Solar™ Decathlon India

TEAM MERAKI

JAMIA MILLIA ISLAMIA

OFFICE BUILDING

FINAL REPORT – APRIL 2021

2. TABLE OF CONTENTS

3. LIST OF TABLES

4. LIST OF FIGURES

5. EXECUTIVE SUMMARY

We the Team Meraki, is a multidisciplinary 15-member student cohort of Jamia Millia Islamia with complementary backgrounds and skills working towards the common goals of Solar Decathlon India competition and upholding the true meaning of the term 'Meraki' symbolizing a piece of yourself (your soul, creativity, or love) in your work. In the due course of the competition we have learnt that collaborative design is an essential approach for sustainable building integration, which leads to higher space efficiency, material conservation, energy consumption reduction, building aesthetics and so on.

Our esteemed project partner Tata Realty & Infrastructure provided us an opportunity to work on the Phase 2 of their project "The Intellion Park" located in Sector 58, Gurugram, Haryana which is proposed as a 5 Million Sq.Ft IT/ITES SEZ spread over 25 Acres. The phase 2 of the project consists of 2 Towers with a built-up Area of 1,38,510 Sq.M. The phase 2 will accommodate 12,000 professionals in one shift and 24,000 in a day since it's a two shift IT SEZ development.

Our journey of the competition began by setting our goals right at the beginning, which we highlighted and updated in the previous and current submission. These goals became our objectives aligning to the 10 contests of the competition. To summarize in brief our endeavour has been to design a development which is self-sustaining in managing its energy, water and waste while it ensures the experience of all the stakeholders is comfortable, enriching and cost-effective without compromising on its integrity.

During the course of competition we have numerous software to iterate our building design, form and orientation to achieve EPI of 150 kWh/ Sq.M/Yr as of now. We studied the IMAC and various standards to achieve thermal and visual comfort through our proposed radiant cooling system. We broke down NBC water requirement value and optimised the daily and annual water balance to achieve overall 85% water autonomy. We have tried to make our building resilient to issues of urban flooding, air quality and infection control through various strategies. We have innovated to create an energy conscious and a healthy environment for its occupant while proposing a prototype landscape structure for smog cancellation and rainwater harvesting. We have designed floor plates which provide flexibility in leasing, proposed MIVAN construction and EPS sandwich panels which will improve affordability, quality and construction time of the project. We have addressed the needs of occupants in terms of wellbeing while ensuring seamless integration of services with architectural spaces. The building services and structure have been iterated as per simulation and architectural inputs for an integrated design solution.

The major challenge we faced was dealing with the scale of the project and its occupancy which makes it demand intensive in all the respects. We initiated with breaking down the demand side and optimise it backed by research and multiple standards. Once the demand was at the lowest we started supplementing it and made interventions to our supply side. It was never a linear process, a lot of back and forth happened before we could come up with design solutions. We have tried to approach our design in a manner which negates the thought that sustainability is expensive. Systems selection were approached with two thoughts, cost impact and availability, to which we are also adding the embodied energy perspective to understand implications in terms of energy and carbon emissions.

6. TEAM INTRODUCTION

Team Name - Team Meraki

Institution Name - Jamia Millia Islamia, New Delhi

Division - Office Building

Jamia Millia Islamia

The 'Faculty of Architecture & Ekistics' at JMI offers bachelor's degree courses in Architecture, six master's courses and Ph. D., FA+E is aimed to produce individuals who should be sensitive towards -pain, -plight, -pleasure, -happiness, -comfort, -leisure, -aspirations, -expectations of the people. Responsive towards- nature, -society and nation. Alive to – Indian ness & Human values.

Table 1 - Team Members

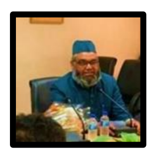
TEAM MEMBERS	QUALIFICATION	ROLE
Sana Paul	Pursuing B. Arch	Team Leader
Juhi Sharma	Pursuing M. Arch Building Services	Energy Analysis & Simulation
Mahtab Alam Saifi		Financial Analysis and Market Potential
Pravar Gupta		Sustainability & Green Design
Ahmed Suhail Choudhury	Pursuing B. Arch.	Thermal Comfort, IAQ & Ventilation
Mohammed Roushell Khan		Façade Design & Presentation
Nishita Agrawal		Building Envelope & Passive Design
Saleheen Rizwan		Interior & Layout Design
Sharon Kaul		Landscape Design
Sonakshi Sharma		Psychology & Environmental Design
Stuti Jain		Passive Strategies & Architectural Planning
Vishwajeet Gupta		Architectural Drawings and Planning
Hammad Mohammad Shakir	Pursuing B. Tech Electrical	Energy & Lighting Analysis
Mohammad Usman Siddiqui	Pursuing B. Tech Civil	Structural & Plumbing System Design
Suhaib Ur Rehman	Pursuing B. Tech Mech.	Mechanical Systems Design

Faculty Lead

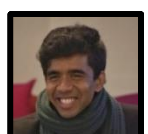
Dr. Hina Zia (*HOD*)
B. Arch, M. Plan, Ph.D.

Faculty Advisors

Dr. Nisar Khan
(Associate Professor)
B. Arch, M. Arch, Ph.D



Dr. Ahteshamul Haque
(Assistant Professor)
B. Tech, M. Tech.,Ph.D



Ar. Iqtedar Alam
(Assistant Professor)
B. Arch, M. Arch, Urban

Ar. Ramya Kuchhal
(Assistant Professor)
B. Arch, Master of Landscape

Ar.Mod Zaheer Abidi
(Assistant Professor)
B.Arch., M - Ekistics

Eng. Adil Ahmad
(Associate Professor)
B.Sc. Engg., M.Sc. Engg. (Structures)

Industry Partners

PSI Energy Pvt. Ltd. are consultants and trainers in sustainability, energy efficiency, passive design, human (thermal, visual and acoustic) comfort, lighting analysis, building physics, building energy systems and renewable energy solution

PSI
PARTNERSHIPS FOR SUSTAINABLE INDIA

Fenesta are known to make windows and doors that are built to last, environment friendly, energy efficient, recyclable and insulate against dust and pollution, making it a natural choice when you're seeking green solutions.

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7. PROJECT BACKGROUND

Project Name - Intellion Park, Gurugram
Project Partner - TATA Realty and Infrastructure Ltd.
TATA Realty has evolved into one of the fastest growing real estate development companies in India. With the primary business being development of properties in residential, commercial and retail sectors, the company's operations span across various aspects of real estate development.

Key individual involved-
Mr. Malay Saurav – Vice President & Head MEP, Tata Realty
Mrs. Devi Karnani – Dy. General Manager , R & D (Structures), Tata Realty

Brief description of Project
Intellion Park is proposed by TATA Realty as a unique podium-style IT/ITeS, and SEZ (for Electronic Hardware) campus development, with intent of providing expansive workspaces, lush greenery and world-class amenities. Intellion Park Gurugram is being envisioned as the next IT destination in the making, with six towers spread over 25.24 acres. We will be designing 5Th & 6th Tower with BUA of 1,38,510Sq.M of the development as the scope for the competition.

Figure 1– Project Site Satellite View

Context and Market Analysis
This part of the district of Gurgaon is slowly experiencing new and an upgraded emerging trend in terms of improvement in infrastructure, new roads development, etc. As the area will achieve good connectivity through sector level roads development by HUDA and through the existing southern peripheral road and Golf link road and railways, hence these factors are likely to attract the IT sectors to come up and set their office. The proposed project will lead to following benefits:

- Improvement in social infrastructure by providing additional employment opportunities to the skilled as well as unskilled people;
- Trigger growth in the district and in the region as the area will be developed and will result in associated development;
- The planned development with modern infrastructure facilities and source of income would improve quality of life of local community.

Profile of occupants- National & International IT companies and professionals
Hours of operation- 24 hours (two shifts)
Estimated total built-up area - For Towers 5 and 6 – 1,38,510 Sq.M
Special requirements of the Project Partner:

- Smog/dust control mitigations with C&D waste management
- Mitigation of PM emissions from DG
- Net zero water management

PHASE	TOWER	STAGE & COMPLETION YEAR	
Phase-I A	1 & 2	Under construction	2021
Phase-I B	3 & 4	Basement constructed	2022
Phase-II	5 & 6	No construction	2024

Table 2 – Project Timeline

We have referred to The Haryana Building Code 2017 and NBC 2016 other provisions for Fire and developments. Table 3 – Building Area Program

AREA STATEMENT				
DESCRIPTION				
TOTAL PLOT AREA	102143			
PHASE 1 (TOWER 1,2,3&4)	58,423.00			
PHASE 2 (TOWER 5&6)	43720			
PERMISSIBLE GROUND COVERAGE (40% OF PLOT AREA)	40857			
REMAINING GROUND COVERAGE (excluding tower 1,2,3&4)	27229			
PROPOSED GROUND COVERAGE (TOWER5&6)	7570			
PERMISSIBLE FAR INCLUDING GREEN BUILDING FAR (2.75 OF PLOT AREA)	280893			
REMAINING FAR (excluding Tower 1,2,3,& 4)	120601			
PROPOSED FAR (TOWER5&6)	120460			
BUILT-UP AREA FOR SINGLE FLOOR PLATE	3645			
TOTAL BUILT UP AREA FOR TOWER 5&6	138510			
FAR AREA FOR SINGLE FLOOR PLATE	3240			
TOTAL ROOF AREA (TOWER 5&6)	9658			
CUT-OUT SINGLE FLOOR	228			
STAIRECASE SINGLE FLOOR	177			Unconditioned
REFUGE AREA (SINGLE FLOOR)	379			Unconditioned
LANDSCAPE AREA	21222			
OCCUPANTS DETAIL				
NUMBER OF REGULAR OCCUPANTS	12000			
APPROXIMATE DAILY VISITORS PER DAY (5%)	600			
SERVICE STAFF (10%)	1200			
TOTAL	13800			
AREA PROGRAM FOR SINGLE TOWER (TOWER 5& 6)				
OFFICE SPACE/FLOOR	OCCUPENTS / PF	AREA / PP (SQM)	TOTAL AREA (SQM)	
OPEN WORK STATIONS	300	6.5	1950	Mix mode
CLOSED WORK STATION	26	13	338	Mix mode
HEAD OFFICE	4	15	60	Mix mode
CONFERENCE ROOM [Type 1]	10		23.27	Conditioned
CONFERENCE ROOM [Type 2]	20		38.8	Conditioned
RECEPTION			8.3	Conditioned
WAITING AREA			18.6	Conditioned
PRINTING AND FAX AREA	12	2.3	27.6	Mix mode
REFERENCE LIBRARY		35	35	Mix mode
RECYCLING SATIONS		2.3	2.3	Mix mode
MAIL AREA		2.4	2.4	Mix mode
INTERVIEW ROOM		12	12	Conditioned
NOOK/ COFFEE COUNTER		5.8	5.8	Mix mode
MEDIC ROOM			20	Conditioned
PANTRY			16	Mix mode
RESTROOMS			48.8	Mix mode
STORAGE		1.2 (PER SHELVES)	50	Mix mode
TOTAL			2651.8	
TOTAL AREA WITH @30% circulation			3447.34	
			Conditioned Spaces	120.97
			Unconditioned spaces	-
			Mix mode spaces	2535.9
NON OFFICE SPACES	OCCUPENTS / PF	AREA / PP (SQM)	TOTAL AREA (SQM)	
AUDITORIUM	500	2.3	1150	Conditioned
FOODCOURT	100	1.8	180	Mix mode
CAFÉ (2)	50*2	1.8	180	Mix mode
CANINE CARE			50	Mix mode
CRECHE		1.1	50	Mix mode
GALLERY	100	1.1	110	Mix mode
GYM + GAMING ARCHADE			650	Mix mode
TOTAL			2370	
			Conditioned Spaces	1150
			Unconditioned spaces	-
			Mix mode spaces	1220

8. PERFORMANCE SPECIFICATION

Input Parameters	**Units**	**Proposed Design Values**
Climate Zone		**Composite**
General		
Building Area	m^2	**1,38,510**
Conditioned Area	m^2	**1,00,387.32**
Electricity Rate	INR/kWh	**8**
Natural Gas Rate	INR/GJ	
Building Occupancy Hours	-	**24 Hr**
Average Occupant Density	m^2 / person	**10**
Internal Loads		
Interior Average Lighting Power Density	W/m^2	**5**
Average Equipment Power Density	W/m^2	**15**
Minimum OA Ventilation (Building Average)	l/sec.m^2	**1.3**
Envelope		
Roof Assembly U value	W/m^2.K	**0.366**
Roof Assembly SRI		**0.7**
Average Wall Assembly U value	W/m^2.K	**0.245**
Window to Wall Area Ratio (WWR)	%	**28**
Windows U value	W/m^2.K	**1.76**
Windows SHGC		**0.25**
Windows VLT	%	**59**
Infiltration Rate	ac/h	**0.70**
Describe Exterior Shading Devices		**600 MM Overhang**
HVAC System		
HVAC System Type and Description	-	**Radiant + DOAS**
Heating Source	-	**Electric**
Heating Capacity	kW	**4136**
Cooling Source	-	**Electric**
Cooling Capacity	kW	**13323.77**
STP Technology		**MBBR (600 kLd)**
RE Sources		**Solar & Biogas**

9. GOALS & STRATEGIES

Table 4 – Goals & Strategies

	GOALS	STRATEGIES
Energy Performance	Reduce direct solar heat gain during summer months and maximise the solar exposure during winter months. Reduce thermal load inside the building.	We did iterations for reduction in heat gain through building envelope components by optimising the built form, orientation, self-shading capabilities, zoning internal spaces, courtyard planning, high thermal mass construction, thermal insulation of walls and roofs, window wall ratio (28%), shaded building components, high performance DGUs with low SHGC.
	Reduce the cooling, heating and ventilation annual energy demand for optimum thermal comfort	Reduced cooling and ventilation annual energy demands up to 70% by designing for natural & mixed-mode ventilation to ensure thermal comfort. Achieved system design at 496 Sq.Ft/ TR or more. We plan to further reduce it to 600 Sq.Ft/TR
		Integrated the low energy cooling technologies - radiant cooling and heating for further reducing the annual energy consumption.
	Reduce the artificial lighting, electrical load and equipment annual energy demand	We reduced lighting energy demand by designing optimum fenestrations to ensure 100% daylit spaces, artificial lighting with lower LPD and uniformity. 50% reduction of plug loads by the use of energy efficient technologies and appliances.
Water Performance	Reduce operational & construction water demand of the building	Reduction and optimization in water demand water right from the foundation construction by reducing embodied water demand to the daily and annual water demand of the building by using low flow fixtures. Optimised the NBC 2016 recommended lpcd values as per the low flow fixtures for system sizing.
	Reuse the treated waste water for non-domestic purposes while ensuring water quality	STP has been proposed for high quality treated water to meet 100% non-potable water demand.
	Reduce annual irrigation water demand	Reduction of irrigation demands by designing water efficient landscaping technique (xeriscaping), and selecting native vegetation with lower plant factor along with integrated with soil moisture sensors.
	Maximise the rainwater harvesting potential of the development	Rainwater harvesting for supplementing annual potable water demand and UV purification system for potable water treatment. Ensure zero discharge from site along with mitigation strategies for urban flooding.
Resilience	Mitigate impacts of urban flooding	Silva cells and swales are integrated in landscape.
	Manage ambient air quality.	Smog Cancellation facades and smog eating sculptures are proposed.
	Infection control & COVID-19 preparedness	Enhance cleaning protocols, leverage hands-free tools, automation and voice activation, Implement screening procedures at entries i.e. IFSS, Smart Material Application are introduced.

Affordability | Scalability & Market Potential	Reduce construction cost and time. Reduce the operational cost. Create modular spaces for flexibility in offering.	The team has tried address the growing affordability challenges by identifying the needs, modernizing O&M best practices and selecting energy efficient construction materials and MEP systems designs that will yield financial dividends for years to come. The design will aim to reduce the on-site construction time and the. The flexibility in design will provide the users an opportunity of maximising the occupancy and provide a more customisable space efficient design. The design intent of the competition will also ensure minimum operating cost for the users.
Innovation	Create energy conscious environment for occupants	Practising healthy policy of waste management from the initial stage.
	Occupant well being	Break-out spaces and balconies are provided on each floor.
	Rainwater harvesting and smog cancellation	We have proposed a prototype landscape feature for the same.
Comfort & Environment Quality	Ensure maximum thermal and visual comfort	We have tried to ensure compliance as per adaptive thermal comfort model conditions by simulation and manual sizing of building components. Maximized the use of passive techniques to ensure comfort. 100% Shaded, glare-free, 100% day lit floor plates are designed. IAQ is being ensured by DOAS, filtration and smog cancelling techniques highlighted in resilience.
Architectural Design	Ensure functionality, flexibility, aesthetics, seamless integration of services and coherence with Phase 1 design.	We have created spaces aesthetically appealing and in response to contextual towers. We have created the possibility of having different kinds and sizes of companies by creating a flexible concept. We have planned site features and landscape as to create spaces or adopt the most innovative ways to shed away the mundane routine that shall create a difference in the market. The research oriented approach has helped us cater to the occupants in relation to the context, occupants' lifestyle and provide a user experience for the same. The aesthetics in itself a part of the functionality and comfort is a representation of a sustainable design celebrating the larger context.
Engineering Design & Operations	Efficient & Optimised design of MEP and structural systems.	We have designed of HVAC systems dependent on cooling requirements and functionality of space. Design of structure as seismic conditions and embodied energy reduction. Electrical systems have been sized and optimised for decreased loads and consumption, energy efficient appliances have been considered.
	Coordination for simulation and architectural input integration	We have iterated the design of services to integrate the simulation and architectural consideration. Renewable energy sources sizing and close loop water cycle have been approached as per the inputs.

10. DOCUMENTATION OF DESIGN PROCESS

In the initial phases of competition we started by getting in touch with our project partners to understand their project, aspirations and requirements. We had couple of meetings to acquaint ourselves with their team, processes and ideologies. This helped us set some basic goals which managed to satisfy competition as well as the TATA Realty's expectations from their project. The goal setting required referring to best practices around the world, study their impacts and also innovate with upcoming interventions which yield better performance results.

We intensified our literature research post the goal setting and then we backed the real-time execution and benchmarks by numerous secondary case studies and presented some observations in the previous submission. We studied developments ranging over multiple climate zones to understand the impact of a similar technology or strategy on varied climatic factors. We identified and understood the best active and passive features for our climate zone i.e composite.

We kept reaching out to industry partners when we were stuck technically apart from referring to the modules which were very comprehensive in imparting right amount of knowledge. One of the biggest resources we have is the academia support from four departments of our university where hundreds of faculties and research scholars are into technology identification and development. We approached various faculties and scholars who we identified are researching in fields that can be part of our design solution. These faculties and scholars then further connected to us professionals and organizations who contributed to our understanding. So subsequently our network grew and we had multiple insights into the technologies.

The timeline we have stuck to is as given in table below:

MONTH	TAKS
October	Problem identification and quantification. Area Analysis/ Climate Analysis/ Site Analysis/ Contextual Analysis. Preliminary estimate of on-site renewable energy generation potential.
November	Conceptual stages of the building design. Detailed Pre-design Analysis.
December/Early January	Basic Designing and Tentative Building structure. Detailed Report on the possible ways to tackle the parallels given by Project Partners, working with Industry Partners by Early January.
February	Drawings, Calculations and Simulation Details, MEP Design, HVAC Design and Simulation. Design integration and Working Drawings along with basic estimation.
March	Cost estimation and project detailing
April	Final Detailed Project Report and Presentation.

Table 5 – Team Meraki Timeline

Although the Pandemic season had its quirks, it helped us document the whole competition using Work Documents and Presentations, which may or may not be documented otherwise. The permutation and combination of Architects and Engineers have made possible to interrelate the 10 said contests. For example, engineering Design + Architecture Design, Psychology + Energy Performance and many other. Good communication and positive working relationships to being upfront on responsibilities and managing conflicts the right way has made this journey of research, discussions, learning and getting to know about the other fields involved in the Design and Construction. Paving way to what we call a 'hollistic approach'.

CONCEPTS & INITIAL THOUGHT PROCESS

For a healthy and energy-efficient office building "with ample daylight, multiple green areas and sufficient space for both creative interaction and individual concentration". Surrounded by a green veil with plants and trees that connect the outer spaces acting as breakout zones and the building, the main focus is on nature inclusion. In fact, "the green spaces in, on and around the building play a connecting role and ensure that the people working in the office come into contact with each other and the outside world".

Highly flexible office utilizes natural ventilation through the passive techniques and its orientation. Through this form we can achieve our goals as the curved main façade hovers over shading the building and create direct visual dialogue between the offices and the outdoors. The courtyard enables passive cooling and cross-ventilation while maximizing internal natural light. Office building should be able to create a resonant magnetic field between the corporate culture and outdoors, and become the "second home" of workers to shape a unique "sense of belonging" and "can relate to habitat".

Standards that formed the basis for Design

Energy Performance & Comfort Control Systems –

Energy Conservation Building Code (ECBC) 2017, ASHRAE 90.1 - 2013

Water Demand, Supply & Performance –

National Building Code (NBC) 2016, National Plumbing Code (NPC), IGBC NC

Comfort & Environment-

Indian Adaptive Thermal Comfort Model NBC & CEPT, ISHRAE Standards for IAQ, ASHRAE 62.1 - 2019

Architecture –

Haryana Building Bye-Laws, Time Saver Standards

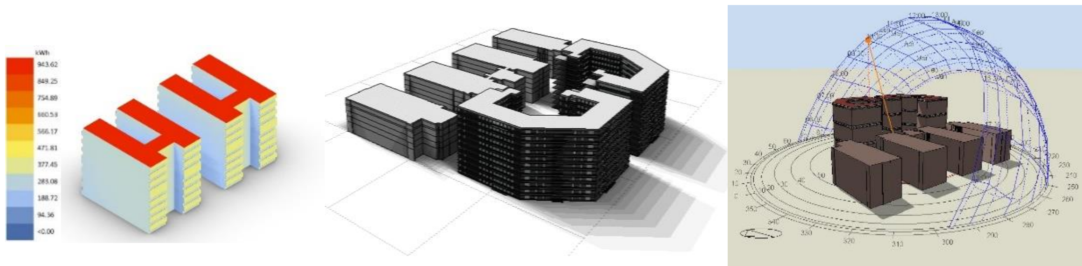


Figure 2 – Design Modeling on Rhino, Ecotect & Design builder

For initial design development we used combinations of multiple software to verify the analysis results across multiple platforms and check their coherence with national standards. The software we relied heavily on were Rhino 6 + Grasshopper, Square One Ecotect & climate consultant. Further into the competition we moved to more advanced software and tools like Design Builder 6.1.7 for energy and comfort simulations and Revit 2020 for creating design models, layouts, renderings and quantity calculation. Various scenarios were modeled on design builder to study the energy performance which has been documented in report below.

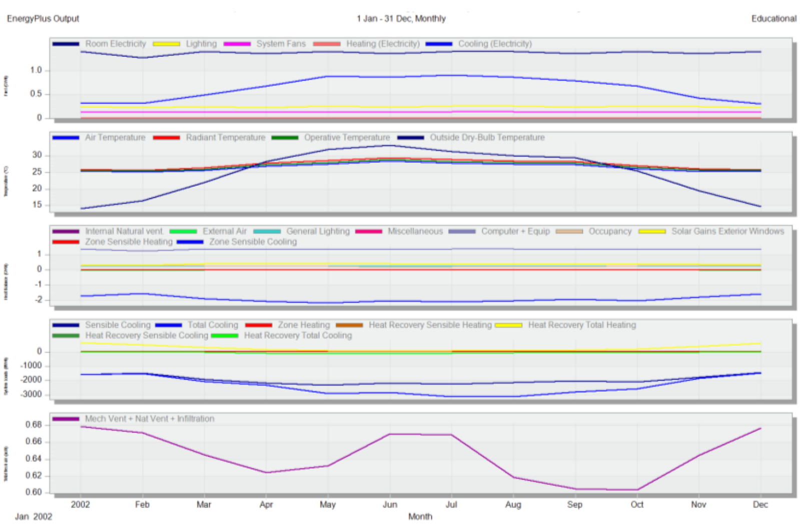


Figure 3 – Design Builder Simulation Monthly Analysis Result for initial design case

In energy performance have optimized the high side mechanical requirements on design builder and manage the electrical load to reduce the annual energy consumption. Also, take informed decisions on sizing of RE sources keeping financial feasibility as prime consideration. In water performance have optimised by further impacting the demand side with researched consumption baselines and ensure systems that energy efficiently treat water to ecommended quality levels.

The affordability we had intensive discussions with industry professionals and some assumptions for baseline. We have filled up the template provided and performed iterations to arrive at the optimum design solutions and also used industry partners & TRG's inputs on the same.

Innovations we have elaborated in terms of scaling up as a solution that is financial feasible. Scalability and market potential was researched and strategized to escalate the impacts of chosen construction technologies on time, quality and cost at the given scale.

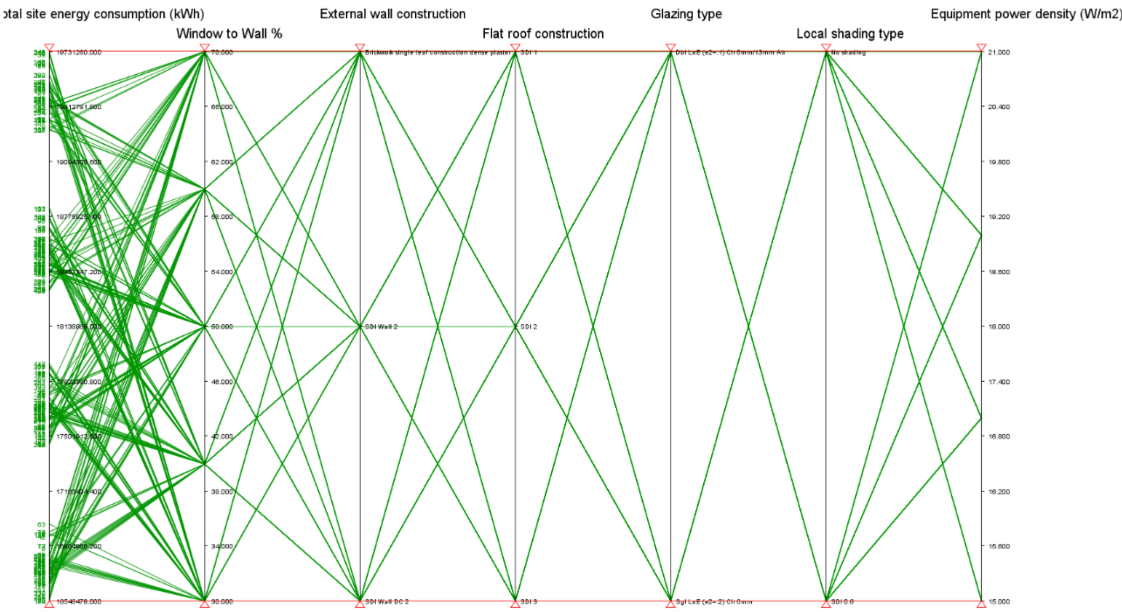


Figure 4 – Parametric Runs & Optimization of Building Parameters

Architectural design has been detail oriented in the this final stage so as to help us understand and create a more impactful communication with project partners and judges in terms of integration, design's ease of execution and implications if not a contemporary solution.

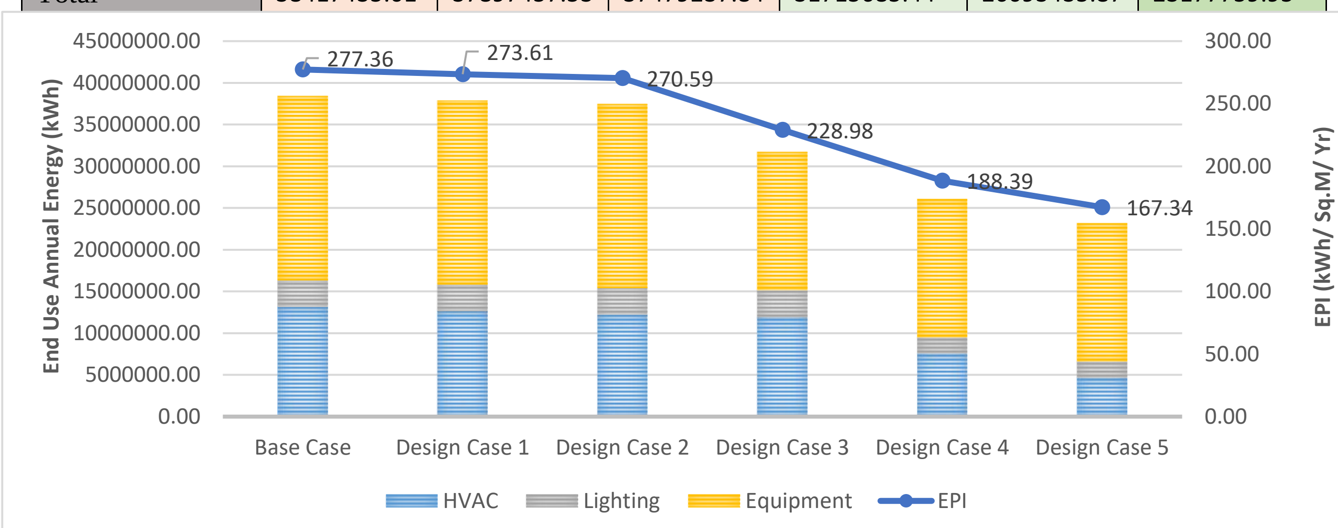
Engineering design and operations have been detailed out, the building automation systems which will integrate the energy management through field level devices and actuators for lighting and HVAC are proposed.

11. DESIGN DOCUMENTATION

1. Energy Performance

We have simulated using Design Builder 6.1.8 for annual energy performance of numerous scenarios optimizing the building envelope configuration, lighting and equipment load, HVAC systems integrating various passive & active techniques. In the tables below we have comprehensively documented proposed case, design cases and compared it with the base case EPI. We have also simultaneously mentioned the HVAC size and system. Heating, cooling, ventilation and fan load has been summarized in HVAC column below.

End Use Annual Energy (kWh)	Base Case	Design Case 1	Design Case 2	Design Case 3	Design Case 4	Design Case 5
HVAC	13151617.91	12631640.43	12213420.74	11945595.18	7591413.37	4675736.45
Lighting	3170169.40	3170169.40	3170169.40	3170169.40	1902101.64	1902101.64
Equipment	22095647.70	22095647.70	22095647.70	16599920.86	16599920.86	16599921.86
Total	38417435.01	37897457.53	37479237.84	31715685.44	26093435.87	23177759.95



Lighting Load	10				5	
Equipment Load	20			15		
HVAC System Specifications						
System Type	VAV (Air Cooled Chiller) + DOAS				VRF + DOAS	VAV (Water Cooled Chiller) + DOAS
DB Calculated System Size (TR)	5224	4677.05	3899	3793	3004	3004
TR/ Sq. Ft	285.29	318.7	382.2	392.93	496.13	496.13

Table 1.1 – Energy Simulation Summary

PROPOSED CASE

Proposed EUI (Total)	kWh/m²/ yr	**150.01**
Heating	kWh	**1474195.095**
Cooling	kWh	**7143667.506**
Fans	kWh	**3144787.39**
Pumps	kWh	**198051.1854**
Heat Rejection	kWh	**1311092.325**
Lighting	kWh	**1816713.434**
Equipment	kWh	**5689899.716**
Total Envelope Heat Gain (Peak)	W/m²	**31.4**

We have achieved an EPI of **150.01 kWh/Sq.M/Yr**,. CoPs have been considered as per minimum ECBC 2017 standards. One of the observation has been high equipment energy consumption. We aimed to reduce at least 10% from benchmark EPI of 159 as shared by SDI. We are proposing radiant cooling systems as final system which we will modelled to study the impact on building energy performance and comfort. Theoretically it can reduce the annual HVAC energy consumption upto 40% compared to VAV with water cooled chillers with similar capital investment. The integration of passive and active thermal comfort strategies have been elaborated along with other considerations in comfort and environment section. 64% reduction in HVAC loads, 40% reduction in lighting loads and 25% reduction in equipment loads has been achieved from base case by iterations. The integration of strategies has been highlighted in engineering design and operation section.

The 5 mWp system on building roofs of our two towers, courtyard and the existing four towers as shown in the figure is sufficient to make the lighting and HVAC annual energy consumption zero. But for meeting 100% demand including equipment we have introduced on-site biogas plant and BAPV, as per calculation 62% autonomy is achieved. Cost can be a major deciding factor. The system specifications are given in APPENDIX . For 100% autonomy additional 5 mWp Rooftop Solar PV system is required.

Monthly energy demand and supply difference has been documented in the table below.

Month	Demand (kWh)	Supply (kWh)				Difference
		Roof Top	Biogas	BAPV	Total	
January	1701797.888	473600	369452	35274	878326	48%
February	1504588.432	548800	333699	40875	923373	39%
March	1511899.664	739200	369452	55056	1163708	23%
April	1523649.576	785600	357534	58511	1201646	21%
May	1853606.696	845600	369452	62980	1278032	31%
June	1940465.888	765600	357534	57022	1180156	39%
July	2056127.592	676800	369452	50408	1096660	47%
August	2054810.864	698400	369452	52017	1119869	46%
September	1808954.528	688000	357534	51242	1096776	39%

Table 1.2 – On-site renewable energy comparison

October	1646010.152	696000	369452	51838	1117290	32%
November	1498796.456	583200	357534	43437	984171	34%
December	1677698.904	499200	369452	37180	905832	46%
Annual	**20778406.64**	**8000000**	**4350000**	**595840**	**12945840**	**38%**

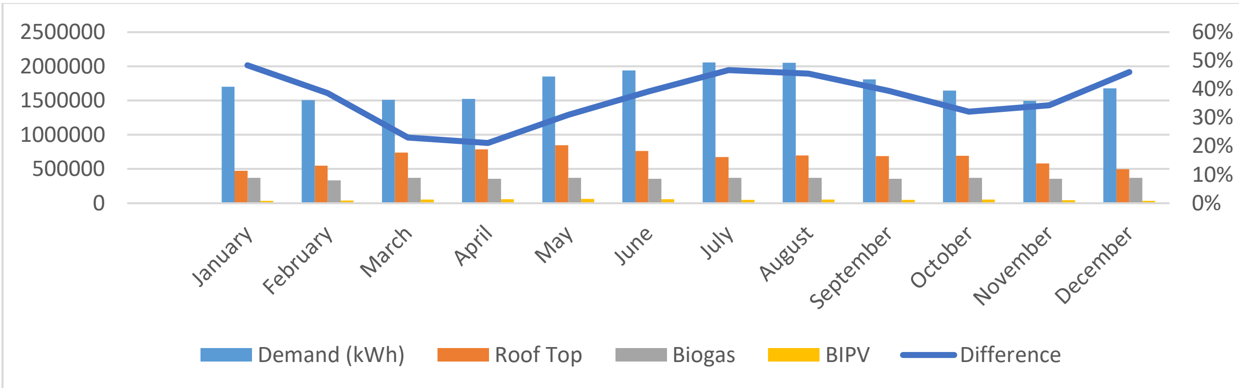


Figure 1.1 – Energy annual demand and supply summary

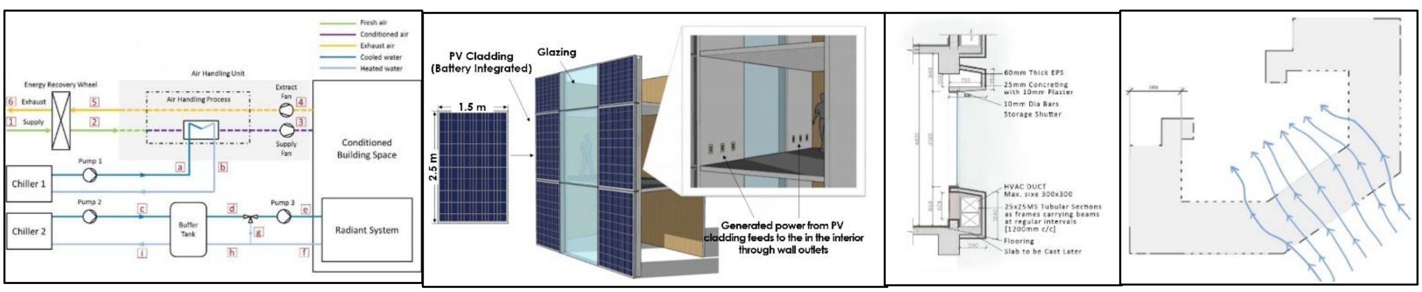


Figure 1.2 – Snippets of strategies highlighted in further sections to enhance energy performance

2. Water Performance

The per capita consumption suggested by NBC is further optimized as per IGBC water efficiency guidelines opting low-flow fixtures. The reduction in lpcd values have been summarized in the table below. As per an audit report of CSE Campus daily per person drinking water requirement is 1.6 Litres. The irrigation demand calculated is peak at 2 litre/Sq.M/Day which is 50% efficient from base case of 6 Litre/Sq.M/Day, native species and micro-drip irrigation has been proposed for 18, 058Sq.M of landscape area.

<table>
<tr><th rowspan="2">End Use</th><th colspan="2">Water Demand (LPCD)</th></tr>
<tr><th>Baseline (NBC)</th><th>Proposed</th></tr>
<tr><td>Flushing</td><td rowspan="2">20</td><td>8</td></tr>
<tr><td>Urinal</td><td>3</td></tr>
<tr><td>Lavatory Faucet</td><td rowspan="3">25</td><td>2</td></tr>
<tr><td>Health Faucet</td><td>9</td></tr>
<tr><td>Drinking Water</td><td>3</td></tr>
<tr><td></td><td>45</td><td>25</td></tr>
<tr><td>Reduction</td><td colspan="2">44%</td></tr>
</table>

Rainwater falling on roof, hardscape and softscape areas is harvested and stored in underground water tank having a separate chamber besides connected to municipal supply. From underground storage tank of 260 KL capacity, water is pumped to overhead tank on each tower, from where water is gravity fed to different outlets.

Table 2.1 – Proposed to Baseline Comparison

To cater the potable water demand of large population, inverted umbrellas are installed on ground that serves dual purpose of harvesting rainwater and simultaneously used as smog mitigation structure. The structure is discussed in detail in the innovation section. Roof areas of other 4 towers that have already been constructed in phase 1 are also taken to maximize quantity of harvested rainwater.

Surface	Area (Sqm.)	Runoff Coefficient	Effective Catchment Area (Sqm.)	Annual RWH potential (kL)
Building Roofs	9658	0.9	8692.2	6206.23
Proposed Structure	3702	0.95	3516.9	2511.07
Hardscape	14148	0.9	12733	9091.5
Soft-scape	18058	0.35	6320.3	4512.69
	11200	0.9	10080	7197.12
TOTAL			**41343**	**29518.6**

Table 2.2 – Run-off Calculations

Greywater generated from sinks and basins and blackwater generated from WCs and urinals is treated and reused in flushing, landscaping, lavatory and health faucets and HVAC make up water after requisite wastewater treatment by MBBR STP to meet water quality. The excess treated wastewater after its utilization in flushing, landscaping and HVAC system is diverted to groundwater recharge wells by ensuring its quality as per CPCB norms.

Based on the above observations water balance diagram has been created for peak demand and supply requirements for a daily FTE population of 24,000. The detailed SLD and layouts are included in the APPENDIX

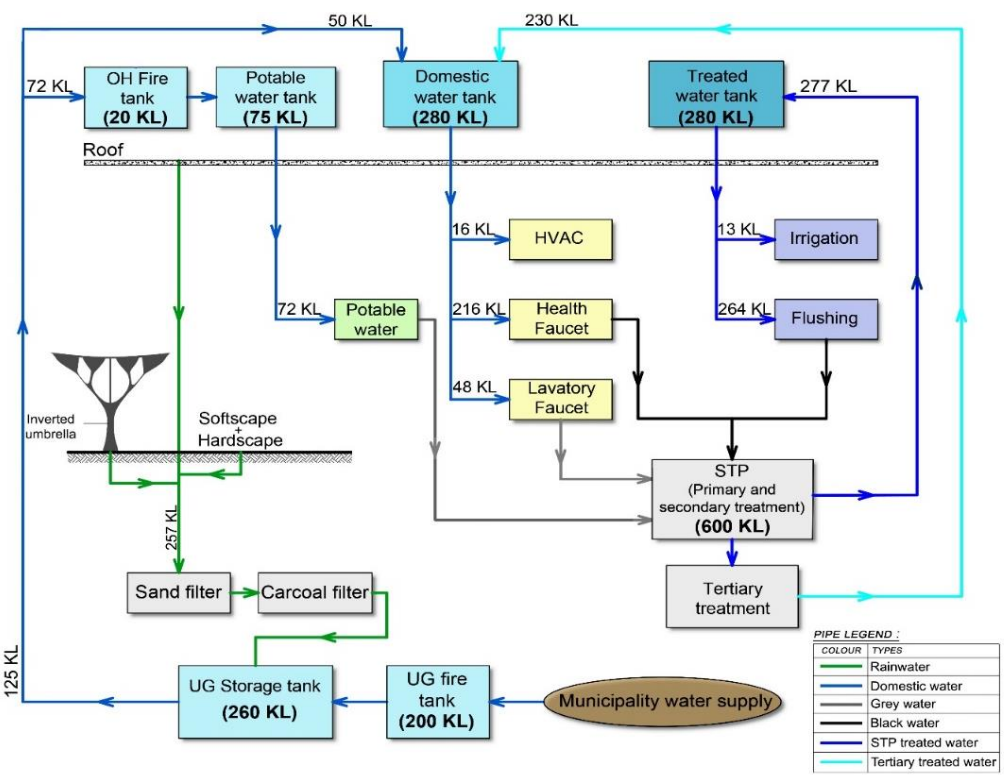


Figure 2.1 – Water Balance Diagram

In the table below we have calculated the annual water demand and supply which shows **85%** net water autonomy.

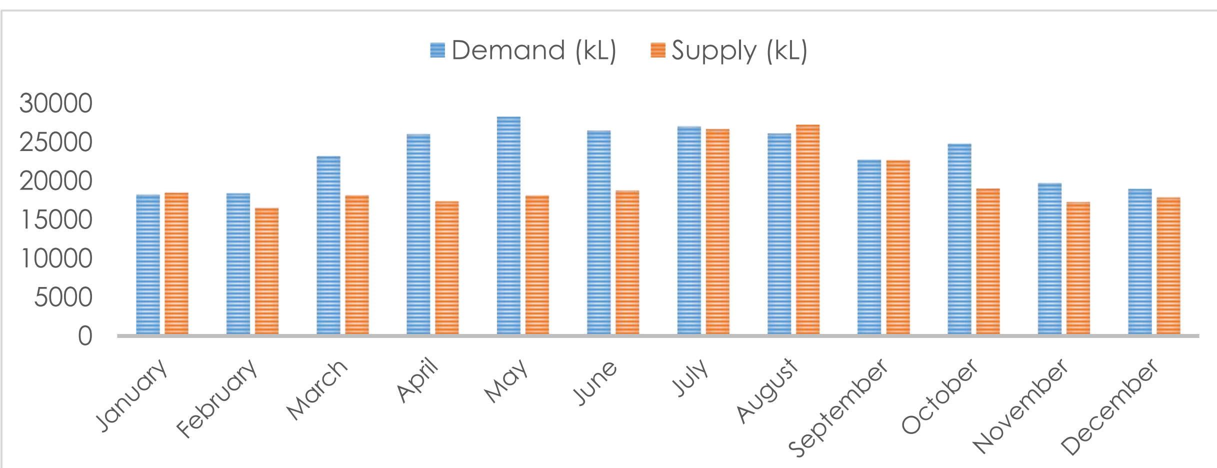


Table 2.3 – Annual water demand and supply summary

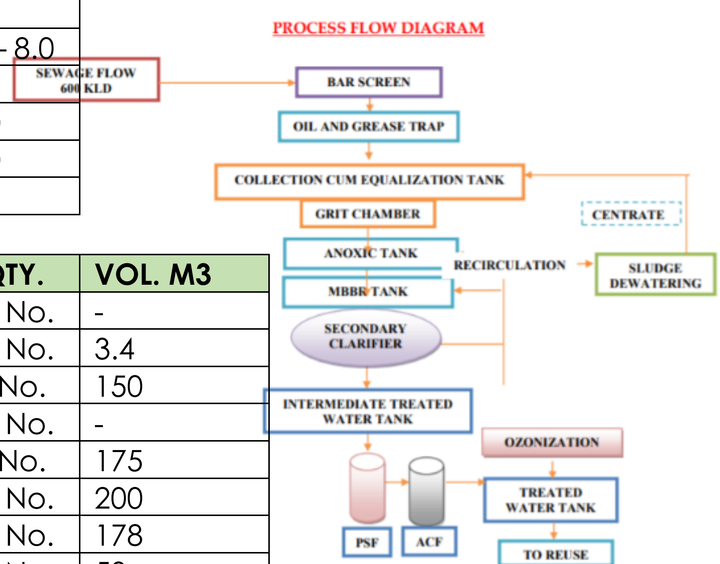
Month	No. Of Days	Demand (kL)						Supply (kL)			Demand Supply Gap (kL)
		Potable	Flushing	Lavatory Faucet	Cooling	Irrigation	**Total**	Rainwater	STP	**Total**	
January	31	2232	14136	1488	0	313	**18169**	764	17670	**18434**	**265**
February	28	2016	13440	1344	1260	283	**18343**	478	15960	**16438**	**-1905**

March	31	2232	14880	1488	4185	353	**23138**	430	17670	**18100**	**-5038**
April	30	2160	14400	1440	7650	341	**25991**	239	17100	**17339**	**-8652**
May	31	2232	14880	1488	9300	353	**28253**	382	17670	**18052**	**-10201**
June	30	2160	14400	1440	8100	341	**26441**	1624	17100	**18724**	**-7717**
July	31	2232	14880	1488	8370	20	**26990**	8980	17670	**26650**	**-340**
August	31	2232	14880	1488	7440	20	**26060**	9553	17670	**27223**	**1163**
September	30	2160	14400	1440	4500	190	**22690**	5493	17100	**22593**	**-97**
October	31	2232	14880	1488	6045	118	**24763**	1290	17670	**18960**	**-5803**
November	30	2160	14400	1440	1350	341	**19691**	143	17100	**17243**	**-2448**
December	31	2232	14880	1488	0	313	**18913**	143	17670	**17813**	**-1100**
Total		**26280**	**174456**	**17520**	**58200**	**2986**	**279442**	**29519**	**208050**	**237569**	**-41873**

Table 2.4 – MBBR STP DESIGN BASIS

PARAMETER		UNIT	INLET	OUTLET
1.	Flow	Cum/day	600	600
2.	pH	SU	7.0 – 8.0	7.0 – 8.0
3.	COD	mg/l	350 - 400	<50
4.	BOD	mg/l	250 - 300	< 10
5.	TSS	mg/l	200 - 250	< 10
6.	O & G	mg/l	20 - 30	<5

CIVIL TANKS		QTY.	VOL. M3
1.	Screen Chamber	1 No.	-
2.	Oil & Grease Trap	1 No.	3.4
3.	Collection Cum Equalization Tank	1No.	150
4.	Grit Chamber	1 No.	-
5.	Anoxic Tank	1No.	175
6.	MBBR Tank	1 No.	200
7.	Secondary Clarifier	1 No.	178
8.	Intermediate Treated Water Tank	1 No.	50
9.	Treated Water Tank	1 No.	150
10.	Sludge Tank	1 No.	0.5-1
11.	Sludge Drying platform	1 No.	-
12.	MCC Room/Lab Room/Centrifuge Room	1 No.	-
13.	Foundation for Blowers, Pumps, PSF, ACF, Panel etc.	1 Lot.	-



3. Resilience

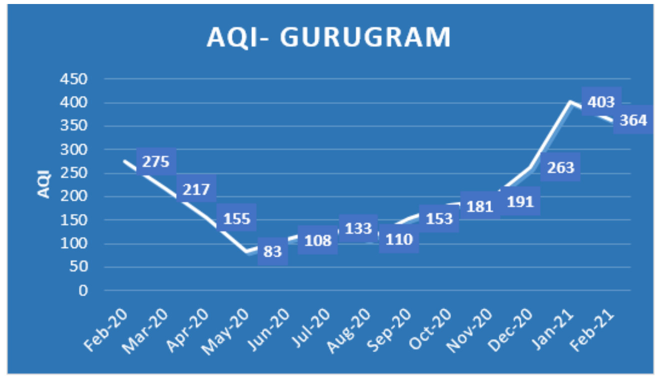


Figure 3.1 – AQI of Gurugram in 20 - 21

One of the goals has been to **manage air quality of the site** as air pollution is one of the biggest concerns in Gurugram. The air quality in this region is problematic due to accumulation of dust from neighboring areas and poor ventilation index that does not allow proper dispersion of pollution. Hence we have proposed smog cancellation facades and other smog mitigating techniques in landscape elaborated in innovation section.

The building facade is covered with smog eating concrete that will clean the air around it. The concrete is made up of traditional cement mixed with titanium dioxide. This unique mixture allows air to pass through while simultaneously capturing nitrogen-oxide particles, a main component of smog. Titanium dioxide functions as a catalyst to the chemical reaction which is activated by UV light. Not only does it filter the air, but the collected smog residue washes off with a light rainfall. It can decrease nitrogen oxide levels by 25-45%.

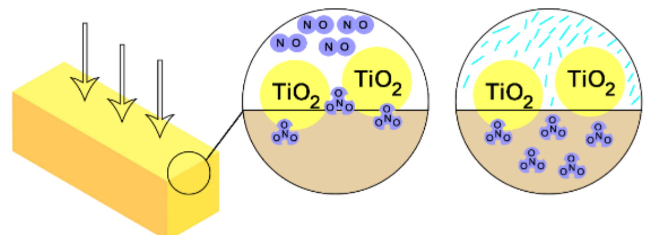


Figure 3.2 – Titanium Dioxide

Gurugram every year chokes due to urban flooding thus we have strategized to mitigate Urban flooding using silva cells. The city's limited drainage capacity, which results in drain overflowing during heavy rains, disruption of the hydrological flow of natural drains, which stops the flow of water into traditional dams are the reasons for Gurugram's Urban Flooding. Use of Silva cell can prevent urban flooding. The Silva Cell system is a modular green infrastructure facility that is designed to provide storm water management benefits equivalent to bio retention. The system is typically installed under pavement applications and can be configured in several different ways, integrated in project landscape can be seen below in figure 3.3.

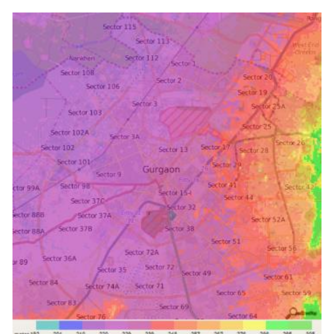
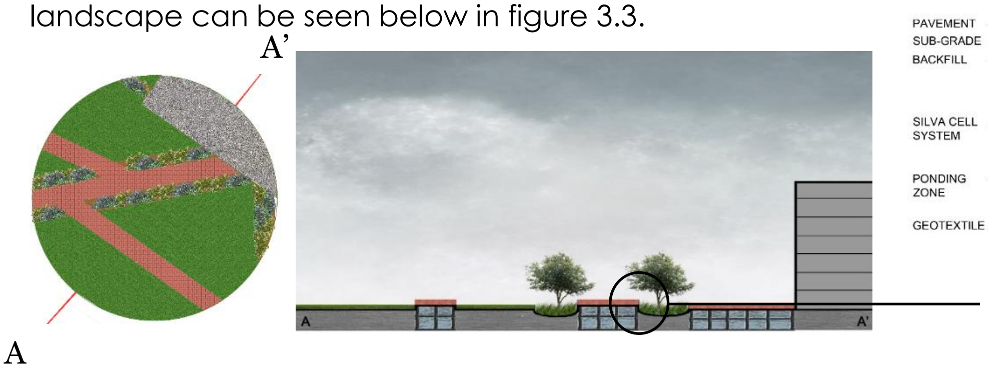


Figure 3.2 – Flood Map of Gurugram



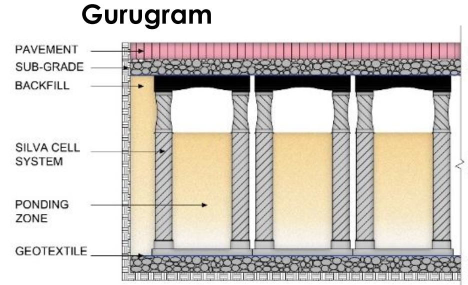


Figure 3.3 – (Left to Right) Part Landscape Plan, Site Section, Silva Cells Section

Infection control & COVID-19 are need of the hour therefore we are proposing protocols to create spaces which are designed to be resilient to any infection spread. Incorporating automation and voice activation tools can minimize touch points and limit the chance of contact exposure to germs. Hands free tools can minimize the need to directly touch door hardware, elevator call buttons, and building directories.

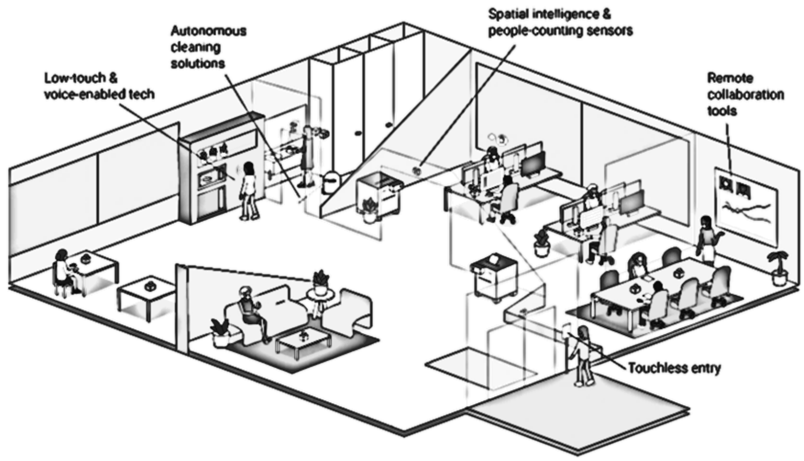
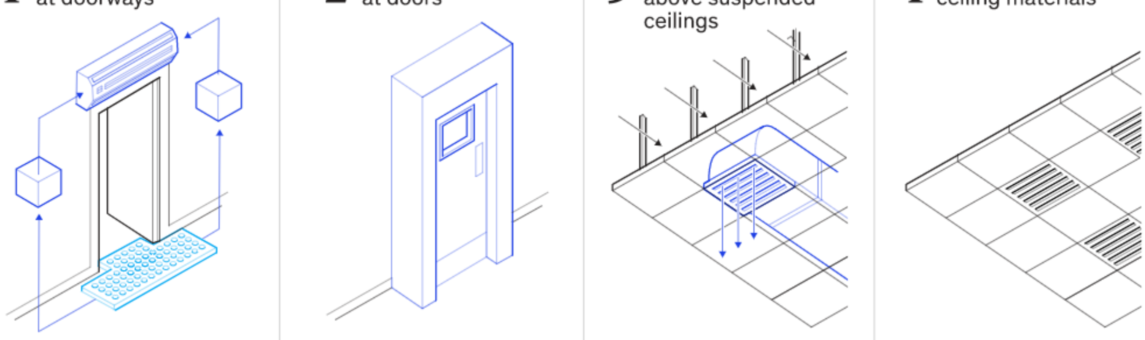


Figure 3.4 – Infection control practices

Enhanced cleaning protocols reduces the risk of exposure to COVID-19 by GUV (Germicidal Ultraviolet) disinfection lighting. It can be used for "surface-sensitive" areas in the office, such as food service spaces. It is proposed that this is a supplement to cleaning the surfaces by hand.

The particular matter (PM) size of airborne coronavirus particles is much smaller than its surface-borne counterparts. Improving the air quality by properly installing and maintaining existing air filtration systems is important. Suitable jacketing for internal lining and thermal insulation of ducts can be done to prevent loose fibers getting into the air stream, separate exhaust for the photocopying and ammonia-printing room and regular treatment of cooling towers can be done with oxidizing agents (chlorine and bromine) to control biological impurities.



1 Install air curtains at doorways

Air curtains ensure limited air mixture between rooms when doors are opened

Existing air-curtain systems can be upgraded to avoid particle kickback from the ground (for instance, by adding a suction duct on the floor)

2 Install air gates at doors

Doors can be installed, if not present, from one room to another or in corridors to reduce airflows

If possible, automatic double door can function as an air gate

3 Overpressure above suspended ceilings

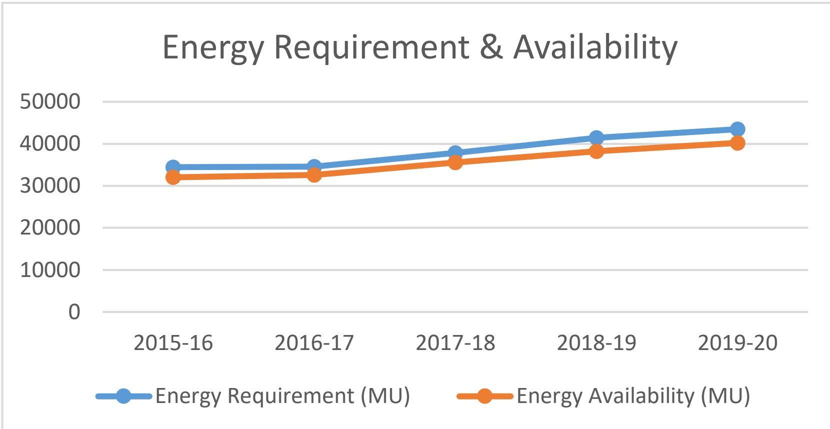
An overpressure above suspended ceilings prevents air from flowing through the suspended ceilings from one room to the other

4 Upgrade suspended-ceiling materials

Some ceilings can be retrofitted with gasketing in areas needing a negative-pressure environment; this traps airborne contaminants and prevents them from leaving the negative-pressure space

Power Outages

Use of Stored energy cells during Emergency grid-failure:



Source: Ministry of Power

Gurugram is inextricably linked to the energy grid and is dependent on its electricity to continue normal operation, the consequences of this dependence become evident when looking at power outage situations. In Gurugram, most offices use gensets because of regular power cuts. Over 3,000 gensets are operational in the city and are a major source of air pollution. Around 200 litres of diesel is burnt every day in Gurugram for gensets. Usage of stored energy cells could conceivably help reduce the impact of power outages. Storage batteries can provide backup power to the office and Energy gateway can detect grid outages and respond accordingly.

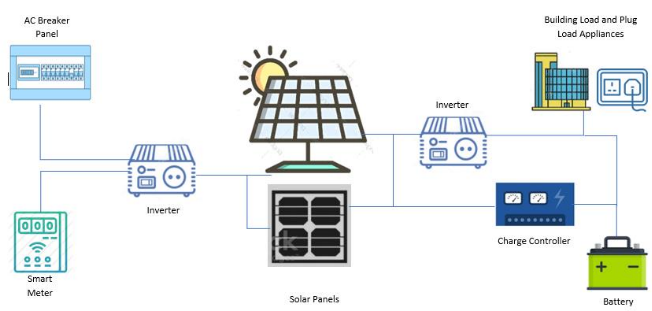


Figure 3.4 – Solar PV flow diagram

4. Affordability

The goal is to address the growing affordability challenges by identifying the needs, modernizing O&M best practices and selecting energy efficient construction materials and MEP systems designs that will yield financial dividends for years to come. The design will aim to reduce the on-site construction time and the. The flexibility in design will provide the users an opportunity of maximizing the occupancy and provide a more customizable space efficient design. The design intent of the competition will also ensure minimum operating cost for the users.

We proposing Renewable Energy Service Company (RESCO) is an ESCO for RE financing which provides energy to the consumers from renewable energy sources, usually solar photovoltaic, wind power or micro hydro. RESCO or BOOT model is about pay as you consume the electricity.

- Solar Power Plant is owned by the RESCO or ENERCO (Energy Company).
- The customer serviced does not own the Solar Power Plant.
- Customer have to sign a Power purchase Agreement (PPA) with actual investor at mutually agreed tariff and tenure.
- The developer would arrange a loan at a rate of 12% for the project. In this case, the levelized tariff discovered is ₹5.96 (~$0.08)/kWh. The bidder may calculate the tariff based on the actual cost of finance, expected return on equity, O&M cost, working capital, depreciation, and site requirements.

Figure 4.1 – RESCO Financing Model

Flexibility in spaces is the key to affordability as per our research.
Flexible office space refers to a fluid space to conduct business that allows for a wide range of diverse work environments. These shared office spaces allow you to have a designated space for work, but on your terms.

1. GREATLY REDUCE COSTS -The first benefit may be the greatest. Flexible office space greatly reduces overhead costs for corporations – cheaper leases, flexible terms (which means a smaller commitment, and less risk), and the cost of rent covers the expenses for not only the workspace, but for Amenities, Break rooms and lounges, Printers, Event space, Desks, Meeting rooms.
2. WIDESPREAD PRESENCE -Corporations could massively cut costs and boast a smaller carbon footprint by simply utilizing the cost-efficiency of co-working spaces to broaden their workforce across the country without the need for the acquisition of expensive and at times frivolous office spaces.
3. FLEXIBLE TERMS -Office space can be rented monthly, avoiding the upfront costs and potential losses of a long-term lease. As corporations take on greater workforces – or cut down – they can adjust their plans accordingly and avoid unnecessary losses.

The construction technologies and material have been highlighted in further sections.

Table 4.1 – Project Cost Estimate Summary

S.No.	Particulars	Baseline Estimate (Project Partner / SOR basis)		Proposed Design Estimate	
		Amount (Rs Millions)	**%**	**Amount** (Rs Millions)	**%**
1	Land	2160.00	28.3%	2160.00	28.3%
2	Civil Works	1363.40	17.8%	1388.23	18.2%
3	Internal Works	100.03	1.3%	100.63	1.3%
4	MEP Services	1664.88	21.8%	1362.58	17.8%
5	Equipment & Furnishing	0.00	0.0%	0.00	0.0%
6	Landscape & Site Development	11.80	0.2%	11.80	0.2%
7	Contingency	363.83	5.0%	307.41	5.0%
	TOTAL HARD COST	**5663.94**	**74.4%**	**5330.64**	**70.7%**
8	Pre Operative Expenses	17.24	0.2%	17.24	0.2%
9	Consultants	68.96	0.9%	68.96	0.9%
10	Interest During Construction	1,890.38	24.7%	1,038.80	13.6%
	TOTAL SOFT COST	**1976.58**	**25.9%**	**1125.00**	**14.7%**
	TOTAL PROJECT COST	**7640.52**	**100.0%**	**6455.65**	**84.5%**

Use of EPS panels and MIVAN structure impact the project schedule as shown in scalability and APPENDIX which is visible in the summary in form of 15% reduction in total project cost. The construction budget of the proposed design is INR 23,139/ Sq.M. The IRR of the proposed scheme is 9.83% where as for the baseline its 5.67%. DSCR of 0.66 is being achieved in the proposed design.

5. Innovation

Our goal os to creat energy conscious office environment/ stakeholder engagement. By observing and analyzing human psychology and their inclination of movement, we have tried to generate and conserve energy in an office environment by introducing the interventions stated below.

Revolving door

The footfall is maximum at the entry of an office building. This simple act of pushing door is used to generate the electricity. The motion of the revolving door will directly drive the generator (this generator will act as a vicious damper.) 0.84 W can be harvested in one push which translates into 20.16 kW in a single day.

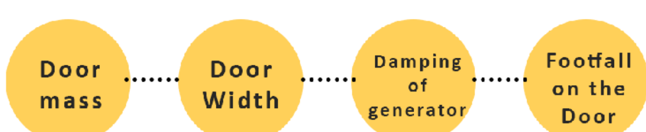


Figure 5.2 – Revolving door factors

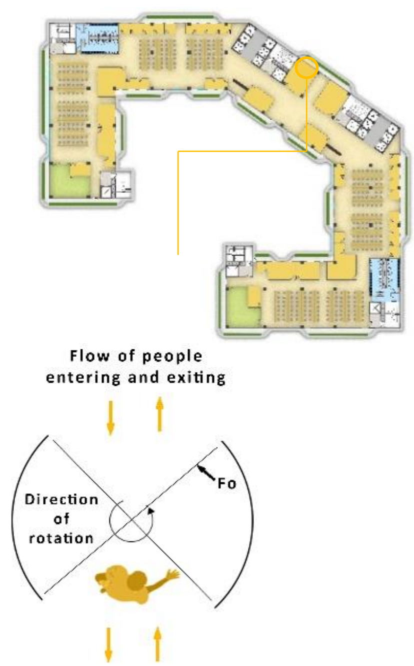


Figure 5.1 – Revolving Door Integration in design

Limitation- the energy generation depends on the footfall on the door. Hence the generation will not be constant throughout the day.

Gym equipment- Many office complexes now incorporate Gym facilities to ensure the well-being of their staff. Ample energy is released in the gym which will be utilized to generate electricity. This electricity will be used to provide power to the gym and charge phones. When the exercise machine is not used, the main supply is used to charge the capacitor bank to provide a continuous supply.

Hans Human Powered Generator (HPG) can generate electricity and charge home electric systems for powering DC LED lights, DC fans, laptops, printers, small DC televisions, mobile phones. This price of this cycle is only a little higher than the conventional one. **Price – INR 18,000 per equipment**

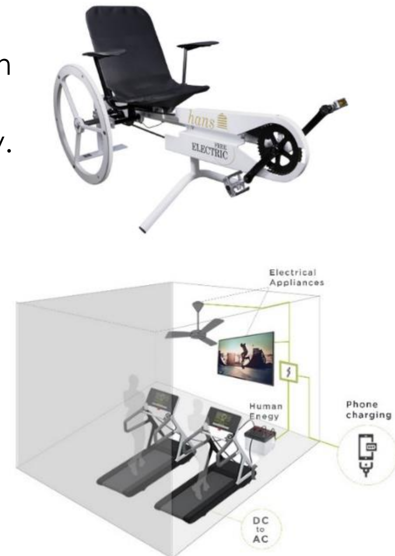


Figure 5.3 – GYM Equipment & Diagram

Energy wheel - Pinning the consciousness of people is how the next intervention, the energy wheel would work. Placed at the reception of the office, this system involves thousands of devices feeding into EMS (detailed in engineering design) that tracks energy use. This wheel would help create awareness amongst the employees who will eventually understand how to efficiently operate the office complex. When its lights shine outward, the building is energy positive. When they shine inward, it is energy negative.

Figure 5.4 – Energy Wheel Interior View

We have innovated to break the monotonous spatial quality for office occupants - Green terraces and balconies, is of immense importance to the public well-being, mitigating climate changes and contributing to a more pleasant life in highly urbanized zones. Employees are exposed to various levels of stress within their workspace. Integrating plants in the work environment not only beautifies the environment but has been proven to reduce absenteeism, stress, and lower blood pressure and increase positivity. They have been designed considering the as per the building bye-law provisions

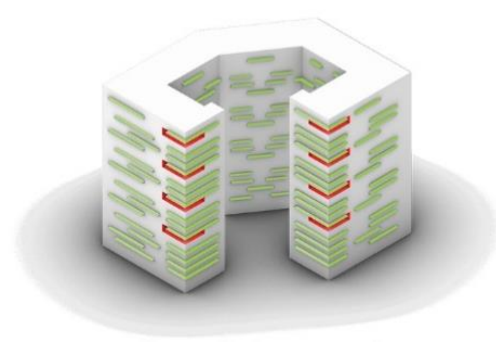


Figure 5.5 – Green Terrace View

Smog eating and rainwater harvesting landscape feature – Inspired by experiment done by Dr Klaus Lackner ,their function is to remove carbon dioxide from the air and release oxygen using a carbon dioxide removal process called "humidity swing".
The leaves look like sheets of paper plastic (PET recycled plastic) and are coated in a resin that contains sodium carbonate, which pulls carbon dioxide out of the air and stores it as a bicarbonate (baking soda) on the leaf. To remove the carbon dioxide, the leaves are rinsed in water vapour and can dry naturally in the wind, soaking up more carbon dioxide. Hence, the only challenge is to keep the plastic dry.
This one tree can absorb Co2 100 times more than a conventional tree. Plastic used in the trunk- PET (Polyethylene terephthalate). Using humidity swing it absorbs Co2 and the level of CO2 decreases from the air A thin membrane of high runoff coefficient is used at the top to harvest maximum rain water. The catchment membrane with a surface area of 21.26Sq.M is connected with a central hollow pipe which leads to the underground storage tank through sand and charcoal filter. The design details are mentioned in the APPENDIX.

The calculated price of one structure is **INR 1,00,390**

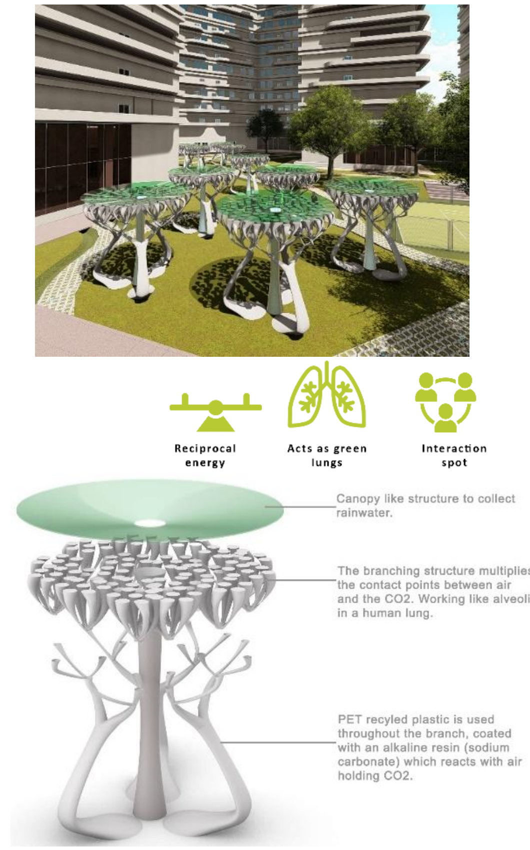


Figure 5.6 – Proposed landscape feature view

6. Scalability and Market Potential

Target Market basic needs have been identified and addressed in architectural design are shown in the image below.

The most basic types of market segmentation include, demographics, geographical, psychographic, socioeconomic, and behavioral segmentation. Having a global footfall, with many companies want to set operations in India, the needs and aspirations should be sensitized on a global scale. This gives rise to coherent working spaces with flexibility as per needs and aspirations (modular system). A design should aspire the inmates to work diligently for their company and for a great cause, these days, climate change. Maslow's Hierarchy of Needs, narrows the needs categorically which ministers our design conceptually. Greens and open by flexibility stimulates the actualization and the

Figure 6.1 - Space Attributes

cognitive needs. With the added positive on aesthetics. Community building and belongingness needs are taken care with crèche, day care, and a canine center.

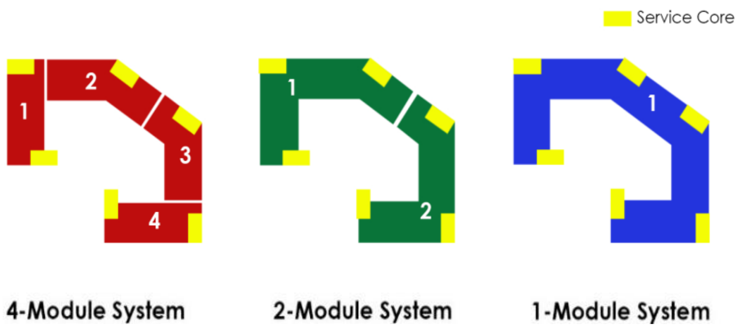


Figure 6.2 - Types of Office Modules

Our approach has been to enhance the quality, reduce time and cost for execution. Hence we are proposing Expanded Polystyrene (EPS) Sandwich Panels for walls and Mivan Formwork. These technologies have been choosen as they optimise cost when used repeatedly on-site, which this scale project can provide.

EPS is made of styrene. Styrene-based plastics are derived from benzene, originally obtained from trees and used to make tires. Styrene is now synthesized artificially. Its popularity gained momentum in the construction industry due to its key characteristics:

- Stability – It withstands freeze/thaw cycling without losing structural integrity or other physical properties. ***(Resilience)***
- Readily available, inexpensive and extremely versatile. ***(Affordability)***
- Water resistance. ***(Comfort and Environmental Quality)***
- It is chemically inert and does not provide food value for termites, insects, parasites, mold or mildew. ***(enhance IAQ)***
- Does not contain ozone-depleting chemicals ***(Environmental-Friendly)***
- High U-Value compared to other walling materials. ***(Energy Performance)***

Figure 6.3 – Features EPS Sandwich Panels

Mivan Formwork System

Mivan shuttering is a fast-paced construction technique which offers strength and durability to a building by use of aluminum formworks.

Factors	Conventional System	Mivan Formwork System
Speed of development	***Slower:*** because of well-ordered fruition of various phases of the exercises	***Speedier:*** one nonstop operation and furthermore the completing work can be begun instantly
Quality	***Ordinary:*** traditional strategy for development	***Superior:*** in-situ throwing of entire structure and transverse dividers done in constant operation.
Proficiency and cost saving	The formwork boards are not light in weight.	The formwork boards are light in weight and can be lifted physically.

Table 6.1 – Mivan Formwork System

Construction Timeline

The time of construction is reduced by using Mivan Formwork and use of EPS Core Panels. The nonstop operations in Mivan and EPS panels can be constructed with 10-12 people, working for a day, can construct upto 100 sqm. of the structure.

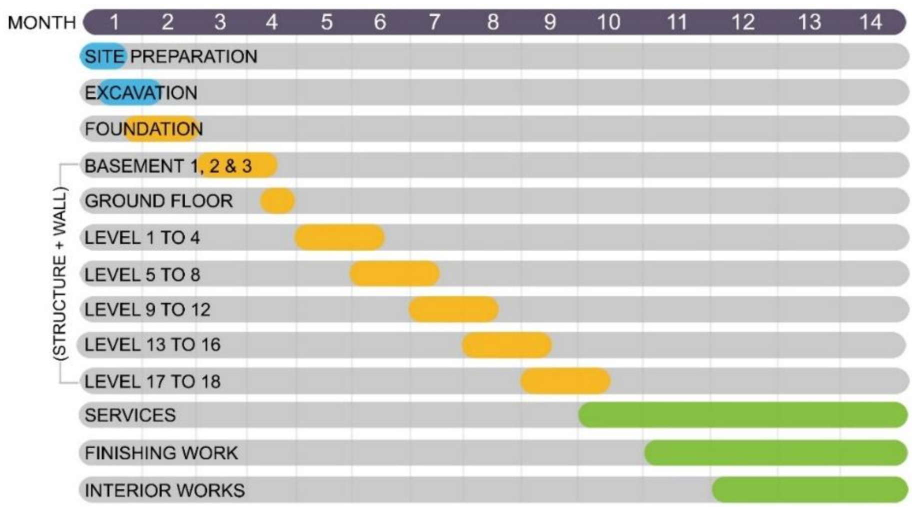


Figure 6.4 – Construction Timeline

Building Maintenance using BIM

The complete process of BIM maturity progression towards digital sustainability encompasses two stages of "transformation". First, it will undergo a model transformation at Level 3 where a "Heavy-weight" BIM (as built) Model is "transformed" into a "Light-weight" 6D BIM Model. Irrelevant information that is not required for facilities management purposes will be taken off from the completed BIM (as built) Models.

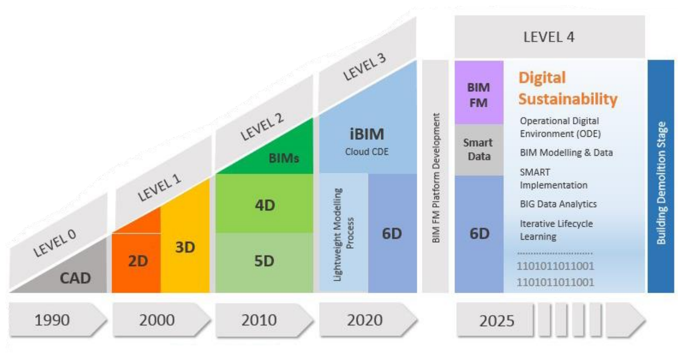
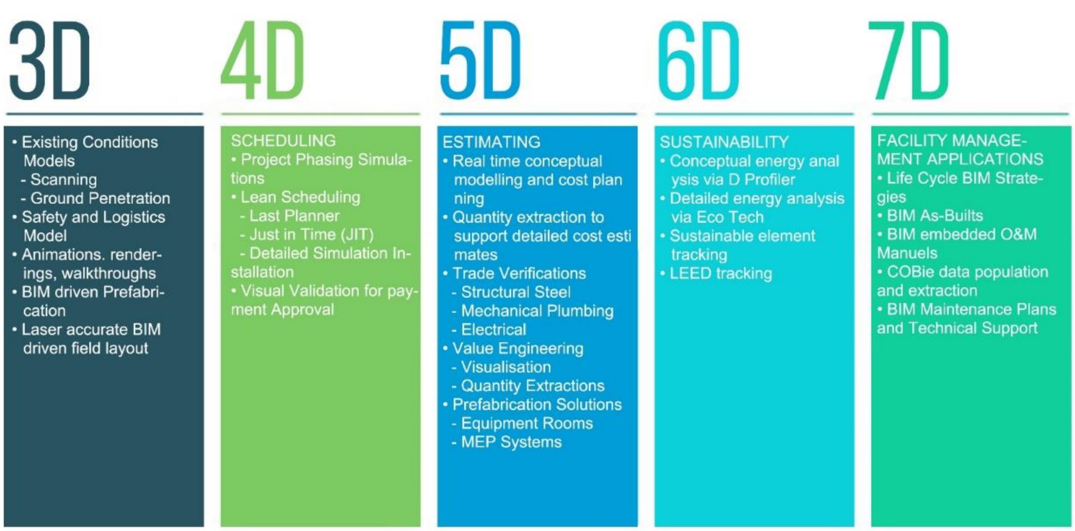


Figure 6.5 – BIM Progression



Secondly, in order to be applicable for Facility Management, a final transformation process at Level 4 into an Asset Management System or "BIM FM" operational readiness is therefore necessary. This final stage of transformation shall rest on the Operational Digital Environment (ODE) for future digital sustainability.

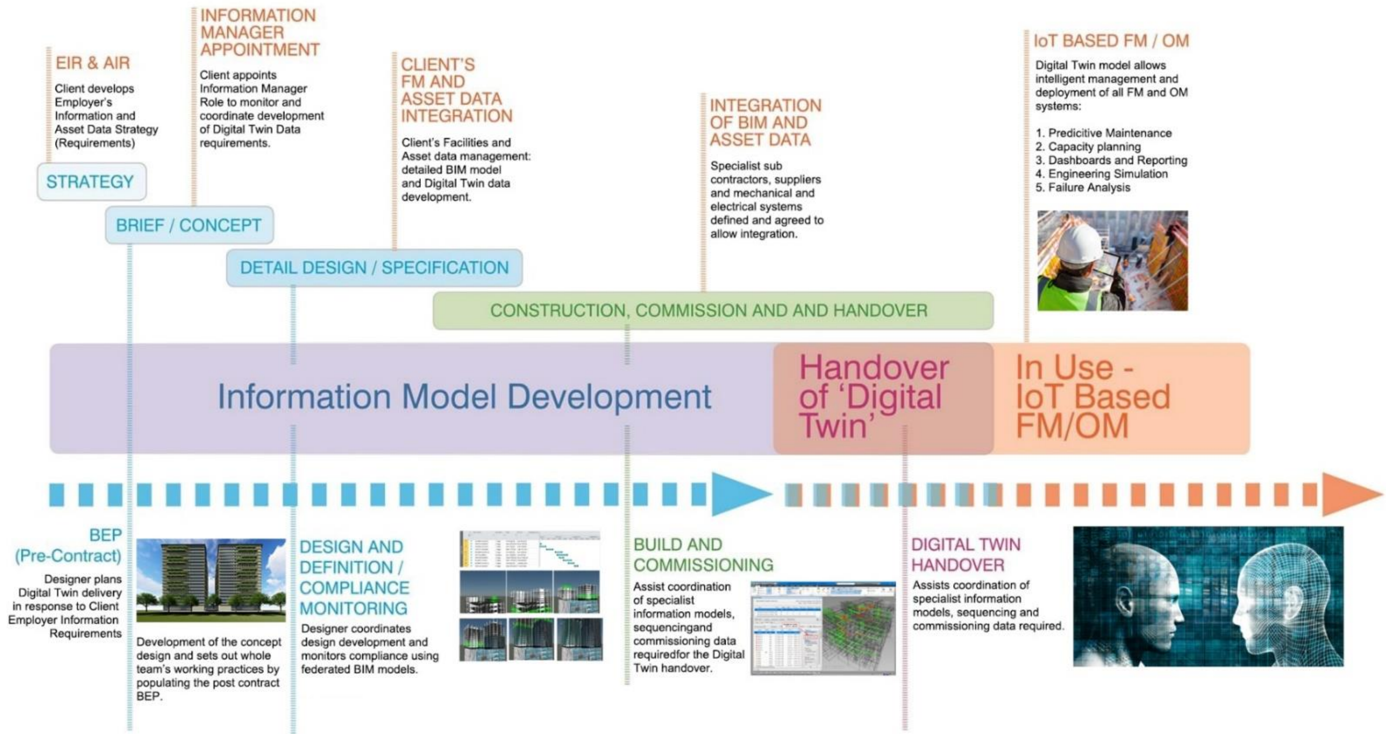
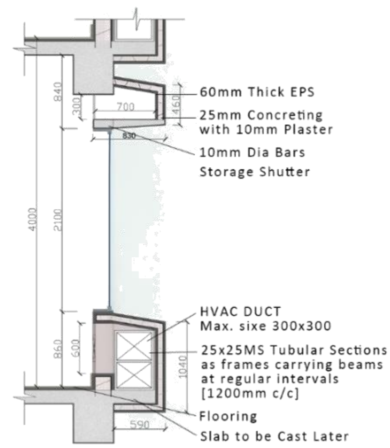


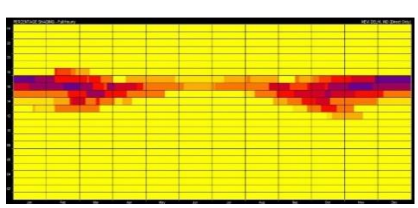
Figure 6.5 – Information Model Development

7. Comfort and Environment Quality

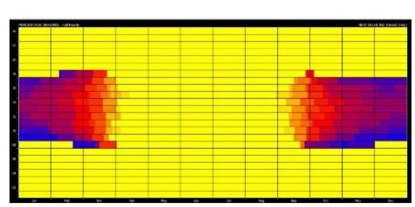
Thermal Comfort

To ensure maximum shading in summers while still allowing the sun to enter in cold months, horizontal shading devices have been integrated. Projected at a length of 600mm, these are efficient, evident in the below shown annual solar shading analysis graphs from Square One Ecotect.





South-West



South

Following is the Psychometric Chart generated through Climate Consultant. It lists the design strategies adopted to achieve 100% comfort in the building throughout the year. These design strategies are integrated and highlighted in architecture section:

- 100% shading of windows with low SHGC values
- Courtyard

Figure 7.1 – Annual solar shading analysis of windows and wall section

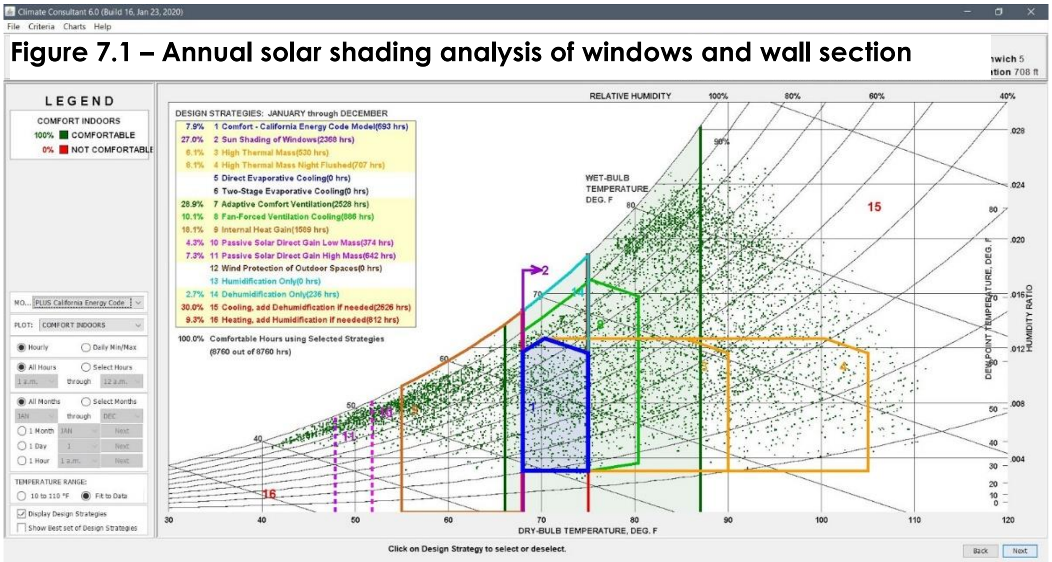


Figure 7.2 – Psychometric Chart generated through Climate Consultant

To reduce the Heat Island Effects in the site the following measures have been adopted: Grass pavers have been used in landscaping. These are pavers made from concrete with voids wherein grass is grown. Grass and concrete not only have lower surface temperature as compared to conventional landscaping materials such as asphalt and brick pavers, but also have a significantly better albedo value of 0.25 (grass) and 0.55 (concrete). Courtyard is shaded by solar panels.

Ventilation

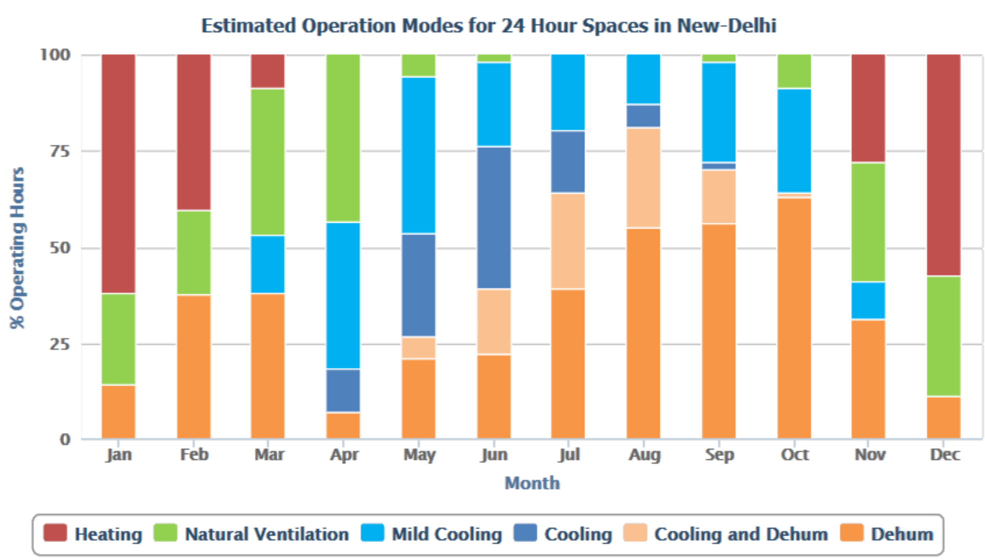


Figure 7.3 – Suggested Modes of Operation

As per NBC 2016, following are the passive methods adopted to ensure enhanced natural ventilation for improved indoor comfort of the occupants:

Narrow floor plates to ensure efficient cross ventilation.

On the windward side, the sill is provided at a lower level, and outlet at a higher level to ensure well distributed wind movement. Similarly, staggered windows, as shown in the floor plan on right. In Delhi, the wind direction is quite variable. Hence, the openings are arranged so that no matter what the wind direction is, there would be some openings directly exposed to wind pressure and others to air suction and effective air movement through the building would be assured. To create a barrier free wind flow, on the windward side, the trees are placed at a distance of >8m) from the Building.
Narrow floor plates have been designed with WWR of 28% to achieve 100% daylight autonomy, the achieved Lux levels are indicated in the figure on right.

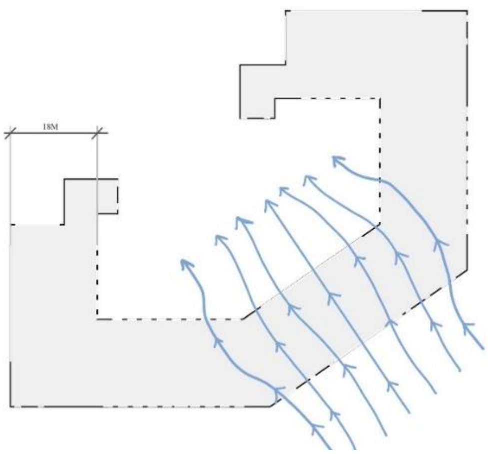


Figure 7.4 – Window arrangement for enhanced air flow and crow ventilation

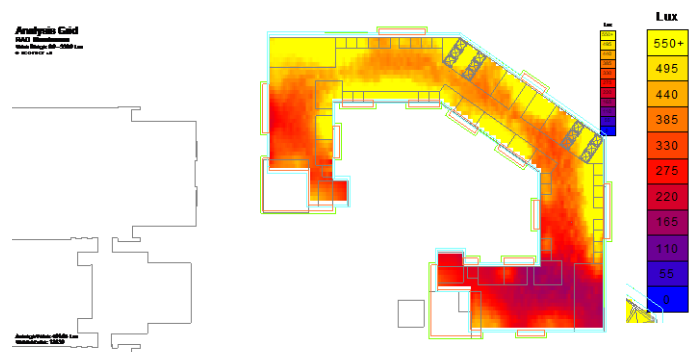


Figure 7.5 – Daylight analysis using Ecotect & Radiance

Figure 7.6 – Typical floor fresh air requirements

Space type	No. of occupant	R_p (CFM/person)	Floor Area (ft^2)	R_a (CFM/ft^2)	Ventilation rate (CFM)
Open Work Station	300	2.5	20989.8	0.06	2009.388
Closed Work Station	26	10	3638.232	0.12	696.58784
Head Office	4	5	645.84	0.06	58.8
Conference Room 1	10	5	250.47828	0.06	65.0
Conference Room 2	20	5	417.6432	0.06	125.1
Reception	3	5	89.3412	0.06	20.4
Waiting Area	4	7.5	200.2104	0.06	42.0
Printing And Fax Area	1	5	297.0864	0.06	22.8
Library	6	5	376.74	0.12	75.2
Recycling Stations	0	0	24.7572	0.12	3.0
Mail Area	0	0	25.8336	0.12	3.1
Interview Room	3	5	129.168	0.06	22.8
Nook/Coffee Corner	1	5	62.4312	0.06	8.7
Medic Room	5	5	215.28	0.18	0.0
Pantry	4	7.5	172.224	0.18	61.0
Restroom	9	5	525.2832	0.06	76.5
Storage	6	0	538.2	0.12	64.6

8. Architectural Design

The five core values that the *TATA Group* espoused—integrity (***structural***), understanding (***approach***), excellence (***market potential***), unity (***work culture***) and responsibility (***employees, culture and environment***) have been the backbone of the design. It is designed to improve the quality of life of the communities serving globally, through long-term stakeholder value creation based on Leadership with Trust. And also to delight customers by providing quality life spaces through continuous innovations.

Figure 8.1 – Vertical Zoning Diagrams

Form Development

The developments were closely on energy efficiency, inclusion of passive techniques and aesthetics. Courtyard planning, narrow floor plates to bring in the daylight, design of green balconies brings the greens inside the office space. The form helps in maximization of views, modularity, and, fire and service provisions on façade. The idea was to create a flexible concept of workspace to foster communities of all kind and to design a space which cater to our psychological needs, improving the employees' health and wellbeing.

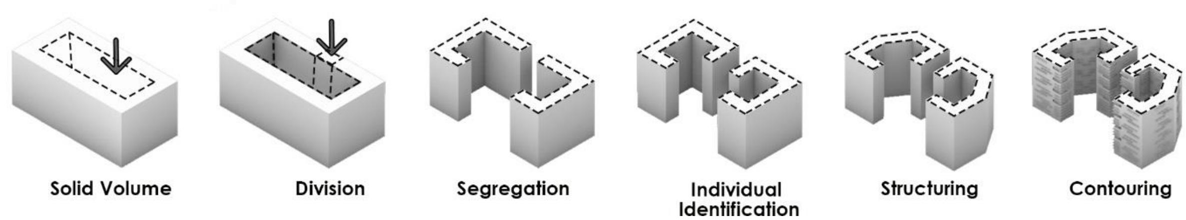


Figure 8.2 – Form Development

BAPV Integration

For some years now, equipping a building with a photovoltaic module has not just been about superimposing a solar installation on an existing roof. The BAPV (Building Applied Photovoltaics) method consists of fitting modules to existing surfaces via superimposition once construction has been completed, such as during an energy renovation project. This is the approach adopted for traditional photovoltaic solutions.

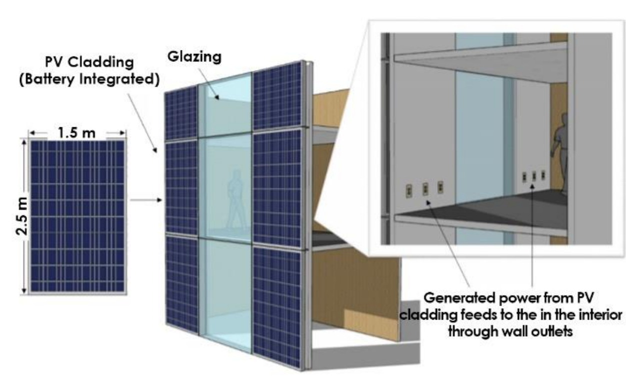


Figure 8.3 – BAPV Integration

Layouts: Site Plan and Floor Plans –

We have created spaces aesthetically appealing and in response to contextual towers. We have planned site features and landscape as to create spaces or adopt the most innovative ways to shed away the mundane routine that shall create a difference in the market. The research oriented approach has helped us cater to the occupants in relation to the context, occupants' lifestyle and provide a user experience for the same. Detailed plans are attached in APPENDIX Document.

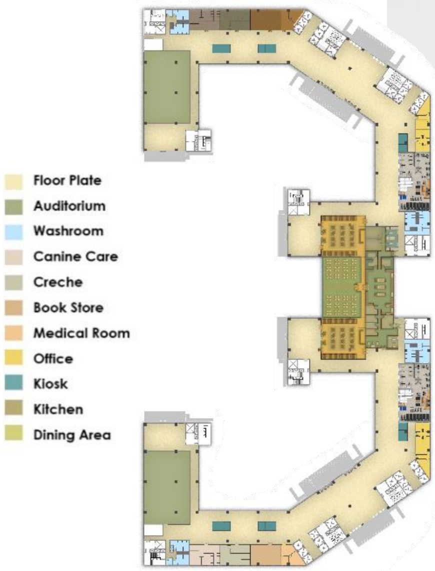


Figure 8.4 – Ground Floor Plan

Figure 8.5 – First Floor Plan

Figure 8.6 – Second Floor Plan

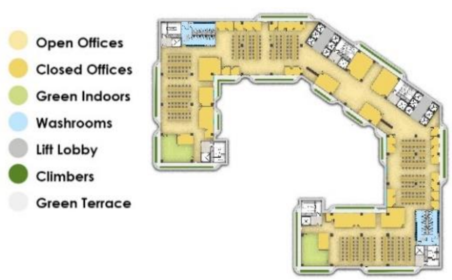


Figure 8.7 – Third Floor Plan

Figure 8.8 – Site Plan

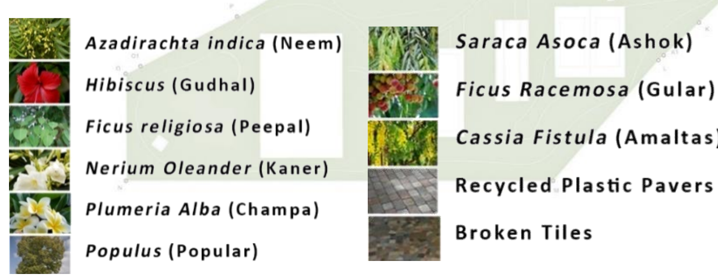


Figure 8.9 – Landscape Elements

The aesthetics in itself a part of the functionality and comfort is a representation of a sustainable design celebrating the larger context. The same is being conveyed in layouts below.

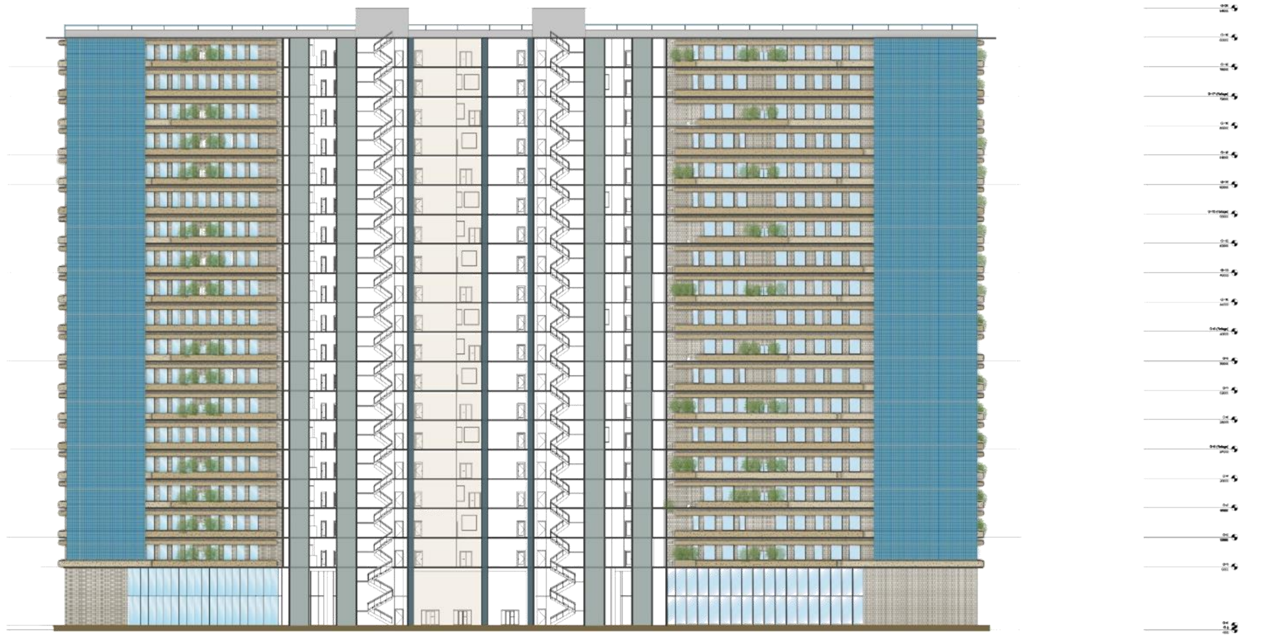


Figure 8.10 – Section A

Figure 8.11 – Section B

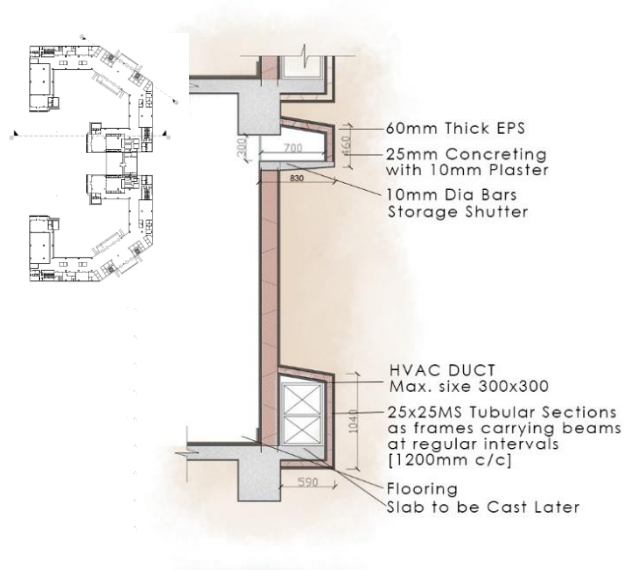


Figure 8.12 – Typical Wall Section

Figure 8.13 –Western Elevation View

Figure 8.14 – Courtyard 3D View

Figure 8.15 – Building Top View

Figure 8.16 – Innovative Structure with RWH and smog eating capabilities landscape 3D View

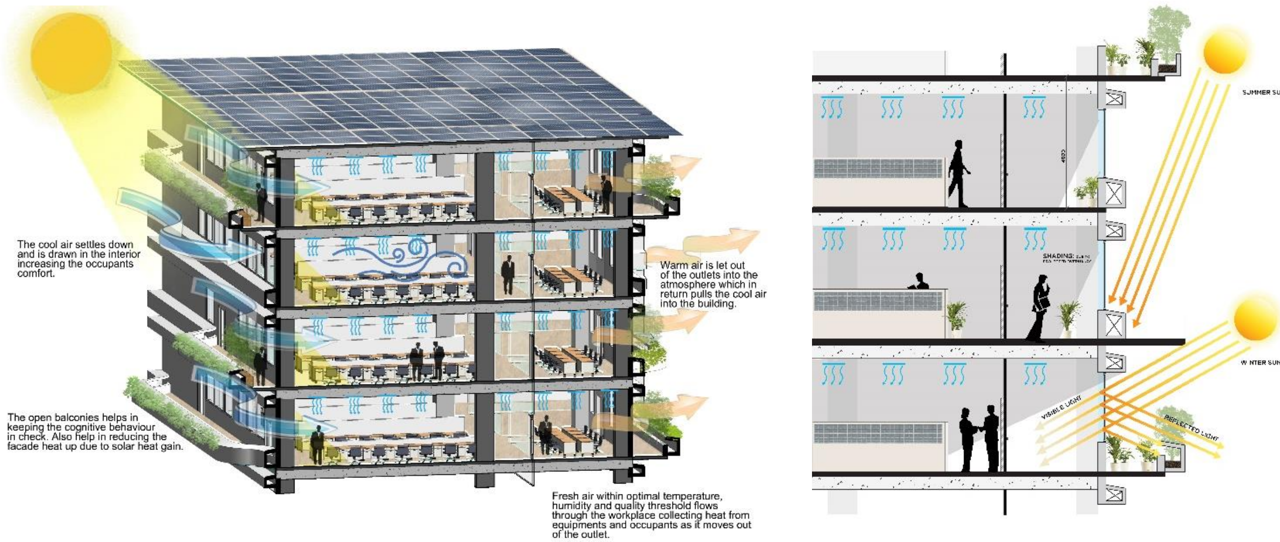


Figure 8.17 & 8.18 – Building sectional view - Design considerations

Figure 8.19 & 8.20 – Building 3D Views

9. Engineering Design and Operation

The intent has been to design electrical, mechanical and plumbing to fulfil the requirement of the building in terms of energy, comfort and water supply. We have designed of HVAC systems dependent on cooling requirements and functionality of space considered.

Mechanical design includes design of proper HVAC system and right-sizing. To ensure maximum comfort of occupants, radiant cooling technology has been adopted and all related systems have been installed. The efficient design has significantly reduced the amount of air conditioning tonnage as compared to a standard design. The comparison between standard design and our proposed efficient design is shown below, detailed layouts are in the APPENDIX Document

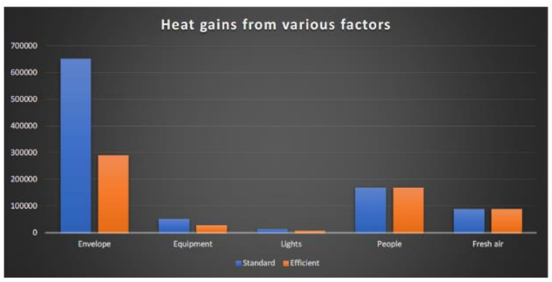


Figure 9.1 - Heat gain reduction from various factors

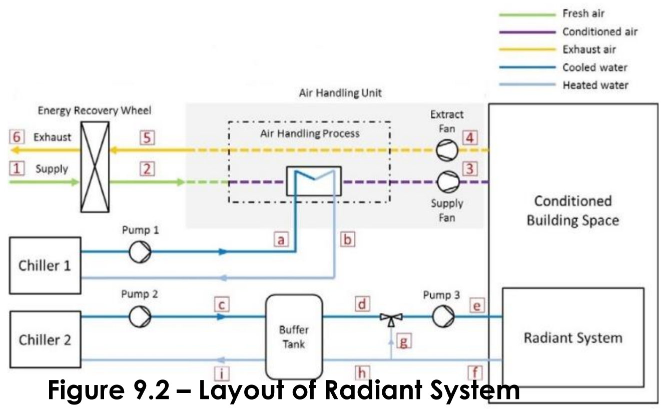


Figure 9.2 – Layout of Radiant System integrated with DOAS

Electrical system requirements are based on the optimized daily load and equipment under use by the occupants of the building. We have integrated suitable substation equipment and solar power generation systems in order to meet the needs. The electrical single line diagram (SLD) for the same is shown on the left.

Lighting Load	17337
Fan Load	6370
Exhaust Fan	220
5A Socket Load	15700
16A Socket Load	18000
5A Socket Load (UPS)	13700
Emergency Lighting	2195
Printer	264
Total Floor Load	**73786**

Table 9.1 – Typical Floor Lighting and Plug Load

The power load of every floor is calculated by optimizing each and every equipment when in use. Energy efficient equipment of low wattage, BEE standards and high efficacy LED lighting is chosen in order to minimize the energy usage and to make the system more efficient and cost-effective. Lighting is installed in a manner to harvest the natural lighting to its maximum potential and to compliment it with sensor based LED fittings in order to achieve the required luminance for a good work atmosphere. Detailed calculations, SLD and layouts are in the APPENDIX document.

The flow chart for the solar power generation system is shown below-

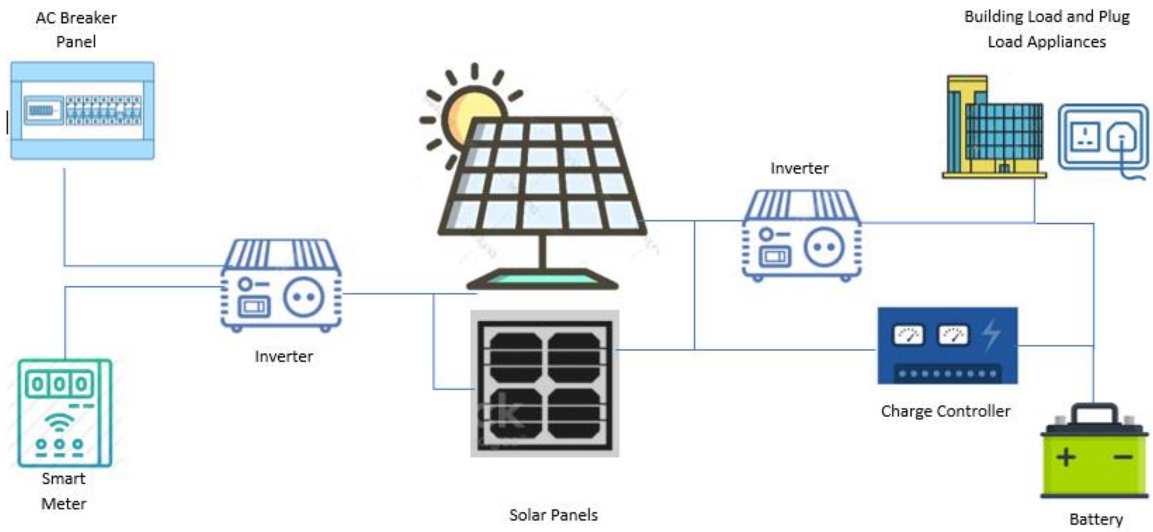
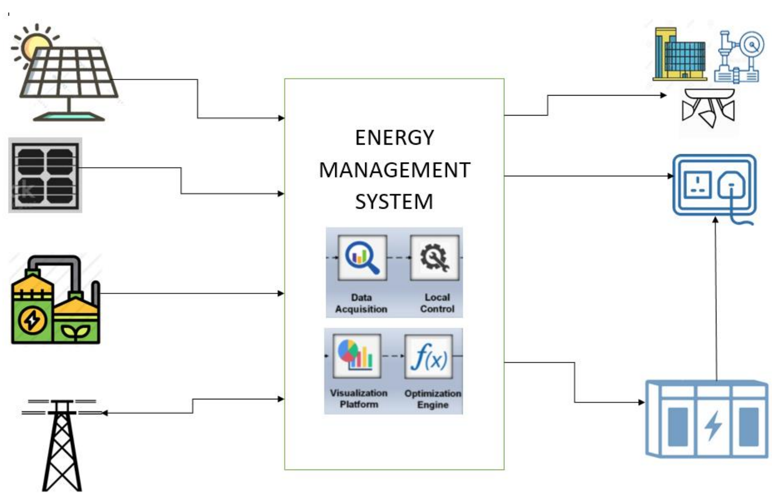
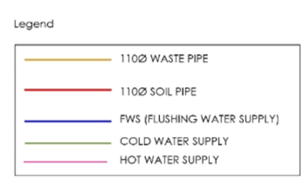


Figure 9.4 – Solar PV flow diagram



Energy Management System is showing the integration of various power generation and supply sources along with grid interaction. The algorithm for management is to match the load demand with the mission profile of the particular source of power at the particular point of time of day. Suitable source is selected and energy is harvested and supplied for use. Required deficit/generated surplus is interacted accordingly with the grid through smart meters and optimization engine.

The **plumbing system** has been designed so as to maximize utilization of water in the cycle and to effciently handle the outflow, minimising the losses. The plumbing SLD is shown in the diagram below, detailed calculations, SLD and layouts are in the APPENDIX document.



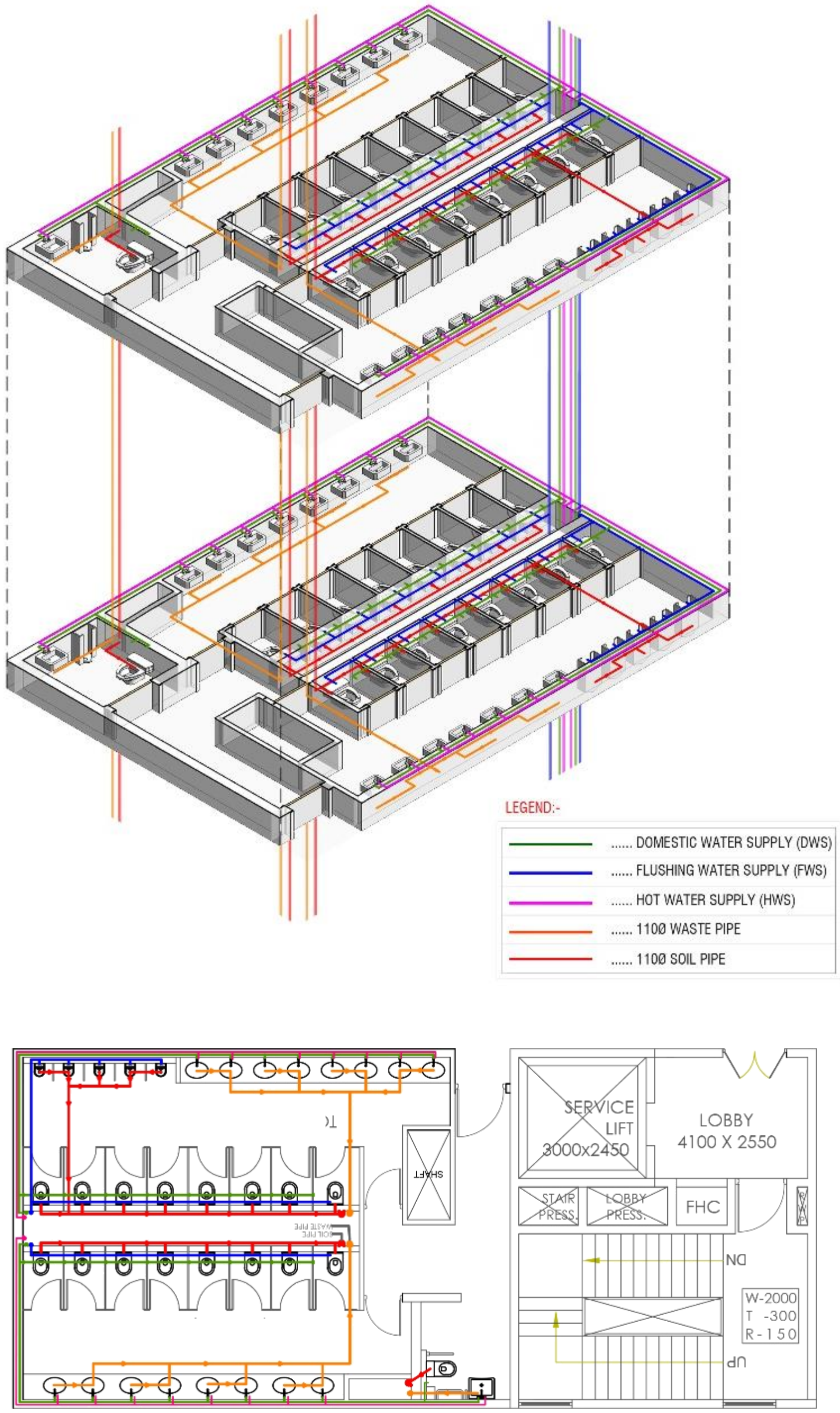


Figure 9.5 – Typical washroom plumbing layout

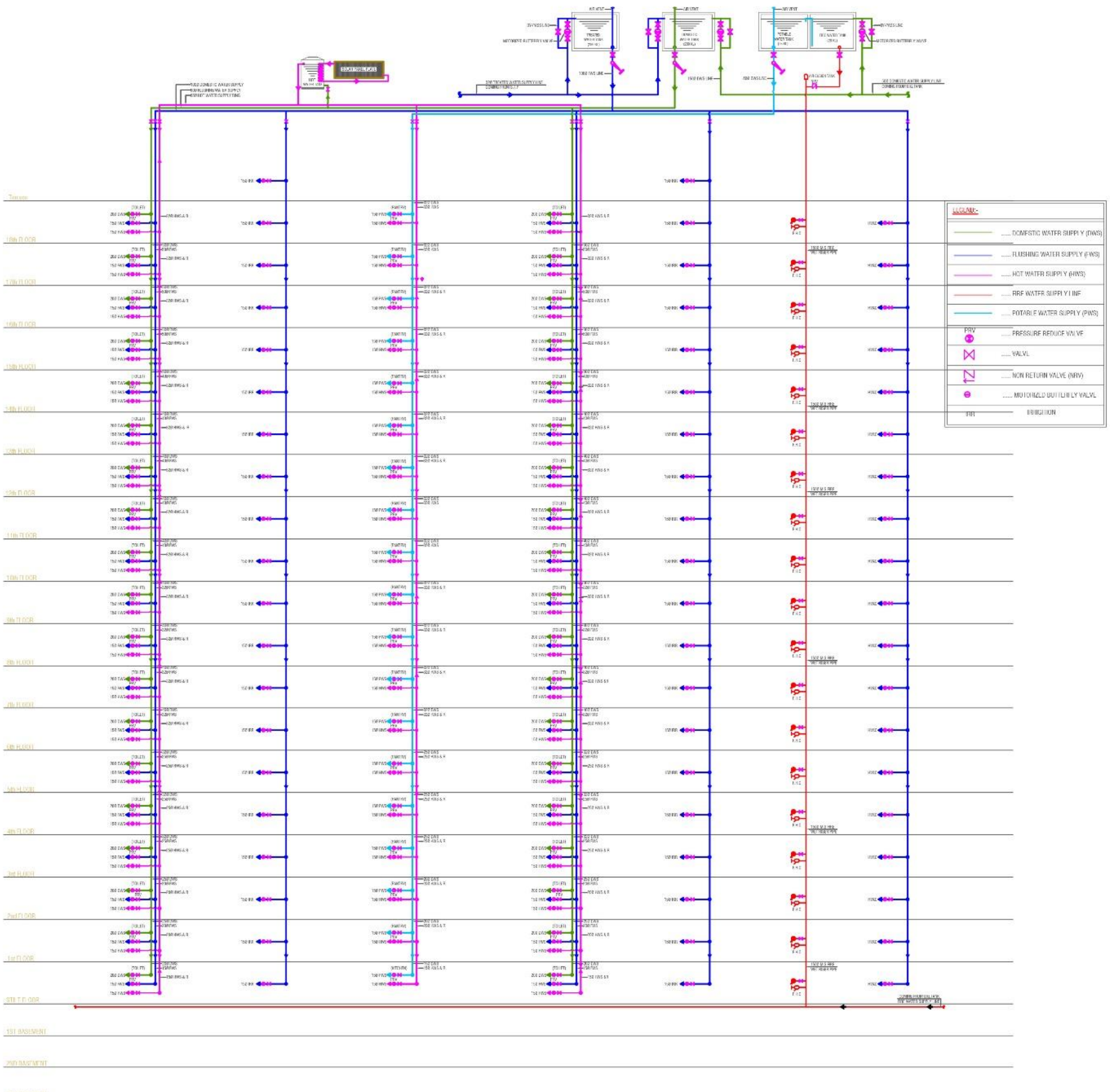


Figure 9.6 – Plumbing SLD of Tower

Washroom plan below depicts the plumbing lines that indicate flow for cold water, hot water, flushing water and other specifications necessary to depict.

Structural Design

Conventional cast in situ RCC framed structure is selected as the main load resisting element of the building. Owing to high rise nature of building, precast RCC framed construction is not opted since our building lies in Seismic Zone 4. The structural grid has been modified as per the functional requirements. The framing plan is shown on the right. To reduce the load on the frame and ultimately have larger clear span expanded polystyrene (EPS) panels are used as infill material. In EPS construction air is pumped into polystyrene panel and wire mesh is tied on both the faces of EPS panel followed by application of cement mortar under a pressure of approximately 2 bars. EPS panel has better structural and thermal performance than conventional masonry walls and has better thermal insulation property than widely used ACC blocks. EPS panels are manufactured in factories and can be tailored according to one's needs. Erection of EPS panels is easy and fast as compared to ACC blocks that consequently reduces construction time and indirect cost. Carpet area is increased due to less finished thickness of EPS which is approximately 220 mm. Detailed drawings, views & ETABs report are included in the APPENDIX.

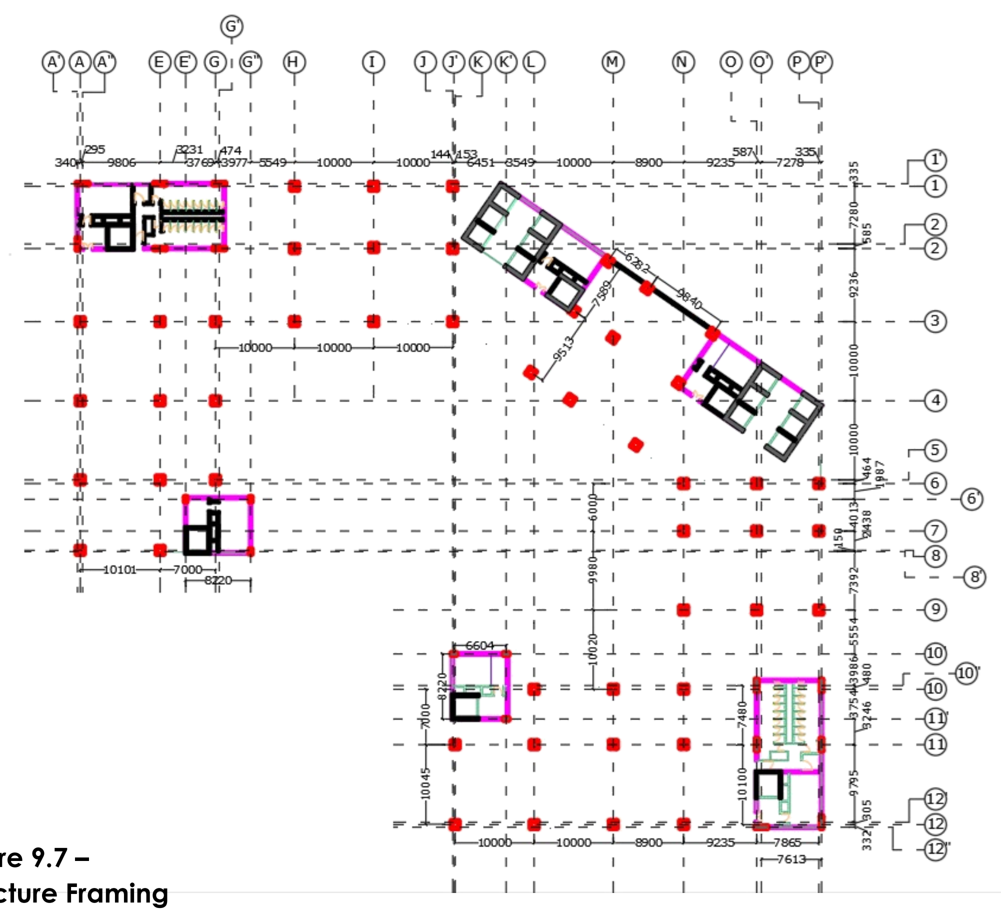


Figure 9.7 – Structure Framing Plan

12. PITCH TO PROJECT PARTNER

With almost 4 decades of experience, TATAs have collaborated with internationally acclaimed architects and design consultants with the biggest proponent of green initiatives in the real estate sector. They have estimated potential target audience of projects is over 25 million

Ideologies: The five core values that the TATA Group espoused—integrity (structural), understanding (approach), excellence (market potential), unity (work culture) and responsibility (employees, culture and environment) have been the backbone of the design. It is designed to improve the quality of life of the communities serving globally, through long-term stakeholder value creation based on Leadership with Trust. And to delight customers by providing quality life spaces through continuous innovations.

***Site Planning*:** The developments were closely on energy efficiency, inclusion of passive techniques and aesthetics. Courtyard planning, narrow floor plates to bring in the daylight, design of green balconies brings the greens inside the office space.

***Placement of Services*:** The main water storage and supply facility is located within the building premises with underground and overhead tanks ensuring reduced pump time and volumes. The electrical and mechanical substations are at the designated subarea at the lowest point inside the site, this is for providing sewage and power facilities throughout the site and for any future expansion.

Design Features: The proposed buildings are designed as feature buildings, because of their look and height, around an evergreen landscape. The building follows 'a contemporary look and feel', but if we stand and look from afar they tend to feel majestic making the inmates feel the zeal too. It is designed as to provide a feeling of fulfillment among the employees, roaring that their organizations do look for their mental health as a priority providing them a well thought of workspace. The constructability strategies with an approach to sustainability has helped in reducing overall project cost, increasing the carpet area, keeping in mind to provide better set of facilities to the users. With the use of optimized hard/ soft paving and green landscapes we have minimized the urban heat island effect.

Signature Building: The building have true essence of being a 'signature' building, starkly contrasts in form and shape and texture, to the rest of the campus, thus standing out effectively as a virtual focal point in the complex and also in the city as an intelligent and self-sufficient buildings.

Double Height Cafeteria: The buildings have been designed as two wings connected by a double height Cafeteria which gives the building a very open look. The double height cafeteria with a huge expanse of display space, adds to the "wow" effect necessary for a "Signature" Building of this stature. Services and Staircases/lifts are concentrated in blocks for a better frontage to the Building for it truly to become a Signature Building.

Barrier Free View: The use of greens and glass in the building façade. The transparency and elegance of the glass lend an "international feel" to the building without compromising on the volumetric quality of the space.

Focal Point: The focal point of the building i.e. the Entry Porch has been designed as welcoming as it maybe to attract visitors and employee to make them 'feel good' and also it diverges to all the facilities which has been provided for the needs of the employee according to *Maslow's Hierarchy of Needs*.

Approach to Sustainable Design (Energy Efficiency)

Orientation: The Building has been designed as per Orientation with maximum light coming from the glazing provided on the facades. A large curved window-glass façade is provided on the Entry / North West side for maximum natural light and views of the formal landscape. Solid facades with minimum and self-shading slit openings on the South West sides effectively cuts down the solar heat gain, while the South West side is provided with overhangs for self shading of the glazing, thereby reducing the harsh impact of the sun on this side.

Open Balconies: Open balconies have been provided at all floors with green landscapes which brings the 'outside in'. This have been designed keeping in mind how plants help in psychologically calming a human mind and how drastic their effects are on mental health.

Landscape Design: The huge sweep of the curved road echoes the curvature of the ellipse, which is further reinforced by the curved form of the building and its various balconies and projections. The landscaping has been done keeping in mind the native species from the Aravalli biodiversity area. The landscape will carry the company name and logo acting as a marker for this signature complex.

Site Features: Smog eating and rainwater harvesting landscape feature has been placed on the site along with the natural trees. Their function is to remove carbon dioxide from the air and release oxygen using a carbon dioxide removal process called "humidity swing". Three assembled units forming a hexagon define the TREE, with social functions that a natural tree has, an interactive interface, allowing people to interact with the tree and each other.

Privacy: The privacy of visitors and employee in different building is respected. The entries to the buildings are different. The green area and entry to the building is separate and their own.

13. REFERENCES

1. Bauer, M., Mosle, P. And Schwarz, M. (2010). Green Building Guidebook for Sustainable Architecture. Germany: Springer-Verlag Berlin Heidelberg
2. Aggarwal, S. (2016 , February). RADIANT COOLING SYSTEMS FOR HIGH PERFORMANCE BUILDINGS. Chandigarh.
3. Arsha Viswambharan, S. K. (April 2014). Sustainable HVAC Systems in Commercial And Residential Buildings . International Journal of Scientific and Research Publications, Volume 4.
4. HANSCOMB, D. (2015). Radiant cooling system by ASHRAE. OPPORTUNITIES FOR RADIANT COOLING IN NORTH AMERICAN CONSTRUCTION, 61.
5. Sastry, G. (2012). FIRST RADIANT COOLED COMMERCIAL BUILDING IN INDIA – CRITICAL ANALYSIS. Banglore: BEE.
6. (1995). HANDBOOK ON FUNCTIONAL REQUIREMENTS OF BUILDINGS (OTHER THAN INDUSTRIAL BUILDINGS) UDC 696/697 (021) ISBN 81-7061-011-7. India: BUREAU OF INDIAN STANDARDS, NEW DELHI
7. n.d. *Advanced Energy Design Guide for Small to Medium Office Buildings*. ASHRAE.
8. Bureau of Energy Efficiency, Ministry of Power, 2016. Energy Conservation Building Code 2016. Government of India
9. Sadineni SB, Madala S, Boehm RF. Passive building energy savings: A review of building envelope components. Renewable and Sustainable Energy Reviews. 2011;15:3617-3631
10. . Lechner, N., 2015. *Heating, cooling, lighting*. Hoboken: John Wiley & Sons.
11. M/s. Tata Realty and infrastructure Ltd., n.d., *Revision & Expansion of Mixed use development project Sector-72, Gurgaon, Haryana*. India: Ministry of Environment, Forests and Climate Change.
12. GRIHA, 2017. Case study: Indira Paryavaran Bhawan (IPB). (Retrieved November 24, 2017, from Green Rating for Integrated Habitat Assessment, India:
13. GRIHA, 2018. Case study of SBD1, Infosys Limited, Hyderabad. (Retrieved February 12, 2018, from Green Rating for Integrated Habitat Assessment, India:
14. Ismail, L.H., 2007. An Evaluation of Bioclimatic High Rise Office Buildings in a Tropical Climate: Energy Consumption and Users' Satisfaction in Selected Office Buildings in Malaysia. School of Architecture, University of Liverpool, Malaysia(Ph.D Thesis Retrieved November 1, 2017)
15. Ministry of Urban Development, Government of India, 2015. Smart Cities: Mission Statement & Guidelines. New Delhi: Ministry of Urban Development, Government of india. (Retrieved November 12, 2017)
16. Raji, B., Tenpierik, M.J., Dobbelsteen, A.V., 2016. A comparative study: design strategies for energy-efficiency of high-rise office buildings. J. Green Building 11 (1), 134–158
17. Zhang, K., Zhu, N., 2013. Comparison and analysis of energy consumption of energy effiecient office buildings in different climate regions in China: case studies. Front. Energy 7 (30), 399–405.
18. Srinivas, S., 2005. Green Building Congress 2005. IGBC Green Habitate, A newsletter on Green Building, October.
19. Haryana Bye-Laws
20. Bureau of Indian Standards, 2016. NATIONAL BUILDING CODE OF INDIA VOL.1 & 2, 2016. Government of India