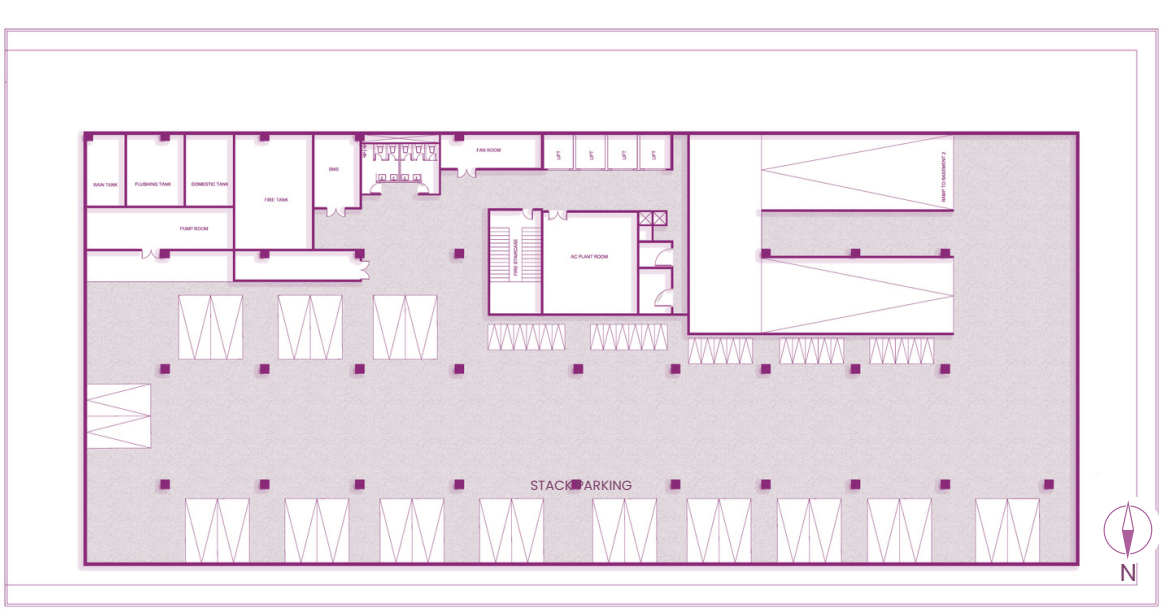
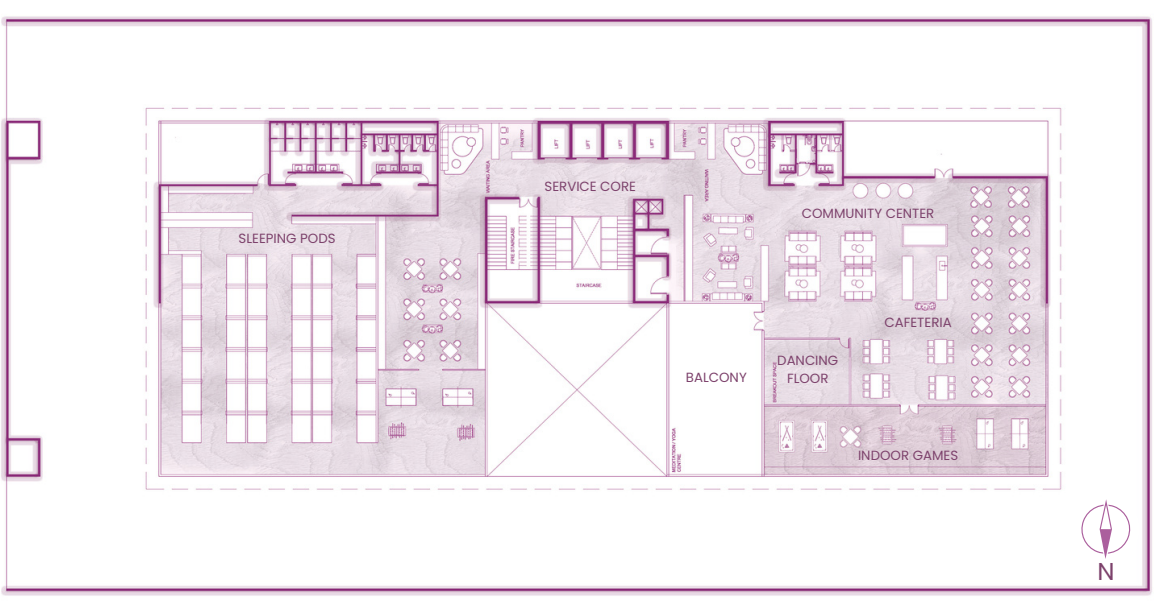


Figure 19

BASEMENT PLAN



FIRST FLOOR PLAN

Figure 20

Keeping the main aspect of designing a self-sustainable building one floor is dedicated to the sleeping pods area and different forms of recreational area. Which will ensure a healthy working style of people and will also provide with different vibe of space breaking the regular stereotype of a working space. This space is also deisgned in such a way that it can withstand any future emergencies.

SLEEPING PODS

Figure 21

INDOOR GAME

Figure 22

LIBRARAY

Figure 23

CAFETERIA

Figure 24

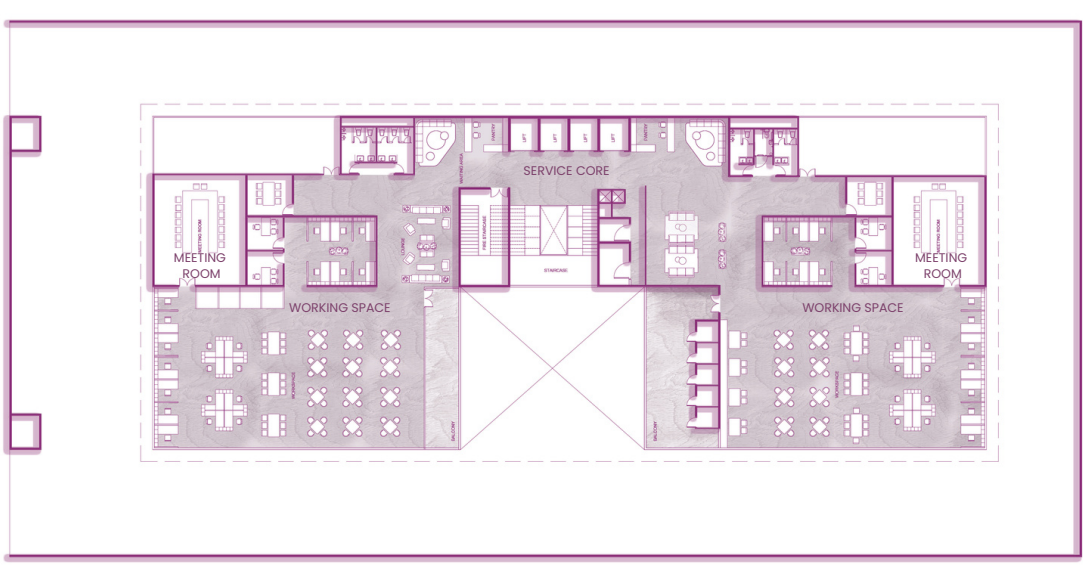


Figure 25

WORKSPACE MODULE PLAN

Working space is designed in such a manner where a person gets the freedom of flexibilty within the space.

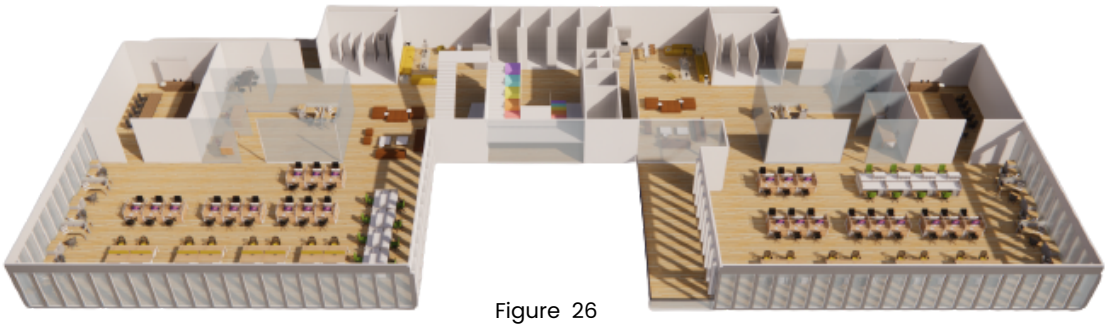


Figure 26

INTERACTIVE STAIRCASE -

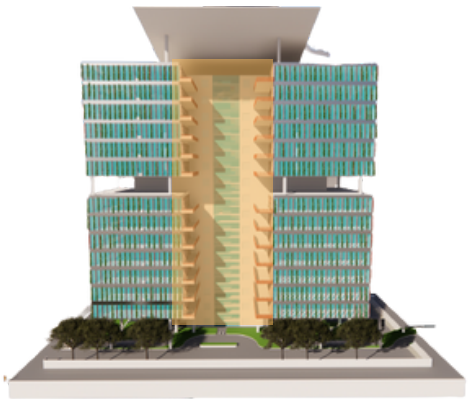


Figure 27

Figure 28

Figure 29

Figure 29

Keeping the health as an important aspect in designing, we have tried to design the staircase in an interactive and playful manner so that people use more staircase.
Location- Facing towards the north side for diffused sunlight, placed at the central of the site and is opened towards the courtyard getting a good view.

SECTION

Figure 30

Our design is modular, which provides flexibility to the design of the project partner wishes to expand vertically. One module comprises three floors, including offices, dedicated desks, and recreational floors between modules.

The ground floor has been kept mostly open, with landscaping, cycling tracks and an open gym area.

The common spaces have mostly been located in the lower floors- making them easily accessible for office-goers as well as visitors. These floors comprise the sleeping pods area, the community centre, kitchen, and recreation centre.

The offices are available in options to suit the user's needs- mainly full-floor offices, dedicated desks, and shared coworking spaces.

TWO LEVEL STACK PARKING

Two Level Stack Parking has two column and a platform, it can be installed in stilt parking, open space, podium level. Cars can be parked very easily. It is a dependent system.

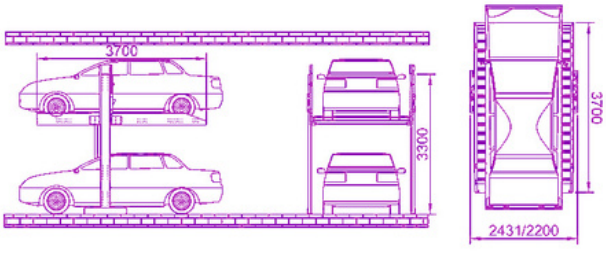


image source-aristoparkingsolutions.

Figure 31

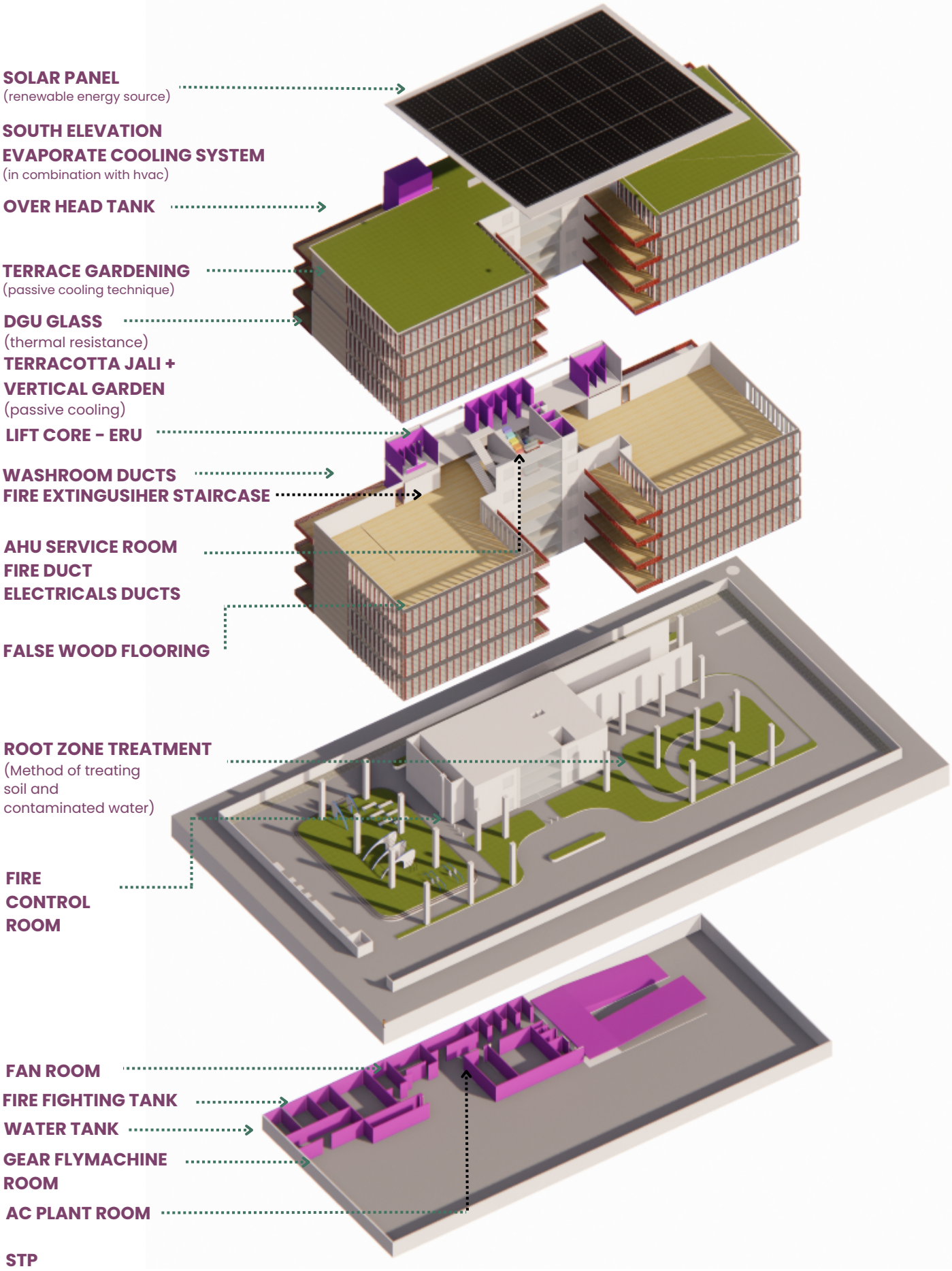


Figure 32 Isometric of the building

8.5.HEALTH AND WELL BEING

WALKING AND CYCLING TRACKS
Figure 33

INDOOR GAME
Figure 34

YOGA AREA
Figure 35

INTERACTIVE STAIRCASE
Figure 36

OPEN GYM
Figure 37

DANCING FLOOR
Figure 38

MENTAL HEALTH

- Space designed to allow **maximum sunlight.**
- **Multiple options of recreational zones** have been given.
- For supporting a healthy lifestyle, **Roof terrace** has given a provision of growing **organic vegetables.**
- For maintain a good quality of air flow inside the building - **air filtering plants** have been provided.
- A Separate **zone of meditation and silent zone** have been provided.

INNOVATION

Providing cycle which generates electricty will help in maintaing health as well produce electricty at the same time.

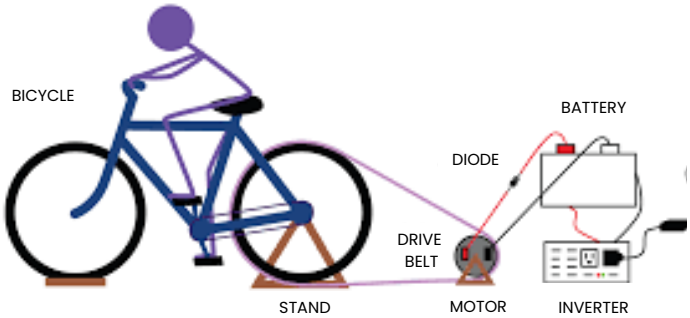


Figure 39 (Google Image)

Pedaling a bike at a reasonable pace generates about 100 watts of power. That's the same energy-per-time used by a 100-watt lightbulb.

8hours pedaling for a month produces 24kwh of energy.

DAYLIGHT

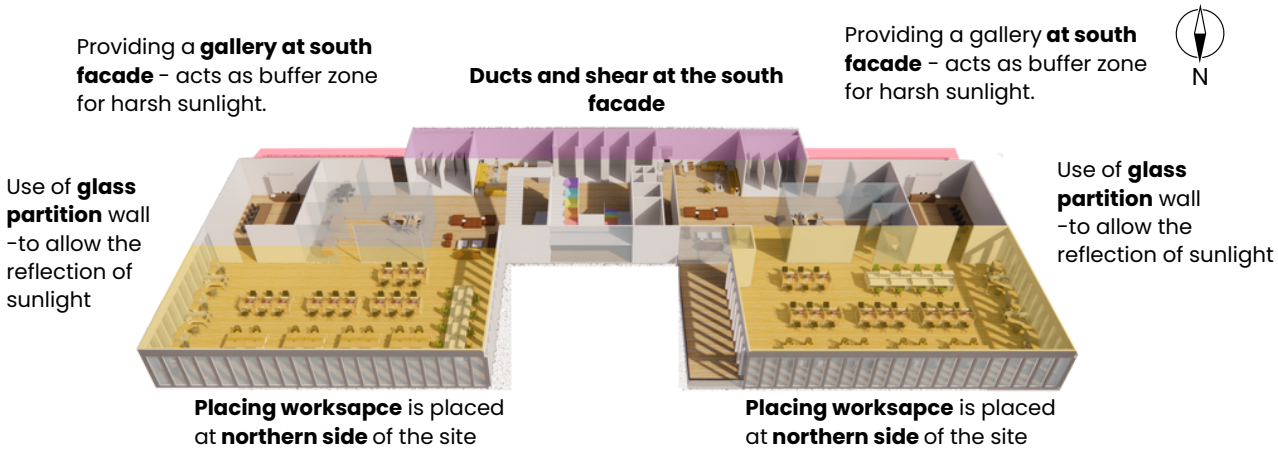
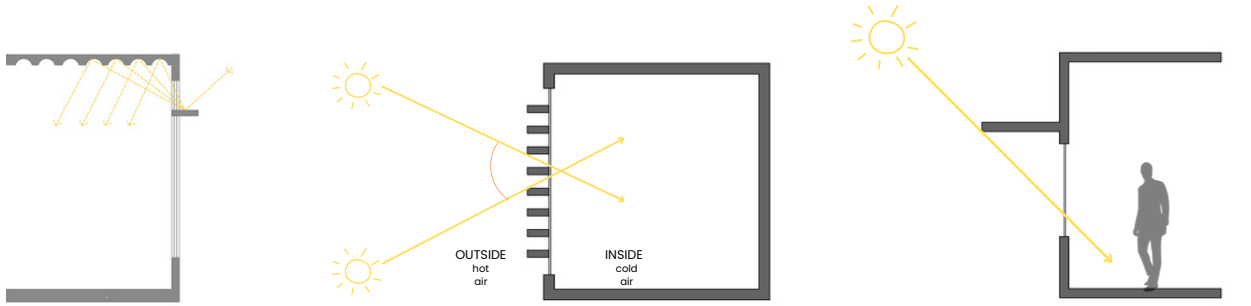


Figure 40 zoning of workspace

MATERIAL PALLETE –

- Not placing any bulky furniture near north facade and the color pallete of furniture is kept in light colors so that it reflects light.
- Use of glass partition wall helps in easy transfer of light in internal spaces.
- The ceiling to be covered by white paint for ease of light reflection.
- Using Reflective glass on the east and west sides of courtyard - it is a annealed glass that has a thin layer of metallic or metallic oxide coating. Since this coating is applied to only one side of the glass, it has a mirror-like appearance.

ROOF PROFILE **VERTICAL SHADING** **HORIZONTAL SHADING**

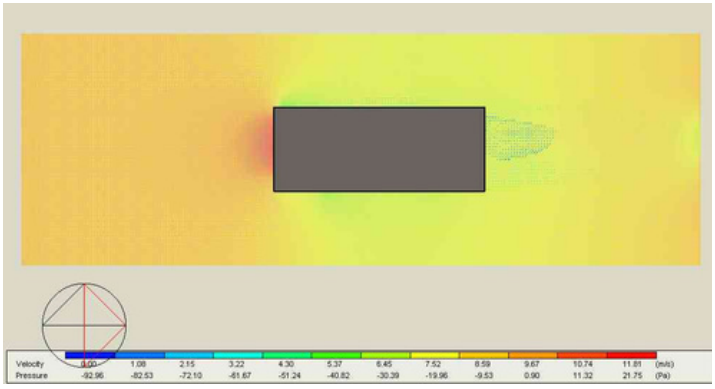


DURING EVENING – When sun is in the west the light falling on east facade will help to reflect the light and enligh the front building.

DURING MORNING– When sun is in the east the light falling on east facade will help to reflect the light and enlight the front building.

Figure 41 Explaining the sunrays reflection on the building facade

8.6. SHOEBOX ANALYSIS



Due to direct exposure to the effective hot wind, the linear constructed form has an east-west longer axis orientation. To allow stack ventilation, masses are added and withdrawn to account for wind movement. The optimised constructed shape is located in the centre, with projected mass (balconies) towards the southern facade.

Figure 42 CFD for linear built

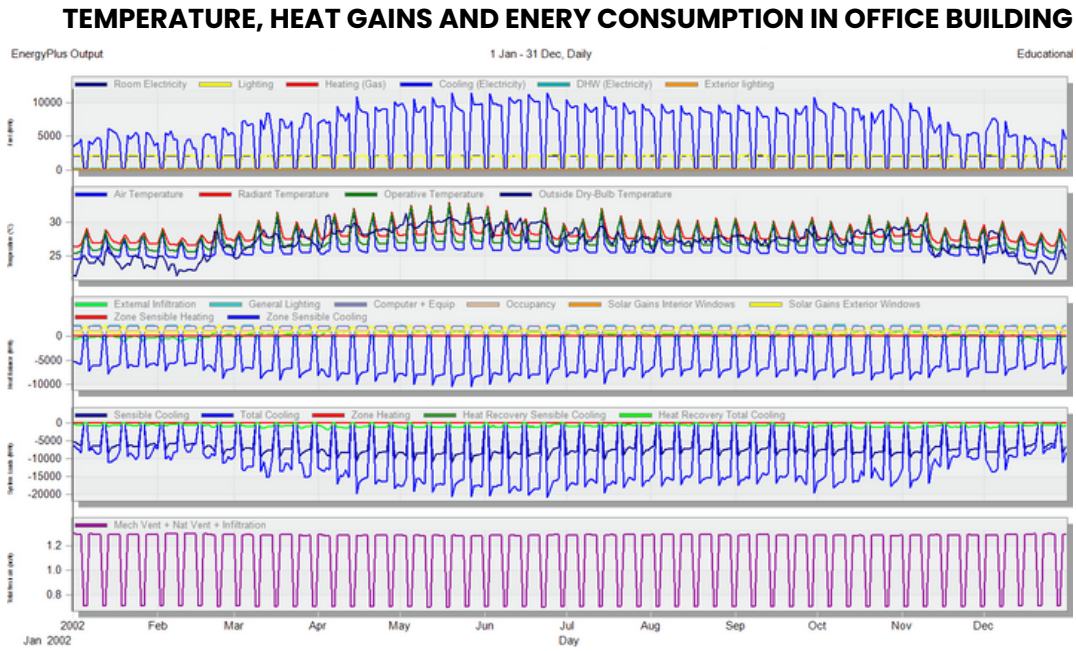
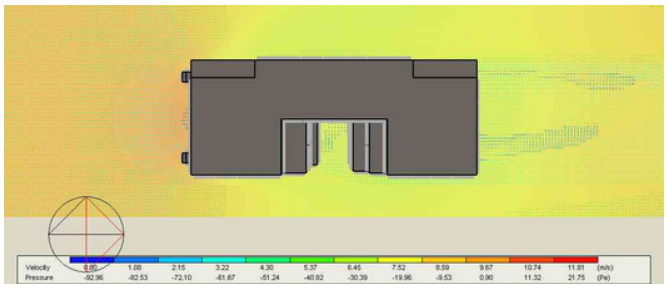
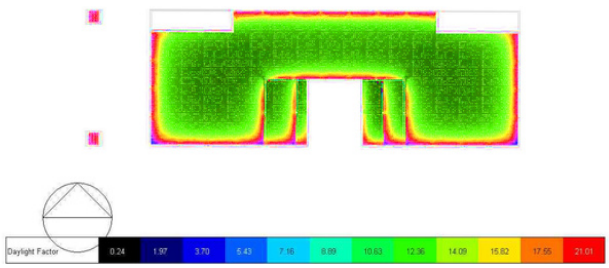


Figure 43 TEMPERATURE, HEAT GAINS AND ENERY CONSUMPTION IN OFFICE BUILDING



The most efficient air flow variability and effective air velocity all around the building will be effective for maximizing the stack ventilation.

Figure 44 : The CFD for proposed building



The reduction the radiation on wall assembly due to induced self shading and projected mass in the southern façade and also increased the roof area for PV panel installation .

Figure 45 Daylight Analysis

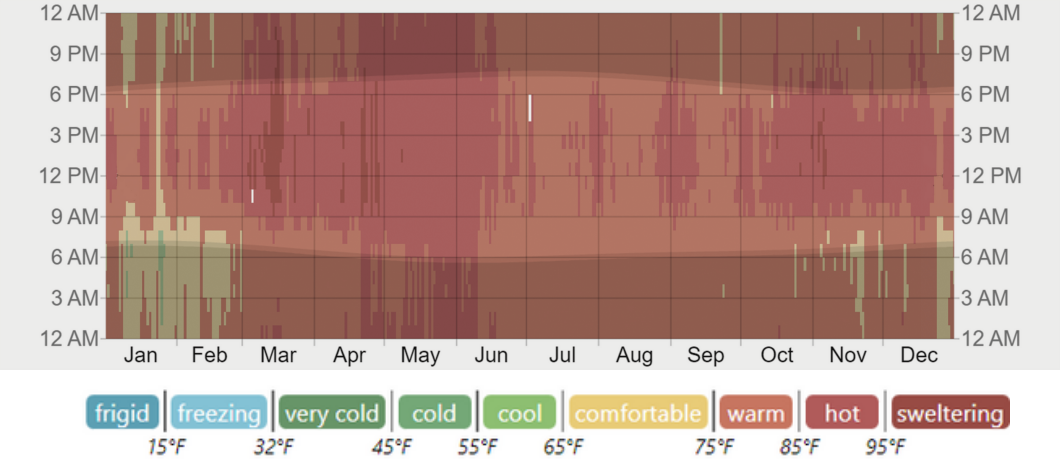
The optimized narrow plan form with the setbacks and orientation results in most efficient daylight performance.

8.7 ENERGY PERFORMANCE

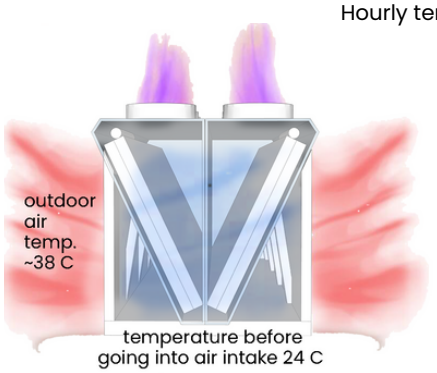
CURRENT SYSTEM - CONVENTIONAL HVAC:

322.15 TONS x 12h x 260 days=**1,005,108 kwH/ year** (assuming 1ton = 1000 wats)

As can be studied from the chart below, average yearly temperature of Mumbai is significantly high, around 25- 35°C, and this is why the load on the outdoor unit of HVAC is high. thus we worked towards decreasing the micro climate around the unit to decrease energy consumption by HVAC



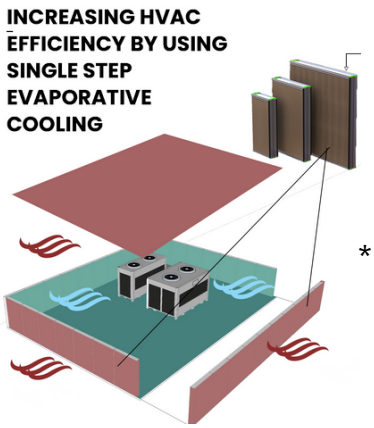
Hourly temperature variation in Mumbai for one year



This form of evoprative pre-cooling uses a **contact-humidifier** to cool down the incoming air before ventilating it through an air-cooled chiller. This increases the efficiency of the chiller considerably since the outdoor unit has to work less to convert hot air to cool air and will result in drastic energy savings.

Figure 46 Air flow movement in the system

The pre cooling is built around (the condensers of) the chiller and **shades the condenser** completely. It creates a **cool microclimate surrounding the condenser**. In addition, the Precool is controlled by energy-saving software taking into account local weather data and the water quality, and the thickening of the water during the cooling process. This way, adjustments are made automatically so that the chiller runs as efficiently as possible at the lowest possible energy costs.

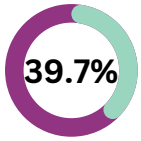


*

Figure 47: Precooling mechanism

ENERGY CONSUMPTION

=(322.15 - 0.39 x 322.15)TONS x 12h x 260 Days
=196.52 TONS x 12h x 260 Days
=6,13,142 kWH/ Year



Decrease in HVAC LOAD

*see appendix for reference

INTRODUCING EVAPORATIVE COOLING IN ADDITION TO CURRENT HVAC

Indirect/direct cooling, also known as two-stage evaporative cooling, uses **both indirect and direct cooling** techniques to cool the air. The first indirect **"cooling step"** uses cold recirculation water to pre-cool the ambient air in a heat exchanger. Because **no moisture is added**, the air reaches a lower dry bulb and wet bulb temperature than the outside air when leaving the heat exchanger. The second direct adiabatic "cooling step" **cools the air further through the wet evaporative media.** As a result of this two-step cooling process, the air can be brought down to a much lower temperature and is *therefore not capable of containing high amounts of humidity(see appendix)*

OFFICE WORKSPACE

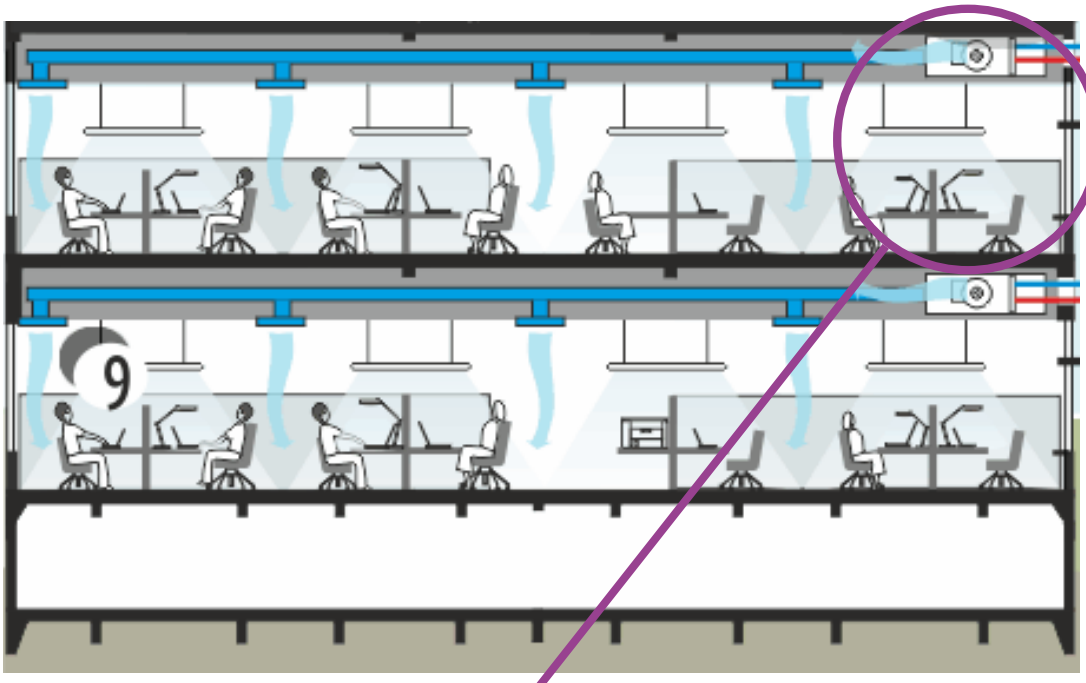


Figure 48: Mechanism of two-stage evaporative cooling

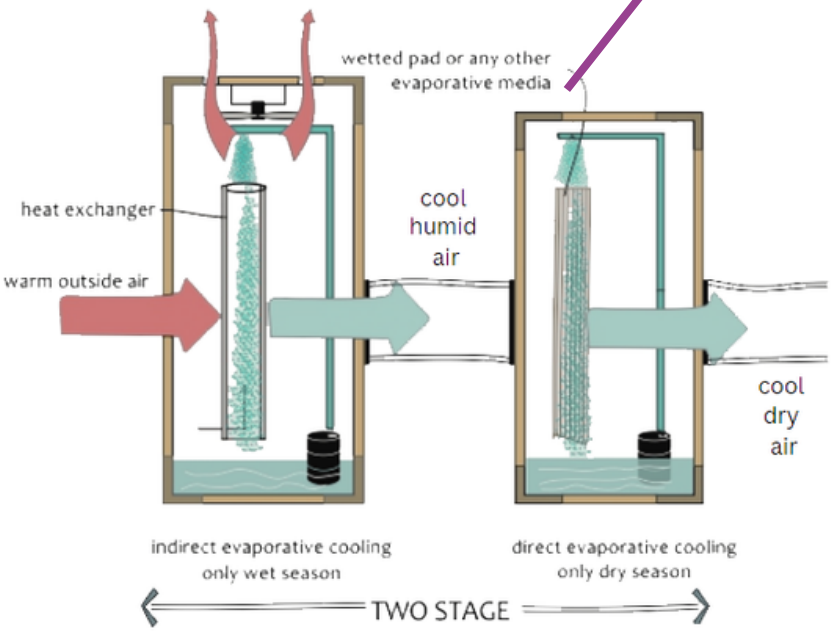


Figure 49: Detail of indirect coolingmechanism

On hot days the cooling **efficiency of the two-stage evaporative cooling system increases.** Warmer temperatures allow for more moisture in the air, and thus the system can evaporate more water. And **the more water is evaporated, the more cooling power the system can provide, without increasing its energy consumption**.(see appendix for reference)

The hotter and dryer a climate is, the higher the performance of an evaporative cooling system. A desert climate is, therefore, the most optimal climate for evaporative cooling. High temperatures and low humidity, provide a lot of cooling power.

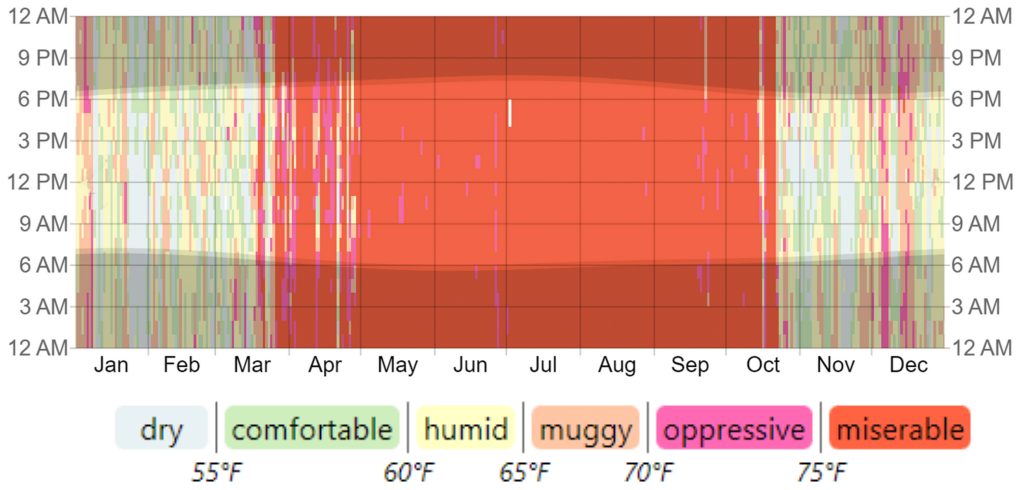


Table 10. Hourly humidity variation in Mumbai for one year

However, though Mumbai has a **warm and humid climate**, **dry and more humid periods alternate** and Humid days occur *mostly during spring and autumn* when temperatures are still relatively low, and the humidity is only high for **a couple of hours during the day.**

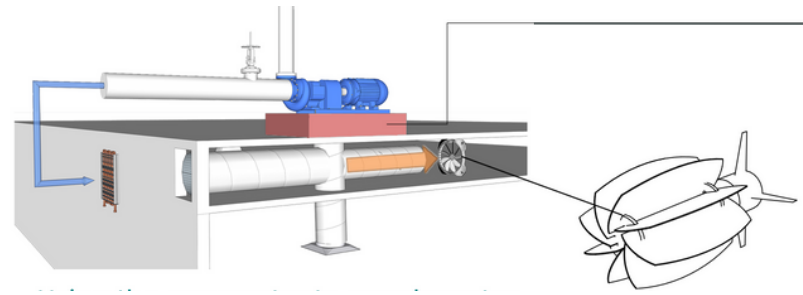


Figure 46: Equipment involved in the process of evaporative cooling

Yet, evaporative cooling remains a physical process: with a relative humidity of 80% or 90%, a two-stage evaporative system cannot cool as effectively as at lower humidity levels. In this case, a semi-hybrid evaporative cooling system can provide an optimal cooling solution. This combines both a two-stage evaporative cooling system with a regular yet smaller, mechanical cooling system.

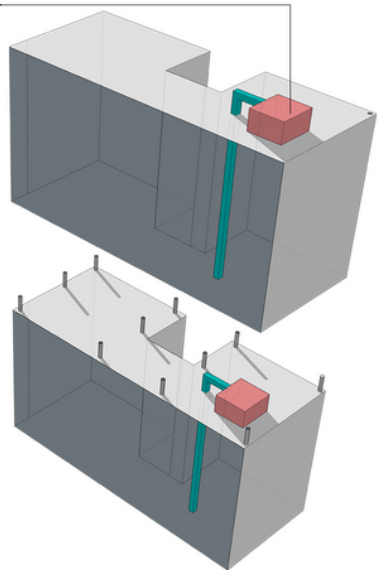
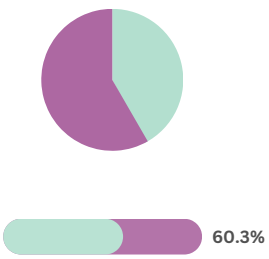


Figure 49: Location of pumps in the building



Conventional HVAC+Pre cooling 7 Months=**3,57,540 kWH**

Evaporative cooling 5 Months
10% energy use of Conventional HVAC= **41,751 kWH**

HVAC running months reduced to 7 (April-October),i.e. months of high temperatures and humidity(see tables 1 and 2), when the cooling of the evaporative cooling method wont be sufficient.
Total energy used= 3,99,292 kWH, compared to 1,005,108 in existing building

*see appendix for reference

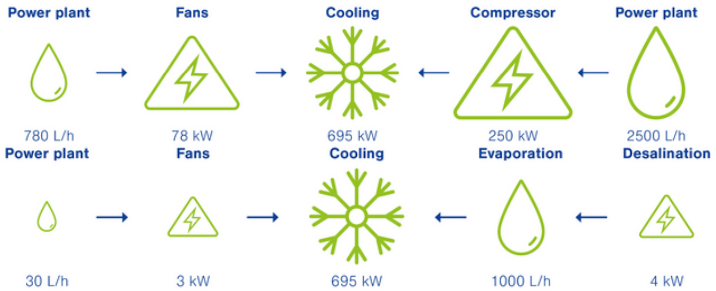
FEATURES	AIR CONDITIONING	EVAPORATIVE COOLING
ENERGY CONSUMPTION	90% more energy use than evaporative cooling	10% less energy use compared to HVAC
COOLING CAPACITY	1kW electricity= 2.5-4KW cooling power	1kW electricity= 40KW cooling power
COP	2.5-4 degrees higher temperature degrades performance	10-40 degrees higher temperature increases performance
INDUSTRIAL COOLING	Power surging cooling solution	Energy efficient cooling solution
CLIMATE	Efficient in all climates	Very efficient in hot, semi-humid and dry climates
WATER CONSUMPTION	Uses damaging refrigerants. Water is also required to generate electricity. At least 10 liters of freshwater per kWh is needed for steam to run the turbines.	Uses water as a refrigerant. Evaporating 1 m3 water generates as much as 695 kW of cooling power
AIR QUALITY	Bad as recirculated air is used for cooling	Improved because of ventilation with fresh, filtered outdoor air
CARBON FOOTPRINT	units release high temperatures from their condenser, negatively impacting the build-up of urban heating.	Evaporative cooling releases process air at low temperatures, thus having a positive impact on the growing problem of “urban heating”.
HUMIDITY	Air conditioning dehumidifies the air. Our immune system is vulnerable against viruses in dry air. Dry air can also cause discomfort such as an itchy throat or dry, irritated eyes.	Humidity level between 40% and 60%, helping fend off viruses and provides comfort against dry eyes and an itchy throat.

90% SAVINGS

10X MORE COOLING POWER

30% WATER SAVINGS

Table 11 Difference between air conditioning and evaporative cooling



AIR CONDITIONING

EVAPORATIVE COOLING

Figure 50 comparison between air conditioning and Evaporative cooling

Space	lux required	Area(m2)	Lumens	Type of Light	Lumes/fixture	Fixtures Needed(1 floor)	Total Fixtures Needed	Rating(W)	Running hrs/day	Days	Total load(Wh)
Reception	200	43	8600	Yellow LED Downlight	1800	5	5	18	6	260	140400
Entrance	150	56	8400	Yellow LED Downlight	1800	4	4	18	7	260	131040
Audi seating	150	327	49050	LED panel white	1980	33	33	22	3	60	130680
store room	150	16	2400	Yellow LED Downlight	1800	2	2	18	2	260	18720
projection room	200	16	3200	White LED Downlight	1000	3	3	10	3	260	23400
Toilets	100	36	3600	White LED Downlight	1000	12	168	10	12	260	5241600
Staircase-open	100	82	8200	Yellow LED Downlight	1800	5	80	18	12	260	4492800
Lift Lobby	150	30	4500	Yellow LED Downlight	1800	3	48	18	12	260	2695680
Fire Staircase	100	31	3100	White LED Downlight	1000	3	48	10	12	260	1497600
Waiting area+pantry	200	46	9200	Yellow LED Downlight	1800	6	78	18	12	260	4380480
Workspace	500	230	115000	White LED Battens	2400	48	1170	20	9	260	54756000
Lounge	200	41	8200	Yellow LED Downlight	1800	6	72	18	8	260	2695680
Cabins	350	15	5250	White LED Downlight	1000	30	360	10	10	260	9360000
Meeting Rooms	400	74	29600	White LED Downlight	1000	7	84	10	6	130	655200
Basement entry	250	450	112500	White LED Battens	2400	47	47	20	12	260	2932800
Basement	75	1473	110475	White LED Battens	2400	46	46	20	12	260	2870400

Table 12

GRAND TOTAL LIGHTING LOAD:
89152080
89152 kWh

Equipment	number	running hrs/day	rating(W)	days	load(Wh)
laptop	1170	7	70	260	149058000
fan	32	8	600	260	39936000
fridge	32	24	285	260	56908800
microwave	32	1	700	260	5824000
printer(printing)	64	2	300	260	9984000
printer(standby)	64	3	30	260	1497600
projector	32	2	300	260	4992000
lift	4	4	750	260	3120000
water purifier	32	16	25	260	3328000
wifi	56	12	20	260	3494400
computer	650	8	150	**260**	202800000
domestic pump	1	4	1100	**250**	1100000
EC water pump	1	4	1100	108	475200
				GRAND TOTAL EQUIPMENT LOAD:	482518000 W

=482518kW

Table 13

Total Room Sensible heat	**3619767**
Total Room Latent heat	**246000**
Grand total heat, BTU/hr	**3865767**
AIR CONDITIONING TONNAGE	**322.15**

Table 14

Conventional HVAC+Pre cooling 7 Months=**3,57,540 kWH**

Evaporative cooling 5 Months :10% energy use of Conventional HVAC=**41,751 kWH**

Total energy used= 89152+482158+357540+41751**= 970,601kWh**

$$EPI = \frac{970601KWH}{22400m2} \quad \textbf{=43.3kWh/m2}$$

8.8 WATER PERFORMANCE

Figure 51

As per National building code 2016, Standard fresh water demand for one person is 45 LPD (litres per day) for office buildings. We have proposed to reduce about 36% water demand.

Occupant water use (45lcpd)	Domestic (25lcpd)	H faucet-5lpcd		H faucet-1lpcd	Domestic (10lcpd)	Occupant water use (28.8lcpd)
		Faucet-8lpcd		Faucet-5lpcd		
		Drinking-2lpcd		Drinking-2lpcd		
	Flushing (20lcpd)	Cleaning-10lpcd		Cleaning-10lpcd	Flushing (15.6lcpd)	
		WC-12lpcd		WC-4lpcd		
		Urinal-12lpcd		Urinal-4lpcd		
Fire Fighting		Sprinkler System(75 litres)		Sprinkler System constant	Fire Fighting (Not used on daily basis)	
Irrigation		28lpcd		12lpcd	Irrigation	
PV maintenance		0.05lpcd		0.05lpcd	PV maintenance	

Base Case *Base case and proposed case per capita water demand* **Proposed Case**

Figure 52

Flow and Flush rate of fixtures(Base Case)

Flow and Flush rate of fixtures(Proposed Case)

Occupant water demand reduction achieved: 36%

Installing dual-flush toilets and low-flush urinals offered for a 56% reduction in the amount of water used each day for flushing, while installing low-flow faucets allowed for a 22% reduction in daily domestic water use.

Reduction in Occupant **Domestic Water Use** **22%**

Reduction in Occupant **Flush Water Use** **56%**

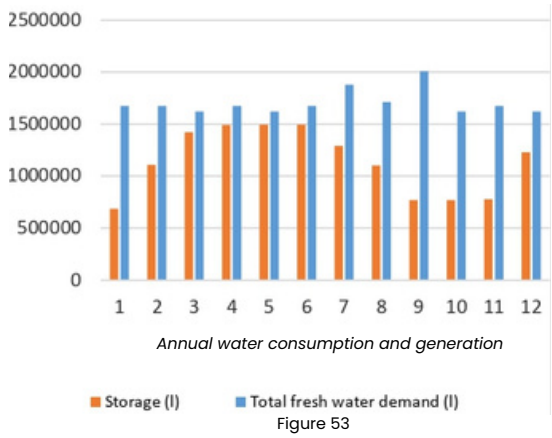
WATER CONSUMPTION

Water harvesting Sources	Area	Runoff coeff
Roof Surfaces	1600	0.1
Hardscape areas	1200	0.15
Softscape areas	2800	0.2
Effective catchment area	900	

Muncipality water supply (l/day)	54,000
Storage size (l)	46,25,000

Water consumption point	Quantity	Liters/day
Occupants : {People x l/person}	1200	45
Irrigation (max) : {m^2 x l/m^2}	2800	15
Cooling tower (max) : {Ton x l/Ton}	0	0

Table 15



Annual water consumption and generation

Figure 53

Months	Rainfall (mm)	Effective rain (mm)	Harvested rainwater (l)
July	769	764	687150
August	472	467	420210
September	356	351	315540
October	82	77	69030
November	9	4	3150
December	3	0	0
January	1	0	0
February	0	0	0
March	1	0	0
April	0	0	0
May	16	11	9810
June	506	501	450900
			1955790

Rain water harvesting Calculations

Table 16

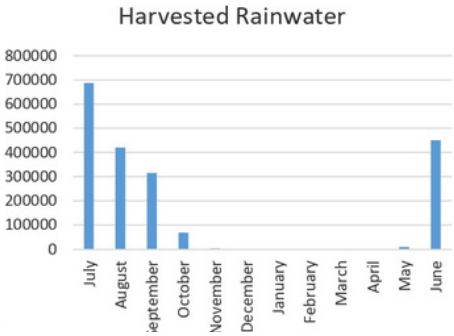
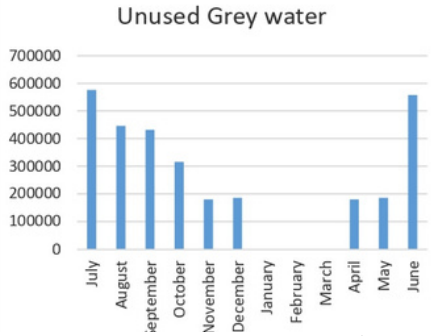


Figure 54



Grey and Black water Generation

Figure 55

Month	Days in month	Generated black water	Generated Grey water	Filtered grey water	Month	Days in month	Occupant demand	Irrigation seasonal factor (%)	Irrigation demand	Cooling tower Usage	Cooling tower water demand (l)	Total water demand (l)
Jul	31	482112	602640	602640	July	31	1674000	20%	208320	0%	0	1882320
Aug	31	482112	602640	602640	August	31	1674000	30%	312480	0%	0	1986480
Sep	30	466560	583200	583200	September	30	1620000	30%	302400	0%	0	1922400
Oct	31	482112	602640	602640	October	31	1674000	40%	416640	0%	0	2090640
Nov	30	466560	583200	583200	November	30	1620000	50%	504000	0%	0	2124000
Dec	31	482112	602640	602640	December	31	1674000	50%	520800	0%	0	2194800
Jan	31	482112	602640	602640	January	31	1674000	80%	833280	0%	0	2507280
Feb	28	439344	549180	549180	February	28	1525500	80%	759360	0%	0	2284860
Mar	31	482112	602640	602640	March	31	1674000	90%	937440	50%	0	2611440
Apr	30	466560	583200	583200	April	30	1620000	50%	504000	100%	0	2124000
May	31	482112	602640	602640	May	31	1674000	50%	520800	100%	0	2194800
Jun	30	466560	583200	583200	June	30	1620000	20%	201600	50%	0	1821600

Table 17

An effective water cycle has been developed to minimize daily fresh municipal demand. Rain water harvesting coupled with a root zone water treatment that treats surface runoff and grey water are used as alternate sources of water. Vegetated swales are designed around the site to help channel surface run-off to the storage tanks. Water from the swales are also used to irrigate the site. Local vegetation has been used to reduce turf area, thus, minimizing on landscaping requirements. In the monsoon months extra grey water is sent to Ground recharge.

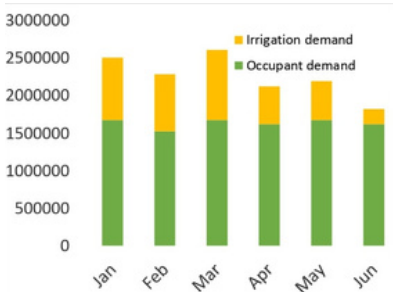


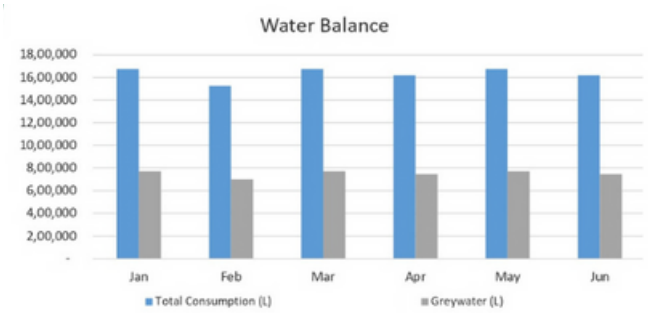
Figure 56

Domestic Use	
Use LPD/Head	45
Number of people	1200
Total LPD	54000
Irrigation Use	
L/m^2	0.2
Area m^2	2800
Max LPD	560
Cooling Use	
L/Tr	0
Tr per Day (peak	0
Max LPD	0

Table 18

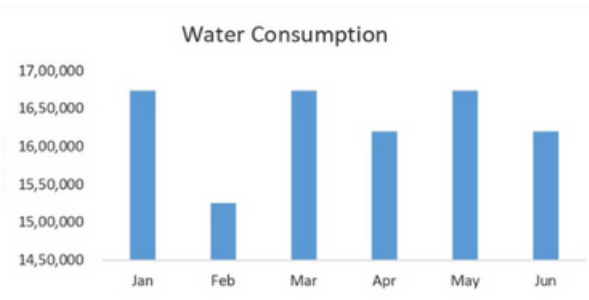
End Use	Percent use	Use in LPD	Greywater in LPD	Blackwater in LPD
Bathing	5%	2700	2,700	
Washing	20%	10800	10,800	
Cleaning house	8%	4320	4,320	
Washing Utensils	8%	4320	4,320	
Others	10%	5400	2,700	2,700
Drinking	4%	2160		2,160
Cooking	3%	1620		1,620
Toilet Flushing	17%	9180		9,180
Total		**40500**	**24,840**	**15,660**

Table 19



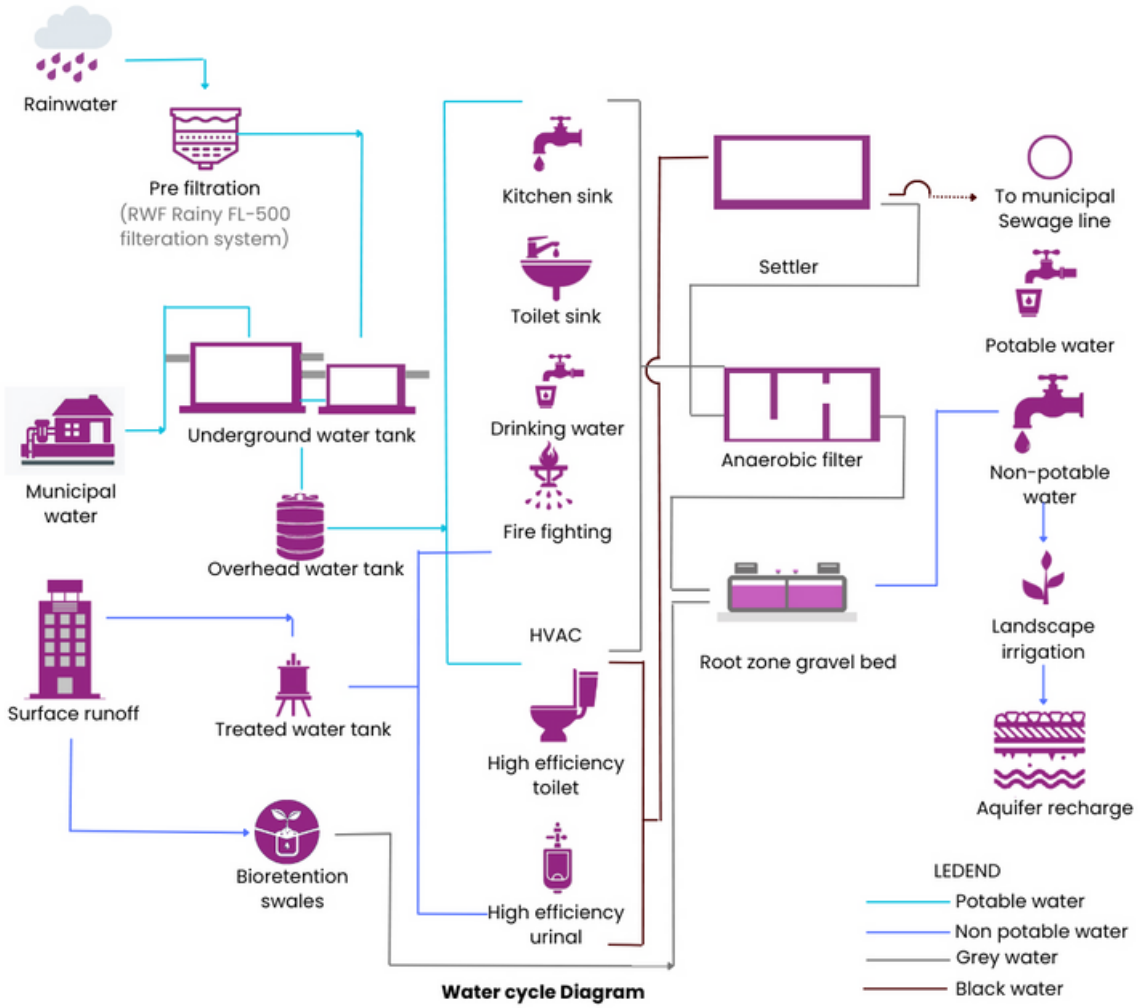
Water usage Vs Generation

Figure 57



Water consumption

Figure 58



Water cycle Diagram

Figure 59

REDUCE (36%) 45LPDTO 28.8 LPD	REUSE(75%) Root zone treatment grey water Table	RECHARGE (RWF Rainy FL-500 filteration system)

Stormwater and Runoff Management in-situ

Rainwater from roof gutters is gathered at a central location and stored in an underground water tank. Using the stormwater drains in the trenches, the stormwater is collected locally and directed.

Grey Water & Black Water Treatment and Reuse

The greywater is collected after the usage in the design and treated using root zone treatment.

8.8.a ROOT ZONE TREATMENT

Root zone treatment is a method of treating contaminated soil or groundwater by applying amendments or other treatments to the area surrounding the root zone of plants. The goal is to reduce or eliminate the presence of contaminants in the soil or water by promoting the natural processes of plant growth and microbial activity.In root zone treatment, the contaminated soil or groundwater is typically treated by applying materials such as compost, biochar, or other organic amendments to the soil. These materials can help to improve soil structure, increase nutrient availability, and promote the growth of beneficial microorganisms. As the plants grow, they take up water and nutrients from the soil, which can help to reduce the concentration of contaminants.

Advantages of using root zone treatment on site:

- Increased nutrient uptake
- ·Water conservation
- ·Reduced chemical runoff
- ·Improved soil health
- ·Reduced labor costs
- The maintenance cost is low·
- It has no sludge handling problem.
- It achieves standard for tertiary treatment
- Least attendance for maintenance
- Enhances landscape .

System that will be Provided on site:

The system that we will be providing on site will be a three phase treatment plant. Three tanks will be provided with following Specification :

1.First Tank:

The plants that would be used in the first tank will be Canna Plants since they grow well in dirty water, Their flowers give an aesthetic look to the surrounding and they grow well in Mumbai's climate and are largely available in market as well as are pretty economic.

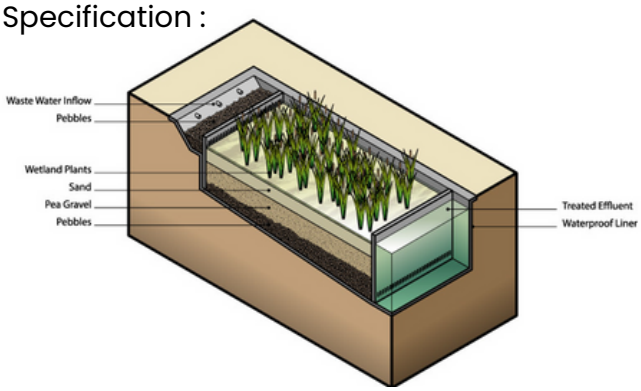


Figure 60 (Google Source)

2. Second Tank:

The output from the first tank will go into second tank. It will only contain water and water plants with fibrous roots. The two major type of plants used here will be Water Hyacinth and Duck weed. Water hyacinths have been effective in removing algae, fecal coliform bacteria, suspended particles, trace toxic metals, organics and many other dis-solved impurities from wastewaters.

Figure 61 Source:Google Image

Figure 62 Source:Google Image

3.Third Tank:

The water from the second tank will go into third tank. This will be similar to the Second Tank but here there will be water lilies and water umbrellas planted in a container and provided in the tank. This will help in shading the water for evaporation Losses. Cleaner Fishes like Gobies, Catfish, and pipefish will be provided. They will help in cleaning the water and avoiding Mosquito breeding.

8.9. LANDSCAPE

Indoor and outdoor plantation

87% removal of toxins

30-60% humidity control

55% Reduction in cost of energy

30-40% noise reduction

20% productivity increased

OUTDOOR PLANTS

Gulmohar tree (Delonix regia).	Planting Gulmohar is very useful in curbing global warming.
Fishtail palm	The Fishtailed palm automatically manoeuvres itself to find sunlight and water, and takes its desired shape.
hemilia patens:Firebush	It is a showy, fast-growing, semi-woody evergreen shrub I firebush is relatively common as a "volunteer" (fancy name for a weed),
phoinex palm: Pygmy Date Palm"	Date palm trees improve the atmosphere by converting carbon dioxide to carbohydrates and oxygen at a higher rate than other plants
alpinia verigated	a beautiful variation of Alpinia zerumbet which is native to India. The 2 foot (60 cm) long leaves are striped with creamy yellow variegations giving them an appearance of a feather.
narium oleander:	Beautiful blossoms, of fragrant pink flowers in bunches. In India they are thus the most favored plants for the road dividers, where a plant has to withstand heat and dust, and little water.

Table 20 - Plants Pallete

INDOOR PLANTS

ARECA PALM
Improve Indoor Humidity

ANTHURIUM
Makes surrounding toxin-free.

PEACE LILY
cleanses the air

MONEY PLANT
Produces more oxygen

Figure 63 (Source:Google Image)

8.10.WASTE MANAGEMENT

Providing office-owned cutlery encourages reusable cutlery over plastic cutlery.

Provide drinking water fountains instead of plastic water bottles.

Ban the use of single-use plastics. Encourage recyclable materials.

Tie-up with an e-waste company to ensure that e-waste is recycled

Provide common waste stations over individual trash bins as it creates more awareness

Set office printers to print pages on both sides.

Provide compost bins. This can prevent food waste from ending up in landfills.

Add an upcycle station to the office. This encourages reuse.

Go paperless. Send and view documents digitally.

Manual paper shredders can be used over electronic ones.

Figure 64

8.11. EMBODIED CARBON ESTIMATION

System Type	Baseline				Proposed			
	Material emissions ($kg\text{-}CO_2\ e$)	Transport 1 ($kg\text{-}CO_2\ e$)	Transport 2 ($kg\text{-}CO_2\ e$)	Total ($kg\text{-}CO_2\ e$)	Material emissions ($kg\text{-}CO_2\ e$)	Transport 1 ($kg\text{-}CO_2\ e$)	Transport 2 ($kg\text{-}CO_2\ e$)	Total ($kg\text{-}CO_2\ e$)
Wall	156.4	0.0	0.0	156.5	10.1	0.0	0.1	10.1
Roof	3109.2	0.3	0.2	3109.7	181.2	0.0	0.0	181.2
Floor	3109.2	0.3	0.2	3109.7	3013.7	0.0	0.2	3013.9
Fenestration	4.2	0.0	0.0	4.2	-1.4	0.0	0.0	-1.4
Structural	546.1	0.1	0.1	546.3	553.0	0.0	0.2	553.2
Grand Total emissions per functional unit ($kg\text{-}CO_2\ e$)				6926.4	Grand Total emissions per functional unit ($kg\text{-}CO_2\ e$)			3757.1

Table 21 SUMMARY OF EMBODIED CARBON

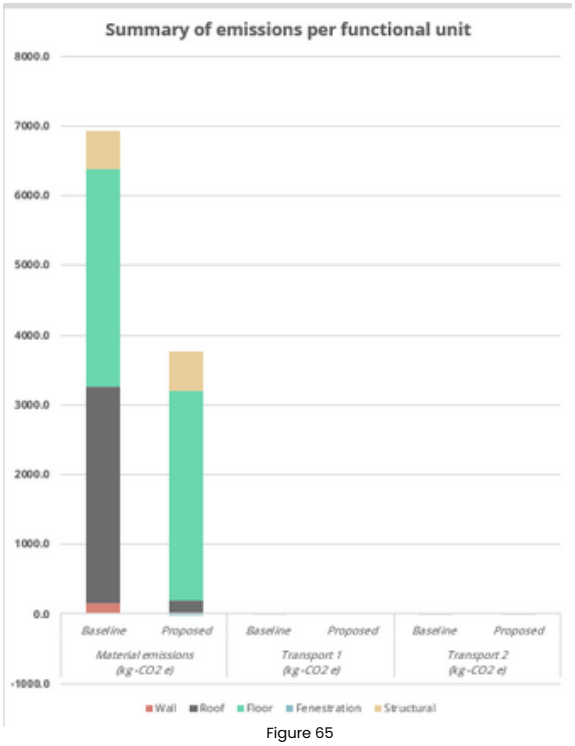


Figure 65

Figure 61

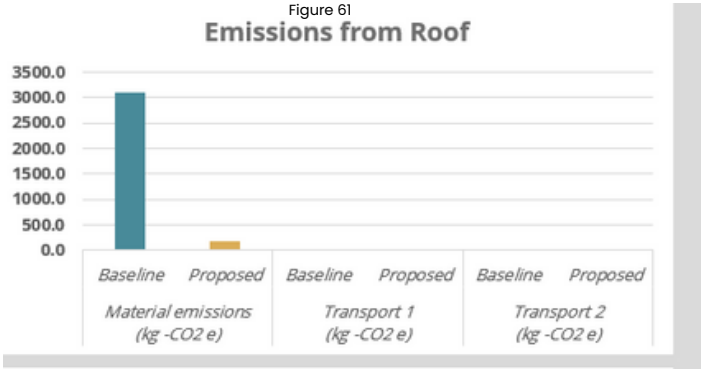


Figure 66

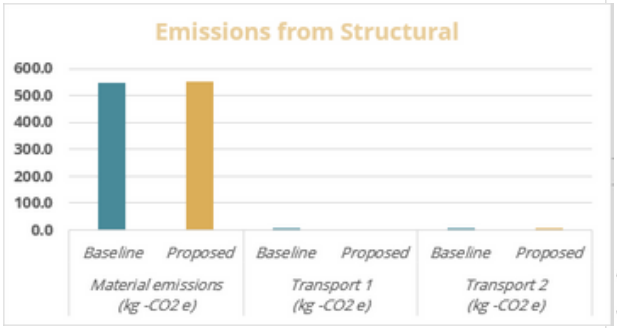


Figure 67

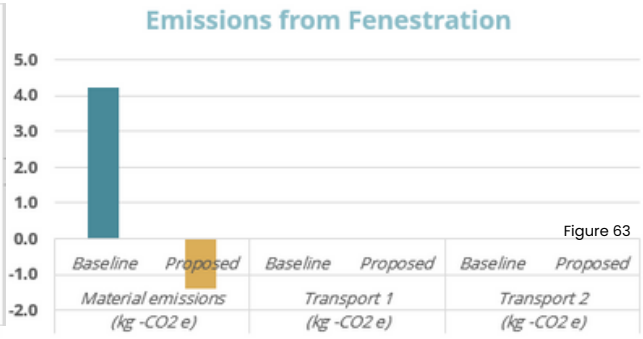


Figure 63

Figure 68

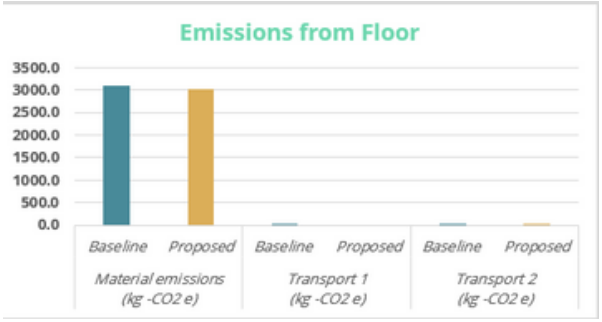


Figure 69

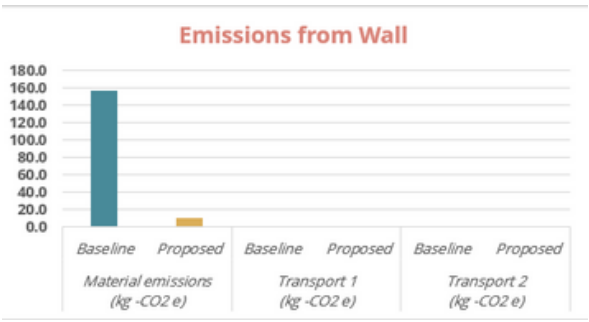


Figure 70

8.12. RESILIENCE

Numerous strategies has been adopted to make the building more adaptable and robust to withstand following resilience in extreme events and climate .

Earthquake resilient design

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

SOLUTION

Appropriate shock absorbers, structural systems has been laid out with column and beam ties, sill and lintel level bands, peripheral beams even the RCC flat slab technique is adopted with column capital.

Heat wave resilient design

Rising temperatures may be partially attributed to the Urban Heat Island (UHI) effect.

SOLUTION The centralised air conditioning system, earthen pot cooling system, and landscaping throughout the office will aid in reducing heat waves.

•EPIDEMICS

Epidemics like COVID-19 can have a global impact.

The appropriate drainage systems and sanitation care will be offered. For social distancing, an open office layout is offered with partition walls in between.

Terrace Garden and food provision

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

Renewable energy generation

Solar energy :It includes the Roof top solar PV

Power Backup and water autonomy

The proposed building is designed to self sufficiency to meet the energy and water demands while running the mechanical system. In addition to that, DG backup is provided at designated areas.

Figure 71 - Ground floor area

8.12. RESILIENCE

RISKS

•FLOODS

The site is prone to flooding given that it is located in Mumbai, which has heavy rainfall, and is close to the Mithi river.

SOLUTION

To encounter deep foundations are used to protect the framed structure from frequent flooding. The building is stilted on ground floor with green spaces on minimum plinth of 0.45m provided to entrance on ground floor with proper drainage system .This ensures that the working spaces are safe from floods.

• FIRE SAFETY SERVICES

The centralised air conditioning system, earthen pot cooling system, and landscaping throughout the office will aid in reducing heat waves.

To make the building more resilient during a fire, fire safety services are implemented in accordance with NBC, Part 4 requirements, which include a 6 m wide driveway around the building for fire tender movement, a fire shaft, a fire extinguisher a hose reel, a yard hydrant in the surrounding area, a wet riser, an automatic sprinkler and detection system, manual call points, fire alarm systems, and an underground tank placed in In addition to this fire escape stairway, a refuge place over every 6 floors is provided.

Figure 72
(Source:Google Image)

Figure 73
(Source:Google Image)

•THUNDER & LIGHTENING

Every year, rains with thunder and lightning hit Mumbai.

SOLUTION

Lightning protection devices, such as lightning protection sockets, antenna feeder protection, signal lightning protection, and lightning arrestors, are used to protect buildings from damage or fire.

8.13.ENGINEERING AND OPERATIONS

GREEN ROOF

Green roof is used in the building to reduce the energy use by cooling roofs and providing shading, thermal mass and insulation.

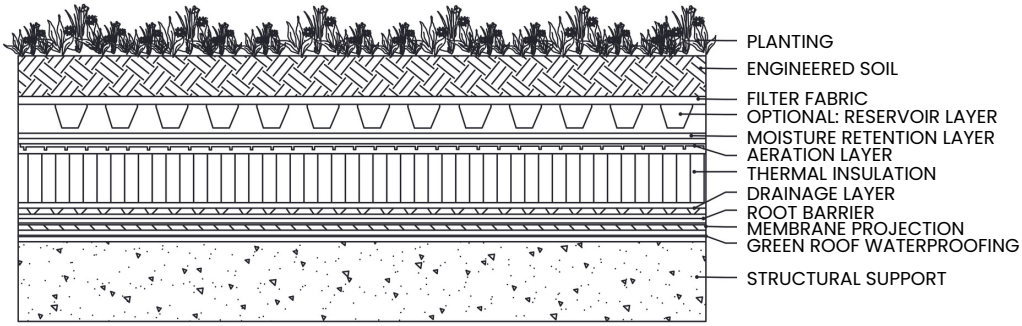
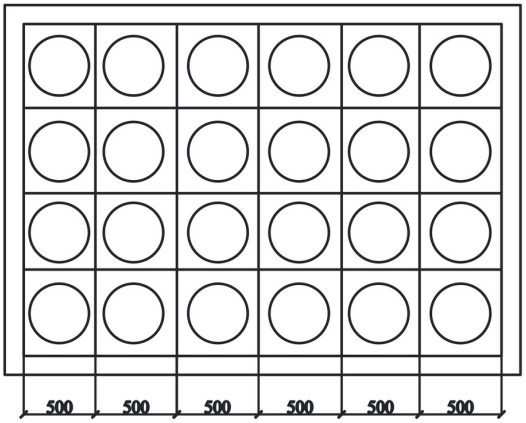


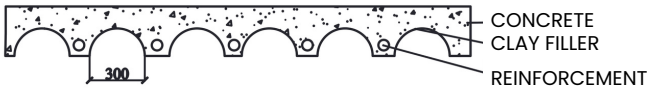
Figure 74



PLAN

FILLER SLAB

Green roof is used in the building to reduce the energy use by cooling roofs and providing shading, thermal mass and insulation.



SECTION

Figure 75

RAISED ACCESS FLOORING

It is used to route cables, wires, air conditioning ducts, and other tubes or pipes through the space between the panels. Wiring repairs, upgrades, and maintenance can be carried out without the requirement for demolition or construction.

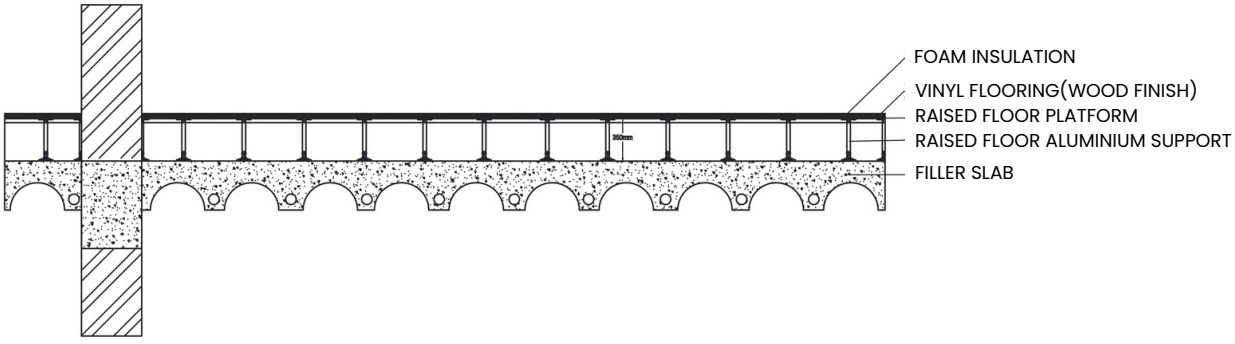


Figure 76

DOUBLE GLAZED UNIT

It insulates against heat and cold up to four times more effectively than single-glazed windows and doors. The space between the two panels of glass acts as a thermal barrier between the workspace and the outside environment.

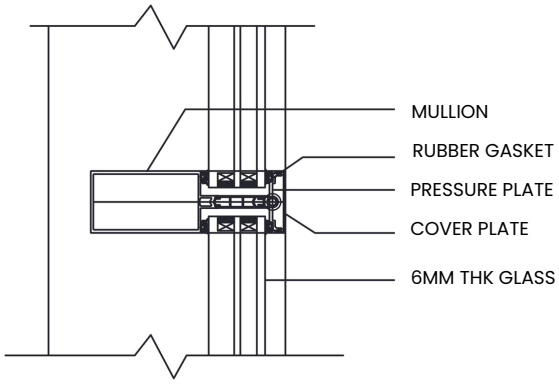
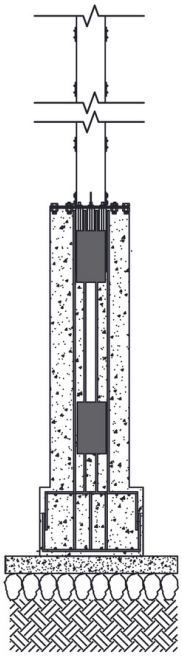


Figure 77



FOOTING

Helical piers are chosen since the site's sandy soil has a limited soil bearing capacity. To reduce total costs and materials, the building's existing footings are utilised.

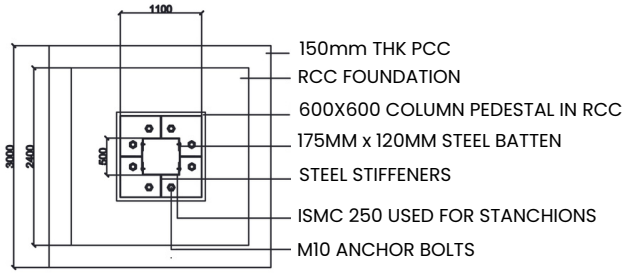


Figure 78

WALL

Fly ash bricks- made completely of waste products, requires almost no energy to produce-**GWP VALE=0.006 kgCO2e per tonne produced**

Cellulose Insulation- made of recycled newsprint and other paper, it reduces greenhouse emissions by reducing the paper going into landfills, thus having a **negative carbon footprint, as it absorbs carbon throughout its lifecycle, GWP during usage=0.0017 kgCO2e**

Cork is an eco friendly material made of 100% renewable and natural materials, with a **GWP value of 0.6kgCO2e**

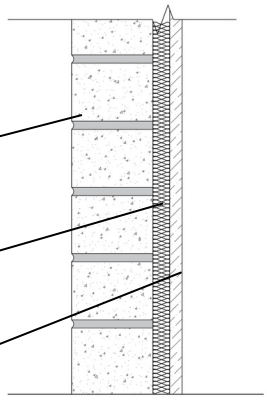


Figure 79

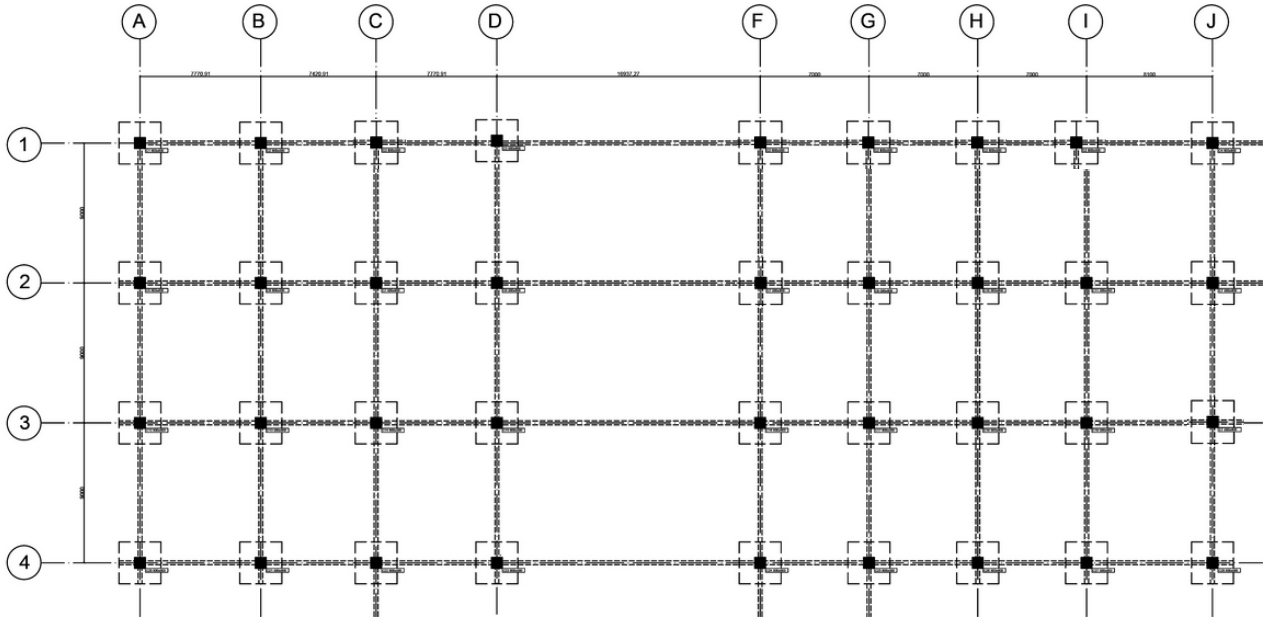


Figure 80

MATERIAL	PURPOSE	RATE	SPECIFICATION	REASON OF SELECTION
Solar Panel	ROOF	Rs36,000 to 44,000	Brand - Navitas Solar Dimension (mm) - 2278 x 1133 x 40 Type - Mono Perc Maximum Power - 440W/550W Maximum Efficiency - 22%	• To genrate electricity
DGU Glass	FACADE	Rs 115/ft	Glass Thickness - 3-12 mm Size - 2140mm x 3050mm	• Good insulating properties
Teracotta jali	FACADE	RS 80/per piece	Size - 200mm x 200mm	• Good insulating properties • Durable
Ashcrete Block	WALL	Rs 10 per piece	Size - 9 in x 3 in x 2 in Material - Fly Ash Shape - cuboidal	• Durable • **Made of waste materials: 0.006 kgCO2e per ton**
Recycled Plastic block	WALL	Rs 10 per piece	Plastic:Sand:Gravel Ratio - 2:1:1 Light weight	• Thinner and lighter • Superb heat insulating properties • **0.7 kgCO2e**
Ecoboard	FURNITURE	18 Mm at Rs 55/square ft	Size - 4090 x 1800 Thickness - 9mm, 12mm, 18 mm, 25mm, 30 mm, 40 mm Fire Rating Above 2 Hours Density of Panel 800 kg/m3	• Flexible • Light in weight
Eco-friendly Paint	INTERIORS	Rs. 250/L	White paint	• Reflecting light inside the building and heat outside
LED	INTERIORS	Rs 1000/per piece	Power - 36 watt Color Temperature - 2700-6500	• Sensor Light
Wood False Flooring	INTERIORS	Rs 300/ft	Size - 600 x 600mm Thickness - 38mm Brand- Kebao	• Easy to install and maintaing the wiring which travles through floor
PVC Plumbing pipe	WASHROOM	Rs. 22/m	Diameter-20MM TO 110MM Brand: SPACE	• Resistant to high water pressure • Resistant to blockage

Table 22 Material Pallete

8.14. INNOVATIONS

TILES PROUCING ELECTRICITIY

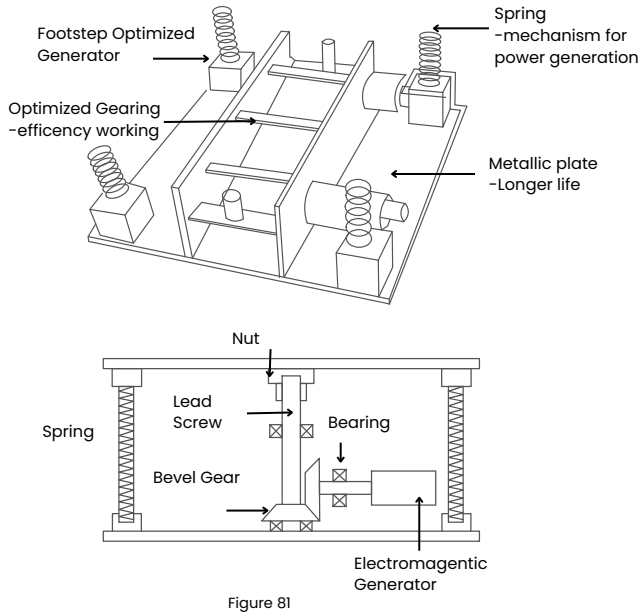


Figure 81

It is placed in all the **lobby area and the entrance area.**

The system makes use of rack and pinion arrangement coupled with efficient gearing mechanism to drive mini generators that produce energy when pressed.

We make use of harvested kinetic energy generated through vertical press foot movement. These tiles are designed to slightly displace vertically when someone walks on them. This vertical movement results in a rotatory motion that generates electrical energy.

ARCHITECTURAL INNOVATIONS

INTERACTIVE STAIRCASE

Providing Interactive Staircase with varying risers height and spacious enough for one to walk freefly. Placing the stairacse at the centre of the building with a good view. This will encourage people to use staircase which will be useful for their health and will also reduce the energy consumption required for lift.

Figure 82

Figure 83

FILLER SLAB

-Light weight
-ecofriendly
-Reduces cost of construction
-Reduces the amount of concrete

AQUAPONICS

Fish have long been proven to help to reduce stress and improve mood, thanks to the hypnotic movement of these creatures through the water. Just watching fish swimming for a few minutes has been proven to enhance mood and lower stress so another great reason to have a tank in the office.

The waste produced by fish can be used as a fertilizer material which helps in nurturing the plants.

Figure 84 (Source:Google Image)

WATER SEER

Figure 85 view

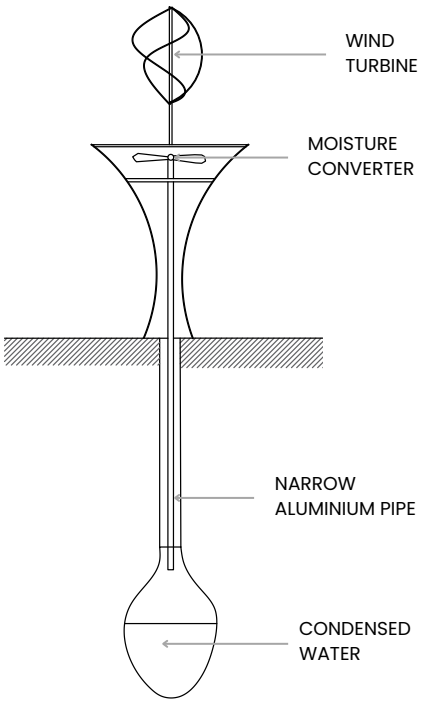


Figure 86 Section

Using the temperature differential between the above-ground turbine and the subterranean collecting chamber, the device draws water from the atmosphere and absorbs moisture before condensing it into water. It also gathers rainwater, which can be utilized to irrigate the green space using a basic pump and hose system.

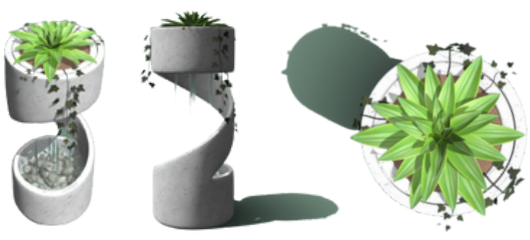
FLORA FOUNTAIN

Using Dr Klaus Lackner's experiment to our advantage by using flora-fountain -their function is to remove carbon dioxide from the air and release oxygen using a carbon dioxide removal process called “humidity swing”.

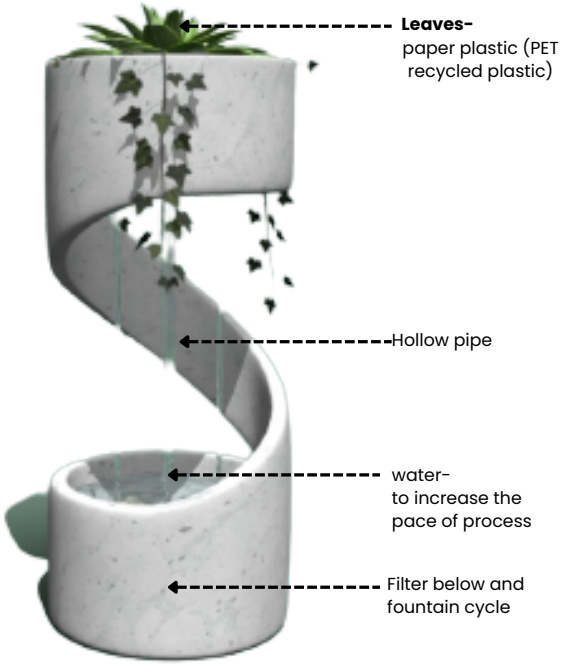
The leaves look like sheets of paper plastic (PET recycled plastic) and are coated in a resin that contains sodium carbonate, which pulls carbon dioxide out of the air and stores it as a bicarbonate (baking soda) on the leaf. The leaves are rinsed in water vapor and can dry naturally in the wind, soaking up more carbon dioxide. Hence, the only challenge is to keep the plastic dry.

This one tree can absorb Co2 100 times more than a conventional tree. Using humidity swing it absorbs Co2 and the level of CO2 decreases from the air.

Place to install - in the workspace



Isometric Rear view Top View



Front View (Details)

Figure 87

8.15. AFFORDABILITY

CONSTRUCTION COSTS have been reduced greatly by implementing the following practices:

1. REUSE OF MATERIALS

Materials such as steel and concrete would be reused from the existing structure. Steel is recyclable and concrete can be re-used as aggregate. Existing foundation can also be re-used

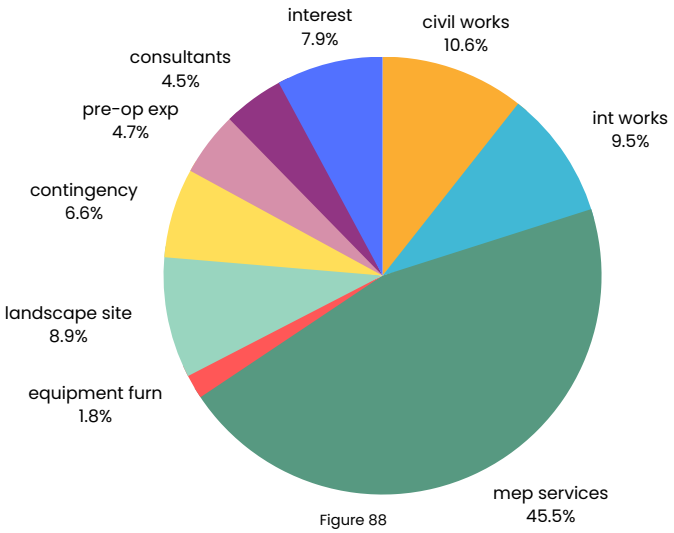


Figure 88

2. INCREASED USE OF LOCAL BRANDS AND MATERIALS

Majority local and Indian brands have been used, in order to cut down transportation costs, and to promote the Indian manufacturing sector. Local materials such as terracotta pots and jalis have been used in the design.

3. CONSTRUCTION TECHNOLOGY

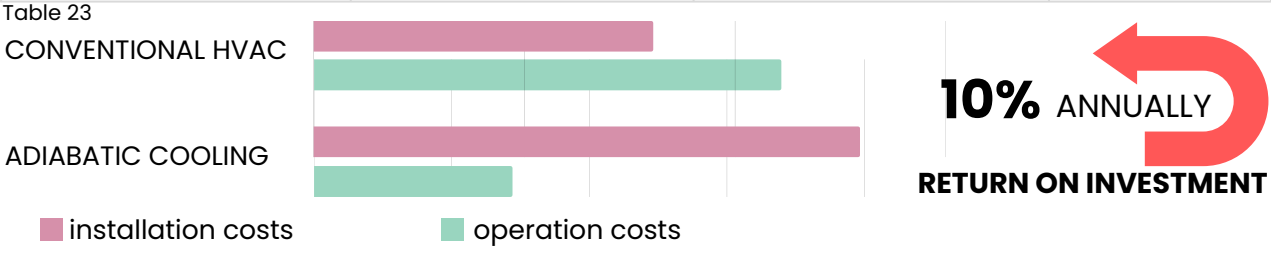
Conventional slabs have been replaced by filler slabs, which reduces the overall use of concrete, and reduces the weight of slab.

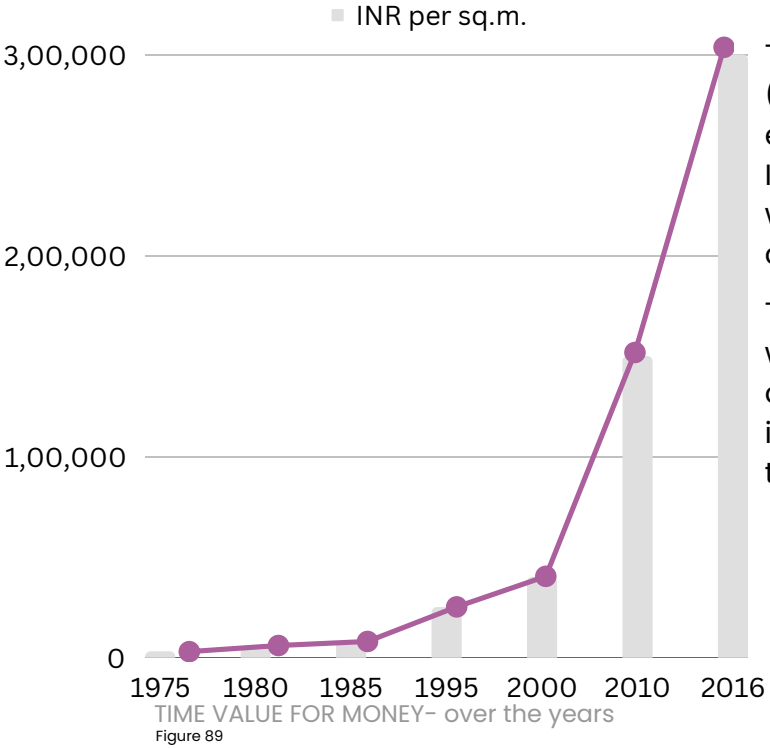
OPERATION COSTS have been reduced by implementing more sustainable alternatives. We have recognised the increased use of HVAC in commercial buildings, and have tried to mitigate the energy consumed by adding interventions such as precooling and adiabatic cooling.

HVAC INTERVENTIONS- PRECOOLING COOLING

	CONVENTIONAL	ADIABATIC	SAVINGS
TONNAGE REQUIRED	322.15 tons	196.5 tons	
INSTALLATION COSTS	1,00,000 INR/ton 3,22,00,000 INR	2,50,000 INR/ton 5,18,30,000 INR	-1,96,30,000
ENERGY CONSUMPTION 62.5%	10,60,400 kWh Consumption of conventional HVAC operation all year-round	3,99,292 kWh 7 months: HVAC+ precooling 5 months: evaporative cooling	6,30,663 kWh
OPERATION COSTS (per year)	84,84,000 INR	34,37,896 INR	52,88,864 INR

Table 23





TIME VALUE FOR MONEY- over the years

Figure 89

The Bandra-Kurla reclaimed land (now BKC) has witnessed an exponential growth in land rates. It is a prime commercial enclave which has attracted several corporate firms.

The returns from this investment, which have been reaped over the course of 7 years, can now be re-invested with the purpose of long-term savings.

8.16. COST ESTIMATION SHEET

S.No.	Particulars	Baseline Estimate (Project Partner / SOR basis)			Proposed Design Estimate		
		Amount (Million INR)	%	Amount (INR per sqm)	Amount (Million INR)	%	Amount (INR per sqm)
1	Land		0.0%	-		0.0%	-
2	Civil Works	0.0	0.0%	-	98.10	16.1%	4869
3	Internal Works	1.44	10.6%	71	18.98	3.1%	942
4	MEP Services	554.65	91.2%	27526	474.61	78.1%	23554
5	Equipment & Furnishing	0.59	0.0%	0	0.59	0.1%	0
6	Landscape & Site Development	0.20	0.0%	10	7.03	0.1%	26
7	Contingency	27.82	5.0%	1380	29.61	5.0%	1470
	TOTAL HARD COST	584.12	96.5%	28989	621.84	102.4%	30861
8	Pre Operative Expenses	10.00	1.6%	496	10.00	1.6%	496
9	Consultants	10.00	1.6%	496	10.00	1.6%	496
10	Interest During Construction	3.75	0.6%	186	2.21	0.4%	109
	TOTAL SOFT COST	23.75	3.9%	1179	22.21	19%	1102
	TOTAL PROJECT COST	607.87	100%	30167	644	106	31963

Table 24 Cost estimation

8.16. VALUE PROPOSITION

12.5% Increase in price of land per sq.ft. per year (approx.)

10% Return on investment

62.5% Energy saved in HVAC

63.8% Energy Performance Index

VALUE FOR PROJECT PARTNER

The Bandra-Kurla reclaimed land (now BKC) has witnessed an exponential growth in land rates. It is a prime commercial enclave which has attracted several corporate firms.

The returns from this investment, which have been reaped over the course of 7 years, can now be re-invested with the purpose of long-term savings.

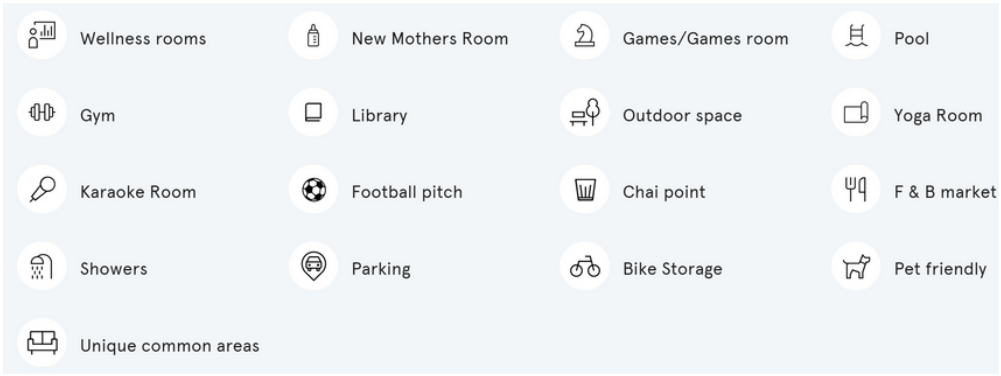
VALUE FOR END USERS

WeWork offers an array of unique amenities across their platforms. They give importance to employee satisfaction through their designs, and cater for a variety of end user groups.
It allows flexibility in terms of:

WORK ***HOW*** YOU WANT- dedicated desk/office suite/meeting room/ office floor
WORK***WHEN*** YOU WANT - by the hour, the day, the month, or even longer.
WORK ***WHERE*** YOU WANT- Work from near home, at multiple locations, or in new cities in India and across the globe

Figure 90

Some of the amenities available in WeWork



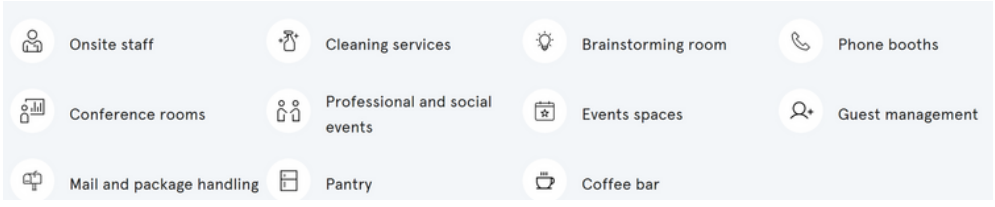


Figure 91

8.17. RENEWABLE ENERGY ESTIMATION

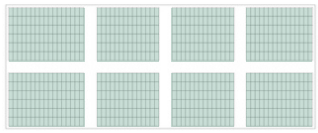
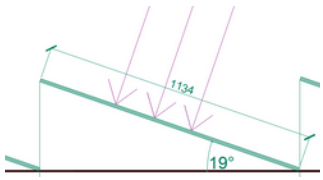
Average generation by 1 kWp solar module annually	1500 kWh
Capacity of one module	540 kW
Dimensions of one module	2278mm x 1134mm x 35 mm
Type	monocrystalline technology
Area required on rooftop by one panel	1.07m x 2.28m
No. of panels	area of roof available for panel installation = 1200sq.m. 1200/(1.07*2.28)=491.8 **400 modules can be provided ,** leaving space for operation and maintenance
Angle of tilt	19°
Energy generated by solar panels	810 kWh by one module annually 810*400= **3,24,000 kWh**
Total energy required	864691 kWh
Arrangement of solar panel on roof	 panel arrangement in plan  One panel in section

Table 25 Solar Panel Energy Estimation

MONTH	SOLAR RADIATION (kWh/m² /day)	ELECTRICITY GENERATION (kWh)
January	6.68	45008
February	7.12	43331
March	7.41	48316
April	7.35	47925
May	6.86	46222
June	5.20	33096
July	5.09	34296
August	4.97	33487
September	5.33	34754
October	6.21	41842
November	6.58	42904
December	6.35	42786
TOTAL		4,93,967

capacity of one module: 540 kW
monocrystalline technology
2278mm x 1134mm x 35mm
angle of tilt 19°
400 modules on roof
efficiency 20.90%

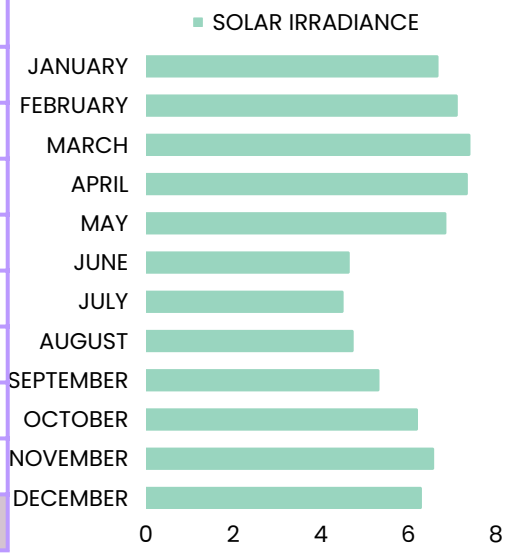
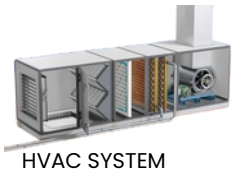


Table 26

9. APPENDIX

9.1 BUILDING MANAGEMENT SYSTEM

DDC CONTROLLER



HVAC SYSTEM

DDC CONTROLLER

LIGHTING CONTROL SYSTEMS

DDC CONTROLLER

VALVES

WATER HEATER

WATER PUMPS

DDC CONTROLLER

ELECTRICAL PANEL

VRD

GENERTAOR

DDC CONTROLLER

DAMPER ACCURATOR

FIRE ALARM SYSTEM

DDC CONTROLLER

CCTV SYSTEM

DDC CONTROLLER

ACCESS CONTROL SYSTEMS

DDC CONTROLLER

ELEVATOR CONTROL SYSTEM

A Building Management System (BMS) is a computer system installed in a building that will communicate with the building's equipment. Allowing its owner to monitor and control its installations and systems, such as air conditioning, heating, ventilation, lighting, alarms, access control or energy supply management systems (electricity, gas, solar panels, smart meters etc.)

FIELD LEVEL

↓

AUTOMATION

↓

MANAGEMENT

- Control the different systems of the building (via the measurement of the HVAC, the air quality, the humidity level, the noise pollution, etc.)
- Manage the energy consumption of a building
- Monitor in real-time and schedule operations
- Set up management of breakdowns and alarms
- Produce data reports

Figure 92 Building management system working and connectivity

INSTRUCTION FOR OPERATING THE BUILDING SYSTEM

• The BMS belongs to the building owner who should act as its administrator managing BMS access rights
• The BMS should be maintained with an appropriate level of servicing
• As with any software driven system, data and files should be backed up on a regular basis
• Critical components should be identified and checked at regular intervals
• BMS functions such as trend data, reports and alarms can be used to perform maintenance by exception
• Maintenance should be approached as the performance of the controlled system not individual components, i.e. AHU or Chiller Plant
• While the BMS equipment vendor should be utilised to maintain the critical components, other suitably qualified technicians can be utilised for field equipment

USER INTERACTION

- Demand response technology being included into WiFi-connected thermostats for HVAC systems. Residents can manage their HVAC systems using a computer, tablet, or smartphone.
- If the weather outside permits it, users are allowed to open and close windows.
- Users have control over their own task lighting through their phones. They can dim as needed. Also, this promotes energy efficiency.
- The user can pull the adjustable remote-control blinds up and down depending on the time of day.

MAINTENANCE

• An suitable level of servicing should be provided for the BMS.
• Data and files, like any other software-driven system, should be backed up on a regular basis.
• Critical components should be identified and tested on a regular basis.
• BMS functions like as trend data, reports, and alarms can be used to execute exception-based maintenance.
• Maintenance should be viewed as the functioning of the controlled system as a whole, rather of individual components, such as the AHU or Chiller Plant. • While the BMS equipment vendor should be used to service essential components, other appropriately skilled experts can be used for field equipment.

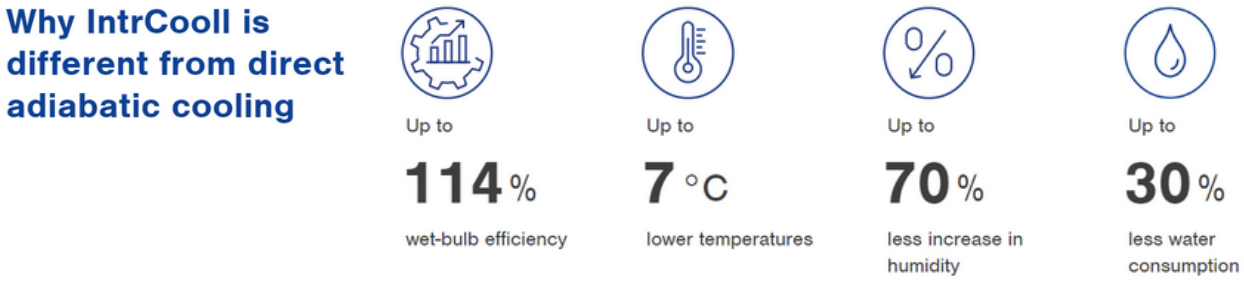
CRITICAL CONDITION

• The power inverters will supply power to the lights and equipment during critical conditions while the building management system will immediately shut down. The needed building system will also be supplied with the stored photovoltaic energy.

9.2 PRE COOLING SYSTEM

EVAPORATIVE COOLING PRODUCT

Figure 93 Evaporative cooling product used



Source
https://www.oxy-com.com/products/adiabatic-cooling-intrcooll

Figure 93

PRE COOLING PRODUCT

Figure 94 Precooling product used

Source:
https://www.paharpur.com/products/adiabatic-coolers/

DOES EVAPORATIVE COOLING WORK IN HUMID CLIMATES?

There are several factors that influence the effectiveness or efficiency of two-stage evaporative cooling. These are:

- The outdoor dry bulb temperature
- The outdoor wet-bulb temperature
- The outdoor air humidity
- Air pressure
- Air volume

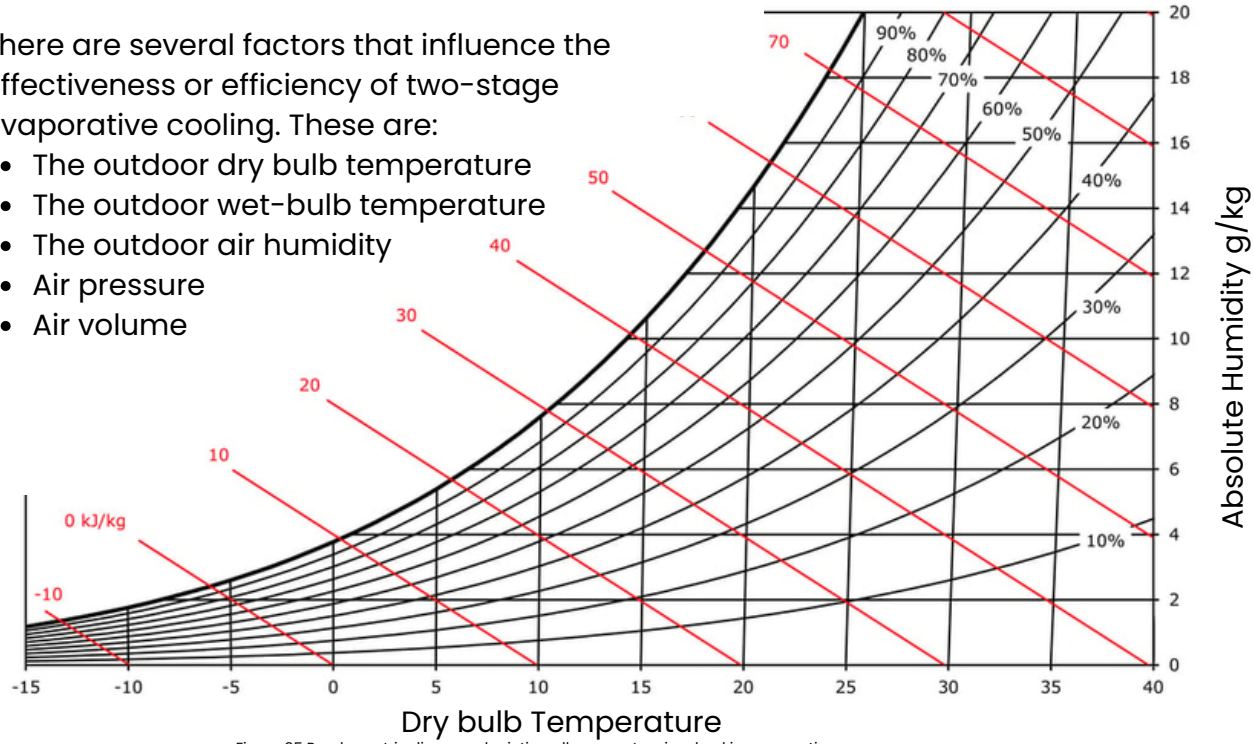


Figure 95 Psychometric diagram depicting all parameters involved in evaporative process

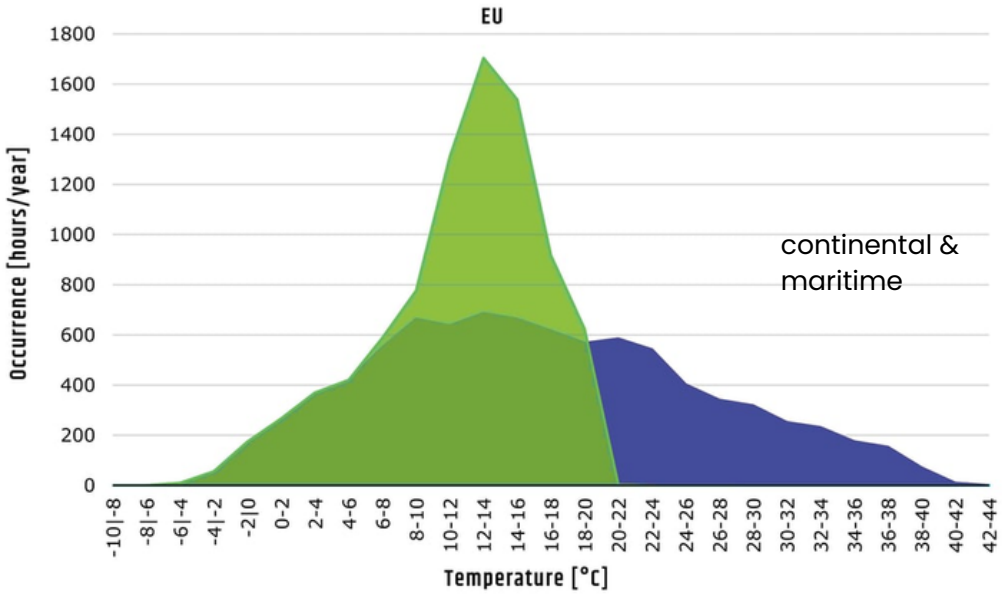


Figure 96 Performance of evaporative cooling in tropical climate

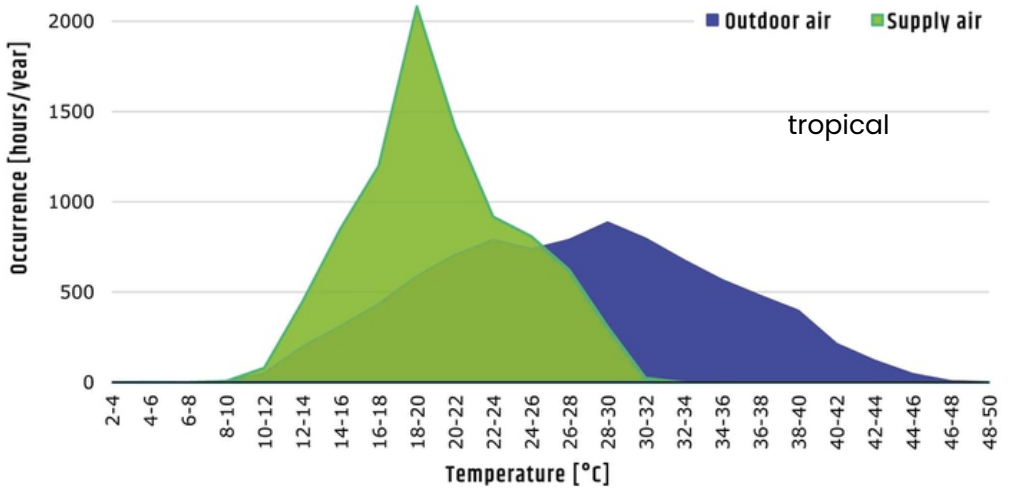


Figure 97 Performance of evaporative cooling in tropical climate

The graphs show the effectiveness of evaporative cooling in continental & maritime, and tropical climates

Two-stage (indirect/direct) evaporative cooling, as opposed to direct evaporative systems, uses both the indirect and the direct cooling process.
As a result, Oxycom's IntrCooll can cool up to 7 °C deeper than other evaporative cooling systems.
Recent practice results from indirect/direct cooling projects in Riyadh with outside temperatures of 48 to 52 °C and dry air resulted in incoming temperatures around 11 °C. The wet bulb was around 20 °C, resulting in a wet-bulb efficiency of the system of up to 135%.
A direct evaporative cooler would reach maximum efficiency of 85% resulting in incoming air temperatures of around 22 °C. The indirect/direct cooling technology in more humid climates will reach at least 114% wet bulb efficiency; for direct evaporative systems, this will be around 85%.

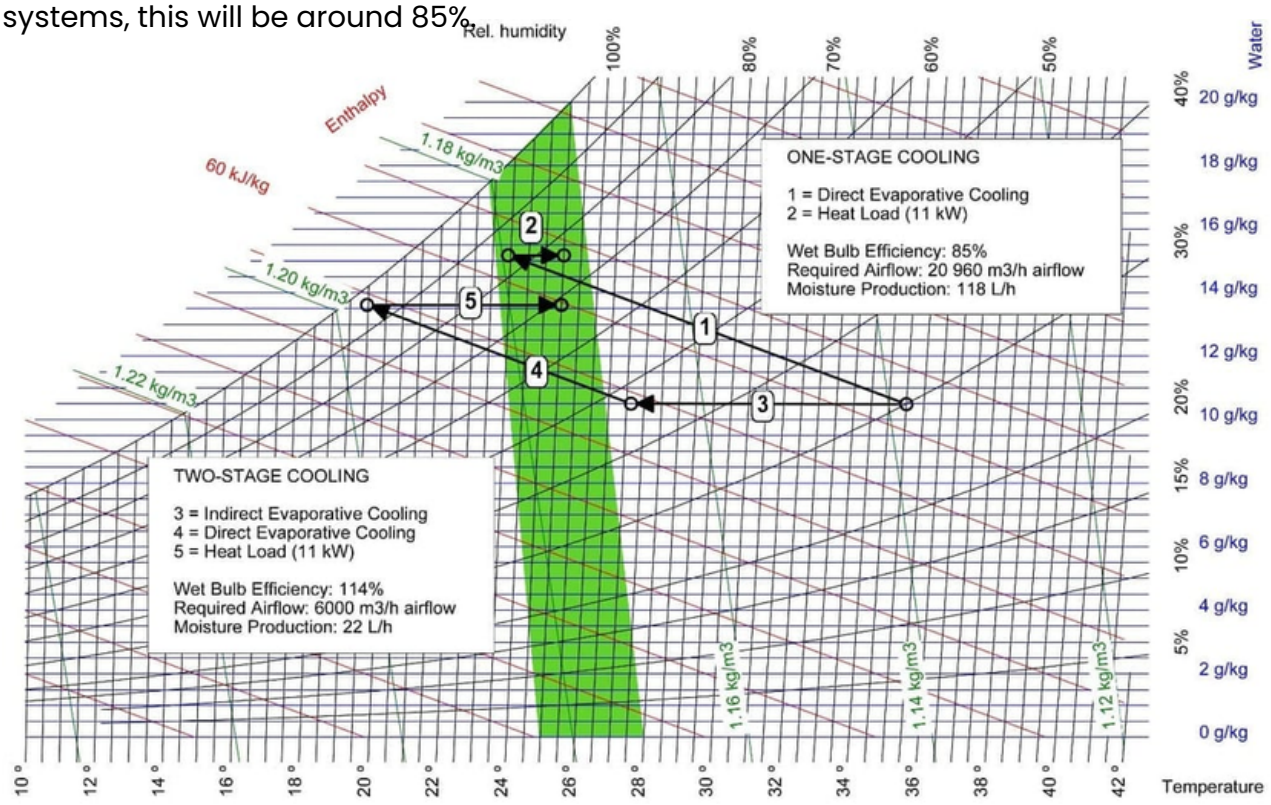


Figure 98 psychrometric chart for air humid pressure

The graphic shows an example of a one-stage evaporative cooling process vs a two-stage evaporative cooling process with outdoor air at 35 °C and 30% relative humidity.

We can see that a one-stage evaporative cooling process produces indoor air with a higher humidity content than a two-stage evaporative cooling process (~80% vs ~69%).
Furthermore, the wet-bulb efficiency of a one-stage evaporative cooling process is lower than a two-stage evaporative cooling process (85% vs 114%).
Finally, the required airflow to achieve the same indoor temperature of 25 °C at the same heat load (11 kW) is more than 3 times higher in case of a one-stage evaporative cooling process (20 960 m3 /h vs 6000 m3 /h).
This implies that the moisture production of a one-stage evaporative cooling process is more than 5 times higher (118 L/h vs 22 L/h).

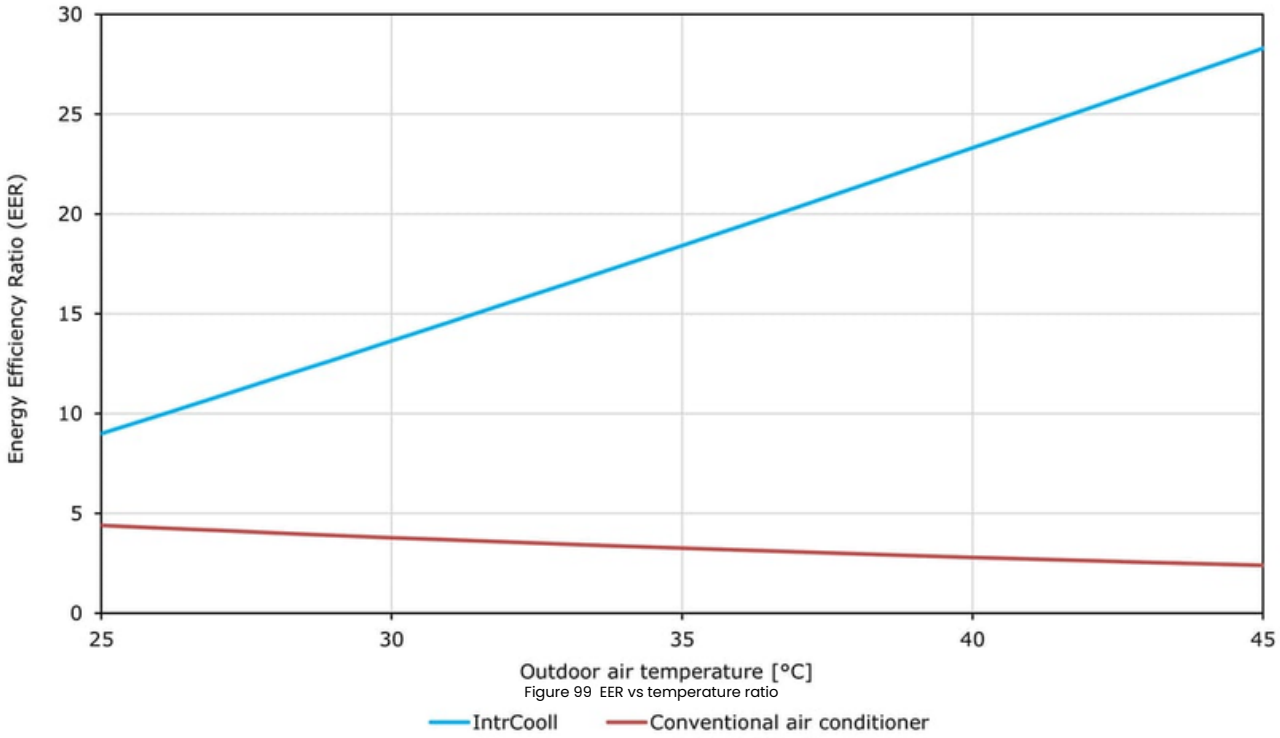


Figure 99 EER vs temperature ratio

	Air volume	Moisture
Direct adiabatic cooling	20.000 m3/h	300 l/h
Indirect/direct adiabatic cooling	14.000 m3/h	100 l/h

Table 27 HVAC distribution table

HVAC SYSTEM DESIGN

INDEX/ TONNAGE DISTRIBUTION SHEET

SR.NO.	DESCRIPTION	AREA	EQUIPMENT LOAD	ROOM OCCUPANCIES	DESIGN CONDITION		AS PER DESIGN CALCULATIONS		SELECTED UNIT CAPACITY		QTY	UNIT TYPE
		IN SQ.FT	IN KW	IN NOS	TEMP (IN °C)	RH (IN %)	COOLING LOAD (IN TR)	VOLUMETRIC FLOW (IN CFM)	COOLING LOAD (IN TR)	VOLUMETRIC FLOW (IN CFM)	IN NOS	
1	MEETING ROOM 01	798	0.5	16	22 °C +-2	N/A	5.19	1640.19	5.20	1640.00	1	FCU
2	CABIN 1A	156	0.5	3	22 °C +-2	N/A	1.36	495.58				
3	CABIN 1B	156	0.5	3	22 °C +-2	N/A	1.36	495.58	5.20	1640.00	1	FCU
4	CABIN SPACE 01	468	2.0	8	22 °C +-2	N/A	2.56	765.97				
5	WORK STATION 01	3720	2.5	103	22 °C +-2	N/A	28.77	9282.84	14.00	4600.00	2	AHU
6	LOUNGE 01	892	0.5	10	22 °C +-2	N/A	3.84	1094.20				
7	WAITING AREA	1241	0.2	10	22 °C +-2	N/A	5.46	1630.16	14.00	4600.00	1	AHU
8	LOUNGE 02	892	0.5	10	22 °C +-2	N/A	4.03	1145.47				
9	MEETING ROOM 02	798	0.5	16	22 °C +-2	N/A	5.36	1730.65	5.20	1640.00	1	FCU
10	CABIN 2A	156	0.5	3	22 °C +-2	N/A	1.36	495.58				
11	CABIN 2B	156	0.5	3	22 °C +-2	N/A	1.36	495.58	5.20	1640.00	1	FCU
12	CABIN SPACE 02	468	2.0	8	22 °C +-2	N/A	2.56	765.97				
13	WORK STATION 02	3720	2.5	75	22 °C +-2	N/A	26.71	9403.50	14.00	4600.00	2	AHU

Table 28 HVAC distribution table

SOLAR GAIN - GLASS						
Item	**Direction**	**Area (ft2)**	**ΔT (°F)**	**Correction fator**	**SHGC**	**BTU / Hour**
Glass	N	30375	13	1.3	1	494344
Glass	NE		13	1.3	0.2	0
Glass	E	15280	13	1.3	0.2	49735
Glass	SE		13	1.3	0.2	0
Glass	S	8787	19	1.3	0.2	41802
Glass	SW		122	1.3	0.2	0
Glass	W	15280	151	1.3	0.2	577697
Glass	NW		80	1.3	0.2	0
Skylight			160	1.3	0.2	0
SOLAR & TRANSMISSION GAIN - WALL & ROOF						
Item	**Direction**	**Area (ft2)**	**ΔT (°F)**	**Correction factor**	**U-value**	**BTU / Hour**
Wall	N	11076	3	6	0.14	13956
Wall	NE		10	6	0.14	0
Wall	E	3813	20	6	0.14	13879
Wall	SE		18	6	0.14	0
Wall	S	4476	15	6	0.14	13159
Wall	SW		14	6	0.14	0
Wall	W	3813	3	6	0.14	4804
Wall	NW		6	6	0.14	0
Roof			32	6	0.07	0
TRANSMISSION GAIN EXCEPT WALLS & ROOF						
Item		**Area (ft2)**	**ΔT (°F)**		**U-value**	**BTU / Hour**
All Glass					0.55	0
Door		128			1.13	0
Partition			-5			0
Ceiling			-5			0
Floor			-5			0
INTERNAL SENSIBLE HEAT						
	Quantity	Unit rates				**BTU / Hour**
People	1200	245				294000
Equip (kW)	480942	3.41			1	1640012
Lights (kW)	89152	3.41			1	304008
Supply air fan gain	5%					172370
INTERNAL LATENT HEAT						
	Quantity	**Unit rates**				**BTU / Hour**
People	1200	205.0				246000
OUT SIDE AIR HEAT						
	Flow rate (CFM)	**ΔT(°F) & Δg/lb**	**Convesion factor**			**BTU / Hour**
Sensible	20		1.08			0
Latent	20		0.68			0
Total Room Sensible heat						**3619767**
Total Room Latent heat						**246000**
Grand total heat, BTU/hr						**3865767**
AIR CONDITIONING TONNAGE						**322.15**

Table 28 HVAC load Calculation

9.3 HVAC LAYOUT

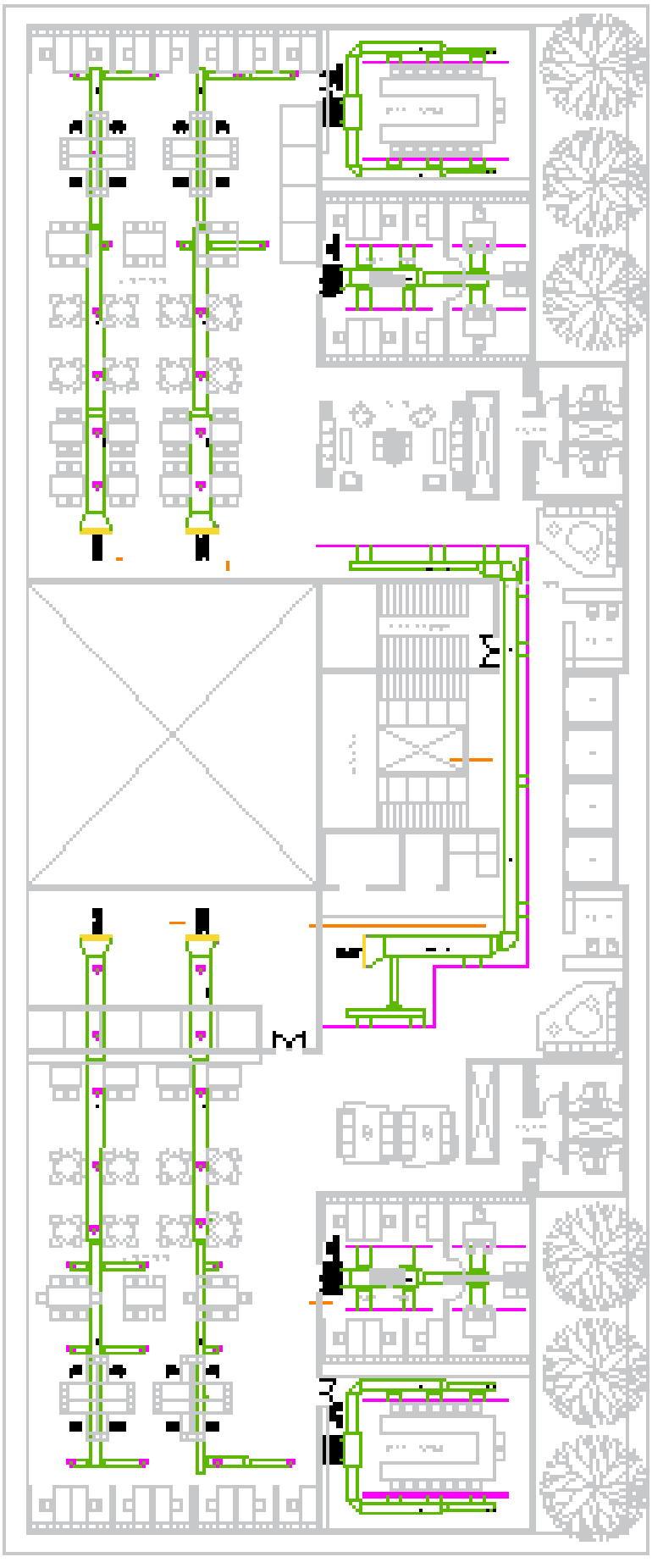


Figure 100

Figure 100. HVAC Layout

	Supply air duct
	CHW pipe
	Duct openings
	Base plan

9.3 ELECTRICAL LOOPING

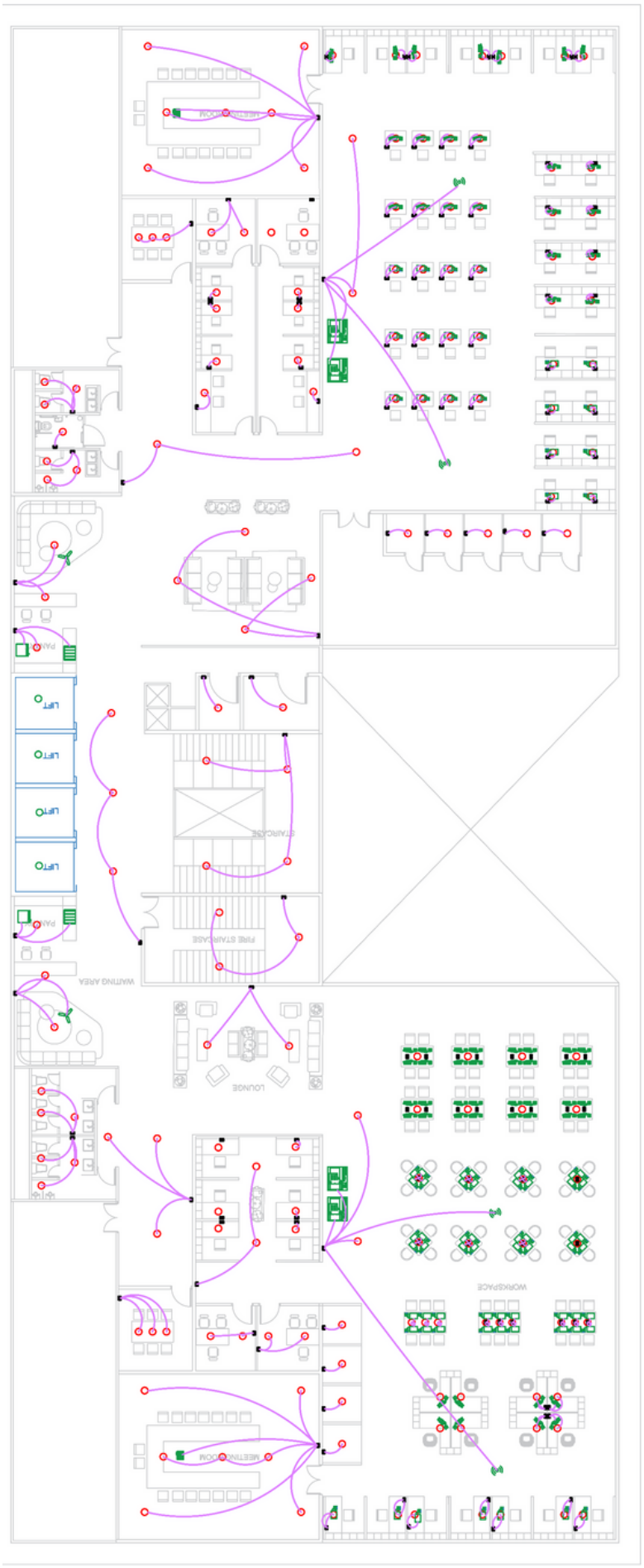


Figure 101. Lighting Layout

9.4 EMBODIED CARBON CALCUATION

	Material	Unit	Material manufacturing emissions			Transport 1 | Manufacturer --> Supplier						Transport 2 | Supplier --> Site					
			Quantity	Emissions Factor	Material Emissions (kg-CO_2e)	Type of Vehicle used	(1) Distance from Factory to Retail shop (km)	(2) No. of trips	(3) Total distance =(1)*(2) (km)	(4) Total Fuel Consumed =(3)/Mileage (litres)	Transport Emissions 1 (kg-CO_2e)	Type of Vehicle used	(1) Distance from Retail shop to Site	(2) No. of trips	(3) Total distance =(1)*(2) (km)	(4) Total Fuel Consumed =(3)/Mileage (litres)	Transport Emissions 2 (kg-CO_2e)
	Cement (ordinary Portla	kg	74,880	0.91	68141	HGV Lorry/ Truck	17	2	32	5	15	HGV Lorry/ Truck	14	2	26	4	12
	Sand	kg	1,49,760	0.009	1348	HGV Lorry/ Truck	15	4	56	9	27	HGV Lorry/ Truck	12	4	45	7	21
System Type Wall	Aggregate (mixed gravel	cu. m	124.8	0.009	1	HGV Lorry/ Truck	18	0	0	0	0	Mini truck	17	0	2	0	0
	Aluminum thin composi	kg	8794.24	18	158296	HGV Lorry/ Truck	12	0	3	0	1	HGV Lorry/ Truck	19	0	4	1	2
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
System Name RCC wall	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
Area (sq.m) 1456	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
				Total material emissions per functional unit (kg-CO_2e)	156					Total Transport 1 emissions per functional unit (kg-CO_2e)	0					Total Transport 2 emissions per functional unit (kg-CO_2e)	0

	Material	Unit	Material manufacturing emissions			Transport 1 | Manufacturer --> Supplier						Transport 2 | Supplier --> Site					
			Quantity	Emissions Factor	Material Emissions (kg-CO_2e)	Type of Vehicle used	(1) Distance from Factory to Retail shop (km)	(2) No. of trips	(3) Total distance =(1)*(2) (km)	(4) Total Fuel Consumed =(3)/Mileage (litres)	Transport Emissions 1 (kg-CO_2e)	Type of Vehicle used	(1) Distance from Retail shop to Site	(2) No. of trips	(3) Total distance =(1)*(2) (km)	(4) Total Fuel Consumed =(3)/Mileage (litres)	Transport Emissions 2 (kg-CO_2e)
	Cement (ordinary Portla	kg	79,714	0.91	72540	HGV Lorry/ Truck	17	2	34	6	16	HGV Lorry/ Truck	14	2	28	5	13
	Sand	kg	1,59,428	0.009	1435	HGV Lorry/ Truck	15	4	60	10	28	HGV Lorry/ Truck	12	4	48	8	23
System Type Roof	Aggregate (mixed gravel	cu. m	133	0.009	1	HGV Lorry/ Truck	18	0	0	0	0	HGV Lorry/ Truck	17	0	0	0	0
	Steel reinforcement (ste	kg	1825125	2.6	4745325	HGV Lorry/ Truck	16	46	730	122	346	HGV Lorry/ Truck	15	46	684	114	324
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
System Name RCC ROOF	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
Area (sq.m) 1550	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
				Total material emissions per functional unit (kg-CO_2e)	3109					Total Transport 1 emissions per functional unit (kg-CO_2e)	0					Total Transport 2 emissions per functional unit (kg-CO_2e)	0

	Material	Unit	Material manufacturing emissions			Transport 1 | Manufacturer --> Supplier						Transport 2 | Supplier --> Site					
			Quantity	Emissions Factor	Material Emissions (kg-CO_2e)	Type of Vehicle used	(1) Distance from Factory to Retail shop (km)	(2) No. of trips	(3) Total distance =(1)*(2) (km)	(4) Total Fuel Consumed =(3)/Mileage (litres)	Transport Emissions 1 (kg-CO_2e)	Type of Vehicle used	(1) Distance from Retail shop to Site	(2) No. of trips	(3) Total distance =(1)*(2) (km)	(4) Total Fuel Consumed =(3)/Mileage (litres)	Transport Emissions 2 (kg-CO_2e)
	Cement (ordinary Portla	kg	14,34,857	0.91	1305720	HGV Lorry/ Truck	17	36	610	102	289	HGV Lorry/ Truck	14	36	502	84	238
	Sand	kg	28,69,714	0.009	25827	HGV Lorry/ Truck	15	72	1076	179	509	HGV Lorry/ Truck	12	72	861	143	407
System Type Floor	Aggregate (mixed gravel	cu. m	2,391	0.009	22	HGV Lorry/ Truck	18	0	1	0	1	HGV Lorry/ Truck	17	0	1	0	0
	Steel reinforcement (ste	kg	3,28,52,250	2.6	85415850	HGV Lorry/ Truck	16	821	13141	2190	6220	HGV Lorry/ Truck	15	821	12320	2053	5831
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
System Name 2 way slab	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
Area (sq.m) 27900	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
				Total material emissions per functional unit (kg-CO_2e)	3109					Total Transport 1 emissions per functional unit (kg-CO_2e)	0					Total Transport 2 emissions per functional unit (kg-CO_2e)	0

	Material	Unit	Material manufacturing emissions			Transport 1 | Manufacturer --> Supplier						Transport 2 | Supplier --> Site					
			Quantity	Emissions Factor	Material Emissions (kg-CO_2e)	Type of Vehicle used	(1) Distance from Factory to Retail shop (km)	(2) No. of trips	(3) Total distance =(1)*(2) (km)	(4) Total Fuel Consumed =(3)/Mileage (litres)	Transport Emissions 1 (kg-CO_2e)	Type of Vehicle used	(1) Distance from Retail shop to Site	(2) No. of trips	(3) Total distance =(1)*(2) (km)	(4) Total Fuel Consumed =(3)/Mileage (litres)	Transport Emissions 2 (kg-CO_2e)
	dgu 16 mm	cu.m	6.96	9.9	69	HGV Lorry/ Truck	21	0	0	0	0	Mini truck	17	0	0	0	0
	XPS	kg	649.6	2.9	1884	HGV Lorry/ Truck	16	0	0	0	0	Mini truck	15	0	7	0	1
System Type Fenestration	<select material>		0	0	0		0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0		0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
System Name DGU	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
Area (sq.m) 464	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
				Total material emissions per functional unit (kg-CO_2e)	4					Total Transport 1 emissions per functional unit (kg-CO_2e)	0					Total Transport 2 emissions per functional unit (kg-CO_2e)	0

	Material	Unit	Material manufacturing emissions			Transport 1 | Manufacturer --> Supplier						Transport 2 | Supplier --> Site					
			Quantity	Emissions Factor	Material Emissions (kg-CO_2e)	Type of Vehicle used	(1) Distance from Factory to Retail shop (km)	(2) No. of trips	(3) Total distance =(1)*(2) (km)	(4) Total Fuel Consumed =(3)/Mileage (litres)	Transport Emissions 1 (kg-CO_2e)	Type of Vehicle used	(1) Distance from Retail shop to Site	(2) No. of trips	(3) Total distance =(1)*(2) (km)	(4) Total Fuel Consumed =(3)/Mileage (litres)	Transport Emissions 2 (kg-CO_2e)
	Cement (ordinary Portla	kg	367885	0.91	334775	HGV Lorry/ Truck	17	9	156	26	74	HGV Lorry/ Truck	14	9	129	21	61
	Sand	kg	735770	0.009	6622	HGV Lorry/ Truck	15	18	276	46	131	HGV Lorry/ Truck	12	18	221	37	104
System Type Structural	Aggregate (mixed gravel	cu. m	613	0.009	6	HGV Lorry/ Truck	18	0	0	0	0	HGV Lorry/ Truck	17	0	0	0	0
	Steel reinforcement (ste	kg	332840	2.6	865384	HGV Lorry/ Truck	16	8	133	22	63	HGV Lorry/ Truck	15	8	125	21	59
	Steel section	kg	156420	2.5	391050	HGV Lorry/ Truck	14	4	55	9	26	<select vehicle>	11	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
System Name column & beam	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
Area (sq.m) 2926	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
				Total material emissions	[illegible]					Total Transport 1 emissions per	[illegible]					Total Transport 2 emissions per	[illegible]

Table 29 Baseline system embodied carbon

System	Material	Unit	Material manufacturing emissions			Transport 1 | Manufacturer --> Supplier						Transport 2 | Supplier --> Site					
			Quantity	Emissions Factor	Material Emissions (kg-CO_2 e)	Type of Vehicle used	(1) Distance from Factory to Retail	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (litres)	Transport Emissions 1 (kg-CO_2 e)	Type of Vehicle used	(1) Distance from Retail shop to Site	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (litres)	Transport Emissions 2 (kg-CO_2 e)
System Type Wall; System Name Fly ash; Area (sq.m) 1456	Fly ash	kg	109200	0.000006	1	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	28	3	76	13	36
	Cellulose insulation	kg	4732	-1.1	-5205	<select vehicle>	0	0	0	0	0	Mini truck	24	4	87	4	12
	Cork Board	kg	8008	0.64	5125	<select vehicle>	0	0	0	0	0	Mini truck	29	6	179	9	25
	Paint	l	22400	0.659	14762	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	17	1	10	2	5
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
				Total material emissions per functional unit (kg-CO_2 e)	10					Total Transport 1 emissions per functional unit (kg-CO_2 e)	0					Total Transport 2 emissions per functional unit (kg-CO_2 e)	0

System	Material	Unit	Material manufacturing emissions			Transport 1 | Manufacturer --> Supplier						Transport 2 | Supplier --> Site					
			Quantity	Emissions Factor	Material Emissions (kg-CO_2 e)	Type of Vehicle used	(1) Distance from Factory to Retail	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (litres)	Transport Emissions 1 (kg-CO_2 e)	Type of Vehicle used	(1) Distance from Retail shop to Site	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (litres)	Transport Emissions 2 (kg-CO_2 e)
System Type Roof; System Name waffle; Area (sq.m) 1550	Cement (ordinary Portlar	kg	40944	0.91	37259	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	34	1	35	6	16
	Sand	kg	81888	0.009	737	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	21	2	43	7	20
	Aggregate (mixed gravel	cu. m	68.42	0.009	1	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	23	0	0	0	0
	Steel reinforcement (ste	kg	93415	2.6	242879	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	14	2	33	5	15
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
				Total material emissions per functional unit (kg-CO_2 e)	181					Total Transport 1 emissions per functional unit (kg-CO_2 e)	0					Total Transport 2 emissions per functional unit (kg-CO_2 e)	0

System	Material	Unit	Material manufacturing emissions			Transport 1 | Manufacturer --> Supplier						Transport 2 | Supplier --> Site					
			Quantity	Emissions Factor	Material Emissions (kg-CO_2 e)	Type of Vehicle used	(1) Distance from Factory to Retail	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (litres)	Transport Emissions 1 (kg-CO_2 e)	Type of Vehicle used	(1) Distance from Retail shop to Site	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (litres)	Transport Emissions 2 (kg-CO_2 e)
System Type Floor; System Name waffle; Area (sq.m) 27900	Cement (ordinary Portlar	kg	1841516	0.91	1675780	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	34	46	1565	261	741
	Sand	kg	3683177	0.009	33149	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	21	92	1934	322	915
	Aggregate (mixed gravel	cu. m	3069.19	0.009	28	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	23	0	2	0	1
	Steel reinforcement (ste	kg	29508935	2.6	76723231	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	14	738	10328	1721	4889
	terracota pots/jali	cu.m	185835	30.4	5649384	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	11	5	51	9	24
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
				Total material emissions per functional unit (kg-CO_2 e)	3014					Total Transport 1 emissions per functional unit (kg-CO_2 e)	0					Total Transport 2 emissions per functional unit (kg-CO_2 e)	0

System	Material	Unit	Material manufacturing emissions			Transport 1 | Manufacturer --> Supplier						Transport 2 | Supplier --> Site					
			Quantity	Emissions Factor	Material Emissions (kg-CO_2 e)	Type of Vehicle used	(1) Distance from Factory to Retail	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (litres)	Transport Emissions 1 (kg-CO_2 e)	Type of Vehicle used	(1) Distance from Retail shop to Site	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (litres)	Transport Emissions 2 (kg-CO_2 e)
System Type Structural; System Name column; Area (sq.m) 1080	Cement (ordinary Portlar	kg	222171	0.91	202176	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	34	6	189	31	89
	Sand	kg	444342	0.009	3999	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	21	11	233	39	110
	Aggregate (mixed gravel	cu. m	370.28	0.009	3	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	23	0	0	0	0
	Steel section	kg	156420	2.5	391050	<select vehicle>	0	0	0	0	0	HGV Lorry/ Truck	14	4	55	9	26
				0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
				Total material emissions per functional unit (kg-CO_2 e)	553					Total Transport 1 emissions per functional unit (kg-CO_2 e)	0					Total Transport 2 emissions per functional unit (kg-CO_2 e)	0

System	Material	Unit	Material manufacturing emissions			Transport 1 | Manufacturer --> Supplier						Transport 2 | Supplier --> Site					
			Quantity	Emissions Factor	Material Emissions (kg-CO_2 e)	Type of Vehicle used	(1) Distance from Factory to Retail	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (litres)	Transport Emissions 1 (kg-CO_2 e)	Type of Vehicle used	(1) Distance from Retail shop to Site	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (litres)	Transport Emissions 2 (kg-CO_2 e)
System Type Fenestration; System Name DGU; Area (sq.m) 464	dgu 16 mm	cu.m	6.96	9.9	69	<select vehicle>	0	0	0	0	0	Mini truck	23	0	0	0	0
	Cellulose insulation	kg	649.6	-1.1	-715	<select vehicle>	0	0	0	0	0	Mini truck	20	0	10	0	1
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
	<select material>		0	0	0	<select vehicle>	0	0	0	0	0	<select vehicle>	0	0	0	0	0
				Total material emissions per functional unit (kg-CO_2 e)	-1					Total Transport 1 emissions per functional unit (kg-CO_2 e)	0					Total Transport 2 emissions per functional unit (kg-CO_2 e)	0

Table 30 Proposed system embodied carbon

9.5 COST ESTIMATION

Project Summary

Project Project Information

Team:	Foot-printers		
Division:		**Land Cost:**	Mil
Site Area (sqm)	400	**City:**	BKC, Mumbai
Built-up Area (BUA) (sqm)	1,550	**State:**	Maharashtra
Ground Coverage (Plinth Area) (sqm)	1,600		

S.No.	Particulars	Definition	Baseline Estimate (Project Partner / SOR basis)		
			Amount	%	Amount (INR
1	Land	Cost of land purchased or leased by the Project Partner		0.0%	-
2	Civil Works	Refer Item A, Civil works in Cost of construction worksheet	90.24	11.9%	58,216
3	Internal Works	Refer Item B, Civil works in Cost of construction worksheet	80.05	10.6%	51,642
4	MEP Services	Refer Item C, Civil works in Cost of construction worksheet	386.69	51.0%	249,480
5	Equipment & Furnishing	Refer Item D, Civil works in Cost of construction worksheet	0.59	0.1%	381
6	Landscape & Site Development	Refer Item E, Civil works in Cost of construction worksheet	0.20	0.0%	130
7	Contingency	Amount added to the total estimate for incidental and miscellaneous	55.78	7.4%	35,985
	TOTAL HARD COST		**613.5**	**81%**	**395,835**
8	Pre Operative Expenses	Cost of Permits, Licenses, Market research, Advertising etc	40.00	5.3%	25,806
9	Consultants	Consultant fees on a typical Project	38.00	5.0%	24,516
10	Interest During Construction	Interest paid on loans related to the project during construction	67.00	8.8%	43,226
	TOTAL SOFT COST		**145.0**	**19%**	**93,548**
	TOTAL PROJECT COST		**758.5**	**100%**	**489,383**

Table 31 Project summary

C. MEP SERVICES		
11	**HVAC**	
11.1	Chilled Water Piping	3.20 Cr.
11.2	AHU, Ducting & Insulation, etc	1.20 Cr.
11.3	Ventilation Fans	15 lacs
11.4	High Side	7.0 Cr.
11.5	DOAS, Ducting & Insulations, etc.	30 lacs
11.6	ADIABATIC COOLING SYSTEM	
11.7		
	"Insert Row" above this row to add more items	
12	**ELECTRICAL & ALLIED SERVICES**	
12.1	Substation (Including Transformers)	55 lacs
12.2	Panels / Distribution Boards & Switch Gears – Main Panels / Distribution Boards & Switchgears – Sub Distribution	2.0 Cr.
12.3	solar panels	– 85 lacs
12.4	Light Fittings	– 1.30 Cr.
12.5	Internal Wiring	– 2.20 Cr.
12.6	Earthing & Lightning Protection	– 60 lacs
12.7	D.G. Sets 4000 KVA	– 3.0 Cr.
	"Insert Row" above this row to add more items	
13	**PLUMBING & SANITATION**	
13.1	Fixtures and Fittings	– 60 lacs.
13.2	Internal Drainage	– 50 lacs
13.3	External Drainage	– 65 lacs
13.4	STP and ETP	– 100 lacs.
13.5	Water Treatment and Distribution	– 75 lacs
13.6	Domestic & Flushing water lift pumps, tank, panels	– 20 lacs
13.7	Irrigation system	– 10 lac
13.8	Rainwater Storage system	– 15 lac
13.9	Solar water heating system	– NA
	"Insert Row" above this row to add more items	
14	**FIRE FIGHTING**	
14.1	Plant Room	– 35 lacs
14.2	Fire Hydrant System	– 30 lacs
14.3	Sprinkler System	– 65 lacs
14.4	Fire Extinguishers & Buckets	– 20 lacs.
	"Insert Row" above this row to add more items	
15	**IBMS AND SECURITY SYSTEM**	
15.1	Fire Alarm System	– 1.80 Cr.
15.2	Public Address System	– 1.50 Cr.
15.3	Access Control System	– 70 lacs
15.4	CCTV System	– 2.0 Cr.
15.5	Building Management System	– 80 lacs.
15.6	Waterleak detection system	– 10 lacs.
	"Insert Row" above this row to add more items	
16	**INSTALLATION OF LIFT**	
16.1	Service Elevator	– 2.25 Cr.
16.2	Passenger Elevator	– 3.50 Cr.
16.3	Escalators	– 1.30 Cr.
	"Insert Row" above this row to add more items	
	SUB-TOTAL (C)	

Table 31 Consultation with experts

Constuction Cost Summary - Hard Cost												
No.	Item Description	Unit	Baseline Estimate (Project Partner / SOR basis)				Proposed Design Estimate				Notes Required?	Justification / Notes
			Quantity	Rate	(Rs)	Amount (Million INR)	Cost per sqm. (INR)	Quantity	Rate	Amount (Million INR)	Cost per sqm (INR)	
A. CIVIL WORKS												
1	EXCAVATION											
1.1	Excavation In Soil	Cu.m			434	-	-		434	-	-	NO
1.2	Excavation In Hard rock	Cu.m			756	-	-		756	-	-	NO
1.3	Rubble Soling	Sq.m			2,286	-	-		2,286	-	-	NO
1.4	Backfilling+ Compaction	Cu.m			109,398	-	-		109,398	-	-	NO
1.5	Antitermite treatment	Sq.m			164	-	-		164	-	-	NO
	"Insert Row" above this row to add more items											
2	RCC WORK											
2.1	PCC Plinth M10	Cu.m	960		6,771	6.5	4,194	960	6,771	6.5	4,194	NO
2.2	PCC For Footing M10	Cu.m			6,771	-	-		6,771	-	-	NO
2.3	Foundation, Raft,Plinth beams, shear walls	Cu.m			8,968	-	-		8,968	-	-	NO
2.4	RCC(M35 grade)	Cu.m			18,244	-	-		18,244	-	-	NO
2.5	RCC (M30 grade)	Cu.m			18,160	-	-		18,160	-	-	NO
2.6	Cement Bags	Sq.m	13,700		275	3.8	2,431	13,700	275	3.8	2,431	NO
2.7	Reinforcement ,TMT Fe 500	M.Ton	14		42,600	0.6	385	14	42,600	0.6	385	NO
2.8	Fabrication of Reinforcement	Sq.m			1,287	-	-		1,287	-	-	NO
	"Insert Row" above this row to add more items											
3	SHUTTERING WORK											
3.1	Shuttering Area	Sq.m			66,269	-	-		66,269	-	-	NO
	"Insert Row" above this row to add more items											
4	STRUCTURAL STEEL WORK	Sq.m										
4.1	Structural steel for column sections,Fe 590B	M.Ton	200		131,412	26.3	16,956	200	131,412	26.3	16,956	NO
4.2	16 mm dia holding down bolts for column grade8.8	M.Ton			118,255	-	-		118,255	-	-	NO
4.3	Structural steel for primary beams (BUILT UP SEC),Fe	M.Ton	300		106,077	31.9	20,552	300	106,077	31.9	20,552	NO
4.4	Structural steel for secondary beams -Castellated Sections	M.Ton	150		113,278	17.0	10,962	150	113,278	17.0	10,962	NO
4.5	Steel Deck for composite floor,ComFlor 60-1.2 mm thick	Sqm			2,143	-	-		2,143	-	-	NO
4.6	Fire Proof Painting	Sqm				-	-			-	-	NO
	"Insert Row" above this row to add more items											
5	FAÇADE WORK											
5.1	230 mm Thick Brick Wall	Sqm			10,171	-	-		10,171	-	-	NO
5.2	200 mm Thick Brick Wall	Sqm			10,000	-	-		10,000	-	-	NO
5.3	External Plaster	Sqm			2,024	-	-		2,024	-	-	NO
5.4	Glass façade	Sqm	6,055		618	3.7	2,414	6,055	2,000	12.1	7,813	YES
5.5	External Aluminum Cladding	Sqm			5,020	-	-		5,020	-	-	NO
5.6	Terracotta jalis	per pc	18,000		25	0.5		18,000	25			
	"Insert Row" above this row to add more items											
	SUB- TOTAL (A)					90.2	58,216			98.1	63,292	
B. INTERNAL WORKS												
6	INTERNAL WALLS , FINISHES											
6.1	115 mm Thick Brick Wall	Sqm			2,220	-	-		2,220	-	-	NO
6.2	Internal Plaster - Walls	Sqm			6,454	-	-		6,454	-	-	NO
6.3	Painting of Internal Wall +Ceiling	Sqm			3,123	-	-		3,123	-	-	NO
	"Insert Row" above this row to add more items											
7	WATERPROOFING											
7.1	Toilet	Sqm	680		1,594	1.1	699	680	1,594	1.1	699	NO
7.2	Raft	Sqm			859	-	-		859	-	-	NO
7.3	Retaining Wall	Sqm			1,473	-	-		1,473	-	-	NO
7.4	Top terrace	Sqm	1,550		1,594	2.5	1,594	1,550	1,594	2.5	1,594	NO
	"Insert Row" above this row to add more items											
8	TILING WORK											
8.1	Flooring - IPS	Sqm			3,749	-	-		3,749	-	-	NO
8.2	Flooring - Lobbies	Sqm	715		5,445	3.9	2,512	715	5,445	3.9	2,512	NO
8.3	Flooring - Polished Kota	Sqm			1,000	-	-		1,000	-	-	NO
8.4	Ceramic 12 x 12 Toilets	Sqm	680		7,535	5.1	3,306	680	7,535	5.1	3,306	NO
8.5	Staircase - Tread	Sqm			5,856	-	-		5,856	-	-	NO
8.6	Staircase - Riser	Sqm			5,000	-	-		5,000	-	-	NO
8.7	Staircase - landing	Sqm			5,588	-	-		5,588	-	-	NO
8.8	Dado - Lift	Sqm			7,005	-	-		7,005	-	-	NO
8.9	Dado - Toilet	Sqm	680		7,550	5.1	3,312	680	7,550	5.1	3,312	NO
8.11	raised access flooring system	Sqm	20,300		3,000	60.9	39,648	20,300	3,000	60.9	39,648	
	"Insert Row" above this row to add more items											
9	DOORS											
9.1	D1(entrance door for toilet)- 0.9 *2.1	Sqm			4,233	-	-		4,233	-	-	NO
9.2	FD1(door for fire staircase)- 1*2.1	Sqm			5,000	-	-		5,000	-	-	NO
9.3	FD2 (fire exit door in the main core)-2*2.1	Sqm			6,000	-	-		6,000	-	-	NO
	"Insert Row" above this row to add more items											
10	FABRICATION											
10.1	Railing for Staircase	Rm			4,649	-	-		4,649	-	-	NO
10.2	Railing for Staircase with escilator	Rm			5,000	-	-		5,000	-	-	NO
10.3	Railing for foyer and foyer cutouts	Rm	1,200		1,200	1.4	929	1,200	1,200	1.4	929	NO
	"Insert Row" above this row to add more items											
	SUB-TOTAL (B)					80.0	51,642			80.0	51,642	
C. MEP SERVICES												
11	HVAC											
11.1	Chilled Water Piping	BUA	1,550		80	0.1	80		5,500,000	-	-	NO
11.2	AHU, Ducting & Insulation, etc	BUA	1,550		650	1.0	650	20,150	990	19.9	12,870	YES
11.3	Ventilation Fans	BUA	1,550		2,000	3.1	2,000	20,150	400	8.1	5,200	YES
11.4	High Side	BUA				-	-		650	-	-	NO
11.5	DOAS, Ducting & Insulations, etc.	BUA			60,000	-	-		1,090	-	-	NO
11.6	ADIABATIC COOLING SYSTEM	BUA				-	550	20,150	300	6.0	3,900	YES
11.7									1,500			
	"Insert Row" above this row to add more items											
12	ELECTRICAL & ALLIED SERVICES											
12.1	Substation (Including Transformers)					-	-		5,500,000	-	-	NO
12.2	Panels / Distribution Boards & Switch Gears – Main	BUA				-	-	20,150	990	19.9	12,870	YES
12.3	solar panels	BUA	20,150		400	8.1	5,200	20,150	400	8.1	5,200	NO
12.4	Light Fittings	BUA				-	-	400	650	0.3	168	YES
12.5	Internal Wiring	BUA				-	-		1,090	-	-	NO
12.6	Earthing & Lightning Protection	BUA				-	-		300	-	-	NO
12.7	D.G. Sets 4000 KVA	BUA				-	-		1,500	-	-	NO
	"Insert Row" above this row to add more items											
13	PLUMBING & SANITATION											
13.1	Fixtures and Fittings	BUA				-	-	20,150	300	6.0	3,900	YES
13.2	Internal Drainage	BUA	1,550		120	0.2	120	20,150	250	5.0	3,250	YES
13.3	External Drainage	BUA	1,550		18,696	29.0	18,696	20,150	320	6.4	4,160	YES
13.4	STP and ETP	BUA				-	-	20,150	372	7.5	4,836	YES
13.5	Water Treatment and Distribution	BUA	1,550		18,638	28.9	18,638	20,150	100	2.0	1,300	YES
13.6	Domestic & Flushing water lift pumps, tank, panels	BUA	1,550		20,136	31.2	20,136	20,150	50	1.0	650	YES
13.7	Irrigation system	BUA				-	-		75	-	-	NO
13.8	Rainwater Storage system	BUA	1,550		24,053	37.3	24,053	20,150	24,053	484.7	312,689	YES
13.9	Solar water heating system	BUA				-	-			-	-	NO
	"Insert Row" above this row to add more items											
14	FIRE FIGHTING											
14.1	Plant Room	BUA	1,550		2,630	4.1	2,630	1,550	173	0.3	173	YES
14.2	Fire Hydrant System	BUA				-	-	1,550	150	0.2	150	YES
14.3	Sprinkler System	BUA	1,550		3,588	5.6	3,588	1,550	320	0.5	320	YES
14.4	Fire Extinguishers & Buckets	BUA				-	-	1,550	100	0.2	100	YES
	"Insert Row" above this row to add more items								890			
15	IBMS AND SECURITY SYSTEM								744			
15.1	Fire Alarm System	BUA	20,150		200	4.0	2,600	20,150	347	7.0	4,511	YES
15.2	Public Address System	BUA			250,000	-	-		992	-	-	NO
15.3	Access Control System	BUA			9,500	-	-		892	-	-	NO
15.4	CCTV System	BUA	1,550		112,000	173.6	112,000	1,550	49	0.1	49	YES
15.5	Building Management System	BUA	20,150		650	13.1	8,450	20,150	650	13.1	8,450	NO
15.6	Waterleak detection system	BUA	1,550		28,000	43.4	28,000	1,550	28,000	43.4	28,000	NO
	"Insert Row" above this row to add more items											
16	INSTALLATION OF LIFT											
16.1	Service Elevator	BUA	1,550		789	1.2	789	1,550	789	1.2	789	NO
16.2	Passenger Elevator	BUA	1,550		900	1.4	900	1,550	900	1.4	900	NO
16.3	Escalators	BUA	1,550		950	1.5	950	1,550	950	1.5	950	NO
	"Insert Row" above this row to add more items											
	SUB-TOTAL (C)					386.7	249,480			643.8	415,385	
D. EQUIPMENT & FURNISHING												
17	Office Interiors:											
17.1	Furnishing	Carpet	1,320		372	0.5	317	1,320	372	0.5	317	NO
17.2	Internal Painting	Sqm	10,000		10	0.1	65	10,000	10	0.1	65	
17.3	False Ceiling	Sqm			100	-	-		100	-	-	
17.4	Internal Electrification					-	-			-	-	
17.5	Ducting					-	-			-	-	
17.6	Lighting					-	-			-	-	
	"Insert Row" above this row to add more items											
	SUB-TOTAL (D)					0.6	381			0.6	381	
E. LANDSCAPE & SITE DEVELOPMENT												
18	SITE DEVELOPMENT											
18.1	Roads and Walkways	Sq.m	120		12	0.0	1	200	12	0.0	2	YES
19	LANDSCAPING											
19.1	Landscaping and Hardscape	Sq.m	200		1,000	0.2	129	21,528	200	4.3	2,778	YES
19.2	Roof Garden with Insulation	Sq.m				-	-	34,000	80	2.7	1,755	YES
	"Insert Row" above this row to add more items											
	SUB-TOTAL (E)					0.2	130			7.0	4,534	
	CONTINGENCY (E)		10%			55.8	35,985	10%		83.0	53,523	
	TOTAL					613.5	395,835			912.6	588,758	

Table 31 Construction cost

FINANCING COST

1) GENERAL ASSUMPTIONS (FOR REFERENCE)

Depreciation

S.No.	Particulars	SLM Method	WDV
1	Computer	16.21%	60.00%
2	Land	0.00%	0.00%
3	Building	1.63%	10.00%
4	Plant & Machinery	4.75%	15.00%
6	Electrification Utilities	4.75%	15.00%
7	Vehicles	9.50%	15.00%
8	Furniture & Fixtures/ Internal Fit outs	6.33%	10.00%
9	Other misc Equipment	4.75%	15.00%
	WDV	No Limit	
	SLM	95% of the value can be depreciated	

Tax

	Basic	With	
Corporate Tax Rate	25.00%	28.33%	28.33%
MAT Rate	15.00%	17.00%	17.00%
Surcharge	10.00%		
Education Cess	3.00%	With E. Cess	Surcharge
Service tax	10.00%	10.30%	2.5%
TDS/Witholding Tax (beore 01.06.05)	20.00%	20.60%	20.91%
TDS/Witholding Tax (after June 05)	10.00%	10.30%	10.455%

2) PROJECT ASSUMPTIONS

Project Cost Assumptions

S.No.	Particulars	Amount (Millions)	
	HARD COSTS		
1	Land Cost (Million INR)		
2	Contingency (Million INR)	1%	
	SOFT COSTS		
3	Pre Operative Expenses (Million INR)	10.00	Provide Detailed Assumption if Required
4	Consultants (Million INR)	10.00	Provide Detailed Assumption if Required

3) Construction Schedule (completion of each item)

	Construction Period	5.00	Years									
S.No.	Particulars		Baseline Estimate (Project Partner / SOR basis)					Proposed Design Estimate				
	ANNUAL SCHEDULE	TOTAL	YEAR 1	2	3	4	5	YEAR 1	2	3	4	5
1	Land	100%	100%					100%				
2	Civil Works	100%		20%	20%	30%	30%		20%	20%	30%	30%
3	Internal Works	100%					100%					100%
4	MEP Services	100%				30%	70%				30%	70%
5	Equipment & Furnishing	100%					100%					100%
6	Landscape & Site Development	100%			20%	30%	50%			20%	30%	50%
7	Contingency	100%					100%					100%
8	Pre-Operative Expenses	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
9	Consultants	100%	80%	5%	5%	5%	5%	80%	5%	5%	5%	5%

4) Term Loan Assumptions

S.No.	Particulars			
1	Debt	50.0%		
2	Equity	50.0%	To be obtained from Project Partner	
3	Debt to Equity Ratio	1.000		
5	Interest Rate	10.0%	To be obtained from Project Partner	
6	Moratorium Period (Years)	5	After Complet After Completion of Construction	two columns
7	Repayment Period (Years)	10	After Complet After Completion of Moratorium Period	two columns
8	Operations begin from year	6		two columns

5) TOTAL PROJECT COST & INTEREST DURING CONTRUCTION (IDC)

Capital Expenditure - Annual

Particulars	Baseline Estimate (Project Partner / SOR basis)						Proposed Design Estimate					
	TOTAL (Millons)	YEAR 1	2	3	4	5	TOTAL	YEAR 1	2	3	4	5
Land		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
Civil Works	90.2	0.0	18.0	18.0	27.1	27.1	98.1	0.0	19.6	19.6	29.4	29.4
Internal Works	80.0	0.0	0.0	0.0	0.0	80.0	80.0	0.0	0.0	0.0	0.0	80.0
MEP Services	386.7	0.0	0.0	0.0	116.0	270.7	643.8	0.0	0.0	0.0	193.2	450.7
Equipment & Furnishing	0.6	0.0	0.0	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.6
Landscape & Site Development	0.2	0.0	0.0	0.0	0.1	0.1	7.0	0.0	0.0	1.4	2.1	3.5
Contingency	55.8	0.0	0.0	0.0	0.0	55.8	83.0	0.0	0.0	0.0	0.0	83.0
TOTAL HARD COST	**613.5**	**0.0**	**18.0**	**18.1**	**143.1**	**434.3**	**912.6**	**0.0**	**19.6**	**21.0**	**224.7**	**647.2**
Pre Operative Expenses	10.0	2.0	0.0	0.0	0.0	0.0	10.0	8.0	0.5	0.5	0.5	0.5
Consultants	10.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0
Interest During Construction	20.3	5.4	6.7	8.2	0.0	0.0	11.7	5.7	6.0	0.0	0.0	0.0
TOTAL SOFT COST	**40.3**	**7.4**	**6.7**	**8.2**	**0.0**	**0.0**	**31.7**	**13.7**	**6.5**	**0.5**	**0.5**	**0.5**
TOTAL PROJECT COST	**653.8**	**7.4**	**24.8**	**26.2**	**143.1**	**434.3**	**944.3**	**13.7**	**26.2**	**21.5**	**225.2**	**647.7**
Upfront Equity	326.9	3.7	12.4	13.1	71.6	217.1	472.1	6.8	13.1	10.8	112.6	323.9
Debt Drawal Required	**317.9**	3.7	12.4	13.1	71.6	217.1	**467.1**	6.8	13.1	10.8	112.6	323.9

Interest During Contruction

Particulars	Baseline Estimate (Project Partner / SOR basis)										
	TOTAL (Millons)	YEAR 1	2	3	4	5	6	7	8	9	10
% Repayment of Loan (Annual)		0%	0%	0%	0%	10%	15%	15%	20%	20%	20%
Opening balance		-	3.68	16.07	29.19	100.76	286.11	455.56	625.01	778.57	932.12
Repayment	**317.90**	-	-	-	-	31.79	47.68	47.68	63.58	63.58	63.58
Debt drawl	**1403.58**	3.68	12.39	13.12	71.57	217.14	217.14	217.14	217.14	217.14	217.14
Closing balance	**4312.75**	3.68	16.07	29.19	100.76	286.11	455.56	625.01	778.57	932.12	1,085.68
Interest	**431.28**	0.37	1.61	2.92	10.08	28.61	45.56	62.50	77.86	93.21	108.57
IDC	**4.90**	0.37	1.61	2.92	-	-	-	-	-	-	-
Int to P&L	**426.38**	-	-	-	10.08	28.61	45.56	62.50	77.86	93.21	108.57

CHECK											
IDC (from Macro)	**20.25**	5.37	6.73	8.16	-	-	-	-	-	-	-
Difference	**15.36**										

RUN IDC Macro!!!

Proposed Design Estimate										
TOTAL	YEAR 1	2	3	4	5	6	7	8	9	10
	0%	0%	0%	0%	10%	15%	15%	20%	20%	20%
	-	6.84	19.92	30.68	143.28	420.43	350.36	280.29	186.86	93.43
467.15	-	-	-	-	46.71	70.07	70.07	93.43	93.43	93.43
467.15	6.84	13.08	10.76	112.60	323.87					
1532.10	6.84	19.92	30.68	143.28	420.43	350.36	280.29	186.86	93.43	(0.00)
153.21	0.68	1.99	3.07	14.33	42.04	35.04	28.03	18.69	9.34	(0.00)
2.68	0.68	1.99	-	-	-	-	-	-	-	-
150.53	-	-	3.07	14.33	42.04	35.04	28.03	18.69	9.34	(0.00)

CHECK										
11.72	5.68	6.04	-	-	-	-	-	-	-	-
9.05										

RUN IDC Macro!!!

Table 31 Financing cost

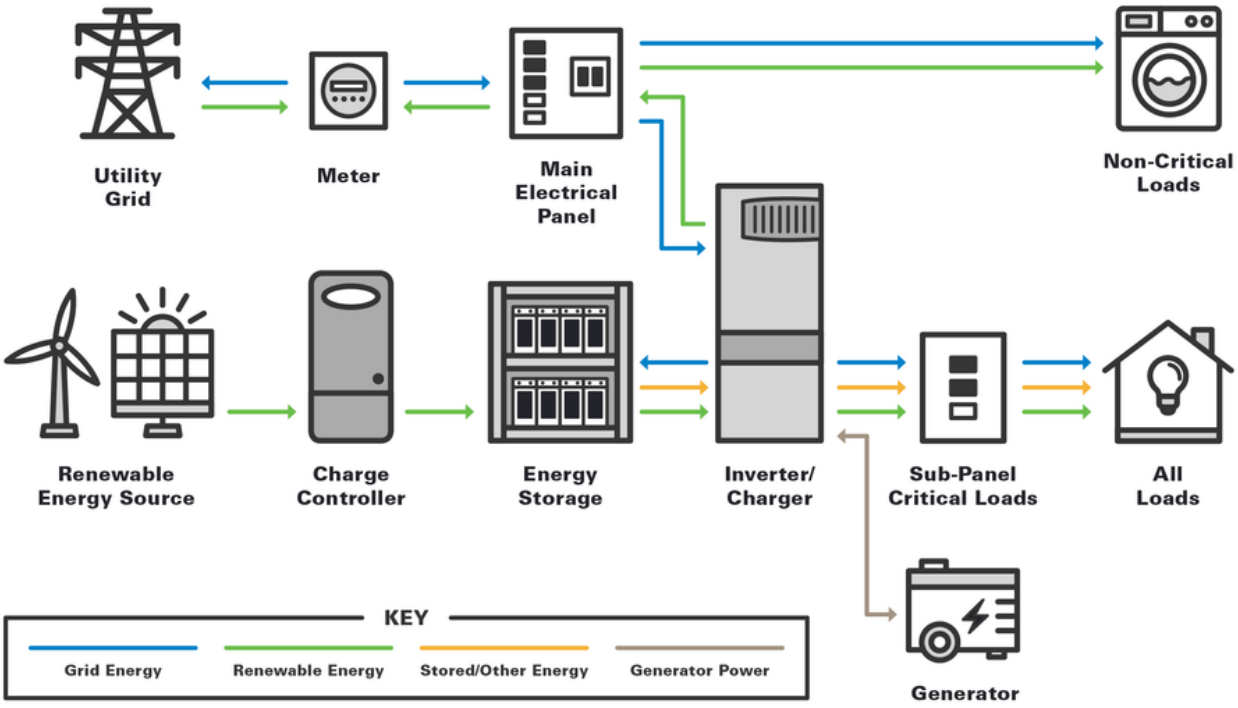


image source: -Interactive Systems (enersys.com)

Figure 102 Grid Interactive System

9.4 GUILDLINES

DO'S

- Regular maintenance of green spaces by trimming on regular intervals of trees and watering them.

- Applying non corrosive paint to all rustic materials.
- Ensuring wet riser and dry risers valves are working properly

- Maintaining all the equipment in the service rooms
- Changing of fire extinguishers on regular basis.

- Cleaning of water tanks to avoid growth of algae.
- Removing dust from solar panel for better performance.

- Clean HVAC Air Filters Regularly
- Check for leakages in ducts

DONT'S

- No smoking in service areas

- Not to have open windows while HVAC's are switched on
- Don't Attempt DIY Methods to Maintain or Repair Your HVAC System

- Don't cover Your Outdoor Unit Completely.
- Access prohibited in service areas.

- Service pipe should not be connected to any water closet. It should be kept separately.

- For BMS System do not permit the use of shared usernames and passwords and be sure the credentials used at one facility are different than those used in other buildings.

- For Terracotta Jalis do not use bleach based or acid-based products to clean the surface as these may damage the surface of the tile.

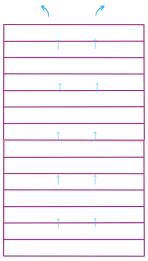
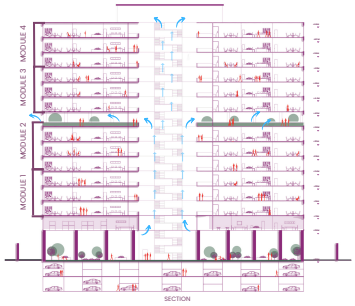
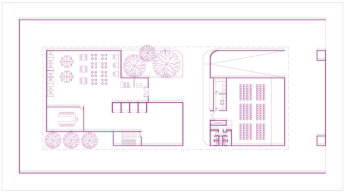
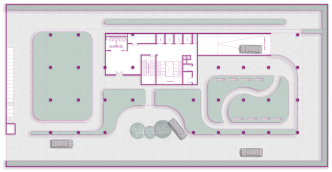
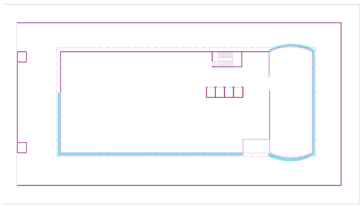
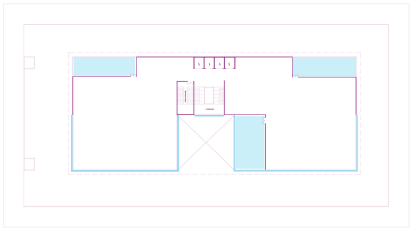
FEATURES	EXISTING BUILDING	NEW BUILDING
ARCHITECTURE	One community space within the building	Providing multiple community spaces, open, semi open as well as within the building
	 No movement of fresh air	 Providing courtyard and open floor space for movement of fresh air
	 -Built up area in the ground floor -High risk of flooding	 -Providing ground floor with green space which act as public space for the health and well being of people. -Less risk of flood.
	 -No balconies -South facde is exposed to the sunlight	 -Balconies provided for good air circulation. -Only north facade os exposed to the glass facade. -At southern side service and balconies are provided which will act as a buffer zone from harsh sunlight.
	Uncontrolled amount of light enters the building.	Louvered are provided for controlling the amount of sunlight entrying the space.

Table 31 Comparison between existing and proposed building

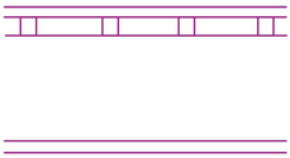
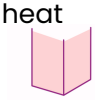
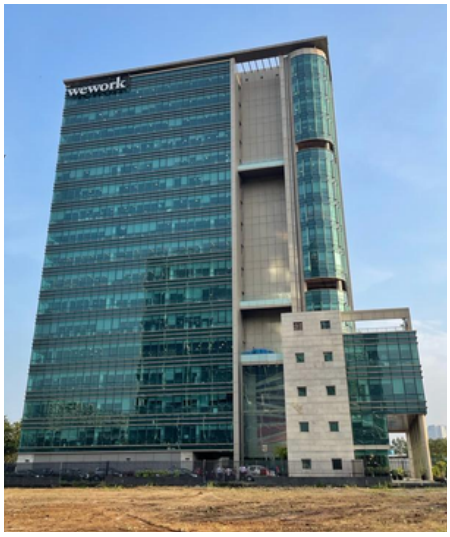
FEATURES	EXISTING BUILDING	NEW BUILDING
MATERIAL	 Concrete slabs and beams and conventinal slab.	 Use of filler slab -greater floor to floor space, -less use of materials, eco friendly and sustainable-About **20%** less concrete used. Due to reduced self weight, about **30%** less steel required.
	Use of concrete and steel for foundation	Reusing the existing foundation and columns reduces cost of construction
	Use of alumninum sheets for facade, attracting more heat 	Using white eco friendly paint 
ENERGY PERFORMANCE	Conventional HVAC all year round	HVAC+ Pre cooling for 7 months, Evaporative cooling for 5 months- **60% reduction**
	Relying on artificial light	Using maximum sunlight in workspaces
	No solar panels or on site energy production	Solar panels on roof generating electricity **4,93,967 kWh**
	EPI = 119 kWh/sqm	EPI = 43kWh/sqm EPI reduced by **64.17%**

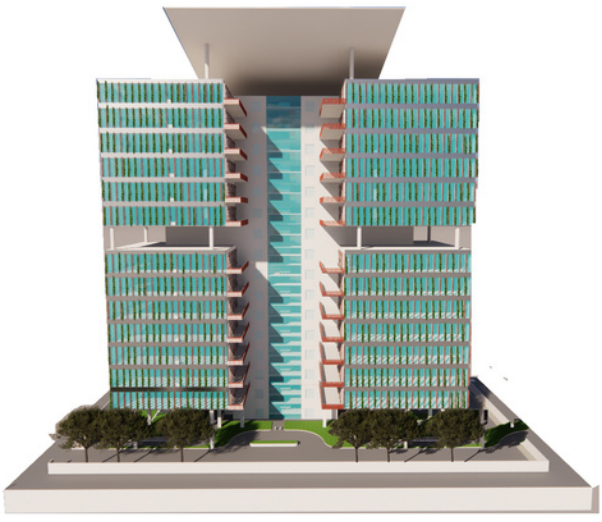
Table 31 Comparison between existing and proposed building

FEATURES	EXISTING BUILDING	NEW BUILDING
WATER	No rain water system was present	Adding of Raintwater treament plant. Which will provide water **4-5 months.**
	No recyclying of grey water.	With the help of root zone treatment Grey water is **reused by 75%**.
	High water consumping faucets.	Using Facucets which consumpe less water had helped to **reduce usage of water by 36%**
RESILIENCE	Building vulnerable to floods	Raising the building by 8 m on columns to make it flood resilient
	Backup generator in basement, making it susceptible to failure during floods	Backup generator on 8the floor, for normal working during emergencies
	STP water treatment, requiring energy use	Rootzone treatment, eco friendly method of treating water

Table 31 Comparison between existing and proposed building



existing bulding



Proposed buuilding

REFERENCES

IntrCool adiabatic cooling | Industrial climate control | Oxycom

IntrCool two-stage adiabatic cooling turns your factory into a comfortable, healthy and productive

Adiabatic Coolers

Paharpur Cooling Towers

5 Best Solar Water Heaters in India for 2023 | Expert Reviews

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https://cdn.cseindia.org/userfiles/Ar%20Deependra%20Prashad_DPAP.pdf
https://blurringboundaries.in/filler-slab/
https://www.structuralguide.com/flat-slab/
https://cpwd.gov.in/Publication/Booklet-Guide-for-Using-NBC-2016.pdf
www.wework.com/solutions
www.oxy-com.com/products/adiabatic-cooling-intrcooll

11 Tricks To Maximize Natural Light In The Workplace

APPENDIX

RACHANA SANSAD'S
ACADEMY OF ARCHITECTURE
AIDED
MUMBAI

Ref. No. 06/ STU/ 677/ Date : 10/11/2002

TO WHOMSOEVER IT MAY CONCERN

You are aware that Academy of Architecture, an Architectural Institution in Mumbai, imparts Five Year (full time) Bachelor's Degree Course in Architecture, affiliated to the University of Mumbai.

As a part of academic curriculum in the subject of Architectural Design, the undermentioned students of ....3rd..... Year B.Arch. studying during session 2022. - 20.23. would like to visit the concerned college/site/places to collect necessary information, data, plans, survey for their study purpose.

It would be appreciated, if you kindly grant them permission to visit the concerned college/site/places and also assist them in collecting necessary information, data, survey, plans etc. for their study purpose.

(Suresh M. Singh)
Principal
Academy of Architecture

ACADEMY OF ARCHITECTURE रचना संसद MUMBAI-28

Names of the Students :-

1] Aditya Srivastava
2] Bhavika Jakhotiya
3] Janhavi Jadhav
4] Mohit Pandharkame
5] Navya Malu
6] Neha Maiani
7] Pragati Shingade
8] Pranjal Tak
9] Prajima Wagh

278, Shankar Ghanekar Marg, Prabhadevi, Mumbai 400 025,Tel : 2430 1024 / 2431 0807 Fax : 24301724
Email : contact@aoamumbai.in website : www.aoamumbai.in

FOUNDED IN 1955. AFFILIATED TO UNIVERSITY OF MUMBAI, RECOGNISED BY COUNCIL OF ARCHITECTURE AND GOVERNMENT OF MAHARASHTRA

PROJECT PARTNER LETTER

Date: 13.12.2022

To,

The Director,
Solar Decathlon India

Dear Sir,

Thisistoinformyou thatour organization WeWorkIndia Private Limited, has provided information about our Solar Decathlon India 2022-23 project to the participating team led by Rachana Sansad's Academy of Architecture, Mumbai, so that their team Footprint-ers may use this information for their Solar Decathlon India 2022-23 Challenge entry.

AsaProjectPartnertothisteamfortheSolarDecathlonIndia2022-23competition,we areinterestedinseeingtheNet-Zero-Energy,Net-Zero-Water,resilientandaffordable solution this student team proposes and the innovation that results from this.

We would not be able to have a representative from our organization attend the Design Challenge Finals event in April/May, if this team is selected for the finals.

Wedonotwantourorganization'slogotobedisplayedontheSolar DecathlonIndiawebsite,recognizingusasoneoftheProjectPartnersforthe 2022-23 Challenge.

With warm regards,

Prateek Bajaj

Name of Representative: Prateek Bajaj

Designation: Area Director - West

Email: prateek.bajaj@wework.co.in

INDUSTRY PARTNER LETTER OF CONFIRMATION

SCION
ENERGY STORAGE

Date : 23rd Feb , 2023

To,

The Director,

Solar Decathlon India

Subject: Confirmation letter from Industry partner

Dear Sir,

This is to inform you that our organization, 'Scion Energy Storage' is collaborating with the participating team led by Rachana Sansad's Academy of Architecture. This team is working on a Office Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will cater to innovative design. We will be a renewable energy-driven division of GITA Group committed to provide clean, green, safe, powerful and sustainable energy storage solutions.

We would not be able to have a representative from our organization to attend the Design Challenge Finals event in April/May, if this team is selected for the Finals.

We would like our organization's logo displayed on the Solar Decathlon India website, recognising us as one of the Industry Partners for the 2022-23 competition.

With warm regards,

N Tapadiya

Neha Tapadiya
Co-Founder
Scion Energy Storage
neha@scionenergy.in
+91 8087681777

HQ: GITA GROUP, 255/1+2/2, Aashiyana Park2, Aundh, Pune- 411007. INDIA
Works: Sr. No. 25/8, Narhe Industrial Area, Narhe Dhayari Road, Narhe, Pune 411009. INDIA
info@scionenergy.in I www.scionenergy.in

INDUSTRY PARTNER LETTER OF CONFIRMATION

MULIK
FURNITURE

Date: 23rd February
2023 Ref: NMP/02/2023

To,
The Director,
Solar Decathlon India

Subject: Confirmation letter from Industry partner

Dear Sir,

This is to inform you that our organization, 'Agnigarbha Pvt. Ltd.' is collaborating with the participating team led by Rachana Sansad's Academy of Architecture. This team is working on a Office Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will cater to innovative design. We will provide options in sustainable furniture design.

We would not be able to have a representative from our organization to attend the Design Challenge Finals event in April/May, if this team is selected for the Finals.

We would like our organization's logo displayed on the Solar Decathlon India website, recognising us as one of the Industry Partners for the 2022-23 competition.

With warm regards,

Sanjay D. Mulik
Owner
Mulik Furniture, Sangli

Mulik Furniture
Plot no.63, Sambhaji Colony,
Timber Area, Sangli- 416416
Tel: (+91) 9923607007/ (0233) 2327185
Email: mulikfurniture.01@gmail.com

INDUSTRY PARTNER LETTER OF CONFIRMATION

JAGDISH TRADING COMPANY

Date: 23rd February 2023

To,
The Director,
Solar Decathlon India

Subject: Confirmation letter from Industry partner

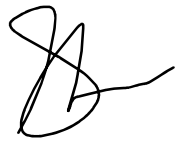
Dear Sir,
This is to inform you that our organization, 'Agnigarbha Pvt. Ltd.' is collaborating with the participating team led by Rachana Sansad's Academy of Architecture. This team is working on a Community Resilience Shelter Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will cater to innovative design. We will provide LED's

We would not be able to have a representative from our organization to attend the Design Challenge Finals event in April/May, if this team is selected for the Finals.

We would not like our organization's logo displayed on the Solar Decathlon India website.

With Warm regards,



Suresh Parekh

Owner

Jagdish Trading Company, Sangli

INDUSTRY PARTNER LETTER OF CONFIRMATION

JAGDISH TRADING COMPANY

Date: 23rd February 2023

To,
The Director,
Solar Decathlon India

Subject: Confirmation letter from Industry partner

Dear Sir,
This is to inform you that our organization, 'Agnigarbha Pvt. Ltd.' is collaborating with the participating team led by Rachana Sansad's Academy of Architecture. This team is working on a Community Resilience Shelter Building project for their Solar Decathlon India 2022-23 competition entry.

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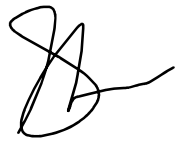
With Warm regards,



Suresh Parekh

Owner

Jagdish Trading Company, Sangli