Solar Decathlon India

EcoTribe

Team - EcoTribe
Office Building

Final Design Report
April 2023

Sustainability is the Balance between Environment- Economy- Ethics

MKSSS Dr.Bhanuben Nanavati college of Architecture, Pune
Navsahyadri Education Society's Group of Institutions, Pune

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5. Executive Summary

Team '**Eco-Tribe'** is composed of 15 students from two different institutes and backgrounds who came together to design a net zero corporate IT hub building for Goel Ganga group located in the Wanowrie area of Pune, Maharashtra. This project is taken as a challenge to understand the market constraints and apply net zero approach into a commercial greenfield project to design an iconic nature inclusive workplace that will be projected towards sustainability.

The design constraints put forward by the client stated that different IT companies should be accommodated into a single plan along with their services, common amenities, multipurpose hall, crèche, a bus service yard in an integrated manner and that building should be air conditioned to maintain indoor occupant comfort and maintain a corporate workplace environment and various open spaces in terms of breakout spaces should be allotted to each of the office space to ensure the connection with nature and outdoor environment to boost health and well being of the occupants. The major challenge was to go beyond conventional IT building designs and provide spaces which encourage creativity and ensure vibrant, healthy and cohesive working environment which optimizing the parameters to achieve the goal of net zero energy, water and many more.

A total project having 24523 sq m site area and 29259.31 sqm of built-up area, the preliminary goals of this project were set to design an office building with an EPI lower than 90 kW/hr/year, maximizing renewable energy potential from the large external envelope (roof area) to offset annual consumption, reduce the total fresh water demand by recycling grey water produced in site and recharge ground water during monsoon season so that this ground water can be used via bore wells to reduce dependency on municipal water supply service, illustrate the use of local materials and induce cultural identity, improve building management systems, integrate landscape to encourage biophilia while improving indoor environmental quality, and control outdoor microclimate to ensure thermal comfort, occupant health, and well-being while promoting environmental sustainability which will help to be more resilient to unforeseen disasters and climate change.

The renewable energy generation potential from Photo Voltaic panels was found to be 591900 kWh/annually and therefore the target EPI was set to 90 kW/hr/year by integration of active and passive design strategies such as climate responsive zoning of spaces, optimization of envelope assembly, mixed mode of ventilation, efficient day lighting, energy efficient lighting fixtures.

The baseline fresh water demand of 81 KLD was reduced to 64 KLD by using efficient water fixtures, it was further reduced to 44 KLD using recycling and reusing of grey water for flushing and landscape purpose. Furthermore rain water was used to recharge the ground water which was later used to reduce the water demand and to achieve net zero water by harnessing the rainfall potential during monsoon months.

The challenge in innovation was facilitated through incorporation of wellness office concept by providing green spaces and breakout spaces for social interaction and technological innovation by incorporating PV panels on the shadow free roof of the courtyard for energy generation. Flexibility in planning was achieved by using a flat slab construction technique which reduce the construction time and allows a tenant to use the space as per their requirements. Green pockets were provided on every floor to maintain the IEQ and vibrant, native vegetation palette was selected for improving the overall microclimate of the site.

6. Respond to Reviewer - 1 comments

Section	Reviewer's comment	Our Response
Energy Performance	• Provide shading strategy for south side. • Mention Efficiency of HVAC system • ECBC compliant roof and wall U values	Considering reviewer's comments, simulation has been performed again for base and design case and the relevant data has been provided on page – 12
Water Performance	• Complete recycle water cycles diagram	The details are provided on page - 14
Embodied Carbon	• Where are concrete blocks used in base case.	The details are provided on page - 17
Resilient Design	• Add a risk assessment wherever possible with numbers. • Add diagrams or calculations to describe details/ design of measures for resilience against heat, flood and other risks.	The details are provided on page - 20
Engineering and Operations	• Explain the integration of the proposed building systems within the building structure and layout. • The ease of integration of these systems should be added	The details are provided on page - 23
Architectural Design	• Try to optimize circulation spaces. • Check the lift banks sufficiency both in terms of placement and numbers.	The details are provided on page - 27
Affordability	• Add narrative about downsizing of HVAC system because cooling loads are reduced from passive measures. • Clearly mention what locally sourced materials are being used to reduce costs.	The details are provided on page - 31
Innovation	• Team can innovate within these in terms of cost, materials or integration within the project etc.	The details are provided on page - 33
Health and Wellbeing	• Mention of thermal comfort standard to be used for the project along with target ventilation rates and indoor air quality. • Any analysis to prove that the project has achieved these targets must be presented.	The details are provided on page - 36
Value Proposition	• The pitch to project partner should be strengthened. • Focus on how this can be a brand equity builder, return on investment and the positive aspects for users in terms of physical and physiological health	The details are provided on page - 39

6. Respond to Reviewer - 2 comments

Section	Reviewer's comment	Our Response
Energy Performance	-	
Water Performance	You can show a high-resolution picture while showing Water efficient fixtures and maybe you can specify the brand name as well.	The details are provided on page - 14
Embodied Carbon	Please provide clarification on the appropriate analysis type used in the project.	The details are provided on page - 17
Resilient Design	Expand on the flood resilience strategies	The details are provided on page - 20
Engineering and Operations	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	The details are provided on page - 23
Architectural Design	-	
Affordability	You can present a cost-comparison analysis between the proposed design and the baseline design. When discussing the percentage of Renewable Energy generation.	The details are provided on page - 31
Innovation	-	
Health and Wellbeing	While you have examined the Visual comfort, it is crucial to detail the annual simulations that demonstrate the achieved thermal comfort in crucial areas during occupied hours and for each mode of operation	The details are provided on page - 36
Value Proposition	-	

7. Team Introduction:

Team Name – Eco Tribe

Institution – MKSSS'S Dr. Bhanuben Nanavati College of Architecture

Navsahyadri Education Society's Group of Institutions, Pune.

Division – Office Building

Team Members –

Yashashree Gogate
M.Arch 2nd Year
Architectural Design And Comfort And Environmental Quality

Pallavi Sahuji
M.Arch 2nd Year
Architectural Design And Water efficiency

Srushti Kumbhar
M.Arch 2nd Year
Architectural Design And Energy efficiency

Rashmi Yelpure
M.Arch 2nd Year
Architectural Design And Resilience

Prachi Patil
M.Arch 2nd Year
Architectural Design And coordinator

Vaishnavi Shinde
B.Arch. 3rd Year
Architectural Design And Water efficiency

Saachi Yadav
B.Arch. 3rd Year
Architectural Design And Scalability And Market Potential

Hrishita Alekar
B.Arch. 3rd Year
Architectural Design And Affordability

Ananya Sakle
B.Arch. 3rd Year
Architectural Design And Comfort

Khushi Gandhi
B.Arch. 3rd Year
Architectural Design And Energy efficiency

Harshada Badgujar
B.Arch. 3rd Year
Architectural Design And Presentation

Kasturi Narkar
B.Arch. 3rd Year
Architectural Design And Health and wellbeing

Samrudhi Dhokale
B.Arch. 3rd Year
Architectural Design And Scalability And Market Potential

Isha Gore
B.Arch. 3rd Year
Architectural Design And Engineering Design

Sayali Shinde
BE Civil 4th Year
Project Estimation

Background of the lead institution:

MKSSS Dr.Bhanuben Nanavati College of Architecture for Women, founded in 1994. The institute offers Bachelor of Architecture (B.Arch), Master of Architecture(M.Arch) and Doctorate programs(PhD)under Savitribai Phule Pune University. The students pursuing Masters of Architecture are trained in Energy Efficient designing through simulation software and resilient structure building. Extensive studios pertaining to climate study and vernacular design are held for students.

Faculty Lead and Faculty advisor:

Ar. Prajakta Dalal-Kulkarni
(Faculty Lead)
Assosiate Professor at Department of Environmental architecture & Plannig, MKSSS's Dr. Bhanuben Nanavati College of Architecture, Pune IGBC AP, GRIHA Evaluator & trainer

Ar. Namrata Dhamankar
(Faculty Advisor)
Assistant Professor at Department of Environmental architecture & Plannig, MKSSS's Dr. Bhanuben Nanavati College of Architecture, Pune Msc. Environmental Design, IGBC AP & GRIHA trainer

b. Design management process

1. INITIAL STAGE -
An integrated design strategy was chosen with the 10 SDI contests in mind. To develop a thorough framework to solve the spatial needs, team members met regularly with the project partner, faculty head. Each of the 10 contests was initially carefully examined in order to fully comprehend the requirements, synergy, and design approaches related to holistic integration that could be implemented into the integrated design development.

2. PRELIMINARY STAGE AND WORK DIVISION –
We then attempted to categorise the preliminary tasks that must be completed throughout the competition in order to accomplish other objectives. To increase our work management and productivity, we divided into Interactive, Research, Technical, and Presentation Teams. Based on all competition's requirement, we also distributed the job among the team members individually

3. LEARNING PHASE AND ACCESSING RESOURCES
While doing so, we worked through the self-learning courses and attended webinars the solar decathlon had scheduled. These resources assisted us in becoming familiar with the idea of net zero buildings and in completing our deliverables. We started with the designing stage while learning new tools and conducting various researches. For design purposes, we evaluated several possibilities, materials, and tools.

4. DEVELOPING NET ZERO BUILDING STRATEGIES AND IMPLEMENTATION -
We originally planned the building passively with the goal of reducing overall energy usage. The facade's material is then selected to reduce heat gain, hence reducing the overall energy required for cooling. The installation of energy-efficient fixtures came next. The solar energy (renewable energy) potential of the roof has been utilised to reduce reliance on the grid by 44%.We put in water-saving fixtures where there was a lot of demand for water. STP is utilised to treat the site's greywater, which is then used for flushing and landscaping. and ground water is refilled using rainwater.

Fig 1 – Internal Discussion

Tools used for design

(Source: google image)

TOOLS USED -
Figure represents the tools used for design and optimization of the office project. AutoCAD and SketchUp were used for 2D and 3D design. Other software's like Climate consultant, design builder , Ecotect, used for climate, daylighting ,CFD simulations, energy stimulation, shadow analysis and UHIE & wind analysis respectively. While MS Office, Photoshop and lumion were used for graphic illustration, report making, estimation etc.

8. Project Background

a. Project Name: VANALAY – A Sustainable Office Building Amidst the Forest

b. Project Partner : Goel Ganga Corporation

Goel Ganga Corporation is one of the most trusted real estate developer in Pune. It is also a multi-faceted business conglomerate with business ventures across myriad sectors like education, logistics and energy. We are known for our time-tested commitment to details, innovation, reliability and value.

- MISSION: To be the most preferred brand for quality, reliability, innovations and value!
- VISION: To create benchmarks of excellence and keep exceeding the expectations!
- VALUE: To provide innovative, efficient and customized construction solutions that drive economic development, while preserving nature, creating a more sustainable greener tomorrow.

Key individuals:

1. Mr. Nikhil Agarwal, Directors of projects at Goel Ganga Corporation

c. Brief Description of Project:

The project is located in Wanowrie, Pune, Maharashtra Pune falls under Warm and Humid climate as per ECBC.
The corporate office is being built to accommodate variable office space requirement with a provision for **1000 employees** occupying for an 8-hour office shift from 9:00 am to 5:00 pm during 5 days a week.
The brief aims not for a typical office building but a combination of working space with forest/nature as the connection with open green spaces enhances our work.
The building has the flexibility of area availability or office spaces. i.e small office spaces, medium office spaces and large office spaces

Context of the project:

Fig 2 – Map of India and Map of Maharashtra (Source: Google images)

Fig 3 – Google Location of site with context (source: google maps)

- **Site location : Wanowarie, Pune**
- **Co-ordinates**: 18.5204° N, 73.8567° E
- **Site Area : 24,673.12 Sqm**
- **Project type : Offices Building**

- The Site is loacted just besides the heritage structure of Mhadaji Shinde Chatri. - A memorial built to honor the Maratha leader Mahadji Shinde
- The Site is surrounded by various amenities like cricket ground, Maruti mandir, with cafe's and restaurants on the front north road.
- The east and south context of the plot have Residential towers while the west side is open and has a water stream called Bhairoba Nala.

d. Total Built-up area:

- **Site Area**: 24523 sqm
- **Permissible Built-up Area**: 26975.3 sqm + 5075.58 sq m (in situ FSI) = **32050.88 Sq m.**
- **Permissible Ground Coverage**: 50 % of total site area
  = 24523*0.5= 12261.5 sqm
- **Roof Area:** 8100 sqm (office building)
  1380 sq m (Amenities building)
- **Proposed Estimated built-up area**: **29259.31 sqm** (Details of the built-up area is provided in detail area statement)

Fig 4 - Site

e. Special Requirements from project partner:

- The project should fulfill local bylaws and guidelines.
- The project should have provision for STP.
- The spaces of the project should have visual connectivity with outdoor surrounding with green pockets in between the workspaces to encourage employees and maintain their health and wellbeing.
- The project should have spaces like multipurpose hall, seminar halls, crèche and dining area for the employees.

Energy Performance Index Goal:

The project aims to achieve EPI of **90 kWh/m2 per year.**
According to BEE standards for office building in Warm and Humid climate, having more than 50% of the regularly occupied area as air conditioned the target EPI is **182kWh/m2 per year.**
Consumption reduction: As a design team we are looking at measures to reduce the energy requirement of the building by incorporating passive architecture at the design stage itself and further reducing the loads by using energy efficient equipment and appliances
Energy Generation: As a Design Team we are Considering using Onsite Renewable Energy (Solar PV Panels) generation potential to its maximum limit to achieve the desired EPI.

Available roof area: **8100 sq m (office building)**
Shadow-free area as per shadow analysis = **4840 sq m = 59.75% ≈ 60%**

9. Goals

1. ENERGY PERFORMANCE –
AIM – To reduce the EPI up to 90 kWh/sq.m. Year
ACHIEVEMENT – EPI of **30 kWh/sq.m**. Year is achieved using passive architecture techniques, energy efficient fixtures and by incorporating renewable energy.

2. WATER PERFORMANCE –
AIM - To achieve net zero water.
ACHIEVEMENT – 62% reduction in consumption using efficient fixtures, **90% Reusing** grey water and **430 KL ground water recharge** using rainwater harvesting techniques.

3. LANDSCAPE AND ECOLOGY –
AIM –To enhance biodiversity and well being of occupants.
ACHIEVEMENT –75% of existing tree cover preserved to prevent soil erosion, reduce UHI effect, and maximize carbon sequestration, while also providing outdoor view for visual comfort.

4. RESILIENCE –
AIM - Designing a sustainable space to promote integrated development and anticipate environmental, natural, and economic challenges..
ACHIEVEMENT – 30 % energy demand reduction by using efficient fixtures, **75% tree preservation** to induce water recharge and reduce chances of flooding and **90% use of grey water.** Spaces with flexible planning to accommodate varying size office demand.

5. ARCHITECTURE AND DESIGN –
AIM –Designing an office building to provide thermal and visual comfort and provide healthy environment for occupants.
ACHIEVEMENT – Green pockets in between office spaces designed for **better visual comfort. Visual connection** with lower floors and promoting **walkability** using interesting landscape features.

6. INNOVATION –
AIM – Proper waste management system for the project and Flexible planning of spaces.
ACHIEVEMENT – Waste Segregation at source for better waste management, **open floor plan** for better planning of tenant occupied spaces, use of **solar panels** as a cover for central courtyard.

7. ENGINEERING AND OPERATION –
AIM- To reduce construction time and energy requirement during operation.
ACHIEVEMENT – Use of **Flat Slab** to reduce construction time, **Independent HVAC system** for each office space for efficient use of energy, use of **BMS system** for control over access, energy use and emergency services.

8. EMBOIDED CARBON –
AIM -To reduce GHG emissions associated with building construction .
ACHIVEMENT: – 75% reduction in CO2/ sq m Using more than **30%** of **Local materials**, use of **EPD and Green Certified products,** use of **BEE rated products** for reduction in energy demand.

9. HEALTH AND WELLBEING –
AIM -To ensure healthy environment through visual and thermal comfort for occupants.
ACHIEVEMENT -75% of regularly occupied spaces with external views, **100% glare-free** spaces, **85%** of daylit areas, and **green pockets** for relaxation and visual connection with outdoor environment using space planning and use of materials, i.e. glass.

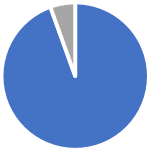
10. AFFORDABILITY –
AIM – To reduce construction cost (by 10-15 %) and operational cost (by 15-20%)
ACHIEVEMENT: 15% reduction in construction cost by using local materials- reducing transport, **29% reduction** in operational energy using efficient fixtures.

10 contests and their evaluation criteria:

1. Energy Performance

Measurement:
For the base case design, the building was designed with no passive strategies, using ECBC compliant material, no energy efficient fixtures, without energy regeneration aspect, etc. The EPI calculated for the base case was 182 kWh/m²/year. This simulation was performed as per ECBC 2017.

Orientation:
Orientation refers to planning of the building in a such a way that it will reduce the energy consumption and can utilize maximum potential of the site and its surroundings. Just the orientation of the building reduced the EPI to 172 kWh/m²/year.



Building Materials:
The energy simulation was run using conventionally available materials to understand the best possible solution. The wall assembly was arranged with simple block wall with insulation. 200 mm AAC block wall with 50 mm insulation and 150 mm concrete roof with 100mm insulation was selected. In base case and design case material were kept same to achieve desired U-value given by ECBC. Therefore no reduction in EPI.

Window Glazing:
Single glaze and double glazed window compositions with different SHGC and U-value were considered and simulated against the base case of 6 mm clear single glazing. A DGU with 6mm thick tinted glass, 6 mm air gap and 6 mm thick internal clear glass was selected which further decreased EPI to 158 kWh/m²/year.

Window shading:
The building was simulated without any shading devices for base case scenario. After calculation for shading devices considering the sun angles across the year, combination of vertical fins with horizontal projections on south side and horizontal louvers on west side to avoid radiation and glare from setting sun was selected with sizes 0.8 m- 1 m. This further reduced the EPI to 149 kWh/m²/year.

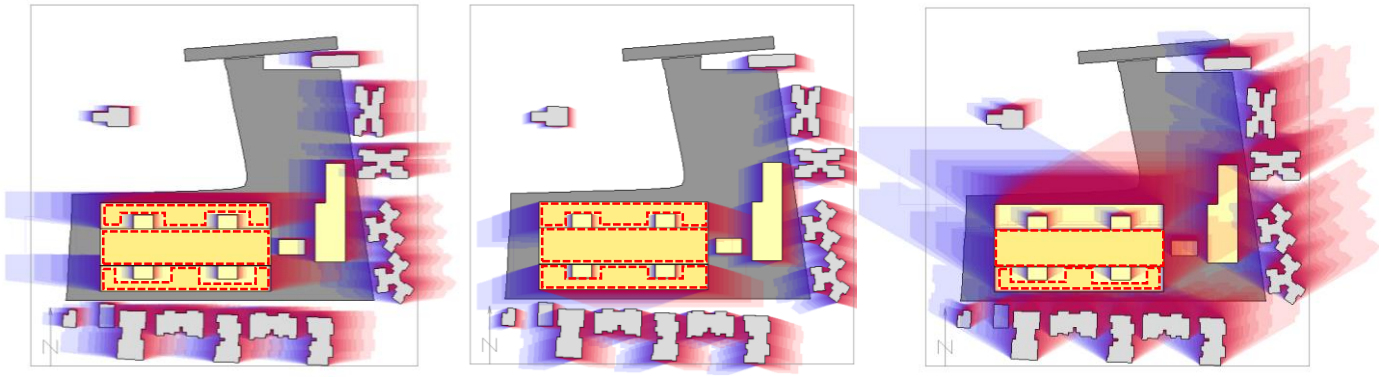
HVAC system:
The HVAC system adopted for baseline study was VAV with parallel fan powered boxes and reheat with chilled water, for design case VRV system with Fan coil units was adopted for each floor. Use of this system further reduced the EPI to 109 kWh/m²/year.

Lighting:
The base case for lighting was considered as per ASHRAE 90.1, for design case, efficient fixtures with lighting control and schedules were applied which further reduced EPI to 60 kWh/m²/year.

Typology	Cooling	Interior Lighting	Exterior Lighting	Equipment Load	Fans	Pumps	Heat rejection	Total
	kWh/yr	kWh/yr	(kWh)²	kWh/yr	kWh/yr	kWh/yr	kWh/yr	kWh/yr
Base case	1513654	1131911	295.9	348410	569178	214.3	144	3563288.0
Proposed Case	400917	285814	295.9	348410	168573	0	0	1203722.2

Table 01– Annual Energy consumption breakup for base case and design case

Renewable energy potential:



MARCH SHADOW RANGE | JUNE SHADOW RANGE | DECEMBER SHADOW RANGE

Fig 5– Shadow analysis roof and surrounding *(source: Ecotect software)*

Shadow free Area:

Available roof area: **8100 sq m (office building)**
Shadow-free area as per shadow analysis = **4840 sq m = 59.75% ≈ 60%**
As per the shadow analysis, building C on the eastern side is covered in shadow in December, hence the roof of the central courtyard and building B (60%) has been studied for the renewable energy (solar energy) potential of the site.

LEGEND

- Site
- Proposed building
- Surrounding building
- Shadow free area

ENERGY REDUCTION TABLE		
Total energy consumption	1203722.2	Kwh/yr
Solar energy generation	591900	Kwh/yr
Annual consumption after offset	611822.2	Kwh/yr
EPI	30.61	kWh/m²/yr
Ratio	30.61/182 = 0.16	
Total energy reduction	83%	

Table.02– Renewable (solar) energy potential and reduction in EPI

Solar Rooftop Calculator

Average solar irradiation in MAHARASHTRA state is 1266.52 W / sq.m
1kWp solar rooftop plant will generate on an average over the year 5.0 kWh of electricity per day (considering 5.5 sunshine hours)

1. Size of Power Plant	
Feasible Plant size as per your Roof Top Area :	394.6kW
2. Cost of the Plant :	
MNRE current Benchmark Cost (without GST) :	Rs. 35886 Rs. / kW
View Benchmark Cost List	
Without subsidy (Based on current MNRE benchmark without GST) :	Rs. 14160616
With subsidy 0 (Based on current MNRE benchmark without GST) :	Rs. 14160616
3. Total Electricity Generation from Solar Plant :	
Annual :	591900kWh
Life-Time (25 years):	14797500kWh
4) Financial Savings :	
a) Tariff @ Rs.10/ kWh (for top slab of traffic) - No increase assumed over 25 years :	
Monthly :	Rs. 493250
Annually :	Rs. 5919000
Life-Time (25 years) :	Rs. 147975000

Source: https://solarrooftop.gov.in/rooftop_calculator

Fig 6– Renewable energy potential calculation

2. Water Performance

As per National building code 2016, Standard fresh water demand for one person is 45 LPD (liters per day) for office buildings. We have proposed to reduce about 62% water demand.

Reduce	Recharge	Reuse
45 LPD to 28 LPD (62% reduction in consumption)	438.4 KL/Year (Rainwater Recharge)	90% of grey water is reused

REDUCE

The water consumption was brought down from the base case of 45 lpd to 28 lpd by efficient use of water saving fixtures. The total occupant Water demand is estimated to be 64000 lpd, consisting 1000 people.

	Per Capita Daily Consumption	Total Number of Occupants	Landscape Water Requirement	Total Water Requirement Daily	Total Water Requirement Yearly
Base-Case	45	1000	36,000	81,000	2,43,00,000
Designed Case	28	1000	36,000	64,000	1,92,00,000

Table 03 – Water Requirement

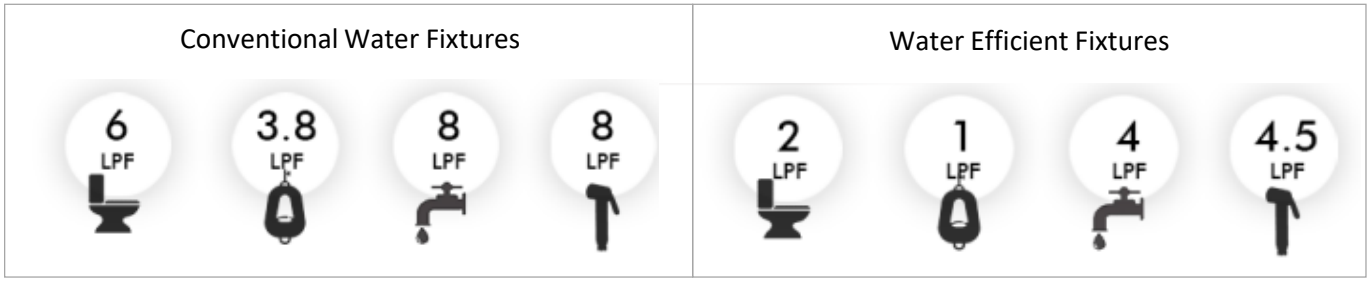


Fig 7 – Comparison between Water fixtures

Products that saves Water

Jaquar faucet
4 LPF

Jaquar Health faucet
4 LPM

Sensor Flushing Valve for Urinals
1 LPF

Jaquar Dual Flush
2 LPF / 4 LPF

Sensotronic Sensor Faucet
4 LPM

Fig 8 – Water Efficient Fixtures

Recharge

Rainwater Harvesting Area calculation – Roof and Non-roof

Sr. No.	Surface Type	Run-off Coefficient	Area (sq.m)	Impervious Area(sq.m)
1	Cemented / Tiled Roof	0.95	9,829	9,337.6
2	Concrete Pavement	0.95	297	282.2
3	Open-grid grass Pavement	0.50	671	335.5
4	Open-grid Concrete Pavement	0.75	6,515	4,886.3
5	Vegetation, Flat (0 - 1% slope)	0.10	3,947	394.7
Total impervious area			(sq.m)	15,236

Table 04 – Area calculations for RWH

Rainwater Calculations

One day rainfall	43.164

For Day Rainfall	0.043	m
Total Impervious Area	15,236	sq.m
Total runoff volume	657.7	cu.m

Table 05 – Surface Runoff Volume

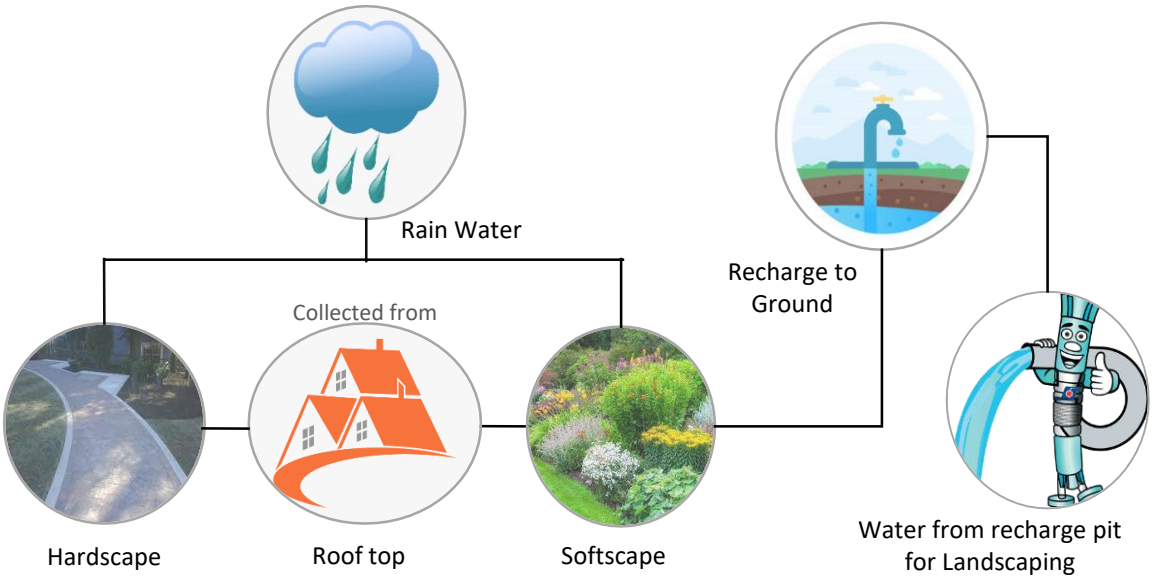


Fig 9 – Flowchart of RWH

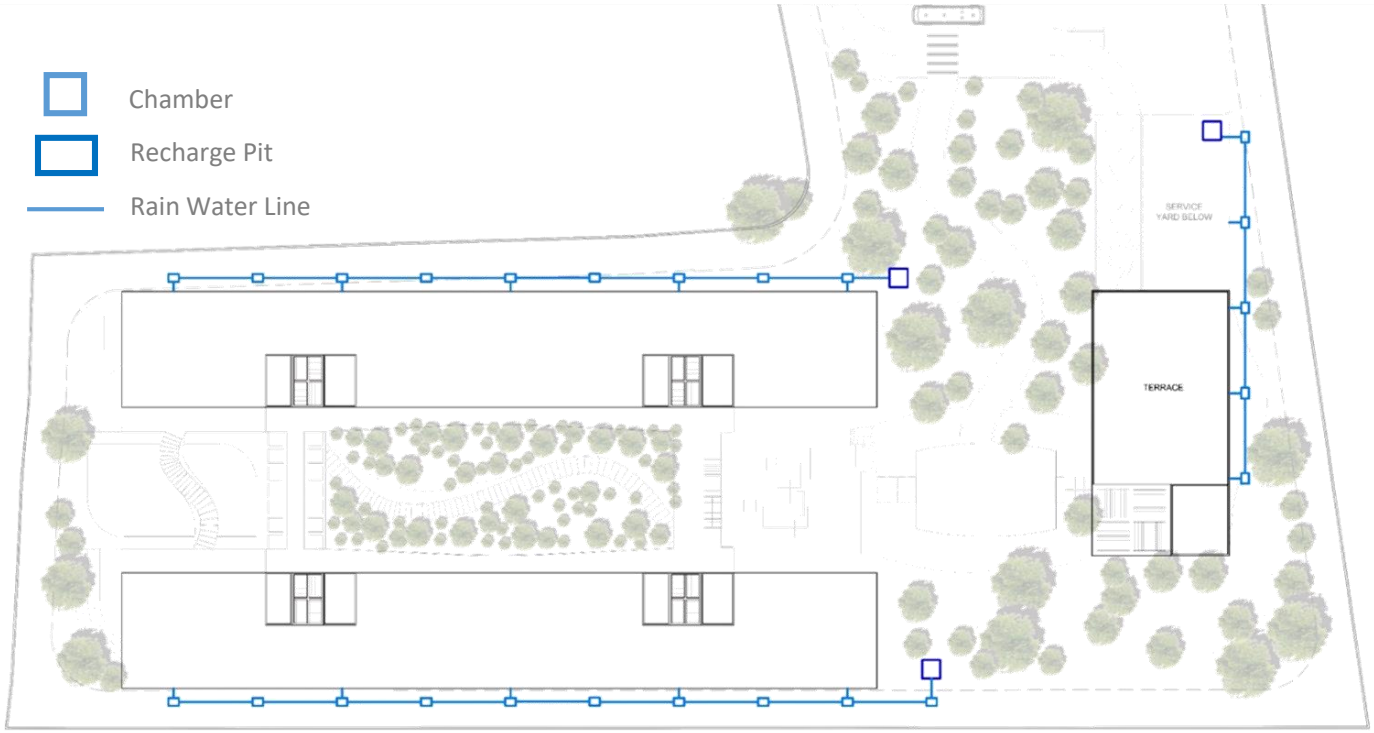


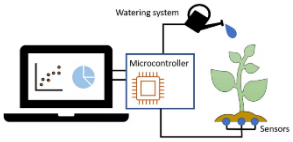
Fig 10 – Rain Water Harvesting Plan

- To preserve water native, drought-tolerant, and adaptable plants have been used in landscaping.
- Irrigation through water efficient management systems and technique are used

Sr. No.	Botanical Name	Common Name
l	Roystonea regia	Royal Palm
2	Cassia fstula	Bahava
3	Polyalthia longifolia	Ashoka
4	Azadirachta indica	Neem
5	Millettia Pinnata	Karanj
6	Mangifera indica	Mango
7	Psidium guajava	Guava
8	Manilkara zapota	Chikoo

Table 06 – Native plant used

Central shut-off valve



Soil moisture sensors

Drip irrigation system to reduce evaporation

Time based controller for the valves

Fig 11 - Water Efficient irrigation (Source: Google images)

Reuse

It is projected that the building generates 23,000 KL of grey water every day. For flushing, irrigation, grey water is recycled, filtered, and reused.

The grey water is collected in an underground storage tank, where it is sedimented and Filtered by Moving Bed Bioreactor (MBBR).

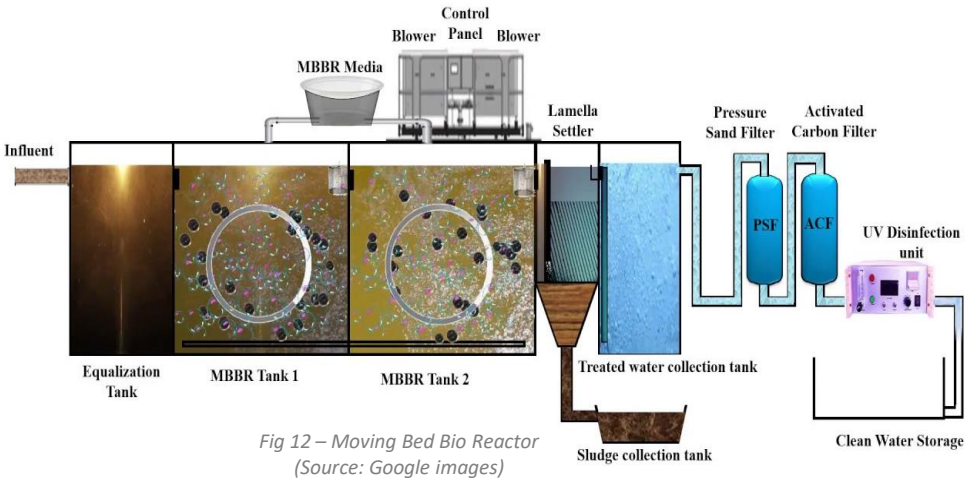


Fig 12 – Moving Bed Bio Reactor (Source: Google images)

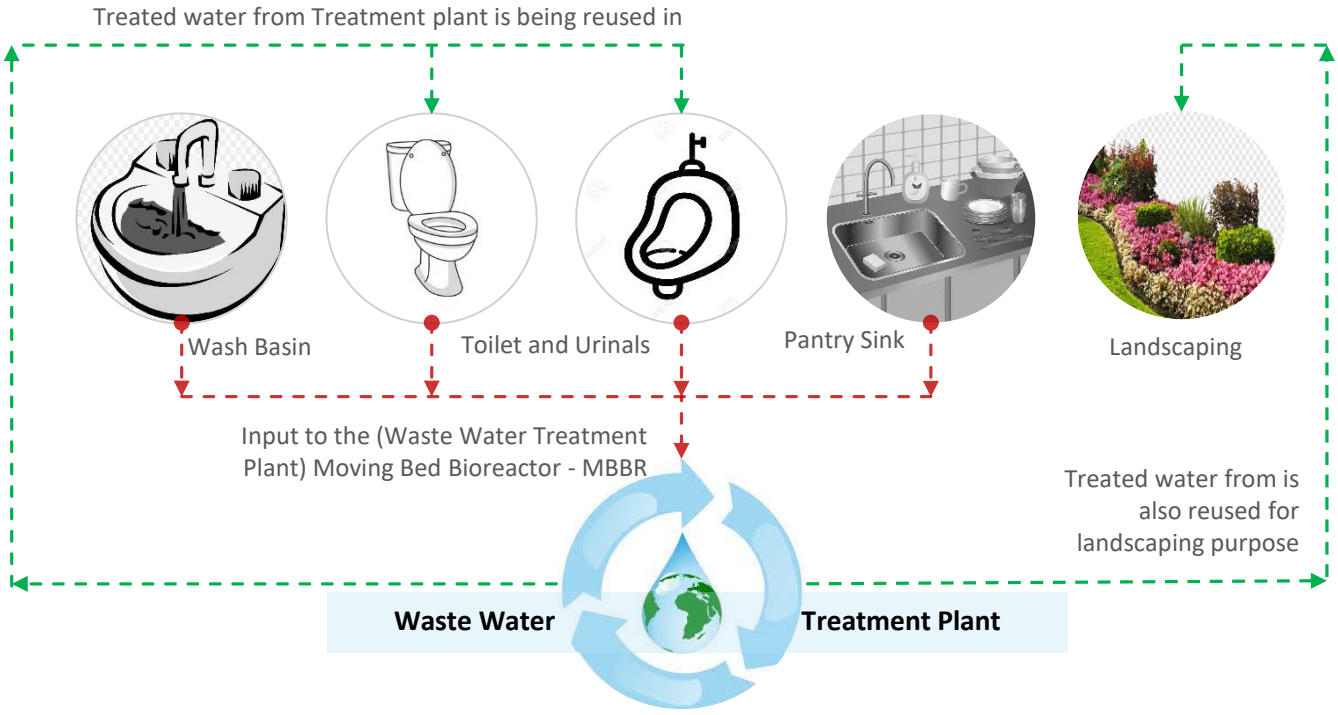


Fig 13 – Flowchart for Reuse of Water

3. Embodied Carbon

This report is created with One Click LCA LEED International office Project. It calculates cradle to grave(A1-C4)embodied carbon impacts and materials efficiency for the 10 most carbon intensive material categories. The analysis of this study is based on the LCA off our typical insulation materials used in different projects. The environmental impact of the project material studied has been analysed in a comparative way.

The values of each category are referred to a 100% relative scale, whose maximum value belongs quantitatively to the registered highest impact in each one of the analysed categories, being visible a similar magnitude for all the impacts. Thus the embodied carbon benchmark of all the 4 project analysis has different life cycle assessment of whole building because of materials used.

Base case Carbon emissions:

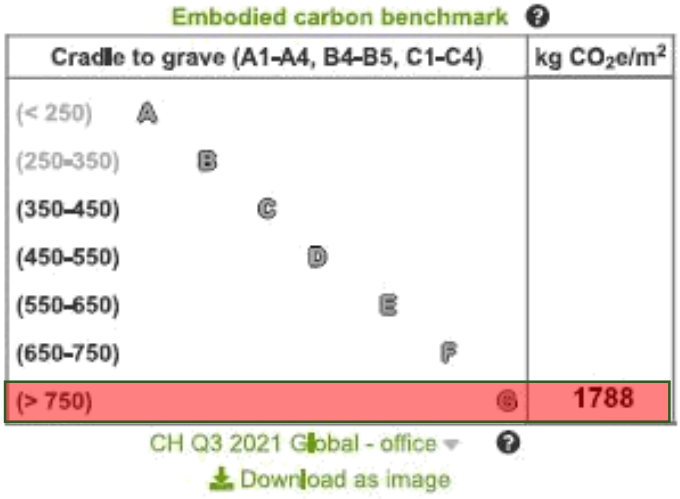


Fig 14– Embodied Carbon for base case

Most contributing materials (Global warming)

Compare data

No.	Resource	Cradle to gate impacts (A1-A3)	Of cradle to gate (A1-A3)	Sustainable alternatives	
1.	Precast concrete wall elements (solid, uninsulated), generic	4,281 tons CO_2e	51.1 %	Show sustainable alternatives	Add to compare
2.	Ready-mix concrete, normal strength, generic	1,531 tons CO_2e	18.3 %	Show sustainable alternatives	Add to compare
3.	Concrete roof tiles	525 tons CO_2e	6.3 %	Show sustainable alternatives	Add to compare
4.	Ready-mix concrete, normal strength, generic	502 tons CO_2e	6.0 %	Show sustainable alternatives	Add to compare
5.	Fire-resistant glazing	471 tons CO_2e	5.6 %	Show sustainable alternatives	Add to compare
6.	Ready-mix concrete, normal-strength, generic	399 tons CO_2e	4.8 %	Show sustainable alternatives	Add to compare
7.	EPS foam insulation	302 tons CO_2e	3.6 %	Show sustainable alternatives	Add to compare
8.	Flooring for patios and walkways	304 tons CO_2e	3.6 %	Show sustainable alternatives	Add to compare
9.	Acrylic topcoat paint for exterior	34 tons CO_2e	0.4 %	Show sustainable alternatives	Add to compare
10.	Aluminium frame sliding windows and patio doors	25 tons CO_2e	0.3 %	Show sustainable alternatives	Add to compare
11.	Concrete roof tiles	kg CO_2e	0.0 %	Show sustainable alternatives	Add to compare

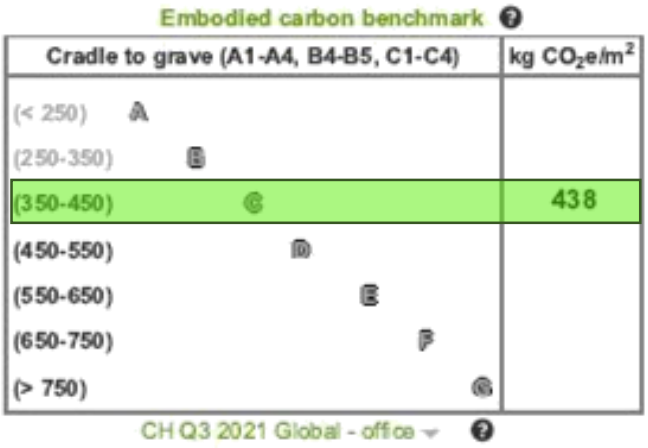
Fig 15– Embodied Carbon contribution of materials base case

Source: https://www.oneclicklca.com/

Material contribution:

- Precast Concrete wall were replaced by AAC blocks from local manufacturer which reduced the overall contribution, material as well as transportation.
- Low VOC paint replaced by emulsion paint reducing the overall impact.
- Ceramic tile manufacturer was changed with lesser transportation distance and low co2 emission potential.

Proposed case Carbon emissions:



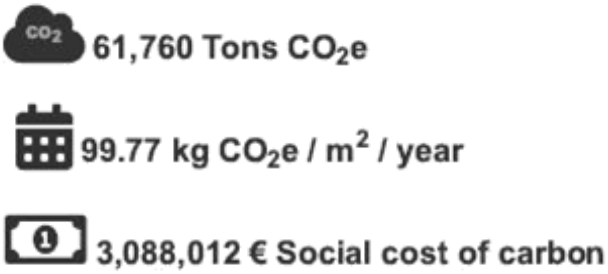


Fig 16– Embodied Carbon for propose case

Most contributing materials (Global warming)

Compare data (1)

No.	Resource	Cradle to gate impacts (A1-A3)	Of cradle to gate (A1-A3)	Sustainable alternatives	
1.	Autoclaved aerated concrete blocks, 460-760 kg/m3	7,127 tons CO_2e	65.1 %	Show sustainable alternatives	Add to compare
2.	Ready-mix concrete, normal strength, generic	1,531 tons CO_2e	14.0 %	Show sustainable alternatives	Add to compare
3.	Ready-mix concrete, normal-strength, generic	991 tons CO_2e	9.1 %	Show sustainable alternatives	Add to compare
4.	Fire-resistant glazing	471 tons CO_2e	4.3 %	Show sustainable alternatives	Add to compare
5.	Ready-mix concrete, normal-strength, generic	399 tons CO_2e	3.6 %	Show sustainable alternatives	Add to compare
6.	Gypsum plaster board, regular, generic	220 tons CO_2e	2.0 %	Show sustainable alternatives	Add to compare
7.	Acrylic emulsion basecoat paint for exterior, waterproofing	148 tons CO_2e	1.4 %	Show sustainable alternatives	Add to compare
8.	EPS foam insulation	57 tons CO_2e	0.5 %	Show sustainable alternatives	Add to compare

Fig 17– Embodied Carbon contribution of materials for proposed case

Source: https://www.oneclicklca.com/

Conclusion:

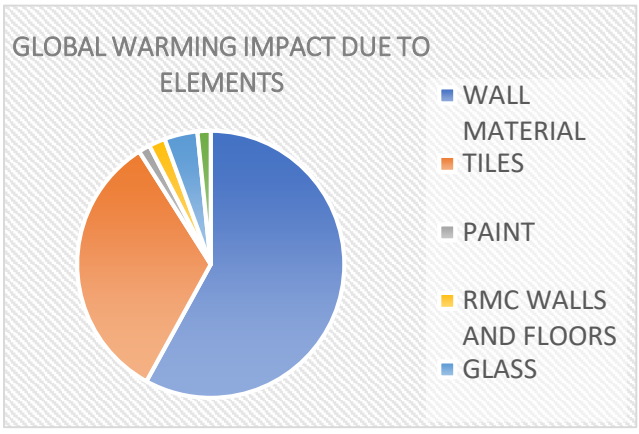


Fig 18– Material contribution in embodied carbon

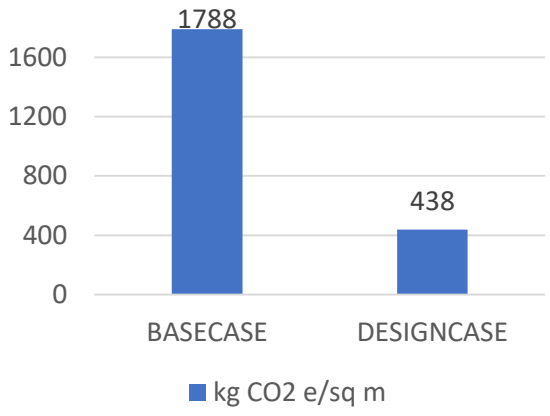


Fig 19 – base case and proposed case comparison

- Adding recycled content to the material can reduce the global warming impact.
- Distance from factory/manufacturer to the site matters while selecting a material as it increases the global warming impact.
- Some paints even if with low VOC can have high impact on global warming.
- Steel used for structure has less impact as it contains recycled content.
- Using locally available manufactured materials like tiles, paints will reduce the impact significantly as the material will be procured from the source directly thus reducing transportation of the materials.

4. Resilience

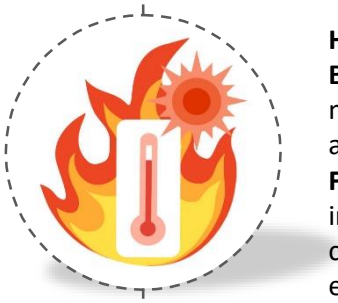
Team Eco-Tribe attempted several measures to make the building adaptive and make it resilient from natural disasters, environmental conditions such as climatic change, hazards and the following measures are considered–

Flood resilient design

While there is no severe flooding in Pune, there may be water logging owing to heavy rainfall and a weak subterranean drainage system. As a result, the whole layout is levelled along the road level (marked as +00 level in the designs), which is about 2 m higher than the contour level of the adjacent storm water channel. The structure is retained on plinth of 0.90 m given for the ground floor entry lobbies.

Earthquake resilient design

Pune lies in Earthquake Zone-III, which have the lowest level of seismic vulnerability, but structural design has been done to sustain the worst-case scenario. Appropriate structural systems has been laid out with column and beam ties, sill and lintel level bands, peripheral beams even the RCC flat slab technique is adopted with column capital.



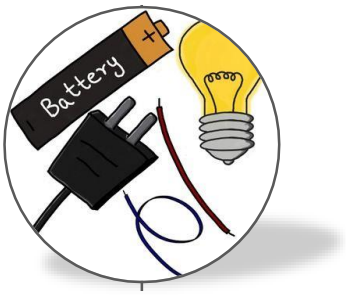
Heat wave resilient design

Building mass - Building materials, geometry, orientation etc affect the overall microclimate. To reduce the heat gain through building envelope, prior attention is given towards climate responsive passive design.

Façade Design - Also, in case of building facade, optimized wall assembly with insulation and appropriate shading strategies in each orientation has been considered. While rooftop solar PV panel with truss system is adopted for the entire roof area.

Power Backup and water autonomy

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



Renewable energy generation

the Roof top solar PV are used to generate the energy from renewable sources. From the optimization, the panels inclination as per latitude, generates the annual energy of 591900 kWh. Conventional Solar PV Panels are Installed on Terrace as well as on Transparent PV Panels are installed on the skylight Central Skylight Area.

Flood Resilience

Slope of site is towards Road Side. All storm water drains from site are connected to the Municipal storm water drainage line.

- More than 20% area on site has landscape with pervious materials.
- Pervious hardscape materials as well as vegetation on site which soak up excess rainwater, preventing run-offs and damage from flooding.

Open Grid Grass and concrete pavers

Gravel Pathway

Fig 21 Pervious materials used (Source: Google images)

Total Site Area	24524 Sq.m
Vegetation on Site	5174 Sq.m
Percentage	21.10%

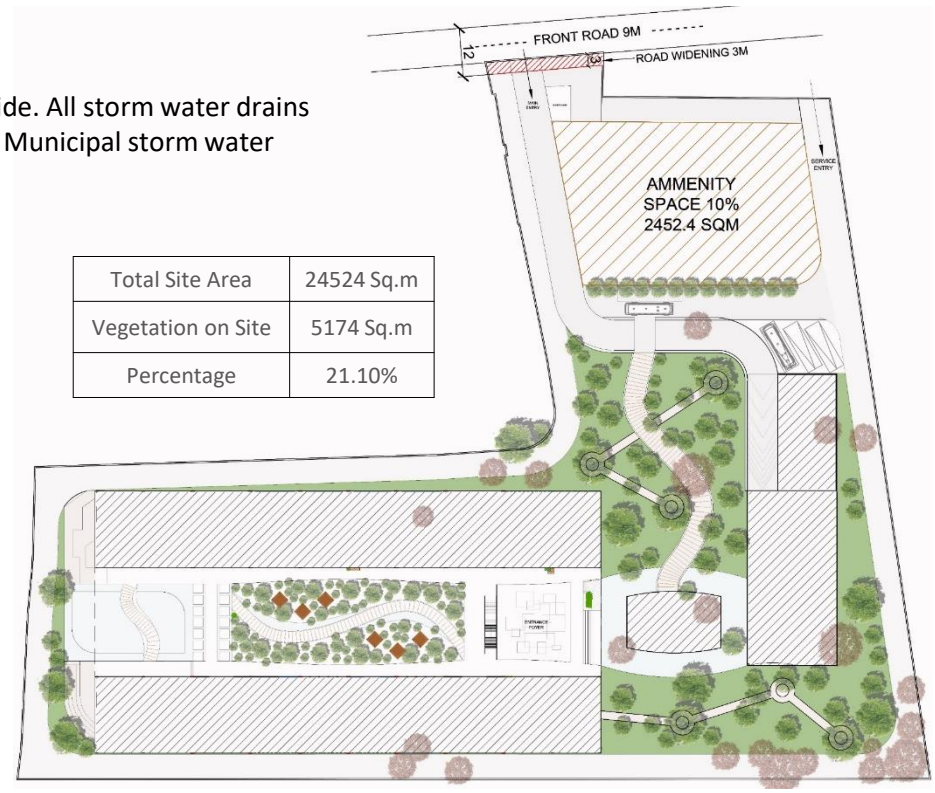


Fig 20 – Plan showing landscape

Urban Heat Island Effect Resilience

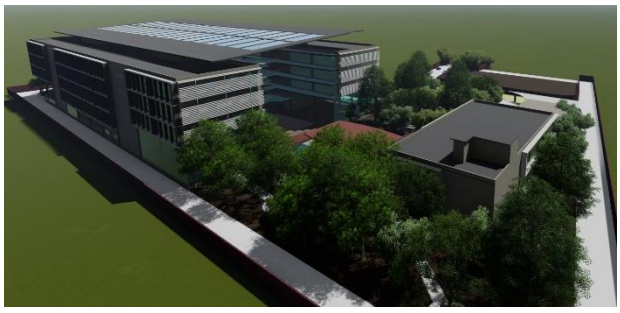


Fig 22 – View Showing Dense Vegetation

Vegetation, Landscaped areas, Surface material, Water bodies, Exterior material, Facade treatment Glazing properties etc. this parameters affect UHIE at microclimate level.
Trees, shrubs and other landscape areas provided in the site affect the ambient as well as surface temperature which helps in achieve overall thermal comfort.

To Minimize heat island effect, High reflective materials has been used to cover Exposed roof areas.

Total Exposed Roof Area	6370 Sq.m
Roof area Covered with High SRI Value Material	6370 Sq.m
Percentage	100%

Table 07 – Roof covered with High SRI paint

100 % Roof areas has been covered by High SRI value material

White Covered Parking Spaces and drop off and pick-up Point for Buses near the entrance

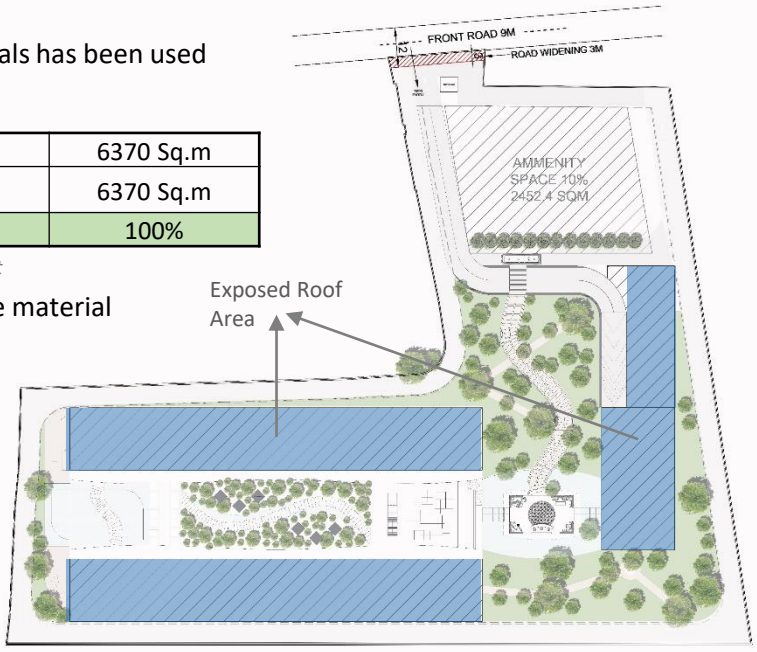


Fig 23 – Exposed Roofs on Site

Services for Fire Safety

To make the building more resilient in the event of a fire, fire safety services are implemented in accordance with NBC, Part 4 requirements, which include a 6 m wide driveway around the building for fire tender movement, a fire shaft, a fire extinguisher, a hose reel, a yard hydrant in the surrounding area, a wet riser, an automatic sprinkler and detection system, manual call points, fire alarm systems, and an underground tank with a capacity of 1,50,000 L and Overhead tank with capacity of 20,000 L ,in addition to this fire escape stairway and a journey distance of 30 m from end points are given.

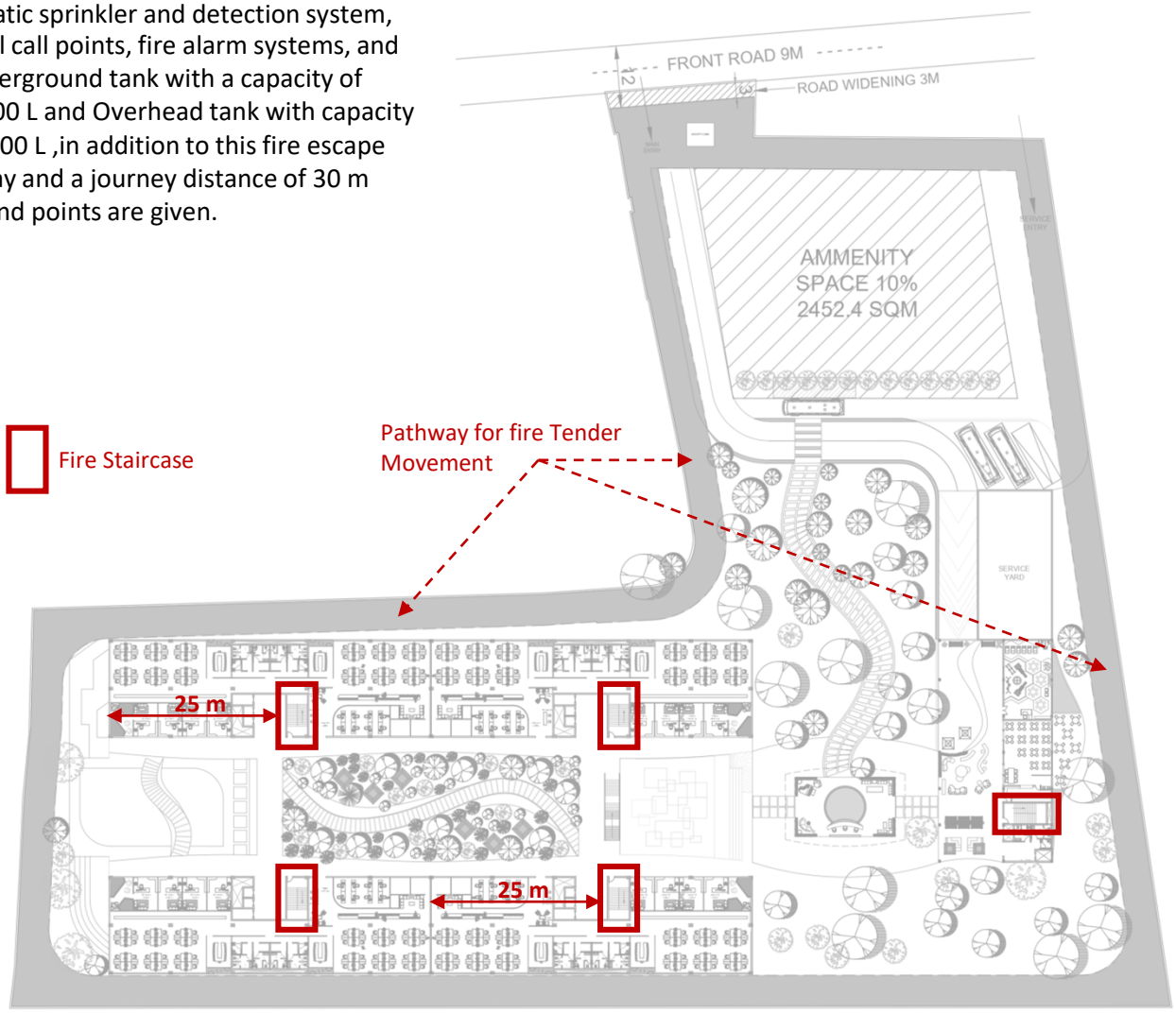


Fig 24 – Fire Services

S.N.	Type of Fire Protection	Description
1	Fire Extinguisher	2 per floor with travel distance not more than 12 m.
2	Wet Riser	Provided at all floors
3	Yard Hydrant	Provided all around the building
4	Automatic detection and Alarm System	For entire building
5	Automatic Sprinkler System	For entire building
6	Underground and overhead water tank	UGT – 1,00,000 litres OHT – 10,000 litres
7	Fire shaft	1 Fire rated lift and staircase

Table 08 – Fire Services

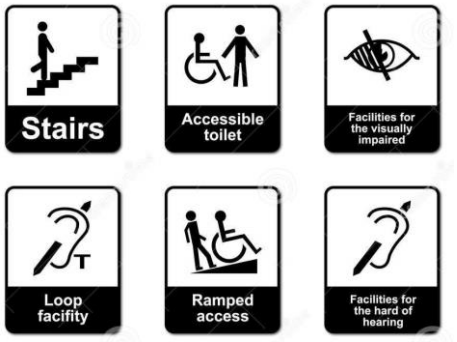
Water facility:

Water storage at a given point is 6,90,000 L.
Water consumption is 45,000 L/day considering 1000 people in office.

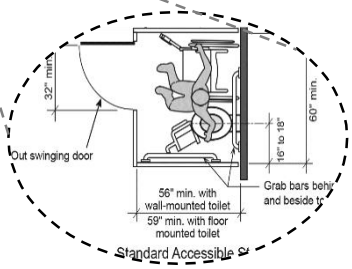
Total Water Storage / per day consumption = Days of Autonomy
6,90,000 / 45,000 = 15.3 days of Autonomy

Universal Design

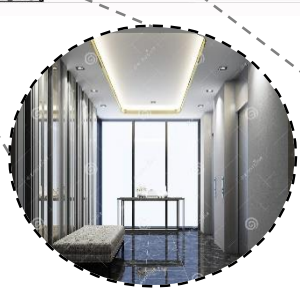
The proposed building is a corporate office- self owned by the project partner. So, universal design aspects are considered in architecture design which includes ramp at entry points, disabled toilet on each floor, barrier free movement connectivity to upper floors through bridges and lifts etc.



Visual warning signage



Restrooms (toilets) for disable people



Seating area near lift

Braille and audio assistance in lifts

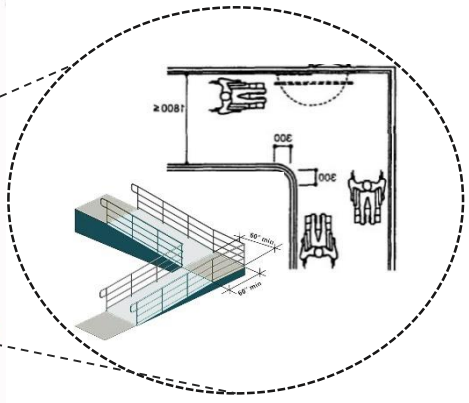


Fig 25 – Universal Design

5. Engineering and operations:

a. Structural Details –

The building is designed with a structural grid of 12M X 9M to allow for flexibility in internal planning, clear floor to floor height, and large open spaces. Flat slab technique combined with RCC structure is used because it is beneficial for large office spaces. Beams are provided at the periphery, near staircases and cut outs, for structural stability.

Flat Slab – Flat slab construction technology expertise are available locally.

- Flexibility in room layout
- Larger internal clear height
- Fast construction
- Ease in installing ceiling services

Flat slab seems beneficial for office building as compared to other slabs.

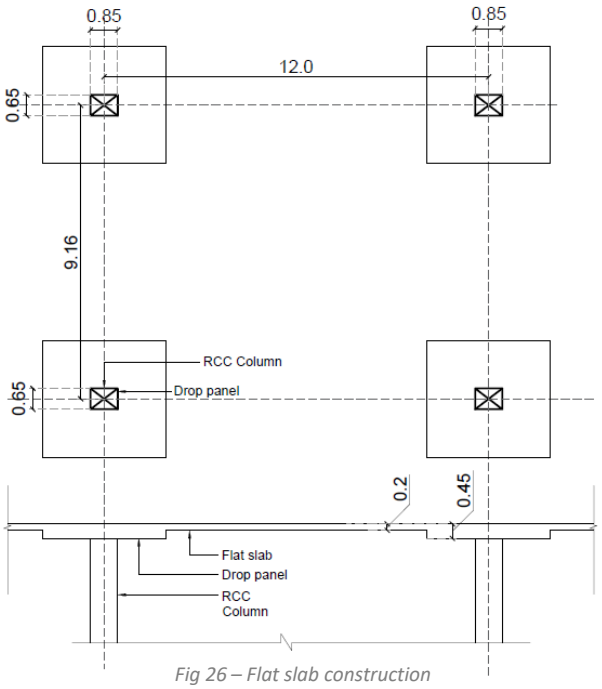


Fig 26 – Flat slab construction

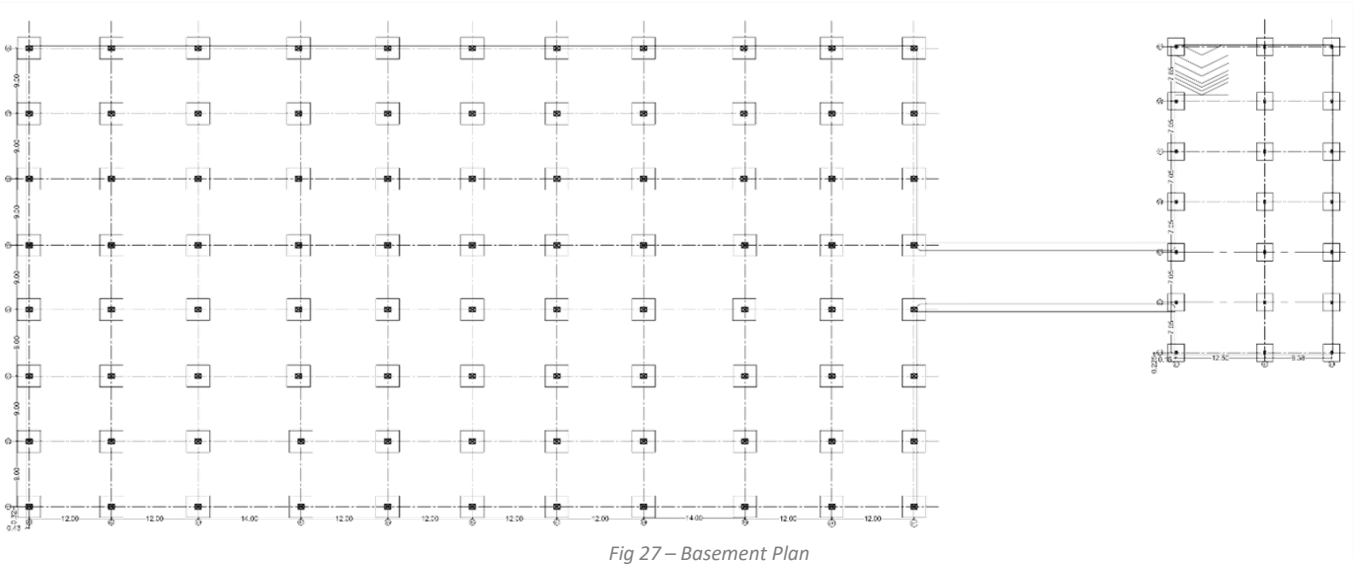


Fig 27 – Basement Plan

b. The below materials are locally available in Pune city.

1. AAC Blocks (Aerated Autoclaved Concrete)-

- an eco-friendly material
- produce lightweight building blocks(2.5 times lighter than conventional bricks)
- heat-resistant
- durable building blocks

2. EPS (Expanded polystyrene insulation)-

- Long-term R-Value and constant thermal resistance
- Energy efficiency and measurable energy savings
- Sustainability and low cost

As these are easily available and locally sourced, the carbon emissions(embodied energy) due to transportation of materials can be reduced with overall reduction in cost and social carbon value of the construction.

c. Building Management System

Demonstrating that the building management system is in place to control and monitor the following systems, as applicable –

1. Air-conditioning management system

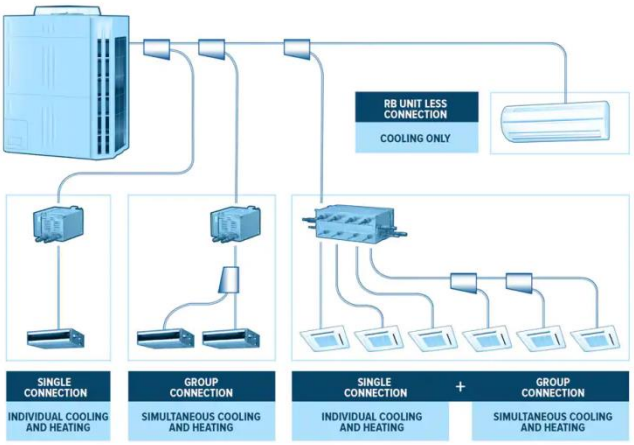


Fig 28 – HVAC VRV system working (Source: Google images)

(a) DAIKIN – VRV System with FCUs

The DAIKIN VRV system is a multi-split type air conditioner for commercial buildings that uses variable refrigerant flow control developed by Daikin to provide customers with the ability to maintain individual zone control in each room and floor of a building.

- R32 is used for refrigeration in VRV HVAC system.
- Per floor Tonnage around 420TR
- **Daikin also provides, integrated building Monitoring system BMS with controllers for Centralised Control.**

	CONFERENCE	SEMINAR HALL SMALL	SEMINAR HALL LARGE	MULTIPURPOSE HALL	GYM	OFFICE 1	OFFICE 2	OFFICE 3	OFFICE 4
TOTAL SPACE COOLING LOAD									
sensible Load	3699.18	3699.18	7395.78	34438.97	4231.08	11776.35	2188.769	11237.07	21939.52
Latent Load	2398.14	2398.14	5334.08	24053.25	1924.5	319.6825	119.6825	119.6825	319.6825
TOTAL COIL COOLING LOAD									
sensible Load	3699.18	3699.18	7395.78	34438.97	4231.08	11997.82	2410.239	11458.54	22160.99
Latent Load	2398.14	2398.14	5334.08	24053.25	1924.5	634.6825	434.6825	434.6825	634.6825
DEHUMIDIFICATION									
Effective room sensible heat load	3699.18	3699.18	7515.2	34438.97	4231.08	11997.82	2410.239	11458.54	22160.99
Room temperature	24	24	24	24	24	77	77	77	77
ADP	12.94	12.94	12.94	12.94	12.94	54	54	54	54
Dehumidified (CFM)	309.69	309.69	629.16	2883.18	354.22	483.0039	97.03054	461.2939	892.1494
TR	1.73	1.73	3.65	16.63	1.75	1.052708	0.237077	0.991102	1.89964
Total TR	11.1	11.1	23.33	77.18	12.39	2.140649	1.4459	2.119337	3.108463
1 TONN = 400 CFM						400	400	400	400
Final CFM	4440	4440	9332	30872	4956	856.2598	578.3601	847.7349	1243.385
DIFFUSER CALCULATIONS									
	CONFERENCE	SEMINAR HALL SMALL	SEMINAR HALL LARGE	MULTIPURPOSE HALL	GYM	OFFICE 1	OFFICE 2	OFFICE 3	OFFICE 4
FINAL CFM	4440	4440	9335	30872	4956	856.2598	578.3601	847.7349	1243.385
CAPACITY OF 1 DIFFUSER	400	400	400	400	400	400	400	400	400
SUPPLY AIR DIFFUSERS	11.1	11.1	23.34	77.18	12.39	2.140649	1.4459	2.119337	3.108463
	11	11	24	77	13	2	2	2	3
RETURN AIR DIFFUSERS	11	11	24	77	13	2	2	2	3

The HVAC system needs to be designed for supplying 228856 CFM of Air into space.
Out of which 7880 CFM to be Dehumidified

Table 09 – HVAC calculations

(b) Ease of integration:

- The VRV Daikin air-conditioning system is viewed as one of the innovative development in the air-conditioning industry. Aside from the features and components, its energy efficiency is also one of the factors which performed better than other units.
- The minimum floor to floor height for Toilets is 3M hence the Fan Coil Units (FCUs) are provided on the top of the Toilets at the height of 2.4M to utilize the space.
- With the innovation in the development of air-conditioners, the use of refrigerant in the VRV air-conditioner are viewed to be environmentally friendly as compared to other types.

- It is normally a quiet air-conditioning system as compared to the other commercial type of air-conditioning system. In addition, since the VRV and VRF units requires longer pipes due to the location and area required, it is often far away from your air-conditioning units or room. Thus, the noise of your VRV units would significantly reduce due to the distance. Furthermore, it is noticed that the noise coming out of the system tends to be lower as compared the split air-conditioning system.

- There are many benefits of installing the VRV air-conditioning system, including greater energy efficiency, modular design to expand the cooling needs if required, less complicated installation, zone control, better cooling comfort and many more. However, when there are pros, there will be cons as well.

Fig 29 – Ground floor key plan

(c) HVAC System Layouts:

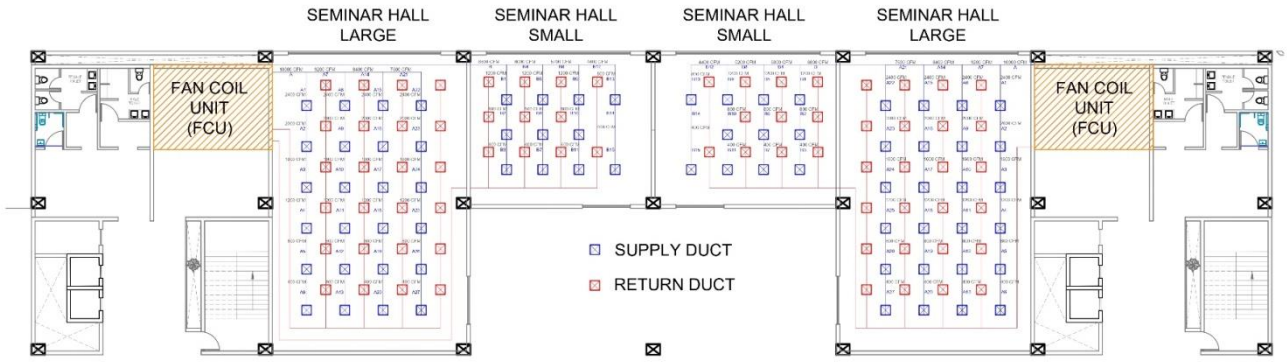


Fig 30 – HVAC VRV system layout for ground floor

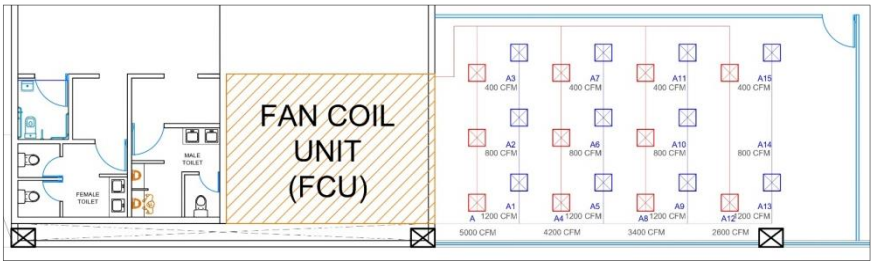


Fig 31 – HVAC VRV system first floor gym detail plan

Fig 32 – First floor key plan

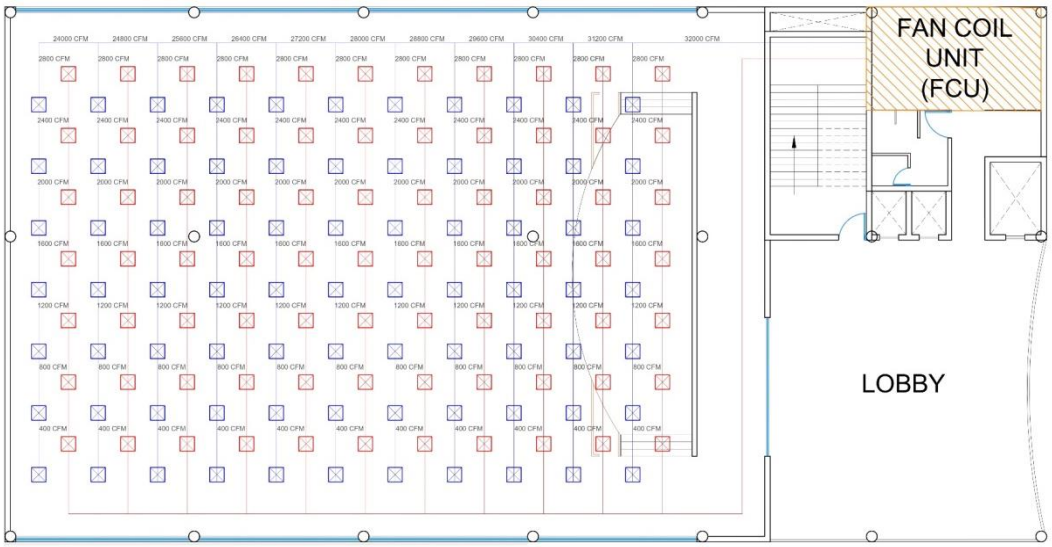


Fig 33 – HVAC VRV system Multi Purpose Hall

2. Lighting management system

Philips Dynalite Room Automation System (PDRAS) is been used for efficient lighting management system.

•The Room Automation System supports up to 5 zones per PDRAS box

•One PDRAS controller supports up to 4 sensors and/or 4 wall switches with pre-programmed behaviours.

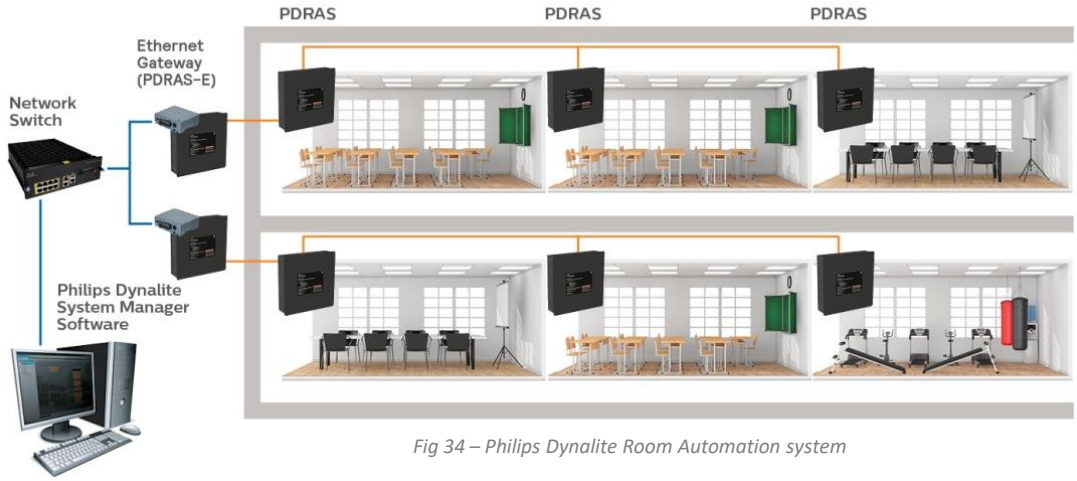


Fig 34 – Philips Dynalite Room Automation system

Space	Number of Lights	Wattage of Light		Floor Area	LPD (Lighting Power Density)
Large Building					
Large Office	260	36	9360	1802	5.2
Small Office	65	36	2340	450	5.2
Medium Office	130	36	4680	900	5.2
Seminar Hall	46	36	1656	225	7.4
Small Training	22	36	792	103	7.7
Restaurant	132	18	2376	754	3.2
Kitchen	24	36	864	112	7.7
Medical Room+Nap room	27	36	972	225	4.3
Large Seminar	44	36	1584	215	7.4
Conference Room	23	36	828	105	7.9
Game Room	50	36	1800	435	4.1
Library	67	36	2412	322	7.5
Staircase	72	15	1080	640	1.7
Core Area	200	15	3000	1028.6	2.9
Toilets	920	15	13800	2700	5.1
Small Building					
MultiPurpose Hall	284	36		874	11.7
Staircase	10	15		64	2.3
Core Area	10	12		15.53	7.7
Toilets	20	15		24.15	12.4
AHU room	8	15		17.08	7.0
Informal seating Small bldg	30	24		542	1.3
Daycare Facility	15	18		140	1.9
Restaurant	32	18		222.44	2.6
Basement					
Parking	309	36		9425	1.2

Table 10 – Lighting calculations

6. Architectural Design

At the site level zoning, the front land parcel from the site was allocated as an amenity space to be hand over to government as per bylaws. Two separate entrances, one for employees and second as a service entrance were provided with surrounding driveway to entire site in case of emergencies.

To encourage pedestrian movement inside the campus a bus service was suggested and provisions for the bus stop and parking yard was proposed near the entrance itself, employees can use the pathway which passes through the dense plantation and water body giving them feeling of forest trail. To enhance health and wellbeing of the occupants of the building Biophilic design has been incorporated which connects occupants closely to nature, green pockets are provided at between the spaces and to make it look like an urban forest.

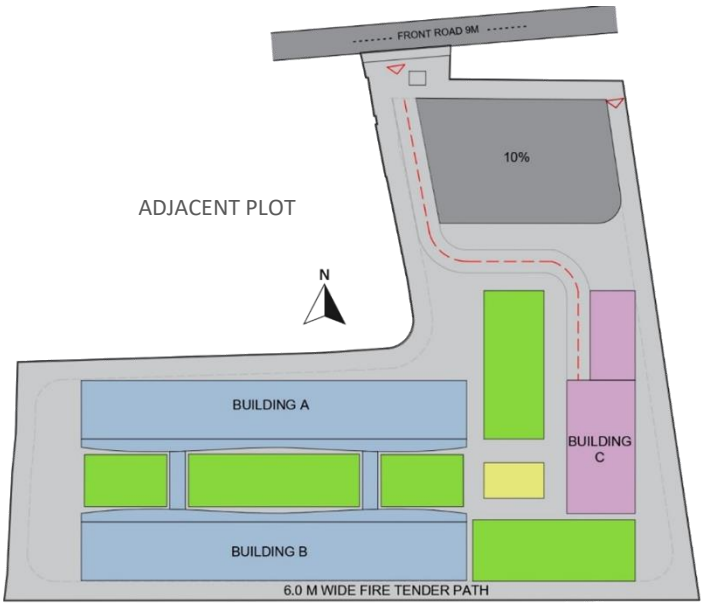


Fig 35 – Site Level Zoning

Fig 36 – Section showing urban forest

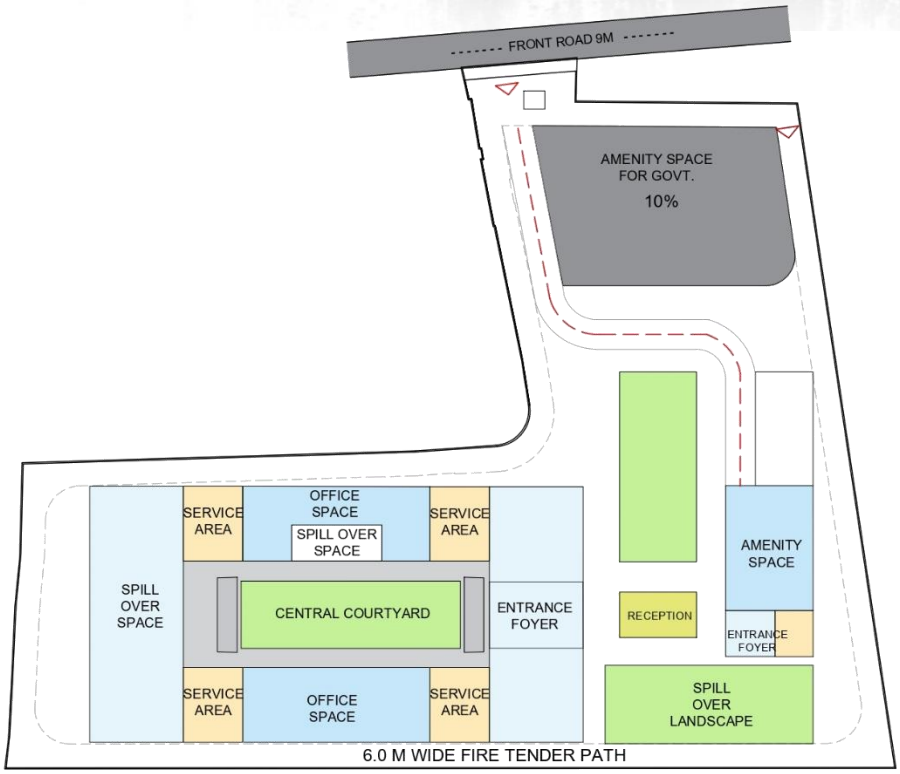


Fig 37 – Building Level Zoning

- As for the form development, the campus has 3 buildings amongst which two are office buildings and one building consists of spaces like multipurpose hall, crèche, etc. as amenities for the employees.
- Both office buildings are east west oriented to maximize the use of north light into the workspaces. Different office space areas were incorporated into the floor planning as per project partner's requirements to ensure open office plans and flexible interior planning solutions.
- A courtyard is planned in between two office building blocks to provide greenery and breakout spaces for visual comfort improvement.

- In case of building planning like entrance foyers, open office space, service area, etc. Visual connectivity between these areas was given priority, for which horizontal and Vertical visual connectivity was maintained in the forms of passages, spill over spaces and staircase looking into the courtyard.
- Vertical segregation of the spaces was kept in such a way that different sized companies can accommodate on any floor they want .

- In addition to this, ***common activities*** like gym, indoor gaming room, rest room, dining area, conference rooms, seminar room, etc. are placed on ground and first floor for better and easy accessibility along with easy maintenance of these spaces.

- On the ground floor, planned green pockets were provided at far west and eastern side of the building for inviting entrance foyer and as a common gathering space for the employees. A central courtyard overlooking from all sides was developed as an urban forest.

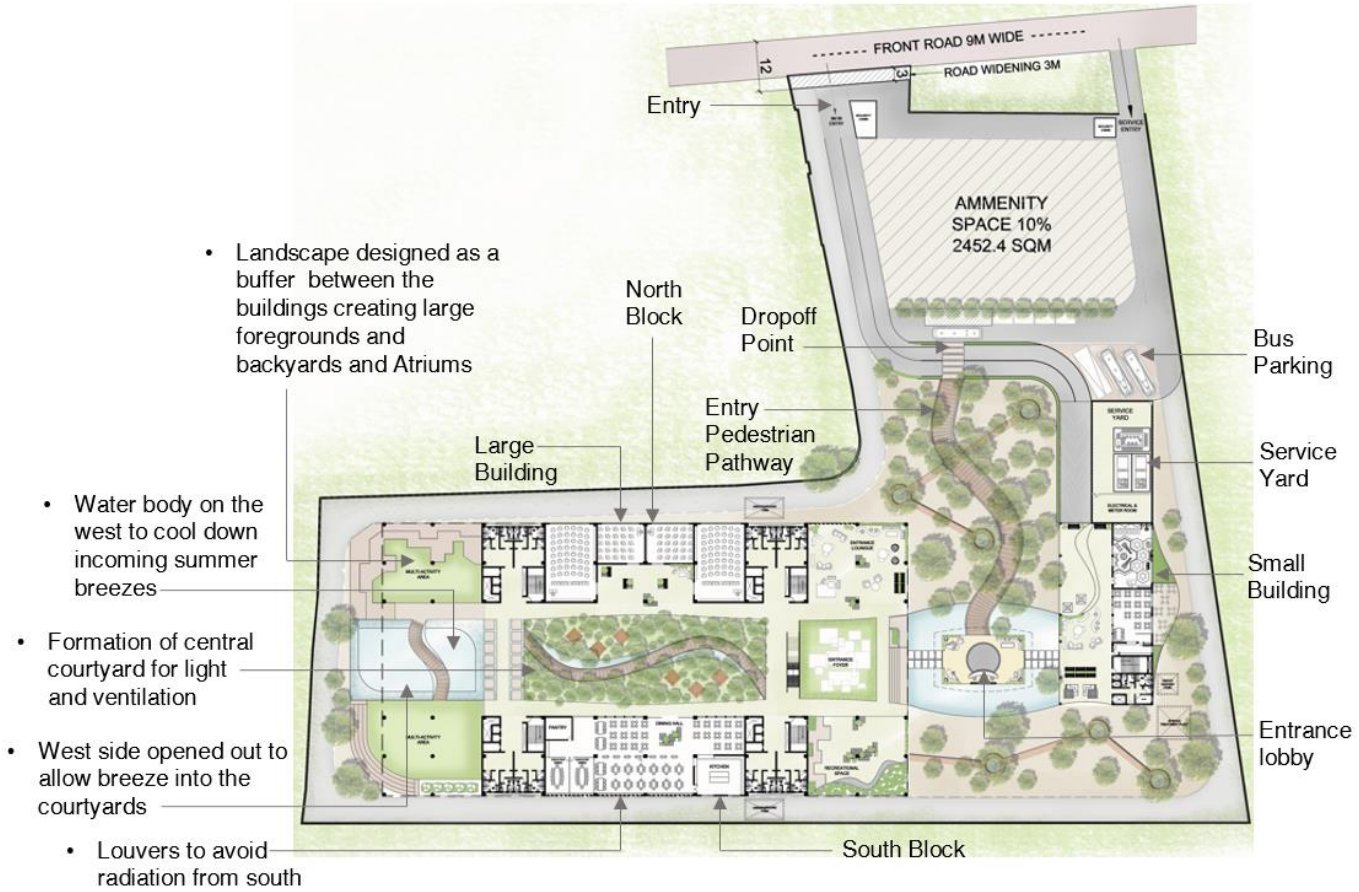


Fig 38 – Master Plan

The Campus is divided into two Main Buildings along with facilities

- Large Building – Office Area
  Small building –Multipurpose building with Auditorium, Day-care and dining halls facilities
- Service yard – Mechanical Electrical and Plumbing facilities
- Bus drop-off point with Bus parking facilities

- We implemented planning principles for the Office campus planning, and it will give a tremendous result in terms of function, economy, and aesthetic value and also enhances microclimate.
- The purpose of master plan is to form a basis for the architectural character, composition, and typology of buildings, groups of buildings and exterior spaces on the campus.

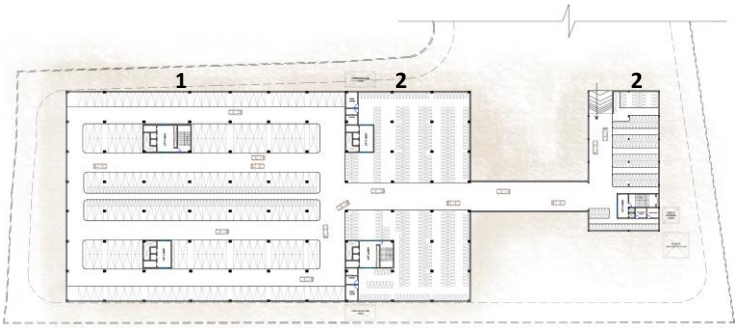


Fig 39 – Basement Plan

- Single level basement parking is provided for the campus which include two wheeler and 4 wheeler parking facilities and charging facilities for Electric Vehicles

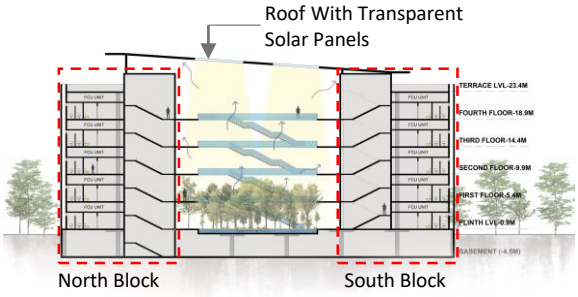


Fig 40 – Section AA

Section AA shows the two blocks North and South and the roof profile, which is inclined towards south for achieving optimum energy for the Transparent solar panels placed on the roof.

- On The first floor The small building has an auditorium and the large building has Rest facility, Conference Rooms, Training halls, Gym & workout place, Library and Yoga space respectively.

- Bridges between the north and south blocks are provided for connectivity and also acts as transition areas

1. Four-Wheeler Parking
2. Two Wheeler Parking
3. Rest facility
4. Conference Rooms
5. Training halls
6. Gym & workout place
7. Library and Yoga space

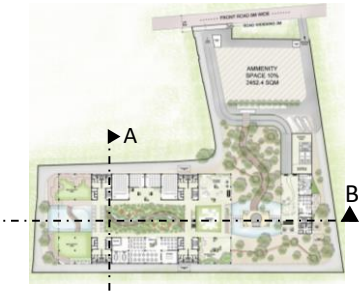


Fig 41 – Key Plan

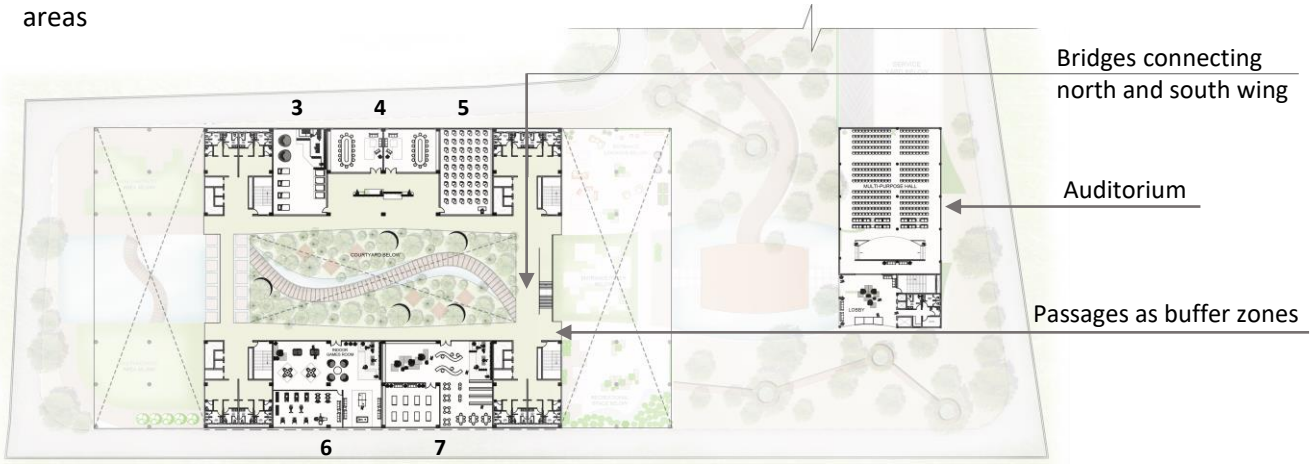


Fig 42 – First Floor Plan

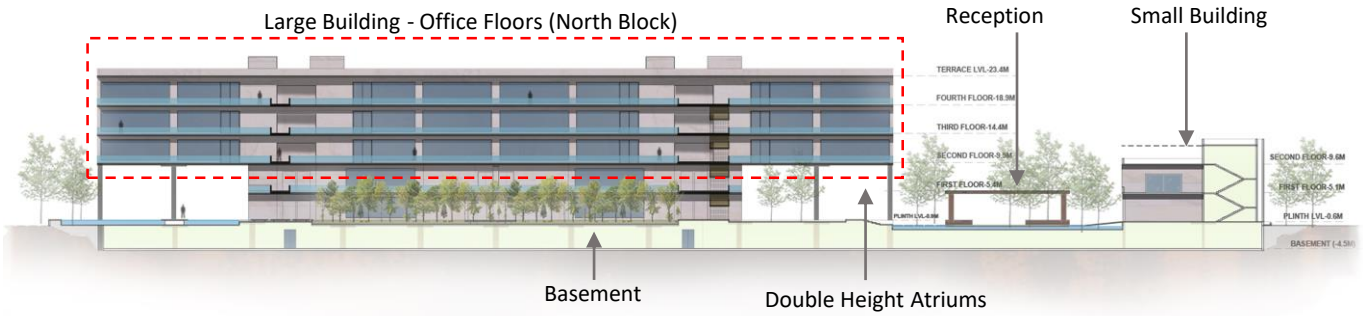


Fig 43 – Section BB

- Longitudinal Section BB shows Large building with office floors - Reception - Small building - Basement - and Double heighted atriums

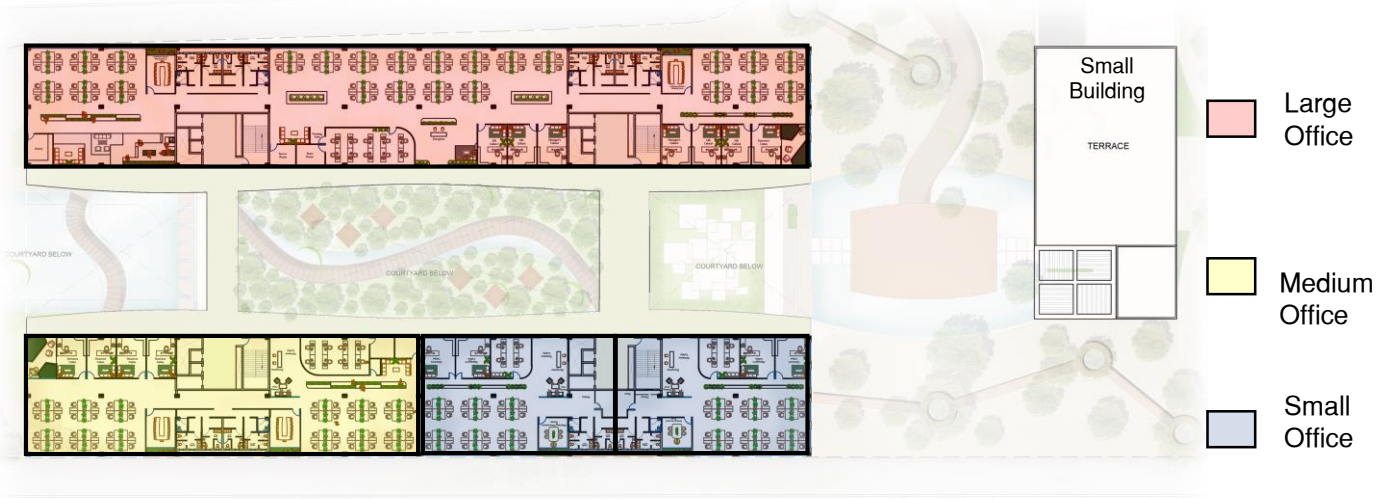


Fig 44 – Combination for Offices – Typical Floor Plans (2nd , 3rd, 4th Floor)

- The 2nd 3rd and 4th floor are typical floor plans of Office areas.
- The office spaces will be occupied by the tenants and hence the layout of these floors are kept flexible like-
- Tenants can have two large offices on any floor, or can have 4 medium offices on any floor
- Can have 8 small offices on a floor and can also have combinations of large medium and small offices respectively on each floor.

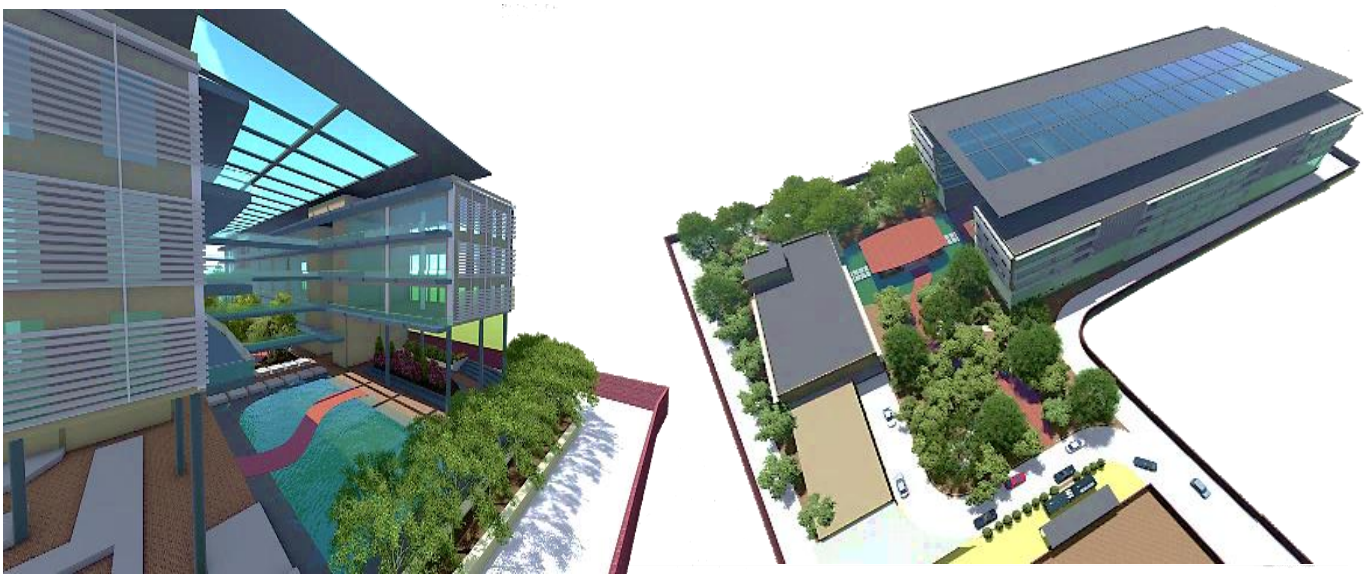


Fig 45 – External Views of the Building

7. Affordability-

Construction Cost-

1. RCC flat slab with column capital

Flat slab structure is more economical than that of conventional slab structure.

The cost of flat slab structure is reduced by 15.8% compared to conventional slab structures.

Flat slab structure leads to economic saving, aesthetic view and yet allow the architect from great freedom of form works as compared to conventional slab structure.

Flat slab structures are the best solution for high rise structure as compared to conventional slab structure

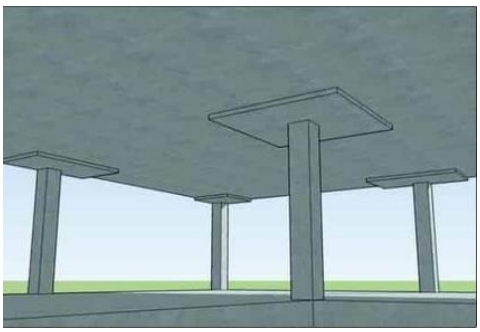


Fig 46 – Flat slab construction

2. Post-Tensioned slab

Since PT floors are thinner, there is generally an overall savings of 20% in the dead load of the building compared to conventional concrete. Due to this decrease in dead load, the amount of reinforcing steel is reduced in columns and foundations. When seismic effects govern the lateral load resisting systems, the cost of shear walls and foundations can be reduced by 20% or more due to the reduced structural mass. Post tension slabs are excellent ways to construct stronger structures at an affordable price.

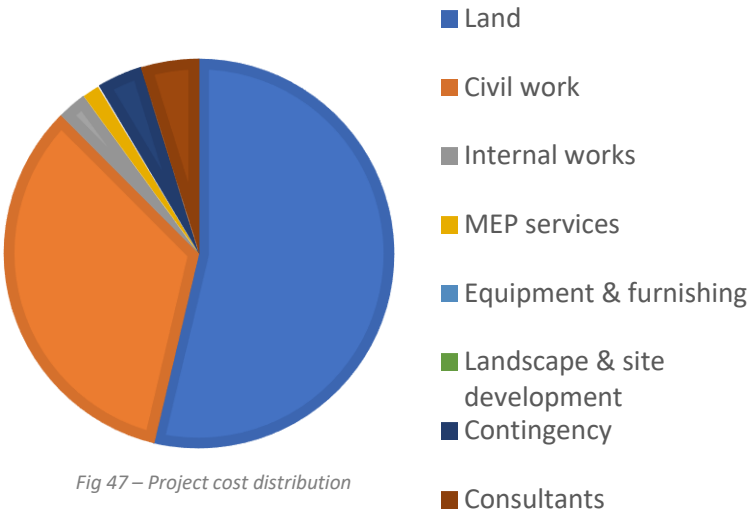


Fig 47 – Project cost distribution

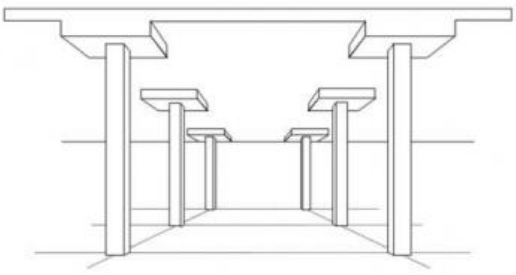


Fig 48– Post tensioned slab

Operation Cost-

1. Renewable Energy Generation

ENERGY REDUCTION TABLE		
Total energy consumption	2712000	Kwh/yr
Solar energy generation	591900	Kwh/yr
Annual consumption after offset	2120100	Kwh/yr
Achieved EPI	30	kWh/m²/yr
Base Case EPI	182	kWh/m²/yr
Ratio	72.44/130= 0.5573	
Total energy reduction	44.27%	

Table 11 – Renewable (solar) energy potential and reduction in EPI

A total of 21.82% of the Total energy is been contributed from Solar renewable energy systems which is used for Interior and exterior lighting and also used for equipment's. Thus a reduction in EPI helps reducing down the overall energy costs making the operation costs affordable.

Affordability-

Operation Cost-

2. Mechanical Ventilation System

- Budgetary constraints on the project necessitated the use of cost effective design solutions to keep within the price points set by the client and yet be able to achieve the desired functionality and effect.
- Thus incorporating various passive climate control strategies became a necessity to reduce the dependence on mechanical environmental control measures.

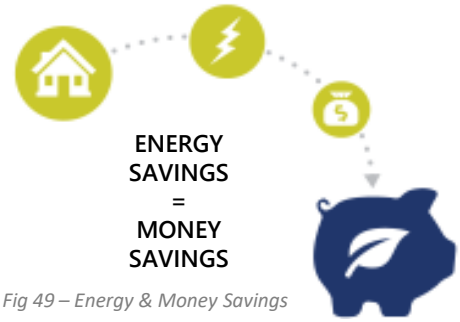


Fig 49 – Energy & Money Savings

- The passive design strategies balanced the energy and performance of the building by reducing heating and cooling mechanically.
- Passive design parameters like –

1. Proper solar orientation
2. Optimal insulation
3. High-performance Windows and doors
4. An airtight enclosure
5. Balanced ventilation

are used in the design and these Passive strategies ended up using 40- 60% less energy for heating and cooling.

- Designing passive building impacted the front-end cost of the project. This also helped us to diminish the cost of active design approaches by lowering heating and cooling quantities, thus downsizing the HVAC system making it a cost effective design.

---

3. Building Materials

1. Local Building Materials

- 20% of the total building materials (by cost) used in the building are manufactured locally within a distance of 400 km.
- Use of local material reduces the overall transportation cost.

List of materials of Local Materials in Pune:
1.AAC Blocks
2. Tiles
3.Ready Mix Concrete
4.Glass
5.Steel
6.Wood based materials
7. Fixtures and fittings

AAC Blocks

Cement Panels for partitions

Insulation boards

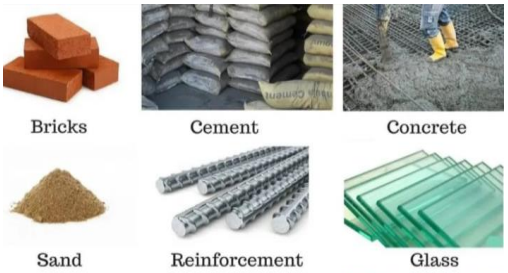


Fig 50 – Locally available materials (Source: Google images)

2. Reuse of Salvaged Materials

- 2.5% of the total building materials (by cost) used in the building are salvaged or reused or refurbished materials.
- Use of refurbished materials helps to reduce overall material cost as it replaces procurement of new materials

Salvaged bricks for waterproofing , paving etc.

Refurbished Furniture

Salvaged floor tiles – China Mosaic for Terrace

- Waste Scaffolding pipes during construction : Reused for fabrication work
- Brocken tiles during construction : Used for tile table top in restaurant area
- Brunt bricks : Used for water proofing (Brick Bat Coba) in washroom

Fig 51 – Reuse of Salvaged Materials (Source: Google images)

8. Innovation

i. Architectural Innovation

The built form is designed considering climate of the city, context of the location along with surrounding constrains and opportunities. Breakout spaces, overlooking central courtyard with vegetation is planned to boost the health and wellbeing of the occupants. These spill over spaces can be used in case of emergencies. Walkability is promoted by restricting majority of footfall near the entrance and by providing a staircase in central courtyard which acts as a inviting element. Office spaces with varying sizes and open floor plans are planned to provide flexibility for the future tenants of the building.

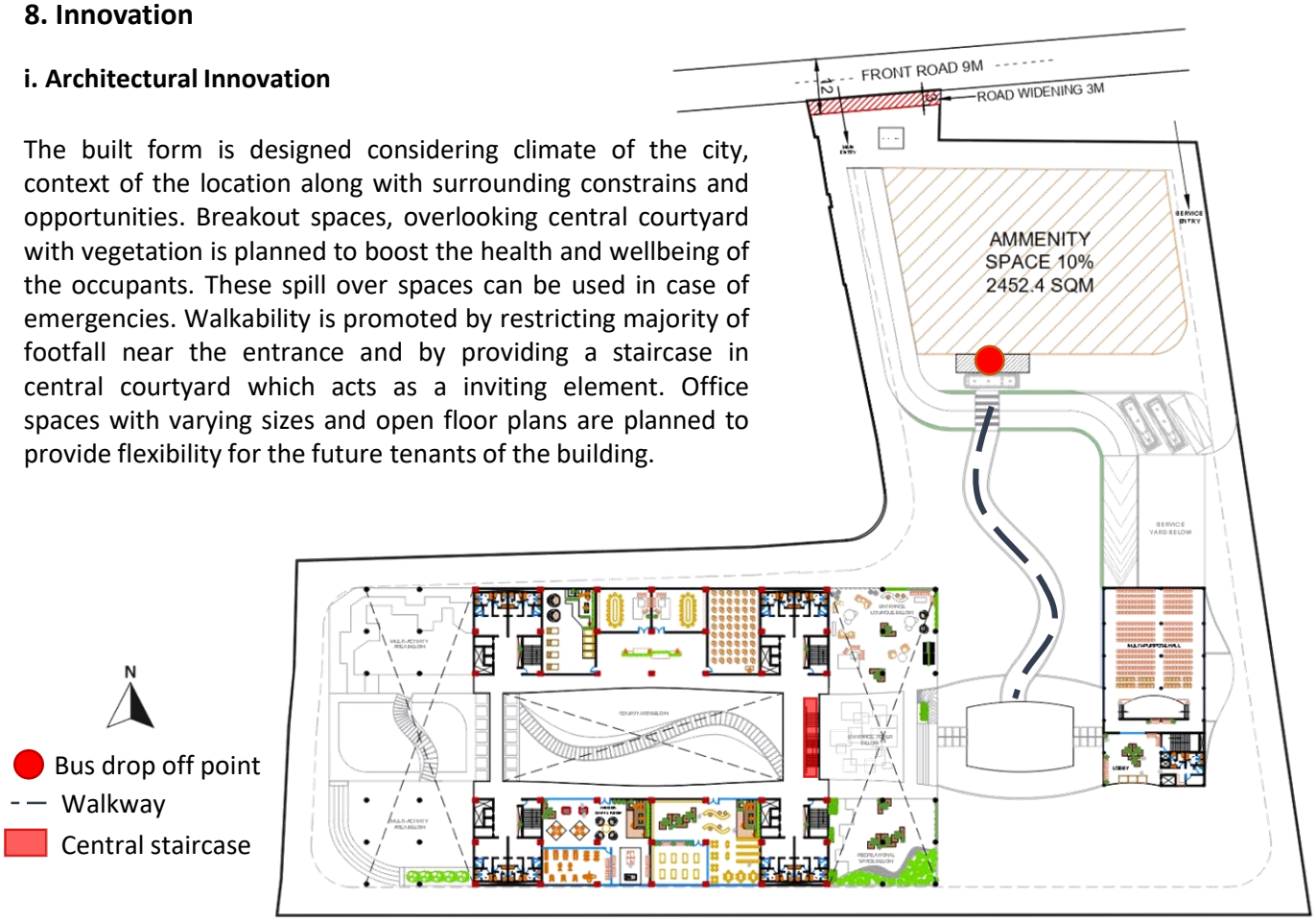


Fig 52– Site plan showing architectural features

Urban forest concept-

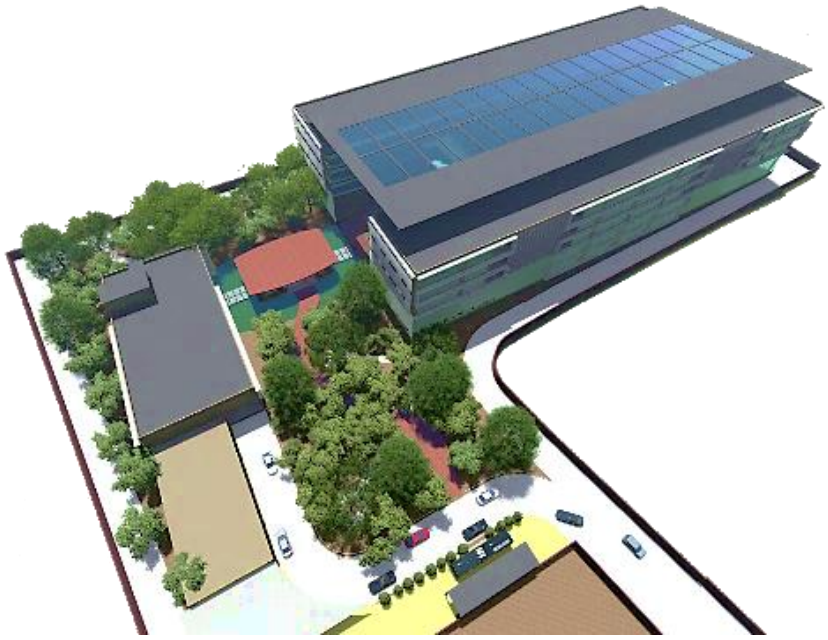


Fig 53– Site plan showing dense vegetation

An urban forest is a collection of trees and shrubs that thrive in urban areas, likewise lush greenery has been provided surrounding pathways and court yards of the building.

Benefits of providing lush green spaces in the site:

- **Contribute to the physical and mental health of users** by buffering stress, creating inviting places for physical activity, and more
- **Mitigate the heat island effect** by reducing temperatures through shading and evapotranspiration
- **Reduce burdens on traditional water infrastructure and reduce run-off** by absorbing and filtering stormwater
- **Improve air quality** by removing harmful pollutants
- **Reduce noise**
- **Improve scenic quality and aesthetic appeal**

ii. Visual Connectivity

Horizontal as well as vertical connectivity has been maintained throughout the design. Balconies/Passages to office opening into a central courtyard, a double height entrance plaza adjacent to central courtyard and staircase overlooking to the same courtyard with green pockets form a connection between all the spaces promoting social interaction.

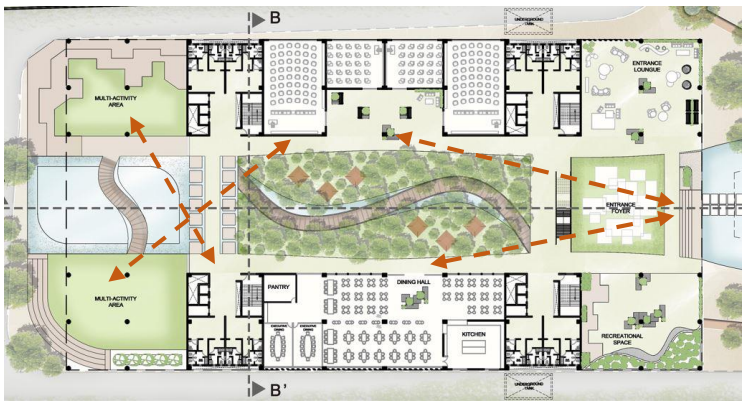


Fig 54– Plan of the building showing horizontal connectivity

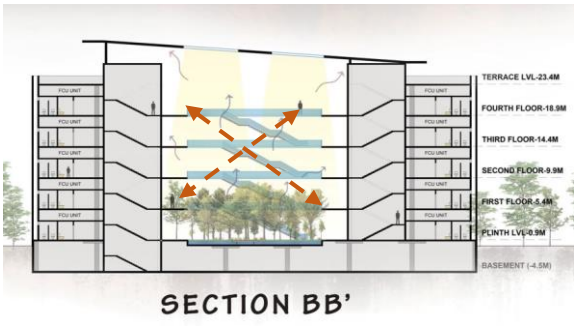


Fig 55 – Section of the building showing vertical connectivity

iii. Material Innovation:

Passive Products & Materials include glazing, insulation, paints & coatings, adhesives & sealants, flash blocks, cement, concrete, composite wood, certified new wood, housekeeping chemicals, false ceiling materials, flooring materials, furniture, gypsum based products, high reflective materials & coatings, etc.
Certified Green building materials, products, and equipment, etc. have been used in the project so as to reduce dependency on materials that have associated negative environmental impacts.

iv. Technological Innovation

Along with new technological features incorporated in the building such as energy efficient lighting and plumbing fixtures, lighting controls, lighting sensors in common areas and landscape areas, Building Management System (BMS) for better and smooth operation of the building, VRV (Variable Refrigerant Volume) system has been used in the building which is a highly efficient HVAC system and gives opportunity of flexible and modular designs at the same time providing simple controls. This system has been used for each office space separately so that they will have separate controls of the system.

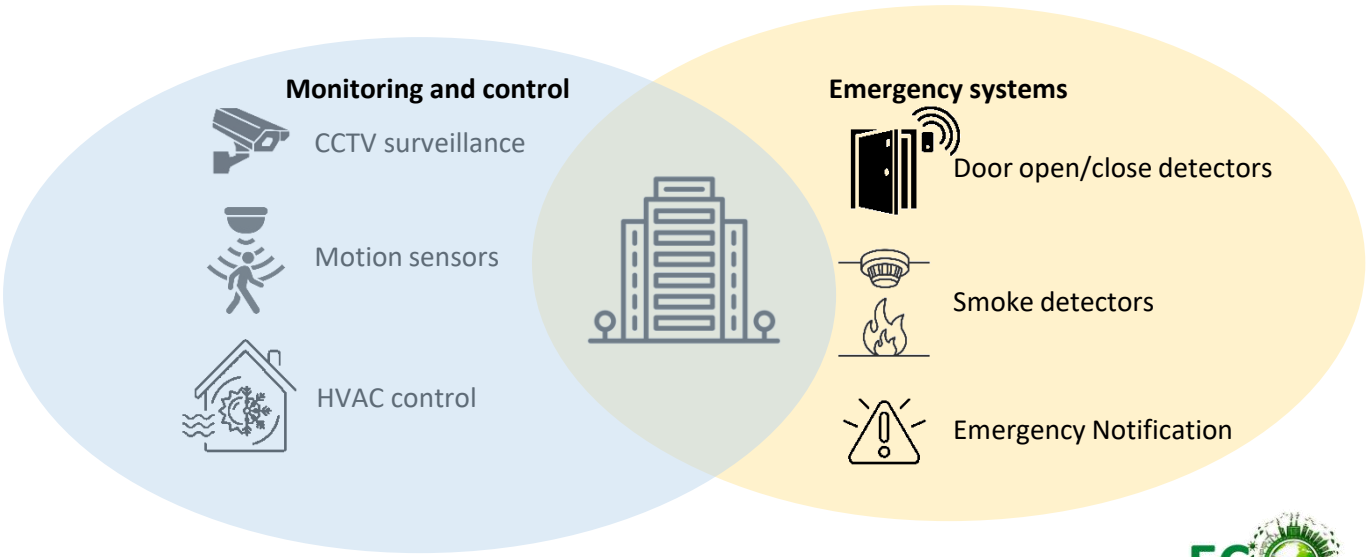
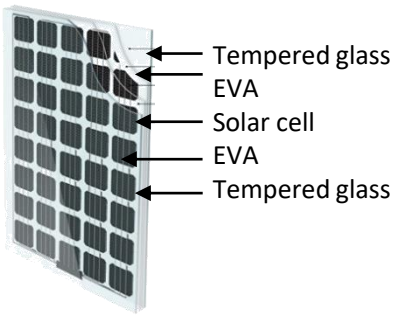


Fig 56 – Building Management System- monitoring and emergency services (Source: Google images)

Renewable Energy: Solar Panels

BIPV transparent bifacial solar panels:
Building Integrated Photovoltaic is a new type of building material, which provides green energy as well as building preservation. Transparent solar panels and modules, semi transparent solar modules. BIPV applications demand flexibility in the PV module having both an aesthetic and functional role. Frameless glass laminates and double glazed products are designed to be compatible with most conventional glazing systems for skylights.



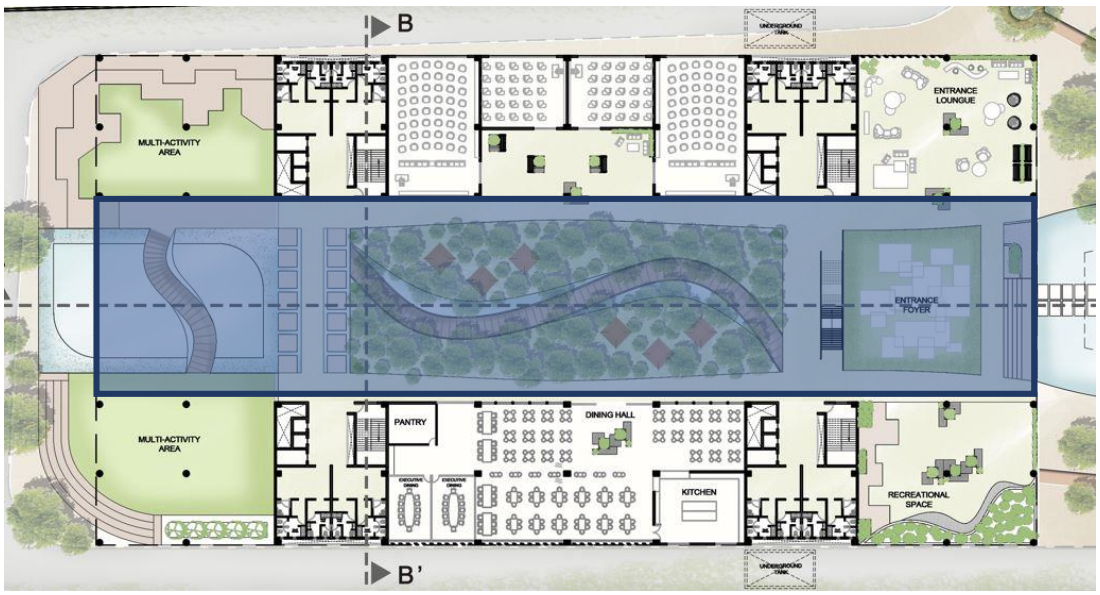


Fig 57 – Plan of the building showing central courtyard roof for BIPV transparent solar panel installation

Bifacial solar panels for rooftop installation:

A bifacial solar cell is nothing but two silicon cells stacked together in such a way that they face the opposite direction. Both sides of bifacial panels generate electricity since solar cells are present on both sides. Under ideal conditions, bifacial panels can produce 27% more energy.

Working of Bifacial panel:

Front side of the bifacial panels collects direct sunlight

↓

Backside of the panel collects sunlight that hits the ground and is reflected

↓

Together, two sides trap more sunlight than any other panel

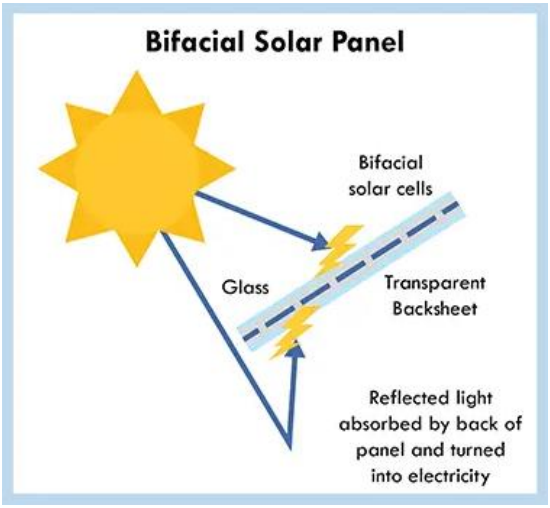
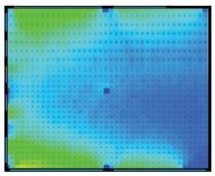


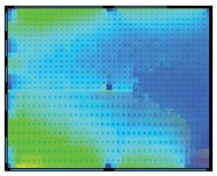
Fig 58 – bifacial panel working mechanism (source: google images)

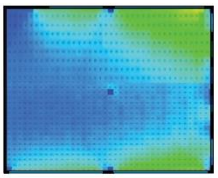
9. Health and wellbeing

Daylight

75 **%** of the regularly occupied spaces with daylight illuminance levels for a minimum of 110 Lux in a clear sky condition on 21st September at 12 noon, at working plane. Hence one credit is achieved. 100% glare-free spaces and maximum daylit areas.


North Side Office 1 (Working Area)


South Side Office 1 (Working Area)


North Side Office 3 (Working Area)

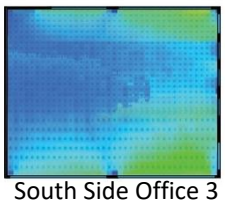

South Side Office 3 (Working Area)

Fig 59 – Daylight

Sr.No.	Space	Area	Daylit Area	% of Daylight
1	Training Hall	210.18	165.3	78.65
2	Training Hall	210.18	169.5	80.65
North Side Working Space				
7	Office Space 1	430.56	354.98	82.45
8	Office Space 2	872.16	664.22	76.16
9	Office Space 3	430.56	354.98	82.45
South Side Working Space				
11	Office Space 1	430.56	341.74	79.37
12	Office Space 2	872.16	694.22	79.60
13	Office Space 3	430.56	341.74	79.37
Average Daylight Percentage of Regularly occupied spaces				**79.83**

Table 12 – Daylight percentage

Designated Smoking areas

It is made sure that at least 8m distance is maintained from the outdoor air intakes. Also, signages for No Smoking will be put up inside the building area. The project has assigned outdoor smoking areas and designated smoking on alternate floor. The exhaust air louver / duct should be located at least 7.6 meters away from building entry or fresh air intakes.

Fig 60 – plan showing smoking areas and gym area

Natural Ventilation:

Air changes per hour, abbreviated ACPH or ACH, or air change rate is the number of times that the total air volume in a room or space is completely removed and replaced in an hour. ASHRAE 62.1 air changes standards have been followed for the design of the spaces. Following values have been considered for calculations.

SPACE	ACPH
BACK OFFICES	3
TOILETS	6
MULTIPURPOSE HALL	5
CONFERENCE ROOM	8

Fans used:

Crompton 250 mm exhaust fans-for toilets

Witt India car parking jet fans: 350 dia with 1.1 Kw.

Thermal Comfort:

Fanger's equations are used to determine the Predicted Mean Vote (PMV) of a group of subjects given a certain combination of air temperature, mean radiant temperature, relative humidity, air speed, metabolic rate, and clothing insulation. this will help to analyse thermal comfort inside spaces. The PMV index predicts the mean value of votes cast by a group of inhabitants on a seven-point thermal sensation scale. Within the PMV index, +3 denotes excessive heat, whereas -3 denotes excessive cold.

Fig 61 – Fanger PMV (Source: Design Builder)

Pandemic care:

Everyone should feel safe and secure at work. In our design, special attention were given to the safety protocols against spreading disease. Structural and technological upgrades help boost confidence and peace of mind, enforce protocols, and track activity for a safer experience.

- Touch-less access control to be installed at the entrances.
- Sanitation stations installed in the office common areas.
- A separate rest room/ first aid room is provided in the design.
- Air purifiers and filers will be installed in the office spaces.

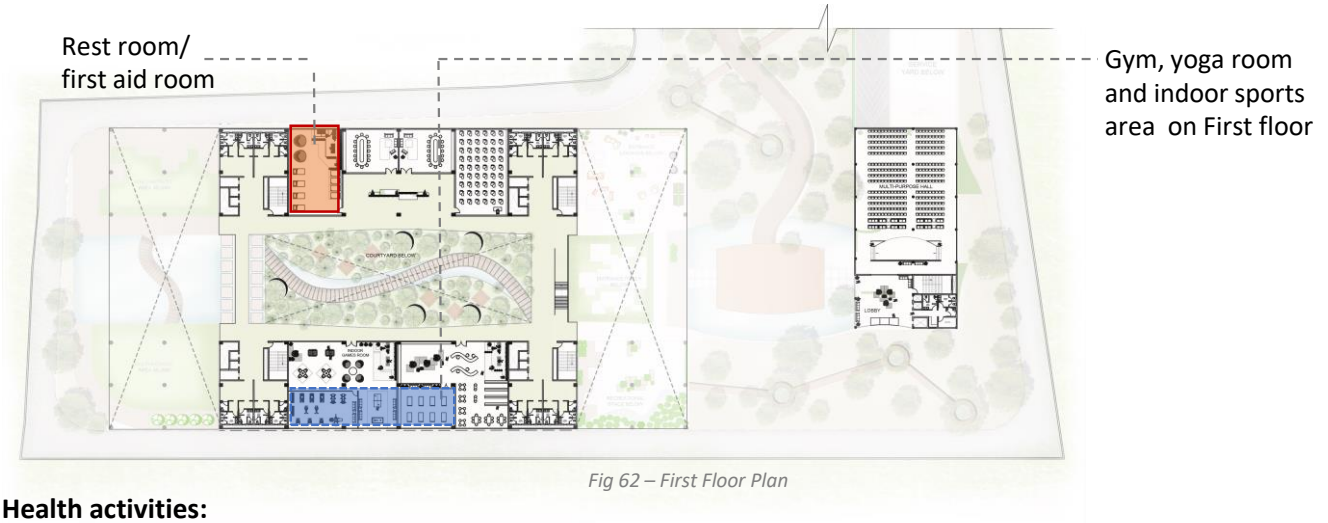


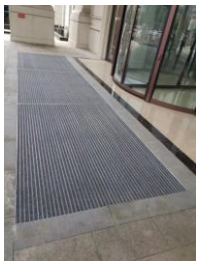
Fig 62 – First Floor Plan

Health activities:

Gymnasium, Yoga room along with indoor sports area with table tennis and pool table has been provided on the first floor of the south block.

Air Filtering Media

HEPA filters are used in the proposed project. HEPA filters from EFS meet the HEPA (high-efficiency particulate air) standards for facilities such as hospitals and data centers. Our HEPA air filters are rated at 99.99% efficiency for critical particulate filtration. The filters are constructed with galvanized steel frames, minipleated wet-laid micro glass filtration media in a V-bank style media pack for low-pressure drop and energy efficiency. EFS HV HEPA filters have tremendous durability and long service life. EFS HEPA filters allow for fast and efficient air filtration without affecting the quality of performance and production.



Printer Rooms, Chemical Storage Rooms, Janitor Rooms

Isolate areas exposed to hazardous gases or chemicals (such as printer / copier rooms, chemical storage rooms, janitor rooms) from regularly occupied areas, as per owner / developer's scope. Also, design such areas with exhaust system, self closing door,deck-to-deck partition / hard ceiling.

Germicidal or UV Lamps

For mechanically ventilated buildings, install germicidal/ UV lamps in Air-Handling-Unit (AHU) cooling coils. UV Lamp has some impeccable features, if used systematically, can give wonderful result and are extensively used in AHU for reduction of bacterial load on the cooling coil. The use of Ultraviolet Lamp reduces mold and algae formation on the cooling coil. Apart from this there are many other benefits, namely,

- Kills bacteria, viruses and germs
- Controls other allergens
- Reduces smells and odors
- Maintains a cleaner AHU unit
- UV light for AHU promotes healthier living and operational efficiency.

Carpet

Green Floor Commercial Carpet will be used in the project All Green Floors commercial carpet are certified by the CRI Green Label indoor air quality carpet testing program for volatile organic compounds. The CRI Green Label sets the standard to ensure that the consumer is purchasing the lowest emitting (VOC) interior products on the market.

Paints & Coatings

Paints and coatings (including primers) with low or no VOC content (as specified in Table-9 given below) for 95% of interior wall and ceiling surface has been used in the project. VOC is a carbon-containing compound that readily vaporizes into the air. As paint dries, these harmful VOC's are released into the air at high levels. Asian paints, Nerolac, Nippon are the companies which manufacture low VOC paints and coatings

Visual Connectivity

The building is linear and has openings on the elongated sides, providing adequate views. Hence, 97% of the regularly occupied spaces have outdoor views.By providing breakout spaces like balconies on each floor for relaxation and visual comfort. Access to clear sky and Vertical landscape

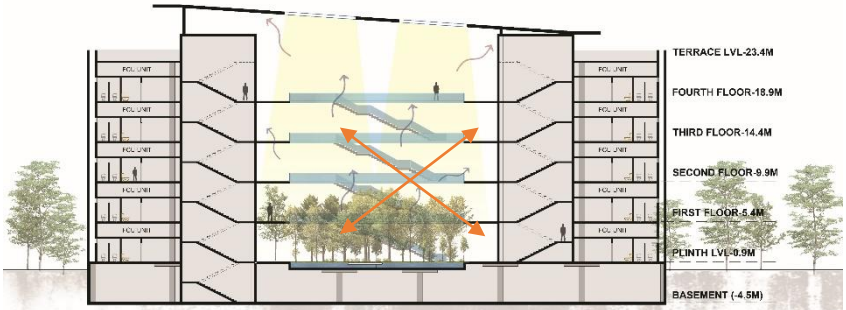


Fig 63 – Visual Connectivity

10. Value proposition:

VANALAY - A Sustainable Office Building in the Heart of the Forest for Goel Ganga Corporation. The corporate office is being constructed to accommodate variable office space requirements, with a provision for 1000 employees working an 8-hour office shift from 9:00 a.m. to 5:00 p.m. five days a week. The building offers the option of area availability or office space. Small office spaces, medium office spaces, and large office spaces totaling 29259.31 sqm in built-up area. A thorough climatic study was carried out in order to comprehend the combination of strategies that could be used to improve the building's performance and achieve 100% comfortable operational hours.

Fig 64 – Site view- reception area

a. Key features:

The proposed design is not for a typical office building but a combination of working space with forest/nature as the connection with open green spaces enhances our work. Combination of vertical fins and horizontal projections are used to cater south sun and horizontal louvers are designed on the west facade of the building . this will help to achieve thermal comfort inside the building naturally. Northern side has a recess for maximum daylight.

44% Reduction in Energy consumption	Thermal comfort	Innovation	Water
•Building Envelope •Passive design •Solar PV panels •Energy efficient HVAC system and Lighting	•Envelope optimization •Natural ventilation •Shading Devices	•BMS •Visual connectivity •Waste management on site	•Rain water recharge •Grey water recycle and reuse •Low flow water fixtures

i. Operational energy saving:

Efficient energy consumption in buildings is one of the most affordable ways to lessen the detrimental effects of climate change and health-related problems.
83% reduction in operational energy saving will lead us to reduced electricity bills for the tenants of the building along with long term benefits of lesser GHG emissions.

ii. Green space provision/ breakout space :

Green spaces promotes a more open and collaborative environment, making it less hierarchical. This further improves employees' engagement with one another and helps them work harmoniously together.
The presence of natural elements increases wellbeing by stimulating each of the five human sense, reducing stress levels, blood pressure and Sick Building Syndrome symptoms, the latter being a disease, where people in a building suffer from symptoms of illness or become infected with chronic disease from the building in which they work or reside.

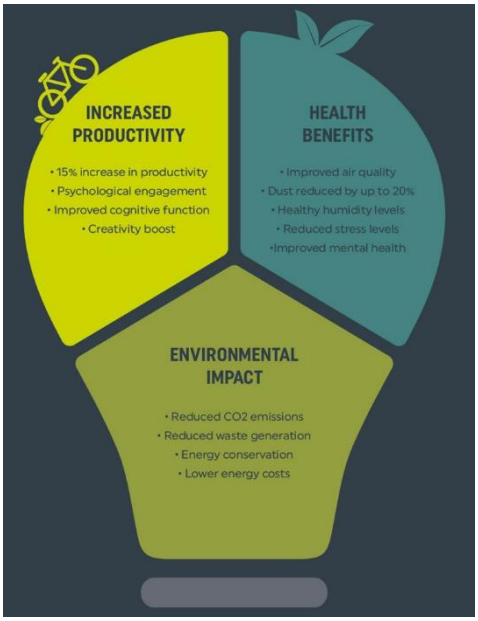


Fig 65 Benefits of green spaces in office
(Source: Google images)

Fig 66– Typical Floor plan showing green breakout spaces in the offices

References:

- Bureau of Indian Standards, The National Standards of India, 2016. National Building Code of India 2016 (Volume1&2). Government of India.
- Bureau of Energy Efficiency, Ministry of Power, 2017. Energy Conservation Building Code2017. Government of India.
- ASHRAE 90.1- 2013
- IGBC Green building Rating System(Version 3.0)
- http://www.nmrda.org/pdf/Updated-UDCPR-2022.pdf
- https://solarrooftop.gov.in/rooftop_calculator
- https://www.oneclicklca.com/
- NBC- volume 4
- Sun, Wind & Light: Architectural Design Strategies: Book by G. Z Brown

Appendix

Appendix 1:

a. Area Statement

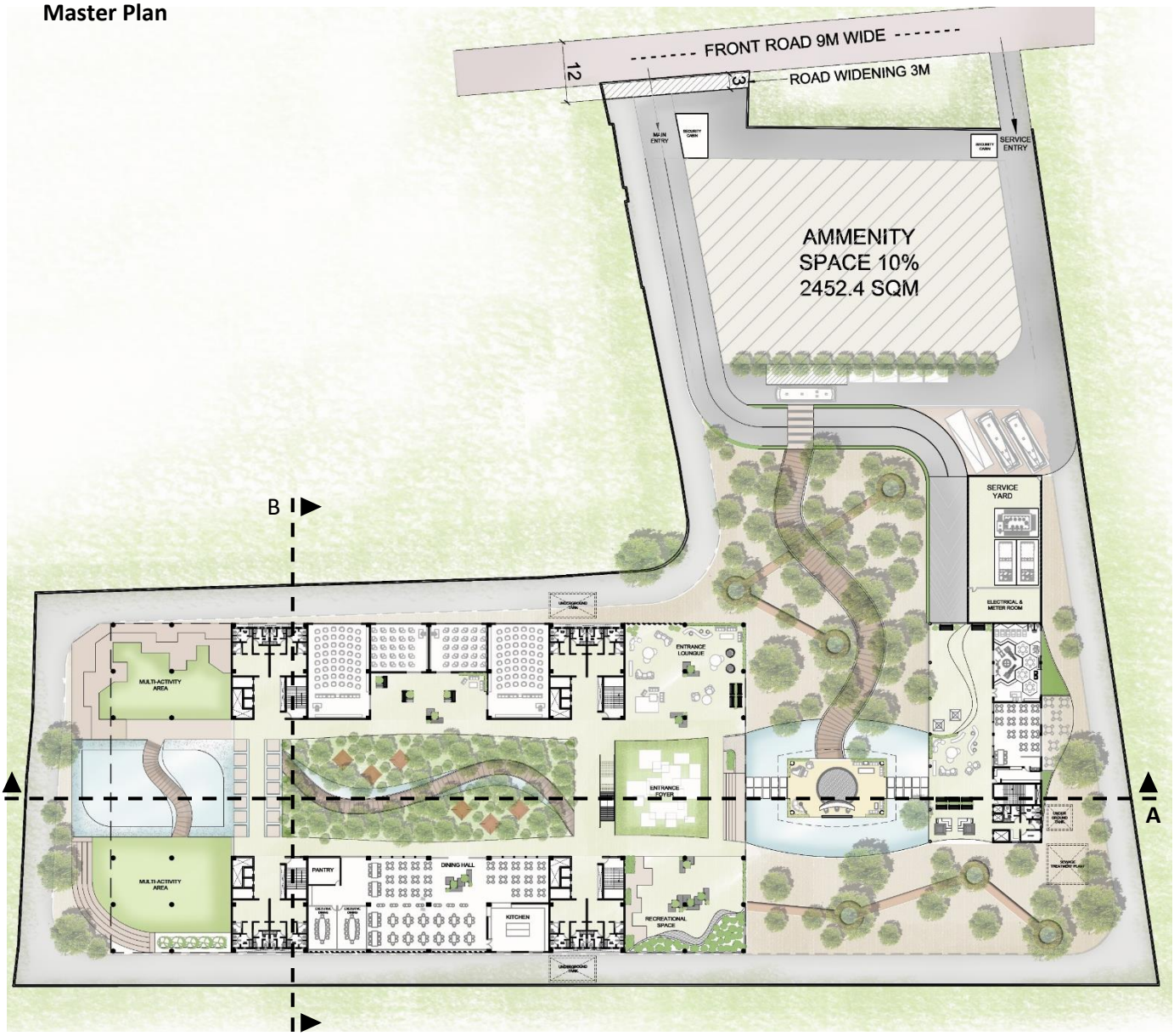
Description	Area (Sq.m)
1. Area of plot	**24523**
2. Deductions for	
(a) Proposed D.P./D.P. Road widening Area	85.49
3. Balance area of plot (1-2)	24437.51
4. Amenity Space (if applicable)	
(b) Required - 10% of total Plot Area	2452.3
5. Net Plot Area (3-b)	21985.21
6. Recreational Open space (if applicable)	
(a) Required - 10%	2452.3
9. Built up area with reference to Basic F.S.I. as per front road width (Sr. No. 5 x 1.1)	**24183.73**
10. In-situ FSI	
(a)In-situ area against D.P. road [2.0 x Sr. No. 2 (a)],if any	170.98
(b)In-situ area against Amenity Space if handed over [2.00 or1.85 x Sr. No. 4 (b)and /or(c)]	4904.6
(c) Total in-situ (a + b)	**5075.58**
11. Total entitlement of FSI in the proposal	
Total entitlement (9 + 10(c))	29259.31
PROPOSED ESTIMATED BUILT-UP AREA	**29259.31**

b. Area Programme for Office Building

	Space	Area (Sq.m)	No. Of units	Total Area (Sq.m)	Conditioned/ Unconditioned
1	Office Spaces	21000	1	21000	Conditioned
2	Service Area	5200	1	5200	Unconditioned
3	Conference Rooms	100	2	200	Conditioned
4	Seminar Halls Large	250	3	750	Conditioned
5	Seminar Halls Small	100	2	200	Conditioned
6	Multipurpose hall	700	1	700	Conditioned
7	Small Dining Area	150	1	150	Unconditioned
8	Daycare	150	1	150	Unconditioned
9	Indoor Games Room	280	1	280	Unconditioned
10	Gym Area	120	1	120	Conditioned
11	Large Dining Area	850	1	850	Unconditioned
12	Library	250	1	250	Unconditioned
13	Yoga Hall	120	1	120	Unconditioned
Total Area				29970	
14	Basement		9347 Sq.m		Unconditioned
15	Circulation Area (Passages)		1800 Sq.m		Unconditioned

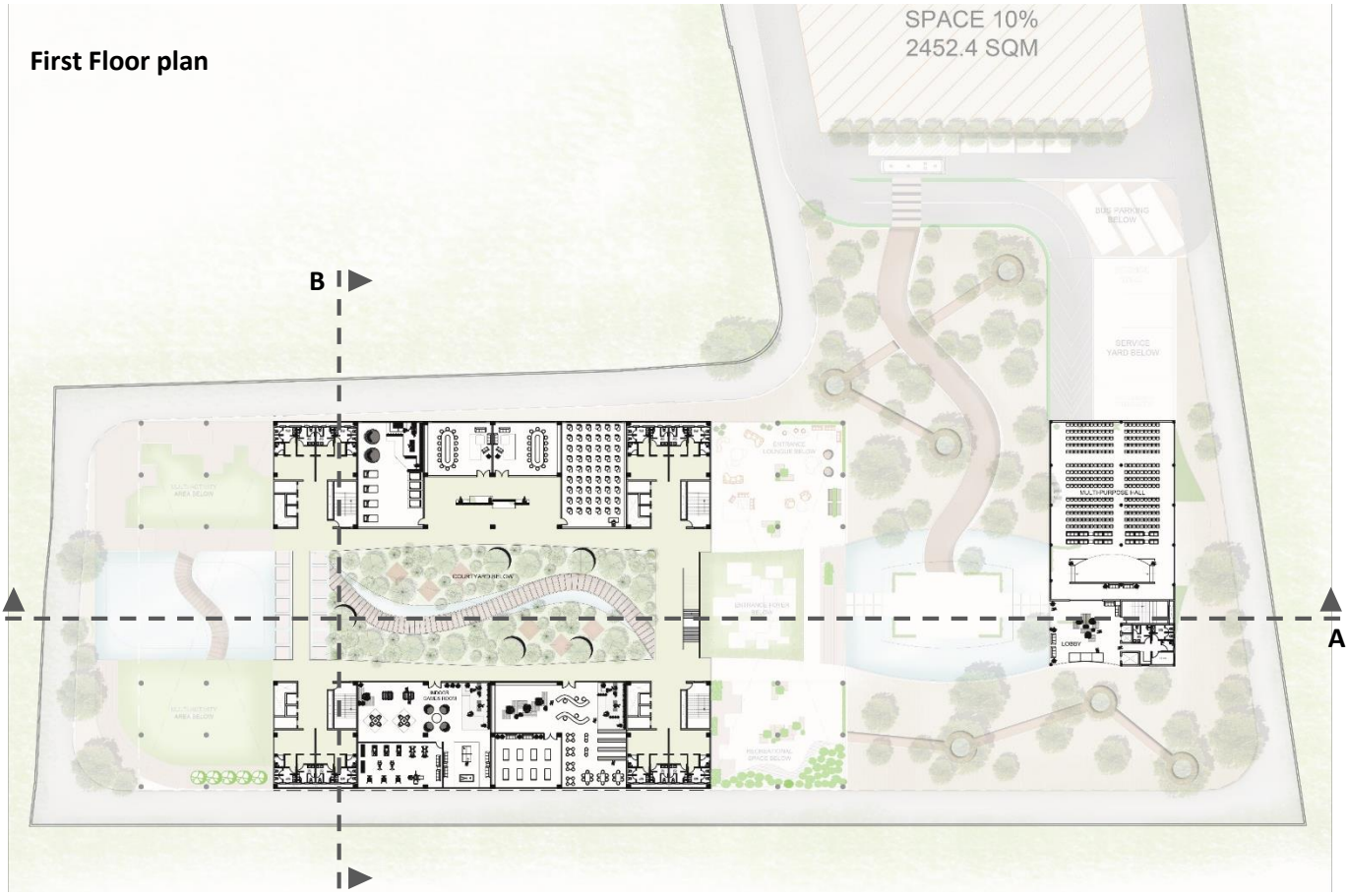
Appendix 2. Architectural Drawing

Master Plan

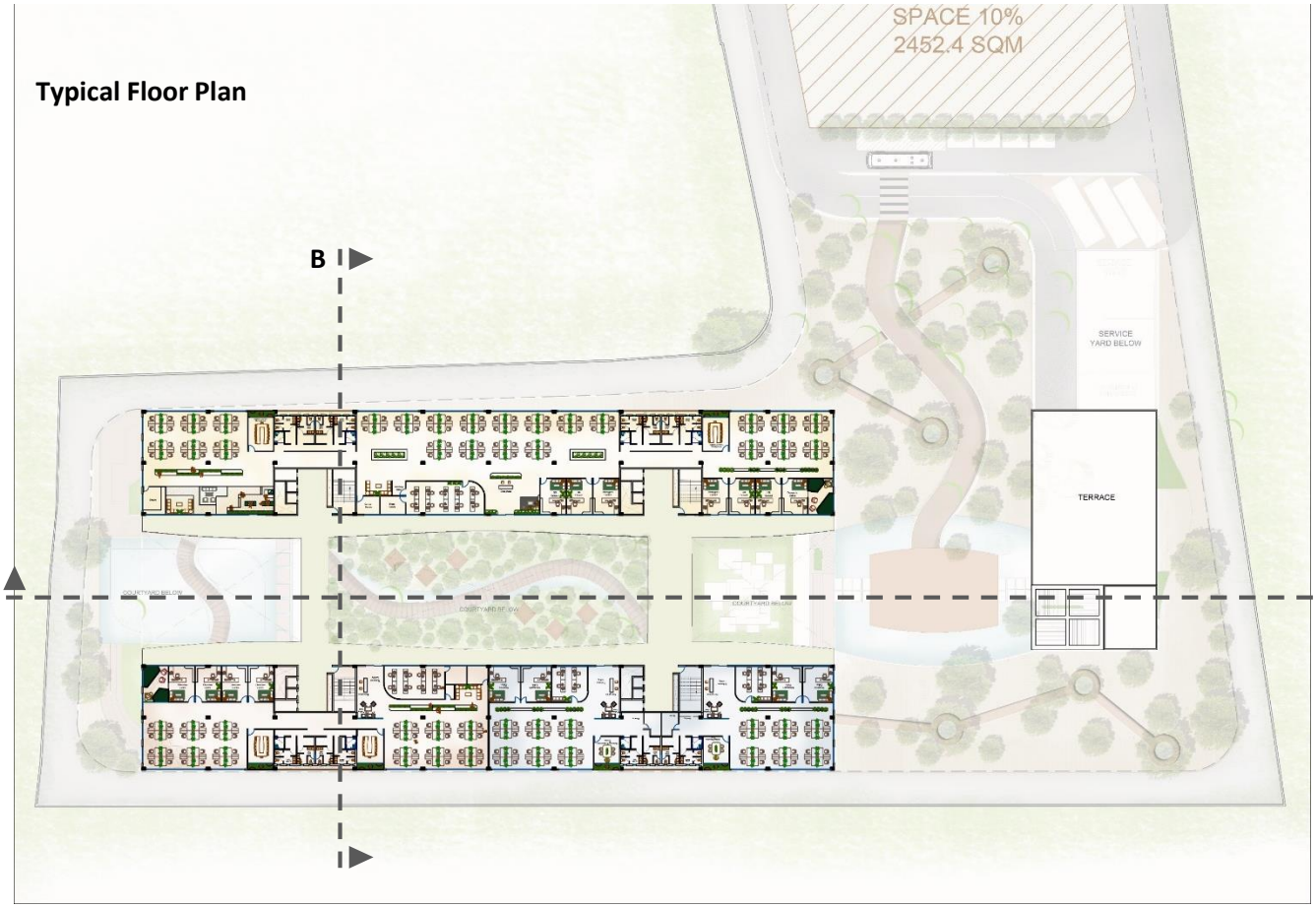


Section A

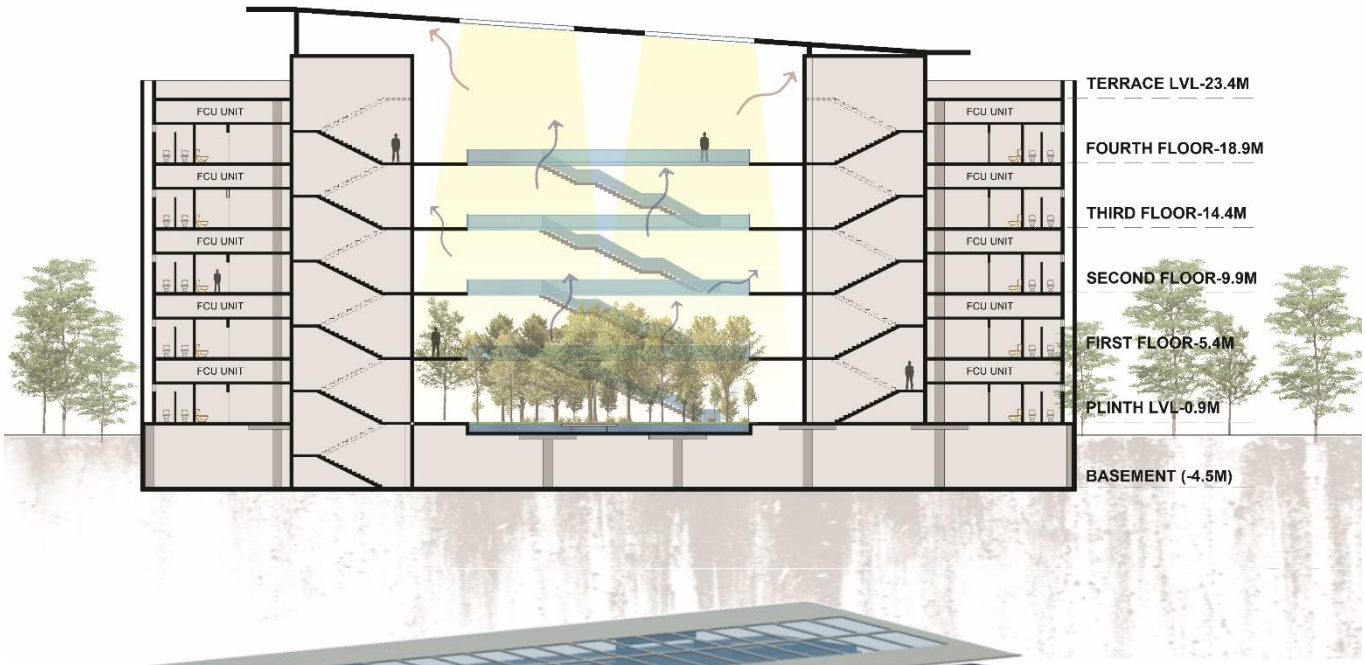
First Floor plan

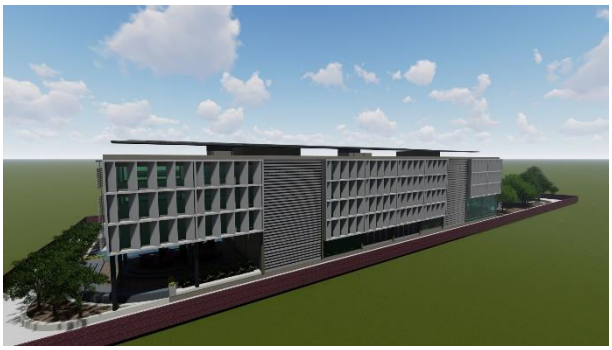


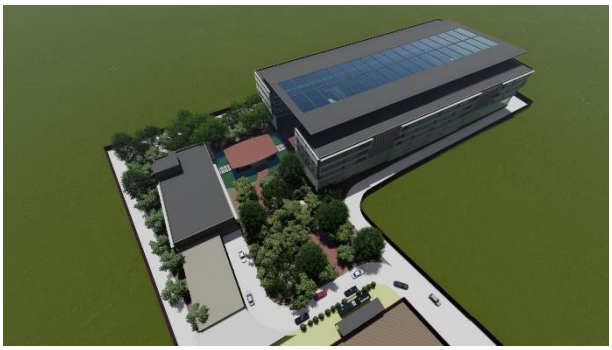
Typical Floor Plan



Section B

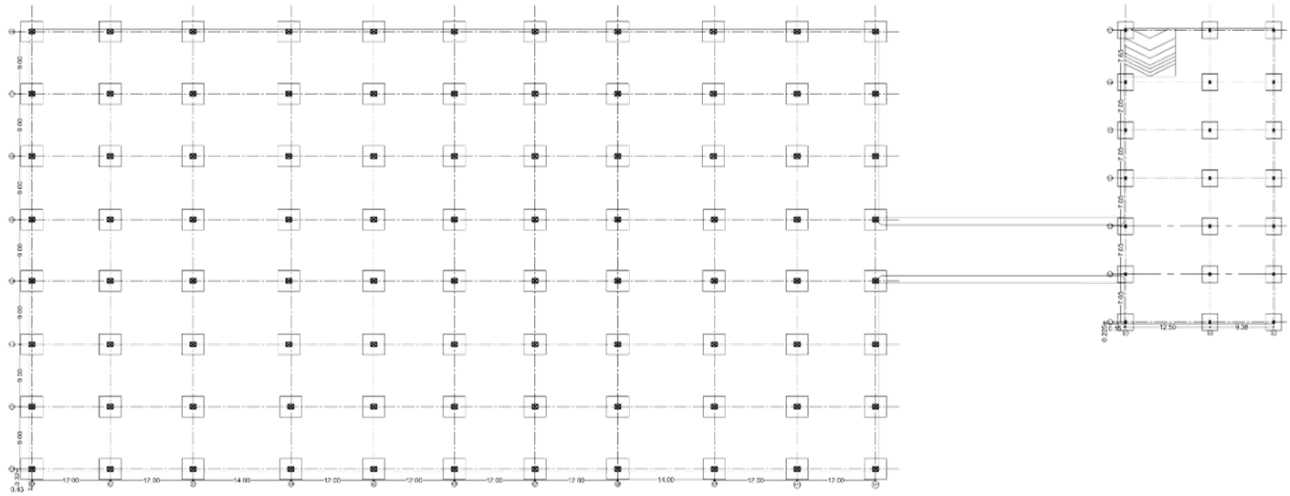

FCU UNIT
TERRACE LVL-23.4M
FOURTH FLOOR-18.9M
THIRD FLOOR-14.4M
SECOND FLOOR-9.9M
FIRST FLOOR-5.4M
PLINTH LVL-0.9M
BASEMENT (-4.5M)



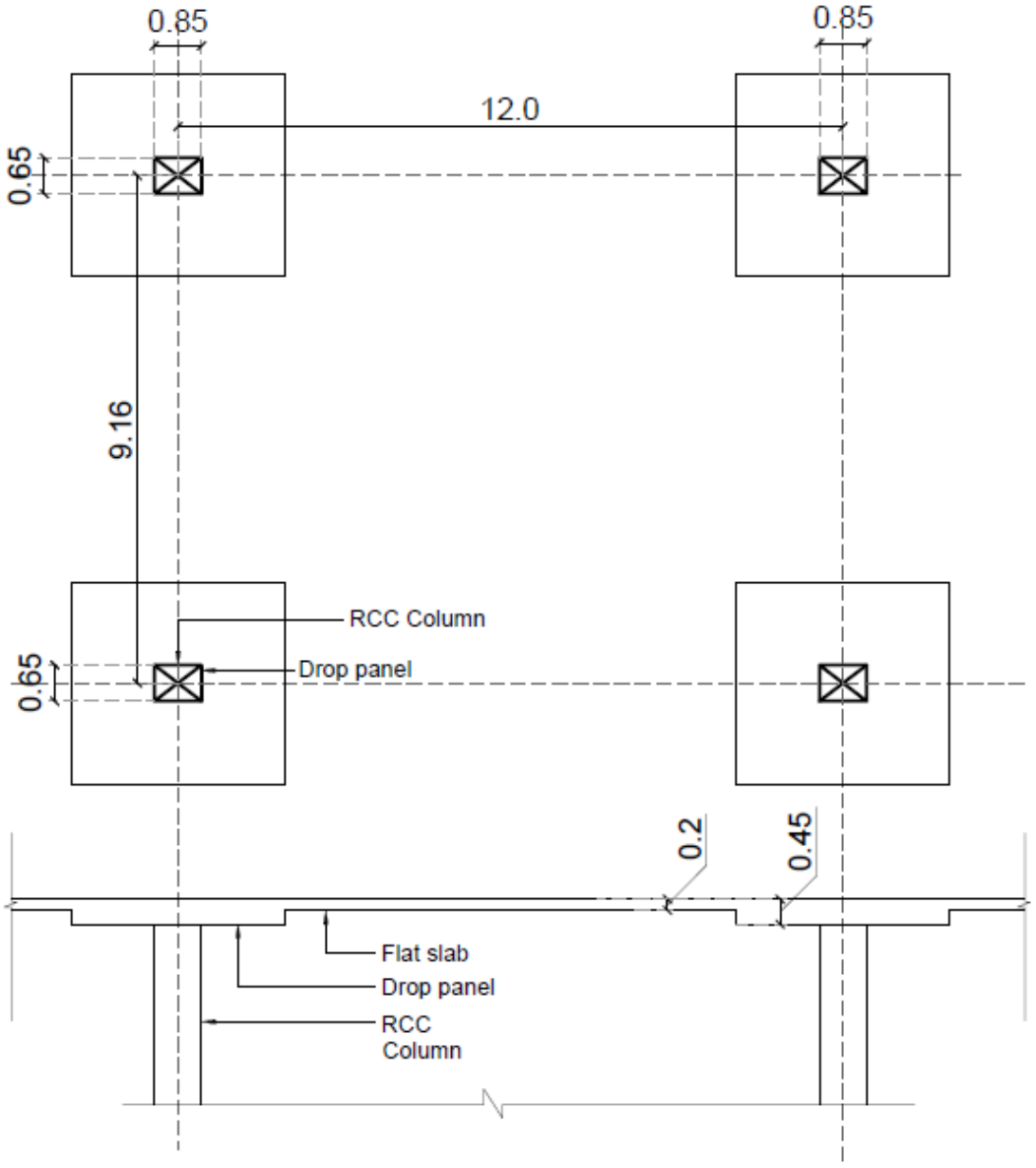


Appendix 3. Engineering Drawing

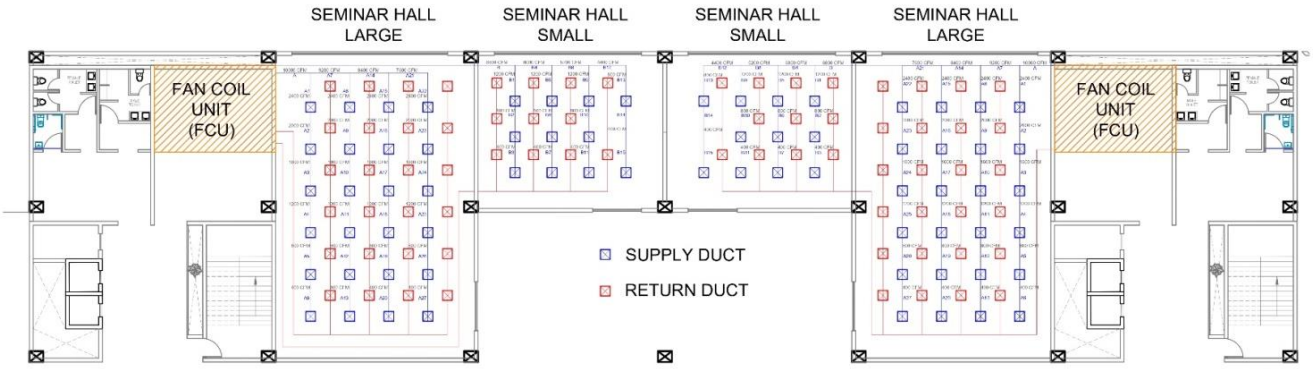
Centre Line Drawing



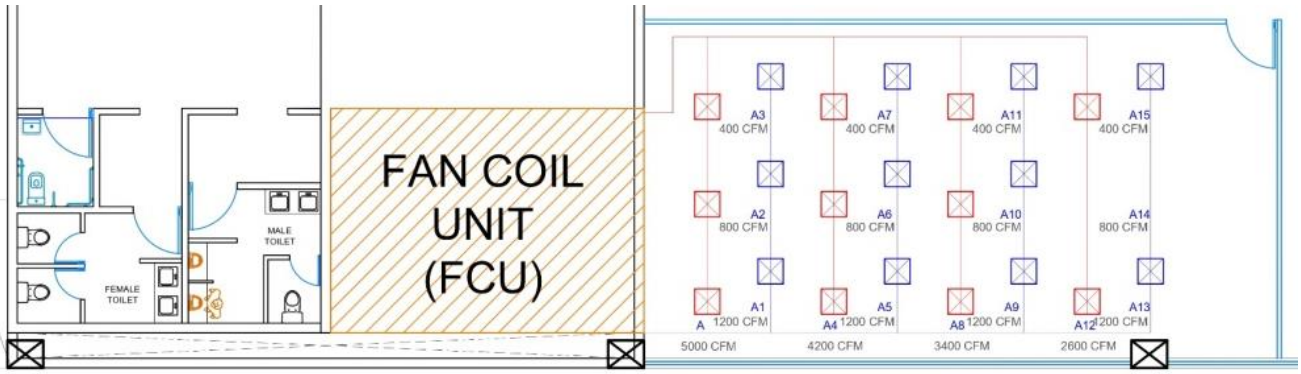
Flat slab details



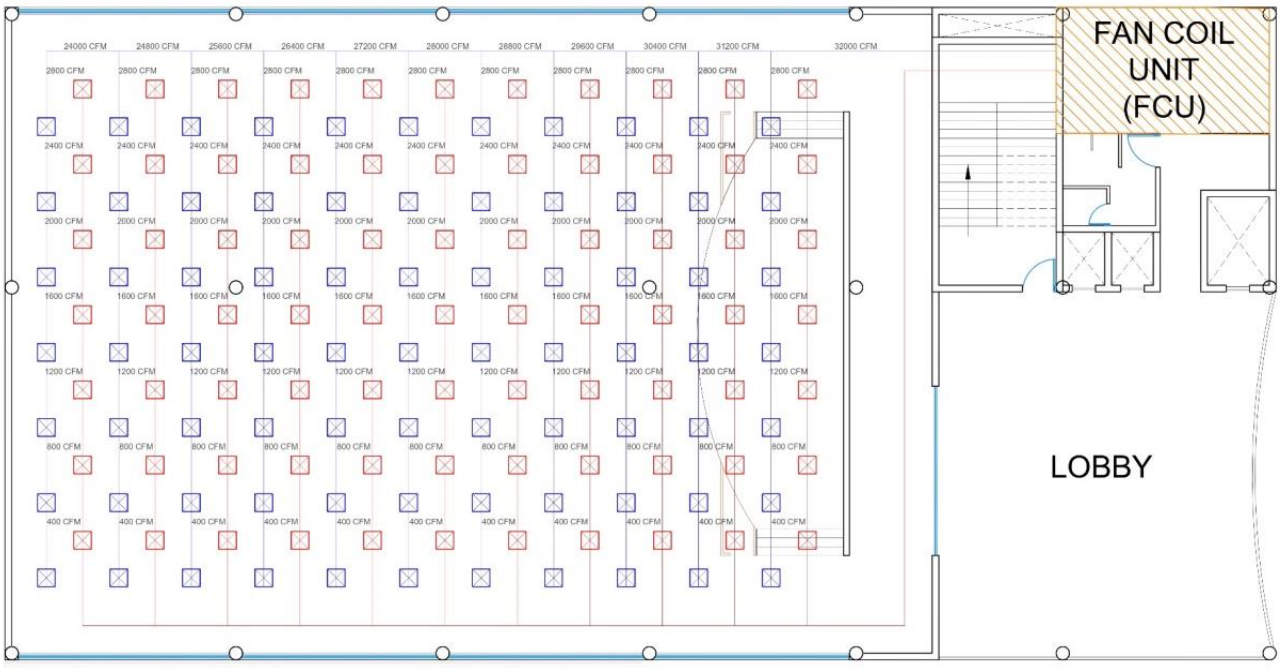
Appendix 3. Engineering Drawing



Ground Floor Plan – Seminar Halls



First Floor Plan – Gym



First Floor Plan – Multi Purpose Hall

Appendix 4. Outline specifications of relevant building systems

i. General Site preparation:

1. Protection fencing of lay down area perimeter, foundations and open excavations.
2. Protection, erosion and dust control.
3. General grading and contouring of site.
4. 12" gravel base to be provided at new walkways and courtyards.
5. Remove excess material from site, if required.
6. Removal of soil top layer before excavation, preserve it and use it for gardening purpose later.

ii. Building sub-structure preparation:

1. Excavate and backfill as required for structure; provide imported gravel/granular backfill throughout.
2. Excavate and backfill interior utilities.
3. Fine grade for slabs.

iii. Concrete:

1. Use, M35 grade concrete.
2. Contractor is responsible for all concrete testing (strength, slump, and air content).

iv. Masonry:

1. Wall masonry: Use AAC blocks where shown.

v. Thermal and moisture protection:

1. Building Insulation: use EPS insulation 50 mm thickness for walling material.
2. Provide waterproofing layer on the rooftop to prevent any leakage.

vi. Openings:

1. Metal door frames: Hollow metal doors and frames at toilets, mechanical rooms, and emergency exits.
2. Glass doors: Provide glass entrance doors for multifunctional halls and common spaces.
3. Hardware: Use levers on all latch and lock sets, except at service or utility areas use spherical knobs. Master key all locks to the system in use at the park.
4. Glazing: A DGU with 6mm thick tinted glass, 12 mm air gap and 6 mm thick internal clear glass to be used. Use tempered glass when required.

vii. Finishes:

1. Ceramic tiles: Ceramic mosaic tile walls and quarry tile floors in Toilets (Public and Staff).
2. Resilient flooring: Provide resilient flooring in utility, storage, and mechanical spaces.
3. Painting: Epoxy coatings in toilet rooms, alkyd enamel semi-gloss paints on scheduled walls and ceilings. Ceiling painted white. Meet state volatile organic compound requirements.

viii. Specialties:

1. Signage: Signs for selected rooms.
2. Toilet compartments: Floor mounted and overhead braced high-density solid polyethylene partitions with self-closing doors with latches and coat hooks.
3. Toilet accessories: Stainless steel (satin finish) recessed accessories including soap dispensers, towel dispensers, waste receptacles, toilet paper holders, grab bars, feminine napkin dispensers and disposals, and framed glass mirrors.
4. Fire protection specialties: Manual extinguishing equipment located at the staircases, gathering areas.
5. Flagpole: Aluminum flagpole to be located near the reception area.

ix. Furnishings:

1. Common space furniture: stackable chairs, box seating in common spaces.
2. Window blinds: Vertical blinds in meeting and conference rooms.
3. Trash and litter receptors: Steel receptacle with top to prevent rain from entering trash bin, including plastic trash bin

x. Fire suppression:

1. Fire suppression sprinkler system: Design, furnish, install, and test automatic wet pipe fire sprinkler and standpipe systems for the entire building including parking space, common areas, etc.

xi. Plumbing:

1. Materials and methods common to all sections including pipe and equipment identification, seismic restraint systems, pipe hangers and anchors, equipment drives, etc.
2. Facility water distribution: Service weight cast iron waste, vent, and sanitary sewer systems; copper water supply systems; and all related equipment accessories .
3. Plumbing fixtures: Low-flow type plumbing fixtures and related trim, fittings, and valves to be installed.

Water Closets -	2 L per flush (max)
Urinals -	1 L per flush
Lavatory Faucet (Public) -	4 LPM(max) at 60 psi

Wall-hung water closets in the public restrooms with dual flushing system. Electronic sensor operated flush valves and faucets in toilets. Sensotronic sensor faucets in the lavatories.

xii. Heating , Ventilation, and Air Conditioning:

1. Duct insulation: External fiberglass blanket type thermal insulation with fiber-scrim-kraft facing and internal duct acoustical insulation for all supply and outside air ducts, plenums, and return air ducts passing through ambient air or unconditioned spaces.
2. HVAC ducts and casings: Ductwork and appurtenances in connection with HVAC. Spiral-wound round ductwork in exposed ceiling areas; rectangular ductwork in concealed locations such as the mechanical equipment room, chases, or above finished ceilings.
3. Diffusers and grills: grilles, and diffusers in heating, ventilating, and air conditioning systems.
4. Cooling equipment: Provide indoor unit attached to VRV system with Fan coil units. Provide ventilation air during all occupied hours.

xiii. Electrical:

1. Connect to existing electrical service.
2. Rigid steel or intermediate metal conduits.
3. Wiring: All copper 600-volt, type THW insulation except that all wiring running underground or in areas susceptible to moisture shall be rubber insulated type RHW.
4. Interior lighting: within tenants scope
5. Exterior lighting: Metal-halide building security and parking lot lighting with high cutoff luminaires to minimize light pollution and glare.

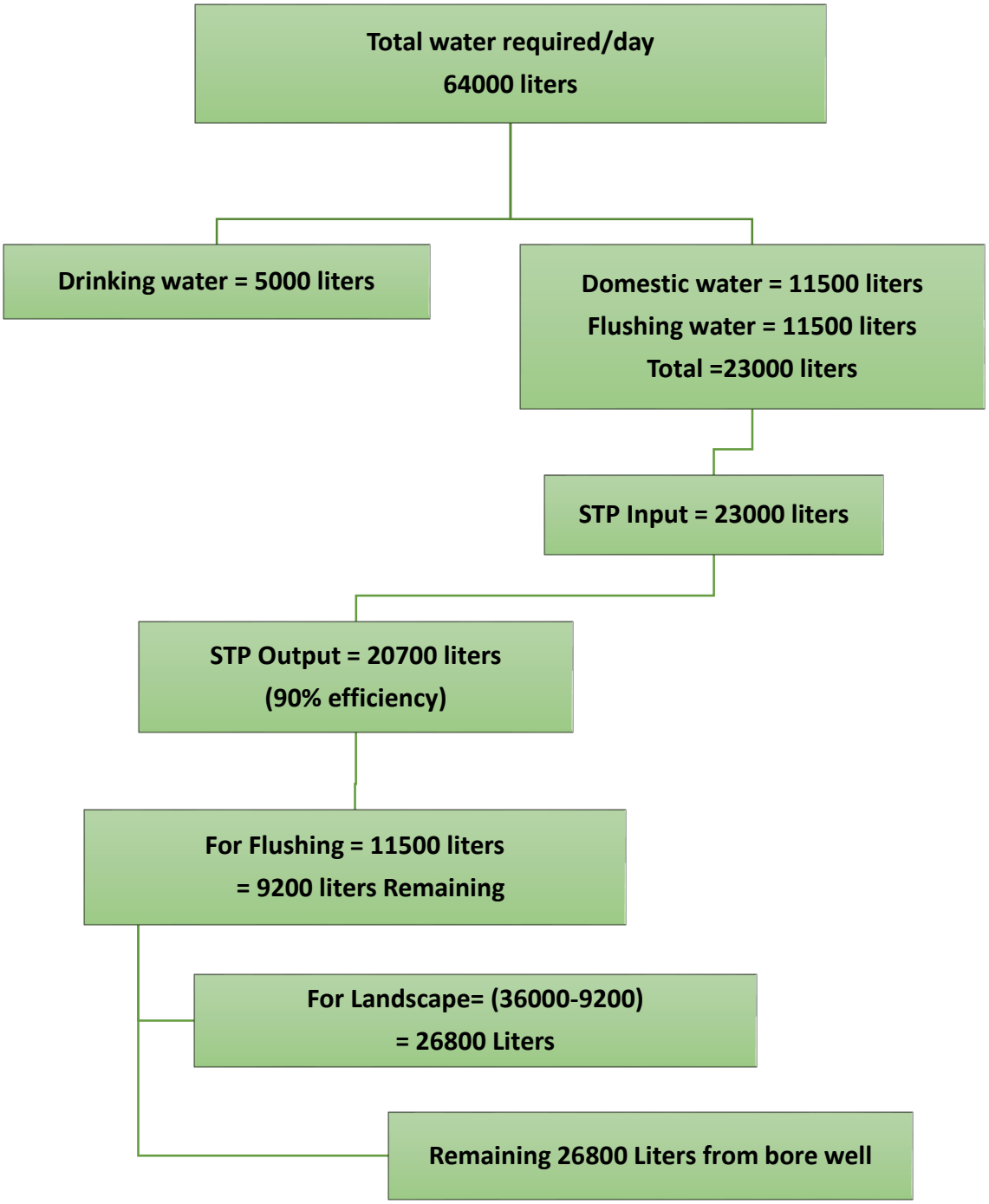
xiv. Integrated Automation:

1. Integrated automation facility controls: Building automation and control system for clerestory windows, HVAC, and lighting.
2. HVAC: Independent control to tenant for their respective space.

Appendix 5. Energy simulation inputs

INPUT PARAMETERS	Baseline (As per ECBC - 2017)	Design option
Location	Pune	Pune
Climate Condition	Warm & Humid	Warm & Humid
Wall Material	AAC block with XPS insulation	AAC block with XPS insulation
Wall U-value (W/Sq.m)	0.40	0.40
Roof material	RCC slab with XPS	RCC slab with XPS
Roof U-value (Btu/hrsq.ft F)	0.33	0.33
Glazing	6 mm clear glass	Double glazing with 6mm air gap
Window SC %	0.25	0.34
Window VLT %	85	42
Window shading (Meter)	No shading	1.0
WWR %	64	64
HVAC System	VAV with parallel fan-powered boxes and rehea	Packaged VVT 8 AM to 8 PM
LPD (W/Sq.m)	12.0	5.2
Annual Consumption **(KWH)**	3563288.0	1203722.2
EPI (KWH)	**182**	**60**
Solar PV Annulal generation **(KWH)**	-	591900
Annual Consumption after Solar offset **(KWH)**	-	611822.2
EPI (KWH)	**182**	**30.61**
Reduction after solar offset %		**83**

Appendix 6. Net-zero water-cycle design and calculations



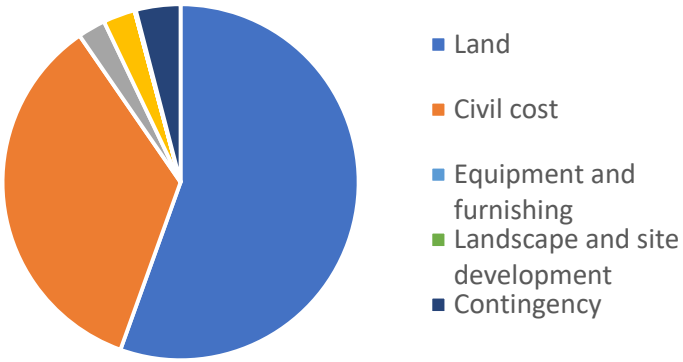
LANDCSCAPE REQUIREMENT

Landscape area = 5312 sq.m
which is **22%** of the site area
Landscape water requirement /day = 31,872 litres
16,125 litres from STP and **15,745 litres from recharge pit.**

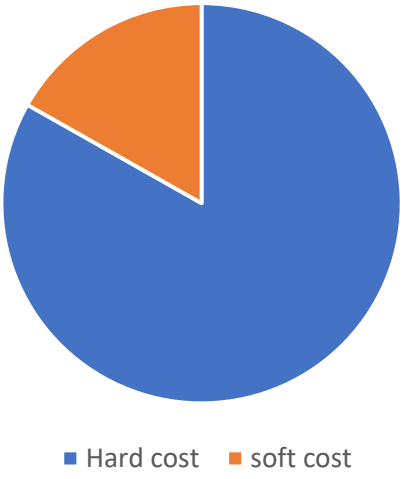
Appendix 7: Summary of cost estimate

			Amount (Million INR)	%	amount per/sq m
1	Land	Cost of land purchased or leased by project partner	923.5	46.16	30785
2	Civil works	Civil work constuction cost	581.0	29.04	19368
3	Internal works	Internal work construction cost	42.0	2.10	1399
4	MEP services	MEP services fitting cost	48.4	2.42	1614
5	Equipment and furnishing	Equipment and Furnishing cost (tenant occupied)	0.0	0.00	0
6	Landscape And Site development	Landscape and site Development cost	1.9	0.10	65
7	Contingency	Miscellaneous expenses	67.3	3.37	2245
	TOTAL HARD COST		1664.2	83.19	55474
8	Pre operative expensed	Cost of permits, Licenses, Marked research, advertising	133.1	6.65	4438
9	Consultants	Consultants fees on a typical project	83.2	4.16	2774
10	Interest during construction	Interest paid on loans related to project during construction	120.0	6.00	4000
	TOTAL SOFT COST		336.4	16.81	11212
	TOTAL PROJECT COST		2000.6	100.00	66686

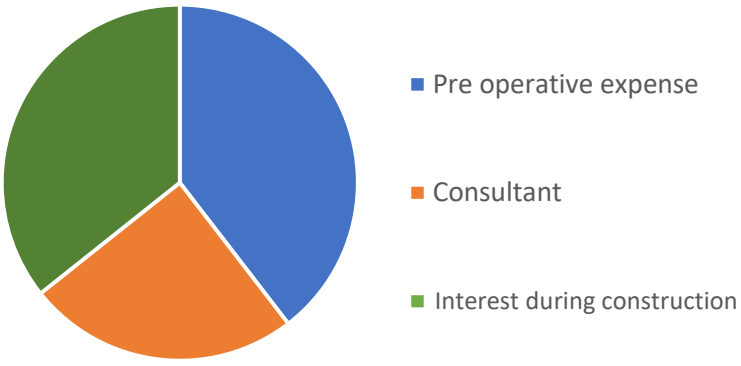
Hard cost distribution:



Project cost distribution:



Soft cost distribution:



Appendix 8: Embodied carbon emissions

Baseline Carbon emission:

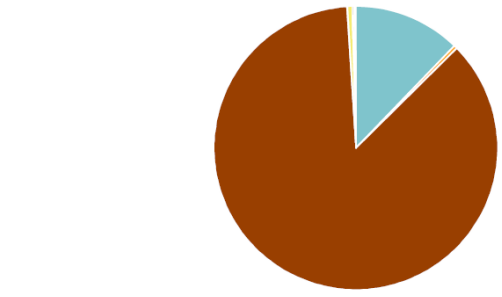
Material transportation:

Item	Value	Unit	Percentage %
A1-A3 Materials	8,400,000	kg CO_2e	12.22 %
A4 Transportation	230,000	kg CO_2e	0.34 %
A4-leg2 Transportation - leg 2	14,000	kg CO_2e	0.02 %
B3 Repair	59,000,000	kg CO_2e	86.43 %
B4-B5 Replacement	410,000	kg CO_2e	0.6 %
C2 Waste transportation	140,000	kg CO_2e	0.21 %
C3 Waste processing	1,600	kg CO_2e	0.0 %
C4 Waste disposal	120,000	kg CO_2e	0.17 %

Material Carbon footprint:

Item	Value	Unit	Percentage %
External walls and facade	54,000,000	kg CO_2e	78.82 %
Foundation, sub-surface, basement and retaining walls	6,400,000	kg CO_2e	9.27 %
Columns and load-bearing vertical structures	5,000,000	kg CO_2e	7.24 %
Floor slabs, ceilings, roofing decks, beams and roof	2,600,000	kg CO_2e	3.74 %
Materials and constructions for external areas	610,000	kg CO_2e	0.9 %
Windows and doors	25,000	kg CO_2e	0.04 %

Item	Value	Unit	Percentage %
Concrete walls	52,000,000	kg CO_2e	75.59 %
Ready-mix, foundations	6,400,000	kg CO_2e	9.27 %
Ready-mix, structures	4,900,000	kg CO_2e	7.15 %
Facades	2,100,000	kg CO_2e	3.12 %
Ready-mix, walls & floors	1,700,000	kg CO_2e	2.52 %
Resilient floors	610,000	kg CO_2e	0.9 %
Concrete products	540,000	kg CO_2e	0.78 %
EPS	300,000	kg CO_2e	0.44 %
Paints & coatings	140,000	kg CO_2e	0.2 %
Alumium windows	25,000	kg CO_2e	0.04 %



Design case Carbon emission:

Material transportation:

Item	Value	Unit	Percentage %
A1-A3 Materials	11,000,000	kg CO_2e	17.72 %
A4 Transportation	200,000	kg CO_2e	0.32 %
A4-leg2 Transportation - leg 2	1	kg CO_2e	0.0 %
B3 Repair	50,000,000	kg CO_2e	81.46 %
B4-B5 Replacement	150,000	kg CO_2e	0.24 %
C2 Waste transportation	91,000	kg CO_2e	0.15 %
C3 Waste processing	12,000	kg CO_2e	0.02 %
C4 Waste disposal	58,000	kg CO_2e	0.09 %

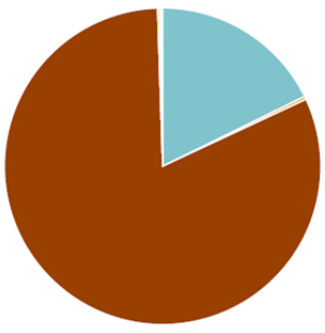
Material Carbon footprint:

Item	Value	Unit	Percentage %
External walls and facade	52,000,000	kg CO_2e	84.57 %
Foundation, sub-surface, basement and retaining walls	7,300,000	kg CO_2e	11.8 %
Floor slabs, ceilings, roofing decks, beams and roof	1,800,000	kg CO_2e	2.91 %
Columns and load-bearing vertical structures	440,000	kg CO_2e	0.72 %

Global warming kg CO_2e - Resource types

Item	Value	Unit	Percentage %
Aerated concrete	50,000,000	kg CO_2e	81.42 %
Ready-mix, structures	7,700,000	kg CO_2e	12.48 %
Ready-mix, walls & floors	1,700,000	kg CO_2e	2.79 %
Facades	1,400,000	kg CO_2e	2.33 %
Paints & coatings	300,000	kg CO_2e	0.49 %
Gypsum board	220,000	kg CO_2e	0.36 %
EPS	67,000	kg CO_2e	0.11 %
Tiles	9,900	kg CO_2e	0.02 %

Global warming kg CO_2e - Life-cycle stages

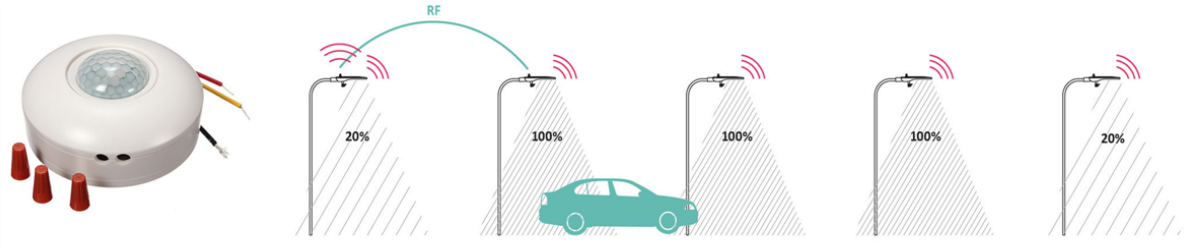


A1-A3 Materials - 17.7%
A4 Transportation - 0.3%
A4-leg2 Transportation - leg 2 - 0.0%
B3 Repair - 81.5%
B4-B5 Replacement - 0.2%
C2 Waste transportation - 0.1%
C3 Waste processing - 0.0%
C4 Waste disposal - 0.1%

Appendix 9 - Building operation narrative

Interior and exterior Lighting system

- Energy efficient Lighting Fixtures are installed in building in interior as well as in outdoor. Lighting Fixtures with higher luminous efficacy and lights with adequate Light Distribution are used in building.
- Lighting control like infrared Sensors, Daylight sensors and motion sensors are used for efficient use of lighting Fixtures.



- ON/OFF control of the general lighting in each open office area will be controlled by a combination of manual wall switches and timeclock schedule functionality residing in a low-voltage relay panel-based control system.
- In case maintenance or replacement of fixtures user should replace old fixtures with energy Efficient Fixtures like LED lights. Outdoor lights should be high pressure sodium lights, metal halides Which has higher luminous efficacy ani will help to save energy.
- The system shall be able to reboot the program up to 14 days in duration. The system shall export lighting energy consumption reports by space and zone. The control system shall operate independently of but be capable of communicating with the building automation system

Ventilation System

- Mechanical ventilation is provided by a VRV HVAC system, which includes air handling units, ductwork, diffusers and Fan Coil Units. Natural ventilation is achieved with windows on Ground Floor.
- HVAC system is fully automated and controlled by a central building management system (BMS). This system regulates the building's temperature and humidity levels to provide a pleasant atmosphere for occupants. Tenants can adjust the temperature beyond the BMS setting by 2°C or 4°C.
- For Air conditioning control temperatures are 26°C in Winter whereas 22°C in summers and humidity to 60%.
- Users of the building may control the windows, ceiling fans and BMS temperatures to preserve comfort, good health and to lessen the building's environmental effect.
- Inspect the fan coil units regularly for more efficiency of HVAC. Also inspect dampers regularly so that it can move easily.

Water supply and wastewater processing system

- In office building 3 Over head water storage tanks and 3 underground water storage tanks are proposed on service cores.
- In basement pump rooms are provided to pump water to over head tank from under ground tank.
- Cleaning of Both the tanks should be done twice a year in order to prevent contamination of water.
- Wastewater Treatment system is located in service yard. Water from System is reused again in flushing and landscaping.
- Storage tank for recycled water should also be cleaned twice a year.
- In case of maintenance and replacement of pipes and Water fixtures, Pipes should be replaced with CPVC pipes or UPVC pipes and Water fixtures should replace only with water efficient Fixture to conserve water.
- For planting new trees in landscape, user should prefer to plant native and draught tolerant species of plants to limit use of water.

Renewable energy and on-site energy storage system

- Solar PV panels are installed on roof to generate electricity which is being used in building itself.
- Electricity generated from solar panels is transferred to the transformer in service yard and then diverted again in building.
- Switch off lights whenever not necessary to avoid excess use of electricity. Do not install anything or any structure near PV panels as small shadow on
- PV panels may lead to breaking of whole circuit of PV panels and hence failure of renewable energy system.
- Cleaning of PV panel glass surfaces should be done twice a month for more efficient use of PV system.

Lift and Escalators

- There are total Ten lifts are installed inn the building.
- The inclusion of braille in lift push-button panels are proposed so that blind and seriously visually impaired people can easily handle functions of lifts. For instance, in the case of an emergency, exactly identify a floor number, press the alarm, or, if required, keep the doors open.
- Maintenance should be done once a year for smooth functioning of lifts.
- The Elevator shall NOT be loaded beyond its rated capacity.
- Machine room of lifts should be clean, Adequately ventilated and locked in safety purpose.
- No any unauthorized person is allowed to enter in Elevator machine Room.

Appendix 10: Key parameters to measure the performance of the building

Building running cost:

- Tracking water consumed daily for building.
- Track energy use of the building.
- Tracking of waste produced in the building due to daily activities. Check the recycling and waste segregation strategies at the source of the wastage.
- Repair and maintenance cost of the common equipment like solar plant, elevators, mechanical systems, etc. in the long run.

Flexibility of the internal spaces:

- Interviews and surveys can be conducted in future to understand the flexibility of the space.

Productivity of the occupants:

- Check the attendance of the office occupants as attendance is directly linked to the willingness to come to office thus indicating productive environment.
- Survey of the occupants can be performed in later stage for understanding productivity of the people.

Environmental impact:

- Analysis of carbon cradle to grave emission during the use stage give the data regarding environmental impact of the build environment.

Reliability of the building and reliance to failure:

- Water stagnation in rainy season can be analyzed in future.

New building certification:
In addition to using benchmarking systems and the building dashboard, there are a handful of sustainability rating systems that can provide you with information about building efficiency.

- IGBC new building certification or LEED certification will give a better idea regarding building overall performance like:

1. Site selection and planning
2. Water performance
2. Energy performance
3. Building materials and resources
4. Indoor Environmental Quality

Appendix 11 - Letter of confirmation from project Partner

G G METROPOLIS PVT LTD

GOEL GANGA GROUP
Pure Delight

Date: 08.10.2022

To,

The Director,

Solar Decathlon India

Dear Sir,

This is to inform you that our organization Goel Ganga Corporation has provided information about our upcoming commercial office building project at Pune to the participating team led by Dr.Bhanuben Nanavati College of Architecture for Women, so that their team Ecotribe may use this information for their Solar Decathlon India 2022-23 Challenge entry.

As a Project Partner to this team for the Solar Decathlon India 2022-23 competition, we are interested in seeing the Net-Zero-Energy, Net-Zero-Water, resilient and affordable solution this student team proposes and the innovation that results from this. We intend to have a representative from our organization attend the Design Challenge Finals event in April, if this team is selected for the finals.

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

With warm regards,

Agrawal

Nikhil Agarwal

Project Director

Email: nikhil.agrawal@goelganga.com

Phone: 9764056076

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