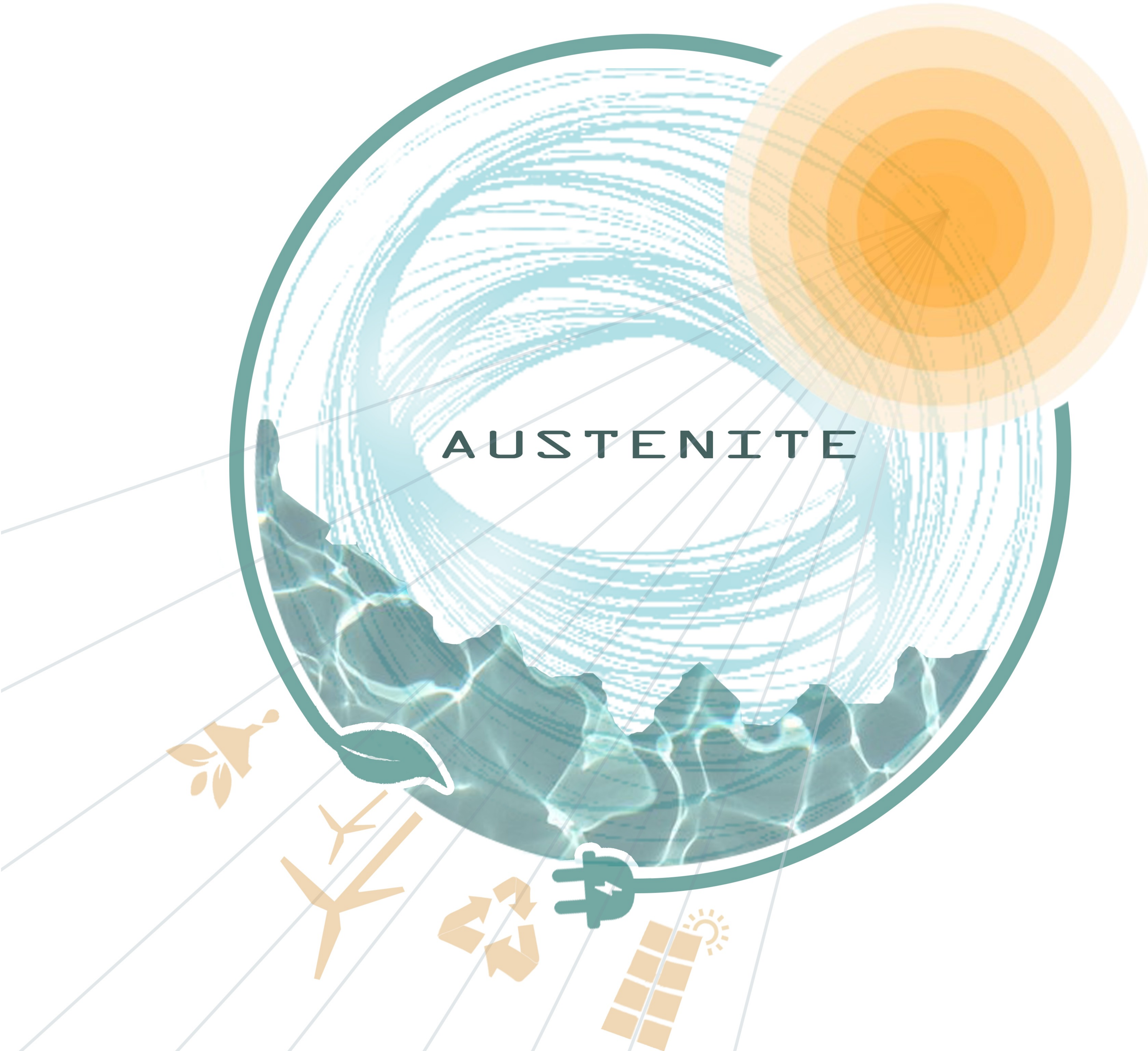
IES COLLEGE OF ARCHITECTURE × IES

Solar Decathlon India



Final Design Development Report – April 2023

EDUCATIONAL BUILDING

CONTEXT

LIST OF FIGURES

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EXCUTIVE SUMMARY

Education is a significant typology. a structure only used for a school or college, acknowledged by the relevant Board or University, or any other competent authority involving assembly for instruction, education, or recreation incidental to educational use.
Due to its specifications, we were able to comprehend its market potential. It may use the space for a number of different things. The ICSE board pattern, which emphasises student interaction and a positive environment, was studied. Its ease of use and secure environment attract more stakeholders.
The students, who serve as the main stakeholders, were taken into consideration when designing the building. Therefore, the students' well-being and comfort came first. The building has cross ventilation and direct sunlight play during working hours. As a result, only the barest amount of energy is used. By correctly orienting the structure and incorporating passive stratergies, this was achieved.
HVAC units can be positioned to use the least amount of energy on the northern side. Working simultaneously with simulations of dehumidification, wind flow, connectivity, and active and passive strategies was extremely difficult because any compromise in one causes the other to become out of balance.
We were able to understand the need for energy through a thorough analysis of wind direction and radiation through simulations.By using the VRf system, passive strategies, and the appropriate energy-efficient lighting, we were able to reduce our energy usage. Up to 50% of your energy requirements can be offset by installing solar panels. Water conservation was another major issue. We used fixtures that used 50% less water to reduce water consumption. We balanced our hardscape and softscape to increase surface runoff water. A rainfall analysis led to the installation of rainwater harvesting systems. By employing the appropriate techniques, 75% of the water used in construction is recycled while maintaining its quality.
We have moved from reading about the goals to applying calculations and strategies that can make them a reality as we move through the deliverables. We collaborate using projectors and conduct online sessions to ensure equitable learning. The SLM in particular has been extremely helpful for all team members because we can use the active and passive strategies in these films to our academic projects. Working with Solar Decathlon has improved our knowledge of the viability of net zero buildings, which will probably soon be a requirement for all projects.

1) TEAM SUMMARY:-

a.) Team name: 'Austenite'

b.) Name of institution: IES College of Architecture,Bandra, Mumbai.

c.) Partner Institution: K. J. Somaiya College of Engineering,
NMIMS School of Technology Management and Enginneerring

d.) Division: Educational

e.) Team members:

f.) Team approach:

Our multidisciplinary team consists of 15 members from the field of architecture. We have frequent discussions to consider different perspectives to come up with comprehensive strategies, and work is delegated accordingly. We divide ourselves into groups to work on different things and the work progress is shared with all the team members through cloud so work progress is clearer and faster. With the different skills every member has to offer, we help each other learn, observe and explore different areas of interests.

g.) Background of lead institution:

The Indian Education Society's College of Architecture located in Bandra, Mumbai was established in 1995 with the aim of moulding architecture students into high calibre professionals. At IES College of Architecture, we serve degree in bachelor's of architecture. We believe that architecture education is a fine balance of not just design and technology but also being rooted to the ground that nourishes and sustains life.

h.) Faculty description:

Ar.Shripad Bhalerao - (Faculty Lead-IES College of Architecture)
Shripad Bhalerao has an M.Arch degree in computer application. He had devised specific modules like "UX+A user experience in Architecture" and "Hybrid Communication skills for design students"

Ar.Khushboo Adhiya - (Faculty Advisor-IES College of Architecture)
Khushboo Adhiya is an alumnus of IES College of Architecture and has completed her masters in Landscape Design from CEPT University. She has worked on various commercial and residential projects at 4.4 Design, while also being a qualified IGBC accredited professional

Ar.Parikshit Wadhmare - (Faculty Advisor-IES College of Architecture)
Parikshit Waghdhare is in the architectural industry since 1999, mostly involving large scale hotels and institutional projects. He was awarded "Claude Batley students design award" for TCS Deccan Park in 1998.

i.) Industry partner:

Our industry partner is Dr.SyedMoazzam Alif from Taiba Engineering Consultants. Dr.Aliisa BEE Certified ECBC Master Trainer, and holds a Ph.D from JNTU-H. He is a veteran in building services design in different sectors including high rise structures, commercial, residential, retail, healthcare, industrial, refurbishment, etc.

j.) Softwares used:

PROJECT INTRODUCTION

a.) Project Name - IES School, Vashi

b.) Project Partner- Indian Education Society

The Indian Education Society's College of Architecture was established in 1995 with the aim of moulding architecture students into high calibre professionals.Located in Mumbai, IESCOA boasts of a committed teaching team and an encouraging environment. At IESCOA, we believe that architectural education is a fine balance of not just design and technology but a community that believes in our ability and the precedents that keep us inspired.

c.) Project Description

The initiative is centred on creating an ICSE school for the Indian Education Society. The project will be built over a site of area 4182 sq m. Based on Vashi's economic status, the students will range from middle class to higher middle class families. The project aims at maintaining the quality of education IES has been upholding all these years, through a sustainable approach.

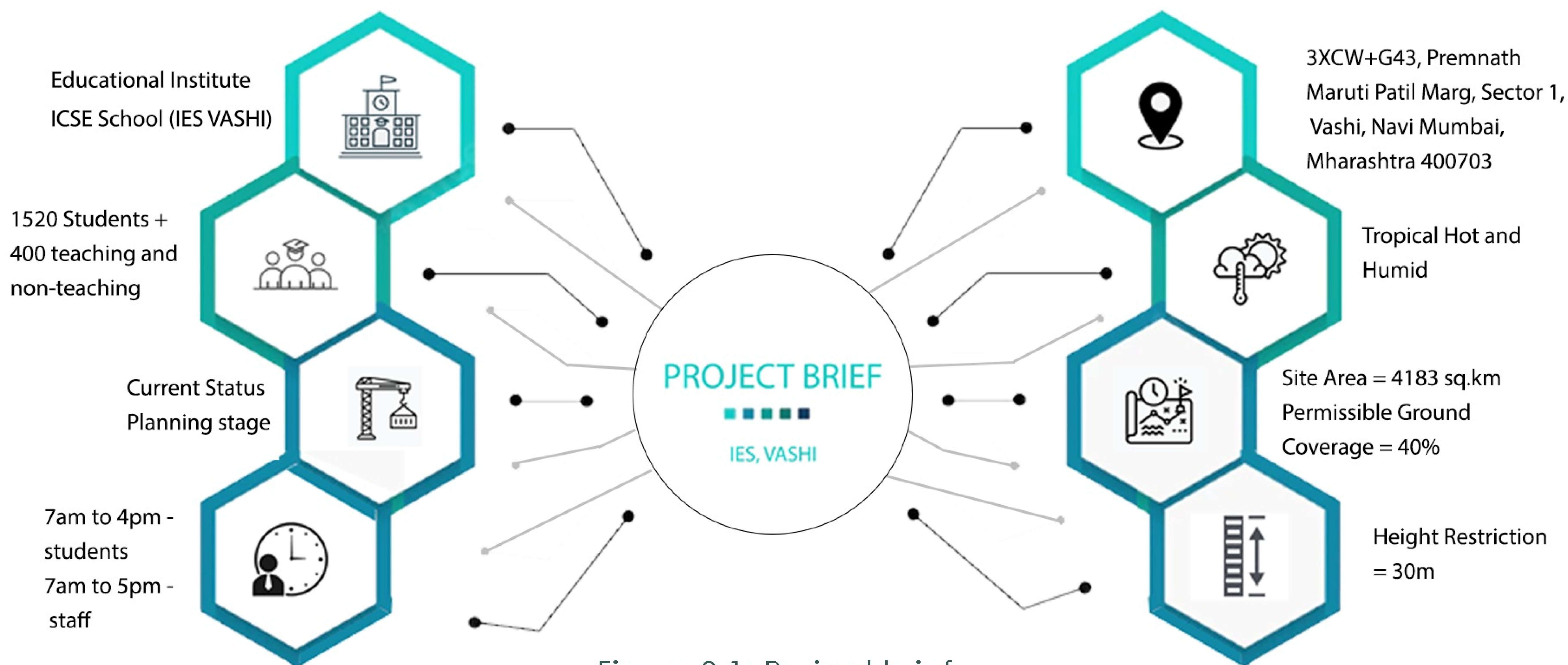


Figure 3.1: Project brief

"FOLLOWING NORMS OF UNIFIED DEVELOPMENT, CONTROL AND PROMOTION REGULATION FOR MAHARASHTRA AND NATIONAL BUILDING CODE OF INDIA"

Sr.no	Particulars	FSI	Area (sqm)	Cost(crores)
	Area of plot		4183	
A	Basic FSI	1.1	4602	0
	80% Ancillary FSI	0.88	3681	1.36
B	Total		8283	1.36
	Total ground coverage (permi.)		1674	
	Total (incl 18% GST)			1.64

Table 3.1: Area statement

IES School, Vashi will cater to students from kindergarten to higher secondary, providing a holistic education to the students. A margin of 6m from each side is taken by considering UDCPR margins and setback area (In the UDCPR, a new concept ancillary FSI has been introduced to denote common areas such as lifts, lobbies, staircases, flower beds, etc, which were earlier excluded from FSI computation) For education, 80% FSI of total FSI (base fsi) is considered.

PROJECT INTRODUCTION

Strength
- surrounded by mix use development,
- providing good user group
- Good connectivity
- Amenities available to vicinity of site

Threats
- Earthquake prone zone (lies under zone 4)
- Water logging and flooding issue

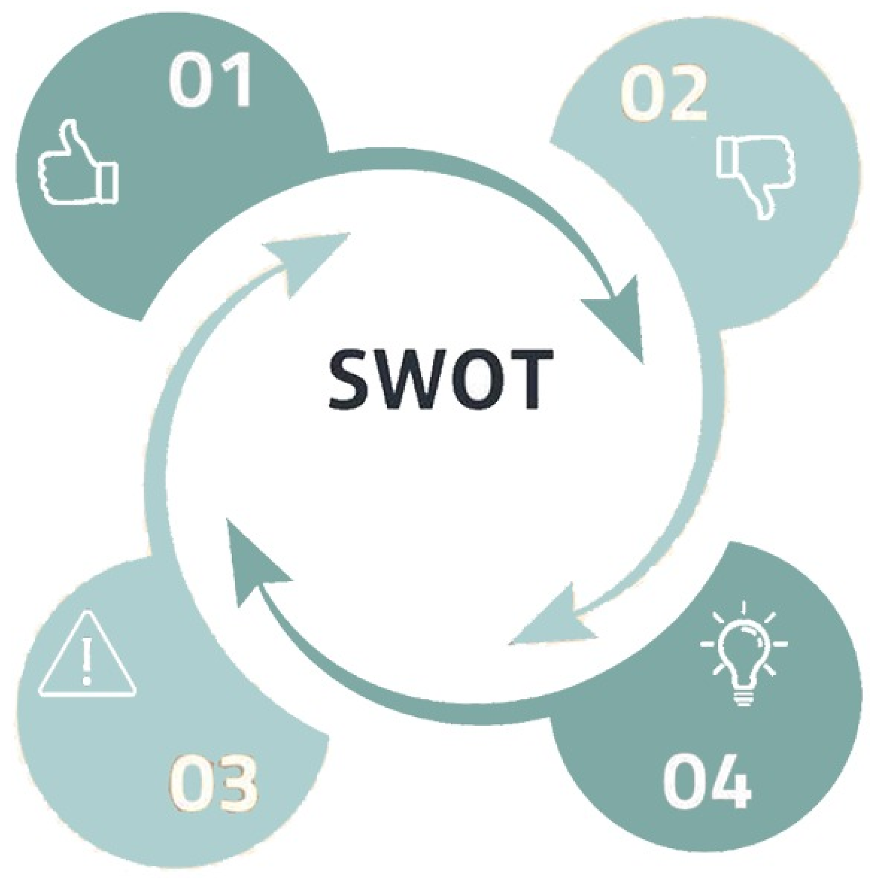


Figure 3.1 : SWOT

Weakness
- compact blocking towards east side of site
- Located in wetlands with high ground water table

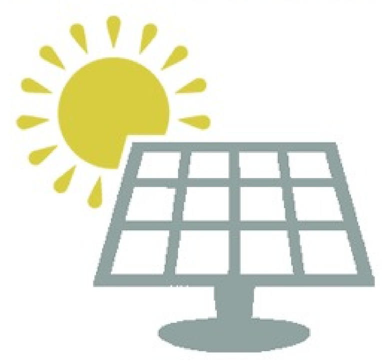
Opportunity
- surrounded by open grounds promoting spill over activites
- Developing city hence investment in infrastructure and potential in renewable energy production

e.) Energy Performance Index:
To achieve Energy Performance Index of 30KW/m2 per year

EPI Goal :- **30** KW/m2 per year

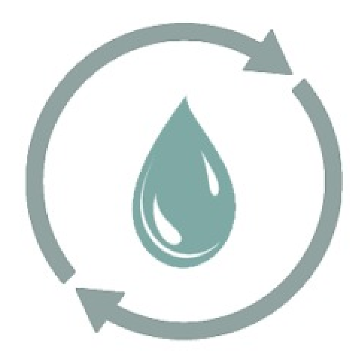
BASED ON THE CASE STUDIES OF PEARL ACADEMY, JAIPUR AND AVASARA ACADEMY, PUNE

f.) On-site renewable energy generation potential:



Solar Energy Generation
301946.6
KW PER ANNUM

The rooftop area of the building is utilized for the installation of solar panels, taking advantage of the solar energy generation potential of the site which helps in offsetting the energy demand from the grid.



Waste Water Recycling
1418.580
KL PER ANNUM

The grey water generated on our site is to be treated and is reused to meet the flushing and landscape water demand. It then exits the system as black water

g.) Preliminary construction budget:

Sr.No.	Particulars	Baseline Estimate (Project Partner / SOR bases)		Proposed Design Estimate	
		Amount in Million INR	%	Amount in Million INR	%
1	Land	NA			
2	Civil Works	₹ 15,06,94,740.00	38.772571	₹ 17,56,677,018.00	38.834952
3	Internal Works	₹ 11,30,21,055.00	29.079428	₹ 13,17,50,263.00	29.126214
4	MEP Services	₹ 3,76,73,685.00	9.6931428	₹ 4,39,16,754.00	9.7087379
5	Equipment & Furnishing	₹ 3,76,73,685.00	9.6931428	₹ 4,39,16,754.00	9.7087379
6	Landscape & Site Development	₹ 4,52,08,422.00	11.631771	₹ 5,27,00,105.00	11.650485
7	Contingency	₹ 43,91,675.00	1.1299434	₹ 43,91,675.00	0.9708737
	TOTAL HARD COST	38,86,63,262.00	100	45,23,42,569.00	100
8	Pre-Operative Expenses	₹ 14,63,892.00	25.000004	₹ 1,12,55,789.00	24.999999
9	Consultants	₹ 43,91,675.00	74.999996	₹ 3,37,67,368.00	75.000001
10	Interest During Construction				
	TOTAL SOFT COST	58,55,567.00	100	4,50,23,157.00	100
	TOTAL PROJECT COST	₹39,45,18,829.00	200	₹49,73,65,726.00	200

Figure 3.1: Construction budget

Preliminary construction budget done under guidance of consultant to receive pertinent figures required to build the whole project.

	GOALS	STRATEGIES	ACHIEVEMENTS
ENERGY PERFORMANCE	• To achieve target EPI is 30 kWh/m2 /year in referance of Pearl academy, Jaipur and Avasara academy, Pune. • Achieving Net-positive Energy Design	• Utilization of passive & active design strategies which include optimal orientation, maximum daylighting, natural ventilation, thermal insulation and right sizing of VRF system. • Creating a net zero energy system in the building with help of on-site solar energy panels.	• Achieved EPI- 30 kWh/m²/yr • Renewable energy based LED site lighting to reduce power consumption. • Building Automated systems and Hybrid VRF systems to reduce energy consumption.
WATER PERFORMANCE	• Trying to provide net zero cycle in building by reduction of water consumption and addition of water conserving methods like rain water harvesting and usage of grey water. • Maintaining the quality of water through on-site filter treatments. • Reduction of load on municipal supply.	• Trying to reduce domestic water consumption using sensor taps, low flow fittings aerators and efficient fixtures. • Harnessing rainwater by optimizing roof footprint and using efficient rainwater harvesting systems. • Recycling grey water for flushing, irrigation, cleaning, etc. Proper filtration and disinfection of grey water.	• Use of hydraulic system control pressure reducing valves and low-flow plumbing fixtures. • Provide vegetated areas as part of green infrastructure. • Absorbent gardens on roofs and facades that capture, filter, and lessen stormwater overflow. • Harvest rainwater and produce solar energy with inverted canopy systems. • To achieve 90 to 95% water efficiency, reduce the amount of water used for irrigation by using effective irrigation systems, such as micro drip irrigation.
EMBODIED CARBON	• To reduce embodied carbon emission.	• Use of bricks instead of AAC blocks or others. • Using materials that prevail within a small radius to reduce the embodied carbon emission due to transportation.	• Utilising bricks, low-u value glass windows, and traditional materials like kota stone for flooring helps lower costs, improve health, and maintain temperature while workers are present.
RESILIENCE	• Structural stability and robustness in design to accommodate temperature fluctuations and make the building resilient to changing environmental conditions, natural disasters (flooding, drought), and economic challenges.	• Construction on stilts and high-plinth to avoid any damage or disruption in services caused by rising water levels. • The building is structurally sound enough to withstand seismic waves in a zone 4 region. • Access to energy, water, sanitation, communication, food, and medications should be available in an emergency as well as in the short term.	•Use of piled raft foundation and seismic dampers to support the structure. Integrating bio retention swales to adapt to potential flooding. Fire safety regulations and necessary equipments have be provided as per NBC norms. Sufficient amount of water and power backup for atleast 6 days. Ensuring security and surveillance for the safety of students and other people in the premises
ENGINEERING & OPERATIONS	• Developing engineering systems that functions as extensions as well as facilitators of user's experience and goals.	• Designing right sizing of columns and beams. • Using BMS (Building Management System) to ensure automation for energy consumption and enhancing occupant comfort and safety. • Using piled-raft foundation to achieve structural stability during earthquakes.	•Building automation system that oversees and regulates every system inside the structure.Right sizing of columns and beams through simulations.High stability of structure with correct placement of columns and foundation.Use of VRF (Variable refrigerant fixture) system for air conditioning spaces.
ARCHITECTURAL DESIGN	• Spatial management and design for a conducive learning environment, as well as other objectives and goals achieved through architectural design.	• Including courtyards as a social area and a means of cooling. • Properly orienting the space and employing a constrained floor plan to maximise airflow and natural light. • Including natural elements to create an engaging learning environment. • Establishing provisions to increase on-site energy production and water management.	•Establishing interactive places for stakeholders the right amount of harmony between the hardscape and the greenery concentrating on the micro and macro climates in relation to each floor. Improving the spatial quality of break through spaces.
AFFORDABILITY	• Lowering down Construction Cost	• To reduce operational costs, an emphasis is placed on passive design strategies and construction management with smart building systems and rightsizing system. • Use of terracota, bricks, kota stone that are also locally available in the area to reduce transportation costs.	•Due to the use of traditional materials while providing comfort indoors, the cost of design is more than the base scenario. Using passive design techniques to allow the structure's various spaces to naturally breathe and be lit will reduce the amount of energy needed from a public source. In a similar vein, treating and reusing water would reduce the amount of water needed from a public source.
INNOVATION	• Creating strategies to maximize daylight and reduce heat radiation. • Use of locally available materials.	• Terracota screens that not only define aesthetics but also improve energy performance by providing shading. • These terracota screens on the exterior blocks the low morning and afternoon sun during warm periods. • Reusing Polyurethene foam board as partition walls between two classrooms. • Enabling terrace gardens to promote the concept of urban farming amongst the students.	•Reducing radiation through facade optimisation. raising awareness of urban farming Use of polyurethane materials again since they are not biodegradable
HEALTH & WELL BEING	• Ensuring that both indoor and outdoor construction is climate-appropriate.	• Improving IAQ (indoor air quality) by using material with low VOC (volatile organic compound). • To achieve ventilation rate of 1114 l/s and indoor temperature range = 22-28 °C (IMAC) • Orienting structure in a way to maximize functionality and comfort through movement, ventilation and lighting.	•- A proper use of daylight in classrooms to provide visual comfort. - Enhancement in indoor air quality through plants which help in dehumidification and provide oxygen. - Thermal comfort is achieved by shading devices and buffer spaces such as green corner, courtyard etc.
VALUE PROPOSITION	• To provide low payback period without compromising on the desired building performance.	• Consider calculation for total cost of an asset over its life over a certain period of time. • Using central atrium as a community space for generating revenue.	•- Low cost construction Healthy environment An efficient payback cycle Community spaces as revenue generation Low maintenance of materials thus reducing cost Detailed justification on designed structure being more efficient than the plan provided by project partner

ENERGY PERFORMANCE

Energy Performance Modelling

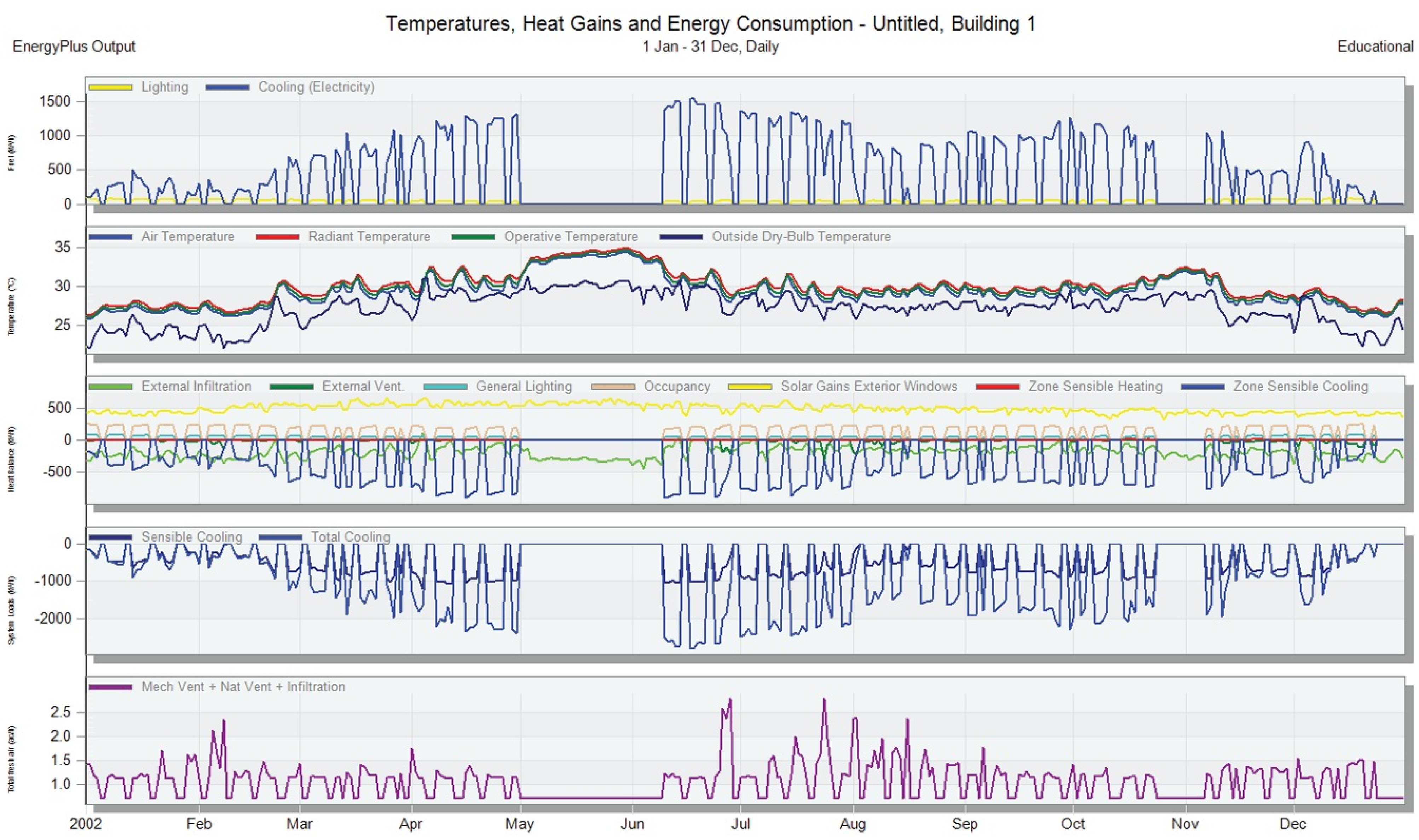


Figure 5.1.1 -Design Builder stimulations - Temperatures, Heat Gains and Energy Consumption

Energy performance timeline

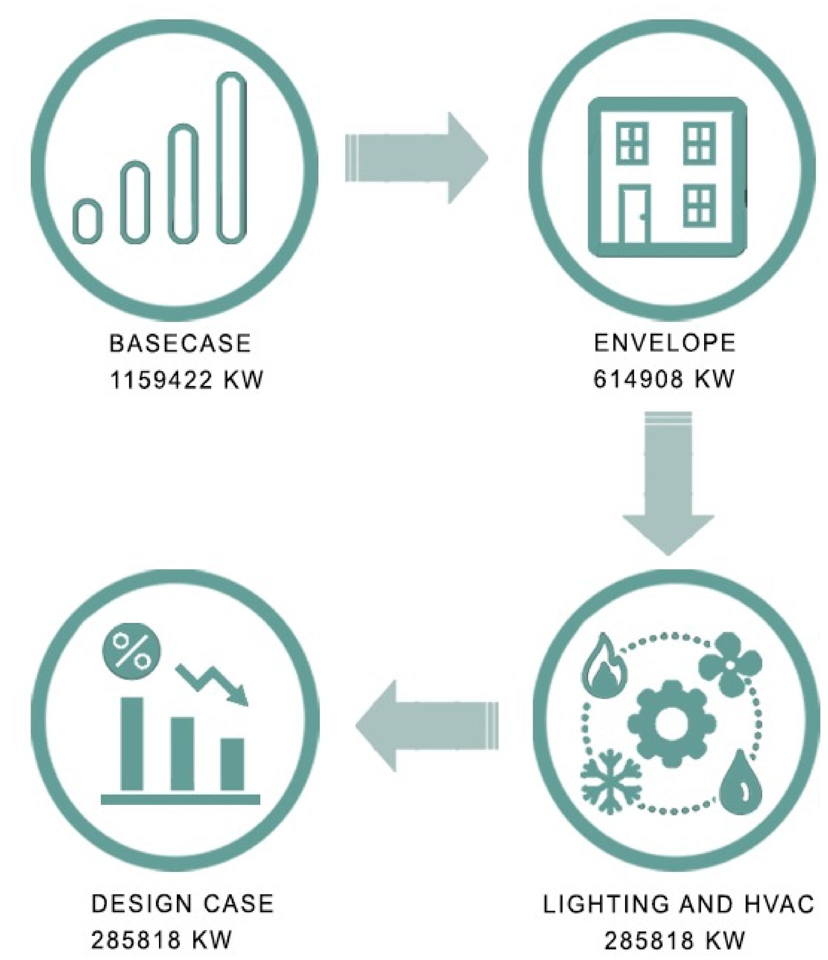


Figure5.1.2- explain the evidence-based design process of how a simple structure achieved intelligent, sustainable and net-zero building com-

MONTHS	NO. DAYS	LIGHTS	FANS	EQUIPMENT	CCTV	HVAC	LIFT	PUMP	TOTAL
JAN	25	3100	2790	5270	1550	77500	1674	7130	99014
FEB	23	2700	2430	4590	1350	67500	1458	6210	86238
MAR	23	3100	2790	5270	1550	77500	1674	7130	99014
APR	20	3000	2700	5100	1500	75000	1620	6900	95820
MAY	10	3100	2790	5270	1550	77500	1674	7130	99014
JUNE	16	3000	2700	5100	1500	75000	1620	6900	95820
JULY	29	3100	2790	5270	1550	77500	1674	7130	99014
AUG	25	3000	2700	5100	1500	75000	1620	6900	95820
SEPT	27	3100	2790	5270	1550	77500	1674	7130	99014
OCT	22	3000	2700	5100	1500	75000	1620	6900	95820
NOV	34	3100	2790	5270	1550	77500	1674	7130	99014
DEC	26	3000	2700	5100	1500	75000	1620	6900	95820
	280	36300	32670	61710	18150	907500	19602	83490	1159422

Table 5.1.1 -Base case monthly calculation of energy consumption including holidays

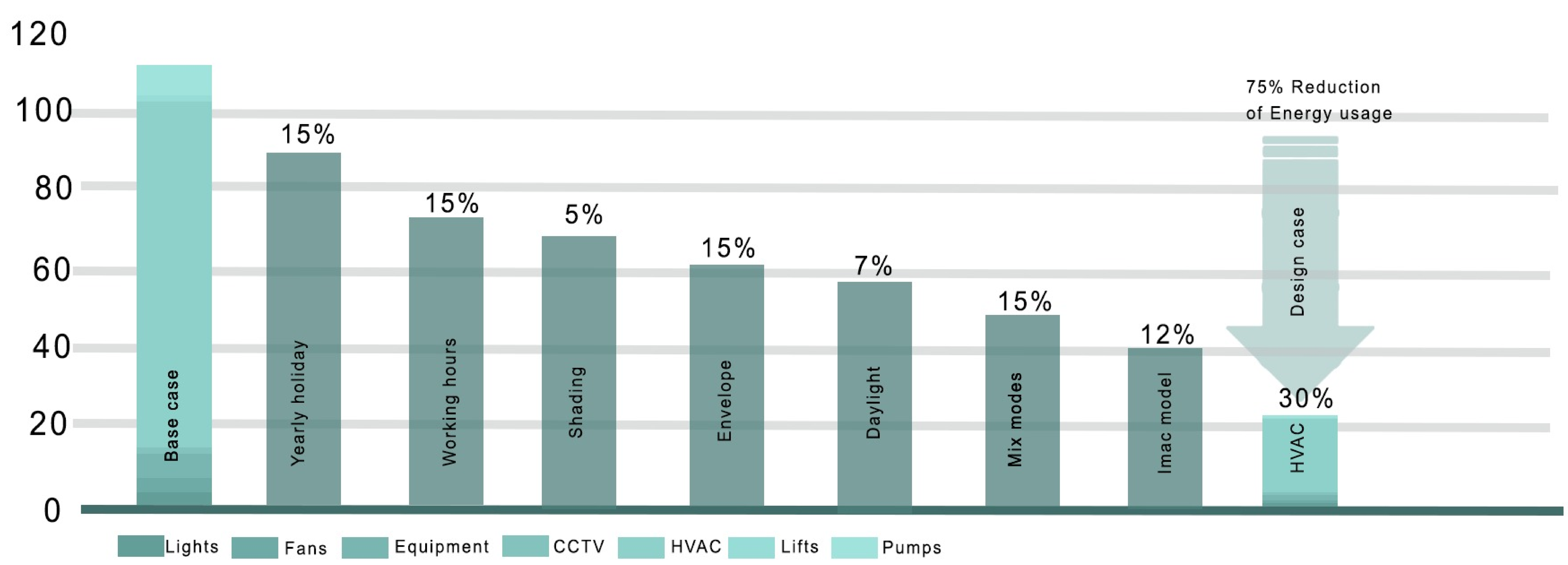


Figure 5.1.3-Optimization of Proposed Design

The main aim is to propose step-by-step procurement of net-zero building design. This is done using simulation models like Design Builder and Edge tool.

Passive Design Strategies:
-Shading: Analysing shading effects on built-unbuilt spaces using climate analysis for maximum comfort.
-Envelope Optimization: This step includes designing an envelope system that minimizes the heat transfer from the exterior to the interior. The envelope includes walls, roof and window. Detailed research on the material specification of the envelope system was done to shortlist a few configurations of wall, roof and window type. The material sets were selected to suit optimal U-value availability and cost.
(Refer to innovation for facade understanding)

Efficiency:
-Daylighting: used to advantage so as to reduce load on artificial lighting.
-Comfort optimization: To operate the AC system according to the adaptive thermal comfort, floating set points are optimized. A range of indoor operative temperatures for warm and humid climate according to IMAC for mixed mode buildings. Comfort is also based on loads from human occupancy. These measures lead to an EPI of 28.5 kWh/m2.yr

MONTHS	NO. DAYS	LIGHTS	FANS	EQUIPMENT	CCTV	HVAC	LIFT	PUMP	TOTAL
JAN	25	400	225	1000	500	22500	1674	1000	27324
FEB	23	368	207	920	460	20700	1458	920	25056
MAR	23	368	207	920	460	20700	1674	920	25272
APR	20	320	180	800	400	18000	1620	800	22140
MAY	10	160	90	400	200	9000	1674	400	11934
JUNE	16	256	144	640	320	14400	1620	640	18036
JULY	29	464	261	1160	580	26100	1674	1160	31428
AUG	25	400	225	1000	500	22500	1620	1000	27270
SEPT	27	432	243	1080	540	24300	1674	1080	29376
OCT	22	352	198	880	440	19800	1620	880	24192
NOV	34	544	306	1360	680	30600	1674	1360	36558
DEC	26	416	234	1040	520	23400	1620	1040	28296
	280	4480	2520	11200	5600	252000	19602	11200	306882

Table 5.1.2 -Design case monthly calculation of energy consumption

Solar energy perfomance

Energy generation and Achievements:All the extensive generations on site are made through solar generation

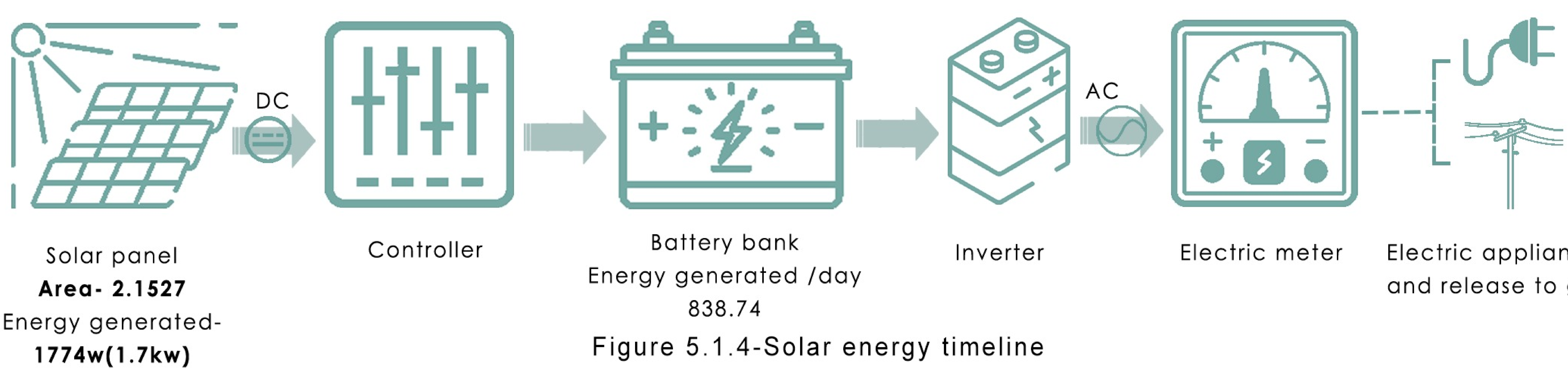
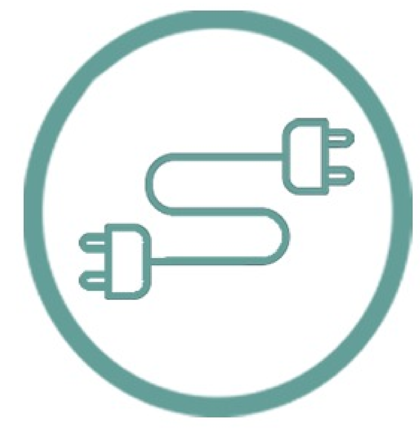


Figure 5.1.4-Solar energy timeline

SOLAR PANEL CALCULATION

LONGi Solar — SOLAR ENERGY	
Solar panel watts x Average hur of sunlight x 75% = Dailt watt hour	
Roof top energy	
Brand and module	Longi 435w 24v mono perc solar panel
Max power	430 W
Dimensions	2094 x 1038 x 35 mm
Area	2.1527 m2
No. of hours of sunlight	5.5 hrs
Solar energy generated	430 x 5.5 x 0.75
per day by 1 panel	1774 W (1.7 KW)
No. of days	300 days
Roof top area	1282 m2
Effective roof top area	1060.766 m2
No. of roof top area	493.3 panels
Total energy generated	838.74KW
Energy generated annually (360)	360 x 838.74 = **301946.6Kwh**
Energy generated annylly (300)	300 x 676 = **202800Kwh**

Table 5.1.3 -Solar PV Calculation

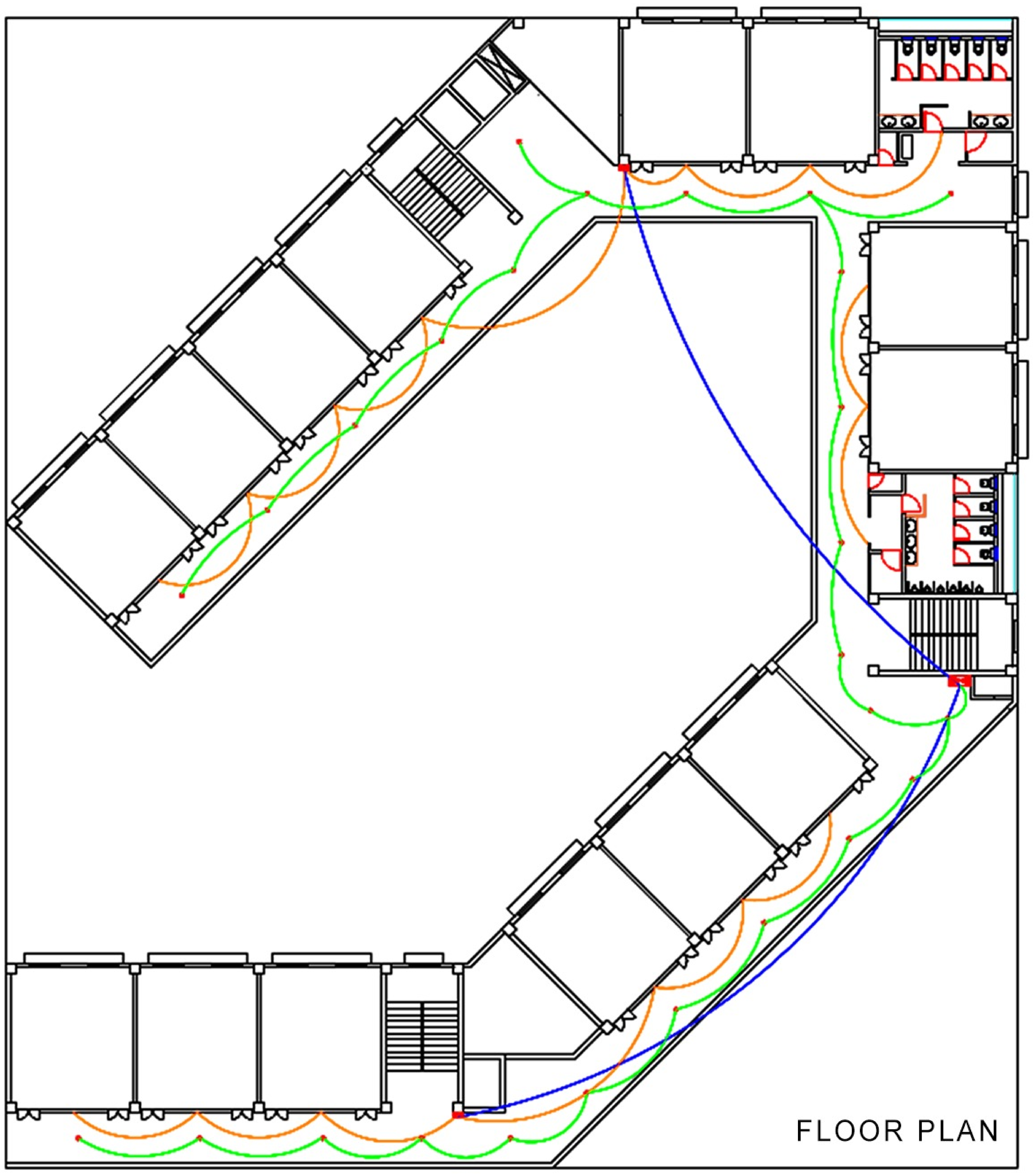


Total Energy Active 288630kwh

Total Energy Generated 301946.6kwh

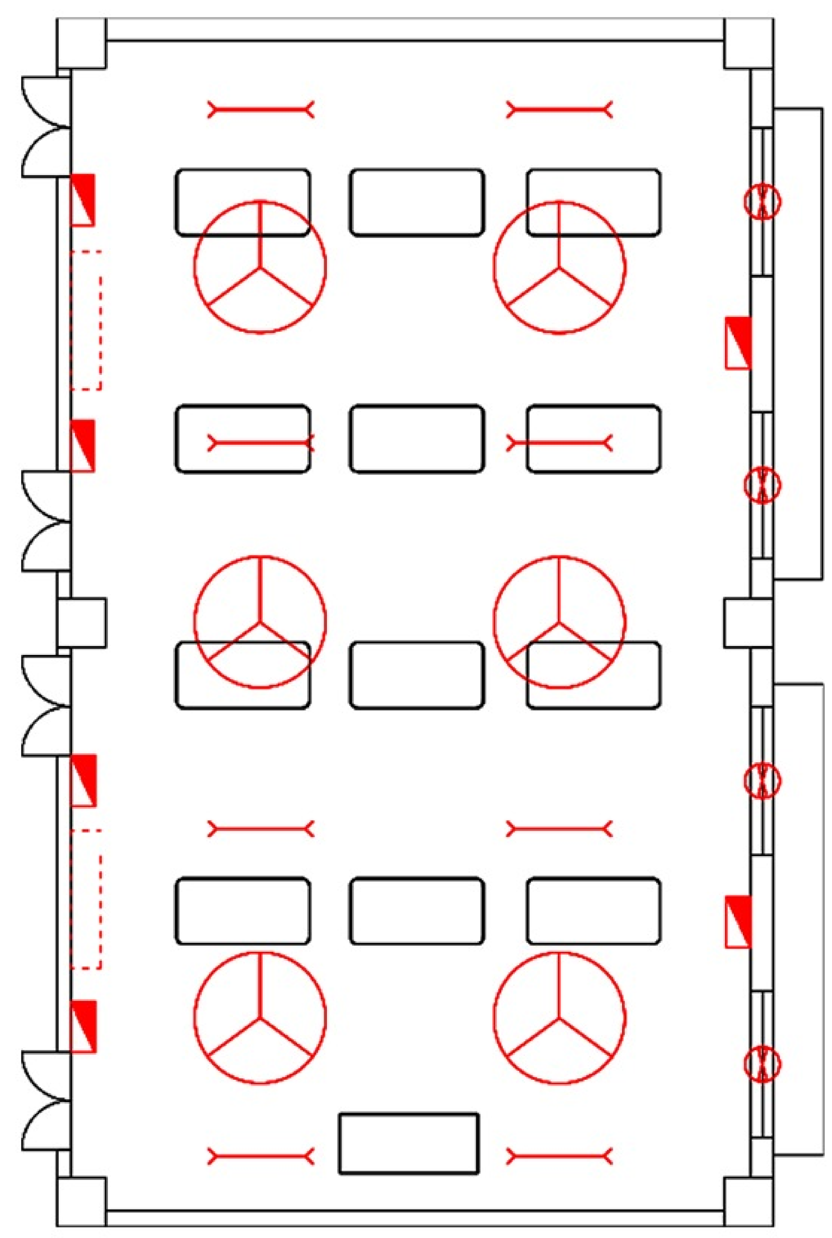
Figure5.1.5 -Solar PV Calculation

ELECTRICAL LAYOUTS

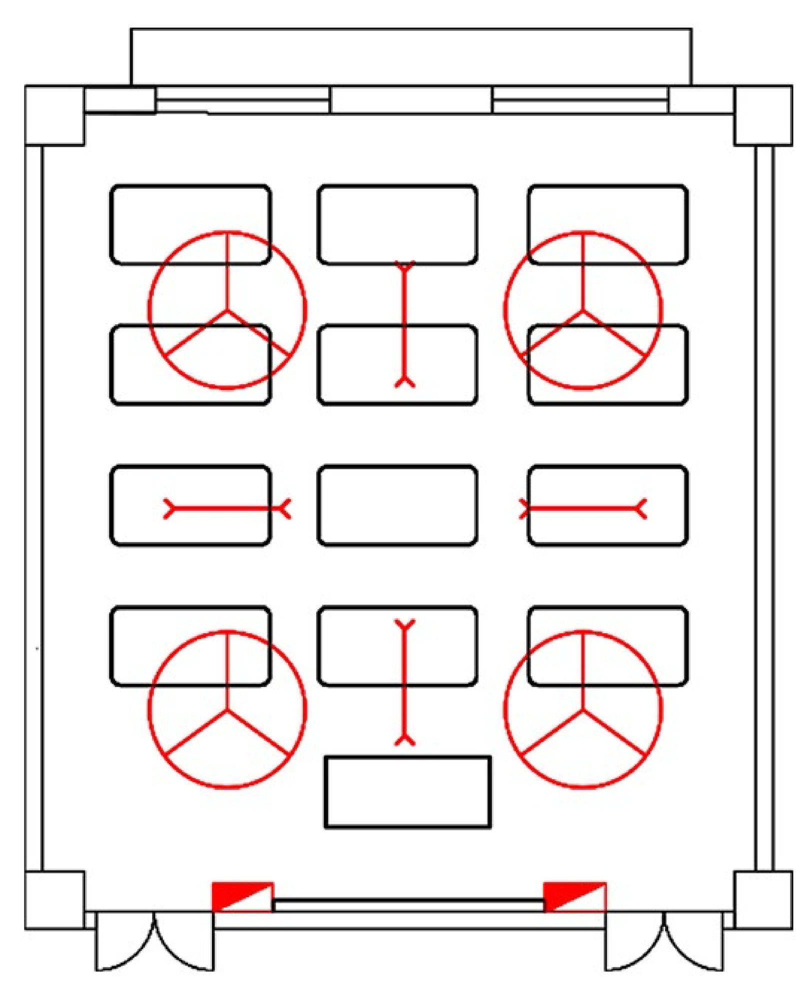


LEGEND

- SWITCH BOX
- LED LIGHTS
- LED TUBELIGHTS
- DB TO CORRIDOOR LIGHTS
- MSB TO CLASS ROOM SB
- DB TO CLASS ROOM MSB



LABORATORY PLAN
(80SQM CONSIST OF TWO 2.5 TON AC)



CLASS PLAN
(40SQM CONSIST MECHANICALLY VENTILATED)

Figure 5.1.6 - Electrical layouts

WATER PERFORMANCE

Numbar of Occupants		Per Capita Daily Consumption (L)	Total Daily Consumption (L)	Total Yearly Demand (L)
1120	Base case	45	50400	18396000
1120	Design case	22	24640	8993600

Table 5.2.1 - explaining difference between base case and design case

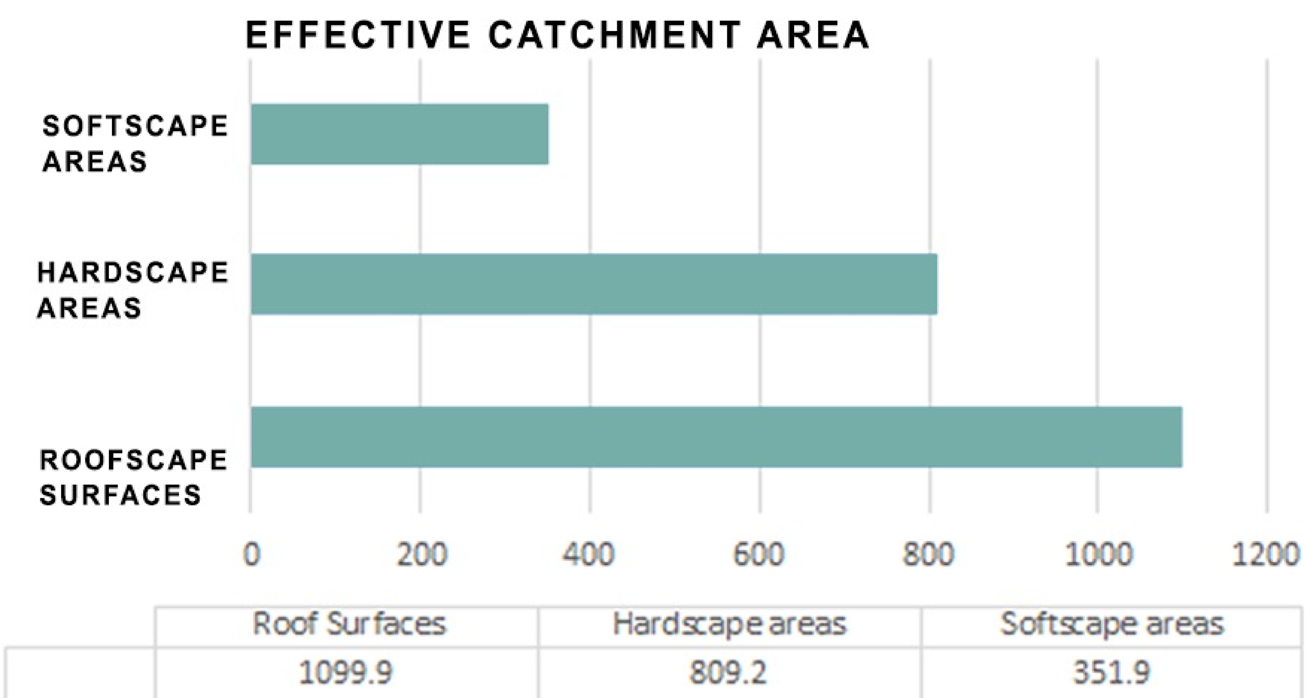
Since water wastage is a growing concern, we have incorporated multiple strategies listed below to a net zero water cycle on site. These include:

-- Rainwater harvesting for potable and non potable uses

-Using efficient plumbing fixtures to reduce water consumption and wastage

-- Reuse of wastewater after treatment on-site

RAINWATER HARVESTING



Figures 5.1.1-Litres collected by catchment area

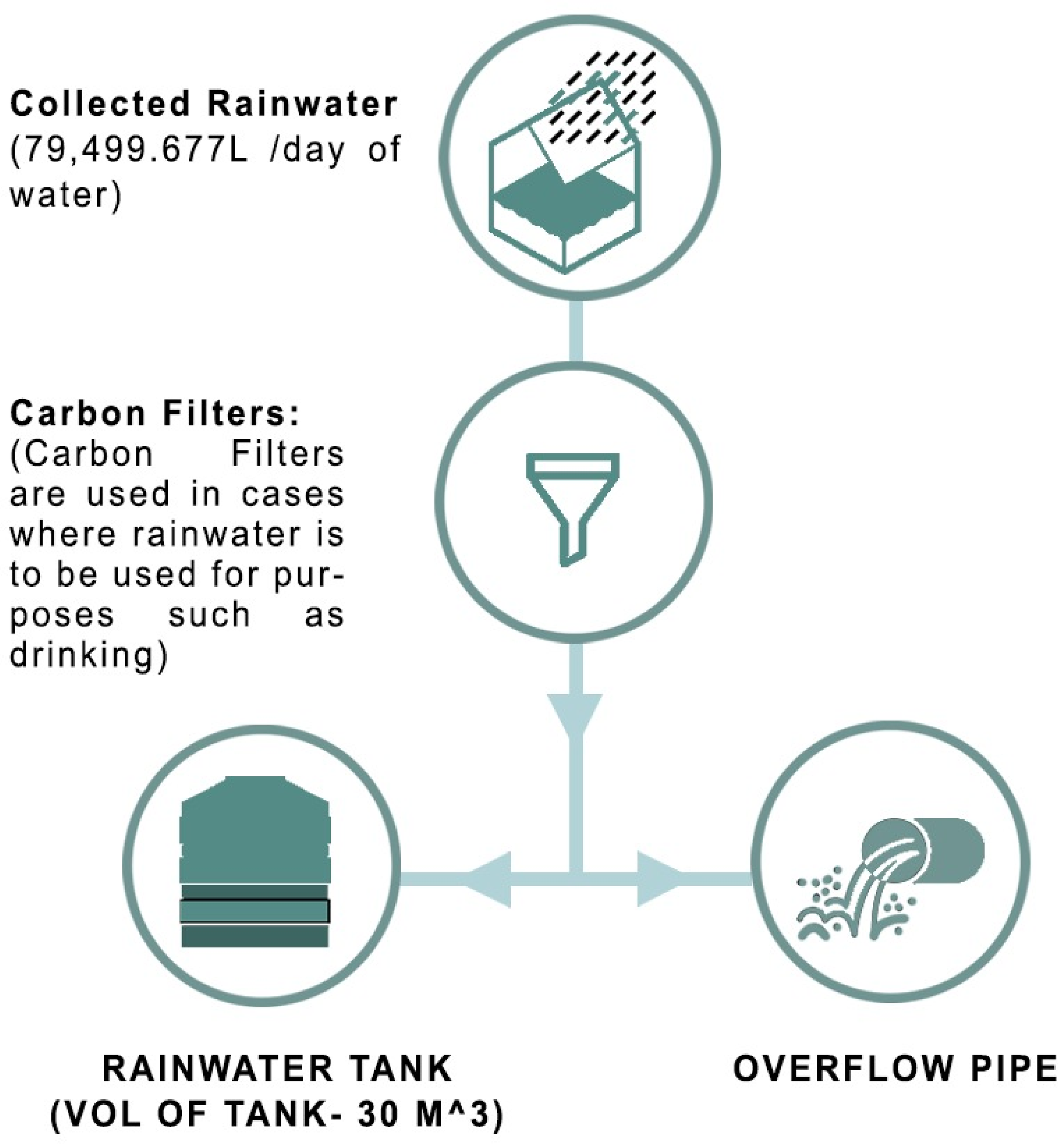
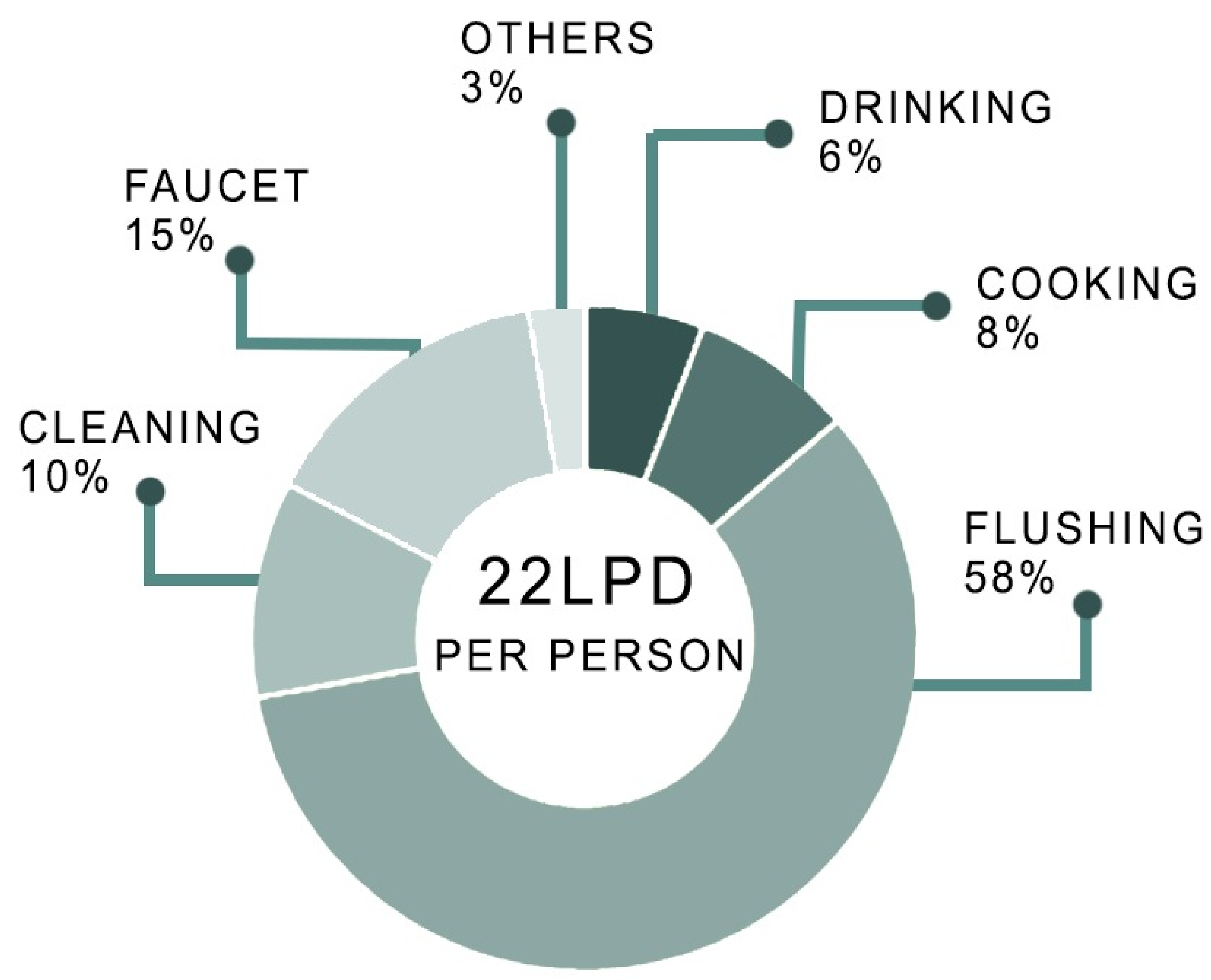


Figure 5.2.2-Litres collected by catchment area

Month	Rainfall (l)	Effective rain (l)	Harvested rainwater (l)
July	1095	1090	2464490
August	713	708	1600788
September	379	374	845614
October	140	135	305235
November	0	0	0
December	0	0	0
January	0	0	0
February	0	0	0
March	0	0	0
April	0	0	0
May	200	195	440895
June	536	531	1200591
Total	**3063**	**3033**	**6857613**

Table 5.2.2 - explaing rainwater harvested in a year

EFFICIENT PLUMBING FIXTURES



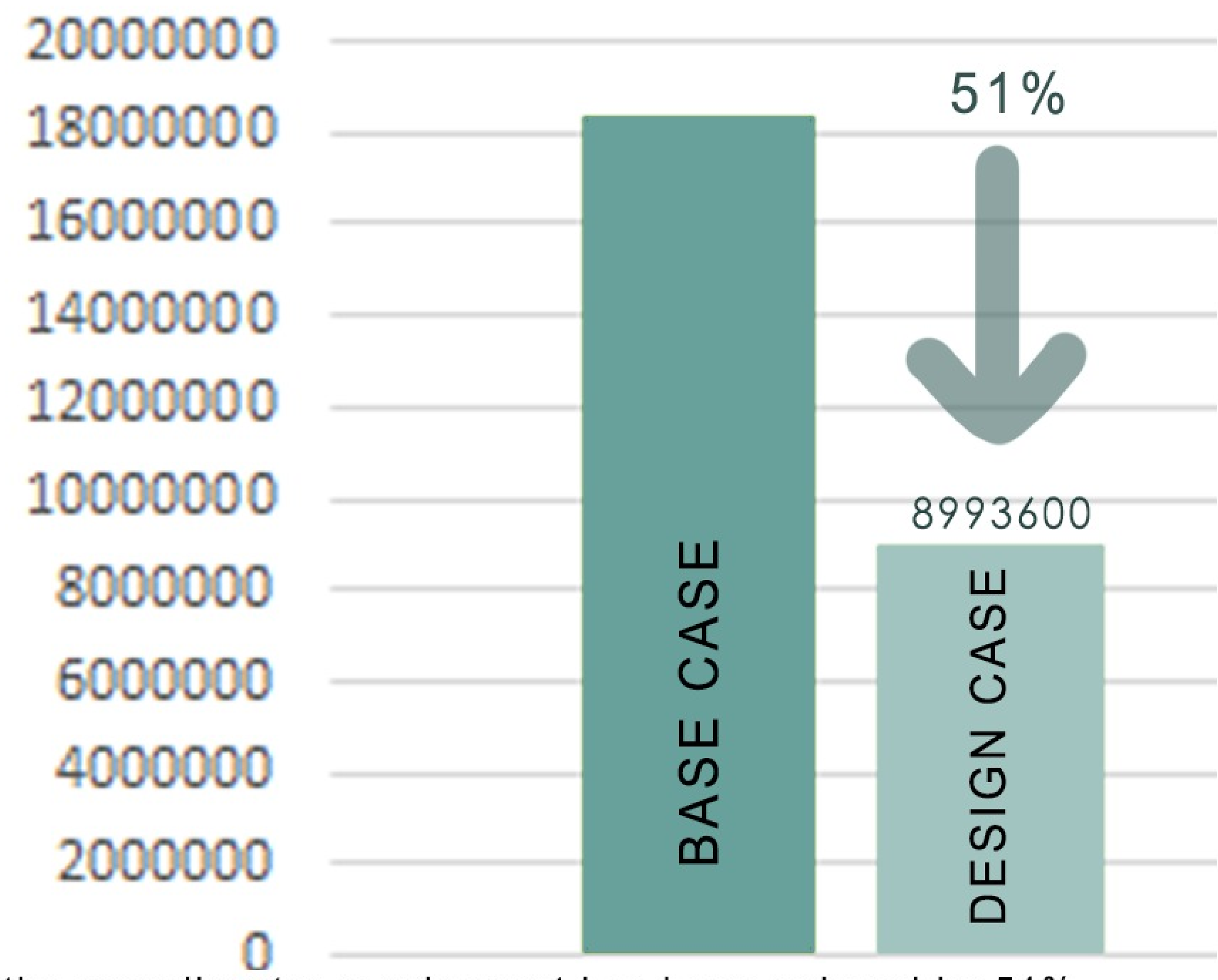


Figure 5.2.3 -Using the above given strategies, the overall water requirement has been reduced by 51%

WATER PERFORMANCE

Figure 5.2.4 -Chart showing difference betewwen ordinary fixtures and griha approved fixtures

EFFICIENT FIXTURES

By using low flow fixtures, aerators, waterless urinals and low flow dual flush water closets,the water demand in design case was reduced by 50%. Rainwater collection on terrace areas, hardscape and courtyard also takes place on our site making it more water efficeint.

GREY WATER AND BLACK WATER TREATMENT

Occupant's Activity	Percent usage	Quantity	Grey water	Black water
Drinking	5.8%	1429.12	0%	0%
Cooking	7.9%	1944.096	0%	100%
Flushing	58%	14407.008	0%	100%
Cleaning	11%	2587.2	100%	0%
Lavtory faucets	14.6%	3597.44	100%	0%
Others	2.74%	675.136	50%	50%

Table 5.2.3-Design case daily requirement of occupant

Month	Irrigation seasonal factor (%)	Irrigation demand
Jul	0.2	10369.32
Aug	0.2	10768.14
Sep	0.2	10369.32
Oct	0.5	25923.3
Nov	0.5	25923.3
Dec	0.5	20938.05
Jan	1	49852.5
Feb	1	47858.4
Mar	1	53840.7
Apr	1	51846.6
May	0.5	9970.5
Jun	0.5	25923.3
Total		343583.43

Table 5.2.4 -Annual water requirement for irrigation

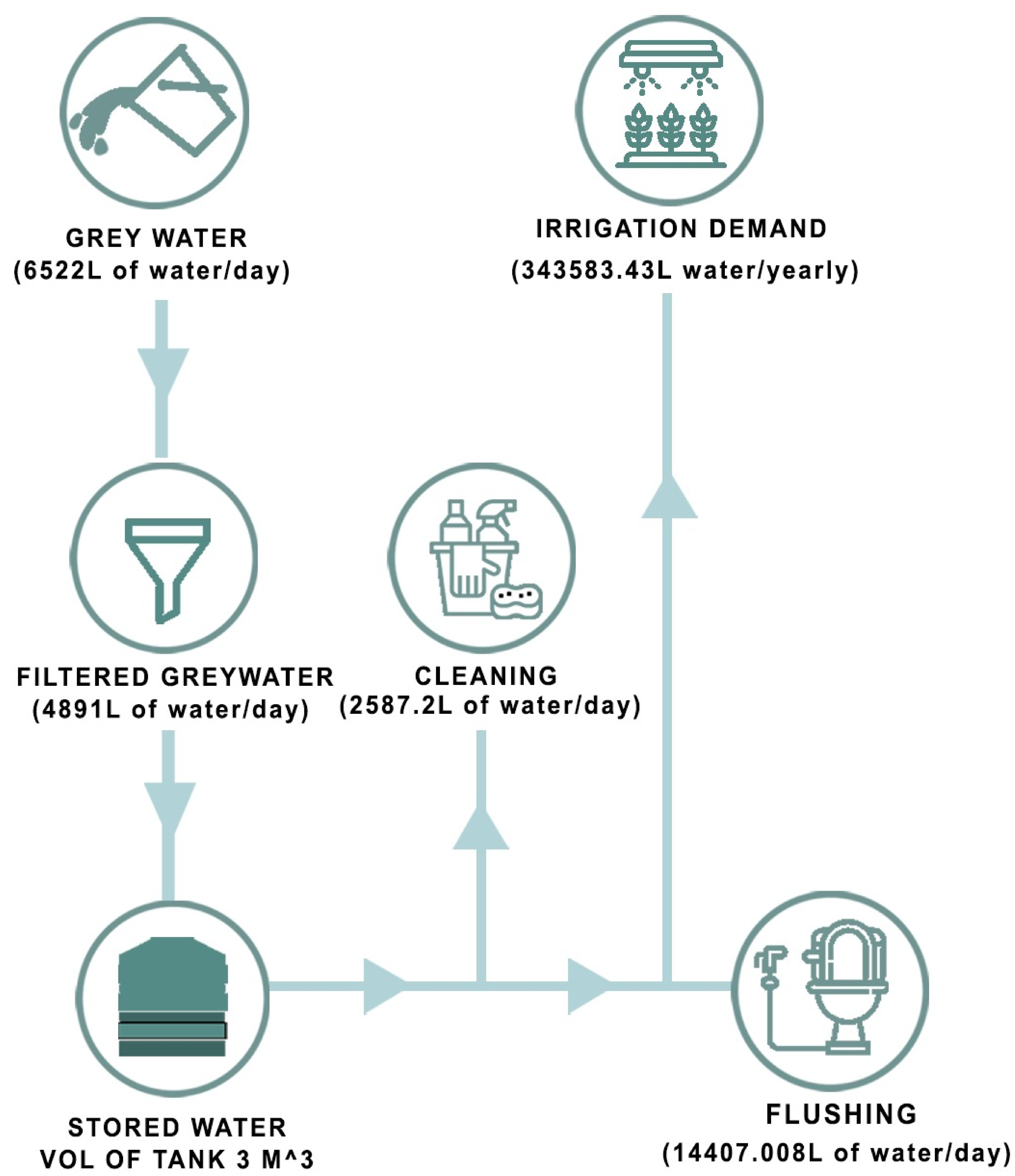


Figure 5.2.5-Chart showing reuse of grey water

The treated waste water is also reused for irrgation, and the overall demand is reduced by using native shrubs and trees with plant factor less than 0.5 within the structure ad well as using Drip irrgation. Drip Irrigation for Planter wall and shrubs will be required only during vacations and weekends since the incorporation of growing plants into the curriculum is proposed and watering would be done by the students and faculty.

WATER PERFORMANCE

WATER BALANCE TABLE

Month	Days in month	Working day in month	Harvested water	Water Used Per Month	Waste water generated	Filterd grey water	Water re-quired from municipal	Water that can be stored
Jul	31	26	2464490	640640	169577.40	127183.05	0	1951033.05
Aug	31	27	1600788	665280	176099.61	132074.71	0	1067582.7
Sep	30	26	845614	640640	169577.40	127183.05	0	332157.06
Oct	31	26	305235	640640	169577.40	127183.05	208221.94	0
Nov	30	26	0	640640	169577.40	127183.05	513456.94	0
Dec	31	21	0	517440	136966.36	102724.77	414715.22	0
Jan	31	25	0	616000	163055.2	122291.4	493708.6	0
Feb	28	24	0	591360	156532.99	117399.74	473960.25	0
Mar	31	27	0	665280	176099.61	132074.71	533205.28	0
Apr	30	26	0	640640	169577.40	127183.05	513456.94	0
May	31	10	440895	246400	65222.08	48916.56	0	243411.56
Jun	30	26	1200591	640640	169577.40	127183.05	0	687134.05
Total	365	290	6857613	7145600	1891440	1418580	3150725	4281318.43

Table 5.2.5-Water balance table

CONCLUSION

In cases of any adversities or water shortage, the water collected and stored on site is enough to last for 6 working days. The surplus water after rainwater harvesting in certain months is also be stored.Excess re-cycled water is used for the purpose of washing the buses that are used by the school.The treated waste water is also reused for irrgation, and the overall demand is reduced by using native shrubs and trees with plant factor less than 0.5 (ref) within the structure ad well as using Drip irrgation.

ECOSTP®
sewage to gold™
"Zero Power Zero Chemical."
Advantage
-No Power Required
-No Mechanical Component Required
-Sludge Removal once in 2-4 Years
-Unlimited STP Life
-10-15% Higher than conventional STP,
Low maintenance cost

BROCHURES

CERA

CERA EWCs save 35% water
Cera urinals flushes just 0.75 litres of water
CERA sensor taps saves almost 70%

Roca

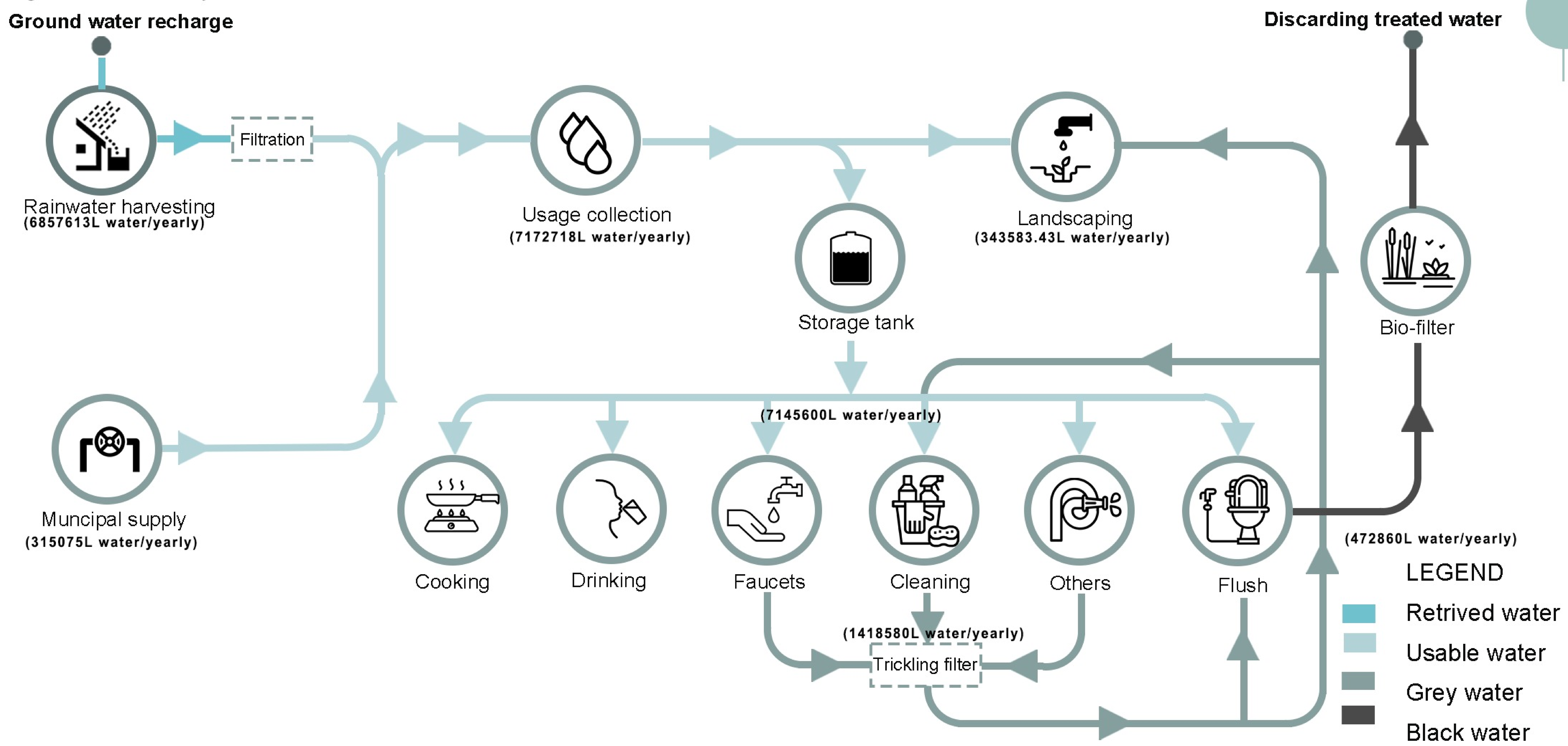
Dual flush that will allow you to use only half of its capacity
Flow limiters reduce the volume of water
The aerators reduce the flow.

Jaquar

Sensor taps, from Jaquar, save water up to 80%
These faucets are designed with a low flow rate, with an aerator
Jaquar offers a smart flushing valve that conserves water

WATER BALANCE CHART

Figure 5.2.6-Yearly water balance chart



WATER SUPPLY LAYOUT

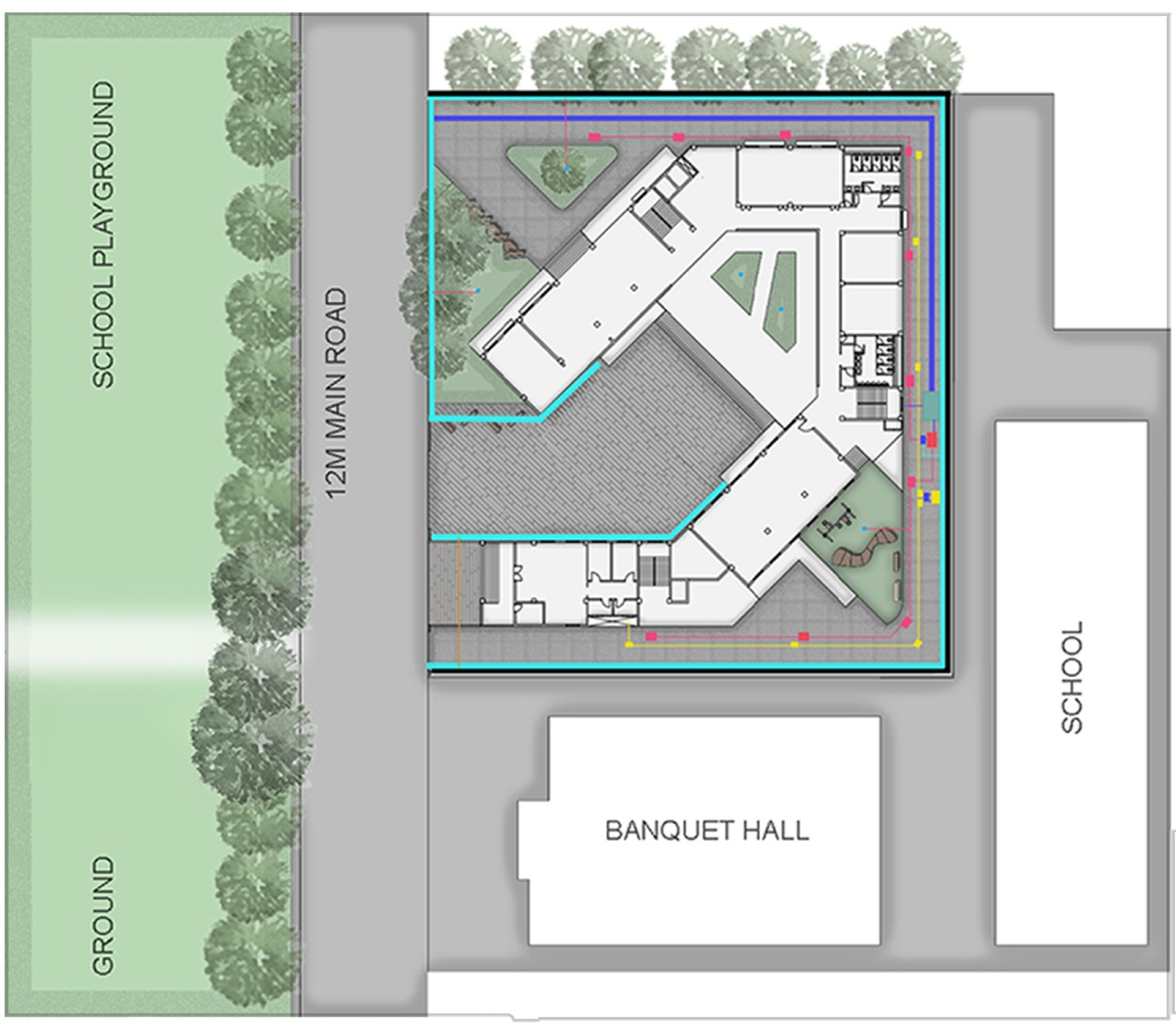


Figure 5.2.7-Site plan water supply

Municipal pipe
UGT
Filter tank
Percolation pit
Grey water pipe
Grey water tank
Rainwater pipe
Rainwater tank

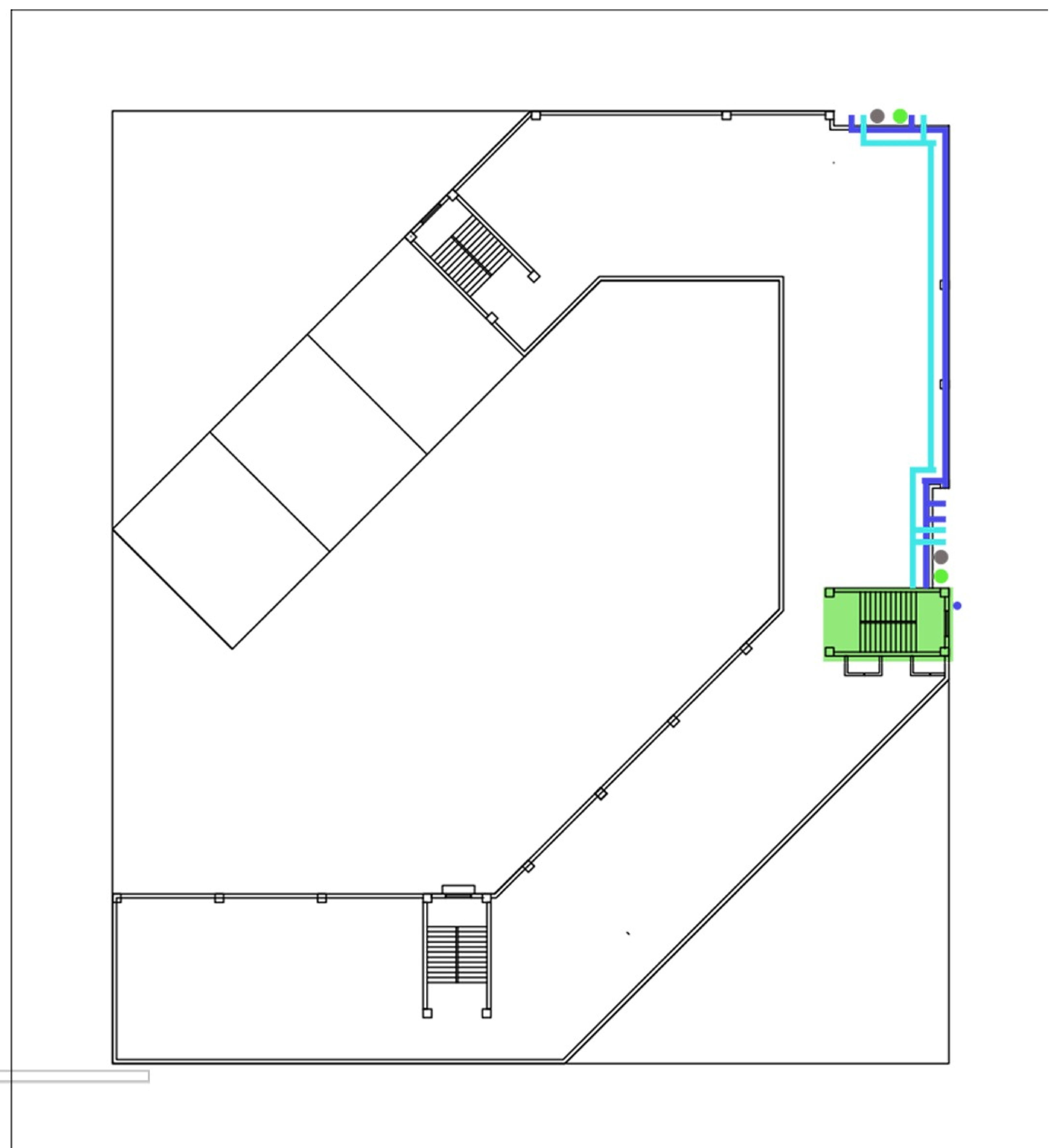


Figure 5.2.8-Floor plan water supply

Flushing water
Faucet water
OHT
Waste water
Solid waste
N

EMBODIED CARBON

System Type	Baseline			
	Material emissions (kg -CO_2 e)	Transport 1 (kg -CO_2 e)	Transport 2 (kg -CO_2 e)	Total (kg -CO_2 e)
Wall	29	3	3	35
Floor	52	7	7	66
Roof	35	2	2	39
Fenestration	23	2	2	27
Structural	42	4	4	50
	Grand Total emissions per functional unit (kg -CO_2 e)			217
System Type	Proposed			
	Material emissions (kg -CO_2 e)	Transport 1 (kg -CO_2 e)	Transport 1 (kg -CO_2 e)	Total (kg -CO_2 e)
Wall	14	3	3	20
Floor	02	7	7	16
Roof	10	2	2	14
Fenestration	06	2	2	10
Structural	21	4	4	29
	Grand Total emissions per functional unit (kg -CO_2 e)			89

TABLE 5.1- Emission comparitive chart

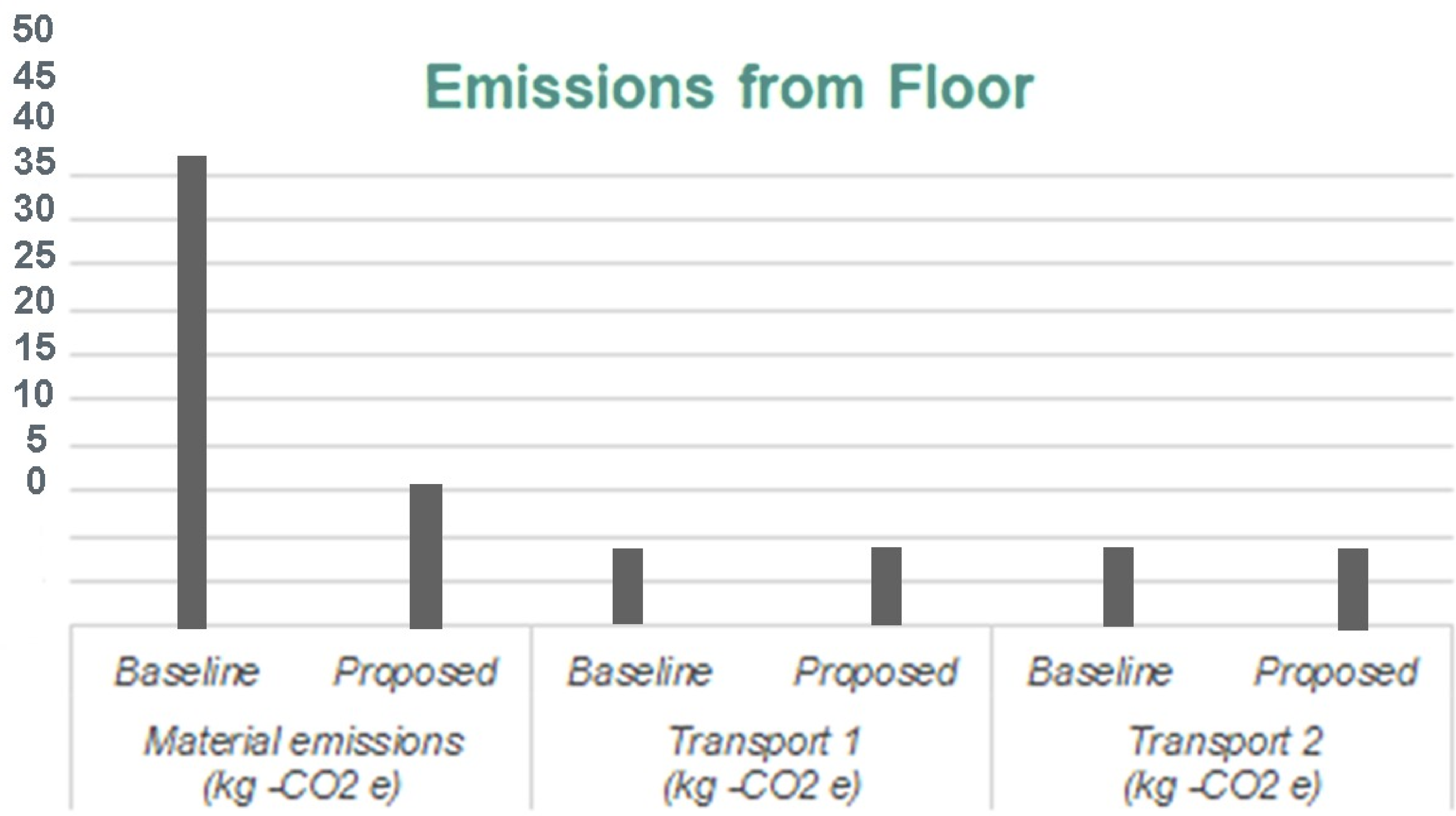


Fig5.1- Graph for emmisions of floor

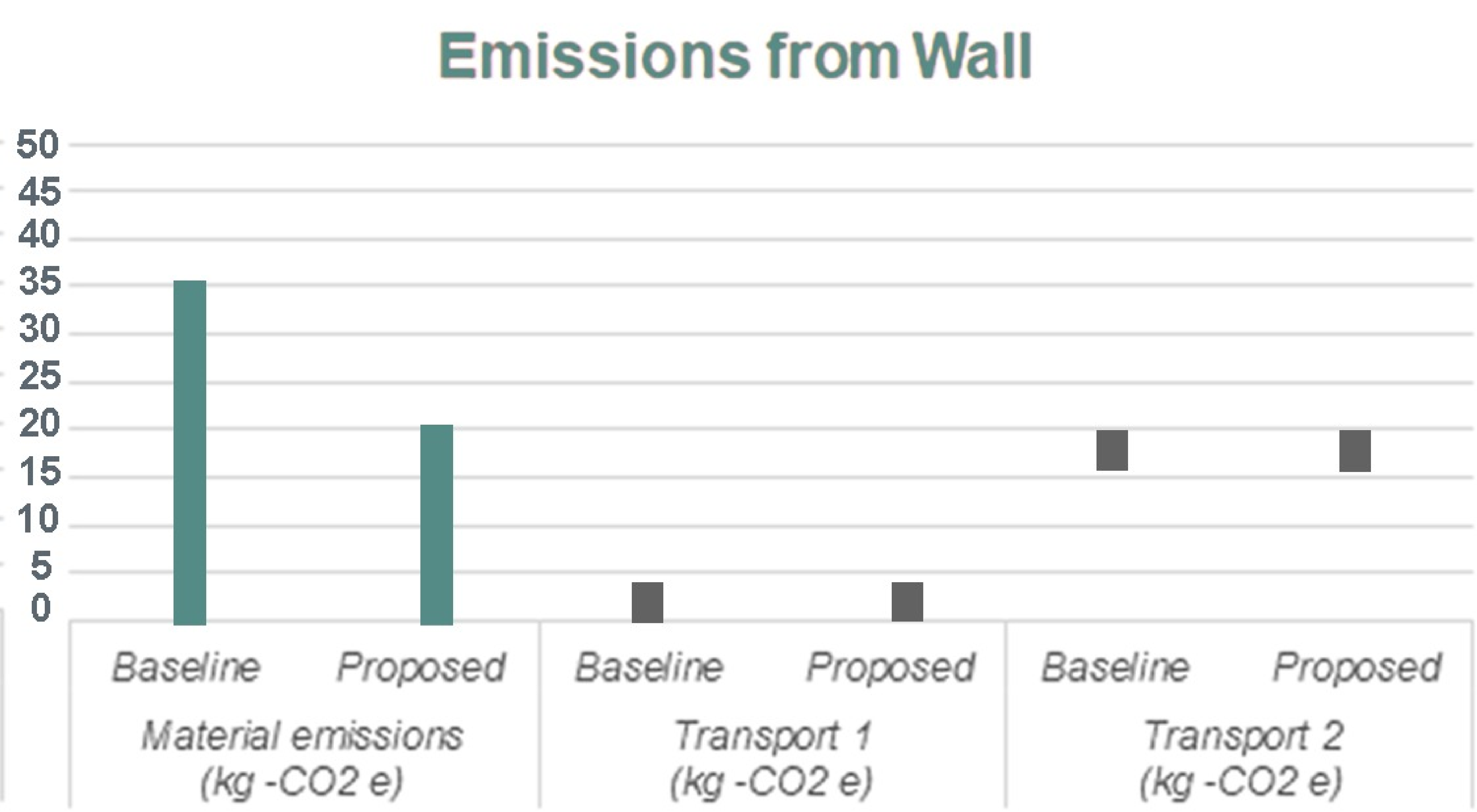


Fig5.2- Graph for emmisions of walls

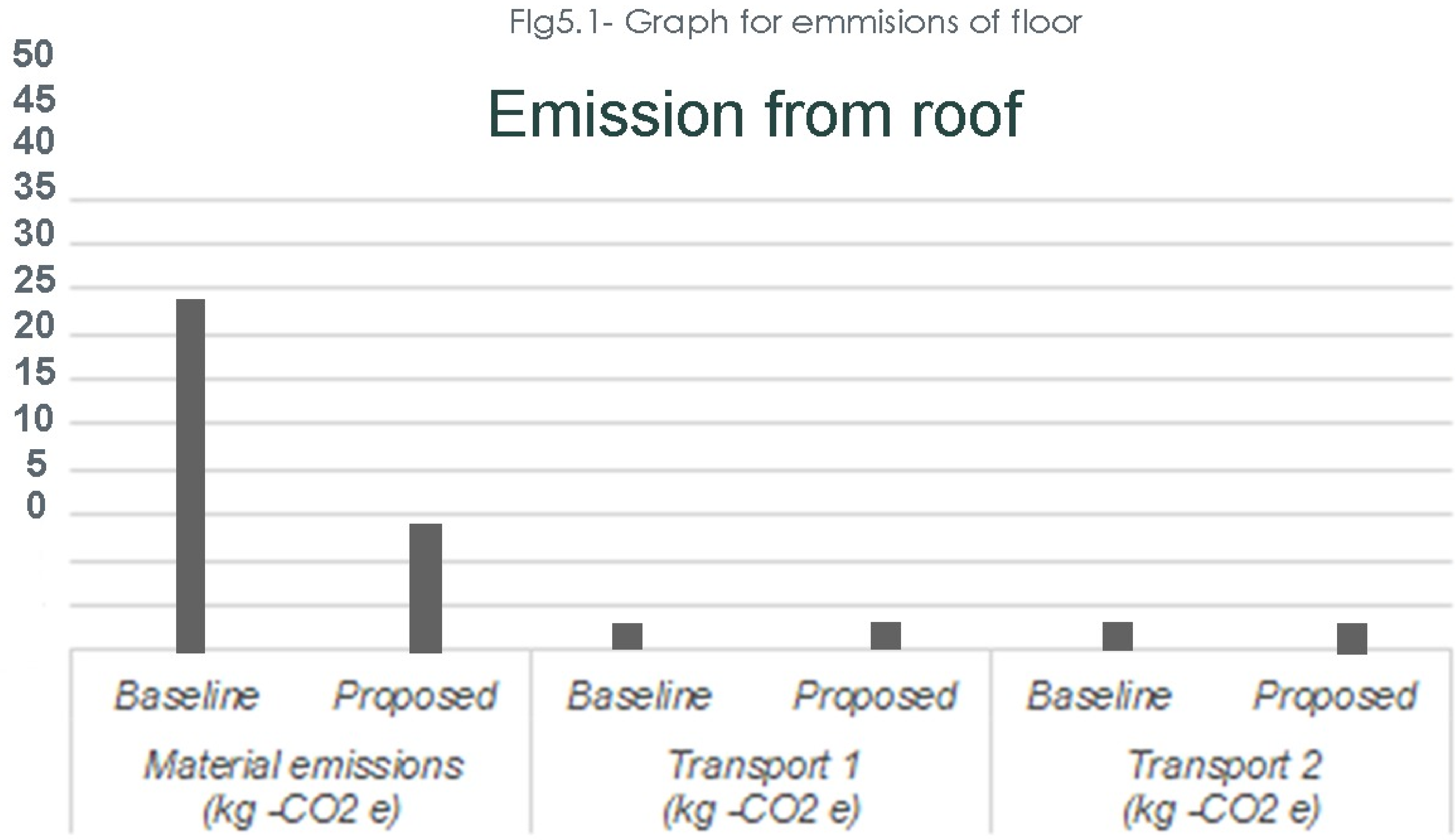


Fig5.3- Graph for emmisions of roof

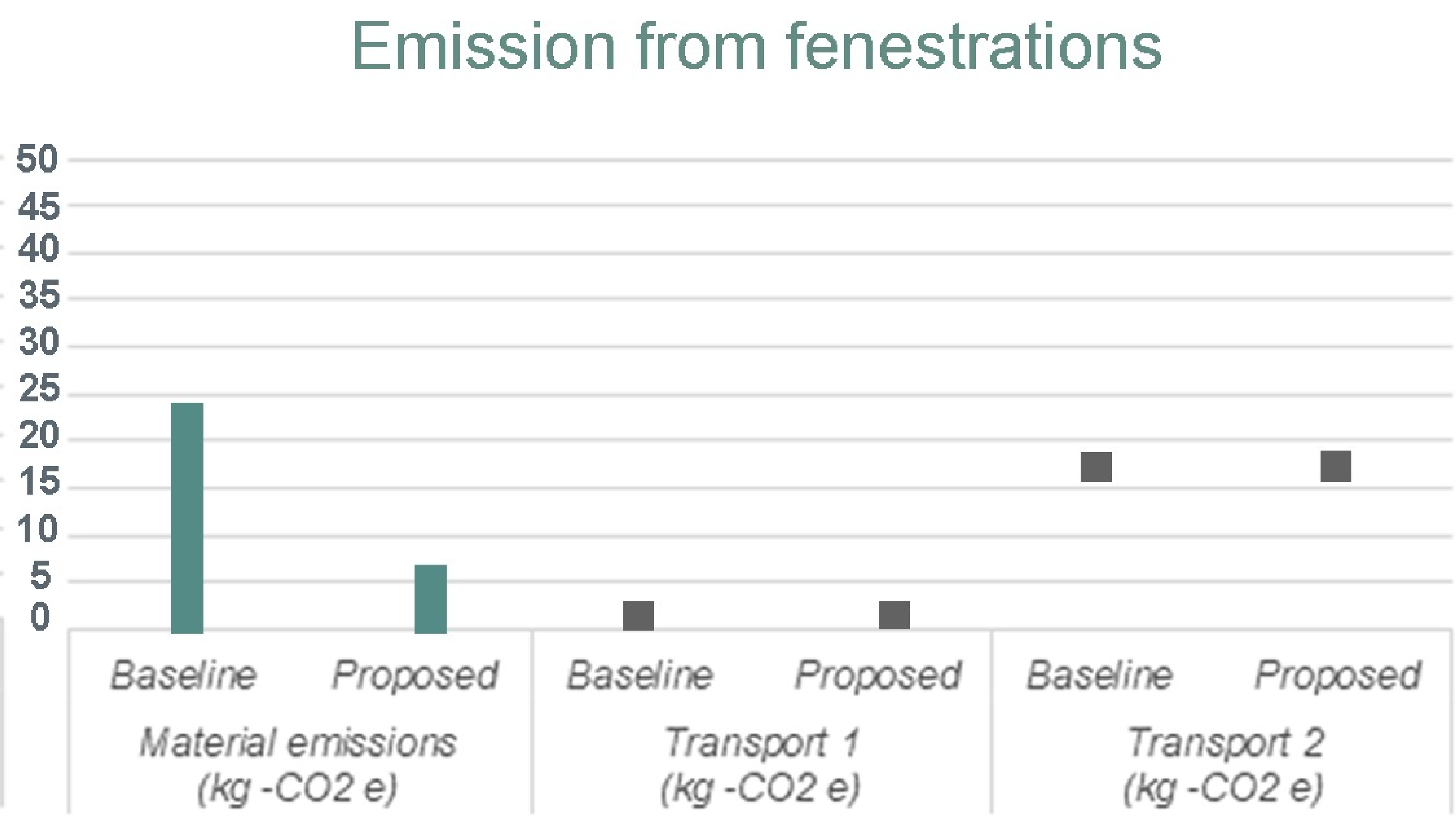


Fig5.4- Graph for emmisions of fenestrations

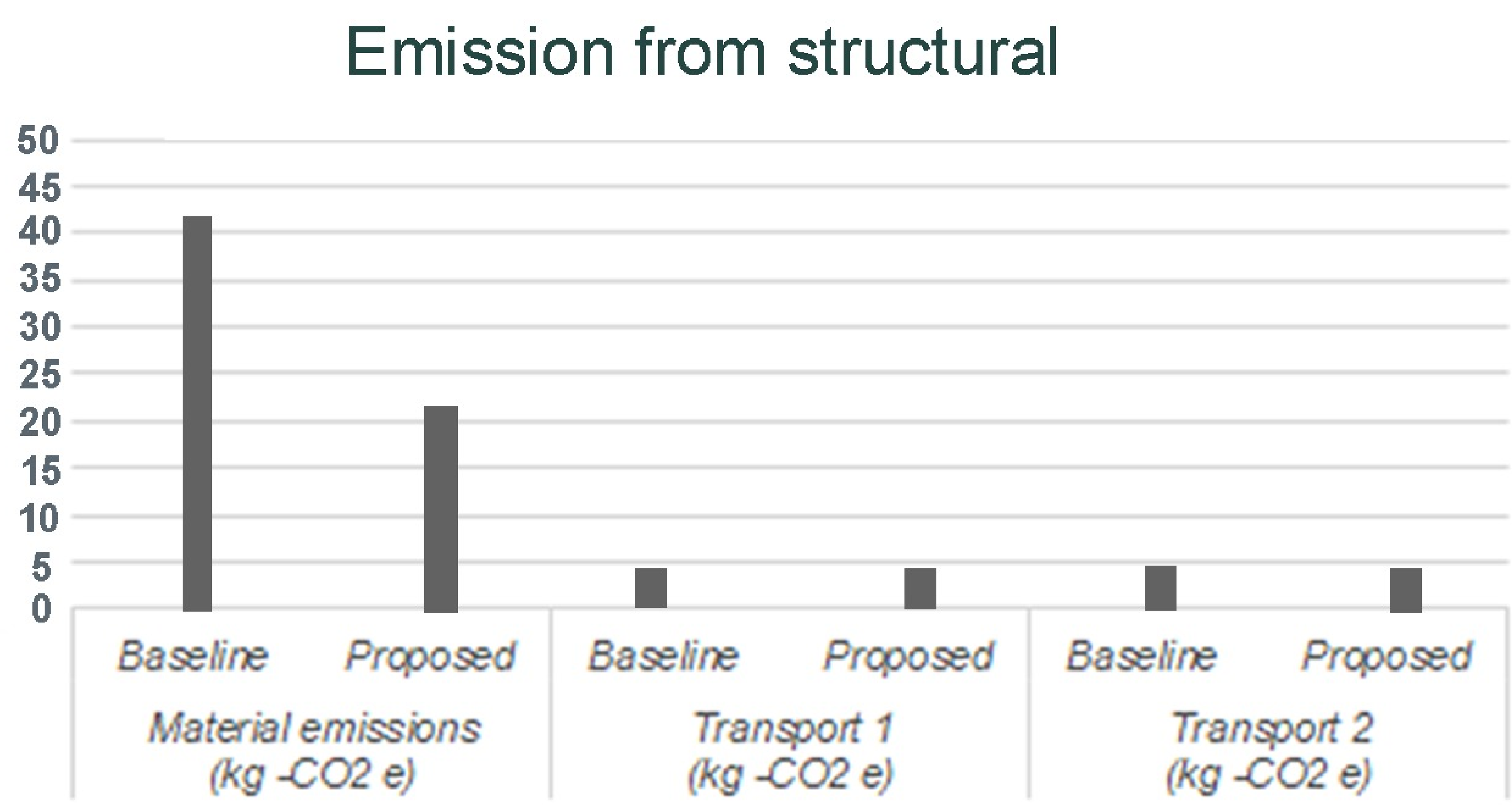


FIg5.5- Graph for emmisions of structutral

Embodied carbon gives an estimate of all the greenhouse gas emissions related to the production, extraction, transportation, and installation of building materials on a construction site. By calculating the required wall and floor area, the baseline embodied carbon per functional unit was derived to be 81 kg-Co2 e. We first considered using AAC blocks for the construction of walls, but on doing the required calculations, the emission factor came out to 0.5, which was higher than brick which has an emission factor of 0.36. Therefore, we have proposed bricks for the construction of our structure. For flooring, we used ceramic tiles as the baseline material, and opted for kota stone tiles as the proposed flooring material for the similar reasons of having a very low emission factor of 0.056 and for internal partition walls, we have proposed gypsum panels which has an emission factor of 0.26. The total proposed embodied carbon per functional unit is 16 kg-Co2 e which is 80.24% less than the baseline embodied carbon.

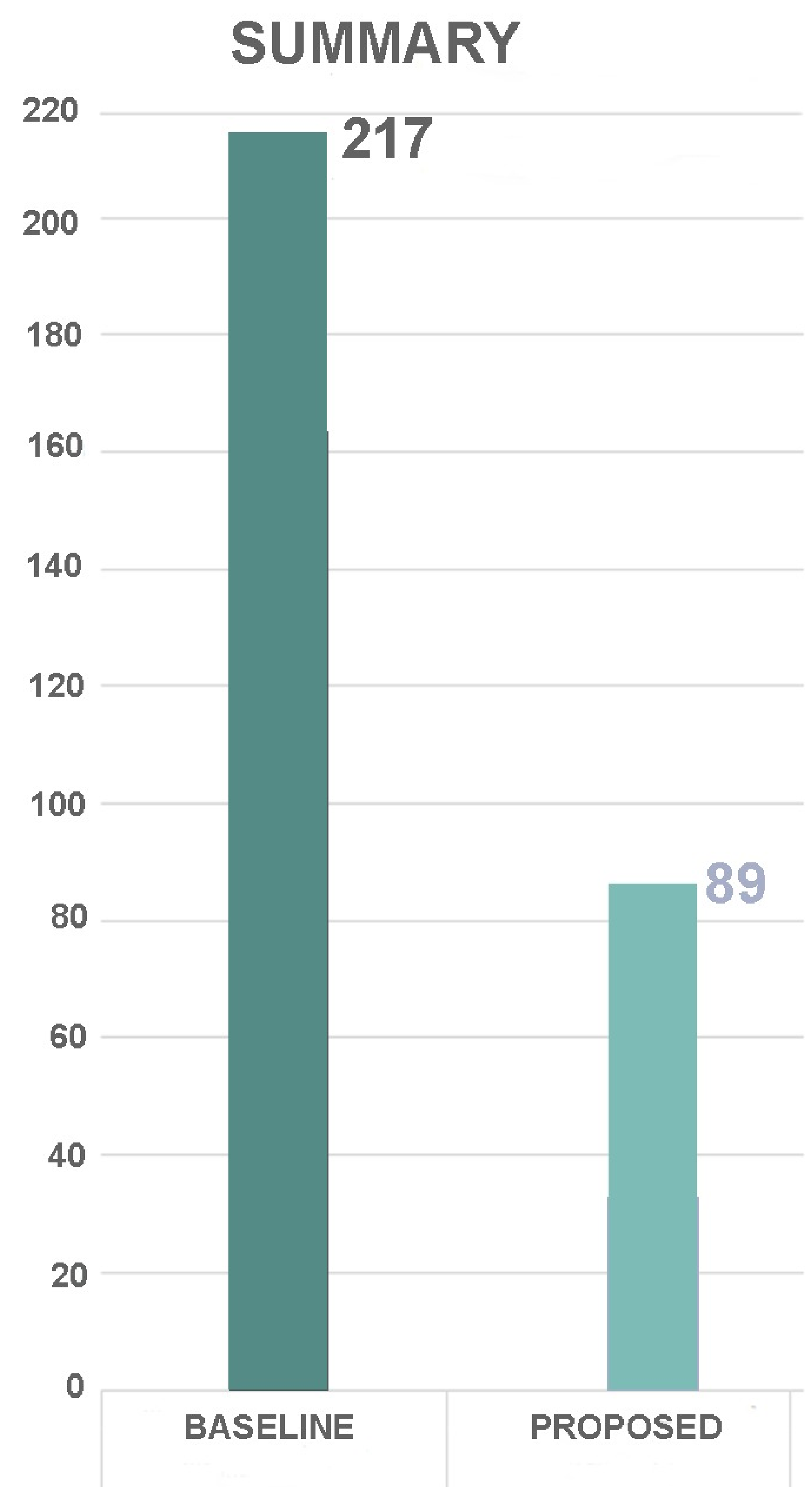


FIg5.6- BASE LINE AND PROPOSED EMISSION

RESILIENCE

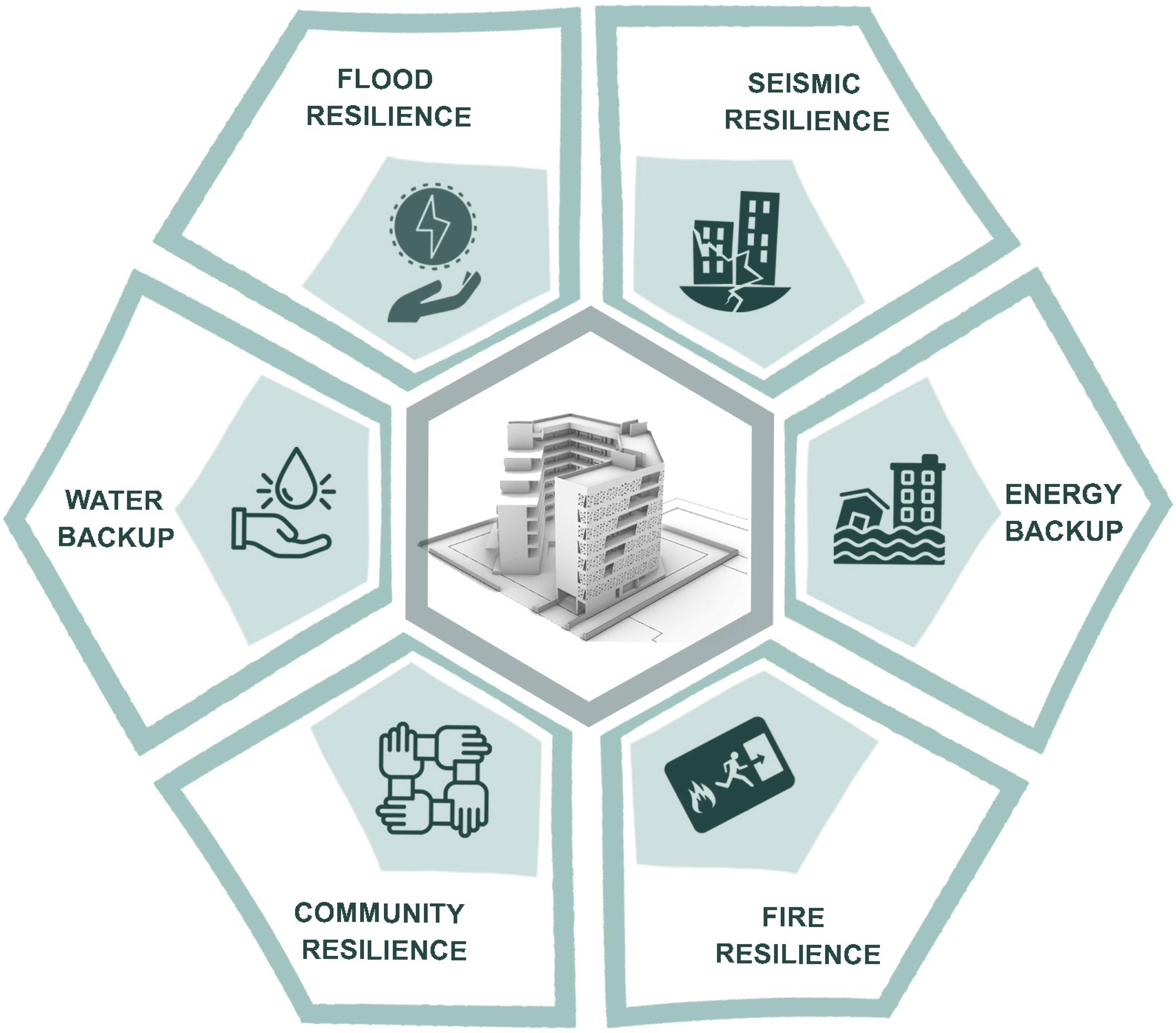


Figure 5.4.1: Resilience chart

In order to increase the building's adaptability to disasters and adversities, resilience has been taken into account.

SEISMIC RESILIENCE

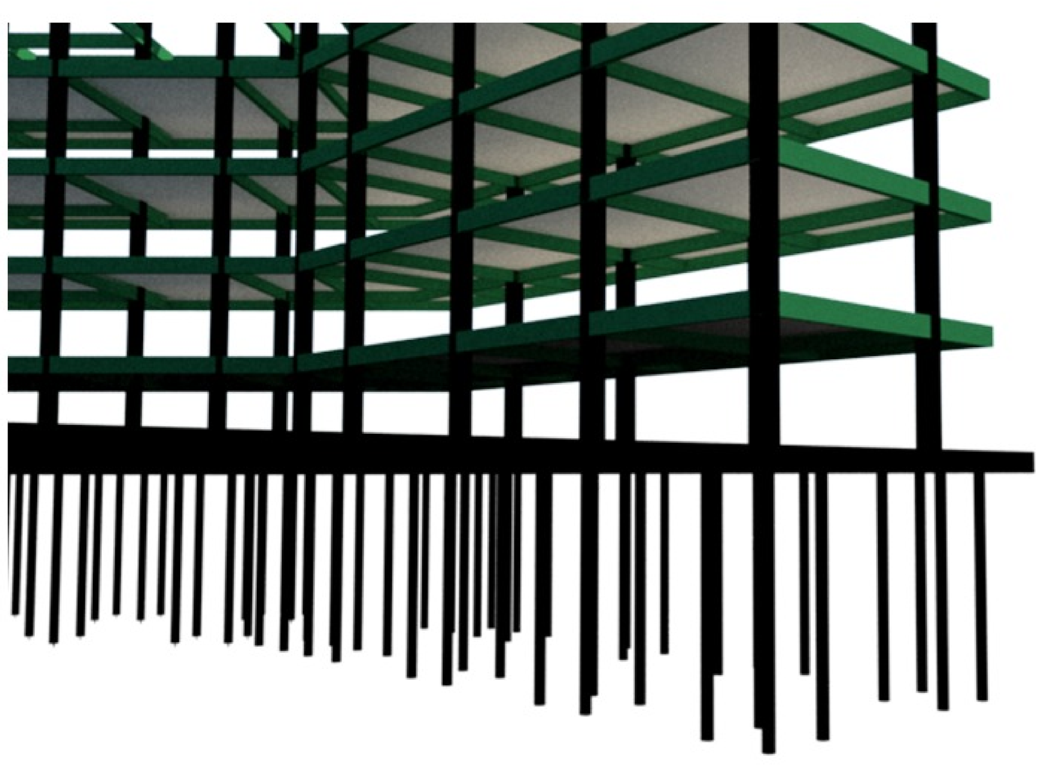


Figure 5.4.2: Foundation

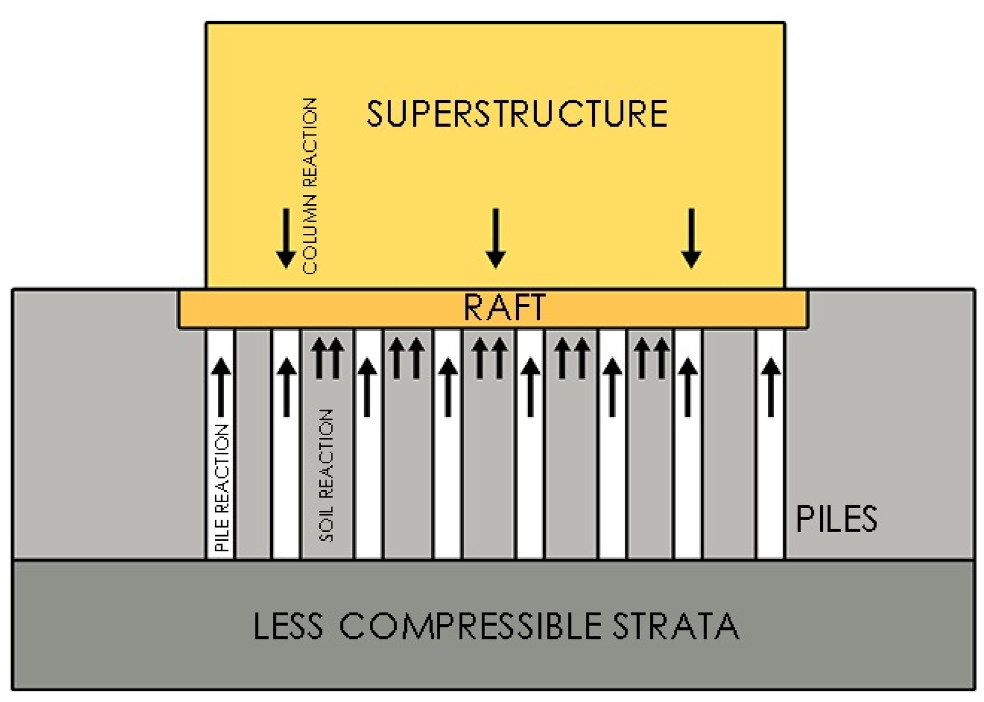


Figure 5.4.3: Load distribution

Structure's seismic resistance in line with IS Code 13920, 1993. for RCC Structures in Zones II, III and IV.
A piled raft foundation spreads the load of the building across the ground. A piled raft foundation uses both methods to support the building. Using raft foundation adds additional stability to the building, especially during earthquakes.

Seismic dampers are used to control earthquake induced vibrations on buildings. Seismic dampers can decrease the damaging effect of seismic waves and improve the buildings seismic performance. These dampers are used in place of structural elements like diagonal braces for controlling seismic damage in structure. It party absorbs the seismic energy and reduces the

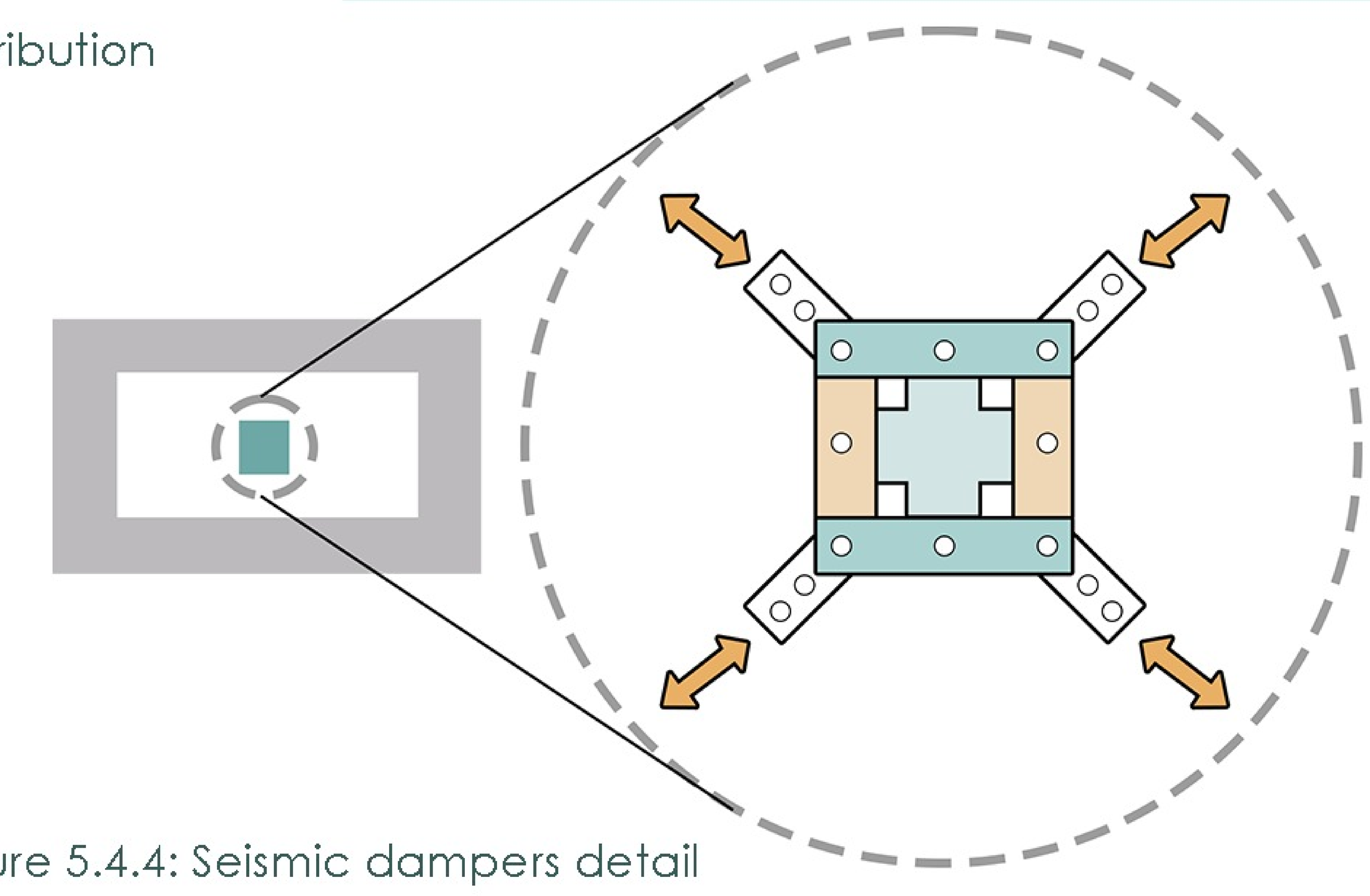


Figure 5.4.4: Seismic dampers detail

FLOOD RESILIENCE

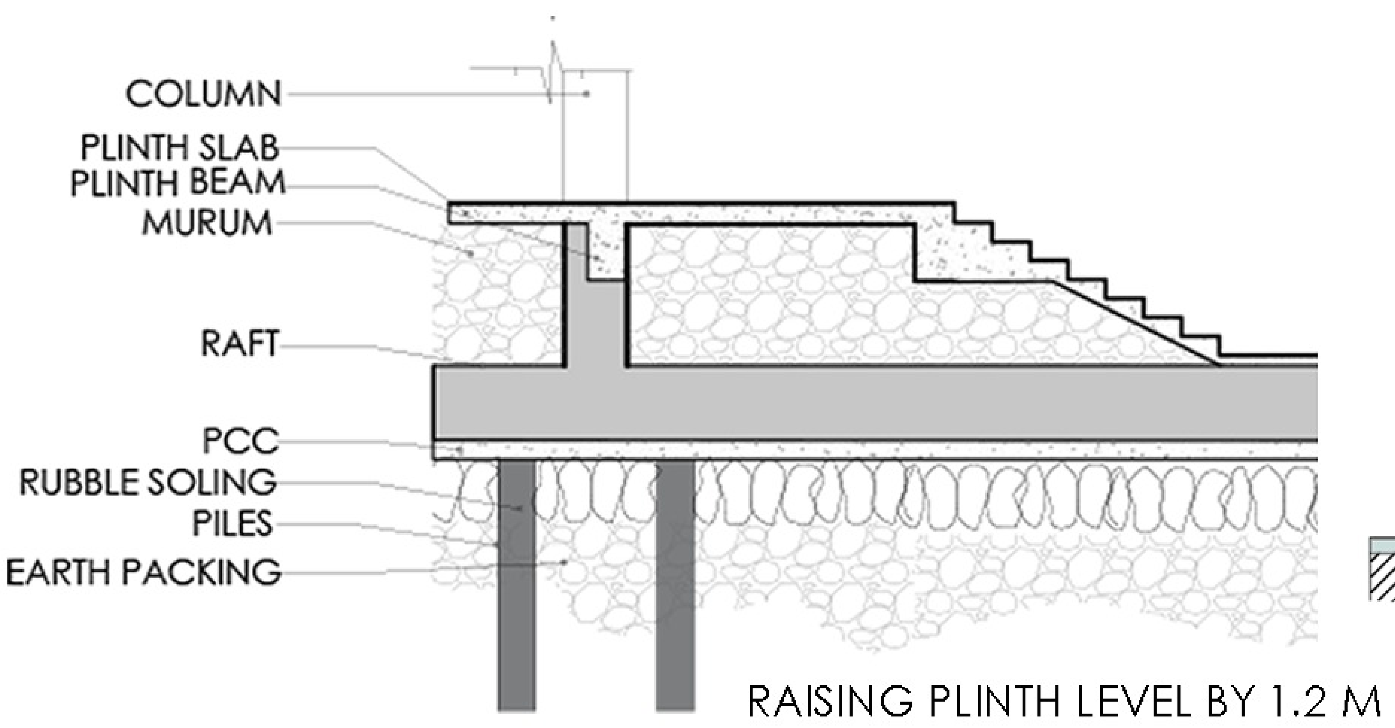


Figure 5.4.5: Plinth section

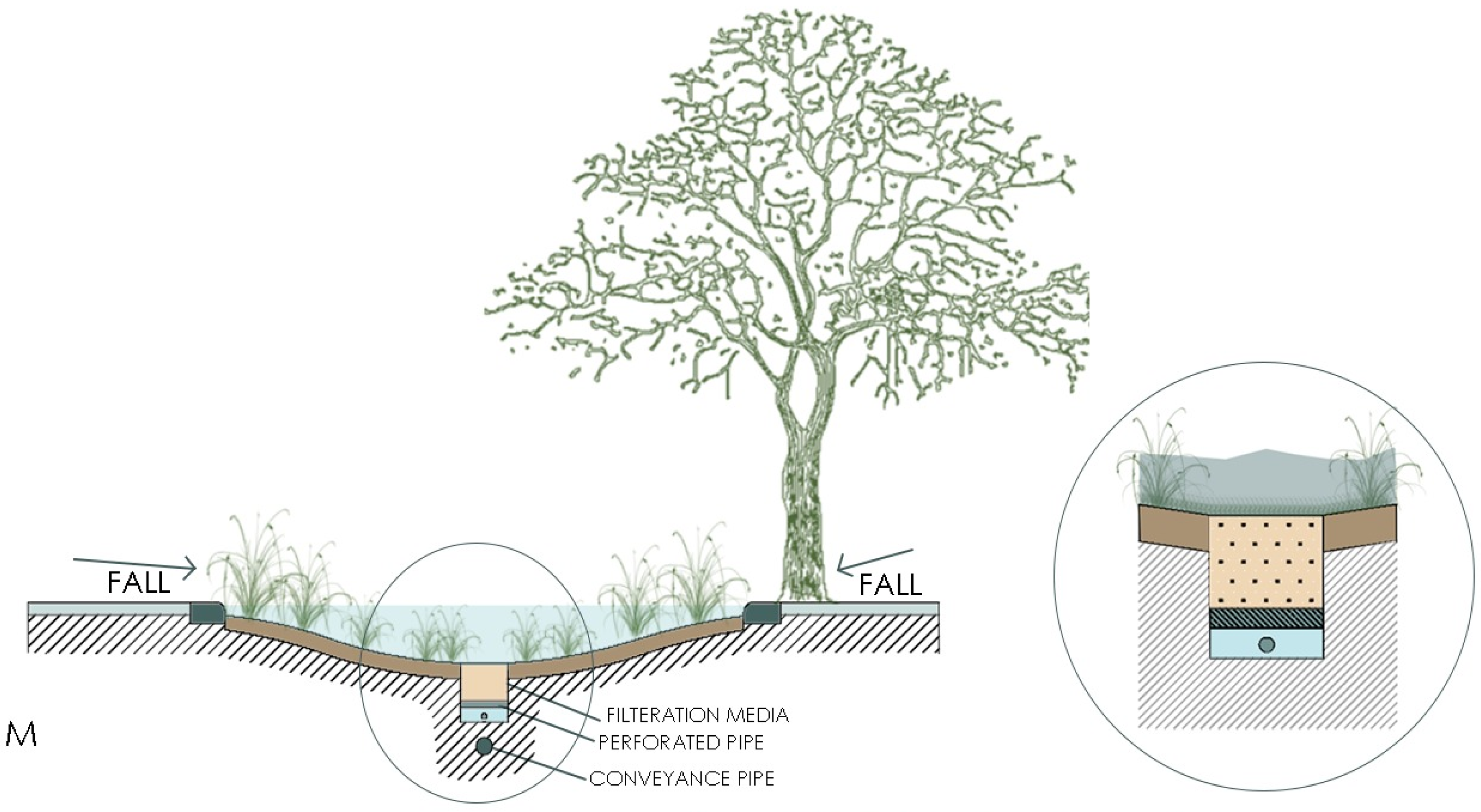
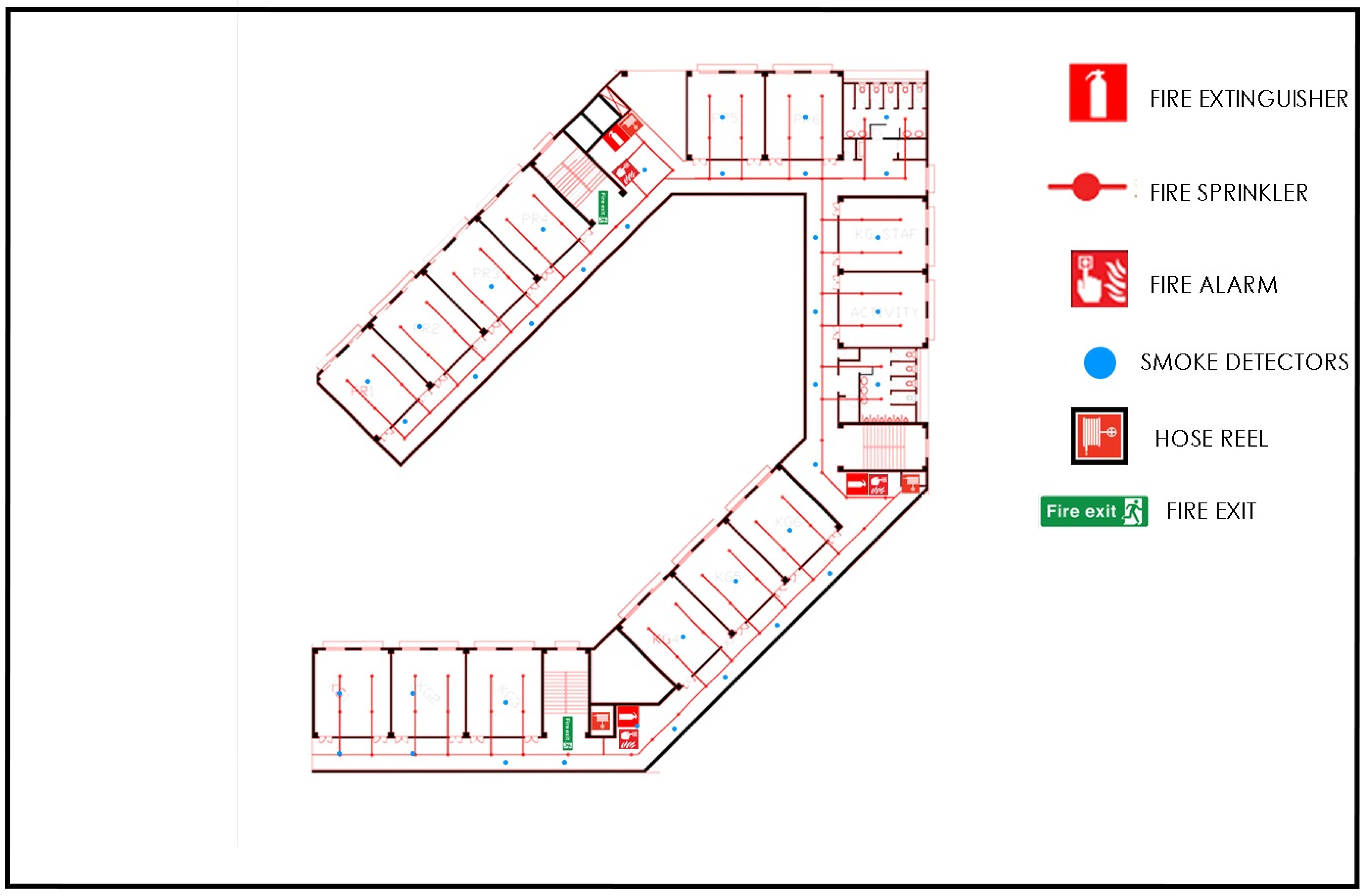


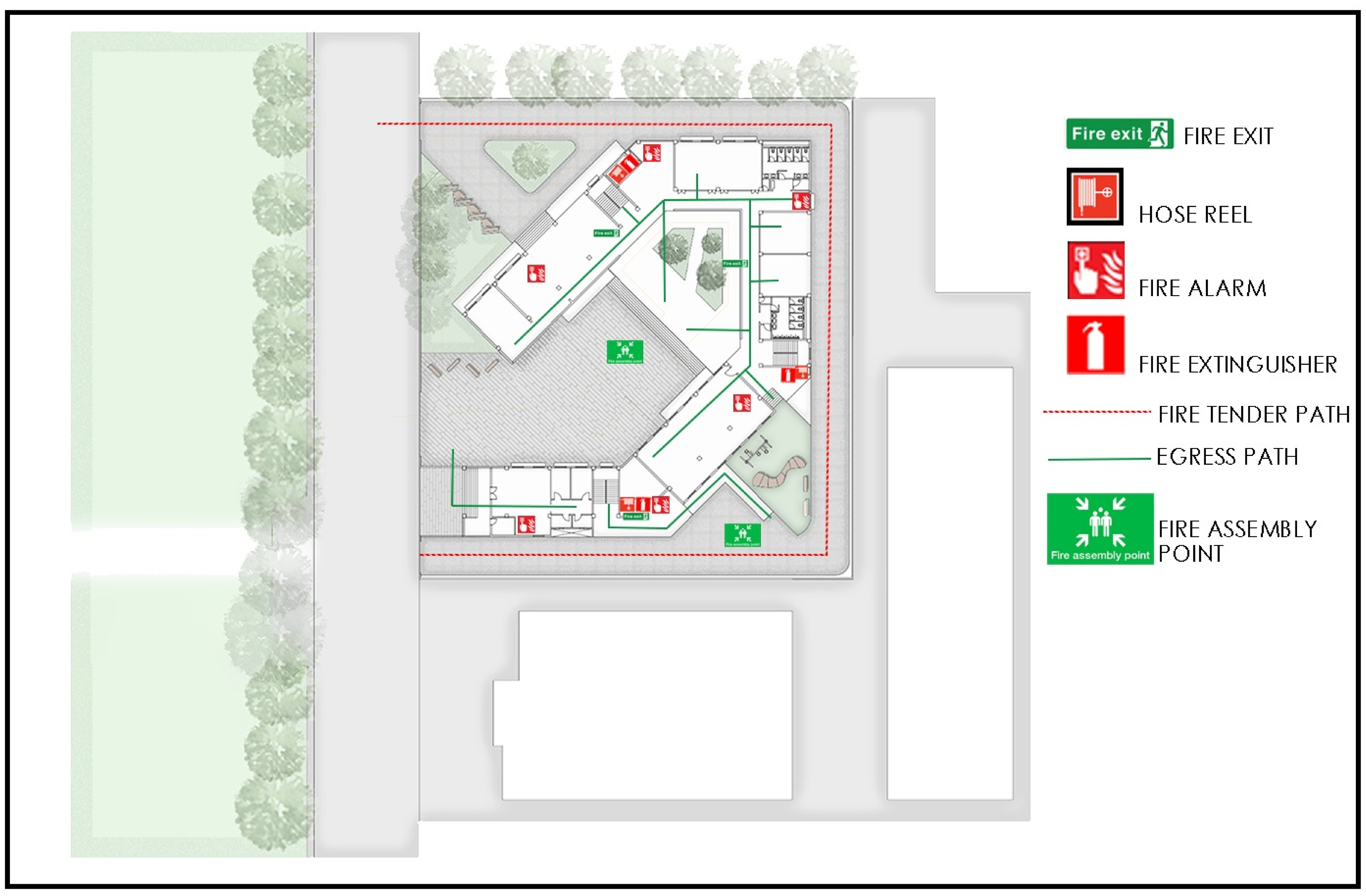
Figure 5.4.6: Bioretension system

Adaptability techniques in case of potential flooding and other natural disasters like cloud bursts, and high groundwater levels nearby. Bioretention swales provide both stormwater treatment and conveyance functions. A bioretention system is installed in the base of a swale that is designed to convey minor floods. The swale component provides pretreatment of stormwater to remove coarse to medium sediments, while the bioretention system removes finer particulates and associated contaminants. It is placed on specific locations on the site for efficient working.

FIRE RESILIENCE



Safety regulations in accordance to part 4 of the National Building Code including fire escape plans, detectors, and wet riser systems:
Fire-resistant stairs lead outside for ease of escape.
Water to be provided to these emergency systems by a firefighting tank.
To facilitate exit during a fire, a 6m wide offset has been built on all sides of the building.



Type 1 construction as per fire safety norms, which provides fire rating of 2 hrs. Two cores are designed and built at a maximum distance of 30M, from farthest point with sufficient equipment as per NBC. Fire extinguishers, detection systems and sprinklers systems are provided in every habitable space. Aditionally, a fire fighting water tank has also been provided. A defined compartmentation and smoke dampers are on each floor to prevent fire smoke from spreading flor to floor or room to room.

COMMUNITY RESILIENCE

Designing flexible community spaces for accommodating local people amidst disasters and unforeseen circumstances has come more into light since the lockdown. Modularity of spaces allow ease in change of function from classrooms to other community spaces like vaccination centres during calamities, with appropriate openings, breakout areas and meeting points. It also allows easy modification of internal walls when needed in the future.

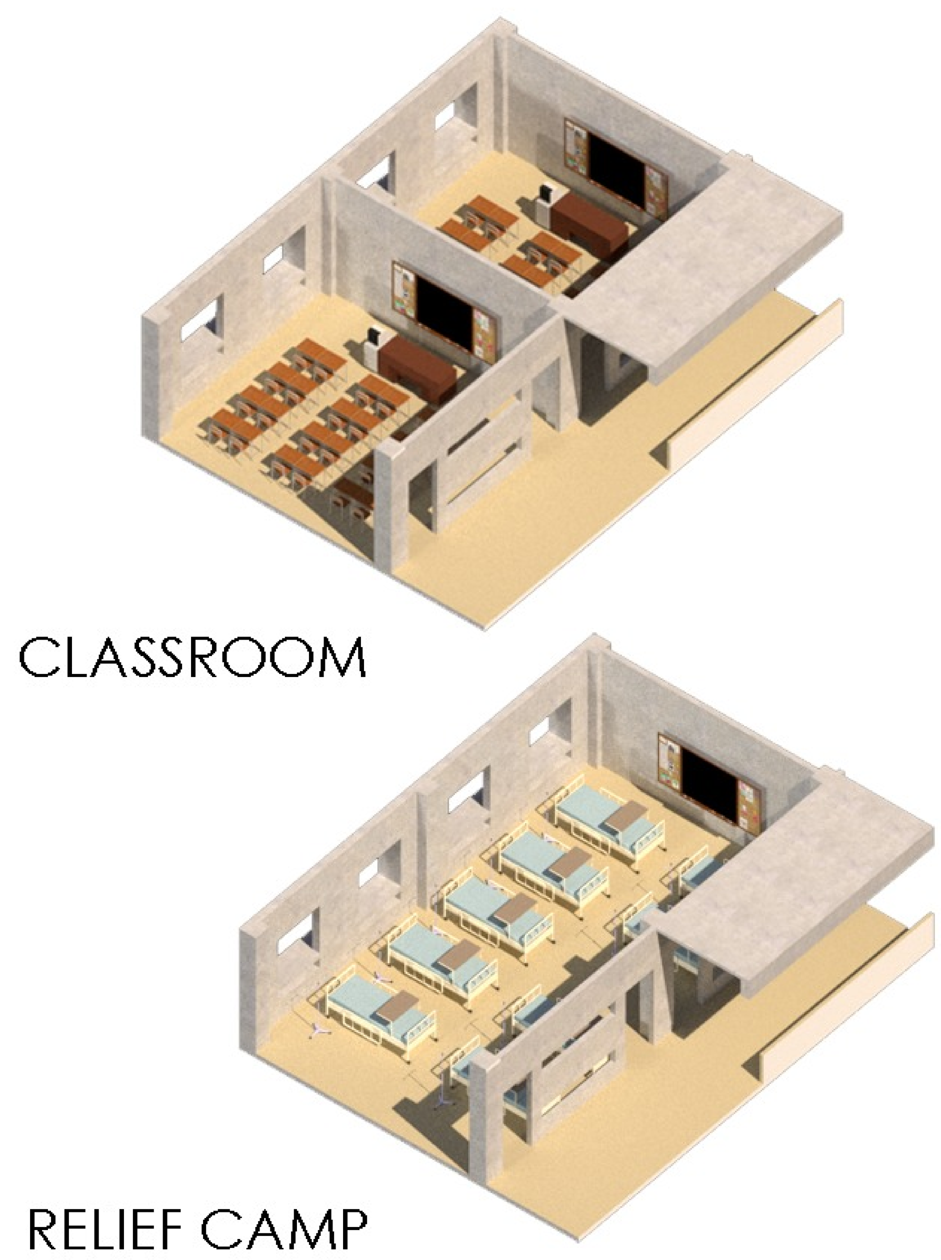


Figure 5.4.8: Modularity in spaces

ENERGY BACKUP

13361 KWH/YR

WATER BACKUP

4281318.43

LPA

Figure 5.4.9: Energy and water backup

SOCIAL RESILIENCE

By giving students places to unwind during breaks and by creating a comfortable workspace with more opportunities for student engagement, break-out spaces are incorporated into the design to help improve the quality of the work. Additionally, green areas around densely populated areas serve as a sound barrier for nearby communities, fostering social resilience.

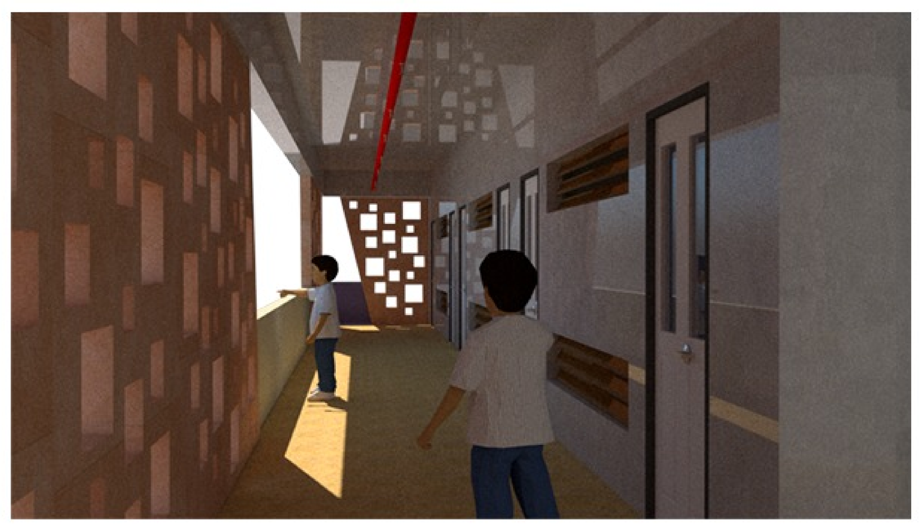
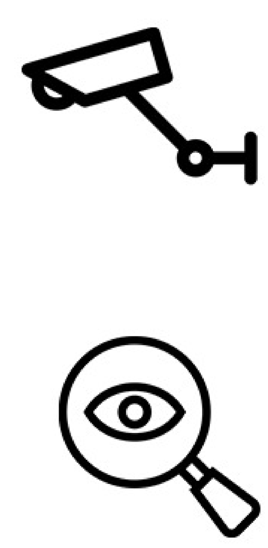


Figure 5.4.10-View of corridoor area acting as a social space

Figure 5.4.11-View of courtyard area acting as a social space

SAFETY AND SECURITY

We aim to incorporate Crime Prevention Through Environmental Design (CPTED) to ensure the safety and security of people information and property of our building.
CPTED is a strategy that focuses on enhancing the design of the built environment to reduce conflict and violence while encouraging positive behavior.
It includes three major methods- the electronic method the architectural method and the organizational method We plan to design our educational building in such a way that it enables maximum natural surveillance and deters any intruder from entering.
The perimeter of the facility has been clearly defined and walled. Separate pedestrian walkways and vehicular thoroughfares have been provided. CCTV cameras are utilised in the technological method to monitor the pupils and trespassers in the public and private locations that are segregated from one another.



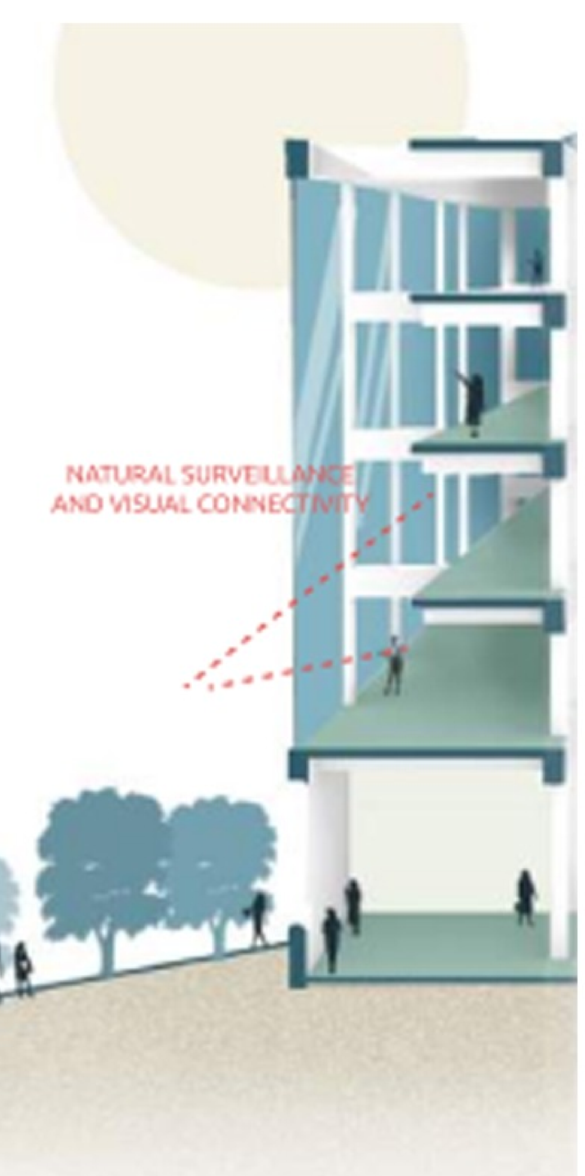


Figure 5.4.12-Natural surveillance

ENGINEERING AND OPERATIONS

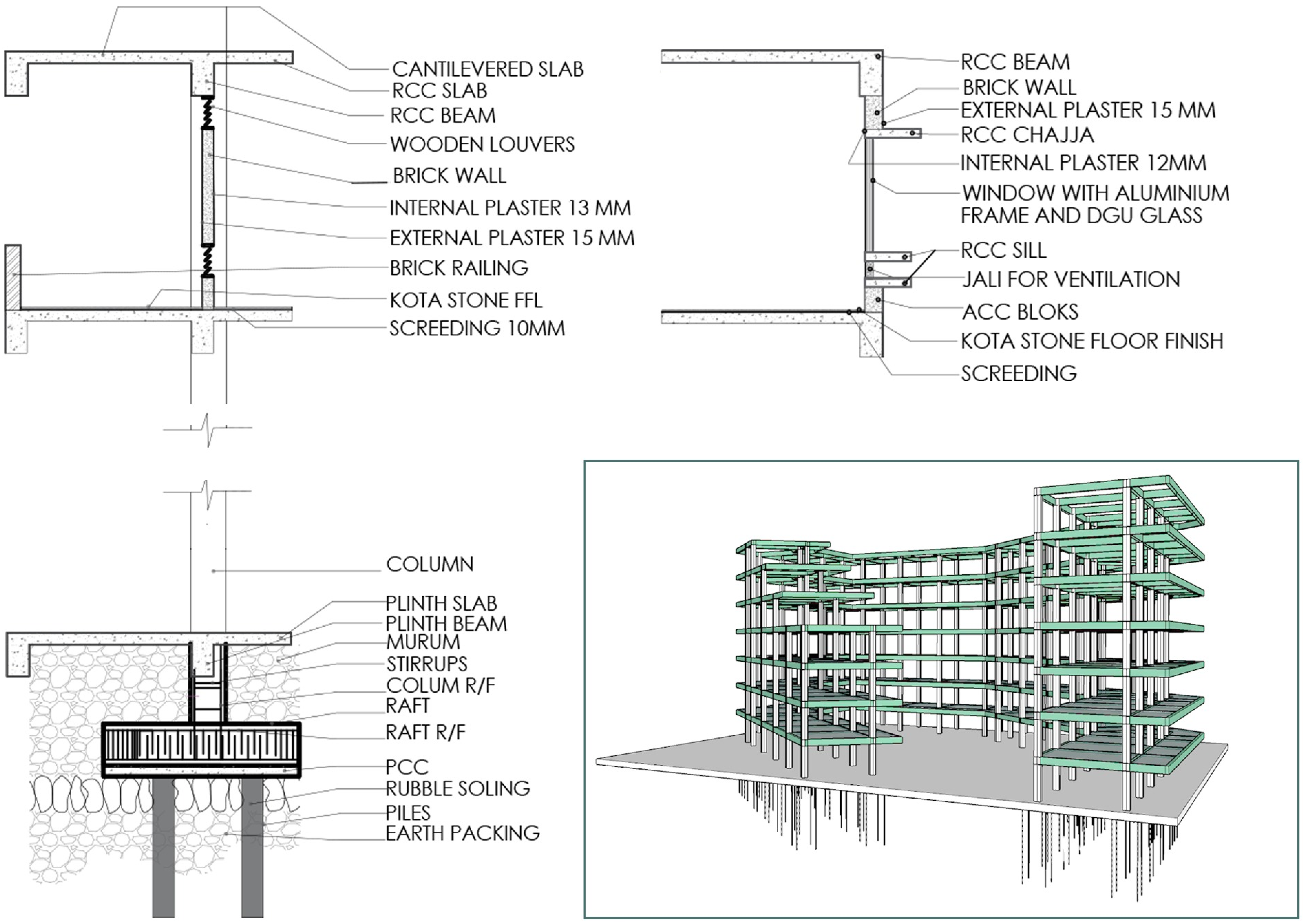


Figure 5.5.1- Detail drawing

The structural design is made such that the column grid is placed and is supporting the classroom slab and the corridors are cantilevered.Being in a seismic zone,the structural foundation is a raft foundation with piles up to 10 m deep.The dimension of column is 500×500 and outer beams and cantilevered beams are 300×600mm. Whereas the internal beams are designed of dimension 230×600.

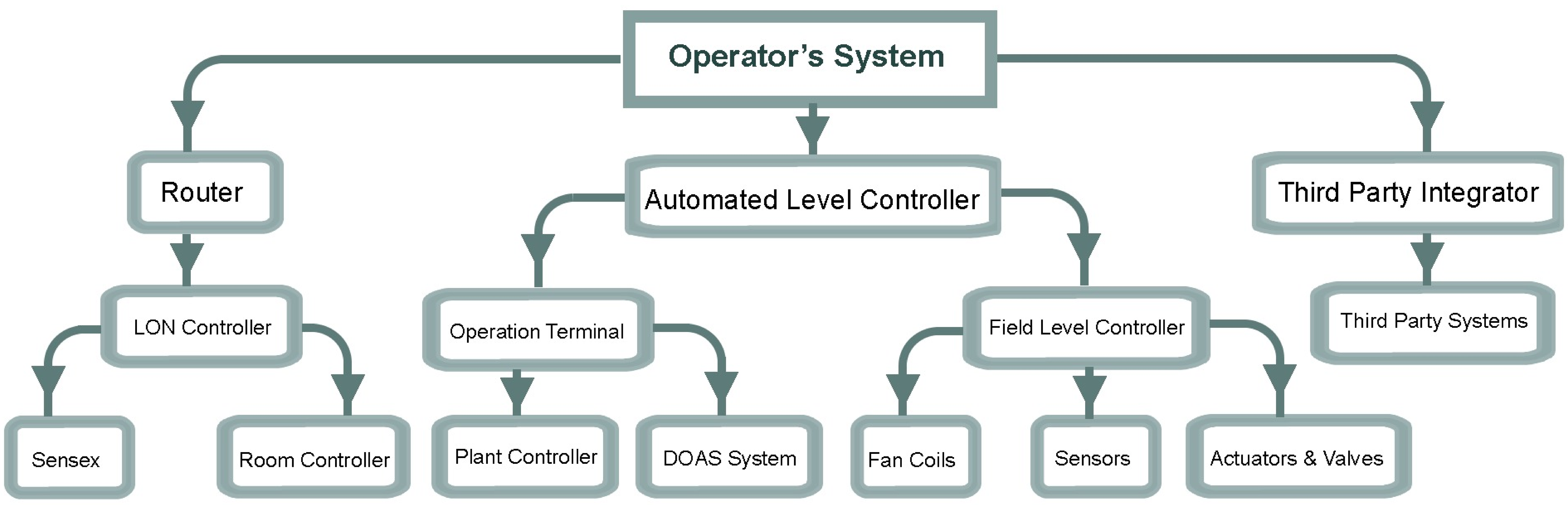


Figure 5.5.2- Operator's systems

The BMS is a computer-based system that uses sensors, controllers, and communication networks to gather data from the building systems and make automated adjustments to optimize their performance, reduce energy consumption, and enhance occupant comfort. The BMS can also be programmed to alert building managers to issues or alarms, allowing for proactive maintenance and quick response to emergencies.

COLUMN LAYOUT

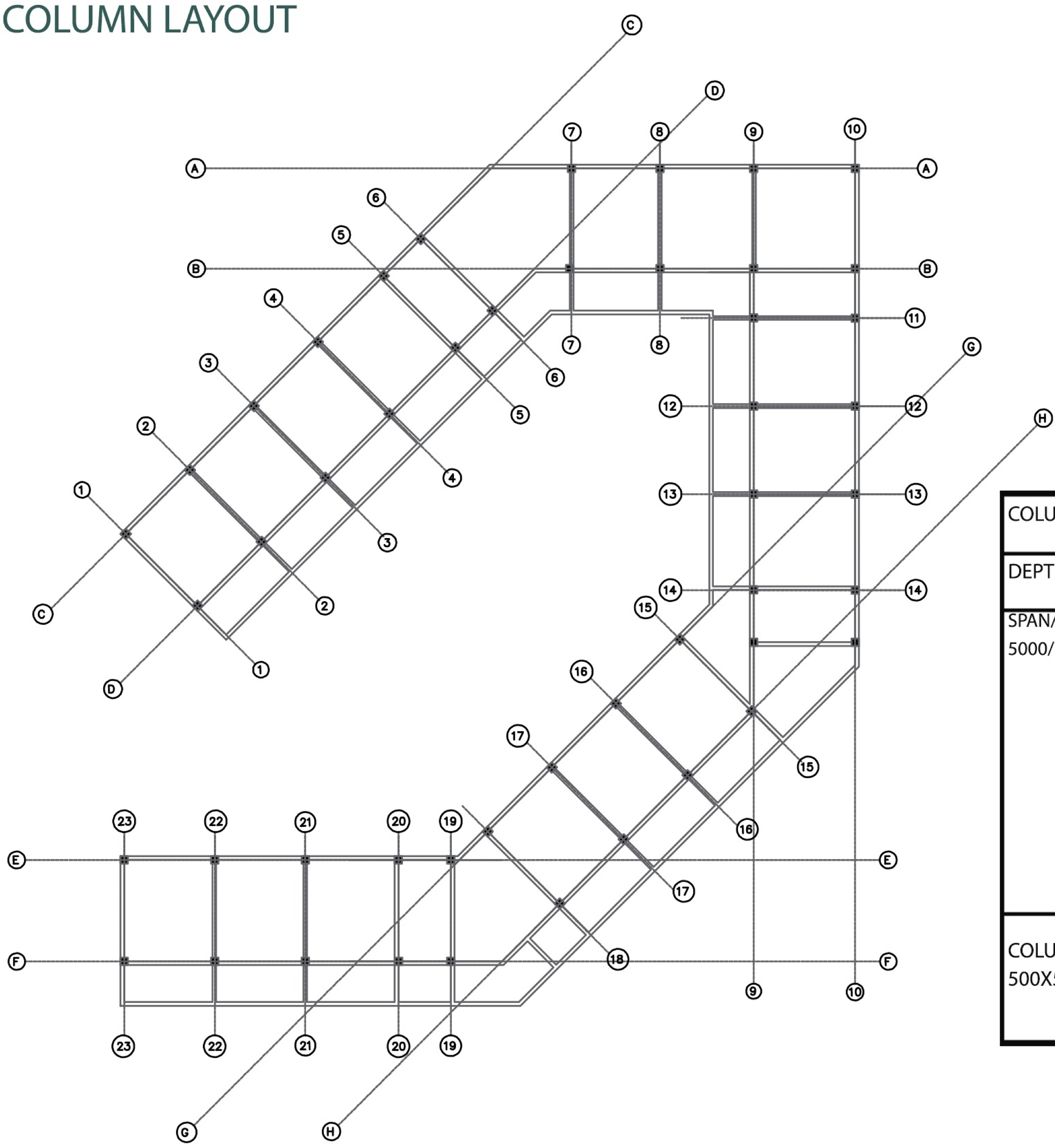


Figure 5.5.3- Column layout

COLUMN	BEAM
DEPTH	DEPTH
SPAN/10 5000/10	SPAN/10 5000/10 500MM (However minimum is 600MM) WIDTH 1/3RD OF DEPTH 600/3 200MM (However minimum is 300MM)
COLUMN 500X500 MM	BEAM 600X600 MM

Table 5.54- Column layout

HVAC SYSTEM

A HVRF system of Mitsubish

DIMENSION :
outdoor - 920mm x740mm x1710mm,
indoor - 840mm x840mm x258mm

CAPACITY:
outdoor Unit - 22.4 kW,
indoor Unit - 3.6kW

POWER INPUT :
outdoor unit - 7kW,
indoor unit 0.0 kW

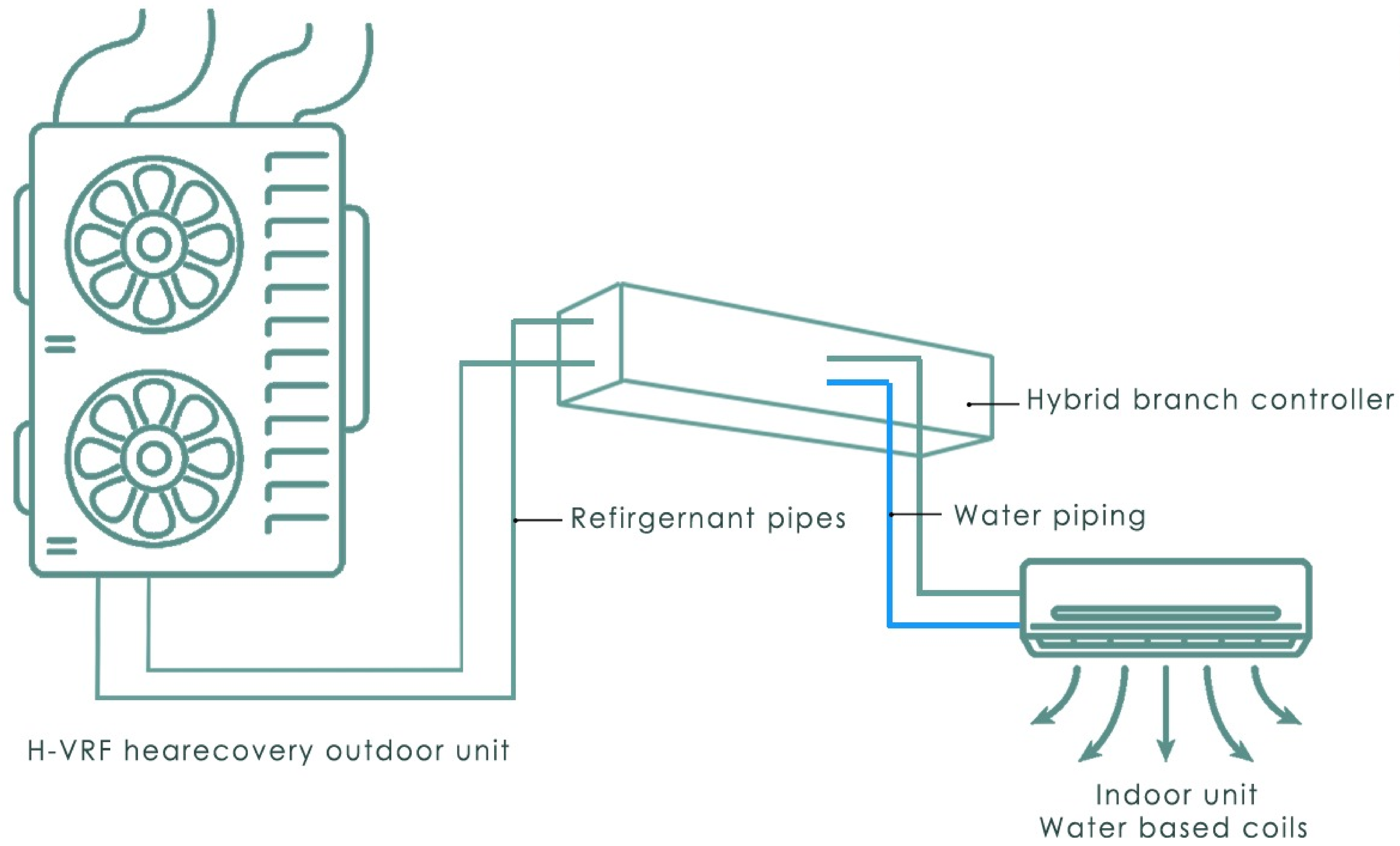


FIGURE 5.6.1-HVRF Sychmatic diagram

VRF system

Variable refrigerant flow, or VRF, is a term that describes how this system uses refrigerant to provide both cooling and heating. VRF enables the operation of several indoor units on a single system, with various configurations depending on the application. VRF systems utilise inverter compressors to achieve their great efficiency. The compressor can ramp up or down dependent on the demands of each room thanks to inverter systems.
The benefits of a VRF system include improved comfort, saving energy, and customizable operation. In a nutshell, these are the advantages of a VRF system:

-Consistent comfort
-Quiet operation
-Energy efficiency
-Installation flexibility, great for tight spaces
-Heat & cool simultaneously
-Zoned heating & cooling
-State-of-the-art controls
-Fewer breakdowns/ less downtime

Besides the benifits of VRF (HVAC) system it is also preffered over radiant cooling system because radiant cooling system is potentially suitable for arid climates, radiant cooling is problematic for spaces in more humid climates due to condensation on the panels when their temperature is below the dew point of the air in the room.

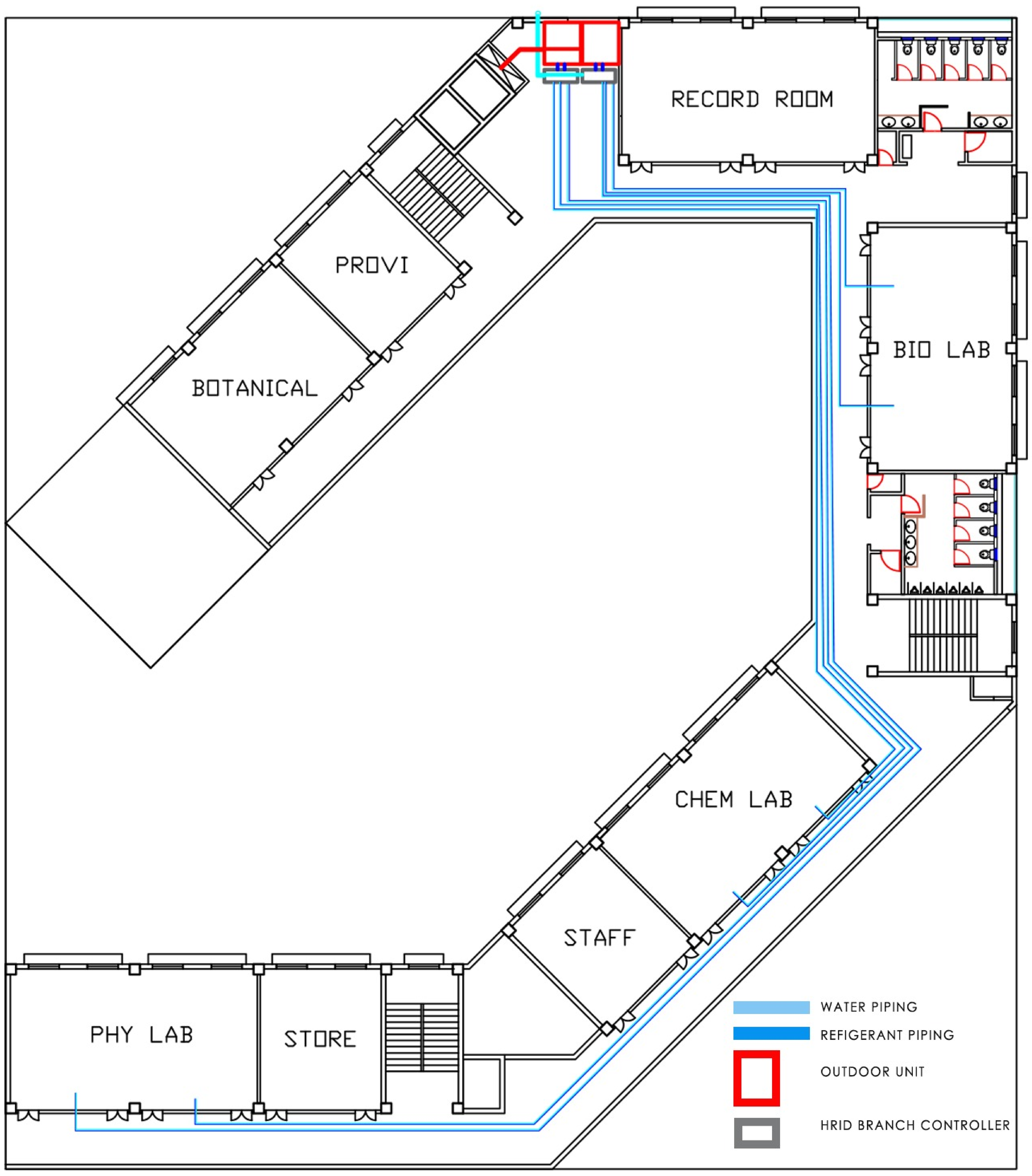


Figure 5.6.2-HVRF floor plan layout

A HVRF system of Mitsubish

HVRF SYATEM	PARAMETERS	OUTDOOR UNIT	INDOOR UNIT
CAPACITY (kW)	COOLING	22.4	3.6
POWER INPUT (kW)	COOLING	7	0.04
COP / EER (nominal)		3.53/3.20	
AIRFLOW (m3/min)	HIGH	185	267
	GLASS	19.05	
	LIQUID	15.88	
SOUND PRESSURE LEVEL (dBA)		59	31
WEIGHT (kg)		205	22
DIMENSIONS (mm)	W x D x H	920 x 740 x 1710	840 x 840 x 258
ELECTRICAL SUPPLY		380-415v , 50Hz	220-240v, 50/60Hz
REFRIGERANT TYPE		R410A	
OPERATION RANGE			

Table 5.6.1-A HVRF system of Mitsubish

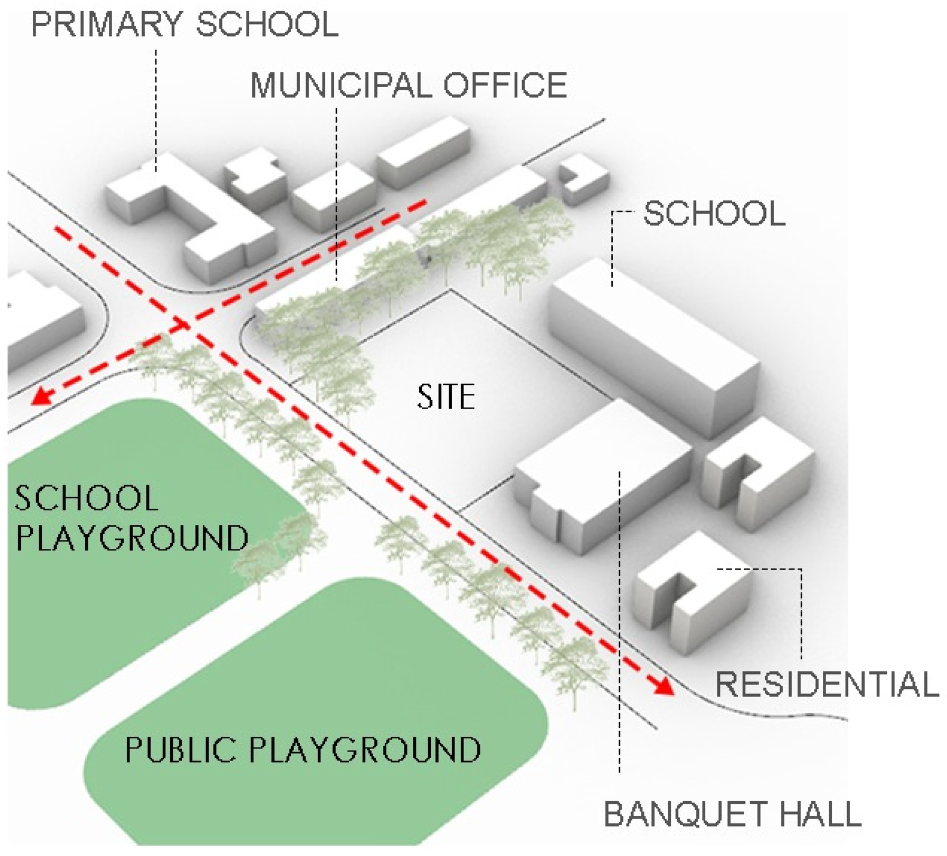
Required tonnage table

USAGE	AREA	LENGTH	BREATH	HEIGHT	AREA	AREA	VOLUME	BTU/SQ FEET	TONNAGE
		m	m	m	sq feet	meter 2	meter 3		
12HRS	BANK A	9.53	8.23	3.4	839.22	78.43	266.67	22658.98	1.89
12HRS	BANK B	6.55	5.27	3.4	369.35	34.52	117.36	9972.39	0.83
9HRS	STAFF A	11.87	6.9	3.4	876.36	81.9	278.47	23661.78	1.97
9HRS	MEDICAL	6.82	6.07	3.4	442.95	41.4	140.75	11959.71	1
10HRS	OFFICE	24.14	6.9	3.4	1782.26	166.57	566.32	48120.92	4.01
5HRS	CRAFT	12.04	6.9	3.4	888.91	83.08	282.46	24000.66	2
5HRS	ART	11.95	6.9	3.4	882.27	82.46	280.35	23821.25	1.99
9HRS	STAFF B	6.82	6.11	3.4	445.87	41.67	141.68	12038.52	1
9HRS	LIBRARY	18.09	6.9	3.4	1335.58	124.82	424.39	36060.79	3.01
5HRS	COMP A	5.9	6.9	3.4	435.6	40.71	138.41	11761.12	0.98
5HRS	COMP B	6.82	6.07	3.4	442.95	41.4	140.75	11959.71	1
9HRS	STAFF C	5.9	6.9	3.4	435.6	40.71	138.41	11761.12	0.98
3HRS	BIO LAB	11.87	6.9	3.4	876.36	81.9	278.47	23661.78	1.97
3HRS	CHEM LAB	12.04	6.9	3.4	888.91	83.08	282.46	24000.66	2
3HRS	PHY LAB	12.04	6.9	3.4	888.91	83.08	282.46	24000.66	2
9HRS	STAFF D	5.99	6.9	3.4	442.24	41.33	140.53	11940.53	1
1HRS	MUSIC R	11.87	6.9	3.4	876.36	81.9	278.47	23661.78	1.97
1HRS	DANCE R	12.34	6.9	3.4	911.06	85.15	289.5	24598.68	2.05
1HRS	DRAMA	7.89	6.9	3.4	582.52	54.44	185.1	15728	1.31
2HRS	PRINCI	6.82	6.07	3.4	442.95	41.4	140.75	11959.71	1
9HRS	STAFF E	5.82	6.9	3.4	429.69	40.16	136.54	11601.65	0.97
TOTAL					15515.94	1450.09	4930.3	418930.37	34.91

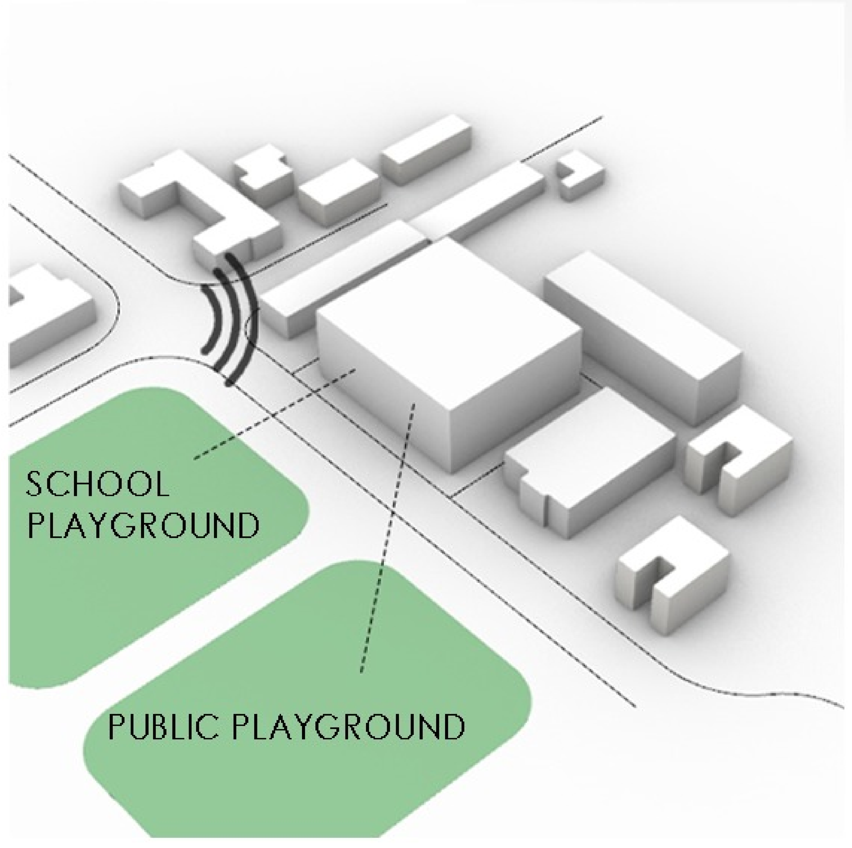
Table5.6.2- showing tonnage of hvac re-

OUTDOOR UNIT POSITIONING AND TYPICAL LAYOUT

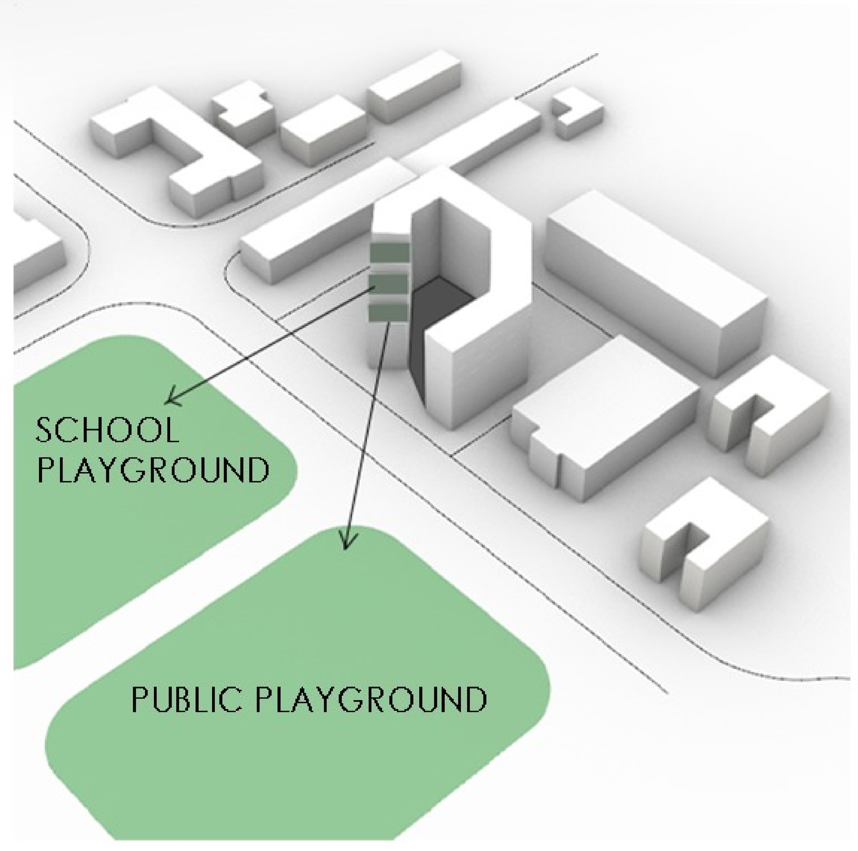
FORM DEVELOPMENT :



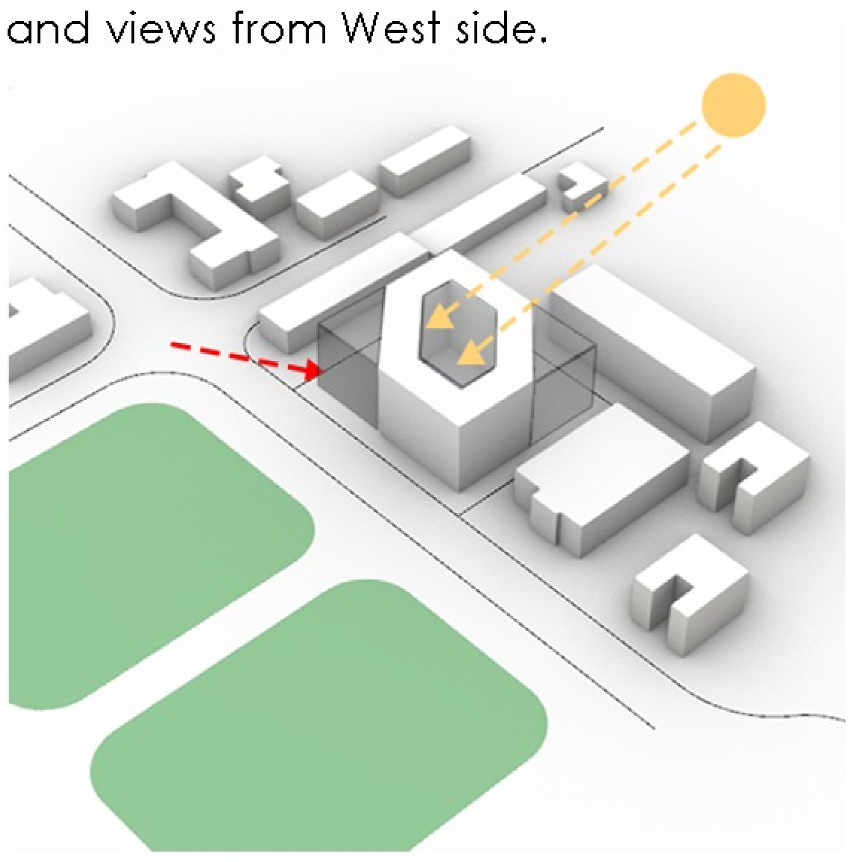
Main block was extruded to understand the noise coming from north west side and views from West side.



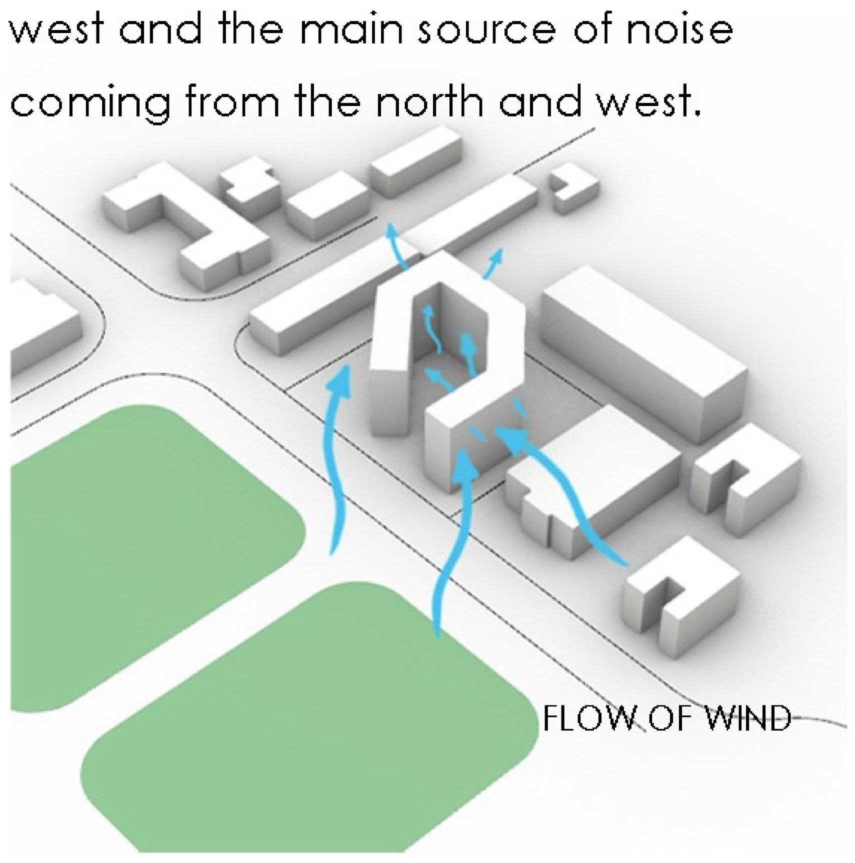
Block was constructed with a 6 m offset, taking into account views to the west and the main source of noise coming from the north and west.



Cutting down the building horizontally, making stepped terraces, and forbidding any internal activity in order to protect against harmful radiation



More light will enter the building by removing a portion of the centre to make a courtyard, and the structure can be angled to maintain views of the nearby buildings.



Buildings should be oriented in the north-west and southeast to maximize the efficiency of the internal airflow.

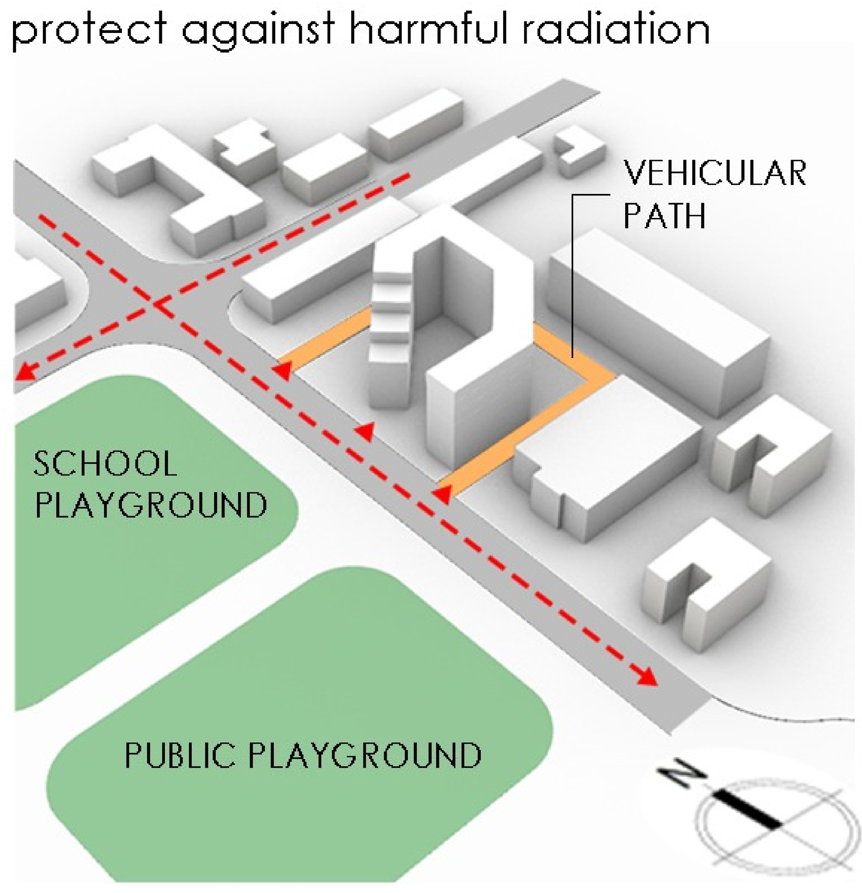
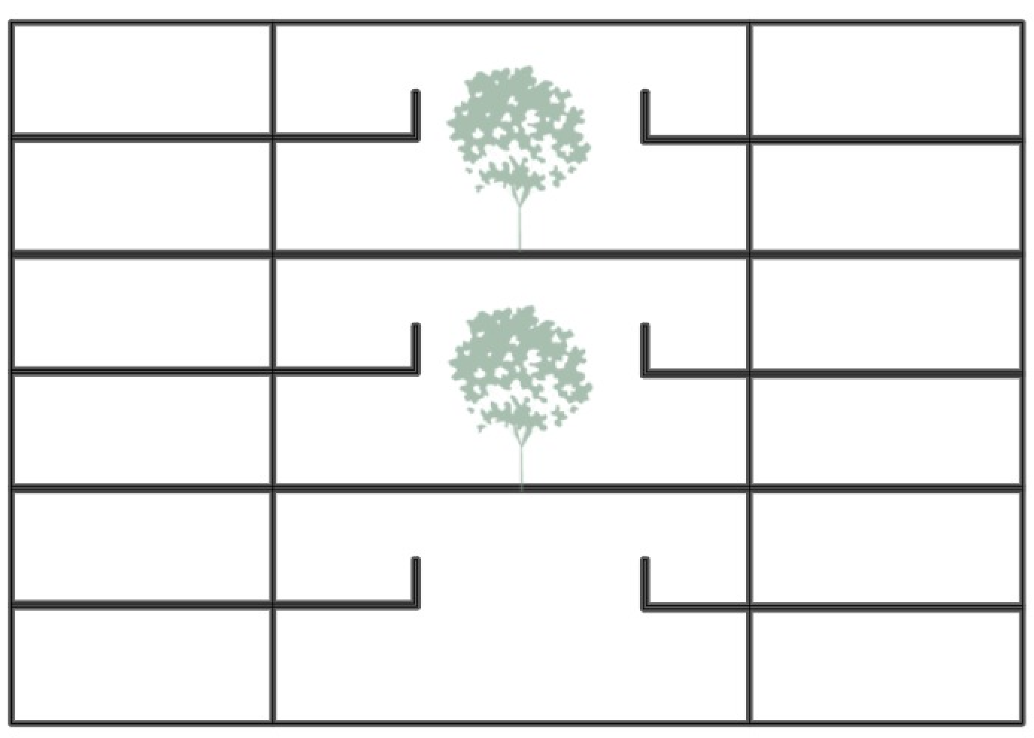
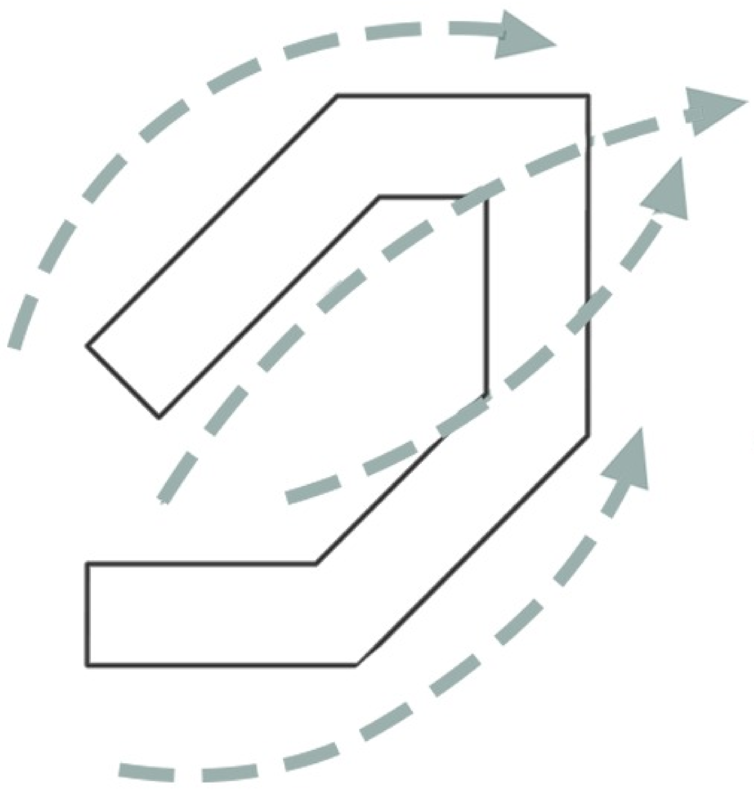


Diagram shows site connectivity with main roads and 6m offset around the building is used for vehicular circulation.

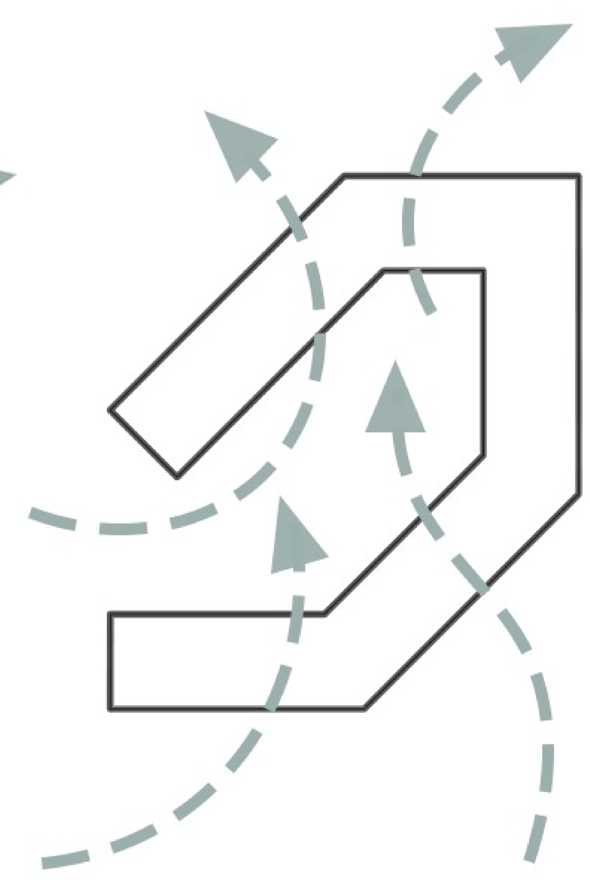
DESIGN STRATEGIES



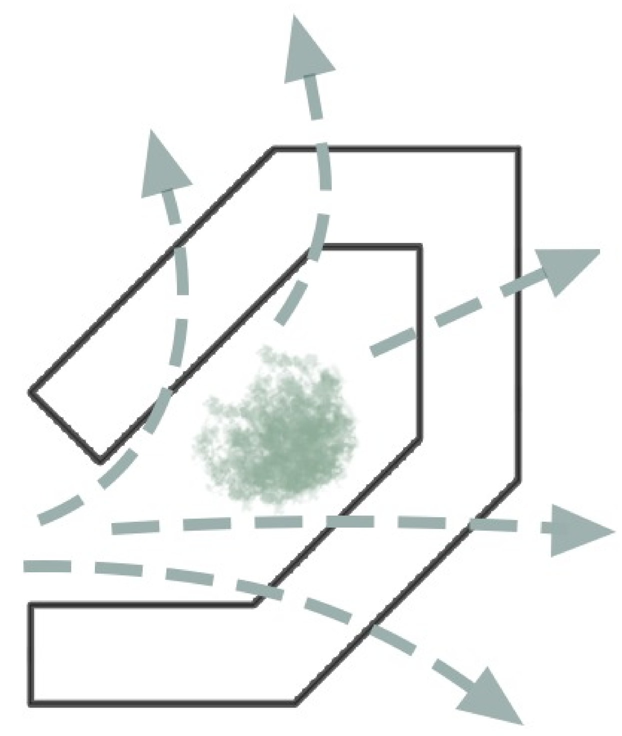
DOUBLE HEIGHT GREEN SPACES



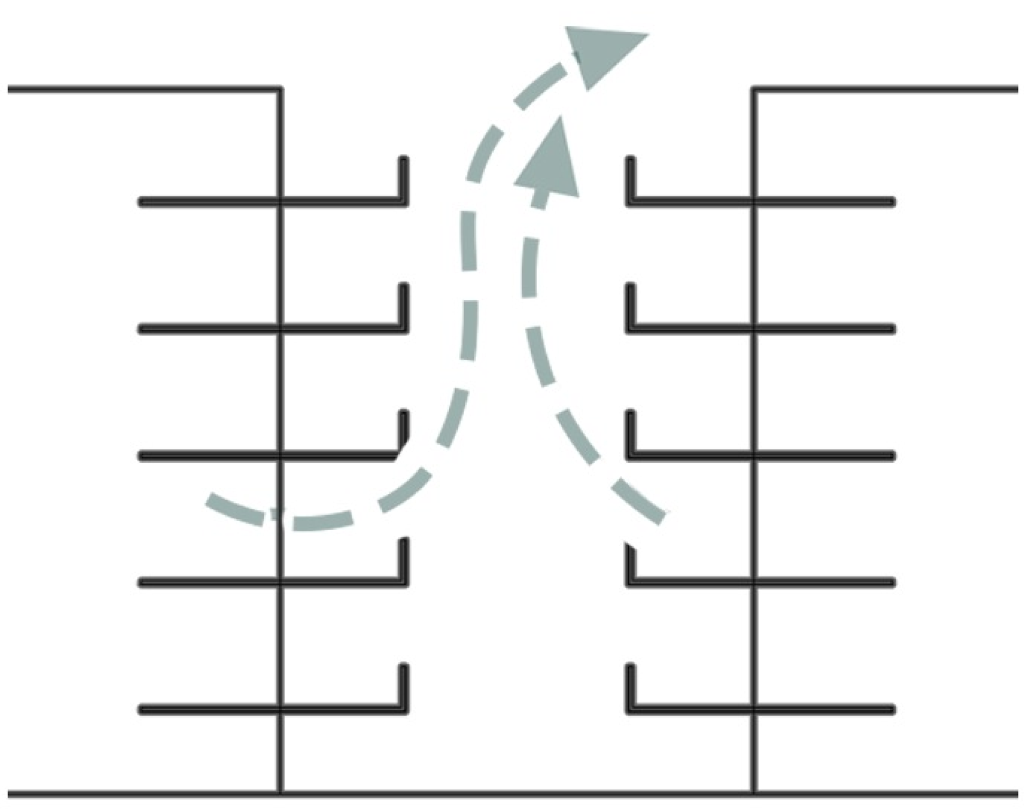
ITERATION FOR VENTILATION



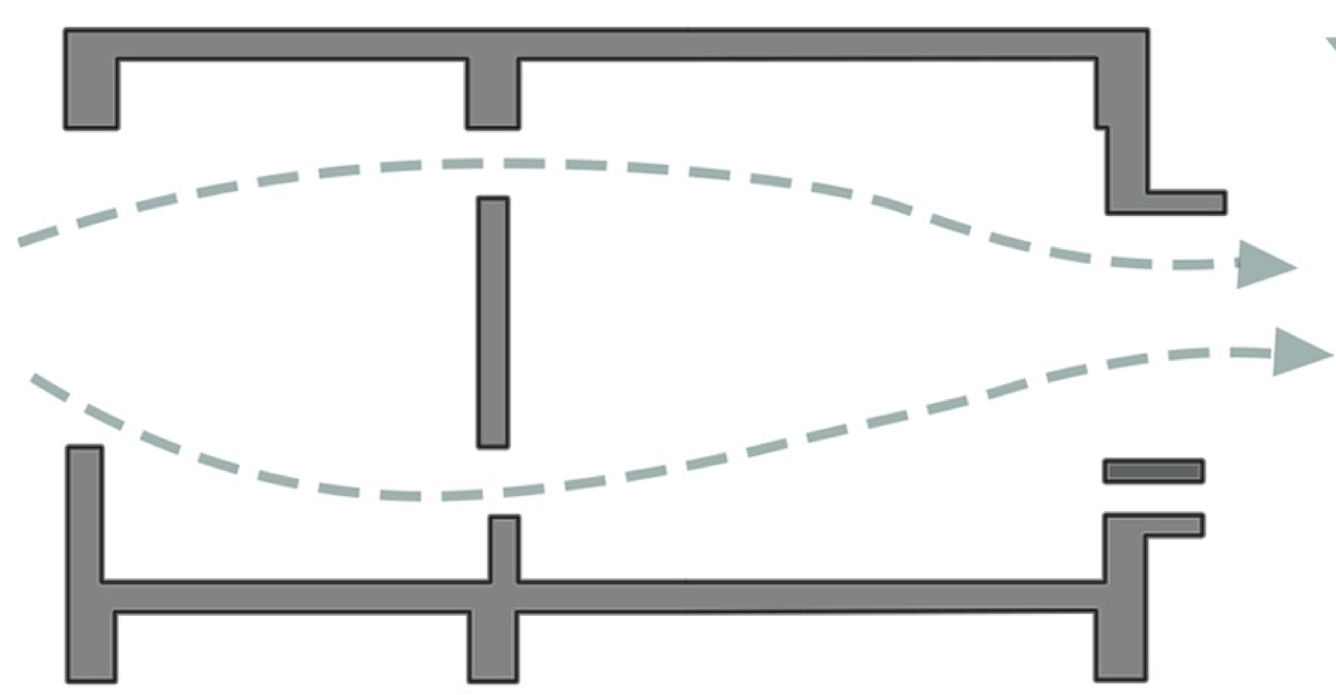
ITERATION FOR VENTILATION ON TYPICAL FLOORS



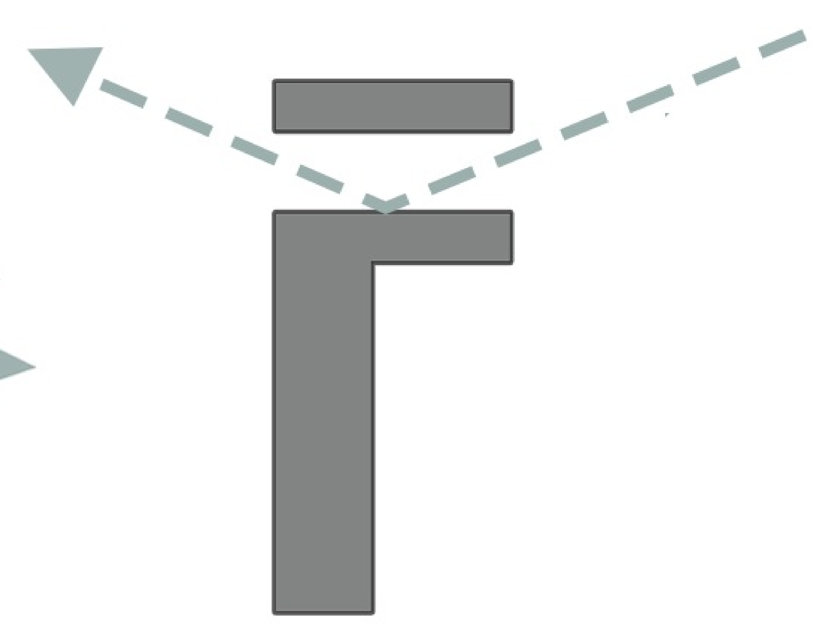
ITERATION FOR VENTILATION ON GROUND FLOOR



CONVENTIONAL COURTYARD



CROSS VENTILATION THROUGH SPACES



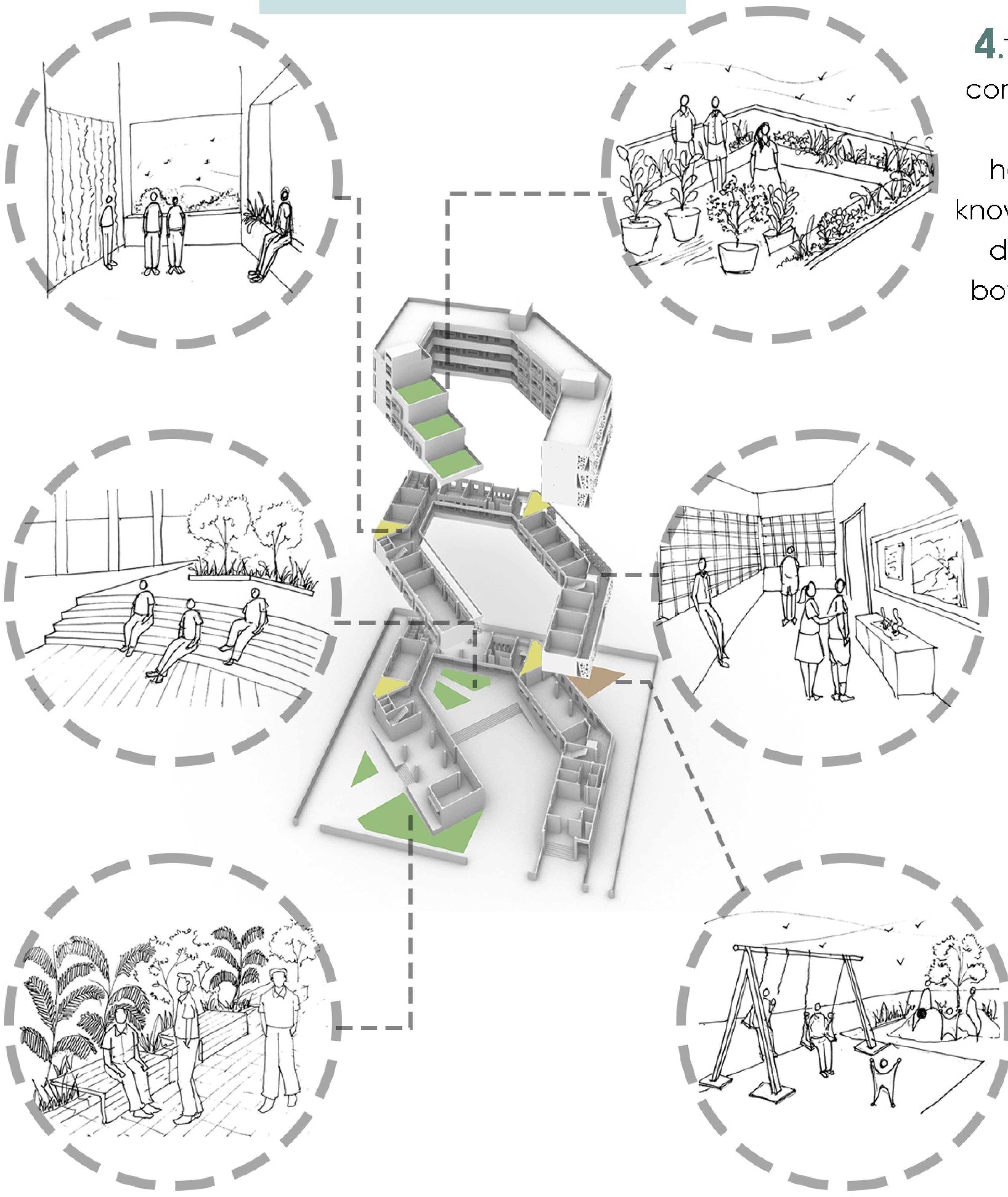
LIGHT SHELVES FOR INDIRECT SUNLIGHT

DESIGN IDEATIONS

1. Breakthrough areas on different floors that face north. Adds pure natural light to the room and makes it simple to conduct small meetings.

2. Student interactions are stimulated by the central atrium, offers multiple uses, such as for sporting events, tournaments, and community shows. becomes the building's magnet.

3. Space near the entrance of the site is designed with high green ratio to ensure healthier environment in the campus and engages student with nature.



4. Terrace gardens are a crucial component of the building since they connect the neighbourhood with the school and raise knowledge of urban farming. Additionally, it teaches kids about botanical gardens and provides the best view of the location.

5. An open concept space design facing south that promotes ventilation in the courtyard and is best suited for small exhibitions.

6. To safeguard the safety of children, a kindergarten garden is located on the site's rear. The areas are kept up nicely and are crucial to the development of the pupils.

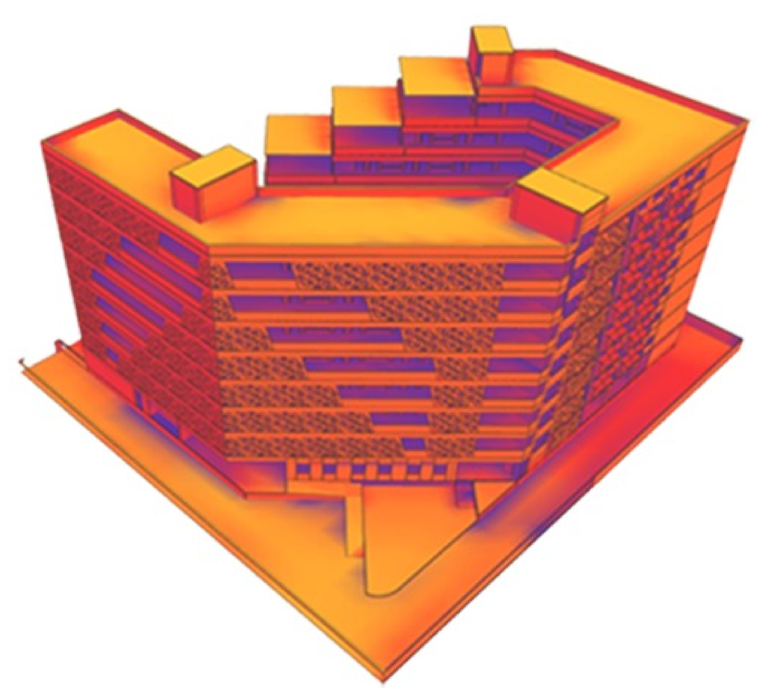
Figure 5.7.3. Design ideation

RADIATION

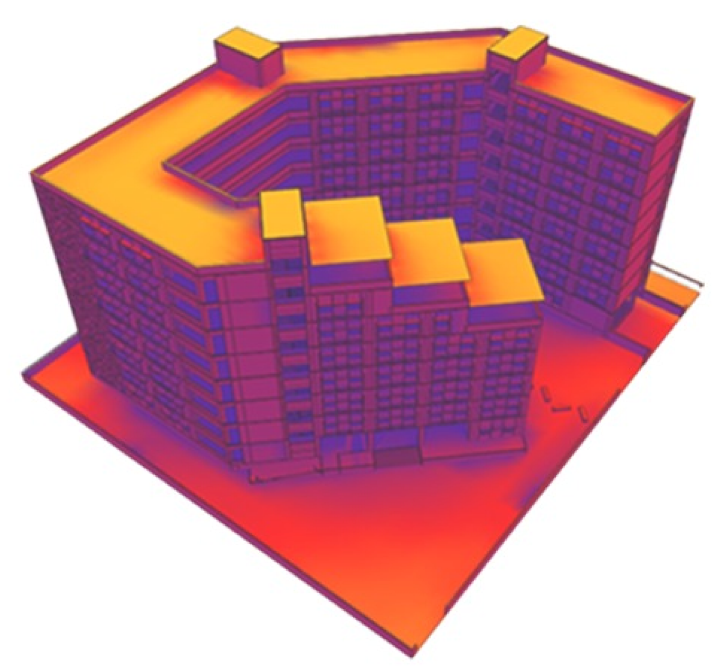
Average: 630.61 KWh/sqm

RADIATION	
1	511.3 KWh/sqm
2	325.5 KWh/sqm
3	699.7 KWh/sqm
4	1577 KWh/sqm
5	1109 KWh/sqm
6	1159 KWh/sqm
7	878.1 KWh/sqm
8	1134 KWh/sqm
9	1116 KWh/sqm
10	441.8 KWh/sqm
11	280.7 KWh/sqm
12	1104 KWh/sqm
13	371.8 KWh/sqm
14	405.8 KWh/sqm
15	276.5 KWh/sqm
16	289 KWh/sqm
17	331.3 KWh/sqm
18	490.9 KWh/sqm
19	617 KWh/sqm

Table 5.7.4- Radiation analysis



S-E ELEVATION



N-W ELEVATION

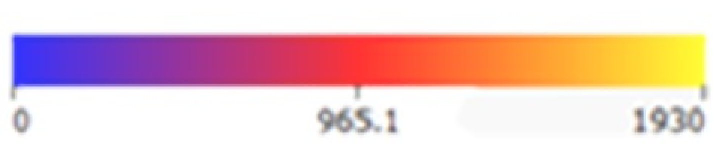
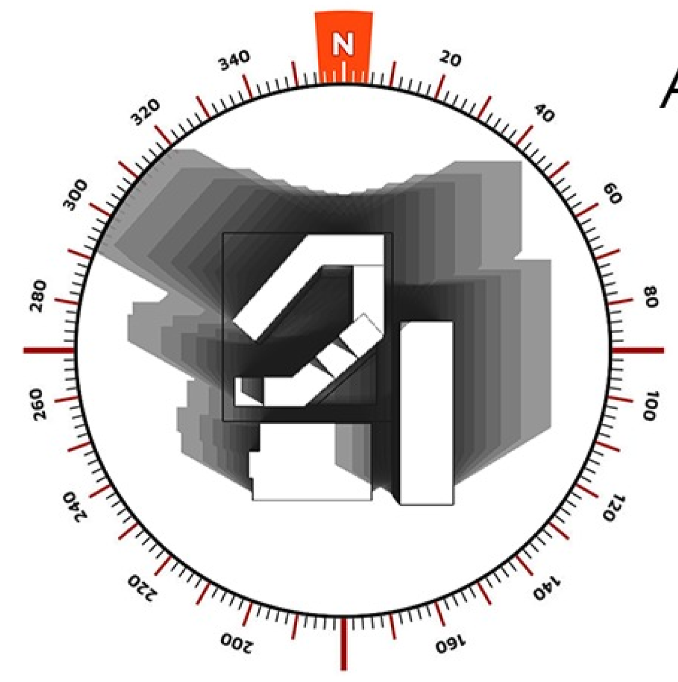
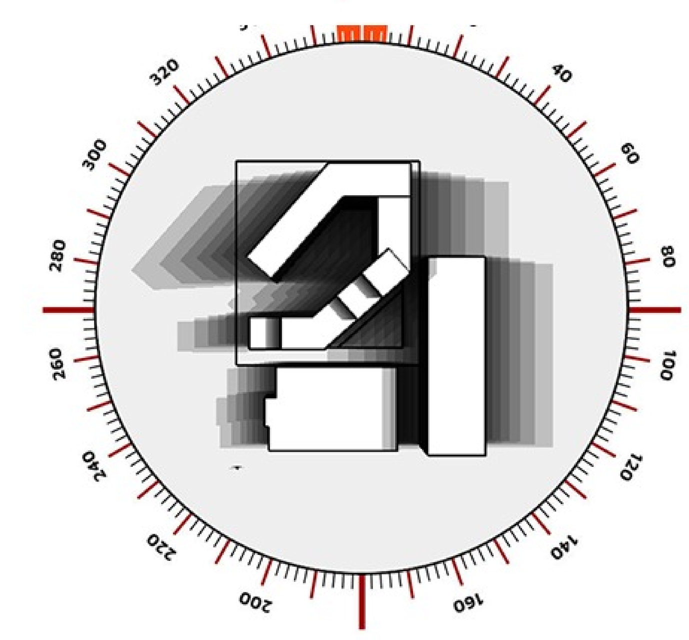


Figure 5.7.5- Elevation

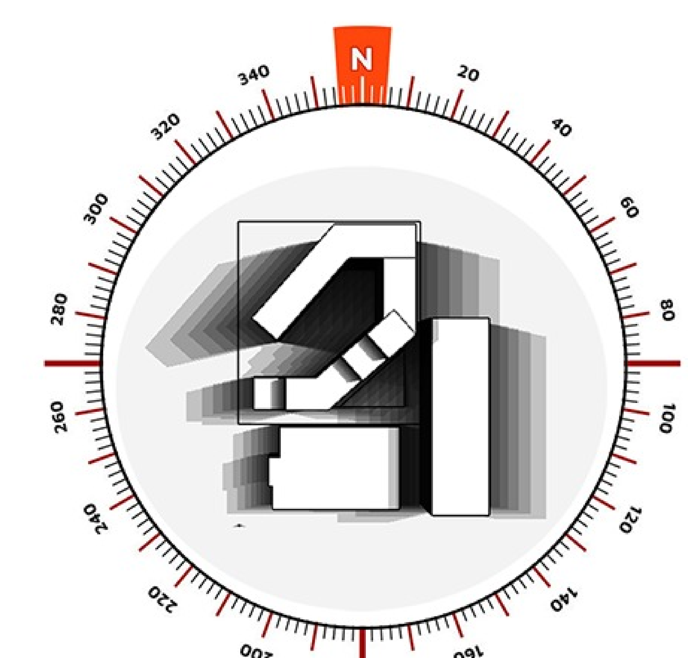
SHADOW ANALYSIS



Activities can run easily because the January moth provides greater shading through the building and allows higher cooling hours.



Even when the sun is directly overhead in April, the courtyard is evenly shaded throughout the day.



There is more diffused light during the monsoon, we feel comfortable all day both inside and outside.

Figure 5.7.6- Shadow analysis

SECTION AA'

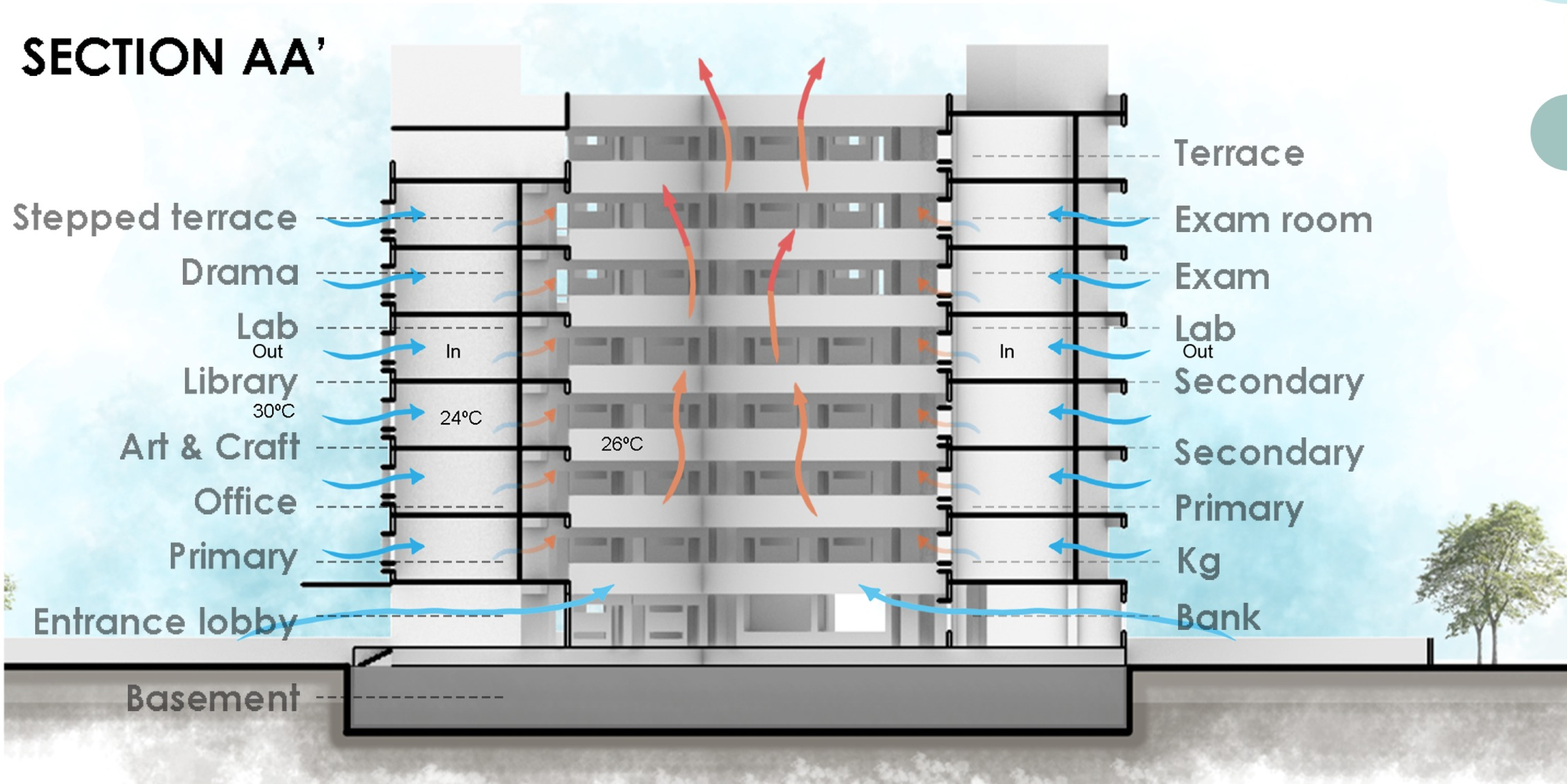
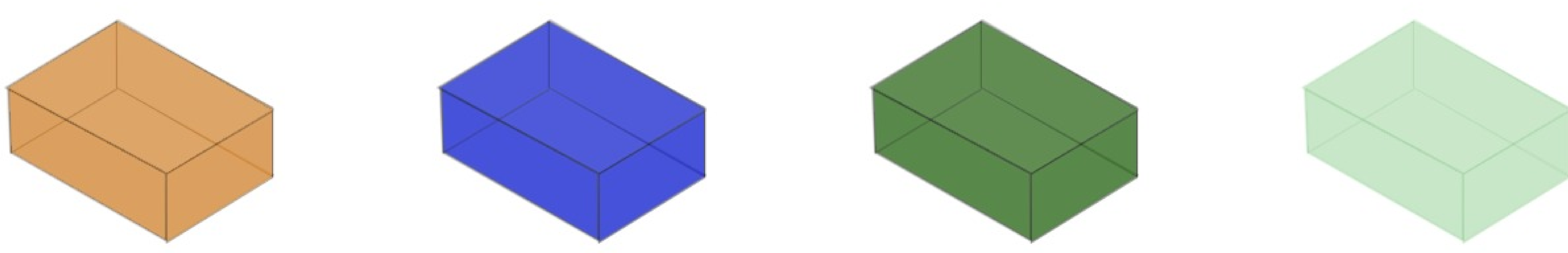


Figure 5.7.7. Section

This is the typical section of our educational building with the floor to floor height of 3.6 M on all floors, ground floor and basement 4.2M.



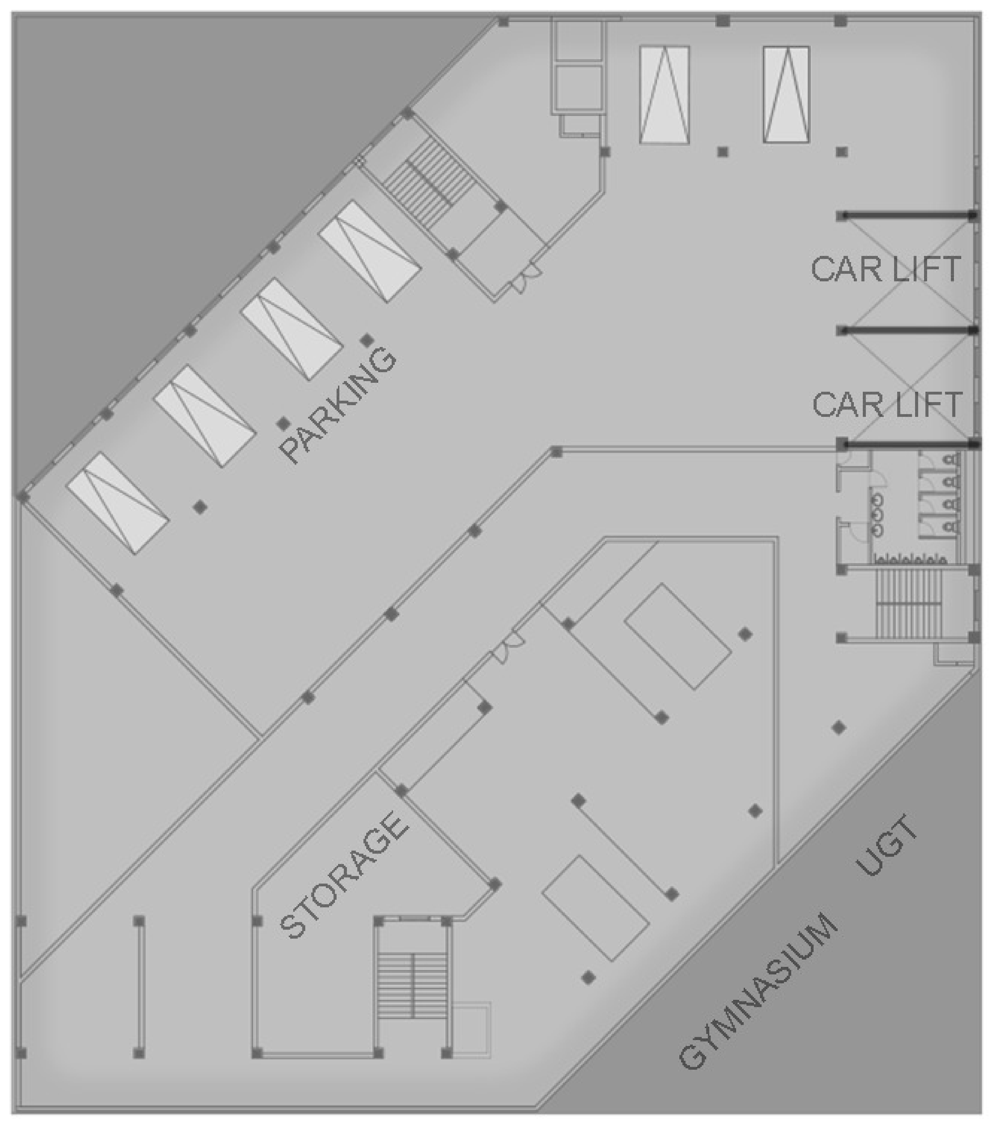
Size: 6m x 7m
Computer lab
Staff room
Medical room
Activity room

size : 12m x 7m
art room
craft room
sports room
music room

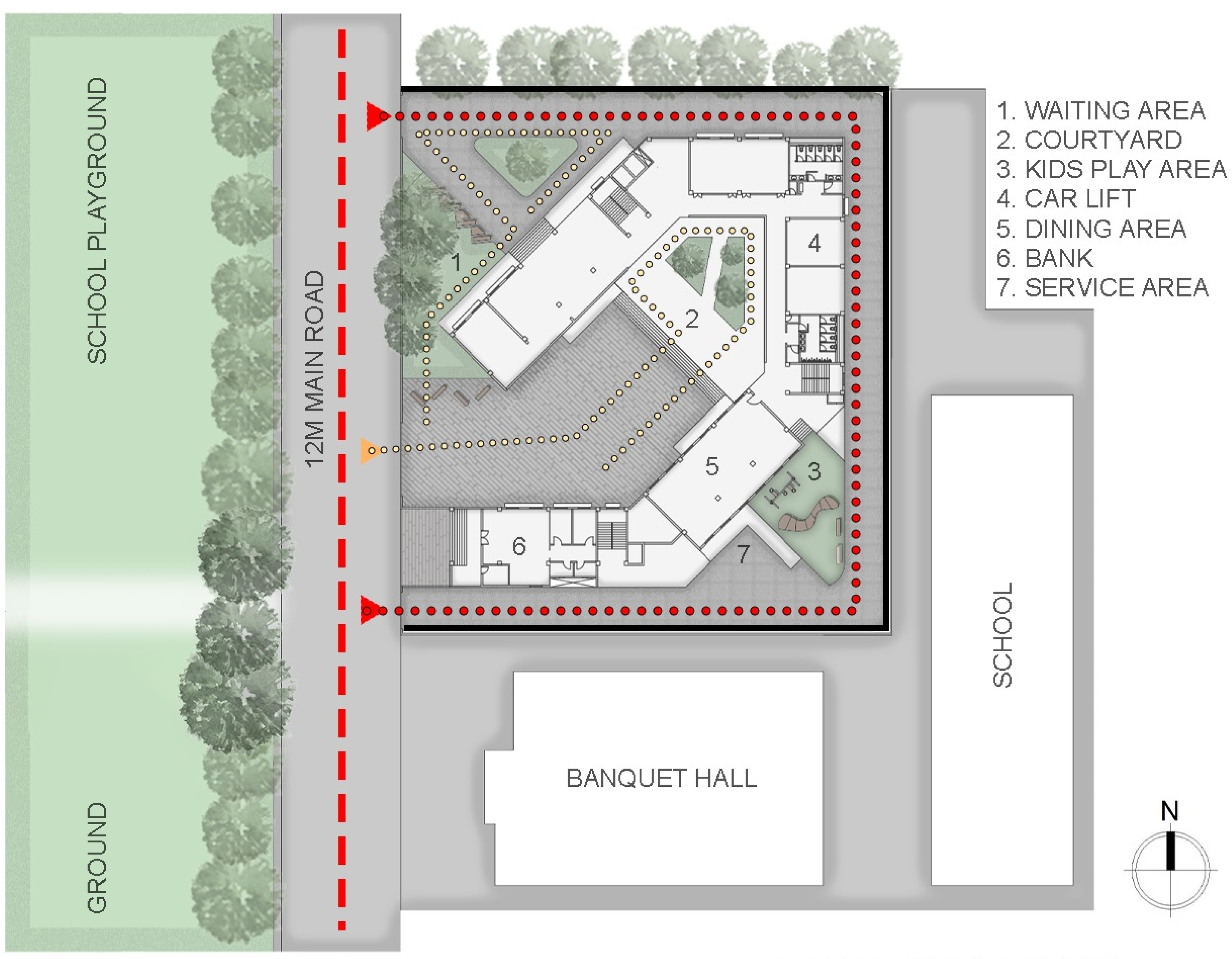
size: 18m x 7m
library
exam room
auditorium

size : 24m x 7m
OFFICE

Figure 5.7.4. Area comparison

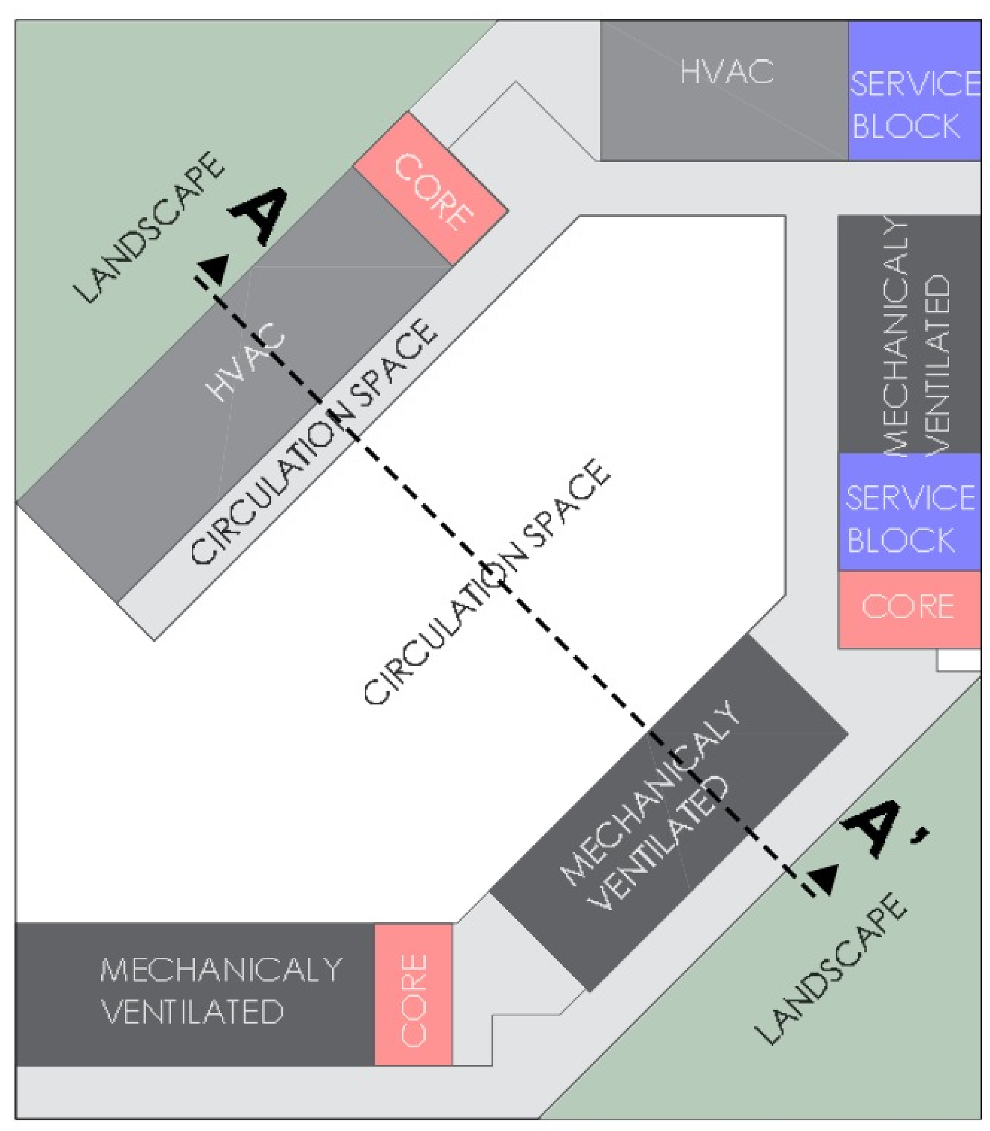


BASEMENT PLAN



GROUND FLOOR PLAN

VEHICULAR PATH
PEDESTRIAN
MAIN ROAD



ZONING PLAN

Figure 5.7.8. Plans

AFFORDABILITY

PROPOSED VS BASECASE

The cost of the proposed case is higher than the baseline estimates due to added cost of installations to reduce the embodied energy, such as, PV panels, alternative materials and hybrid construction.

Our team has created long span corridors to ensure less srtucutral builtup with floor height of 3.6m (beam depth 0.6m). Preliminary construction budget done under guidance of consultant to receive pertinent figures required to build the whole project.

PROJECT SUMMARY

S.No.	Particulars	Baseline Estimate (Project		Proposed Design Estimate	
		Amount in Million INR	%	Amount in Million INR	%
1	Land	NA			
2	Civil Works	₹ 15,06,94,740.00	38.772571	17,56,67,018.00	38.834952
3	Internal Works	₹ 11,30,21,055.00	29.079428	13,17,50,263.00	29.126214
4	MEP Services	₹ 3,76,73,685.00	9.6931428	4,39,16,754.00	9.7087378
5	Equipment & Furnishing	₹ 3,76,73,685.00	9.6931428	4,39,16,754.00	9.7087378
6	Landscape & Site Development	₹ 4,52,08,422.00	11.631771	5,27,00,105.00	11.650485
7	Contingency	₹ 43,91,675.00	1.1299434	43,91,675.00	0.9708737
	TOTAL HARD COST	**38,86,63,262.00**	**100**	**452342569**	**100**
8	Pre Operative Expenses	14,63,892.00	25.000004	1,12,55,789.00	24.999999
9	Consultants	43,91,675.00	74.999996	3,37,67,368.00	75.000001
10	Interest During Construction				
	TOTAL SOFT COST	**58,55,567.00**	**100**	**4,50,23,157.00**	**100**
	TOTAL PROJECT COST	39,45,18,829.00	200	49,73,65,726.00	200

PROPOSED VS BASECASE

fig7.1 : comparison between base case and proposed case

INNOVATION -

a.) Polyurethene foam Partition Walls -

The Polyurethene sandwich panels are design for a fast and easy assembly. These panels comprises of two steel skin (Pre-painted Galvanized Iron Sheet - PPGI) that are bonded with high pressure injected polyurethane foam with tongue and groove joint system complete with cam-locking mechanism. This Tongue and Groove system makes it easy for quick installation and dismantling.

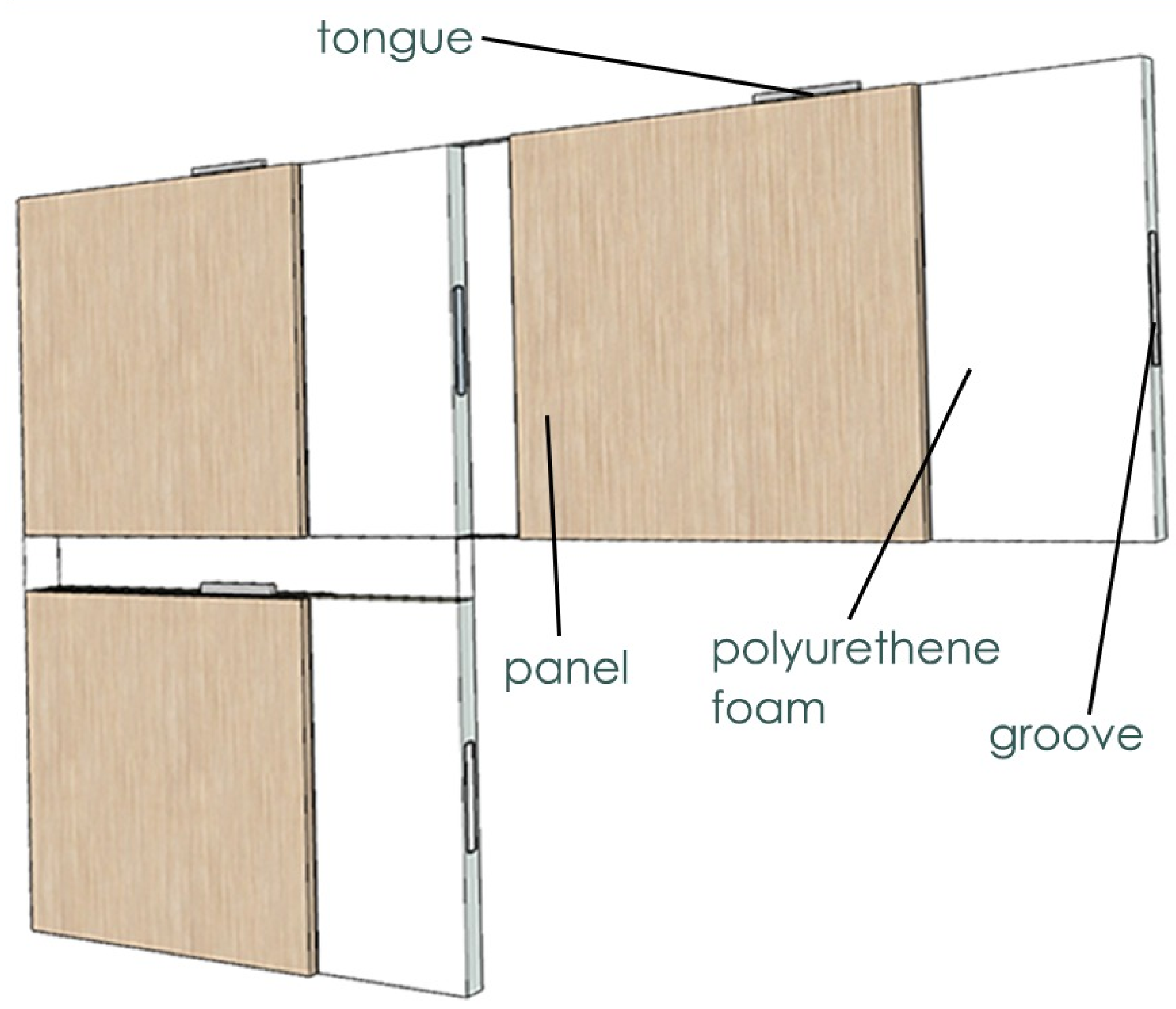


Figure 5.9.1Sandwich panel showing connections

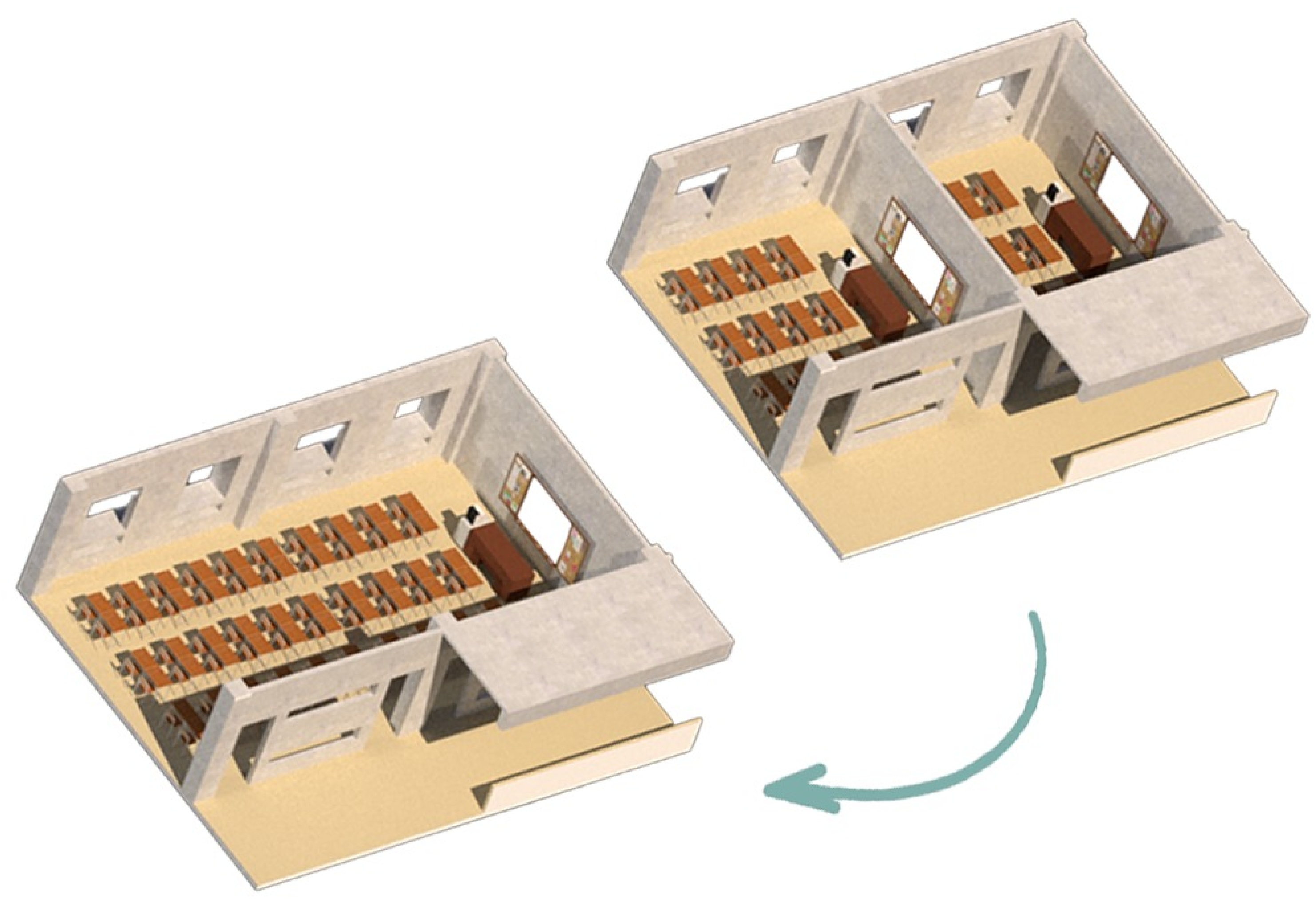


Figure 5.9.2 Sandwich panel showing connections

These panels consists of Polyurethene foam,sound absorbing material glasswool covered entirely with decorative panels. This Polyurethene Foam is a non-biodegradable material filling up the lanfills without getting decompose, thereby further degrading the soil quality. Thus the idea behind the foam is to utilize it creatively in partition walls for classrooms.

PROS
- Good load bearing capacity
- Fire Resistant
- Fast installation
- Easy dismantle

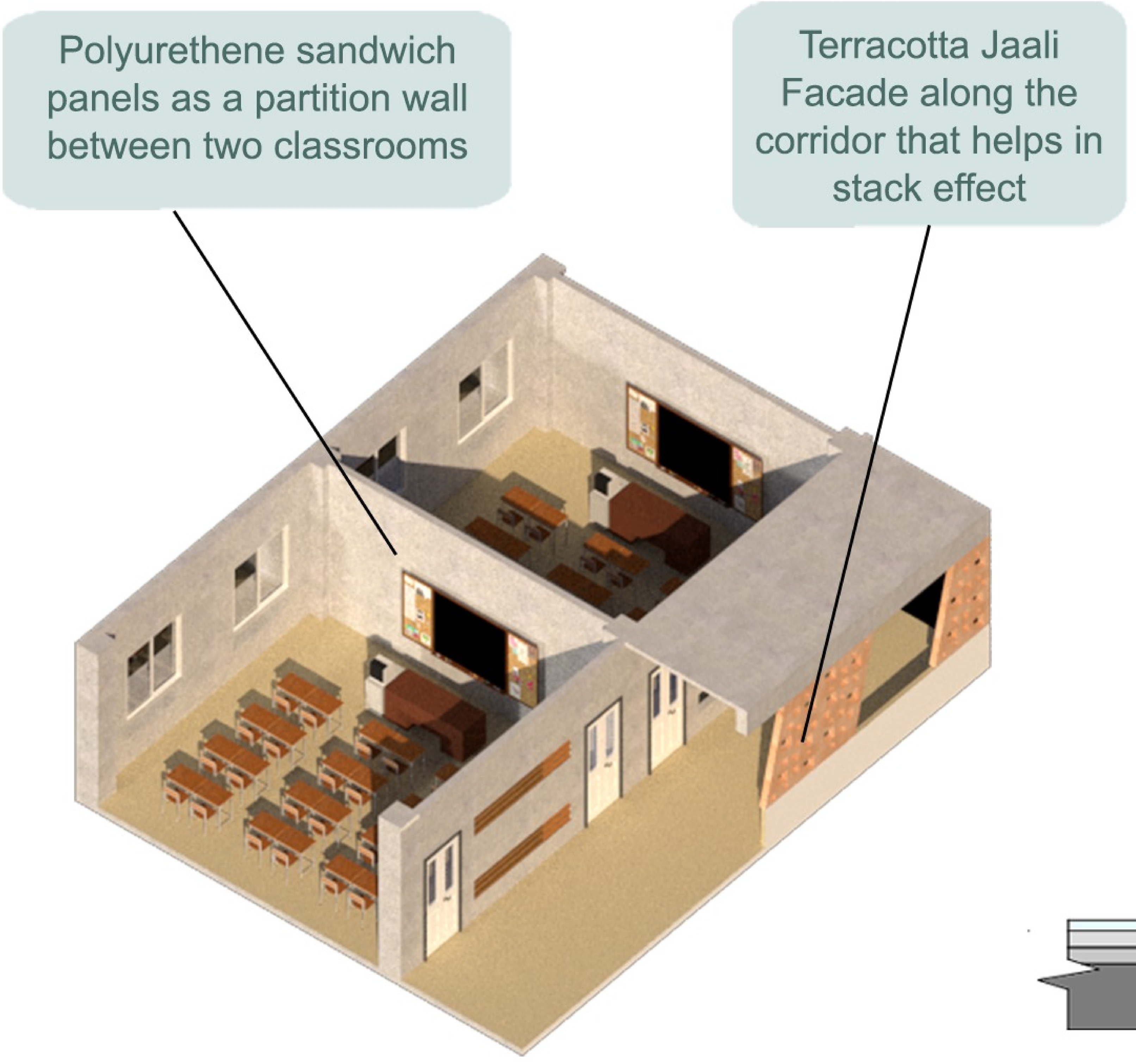


Figure 5.9.3-Typical Isometric view of classrooms

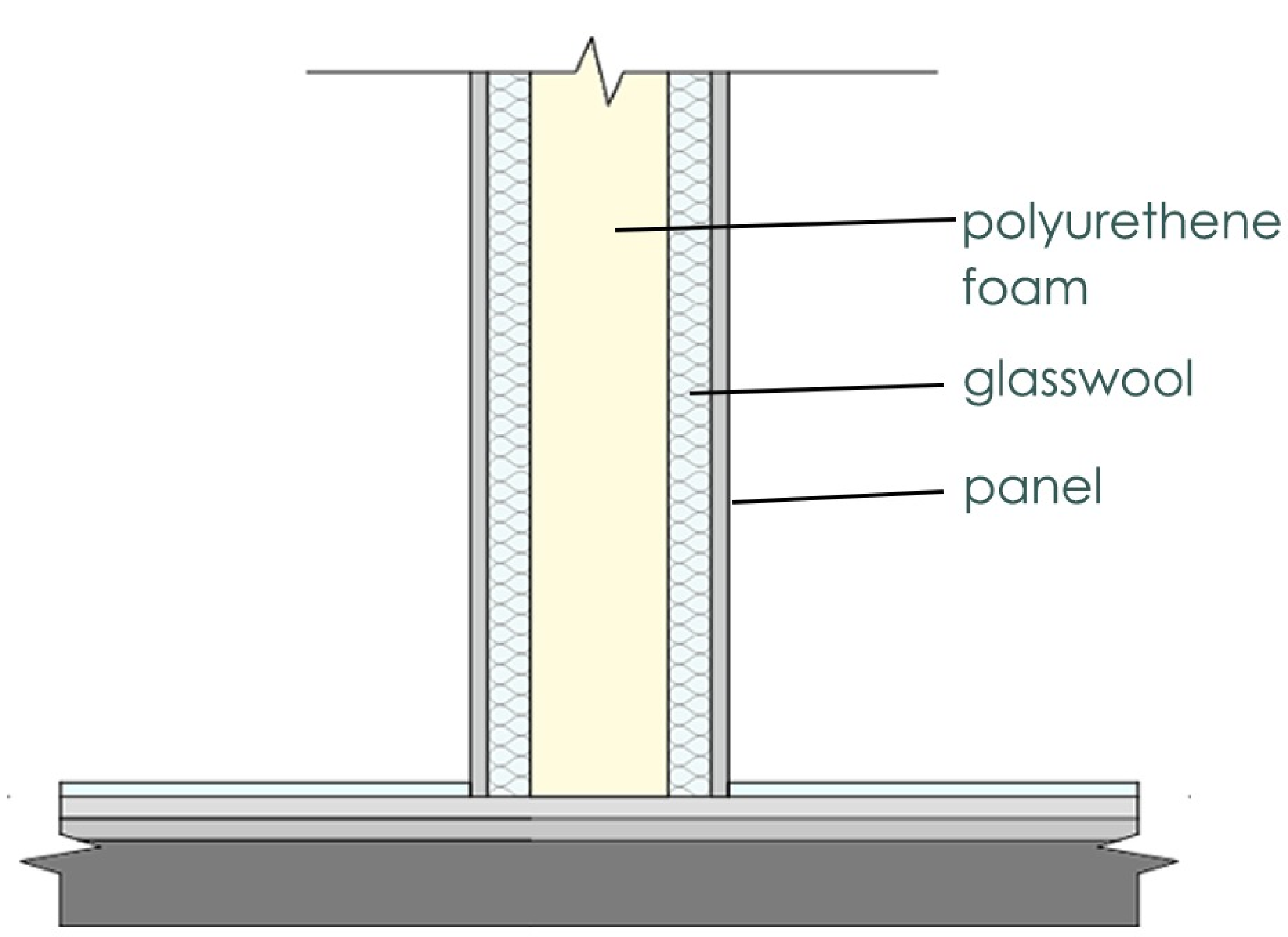
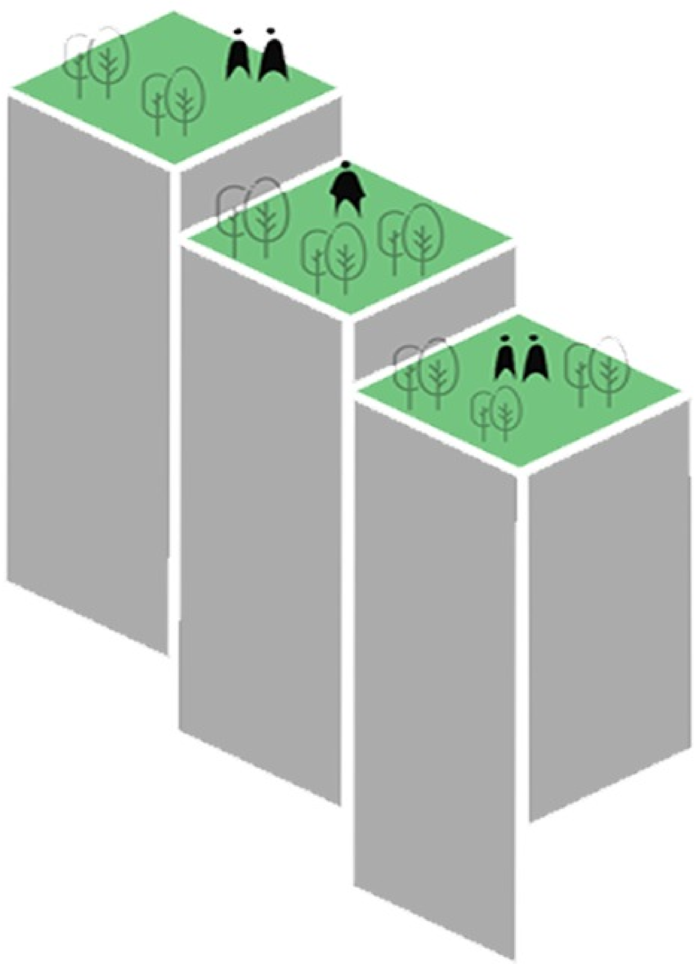


Figure 5.9.4Typical Cross section of Partition wall

INNOVATION -

c.) Terrace Garden promoting urban farming concept-



The building is designed in a way that promotes terrace gardens on the top three floors facing south west direction.
These gardens are shaded with the help of pergolas equipped with solar panels which can be rotated to certain angle as per seasonal requirements.
The idea behind terrace garden is to sow the concept of urban farming in the minds of young individuals and make them more aware of nature.

The idea behind terrace garden is to sow the concept of urban farming in the minds of young individuals and make them more aware of nature.

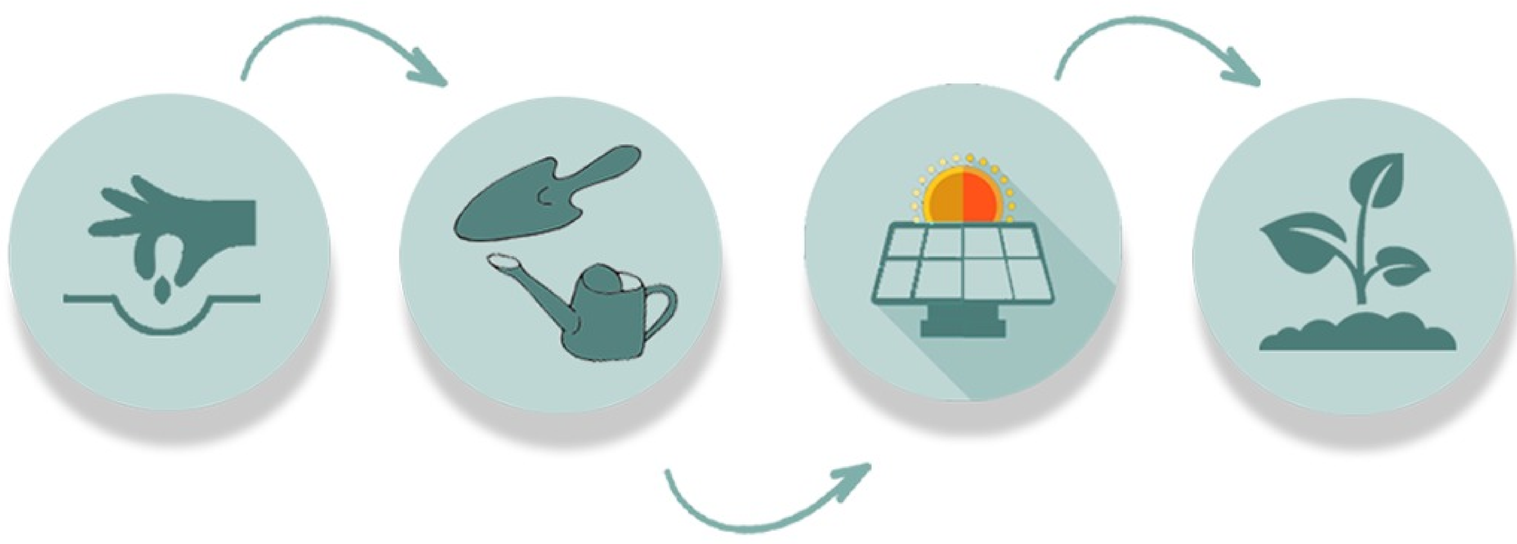


Figure 5.9.5- Learning carried out from simple steps

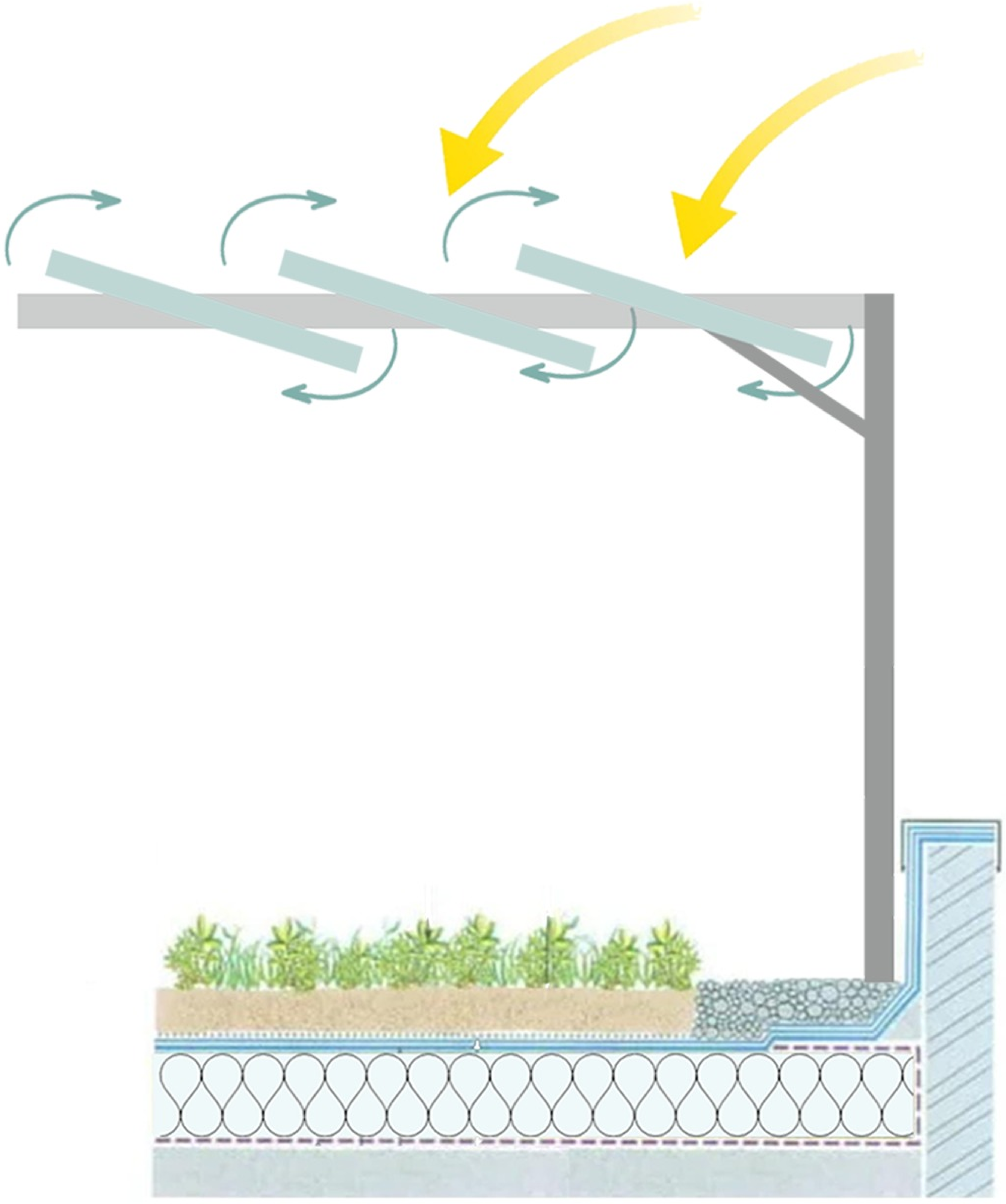
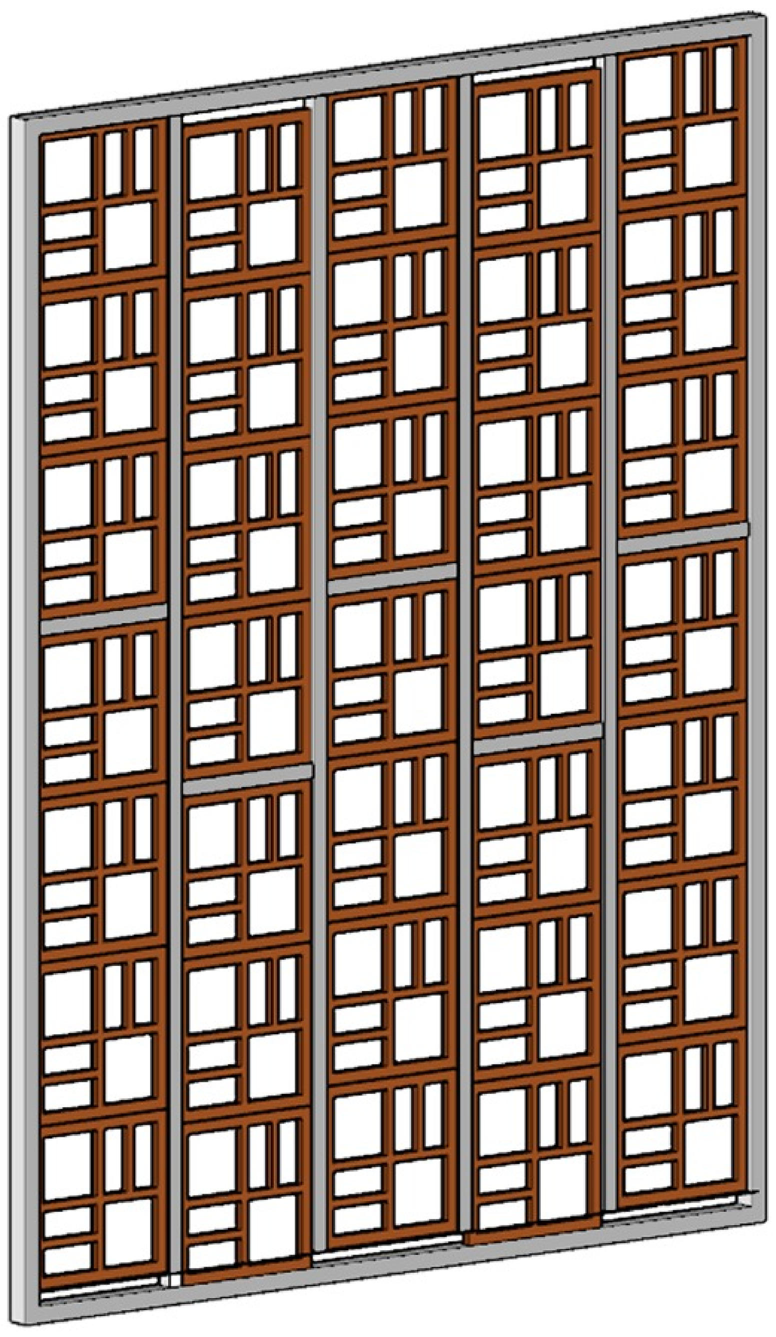
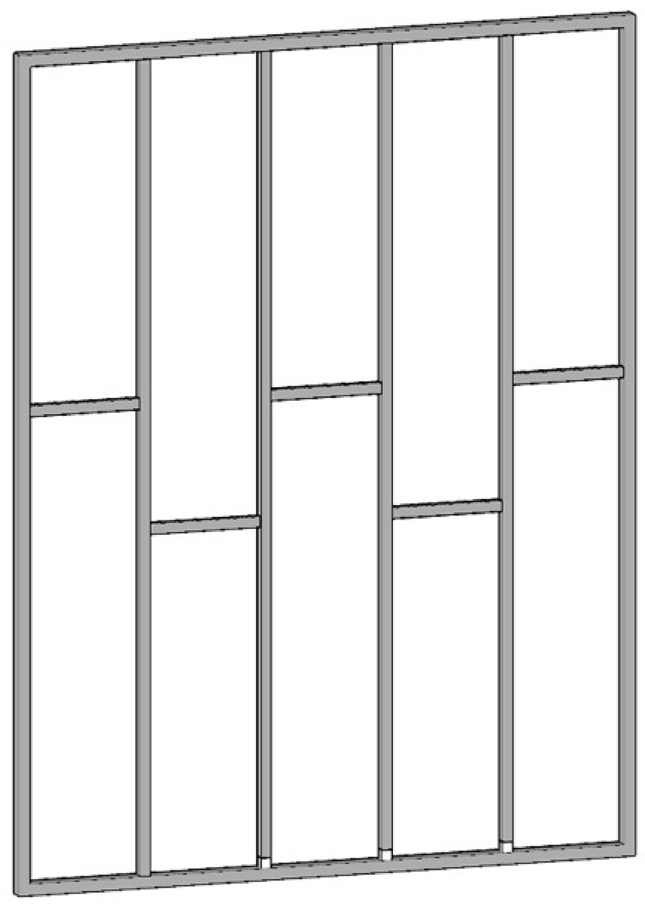


Figure 5.9.6-Typcial Cross section of Terrace Garden

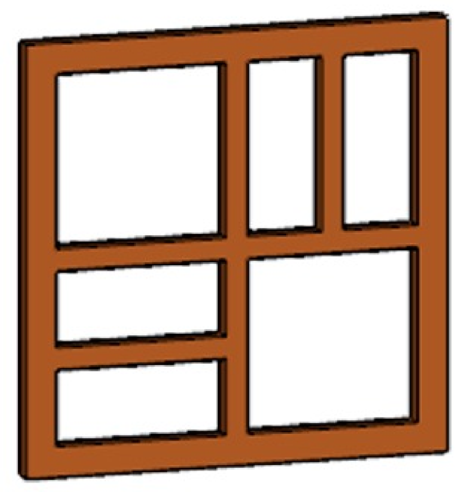
b.) Terracotta Screens -



TERRACOTTA JAALI

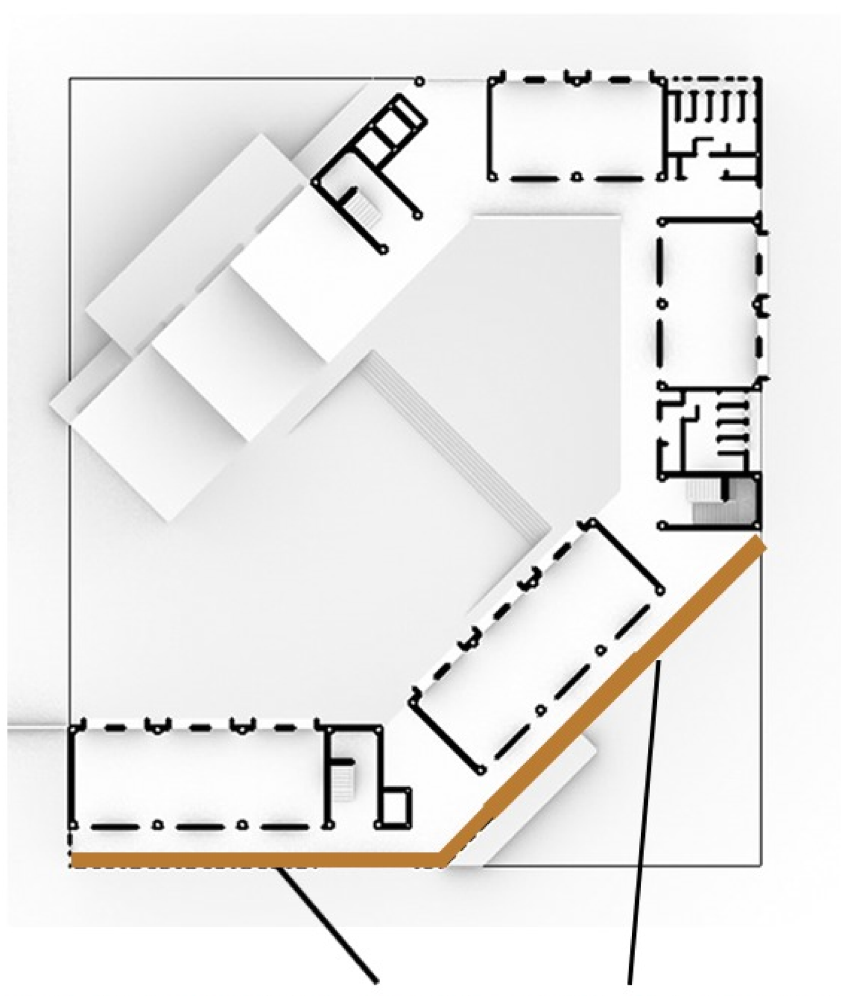


SUPPORTING STEEL FRAME



TERRACOTTA TILE

Terracotta screens have been placed at intervals of 3m on the building facade. This adds character to the structure while purifying the air that enters the building, keeping in mind the well being of the users. These screens are made of clay,



TERRACOTTA SCREENS ON SOUTH AND SOUTH-WEST FACADE

SOUTH AND SOUTH - WEST FACADE

Figure 5.9.6- Terracotta screens

Terracotta screens have been placed at intervals of 3m on the building facade. This adds character to the structure while purifying the air that enters the building, keeping in mind the well being of the users. These screens are made of clay, which is a traditional material and promotes the locals. Their flexibility reduces air temperature inside the structure. These screens have been placed in south and south-east direction as these sides will receive maximum radiation throughout the day.

FLOOR	SOLID WALL AREA	TOTAL PORE AREA IN ONE PANEL	NO. OF PANEL	TOTAL PORE AREA	VOID AREA	TOTAL VOID	VOID %	SHADED %
1	217.15	2.74	28	76.72	23.46	100.18	46.13400875	53.86599125
2	217.15	2.74	24	65.76	37.22	102.98	47.42344002	52.57655998
3	217.15	2.74	20	54.8	50.94	105.74	48.69445084	51.30554916
4	217.15	2.74	16	43.84	64.68	108.52	49.97467189	50.02532811
5	217.15	2.74	16	43.84	64.68	108.52	49.97467189	50.02532811
6	217.15	2.74	16	43.84	64.68	108.52	49.97467189	50.02532811
7	217.15	2.74	24	65.76	37.18	102.94	47.40501957	52.59498043
							AVERAGE SHADI	51.48843788

Figure 5.9.6- Terracotta jaali shading proof

HEALTH AND WELL BEING

Visual Comfort

A useful daylight illuminance(UDI) was performed on individual classrooms. The classrooms have been designed to have sufficient daylight to meet the SuperECBC compliance, i.e. UDI for 90% of the potential daylit time in a year for at least 60% of the floor area.

Terracotta jaails at south and north-east façade and appropriate shading devices are used to block direct solar gain. UDI comes at an average of 80.28% and day-light autonomy with an average of 82.30%.

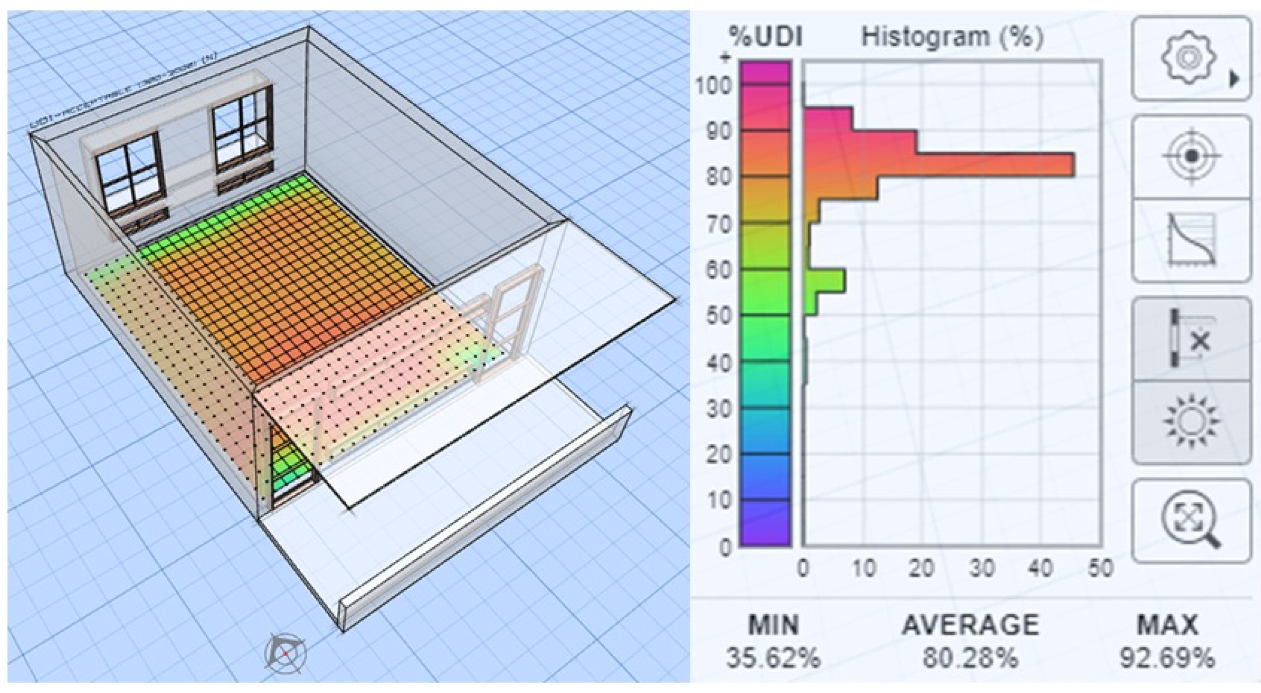


Figure 5.10.1-Useful daylight illuminance

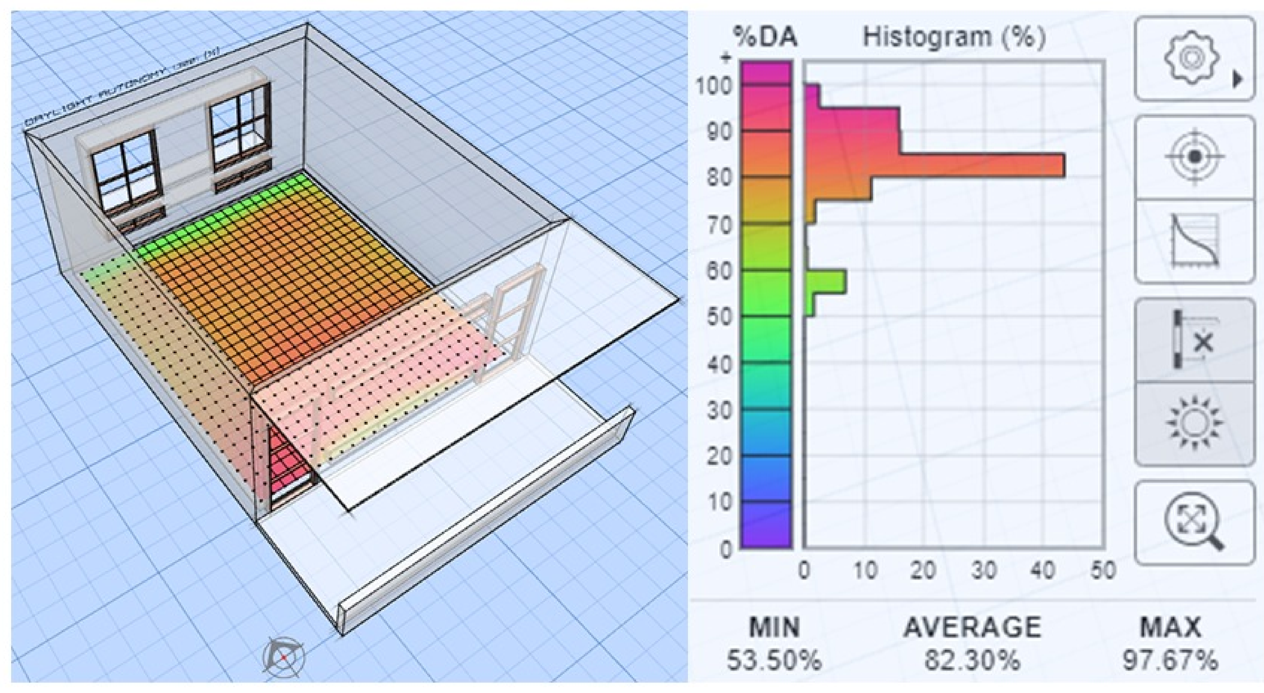


Figure 5.10.2-Daylight autono-

Indoor air quality

Maintaining indoor air quality is important to increase productivity and create a healthy environment. In the buffer open spaces, provided at each floor used to gather, we provided plants that encourage dehumidification and produce oxygen. This helps in keeping CO2 levels below 1000ppm as per recommended by ASHRAE for schools.

Monstera

Peace lily

Sansevieria

Money plant

Ventilation

The spaces most used like classrooms,etc are naturaly ventilated. All the spaces are de-signed in such manner that allows cross ventilation to provide minimum fresh air re-quired as per NBC.

Ventilation rates of different spaces is given by:

Ventilation rate = (number of people x Rp) + (Area x Ra)

SPACE TYPE	No.of student	Rp(l/s.person)	Floor area (m2)	Ra(l/s.m2)	Ventilation rate (l/s)
Kinder garden	25	5	40	0.6	149
Primary classroom	26	5	40	0.6	154
Secondary classroom	26	3.8	40	0.3	110.8
Computer room	80	5	100	0.6	460
Chemistry lab	60	5	80	0.9	372
Physics and Bio lab	45	5	60	0.9	279
Activity room	45	5	60	0.9	279
Library	60	2.5	80	0.6	198
Dining area	150	3.8	200	0.9	750

Ventilation rate

Table 5.10.1- Ventilation rate

IMAC comfort analysis annauly is studied to understand the daily average temperature inside the spaces. A target of 22-27 degree is achieved by using passive stratergies for 8 hours of occupancy. Use of traditional facade shading techniques reduces indoor temperatures by 4-5 degrees.

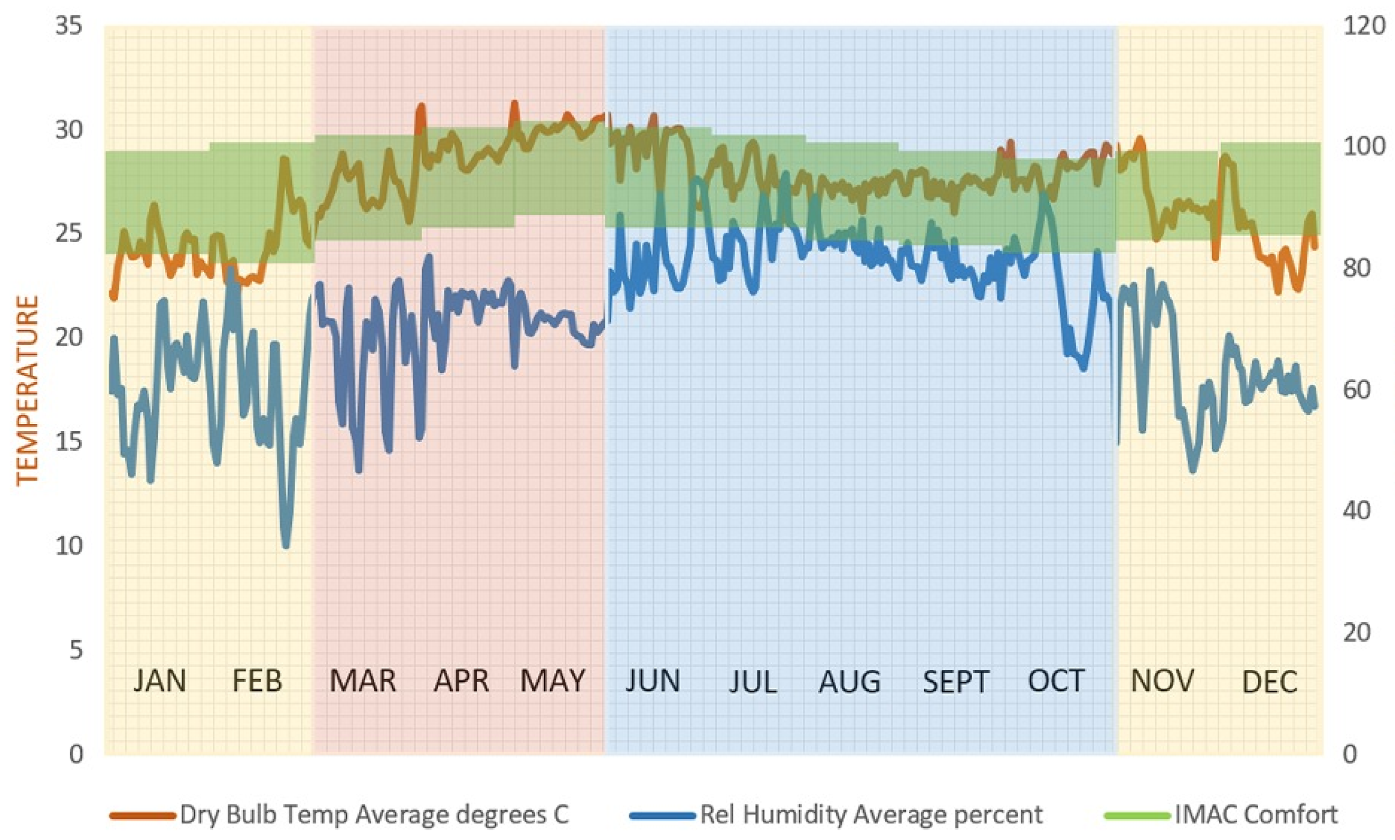


Figure5.10.3-Annual IMAC chart

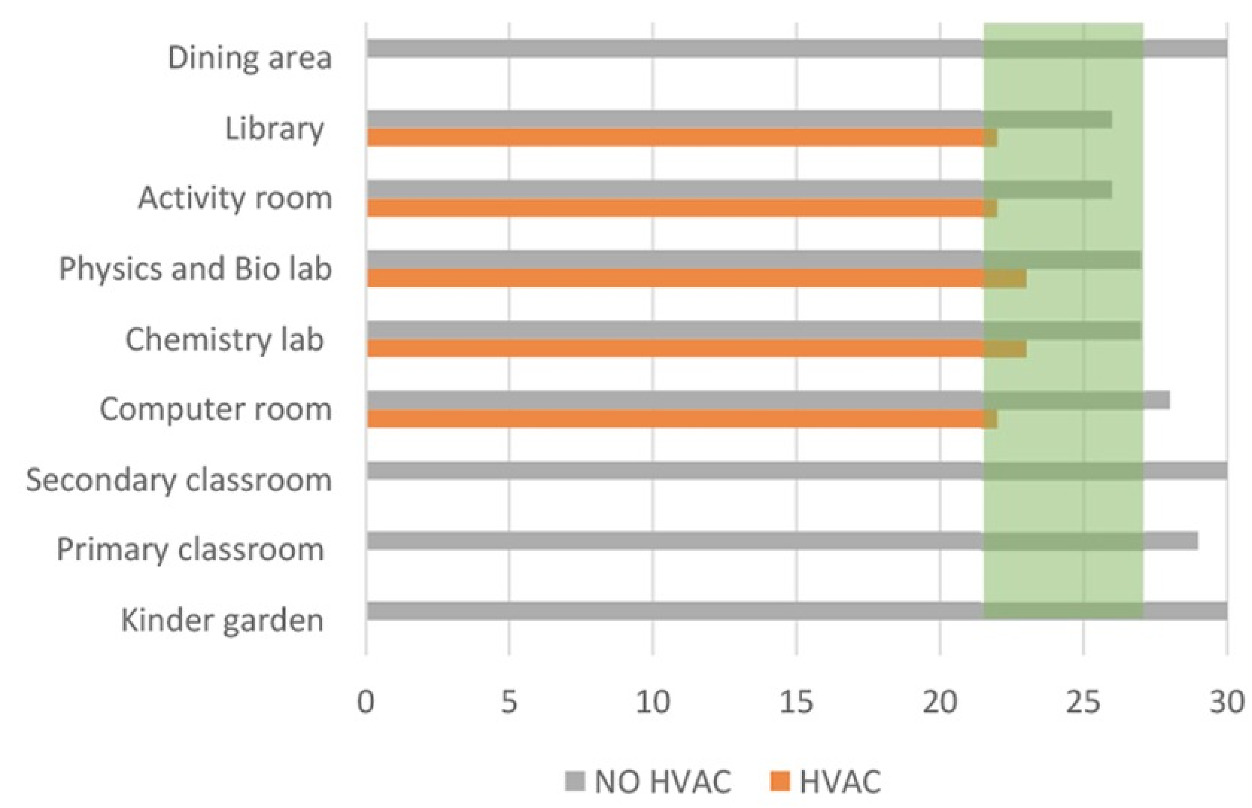


Figure5.10.4-Daily average temperature band

Thermal comfort

For our design, we have followed the IMAC model for thermal comfort, where the occupants are able to tolerate a wider range of environmental conditions, which, in turn helps save energy.

To maintain thermal comfort in non-conditioned spaces, passive cooling techniques are employed.

Fundamentals of orientation have been considered.Orientation of class rooms and occupant spaces are done such that buffer spaces are designed in the direction receiving harsh sunlight i.e. south and south- west and maximizing light from north-west, north and east direction.

Shading devices and buffer spaces around unconditioned occupancy spaces, such as corridors, courtyards, stairwell, terraces, etc to reduce direct sun and hot winds.

Terra cotta jaali façade in the south and north-east direction is designed to help diffused light enter the interiors and in dehumidification by creating venturi effect of wind.

The occupancy spaces are planned around a courtyard and open-buffer spaces are created on each floor acting as air pockets. This encourages cross ventilation and hence helps to dehumidify and create a comfortable environment for users.

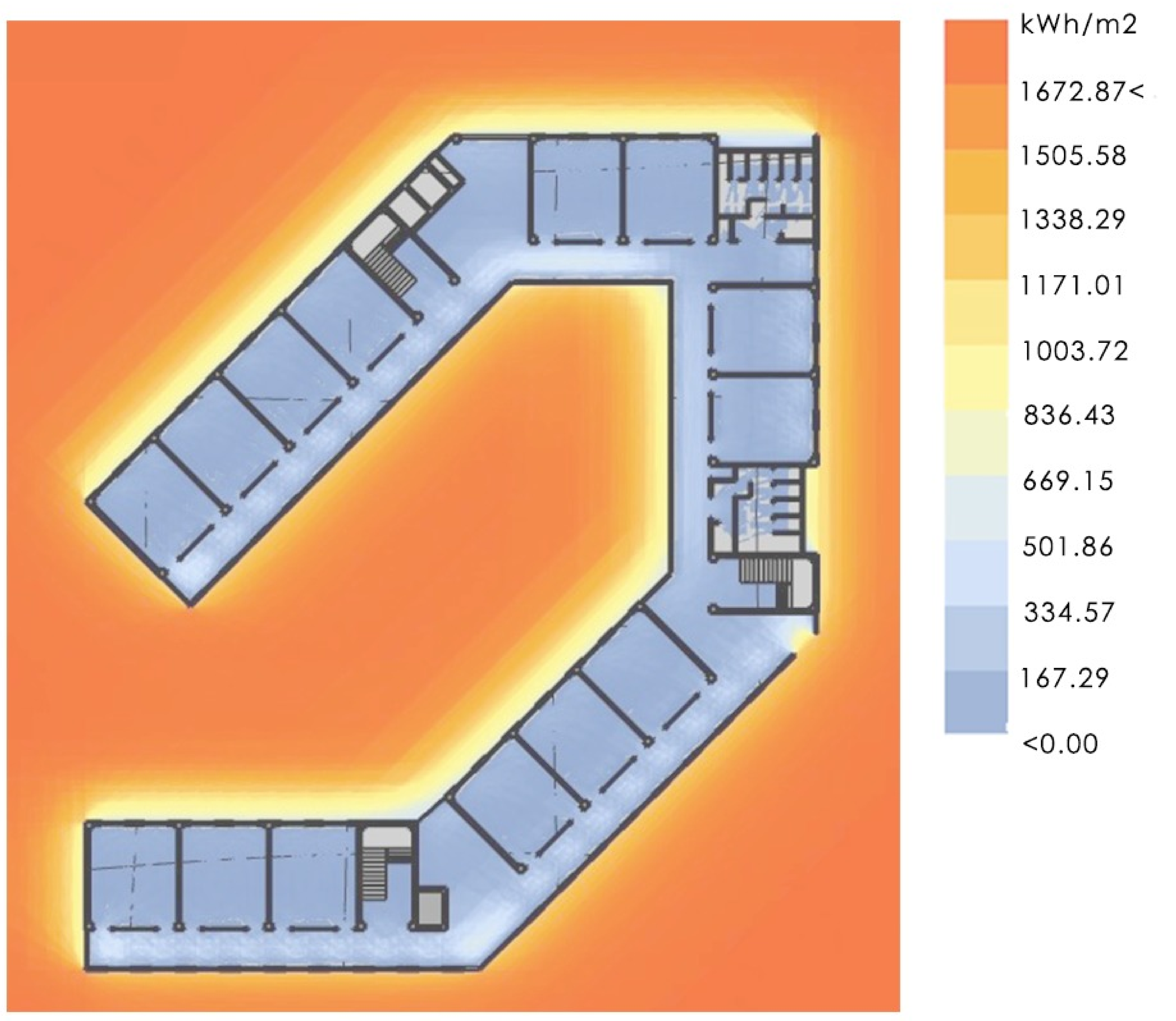


Figure 5.10.5-Radiation analysis (source:Grasshopper)

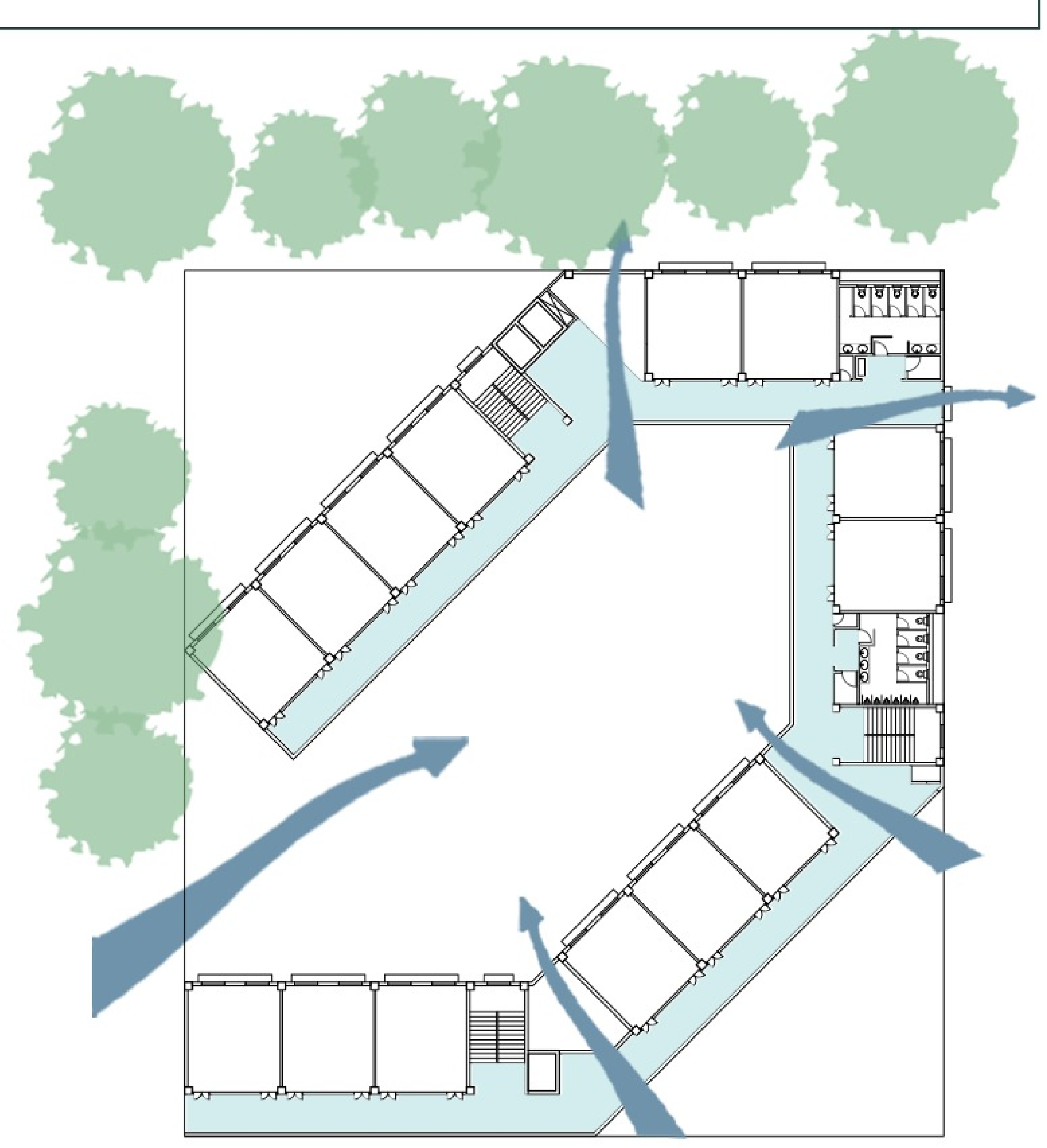


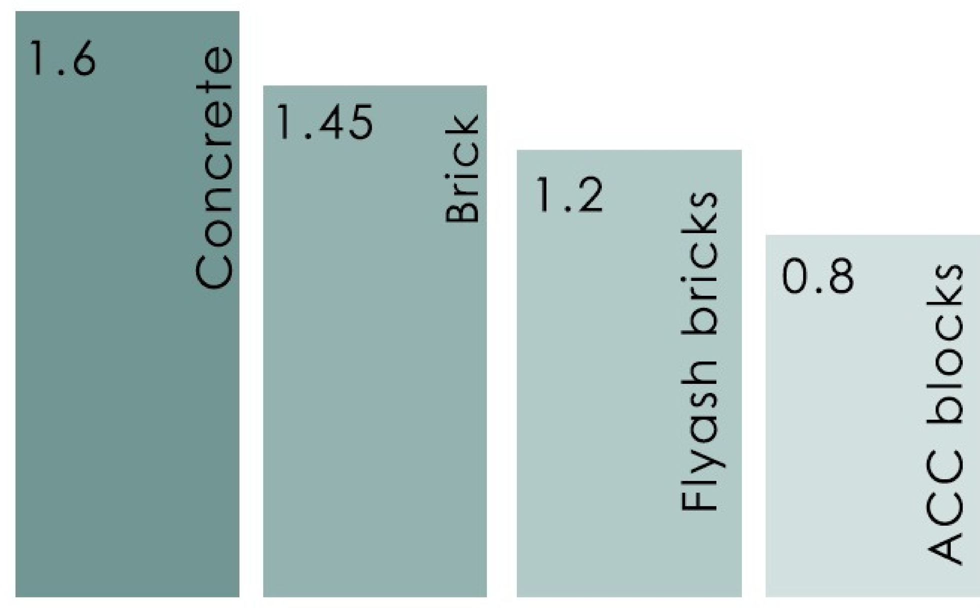
Figure 5.10.6-WInd pattern

Learning and Productivity
Places are planned around the courtyard, enhancing the spatial quality and ensuring the blend of nature with the built mass. Provision of courtyards and open spaces boost social interaction among students and staff and hence, increasing the productivity.
Spaces are planned according to the user age groups.

Pollution
The periphery of the site is lined with local vegetation to create a buffer zone that blocks external pollution and noise from entering the site.

Materials

The external structure is made of AAC blocks which has lower U value suitable for construction in compliance to IGBC guidelines.The external façade also uses terracotta jaali on south and north-east side. As Vashi has a warm and humid climate, the jaali encourages natural ventilation with the help of venturi effect being created due to jaalis. During Summers, where it tends to get uncomfortably humid, the terracotta jaali facade (which is porous in nature) can absorb the moisture and help encourage evaporative cooling.
The interior finishes are selected to limit the emission of Volatile Organic Compounds (VOC) in the indoor environment.



TYPES OF PAINTS & COATINGS	VOC LIMIT (g/L less water)
Non- flat (Glossy)	150
Flat (Mat)	50
Anti-corrosive/ Anti-rust	250
Clear Wood Finish: Varnish	350
Clear Wood Finish: Lacquer	550

Table12.1-Material list

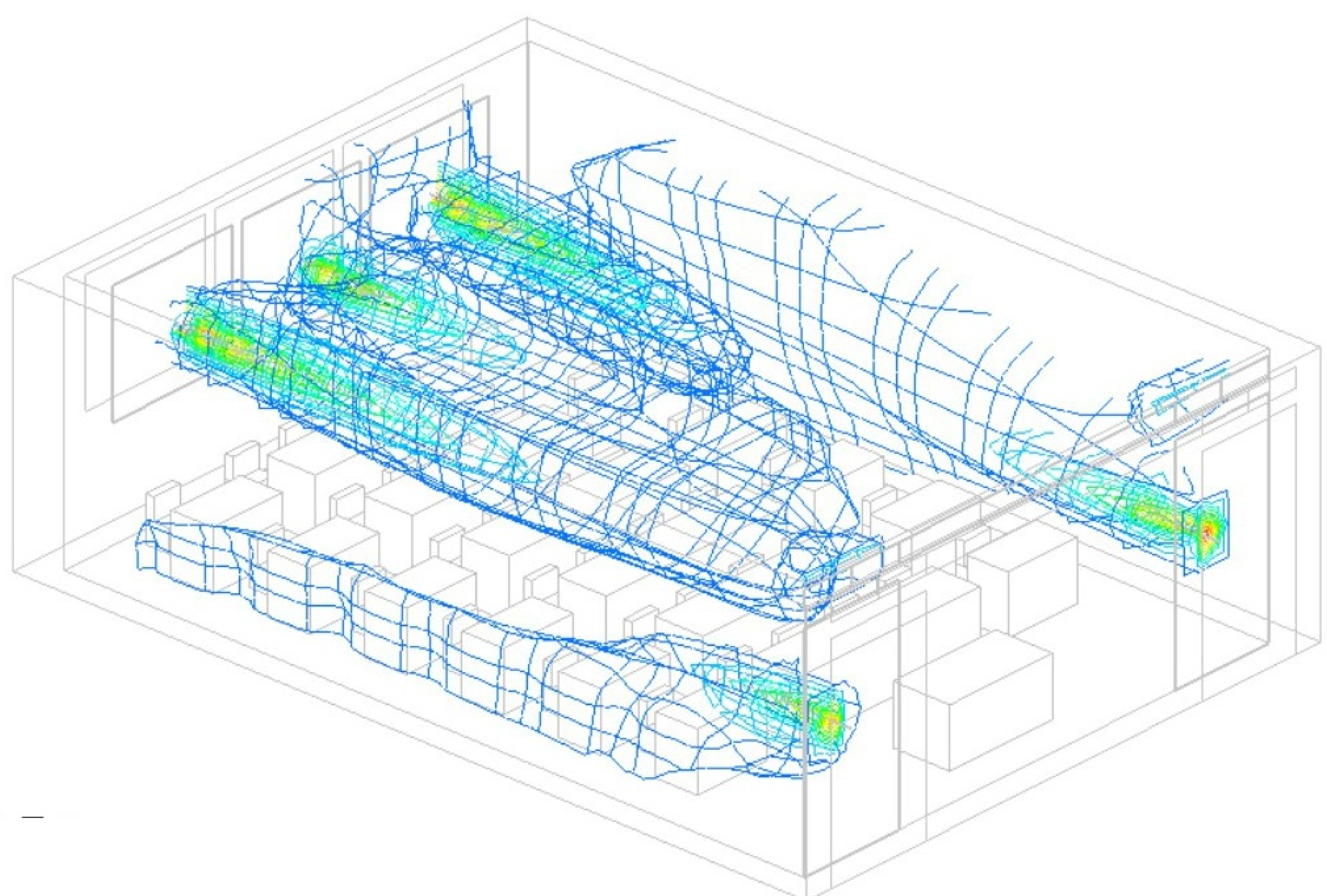


Figure 5.10.9-Natural Ventilation Simulation

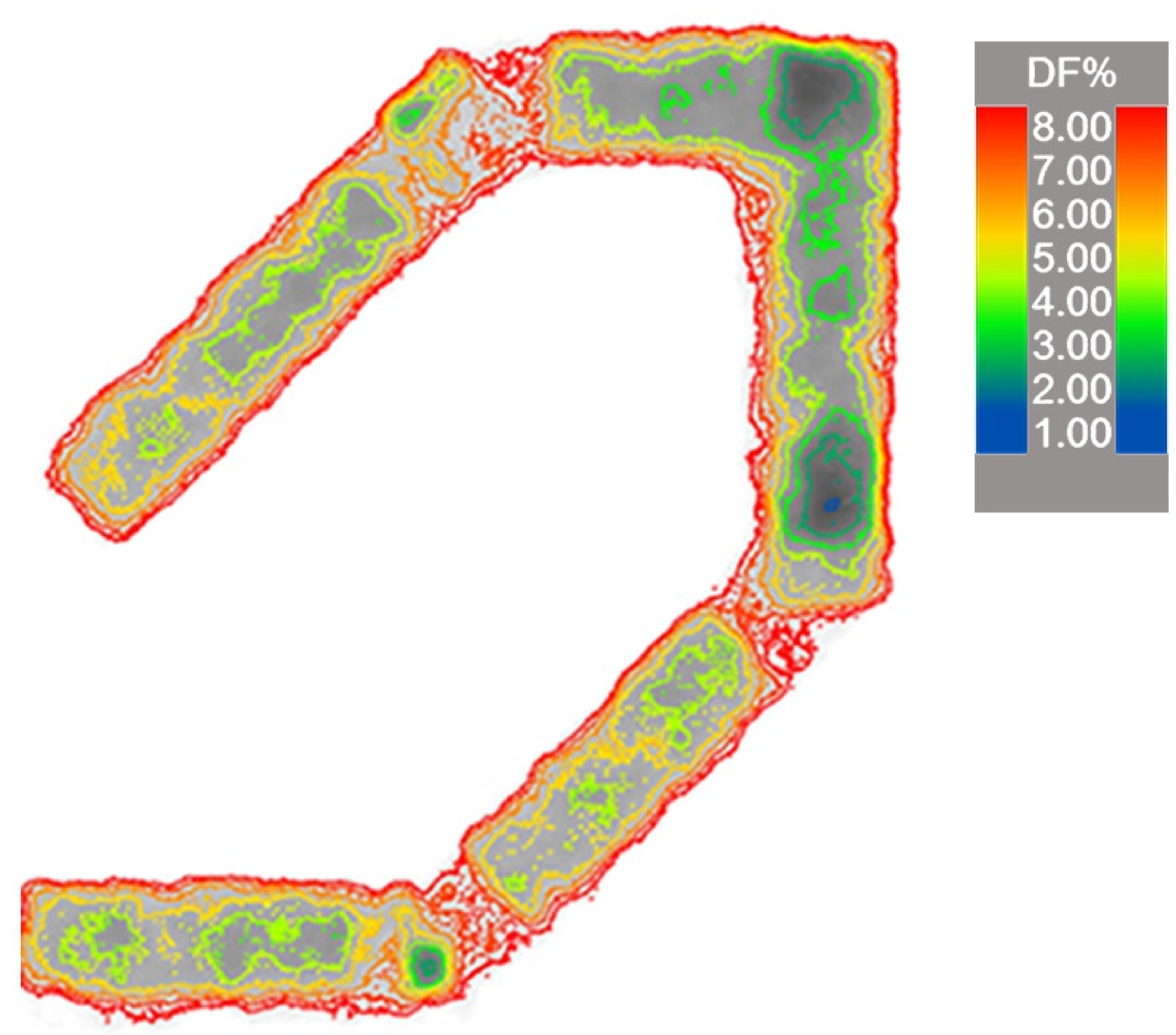


Figure 5.10.10-Day light factor (source:Velux)

VALUE PROPOSITION

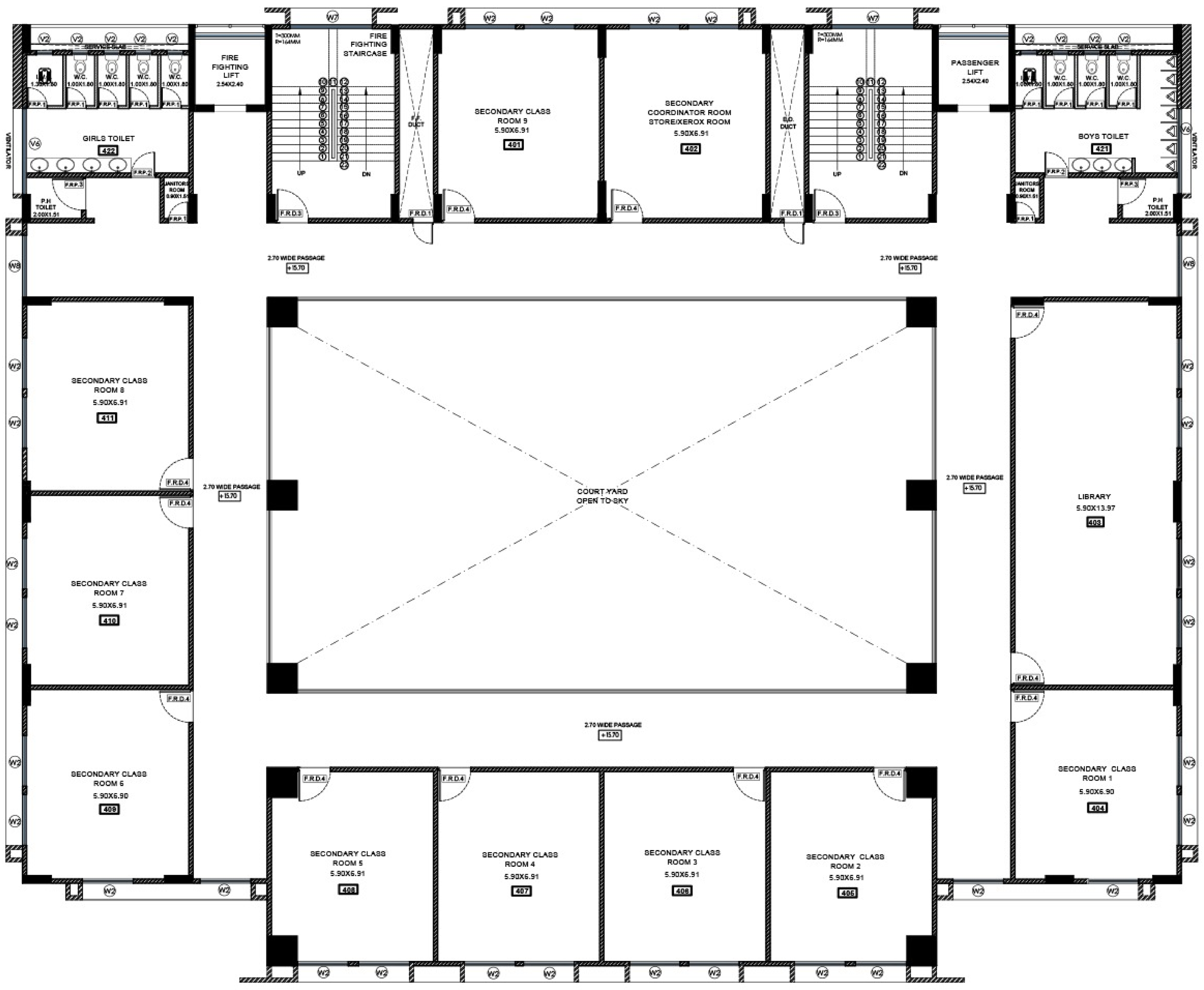


Figure5.11.1-Typical layout (source: project partner)

A layout provided by our project partner was been examined from a various angles to make sure the structure we create becomes flawless. There are lack of recreational spaces for students. The building also features forced ventilation and doesn't interfere with nature resulting in increasing electrical cost. Although if it is in the ideal position, the construction lacks a precise landscape ratio and all of the rooms are stacked on top of one another, which limits the use of space. Students should receive their education in a setting that helps them become healthier and better learners. Hence there was a need in altering

Team **Austenite**, which advocates for a comprehensive approach to mitigating carbon emissions, has concentrated on all issues related to lowering emissions and promoting a better environment. Because of the structure's high climatic responsiveness, the environment is favourable for a longer duration. By fusing the architectural form with nature, teachers can ensure that their kids are comfortable during class time and that their children will grow up healthily. The project's eco-friendly components and materials like : terracotta lower heat gain windows and local flooring, which prioritise health over everything else, prevent the earth from becoming carbonised. These materials are readily available and may be bought from nearby sources, which will save down on the expense of transportation. These materials are cost effective and can be reused giving maximum payback.

- HEALTHY ENVIRONMENT
- AFFORDABLE FOR USER
- ECOFRIENDLY MATERIALS
- EASY MAINTAINANCE
- ENERGY EFFICIENT

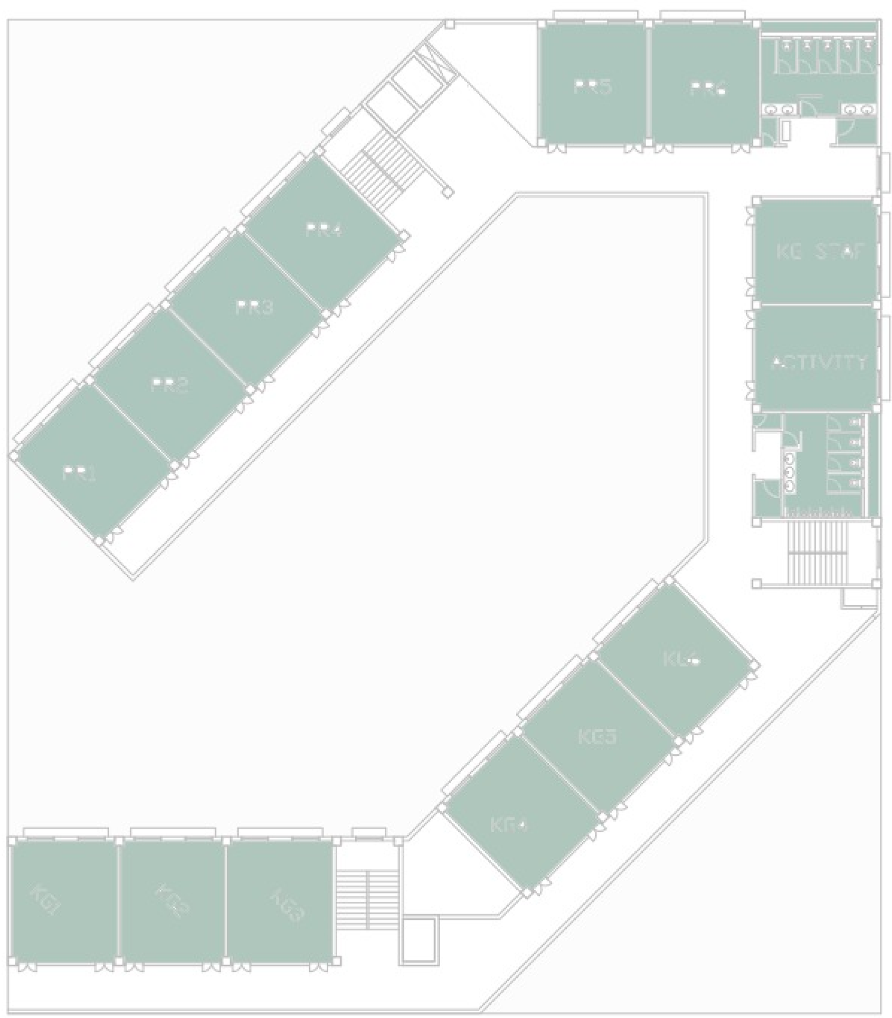
ENERGY AND WATER MANAGEMENT

Net zero building design is achieved using passive design stratergies like shading , envevlope optimisation , increase in efficiency of the building by taking advantage of daylight and using efficient light fixtures and considering comfort optimisation and right sizing of hvac systems.

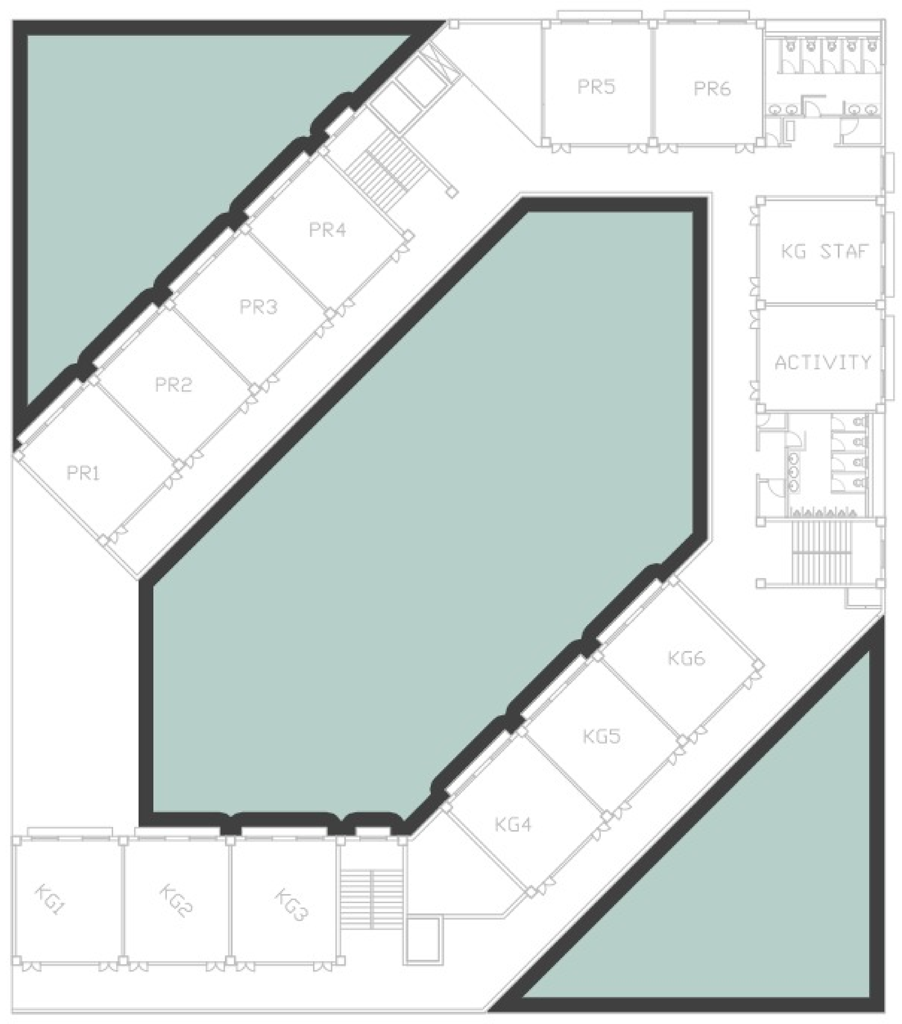
By using low flow fixtures, aerators, waterless urinals and low flow dual flush water closers, the water demand in design case was reduced by 51%. Rainwater collection on terrace areas, hardscape and courtyard also takes place. Grey and Black water generated is channeled into the Eco STP for reuse.

Figure5.11.2-Energy balance

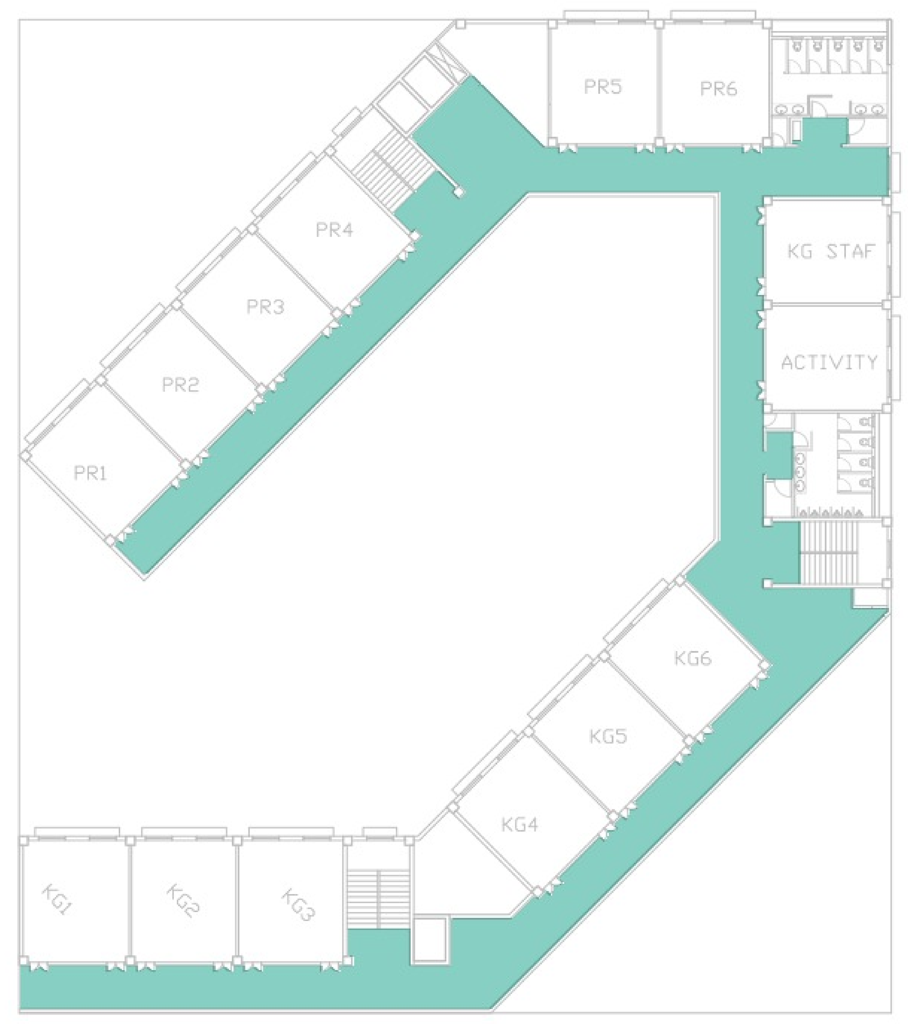
15.77% STP
76.24% RAIN WATER
7.98% MUNCIPAL



A: Dividing the plan into 4 wings for allowing wind and user circulation. Seperation creates in between break through spaces for children.



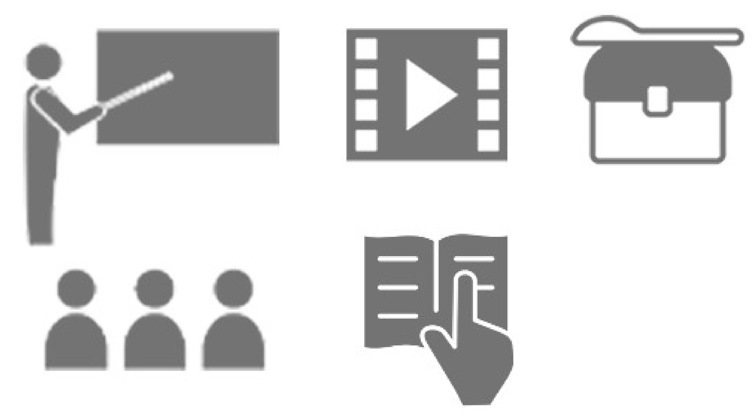
B: Site is divided into 3 zones that gets shaded according to annual shadow analysis. This balances the landscape ratio on the site.



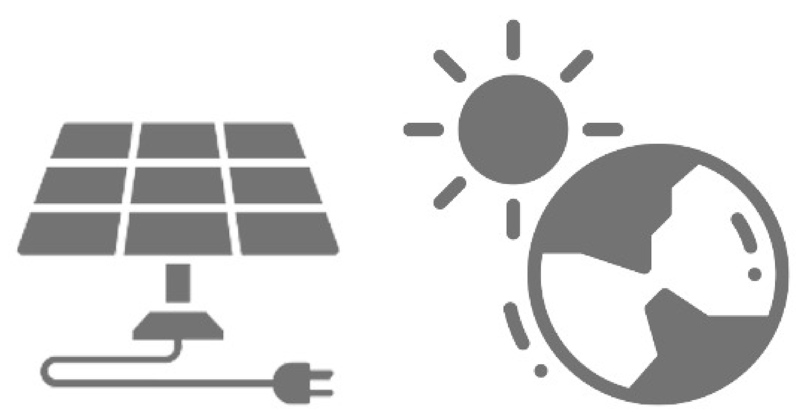
C: To achieve maximum daylight cut, the corridors are facing the southern facade. Classroom are oriented north south to avoid radiation.

Figure 5.11.3-Design evolution

The classroom has been planned to have enough natural light to give the pupils comfort in their visual environment. Teraracota jalis on the south and north-east facades contributes to the necessary shading, reducing the excessive heat gain.



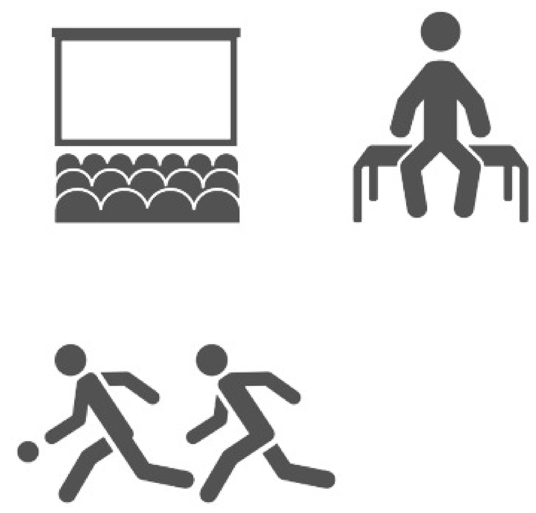
On-site solar roof tiles are used in the design of the solar grid. All of the fundamental equipment loads, including fans, lights, water coolers, etc., are met by the electricity generated by the solar grid. provide energy backup for at least 6 days as well, just in case there are power outages or other crises.



A number of trees are present on the property, both inside and out, including ones in the waiting room and foyer at the entry. These trees help to reduce pollution. The trees and foyer areas serve as natural barriers and thresholds separating the school grounds from the surrounding roads, enhancing student safety and security.

The structure's geometry enables the creation of a number of breakout areas that act as microclimates. Transitional zones provide opportunities for a variety of activities and promote learning through social interaction. It fosters an enjoyable learning environment for all. The areas can all serve as achievement boards and showcase areas to motivate students to engage with the curriculum.

Numerous advantages are provided by the centre courtyard. It serves as a ventilation system for the building by acting as an air court. In addition, this courtyard offers a multipurpose setting for a variety of community activities, including displays, exhibitions, and other activities. For the school, it also serves as a source of income. These settings foster community, education, and overall wellbeing.



A quiet area is where the Kinder Garden was designed. Keeping kids safe while allowing them to appreciate nature. They can play with a seesaw and enjoy bird viewing and would aid them in finding their own voice.

Our building blends in with the surroundings the best and strikes a good balance between energy, water, technology, and the environment. For the benefit of the stakeholder groups, including kids, instructors, parents, and the local community, a perfect net zero construction option has been put forth. The types of places like , breakthrough spaces , air court , kindergarden , corridors , etc spread more interconnectivity betwenn different spaces as well as with nature and sets an example in the society for a perfect solution for sustainable design. This design is particularly site specific and has its own unique specialty. This design also empowers the local labourers.

PARAMETERS	DESIGN CASE	BASE CASE
Lower heat gain	✓	X
Optimum daylighting	✓	X
Natural ventilation	✓	X
Energy genereation potential	✓	X
Orientation	✓	✓
Architectural aesthetics	✓	X
Green spaces	✓	X
Resilient	✓	✓
Traditional materials	✓	X

COMPARISON TABLE

Figure 5.11.4-Facade solution

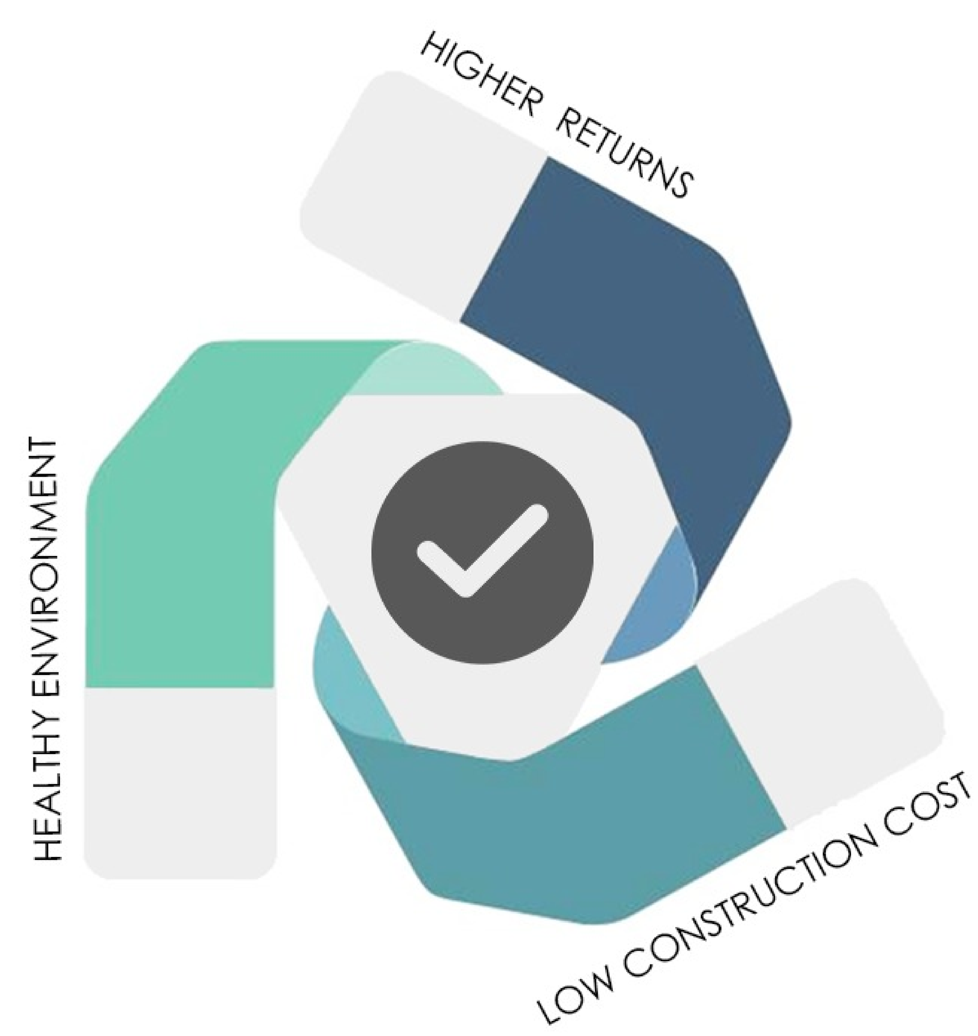


Figure 5.11.5-Our overall goal

APPENDIX

Tel.: 2419 9595
2419 9500

Website : www.ies.edu
E-mail : admin@ies.edu

VALUE ADDITION THROUGH EDUCATION

INDIAN EDUCATION SOCIETY

[Registered under Society's Registration Act,1860 bearing Reg. No. Bom. 79/GBBSD and under Public Trust Act.1950 bearing Reg. No. F-190 (Bom.)]

◆ Raja Shivaji Vidyasankul, Hindu Colony, Dadar (East), Mumbai - 400 014. ◆

सा विद्या या विमुक्तये

IES/ Sect/ 2352 /2022-23

22nd September, 2022

To,
The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organization INDIAN EDUCATION SOCIETY has provided information about our Project – IES NAVI MUMBAI HIGH SCHOOL, VASHI to the participating team led by IES's COLLEGE OF ARCHITECTURE, so that their team AUSTINITES 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,

Name of Representative: SAGAR SULE

Designation: Vice President, IES

Email: sagarsule@ies.edu

Phone: 9820305891

Indian Education Society's
College of Architecture
VALUE ADDITION THROUGH EDUCATION
'Vishwakarma' M. D. Lotlikar Vidya Sankul, Gate No.1, Opp. Lilavati Hospital, Bandra Reclamation, Mumbai 400 050.
Tel. : 26561717/856/858/855 • Fax : 2656 1899
E-mail : iescoa@ies.edu • Website : www.ies.edu/architecture

Date: 22nd February 2023

To,
The Director
Solar Decathlon India

Sir/Madam,

This is to inform you that our institute IES College of Architecture has taken part in Solar Decathlon and following are the bonafide students of our college who participating in 'Solar Decathlon Competition 2022-23. These students are team members of Austenite Team.

1. **Jainik Shah- 3rd Year (Team Leader)**
2. Preksha Shah- 3rd Year
3. Bhargav Patel- 3rd Year
4. Ami Khandor-3rd Year
5. Sakshi Somya- 3rd Year
6. Prajakta Mestry-3rd Year
7. Rucha Subhedar-3rd year
8. Akash Kamble- 3rd Year
9. Vrushali Shah-3rd Year
10. Mayank Kanade- 4th Year
11. Atharv Vaidya- 5th Year
12. Yutika Doshi – 3rd Year

Thanking you,

Ar Vinit Mirkar
Principal
IES College of Architecture

SVKM'S NMIMS Deemed to be UNIVERSITY

MUKESH PATEL SCHOOL OF TECHNOLOGY MANAGEMENT & ENGINEERING

Date: 16 th March, 2023

TO WHOM SO EVER IT MAY CONCERN

This is to certify that the following students are bonafide students of SVKM's NMIMS, MUKESH PATEL SCHOOL OF TECHNOLOGY MANAGEMENT & ENGINEERING studying in 4th year MBA Tech (Civil Engineering) and B Tech (Civil Engineering) for the academic year 2022-2023.

Name	Roll No.	SAP Id
Harshil Parekh	M013	70441019015
Akshata Khande	G013	70051019016

This certificate certifies that the above mentioned students are a part of team Austenite and the certificate is granted on their request for the purpose of participating in Solar Decathlon Competition 2022-23.

16/3/2023

Gauri Pedgulkar
Assistant Registrar
MPSTME

Mukesh Patel School of Tech. Mangmt & Engg.
SVKM'S NMIMS Mumbai 56

06/14/2000

K. J. SOMAIYA COLLEGE OF ENGINEERING

(A Self-financed Autonomous College Affiliated to University of Mumbai)
Vidyanagar, Vidyavihar, Mumbai - 400 077.

Ref. : KJSCE/BON/ 444/2022-23 Date 16/03/2023

This is to certify that Bro./~~Sis~~ Bhanushali Pranay Jayanti is/~~was~~ a bonafide student of this College in the Last Year B.Tech (Mechanical Engg) class during the year 2022-23 and that to the best of my knowledge he/~~she~~ bears good moral character. This certificate is issued at his/~~her~~ request to enable him/~~her~~ to apply for 'Solar Decathlon competition 2022-23' as a member of team 'Austenite'.

K.J. SOMAIYA COLLEGE OF ENGINEERING MUMBAI-77. VIDYAVIHAR

Registrar
Administrative Officer
K. J. Somaiya College of Engineering
Vidyavihar, Mumbai - 400 077

Taiba Engineering Consultants

PROJECTS ● TRAINING ● PLACEMENTS

28 November 2022

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organization, Taiba Engineering Consultants, is collaborating with the participating team led by IESCOA on a Educational Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be very helpful to the team in terms of MEP Integration and knowledge regrading HVAC systems and green building simulations.

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

We would like / do not want our organization's logo to be displayed on the Solar Decathlon India website, recognizing us as one of the Industry Partners for the 2022-23 competition.

With warm regards,

TAIBA ENGINEERING CONSULTANTS ★ INDIA ★

Name: Dr.Syed Moazzam Ali

Designation: Director

Taiba Engineering Consultants

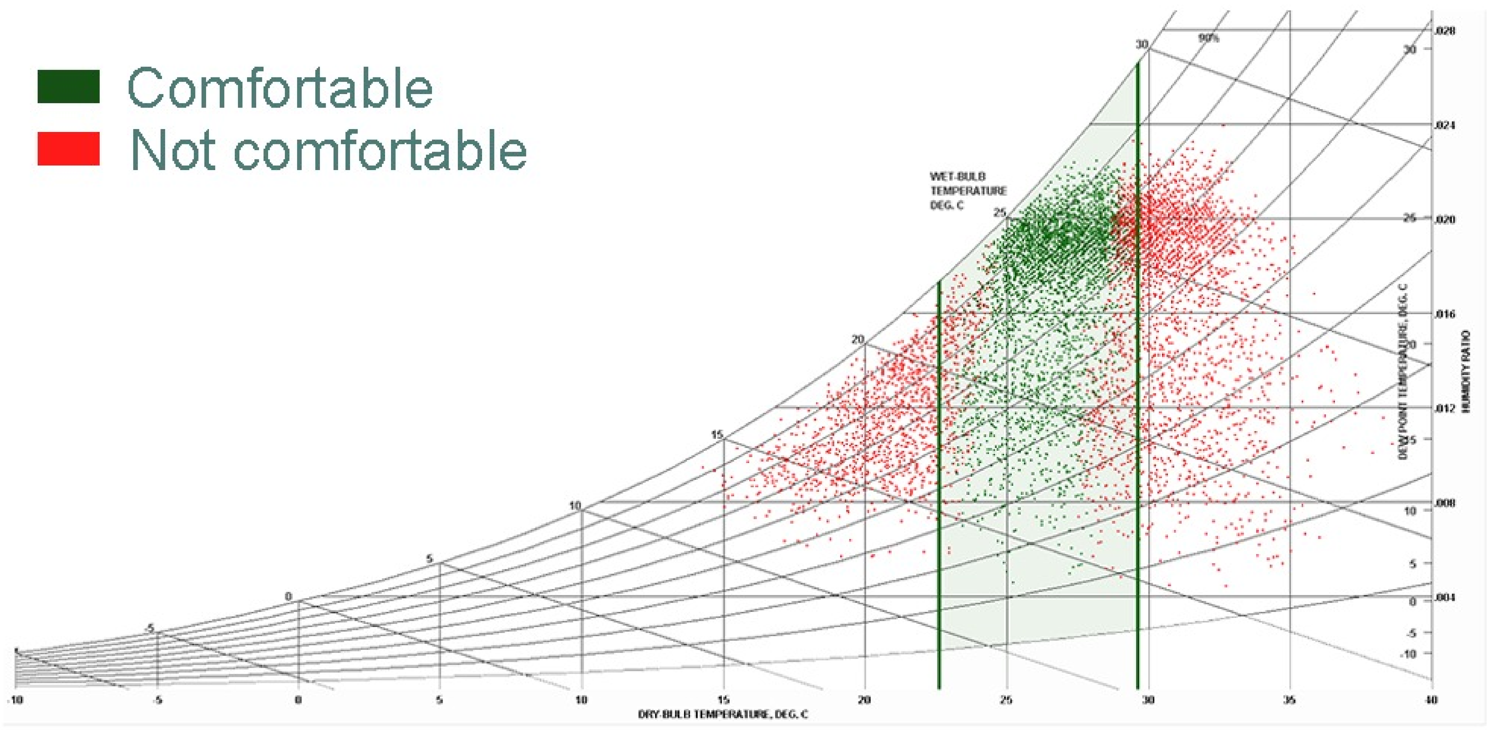
Email: Ali@Taibamep.com

Phone+91 9848461870

a.) Climate analysis:

Psychometric chart:

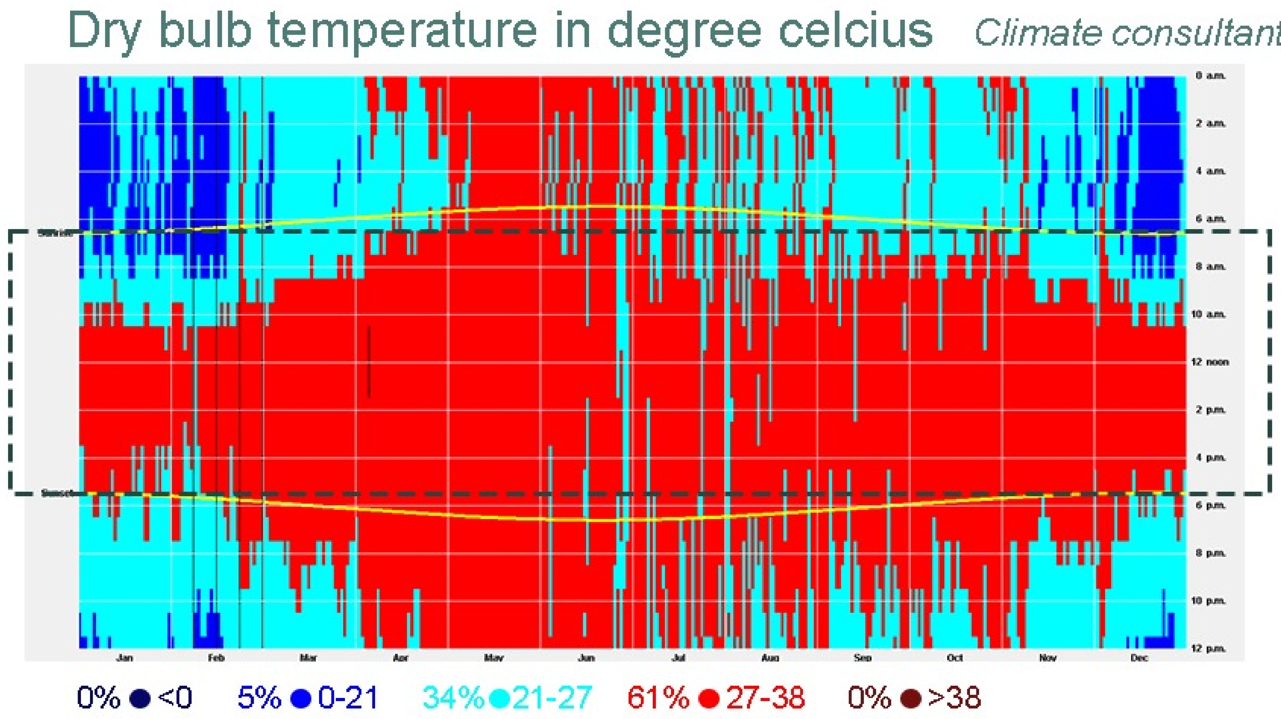
Climate consultant



Navi-Mumbai has a warm and humid environment, so in order to reach the comfort level, dehumidification and temperature reduction are needed.

- December, January, and February have below-comfortable morning temperatures.
- March, April, and May have a majority of days that are warmer than comfortable.
- Temperatures throughout the months of June, July, August, and September are well within the comfort zone.

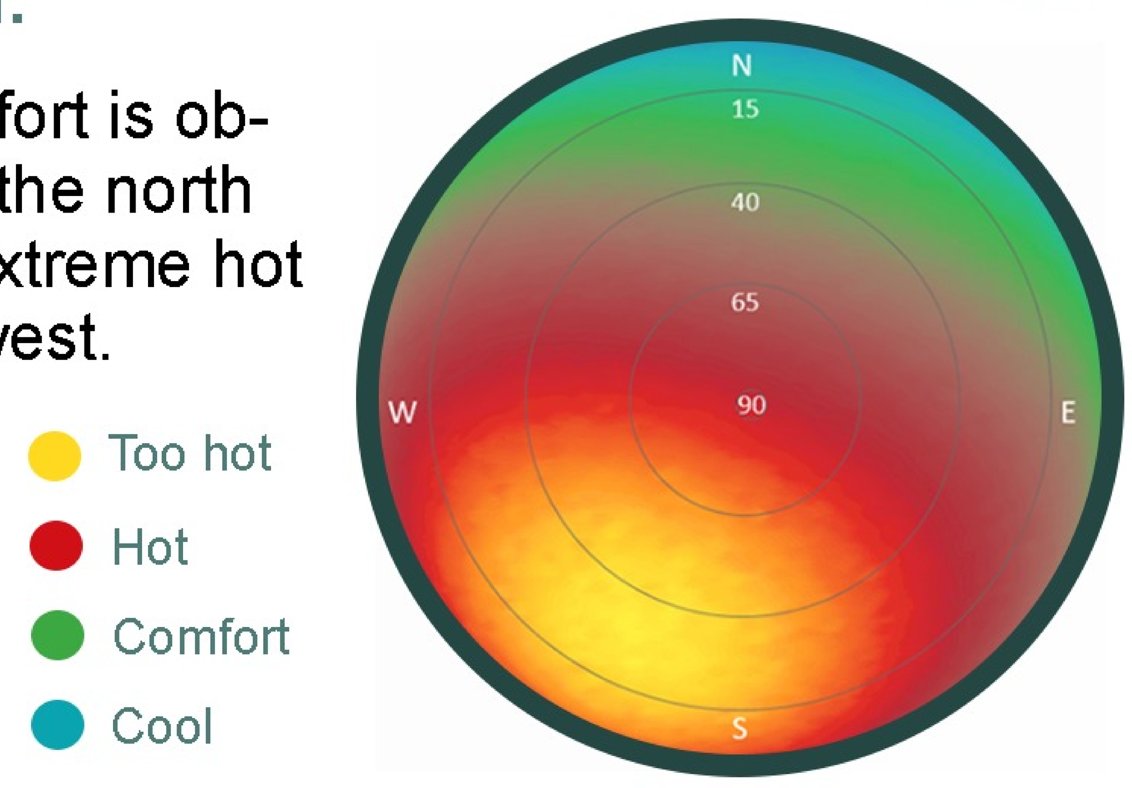
Dry bulb temperature in degree celcius *Climate consultant*



Radiation:

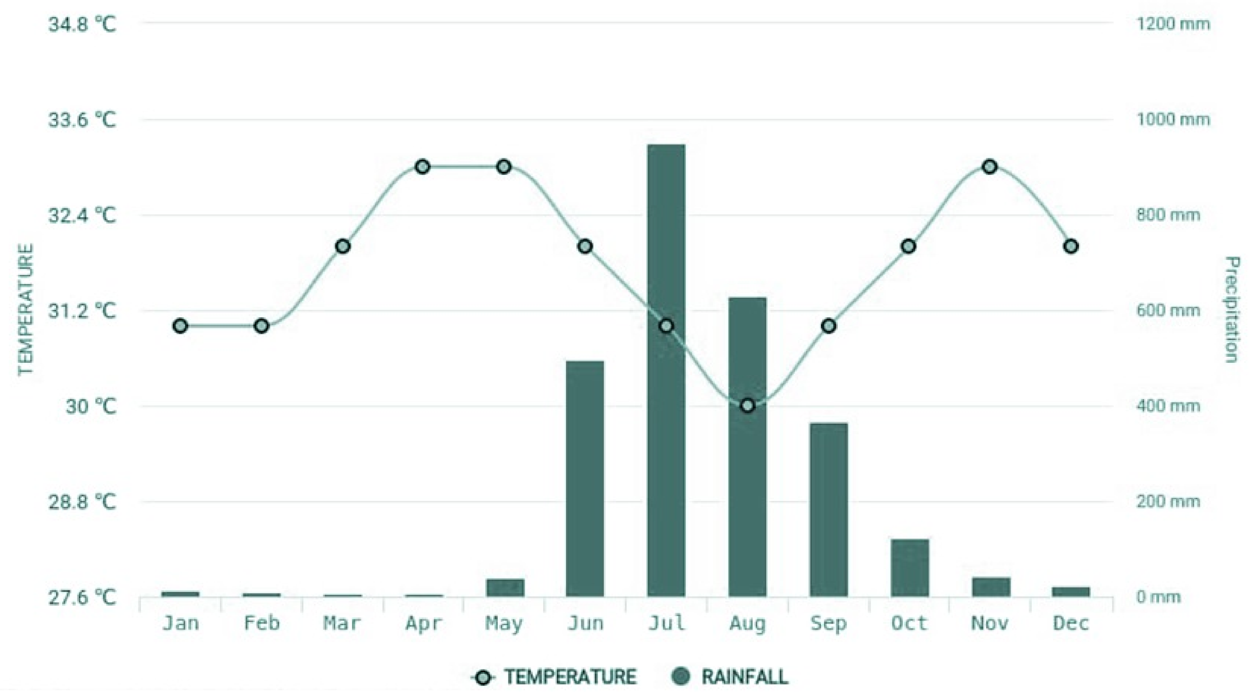
Climaplus

Major comfort is observed on the north side and extreme hot on south-west.



Rainfall and precipitation:

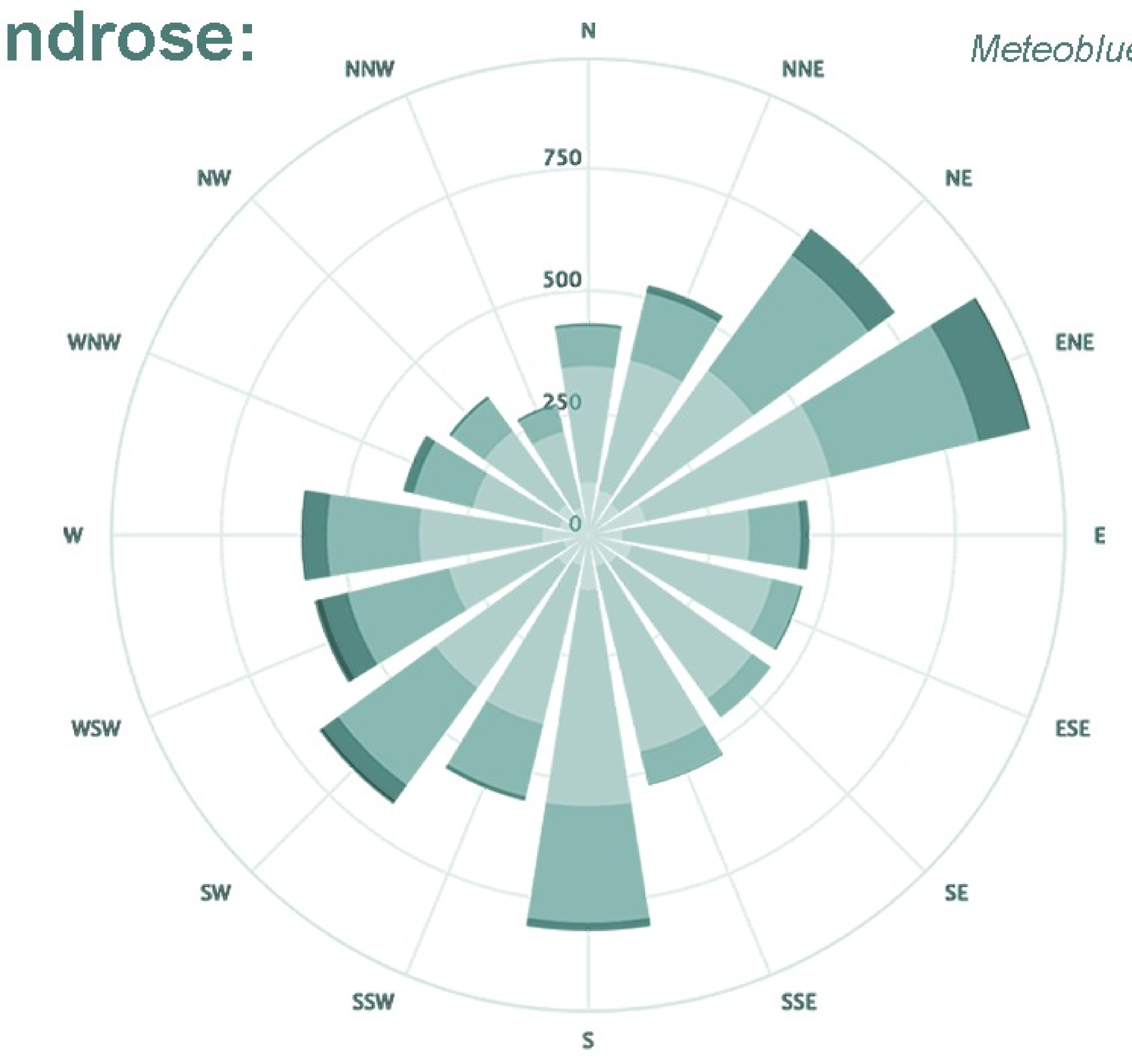
Meteoblue



Out of total rainfall, 80% rainfall is experienced during June to October. Average annual rainfall is 2000-2500 mm and humidity is 61-86 %.

Windrose:

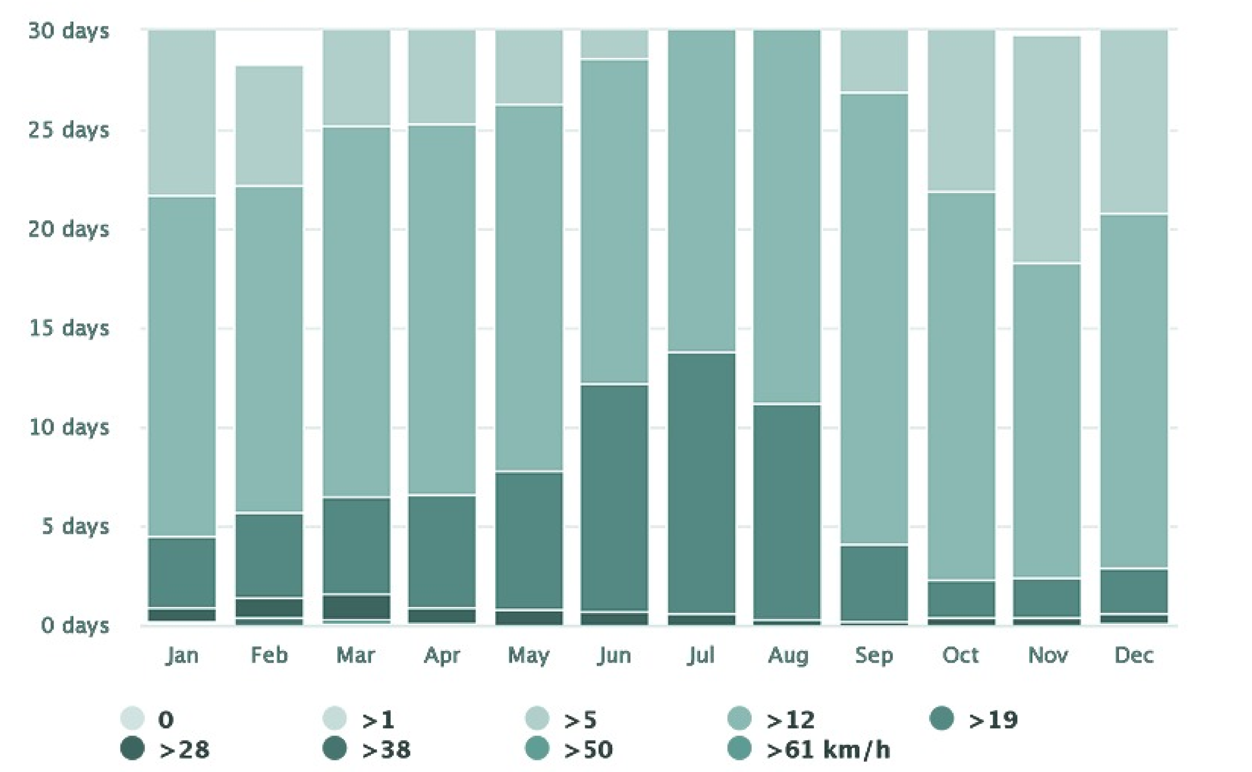
Meteoblue

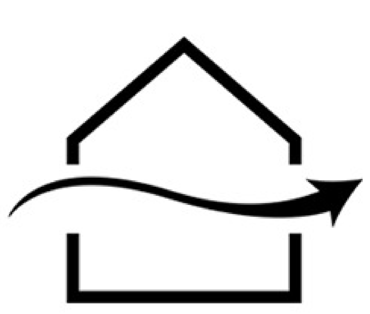
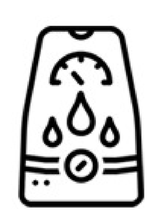
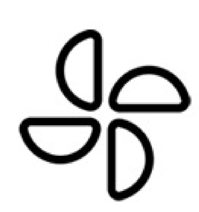
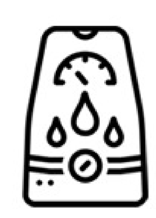
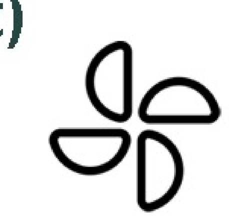
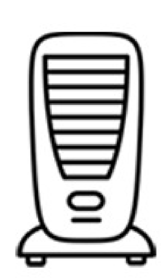
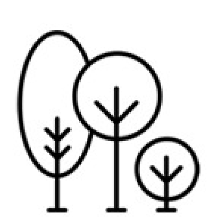
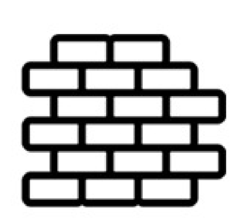
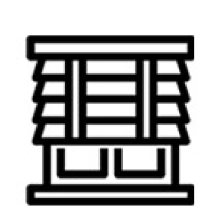


Major winds are observed from the south and south-west direction.

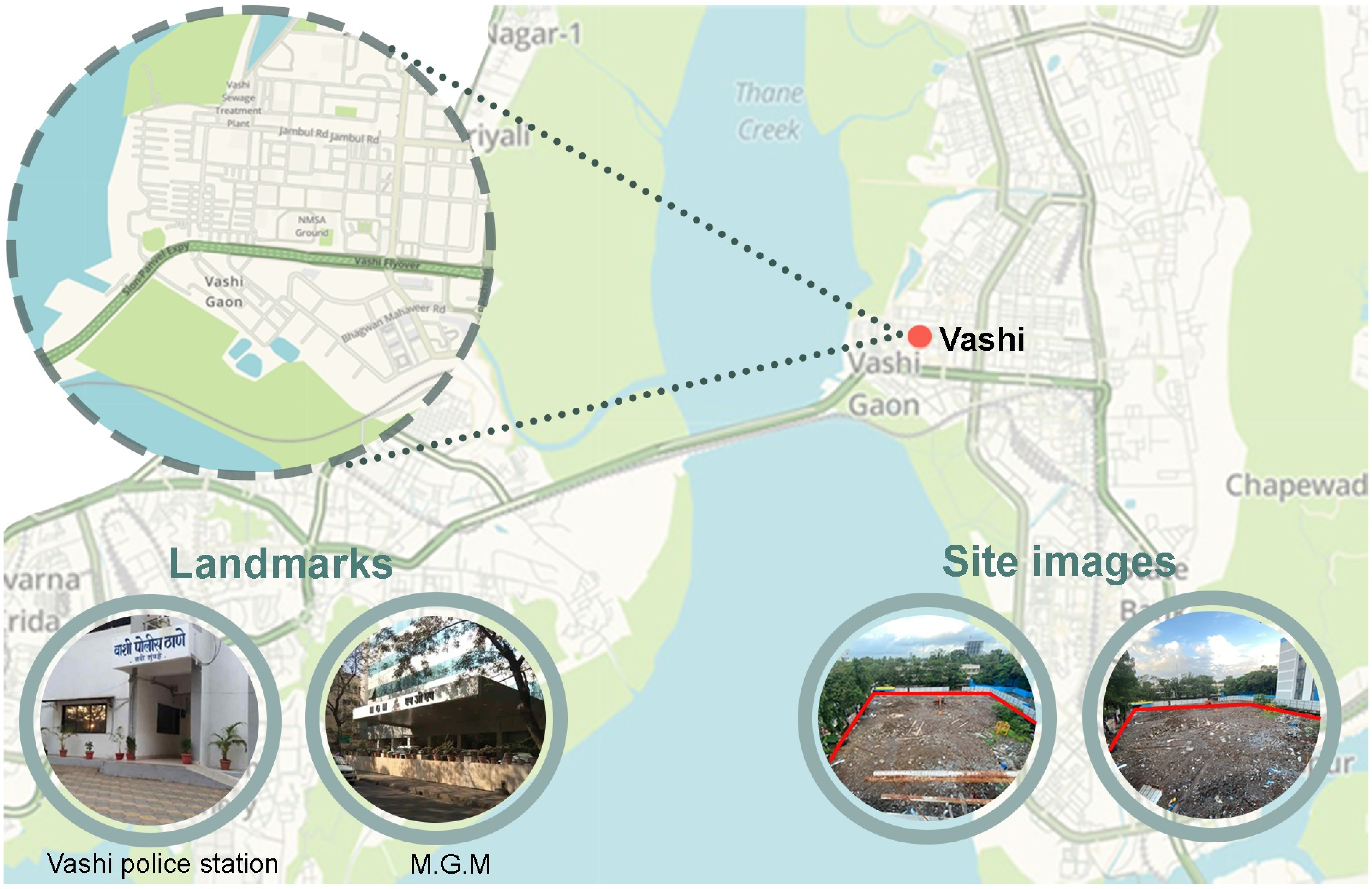
Wind speed:

Meteoblue

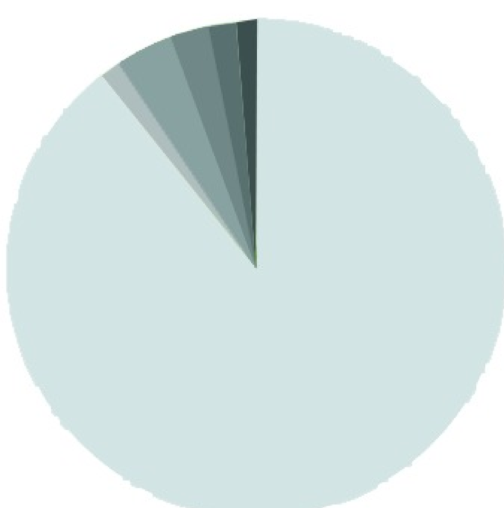


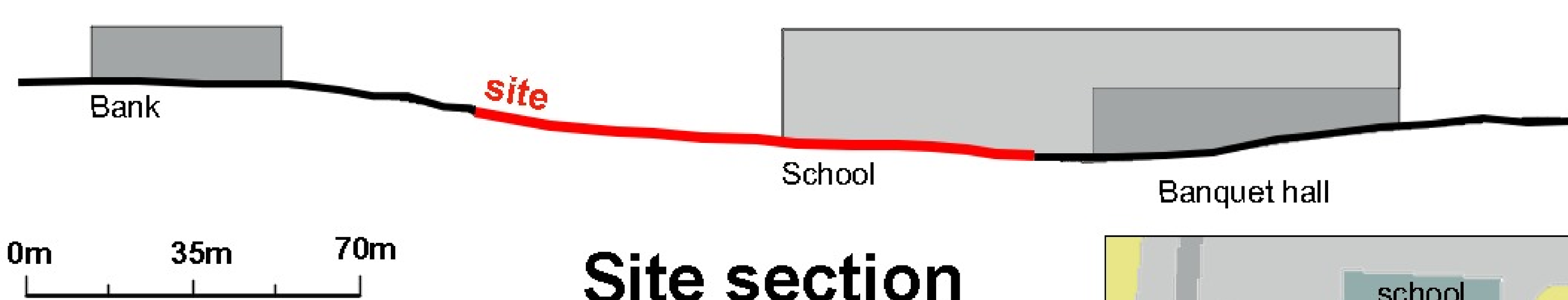
Comfort (Nov, Dec, Jan, Feb)	Hot (Mar, Apr, May)		Humid (Jun, Jul, Aug, Sept, Oct)	
 Natural ventilation	 Dehumidification	 Fan forced ventilation	 Dehumidification	 Fan forced ventilation
		 Spatial buffer	 Wing/screen wall	 Proper shading

CONTEXT ANALYSIS

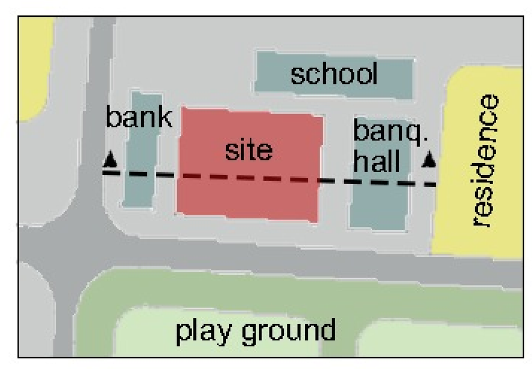


Stakeholders





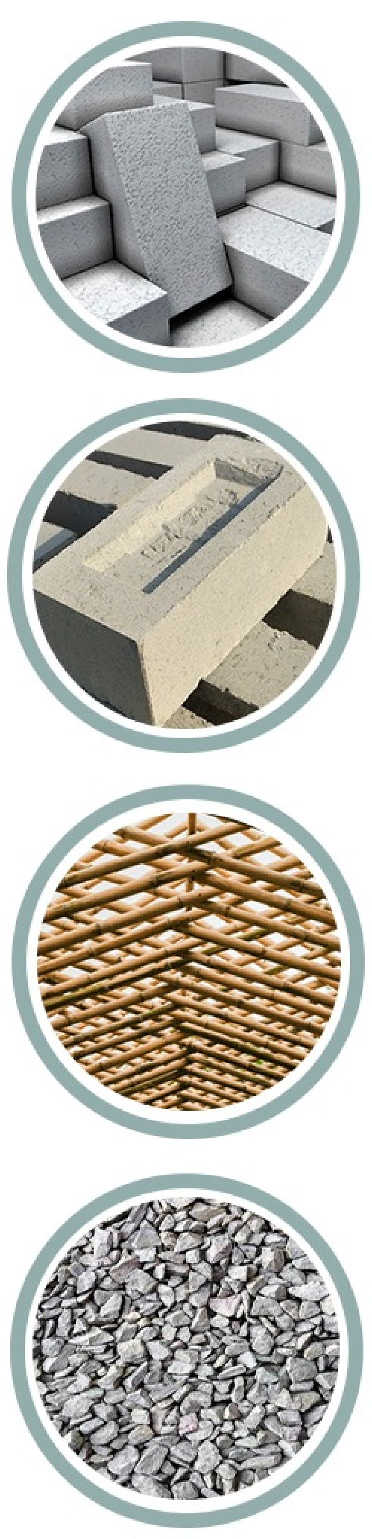
Site section



Site key plan

Vashi lies in the city of Navi Mumbai, Maharshtra.The development plan for Navi Mumbai envisages planning and development of various nodes or townships which are further sub-divided into sectors. All basic amenities like health & education are available in vicinity.

Available materials



AAC Blocks
U value: 2.5-3W/m2K
Sound absorption: up to 55db

Fly Ash Bricks
U value: 1.79W/m2
Sound absorption: up to 40db

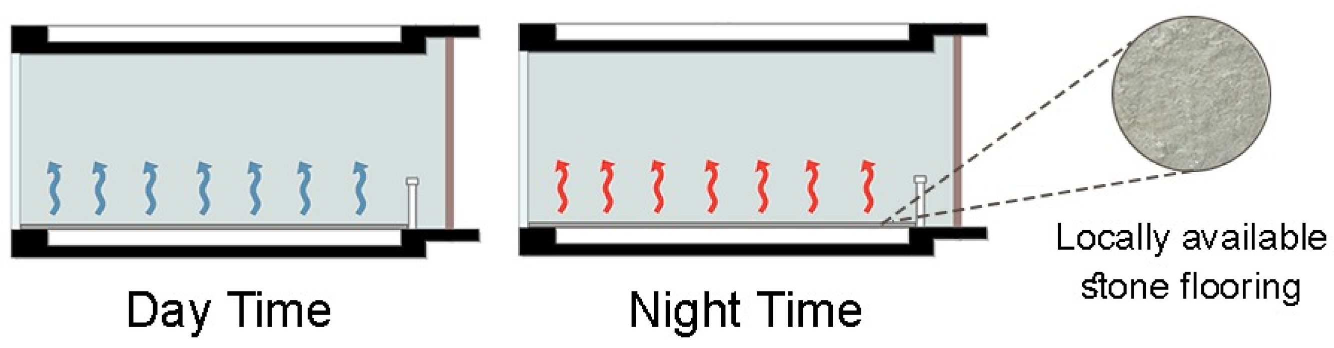
Bamboo
U value: 1.4W/m2

Crushed stone
U value: 0.19W/m2

Sr.	Parameters	2011-2022 census
1	Population	1839491200.00%
2	Population growth	8.66%
3	Place of origin	Maharashtra - 73.4%
4	Literacy rate	98% (99%- male, 97%-female)
5	Graduate and PG	34%
6	Up to HSC	54%
7	Average family size	3.4 members
8	Earning members	1.3
9	Household income	Rs. 24,686
10	Household expenses	Rs. 16,496
11	Sex ratio	831 females per 1000 males
12	Child Sex Ratio	910 females per 1000 males
13	Population density	4167/ sq.km

Avasara Academy

Location: Pune
Geographical coordinates: 18° N, 73° E
Climate: Warm and Humid
Project area:11,148 m2

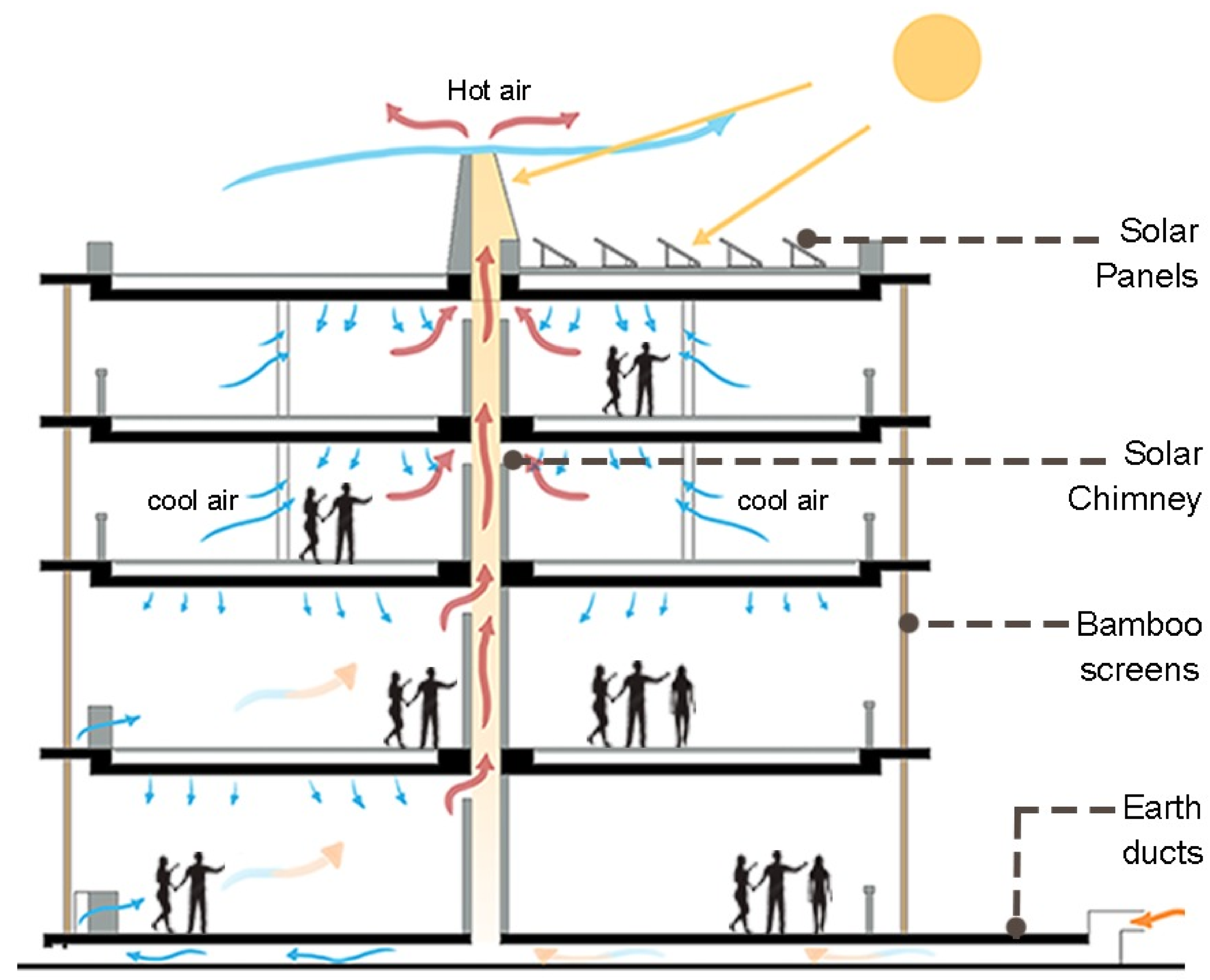


Climatic response

The raw concrete along with the locally sourced stone interior acts as an inert thermal mass; absorbing the solar thermal energy during the day and releasing it again after a delay overnight, resulting in a moderate, more

Façade treatment

Sun protection is provided by bamboo screens, preventing excessive heating of the interior from direct sunlight.
As a result of the projection/overhang, spaces are slightly stepped back.



Ventilation design

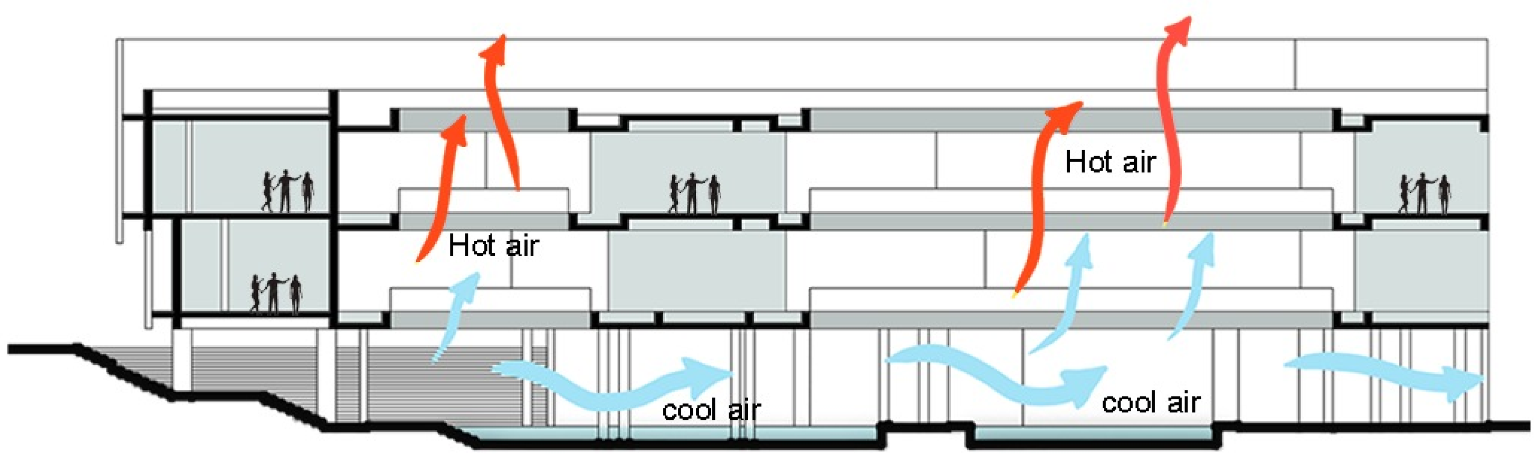
Earth ducts are concrete Hume pipes laid between the building foundation.Supply air enters the spaces through the strategically designed window and the doorways.

Renewable energy

Photovoltaic solar panels and solar water heaters have been installed on the roof to provide electricity and supply hot water ,

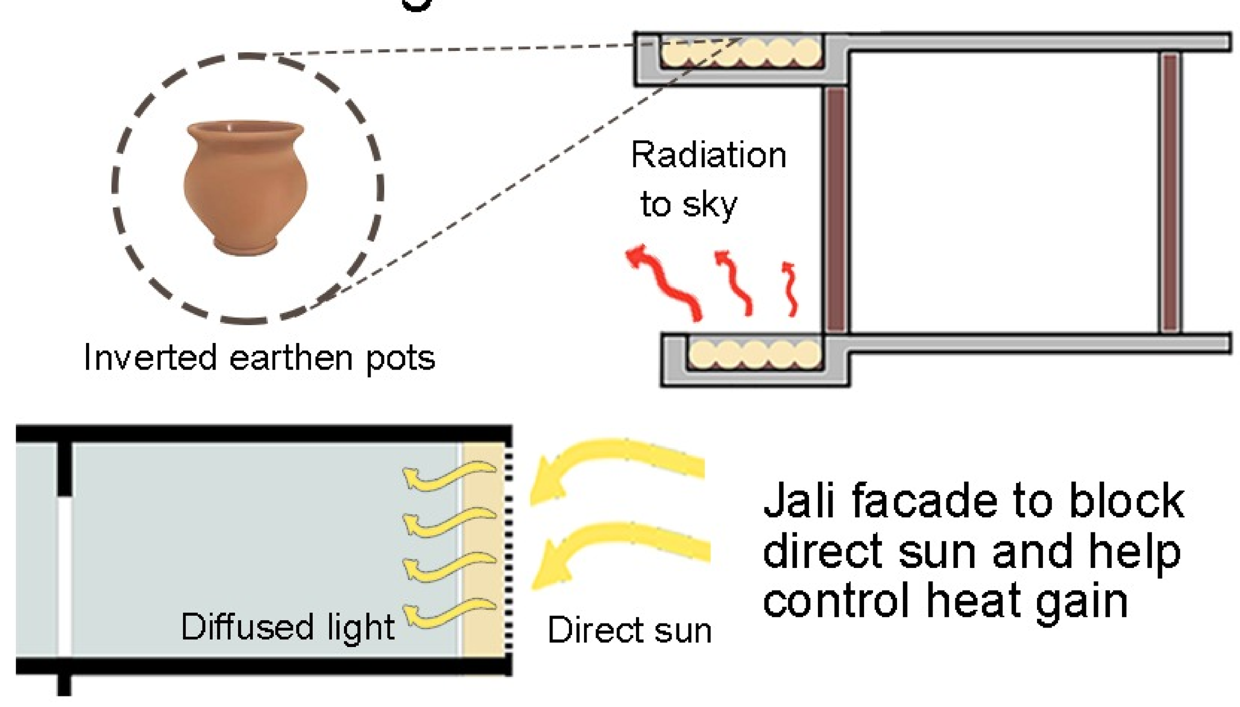
Pearl Academy

Location: Jaipur
Geographical coordinates:27.0307414N, 75.8966181E
Climate: Hot semi-arid
Project area: 11745 m2



Intent

Courtyard planning :It is a mix of curves and corners and the segregation of these areas blend together.



Climatic response

Rounded courtyards stop direct sunlight from reaching the insides of the building.The building is raised to create a natural thermal sink, which keeps the temperature stable.Waterbody act as cooling agent.

Ventilation design

The jalis have a drip system providing a cooling effect.Air ventilation is provided through stack effect with help of jalis,courtyards also play a major role in ventilation

Façade treatment

Self shading of sliver courts to control the temperatures of internal spaces and open stepped wells for sufficient day lighting inside

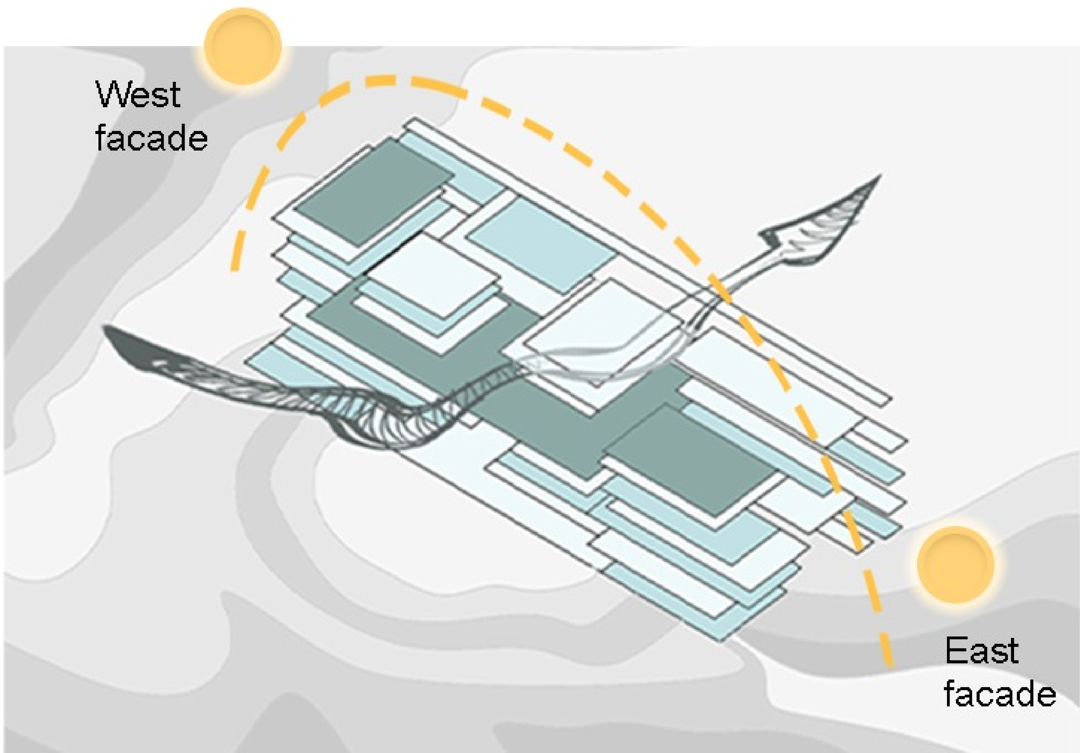
Renewable energy

It is self-sufficient in terms of captive power and water supply. There is a provision for rainwater harvesting & wastewater recycling through the sewage treatment plant.

Case studies :-

NUS School of Design & Environment

Location: Singapore
Geographical coordinates: 1° N, 104° E
Climate: Tropical
Project area: 8,514 m2
EPI: 58 kWh/m2/yr



Climatic response

The building mass is broken up by a series of **shaded terraces** and **landscaped balconies** that serve as **thermal buffers.** Light is filtered through **perforated corrugated aluminium panels.**

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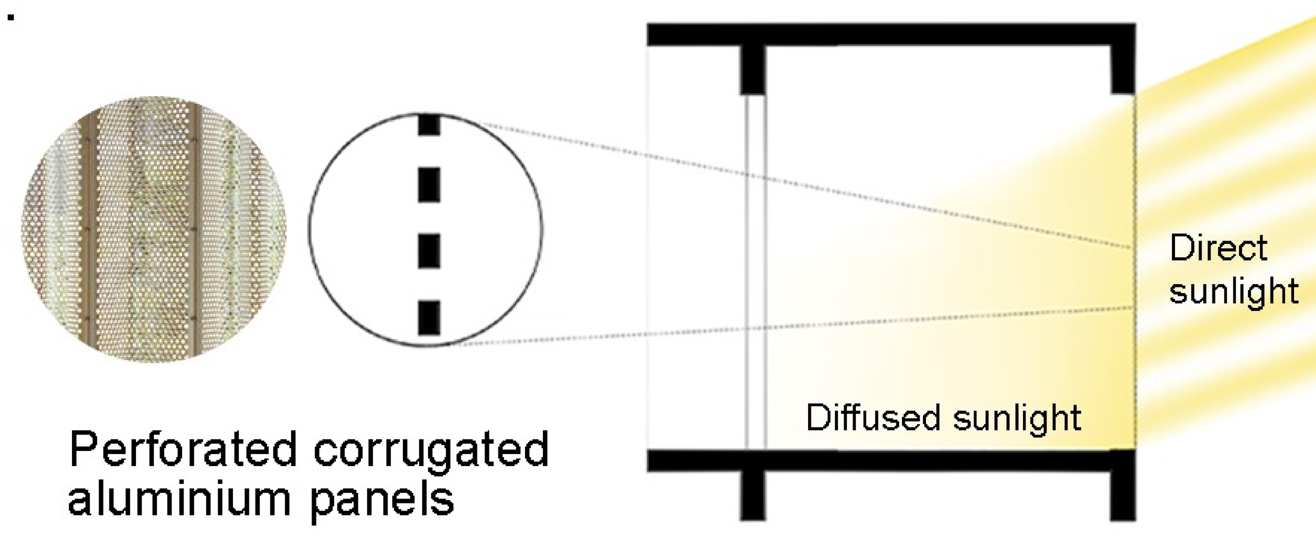
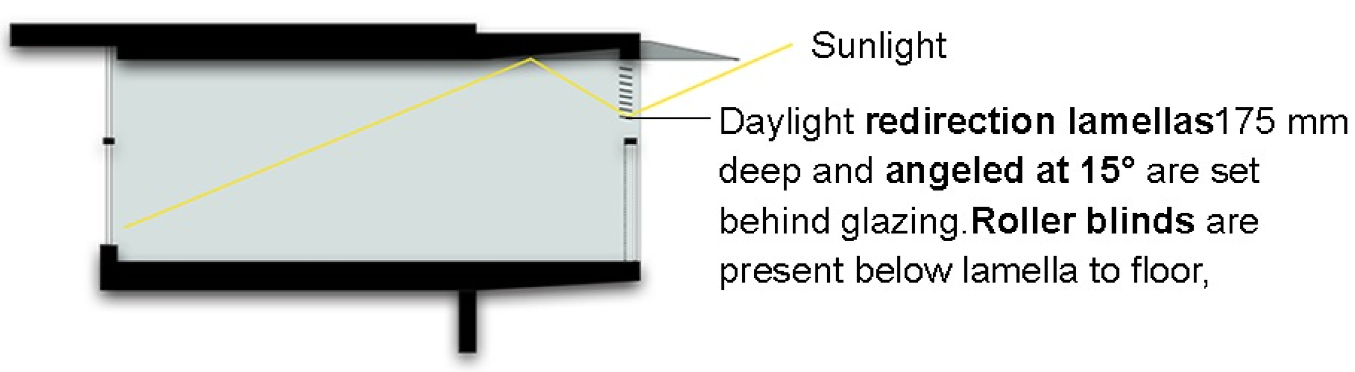
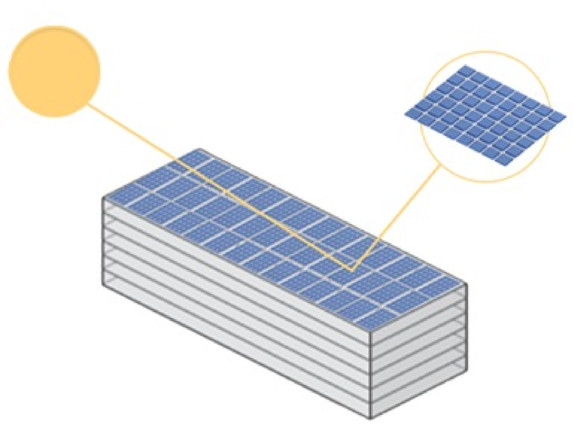




Façade treatment

Light is filtered through perforated corrugated aluminium panels.

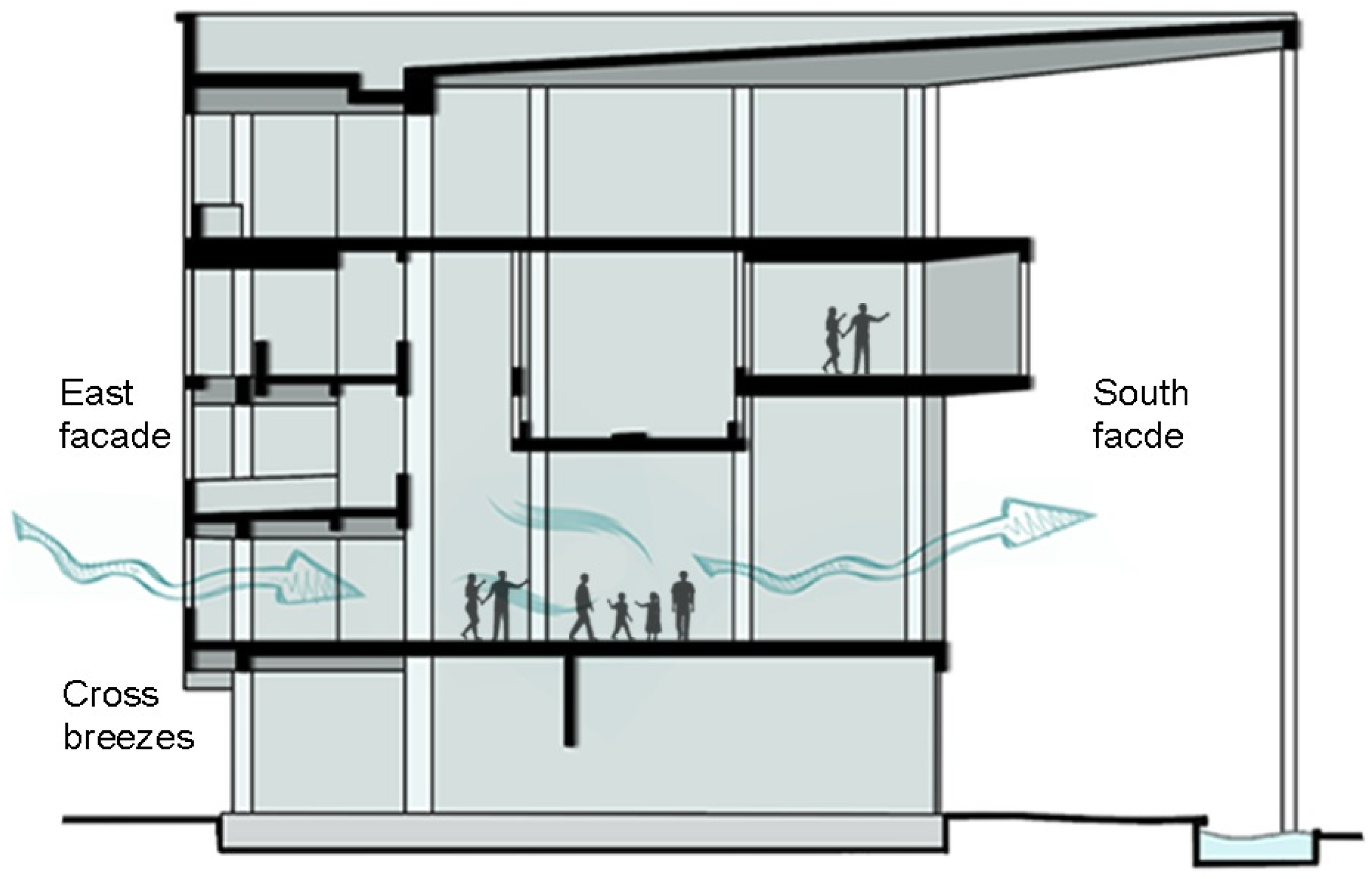


Renewable energy

On site energy source: On its roof, more than 1,200 solar **photo voltaic panels** generate approximately **500 MWh/yr** of electricity.

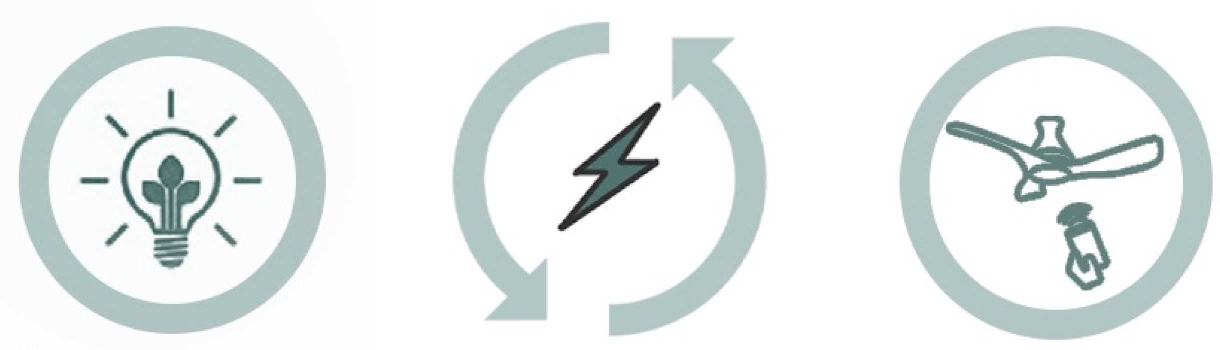
Intent

Biophilic design and Ambiguous boundaries between the indoors and outdoors.



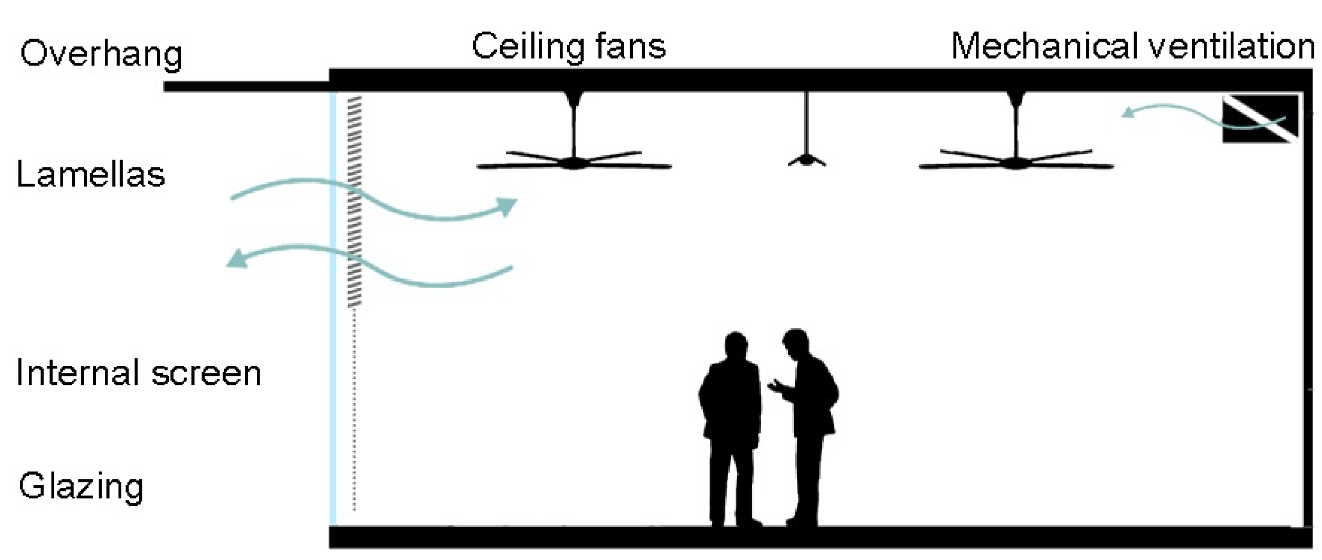
Ventilation design

The optimal **North-South** openings allow **natural light** to enter and provide views of the outside. **Cross-breezes** are encouraged by the **shallow plan** and **porous layout**. Only **17%** of the building is **fully air-conditioned**, whereas **46%** of the building is **naturally ventilated** and **26%** of the building is **hybrid tempered**.



Smart features

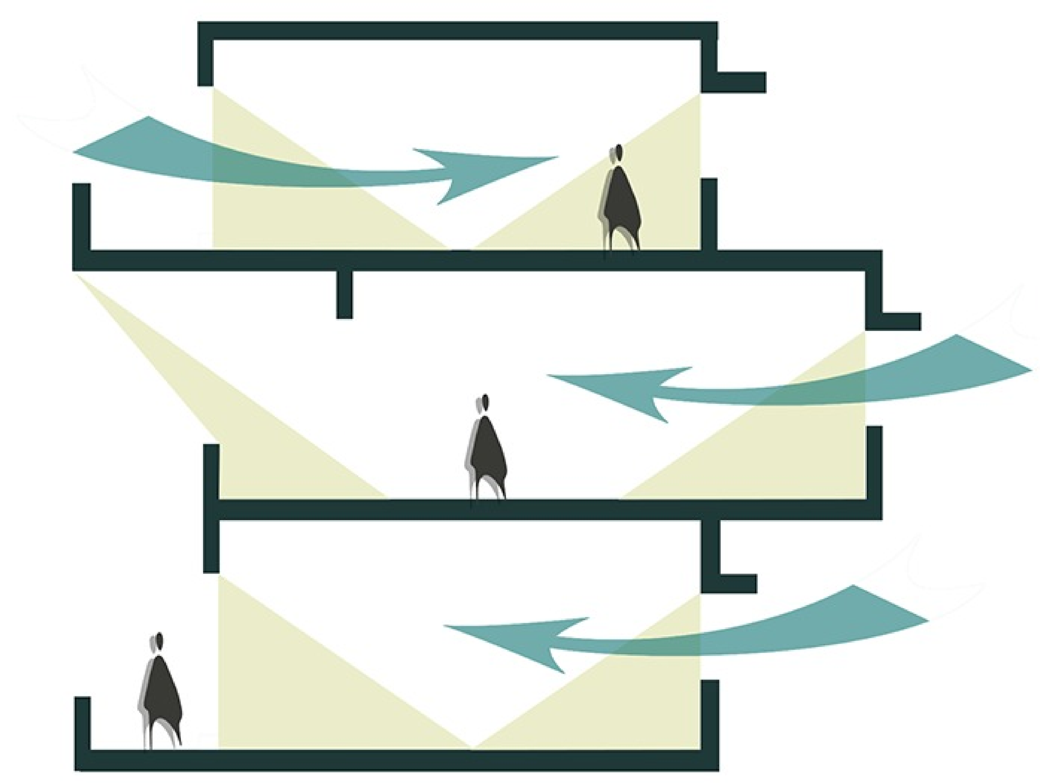
90% of the lighting requirement is met by **LEDs** and The windows. Most of the rooms are equipped with **sensors fixtures.**

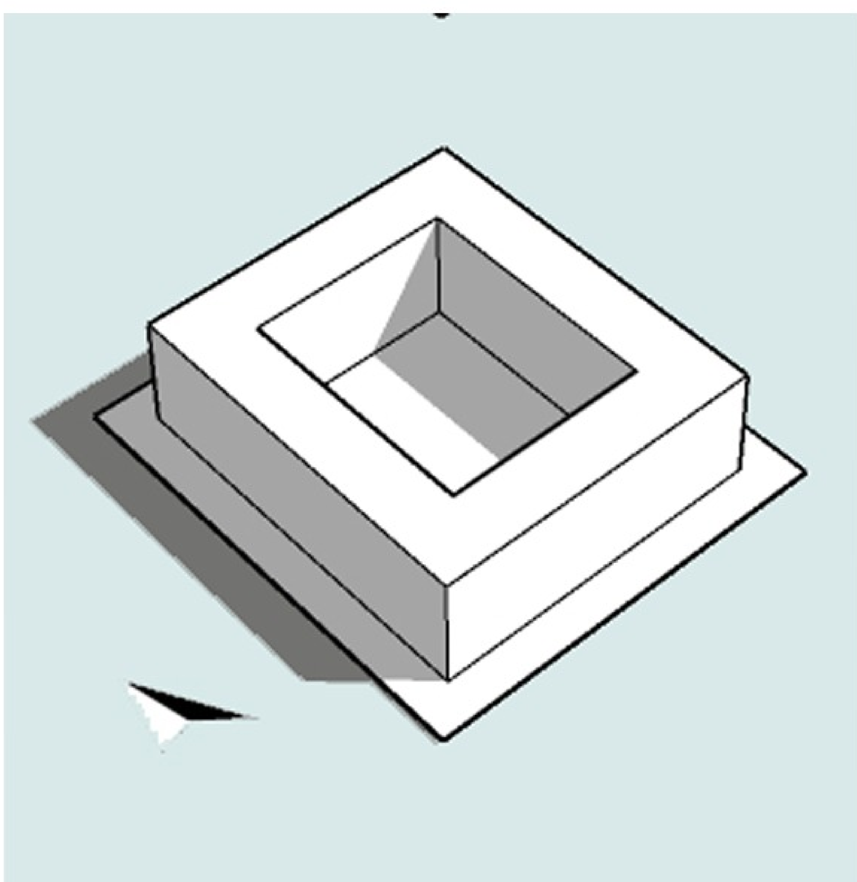


Hybrid Tempered System

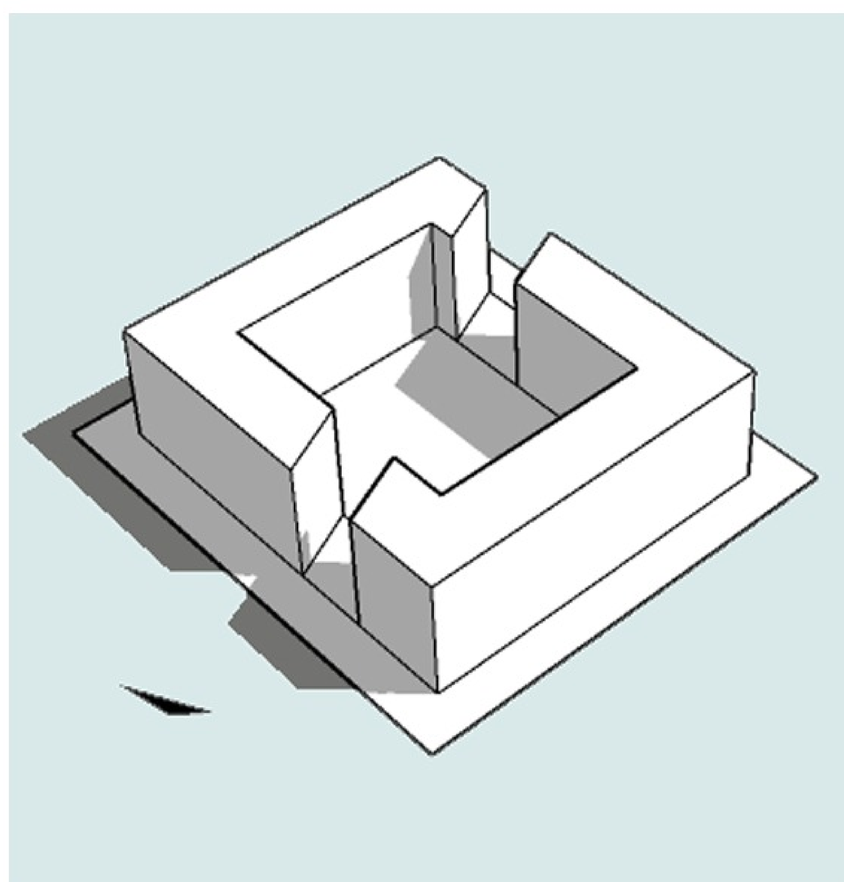
Air temperatures, air speeds, humidity, and mean radiant temperatures are all controlled by the system, resulting in adaptive tempered comfort conditions.

C. Preliminary energy and thermal analysis of simple box models :-
In order to design an ideal from, we did many iterations in design to achieve :-
1. Least possible heat gain.
2. Strategic orientation as per sun path.
3. Adequate daylighting and natural ventilation.
4. Maximize rooftop space for solar energy generation and rainwater harvesting.
5. Creatiing better wind flow through built mass.

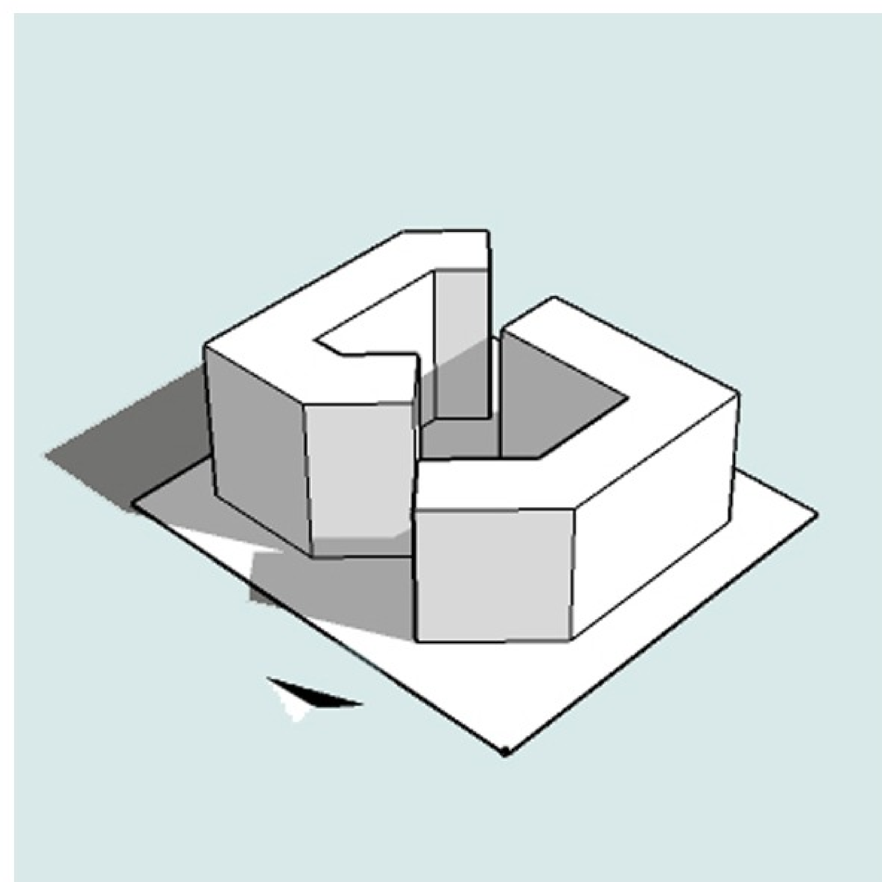




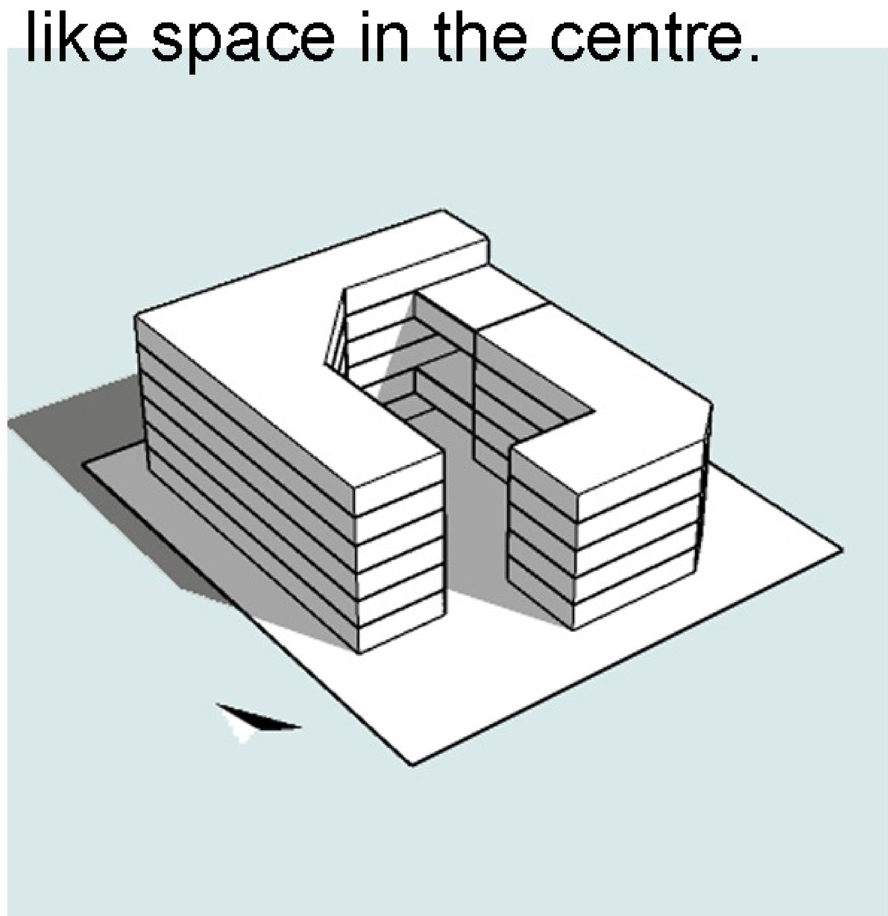
option a:In this option there is a central courtyard being formed. The form of the mass is perpendicular to north side. it form a well like space in the centre.



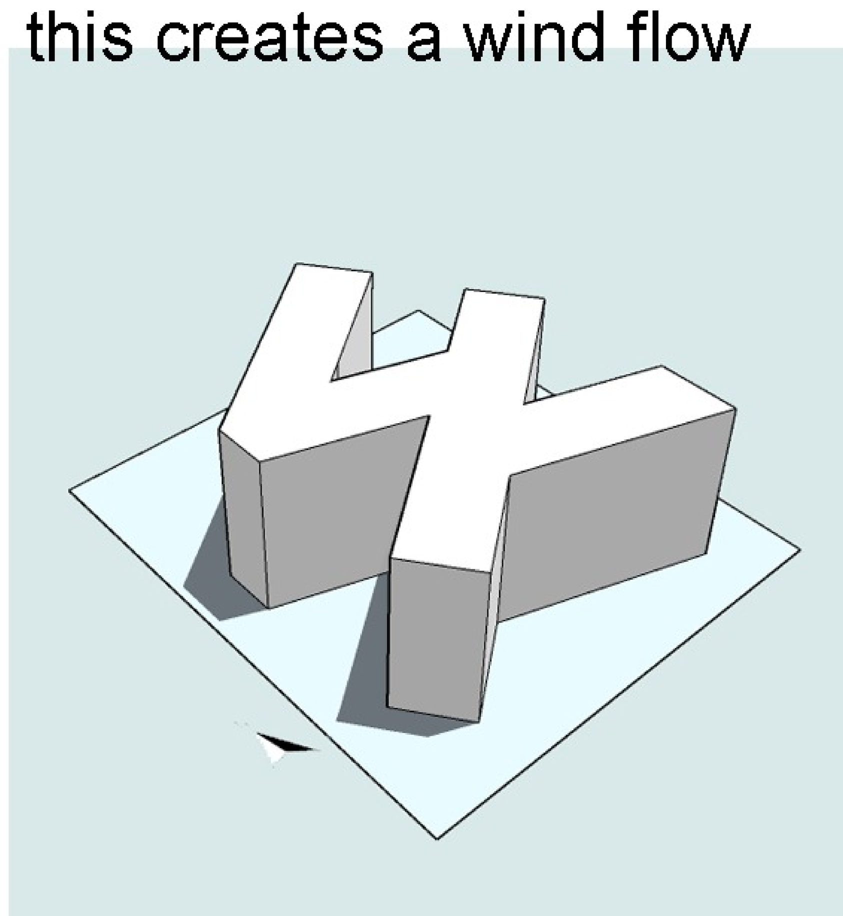
option b: to create beter ventilation throughout the mass the mass has been opened up from south-west and north-east. this creates a wind flow



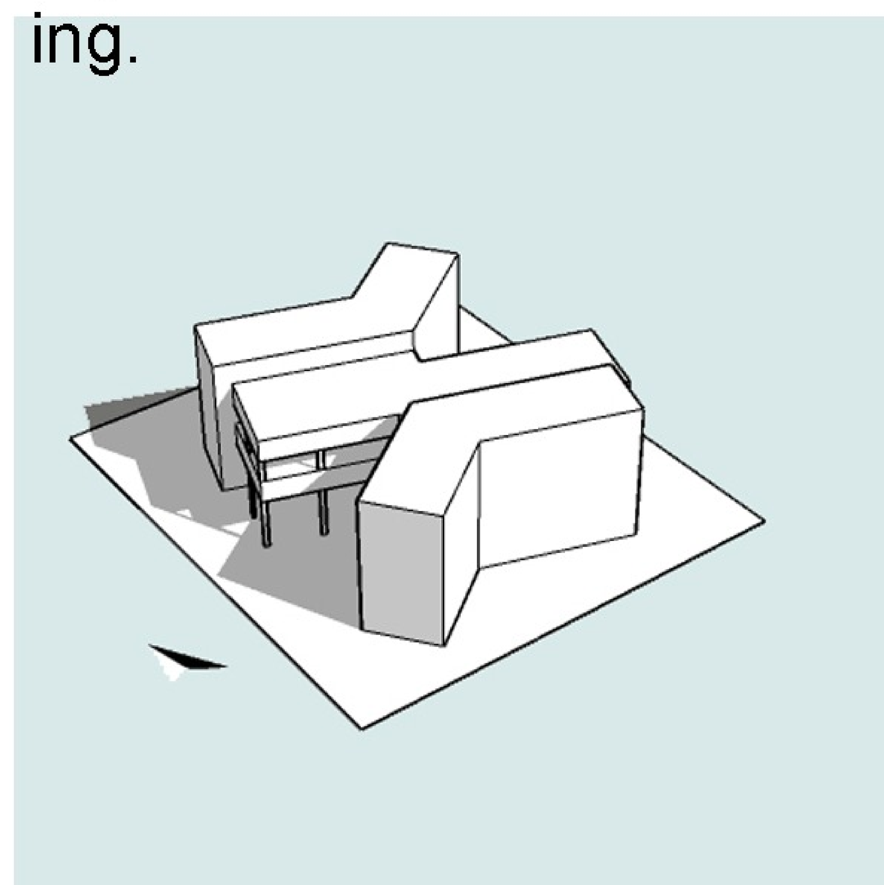
option c: Creating a further iteration in the form , the building has been chamfered at 30 deg. as to avoid perpendicular south sun rays and reduce heat massing.



option d: this massing was done by trying to minimaze the volume at south facade hence ultimately reducing heat gain.

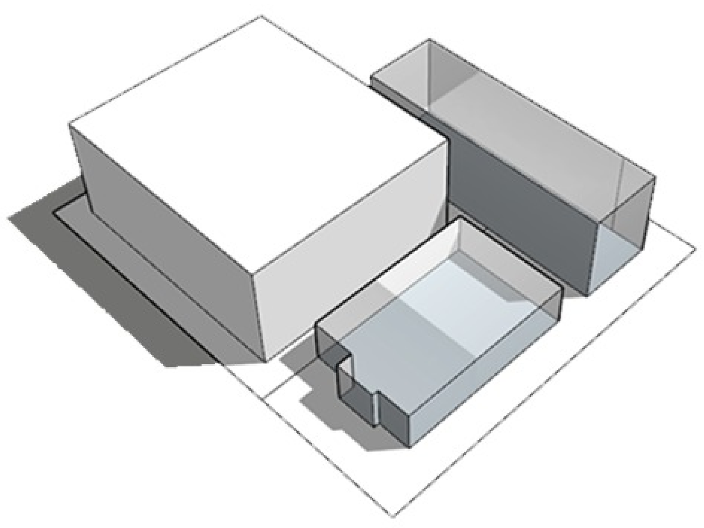


option e: in this option we have tried to decrease direct sunlight on facade by making the mass at an angle.

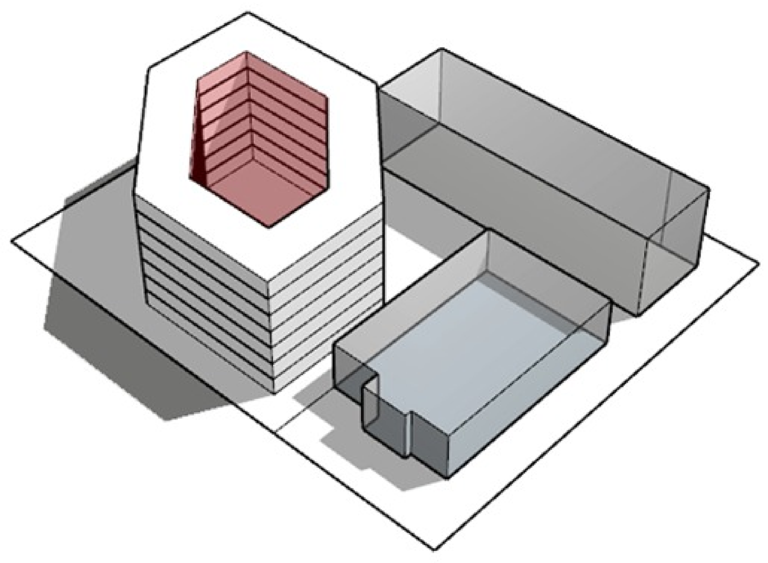


option f: this is further iteration of option e where we have given provision of south west wind to flow through the central space by cutting into the volume of central space

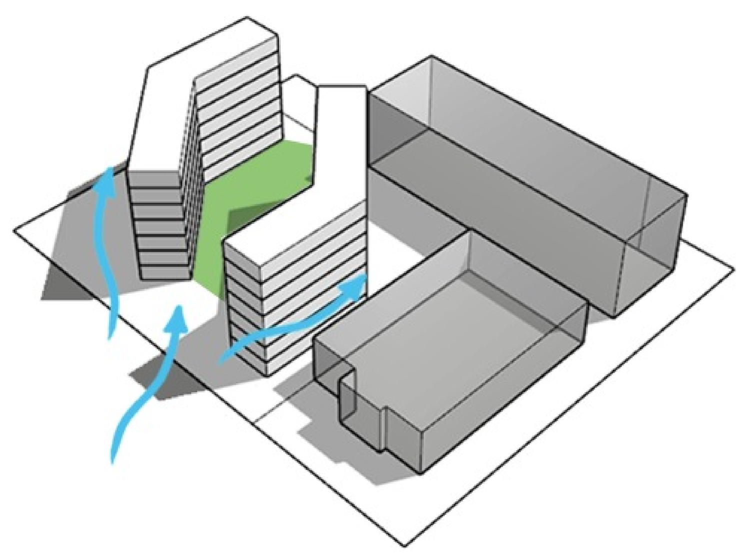
FORM DEVELOPMENT :



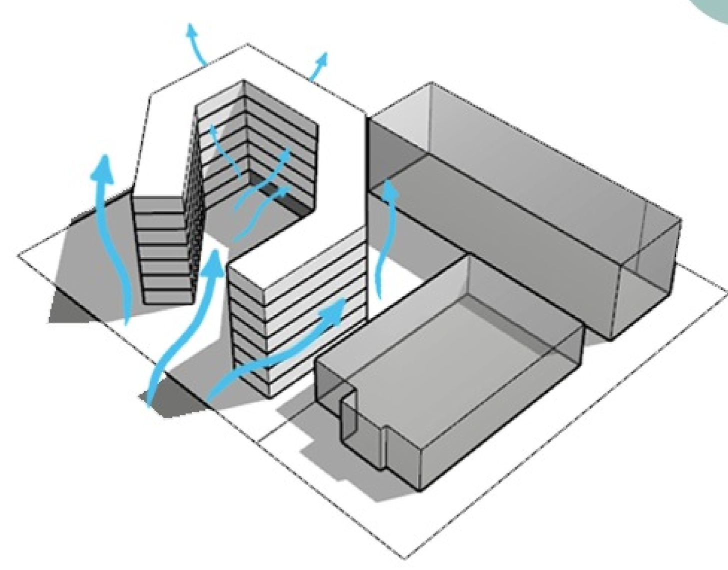
A: The main block is extruded with a setback of 6m from all 4 sides.



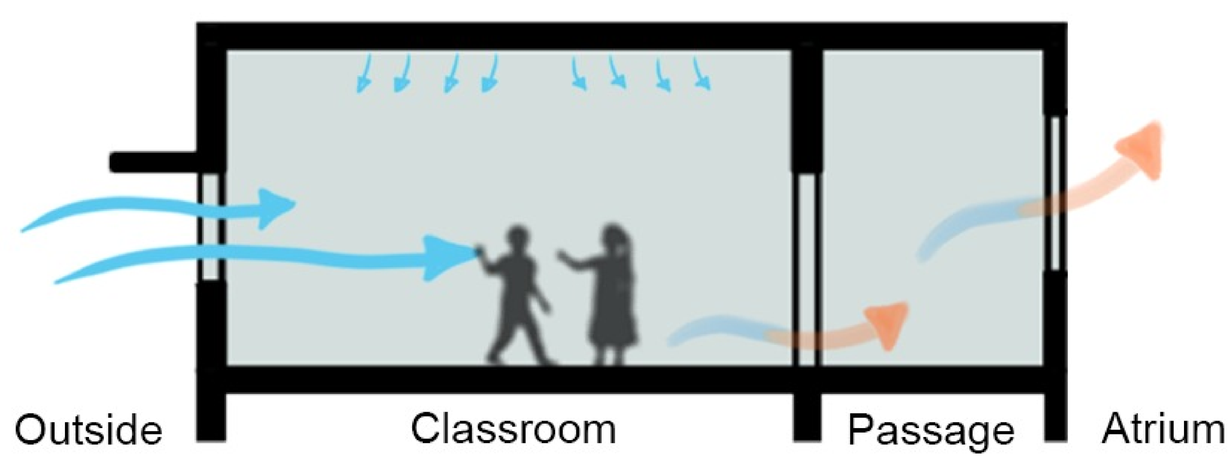
B: For proper lighting and ventilation, corners are chipped off, and a central courtyard is built.



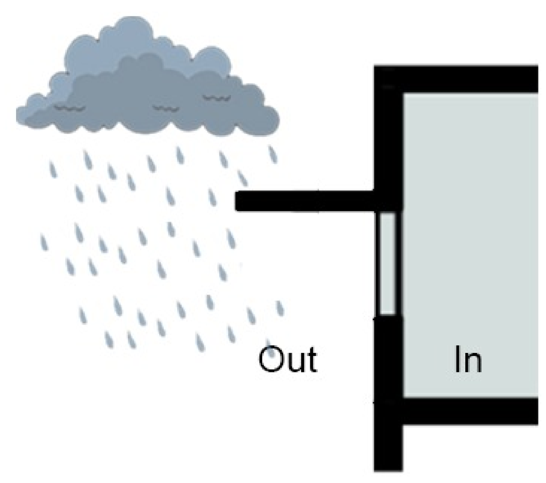
C: The form is divided into two parts to allow wind to move through the building that will increase comfort indoors.

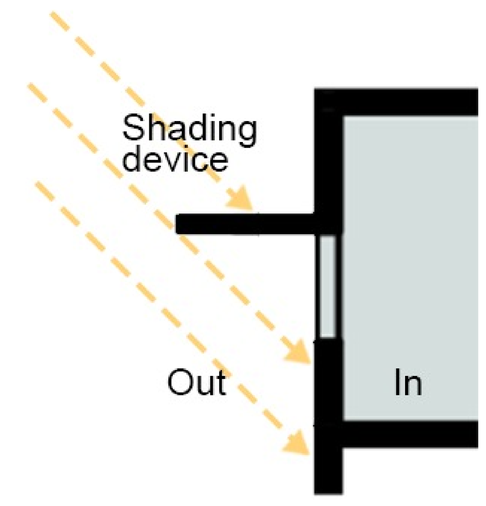


D: Two separate blocks are joined for easy circulation and to provide shading in the courtyard.



The classroom has cross ventilation, which helps to keep it at a comfortable temperature all day.





The interiors are protected from monsoon rains and direct sunshine by larger overhangs of up to 2 metres.

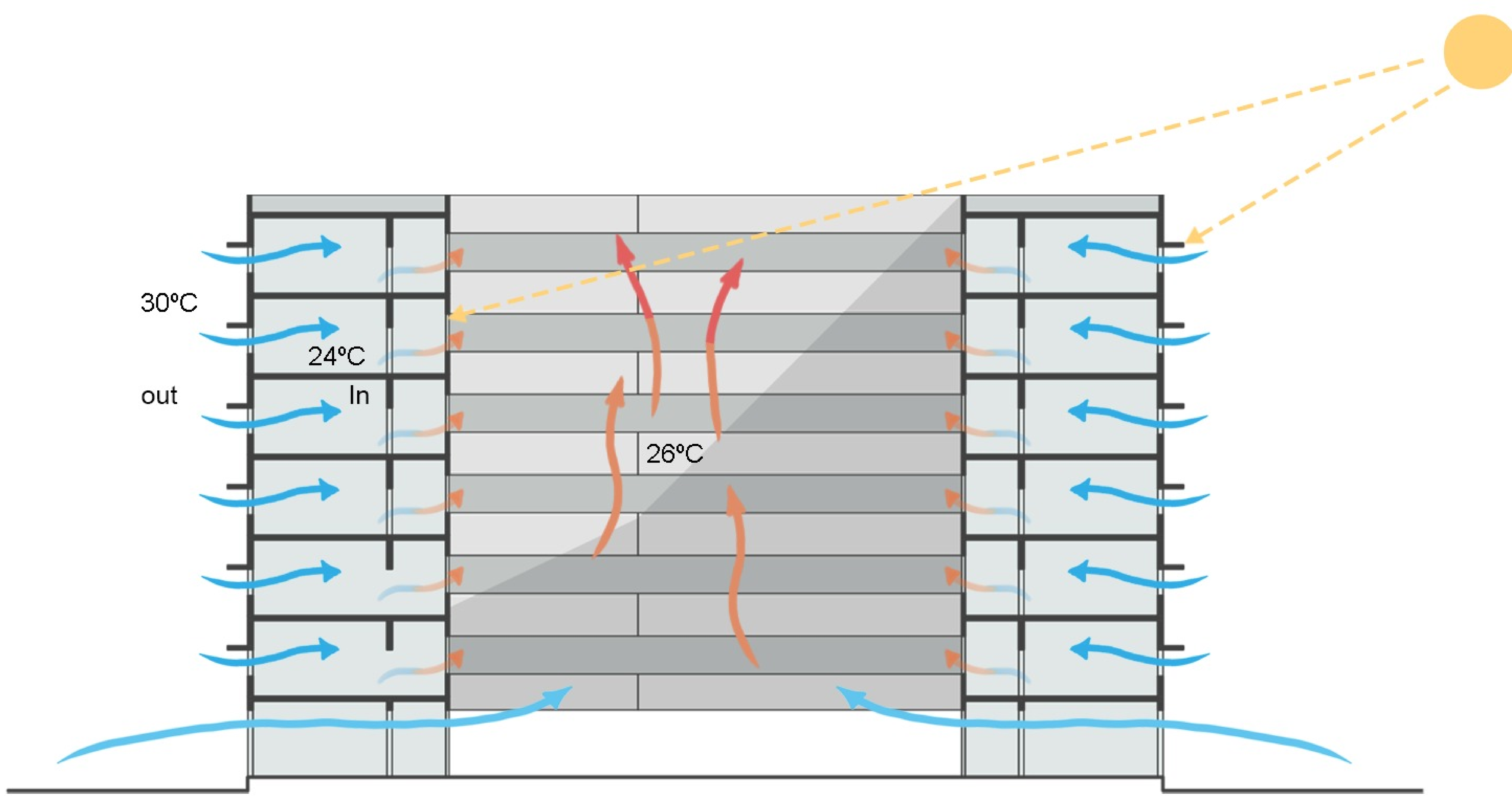
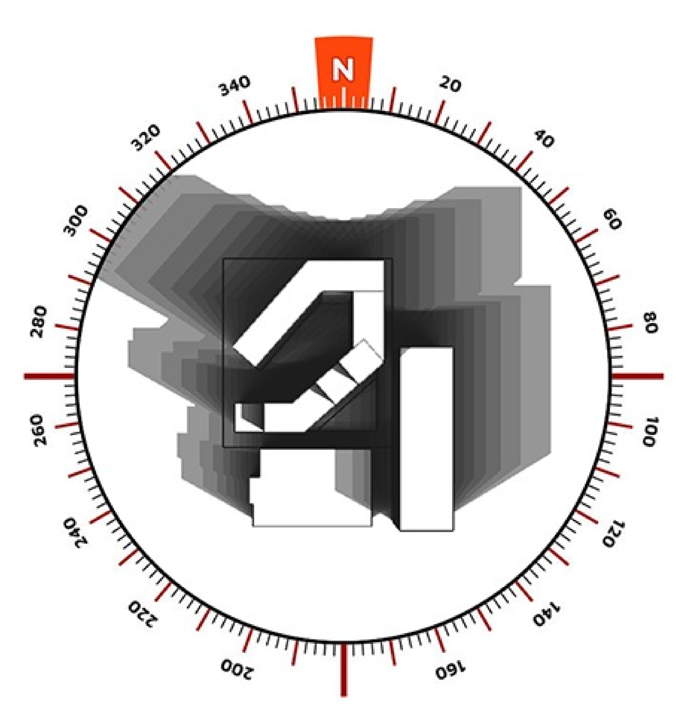
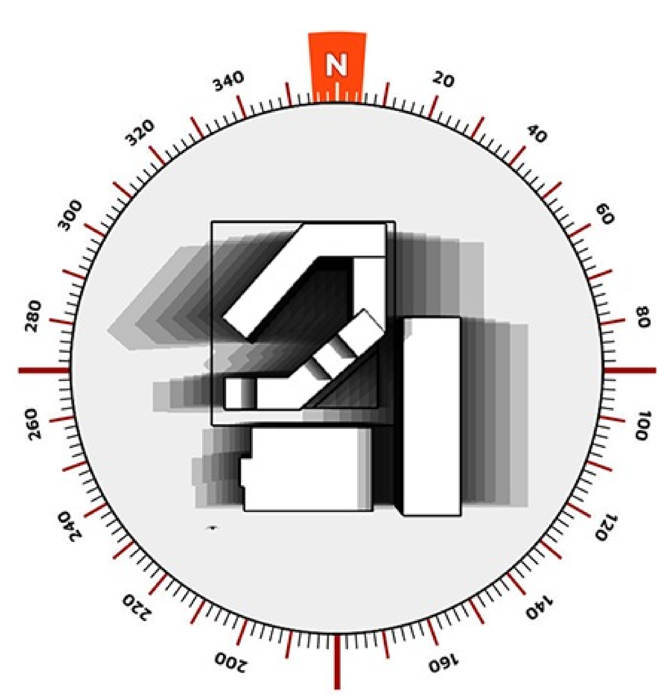


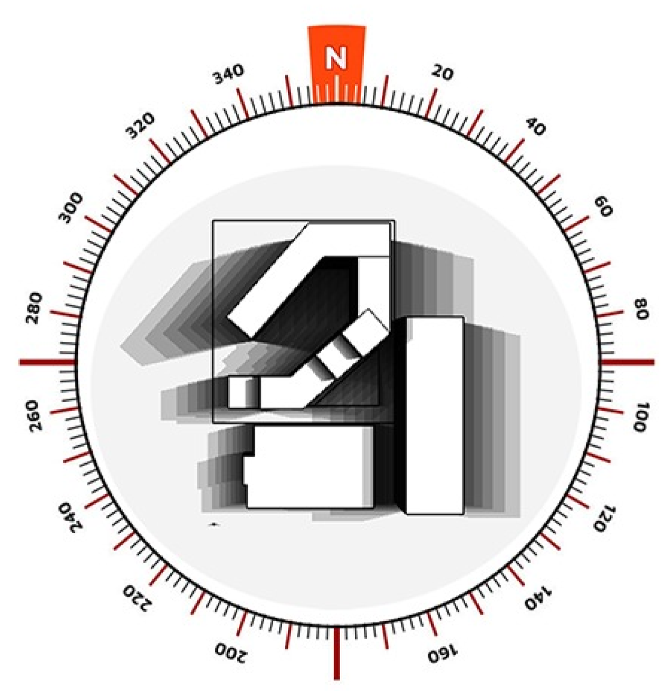
fig.00.Air circulation patterns and energy optimisation stratergies



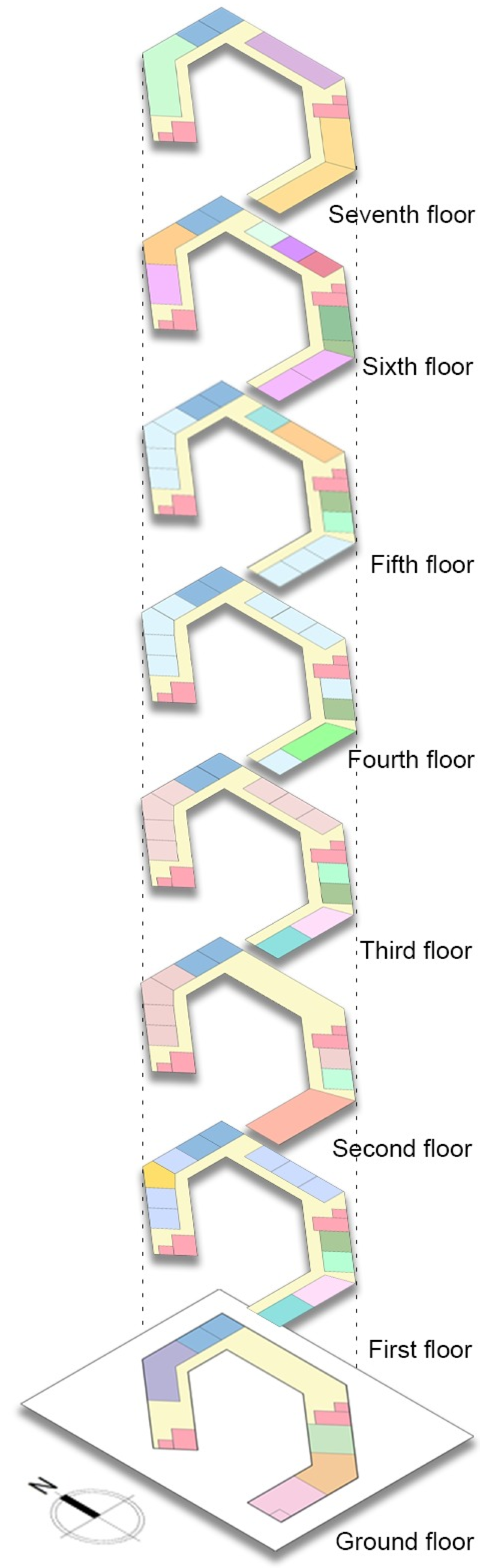
Activities can run easily because the January moth provides greater shading through the building and allows higher cooling hours.



Even when the sun is directly overhead in April, the courtyard is evenly shaded throughout the day.



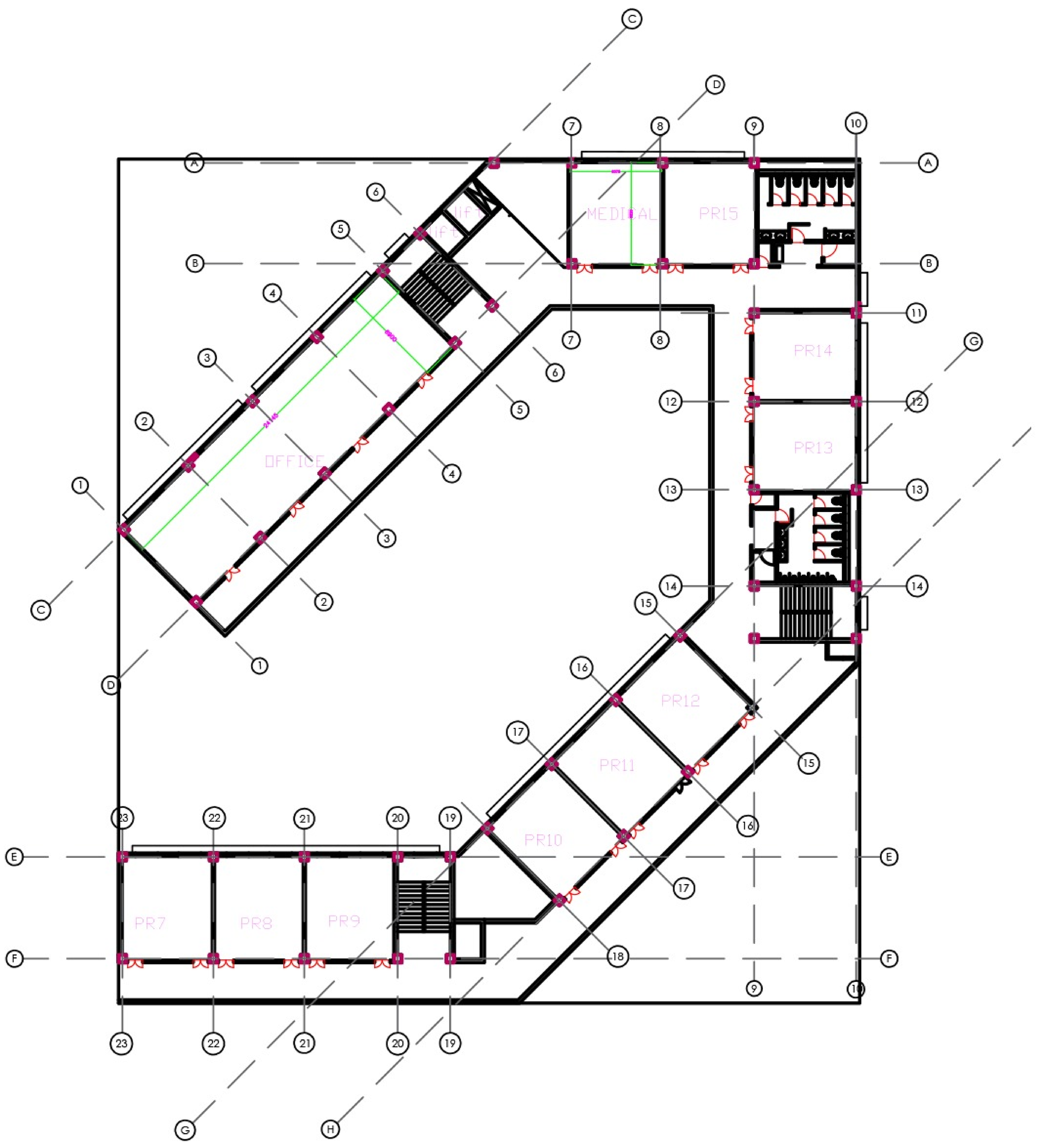
There is more diffused light during the monsoon, we feel comfortable all day both inside and outside.



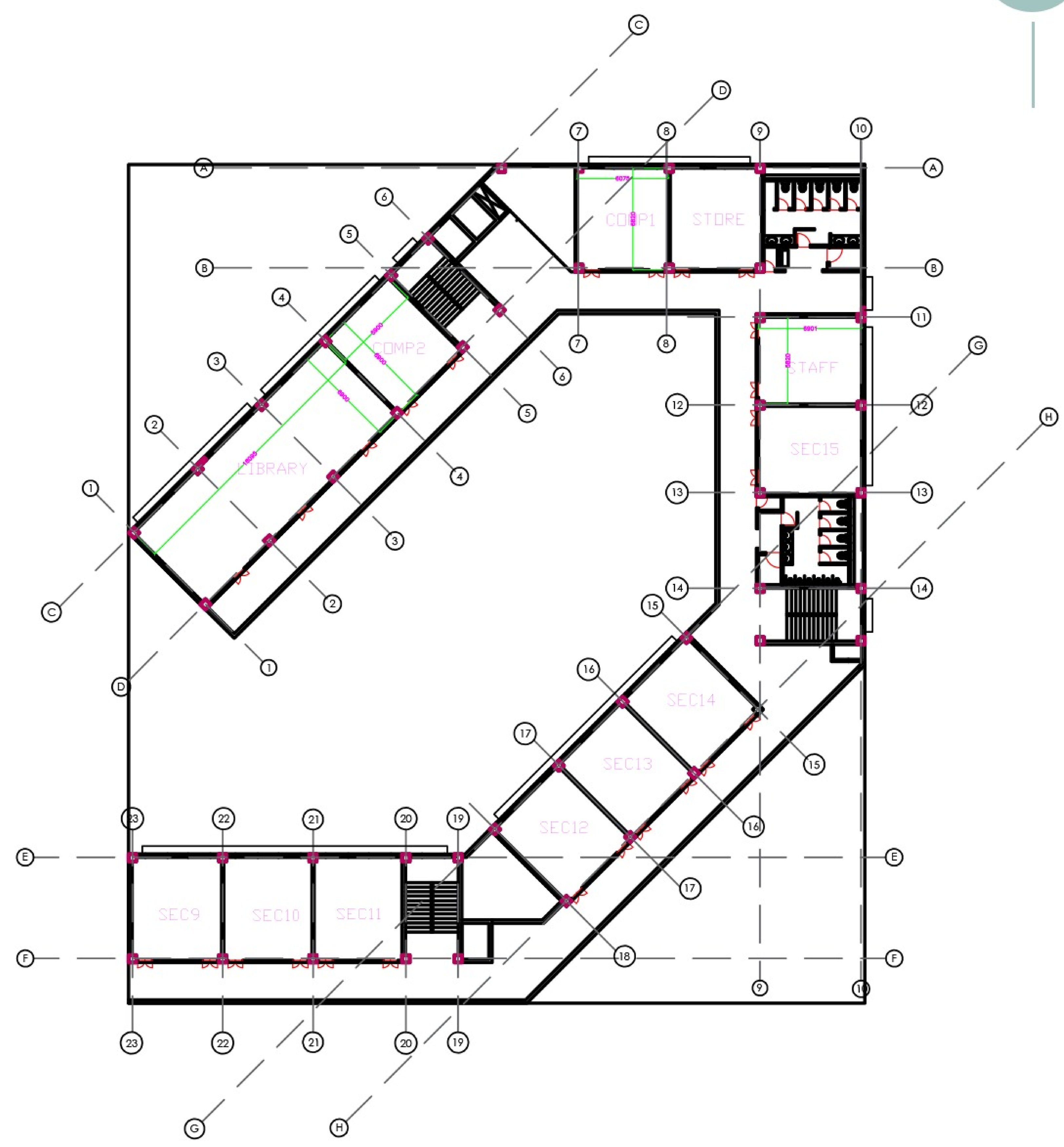
CONCEPTUAL ZONING

LEGENDS

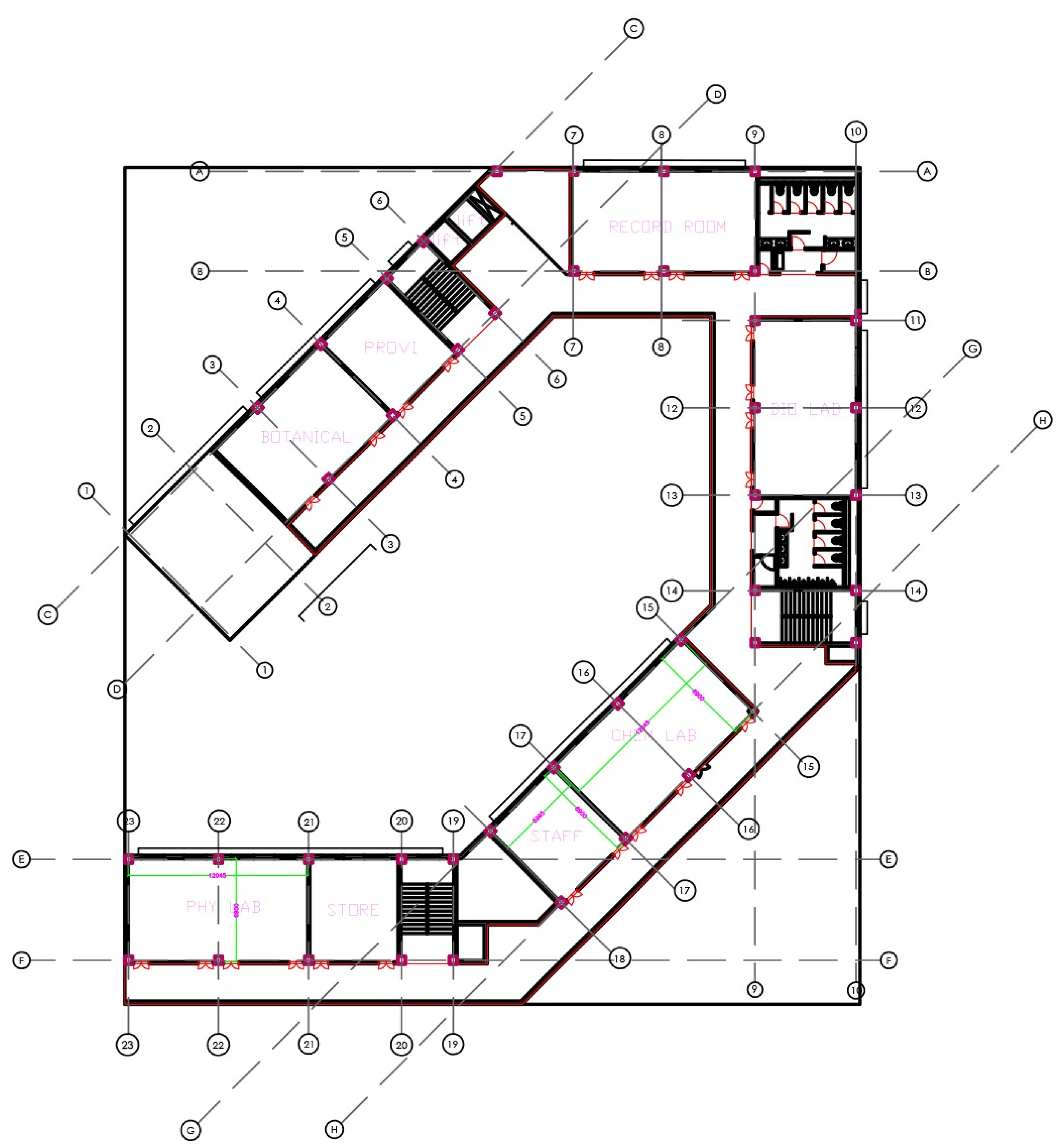
- Sports room
- Car lift
- Bank
- Passage
- Dining
- Toilet
- Core
- Computer room
- Activity room
- K.G classroom
- Store room
- Staff room
- Pre Primary
- Office
- Art room
- Secondary
- Record room
- Labs
- Music room
- Speech and Drama
- Dance room
- Refuge
- Examination hall
- Language room
- Library
- Secondary



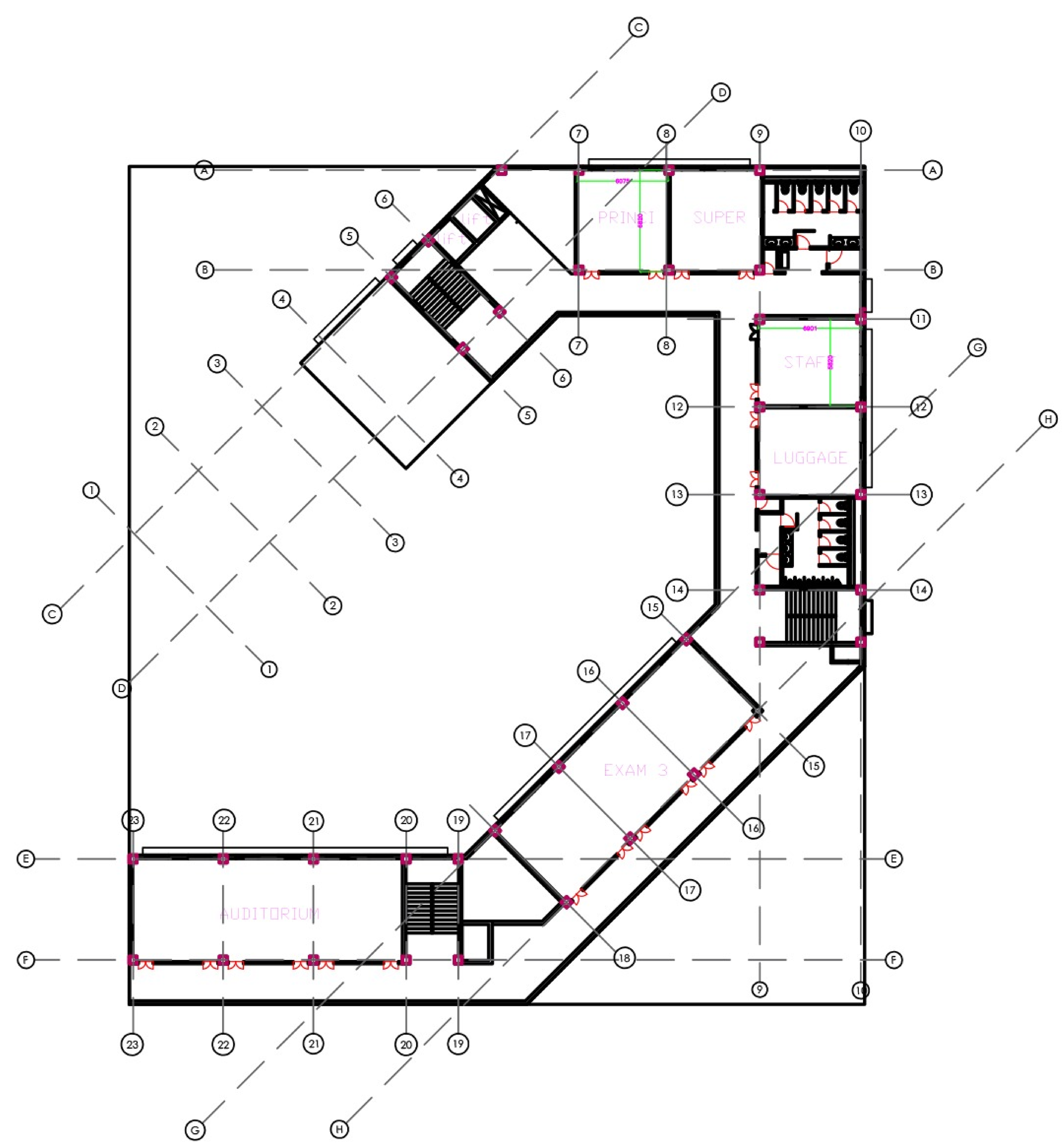
THIRD FLOOR



FOURTH FLOOR

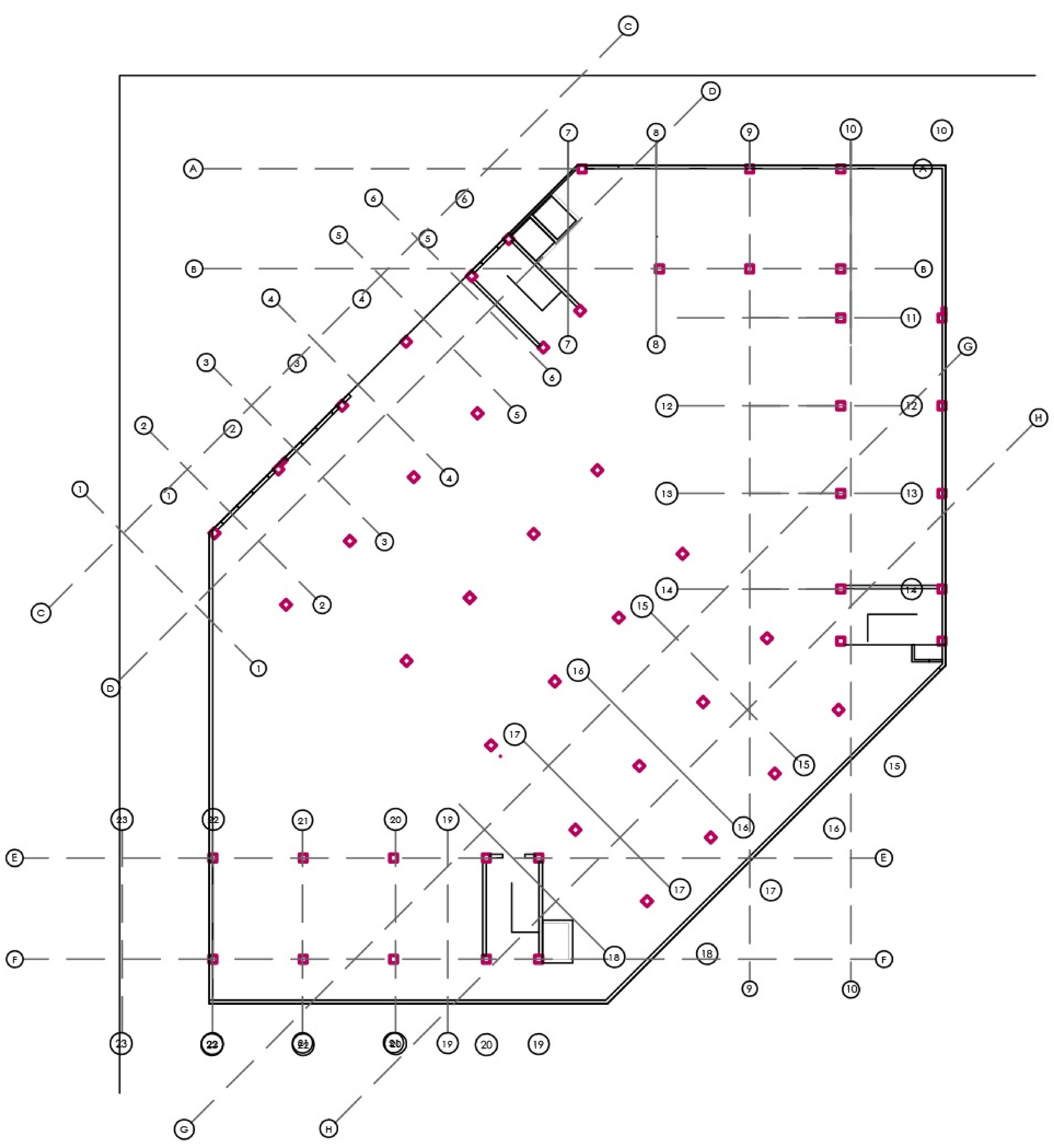


FIFTH FLOOR

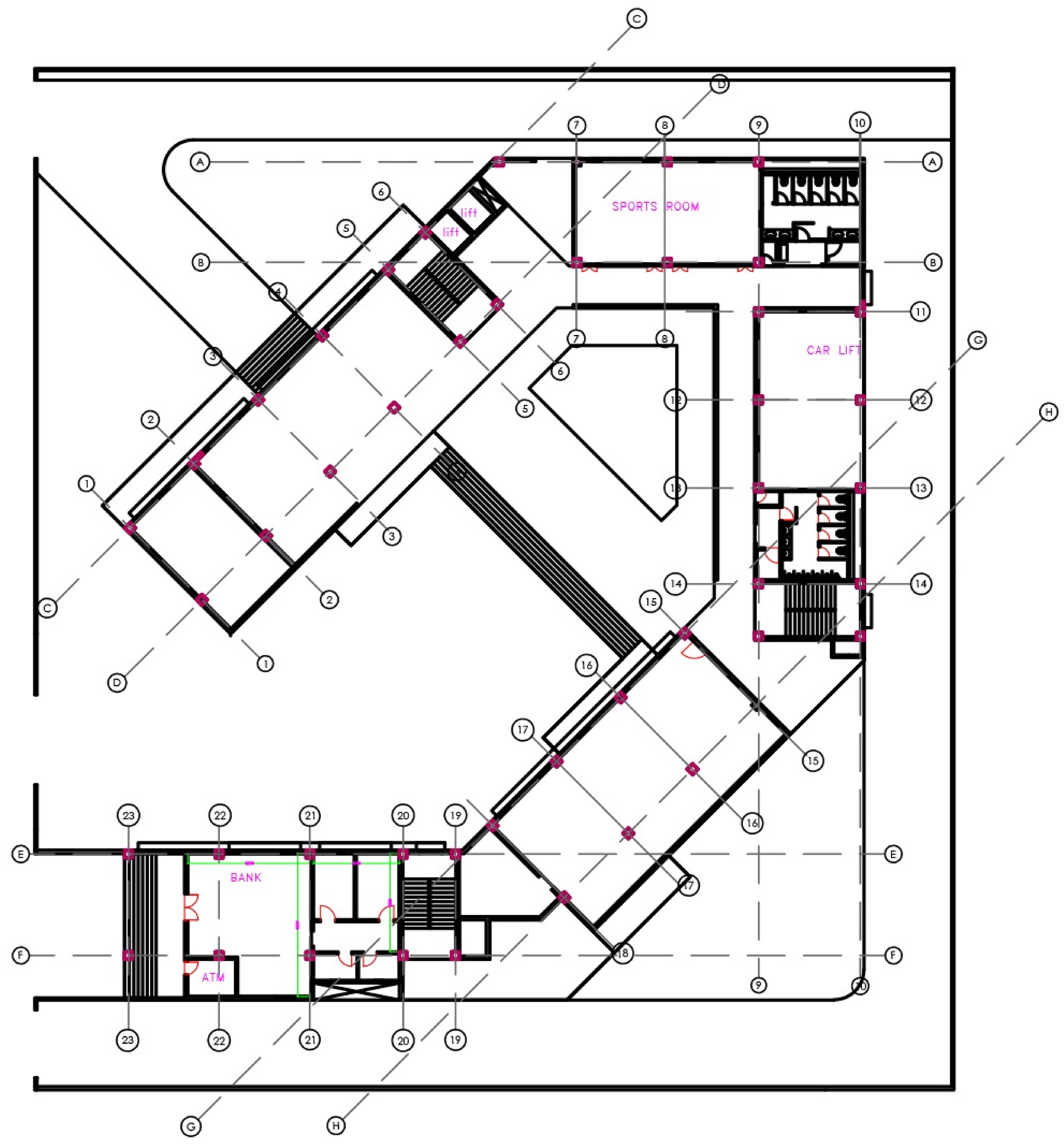


SIXTH FLOOR

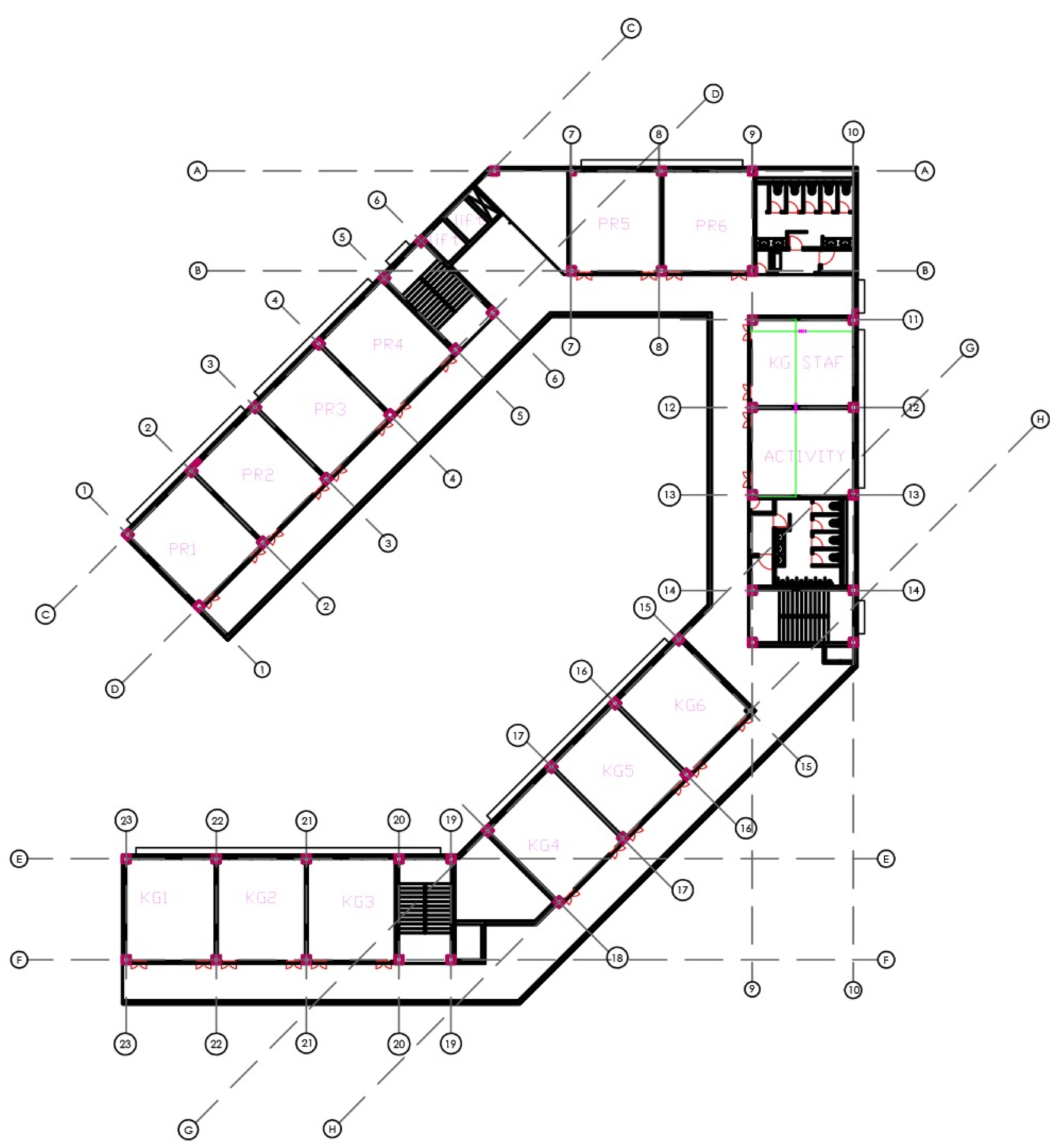
FLOOR PLANS



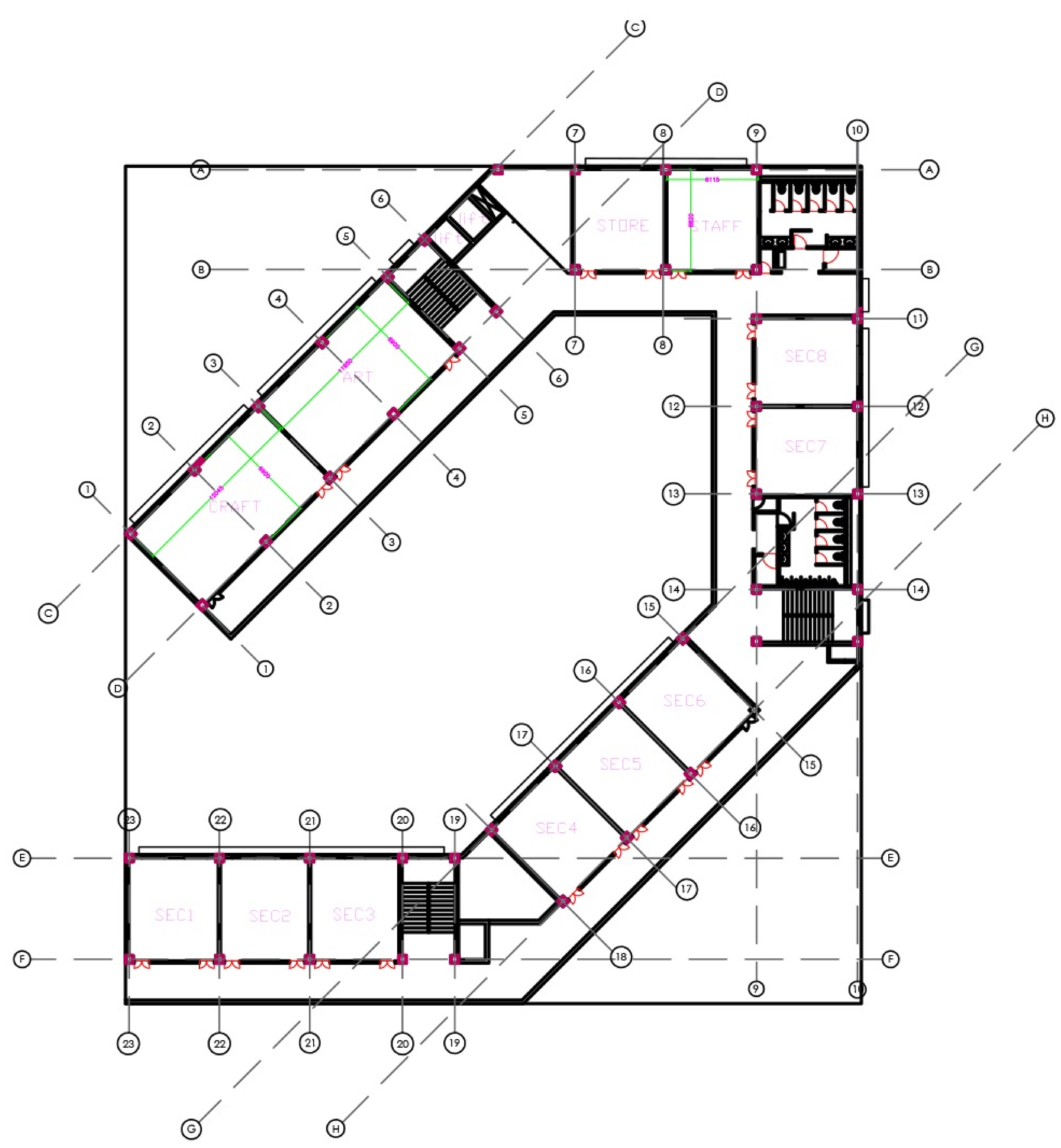
BASEMENT FLOOR



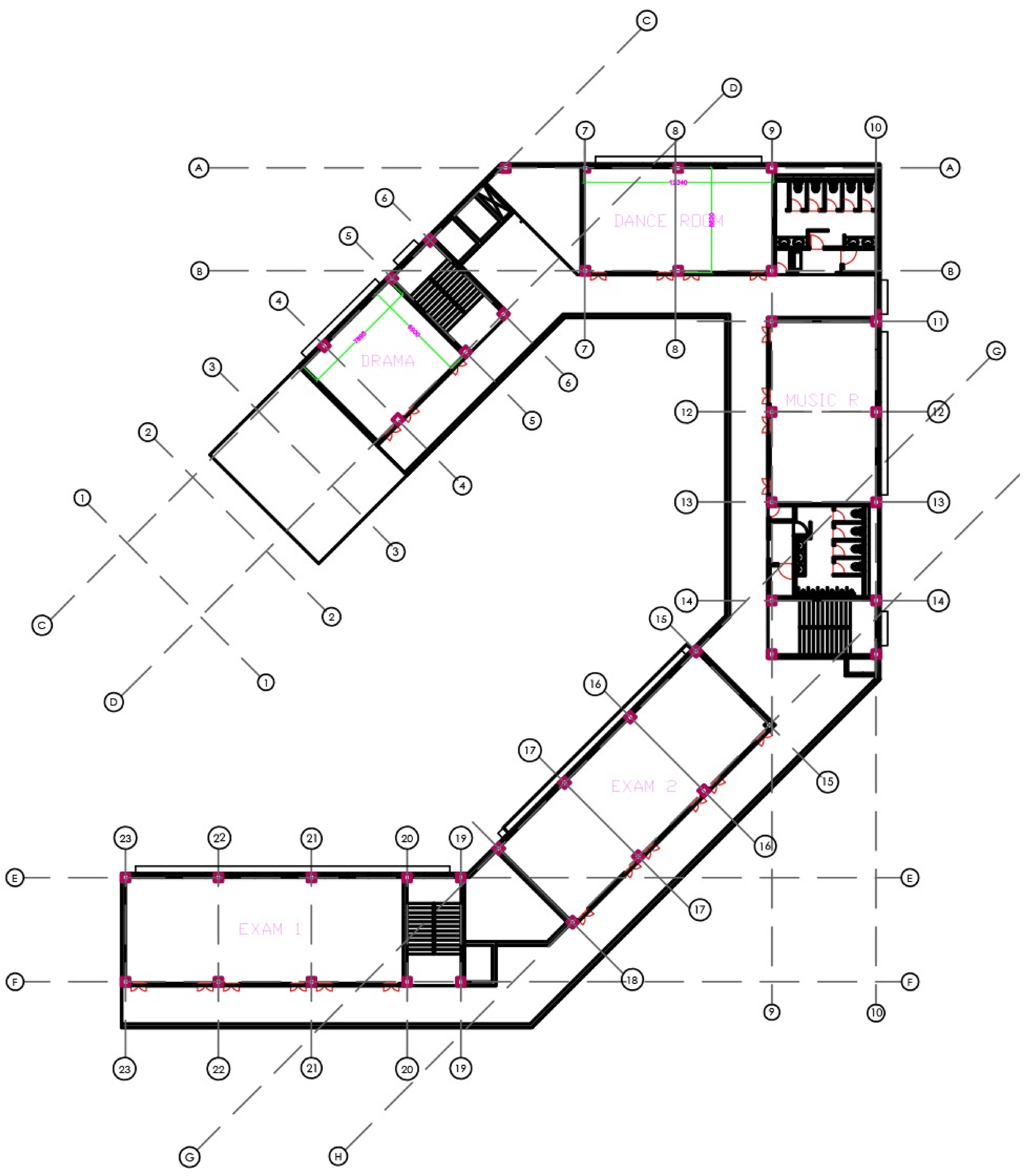
GROUND FLOOR



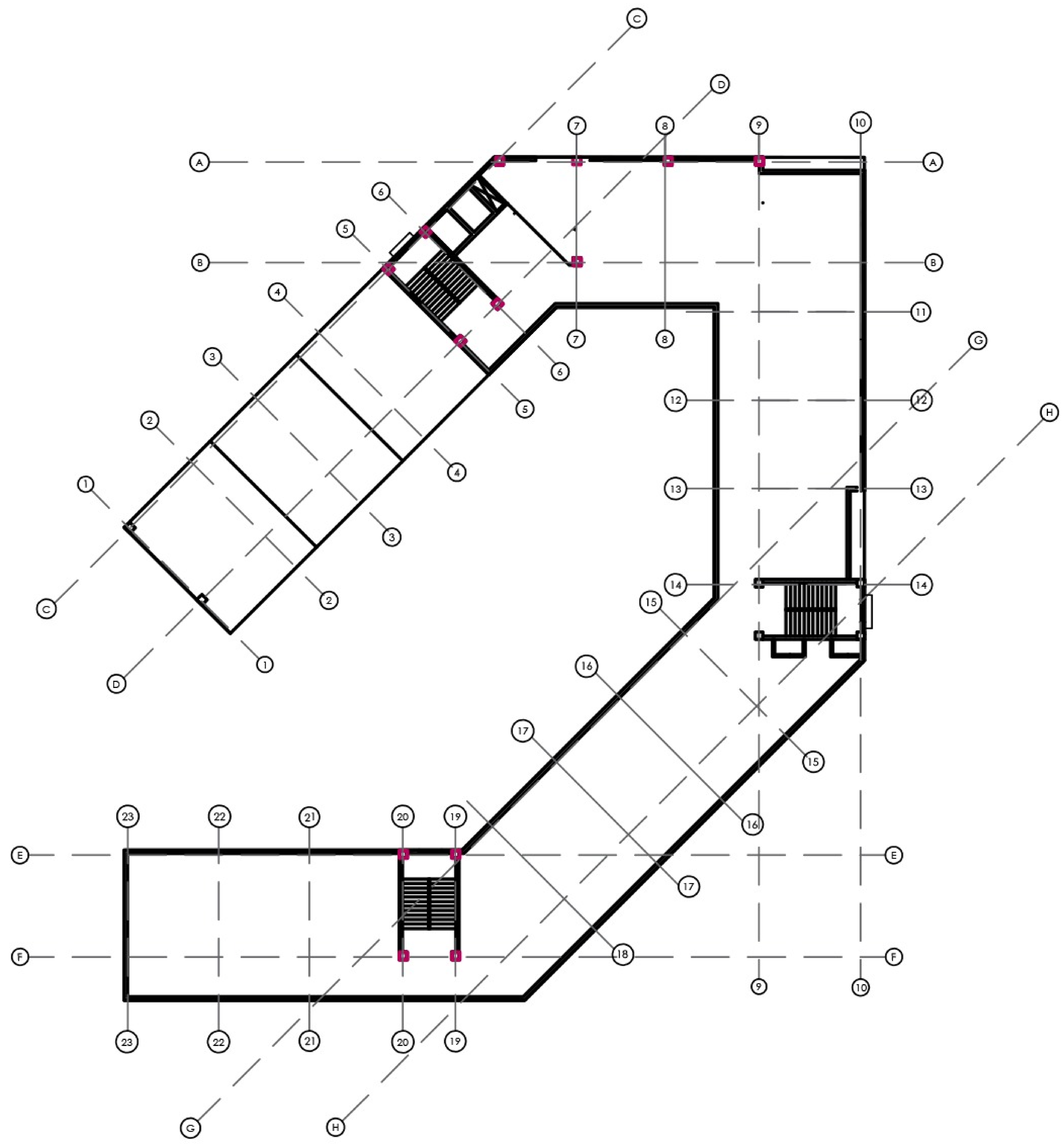
FIRST FLOOR



SECOND FLOOR



SEVENTH FLOOR



TERRACE FLOOR