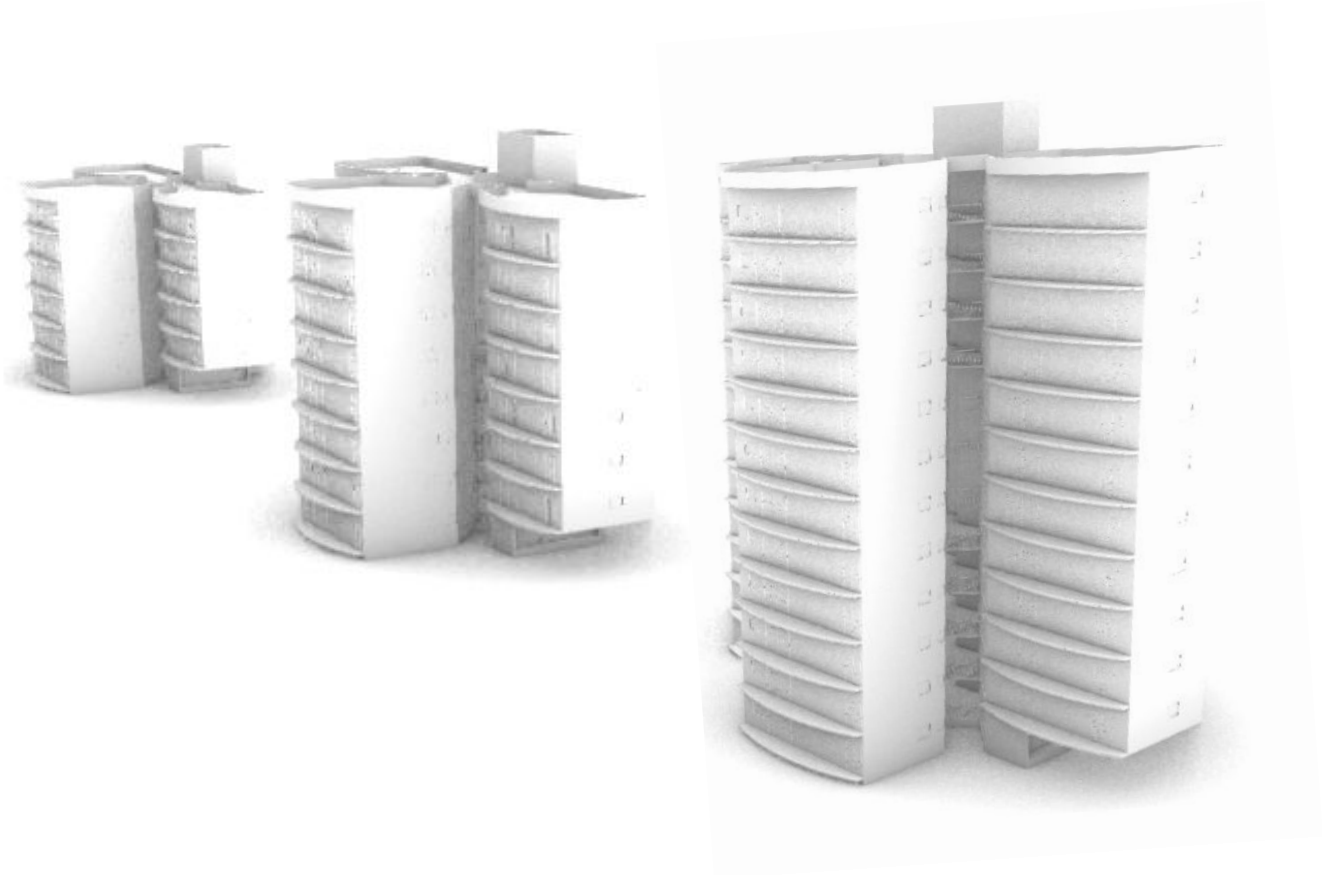
FINAL DESIGN REPORT

Team Lagom

Multi-family Housing



School of Planning and Architecture, New Delhi

REVIEWER 1 :

S.no	TOPIC	EVALUATION	RESPONSE TO REVIEWERS COMMENTS
1.	Energy Performance	Good	The values of total solar panel capacity has been revised and new values are added.
2.	Water Performance	Very Good	We have crossed checked and corrected roof runoff coefficient and upgraded xeriscaping techniques
3.	Embodied Carbon	Very Good	In the excel file provided earlier, we could only find for 20sqm. Revised one is not accessible for some reasons too.
4..	Resilient Design	Excellent	We appreciate your feedback.
5.	Engineering and Operations	Very Good	We appreciate your feedback.
6.	Architectural Design	Excellent	We appreciate your feedback. We have added more graphics for better understanding.
7.	Affordability	Excellent	We appreciate your feedback

REVIEWER 1 :

S.no	TOPIC	EVALUATION	RESPONSE TO REVIEWERS COMMENTS
8.	Innovation	Excellent	We appreciate your feedback.
9.	Health and wellbeing	Very Good	We appreciate your feedback.
10.	Value Proposition	Very Good	We appreciate your feedback.

REVIEWER 2 :

S.no	TOPIC	EVALUATION	RESPONSE TO REVIEWERS COMMENTS
1.	Energy Performance	Excellent	We appreciate your feedback.
2.	Water Performance	Excellent	We really appreciate your feedback
3.	Embodied Carbon	Very Good	The table of breakup for the 20sqm is given in the appendix (Pg no:)
4..	Resilient Design	Very Good	We have covered transportation resilience in 7.6.3 and have tried to include eco resilience in all of the points incorporated.
5.	Engineering and Operations	Good	A note on foundations and electro-mechanical system engineering design approach addressed and updated accordingly.
6.	Architectural Design	Excellent	We appreciate your feedback. We have added more graphics for better understanding.
7.	Affordability	Very Good	We appreciate your feedback

REVIEWER 1 :

S.no	TOPIC	EVALUATION	RESPONSE TO REVIEWERS COMMENTS
8.	Innovation	Very Good	We appreciate your feedback.
9.	Health and wellbeing	Very Good	We appreciate your feedback.
10.	Value Proposition	Excellent	We appreciate your feedback.

1. EXECUTIVE SUMMARY

Team Lagom is a multidisciplinary team of eight architectural students and one BEM student from **School of Planning & Architecture**, New Delhi and one mechanical engineer from **IIT New Delhi**. Our team is guided by sustainable design professional and other professionals and advisors from diverse backgrounds. Our team has worked together harmoniously, with everybody providing their unique inputs throughout the process.

We began by coming together as a team and working on different iterations of design of which one was taken forward on the basis of thermal comfort, orientation and passive strategies. Here on we worked together to develop the design, with each person assigned a topic, cumulatively working on sustainable solutions.

Our Project Partner **DDF Private Consultants** have provided us the necessary information on the mixed-use university design of **Major Dhyan Chand Sports University** in Meerut, Uttar Pradesh. The university comprises of and academic area, hostels, and staff-housing which is being addressed to in this project report.

Lagom meaning the '***perfect balance***' is inspired from our target striving to achieve a net-zero building where the amount of water and energy consumed is replenished or generated by adopting sustainable strategies such as adopting water efficient devices and harnessing solar potential in the site.

The energy generation potential from the renewable energy sources was found to be **555660 KW** and therefore target EPI for the project was set at **37 kWh/year.** The EPI was reduced to **33.49 kWh/year** by integration of active and passive design strategies such as climate responsive orientation, integration of solar chimney in common spaces of the dwelling units, which was further enhanced in form to assist for efficient flow of air. Building envelope materials of low U-value were chosen as per super ECBC standards.

Health and wellbeing of occupants was addressed to by providing South sun to all the dwelling units, providing sunlight to all units at most times of the day, to promote ventilation and natural disinfection of living spaces. A proper waste management technique is employed to assist for safe disposal of waste. Segregation of dry and wet waste is made unit wise. Garbage chute is given at each floor for disposal. A **Waste Recovery System (WRF)** has been provided to reuse and recycle waste generated from units. Yard waste generated on site along with some percentage of organic waste from kitchen is being vermicomposted and stored as solid pellets. These pellets are to be used to produce biogas on site to address to heating needs in winters.

Carbon emissions were reduced by 86% by adopting carbon-negative material for building envelope such as cork cladding and carbon captured concrete instead of precast concrete.

The baseline fresh water demand of **135 KLD** was reduced to **75 KLD** by integrating water efficient fixtures, drip irrigation technique with recycling and reusing of grey water. **We have proposed to reduce about 56% water demand**. Furthermore rain water harvesting system was adopted at the building and site level to offset the fresh water consumption to achieve net zero water by harnessing the huge potential of stormwater runoff during the monsoon months of almost **1400 mm**.

2.1 Team Name
Team Lagom

2.2 Division
Multi-family Housing

2.3 Institution
School of Planning and Architecture, New Delhi (Est. in 1941)

SPA Delhi is a deemed university specializing in education and research in the field of architecture and planning. The institute's primary concerns are human habitat and the environment, the range of academic courses are constantly being broadened by offering courses in newly emerging and developing topics. A collaboration with the students pursuing Master's in building engineering and management (BEM) is taken up to facilitate us with a better understanding of building engineering and services. The institute primarily offers Undergraduate Degree in Architecture and Planning, Postgraduate Programs, Doctoral Programs and Executive Education Programs.

2.4 Team Members

LUNAVATH AKHIL RAJ
B.ARCH,3rd year
[Design and Water Performance]

THANISHKA THOUDABOINA
B.ARCH,3rd year
[Embodied Carbon and Innovation]

SHRIYA SAMPALLI REDDY
B.ARCH,3rd year
TEAM LEAD
[Design and Passive Strategies]

RHEA KAUR PADAM
B.ARCH,3rd year
[Working Drawings and Design]

NARRA DEEKSHITA
B.ARCH,3rd year
[Graphics]

SWETHA S.
B.ARCH,3rd year
[Resilience and HVAC]

ADARI BALA CHANDRA DEEPAK
B.ARCH,3rd year
[Energy performance and Cost Analysis]

HILOR SHARMA
B.E.M,2rd year
[Cost Analysis and Value Proposition]

RAHUL KAUTILYA VYDYA
Mech. Eng.,4rd year
[Building services]

AARZOO
B.ARCH,3rd year
[Structures and Wellbeing]

2.5 Approach

We, Team Lagom, have partnered with U.P. State Government to create a net-zero energy, waste, and water multi-family housing on a mixed-use site of a sports University located in Meerut. The housing will cater to the staff working at the university and their families.

Our design aims to create efficient space planning, and thermal comfort to the residents in the composite climate of Meerut using passive strategies based on the vernacular architecture of the region culminating with current innovation and technology. We intend to achieve a design that is functional, provides ease in maintenance, and most importantly promote and upbring the lifestyle and well-being of the residents.

2.6 Faculty Lead

Dr. Khushal Matai
Assistant Professor in Architecture, SPA, New Delhi
Bachelors from SPA, New Delhi
M.Arch. From SPA, New Delhi

2.6 Faculty Advisors

Dr. Shweta Manchanda
Sustainable Design Professional
Architecture Faculty, SPA, New Delhi
B.Arch from School of planning and architecture, New Delhi
M.Phil. (Environmental design) from University of Cambridge
PhD Energy and Environmental from university of Cambridge

Ar. Ashwini Kumar Dutta
Visiting faculty, SPA, New Delhi.
B.Arch. in CEPT University, Ahmedabad.
Masters in Architectural Design, University of Arizona

Dr. Deepti Gupta
Visiting faculty, SPA, New Delhi.
B.Arch from School of planning and architecture, New Delhi
B.Eng. from SPA, New Delhi.
B.Eng. (Membranes), Hochschule Anhalt, Germany.

Dr. Amit Kumar Jaglan
Assistant Professor, SPA, New Delhi
PhD. (IIT Kharagpur)

Ar. Jasmeet Singh
Visiting Faculty, SPA, New Delhi
B.Arch from School of planning and architecture, New Delhi

Ar. Soumya Uttam
Contract faculty at the department of Architecture, SPA, Delhi.
B.Arch from School of planning and architecture, New Delhi with a Gold medal

2.7 Industry Partners

NAVEEN ASSOCIATES
Landscape Architects

SATYAM

iqubx interior systems
intelligent innovative integrated

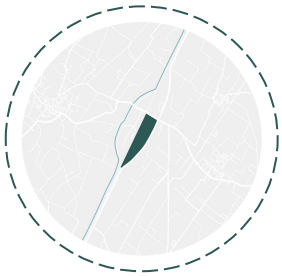
2.8 Tools Used :

2.9 Project Partner :

DDF Consultants Private Limited

DDF Consultants Pvt. Ltd. is a leading Consultancy organization providing research and consultancy in various fields related to Built Environment. They provide research and consultancy services in the areas pertaining to Design and Development of Human Settlements, Regional and Urban Planning, Environmental Planning, Engineering and Architectural Design. They have collaborated with us throughout the design process while continuously improving and helping us make the design as practical and workable as possible with their industry exposure. ,

2.10 Site Description :



The site is located nearby Salawa village in Meerut, Uttar Pradesh.

Project Site

Upper Ganges Canal

Soil type : alluvial soil

Climatic zone : composite

2.11 Swot Analysis :

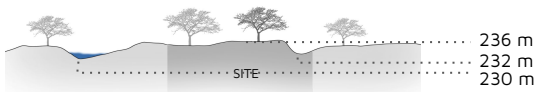
Good connectivity, adjacent canal, less urbanisation, less noise

The project will act as a landmark and support local businesses

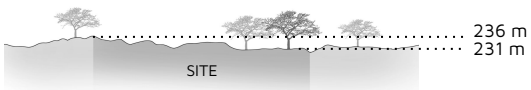
Moisture in soil might hinder construction process

Prone to flooding during monsoon season

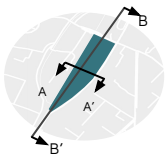
Site Sections :



Section AA'



Section BB'



KEY PLAN

3.1 Project Name

Staff housing for Major Dhyan Chand Sports University

3.2 Project Partner

D.D.F Consultants Private Limited

3.3 Project Description

The Major Dhyan Chand Sports University is been planned with all the modern, state-of-the-art sports infrastructure – including a synthetic hockey ground, football ground, separate grounds for basketball, volleyball, handball, and kabaddi.

The residential part of the campus will house the hostels and staff accommodation, out of which we will be focusing on staff housing for this segment of multi-family housing. Our design will cater to the needs of 80 families consisting of 26- 3 BHK apartments and 54- 2 BHK apartments.

3.4 Site Specifications

Location	Meerut, Uttar Pradesh
Total site area	22000 sq.m
Estimated built up area	16308 sq.m
Permissible ground coverage	30%
Permissible built up area	33000 sq.m
F.A.R	1.5

STATUS OF THE PROJECT : Unbuilt

USER PROFILE : 80 families (University staff and their families)

HOURS OF OPERATION: 24hrs

CIIMATE TYPE : Composite

S. No	SPACE	Type of Space	Qty	Area	Total Area used by the space	No. of Persons	Activity	System
1	Landscape area	Kids play area	1	450 sqm	450 sqm	80	Physical excercise, entertainment	Naturally ventilated
		Courts of multiple sports	3	1000 sqm	1000 sqm	180	Interaction	
		Lawn/ park	1	450 sqm	450 sqm	370	Relaxing, interaction	
		Roads	1	2600 sqm	2600 sqm	400	Circulation	
		Pedestrian paths	multiple	580 sqm	580 sqm	400	Circulation	
		Green spaces beside pavements and roads	multiple	2865 sqm	2865 sqm	400	Dust control, Acoustic, Greenery	
2	Circulation (25% of total area for Residential)	Corridors		minimum width 1.5m	2900 sqm	-	Interaction	Non air conditioned
		Staircases (Residential)	10	37 sqm	370 sqm	400	Circulation	Non air conditioned
		Lifts	10	2.6 sqm	26 sqm	370	Circulation	Non air conditioned
		Stretcher/Service lift	5	3.9 sqm	19.5 sqm	30	Circulation	Non air conditioned

Table 3.1. Area programme for circulation and landscaping

ENERGY PERFORMANCE

Using renewable energy sources optimally along with passive design strategies to accomplish an EPI of 34 kWh/sqm/yr. Furthermore, designing such that the building not only consumes minimal energy, but also gives back to the environment by producing its own.

- Using passive cooling strategies suitable for the composite climate of Meerut
- Minimize eastern and western exposure
- Location, sizing and glazing of windows can be used judiciously to reducing cooling load
- Reducing HVAC requirements via simulations for efficient design with respect to direct radiation, daylight, wind etc

WATER PERFORMANCE

We aim to achieve zero wastage of water by ensuring all the water is reused or recharged via rainwater harvesting and subsequent treatment.

- Proper water treatment system integrated with swales (grey water treatment plant), sewage treatment plant and rain water harvesting
- Reusing or recycling water to utilize water that would otherwise be sent to a storm or sewage sewer
- Constantly monitoring the total water usage, alternative water usage and returned water and ground water table to maintain net zero wastage
- Use of low flow fixtures in the building to reduce wastage of running water

RESPONSE TO CLIMATE

To utilise the available climatic data analysis and deduce measures, materials and passive strategies that are required to be implemented for ensuring thermal comfort of the users with emphasis on air supply/ventilation, dehumidification, daylight and heat gain.

- Accounting for orientation, massing and innovative building envelope or facades
- Using mutually shaded courtyards with correct proportions
- Maintaining a Window-Wall-Ratio of no more than 35% to reduce energy requirements
- Incorporating passive dehumidification strategies such as natural ventilation, solar air heaters etc.

AFFORDABILITY

To develop a scheme that entails minimum initial, construction, operational and maintenance costs with the correct choice and judicial use of materials and sustainable design strategies.

- Limiting initial investment while focusing on extensive use of recycled and economical materials, techniques and methods

INNOVATION

Exploring and thoroughly researching strategies, materials, methods and technologies and their market potential at the local and global level and incorporating the most feasible findings into the design in accordance with the site analysis.

- Integrating current technology with the vernacular architecture and traditions. For instance, modern interpretations of cultural elements like jharokhas can be used to achieve a responsive design
- Attaining optimum utilization of space by expanding vertically rather than horizontally by means of elements like terrace gardens
- Taking advantage of the verticality of the built form by integrating solar PV panels and using appropriate SHGC and U-value materials in the facade/building envelope

RESPONSE TO CONTEXT

To analyse the vernacular architecture of the site, derive passive strategies from it so as to maintain continuity in terms of vocabulary and architectural language.

- Incorporating design elements inspired from the vernacular vocabulary of Meerut such as jharokhas and jaalis. They function as culturally responsive passive strategies while enhancing aesthetics as well
- Making use of a traditional water harvesting technique known as Nadi which also caters to ground water recharge

SOLAR POWER

Making utmost use of the direct sun that this specific site receives by harnessing it via solar panels and optimising exposure to and permissibility of daylight.

- Placing solar PV panels over areas like surface parking, roofs of the built form, terraces etc.
- Using the concept of solar chimneys to maintain thermal stability and comfort

RESILIENCE

To devise a structurally sound design that is capable of withstanding natural calamities that the site is prone to encounter such as earthquakes, floods, droughts and fires.

- Building framed structures with horizontal bands to increase resistance to earthquakes
- Elevated plinths and raised pumps/generators can be considered for prevention against floods
- Groundwater recharge strategies to be incorporated for maintenance of water table as a strategy against droughts
- Providing a full proof evacuation system with sufficient fire exits in accordance with fire norms along with fire rated materials

FUTURE EXPANSION

To design keeping in mind the potential need for future expansion on the site and giving adequate provisions for the same such that it can be carried out without disturbance to the existing buildings.

- Limiting the ground coverage on site to a maximum of 30%
- Ensuring that ample space is left untouched for future expansion if and when the need arises
- Strategically zoning and planning the site such that it allows for obstacle-free additions and alterations (as per the needs of the occupants) to the designed space

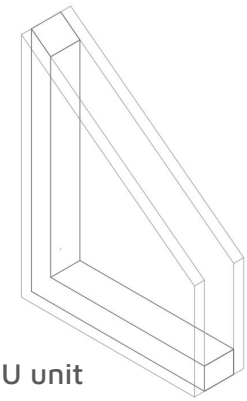
ADHERING TO FUNCTION

To cater to one of the fundamentals of residential design by providing visual and physical privacy throughout the complex while simultaneously maintaining universal accessibility.

- Building user-oriented spaces with efficient circulation and easy movement paths
- Providing easily accessible breakout and multipurpose spaces to promote community building and collaborative learning
- Accounting for all user groups by providing universally accessible toilets, ramps, parking zones, lifts etc.
- Maintaining a reasonable balance between privacy – both visual and physical – and interactive spaces

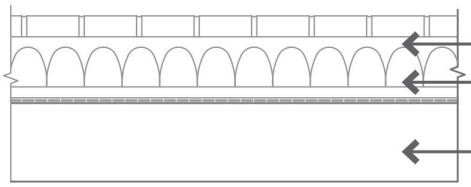
Passive Strategies

Use of deciduous trees in landscaping to shade pedestrian paths.



DGU unit

Fig 4.1



Earthen pot mud phuska insulation done on roof surfaces

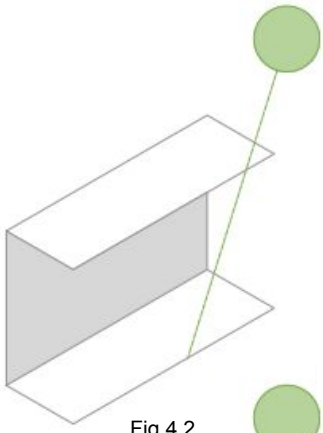


Fig 4.2

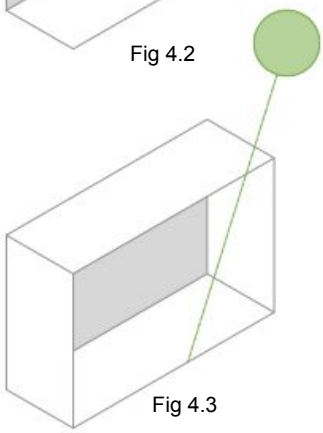
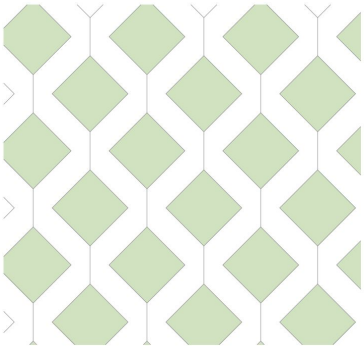


Fig 4.3



Grass Pavers used on pedestrian pathways

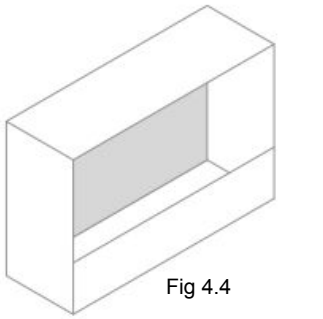
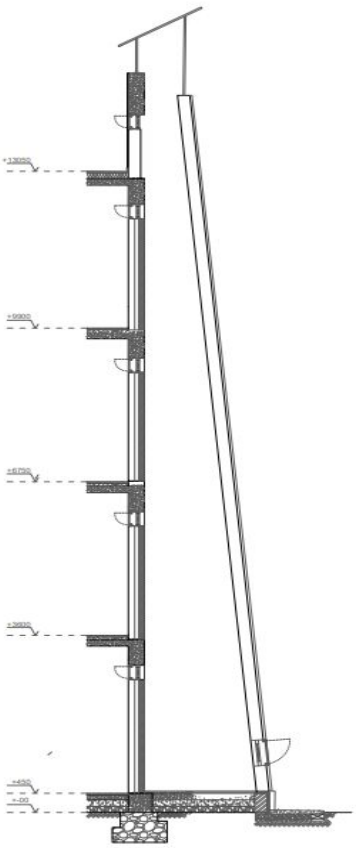


Fig 4.4

Vertical shading and horizontal shading combine to give a boxed window which enhances the balcony space



SOLAR CHIMNEY

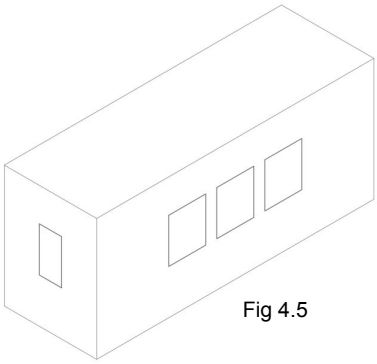


Fig 4.5

Facade treatment such that larger openings on the N-S facing facade

5.1 Envelope

	BASE CASE		DESIGN CASE	
WALL SECTION	Material	Thickness (mm)	Material	Thickness (mm)
			Cork Cladding	50
	Cement Plaster (Int)	12	Lime Plaster (Int)	12
	Brick Wall	230	Brick Wall	115
	Cement Plaster (Ext)	18	XPS Insulation	75
			AAC Blocks	100
			Lime Plaster (Ext)	18
	U-Value (W/m2-k)	**1.739**	**U-Value (W/m2-k)**	**0.23**
ROOF SECTION			Ceramic Tiles	20
	Asphalt	19	XPS Insulation	50
	Fibreboard	13	Screed	50
	Cast Concrete	100	Modified Silane W/P	2
			Concrete Slab	150
			Lime Plaster(Int)	12
	U-Value (W/m2-k)	**1.546**	**U-Value (W/m2-k)**	**0.214**

Table 5.1.Envelope

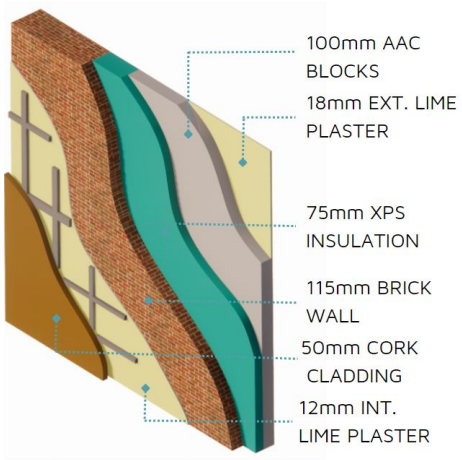


Fig.5.1. Wall section

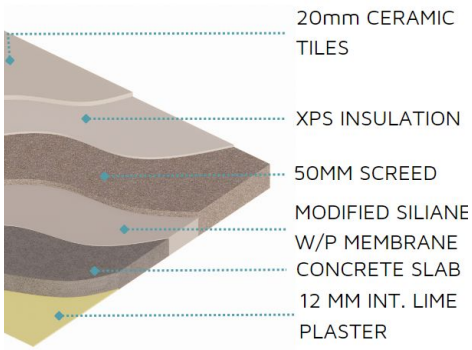


Fig.5.2. Roof section

5.2 HVAC System

System Type VAV Hybrid System - Heat Recovery System Water Cooled (Only Cooling)
Manufacturer DAIKIN INDIA

5.3 Electricity

On site Consumption - EPI 19.8 kWh/m2-yr

On site Generation

Type	Photovoltaic panels
Total Energy generation	330750 KWh
Water required for maintenance	3 L/panel/week

5.4 Lighting & Equipments

LPD 3.1 W/m2
EPD 35.7 W/m2

5.5 Shading device

The window to wall ratio (WWR) for shading devices is designed specifically for each orientation. This allows for sufficient natural daylighting while minimizing excessive heat gain during summers and heat loss during winters. The use of shading devices, such as overhangs or shading fins, is used to further reduce direct sunlight penetration and glare, especially during the hot summer months in Meerut.

Orientation	WWR
North (0°)	0.35
East (90°)	0.2
West (270°)	0.2
South (180°)	0.25

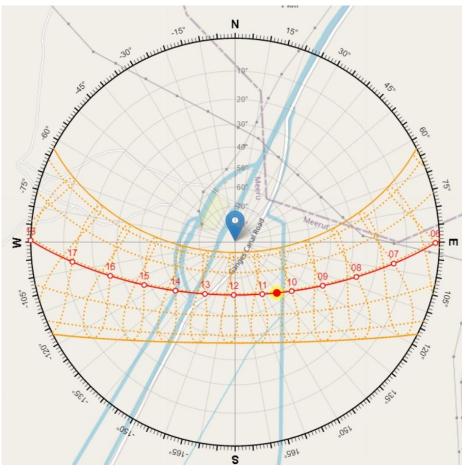


Fig.5.5.1. Sun path diagram

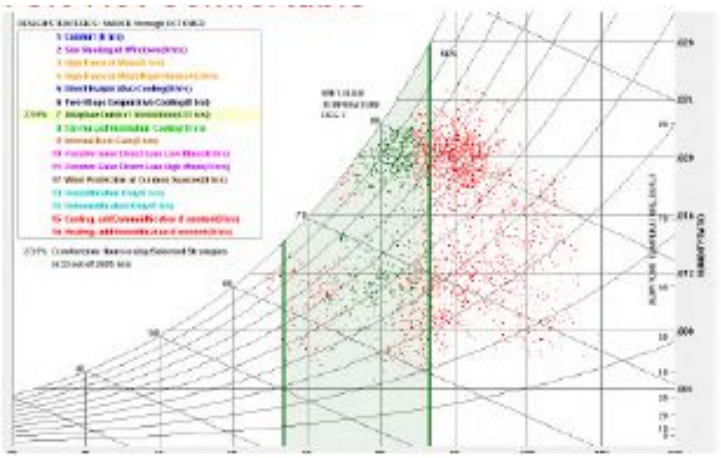


Fig.5.5.2. Psychrometric Chart

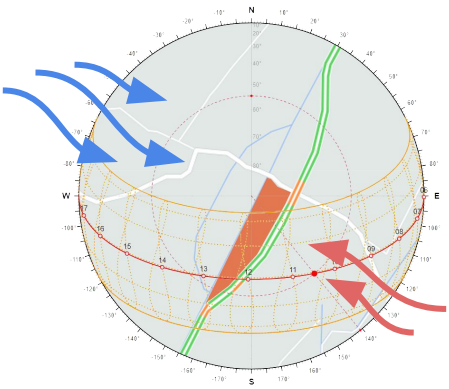
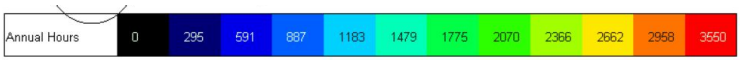
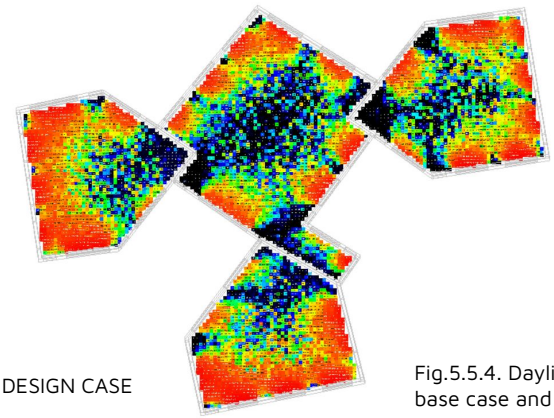


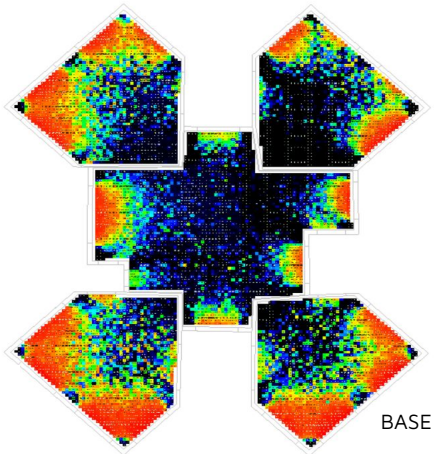
Fig.5.5.3. Wind path diagram

The direction and position of the windows and openings are planned accordingly to make the best use of the wind and create a comfortable indoor environment all year round. The building is also designed to allow for cross ventilation, which not only makes the indoor environment more comfortable but also helps reduce the dependency on mechanical cooling systems.





DESIGN CASE



BASE CASE

Fig.5.5.4. Daylight analysis for base case and design case.

6.1 Summary Of Case Studies:

6.1.1 Based On Typology (Residential Housing)

Tara Housing Group, New Delhi

Major Strategy :

Fig 6.2.1 Spatial organization

The dwelling units are arranged in clusters similar to that of row housing in which the central street is developed as multifunctional landscape spine. The spaces are arranged (Fig 3.1.1) in the plan in accordance to the amount of natural light falling on it without the heat affecting the comfort of the inhabitants.

Other Strategies :

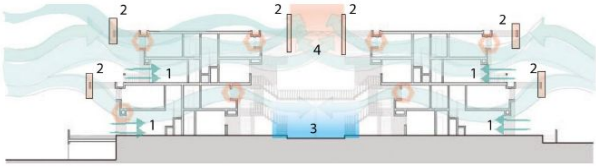
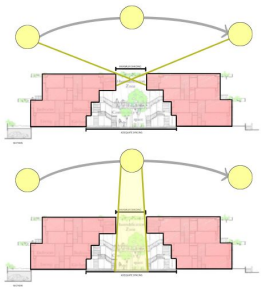


Fig 6.2.2Circulation of air

- Air circulation - The building utilizes courtyard effect to get adequate cool air. The window openings are placed accordingly such that it allows and guides ventilation into the building.



- Mutual Shading - the interlocking of the two longitudinal staggered decks provides mutual shading and provides thermal comfort to the users in the central spine.

Interlace, Singapore

Major Strategy :

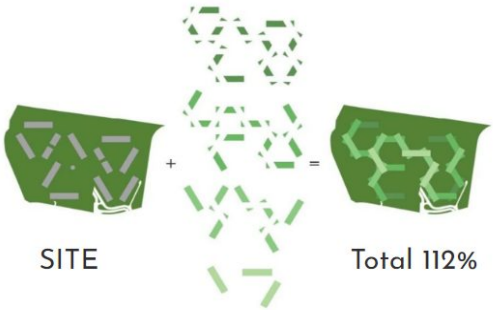


Fig 6.2.3 Maximized green area

Through stacking the apartments, the design generates a multiplication of horizontal surfaces populated by extensive roof gardens and landscaped terraces that offer more green space than the size of the unbuilt site.

Other Strategies :

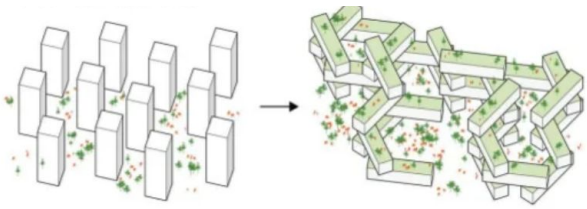


Fig 6.2.5 Spatial organization

- Instead of following the default typology of housing in dense urban environment like clusters of isolated towers,horizontal connectivity is explored.
- The design turns vertical isolation into horizontal connectivity, generating an extensive network of private and shared social spaces in a radial reinterpretation of contemporary life in a community.

6.1.1 Based On Different Passive Strategies

Infosys, Hyderabad

Major Strategy :

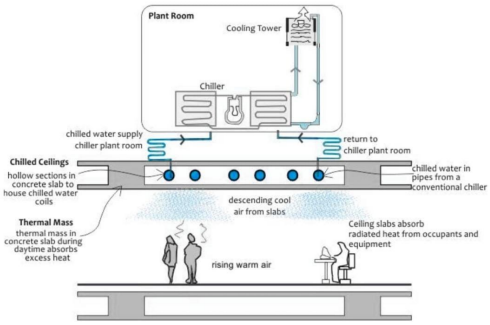


Fig 6.1.1 Radiant Cooling

Radiant cooling (Fig 3.1.1) is about 3,400 times more efficient in transferring heat than conventional air Conditioning. Quality of air is much higher in radiant side because there is no recirculation needed.

Other Strategies :

Fig 6.1.2 Infosys hyderabad

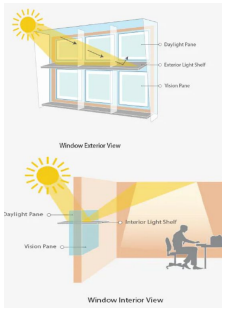


Fig 6.1.3 light shelves

- Light shelves (Fig 3.1.3) are used to reflect natural light into a building and reduces the ingress of heat.
- Building Envelope - Use of insulation with high thermal resistance to reduce external heat gain into the building.
- Orientation - The longer axis (Fig 3.1.2) of the building is oriented on the East-West axis in order to reduce solar heat gain

Manitoba Hydro Place, Canada

Major Strategy :

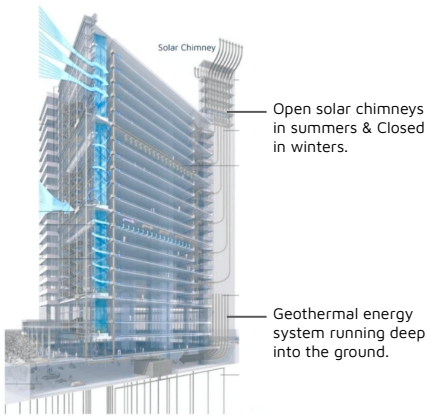


Fig 6.1.4 Solar Chimney

115 metres high solar chimney (Fig 3.1.4) is on North side of the building and exhaust the used and contaminated air from the building to the exterior using stack effect.

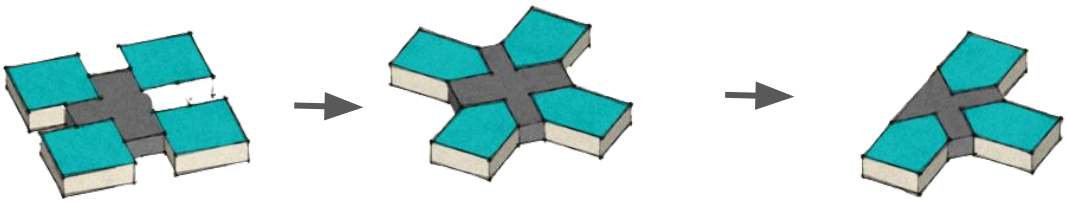
Other Strategies :

Fig 6.1.5 Manitoba Hydro Place

- Ventilation -Fresh air is drawn into the atrium space, conditioned before entering the other spaces of the building.
- Dynamic double skin curtain wall facade - lowers heating and cooling by creating an intermediate space from the extremes of the exterior.
- Dehumidification-Humidification - A 6 floor high water feature maintains the moisture levels in the atrium
for a comfortable microclimate within the building.
- Green Roof - Helps as an insulator which prevents the solar gain in summer and heat loss in winter. Because of the porous surface, it also decreases the amount of runoff water.

7.1 Architectural Design

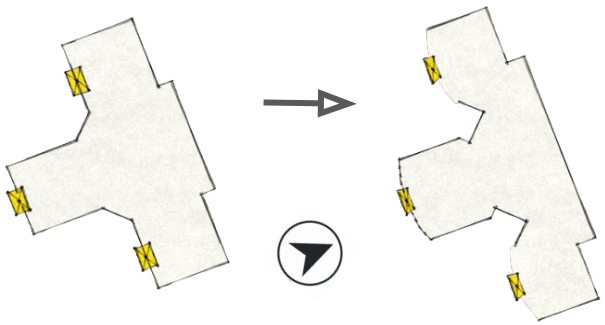
7.1.1 Form Development



Central core surrounded by dwelling units on 4 edges

Form chamfered to provide additional ventilation and daylighting.

Removal of unit which wasn't receiving South side sun at any point of the day.



The form is oriented in a way that the longer side faces North and Sun. Providing South for all units allowed us to integrate a solar chimney as a passive strategy. Inspired by the concept of the solar window, the outer edge of the balcony in every unit is curved later to give it a larger area to capture maximum possible radiation from sun for a longer duration of the day.

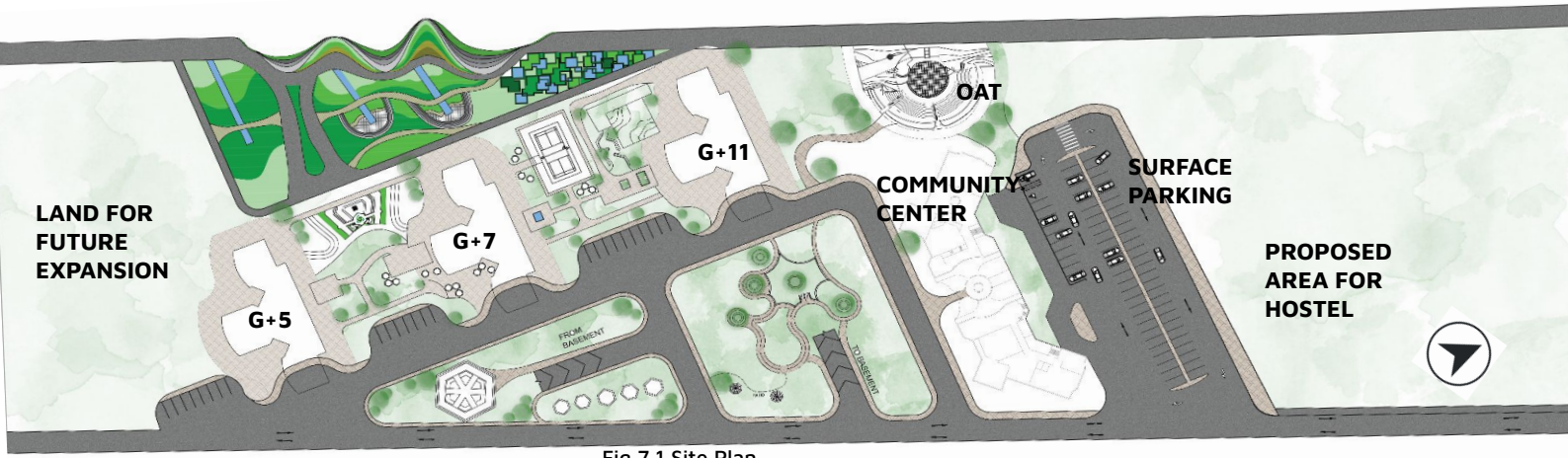


Fig 7.1 Site Plan

SITE PLAN

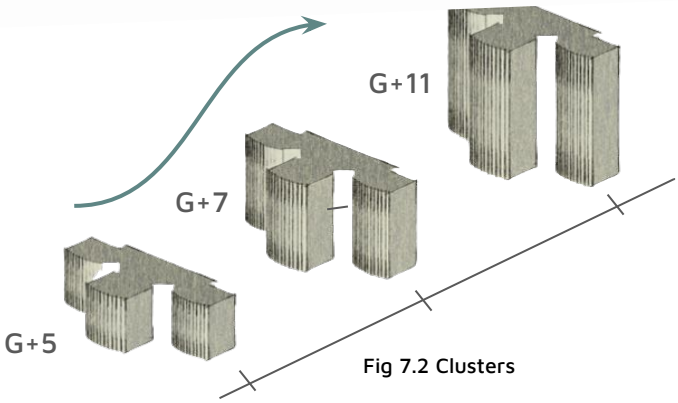


Fig 7.2 Clusters

The housing clusters vary in height so as to minimize mutual shading, and get in more sun from South. The distance between the blocks has also been strategically adjusted to suit the same purpose. This has been deduced by means of simulation. This is imperative for the working of our solar chimney.

7.1.2 Zoning

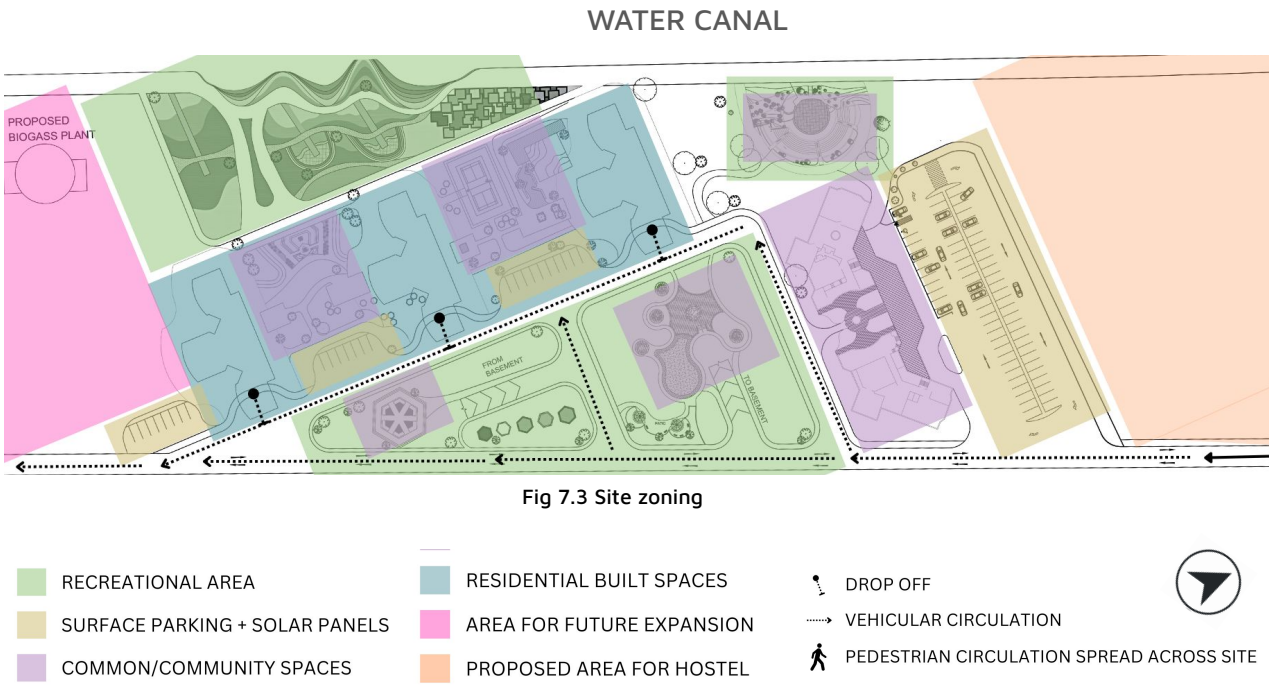


Fig 7.3 Site zoning

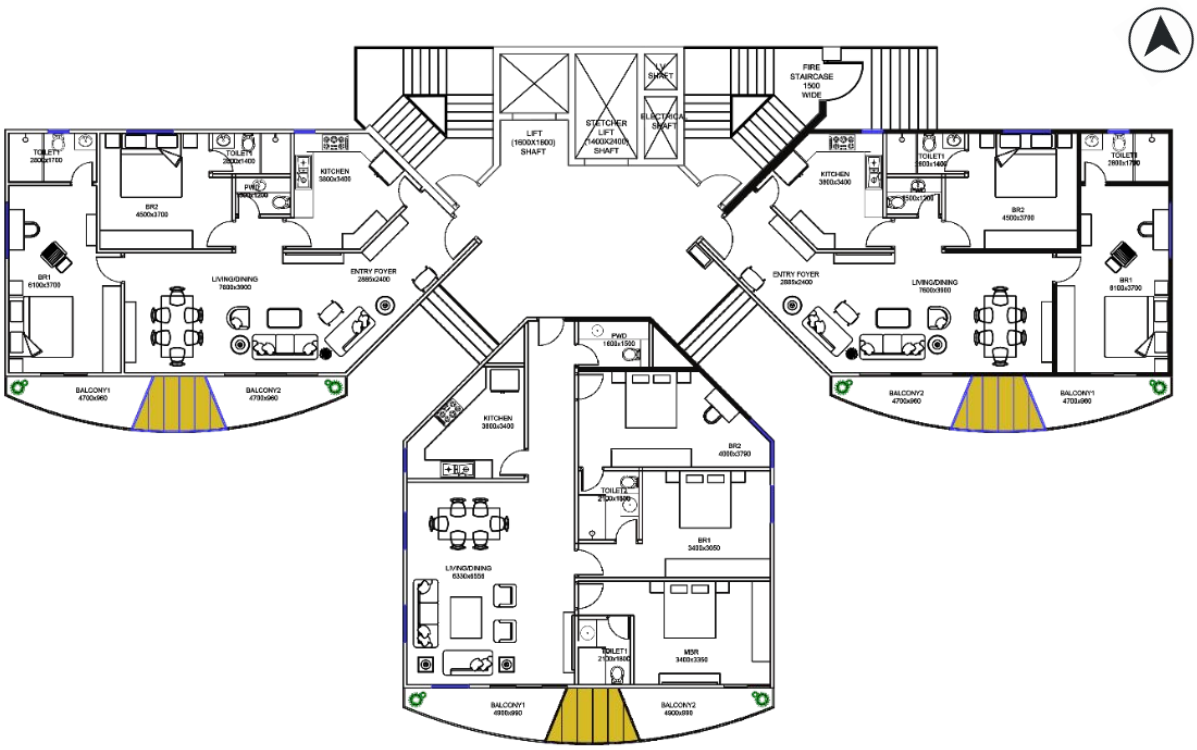


Fig 7.4 Typical floor plan

7.1.2 Iterations for Optimum Orientation

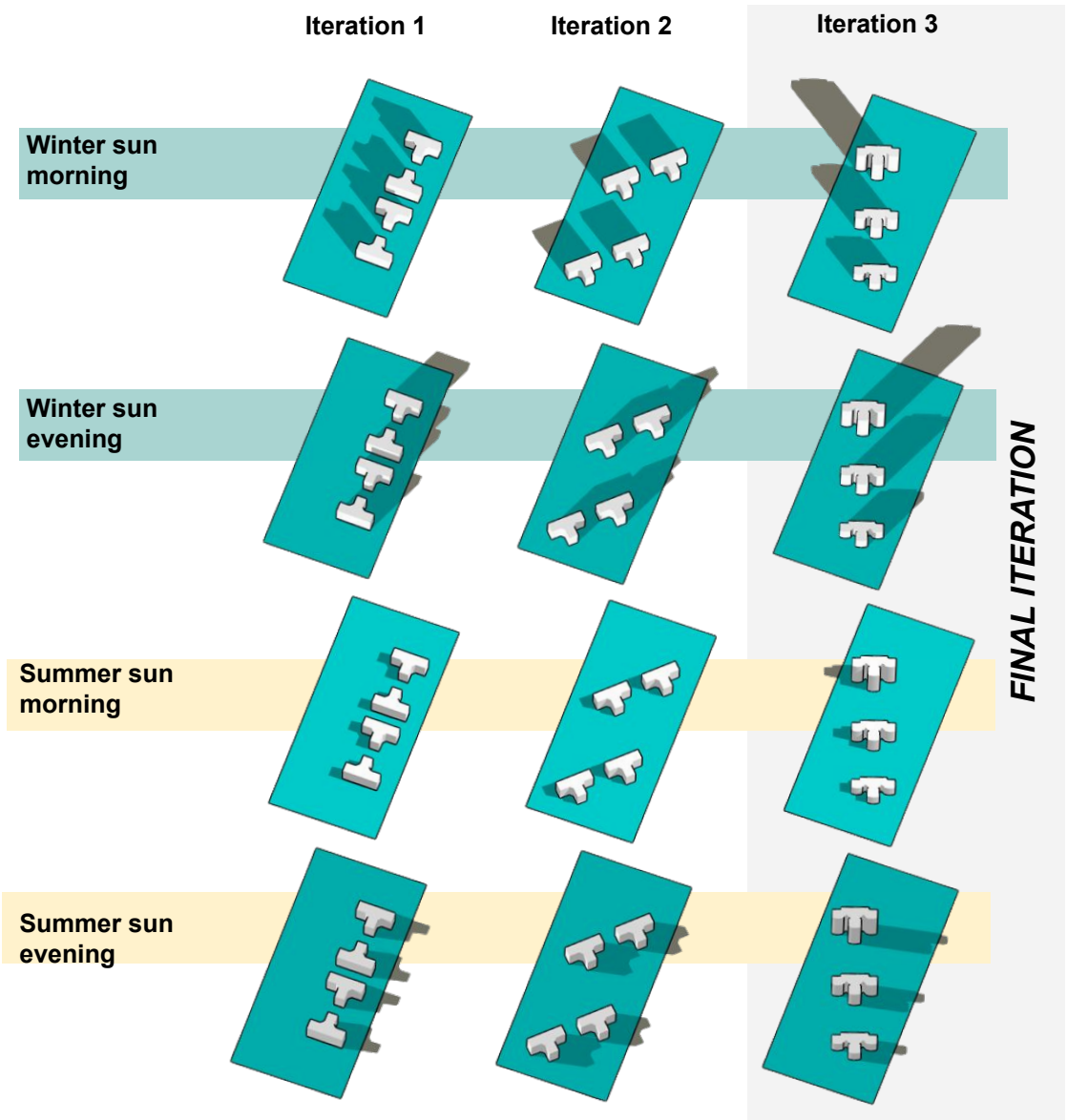


Fig 7.5 Shadow analysis

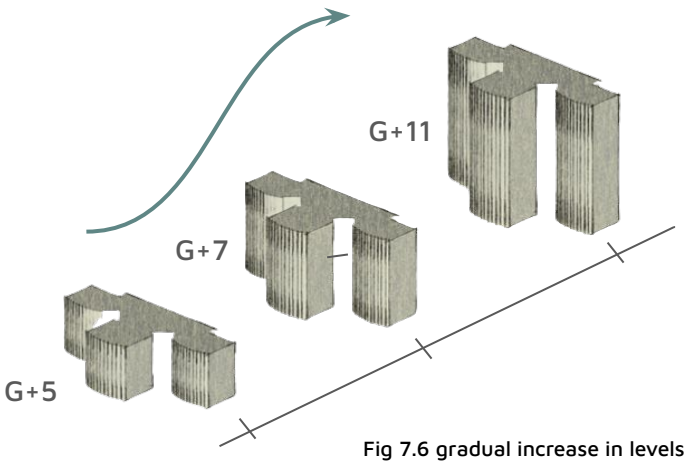
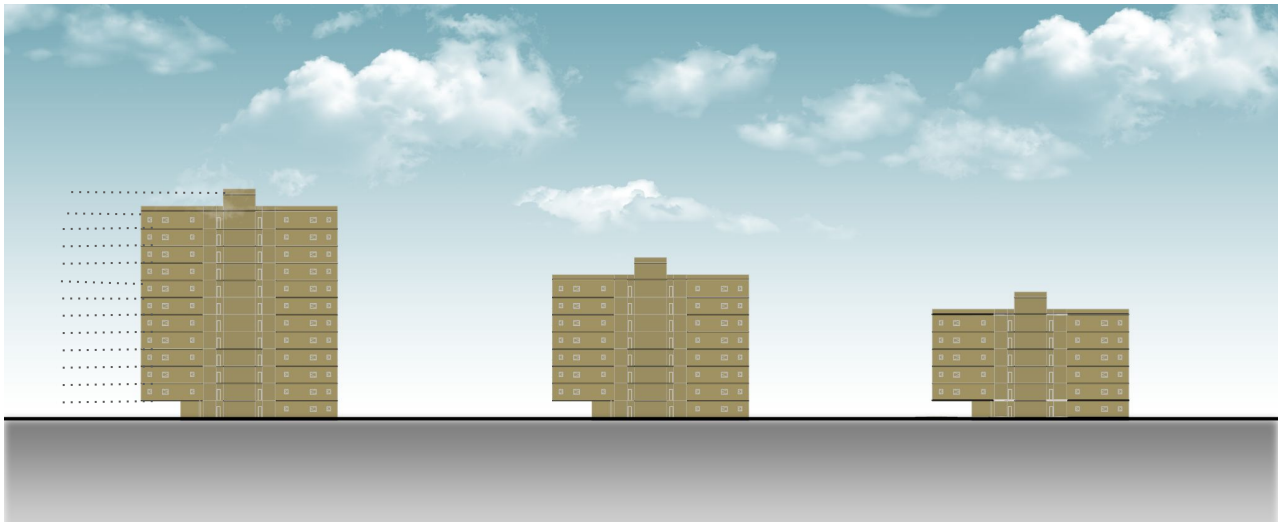


Fig 7.6 gradual increase in levels

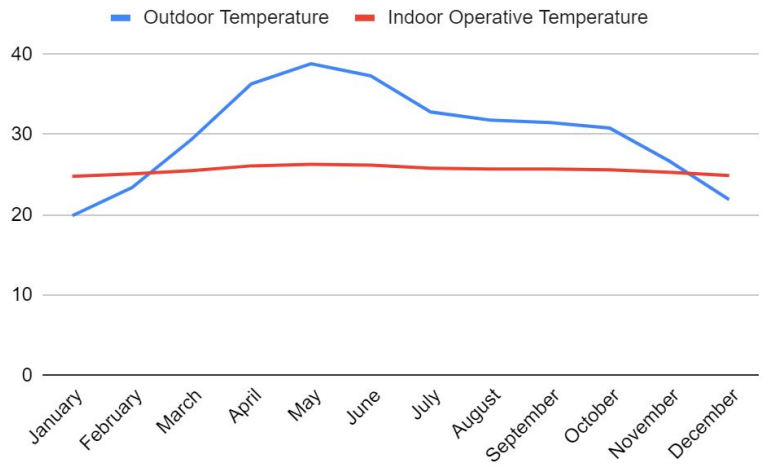
The housing clusters vary in height so as to minimize mutual shading, and get in more sun from South. The distance between the blocks has also been strategically adjusted to suit the same purpose. This has been deduced by means of simulation. This is imperative for the working of our solar chimney.

7.1.2 Zoning



7.2 Health And Wellbeing

7.2.1 Thermal Comfort



Following the Indian Model for Adaptive Comfort (IMAC),the indoor operative temperature varies in response to the outdoor temperatures. For air conditioned buildings, using the formula :
Indoor Operative Temperature = (0.078 x outdoor temperature) + 23.25

The outdoor temperature values are the critical peak values of each month annually. From this indoor operative temperature, a range of ±3.46 C is accepted as comfortable by almost everyone.
We mostly rely on ceiling fans, stack effects, and shade devices in the summer. After running simulations, it was determined that we could reduce solar gain by using shading. The availability of natural ventilation throughout the summer decreases the demand for mechanical ventilation.
After carefully examining the IOT for winter design, it was discovered that the passive strategy, illumination, occupancy, and equipment had resulted in a substantial heat gain.

7.2.1 Visual Comfort and Indoor Air Quality

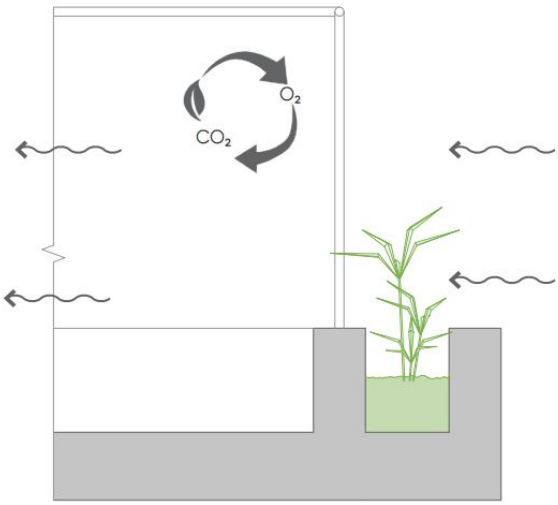
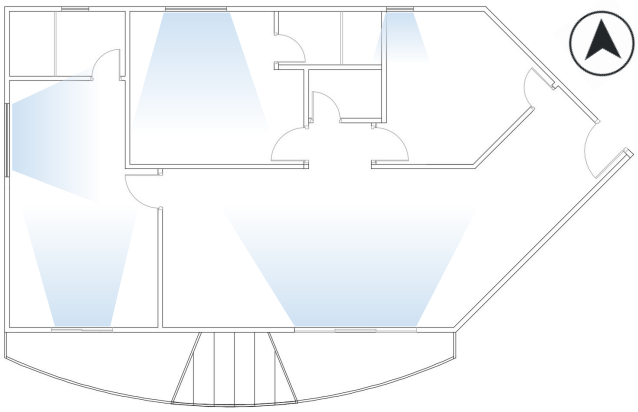


Fig 7.1 Buffer Plantations in balconies



Each space has provision of natural daylight and ventilation in each residential unit. This aids to the visual comfort and indoor air quality of spaces. In addition to that, indoor plants further improve the quality of the space

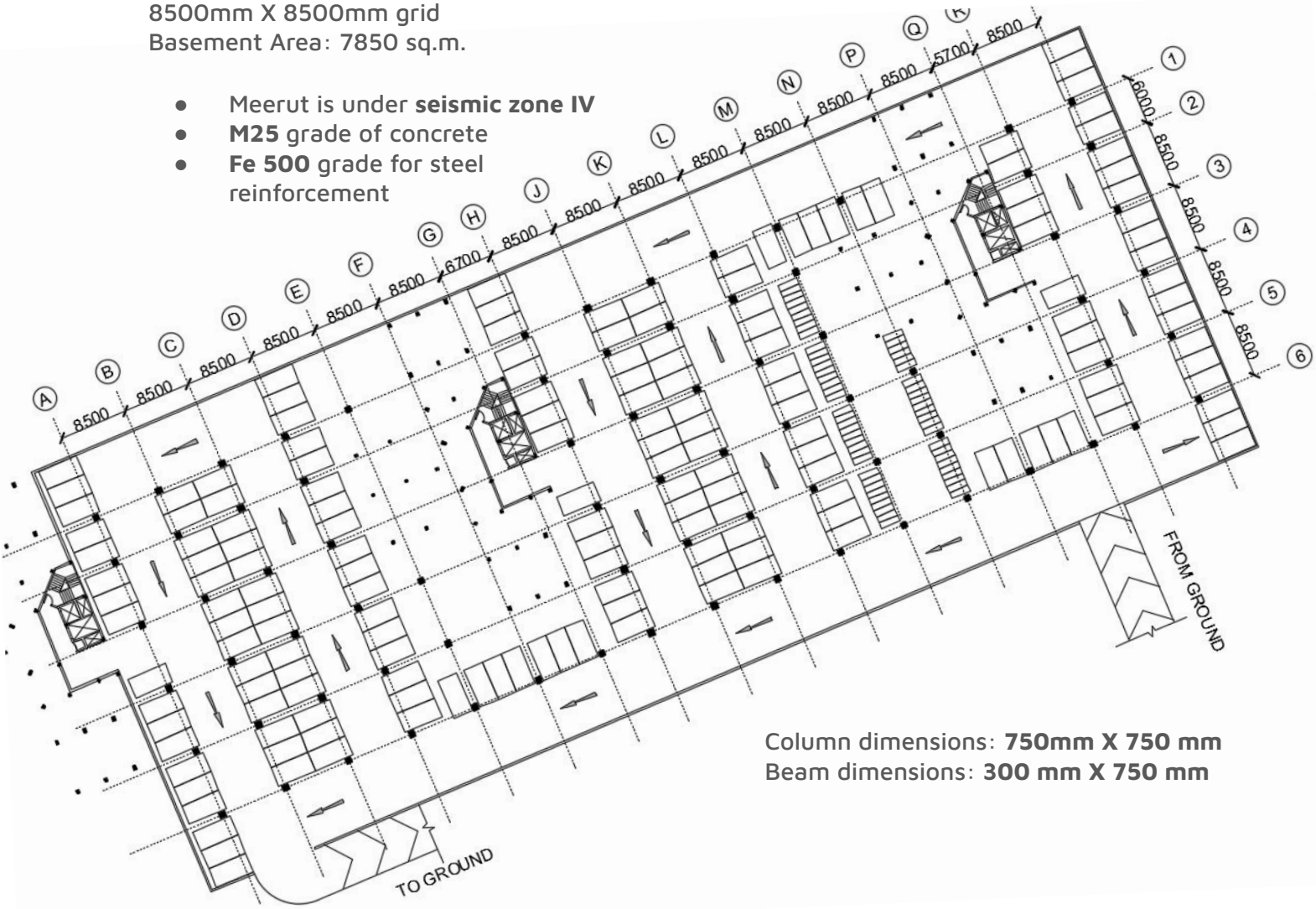
7.3 Engineering Design And Operations

7.3.1 Structural Design

Basement Column Grid Layout

8500mm X 8500mm grid
Basement Area: 7850 sq.m.

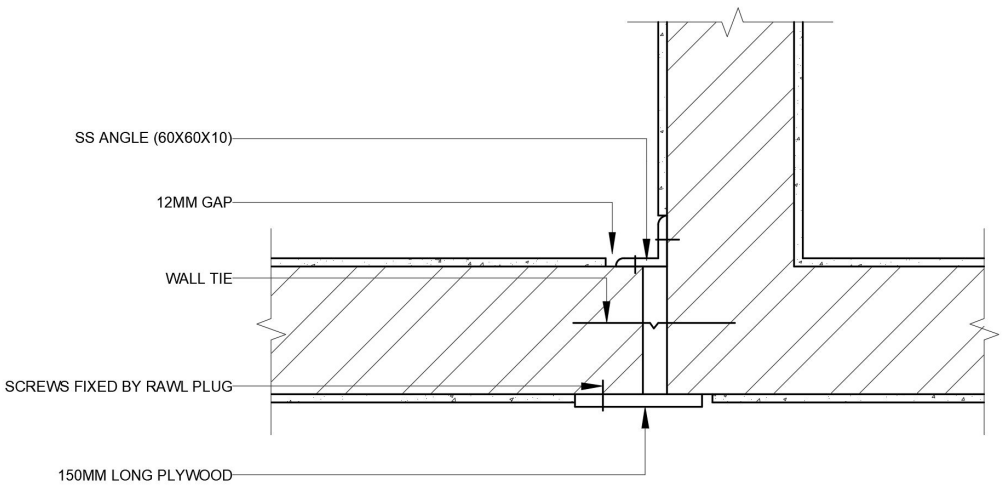
- Meerut is under **seismic zone IV**
- **M25** grade of concrete
- **Fe 500** grade for steel reinforcement



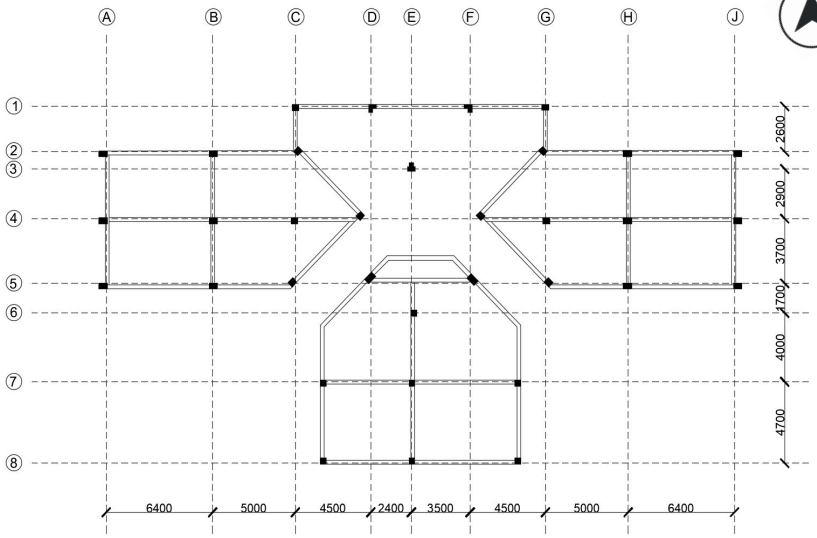
Column dimensions: **750mm X 750 mm**
Beam dimensions: **300 mm X 750 mm**

Expansion Joint Detail

The building frame system used in our design is Reinforced concrete with expansion joints provided at an interval of 30 metres (IS code 3414 of 1968,table 2 Clause 4.4).



Cluster column - beam layout



Span : 4000 mm
Column dimensions : 400mm x 350 mm
Beam dimensions : 300 mm X 750 mm

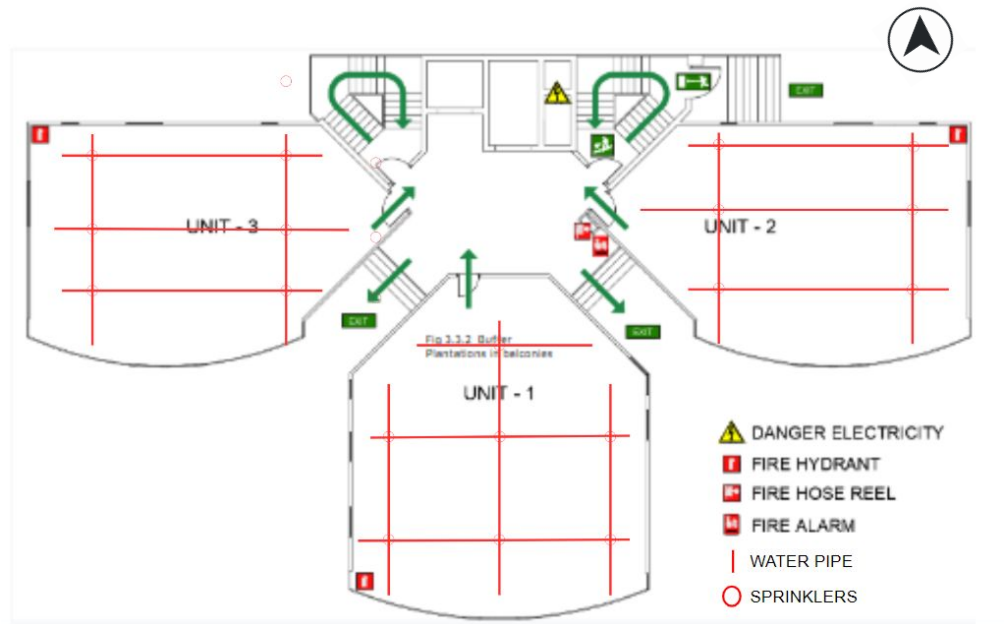
L-shaped columns are designed to combat wind force in areas where the angular momentum is greater owing to wind load and shear wall is used to construct the lift core walls.

- Each tower comprises of two vertical circulation staircases i.e. two per 3 units, due to the building's high rise typology.
- The Design is IS-456 Code complaint, which implies the building strength is evaluated to last a 100 years.

Foundation detail

The soil type at the site is known for being clayey. In case of such soils, the potential for long-term settlement through a process called consolidation will negatively impact the performance of foundations and other building systems. A typical foundation that leaves quite a bit of space between your structure and the ground is needed for these kinds of soils. It would be best to use typical pier and beam foundation. Piers are large beams that are set deeply into the ground. The structure is then supported above the ground by beams that are positioned across the piers. The piers are installed deep so that they hit bedrock.

7.3.2 Fire and Life Safety



Out of the two staircases, one is a 1500mm wide fire staircase in compliance with NBC part 4.
There is a provision of fire hose reel and fire alarm on each floor and fire hydrants in each residential unit.

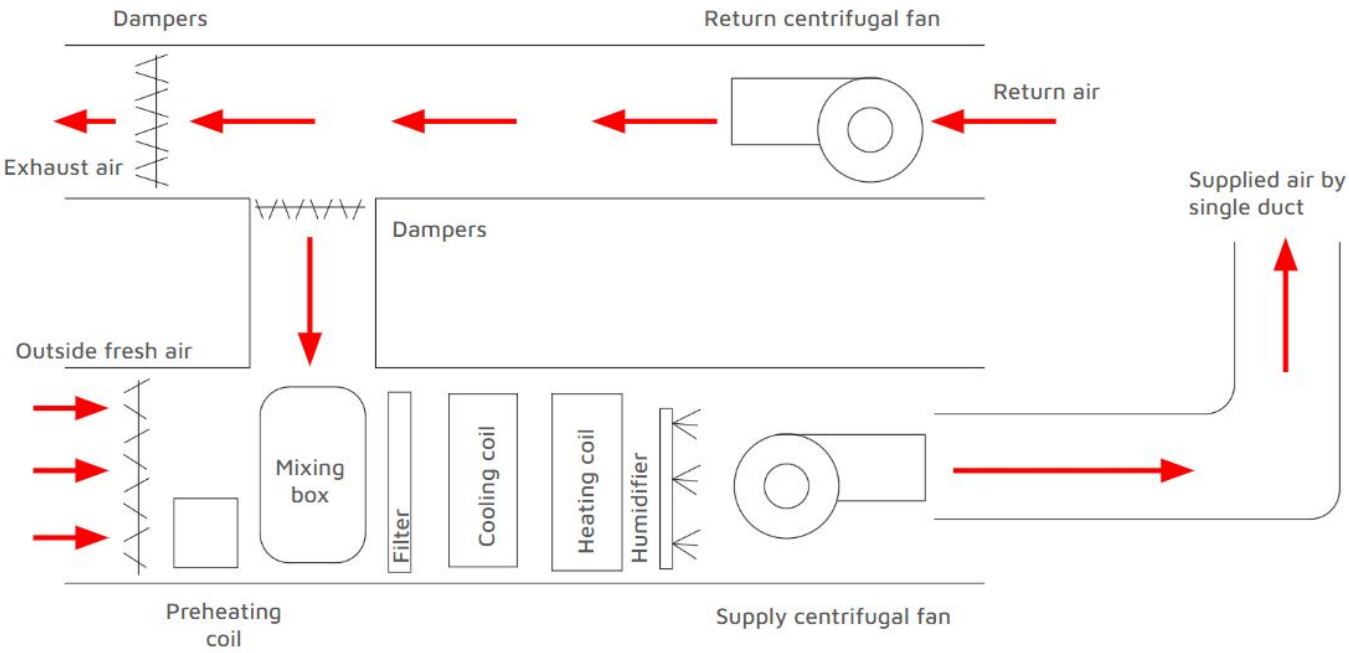
7.3.2 Operations

BEE Star Label

In order to reduce the EPI of the building, equipments like fans, lighting etc has BEE 5 star label appliances which also further reduces the carbon footprint of the building. Equipments majorly used in residential units such as air conditioners, ceiling fans, computers, refrigerator and freezers, domestic gas stoves,water heaters, washing machines,LED lamps, microwave ovens etc.

Electro mechanical system design

VAV system provides optimum control of temperature especially in the areas with wide load variations. Rooms with similar loading patterns are often placed on the same VAV box, and through the use of a VAV system.
The VAV boxes are located in the branch ductwork, above the ceiling.



One of the most elementary air terminal units, this one has a damper, an actuator, a flow sensor, and a few controls. It is only a simple enclosure with a single air valve between the single intake and single outlet. It is only deployed in areas where load fluctuation is minimal. The building's interior is where it is most frequently used for cooling purposes solely. These boxes should typically only be used in situations where minimal ventilation is not an issue; they can thus be set to zero.

7.4 Energy Performance :

Orientation :

The blocks are oriented in North - South direction for better climatic and site response. Each block receiving the south sun helps in the effective working of solar chimney.

Energy Performance Index :

Energy Performance Index is the ratio of annual energy consumption with the total built-up area.

Appliance	Wattage	Duration of usage	No. of Appliances	No. of days	Electricity consumed (W)	WH (Per day)	Annual electricity consumption
Ceiling fan	28	5	346	240	9688	48440	11625600
Lighting - A	12	3	452	365	5424	16272	5939280
Lighting - B	25	4	160	365	4000	16000	5840000
Lighting - C	16	1.5	372	365	5952	8928	3258720
Refrigerator	130	8	80	365	10400	83200	30368000
Washing Machine	480	1	80	104	38400	38400	3993600
Water pump	750	1	4	365	3000	3000	1095000
Lifts	5600	1	8	365	44800	44800	16352000
Television	60	3	106	365	6360	19080	6964200
HVAC	160000	6	4	120	640000	3840000	460800000
						Total	**546236.4 KWH**

Table 3.3.Energy Performance

Total annual energy consumption = 546236 KWH

Therefore, Energy Performance Index = $\frac{546236}{16308}$ = 33.49

Onsite Renewable Energy - Solar photovoltaic cells :

The site receives an ample amount of solar radiation throughout the year, making solar energy a viable option for energy generation. Roof-mounted solar panel system of **343 KW** generation capacity are installed on the terrace with a 18° tilt, facing towards the south side. A total of **980 panels** have been arranged over the building and roof top of parking area.

Onsite Renewable Energy - Solar photovoltaic cells :

At the cluster level, the additional electricity consumed is directly taken from the township grid. The extra electricity generated from the renewable panel is delivered back to the township grid. Thus, making it a net-zero project.

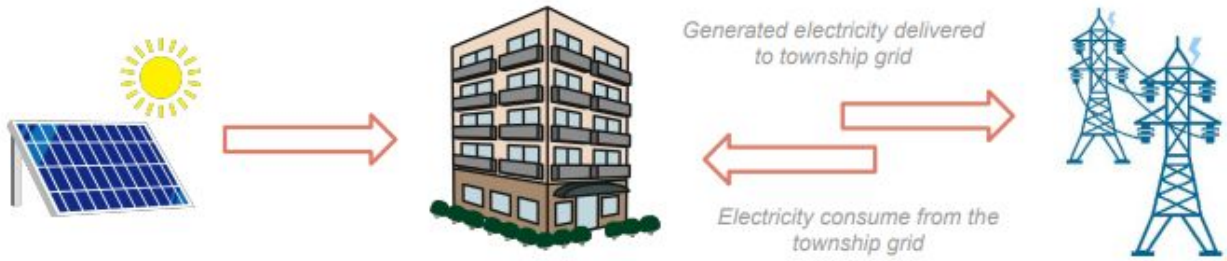


Figure 3.3.3 : Electricity consumption and redistribution to township grid

Total electricity consumed in a year	546236 KWH	Cost of panels	10290000
Total electricity generated in a year	555660 KWH	Maintenance cost of the panels	102900
Cost of electricity	**6.5 INR**	**Total cost (INR)**	10392900
Annual energy savings (KWh)	3611790	Payback period (in yrs)	2.9 yrs

Table 3.4 : Energy savings calculation

Solar Panels(350w)	**No. of watts produced**	**Electricity generated per day (in KWH)**	**Annual electricity generation (in KWH)**
980	257250	1852.2	555660

Table 3.5. : Annual electricity generation from Solar panels

Payback Period :

Total cost of Solar panels = 10392900 rs, Annual energy savings = 3611790

Therefore, Payback period = $\frac{\text{cost of solar panels}}{\text{Annual energy savings}}$ = 2.9 years

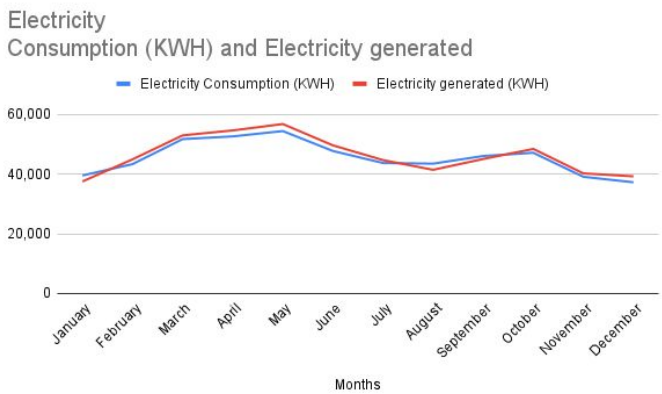


Figure : Line graph showing the electricity consumption and generation

The electricity consumption is different in each month which is shown in figure. The shown line graph represents the amount of electricity generated by solar panels and the electricity consumed monthly.

Onsite Renewable Energy - Solar photovoltaic cells :

The Solar panels were arranged on the rooftop at a certain height where they doesn't block the circulation of residents on the terrace. The Parking shed for vehicular parking on the ground is also used as a source for placing the solar panels to meet the renewable energy requirements.

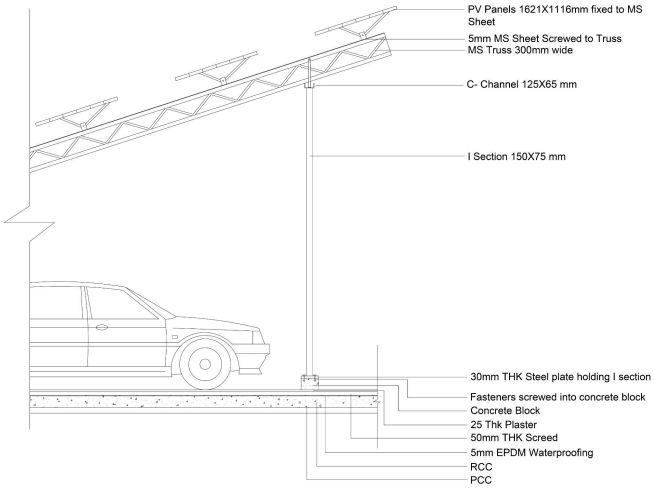


Figure 3.4.1: Solar panel arrangement detail over parking shed

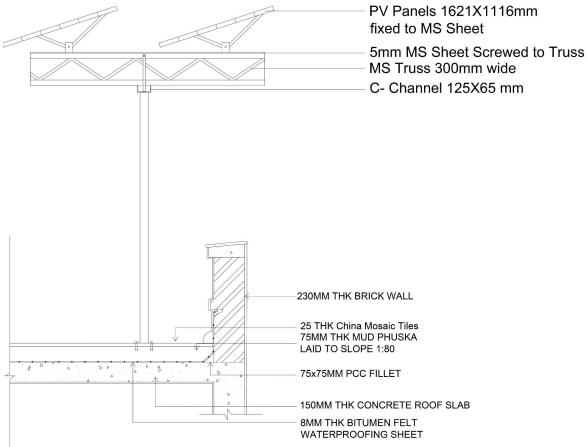


Figure 3.4.2: Solar panel arrangement detail on rooftop

Total no. of solar panels = 980, each 350W solar panel requires 1.76 sqm of area.
On roof, we have an area of 3000 sqm.

The 980 solar panels are arranged over the roofs of buildings and over the surface parking by consuming an area of 2326 sqm along with the circulation.

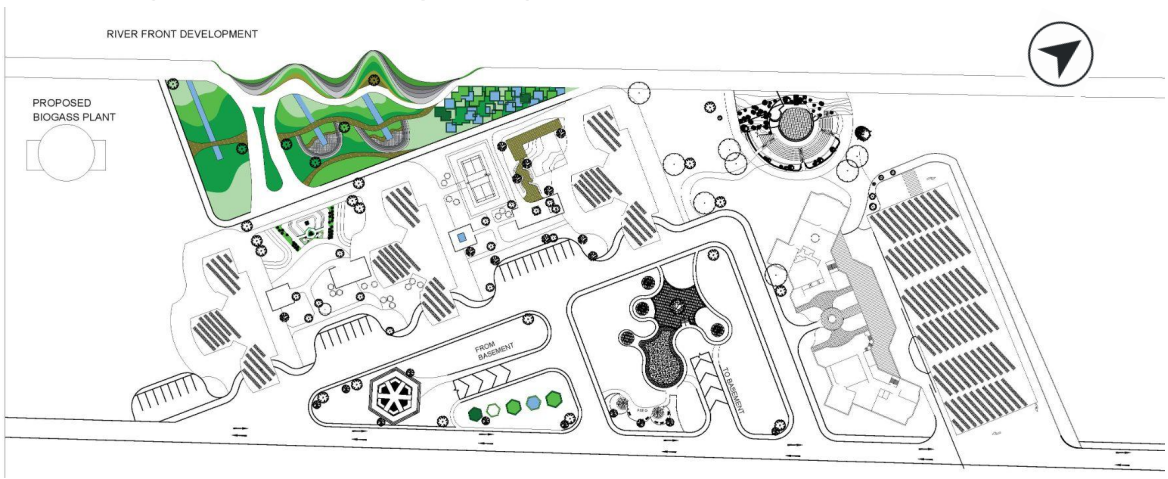
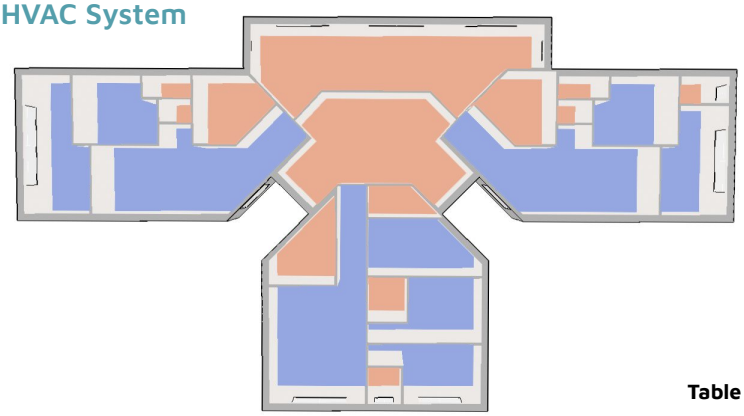


Figure 3.4.3: Solar panels arrangement proposed

The solar panels of 350w made a 343 KW solar renewable system which are aligned towards the south direction. The azimuth angle of 165 degrees is maintained for every solar panel, which happens to be the best angle for highest energy generation. The solar panels are fitted in a way, where the angle can be changed according to the angle of the sun. The tilt angle for summer is 18 degrees and for winter is 40 degrees.

HVAC System



- Unconditioned Area
- Conditioned Area

Table 3.6. : Zoning Of Hvac System

System Type	VAV Hybrid System - Heat Recovery System
Manufacturer	DAIKIN INDIA
Condenser Type	Water Cooled (Only Cooling)
Conditioned Area	6552 Sq m
Unconditioned Area	4576 Sq m
Chiller Type	160 Kw 60 Hp water cooled chiller (7 nos.)
Total Cost	70 Lakh (approx.) (7 nos.)

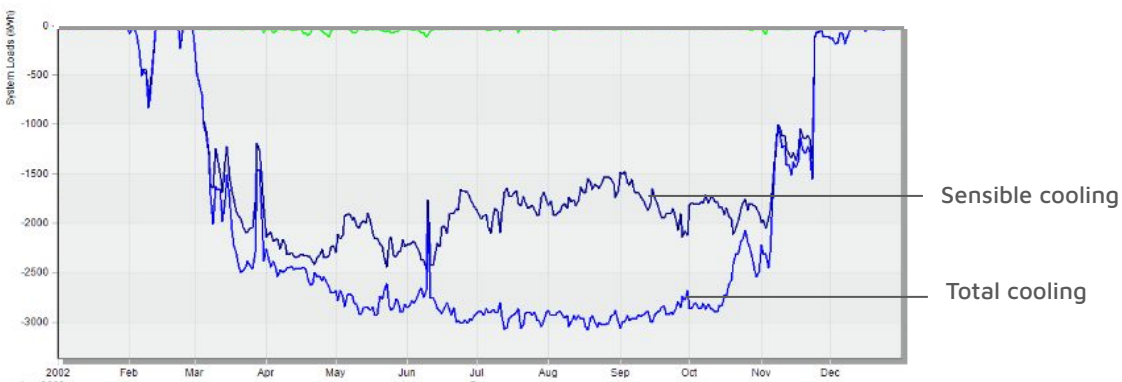
Tonnage required per hour for G+5 = 60 Tons
Tonnage required per hour for G+7 = 80 Tons
Tonnage required per hour for G+11 = 120 Tons

No; of chillers installed in G+5 = 2 (60 Hp chiller)
No; of chillers installed in G+7 = 2 (60 Hp chiller)
No; of chillers installed in G+11 = 3 (60 Hp chiller)
Total no: of chillers = 7 nos.

No: of hours hvac system is used per day in 2BHK = 10 hours
No: of hours hvac system is used per day in 3BHK = 13 hours
Total electricity consumption per day in all the 2BHK units = 3200 Kw
Total electricity consumption per day in all the 3BHK units = 4160 Kw

Total electricity consumed per day for hvac system = 7,360 Kw (approx.)(4 months)
Total water consumption per day for hvac system = 28,000 L (approx.)(4 months)

In a VRF system, the refrigerant passes through condenser units to indoor units, cutting down on the need for extensive ductwork and air handlers. The smaller pipes make it a bit easier to retrofit in buildings than traditional HVAC systems. To serve the cooling to all of the dwelling units, a VRF water cooled System with a capacity of 60HP is proposed, which can provide 60 tons per hour cooling load. (2BHK and 3 BHK requires a cooling load of 3 tons and 4 tons respectively) A water cooled VRF system is proved to be the best efficient and low energy consuming HVAC system which leads to energy savings of 30%.



7.5 Water Performance

As per National building code 2016, Standard fresh water demand for one person is 135 LPD (litres per day) for residential buildings. We have proposed to reduce about **56%** water demand. As per GRIHA, Recycle and reuse of resources enables us to reduce pressure on our valuable natural resources. Recycling of resources and putting these back into use for the building is significant.

REDUCE

135 lpd to 75 lpd
(**56%** reduction in consumption)

Reducing Water Demand from the base case of 135 lpd to 75 lpd by efficient use of water saving fixtures. The total occupant Water demand is estimated to be 25,950 lpd, consisting 346 people

	PER CAPITA DAILY CONSUMPTION(L)	NUMBER OF OCCUPANTS	TOTAL CONSUMPTION DAILY (L)	TOTAL WATER REQUIREMENT IN A YEAR (L)	GREY WATER EFFICIENCY
BASE CASE	135	346	46,710	1,70,49,150	75%
DESIGN CASE	75	346	25,950	94,71,750	75%

Table 3.6. : Water Performance

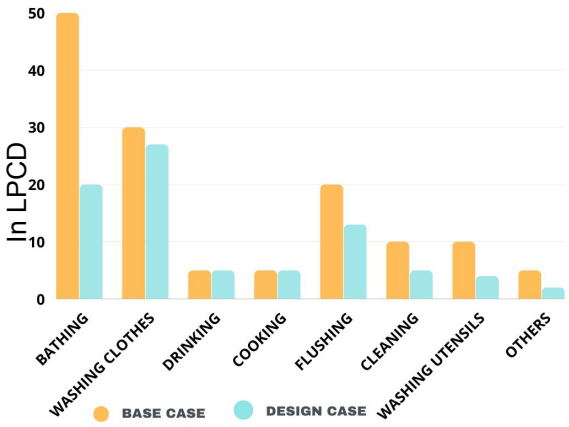


Fig 7.5.1 : Flow Rate Fixtures

REUSE

75%GREY WATER IS FILTERED

It is calculated that the building generates 19.368KL of grey water and 6.6013 KL **of black water** everyday. For flushing, irrigation, and PV maintenance,grey water is recycled, filtered, and reused. The extra treated wastewater is used to recharge the groundwater. The grey water is collected in a underground storage tank, where it is sedimented and anaerobically treated before being filtered by the "ROOT ZONE SYSTEM"

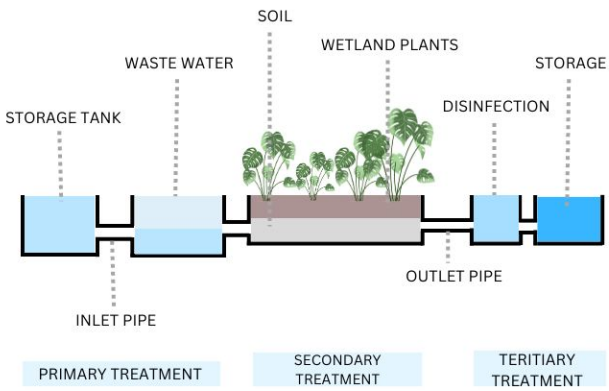


Fig 7. 5.2. : WasteWater Treatment

OCCUPANT'S ACTIVITY	PERCENT USAGE	QUANTITY	GREY WATER	BLACK WATER
BATHING	29%	7525.5	100%	0%
WASHING	20%	5086.2	100%	0%
DRINKING	4%	1012.05	0%	100%
COOKING	3%	752.55	0%	100%
TOILET	17%	4411.5	0%	100%
CLEANING HOUSE	8%	2076	100%	0%
WASHING UTENSILS	15%	4255.8	100%	0%
OTHERS	3%	830.4	50%	50%
TOTAL		25956	19368.7	6601.3

Table 3.7. : GREY AND BLACK WATER GENERATION

RECHARGE

RWF filter
Rainy FL-500

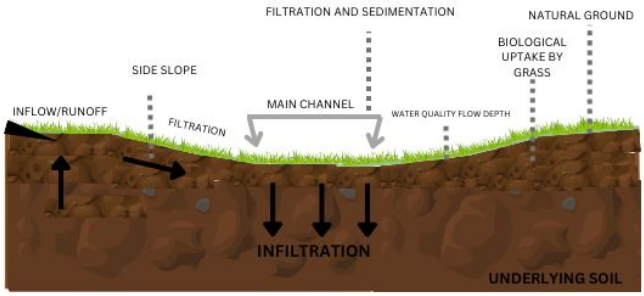


Fig 7. 5.3. :RAIN WATER TREATMENT AND COLLECTION METHOD

- Permeable pavement is designed to allow water to infiltrate into the soil and recharge the groundwater. They are typically dug into the ground and filled with layers of gravel, sand, and soil.
- Constructed wetlands are designed to mimic the natural wetland ecosystem.
- Rainy FL-500 filtration system is used to remove the dirt and impurities with more than 90% efficiency, is later deposited in
- underground water tank (UGT).

RAINWATER HARVESTING SURFACE	AREA(m2)	RUNOFF COEFFICIENT	EFFECTIVE CATCHMENT AREA (m2)	ANNUAL RAINFALL OF SITE (m2)	ANNUAL RAINFALL (m2)	ANNUAL RAINFALL (LITERS)
ROOF SURFACE	2626	0.95	2494.7	0.792	1975.80	197580
HARDSCAPE	16443.99	0.70	11510.79	0.792	9116.54	911654
SOFTSCAPE	19995.6	0.3	5998.68	0.792	4750.85	475085

Table 3.8. :Rain water Harvesting calculations

Total Effective catchment area (m^2) = 15489.62 m^2
Total Rainfall harvested in a year (litres) = 1548,962 litre := 1548.962KLD

TOTAL WATER REQUIREMENT (KL/YEAR)	HARVESTED RAINWATER (KL/YEAR)	RECYCLED GREY WATER (KL/YEAR)	MUNICIPAL WATER (KL/YEAR)
9471.750	1548.962	7103.812.5	818.976

Table 3.9. : Annual water consumption and generation

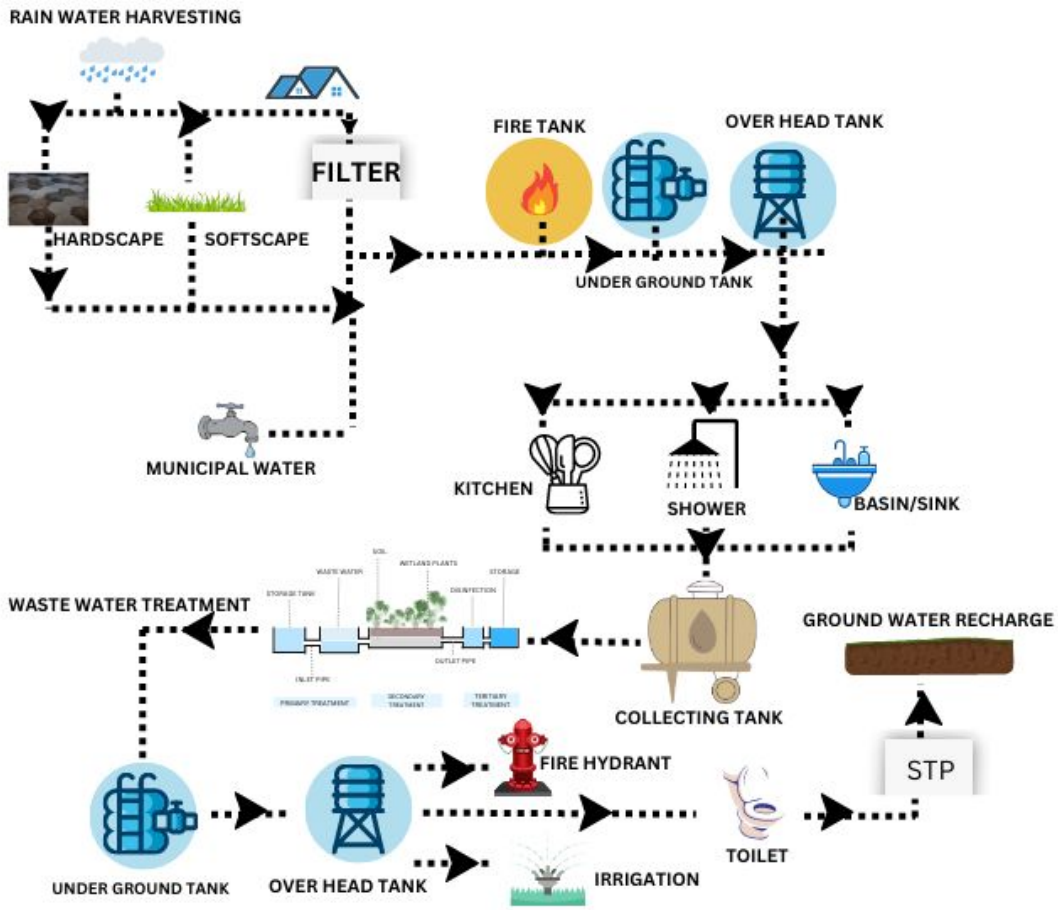


Fig 7. 5..4. : WATER CYCLE DIAGRAM

XERISCAPING :,

Xeriscaping, also referred to as "zero scaping," is a gardening strategy that makes use of plants and construction strategies that use little water.

These are some examples of vegetation that can be cultivated using grey water.

s.no	Trees/plants
1	Neem tree
2	Jamun tree(Syzygium cumini)
3	Bougainvillea plant
4.	Zinnia plant

7.6 Resilience

7.6.1 Disaster Resilience

Hazard profile of Meerut, Uttar Pradesh

Earthquakes : The whole district of Meerut is in Earthquake High Damage Risk Zone IV. The Richter scale intensity of the recent earthquake in Meerut is roughly 4.9 on November 9, 2022.

Floods : Approximately 27 hectares are affected due to floods and annual estimated loss is about Rs. 432 crores in UP. However after speaking with locals, we were able to conclude that there won't be any flooding concerns in our site because of the vicinity of the dam and continuous flow of water.

Heat waves & Droughts : Banda in Uttar Pradesh on Wednesday (May 18, 2022) recorded country's highest temperature of 46.2 C. Drought is another major disaster affecting the state of Uttar Pradesh. The recurrence period of highly deficient rainfall in Meerut has been calculated to be 10 years.

Fires : Annually, Fires destroy large number of buildings and thousands of acres of land especially in summer in rural areas due to disregard for fire safety procedures.

- Data provided by Uttar Pradesh State Disaster Management Authority, Government of Uttar Pradesh

Earthquake Resilience

- Lack of vertical irregularities in the structural system to resist the lateral loads from earthquakes, the soft-story structures such as basements, parking, ground floor the columns are continued without breaking the structural grid or use of floating columns for maximum stability.
- Framed RCC symmetrical structures can withstand earthquakes effectively.
- Placing horizontal R.C.C. bands on plinth, lintel and gable level can increase earthquake resistance.

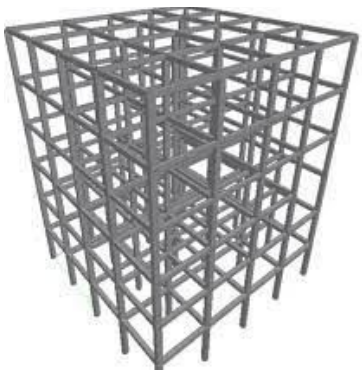


Fig 7.6.1 RCC framed structures

Heat Waves Resilience

With the Meteorological department predicting rise in temperatures, the Meerut health department has issued a heat wave advisory, emphasizing the importance of building envelopes that can handle added heat stress. To minimize heat gain inside the building, the roof and walls have a reduced U-Value. The walls consist of multiple layers including 18mm external plaster, 100mm ACC blocks, 75mm XPS Extruded Polystyrene insulation, 115mm mud-burned brick, 12mm internal plaster, followed by a final layer of 50mm cork cladding, which adds an additional layer of insulation and soundproofing.

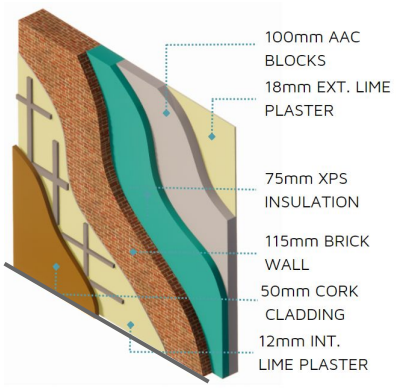


Fig 7.6.2 RCC framed structures

Fire Resilience

- Automated Water sprinklers systems, Automatic fire detection system, Fire extinguishers, First aid hose reel, and Manually operated fire alarm system have been provided at appropriate distances as per NBC Part 4 2016 - Fire and life safety.
- All the staircases are compliant to fire safety and the code for egress. Each tower comprises of two vertical circulation staircases i.e. two per 3 units, due to the building's high rise typology. One staircase leads to the basement, while the other leads to an emergency exit outdoors.

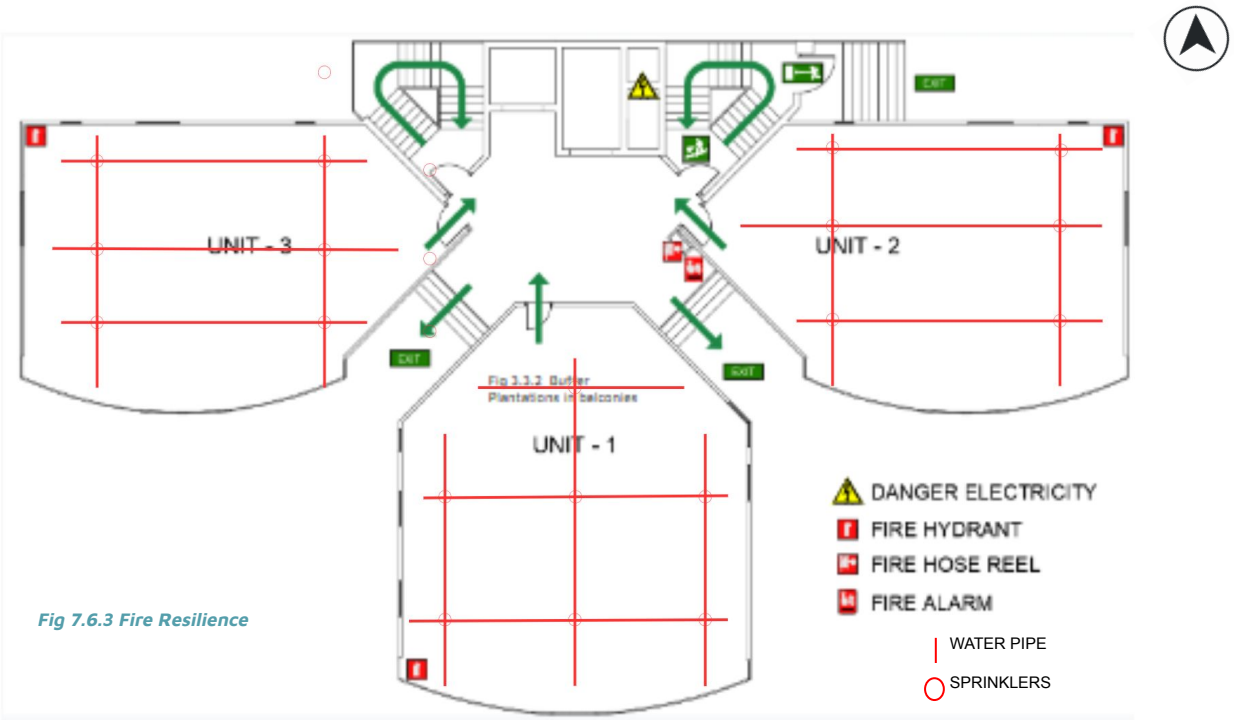


Fig 7.6.3 Fire Resilience

Water Sufficiency

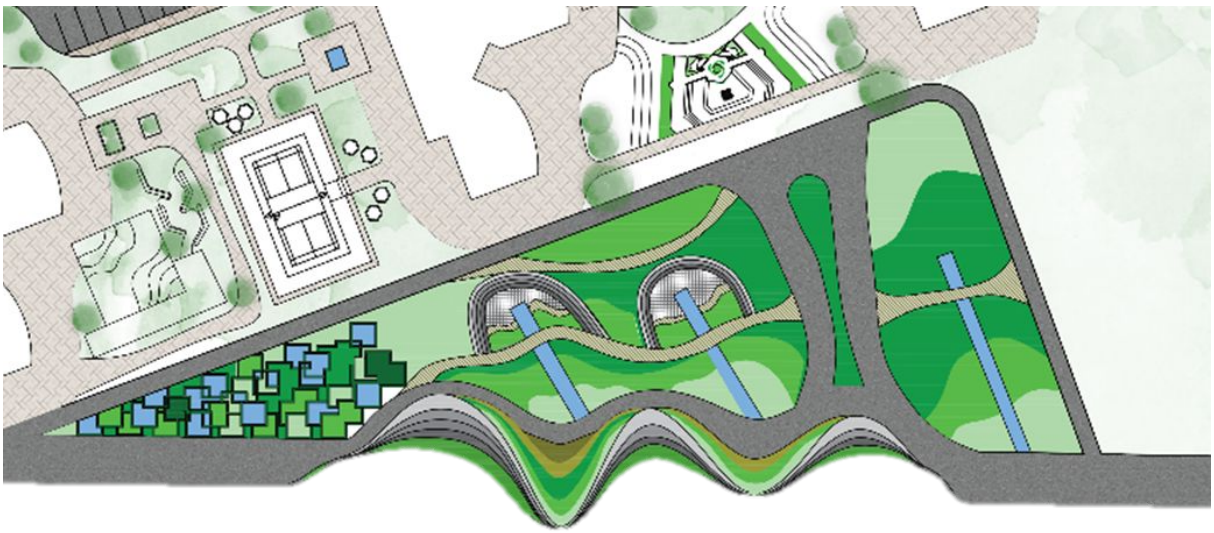
On an average our yearly fresh water consumption is around 9471.750kLD. Recycled gray water 7103 (KLPD) is used to meet the rest of the water demand. Water is initially poured into specially designed Fire Tanks. When these tanks reach their maximum capacity, the water overflows into the domestic tanks that supply water. In this way water is first prioritized to the Fire Tanks.

Energy Sufficiency

Energy consumption per day is 324836 kWh which includes lighting, equipment and an HVAC system. The energy required is generated using Solar PV (330750 kWh/year). Indoor generators are used for energy storage. They don't require gas or emit fumes, they can safely be used indoors, and can be recharged using solar panels.

7.6.2 Social Resilience

The clusters are set up in a way that allows for shared interactive areas between them, featuring seating areas, outdoor play courts, and playgrounds for children. Additionally, there are landscaped spaces surrounding the buildings, with cycling tracks and pavements located throughout. One of the most notable aspects of our design is the development along the **riverfront**, which creates a versatile space along the canal that allows for both a connection with nature and a social environment for people. The shared interactive areas provide ample opportunities for socializing and bonding between neighbors, while the seating areas allow for relaxation and conversation. Overall our design seeks to create a harmonious and balanced living environment.



CANAL

7.6.3 Transportation Resilience

Multi-modal accessibility and Transit-oriented design :

Integrating various modes of transportation into the design of a linear plot of land, such as this building complex that includes residential, community, hostel, and educational blocks, can promote sustainable transportation options and offer alternative means of transportation during disruptions. This can be achieved by incorporating features such as designated **bicycle parking areas**, **electric vehicle charging stations**, and other amenities that support sustainable transportation modes. By providing ample bicycle parking spaces and charging stations for electric vehicles within the building complex can encourage residents, students, and visitors to use bicycles or electric vehicles for commuting between different blocks within the complex. This promotes a healthier and eco-friendly mode of transportation, reduces greenhouse gas emissions, and decreases reliance on fossil fuel-powered vehicles. The building complex is designed to be **pedestrian-friendly** with walkways, sidewalks, and pedestrian crossings. This encourages residents, students, and visitors to use public transit as a sustainable mode of transportation for commuting between different blocks within the complex or connecting to other destinations in the surrounding area.

7.7 Innovation

7.7.1 Solar Chimney:

The solar chimney is inclined at 70 degree angle to maximize the exposure to sunlight.

The inlet allows the external air which pressurizes the whole chimney and allows the air to move fast in chimney

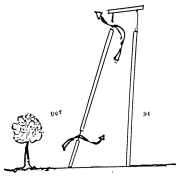


Fig .7.7.1.1 inlet in solar chimney

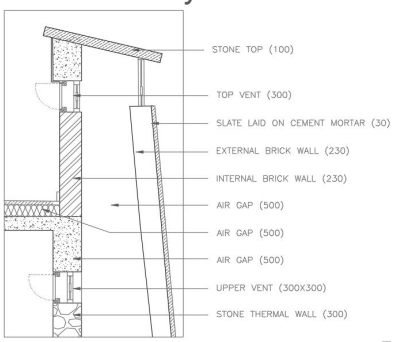


Fig.7.7.1.3 DETAIL AT Top of solar chimney

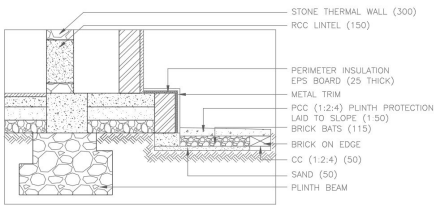


Fig .7.7.1.4 detail at the bottom of the solar chimney

Concept of Solar Chimney:

The solar chimney is placed in the south direction as the sun follows southeast to southwest in northern hemisphere

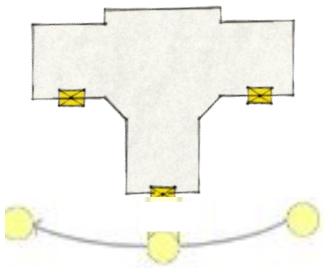


Fig .7.7.1.5 placement of solar chimney

The solar chimney adoptes the curve shape to achieve the maximum exposure of sun from morning to evening

The solar chimney is painted black to observe more sun radiation

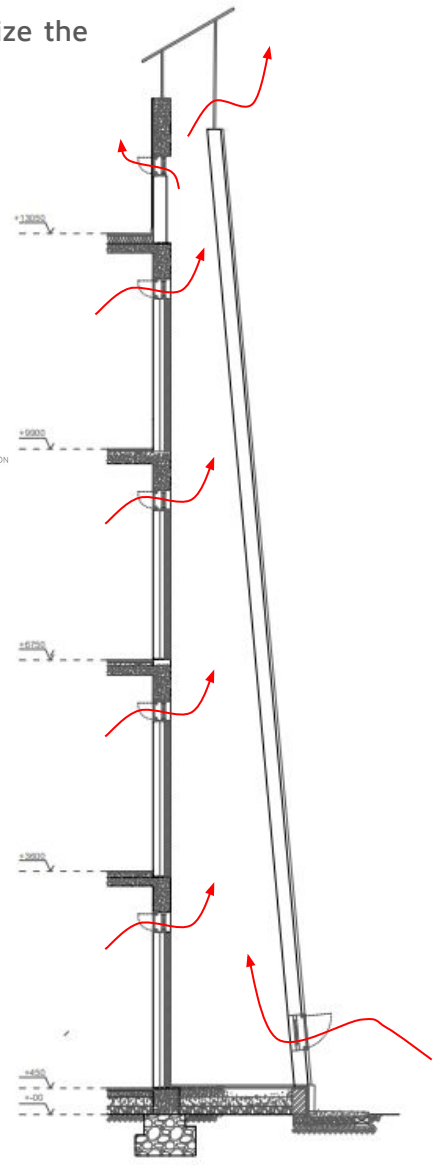
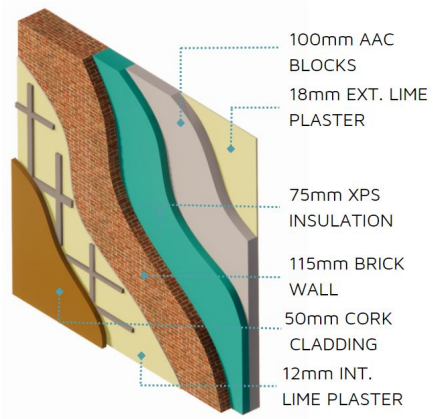


Fig .7.7.1.1 section through solar chimney

7.7.2 Cork Cladding :

It is an exciting new innovative product that can be easily manipulated and highly sustainable and has a range of attributes that make it is highly desirable. It is 100% natural product and is in fact has negative Global warming potential, meaning the production process actually removes more carbon from the environment than it creates. It offers good thermal insulation whilst also offering a number of acoustic benefits for its ability to absorb and dissipate sounds.



7.7.3 BIOMASS Plant

The idea of using renewable sources of energy to provide heat for the project during the winter months is done by collecting yard waste and wet waste from the apartment complex during the summer months and processing it into natural gas, which can be used as fuel for heaters during the winter months. By using biomass to generate natural gas, the project can reduce its reliance on fossil fuels and reduce its carbon footprint. The yard waste and wet waste is processed using a variety of techniques such as anaerobic digestion or gasification, which breaks down the waste and produces natural gas. The natural gas produced can then be stored and used during the winter months to power heaters in the apartments. This method is much more energy-efficient than traditional heating systems, which rely on electricity or fossil fuels to produce heat.

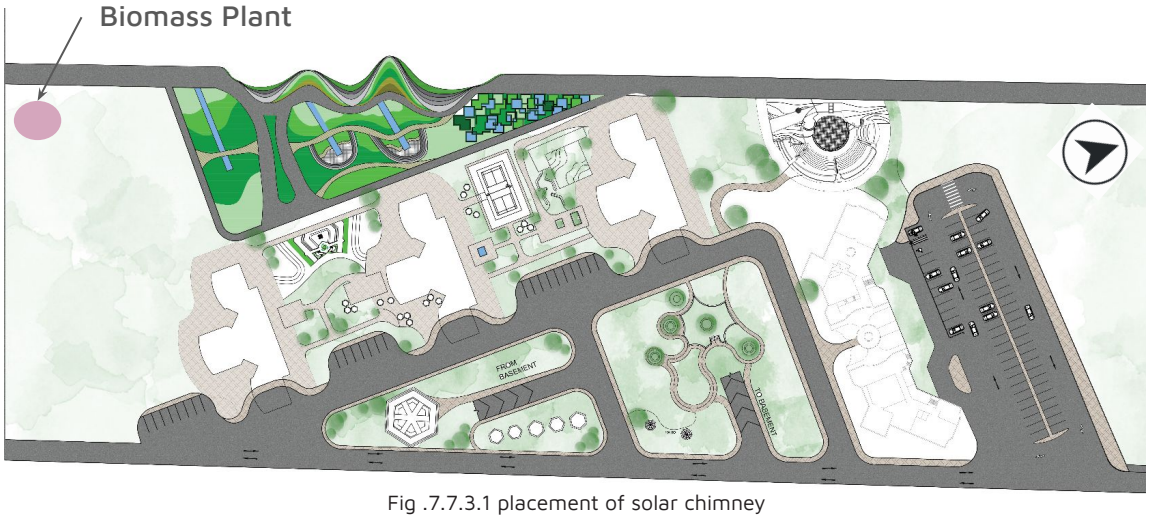


Fig .7.7.3.1 placement of solar chimney

7.7.4 : Waste Management :

In compliance with Uttar Pradesh's waste management rules, the in-situ MRF was sized to facilitate waste segregation at source for institutions over 5000 square meters. This ensured effective waste management in the project.

Total domestic (raw water demand was estimated to be 45,200 Litres per day

- Estimated Sewage = 90 % of TWD (in KLDt)[60 to 70% for flushing and gardening]
- Capacity of S.T.P = 90 / 100 * 45.2 KLD = 40.6 KLm
  Now, let assume, if total depth of the pit is 3.30 Meter including Free Board 300 MM (Standard Depth Therefore the Liquid Depth (L = 3.0 Meter)
- Size Of STP = 40.6 /3 = 13.53
  Therefore the either dimensions will be = √13.53 = 3.67 Meter
- Total Capacity of the S.T.P = 3.6 x 3.6 x 3 Meter

7.7.5: Garbage chute :

It is a shaft which will be available from every floor.

1.2mm ,600 dia . Stainless Steel Standard Garbage Chute RS. 33,000/Unit.

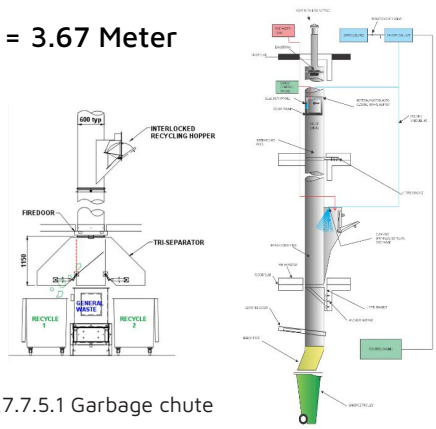


Fig .7.7.5.1 Garbage chute

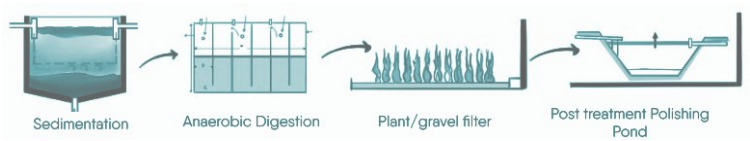
7.7.6 Material Recovery Facility (MRF)

Dry waste, wet waste and hazardous waste will be segregated at a Material recovery facility at the basement. The garbage from each floors are are collected from the garbage chute and segregated. The dry wastes would be given to the third party recycle plants. The wet wastes (organic waste) with the yard waste is converted into Natural Gas in Biomass Plant. The natural gas produced are used during the winter months to power heaters in the apartments. Hazardous waste generated on site will be segregated and disposed safely with the help of a third-party agency.

7.7.6.1 In Situ (MRF)

Utilization of Decentralized Wastewater Treatment System (DEWATS) for treating black water, with an efficiency of 75%.Implementation of DEWATS system with a size of 8.5

KLD (kilo liters per day) for decentralized wastewater treatment.



7.7.6.1 dewats for wastewater treatment

7.7.7. Carbon captured concrete :

17
07

In an effort to reduce carbon emissions from slab production, traditional cast concrete is being replaced with carbon captured concrete.

CarbonCure's proprietary technology injects captured CO2 into the concrete during mixing, resulting in the carbon being sequestered forever as it reacts with the concrete, effectively reducing the embodied carbon in the manufacturing process.

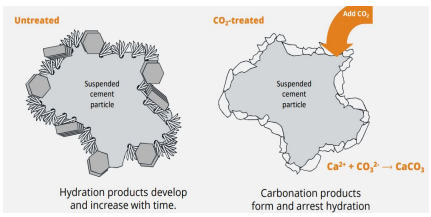


Fig. 7.7.7.1 difference in composition of cast concrete and carbon cure concrete

CarbonCure For Ready Mix | CarbonCure for Precast | CarbonCure For Reclaimed Water

Fig. 7.7.7.2 carbon cure technology

A collaboration with CarbonCure is proposed to utilize this innovative ad mixture technology in concrete production.

7.7.8. Waterfront development :

Fig. 7.7.8.1 concept

Concept of the waterfront development inspired from the waves of the river

Incorporation of landscaped spaces, cycling tracks, and pavements in the waterfront development for a connection with nature and social interactions.

Creation of shared interactive areas, seating spaces, and a harmonious living environment along the riverfront to foster socializing, relaxation, and community bonding.

Fig. 7.7.8.2 waterfront development
[For site plan please refer fig. 7.7.3.1]

7.8 Embodied Carbon

The GWP (Global Warming Potential) value of the material is taken as per for IFC Database for global Warming potential.
Baseline and design case materials are compared FOR 20 SQ.M

7.8.1 Low Gwp Value Materials :

1. Cork cladding[50mm thk] is used for the wall as it has negative gwp value.
Available at Indian cork industries,haryana

2. Recycled steel bars are used for reinforcement as it has less gwp value.
Available at tata steel recycling business,haryana

3. XPS Insulation is used for the wall as it has low gwp value.
Available at analco Impex,Delhi

Fig 7.8.1 STAGES IN LIFE CYCLE ASSESSMENT

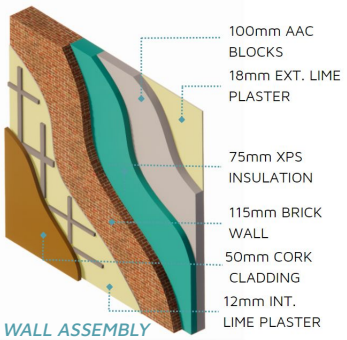


Fig 7.8.2 WALL ASSEMBLY

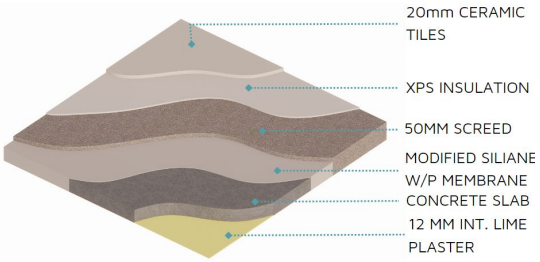


Fig 7.8.3 ROOF ASSEMBLY

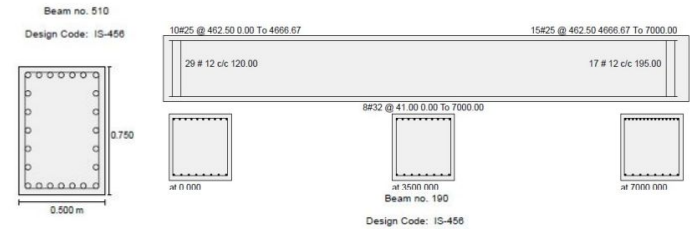
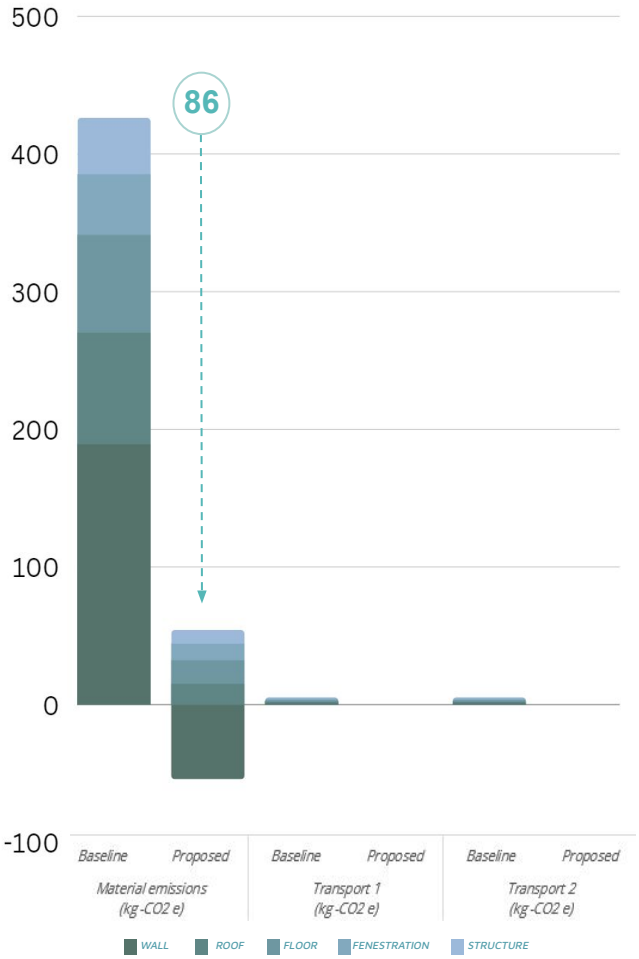


Fig 7.8.5 REINFORCEMENT DESIGN [REFER IS-456]

Fig.7.8.6 SUMMARY OF EMISSIONS PER FUNCTIONAL UNIT



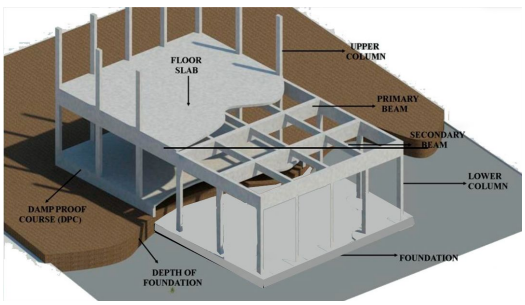


Fig 7.8.4 STRUCTURAL ASSEMBLY

	BASELINE	PROPOSED LINE
WALL	189	-54
ROOF	81	15
FLOOR	71	17
FENESTRATION	44	12
STRUCTURE	41	10

Fig 7.8.7 TABLE SHOWING EMISSIONS PER FUNCTIONAL UNIT

86% of reduction in carbon emission from baseline

7.9 Affordability & Value Proposition :

7.9.1. Savings from Construction :

- Recycled steel bars are used for reinforcement in the slabs, columns and beams. This results in less carbon emissions from the usage of steel bars. It also results in cost savings of reinforcement upto 50% . This is a low-cost and low material approach. The diameter of steel bars on progressive floors reduces while the column size remains constant.
- The window wall ratio is maintained is optimized in a way, where the lighting load and heating load, cooling load is decreased compared to base case.
- The solar panels are placed on the terrace at a certain height with the help of trusses which may be a bit costly, but it results in no losses through shadow and dust. It also allows circulation under the solar panels. The terrace garden on the roof with insulation under it, traps the radiation from the sun and the solar panels and restricts the heat gain upto 5-6 degrees.

7.9.2. Savings on OPEX

- All the electrical appliances in the dwelling units are 5 star rated, which will save a lot of energy in the future.
- The occupant comfort inside the dwelling is maintained well with cross ventilation and envelope optimization, reducing the cooling and heating loads.
- High efficient and low water consuming sanitary fittings are used to reduce the water wastage while reducing the building operational costs.
- Mutual shading by the buildings provide shelter in the buffer spaces between the clusters, reduce the shelter costs in those spaces.
- The Construction schedule is maintained in a way where the entire construction is finished by 18 months. That makes it a way for early returns.

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

Capital Expenditure - Annual

Particulars	Baseline Estimate (Project Partner / SOR basis)						Proposed Design Estimate					
	TOTAL	YEAR 1	2	3	4	5	TOTAL	YEAR 1	2	3	4	5
Land	320.0	320	0	0	0	0	320.0	320	0	0	0	0
Civil Works	394.5	0	33.6	33.6	50.4	50.4	267.9	50.4	50.4	33.6	33.6	0
Interior Finishes	38.1	0	0	0	0	38	35.8	0	3.6	7.1	10.7	14.3
MEP Services	81.0	0.0	20.3	20.3	20.2	20.2	80.5	0.0	20.1	20.1	20.1	20.2
Equipment & Furnishing	8.1	0	0	0	0	8.1	8.1	0	0	0	0	8.1
Landscape & Site Development	11.5	0	0	2.3	3.4	5.7	11.5	0	1.1	3.4	4.6	2.3
Contingency	9.0	0	0	0	0	9	6.5	1.3	1.3	1.3	1.3	1.3
TOTAL HARD COST	**862.2**	**320.0**	**53.9**	**56.2**	**74.0**	**131.4**	**730.3**	**371.7**	**76.5**	**65.5**	**70.3**	**46.2**
Pre Operative Expenses	80.0	16	64	64	64	64	80.0	64	4	4	4	4
Consultants	40.0	32	2	2	2	2	40.0	32	2	2	2	2
Interest During Construction	20.3	5.4	6.7	8.2	0	0	11.7	5.7	6	0	0	0
TOTAL SOFT COST	**140.3**	**53.4**	**72.7**	**74.2**	**66.0**	**66.0**	**131.7**	**101.7**	**12.0**	**6.0**	**6.0**	**6.0**
TOTAL PROJECT COST	**1002.5**	**373.4**	**126.6**	**130.4**	**140.0**	**197.4**	**862.1**	**473.4**	**88.5**	**71.5**	**76.3**	**52.2**
Upfront Equity	300.7	112.0	38.0	39.1	42.0	59.2	258.6	142.0	26.6	21.5	22.9	15.7
Debt Drawal Required	677.4	261.4	88.6	91.2	98.0	138.2	533.3	331.4	62.0	50.1	53.4	36.5

Team Lagom from School of Planning and Architecture are designing multifamily staff-housing project located in Meerut, Uttar Pradesh. The design was developed by an integration of a multidisciplinary team from building engineering management, architecture and engineering disciplines along with the technical support of industry partners and guidance from our faculty and instructions from our project partner.

Our team strived to accomplish the following goals :

The energy generation potential from the renewable energy sources was found to be 555660 KWh and therefore target EPI for the project was set at 37 kW/h/year. The EPI was reduced to 33.49 kW/h/year by integration of active and passive design strategies such as climate responsive orientation, integration of solar chimney in common spaces of the dwelling units, which was further enhanced in form to assist for efficient flow of air. Building envelope materials of low U-value were chosen as per super ECBC standards.

Health and wellbeing of occupants was addressed to by providing South sun to all the dwelling units, providing sunlight to all units at most times of the day, to promote ventilation and natural disinfection of living spaces. A proper waste management technique is employed to assist for safe disposal of waste. Segregation of dry and wet waste is made unit wise. Garbage chute is given at each floor for disposal. A Waste Recovery System (WRF) has been provided to reuse and recycle waste generated from units. Yard waste generated on site along with some percentage of organic waste from kitchen is being vermicomposted and stored as solid pellets. These pellets are to be used to produce biogas on site to address to heating needs in winters.

Carbon emissions were reduced by 86% by adopting carbon-negative material for building envelope such as cork cladding and carbon captured concrete instead of precast concrete.

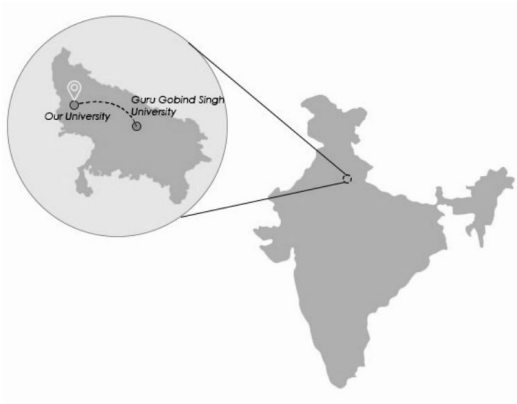
The baseline fresh water demand of 135 KLD was reduced to 75 KLD by integrating water efficient fixtures, drip irrigation technique with recycling and reusing of grey water. We have proposed to reduce about 56% water demand and furthermore rain water harvesting system was adopted at the building and site level to offset the fresh water consumption to achieve net zero water by harnessing the huge potential of stormwater runoff during the monsoon months of almost 1400 mm.

7.9.3. Scalability :

Scalability for Major Dhyan Chand Sports University means expanding its capacity to accommodate more students, faculty, and infrastructure while maintaining high-quality education and sports training standards with good accommodation. This is one of the biggest sports university in the country.

We got a huge site for staff housing with community centre with an area of 22000 sqm out of which we have a ground coverage of 10% i.e., 2400 sqm , whereas we have the maximum allowance of 30% , which means we have 20% of land for future expansion.

The university's expansion plans are supported by government and other funding sources, enabling investments in infrastructure, faculty, and resources to attract more students and faculty.



- NBC - National Building Code - Volume 1 and Volume 2
- ECBC - Energy Conservation Building Code 2017
- ECBC - Eco Niwas Samhita 2018
- IGBC Green Homes Rating System - Version 3.0 2019
- IGBC Net Zero Energy Building Rating Systems
- GRIHA - https://www.grihaindia.org/case-study
- https://nzeb.in/webinars/policy/igbc-net-zero-energy-rating-system/
- GIFT SEZ Development Control Regulations (GIFT SEZ DCR)
- CEPT University, 'Indian Model for Adaptive Comfort' (IMAC)
- System Advisor Model (SAM) General Description (Version 2017.9.5)

Area programme:

S. No	SPACE	Type of Space	Qty	Area	Total Area used by the space	No. of Persons	Activity	System
1	Landscape area	Kids play area	1	450 sqm	450 sqm	80	Physical excercise, entertainment	Naturally ventilated
		Courts of multiple sports	3	1000 sqm	1000 sqm	180	Interaction	
		Lawn/ park	1	450 sqm	450 sqm	370	Relaxing, interaction	
		Roads	1	2600 sqm	2600 sqm	400	Circulation	
		Pedestrian paths	multiple	580 sqm	580 sqm	400	Circulation	
		Green spaces beside pavements and roads	multiple	2865 sqm	2865 sqm	400	Dust control, Acoustic, Greenery	
2	Circulation (25% of total area for Residential)	Corridors		minimum width 1.5m	2900 sqm	-	Interaction	Non air conditioned
		Staircases (Residential)	10	37 sqm	370 sqm	400	Circulation	Non air conditioned
		Lifts	10	2.6 sqm	26 sqm	370	Circulation	Non air conditioned
		Stretcher/Service lift	5	3.9 sqm	19.5 sqm	30	Circulation	Non air conditioned
3	Community centre	Parking	1	300 sqm	300 sqm	50	Parking of vehicles	Naturally ventilated
		Common Hall	1	750 sqm	750 sqm	300	Festivals, gathering & interaction	Air conditioned
		Indoor game spaces	1	150 sqm	150 sqm	50	Fun, entertainment	Air conditioned
		Pool	1	400 sqm	400 sqm	100	Physical excercise, entertainment	Naturally ventilated
		Pharmacy	1	15 sqm	15 sqm	2	Health care	Non air conditioned
		Reception	1	10 sqm	10 sqm	4	Information	Air conditioned
		Sitting Area					Relaxing	Non air conditioned
		Lounge					Relaxing, interaction	Non air conditioned
		Storage	1	40 sqm	40 sqm	-	To store wanted things	Non air conditioned
		Service room	1	6 sqm	6 sqm	-	electrical supplies and cables	Non air conditioned
		Gym	1	600 sqm	600 sqm	300	Physical excercise	Air conditioned
		Cafe	1	200 sqm	200 sqm	50	Food & entertainment	Air conditioned

RESIDENTIAL UNITS								
S. No	SPACE	Type of Space	Qty	Area	Total Area used by the space	No. of Persons	Activity	System
1	Residential (2BHK)/ per unit (Total units = 54 units)	Living + Dining	1	26 sqm	26 sqm	2-4	Living, eating	Non air conditioned
		Kitchen	1	10 sqm	10 sqm	2-4	Bathing, Sanitary	Non air conditioned
		Bedrooms	2	24 sqm	48 sqm	2-3	Sleeping, Working, Wardrobe	Air conditioned
		Washrooms	2	5 sqm	10 sqm	2-4	Cooking, Storage	Non air conditioned
		Balcony	1	6 sqm	6 sqm	2-4	Relaxing	Naturally ventilated
		Area per dwelling unit			**100 sqm**			
		Area of all dwelling units			**5400 sqm**			
		Parking		1350 sqm	1680 sqm	100	Parking of vehicles	Non air conditioned
		Circulation			1600 sqm		Circulation	Non air conditioned
		TOTAL AREA of 2BHK			**8680 sqm**			
2	Residential (3BHK)/ per unit (Total units = 26 units)	Living + Dining	1	25 sqm	25 sqm	2-6	Living, eating	Non air conditioned
		Kitchen	1	12 sqm	12 sqm	2-3	Bathing, Sanitary	Non air conditioned
		Bedrooms	3	20 sqm	60 sqm	1-3	Sleeping, Working, Wardrobe	Air conditioned
		Washrooms	3	5 sqm	15 sqm	1-3	Cooking, Storage	Non air conditioned
		Balcony	1	8 sqm	8 sqm	2-6	Relaxing	Naturally ventilated
		Area per dwelling unit			**120 sqm**			
		Area of all dwelling units			**3120 sqm**			
		Parking		550 sqm	780 sqm	50	Parking of vehicles	Non air conditioned
		Circulation		780 sqm	780 sqm		Circulation	Non air conditioned
		TOTAL AREA of 3BHK			**4680 sqm**			
		TOTAL RESIDENTIAL AREA			**13360 Sqm**			

* 1. Per capita water requirement for various Occupancies/ Uses - Residential (135 ltrs), Educational (45 ltrs for day schools, 135 ltrs for boarding schools)
2. 900 lt net per w.c. seat for tenements having common convenience
3. 270 lt net for one w.c. seat each and 180 lt for each additional seat in the same flat for residential premises other than tenement having common conveniences
4. urinals - 1 per 25 persons
5. Water closet - 1 per 8 persons for males, 1 per 6 for females
6. wash basins - same as water closet

SITE PLAN

Water calculation :

Design case	Building occupancy (x)	346		Working days	365
	Fixtures	No. of fixtures	rates (lpf/lp	No. of uses *	Water Consumption (l)
1	toilet flush (full)	180	2	2	1384
2	toilet flush (half)	180	1.2	0.75	311.4
3	kitchen faucets	180	3	18.5	19203
4	shower	180	5	3	5190
5	Lavatory faucets	180	4	0.75	1038
			Daily water consumption		27126.4
			Annual water consumption (l)		9901136
Base case					
	Fixtures	No. of fixtures	rates (lpf/lp	No. of uses *	Water Consumption (l)
1	toilet flush (full)	180	6	2	4152
2	Kitchen Faucets	180	8	18.5	51208
3	shower	180	10	3	5400
4	Lavatory faucets	180	8	0.75	1080
5					
			Daily water consumption		61840
			Annual water consumption (l)		22571600
Water use reduction (%) = 56		56.13454(	[Annual water demand (Base case) - Annual water demand (design case) / Annual water demand (Base case)] *100		

*GRIHA v. 2015 Manual

The data in yellow highlighted cells will be drawn from your design. Count the number of fixtures you have installed and feed in the data here.

This data will be drawn from product specification. Go online, select fixtures (WC, faucets etc) and feed in the data here.

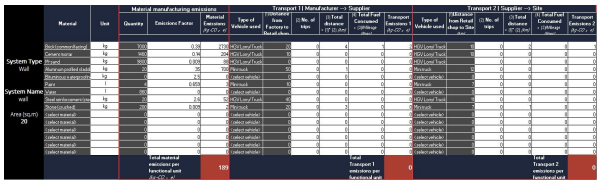
Our intent is to reduce overall building and landscape water demand of the project, so we have followed GRIHA "**criteria 14 : Reduce Building Water use**" by calculating base case and design case we were manageable to achieve **56%** reduction in water demand from base case

XERISCAPING TECHNIQUES :

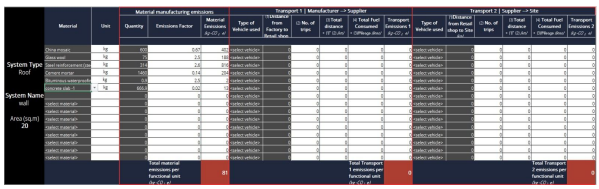
1. Choosing appropriate plants: Native plants that are adapted to the local climate are typically more drought-tolerant and require less water than non-native plants. By selecting plants that are well-suited to the local environment, xeriscaping reduces the need for frequent watering and ensures that plants can thrive with less water.
2. Grouping plants according to water needs: Grouping plants with similar water requirements together helps to ensure that each plant receives the appropriate amount of water. This means that water is not wasted on plants that don't need it, and plants with higher water demands can receive the necessary amount without over watering others.
3. Using efficient irrigation methods: Drip irrigation delivers water directly to the roots of plants, minimizing water loss due to evaporation and reducing the amount of water needed to keep plants healthy. Rainwater harvesting techniques can also help to reduce the demand for municipal water supplies.
4. Mulching the soil: Mulching helps to retain moisture in the soil, reducing the amount of water that plants need to stay healthy. This means that plants can go longer between watering, further reducing water demand.
5. Incorporating hardscaping: Hardscaping features like rocks and paving stones help to reduce water runoff and prevent erosion, reducing the amount of water needed to maintain healthy plant growth.

Embodied Carbon detailed calculations :

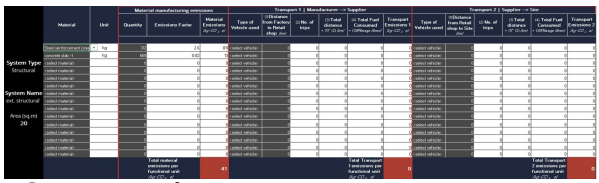
Base case



Wall



Roof

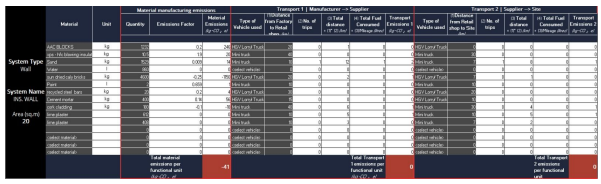


Structural

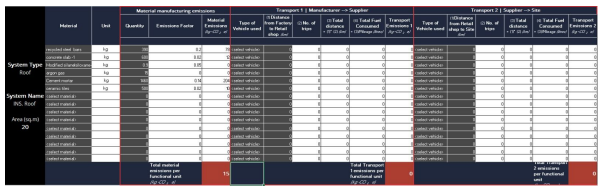
Fenestration

Floor

Design case



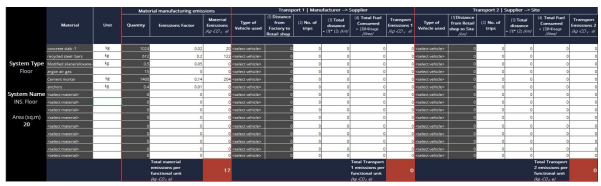
Wall



Roof

Structural

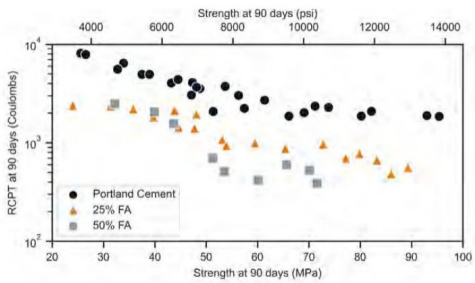
Fenestration



Floor

Carbon Captured Concrete :

carbonCure Ready Mix reduce cement content by 4-6% with no compromise on concrete quality or performance.



To minimize the embodied carbon of the building, we opted for materials with a negative embodied carbon We utilized methods such as material selection, merchant selection, and mode of transportation selection to decrease the carbon footprint associated with the construction of the building.

Building Operations Narrative :

The basic building operation system used for heating, ventilation and air conditioning is VAV hybrid system. VAV systems create comfortable living spaces is the goal of HVAC system design. In addition to lowering the cost of the facilities during their lifetime, the objective is to improve user performance. By enabling more cost-effective zoning flexibility, better temperature management, better passive humidity control at part load, and higher energy economy, VAV systems improve comfort.

The most prevalent flaw in most designs is that the systems are too complex to operate consistently. Control systems are the primary cause for worry. To offer effective control, control systems should be constructed as simply as feasible.

Dos and Don'ts for designing a suitable VAV system :

- Do not oversize the system.
- Set the minimum ventilation rate on the VAV Box.
- Use fan arrays.
- Utilise automated load estimations that are based on the ASHRAE transfer function approach.
- Design and specification must account for peak and part load situations.
- It is important to consider both the maximum and lowest flows when sizing VAV terminal boxes.
- With a minimum supply airflow of 4 air changes per hour, it is advised that the system be configured for 8 to 12 air changes per hour.
- Design for a continuous cooling supply air temperature to manage humidity and for ease of use.
- Linkages (VAV terminal unit damper, fan inlet guide vanes, and variable pitch vanes) should get special attention.

Safety precaution :

Before carrying out any maintenance or diagnostics, all components should be powered down to a safe condition, as with any electromechanical equipment. VAV system functionalities can be enabled as needed and in accordance with manufacturer and electrical safety requirements for testing and performance. These systems follow common electrical and mechanical safety procedures.

Maintenance :

Although VAV systems are intended to require little maintenance, they do need occasional care since they contain (depending on the kind of VAV box) a range of sensors, fan motors, filters, and actuators. While some of the maintenance tasks are time-based preventative measures (such as inspecting, cleaning, and replacing filters or validating actuator functionality), others may come under the area of predictive maintenance, whereby temperature data may be utilised to spot miscalibrated sensors.

DDF Consultants
Private Limited

Head Office:
501, B-9, ITL Twin Tower, Netaji Subhash Place,
Pitampura, New Delhi - 110034
(T) +91-11-47400500
(F) +91-11-47400555
(E) info@ddfgroup.com
www.ddfgroup.com

Date: 25th November, 2022

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organization DDF Consultants Private Limited, has provided information about our Major Dhyan Chand Sports University project to the participating team led by School of Planning and Architecture, New Delhi so that their team **Lagom** 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 would like 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 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,

DDF CONSULTANTS PVT. LTD. NEW DELHI

Name of Representative: Saurabh Chandra
Designation: Director
Email: saurabh@ddfgroup.com
Phone: +91 9810795454

redefining future
25 Years
Improving lives

• Architecture & Planning • Healthcare • Engineering & Project Management • Disaster Management

योजना तथा वास्तुकला विद्यालय, नई दिल्ली
(संसद के अधिनियम के तहत राष्ट्रीय महत्व का संस्थान,
शिक्षा मंत्रालय, भारत सरकार)
School of Planning and Architecture, New Delhi
(An Institution of National Importance under an Act of Parliament,
Ministry of Education, Government of India)

आज़ादी का अमृत महोत्सव

Prof. Dr. Anil Dewan
Professor and Head of
Department of Architecture

Ref. No.1/HOD-Arch/SPA/2022 6th October, 2022

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Mr. /Ms. **Shriya Sampalli Reddy (A/3470/2020), Lunavath Akhil Raj (A/3289/2019), Rhea Kaur Padam (A/3360/2019), T. Thanishka (A/3487/2020), Swetha S. (A/3485/2020), Aarzoo (A/3365/2020), Narra Deekshita (A/3439/2020), Adari Bala Chandra Deepak (A/3235/2019)** are bonafide students of full time **Five Year's Bachelor's Degree Course in Architecture at the School of Planning and Architecture**, New Delhi in the academic year 2022-23.

At present they are studying in Third year Fifth semester B. Arch.

There are 8 students Participating in **Solar Decathlon India 2022**.

(Prof. Dr. Anil Dewan)
विभागाध्यक्ष/Head of the Department
वास्तुकला विभाग/Deptt. of Architecture
योजना तथा वास्तुकला विद्यालय
School of Planning & Architecture
नई दिल्ली-2/New Delhi - 2

School of Planning and Architecture INDIA New Delhi

4-ब्लॉक-बी, इंद्रप्रस्थ एस्टेट, नई दिल्ली, 110002 भारत
दूरभाष : 011-23702375/76, फैक्स : +91 11 23702383
वेबसाइट: www.spa.ac.in

4-Block-B, Indraprastha Estate, New Delhi-110002 India
Ph.: 011-23702375/76, Fax : +91 11 2370 2383
Website : www.spa.ac.in

NAVEEN ASSOCIATES
Landscape Architects

Date: 09-02-2023

To,
The Director,
Solar Decathlon India.

Dear Sir,

This is to inform you that our organisation, **NAVEEN ASSOCIATES** is collaborating with the participating team **Lagom** led by **School of Planning and Architecture, New Delhi** on a **Housing Building** project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be to provide technical guidance, support and consultation regarding sustainable landscaping strategies.

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

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

With warm regards,

NAVEEN PANUGANTI
Principal Landscape Architect
NAVEEN ASSOCIATES
naveen@naveenassociates.com
Ph: 9849004965

First Floor, Plot No. 57, Kavuri Hills,
Phase-I, Madhapur, Telengana-500 081,
Tel: +91-40-40206966
Cell:+919849041999,+919866933669
Email: email@naveenassociates.com

Date: 09-02-2023

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organisation, **IQUBX PRIVATE LIMITED** is collaborating with the participating team **Lagom** led by **School of Planning and Architecture, New Delhi** on a **Housing Building** project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be to provide technical guidance, support and consultation regarding (IQUBX are the designers and manufacturers of some very Innovative green certified and world class modular systems for interiors like different baffle ceiling, glass partitions, workstation systems, trapdoors etc which are short world over. They have patent applied system and very unique).

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

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

With warm regards,

Name - **Sumit Singh**
Designation - **Marketing Manager**
Name of the Organization - **Iqubx Pvt Ltd**
Email - **info@iqubx.com, amit@iqubx.com**
Phone - **9999001967, 9811204811**

IQUBX PVT. LTD. New Delhi

iqubx interior systems
intelligent innovative integrated

Modular Integrated
Green Building Interior Solutions

www.iqubx.com
www.linkedin.com/company/iqubx/
www.facebook.com/iqubx

+91 9999001967
+91 8506074444
+91 7065666770 South India
+91 9811200111

info@iqubx.com
amit@iqubx.com

Iqubx Private Limited
Plot No 22, khasra no 27/10,
Industrial Area, **Nangli** Sakrawati,
Near Campa **Cola** Factory,
Najafgarh, **New Delhi**, 110043

ISO 9001 : 2015 certified
MSME UAN DL11A0004500

Our Products

Ceiling Trapdoor
Baffle ceilings

Glass Partition systems
Demountable partition wall systems
Door and door frames
Wall Paneling Systems
Skirting, Chair rail
Corner guard, Transition profile

Modular open frame free standing frames for temporary and permanent room spaces

Aluminium Cable Termination Racks
Aluminium Cable Distribution Racks

Floor cable raceway
Floor Junction Box (patent)
Cross Junction Box
Access Floor Box

Largest number of **GREEN CERTIFIED Modular Interior Systems IN INDIA**

SATYAM UPVC WINDOWS AND DOORS

Factory/Fabrication unit Address
45-7-1247, Keerthi Nagar Colony, Gorre Kunta
Warangal
Mail: upvcsatyam@gmail.com
GSTN: 36BDYPN1838D1Z6
Prop: N. SATYANARAYANA Mob No: 7893322850

Date: 09-02-2023

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organisation, **Satyam UPVC Windows and Doors** is collaborating with the participating team **Lagom** led by **School of Planning and Architecture, New Delhi** on a **Housing Building** project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be to provide technical guidance, support and consultation regarding installation and technical details of UPVC windows and doors.

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

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

With warm regards,

Rajesh
Chief Executive Officer,
Satyam UPVC Windows and Doors
upvcsatyam@gmail.com
7893322850