Solar Decathlon India

FINAL DESIGN REPORT

DIVISION: MULTI-FAMILY HOUSING

TEAM
AL-MA'ARIJ
SDI 2022-2023

M.H. SABOO SIDDIK COLLEGE OF ENGINEERING
RIZVI COLLEGE OF ARCHITECTURE

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LIST OF FIGURES

RESPONSE TO REVIEWERS

Section	Reviewer's Comment	Our Response
Reviewer 1		
Energy Performance	The section on Energy Performance is well written. Your team has also listed the ECMs and the consecutive reduction in EPI. More details about energy simulation for EPI calculation- like the input parameters for both cases, or the schedules that your team has considered for the building, will help communicate your thoughts better. Also, detailed calculations about the energy consumption under various heads are desired at this stage.	Answers are provided on page 10.
Water Performance	Your team has done a good job in the water consumption calculations and also listed the strategies for lowering per capita demand. However, in your report, this section seems a little mixed up. A single comprehensive water cycle table, with clear and concise representation of the source, consumption and storage calculations, highlighting the Net Zero aspect, should help put across your thoughts more effectively. Also consider all uses of water including HVAC systems. Do make it a practice to mention sources for all numbers, wherever you have taken a reference.	We have represented source, consumption calculations on pg. 20.
Embodied Carbon	Your team has enumerated your strategies and construction technologies that reduce embodied carbon emissions, and your research on locally available materials is commendable. However, calculations demonstrating the reduction in embodied carbon content of the project, as against a baseline, are expected at this stage.	The Embodied Carbon Sheet is attached with he report.
Resilient Design	The section on Resilience shows how your team has planned well for seismic or fire hazard. However, there is not much progress from D2 work seen in this report. You need to identify the potential risks from climate change, especially hydro meteorological hazards. Also, consider the building's ability to adapt to disruption in energy or water supply etc. Assessment of potential risks and design/ infrastructure intervention to address the risks is expected at this stage.	Different problems are addressed on page 19.
Engineering and Operations	The narrative on Engineering and operations is well-written. It explains your team's thoughts on the integration of water, energy, HVAC and sewage management systems within the structure. However, calculations showing right-sizing, and drawings explaining space provision are also expected at this stage.	Right Sizing is given, other details are clarified on page 17

Section	Reviewer's Comment	Our Response
Reviewer 1		
Architectural Design	The architectural design incorporates climatic considerations and structural systems well. The design detailing for increased accessibility and livability is commendable.	No Response. Work presented from page 19 onwards
Affordability	Your team has enumerated the strategies for obtaining economy in CAPEX as well as OPEX, while also considering revenue generation model from renewable electricity generation, hydroponic farming etc. This is a commendable effort. However, you need to demonstrate the actual cost reduction as compared with a baseline design, at this stage.	Cost Estimation sheet is attached and comparison is provided.
Innovation	Your team has identified various problems the building might face and proposed four innovative technologies to counter the same. The constructed wetland-based STP will cater to your water treatment needs, but will take up a lot of space on your site. You should look into its surface space requirements . Also the high cost implications of setting up a flywheel generator and its suitability for such a large capacity generation should be checked. The IoT-based control system may be better suitable and effective in a building where most of the systems are centrally-operated and managed. The hydroponics system seems interesting and might be beneficial. Make sure that the water and energy requirements for the same are considered in your annual calculations.	The problems is addressed on page 15.
Health and wellbeing	Your strategies to achieve indoor thermal comfort and the desired air quality, seem to be still on the narrative level. Annual simulations for demonstrating thermal comfort achieved, and operation schedules are expected at this stage.	the work has been updated a bit. Given on page 27
Value Proposition	Advantages of the site in terms of connectivity have been listed by your team. However, location is not the only plus point here! The value proposition section needs to elaborate how the project partner will benefit from the net-zero energy-and-water project that you have proposed. A compelling narrative for the project partner is expected at this stage.	Better presentation is given on page 31.

Additional Comments:
Going further, use of different systems of units should be avoided and the team should stick to SI units for easier comprehension.

Section	Reviewer's Comment	Our Response
Reviewer 2		
Energy Performance	The team have presented EPI reduction well, please use the correct units and use METRIC systems. EPI reduction is visible, the team could have included the measures they have adopted to do so. The team have dealt with energy generation as well, please deal with energy storage as well considering load change over time.	the Review has been answered on page 10
Water Performance	Please address water filtration and water storage subjects approaches to deal with both.	Water filtration is explained on page 12.
Embodied Carbon	The team have not demonstrated their approach to reduce embodied carbon at dwelling unit and at site level with the help of calculations.	The proper Calculations are given this time.
Resilient Design	The team should deal with resilience against floods, heat waves, and electric grid failures, and already address seismic and fire resilience. In fact it dominates evaluation strategies in case of fire but does not demonstrate resilience.	The resilience is demonstrated in detail.
Engineering and Operations	The team could have dealt with more about the engineering and operations instead of focusing on STPs and Power generation. It's important to demonstrate the operational strategies that meet the design objectives, seasonal and daily variations in water and energy consumption should be dealt with at the dwelling unit level and site level.	Page 17 onward has details of Engineering and operation.

Section	Reviewer's Comment	Our Response
Reviewer 2		
Architectural Design	The north line shown on sunpath diagram and in the floor plans does not match. The team has not approached architectural design from climate - resilience perspective, the current approach of having multiple floors with the same units rotated/mirrored might not lead the design to the desired level of environmental performance.	The necessary corrections are made
Affordability	The team has demonstrated the intent to achieve affordability but does not quantify that in the document prepared for the SDI submission. Actual cost numbers are needed	The numbers are provided in the Excel sheet of Embodied Carbon.
Innovation	1MW flywheen assisted power generation innovation needs cost back up to prove its feasibility. The siteplan does not reflect the location of it.	Cost is given in this report.
Health and wellbeing	Please address heat stress, thermal comfort and IAQ/IEQ simultaneously. Instead of demonstrating the intent, please demonstrate it with performance-based strategies.	The response has been taken to notice and worked upon
Value Proposition	No specific comments.	No Response

EXECUTIVE SUMMARY

In the construction sector, multi-family housing projects using net-zero energy are relatively unexplored. Even more, so is a net-zero energy and water design. This project is a G+22 multi-family high-rise located in Taloja, Maharashtra, and is being worked on by Team Al-Ma'arij, a group of students from M.H. Saboo Siddik College of Engineering and Rizvi Institute of Architecture. A group of multidisciplinary students from the professions of architecture, civil engineering, and mechanical engineering designed the building to adhere to net zero energy and water norms. Faculty advisors advised the team, and industry partners provided assistance.

The primary objective of this project was to design a Multi-Family High-Rise building with a built-up area of **10368.42 sq.m**, which is both sustainable and affordable for the general public. The building aims to achieve net-zero energy consumption with a target **EPI of 35 kW/hr/year**. To achieve this goal, the building design prioritizes the maximization of on-site renewable energy sources, reduction of annual electricity consumption by using energy-efficient equipment, minimization of freshwater demand, treatment of grey water on-site using green sewage treatment plants, collection of rainwater during the monsoon season, incorporation of resilient design choices to enhance adaptability to unforeseen disasters and climate change, optimization of building management systems, integration of the landscape to promote biophilia, improvement of indoor environmental quality, provision of thermal comfort, enhancement of occupant health and well-being, and fostering environmental sustainability. Furthermore, the building design incorporates the use of local and low-carbon materials to achieve these objectives.

The project's renewable energy sources have a combined **energy-generating potential of 3,46,750 kWh/year**. The project's initial goal was to reach an EPI of 61.8 kW/hr/year. However, the EPI was successfully **decreased to 35 kW/hr/year** by utilizing both active and passive design strategies, such as enhancing the building's envelope assembly, incorporating forced and crossed ventilation systems, efficient building orientation and day-lighting, utilizing façade and rooftop shading, utilizing energy-efficient lighting fixtures, and putting zone-wise HVAC systems into place. The project's overall energy consumption and cost were significantly reduced as a result of the incorporation of these design principles, which assured effective energy utilization.

The initial **baseline freshwater** demand of **135 KLD** was successfully **reduced to 58 KLD**, resulting in a remarkable **reduction of 57.22%**. This was achieved through the implementation of a range of sustainable practices, including the integration of low-flow fixtures, a low flush system, and the recycling and reusing of grey water with the assistance of an **Integrated Wetland Based Green STP**. In addition, a rainwater harvesting system was adopted, along with the utilization of an abundant supply of groundwater, to effectively offset freshwater consumption and attain a net zero water status. Notably, the collection of rainwater and groundwater during the monsoon season has proven to be particularly effective in fulfilling consumption requirements.

The project team encountered several challenges during the building design phase and introduced innovative solutions to address them. One such challenge was the limited space available for the installation of solar panels, which could potentially impact energy generation. To overcome this challenge, the team designed a Flywheel Generator, which has the capability of producing 1 MW of energy per day. Additionally, due to the lack of ground space, it was difficult to provide a community garden for food security. To tackle this issue, an Automated Hydroponics system was designed on the walls of the podium. Moreover, the team opted to replace the conventional STP system for cleaning grey water with a IWT Based STP, which operates with minimal electricity consumption, produces less waste, and is sustainable in the long run.

TEAM INTRODUCTION

TEAM AL-MA'ARIJ

The word "AL-MA'ARIJ" is a word of Arabic origin meaning, "The Ascending Stairways". We chose this name because it represents our goal to "ascend to the highest level of energy conservation and make the construction, Energy Efficient & Sustainable & to offer a modern way of living that respects the environment.

DIVISION

Multi-family Housing.

ABOUT THE LEAD INSTITUTION

M. H. Saboo Siddik College of Engineering (MHSSCOE), affiliated with the University of Mumbai, is an AICTE accredited A-level institution. Founded in 1936 with a clear mission, the College provides quality technical education and value-driven personal development. It provides education for automotive, civil, mechanical, computing, EXTC & IT Engineering. The vision of the Department of Civil Engineering is to build a sustainable environment by providing technical knowledge and leadership skills. Courses include practical and real-world experience of various subjects of civil engineering field. The mission of the Mechanical Engineering department is to develop creative and innovative solutions to industrial and societal problems by providing technical knowledge to the students.
As the project involves many disciplines, M. H. Saboo Siddik College of Engineering is collaborating with Rizvi College of Architecture.

Rizvi College of Architecture is one of the most prestigious architecture colleges in Mumbai. This college is affiliated with the University of Mumbai and is accredited by the Council of Architecture (COA). The college is also approved by the University Grants Commission (UGC). The college aspires to educate sincere professionals with high moral and ethical standards, intellectual honesty, clarity of mind, and an entrepreneurial spirit.

FACULTY PROFILE

FACULTY LEAD

Prof. Rabia Sameen.

M.Tech Environmental Engg.

Rabia Sameen specializes in solid waste management, environmental engineering, and other topics related to the environment. As a result of Prof. Rabia's 12 years experience in the field, we will be able to analyze, understand, and design the different renewable energy systems in the project.

FACULTY AVISORS

Prof. Ateeque Ur Rehman.

M.Tech. Structural Engg.

Prof. Ateeque Ur Rehman has specialised in structural engineering. His teaching experience of 27 years and research experience will give us major guidance. His 4 year research in structural dynamics is going to have an immense impact on the projects' structural stability and resilience.

Prof. Shahab Dabir.

M.Tech. Thermal Engg.

Prof. Shahab Ahmed Dabir specializes in Refrigeration & HVAC, Mechanical Utility Systems, Metrology & Quality Engineering, Industrial Engineering & Management. In addition to 8 years of experience, he is affiliated with professional bodies such as ISHRAE & SAE to broaden his knowledge of HVAC, IAQ, & Thermal Comfort.

Prof. Rekha Desai.

M.Arch (Environmental Design)

Prof. Rekha Desai is the Principal of Rizvi College of Architecture, one of Mumbai's oldest and most renowned colleges. She has 23 years of experience. Her Master's thesis focused on the necessity for a decentralised solid waste management system in Mumbai. She has given several papers on the importance of efficient solid waste management and the revitalization of the Mithi River.

ROLES OF STUDENTS

Energy Performance: Abdurrahmaan, Amaan, Siddique
Water Performance: Sabrin, Shamsher
Innovation: Siddique
Resilience: Manu, Sajjad, Sariya
Engineering and Operations: Rehan, Amaan
Embodied Carbon: Sabrin, Shabnam, Nousheen
Architectural Design: Manu, Sariya, Sharik
Health and Well Being: Abdurrahmaan, Sanskruti, Shabnam
Affordability: Sakshi, Sanskruti, Sharik
Value Proposition: Nousheen, Sakshi
Integrated Waste Management: Rehan, Sajjad

INDUSTRY PARTNER

Abdul Moeed Chaudhary
Designation: Founder of Essential India.
Role: Guiding us to improve sustainability and energy performance.

APPROACH

A team comprising of students with diverse backgrounds in civil, mechanical, and architectural engineering collaborated proficiently to design a building that would satisfy the requirements of the SDI competition. They maintained consistent communication with the project partner, industrial partner, and faculty head to lay the groundwork for their design. The team was divided into sub-groups to conduct in-depth analysis of various problems, inclusive of active and passive techniques, and their respective solutions. Furthermore, they conducted extensive research to gather pertinent information about the site, local regulations, codes, materials, construction techniques, and other factors that could impact the building's performance and design. The team endeavored to integrate sustainable design principles and practices into their building design with the objective of reducing its environmental impact, amplifying energy efficiency, and enhancing the comfort and well-being of the occupants. After identifying the optimal strategy, they embarked on the building design process.

PROJECT BACKGROUND

PROJECT NAME

ECOTOPIA is a multi-family high rise that will be designed by Team Al-Ma'arij. According to Ernest Callen Bach's theory, ECOTOPIA refers to "an ecologically ideal area," as the name would imply. We intend to create a multifamily structure that produces between 60% and 70% of its own electricity and has a carbon impact that is almost zero (Net Zero). The structure will be a perfect place to live as a result.

PROJECT PARTNER

Anas Dokadia
Designation: Builder and Developer

Sumit Adkhale
Designation: Structural Consaltant.

Role in Project: Provided Land and layout of the site and guided in different site related problems.

MAJESTIC
BUILDERS & DEVELOPERS

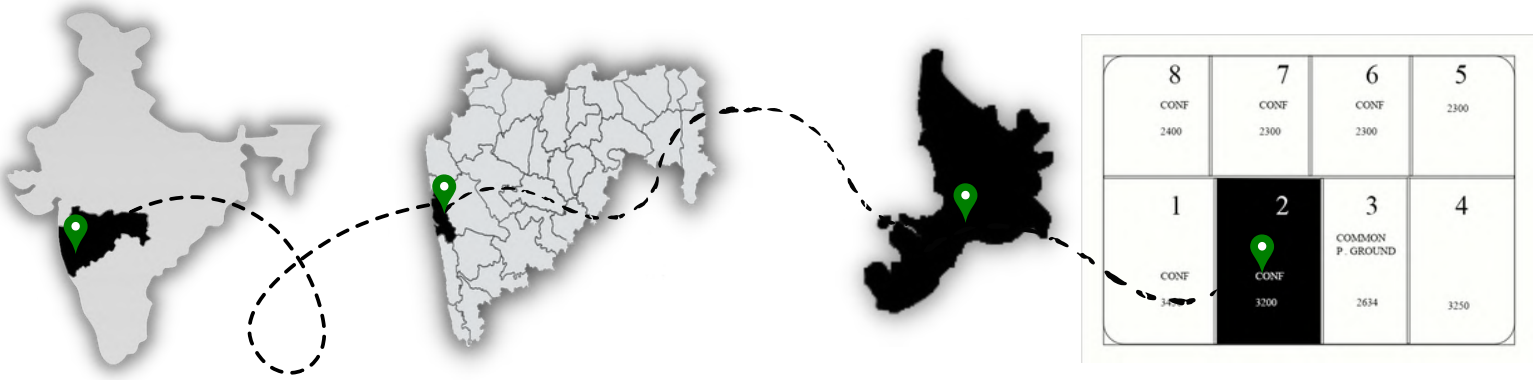
BRIEF DISCRIPTION OF PROJECT

Fig. 1; Site view of Taloja Sector 25 Taloja Phase 2

Location: Taloja, Navi Mumbai
Climate: Warm and Humid
Stage of Project: Design Phase
Hours of Operation: 24 hrs
Working Hours: 8am-7/9pm
Permissible Built-Up Area: 8706.38
Estimated Built-Up Area: 10368.42
Total Site Area: 3200.13 sqm
Target Energy Performance: 55 kWh/m2/year
Preliminary estimate of Renewable Energy Generation: 802043.7 kW/year
Occupation of Residents: Office Works, Students, Homemakers

ABOUT TALOJA:

Taloja, a census town located in the Raigad district of Navi Mumbai, Maharashtra, is governed by the Panvel Municipal Corporation and is part of the Kharghar node. The Navi Mumbai Metro's first phase begins at Pendhar, providing Taloja with convenient transportation options. Taloja is divided into two phases, Phase I and Phase II, by the City and Industrial Development Corporation of Maharashtra Limited (CIDCO). According to the 2011 India Census, Taloje Panchnand has a population of 14,318, with a gender ratio of 54% male and 46% female. The average literacy rate of Taloje Panchnand is 68%, surpassing the national average of 59.5%. Male literacy is recorded at 73%, while female literacy is 61%. The population of children under six years of age accounts for 18% of Taloje Panchnand's total population.



India | Maharashtra | Navi Mumbai | Taloja (Sector 25)

EDU-TECH School

Skyline Jewel

Trikon Residency

Taloja RTO

Max Hospital | Taloja Metro Station | Mangala Residency | Babloo Fruit Shop

Water Supply:
Supplier: CIDCO
Time: 9am - 11am
Problem Faced:
Water Cut upto 25%

Electricity Supply:
Supplier: Maharashtra Electric Board (MEB)
Rate: ₹ 6.50 per Unit
Problem Faced: Nil

Economic Background:
Presence of various small and large industries has drawn people from MIG and LIG groups; as a result, the majority of locals work in these industries.

Waste Disposal:
Mumbai Waste Management Limited (MWML)
Problem Faced:
The problem of non-lifting of garbage is increasing.

Transportation:
Easy to travel to Mumbai, Pune & Thane.
Problem Faced:
Public transport is not highly active.

Family Members:
4-6 Members per Family.
Accommodation Type: 1 & 2 BHK
Hours of Operation:
24 hrs

Government Facilities:
Water, Proper waste management, Electricity, etc.

Rent:
Land price: ₹4600-₹5300/ft²
Rent: 1 BHK - ₹6000/Month
2 BHK - ₹8500/Month

SOLUTION TO PROBLEM FACED BY LOCALS

Water harvesting technology is needed to cope with the water cutoff.

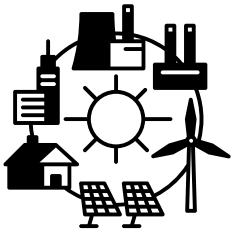
The properties have car-pooling facilities and a taxi/bus stand.

Alternative month cooking gas supply to all the flats via onsite Biogas plant.

AMENITIES NEAR SITE

Airport
Metro Station
D-Mart
Reliance Mart
Bajaj International School
Kharghar Central Park Flyover
Metro Taloja phase II
India's First Data Center
Subway for road transport

GOALS



ENERGY PERFORMANCE

GOALS

50% EPI REDUCTION
100% ENERGY GENERATION

STRATEGIES

EPI Reduction by Envelope Optimization, Daylighting, Natural and Cross Ventilation, Use of 5-Star Equipment, etc.
50% (335800 kWh/year) energy generation from Solar & Wind.
Rest 50% (365000kWh/year) from Flywheel Generator.

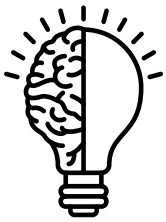
WATER PERFORMANCE

GOALS

55.43 % Water Consumption Reduction
55.7 % Water Consumption Recycle
55.7 % Harvested Water

STRATEGIES

Use of Low Flow Fixtures, Dual Flush, etc.
Use of the Sewage Treatment Plant (STP) to treat the grey water and then reuse it fo various purposes.
Water is harvested by rain water and ground water , reduced supply load from municipal by 53.65%.



INNOVATION

GOALS

1Mw Energy Generation on-Site by flywheel generator.
Design of Integrated Wetland Green STP
Automated Hydrophonics System

STRATEGIES

The design of a 1 MW flywheel generator by taking reference from Kamma flywheel generators, the design of an IWT STP, and providing food security through an automated hydrophonics system

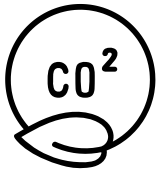
EMBODIED CARBON

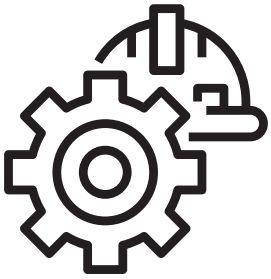
GOALS

Reduce Embodied Carbon

STRATEGIES

By use of locally available material, Recycling, Carbon farming,





RESILIENCE

GOALS

To increase the livelihood by designing buildings and landscapes to mitigate the impact of extreme weather and other external threats such as Earthquake, Fire resistance, Power outage, Water cutoff, etc.

STRATEGIES

To mitigate the impact of earthquakes, reinforce walls with shear walls and maintain the structural grid. Ensure fire safety by providing refuge areas, fire staircases, fire-rated doors, and walls. Address water cutoff by harvesting on-site rain and groundwater. For power outages, generate renewable onsite electricity.

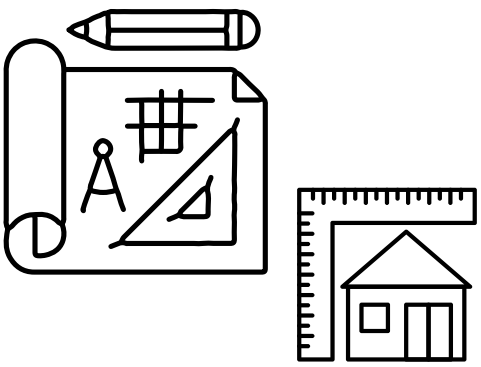
ARCHITECTURAL DESIGN

GOALS

Natural ventilation, daylighting, better community spaces, cost effectiveness, and efficient construction Façade optimization and age-friendly design

STRATEGIES

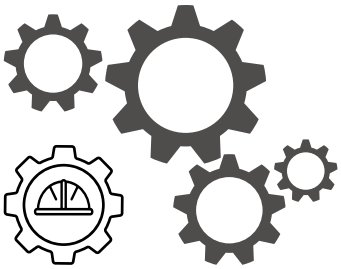
Natural ventilation and consolidation of service grids for kitchen and toilets, Maximizing natural lighting and incorporating passive shading design strategies, Creating accessible recreational areas and visual connectivity among occupants, Designing for cost effectiveness and efficient construction, Optimizing facades with passive shading and aesthetic treatments, Incorporating friendly details such as handrails for different age groups.



AFFORDABILITY

GOALS

To control the cost and time of high-performance buildings by employing locally accessible, low-cost materials and techniques that can speed up construction, save money, and be environmentally friendly. To satisfy energy demands, switching from non-renewable to accessible renewable sources & reusing on-site wastewater.



ENGINEERING AND OPERATIONS

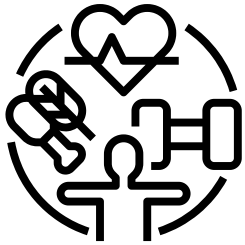
GOALS

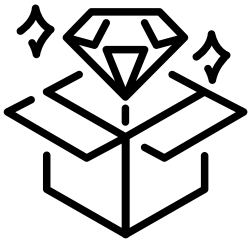
To control the cost and time of high-performance buildings by employing locally accessible, low-cost materials and techniques that can speed up construction, save money, and be environmentally friendly. To satisfy energy demands, switching from non-renewable to accessible renewable sources & reusing on-site wastewater.

HEALTH AND WELLBEING

GOALS

To attain highest level of human comfort and indoor air quality. By Implementing passive strategies such as natural ventilation, sun shading, low or zero VOC paints, and proper filtration. Also Strategies for boosting visual comfort, daylighting, safety and security are also included.





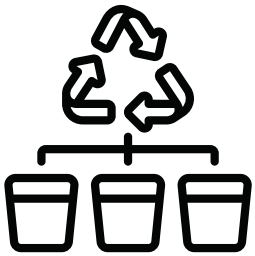
VALUE PROPOSITIONS

GOALS

To clearly describe a project partner's advantages by taking into account his advertising, in-hand building planning and design, and benefits in accordance with green building norms. End users by emphasizing benefits such as improved lifestyle, one-time investment with lifetime rewards, sustainable technology, and future plot demand.

WASTE MANAGEMENT

Integrated waste management minimizes landfill use via waste reduction, reuse, recycling, and safe disposal. Its goal is a sustainable system that's environmentally, economically, and socially acceptable.



The next chapter outlines the design process developed to achieve the goals and strategies for our building, incorporating sustainable design principles. The process involves careful consideration and planning, including analyzing requirements, identifying constraints, and evaluating alternatives.

DESIGN DOCUMENTATION

1. ENERGY PERFORMANCE:

CLIMATE ANALYSIS:

Taloja is situated in a warm and humid climate zone, where the average peak temperatures during the months of March to July fall within the range of 27°-33°C. The direct normal radiation in the area varies from 870Wh/m² in March to 320Wh/m² in July. Taloja experiences high levels of direct sunlight, with the average peak hourly direct normal illumination ranging from 90000-22000 lux between March to October.

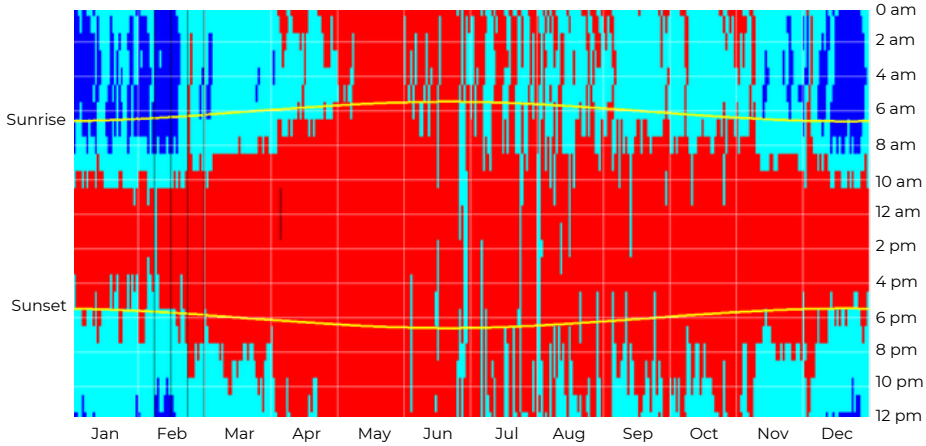


Fig: 2. Annual Heat Map

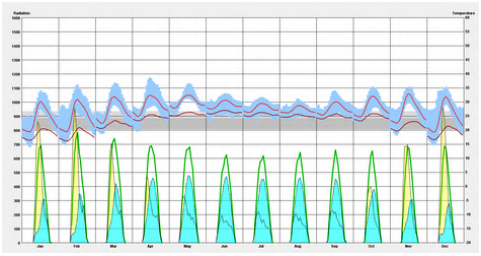


Fig: 3. Monthly Diurnal Avg

Fig: 3..1 Annual Temperature Variation

In Taloja, the relative humidity varies between 60% to 90% during the monsoon season, which typically occurs between mid-June to September. The temperature range in the region is quite wide, with highs of 98.6 F and lows of 57.2 F. The dry bulb temperature in the area can reach as high as 95.2 F, while the wet bulb temperature averages around 82.2 F.
The peak load in the region typically occurs in May at 4:00 pm when the wind speed ranges from 8 - 11 KM/H. Based on the climate analysis of Taloja, it is suggested that shading systems should be implemented to maintain comfortable indoor temperatures. This is because the average peak temperatures in the region exceed the standard comfort zone levels of 22°-24°C.

OPENINGS & SHADING:

Optimizing openings and shading is a key strategy for achieving energy efficiency in building design. Installing vertical louvers on the west-facing side and right-sizing openings and facades on other sides can reduce heat gain and cooling costs while improving occupant comfort. Overall, optimizing openings and shading can significantly reduce energy costs and the building's carbon footprint.
A context-specific approach and seeking expert advice can ensure sustainable and efficient buildings that meet occupants' needs while minimizing their environmental impact.

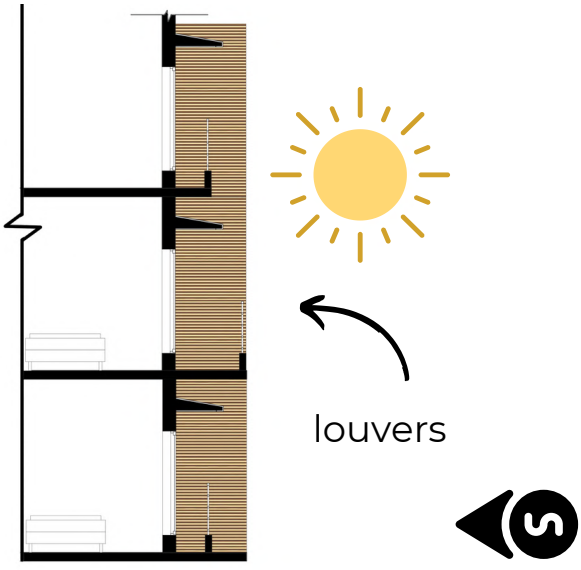


Fig: 3.2. West Section of Building

ENVELOPE OPTIMIZATION

Our team analyzed the conventional building envelope used in the area and designed & optimized it based on the climate. We used locally available materials to reduce embodied carbon and performed simulations to identify the most feasible and energy-efficient design. This ensured that the building envelope was suitable for the location's climate and environmentally responsible.

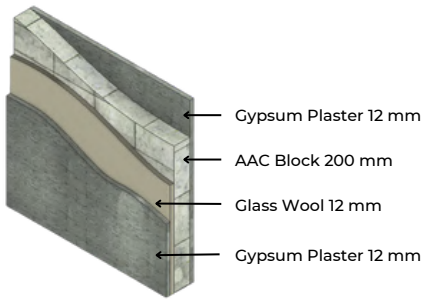


Fig: 4. Exterior Wall

The Composition is as Follows:

Exterior Wall: U-Value 0.23
SRI PAINT + Gypsum Plaster 12 mm + AAC Block 200 mm + Glass Wool 12 mm + SRI PAINT + Gypsum Plaster 12 mm.

Internal Wall: U-Value 0.33
SRI PAINT + Gypsum Plaster 12 mm + AAC Block 200 mm + Glass Wool 12 mm + SRI PAINT + Gypsum Plaster 12 mm.

Ceiling: U-Value 0.33
Terrazzo Tile 12 mm + Mortar 12 mm + RCC Slab 150 mm + SRI PAINT + Gypsum Plaster 12 mm

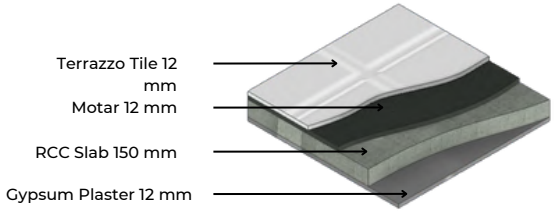


Fig: 5. Ceiling

Roof: U-Value 0.25
Brick Bat + Plaster 75 mm + Mortar 25 mm + RCC Slab 150 mm + SRI PAINT + Gypsum Plaster 12 mm

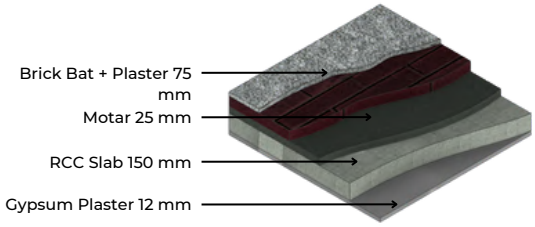


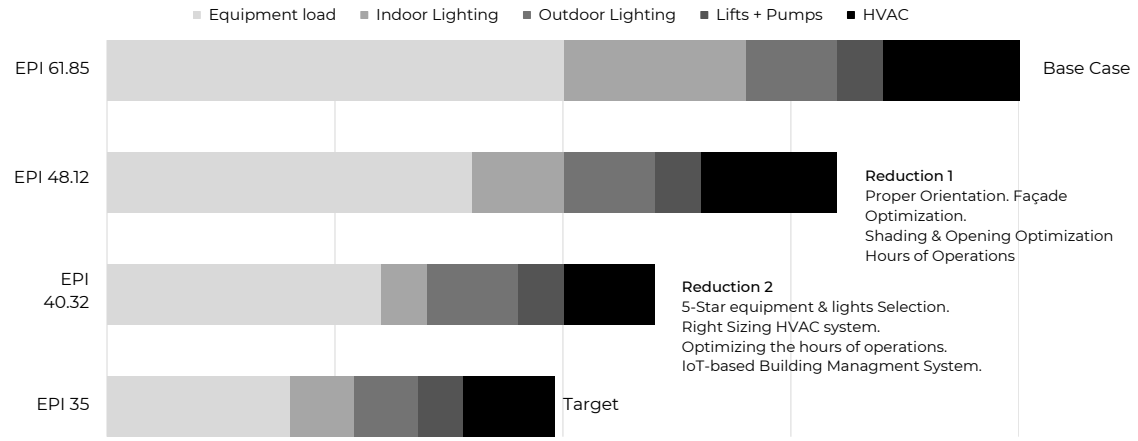
Fig: 6. Roof

ENERGY PERFORMANCE INDEX (EPI):

ENERGY CONSUMPTION DETAILS BASE CASE:

Space	Appiliance	QTY	Watt	Hours	kWh	1 Floor Energy Consupmtion (Wh/Year)	Misc Equipment Elevator, Pumps,etc	Total Consumption G+22	EPI
1 BHK (4/floor)	Led Light	6	15	8	0.72	30819.14	580000	641317.08	61.85292262
	Fan	2	45	8	0.72				
	T.V	1	120	2	0.24				
	Air Conditioner	2	1000	5	10				
	Refrigerator	1	780	15	11.7				
	Oven	1	700	0.5	0.35				
	Toster	1	700	1	0.7				
	Geyser	1	1000	1	1				
	Washing Machine	1	500	1	0.5				
	Exhaust Fan	1	40	3	0.12				
	Iron	1	550	1	0.55				
2 BHK (3/floor)	Led Light	7	15	8	0.84	25241.94			
	Fan	3	45	8	1.08				
	T.V	1	120	2	0.24				
	Air Conditioner	3	1000	5	15				
	Refrigerator	1	780	15	11.7				
	Oven	1	1000	0.5	0.5				
	Toster	1	700	1	0.7				
	Geyser	1	1000	1	1				
	Washing Machine	1	500	1	0.5				
	Exhaust Fan	2	30	3	0.18				
	Iron	1	550	1	0.55				
Shop	Led Light	6	15	8	0.72	5256			
	Fan	6	45	8	2.16				

Table: 1. Energy consumption details Base Case



Energy performance optimization and reduction can be achieved through the implementation of both active and passive strategies. Our initial analysis revealed that the building had a Base Energy Performance Index (EPI) of 61.85 KWh/year/m², which needed to be reduced for achieving our target energy performance level.

To start with, we optimized the building orientation and façade to enable daylighting and natural ventilation, which significantly reduced the lighting load. As a result, we were able to achieve an EPI of 48.12 KWh/year/m². Further optimization was carried out by selecting 5-Star equipment and lights, and optimizing the HVAC system. These measures led to a significant reduction in the EPI to 40.32 kWh/year/m². To achieve our target EPI of 35 KWh/year/m², we focused on optimizing the hours of operations, further optimizing the HVAC system, and introducing IoT-based control of indoor and outdoor equipment and appliances.

Through the implementation of these active and passive strategies, we were able to achieve our target EPI while ensuring optimal building performance and energy efficiency.

ON-SITE ENERGY GENERATION

Fig: 7. Solar Panel

Make: Atum
Cost/Panel: 65,000 INR
Dimensions: 2.08 x 1.02 x 0.017
Installed capacity = 200 kwh
Number of Panels: 400
Annual Energy Generation: 73,000 kWh/year

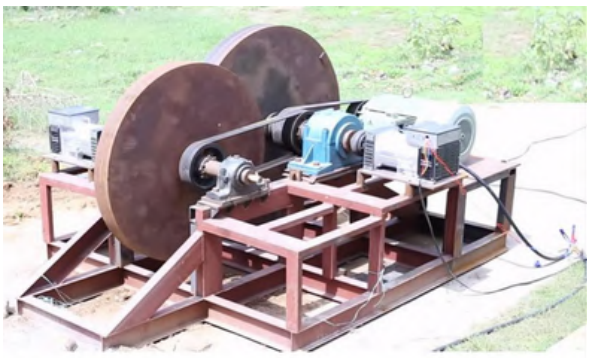


Fig: 8. Flywheel Power Generation by Chaganti

Make: Kamma Fly Wheel
Cost: 4,10,00,000 INR
Dimensions: 2.08 x 1.02 x 0.017
Installed capacity = 750 KW
Number of Machine: 1
Annual Energy Generation: 2,73,750 kWh/year.

To fulfill the energy requirement of 3,17,205.05 kW/year, we implemented a solar power plan with an installed capacity of 200 kW, generating 73,000 kWh/year, which only accounts for 21.05% of the total energy required. To fulfill the remaining 80% of energy, we installed a flywheel generator with an installed capacity of 750 kW, generating 2,73,750 kWh/year. The solar panels were placed on the southern façade of the building, while the flywheel generator was installed on the ground floor. The report also provides specific details about the flywheel generator in the innovation section.

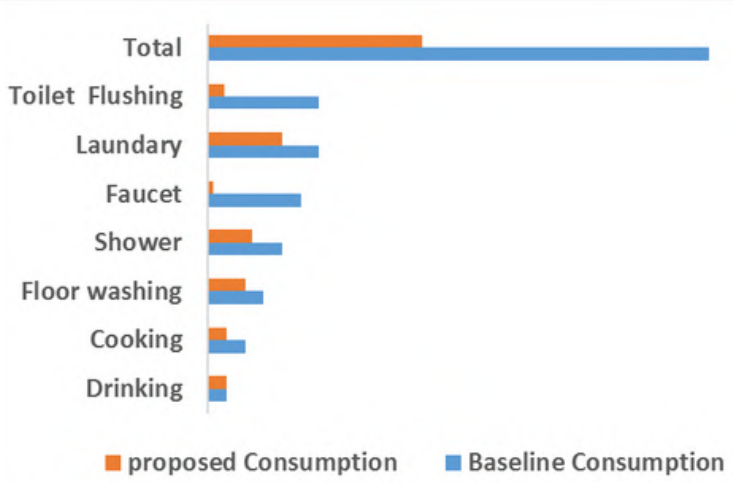
2. WATER PERFORMANCE:

As per the National Building Code 2016, the water demand per capita for residential buildings is 135 liters. We proposed a reduction in water consumption up to 55%, recycling 65% of the total water demand, harvesting rainwater, using and recharging groundwater, which brought us to achieving net zero water usage in our building.

REDUCE

Water consumption was reduced from 135 LPD to 58 LPD. This reduction was through installation of water-saving fixtures such as Low-flow showerheads, Dual-flush systems and Water-saving nozzles.
The estimated water demand for the building is 64,680 LPD based on an estimated 1,120 occupants

Fig: 9. Water saving fixtures with efficiency



WATER CONSUMPTION

RECYCLE

Grey water is collected from various arts of the building and treated in an Integrated Wetland construction STP, then reused for non-potable purposes such as car washing, flushing, and landscaping, as well as to recharge the ground water table.

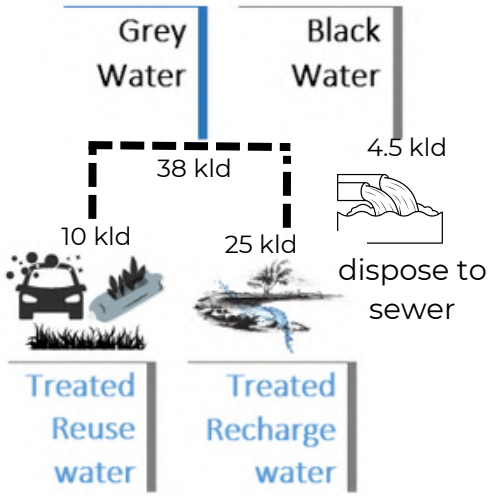


Fig: 9. 1. Recycled Water

WATER TREATMENT

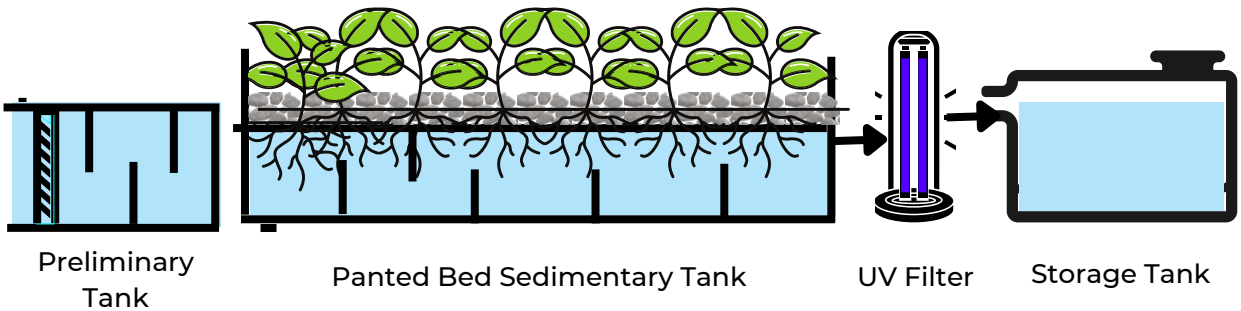


Fig: 10. Integtared wetland constructed STP

In an Integrated Wetland Construction STP, the water undergoes a multi-stage treatment process. Firstly, it is physically filtered in a preliminary tank, followed by biological treatment and sedimentation in a planter bed sedimentation tank. The treated water then undergoes disinfection through a UV filter before being stored in a tank.

WATER HARVESTED

1.RAIN WATER HARVESTING

The building's roof functions as a **catchment area for rainwater**, while other surfaces such as **paved and unpaved ground, green lawns, and ramp areas** are also utilized to collect runoff.

Surfaces	Area	Runoff
roof surface	977.11	95
Planted Bed	337.308	50
Green Lawn	112	25
Ramp Area	493	100
Unpaved Grour	303	95
Unpaved Grour	446	85
Total Area (m2)		2668.418
Total Runoff (%)		75

Fig: 10 Integrated Wetland Constructed STP

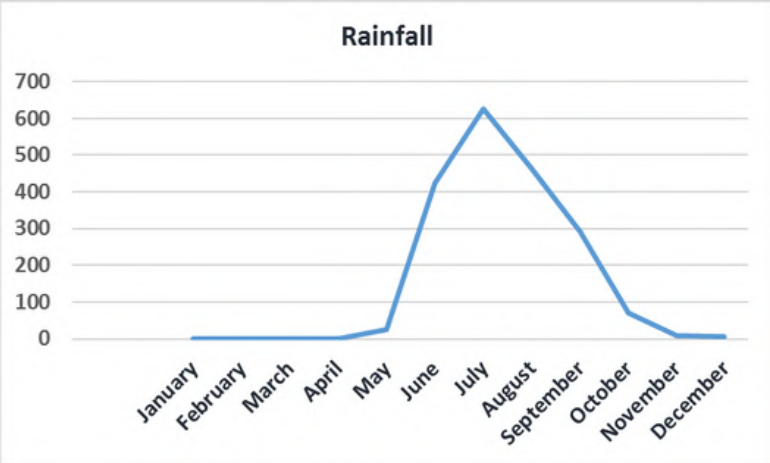


Fig: 11. Monthly Rainfall

Total catchment area = 2679 sq.m
Total Rainwater harvested in a year = 3829710 liter.

2. GROUND WATER

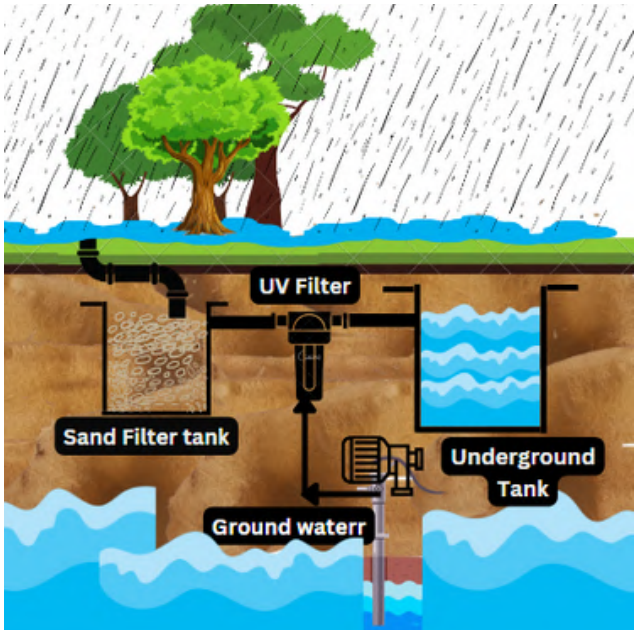


Fig: 12. Ground Water Collection

The water is extracted from the groundwater table using three bore wells that pump out a total of **5000 liters per hour**.
The collected water from rain water and ground water sent underground to the sand filter to remove suspended matter, water then passes through the UV filter, which disinfects the water to make it fit for drinking. Finally, the water is stored in an underground tank.

TOTAL WATER COMSUMPTION

Baseline Demand	Proposed Demand	Grey Water	Black Water	Recycled Water	Recharged water	Rain Water Harvested	Ground Water extracted	Municipal Supply
135 kld	57.75 kld	47 kld	4.5 kld	10 kld	28 kld	30 kld	25 kld	30 kld

Fig: 13. Water Consumption

WATER FLOW DIAGRAM

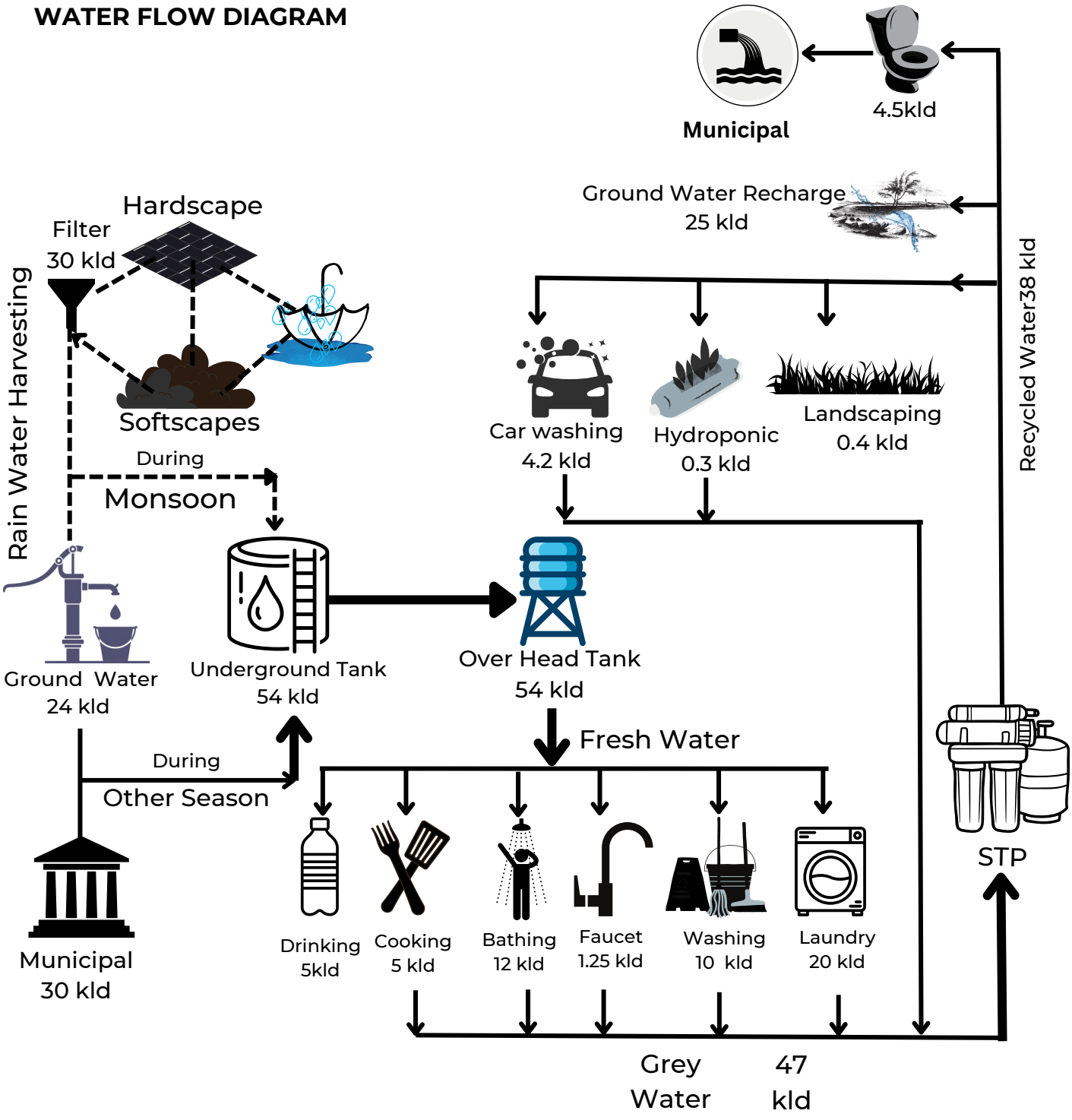


Fig: 14. Water Flow Diagram

3. INNOVATION:

INTEGRATED WETLAND TREATMENT GREEN STP:

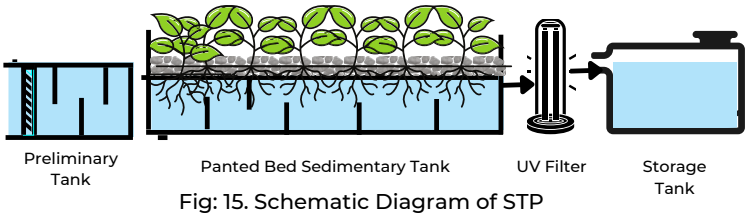


Fig: 15. Schematic Diagram of STP

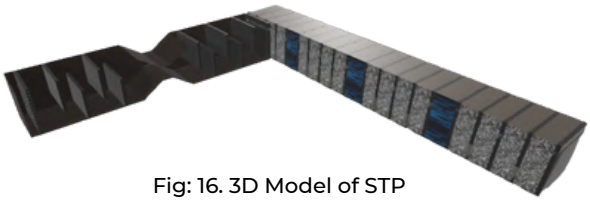


Fig: 16. 3D Model of STP

Integrated wetland treatment Green STP works by using a series of physical and biological processes to treat wastewater. The water is first filtered in a preliminary tank, then undergoes biological treatment and sedimentation in a planter bed sedimentation tank. Finally, the treated water is disinfected with a UV filter before being stored in a tank. The process utilizes natural wetland plants to purify the water and is an environmentally friendly and sustainable solution for wastewater treatment.

TREATED WATER QUALITY:

Parameters	Inlet	Outlet - AD	Outlet – AD+
Ph	6.0 – 9.0	6.0 – 9.0	6.0 – 9.0
Color	Blackish	Colorless	Colorless
Odor	Characteristic	Slight Odor	Odorless
Oil & Grease [mg/l]	30.0 - 50.0	< 10.0	< 10.0
TSS [mg/l]	150 - 200	5.0 - 10.0	< 1.0
BOD [mg/l]	300 - 500	10 – 20	< 10
COD [mg/l]	600 – 800	80 - 150	< 80
DO [mg/l]	NIL	1.0 – 2.0	3.0 – 5.0
Micro organisms	10 x 10^6	Higher	NIL

Table: 2. Wetland STP Specifications

AUTOMATED HYDROPHONICS SYSTEM:

Automated Hydroponic systems use computer-controlled environments and soil-less cultivation to optimize plant growth. Specialized equipment regulates nutrient delivery, water circulation, and light intensity, resulting in higher crop yields and resource efficiency. This technology has gained popularity in commercial agriculture due to its sustainability and productivity benefits.

Automated Hydroponics Specifications:

Total Plants Grown: 14,000 | **Water Required:** 3,000 liter | **Electricity Required:** 4.1 kW

Plants which can be grown:

Tomatoes, Cabbage, Bottle gourd, Bitter gourd, Basil, etc.

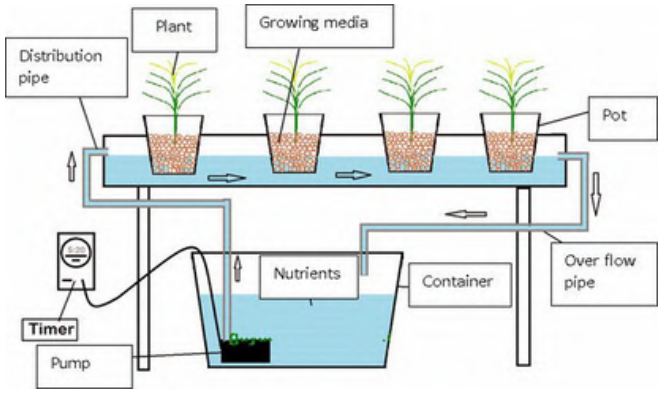


Fig: 17. Schematic Diagram of Automated Hydroponics System.

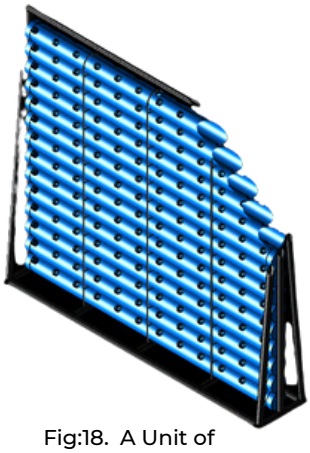


Fig:18. A Unit of Hydroponics System.

Fig: 19. Plants which can be grown.

FLYWHEEL GENERATOR:

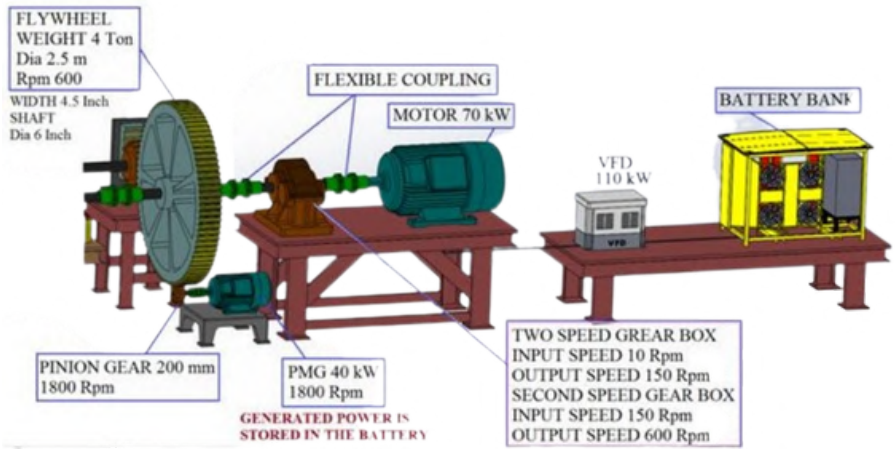


Fig: 20. 750 kW Kamma Flywheel Generator.

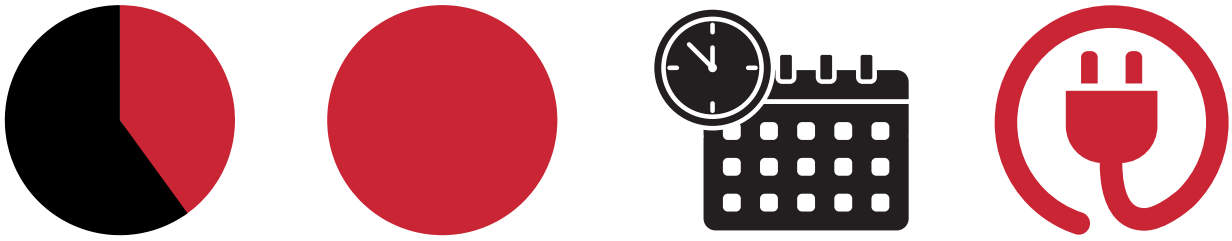
Flywheel power generation and multiplication technology is a method for generating and storing electricity that utilizes a spinning flywheel to store energy. The design of the flywheel is critical to its efficiency and can be made from various materials, including steel, rubber, plastic, concrete, and hybrid glass.

The Kamma Flywheel generator weighs 67 tons, has a 3-meter diameter, and generates 744.11 KWh of useful energy while using a 350 kW motor.

To generate 750 kW of power, the flywheel needs to be built to spin at very high speeds while also possessing a large moment of inertia. The moment of inertia is a measure of the flywheel's resistance to changes in rotational speed, and a greater moment of inertia allows the flywheel to store more energy for a given speed.

This technology is cost-effective, efficient, and scalable, making it a promising solution for power generation, energy storage, and load balancing in power grids.

INTEGRATION OF IOT FOR HOME AND BUILDING CONTROL:



An IoT based building management system will help optimize the comfort in building, increase energy efficiency, provide insights to how a building uses the energy, decrease the environmental impact of the building, etc.

Companies that offer IoT-based building management system services in India, includes Siemens, Schneider Electric, Honeywell, Johnson Controls, and many others.

Energy Management: IoT sensors and software can optimize energy usage and reduce costs by monitoring and controlling the use of lighting, HVAC, and other building systems.

IAQ: IoT-based building management systems can be used to monitor and control indoor air quality parameters such as temperature, humidity, and pollutants to ensure a healthy and comfortable indoor environment.

Predictive Maintenance: IoT sensors can monitor the performance of building systems and equipment, detecting potential issues before they become major problems and scheduling maintenance accordingly.

4. ENGINEERING AND OPERATIONS:

VRF HVAC SYSTEM

INDOOR DOOR UNIT:

Make: Mitsubishi
Model: PKFY-P25VLM-E
Tonnage: 0.8 TR
CFM: 141 - 237
Power: 0.5 Kw

Make: Mitsubishi
Model: PKFY-P40VLM-E
Tonnage: 1.28 TR
CFM: 222 - 353
Power: 0.8 kW

OUT DOOR UNIT:

Make: Mitsubishi
Model: PUCY-P350YKD
Tonnage: 12 TR
BTU/HR: 136500
COP EER: 4.14
CFM: 7415
Power: 9 kW

Fig:21. Air Conditioning Units.

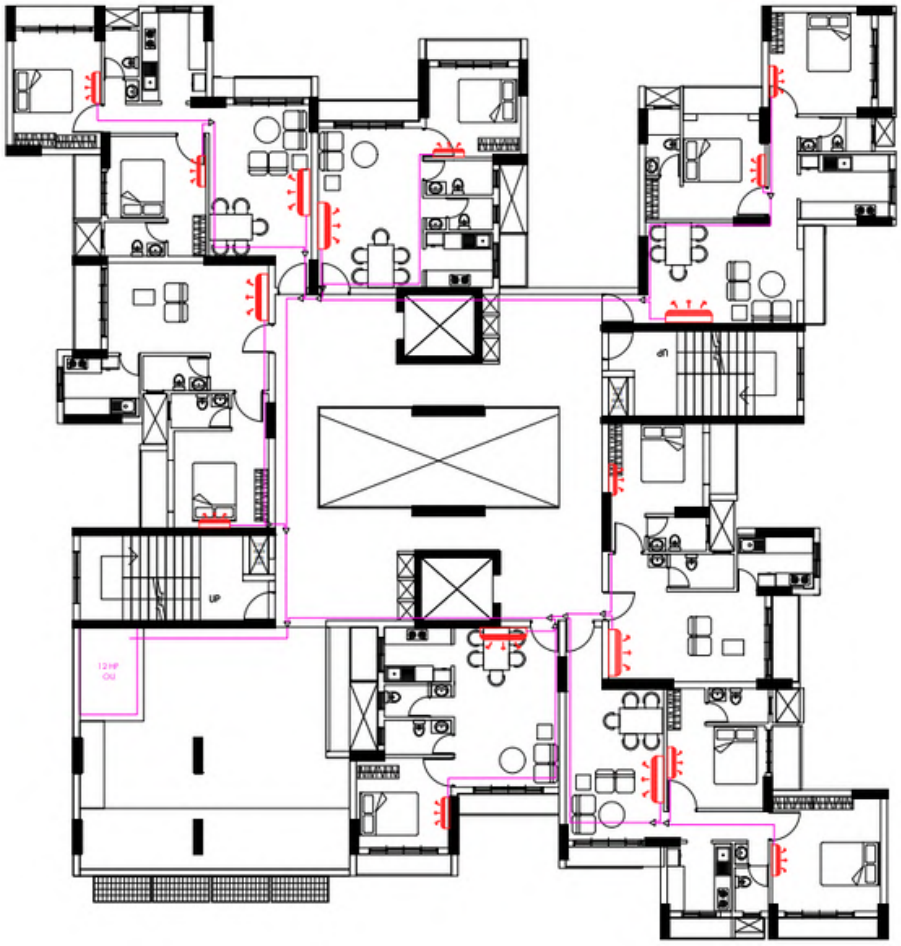


Fig: 21. 1. VRF Piping.

Based on the envelope design, orientation optimization, and thermal and energy simulations, our team opted for a centralized Variable Refrigerant Flow (VRF) system for the building's cooling needs. To centralize the system, we created clusters on each floor, where all the indoor units are connected to a single outdoor unit, placed on that floor. A total of 20 clusters were formed, with each cluster having a 12 TR and 14 HP outdoor unit capacity. For ventilation purposes, exhaust fans were provided in the kitchen and bathroom spaces, while natural ventilation is facilitated in the lobby area through a centrally located cut-out. In the podium area, there are five axial fans with a capacity of 2500 m3/h each, and there are two podiums in the building. The total cooling load of the building is 250 TR.

VENTILATION EQUIPMENT:

Application: Podium
Make: ebm-papst
Model: W4E315-DS20-38
CFM: 2320 m3/h
Supply: 230 V
Noice Level: 58db(A)
Size: 430 x 430 x 155.5 mm
Cost: 27, 601 INR

Application: Kitchen
Make: Havells
Model: Ventil Air DX
CFM: 520 m3/h
Supply: 230 V
Noice Level: 42 db(A)
Size: 16 x 20 x 30 mm
Cost: 1,498 INR

Application: WC
Make: KAFF
Model: SIRI-6
CFM: 150 m3/h
Supply: 230 V
Noice Level: 42 dB(A)
Size: 200 x 200 x 110 mm
Cost: 1,790 INR

WATER CYCLE:

Our water management strategy involves a comprehensive approach to the entire water cycle. The cycle begins with water being pumped out of a borewell and linked to a rainwater tank, where it undergoes filtration. From there, it is diverted to a recharge pit, where it can be repurposed for a variety of uses.

In addition to these measures, we also utilize an advanced grey water treatment system that leverages the benefits of wetland vegetation, soils, and microbial assemblages to effectively treat the water. The resulting treated grey water is then repurposed for various non-potable applications, such as hydroponic cultivation, car washing, toilet flushing, and landscaping.

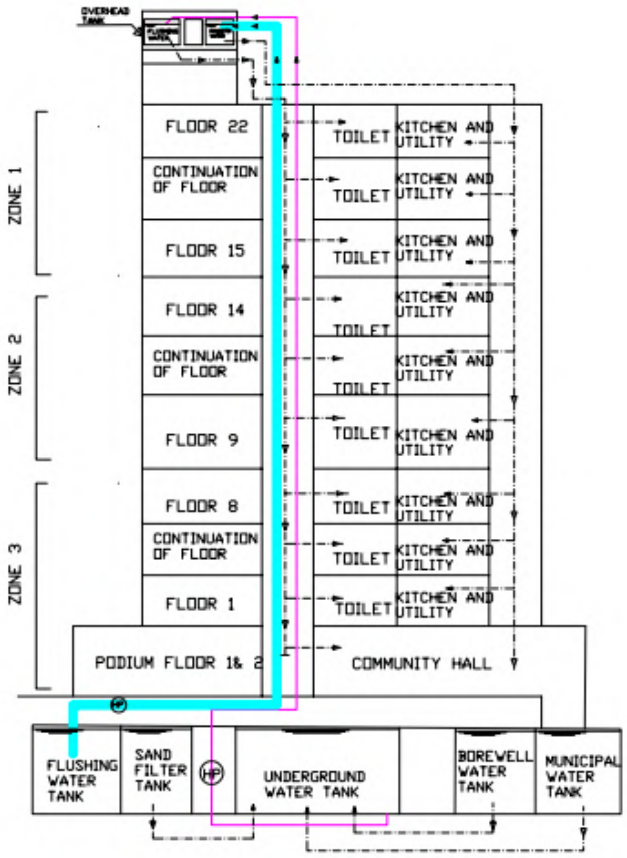


Fig: 22. Water Flow Diagram

Our approach to the water cycle emphasizes the importance of responsible water management practices, and highlights our dedication to promote sustainability and environmental stewardship.

ENERGY GENERATION:

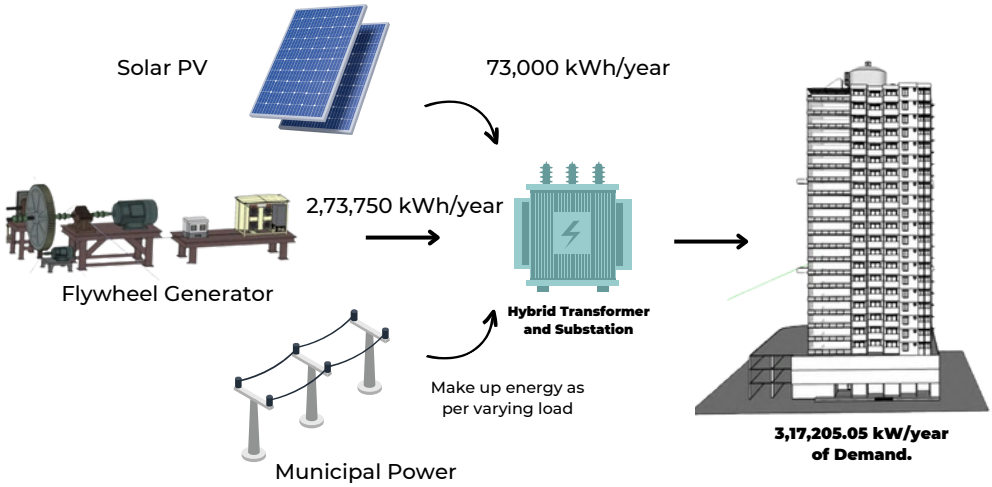


Fig: 23. Energy Flow Diagram

We have implemented a comprehensive on-site power generation system that meets the total energy requirement of our building, which amounts to 3,17,205.05 kW/year. This system utilizes 100% renewable energy sources, with 73,000 kWh/year generated through solar power, and an additional 2,73,750 kWh/year generated through a flywheel generator.

To ensure that these renewable energy sources are effectively managed, they are connected to a state-of-the-art hybrid transformer that can handle the energy flow. However, in the event that these generators experience any operational issues or maintenance requirements, we have taken a connection from the municipality as a backup.

5. RESILIENCE:

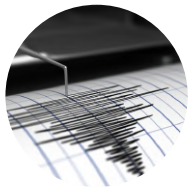
"The ability to withstand adversity and bounce back from difficult life events is called as Resilience". But to face a problem and find a solution we need to know the problems associated with our Structure.

Problems Faced by the Building and in it's locality

GRID DISRUPTIONS AND BLACKOUTS

Taloja Phase 2 faces power cuts on a weekly basis. Onsite generation is done.

EARTHQUAKE



Taloja Phase 2, comes under Zone 3 for Earthquake. Shear walls are provided.

FIRE SAFETY

The Unsaid problem of fire hazard is tackled with extra water tank for fire safety.

EPIDEMIC

In Pandemic situation residents have enough food grown for a week or 2 through Hydroponic.

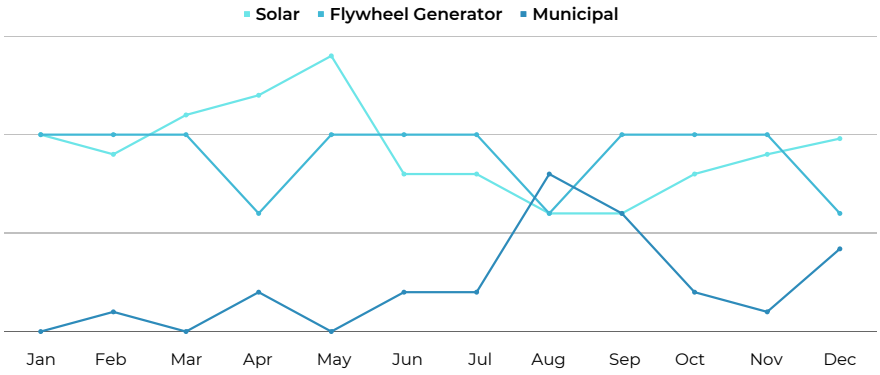
POOR PUBLIC TRANSPORT

Poor services in emergency, we'll provide car pooling for the residents.

HIGH TEMPERATURES

Having many Construction projects going on, the temperatures are quite high. Active design and cooling systems are given.

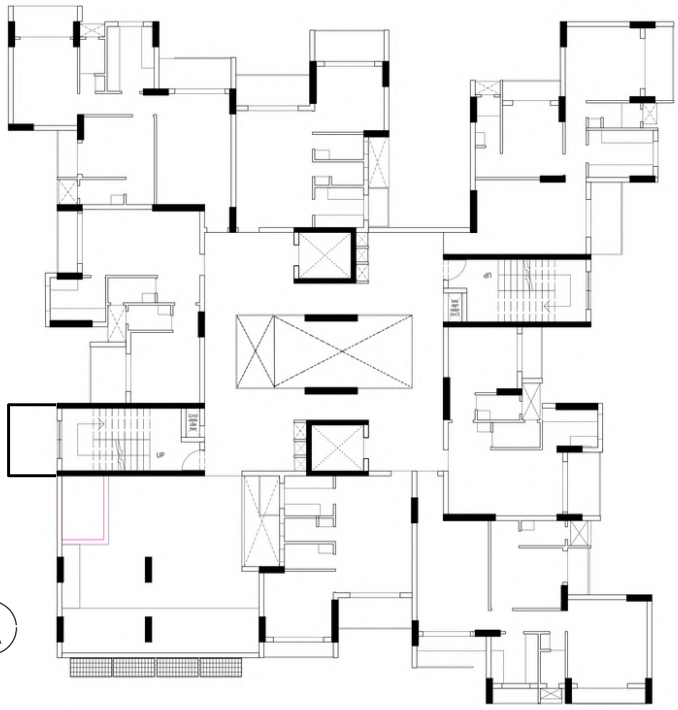
ENERGY FALIURE:



To ensure uninterrupted energy supply to the building, our team designed a hybrid system that utilizes both renewable energy sources and municipal energy supply. The onsite renewable energy sources include a solar PV power plant and a flywheel generator, which are capable of fulfilling the building's energy requirements under ideal conditions. However, in situations where the climatic conditions are not suitable for energy generation through solar panels or when the flywheel generator is undergoing maintenance, energy from the municipal source will be utilized to meet the energy demand of the building.

This hybrid system provides a reliable and sustainable solution for energy supply to the building. By utilizing renewable energy sources, it reduces the dependence on fossil fuels and helps in reducing greenhouse gas emissions. The solar PV power plant is placed on the south façade and roof of the building and the flywheel generator is placed on the ground floor. This arrangement ensures maximum utilization of available space while minimizing the energy loss that may occur during transmission.

Moreover, the system is designed to operate automatically and switch between the renewable energy sources and municipal energy supply as needed. This ensures that the building's energy demand is always met, irrespective of the availability of the renewable sources.



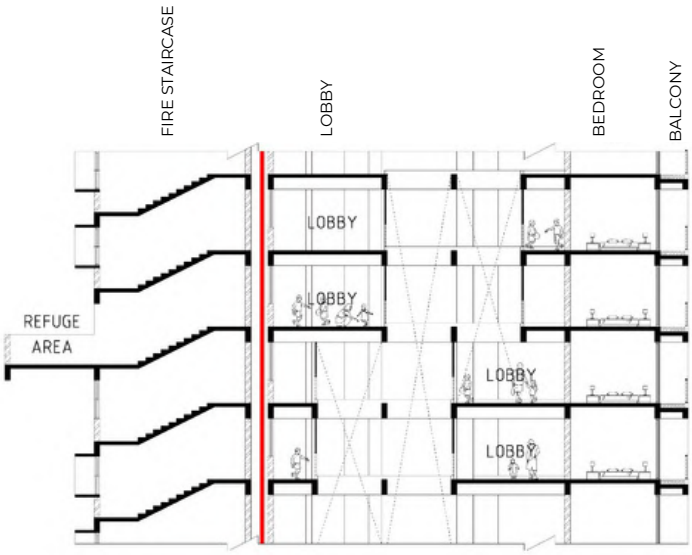
shear walls

Plan of the floor with shear walls

EARTHQUAKE:

1.Reinforcement of walls, lift core with shear walls to provide extra stability to the structure.

2. Maintaining the structural grid intact by providing simple planning



Section @ A-A'

FIRE SAFETY:

1.Running distance between the staircase and the flats is less than 11 M.

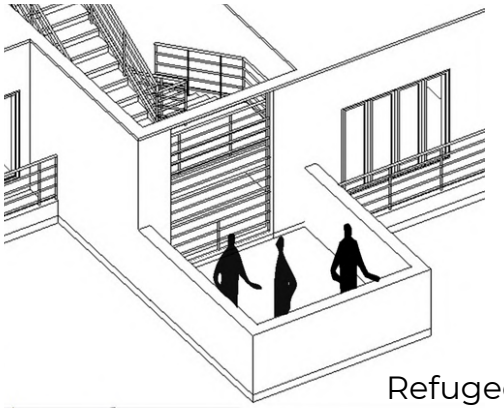
2. Fire staircase is provided to access it during emergencies.

3.Refugee Area is Provided on alternate floors at staircase mid landing to rescue people during fire or any breakouts.

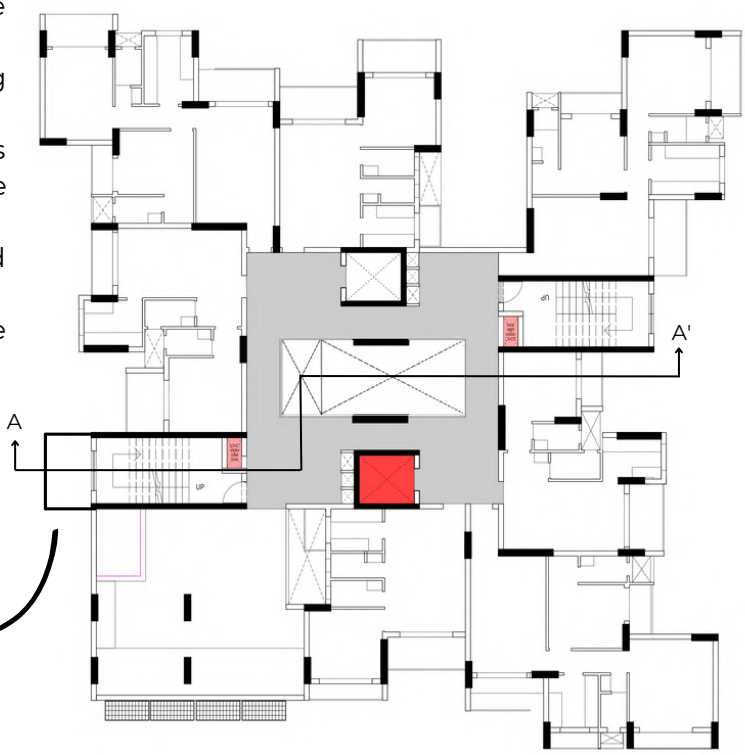
4.Door and walls of the staircases provided are 2 hours fire rated .

5. Fire lift is Provided keeping in mind the fire regulations.

References: Norms of fire Regulations abides by the Regulations Provided by the National Building Code (N.B.C)



Refugee Area



Floor Plan

Fire lift

Fire Wet Riser Duct

Lift Lobby Area

6. ARCHITECTURAL DESIGN:

GOALS:

Maximizing Natural Ventilation

1. Using natural and cross ventilation techniques in tandem with mechanical and exhaust systems.
2. Natural Ventilation of services such as kitchen and toilets with fresh air.

Maximizing natural lighting during the day

1.Well lit common areas
2.Well lit spaces inside individual flats

Better community spaces

1.Accessible recreational areas on the podium terrace level.
2.Staggered double height spaces on the lobby areas on each floor ensure visual connectivity and interaction among occupants

Design for cost effectiveness & efficient construction

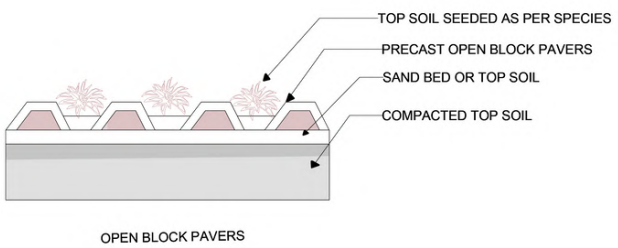
1.Consolidation of service grids for kitchen and toilets to make construction planning simpler.

Facade optimisation

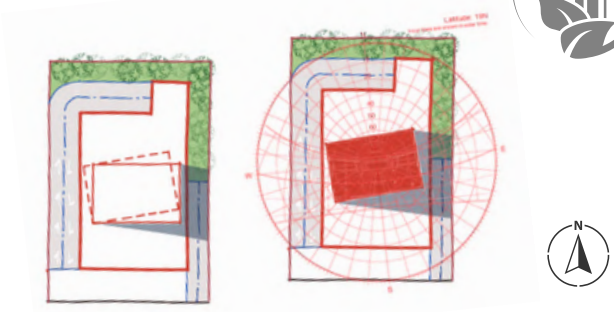
1.Passive shading design strategies.
2.Aesthetic treatment is given to the façade having utility and service areas.

Friendly details for different age groups

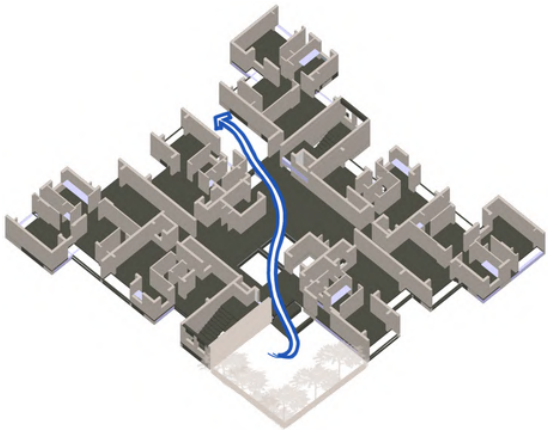
1.Handrail design for kids and elderly people.
2.Designing railings that don't heat up during the hottest part of the day for tactile comfort



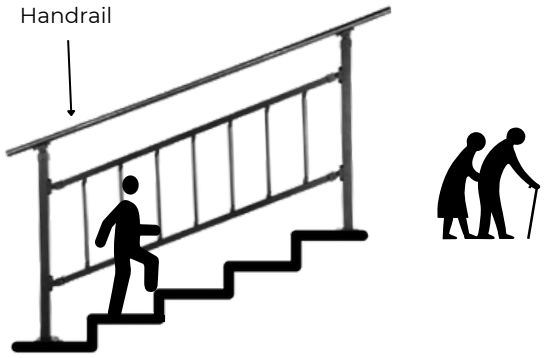
- Open Paver blocks provided on the ground, which helps in water percolation and ground water recharge.



Suitable orientation for the built mass to reduce light penetration for ground vegetation during Summer solstice and the equinoxes.

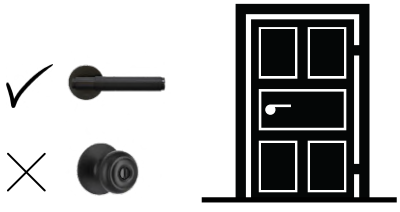


Cross ventilation through the floor lobby.



Placing railings at various heights:

ACCESSIBILITY & DESIGN DETAILS:



Use of door lever instead of the doorknob

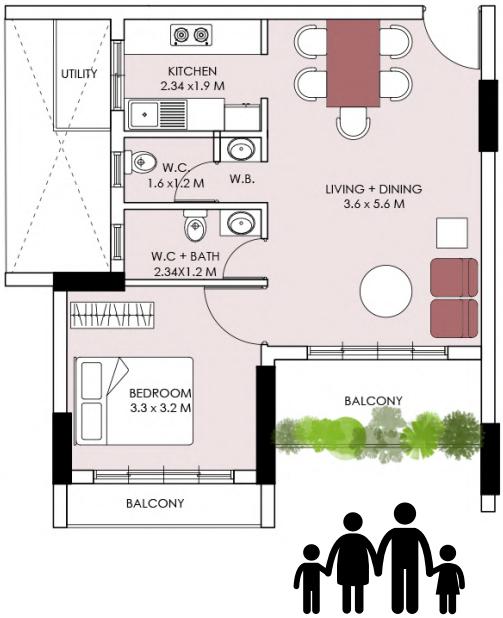
- Lever will be easier for children and older adults to use.
- Easier to use if hands are wet and slippery or carrying something with both hands.

LIVEABILITY & AFFORDABILITY:

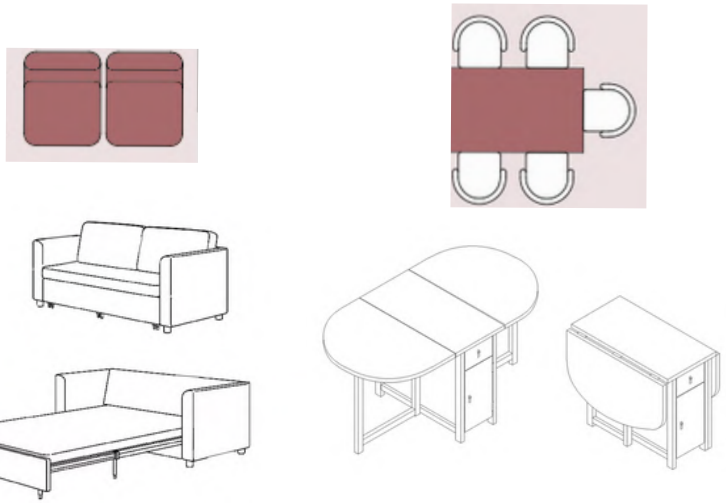
Living in a net-zero home means choosing not only an energy-efficient building but also an energy-efficient way of living.

- The project must provide the inhabitants freedom in Plan Modification as per their needs .
- Giving residents the choice to pick between 1 and 2 bedrooms opens up a range of affordable possibilities.
- In addition to saving space, providing furniture modification adds value to the living spaces based on the needs.

FURNITURE MODIFICATION:

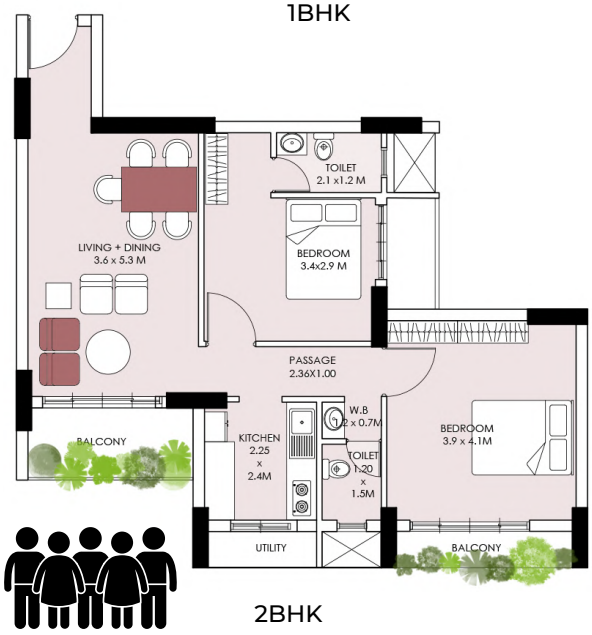


1BHK

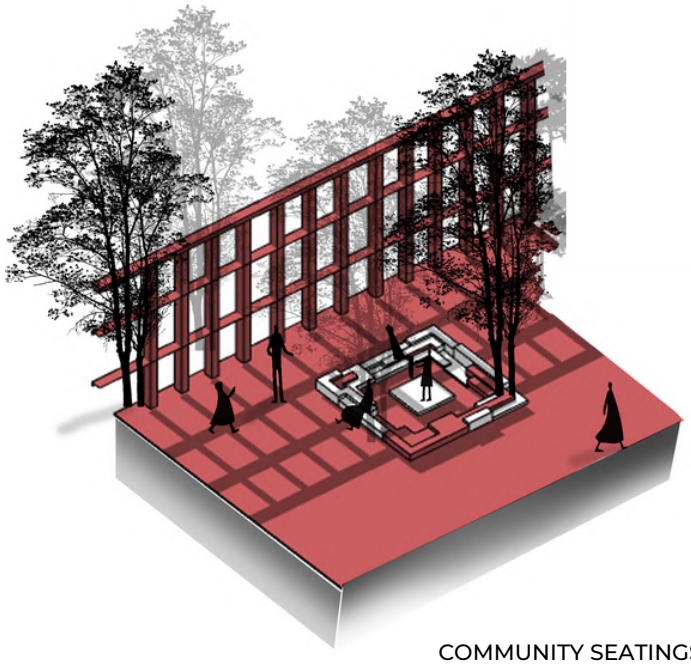


Sofa Cum Bed

Foldable Dining Table

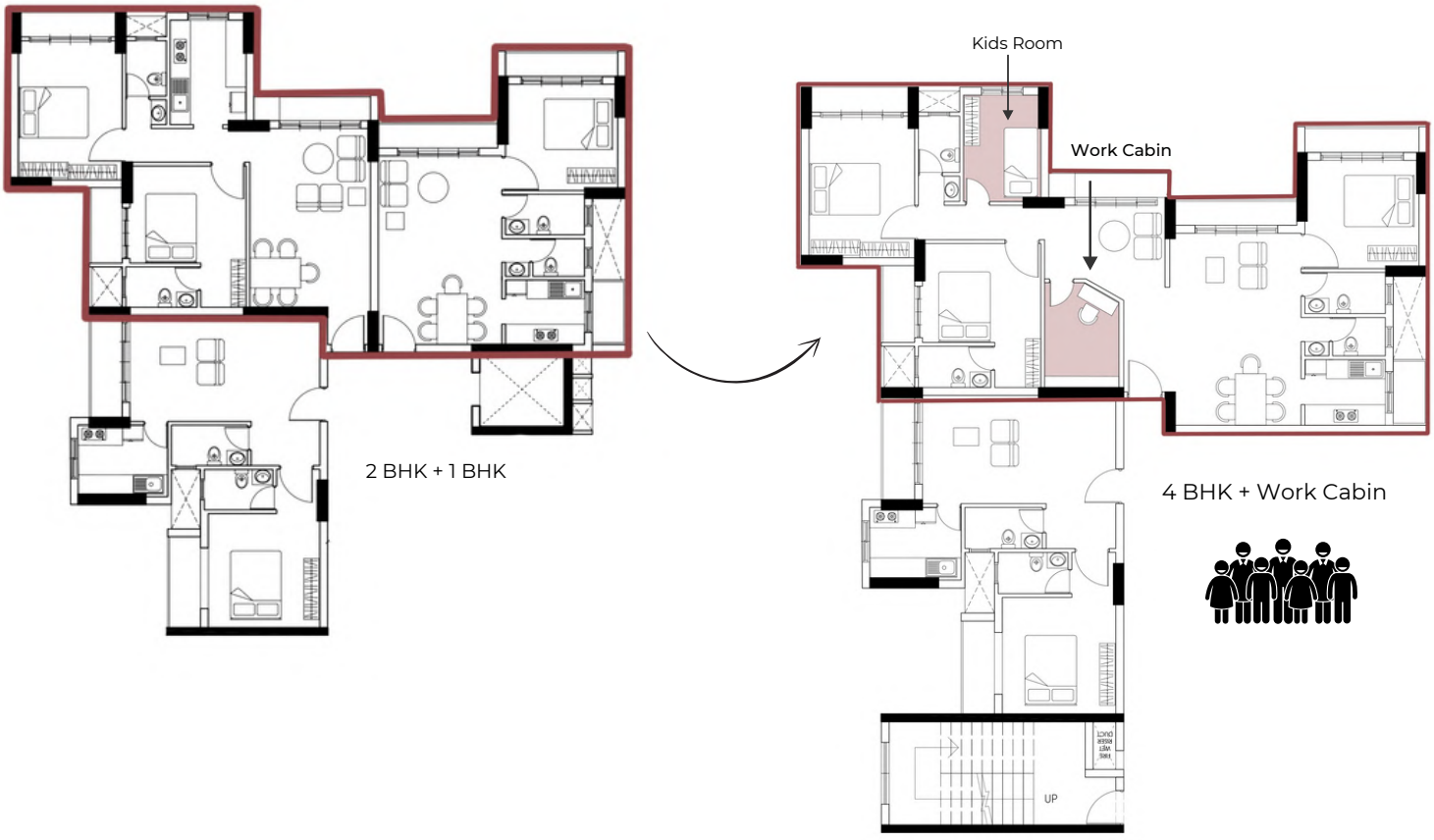


2BHK

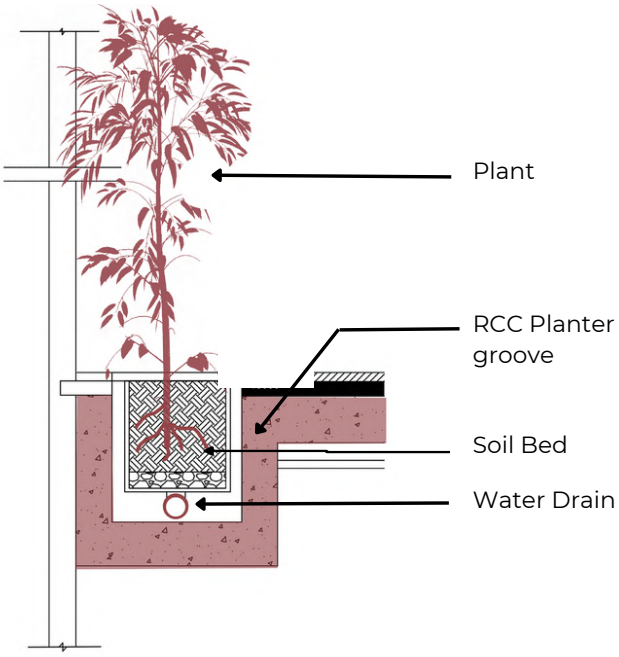


COMMUNITY SEATINGS ON THE PODIUM TERRACE

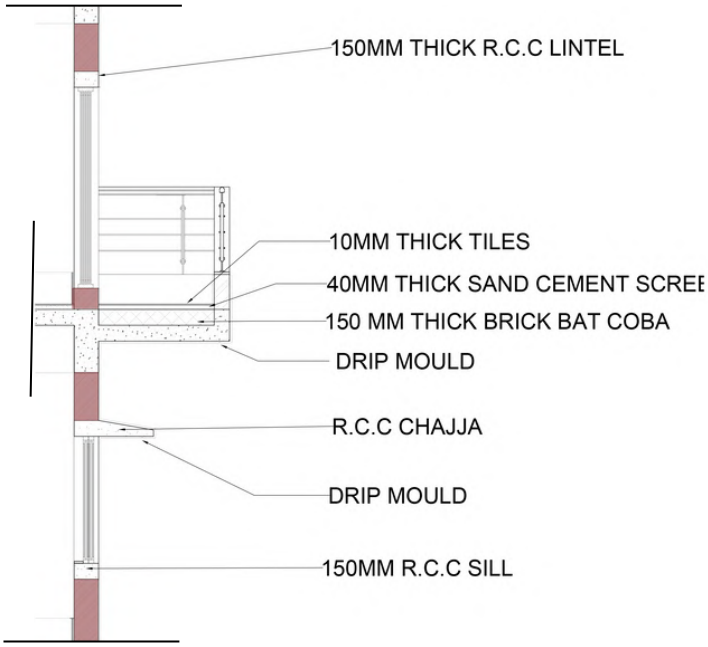
LIVEABILITY: Flexibility in module as per family requirements.



DETAILS OF THE PLANTER BED & BALCONY:



DETAIL SECTION OF THE PLANTER BED ON THE PODIUM TERRACE



DETAIL SECTION OF THE BALCONY

BUILDING ENVELOPE & SHADING

GRC JAALIS ON FACADE:

Bamboo Blinds

Bamboo Blinds with Patterns

Credits: CAIJUN Roman Blinds for Windows

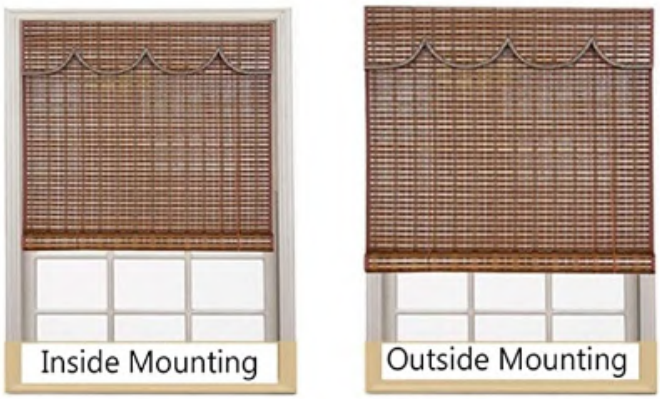
Blinds with different patterns.

1.Protects from harsh sun rays during day

2.Add aesthetic value to the façade.

GRC Jaali Provided Incorporating it into functional spaces such as laundry rooms, enhance the aesthetic of the façade by allowing adequate ventilation and sunlight without obstructing it

BAMBOO BLINDS ON WINDOWS:



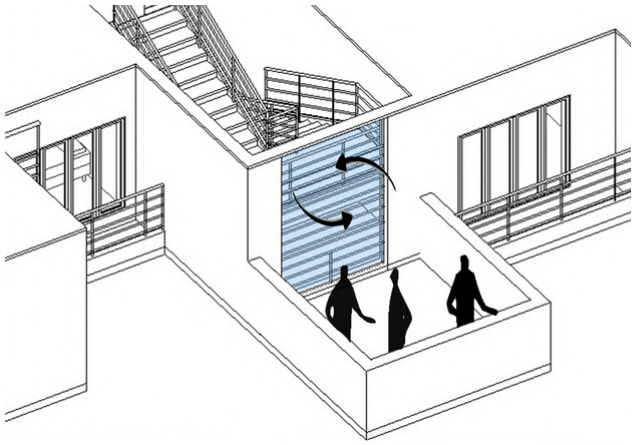
Credits: CAIJUN Roman Blinds for Windows

GRC JAALIS PROVIDED AT THE MIDLANDING OF THE STAIRCASE:

1.Aids in Natural Ventilation and lighting into the building.

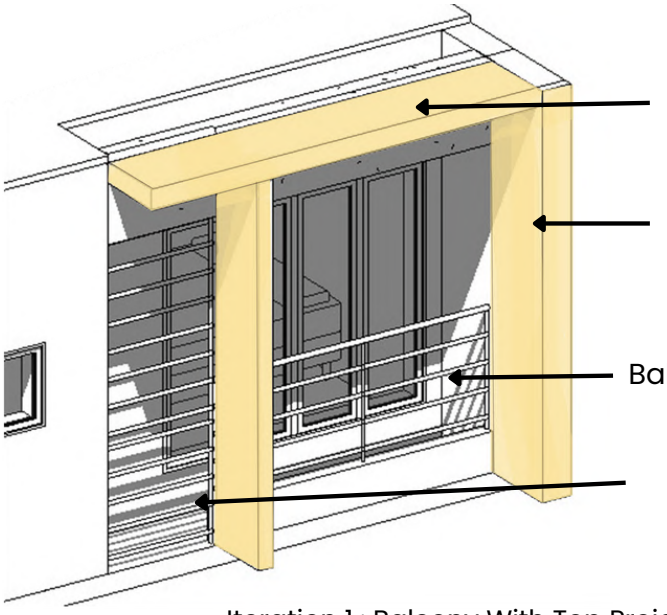
2.Gives Aesthetic appearance to the building façade

1.GRC (Glass Reinforced Jaalis) are expensive as compared to conventional Brick Jaali Pattern.



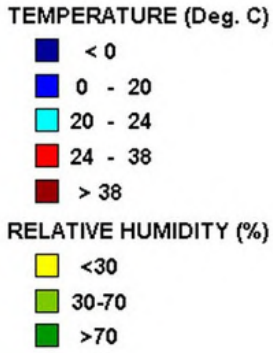
GRC Jaali Provided on the Midlanding

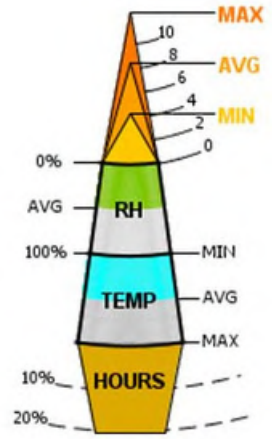
BUILDING ENVELOPE & SHADING



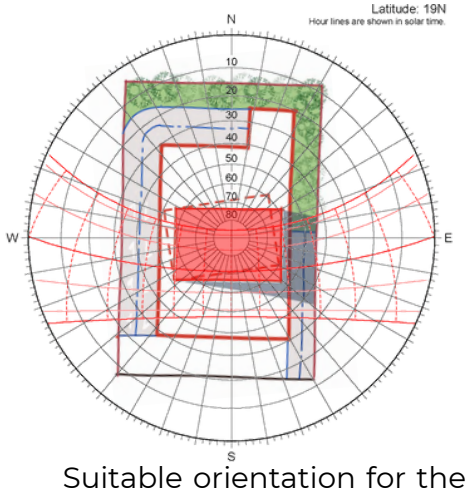
Iteration 1 : Balcony With Top Projection

- Windows on the west façade Provided 1500mm x 2100 mm as compared to East façade which is 1800 mm x2100 mm.
- Thus reducing the sun exposure into the Room, during harsh days, also the blinds provided restricts the entry of the sunrays.



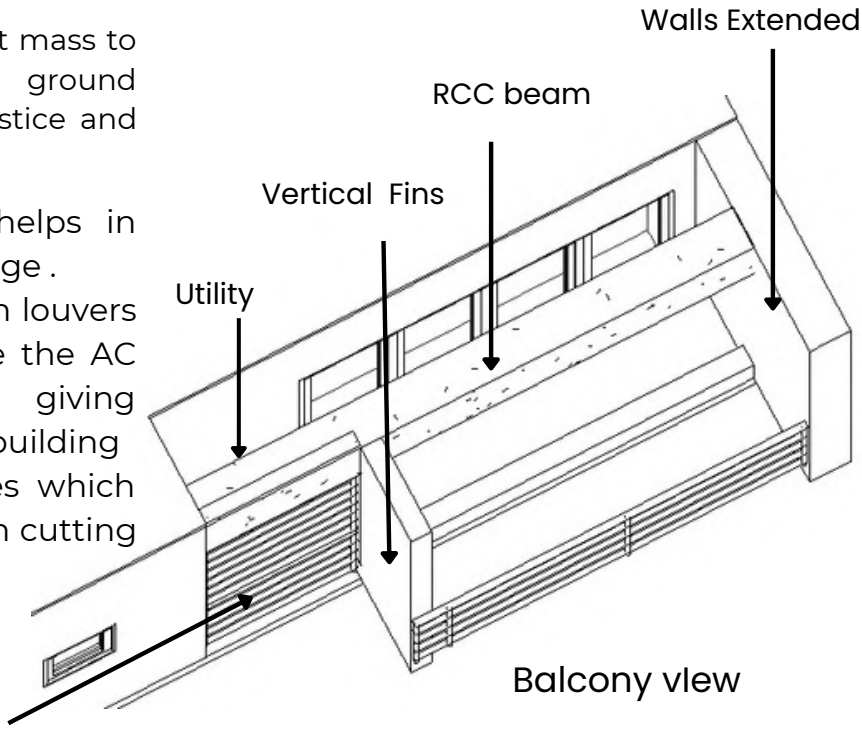


Wind rose diagrams for
March to September
Source : Climate Consultant 6.0



Suitable orientation for the built mass to reduce light penetration for ground vegetation during Summer solstice and the equinoxes.

The louvers at one ends helps in ensuring sufficient air exchange .
1.The balcony is provided with louvers on the AC vent Side to hide the AC units at the same time giving aesthetic appearance to the building
3. Fins Provided at the sides which acts like Brise soleil helping in cutting sun rays during harsh days.



7. EMBODIED CARBON:

We won't be wrong if we say that Embodied Carbon is the Heart of a Net-Zero Energy Building, as it is one of the most crucial part of the life of the building. We aimed to Achieve the Carbon Negative goal for our building and we could reach till Carbon Neutrality for the proposed design of our building.

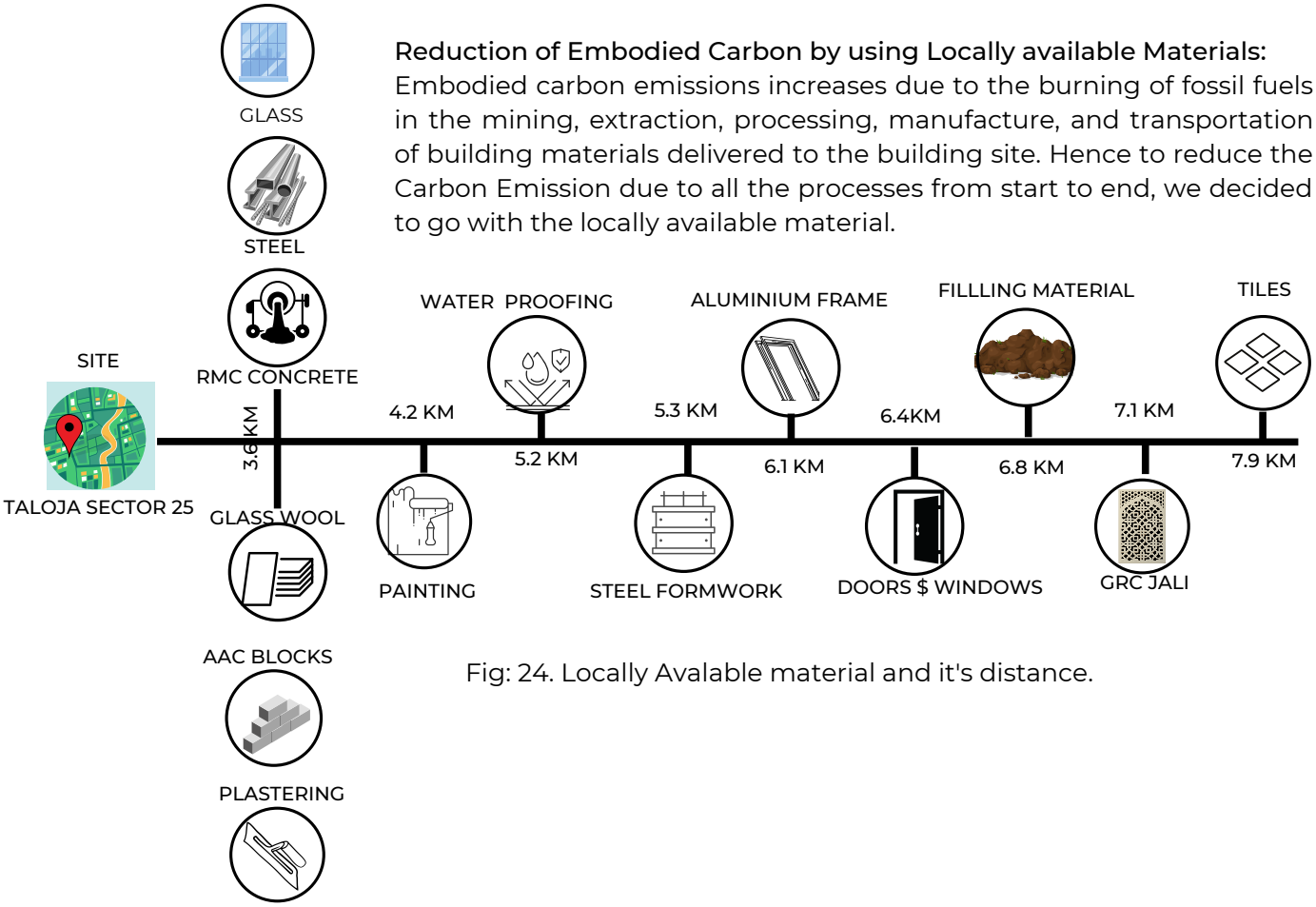


Fig: 24. Locally Avalable material and it's distance.

Reduction of Embodied Carbon by using Locally available Materials:
Embodied carbon emissions increases due to the burning of fossil fuels in the mining, extraction, processing, manufacture, and transportation of building materials delivered to the building site. Hence to reduce the Carbon Emission due to all the processes from start to end, we decided to go with the locally available material.

Onsite electricity generation Annual Energy Generation:
Where MSEDCL provides electricity in the Taloja locality, generated from Coal that is a non-renewable recourse and gives out large amount of Carbon Emission. We will b generating our own electricity through **Solar PVs and Flywheel Generator. Annual Energy Generation through Solar PV: 73,000 kWh/year. And Annual Energy Generation through Kamma Fly-wheel generator: 2,73,750 kWh/year.** None of the materials composing the Solar Panel or Flywheel has higher embodied carbon and hence are the most remarkable part of our proposed design.

Reuse of Biodiesel from the Organic Waste:
The organic waste from Kitchen, Human Excreta from the washrooms, and green waste from the different Landscape throughout the building and Gardens. The Bio mass decomposer is designed for the proposed design having a diameter of 5 m and depth of 10 m. This will help in controlling the Embodied carbon generated due to LPG generation and transportation.

Fig: 25. Bio-mass decomposer

REPLACING WITH LOW EMBODIED CARBON MATERIAL:
Conventional materials usually have higher Carbon Emission Factor but there are a few exceptions here as well.
We had 2 Choices,

CHOICE 1:
Low Carbon Emitting materials near the site.
Such materials like, Gypsum Plaster, Glass wool, Granites, GRC had lower Embodied carbon, 0.09, 2.5, 2.92 and 10 respectively. Choosing local and low carbon embodied reduced the Embodied carbon remarkably.

CHOICE 2:
Low Carbon Emitting materials far from the site. Materials like Hemp Concrete, Eco Friendly Plaster and paint. These materials were drastically far from the site. which then was in creasing the Embodied Carbon due to the burning of fuel for the trips and transporting.

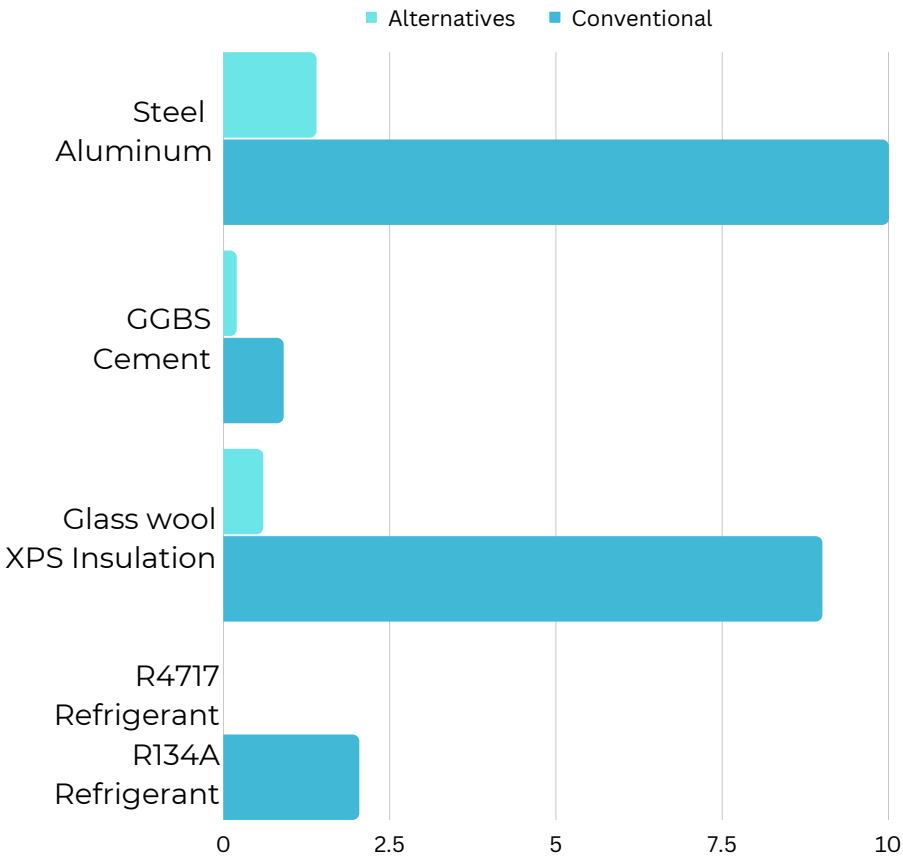


Fig: 26. GWP comparison chart

Carbon Farming to Tackle the Carbon emission
Through numerous different approaches we are going to be doing carbon farming. Through Hydroponic system, Community Gardens and Plantations in each balcony of the building providing carbon absorbing plants and medicinal plants in the balcony and food based plants in vertical hydroponic, Xerophytic Plants in community garden. The treated water is reused in Carbon Farming, hence keeping the Embodied carbon lower.

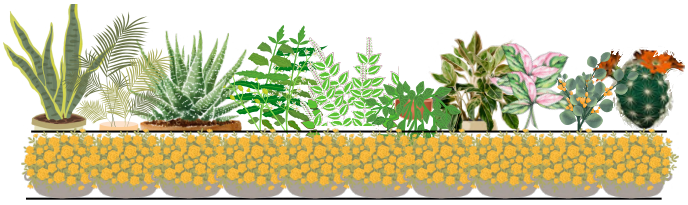
Dismantling and Reuse of Scrap of the building:
After the building has served its purpose for 50 years. We've decided to let the scrap material go for the purpose of backfilling for other new constructions. This way we'll be successful to keep the Embodied Carbon within the system and not let it cause any harm the the mini aur whole environment.

8. HEALTH AND WELLBEING:

BIOPHILIC DESIGN:

Each Balcony is provided with 2 types of plants Inner layer of plants are Carbon absorbing, Require less water, and less sunlight. The outer layer is of medicinal plants and are colourful for aesthetic view. The clay soil from excavation will be treated and used for plantation, for its nutritional value. The Balcony plantation needs 86.4 cu.m of soil and 208 L of water.

EXIBIT A



TOP VIEW OF PLANTATION IN BALCONY

SECTIONAL VIEW

EXIBIT B

Bird Feeders are installed at the Community garden on the Podium roof.. It's not only rewarding to the person doing it, but to the environment as well. This attraction of birds will result in getting rid of bugs and insects, increased garden pollinations etc. it affects the mood positively and keeps one engaged and bounded to a healthy routine.

Fig: 27. Bird Feeder for Biophilic Design

EXIBIT C

SOCIAL INTERACTION:

Social Interaction is increased by providing common Lobbies and Lounge on each floor. The excess floor area on the slab where Solar PVs are provided on the South-West face of the building, is used for making the lounge area. This will keep the social animal in us human beings alive and happy. People can use this area for small meetings and gatherings, or evening and morning tea breaks.

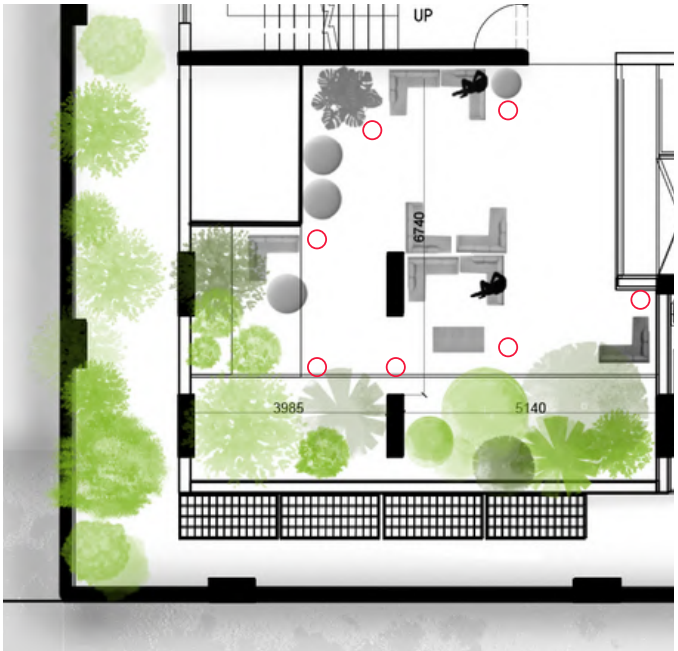


Fig. 28. Schematic Diagram of Community Garden at Podium Roof with Bird feeders marked red

	H & W Indicators	Emergent Themes
Design and Operation Strategies	Indoor/Outdoor Air Quality	☑
	Lightning Control/ Daylight	☑
	Thermal Comfort	☑
	Social Interaction	☑
	Biophilic Design	☑
	inclusive Design	☑
	Access to Healthy Food	☑
	Water Quality	☑

Fig. 29. Health & Well Being Indicators

This physical activities are proved to increase the psychological well-being of humans .

NATURAL VENTILATION & LIGHTNING:

GRC JAALIS provide at the Midlanding of the staircase aids in Natural Ventilation. The building orientation and façade enables daylighting and natural ventilation, which significantly reduced the lighting load. Exposure to natural light can improve mood, productivity, and overall health. Windows are positioned in a way to maximize daylight. Use of automated shading systems can regulate the amount of light entering the building to reduce glare and heat gain.

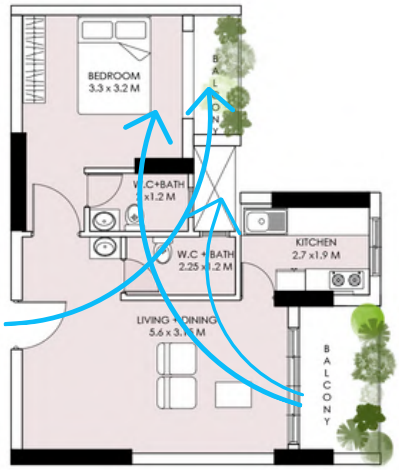


Fig. 30. Schematic Diagram of Air Floor in Sample 1 BHK Flat

INDOOR AIR QUALITY:

Indoor Air Quality is monitored and controlled through CO Monitors. The plantations in each apartment will help reduce the level of CO and CO2 emission in the mini environment. Low VOC paints and building materials are used. To bring down the entrapment of the pungent smell of garbage, we've provided with 2 chutes on each floor. Mechanical Ventilation and active design will keep the air flowing and won't let any harmful bacteria lodge in the apartments.

WATER QUALITY:

The water supply to the building is given by CIDCO, is filtered using Chlorine , where as the water that is cleaned through IWC STP is filtered using UV light. Which doesn't alter the chemical composition of the water and kills almost 99% of bacteria. The treated water has 90-97% less Biochemical Oxygen Demand and Chemical Oxygen Demand. This will help grow chemical free vegetables through Hydroponic and will eventually benefit to the biological life of the building.

Parameters	Inlet	Outlet - AD	Outlet – AD+
Ph	6.0 – 9.0	6.0 – 9.0	6.0 – 9.0
Color	Blackish	Colorless	Colorless
Odor	Characteristic	Slight Odor	Odorless
Oil & Grease [mg/l]	30.0 - 50.0	< 10.0	< 10.0
TSS [mg/l]	150 - 200	5.0 - 10.0	< 1.0
BOD [mg/l]	300 - 500	10 – 20	< 10
COD [mg/l]	600 – 800	80 - 150	< 80
DO [mg/l]	NIL	1.0 – 2.0	3.0 – 5.0
Micro organisms	10 x 10^6	Higher	NIL

Fig: 31. Treated Water Quality

THERMAL COMFORT:

Thermal Comfort was achieved through both Natural Ventilation and Mechanical Ventilation. A study from Indian Model of Adaptive Comfort by Manu et al 2016, only providing with the Natural Ventilation may not be completely fruitful. Where through natural ventilation at Taloja Phase 2 is only 2-3 Degree Celsius is reduces, where as Mixed Mode design is successful in reducing up to 5-7 Degree Celsius. To achieve the thermal comfort we've used Double Glazed Glass (U factor 0.55) in balconies and rooms. The assembly of roof (U Value 0.25), wall (U Value 0.23-0.33) and floor (is arranged in such a way that they do not have higher Specific Heat Capacity, and hence they cool down easily. This was achieved through insulation in Walls and Roof and higher SRI value paint on Walls and Roof. All these aspects allows the mini environment to be more natural and affects positively to the biology of the building.

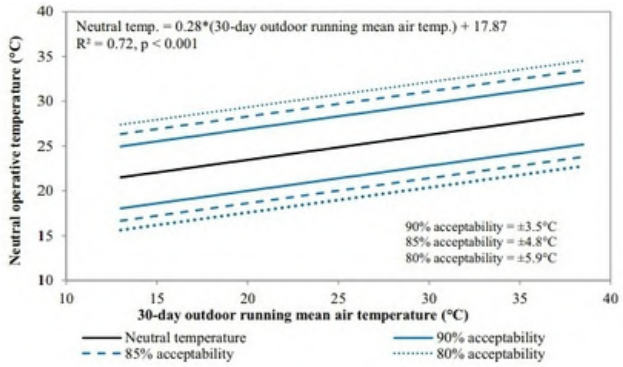


Fig: 32. IMAC model for mixed mode building

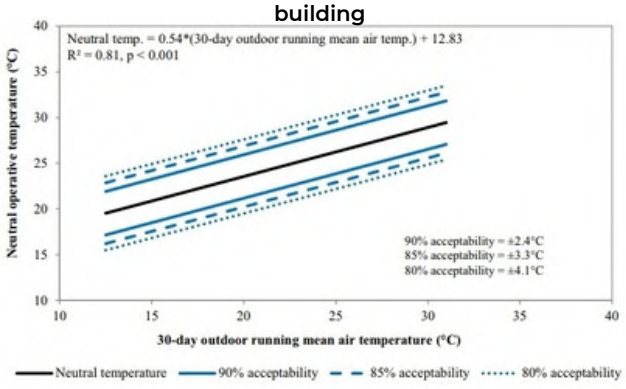
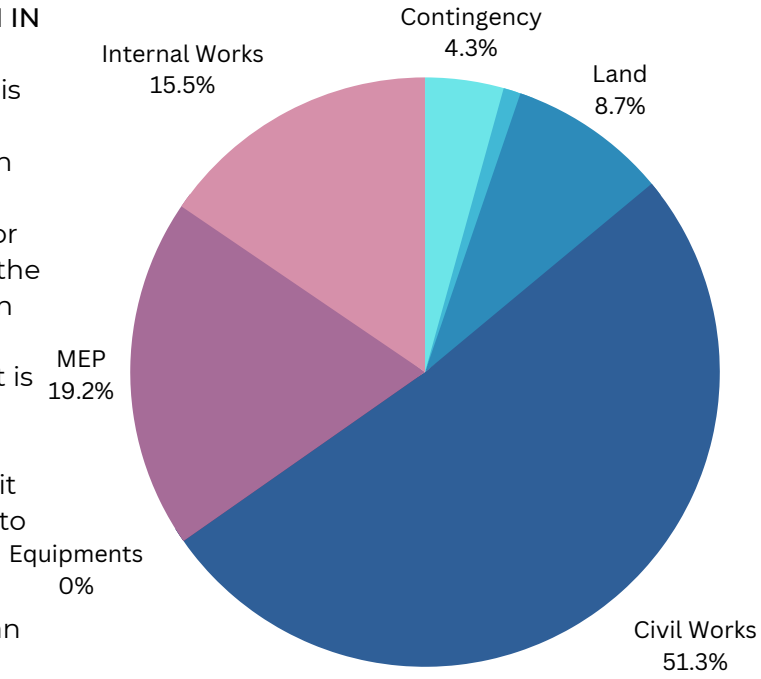


Fig: 33. IMAC model for natural ventilation building

9. AFFORDABILITY:

SUSTAINABLE BUILDING CONSTRUCTION IN INDIA:

Sustainable building construction in India is becoming increasingly important as the country seeks to balance economic growth with environmental conservation. The construction industry is a major contributor to India's economy. And hence it is one of the most expensive industries as well. But even after the government sanctioning to build Sustainable, Net Zero or Green buildings, it is still quite a task to decrease the Capital Expenditure of the building. As the technologies used are new and advanced it requires skilled labors, which further adds to the CAPEX.



The cost of sustainable building in India can vary depending on several factors such as location, materials used, and size of the building. However, sustainable buildings are generally more expensive than traditional buildings due to the use of Eco-friendly materials, energy-efficient systems, and the incorporation of sustainable design principles.

Even though its a Sustainable Building The Maintenance cost of the apartments is only Rs4000/- where as the conventional building's maintenance is Rs 6000/-

Builder's Requirement: Multi-Family Housing System is of '"**Build-Sell-Occupy**" type of the building. Where the builder expects a Higher Sale Value but Low Capital Cost.

Solution: Keeping in mind all the requirements of the builder and the occupants, we decided to tackle the hurdle of Cost with

- Innovative and effective
- Passive design solutions, Advanced architectural design,
- Smart orientation and Cross Ventilation,
- Shading to reduce the cooling load of the building,
- Optimized Envelope to reduce Heat exchange from outer to inner surface,
- Producing and exceeding the amount of Electricity required from the grid,
- Breathable structural walls,
- Using locally available material, '0 'Landscaping cost (Using soil excavated from the site)

Even though we cannot lower CAPEX, we can successfully reduce OPEX and ultimately make the structure economical for the builder.

Builder's Benefit: Builder can earn money though different systems provided in the building. for eg. Excess Electricity generated through Solar PV and Fly Wheel. Earning through Carbon Credits Selling the food/vegetables produced through Hydroponics Providing Bio Gas every alternative month to the occupants

Pre-Design Survey and Occupant Requirement: Personal Survey was conducted to understand the needs of the residents and the locality. This helped us to come to a conclusion that, Majority of the population in Taloja is Self Employed **(MSMEs),** hence they can afford a quality housing.

AFFORDABILITY:

Fig: Cost Comparison of Base and Proposed Case

The proposed NZEB design offers numerous benefits beyond energy efficiency and cost savings. By using sustainable materials and technologies, the building reduces its environmental impact and contributes to a healthier indoor environment for occupants. Additionally, the NZEB provides advanced features and services that meet the needs of modern lifestyles and enhance the overall quality of life for residents.

The Life Cycle Cost Analysis provided valuable insights into the long-term costs associated with both the proposed NZEB design and the Baseline. By factoring in maintenance and utility costs over the life cycle of the building, we were able to demonstrate the superior economic performance of the NZEB. This analysis can provide useful guidance for building owners and decision-makers looking to invest in sustainable and cost-effective building designs.

Overall, the proposed NZEB design offers a range of benefits that extend far beyond its immediate costs. By reducing environmental impact, improving indoor air quality, and enhancing the overall quality of life for residents, the NZEB represents a significant step forward in sustainable building design.

10. INTEGRATED WASTE MANAGMENT:

Integrated waste management is a holistic approach that involves a combination of waste reduction, reuse, recycling, and disposal strategies to manage waste effectively. The primary objective of integrated waste management is to minimize the amount of waste sent to landfills or incinerators, which can cause significant environmental and social problems.

The process of integrated waste management begins with waste reduction, which aims to reduce the amount of waste generated at the source. This can be achieved through initiatives such as reducing packaging materials, using reusable products, and promoting sustainable consumption patterns.

The next step is waste reuse, which involves finding new uses for waste materials instead of disposing of them. This can be achieved through initiatives such as composting, repurposing, and refurbishing.

The third strategy is waste recycling, which involves converting waste materials into new products. Recycling can help conserve natural resources, reduce energy consumption, and create employment opportunities.

Finally, the remaining waste that cannot be reduced, reused, or recycled is disposed of through safe and environmentally sound methods such as landfilling, incineration, or other waste-to-energy technologies.

The goal of integrated waste management is to create a sustainable waste management system that is environmentally sound, economically feasible, and socially acceptable. This involves balancing environmental protection, economic development, and social equity.

DURING OPERATION IWT

At our project, we adopt an efficient waste management approach that begins with source segregation of garbage. This is achieved by providing separate waste compartments in each flat's garbage cabinet for different types of dry waste, while wet waste is disposed of in the garbage chute for proper decomposition. To promote a sustainable waste management system, we collaborate with a scrap dealer who collects the segregated dry waste on a monthly basis or when the waste compartment gets full. In this process, residents are also compensated for their waste material by the scrap dealer. For waste that cannot be recycled, we have a separate collection system in place. This ensures that the waste is disposed of properly in a solid waste management landfill. Our approach not only reduces the amount of waste that ends up in landfills or incinerators, but also promotes a sustainable waste management system that is environmentally sound, economically feasible, and socially acceptable. We believe that by prioritizing integrated waste management, we can create a cleaner, healthier, and more sustainable future for everyone.

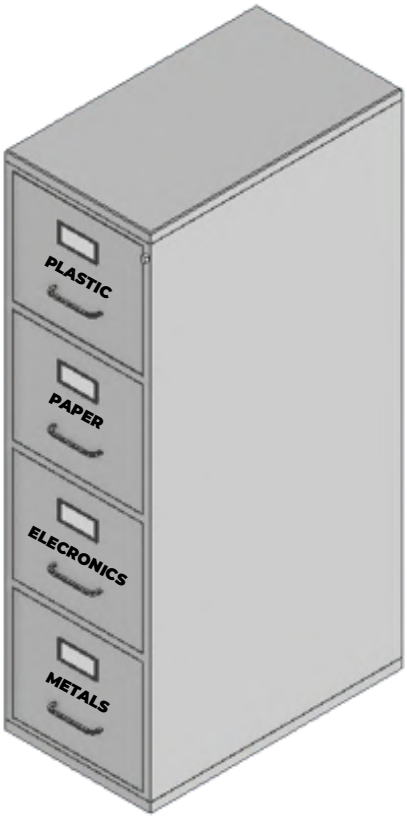


Fig: 34. Reusing Old File Drawers for segregation of waster at source

DURING CONSTRUCTION IWT

During construction, we achieved a recycling rate of 63% and a reuse rate of 9% for waste materials. To reduce transportation and embodied carbon, we collaborated with nearby industries for local recycling and reuse. Our sustainable practices promote a circular economy, minimize waste, and reduce environmental impact.

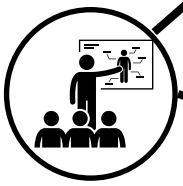
DURING OPERATION IWT

SEGREGATE AT SOURCE

REDUCE

GOING PLASTIC-FREE

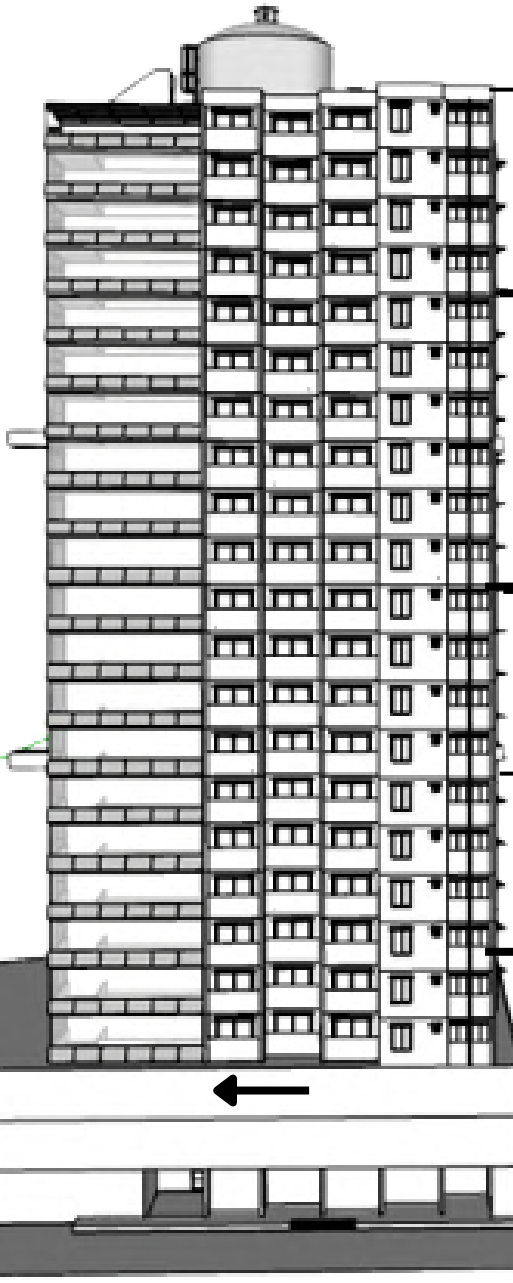
USING ECO-FRIENDLY MATERIALS



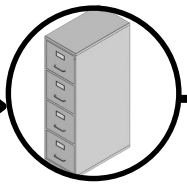
EDUCATE AND AWARNESS

POSTERES AND PRINTING MATERIAL

COMMUNITY AWARENESS MEETING



RECYCLED



DRY WASTE

SCRAP DEALER @ 35 KKM

WET WASTE

GARBAGE CHUTE PER FLOOR

BIOMASS DECOMPOSER

REUSED

REUSE MATERIAL

REUSE COLLECTION POINT BEHIND THE DOOR OF STAIR

DURING CONSTRUCITN IWM

Seggregation

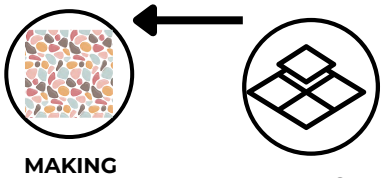
Providing Waste Containiner

Reduce

- Procurement of material in right quantity
- Return the excess material
- Pre-hung doors and windows

Reuse

9%



MAKING MOSAIC WALL

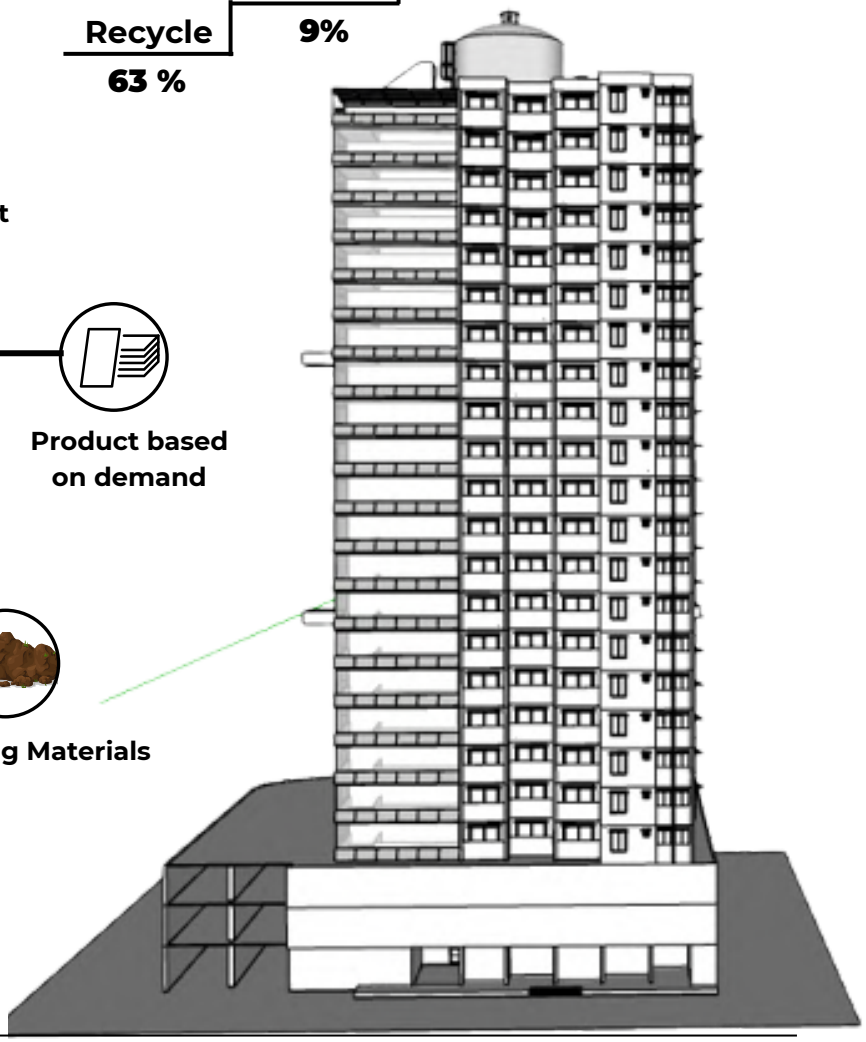
TILING

Seggregation

Reduce

Reuse 9%

Recycle 63 %



Recycled

Trans Thane Creek Waste managment Association @16.6 km

- 20% Plastic
- 4% Water Proofing
- 5% Wiring Conduit
- 7% Painting Plastering
- Product based on demand

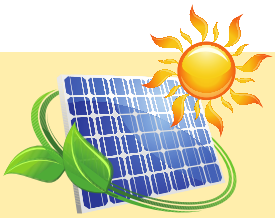
Blue Star Enviro @28 km

- 4% Glass
- 6% AAC blocks
- 10% concrete
- Filling Materials

JSW Steel @28 km

- 2% Steel Formwork
- 8% Steel
- steel Product

11. VALUE PROPOSITIONS:



01

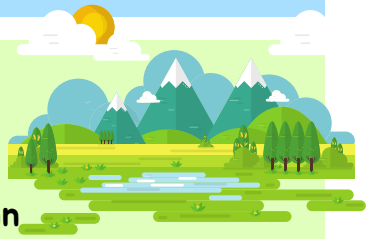
100% Energy Generation

Our building is powered by 100% renewable energy through the use of solar PV and flywheel generator technologies, reducing our reliance on traditional energy sources and promoting sustainability.

02

Water Sustainability

Reduction in water consumption up to 55%, recycling 65% of the total water demand, harvesting rainwater, using and recharging and groundwater, which brought us to achieving net zero water usage in our building.



03

Biophilic Design

Plants on balconies and a bird feeder bring biophilic design to our building, improving air quality and reducing stress while connecting residents with nature.

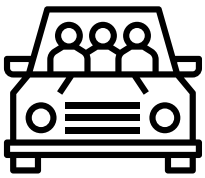
04

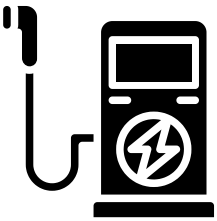
Integrated Waste Management

Integrated waste management minimizes landfill/incinerator use via waste reduction, reuse, recycling, and safe disposal. Its goal is a sustainable system that's environmentally, economically, and socially acceptable.

FACILITY

Car pooling - reduces traffic congestion, saves money on fuel and maintenance, promotes community building



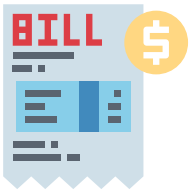


EV charging point - encourages sustainable transportation, provides a desirable amenity, can increase property value

Community hall - provides space for events and gatherings, fosters community and social cohesion, enhances livability

Alternative month bio gas - provides renewable energy, reduces greenhouse gas emissions, can lower energy costs

Lounge - provides space for relaxation and socialization, enhances livability and appeal, can be a selling point



Low maintenance - saves time and money on upkeep, enhances durability, can lower operating costs

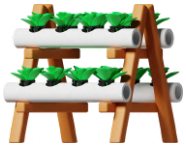
Gym - promotes healthy living, provides convenient fitness space, improves overall health and well-being

low electricity bill - saves money, reduces emissions, contributes to sustainability

Study room - provides quiet and focused space, enhances livability for students or professionals, can be a selling point

Commercial area - provides convenient access to goods/services, enhances walkability, generates additional revenue.

Hydroponics - provides sustainable growing space, improves indoor air quality, can provide fresh produce



Garbage chute - access doors, vertical chute connecting all floors, and a central collection point at the base.

Car parking - provides safe and accessible parking for vehicles, accommodating their size and number.

Features of eco-friendly building materials - use of renewable resources, low environmental impact, improved energy efficiency, health benefits, and durability.

APPENDIX

BUILDING AREA PROGRAMME

DEVELOPMENT NORMS AND BUILDING AREA PROGRAMME.

- The building area program has been clarified by the project partner.
- Apart from the residential tower, there is a need for a commercial ground floor and two podiums for parking requirements of the site.
- While these areas will be counted in the architectural design, they lie out of the purview of the targets set for the net zero challenge.
- The footprint of the residential tower will have stilts on the ground floor to be used for site services.
- A clear program is mentioned below highlights all the areas and their respective distributions in the floor area ratios of the entire project.

Table 3.0 Development regulations & buildable areas

Description	Area *(sq. metres)*	Standards/ Development norms/ notes
Net Plot Area	3200.13	*Made available by the Project Partner*
Area for recreational open space 25 %	800.03	*LEED*
Buildable area as per Basic f.a.r is 1.1	4800.20	*UDCPR 2020 Maharashtra state, Clarified by the project partner*
Additional buildable area as per Transfer development rights f.a.r is 0.9	2880.12	*UDCPR 2020 Maharashtra state, Clarified by the project partner*
Additional buildable area as per premium f.a.r is 0.5	-	*UDCPR 2020 Maharashtra state, not availed at this stage by the Project Partner*
Additional buildable area as per Incentive f.a.r. for green building	-	*As per IGBC/ GRIHA rating, an additional 3-7 % of buildable area could be availed later upon the basic f.a.r*
Total permissible area for development	7680.31	*Total f.a.r. = basic f.a.r. + TDR f.a.r.*
Additional buildable area as per Fungible f.a.r is 35 % of buildable area	2688.11	*UDCPR 2020 Maharashtra state*
Total built up area	10368.42	*Total permissible area + fungible f.a.r.*
Permissible ground coverage as 15% of net plot area	480.00	*Leed or IGBC codes*

10.b Program area statement

Sr.no.	Program	Conditioning	Area (sqm)	Nos	Total area (sqm)
1	**Commercial plaza**				
	Retail shops	Conditioned	75.0	5	75.0
	Common Toilets	Naturally ventilated	7.0	2	14.0
	Total area of commercial floor				**89.54**
2	**Building Footprint**				

APPENDIX

	Podium at G+1 level	Naturally ventilated	1956.06	1	1956.06
	Podium at G+2 level	Naturally ventilated	1956.06	1	1956.06
	Ramp for access to podium parking	Naturally ventilated		1	49.67
	Ground Coverage				**3961.79**
3	**Residential tower**				
	One BHK	Conditioned, naturally & mechanically ventilated	49.2	4	196.08
	Two BHK	Conditioned, naturally & mechanically ventilated	71.5	3	214.5
	Stair case	Naturally ventilated	24.39	2	42.63
	Stretcher lift	Mechanically ventilated	5.50	1	5.50
	Lift	Mechanically ventilated	5.50	1	5.50
	Electrical duct	Not ventilated	0.19	2	0.39
	Fire duct	Not ventilated	0.91	2	1.82
	Network duct	Not ventilated	0.19	2	0.39
	Reception and lobby for residential	Naturally ventilated	129.71	1	129.71
	Total area for a residential floor plate				597.24
	Total number of floors			**20**	

4	**Areas on the podium terrace**				
	Total area of podium terrace				1956.06
	Footprint of residential floor				742.25
	Space available for terraces on the podium top				**1213.**
	Clubhouse	Conditioned			1005.94
	Staircase	Naturally ventilated			
	Lift	Mechanically ventilated			

Note: All the dwelling units in the residential apartment will be air-conditioned and their active energy consumption will be counted within the purview of the net-zero energy efficient structure. Each floor will consist of Seven dwelling units.

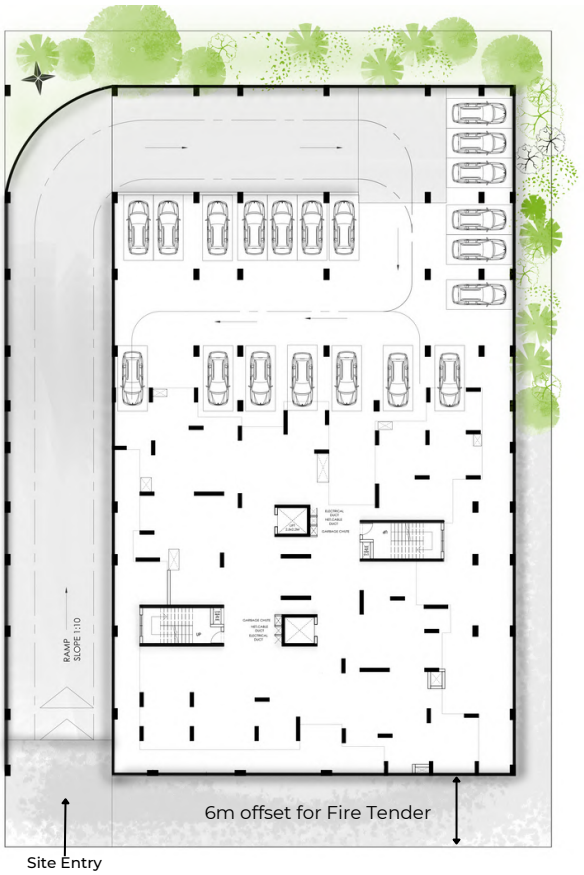
APPENDIX

5	**Vegetated Areas**				
	Minimum required area for natural open space on ground				333.35
	Minimum vegetated area required on podium top				514.36
	Minimum vegetated area required on terrace of residential tower				112.6
	Total vegetated area				**960.06**
6	**Vehicular circulation**				
	Vehicle circulation on site				427.69
	Ramp area for circulation				698.10
	Total circulation				1125.79
7	**Site Services**				-
	Area for Sewage treatment plant (placed on ground floor)				60.00
	Area available for underground tanks for municipal water supply, grey water, rainwater harvesting (to be placed under the vehicular ramp)				326.24
	Area of battery room for photovoltaic panels				
	Watchman's cabin				9.00

All bedrooms in the residential floor are accounted to have active air conditioning systems. The living & kitchen areas in each unit are cooled using combinations of passive techniques and forced internal ventilation systems. Remaining spaces are rendered unconditioned.

Ground Floor Plan

Plan at G+1 Podium Floor

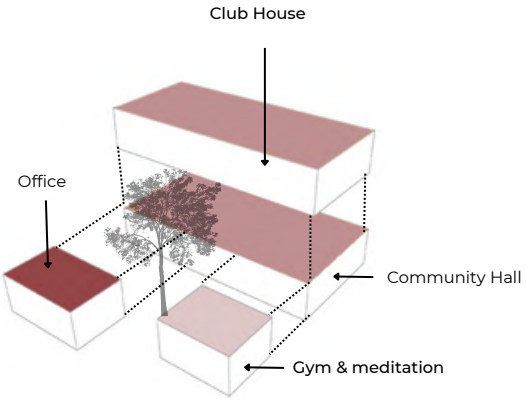


Plan at G+2 Podium Floor

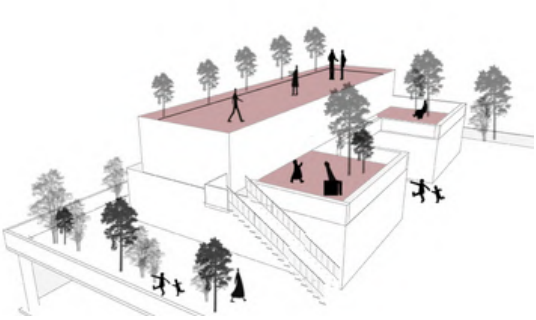
Roof Plan

PLANS:

Plan at G+3 Podium Terrace

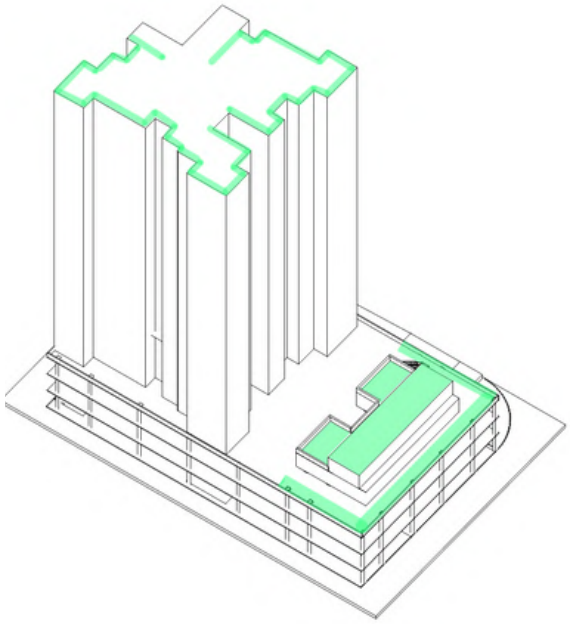


Podium Social Area Massing



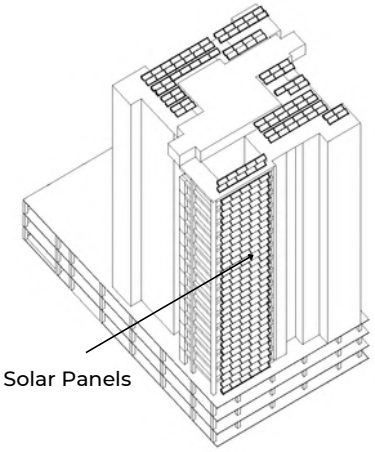
View of the Podium Area

1.Accessible green Roof Top
2.Community Engagement Area

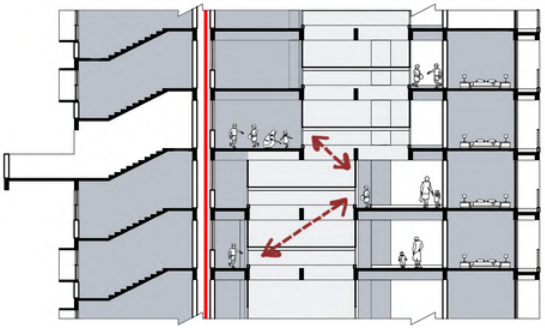


Softscape Provided

Typical floor Plan



Solar Panels provided on the roof top & on the southern facade of the Building.



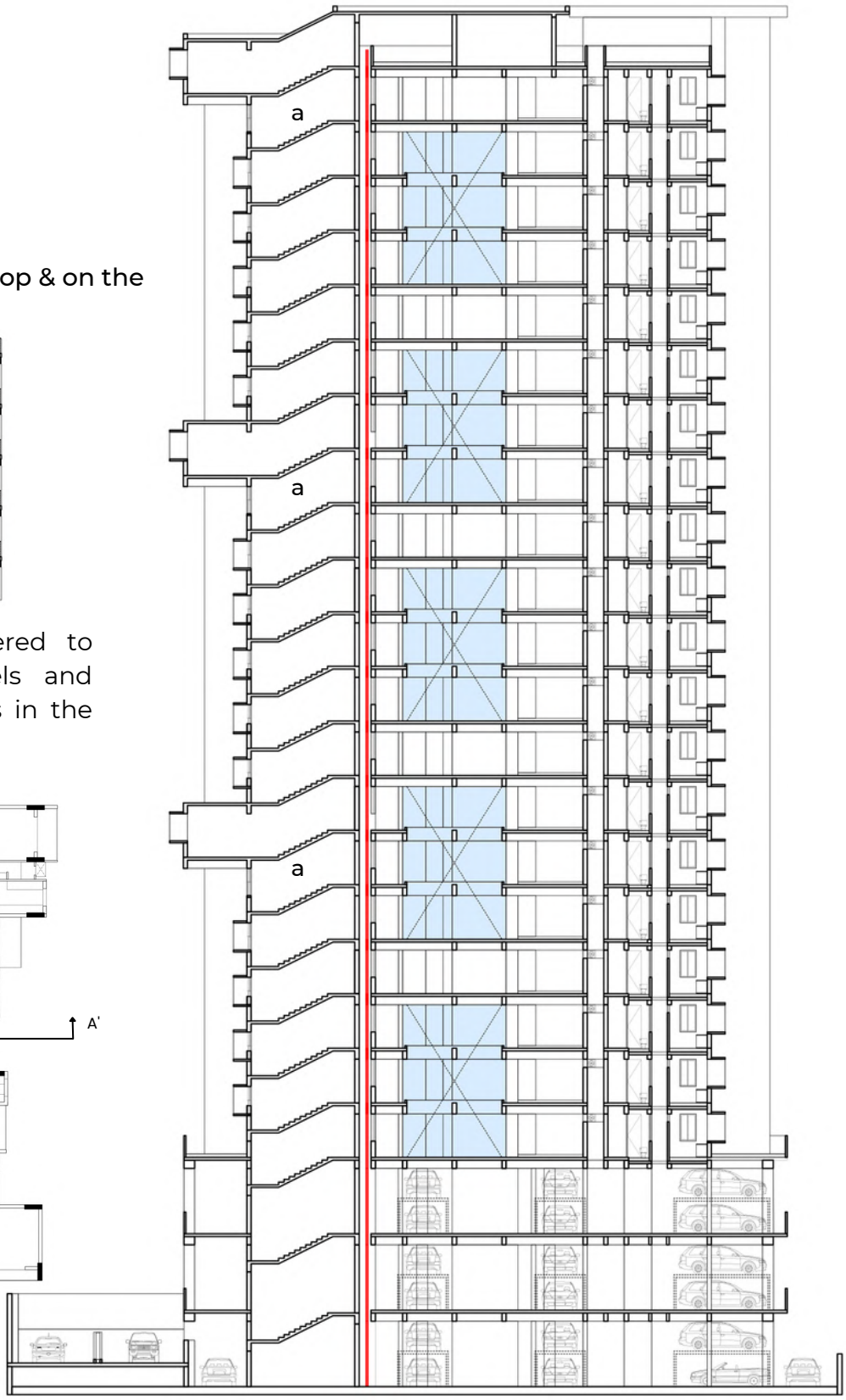
Double height volumes staggered to create interaction among levels and create better community spaces in the building lobby

Lift Lobby Area

The common lobby area in the residential floor

double height lobby spaces

a Refuge balconies



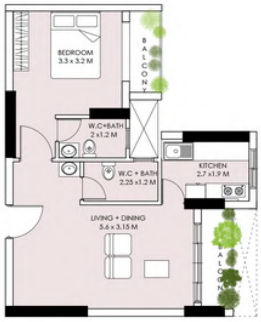
SECTION A.A'

TYPES OF UNITS:

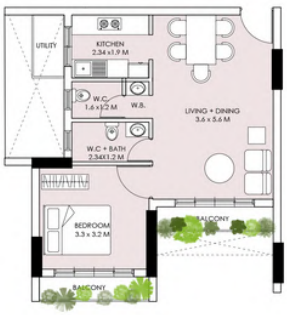
TYPICAL FLOOR PLAN

ALTERNATE FLOOR PLAN

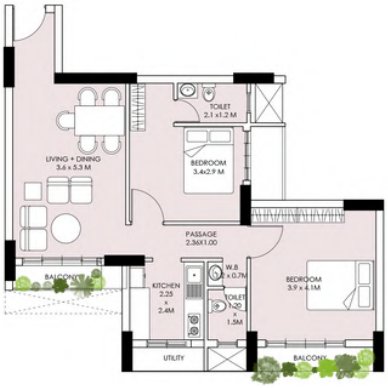
INDIVIDUAL UNIT PLAN:



ONE BHK TYPE 1

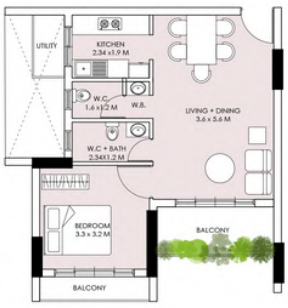


ONE BHK TYPE 2

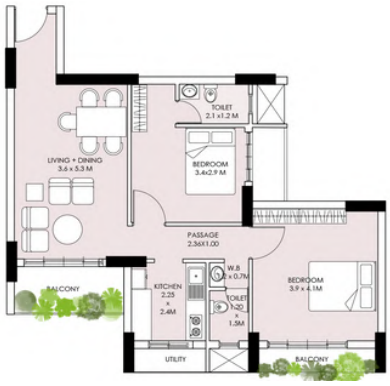


TWO BHK

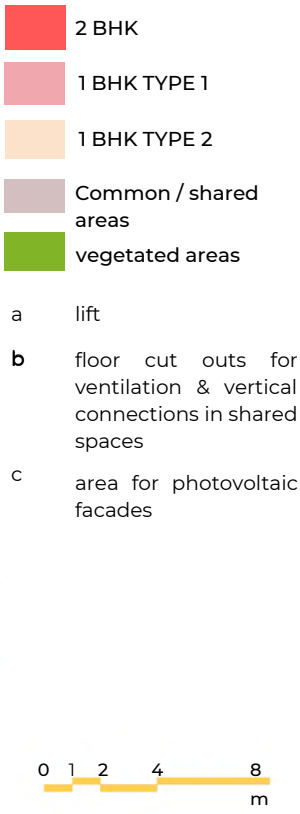
ONE BHK TYPE 1
(ALTERNATE FLOOR)
50.5 sqm



ONE BHK TYPE 2
(ALTERNATE FLOOR)
49.2 sqm



TWO BHK TYPE
(ALTERNATE FLOOR)
72.5 sqm



365 DAYS CONSTRUCTION LLP

UNIT NO. 14, A-WING, SHREE NAND DHAM BUILDING, PLOT NO. 59, SECTOR-11, CBD BELAPUR, NAVI MUMBAI-400614

MAJESTIC
BUILDERS & DEVELOPERS

Date: 16/09/2022

To,

The Director,

Solar Decathlon India

Dear Sir,

This is to inform you that our organization Majestic Builder and Devlopers has provided information about our ECOTOPIA project to the participating team led by M.H SABOO SIDDIK COLLEGE OF ENGINEERING, so that their team AL MA'ARIJ 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,

Name: Mohammed Anas Abdul Wahab Dokadia

Designation: PARTNER

Name Of Organisation: MAJESTIC BUILDER AND DEVELOPERS

EMAIL ID: ANAS_DOKADIA@YAHOO.CO.IN

MOBILE NO: 9619133361

ADD: UNIT NO 14, SHREE NAND DHAM, SECTOR 11, OPP RAHEJA ARCADE, BELAPUR NAVI MUMBAI

APPENDIX

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(Approved by AICTE and Affiliated to University of Mumbai)

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Ref. No. : CE/Admn./708/22 Date : 23/08/2022

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Mr. Shaikh Shamsher Siraj** is a Bonafide student of final year Civil engineering for the academic year 2022-2023.

This certificate is issued to him on his request for the purpose participating in Solar Decathlon India 2022-23.

I/c Principal

M.H.S.S. COLLEGE OF ENGINEERING MUMBAI 400 008

8, Saboo Siddik Polytechnic Road, Byculla, P.O. Box 4627, Mumbai - 400 008.
Tel.: 2301 2922 / 2305 1356 / 2308 1294 (D) • Telefax : 2308 2640 • T.P.O.Tel.: 2300 5896 • Exam Cell : 2302 1357
• E-Mail : aimhssce@mhssce.ac.in / mhssce@yahoo.in / aimhssce@gmail.com / mhss.exams@yahoo.in / mhsstpo@gmail.com • URL: http://www.mhssce.ac.in

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Ref. No. : CE/Admn./7071/22

Date : 23/08/2022

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Ms. Manihar Sabrin Ziyaullah** is a Bonafide student of final year Civil engineering for the academic year 2022-2023.

This certificate is issued to her on her request for the purpose participating in Solar Decathlon India 2022-23.

I/c Principal

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Ref. No. : CE/Admn./710/22 Date : 23/08/2022

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This is to certify that **Ms. Khan Shabnam Afzal** is a Bonafide student of final year Civil engineering for the academic year 2022-2023.

This certificate is issued to her on her request for the purpose participating in Solar Decathlon India 2022-23.

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Ref. No. : CE/Admn./709/22 Date : 23/08/2022

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Mr. Aminnaik Mohd. Sharik Mohd. Ghaus** is a Bonafide student of final year Civil engineering for the academic year 2022-2023.

This certificate is issued to him on his request for the purpose participating in Solar Decathlon India 2022-23.

I/c Principal

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Ref. No. : CE/Admn./718/22 Date : 23/08/2022

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Ms. Chougule Sanskruti Anand** is a Bonafide student of Third year Civil engineering for the academic year 2022-2023.

This certificate is issued to her on her request for the purpose participating in Solar Decathlon India 2022-23.

I/c Principal

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DTE Code No.: EN-3183

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Ref. No. : CE/Acad./ 715/22

Date : 23/08/2022

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Ms. Patil Sakshi Ashok** is a Bonafide student of Third year Civil engineering for the academic year 2022-2023.

This certificate is issued to her on her request for the purpose participating in Solar Decathlon India 2022-23.

I/c Principal

M.H.S.S. COLLEGE OF ENGINEERING MUMBAI 400 008

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APPENDIX

ANJUMAN-I-ISLAM'S

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Ref. No. : CE/Addnal./711/22 Date : 23/08/2022

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Ms. Shaikh Nausheen Aejaz** is a Bonafide student of Third year Civil engineering for the academic year 2022-2023.

This certificate is issued to her on her request for the purpose participating in Solar Decathlon India 2022-23.

I/c Principal

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Ref. No. : CE/ Admn./ 713/22 Date : 23/08/2022

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Mr. Sayyed Sajjad Hussain** is a Bonafide student of Third year Civil engineering for the academic year 2022-2023.

This certificate is issued to him on his request for the purpose participating in Solar Decathlon India 2022-23.

I/c Principal

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Ref. No.: CE/Admn/854/22 Date : 10-10-2022

TO WHOMSOEVER IT MAY CONCERN

This is to inform that **Mr. Kazi Siddique Munaf** is a Bonafide student of Final Year Mechanical Engineering for the A. Y. 2022-23.

This certificate is issued to him on his request for the purpose participating in Solar Decathlon India 2022-23.

I/C PRINCIPAL

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Ref. No. : CE/Admn./712/22 Date : 23/08/2022

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Mr. Naik Rehan Haider Ali** is a Bonafide student of Third year Civil engineering for the academic year 2022-2023.

This certificate is issued to him on his request for the purpose participating in Solar Decathlon India 2022-23.

I/c Principal

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RIZVI EDUCATION SOCIETY'S

RIZVI

COLLEGE OF ARCHITECTURE

RIZVI EDUCATIONAL COMPLEX, OFF CARTER ROAD, BANDRA (W), MUMBAI-50.TEL.: 2605 0624, 2604 4196 rizviarchitecture@gmail.com

24th August 2022.

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Mr. Manu Mohnish Gupta is a bonafide student of this institution, studying in 5th Year Bachelor of Architecture for the academic year 2022- 2023.

This certificate is issued to enable him to Participate in Solar Decathlon India competition 2022-23

Prof. Rekha Desai
Principal
Rizvi College of Architecture.

RIZVI COLLEGE OF ARCHITECTURE * MUMBAI-400 050. *

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24th August 2022.

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Ms. Sariya Afzal Khan is a bonafide student of this institution, studying in 4th Year Bachelor of Architecture for the academic year 2022- 2023.

This certificate is issued to enable her to Participate in Solar Decathlon India competition 2022-23

RDesai

Prof. Rekha Desai
Principal
Rizvi College of Architecture.

RIZVI COLLEGE OF ARCHITECTURE * MUMBAI-400 050. *

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Ref. No.: CE/Admn/856/22 Date: 10-10-22

TO WHOMSOEVER IT MAY CONCERN

This is to inform that **Mr. Abdurrahman Kazi** is a Bonafide student of Final Year Mechanical Engineering for the A. Y. 2022-23.

This certificate is issued to him on his request for the purpose participating in Solar Decathlon India 2022-23.

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Ref. No. : CE/Admn/855/22 Date : 10-10-22

TO WHOMSOEVER IT MAY CONCERN

This is to inform that **Mr. Amaan Kondkar** is a Bonafide student of Final Year Mechanical Engineering for the A. Y. 2022-23.

This certificate is issued to him on his request for the purpose participating in Solar Decathlon India 2022-23.

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