Solar™ Decathlon India

FINAL DESIGN REPORT - APRIL 2023

GREEN SPACE

Live Life cleaner. Make it greener

DIVISION : OFFICE BUILDING

VIVEKANAND EDUCATION SOCIETY
College of Architecture

Vivekanand Education Society's
Institute of Technology

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SECTION		REVIEWER'S COMMENT	OUR RESPONSE
Energy Performance	Reviewer 1	Apart from the renewables, The energy efficiency with respect to the efficiency of HVAC systems, lighting, equipment, and other measures needs to be elaborated.	Acknowledged in appendix
	Reviewer 2	You can provide more detail about the low-energy comfort systems that were showcased through an annual energy analysis as compared to the baseline scenario.	Acknowledged in appendix
Water Performance	Reviewer 1	In addition to the strategies, the justification of water saving potential by quantity in total needs to be mentioned.	A short narrative is added addressing this on page 18 and detailed calculations regarding the same are provided in the appendix
	Reviewer 2	Good. No comments..	---------
Embodied Carbon	Reviewer 1	The total embodied carbon mentioned is significantly reduced, It would have been appreciated if it was justified quantitatively through calculations.	Acknowledged in appendix
	Reviewer 2	You need to elaborate the construction technologies that you intend to incorporate into your design	Acknowledged
Resilient Design	Reviewer 1	The resilience factors are well defined and justified with strategic solutions in design.	Acknowledged
	Reviewer 2	No comments	----------
Engineering & Operations	Reviewer 1	Although the strategies for energy efficiency are mentioned, they need to be elaborated and explained with calculations regarding the feasibility for proposed design. The calculations and sizing of HVAC plant, SWM plant, RWH plant needs to be done.	Acknowledged & responded

SECTION		REVIEWER'S COMMENT	OUR RESPONSE
Engineering & Operations	Reviewer 2	It would be beneficial to provide additional details on the engineering system design and appropriate sizing, supported by calculations and drawings. Additionally, it would be advantageous to analyze and explain the constructability at scale, taking into consideration the availability of materials, technology, and labor, using analysis and narratives	Acknowledged but not responded
Architectural Design	Reviewer 1	The visuals are impressive. Since you haven't located the north on the design plans, it is difficult to evaluate the design. The functionality with regard to interior spaces in the office is not readable from the provided site plan	Acknowledged but not responded
	Reviewer 2	It is necessary to employ an integrated, evidence-based, and creative process, which should be clarified through the use of narrative and visual narratives. You need to also add drawings that showcase how circulation, space allocation, servicing, adjacencies, and densities have been optimized for the site, building, and interiors to improve functionality and efficiency	Acknowledged but not responded
Affordability	Reviewer 1	The affordability section is fairly elaborated.	Acknowledged
	Reviewer 2	No comments	------
Innovation	Reviewer 1	Multiple innovation strategies are listed and well explained	Acknowledged
	Reviewer 2	No comments	------

SECTION		REVIEWER'S COMMENT	OUR RESPONSE
Health & Well being	Reviewer 1	In addition to the mentioned strategies with respect to achieving thermal comforts, The number thermal comfort hours needs to be calculated.	Acknowledged but not responded
	Reviewer 2	The simulations conducted predominantly pertain to visual comfort, and therefore it is necessary to also incorporate parameters pertaining to thermal comfort. In order to achieve indoor thermal comfort, it is crucial to select a standard and outline detailed strategies for all building operation modes. Additionally, it is important to ensure the desired indoor air quality and adequate fresh air through detailed design and strategy descriptions, airflow network diagrams, and schedules for natural/mechanical ventilation operation modes.	Acknowledged but not responded
Value Proposition	Reviewer 1	Overall report is self explanatory and concise.	Acknowledged
	Reviewer 2	No comments	Acknowledged

Our Team Greenspace, consisting of five Architecture Students from Vivekanand Education Society's College of Architecture (VESCOA) and three Engineering students from Vivekananda Education Society's Institute of Technology (VESIT), has taken on the challenge of designing a net-zero corporate headquarter for the Infosys located in Hyderabad.

This project was taken as a challenge to understand the design constraints and apply an integrated approach to creating a sustainable commercial greenfield project. The client has specified that the building must accommodate 8500 people. The design must also prioritize indoor comfort and create a corporate workplace environment. The challenge for Team Greenspace is to design a workspace that fosters creativity and promotes a vibrant, healthy, and cohesive working environment, while also optimizing the building's parameters to achieve net-zero energy, water consumption, and more. After careful analysis of building science principles and affordability, we conducted a pre-design simulation to enhance the building's energy efficiency and comfort.

We have optimized the building massing to take advantage of natural lighting and mixed-mode ventilation to provide thermal comfort for its occupants. Our concept and focus are towards biophilia, placing plantations inside the offices to improve the indoor air quality, and adding sky courts which also act as buffer spaces and purify the air. Introduction stack Ventilation through the atrium and night flush ventilation. Our approach emphasizes affordability and environmental sustainability, using innovative technologies that minimize energy consumption and reduce carbon emissions. By employing these strategies, we have created a building that is both cost-effective and environmentally conscious, ensuring that it will continue to be an efficient and comfortable living or working space.

With a Built-up area of 110,040 sq. m our final building design has been able to achieve an EPI of 75, Requirement given by the project partner was 65 kWh/sqm/year. Utilizing the existing water body for the cooling system, radiant cooling was used to eliminate the sensible cooling load. The Baseline case for water was 45l/ person which was reduced to 21l/ person. Water resources from lakes, borewells, municipal corporations, etc were balanced by treating and reusing wastewater onsite, using xeriscape for landscaping, and recharging groundwater. Coming up with innovative ideas on vermicomposting, bi-layered solar panels, IoT-based innovation, etc we were able to tackle this challenge and design a net zero building.

7.TEAM INTRODUCTION

a. Team Name: Greenspace

b. Institution Name: Vivekanand Education Society's College of Architecture.

: Vivekanand Education society's Institute of Technology.

c. Division: Office Building

d. Team Members :

Fig 01: Team Members

e. Approach:

The team's name '**Greenspace**' itself specifies a green and environmentally friendly workplace for employees. Greenspace is a team of seven people, five of whom are pursuing an Architecture degree and two pursuing an Engineering degree. Each member possesses different skills for a wide variety of interests, which contribute to creating a rich environment for discussion. It was open for everyone to share ideas, but a firm grounding platform was provided by the faculty lead and team leader, which enabled us to discuss the best building plans and put down various goals for a high-performance, work-healthy, net-zero energy office building. The team is divided into each parameter to make the tasks easier..

VIVEKANAND EDUCATION SOCIETY
College of Architecture

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INSTITUTE OF TECHNOLOGY

Industry Partners:

V3 FACADE DESIGN STUDIO
VERSATILE • VIBRANT • VIGOROUS

GREEN ENERGY Solar Solutions

g. Faculty Lead and Faculty Advisors:

Faculty Advisor
Name - Prof. Anand Achari
Designation - Principal, VESCOA
M.Arch., F.I.I.A., USGBC Faculty, IGBC-AP, GRIHA-Trainer, EDGE Expert -Auditor, ECBC Master Trainer, WSE member, Research Scholar (Ph.D.) – IIT Bombay.

Faculty Lead
Name - Ar. Ajit Nirmal
Designation - Associate professor
Masters in Environmental Architecture from YCMOU. For the past 9 years he has been involved in research, academics and professional work.

Faculty Lead
Name - Ar. Monica Giduturi
Designation - Assistant Professor
M.Arch in Sustainable Architecture. She has worked on diverse projects across commercial, residential and urban design. She is also an IGBC Accredited Professional.

Special Thanks
Name – Shirish Deshpande
Designation –. Practicing energy and Green building consultant since 2002. Graduate Chemical engineer with the overall experience of 30 years, LEED AP, Certified energy auditor from BEE GOV of India. CMVP certified measurement and verification professional. ECBC master trainer. Teaching experience of 15 years.

Special Thanks
Name – Jayesh Vira
Designation - Assistant Professor
Managing Director at Enviro Consultancy Pvt. Ltd

Tools Used:

Microsoft Powerpoint | Adobe Photoshop | Enscape | Opaque 3.0 | Corel Draw | Climate Consultant

Microsoft Excel | Autodesk Ecotect | Design Builder | Sketchup | Archicad | Autodesk Autocad

8. PROJECT INTRODUCTION

Project name : Infosys SDB 8 , Hyderabad.

Project partner : Infosys Limited

Project partner description : Established in 1981, Infosys is a NYSE-listed global consulting and IT services company with more than 335k employees. Infosys is a global leader in next-generation digital services and consulting. It has a wide spread of clients in more than 50 countries to navigate their digital transformation. With over four decades of experience in managing the systems and workings of global enterprises. Infosys pioneered the Global Delivery Model and became the first IT Company from India to be listed on NASDAQ.

Name and designation of key individuals involved:
Mr. Chetan Raghupati (Manager – Infrastructure, Infosys)

Purpose : Build -Own -Operate

Location : Hyderabad ,Telangana

Site Area : xxxxxsq.m.

Climate zone : Composite

Operational hours : 9:00 am to 5:00 pm (8 hours per day)

Latitude : 17.26°N **Longitude** : 78.37°E

Stage of project : Under Construction

Budling Type : Office Building

Mr. Chetan Raghupati
(Manager – Infrastructure, Infosys)

Project description : The office building will be developed in Hyderabad, Telangana which comprises a composite climate. The office will be operational from 9 am to 5 pm. The site area is 65 acres approx. There are no height restrictions. The adjacent to the site is Solar power plant from which energy is restricted to show the net zero energy performance.

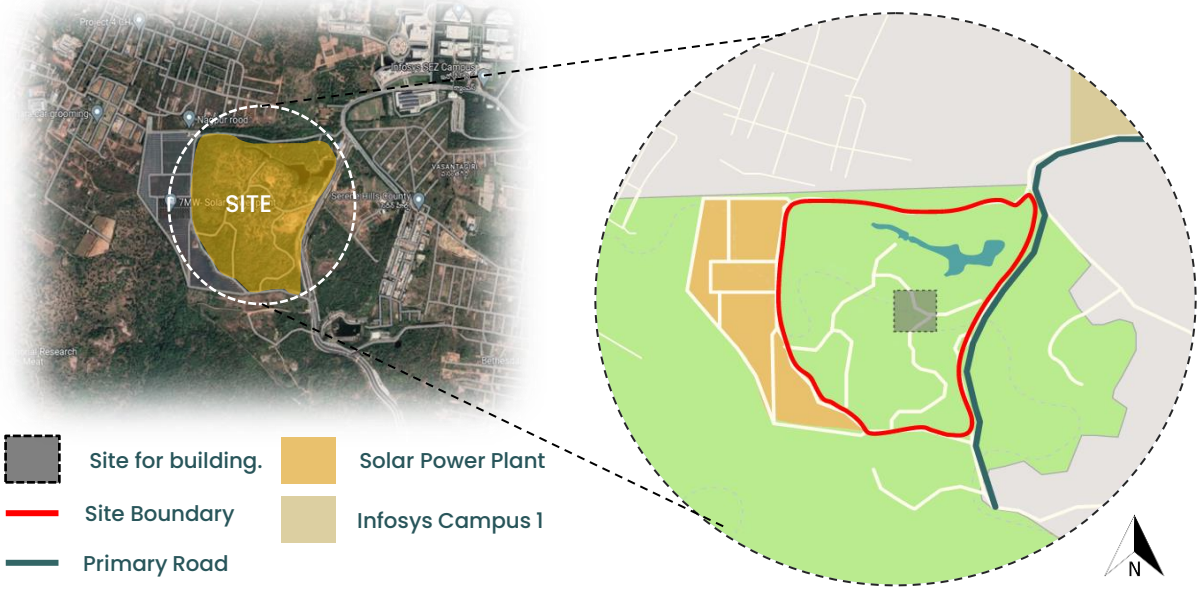
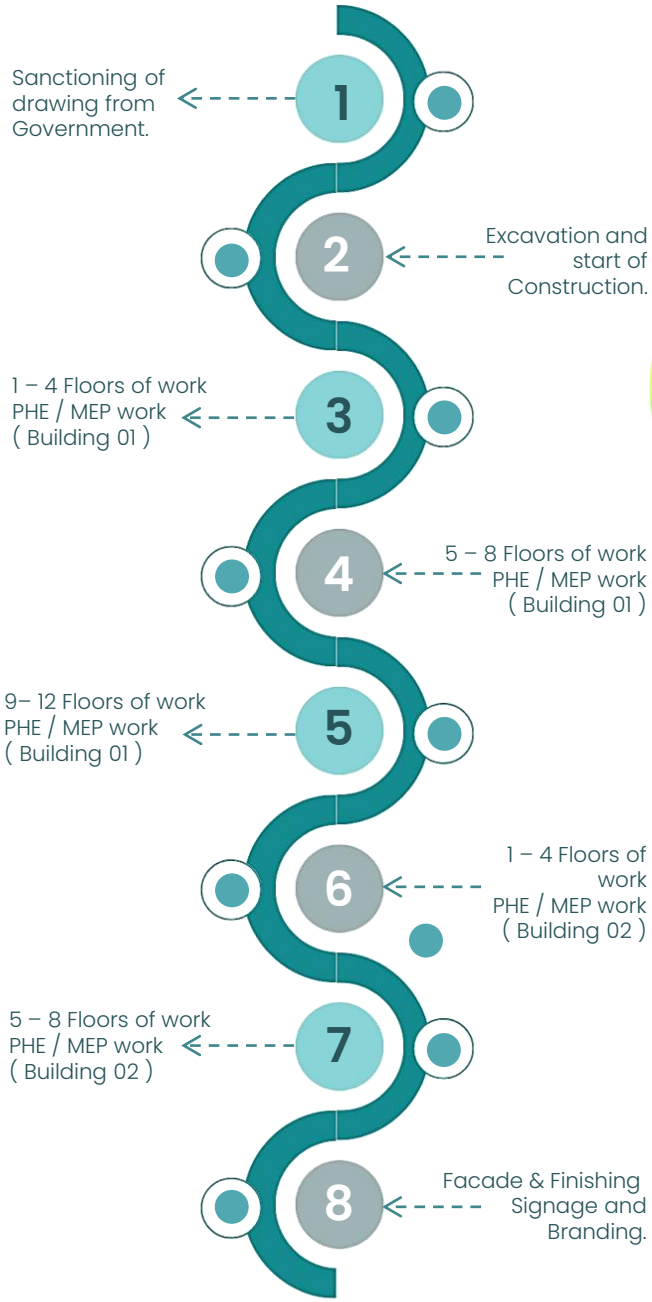


Fig 03 : Site Plan with Context

Site Context :
The site is surrounded with the dense vegetation and the small lake towards the north. The west side has solar power plant. The main road is towards the east side. The site is sloping towards the Northeast side. The North has Infosys Campus 01 , Pocharam, Hyderabad.

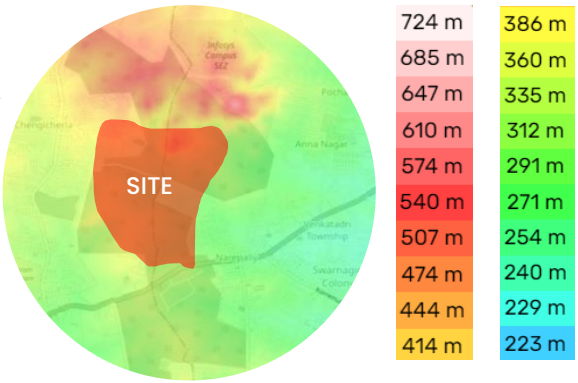
Construction Timeline of the Project :



Energy Performance Index (EPI):

Projector Partner has set a benchmark for Energy Performance Index (EPI) as **65kWh/m2 per year** for Net-Zero-energy design.

Topography of Site :



Hyderabad tourist map, the city is spread over an area of 650 kilometers square, thus, having the coveted title of the largest metro in India. Its contour is sloping rocky terrain of grey and pink granites. There are a few regions with high elevation covering the city, thus appearing to be small hillocks. Its highest post is the famous Banjara Hills at 2,206 feet.

Typology	Area (sqm)
Site Area	258998.8
Permissible built-up area	110040
Permissible Ground Coverage	10830.9
Proposed (Estimated) built-up area	110040
Floor plate	10830.9
Roof Area	10830.9

SWOT Analysis :

STRENGTHS

- No noise production in and around the site.
- Dense vegetation and retaining the rocks and boulders on site.

THREATS

- Site is very secluded from the main city.
- Site is susceptible heat wave, floods.

WEAKNESS

- Lack on Public Transport and public Amenities.

OPPORTUNITIES

- Site is located in Special Economic Zone.
- Water Body on site can be used for building comfort.

Special requirements of the Project Partner:

- Building Adheres To NBC 2016 Part.4 Fire And Safety Norms , Water Supply – Municipal Supply. ,Sewage To Be Treated 100% At Site With Zero Discharge, Electricity – State Electricity Board, LEED V 4.1, Well & Water, Radiant Cool Building , ECBC+ above, LCA analysis.

Energy:

- EPI < 65 kWh/m2/year
- LPD : 0.5 W/Sqft o HVAC : 750 Sqft/TR
- Electrical : 3.5 W/Sqft

Water :

- Software Development Block : 25 Liters/Person (16 Liters fresh water & 9 liters recycle water)
- Food Courts : 40 Liters/Seat– 23Liter/Captia/day
- Taps : 1.9 Liters/Min o Water Closet : 3-6 Liters/Flush

Facade & Daylight :

- Total Facade solar loads in the building at peak design conditions for the location cannot exceed 0.65 W/sqft
- Spatial daylight autonomy 100/100% (SDA100/100%) of at least 85% of regularly occupied area is achieved.
- Annual sunlight exposure 1000,250 (ASE 1000,250) of no more than 10% of regularly occupied area is achieved (Use the regularly occupied floor area that is daylit per the sDA100/100% simulations).
- No direct solar radiation on any workstation.

Preliminary construction budget

- Design Fees 4%
- Excavation 3%
- Sand 4%
- Water 1%
- Reinforcement 4%
- Bricks 9%
- Stones 5%
- Concrete Contractor 9%
- Framework 3%
- Borewell 3%
- Painting 10%
- Plumbing 7%
- Electric Work 5%
- Exterior Flooring 6%
- Compound Wall 2%
- Doors & Windows 3%
- Miscellaneous 8%
- Soil 2%
- Cement 12%

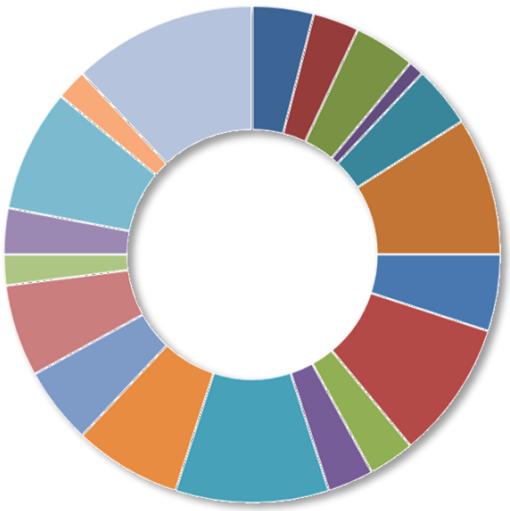


Fig 05 : Budget Pie Chart

Pre-Construction Stage	Construction Stage	Post - Construction Stage	Total Cost
8.16 Cr	76.94 Cr	31.47 Cr	116.58 Cr

The preliminary construction budget is **21.52 k INR/sqm**

ENERGY EFFICIENCY

AIM: To maximize energy efficiency of the built environment, aiming towards reduction of EPI up to 65 kWh/m2 .year

Strategies:

- Minimize the need for HVAC systems by employing passive techniques like radiant cooling, climate-responsive design, and the use of envelope materials with longer thermal lags.
- Use renewable energy sources, such as photovoltaics and solar water heating.
- 60% of rooftop area is utilized to produce solar energy.
- devices to limit thermal heat gains, such as louvres, insulated walls, and Low-e glass for the façade..

WATER EFFICIENCY

AIM: To recycle and reuse 75% of the water used on site, and to reduce down on water use by 50%.

STRATEGIES:

- Using Low-flow fixtures to attain net-zero water.
- Recovering greywater and blackwater onsite using membrane bed bioreactor systems.
- Treating rainwater using bio-sand filters and borewell water using carbon filtration system for non-portable water use.
- Introducing Xeriscaping to reduce use of excessive water.
- Creation of green areas with native plants and draught tolerant species. Using drip irrigation system.

EMBODIED CARBON

AIM: To maximize the built environment's energy efficiency by aiming towards reduction of carbon emission and global warming potential (GWP).

STRATEGIES:

- Conducting life cycle assessment for assessing the entire environmental impacts of construction materials, processes, or services throughout all stages of construction.
- Using materials with higher recycled content.

RESILENCE

AIM: To increase the building's ability to function w.r.t local climatic conditions, prevailing disasters, and critical operations during power/water supply disruptions.

STRATEGIES:

- Providing resilient design aiming towards durability, social equity, local resources, resilience in nature.
- Placing large-span spaces/areas which can adapt to change in use according to the scenarios. For disaster management(flooding) designing raised plinths and proper drainage system of the buildings.
- Designing building envelope to resist the heat gain and thus prevent heat waves.
- Following fire safety norms and providing refugee areas according to NBC.
- Providing autonomy of 5 days for water and food .
- Installing public address systems to help people to navigate areas of shelter within the structure.

ARCHITECTURAL DESIGN

AIM: To design intelligently in terms of sustainability, and energy efficiently right from the initial phase.

STRATEGIES:

- Reducing heat gain of the building facade by using louvers, by having punctures in building form to create mutual shading.
- Introducing skycourts at E-W facades to create buffer zones which will act as a air purifier , and lobby areas placed at the periphery of the built form to create interactive spaces.
- Passive cooling strategies to improve indoor air quality – night flush ventilation, stack ventilation via atrium.

9. GOALS

INNOVATION

AIM: Integrating modern and efficient technology, systems which helps to Improve energy performance, water performance and indoor comfort of end users.

STRATEGIES:

- Increasing water efficiency in landscaping with xeriscaping.
- Introducing solar tree to use renewable sources and reduce carbon emission.
- using IOT based innovation for presence detector.
- Managing all categories of waste : solid waste(Organic waste composting machine), e-waste(Donate To EWASTE authorised units registered in Telangana state pollution control board) and dry waste(Recycle and reuse the final products).
- Introducing bifacial solar panel for energy generation.

AFFORDABILITY

AIM: Optimizing the construction cost and life cycle cost by implementing cost-efficient strategies.

STRATEGIES:

- Using radiant cooling over another conventional system as its operational cost is comparatively less.
- Using flat slabs for Greater Design Flexibility.
- Using locally available material (granite-more resistant to temperature changes) for dry cladding.
- Using Autoclaved Aerated Concrete (AAC) block which allows the masonry to be done more quickly and saves labor.

ENGINEERING & OPERATIONS

AIM: Adapting advanced technology to have ease in the operational system

STRATEGIES:

- Adopting BMS(Building management system) that will integrate all the building operation systems through IoT such as water management system, vertical transport, and energy management.
- Adopting high-performance & smart building operations using machine learning and artificial intelligence(ML/AI) making the building both programmable and responsive to the needs of the users and the building manager.
- Planning MEP services consciously for the efficient functioning of the building.

VALUE AND PROPOSITION

AIM: Addressing the USP of the design.

STRATEGIES:

- Providing people with modern facilities
- Environment friendly offices with improved indoor air quality
- Focusing on the amenities by adopting to new social behaviour.

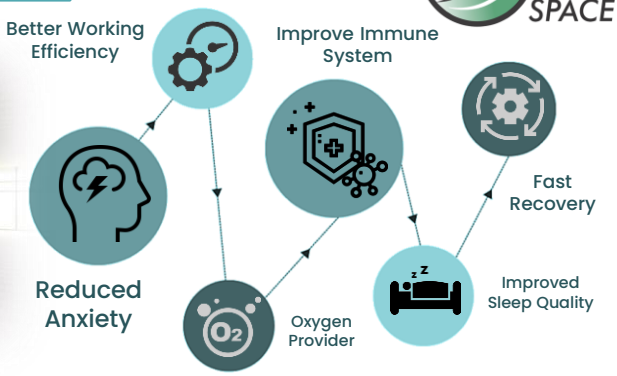
HEALTH & WELL-BEING

AIM: To consider factors providing a healthier, more comfortable standard of working for the occupancies.

STRATEGIES:

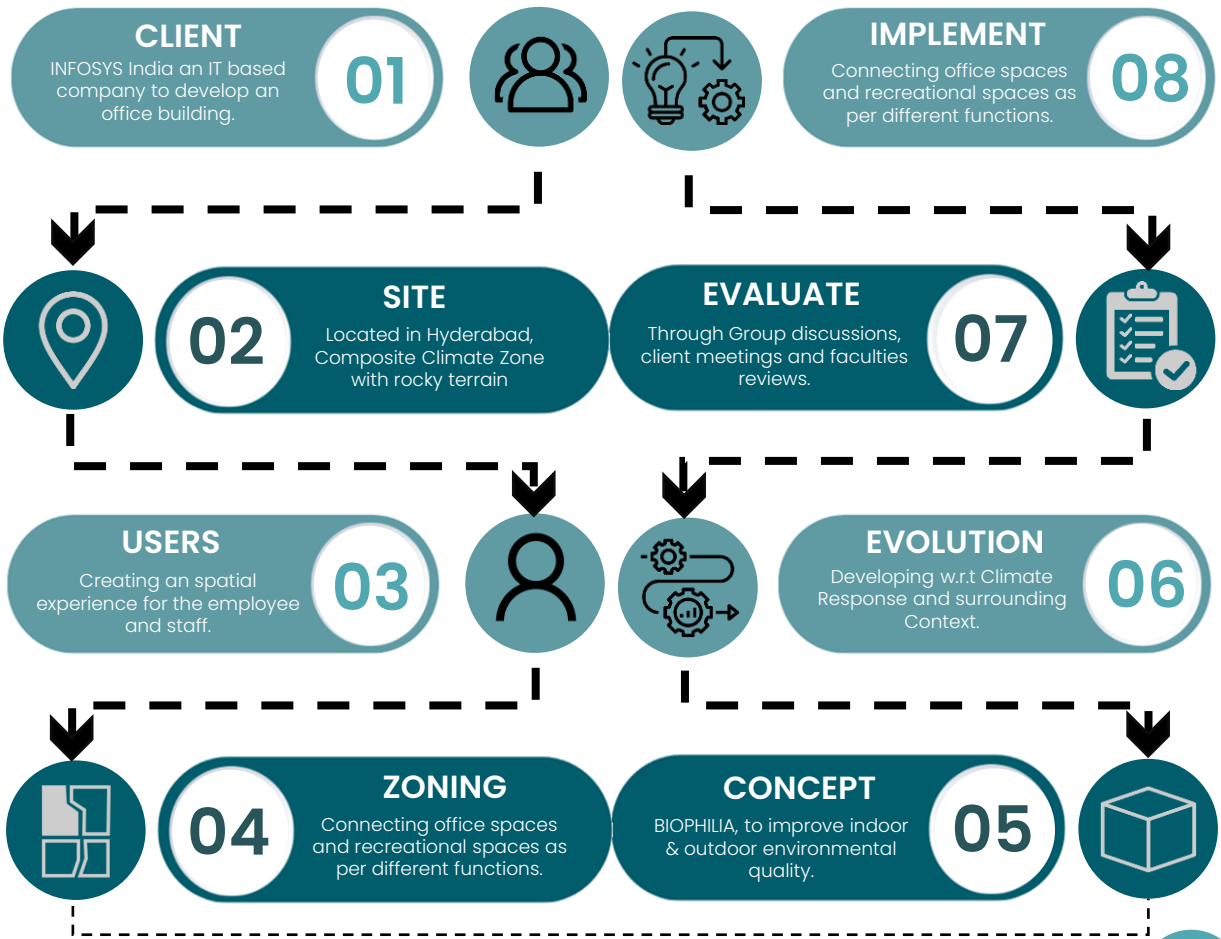
- Ensuring visual comfort through monitoring illumination levels.
- Breathable areas at equal intervals with maximum plantations around.
- Use of no VOC paints.
- Use of adjustable furniture and different workstation not only inside a room but also in open, semi-open areas with pleasant views.
- Introducing indoor plantations for offices.
- Tackling acoustic by using acoustic panels. Masking of sounds.

10. DESIGN PROCESS

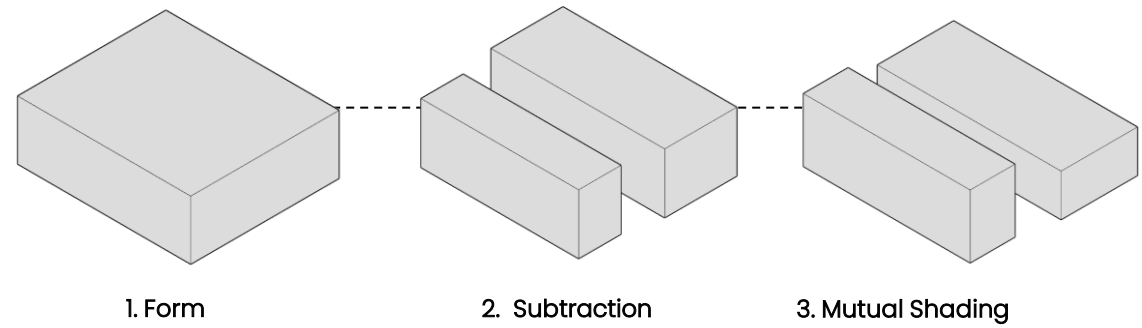


The concept of biophilic office design refers to bringing the outdoors indoors, or to put it more accurately, into the workplace.

- **Access to natural light and views of the outside matters :** Natural light and views of the outdoors have a major impact on employee wellbeing, productivity and energy levels.
- **Utilize available outside areas:** Add some comfortable seating and tables so staff can work outdoors when the weather permits as this access to natural light and fresh air has numerous benefits including increased productivity, creativity and wellbeing.
- **Embrace color :** Color can have an impact on staff wellbeing with numerous reports finding that dull colors can have a detrimental effect.
- **Incorporate natural features like wood and stone :** These natural features and textures emulate the outdoors and really help to create a cozy atmosphere.
- **Include plantlife in the workplace :** Including plants in the workplace can improve oxygen levels, thus improving concentration and relieving mental fatigue.



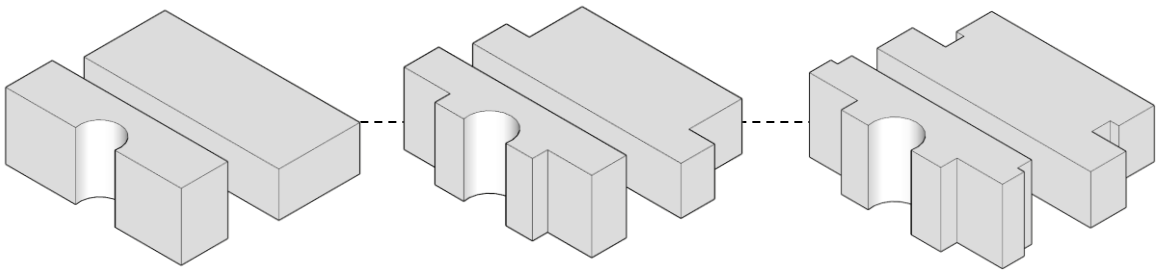
FORM DEVLOPMENT



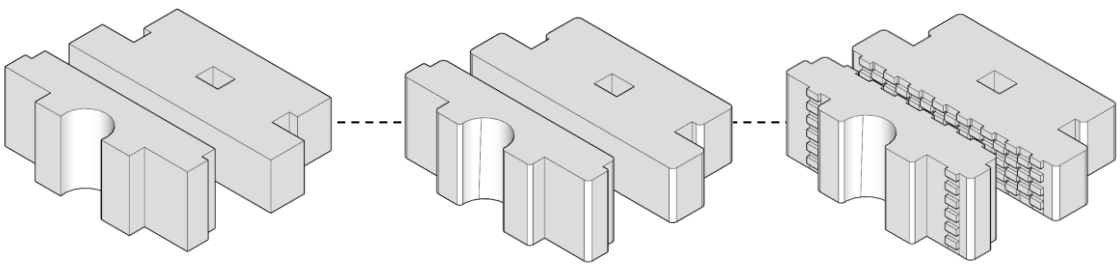
1. Form

2. Subtraction

3. Mutual Shading



4. Preserving Contour



7. Atrium

8. Green Pockets

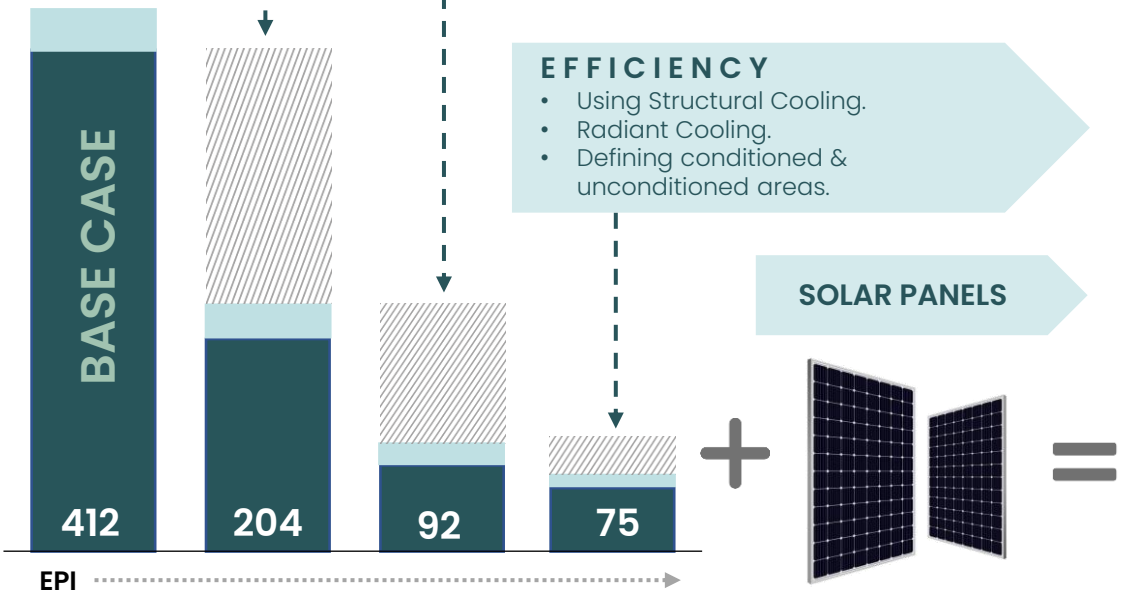
ENERGY PERFORMANCE

OPERATION
- Setting U-values according to Telangana ECBC.
- Mentioning Occupancy Schedule.
- Setting lighting & HVAC schedules.

PASSIVE DESIGN
- Specifying high-performance wall & roof assembly.
- Specifying high-performance low-E glass.

EFFICIENCY
- Using Structural Cooling.
- Radiant Cooling.
- Defining conditioned & unconditioned areas.

SOLAR PANELS



NET ZERO ENERGY

Table 10: EPI Reduction process

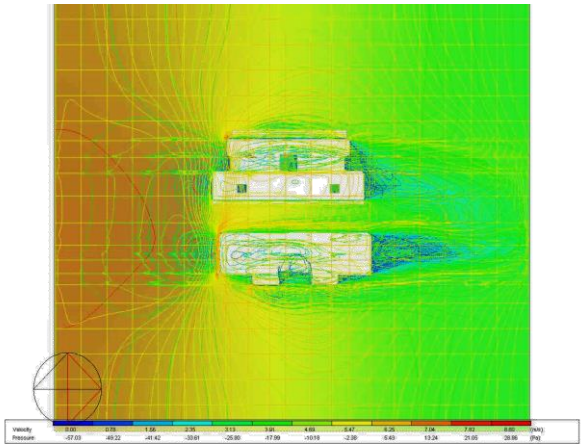
BUILDING FORM
- Longer facades facing North-South directions thus reducing the direct solar heat gains from east and west directions.
- Reduced heat gain from East-West directions.
- Maximum defused light gain from the North direction.

LIGHTING
- LPD = 5W/m2
- 20% reduction from ECBC 2017 requirements
- Use of energy-efficient energy fixtures
- Occupancy sensors
- LED lighting (reducing energy load by 30 %)

ENVELOPE
- Innovating shading devices in facade
- AAC Blocks for walls
- Adding insulation
- Low-e glass
- High reflective terrace tiles for heat ingress & high strength.

FENESTRATION
- WWR(30%)carefully worked out to reduce heat gain.
- Windows with high-efficiency glass, shaded with operable louvers.

ENERGY PERFORMANCE



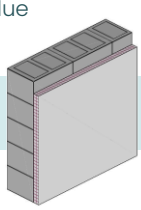
Average solar irradiation in the TELANGANA state is 1266.52 W / sq.m	
1kWp solar rooftop plant will generate an average over the year 5.0 kWh of electricity per day (considering 5.5 sunshine hours)	
Size of PV Panels	
Feasible Plant size as per your Roof Top Area	163.6kW
Cost of the plant	
MNRE current benchmark cost (without GST)	Rs. 35,886 / kW
Total Electricity Generation from Solar Plant	
Annual	24,54,000kWh
Life-time (25 years)	6,13,50,000kWh

Solar Calculations are done using (solarrooftop.gov.in)

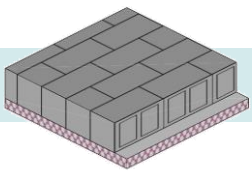
CFD Analysis :

- Visual representation of the Wind velocity & pressure distribution around the buildings.
- Placement of sky courts along the east & west facade of the building.
- Primary wind direction is from West to east, so the corridor is opened so the wind ka funnel from west to east direction.

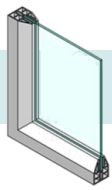
Standard Design					
	Wall Assembly	Roof Assembly		Window Assembly	WWR
Layer 1	Aerated cement block 250 mm	Aerated cement block 250 mm	SHGC 0.6	Aluminum	40%
Layer 2	Standard insulation	Standard insulation	VLT 60 %	Clear Glass	
U-value	0.44	0.4	U-value	5.3	



Standard Walling Assembly

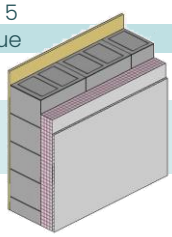


Standard Roofing Assembly

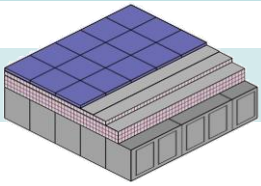


Standard Window Assembly

Proposed Case					
	Wall Assembly	Roof Assembly		Window Assembly	WWR
Layer 1	Cement Plaster 25mm	China Mosaic Tiles 25mm	SHGC 0.2	Aluminium	30%
Layer 2	AAC Block wall 200mm	Screed	VLT 70%	Low E Glass 6 mm	
Layer 3	Cellulose insulation 50mm	XPS 60mm	U-value	Air gap 12 mm	
Layer 4	Gypsum Plasterboard 12 mm	Concrete slab 150mm		Tinted Glass 6 mm	
Layer 5	-			SHGC : 0.23	
U-value	0.26	0.32			



Proposed Walling Assembly

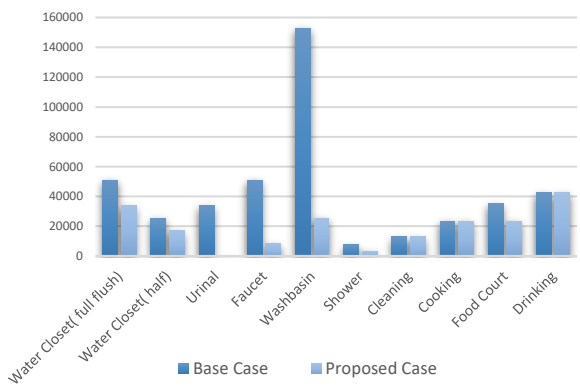


Proposed Roofing Assembly

Proposed Window Assembly

WATER PERFORMANCE

As per National Building Code 2016, standard freshwater demand for one person in office building is 45 LPD. We have proposed to reduce the water consumption by **54%**



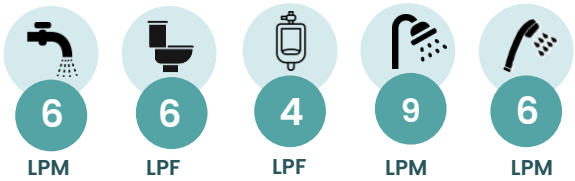
Reduction in water consumption

	Daily Consumption (L) per person	Number of Occupants	Total Consumption Daily	Total water requirement in a year	Grey water efficiency
Base Case	45	9350	420750	96,772,500	75 %
Proposed Case	21	9350	196350	4,516,0500	80 %

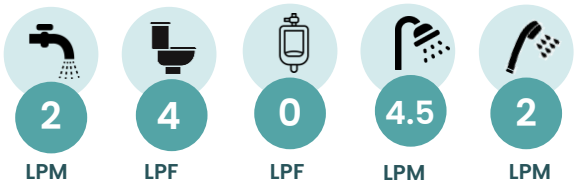
Water required for radiant cooling is 40000 L per hour which is harvested from the existing lake after carbon filtration and is used in a closed loop system.

Sr. No.	Application & Name	Company	Cost	Image	Technical Specification
1.	(WC) Tankless S1 Wall Mounted EWC Round	Hindware	Rs. 10,910		2-4 LPF
2.	(Faucet Nozzle) Single Mode Water Saving Nozzle Umbrella Flow	Greenly	Nozzle Cost Rs. 450-Rs.490		1 LPM
3.	(Kitchen Faucet Nozzle) Automized Dual Flow Water Saving Nozzel- Mist & Shower	Greenly	Nozzle Cost Rs. 890		Mist Flow- 0.5 LPM Spray Flow- 4 LPM
4.	(Urinals) Astute Waterless Urinal,C0586	Parryware	Rs. 9524		---
5.	(Health Faucet) Hand Shower	Jaqur	Rs. 1625		2LPM

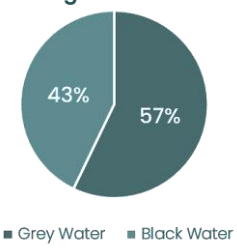
Conventional Fixtures



Efficient Fixtures



Percentage of Waste water generated :



Water harvested from Bore wells

21,320KL

Water supplied from Municipal Authority

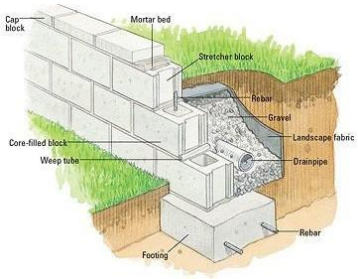
9,435KL

- The annual grey water generated on site is treated separately in a membrane bed Bio reactor with 80 % efficiency.
- Annual Grey water reclaimed 1,75,16,409 L which is used for flushing and recharging
- The annual black water reclaimed is 1,31,37,600 L is used for the landscaping and recharging.

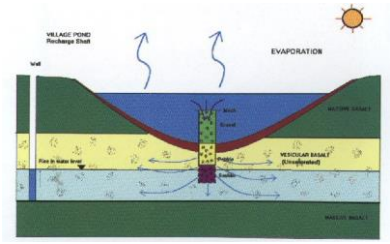
Waste water treated calculations and used for different purposes :

Reusing the grey water		Reusing black water	
Available grey water	76158.3	Available black water	57120
Water closet	52700	Landscape	36013.14
balance	23458.3	balance	21106.86
Balance		44565.16	
Annual balance		10249986.8	

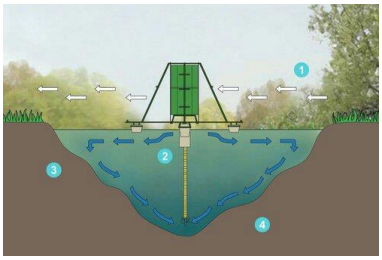
WATER PERFORMANCE



Check dams

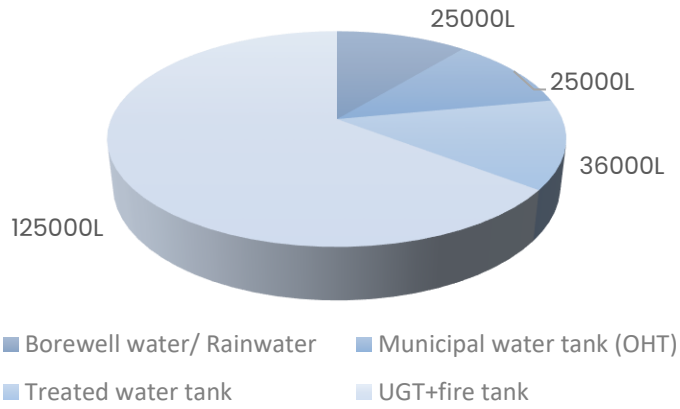


Recharge pit



Open pond with aerators

GROUNDWATER RECHARGE METHODS



WATER TANK REQUIREMENT

Xeriscaping :
Vegetation that thrives with little added irrigation is called drought-tolerant vegetation.
It can reduce water use by 40% or 50%.

Delosperma

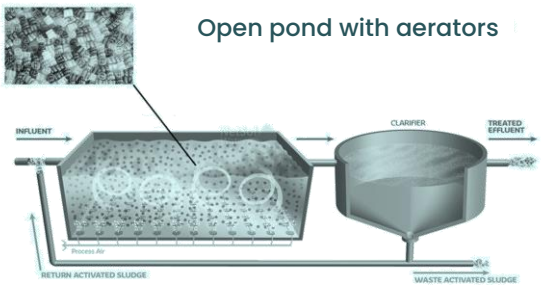
Ophiopogon japonicus

Helleborus foetidus

Landscaping Requirements

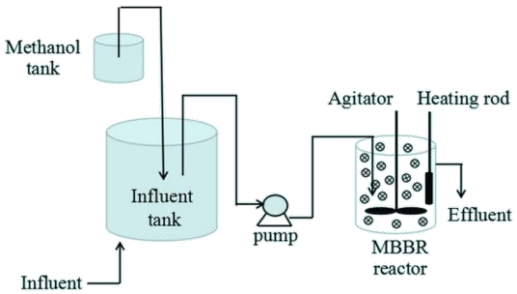
	Area	Litres Per sqm/ Day	Required Water(KL)
Landscape requirement	35307	1.7	60
Reducing water requirement by 40% by xeriscape			36

The requirement for landscape is fulfilled by using treated blackwater.(36000L)



MEMBRANE BED BIOREACTOR (MBBR)

- In an MBR, microorganisms are used to break down and consume organic matter and nutrients in wastewater.
- The membrane bed bioreactor (MBBR) is a variation of the MBR, where biofilm carriers or suspended media are used.



- The total consumption of water will be reduced by 54% by the use of efficient fixtures.
- The water used for cooking, drinking and other potable purpose will be used from the Municipal supply(9435KL)
- The water used for washing, cleaning etc is sourced from borewells(21320KL). On rainy days, the harvested rainwater will be used instead.(9560KL)
- For flushing, treated grey water is used.(52,700L)
- For radiant cooling, water from the lake is used in a closed loop system.
- The remaining water is left to recharge the ground through recharge pits and check dams.

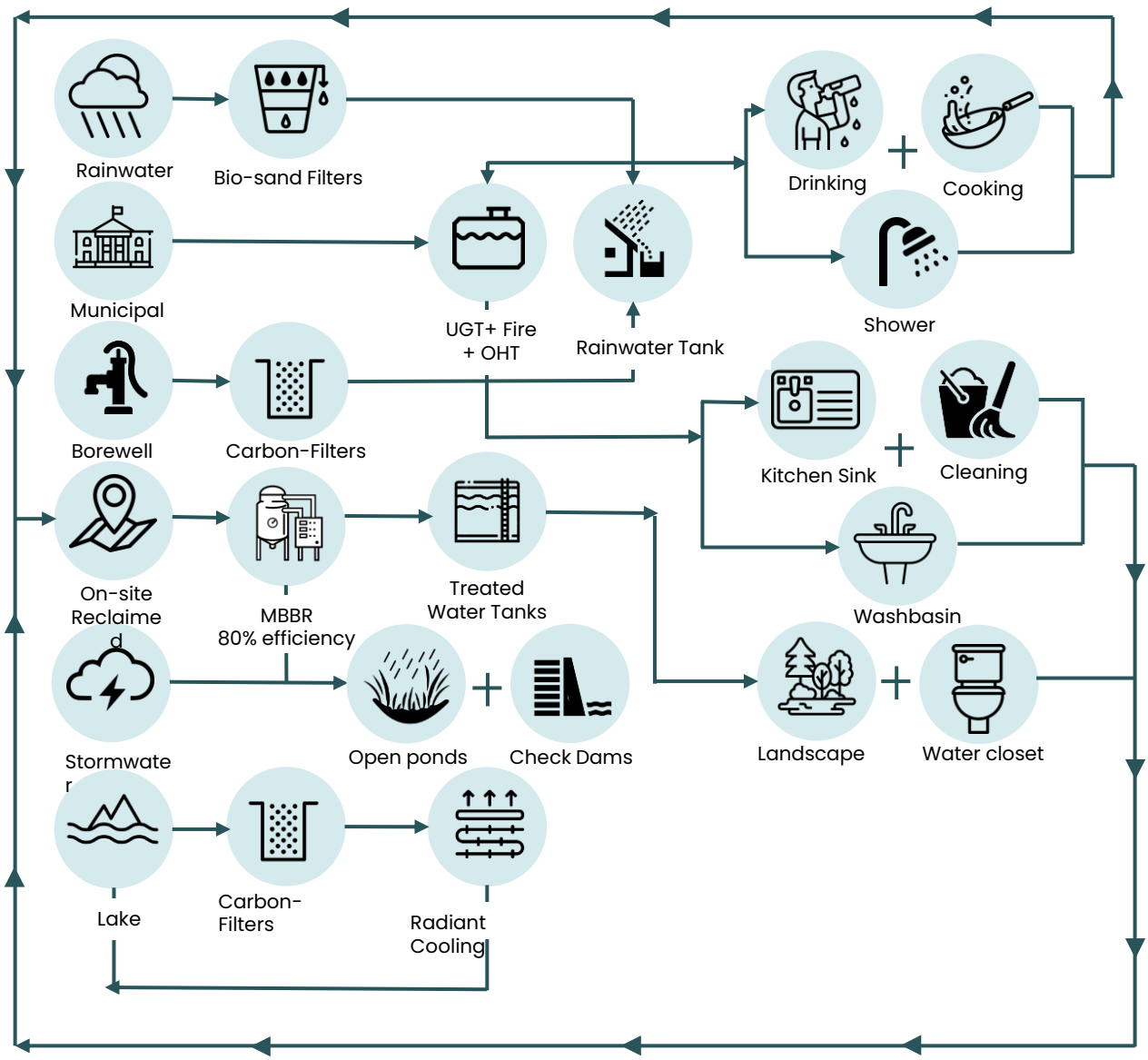
WATER PERFORMANCE

Rainwater harvesting surfaces	Area m2	Runoff coeffecient	Effective catchment area (m^2)	Annual Rainfall on site (m)	Annual Rainfall (m)	Annual Rainfall (kL)
Roof Surfaces	10830.9	0.95	10289.355	0.933	9599.968215	9600
Paved Areas	9437	0.95	8965.15	0.933	8364.48495	8365
Landscaped Areas	38213	0.2	7642.6	0.933	7130.5458	7130
Other			0		25094.99897	25095

TOTAL WATER REQUIREMENT

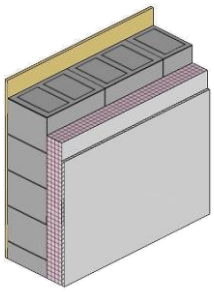
45540 KL

9599 KL | 30654 KL | 21320 KL | 21320 KL | 25745 KL



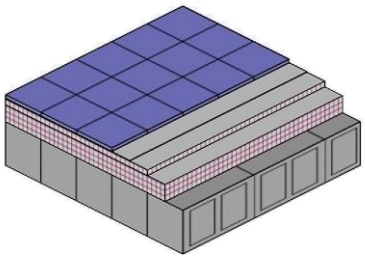
EMBODIED CARBON

- Embodied carbon refers to the carbon dioxide emissions associated with the production, transportation, and construction of building materials. As part of our commitment to sustainability, we have conducted an embodied carbon assessment for the construction of an Infosys office building. This report summarizes the results of the assessment and highlights opportunities for reducing the carbon footprint of future building projects.
- The materials used in the construction of the building are listed below. The embodied carbon values were obtained from the Industry Foundation Classes (IFC) database.



Walling System

- AAC Blocks
- Gypsum Board
- Cellulous Insulation
- Cement Based Plaster
- Granite
- Terracotta Jalis



Roofing System

- China Mosaic
- Polyurethane (PU) Foam
- Polyethylene Foam High Density
- XPS Insulation

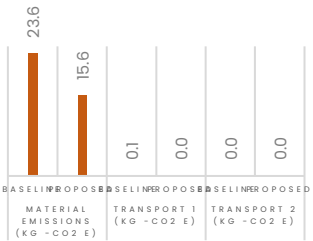
Fenestration System

- Aluminum
- Low E Glass
- Air Gap
- Tinted Glass

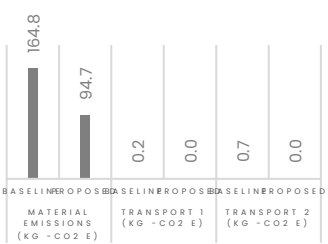
Carbon emissions

System Type	Baseline				Proposed			
	Material emissions ($kg\ -CO_2\ e$)	Transport 1 ($kg\ -CO_2\ e$)	Transport 2 ($kg\ -CO_2\ e$)	Total ($kg\ -CO_2\ e$)	Material emissions ($kg\ -CO_2\ e$)	Transport 1 ($kg\ -CO_2\ e$)	Transport 2 ($kg\ -CO_2\ e$)	Total ($kg\ -CO_2\ e$)
Wall	23.6	0.1	0.0	23.7	15.6	0.0	0.0	15.6
Roof	164.8	0.2	0.7	165.7	94.7	0.0	0.0	94.7
Floor	23.0	0.0	0.0	23.0	15.5	0.0	0.0	15.5
Fenestration	379.9	0.0	0.0	379.9	293.7	0.0	0.0	293.8
Structural	6987.7	3.0	22.1	7012.9	670.0	0.5	1.2	671.6
			Grand Total emissions per functional unit ($kg\ -CO_2\ e$)	**7605.3**			**Grand Total emissions per functional unit** ($kg\ -CO_2\ e$)	**1091.2**

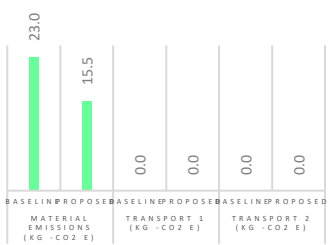
EMISSIONS FROM WALL



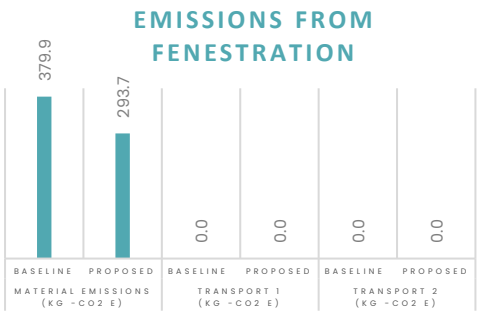
EMISSIONS FROM ROOF

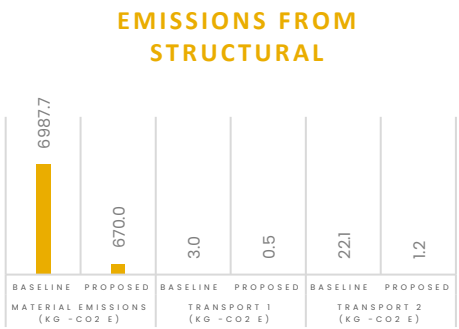


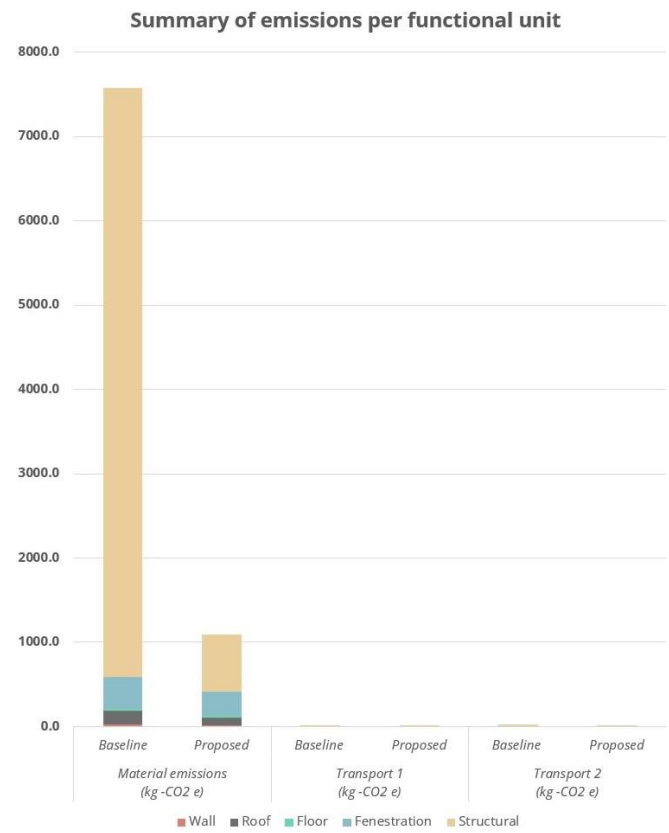
EMISSIONS FROM FLOOR



EMBODIED CARBON







The total embodied carbon we got for base case is **7605.3 kgCO2e.**

Structural Material is taking the largest contribution to embodied carbon, accounting for over **60%** of the total. Glass also have significant contributions.

Aluminum, although a small quantity, has a high embodied carbon value, and thus, contributes significantly to the total.

Reducing embodied carbon is a critical part of sustainable building design. Based on the results of our embodied carbon assessment, we have identified several opportunities for reducing the carbon footprint to **1091.2 kgCO2e** :

- Reduced the use of concrete and steel: Using alternative building materials, such as recycled materials, wherever possible.
- Reduced the amount of glass used: Using high-performance Glass & Granite cladding that have lower embodied carbon.
- Selected low-carbon alternatives: Selected building materials with lower embodied carbon values, such as low-carbon concrete or recycled steel.
- Sourced materials locally: Selected materials that are available locally to reduced transportation-related emissions.
- Also most of materials used for the construction of the building can be recycled such as AAC Blocks, Terracotta Jails , Aluminum, etc which is also reducing carbon emission.

RESILIENCE

01. Water facility

- Water storage= **9,38,000L**(UGT+ Firefighting) + 1,34,000L(2 OHT)
- Water consumption per day= 1,97,348 L
- Days of Autonomy = 9,38,000+ 1,34,000/ 1,97,348
  = **5.5 days of autonomy**

02. Energy efficiency

- During power outage, a diesel generator is provided which will operate about **60%** of appliances.
- Annual Renewable Energy generated from rooftop solar panels is 2454 MWh

03. Food facility

- Proposing culinary farming and storing frozen food in the cold storage of kitchen.
- Able to withstand and recover from disruptions in a way that ensures a sufficient supply of acceptable and accessible food for all.

04. Waste disposal

- Waste disposal shaft provided on every floor along with segregation for dry, wet and e-waste.
- Proposing an Organic waste composting machine for decomposing organic waste.

05. Accommodation facility

- Providing wellness rooms in every building for first aid and accommodation during calamities.
- This includes matching housing to community and environmental issues, so people, communities and their homes are safe, comfortable and resilient.

Threat 1: Earthquake

Hyderabad lies in the Zone 2 (moderate to low-risk zone). It also has no history of earthquake.

Solution: Structure is designed as per IS 4326 : 2013.

Threat 2: Heat wave

Heat waves are common in Hyderabad, particularly from April to June. During heat waves, the temperature can often soar above 40 degrees Celsius sometimes upto 45 degree Celsius.

- **Building orientation**

Orienting the building with longer facade facing north-south and shorter façade facing east-west.

- **Envelope**

Use of material with high thermal mass and high-quality insulation

Wall: Cement plaster 12mm, AAC block 200mm, cellulose insulation 50mm, Gypsum plasterboard 12mm.

Roof: Highly reflective ceramic tiles to reduce absorbing the heat

Window: Use of low-e glass which will reduce heat gain.

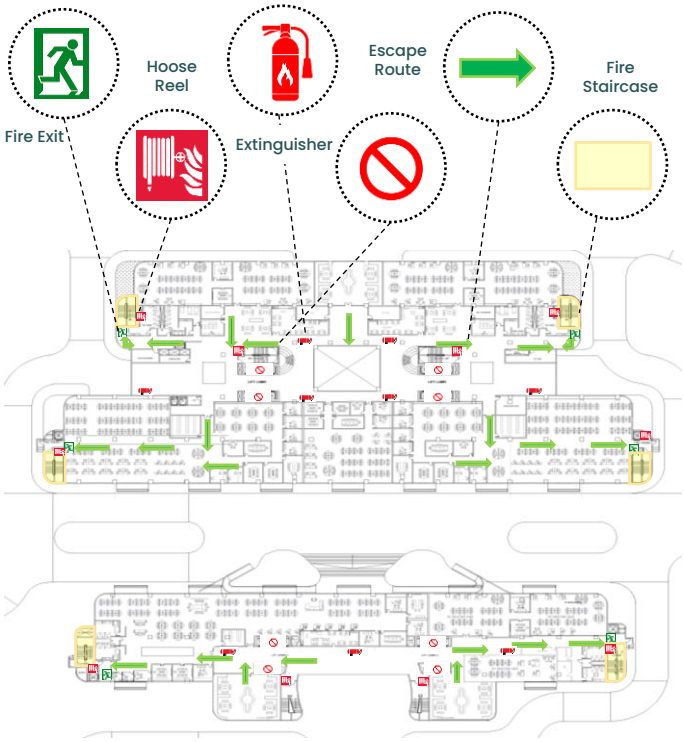
Threat 3: Flood

The site experiences heavy rainfall and is thus susceptible to floods.

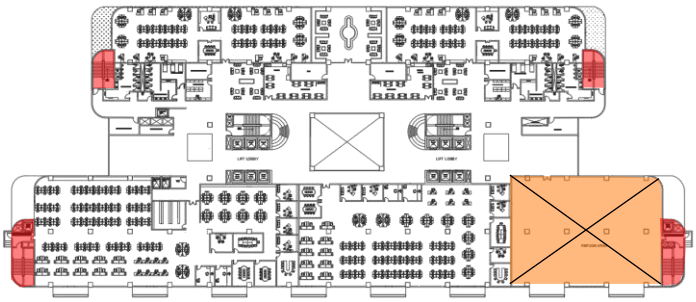
Solution: Raising the level of arrival court by 0.8m and the lobby by 1.5m

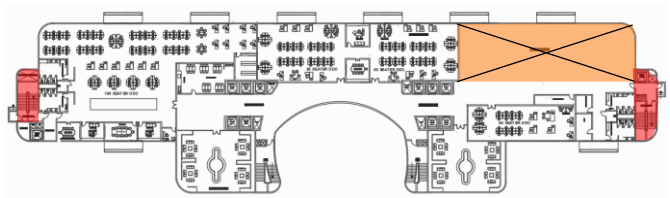
Minimum habitable spaces kept on the ground floor

Pipes have non returnable valves.



Fire Escape Layout



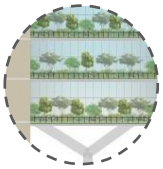


Refuge Area at 6TH floor

Fire Staircase

Refuge Area

Resilience In Nature
Preserving the natural topography and vegetation of the site to avoid landslides and flooding.



Social Resilience
Providing green pockets and sky courts to relax and increase efficiency of work

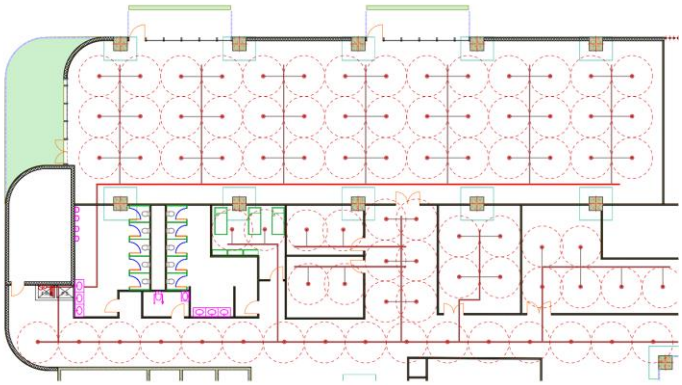
Simplicity In Form
Using simple strategies: Orienting the longer facade towards north-south. Adding buffer spaces and courtyards.

Public Address System
Installing public address systems to help people to navigate areas of shelter within the structure.

TYPE OF FIRE PROTECTION	BUILDING 1	BUILDING 2
Fire Extinguisher	1 in each room	1 in each room
Wet Riser	Provided at all floors	Provided at floors
Fire hose reel	Provided in shafts	Provided in shafts
Fire detection alarm system	On all floors	On all floors
Automatic sprinkler system	In all hospitable spaces	In all hospitable spaces
Fire rated lifts	3	2
Fire staircase	4	2
Emergency lights	At staircase landing and exit routes	At staircase landing and exit routes
Fire balls	On all floors	On all floors
UGR	12,500,000 lts	-

Refuge Area
After 24 m from ground level one refuge area is provided which is located in east of the building because of the vehicular access.

Awning windows: During fire the smoke rises upwards in a room. In order to evacuate the smoke and prevent people from inhaling it awning windows which open from the top are used.



Sprinkler Layout

Fire Recovery

1. Even after the fire is out, property and contents damage can continue.

- Water left behind from firefighting results in mold and mildew growth
- Soot and ash create air quality hazards.
- Unsound roofs and floors can cave in Emergency mitigation is a job left to expert property restoration firms. They provide fencing, shoring, and board-ups, and have the equipment and experience for proper water extraction and dry-outs.

2. To facilitate repairs and rebuilding, unaffected furniture, equipment, and possessions are moved out of the way. Even though they may not be fire damaged or scorched, it's likely that most items will have some degree of soot or smoke contamination, or water damage.

3. Burning different materials creates different kinds of smoke that need specific types of cleaning. Removing smoke from crawl spaces, attics, and HVAC systems where harmful odor-causing residue will be found is done by a restoration company.

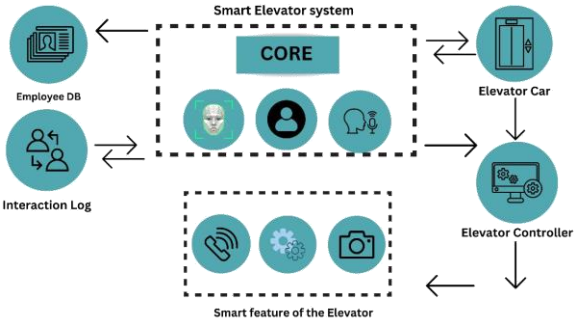
Flood recovery

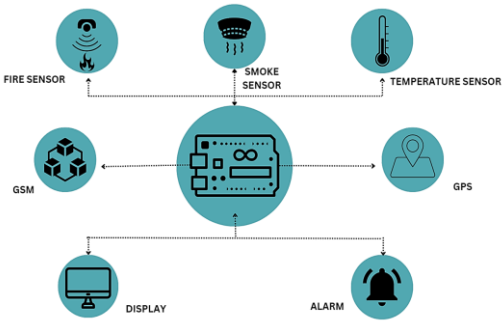
1. De-energize electrical equipment and replace them
2. Remove all debris and clean up the area to prevent health hazards such as mold growth. Use disinfectants and sanitize the area thoroughly.
3. Repair damages: repair any damages to the property and infrastructure as soon as
4. Support affected individuals: providing support and assistance to affected individuals. Offer counseling services and connect them with community resources and organizations that can provide aid.

ENGINEERING & OPERATIONS

Smart Elevator System:

- Smart elevators are mainly focused on dispatch problems and alleviating the waiting time problem.
- In this system travelers were identified using ID card's location, and persons were registered within the system with their regular destination floor.



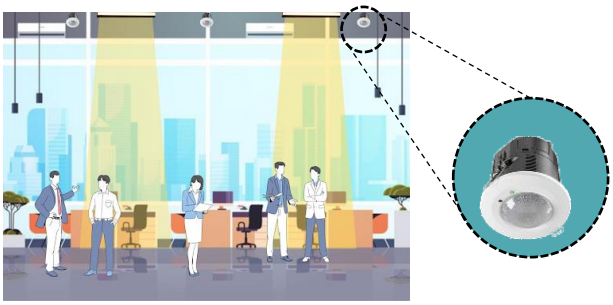


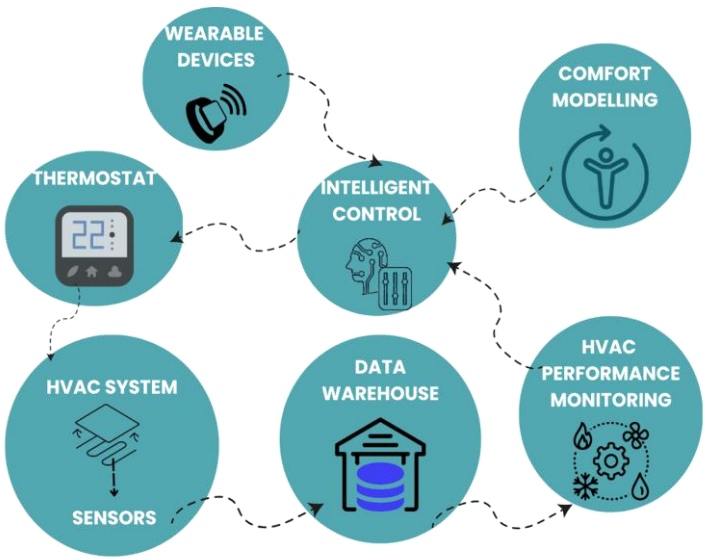
Fire Detection and Alerting System :

- Fire alarm systems are designed to warn people about fires so that they can evacuate the fire-affected area and take immediate action to control the fire. An Arduino UNO microcontroller controls the IoT-based fire alarm navigation.
- Upon hearing a buzzer, the Global Positioning System (GPS) will send a text message to the GSM module of the fire head station informing it of its location.

Energy saving daylight sensors:

- These sensors use photocells to turn off or dim the lights, depending on the amount of natural light available.
- This photosensor can also be used to raise or lower blinds to optimize lighting. Typically, savings of 40% or more are achieved.

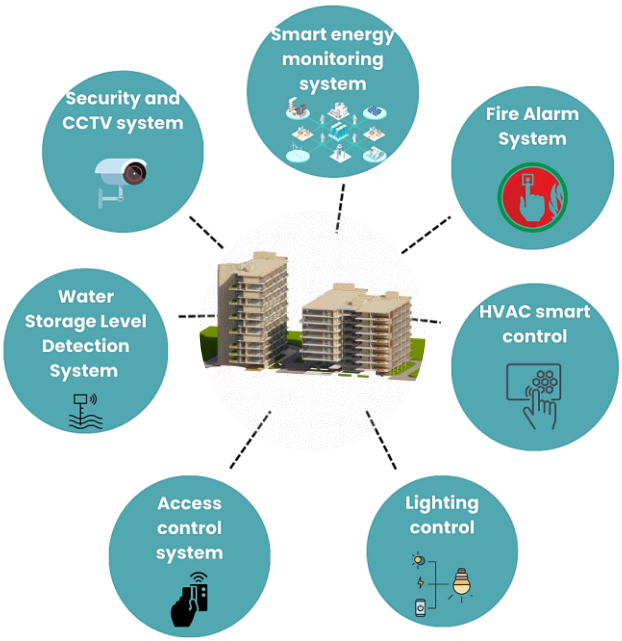




Smart HVAC control:

- Intelligent HVAC control systems help optimize the amount of conditioned (e.g. heated or cooled) air supplied throughout the building.
- Smart Control uses data from CO2, occupancy, temperature, humidity and air quality sensors to optimize airflow.
- For early fault detection and prioritization, the IoT-based HVAC system is equipped with an automatic fault detection and diagnosis (FDD) function that includes a combination of sensors and algorithm. This data may be processed and used for quick maintenance.

ENGINEERING & OPERATIONS



Building Management System:

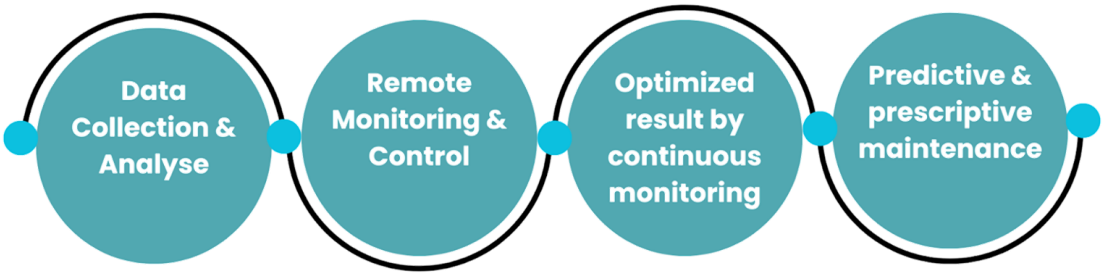
- We have incorporated an Integrated Building Management System (IBMS), which is an innovative integration of HVAC smart control, Smart energy monitoring system, Fire Alarm System, Water Storage Level Detection System , Lighting control, Access control system and Security and CCTV system.
- The Building Management System (BMS) computer system will be communicating with the building's equipment as a master control and monitoring system.
- Depending on the presence of people in a particular area, we can schedule the operation of the equipment for a specific amount of time.

IoT based attendance :

- Traditional attendance evaluation methods should be replaced with artificial intelligence-based attendance monitoring systems. The traditional process of checking attendance is time consuming and prone to fraud. The use of biometrics poses a virus threat.
- In order to overcome the above problems, a contactless attendance management system (CAMS) is proposed. The AI-powered attendance monitoring system automatically captures attendance when employees enter the classroom by recognizing their face.

Smart energy monitoring system :

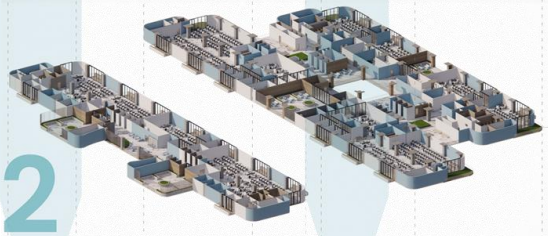
- Energy monitoring system technology monitors energy usage data 24/7 in real time to effectively manage energy usage in buildings.
- Energy management automation collects energy measurement data from the premises and sends it to cloud-based energy management software.
- Data related to power usage is processed and displayed by the system, which is then transmitted to a local network or cloud server.



ARCHITECTURAL DESIGN

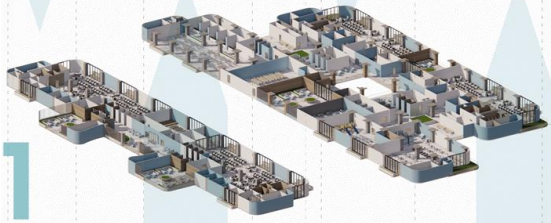
3

ODD FLOOR



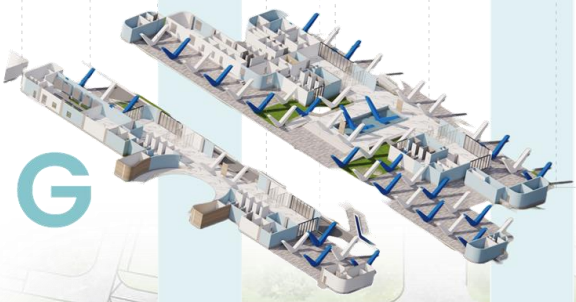
2

EVEN FLOOR



1

FIRST FLOOR



G

GROUND FLOOR

Site Plan

ARCHITECTURAL DESIGN

Louvers

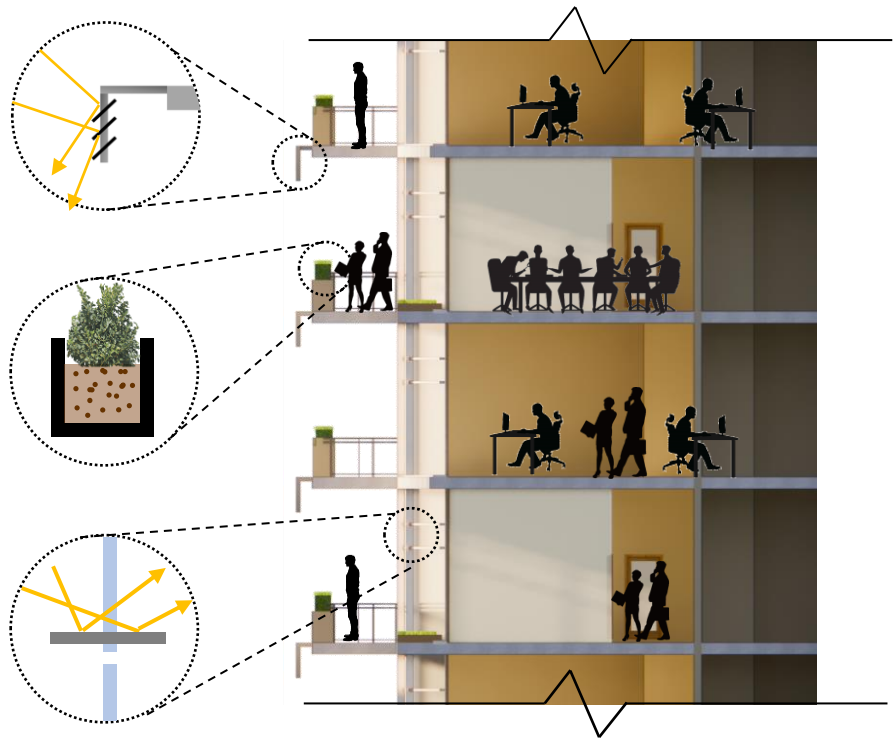
Louvers to cut off harsh sun angles so as to provide thermal comfort to the end users and also reduces cooling load.

Planter Box

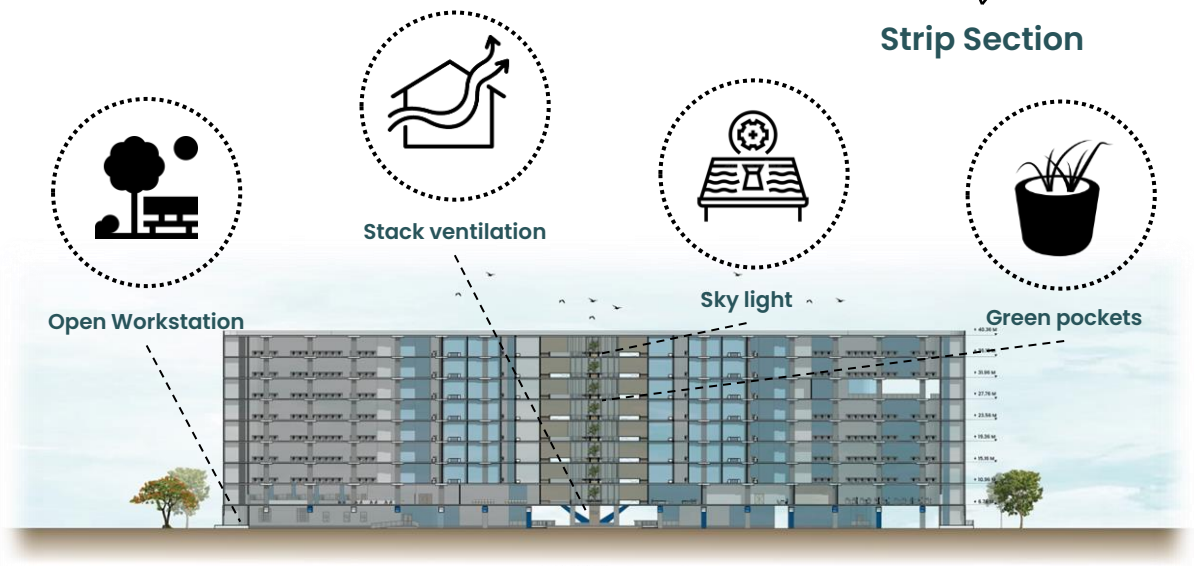
Planter Box helps to flow fresh air and creates a diffused light in to spaces and also acts as the biophilic elements and creates a kind of experience to employees.

Light Shelves

Light Shelves helps to penetrates more light insides the office spaces which will reduces the artificial light load which intern reduces cost.

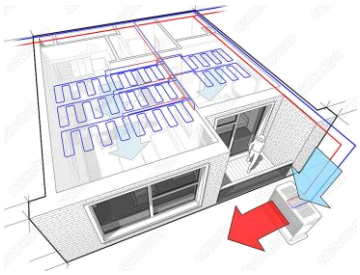


Strip Section



SECTION AA' (SCALE 1 : 250)

AFFORDABILITY

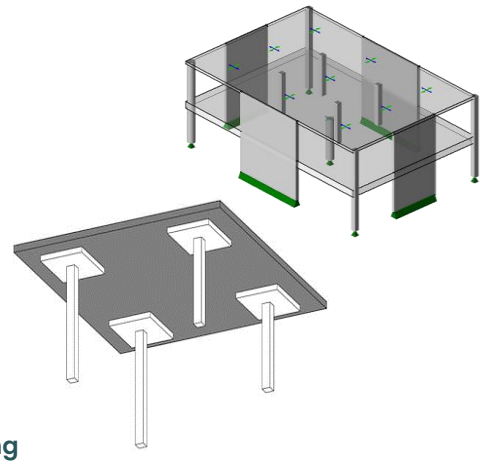


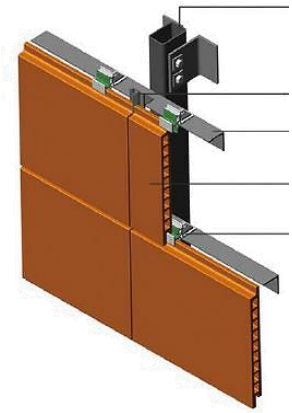
1. Radiant Cooling

- Radiant cooling takes the sensible and latent heat from the building
- As the pipes are carried through the slabs, the height required for ducting is reduced, thus minimizing the area that has to be cooled.
- It also saves material, reduces the embodied carbon, the construction time and hence the overall cost of the building.

2. Flat slabs

- **Reduced construction time :** Flat slab construction can be faster than conventional slab and beam construction because there are fewer elements to construct and assemble.
- **Lower construction costs** : Flat slab construction can be less expensive than conventional slab and beam construction because there are fewer materials and labor required to construct the structure.
- **Better fire resistance:** Flat slab construction can offer better fire resistance compared to conventional slab and beam construction because there are no beams or columns to act as fuel for a fire.





3. Granite Dry Cladding

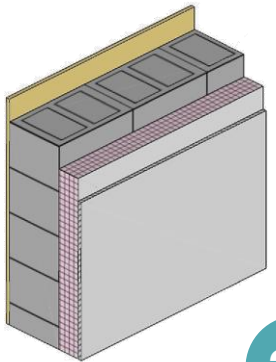
- **Locally Available:** Hyderabad has a rocky terrain with heavy boulders, granite rock is a naturally occurring material on-site.
- **Heat resistance:** Granite is highly resistant to heat and can withstand high temperatures without cracking or warping.
- **Strength and durability:** Granite is an extremely strong and durable material that is resistant to weathering and erosion thus making it long lasting.
- **Sustainability:** Granite is a sustainable building material that is sourced from quarries. It can be reused and repurposed at the end of its lifespan.

Comparing Cost of Materials

Volume	Unit	Base Case	Cost	Total cost	Design Case	Cost	Total Cost
10215	cu.m	Exterior Brick Wall	8288	84661920	AAC Blocks	8430	86112450
70700	cu.m	Interior Brick Wall	8288	585961600	Dry Wall	400	28280000
600	cu.m	Heat Strengthened Glass	649	389400	Low-e Glass	1000	600000
74800	cu.m	Beam Column Construction	7783	582168400	Flat Slab	2500	187000000

4. AAC Blocks

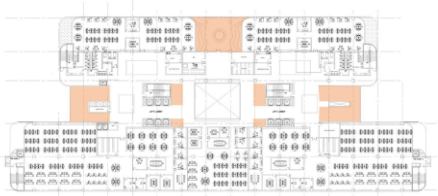
- **Lighter weight :** AAC blocks are lighter than fired bricks, which makes them easier to transport, handle, and install. This can help reduce transportation costs and construction time.
- **Energy efficient :** AAC blocks have a low thermal conductivity, which means that they offer better insulation properties than fired bricks. This can help reduce energy consumption and lower cooling costs.
- **Fire resistant:** AAC blocks are highly fire resistant, fired bricks can be damaged or weakened by fire.

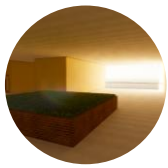


INNOVATION

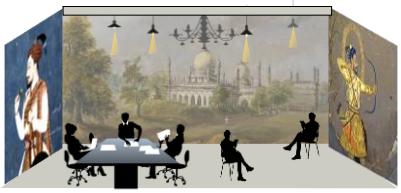
Innovation on end user level

- Introducing biophilia also within the offices. Providing indoor plants to improve indoor air quality.
- Due to covid scenarios people have been confined indoors, and these spaces will act as breakout areas Inculcating the history and culture of Hyderabad through the interiors.

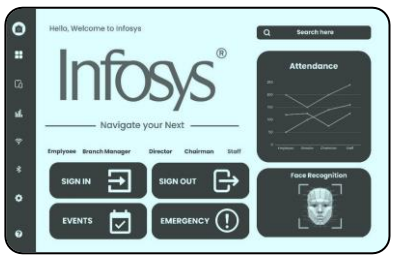




Biophilic Plants and Green Pockets

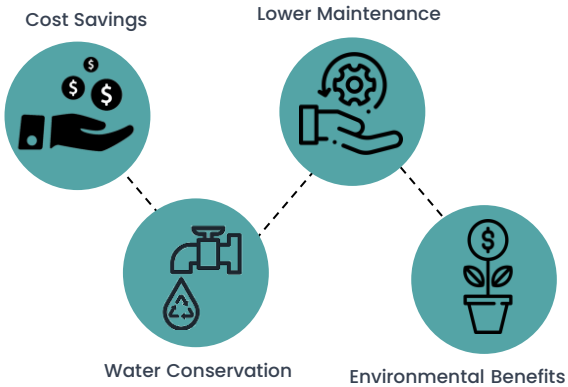


Inculcating the history and culture of Hyderabad



Introducing bifacial solar panel for energy generation.

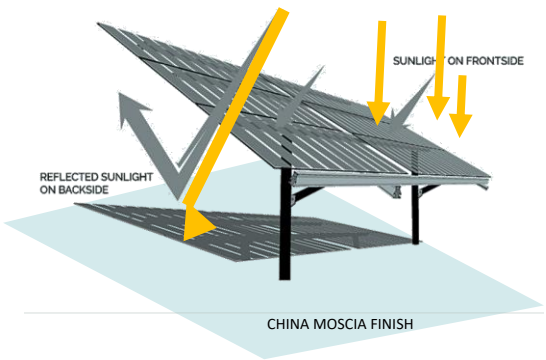
- Bifacial solar panels have a transparent backsheet that allows light to pass through and be absorbed by the solar cells on the back side of the panel.
- Using china mosaic tiles (80-90% solar reflective index) for the roof which will help in reflecting sunrays to the back side of the panels hence offering more energy output.



Innovation on building level

Using IOT-based innovation for presence detector :

- This is one of the innovative ways to save time as well as manpower when it comes to presence detection. This technology uses RFID detection to sense and locates each employee if she/he is present at any location within the campus.



Increasing water efficiency in landscaping with xeriscaping.

- Xeriscaping uses less water, according to the Environmental Protection Agency (EPA) It can cut outdoor water use by up to 50–75%. Reduces the need for pesticides and fertilizers, promoting biodiversity, and reducing erosion.
- Grouping plants (similar moisture, sun, or exposure requirements) to minimize wastage of water.

Neem (Azadirachta indica)

Indian Almond (Terminalia catappa)

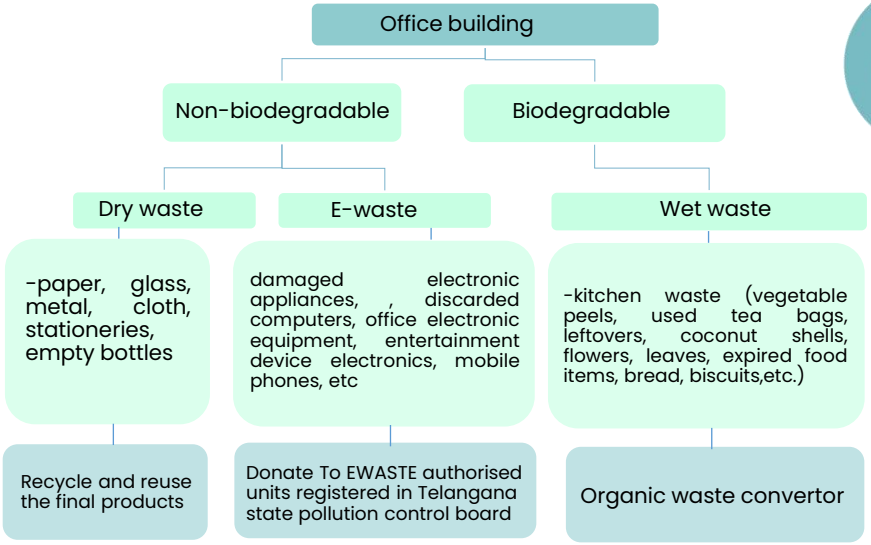
Babul (Acacia nilotica):

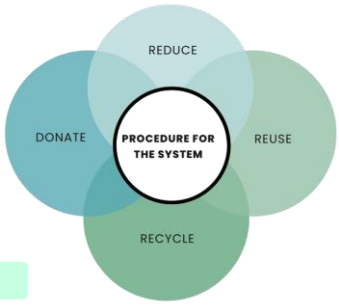
Indian Beech (Pongamia pinnata)

Indian Jujube (Ziziphus mauritiana)

INNOVATION

Managing all categories of solid waste :





Organic Waste Convertor

Organic Waste Convertor is an easy to use Decentralized Waste Management System to turn large amounts of organic waste such as kitchen waste, garden waste, food processing waste etc. into compost. The system is designed to eliminate odour and also to remove the problem of irritants such as flies and rats.

As per Griha manual 2019,

The municipal refuse generation rate
= 0.1-0.2kg/ capita/day
Occupancy= 8500
Per capita, solid waste generated can be ascertained to be 0.2kg/day
The total solid waste generated from the project
= 0.2 x 8500= 1700kg/day
Assuming the density of waste to be 450 kg/m3 (CPHEEO 2016)
The total volume of solid waste
= 1700 divide by 450= 3.7 m3
Biodegradable waste per day = 0.4 x 3.7=1.48m3
Non-biodegradable waste per day = 0.6* 3.7 = 2.2m3
Total organic waste generated=
1.48m3 to kg/day
1480 kg/day

Introducing solar tree to use renewable sources and reduce carbon emissions. (Contributing a step towards 'the climate pledge' signed up by Infosys, June 2020.)

- Solar panels are mounted on the branches of solar trees, which have a metal trunk and branches to maximize the surface area for absorbing solar energy. After then, the solar panels' output is stored in batteries to use when required.

Acts as a landscape element.

Serves as a symbol of sustainability and environmental awareness.

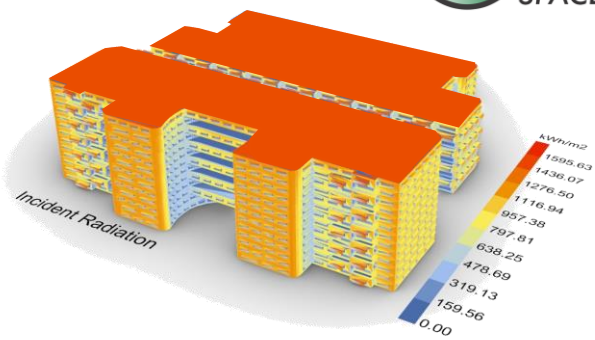
It is incorporated with seating, lighting, or charging stations for electronic devices

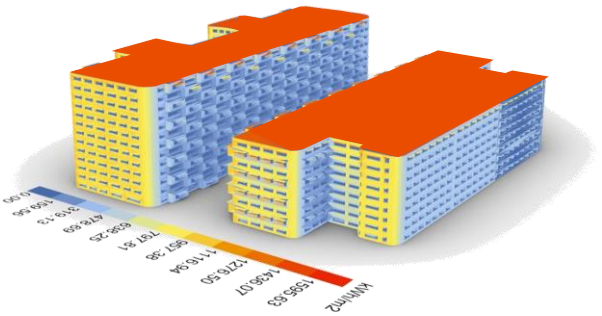
13Kw Solar tree
Daily energy delivered: 52 kWh
Yearly energy delivered: 18720 kWh
CO2 gas reduction per year: 18.72 TON
Max. height 15 ft
Diameter: 11.5 meter

HEALTH & WELL BEING

Comfort & Indoor Environmental Quality:

- To begin with the comfort analysis of our building, we first simulated Solar Radiation on the two buildings.
- The result from the simulation thus proved our design strategies of staggering the floor plate to be efficient as it reduced the heat load on the lower floors.
- The roof areas with the most irradiation will be occupied by solar panels thus reducing the heat load from there as well.



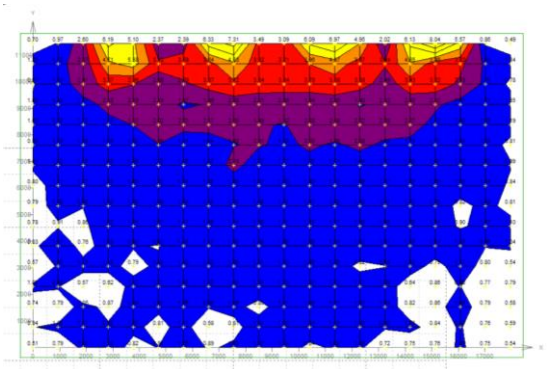


- Average Solar incidents on the building:

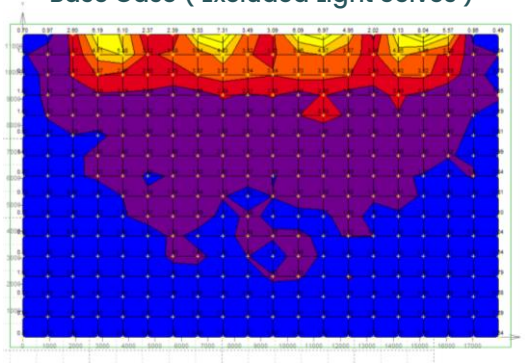
1. Building 1 (G+8)
   - North Facade: 300-600 kWh/m2
   - South facade: 1300-1500 kWh/m2
   - East Facade: 800-1000 kWh/m2
   - West Facade: 800-1000 kWh/m2
   - Roof: 2000-2500 kWh/m2

- This reduced amount of solar incidents in the building provides improved comfort, by reducing the amount of heat and light entering a building, we are creating a more comfortable environment for the occupants, especially during the hot months.

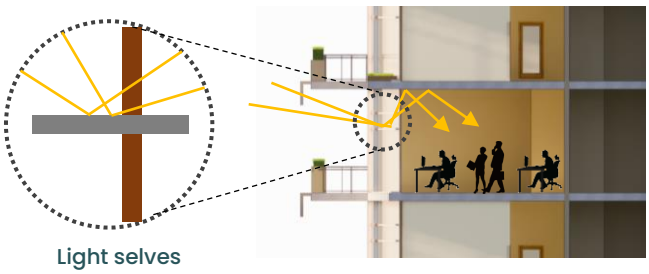
- Another benefit from this is improved visual appearance. By reducing the amount of glare and bright light entering a building, we are improving the visual appearance of the interior, creating a more inviting, positive, and aesthetically pleasing environment.



Base Case (Excluded Light Selves)



Proposed Case (Included Light Selves)



Light selves

Optimizing Daylight in the Offices:

- 82.5% area above SDA 100/100 threshold.
- The atriums added to the building help in daylighting to some extent and the rest must be managed by artificial lighting.
- But through this artificial lights can be reduced .
- Visual comfort and distribution of brightness according to the activity in the space provides high visual quality and good spatial orientation which in turn leads to concentrated, productive work.

HEALTH & WELL BEING

Integration of Biophilic design inside the buildings :

- Biophilic design is a design approach that incorporates elements of nature into the built environment and has been shown to positively impact human well-being, health, and productivity.
- Including plants in the workplace can improve oxygen levels, thus improving concentration and relieving mental fatigue.

Fig 13 : Biophilic wall inside the building

Fig 15 : Biophilic plants used

These Plants are known to absorb pollutants and improve air quality by removing volatile organic compounds (VOCs) and other harmful substances from the air.

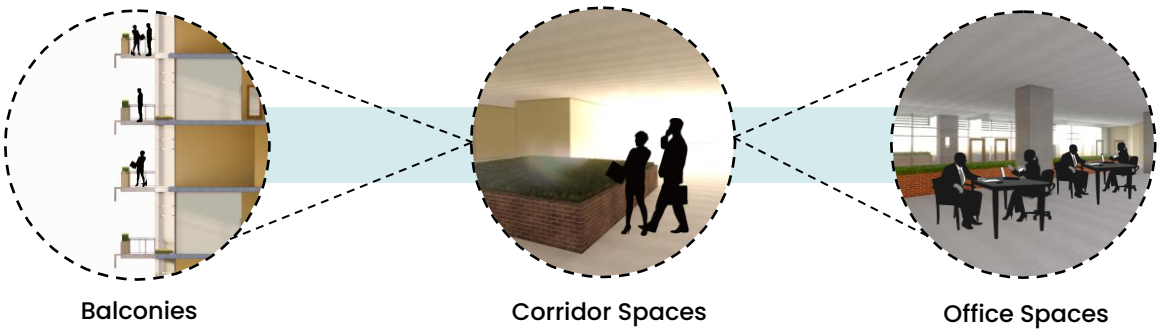


Fig 13: Formaldehyde-free plywood

Using No Urea-Formaldehyde plywood furniture inside the buildings :

- Using formaldehyde-free plywood can help to improve indoor air quality, as it reduces the amount of formaldehyde released into the air.
- It also reduces the number of harmful chemicals released during the manufacturing process.

Masking of sound in Offices:

- Using sound masking in open-plan offices where there may be a high level of ambient noise and distractions from nearby coworkers.
- This problem can be solved by the use of white or pink noise machines.
- This technique can increase productivity by 30 %.

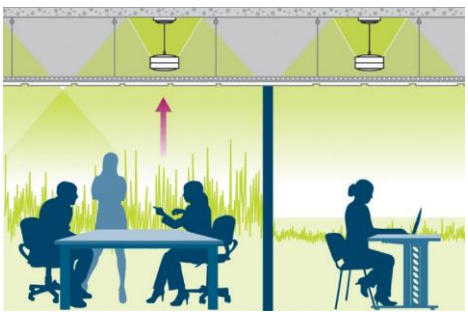


Fig 13: Sound masking system in the office

VALUE PROPOSITION

Prime Location:

- Located in a prime area and an ideal location for a business the building can attract potential employees looking for a location that is easily accessible and has a good business environment.
- Transport from and to the Office plays an important role in the convenience of the employees.

Modern Facilities :

- Offering modern facilities for working such as high-efficiency IOT-based innovations, instant internet, efficient HVAC system, secure by design & fire safety systems.
- Providing robust security and fir safety systems can help to ensure that the employees feel safe and protected.

Environment Friendly:

- Green buildings reduce energy consumption and have a very low impact on the environment.
- Implementing sustainable practices, rainwater harvesting, and waste management also act as a plus point for the future of the building.s

Indoor air quality :

- With the help of AHU shafts, we are proposing an increase in the fresh air quantity inside the building by 40%, simultaneously maintaining the indoor temperature comfort levels.
- This also improves the energy efficiency benefits, as we use high energy efficient air filters which help to reduce energy consumption.

Amenities:

- Taking into consideration the post-pandemic situations, the office areas are designed to be more amenity centric. Including cafes, gyms, & many more recreational spaces adapting to the new social behaviors.

Biophilic Design:

- Integration of biophilia as the basic concept to design provides us with a number of benefits.
- The health and well-being of the employees are improved, thus increasing creativity & productivity.

V3 FACADE DESIGN STUDIO
VERSATILE · VIBRANT · VIGOROUS
Office: 407, Mahant Chambers, Road no. 34, Wagle Estate, Opposite Cybertech House, Thane – 400 604
Email: admin@v3facade.com | Ph: +91-9867091732 | Website: www.v3facade.com

Date : February 15, 2023

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organisation, V3 FAÇADE DESIGN STUDIO, is collaborating with the participating team led by Greenscape on an Office Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be assisting team for façade designs and specifications.

We would like to have a representative from our organisation attend the Design Challenge Finals event in April/May, if this team is selected for the Finals.

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

With warm regards,

FACADE DESIGN STUDIO V3 MUMBAI

Name: Vicky Vora
Designation: Founder and Principal Façade Consultant
Name of the Organisation: V3 Façade Design Studio
Email: vicky@v3facade.com
Phone: 9867091732

GREEN ENERGY
Solar Solutions

Date: 08/02/2023

To,

The Director,

Solar Decathlon India

Dear Sir,

This is to inform you that our organisation,(Green Energy Solar Solutions), is collaborating with the participating team led by Greenspace on an Office Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be giving calculations and placement solutions of solar panels for generating energy on site.

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

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

With warm regards,

For Green Energy Solar Solutions

Name of person: Abhishek Chavan

Designation: Proprietor

Place: Thane

Green Energy Solar Solutions
C-2/604, Rutu Park
Near Majiwada, Thane (W), 400601
Contact No: 9321736556 / Email Id: gesolarsolutionsindia@gmail.com

Vivekanand Education Society's
Institute of Technology

(Affiliated to University of Mumbai, Approved by AICTE & Recognised by Govt. of Maharashtra)

Dr. (Mrs.) J. M. Nair
M. Tech., Ph.D. (IIT-B)
Principal

Ref. No.: VESIT/SP/INST/2254/22-23

Date : 22/02/2023

TO WHOMSOEVER IT MAY CONCERN

This is to certify that the below mentioned students are bonafide students of Vivekanand Education Society's Institute of Technology studying in Third year of Bachelor of Engineering in Instrumentation Engineering. The concerned students names are mentioned below:

Sr. No.	Name of the Student	Class with Roll No.
1	Ms. Naik Shriya Arvind	D13-44
2	Mr. Komte Prathamesh Ravindra	D13-36
3	Mr. Rasal Vinayak Sambhaji	D13-55

This letter is issued based on students request to participate for **SOLAR DECATHLON INDIA 2022-23**.

With Kind Regards,

HOD

VIVEKANAND EDUCATION SOCIETY'S INSTITUTE OF TECHNOLOGY * CHEMBUR, MUMBAI-400 074 INDIA

Hashu Advani Memorial Complex, Collector's Colony, Chembur, Mumbai - 400 074. INDIA.
Phone : +91 22 6153 2532 | Fax : +91 22 6153 2555 | Email : vesit@ves.ac.in / principal.vesit@ves.ac.in | Website : www.ves.ac.in/vesit

VIVEKANAND EDUCATION SOCIETY'S
College of Architecture
(Approved by Council of Architecture (COA), Recognised by Govt. of Maharashtra & Affiliated to University of Mumbai)
V.E.S. Since 1962

Reg. No. : VESCOA/718/2022-23

Date : 22/02/2023

TO WHOMSOEVER IT MAY CONCERN

This is to certify that students mentioned below are bonafide students of our College, studying in Second & Third Year B.Arch. course for the Academic Year 2022-23. The B.Arch. course is Approved by Council of Architecture, recognized by Government of Maharashtra and Affiliated to University of Mumbai.

Roll No.	Students Name	Gender
AR20004	Dedhia Yash Paresh	Male
AR20036	Shetty Shraddha Umanatha	Female
AR21016	Diwan Aarya Sachin	Female
AR21032	Kambli Disha Pravin	Female
AR21050	Mulik Siddhi Sanjay	Female

This Bonafide letter has been issued for the purpose of Solar Decathlon India Design Competition (2022-23).

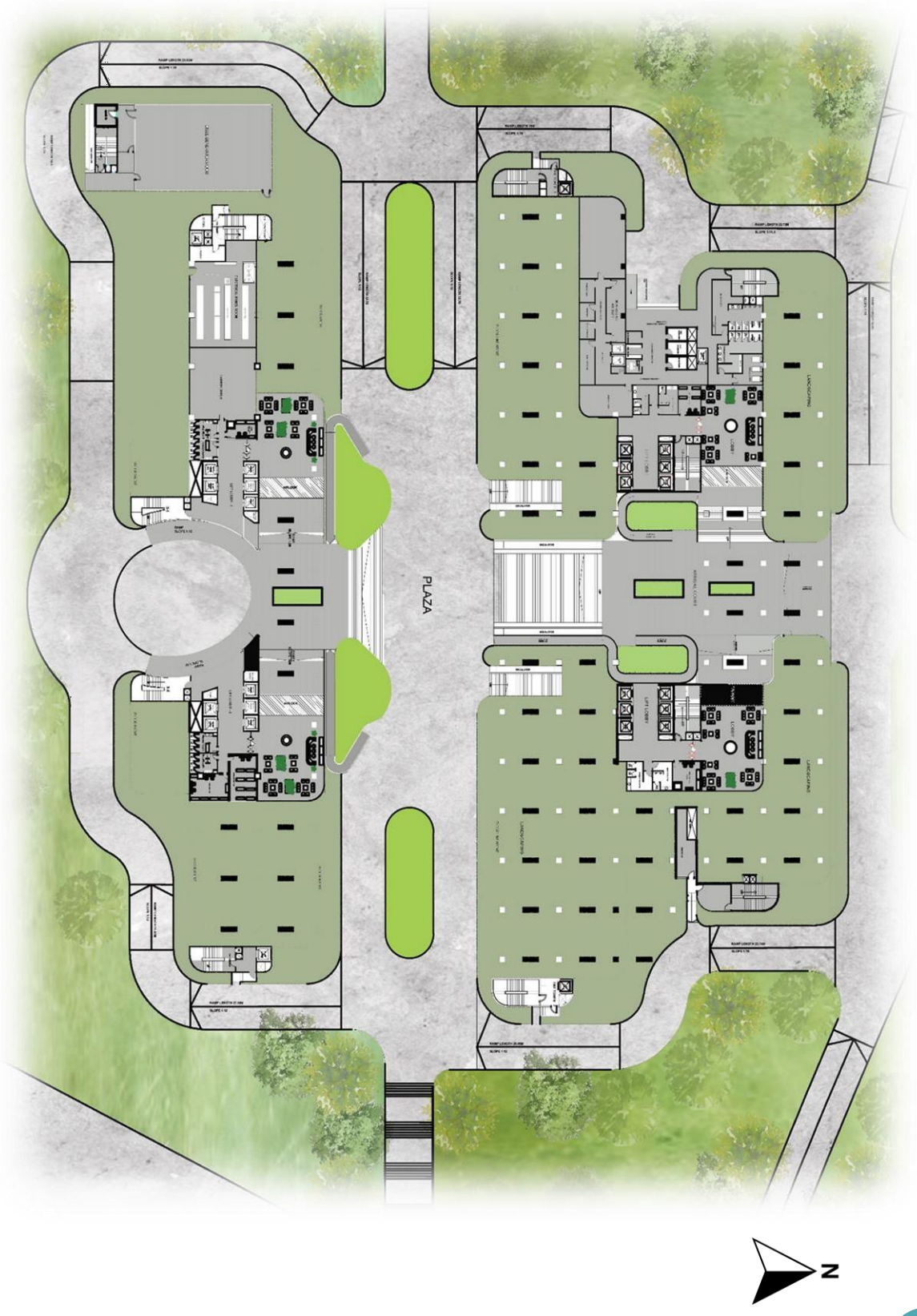
Dr. Prof. Anand Achari
Principal
VESCOA

Hashu Advani Memorial Complex, Collector's Colony, R. C. Marg, Chembur, Mumbai - 400 074.
Tel.: 022-6291 3333 Email : principal.vescoa@ves.ac.in Website : www.ves.ac.in / architecture

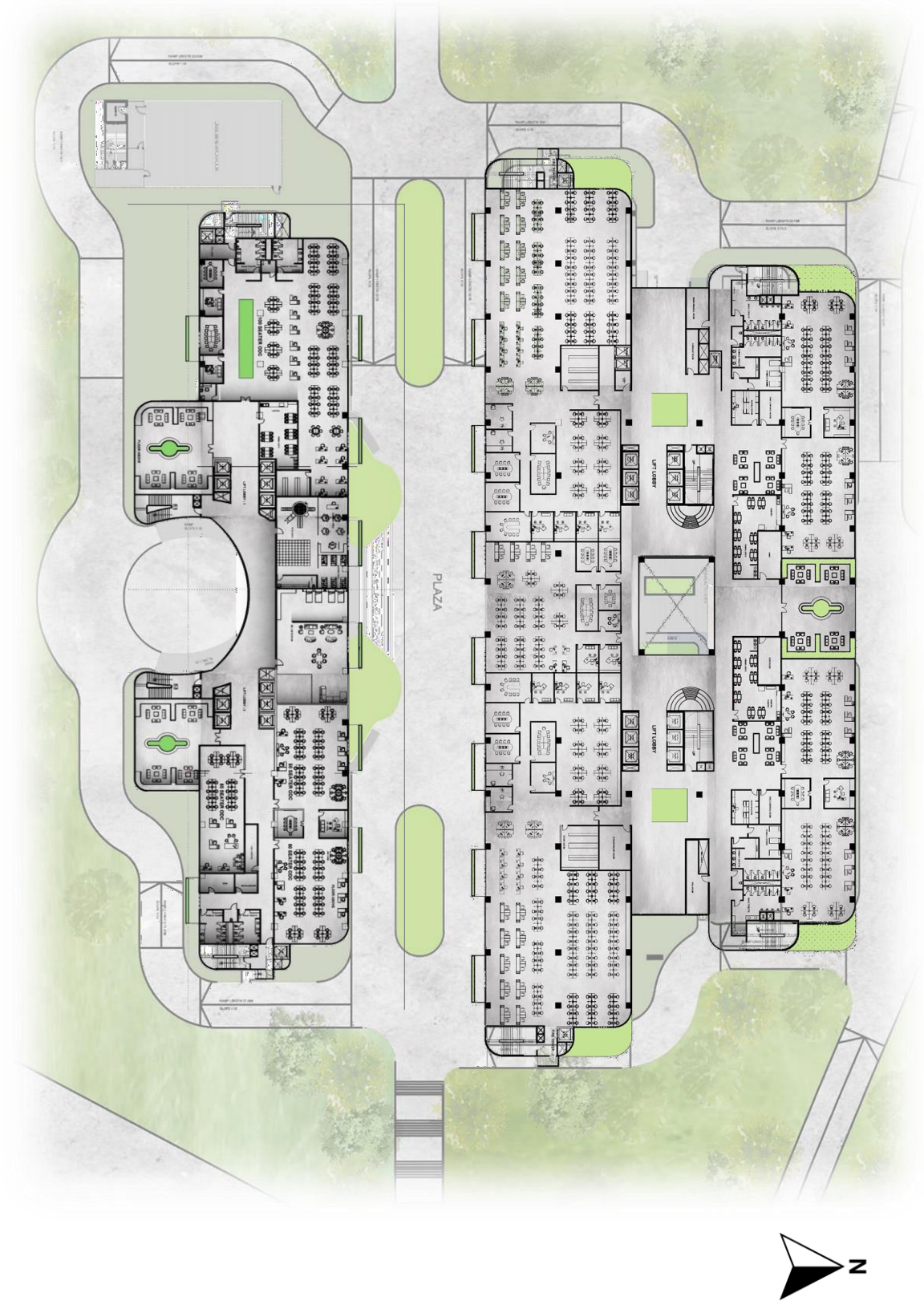
Total footfall: 8500

Typology	Sr. No.	Particulars	Quantity	Area	Total Area	HVAC provision
Office Spaces	1	25-50 Seater OOC	61	260	15860	Conditioned
	2	80-100 Seater OOC	14	750	10500	Conditioned
	3	150-200 Seater OOC	22	1400	30800	Conditioned
Entrance	4	Lobbies	4	154	616	Conditioned
	5	Reception	4	10	40	Conditioned
	6	Arrival Court	2	300	600	Unconditioned
Recreational Spaces	7	Informal Breakout spaces	60	44	2640	Unconditioned
	8	Open Workspace	32	200	6400	Unconditioned
	9	Stationary Shop	2	40	80	Conditioned
	10	Pantry	18	56	1008	Conditioned
	11	Cafeteria	1	1810	1810	Mixed
	12	Creches	2	185	370	Unconditioned
	13	Wellness Room	2	250	500	Conditioned
	14	Indoor Games	2	150	300	Conditioned
	15	Gym	2	350	700	Mixed
	16	Other Recreational zones	20	420	8400	Unconditioned
Services	17	Toilet	42	80	3360	Unconditioned
	18	Store Room	20	40	800	Unconditioned
	19	House keepimg	20	3	60	Unconditioned
	20	Server Room	20	20	400	Unconditioned
	21	IBMS	20	20	400	Unconditioned
	22	Fire control Room	20	25	500	Unconditioned
Total Area					86144	
Circulation				30%	23896	
Grand Total					110040	

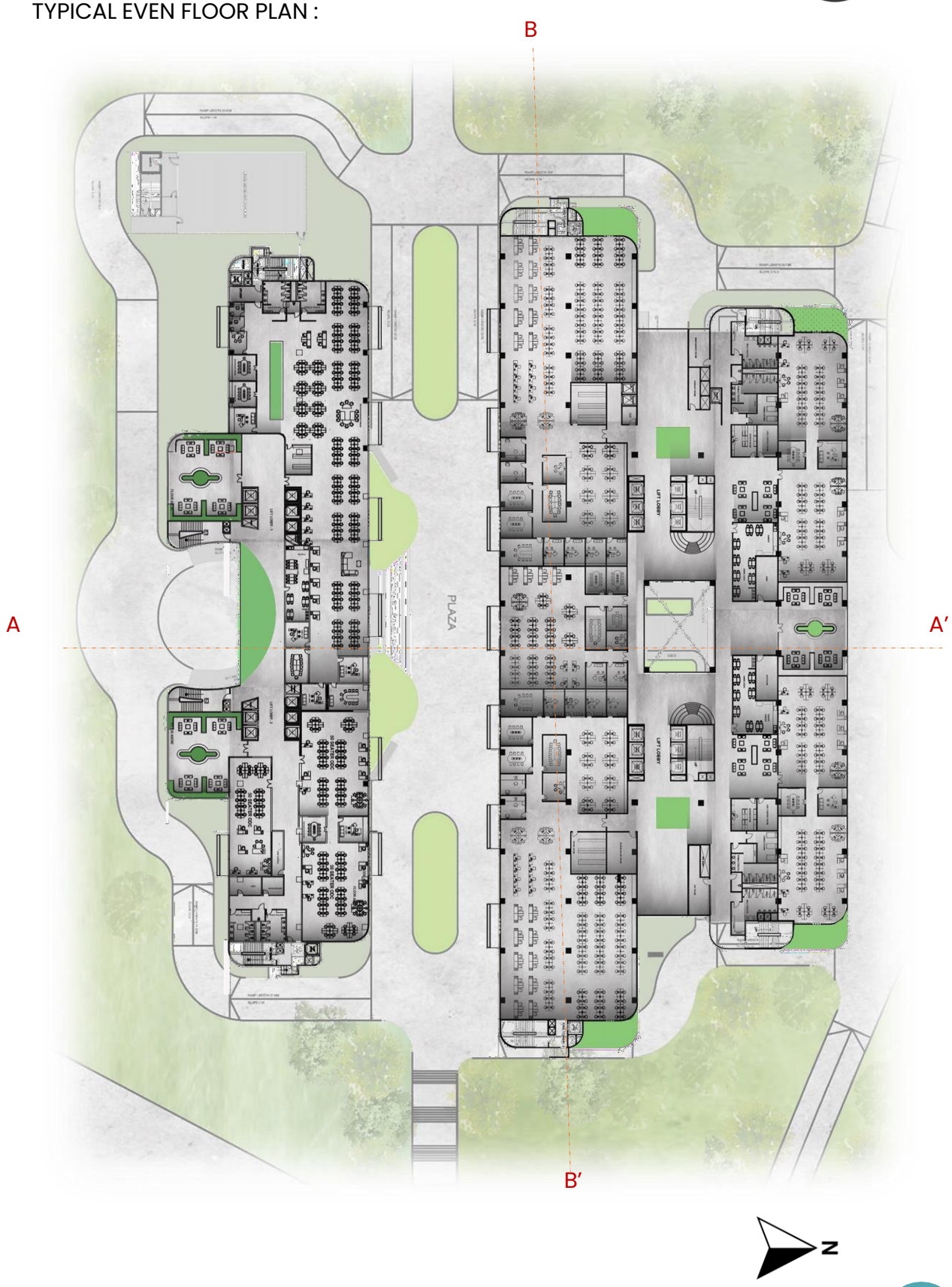
SITE PLAN :



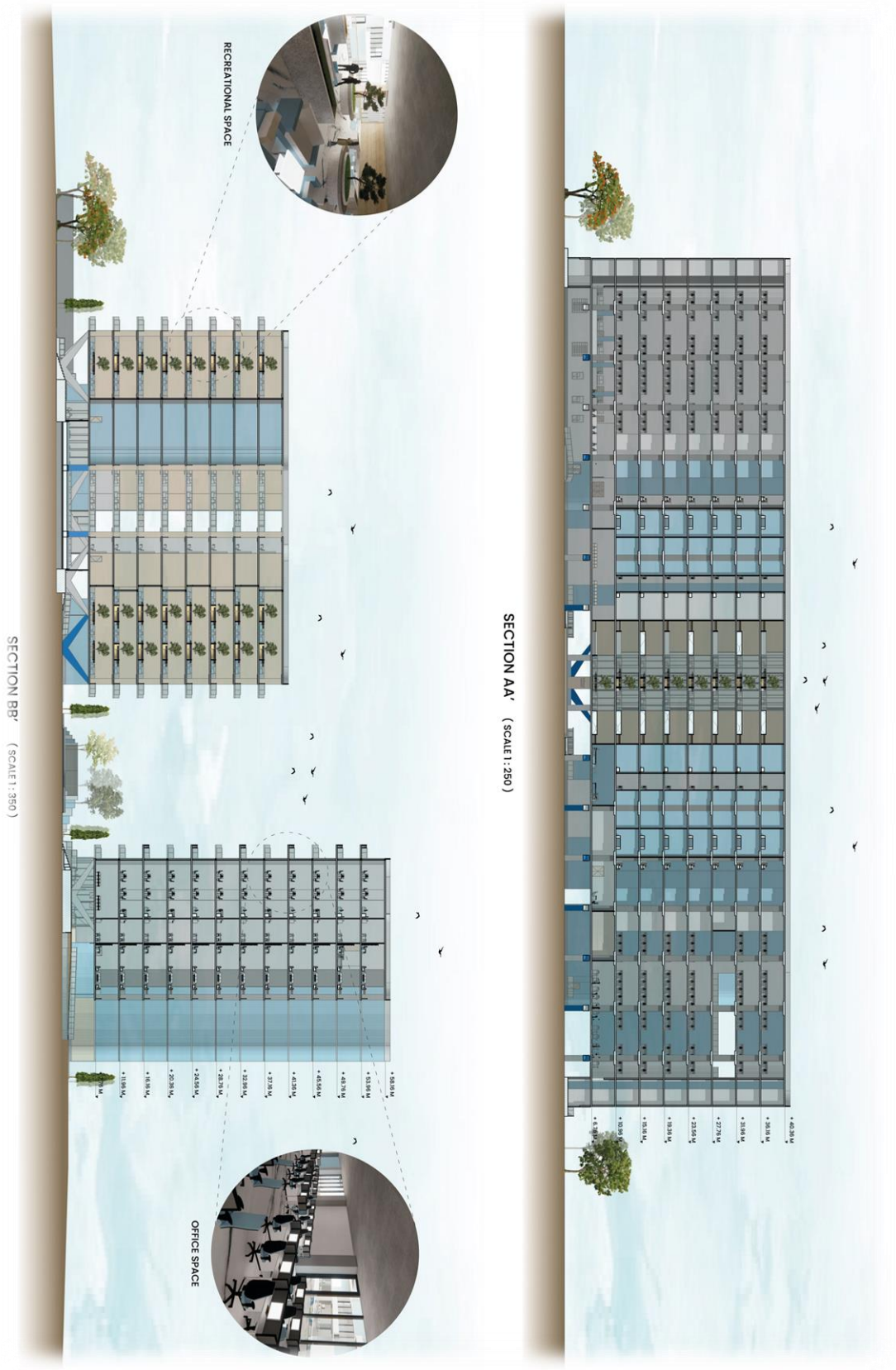
TYPICAL ODD FLOOR PLAN :



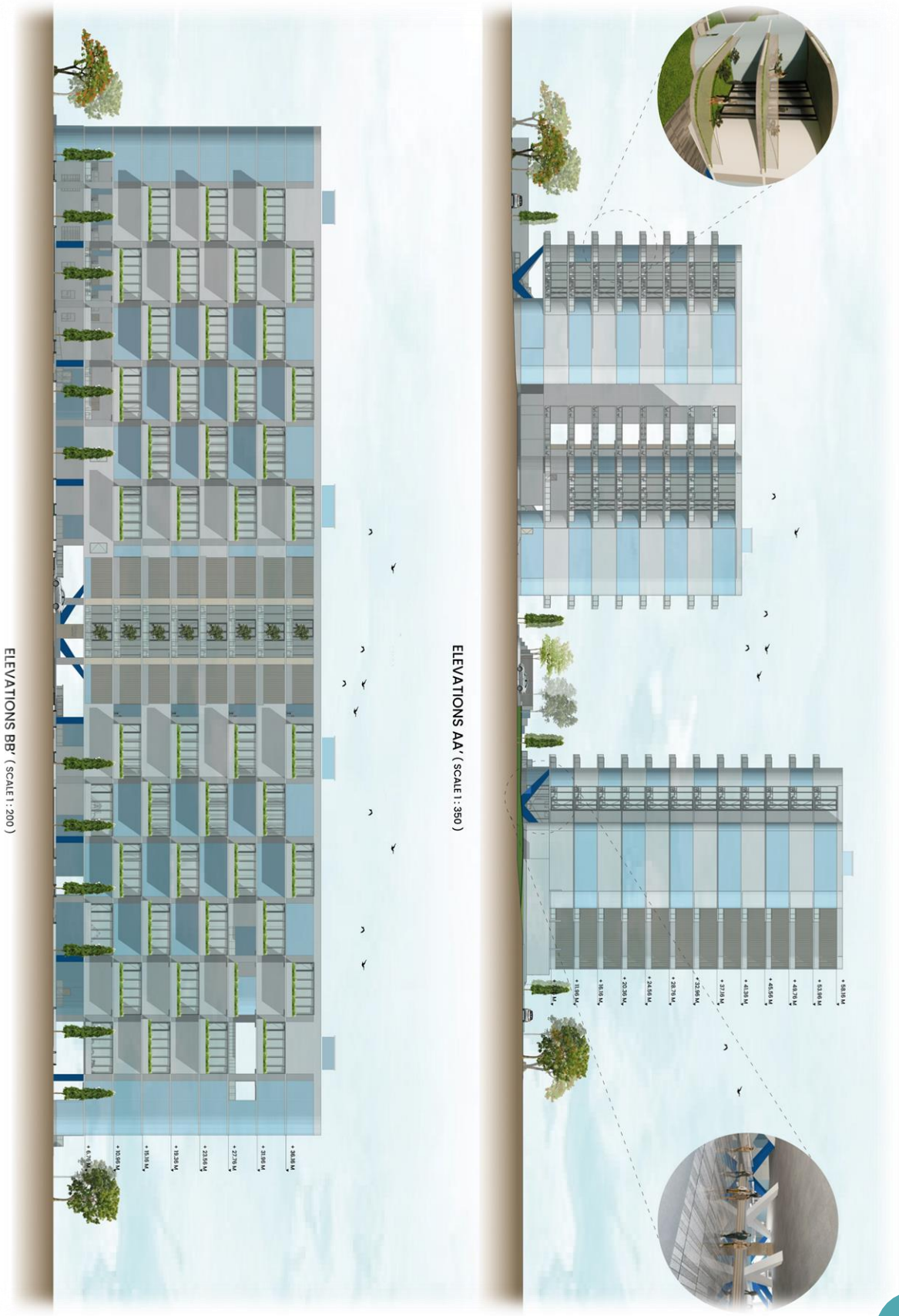
TYPICAL EVEN FLOOR PLAN :



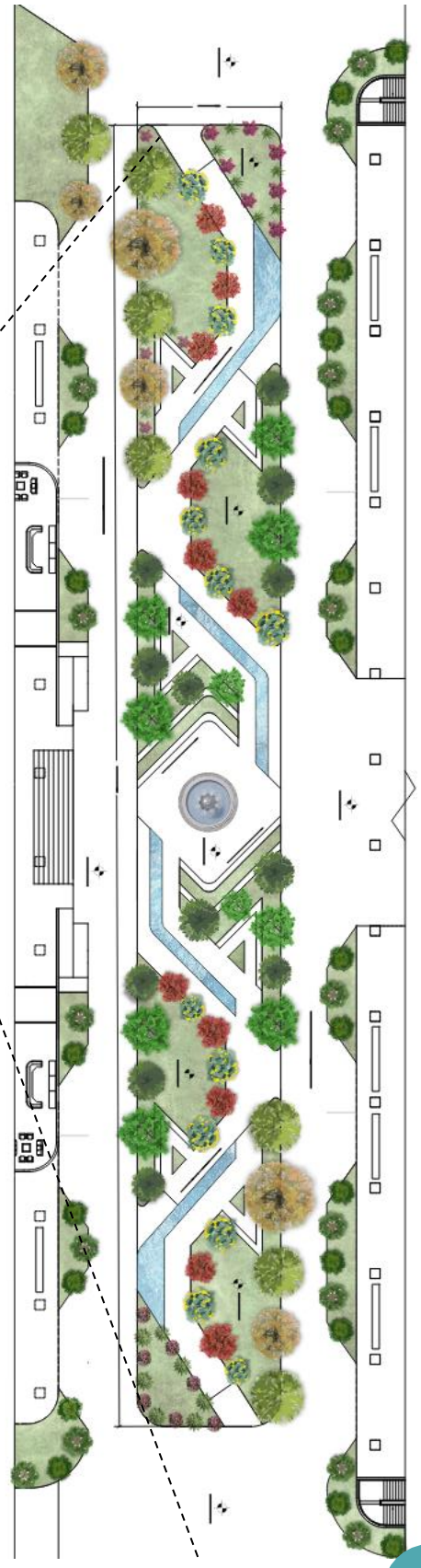
SECTIONS :


RECREATIONAL SPACE
OFFICE SPACE
SECTION BB' (SCALE 1 : 250)
SECTION AA' (SCALE 1 : 250)

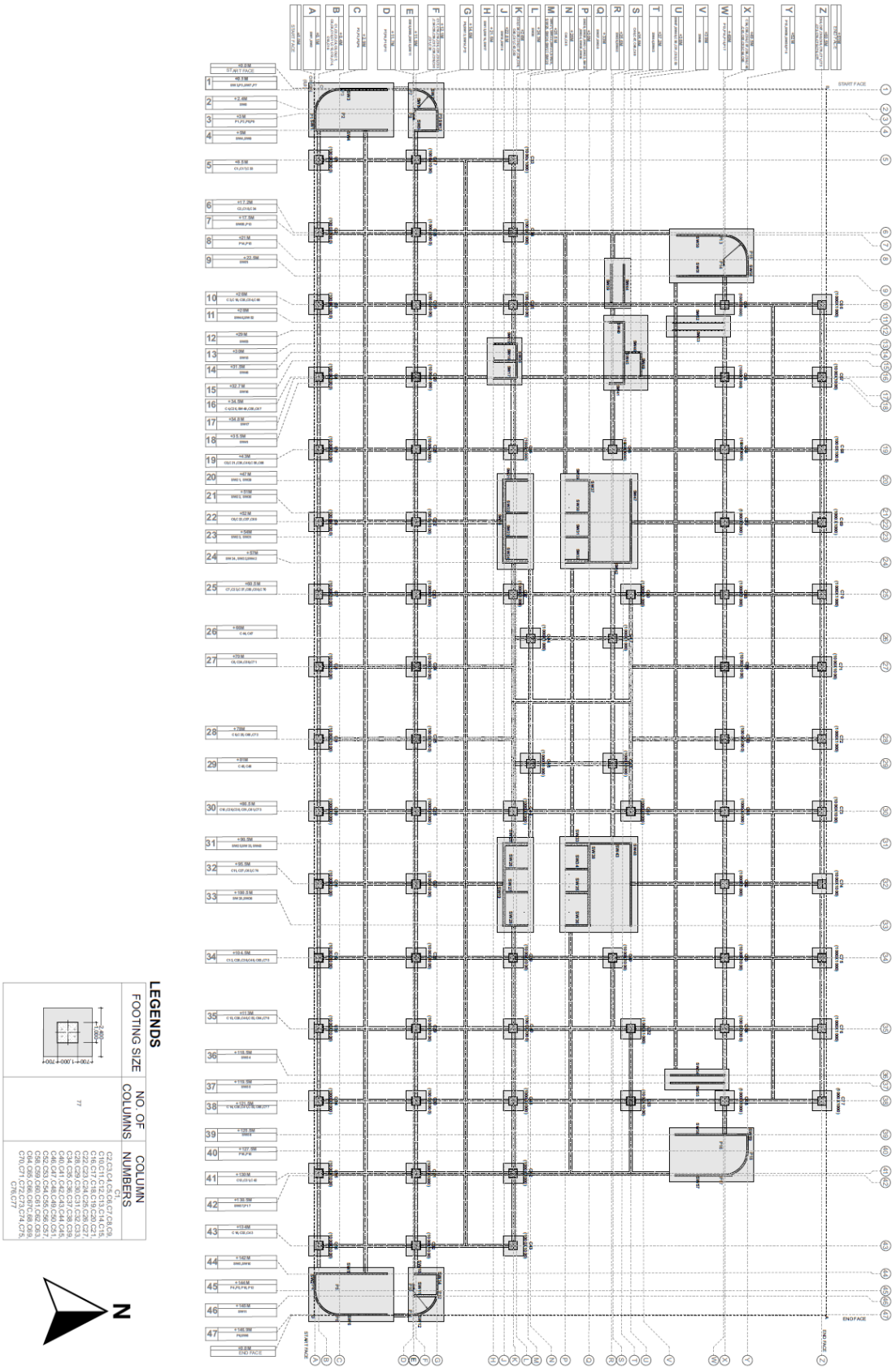
ELEVATIONS:



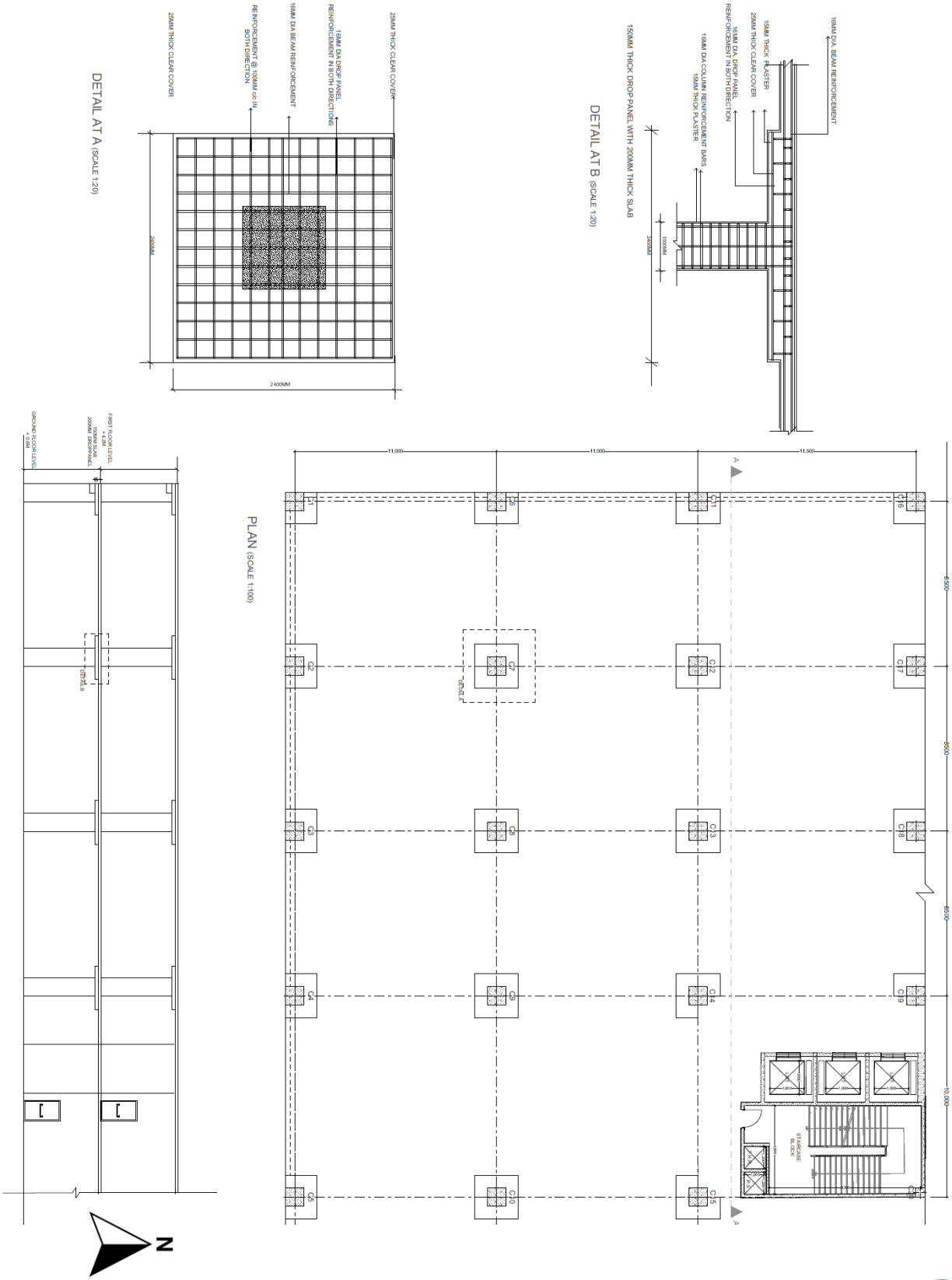
SOFTSCAPE PLAN WITH VIEWS:



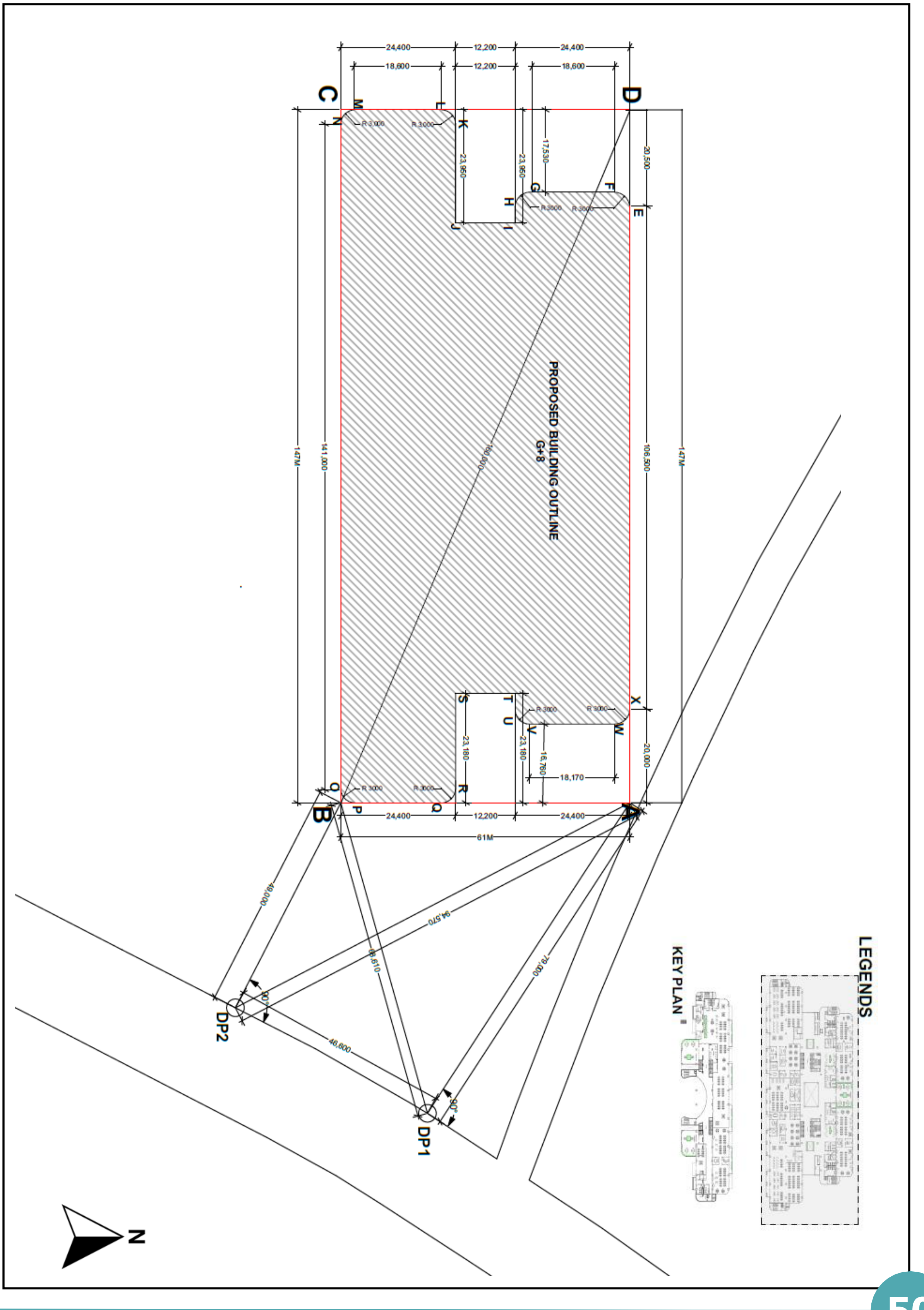
FOUNDATION LAYOUT:



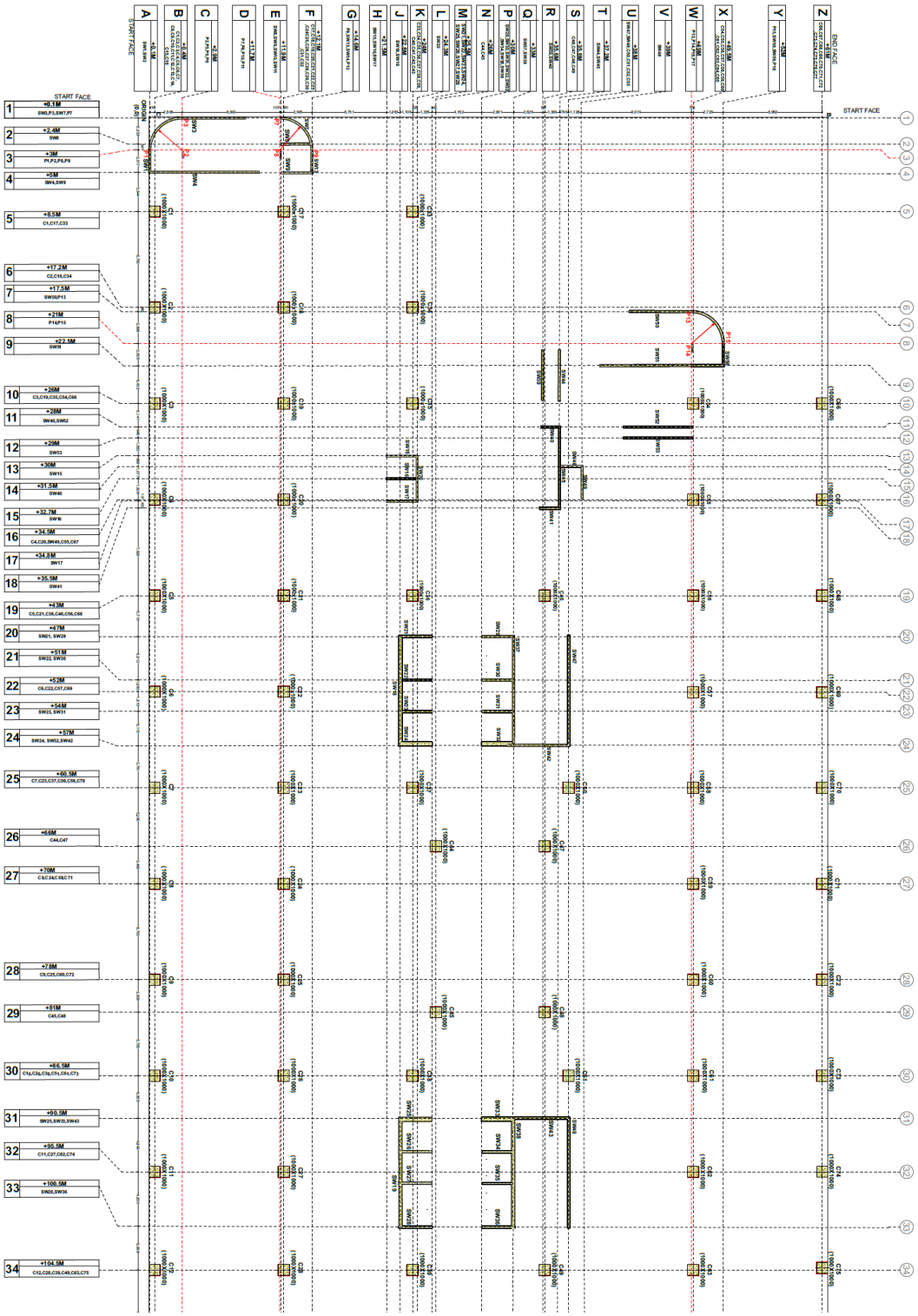
FLAT SLAB WD:


DETAIL AT A (SCALE 1:20)
25MM THICK CLEAR COVER
REINFORCEMENT @ 100MM c/c IN BOTH DIRECTION
16MM DIA BEAM REINFORCEMENT
16MM DIA DROP PANEL REINFORCEMENT IN BOTH DIRECTIONS
25MM THICK CLEAR COVER
2400MM
DETAIL AT B (SCALE 1:20)
150MM THICK DROP PANEL WITH 200MM THICK SLAB
16MM DIA COLUMN REINFORCEMENT BARS
19MM THICK PLASTER
16MM DIA DROP PANEL REINFORCEMENT IN BOTH DIRECTION
25MM THICK CLEAR COVER
15MM THICK PLASTER
16MM DIA. BEAM REINFORCEMENT
1000MM
2400MM
PLAN (SCALE 1:100)
11,000
11,000
11,500
8,500
8,500
8,500
10,000
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C16
C17
C18
C19
STAIRCASE BLOCK
N

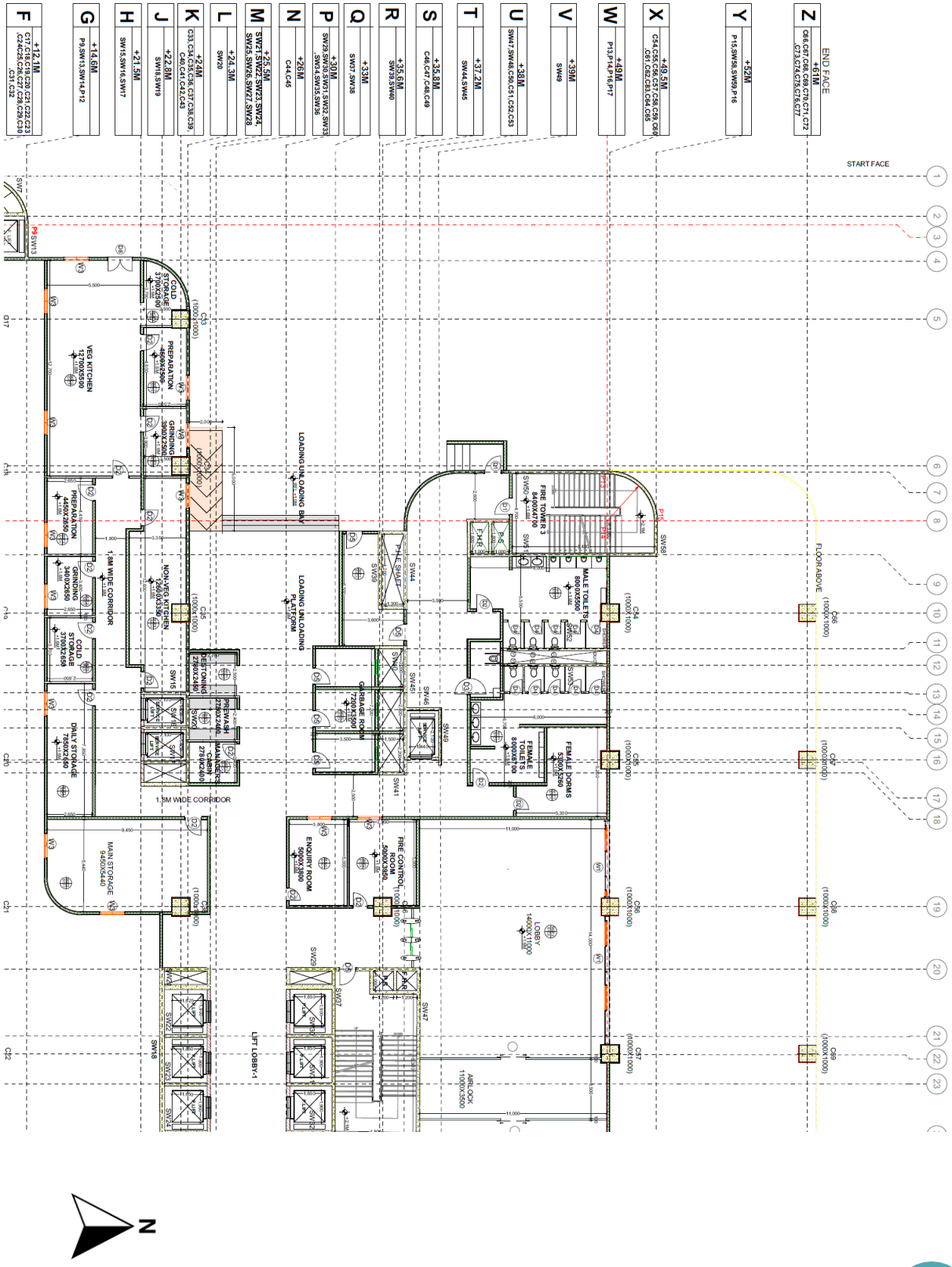
SET OUT PLAN :



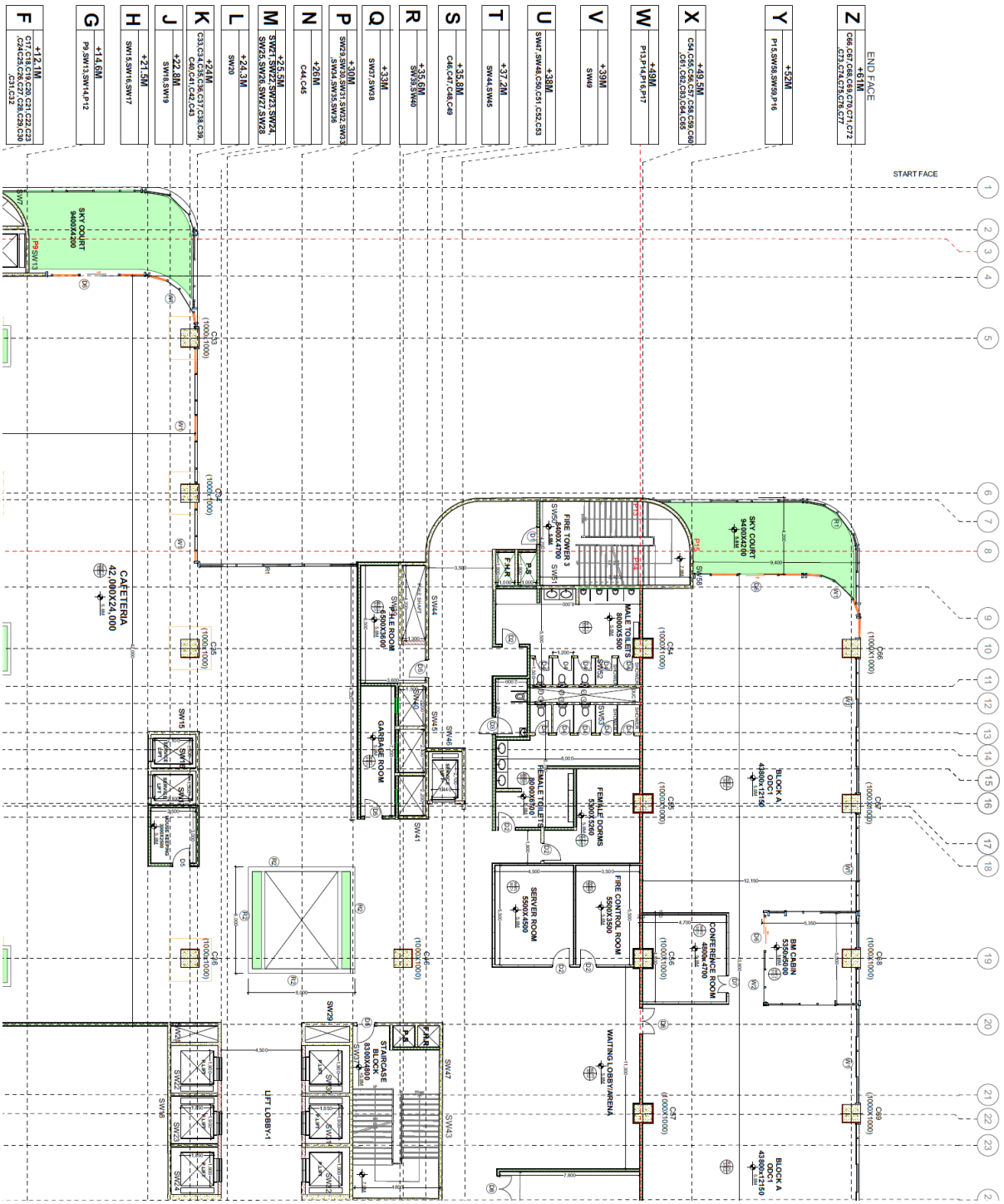
CENTER LINE PLAN:



Working Drawing of Ground Floor :



Working Drawing of First Floor :



WATER EFFICIENCY

BASE CASE					
STAFF ONLY					
Fixture	Flow rate	Units	Count per day	Footfall	Value (in litres)
Water Closet(full flush)	6	LPF	1	8500	51000
Water Closet(half)	3	LPF	2	4250	25500
Urinal	4	LPF	2	4250	34000
Faucet	6	LPM	1	8500	51000
Washbasin	6	LPM	3	8500	153000
Shower	9	LPM	1	850	7650
Cleaning	0.6	L/sqm	1	10830	6498
Cooking	4	l	1	5900	23600
Food Court	5	LPM	1	5900	29500
Drinking	1.5	L	1	8500	12750
					394498
VISITORS					
Fixture	Flow rate	Units	Count per day	Footfall	Value (in litres)
Water Closet(half)	3	LPF	2	425	2550
Urinal	4	LPF	2	425	3400
Faucet	6	LPM	1	850	5100
Washbasin	6	LPM	3	850	15300
					26350
Total daily water consumption					420848

PROPOSED CASE					
STAFF ONLY					
Fixture	Flow rate	Units	Count per day	Footfall	Value (in litres)
Water Closet(full flush)	4	LPF	1	8500	34000
Water Closet(half)	2	LPF	2	4250	17000
Urinal	0	LPF	2	4250	0
Faucet	2	LPM	1	8500	17000
Washbasin	2	LPM	3	8500	51000
Shower	4	LPM	1	850	3400
Cleaning	0.6	L/sqm	1	10830	6498
Cooking	4	l	1	5900	23600
Food Court sink	4	LPM	1	5900	23600
Drinking fountain	1.5	L	1	8500	12750
					188848
VISITORS					
Fixture	Flow rate	Units	Count per day	Footfall	Value (in litres)
Water Closet(half)	2	LPF	2	425	1700
Urinal	0	LPF	2	425	0
Faucet	2	LPM	1	850	1700
Washbasin	2	LPM	3	850	5100
					8500
Total daily water consumption					197348
Annual requirement					45390040
Firefighting				150000	45540040

WATER EFFICIENCY

LANDSCAPE REQUIREMENT			
	Area	Litres Per Day	Required Water
Landscape requirement	35307	1.7	60021.9
Reducing water requirement by 40% by xeriscape			36013.14

WATER HARVESTED FROM BOREWELLS					
Washbasin	2	LPM	3	9350	56100
Cleaning	0.6	L/sqm	2	10830	12996
Food Court	4	LPM	1	5900	23600
					92696
Annual requirement					2,13,20,080

WATER SUPPLIED BY MUNICIPAL					
Drinking	1.5	LPD	1	9350	14025
Cooking	4	LPD	1	5900	23600
shower	4	LPM	1	850	3400
					41025
Annual Requirement					94,35,750

Occupants activity	Value(in litres)	Grey Water(%)	Black Water(%)
Water Closet(full flush)	34000	0	34000
Water Closet(half)	18700	0	18700
Urinal	0	0	0
faucet	18700	0	18700
Washbasin	56100	56100	0
Shower	3400	3400	0
Food court sink	23600	23600	0
Cleaning	6498	6498	0
		89598	71400
With 80% efficiency		76158.3	57120
		17516409	13137600
Annual wastewater generated		30654009	

Reusing the grey water		Reusing black water	
Available grey water	76158.3	Available black water	57120
Water closet	52700	Landscape	36013.14
Balance	23458.3	Balance	21106.86
Balance		44565.16	
Annual balance		10249986.8	

WATER EFFICIENCY

Rainwater harvesting surfaces	Area m2	Runoff coeffecient	Effective catchment area (m²)	Annual Rainfall on site (m²)	Annual Rainfall (m²)	Annual Rainfall (Litres)
Roof Surfaces	10830.9	0.95	10289.355	0.933	9599.968215	9599968.215
Paved Areas	9437	0.95	8965.15	0.933	8364.48495	8364484.95
Landscaped Areas	38213	0.2	7642.6	0.933	7130.5458	7130545.8
Total					25094.99897	25094998.97

Recharging	
Stormwater from paved and unpaved surfaces	15495030.75
Balance grey/black water	10249986.8
Annual	25745017.55

Sr. No.	Application & Name	Company	Image	Technical Specification
1.	(WC) Tankless S1 Wall Mounted EWC Round	Hindware		2-4 LPF
2.	(Faucet Nozzle) Single Mode Water Saving Nozzle Umbrella Flow	Greenly		2LPM
3.	(Kitchen Faucet Nozzle) Automized Dual Flow Water Saving Nozzel- Mist & Shower	Greenly		Spray Flow- 4 LPM
4.	(Urinals) Astute Waterless Urinal,C0586	Parryware		---
5.	(Health Faucet) Hand Shower	Jagur		LPM

HEALTH & WELLBEING

Benefits of each biophilic plant :

Poth os

These plants serve to purify the air of formaldehyde, benzene, and carbon monoxide while also helping eliminate odors.

Draca ena

Dracaena helps reduce indoor pollution levels. Increase humidity: The plant releases water vapor and increases moisture levels in the air.

Snake Plant

They clean the air of toxic substances, particularly benzene, formaldehyde, xylene, and trichloroethylene.

Peace Lily

It purifies the air, it beautifies your room It's a low- maintenance plant that prevents Mildew formation, and it absorbs Acetone vapors.

Boston fern

It helps to rid the indoor air of toxins, like formaldehyde, plastic off-gassing, and cigarette smoke.

ZZ plant

ZZ plants must be grown indoors as they will attract protective and purifying energy.

1 Improved mental health: By incorporating biophilic elements such as plants, water features, or natural materials, we are creating a more calming and stress-reducing environment for employees.

2. Increased productivity: By incorporating elements such as large windows, green walls, or skylights, we are creating a more productive and efficient work environment.

3. Enhanced creativity: By incorporating elements, such as natural patterns and textures, into the office environment, you can create a space that inspires creativity and fosters innovation.

4. Improved air quality: Plants and other biophilic elements help to improve air quality by absorbing pollutants and removing volatile organic compounds (VOCs) from the air. This will help to create a healthier work environment and reduce the risk of respiratory issues for employees.

5. Better overall health: Exposure to natural elements has been shown to have a positive impact on overall health and well-being, including reducing stress levels, blood pressure, and heart rate. By incorporating biophilic design elements into an office building, you can create a healthier work environment for employees.

BUILDING 1 (G+8) 650 Occupants						
Appliance	No. of fixtures	kW	Hours of usage	Energy Used per day	Days	Annual Energy used
Passenger Lifts	10	2	6	120	230	27600
Service Lifts	4	4	4	64	230	14720
Fire lifts	2	2	1	4	230	920
Laptop	1560	0.08	7	873	230	200928
Desktop	3640	0.2	7	5096	230	1172080
Printer	1040	0.4	4	1664	230	382720
Projector	112	1.6	4	716	230	164864
Water pump	3	3	7	63	230	14490
Fan	800	0.2	4	640	230	147200
Microvave	70	1	3	210	230	48300
Refrigerator	35	1	23	805	230	185150
Water purifier	70	1	5	350	230	80500
Vending Machine	18	2	4	144	230	33120
Lighting	6000	0.6	6	21600	230	4968000
Total energy consumed by appliances=						7397352

BUILDING 2 (G+12)						
Appliance	No. of fixtures	kW h	Hours of usage	Energy Used per day	Days	Annual Energy used
Passenger Lifts	10	2	6	120	230	27600
Service Lifts	4	4	4	64	230	14720
Fire lifts	2	2	1	4	230	920
Laptop	1260	0.2	7	1764	230	405720
Desktop	2940	2	7	41160	230	9466800
Printer	828	0.4	4	1324	230	304704
Projector	96	1.6	4	614	230	141312
Water pump	3	3	7	63	230	14490
Fan	420	0.2	4	336	230	77280
Microvave	48	1	3	144	230	33120
Refrigerator	24	1	23	552	230	126960
Water purifier	48	1	5	240	230	55200
Vending Machine	25	2	4	200	230	46000
Lighting	4500	0.6	6	16200	230	3726000
Total energy consumed by appliances=						14397586

Base case Energy consumption by appliances

- Base case of the Office Appliances Used in both the buildings
- For the base case average market energy consumption values of appliances are considered.
- Along with this the ratio of Computers to laptops in the base case is kept at 70:30 respectively.
- Lighting fixtures are of basic 4000 lumens

BUILDING 1 (G+8)						
Appliance	No. of fixtures	kW	Hours of usage	Energy Used per day	Days	Annual Energy used
Passenger Lifts	10	1	6	60	230	13800
Service Lifts	4	2	4	32	230	7360
Fire lifts	2	2	0.25	1	230	230
Laptop	3640	0.02	7	509	230	117208
Desktop	1560	0.8	7	8736	230	2009280
Printer	624	0.4	4	998	230	229632
Projector	112	0.4	4	179	230	41216
Water pump	3	12	7	252	230	57960
Fan	700	0.025	4	70	230	16100
Microwave	36	1	3	108	230	24840
Refrigerator	35	1	15	525	230	120750
Water purifier	70	1	5	350	230	80500
Vending Machine	18	2	4	144	230	33120
Lighting	480	0.02	6	57	230	13248
Total energy consumed by appliances=						2743854

BUILDING 2 (G+12)						
Appliance	No. of fixtures	kW	Hours of usage	Energy Used per day	Days	Annual Energy used
Passenger Lifts	10	1	6	60	230	13800
Service Lifts	4	2	4	32	230	7360
Fire lifts	2	2	0.25	1	230	230
Laptop	2940	0.08	7	1646.4	230	378672
Desktop	1260	0.8	7	7056	230	1622880
Printer	168	0.4	4	268	230	61824
Projector	96	0.4	4	153	230	35328
Water pump	3	12	7	252	230	57960
Fan	350	0.025	4	35	230	8050
Microwave	26	1	3	78	230	17940
Refrigerator	24	1	15	360	230	82800
Water purifier	48	1	5	240	230	55200
Vending Machine	25	2	4	200	230	46000
Lighting	360	0.02	6	43	230	9936
Total energy consumed by appliances=						2376590

Proposed case Energy consumption by appliances

- The Proposed case for appliance usage shows an 84% reduction in energy usage.
- For the proposed case energy efficient appliances are considered along with reducing their usage.
- The ratio of Computers to laptops in the base case is kept at 30:70 respectively.
- Lighting fixtures are of 50,000 lumens LED lighting.

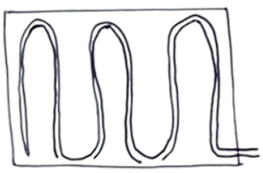
General		
Building Area	m²	110,040 sq. m.
Conditioned Area	m²	103,438 sq. m.
Electricity Rate	INR/kWh	Rs. 7.34 / unit
Natural Gas Rate	INR/GJ	Rs. 1,105.00 / cylinder (14.2kg)
Building Occupancy Hours	-	9 am – 5 pm
Average Occupant Density	m² / person	0.73
Interior Average Lighting Power Density	W/m²	6
List of Lighting Controls	-	✓ Using high-efficiency LED lights ✓ Motion sensor lights ✓ Specifying different LPDs as required for different zones.
Average Equipment Power Density	W/m²	7.0
Minimum OA Ventilation (Building Average)	l/sec.m²	7.5
Envelope		
Roof Assembly U value	W/m².K	0.34
Roof Assembly SRI		105%
Average Wall Assembly U value	W/m².K	0.38
Window to Wall Area Ratio (WWR)	%	30
Windows U value	W/m².K	1.4
Windows SHGC		0.23
Windows VLT	%	40
Infiltration Rate	ac/h	0.01
Describe Exterior Shading Devices		✓ 1m overhang over the windows(as calculated from respective sun angles) ✓ An assembly of 5 louvers at a distance of 1.7m from the fenestration. ✓ Thus reducing the heat load from the buildings.
HVAC System		
HVAC System Type and Description	-	Chilled Ceiling Free Cooling Ground HX.
Describe Mixed mode strategy in operation/controls of AC and windows	-	Mixed Mode strategies are used to reduce the cooling load on the building. Reducing 90% of the sensible cooling load through structural cooling.
Heating Source	-	-
Heating Capacity	kW	-
Heating COP		-
Cooling Source	-	Electric
Cooling Capacity	kW	
Cooling COP		14
Operation Hours		9 hrs.
Heating Set Point	ºC	-
Cooling Set Point	ºC	24°C
Relative Humidity Setpoint		65

SHW Type and Description	–	Solar thermal system: using solar collectors to capture energy from the sun and heat water for use in buildings.

Proposed EUI (Total)	kWh/m²/ yr	72	
EUI Breakdown by End Use			
Heating	kWh/m²/ yr	–	
Cooling	kWh/m²/ yr	4.45	
Fans	kWh/m²/ yr	0.17	
Pumps	kWh/m²/ yr	0.88	
Heat Rejection	kWh/m²/ yr	–	
Service Hot Water	kWh/m²/ yr	–	
Lighting	kWh/m²/ yr	(Interior) + (Exterior) = 46.4	
Equipment	kWh/m²/ yr	36.57	
Total Envelope Heat Gain (Peak)	kW/m²	4.17	
Cooling Load of Conditioned Area	SF/ Tr	500	
Building Electric (Peak)	kW/m²	51,44,065	
Annual Operating Energy Cost	INR/m²	Rs. 504	
Annual Unmet Hours	–	111hrs	
Cooling Capacity	Tr	6,24,311	
Annual Hours of Comfort without Air Conditioning		3361 out of 5544	
Monthly Energy Performance		Generation	Consumption
Jan	kWh	2,30,000	570,240
Feb	kWh	2,45,000	595,240
Mar	kWh	2,50,000	660,240
Apr	kWh	2,60,000	660,240
May	kWh	2,64,000	660,240
Jun	kWh	2,00,000	600,650
Jul	kWh	2,10,000	620,240
Aug	kWh	2,30,000	599,000
Sep	kWh	2,40,000	591,500
Oct	kWh	2,45,000	600,300
Nov	kWh	2,30,000	560,290
Dec	kWh	2,35,000	590,240

❑ CALCULATIONS :

- Fresh Air : Requirement as per ASHRAE 62.1
- An Office Building requires 25 cfm / person + 0.06 cfm / sq. ft
- Δ Enthalpy = **17.18 kcal / kg**
  ∴ 25 * 8500 = (212500 cfm) / 0.59
  = 3,60,169.4 * 1.22 (density)
  = 4,39,406
  = **4,40,000 kg/hr**
- Dividing this value by 4 to get the air requirement in 2 buildings having 2 AHU units each.
  ∴ (4,40,000 / 4) = **1,10,000 kg/hr**
- Therefore, per floor fresh air supplied :
  For (G+12) = 9,166 kg/hr = **7,513 cu. m/hr**
  For (G+8) = 13,750 kg/hr = **11,270.49 cu. m/hr**
- ∴ We are providing 40% more fresh air than required always, improving indoor air quality as well.
- Considering the length of the pipe used for Radiant cooling to be **7m / sq. m** , the temperature of the water to be maintained at 25°C to maintain the temperature at 28 to 30°C.



- 20 / 1000 * π * L = 0.4396 cu. m / hr / sq. m
- 0.4396 cu. m/hr is the quantity of water required for the structure to cool. We will consider 10% more water to be running through the pipes at a time to set margin.
- ∴ Total water required = **48,500 cu. m / hr**
- **All the water used in Radiant cooling will be used from the existing lake on site and reused as necessary.**
- ∴ Calculating the pump values :

  ∴ (Q * 9.8 * height of building) / (3600 * % Efficiency)
  ∴ For (G+12) Building = **2402.9kW** & for (G+8) Building = **1663.5kW**
- ∴ Two Pumps each in the two office Buildings.

❑ Simulating the Total energy consumed by the 2 buildings & their EPI :

From simulation we get,
Sensible load / day = **5919 kW**
Latent load / day = **4065.6kW**

Converting these to tons(TR):
Sensible load = **1,686TR**
Latent load = **1,158TR**

∴ Proposed case latent load = (Total air * 60) / 3024
= **89.58TR** _____(Reduction in Latent Load by using supply of fresh air)

∴ Net Latent load / day = 1158 – 89.58
= 1068TR

- Using the water from the lake, the sensible load of the buildings can be reduced from

(5919kW per day----------→(1346kW per day)

- By calculating with **Conductance formula** ;

$$C = \frac{2\pi L K}{\ln((E/(\pi R))\sinh(\pi D/E))}$$

$$\therefore C = 31.43\ W/hr^{\circ}C$$

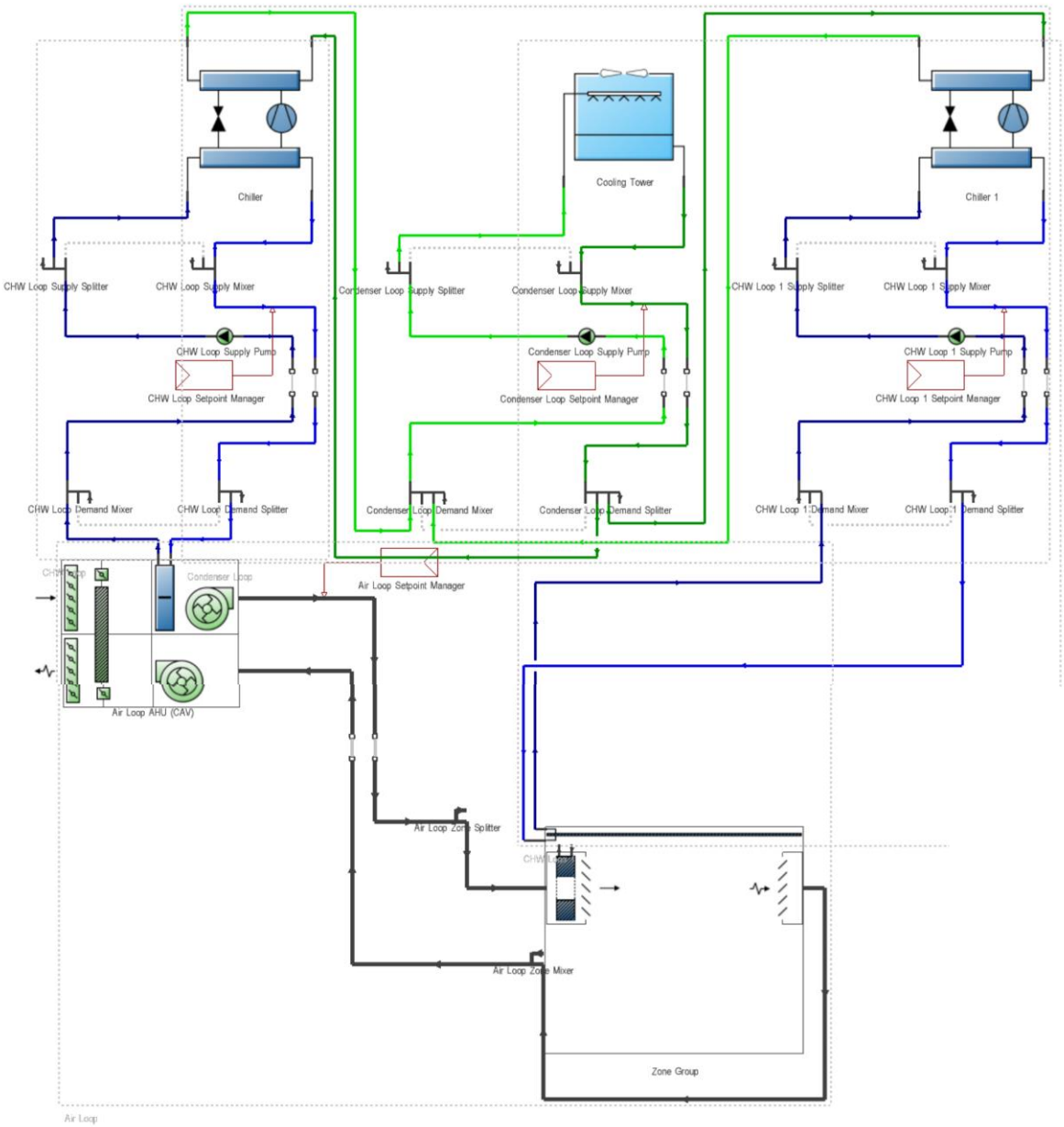
$$= 192.8\ BTU/hr^{\circ}F$$

- Where,
- C = Thermal conductance of one pipe in (W/°c)
- π = 3.14
- L = Length of single pipe in the grid (7m)
- K = Thermal conductivity of surrounding material (W /m ° c)
- E = Distance between 02 pipes (0.3)
- R = Radius of pipe in meters (0.0100m)
- D = Distance between the top of the Slab and the center of the pipe in meters (0.0508)

- With these calculations, further simulating the Design Builder Model with the above-found value for water temperatures and pump efficiencies, we can see a reduction of 60% in the Energy loads.
- In this way we are utilizing the lake water for reducing the energy loads while not polluting the lake water as well.
- This gives us an EPI reduction from 90 to 75, which we further propose to be reduced to an EPI of 65 kWh/h/yr by the use of Solar trees.

FURTHER DESIGN BUILDER SPECIFICATION

Air loop created in Design Builder for Radiant Cooling System :



- In Design Builder, a detailed HVAC system was designed with a DOAS system and chillers with a chilled ceiling component in the zone group connected to the CHW loop.

- Following this specification were entered for the HVAC system thus created to be efficient in two steps,

Step 1 :

- ✓ Setting the Thermostat schedules according to the working of the building
- ✓ Setting the Humidistat control schedule.
- ✓ Outside air flow per person (cu.m/s-person) = 0.0068

- ✓ Setting the AHU schedule and setting the supply flow rate (cu.m/s) = 1.4
- ✓ Turning on the Heat Recovery system and setting all air flows at 0.750
- ✓ Setting a schedule for the chilled water loop
- ✓ Specifying the Chiller as Electric EIR Chiller Centrifugal Carrier 19XR 1143 and mentioning specific performance curves.
- ✓ Adding a Chilled ceiling to the zone group, specifying the number of circuits
    - Circuit length
    - Zone temperature control type
    - Setting cooling control temperature and schedule
    - Setting condensation control dewpoint offset (°C) as 2 Setting the Schedule
- ✓ Enabling an internal source option for the ceiling with dimensions 2D and tube spacing 0.300
- ✓ Adding a chilled water plant and defining its schedule and designing the connections.

- ❑ DOAS load sharing 63 %
- ❑ Radiant 37%
- ❑ EPI 75

EMBODIED CARBON

Justifying Quantitative Calculations of Walling System, Roofing System, Flooring System, Fenestration & Structural System.

- **BASE CASE :**

	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 shop (km)	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (liters)	Transport Emissions 1 (kg -CO_2 e)	Type of Vehicle used	(1) Distance from Retail shop to Site (km)	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (liters)	Transport Emissions 2 (kg -CO_2 e)
System Type Wall, **System Name** Walling System, **Area(sq. m.)** 37146.634	Brick - Clamp kiln	kg	456666	0.57	260300	HGV Lorry/ Truck	228	11	2603	434	1232	HGV Lorry/ Truck	19	11	217	36	103
	AAC	kg	43,243	0.5	21622	HGV Lorry/ Truck	221	1	239	40	113	HGV Lorry/ Truck	19	1	21	3	10
	XPS	kg	167,162	2.9	484768	HGV Lorry/ Truck	291	4	1216	203	576	HGV Lorry/ Truck	28	4	117	20	55
	Gypsum panel	kg	43435	0.26	11293	HGV Lorry/ Truck	590	1	641	107	303	HGV Lorry/ Truck	19	1	21	3	10
	Expanded polystyrene insulation (EPS)	kg	29717.6	2.9	86181	HGV Lorry/ Truck	221	1	164	27	78	HGV Lorry/ Truck	28	1	21	3	10
	Paint	l	3714.7	0.659	2448	HGV Lorry/ Truck	233	0	22	4	10	HGV Lorry/ Truck	57	0	5	1	3
	Granite	kg	19377.92	0.31	6007	Bike	0	194	0	0	0	Bike	0	194	0	0	0
	Terracotta	kg	10881	0.5	5441	Mini truck	0	8	0	0	0	Mini truck	0	8	0	0	0
	Total material emissions per functional unit (kg -CO_2 e)				**24**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**
System Type Roof, **System Name** Roofing System, **Area(sq. m.)** 16358.87	Ready mix concrete with ordinary Portland cement (OPC)	kg	11320591.59	0.11	1245265	HGV Lorry/ Truck	12	283	3396	566	1608	HGV Lorry/ Truck	88	283	24905	4151	11789
	Polyethylene Foam High Density	kg	1717.68135	2.9	4981	HGV Lorry/ Truck	210	0	9	2	4	HGV Lorry/ Truck	28	0	1	0	1
	Steel reinforcement (steel rebar)	kg	114349.41	2.6	297308	HGV Lorry/ Truck	12	3	34	6	16	HGV Lorry/ Truck	88	3	252	42	119
	China mosaic	kg	327177.4	0.67	219209	HGV Lorry/ Truck	34	8	278	46	132	HGV Lorry/ Truck	27	8	221	37	105
	XPS	kg	320633.852	2.9	929838	HGV Lorry/ Truck	221	8	1772	295	839	HGV Lorry/ Truck	28	8	224	37	106
	Total material emissions per functional unit (kg -CO_2 e)				**165**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**	**Total material emissions per functional unit** (kg -CO_2 e)					**1**
System Type Floor, **System Name** Flooring System, **Area(sq. m.)** 32,711,774	Vitrified ceramic floor tiles	kg	785082576	0.68	533856152	HGV Lorry/ Truck	34	19627	667320	111220	315865	HGV Lorry/ Truck	27	19627	529931	88322	250834
	Cement floor screed (concrete screed)	kg	1177623864	0.18	211972296	HGV Lorry/ Truck	34	29441	1000980	166830	473797	HGV Lorry/ Truck	27	29441	794896	132483	376251
	Soil	kg	0	0	0	Bike	0	0	0	0	0	Bike	0	0	0	0	0
	Total material emissions per functional unit (kg -CO_2 e)				**23**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**
System Type Fenestration, **System Name** Low-E Glass, **Area(sq. m.)** 10,159.401	Aluminum extruded profile	kg	81280	33	2682240	HGV Lorry/ Truck	9	2	18	3	9	HGV Lorry/ Truck	54	2	110	18	52
	Low- E Glass	kg	2532.738669	2.37	6003	HGV Lorry/ Truck	610	0	39	6	18	HGV Lorry/ Truck	19	0	1	0	1
	Aluminium Louvers	kg	24490.3	47.7	1168187	HGV Lorry/ Truck	9	1	6	1	3	HGV Lorry/ Truck	54	1	33	6	16
	Float glass	kg	2550.009651	1.2	3060	HGV Lorry/ Truck	19	0	1	0	1	HGV Lorry/ Truck	19	0	1	0	1
	Total material emissions per functional unit (kg -CO_2 e)				**380**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**
System Type Structural, **System Name** Column, **Area(sq. m.)** 164	Ready mix concrete with ordinary Portland cement (OPC)	kg	1355186.25	0.11	149070	HGV Lorry/ Truck	12	34	407	68	192	HGV Lorry/ Truck	88	34	2981	497	1411
	Steel reinforcement (steel rebar)	kg	86501.25	2.6	224903	HGV Lorry/ Truck	12	2	26	4	12	HGV Lorry/ Truck	88	2	190	32	90
	Total material emissions per functional unit (kg -CO_2 e)				**2280**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**

EMBODIED CARBON

System Type / System Name / Area(sq. m.)	Material	Unit	Material manufacturing emissions			Transport 1 | Manufacturer --> Supplier						Transport 2 | Supplier --> Site					
			Quantity	Emissions Factor	Material Emissions ($kg\text{-}CO_2e$)	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 (liters)	Transport Emissions 1 ($kg\text{-}CO_2e$)	Type of Vehicle used	(1) Distance from Retail shop to Site (km)	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (liters)	Transport Emissions 2 ($kg\text{-}CO_2e$)
System Type: Structural, System Name: Slab, Area(sq. m.): 340297.4	Ready mix concrete with ordinary Portland cement (OPC)	kg	2266637012	0.11	24933007	HGV Lorry/ Truck	12	56666	679991	113332	321862	HGV Lorry/ Truck	88	56666	4986601	831100	2360325
	Steel reinforcement (steel rebar)	kg	2289262.746	2.6	5952083	HGV Lorry/ Truck	12	57	687	114	325	HGV Lorry/ Truck	88	57	5036	839	2384
	Total material emissions per functional unit ($kg\text{-}CO_2e$)				750	Total material emissions per functional unit ($kg\text{-}CO_2e$)					1	Total material emissions per functional unit ($kg\text{-}CO_2e$)					7
System Type: Structural, System Name: Beam, Area(sq. m.): 142.3375	Ready mix concrete with ordinary Portland cement (OPC)	kg	620357.5371	0.11	68239	HGV Lorry/ Truck	12	16	186	31	88	HGV Lorry/ Truck	88	16	1365	227	646
	Steel reinforcement (steel rebar)	kg	12660.3574	2.6	32917	HGV Lorry/ Truck	12	0	4	1	2	HGV Lorry/ Truck	88	0	28	5	13
	Total material emissions per functional unit ($kg\text{-}CO_2e$)				711	Total material emissions per functional unit ($kg\text{-}CO_2e$)					1	Total material emissions per functional unit ($kg\text{-}CO_2e$)					5
System Type: Structural, System Name: Footing, Area(sq. m.): 1754.8	Ready mix concrete with ordinary Portland cement (OPC)	kg	189837.216	0.11	20882	HGV Lorry/ Truck	12	5	57	9	27	HGV Lorry/ Truck	88	5	418	70	198
	Steel reinforcement (steel rebar)	kg	2183127.984	2.6	5676133	HGV Lorry/ Truck	12	55	655	109	310	HGV Lorry/ Truck	88	55	4803	800	2273
	Total material emissions per functional unit ($kg\text{-}CO_2e$)				3247	Total material emissions per functional unit ($kg\text{-}CO_2e$)					0	Total material emissions per functional unit ($kg\text{-}CO_2e$)					1

- PROPOSED CASE :

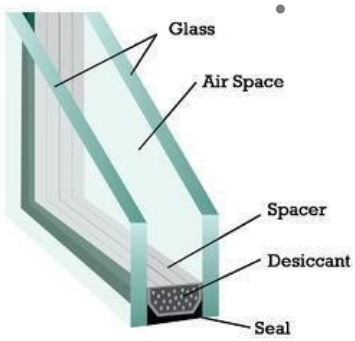
System Type / System Name / Area(sq. m.)	Material	Unit	Material manufacturing emissions			Transport 1 | Manufacturer --> Supplier						Transport 2 | Supplier --> Site					
			Quantity	Emissions Factor	Material Emissions ($kg\text{-}CO_2e$)	Type of Vehicle used	(1) Distance from Factory to Retail shop (km)	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (liters)	Transport Emissions 1 ($kg\text{-}CO_2e$)	Type of Vehicle used	(1) Distance from Retail shop to Site (km)	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (liters)	Transport Emissions 2 ($kg\text{-}CO_2e$)
System Type: Wall, System Name: Walling System, Area(sq. m.): 37146.634	AAC	kg	594346.144	0.5	297173	HGV Lorry/ Truck	21	15	312	52	148	HGV Lorry/ Truck	19	15	282	47	134
	Gypsum panel	kg	371466.34	0.26	96581	HGV Lorry/ Truck	21	9	195	33	92	HGV Lorry/ Truck	28	9	260	43	123
	Cellulose insulation	kg	148586.536	-1.1	-163445	HGV Lorry/ Truck	21	4	77	13	36	HGV Lorry/ Truck	19	4	69	12	33
	Cement based plaster	kg	757791.334	0.44	333428	HGV Lorry/ Truck	21	19	398	66	188	HGV Lorry/ Truck	28	19	530	88	251
	Paint	l	3714.6624	0.659	2448	HGV Lorry/ Truck	19	0	2	0	1	HGV Lorry/ Truck	57	0	5	1	3
	Granite	kg	19377.92	0.31	6007	Bike	0	194	0	0	0	Bike	0	194	0	0	0
	Total material emissions per functional unit ($kg\text{-}CO_2e$)				16	Total material emissions per functional unit ($kg\text{-}CO_2e$)					0	Total material emissions per functional unit ($kg\text{-}CO_2e$)					0
System Type: Floor, System Name: Flooring System, Area(sq. m.): 32,711,774	Cement floor screed (concrete screed)	kg	588811932	0.18	105986148	HGV Lorry/ Truck	34	14720	500490	83415	236899	HGV Lorry/ Truck	27	14720	397448	66241	188125
	Soil	kg	0.00	0	0	Bike	0	0	0	0	0	Bike	0	0	0	0	0
	Vitrified ceramic floor tiles	kg	588811932	0.68	400392114	HGV Lorry/ Truck	34	14720	500490	83415	236899	HGV Lorry/ Truck	27	14720	397448	66241	188125
	Total material emissions per functional unit ($kg\text{-}CO_2e$)				15	Total material emissions per functional unit ($kg\text{-}CO_2e$)					0	Total material emissions per functional unit ($kg\text{-}CO_2e$)					0

EMBODIED CARBON

	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 shop (km)	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (liters)	Transport Emissions 1 (kg -CO_2 e)	Type of Vehicle used	(1) Distance from Retail shop to Site (km)	(2) No. of trips	(3) Total distance = (1)* (2) (km)	(4) Total Fuel Consumed = (3)/Mileage (liters)	Transport Emissions 2 (kg -CO_2 e)
System Type Roof, **System Name** Roofing System, **Area(sq. m.)** 16358.87	China mosaic	kg	2617.44	0.67	1754	HGV Lorry/ Truck	34	0	2	0	1	HGV Lorry/ Truck	27	0	2	0	1
	Polyurethane (PU) Foam	kg	171768.135	2.6	446597	HGV Lorry/ Truck	21	4	90	15	43	HGV Lorry/ Truck	28	4	120	20	57
	Polyethylene Foam High Density	kg	1717.68135	2.9	4981	HGV Lorry/ Truck	21	0	1	0	0	HGV Lorry/ Truck	28	0	1	0	1
	XPS	kg	320633.852	2.9	929838	HGV Lorry/ Truck	21	8	168	28	80	HGV Lorry/ Truck	28	8	224	37	106
	Steel reinforcement (steel rebar)	kg	12,269.15	2.6	31900	HGV Lorry/ Truck	12	0	4	1	2	HGV Lorry/ Truck	30	0	9	2	4
	Ready mix concrete with ordinary Portland cement (OPC)	kg	1214646.1	0.11	133611	HGV Lorry/ Truck	12	30	364	61	172	HGV Lorry/ Truck	30	30	911	152	431
	Total material emissions per functional unit (kg -CO_2 e)				**95**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**
System Type Fenestration, **System Name** Fenestration, **Area(sq. m.)** 10,159.401	Aluminum sheet	kg	27086.4	32	866765	HGV Lorry/ Truck	22	1	15	2	7	HGV Lorry/ Truck	25	1	17	3	8
	Aluminum extruded profile (window frame)	kg	81275.208	26	2113155	HGV Lorry/ Truck	22	2	44	7	21	HGV Lorry/ Truck	25	2	51	8	24
	Glass	kg	2550.009651	0.85	2168	HGV Lorry/ Truck	19	0	1	0	1	HGV Lorry/ Truck	17	0	1	0	1
	Low- E Glass	kg	920.4417306	2.37	2181	HGV Lorry/ Truck	550	0	13	2	6	HGV Lorry/ Truck	19	0	0	0	0
	Total material emissions per functional unit (kg -CO_2 e)				**294**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**
System Type Structural, **System Name** Column, **Area(sq. m.)** 164	Ready mix concrete with fly-ash (30% pozzolana)	kg	290812.5	0.084	24428	HGV Lorry/ Truck	12	7	87	15	41	HGV Lorry/ Truck	30	7	218	36	103
	Steel reinforcement (steel rebar)	kg	18562.5	2.6	48263	HGV Lorry/ Truck	12	0	6	1	3	HGV Lorry/ Truck	30	0	14	2	7
	Total material emissions per functional unit (kg -CO_2 e)				**443**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**	**Total material emissions per functional unit** (kg -CO_2 e)					**1**
System Type Structural, **System Name** Slab, **Area(sq. m.)** 340297.4	Ready mix concrete with fly-ash (30% pozzolana)	kg	48634551.9	0.084	4085302	HGV Lorry/ Truck	12	1216	14590	2432	6906	HGV Lorry/ Truck	30	1216	36476	6079	17265
	Steel reinforcement (steel rebar)	kg	491258.1	2.6	1277271	HGV Lorry/ Truck	12	12	147	25	70	HGV Lorry/ Truck	30	12	368	61	174
	Total material emissions per functional unit (kg -CO_2 e)				**16**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**
System Type Structural, **System Name** Beam, **Area(sq. m.)** 142.3375	Ready mix concrete with fly-ash (30% pozzolana)	kg	133123.935	0.084	11182	HGV Lorry/ Truck	12	3	40	7	19	HGV Lorry/ Truck	30	3	100	17	47
	Steel reinforcement (steel rebar)	kg	2716.815	2.6	7064	HGV Lorry/ Truck	12	0	1	0	0	HGV Lorry/ Truck	30	0	2	0	1
	Total material emissions per functional unit (kg -CO_2 e)				**128**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**
System Type Structural, **System Name** Footing, **Area(sq. m.)** 1754.8	Ready mix concrete with fly-ash (30% pozzolana)	kg	468482.4	0.084	39353	HGV Lorry/ Truck	12	12	141	23	67	HGV Lorry/ Truck	30	12	351	59	166
	Steel reinforcement (steel rebar)	kg	40737.6	2.6	105918	HGV Lorry/ Truck	12	1	12	2	6	HGV Lorry/ Truck	30	1	31	5	14
	Total material emissions per functional unit (kg -CO_2 e)				**83**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**	**Total material emissions per functional unit** (kg -CO_2 e)					**0**

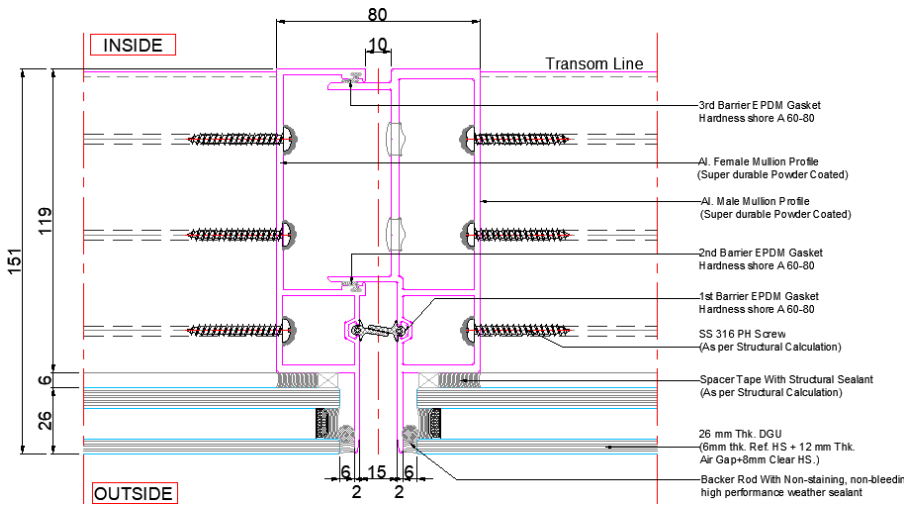
ENERGY PERFORMANCE :

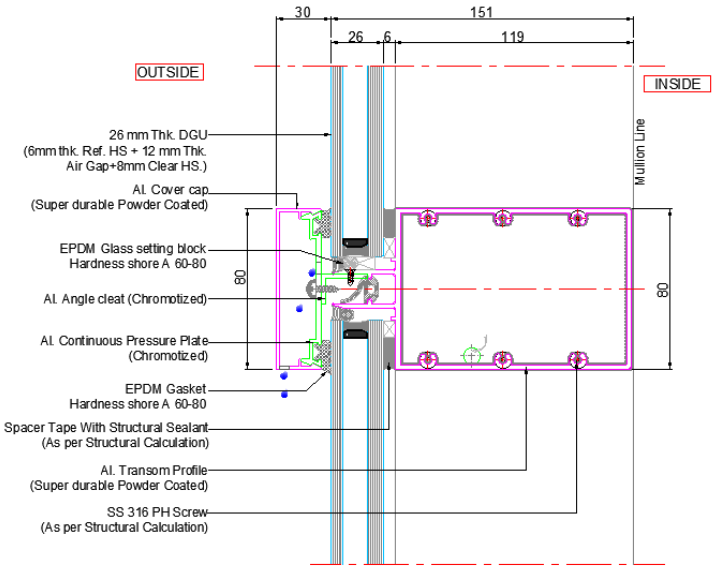
DOUBLE GLASS UNIT



- DGU (Double Glass Unit) / IGU (Insulated Glass Unit) :
  - Used for façade safety and increased thermal performance
  - Two glasses are processed and bonded using structural sealant
  - The gap between the two is filled with either Air / Argon (contains Air upto 5-10%)

UNITIZED GLAZING TYPICAL SYSTEM (NON-THERMAL) is used for facade.

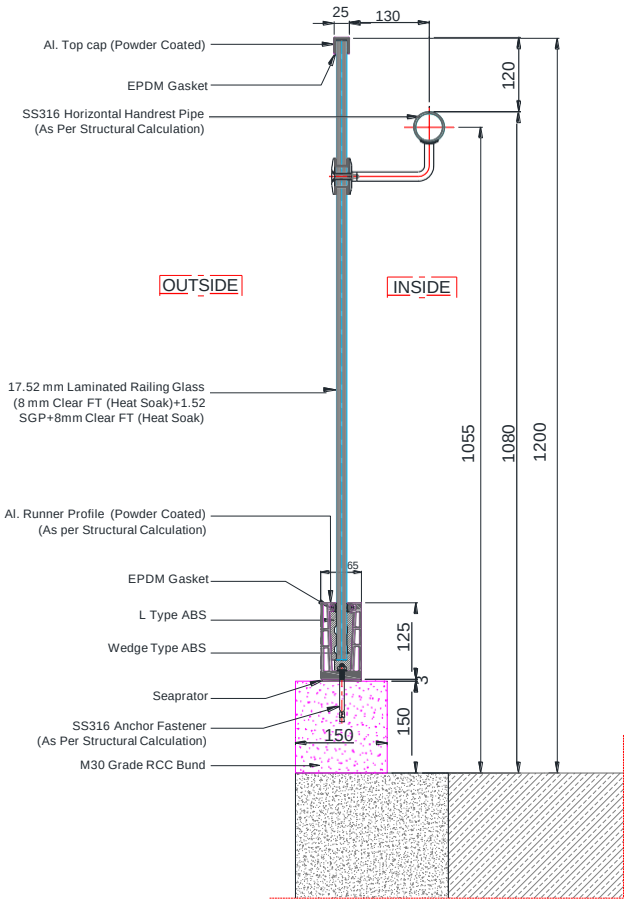




STONE CLADDING FIXING DETAIL

TRANSVERSING BMU SYSTEM IS USED FOR FAÇADE CLEANING AND MANAGEMENT SYSTEM.

SEAMLESS GLASS RAILING



TYP. RAILING SECTION DETAIL