D Y PATIL SCHOOL OF ARCHITECTURE
LOHEGAON, PUNE.

TEAM GET THEM GREEN

Get Them GREEN

FINAL DESIGN REPORT

APRIL 2023

MULTI - FAMILY HOUSING

PROJECT PARTNER

C. H. PATIL & SONS

Solar Decathlon India

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RESPONSE TO REVIEWERS COMMENTS

SECTION	REVIEWER 1 COMMENT	OUR RESPONSE
ENERGY PERFORMANCE	It's a good work done on detailing the supply and demand situation and a sincere effort to reduce EPI meeting the BEE standards. I also observe few critical components on demand side with lower operation hrs estimations like Refrigerator and TV. Besides we have not captured the highest energy consuming appliances like AC and Geysers. While the developer may not be providing it but the User will still be installing it and it needs to be estimated which will have its impact on Supply loads as well and hence an impact on Net Zero calculations	Thank you for your observation which helped a lot. We kept that in mind and revised our EPI calculation keeping in mind the highest energy consuming appliances like AC and Geysers.
WATER PERFORMANCE	Good work. I did not observe any reference to the NBC Guidelines	Thank you. References are added in the Deliverable 4
EMBODIED CARBON	Appreciate the guidance of the external organization enabling the team to understand the impact and use the knowledge in reducing it as much as possible.	Thank you.
RESILIENT DESIGN	Like the comprehensive approach. Would like the team to consider flooding as another risk with Mumbai having experienced the same quite a few times in Monsoon and have a strategy to avert/minimize the risk	Thank you. We have considered flooding for the Deliverable 4
ENGINEERING & OPERATIONS	Good work around Solid waste management and reduction of Water consumption. Will advise team to consider BMS and other digital means for managing Services thus improving Productivity and turn around time for inhabitants and include the same in report.	We have tried to incorporate some systems except BMS.
ARCHITECTURAL DESIGN	Good work	Thank you
AFFORDABILITY	Did not find this in the available documents. Regret if I missed it.	A comprehensive study has been done on Affordability, Page __

INNOVATION	Good work	Thank you.
HEALTH & WELL BEING	Thoughtful approach for the apartments. Would like to see the same for Public spaces	Revised work with the mentioned observation has been updated.
VALUE PROPOSITION	Comprehensive work for the Partner	Thank you.
ADDITIONAL COMMENTS:	Good work for the stage. Irrespective of whether the Project qualifies for the next level, I find this to be a quality work and recommend the interventions be used in the Project.	Thank you.

Table 1: Response sheet to Reviewer's 1 comments

SECTION	REVIEWER 2 COMMENT	OUR RESPONSE
ENERGY PERFORMANCE	You have well highlighted the passive strategies and details. Wherever you put the plan, please include north (it is essential to understand your passive strategies). 1.09 sq.m meters is significantly less for one solar panel generating 445 W. Also, you have yet to consider energy losses of generation and storage of solar energy. In this case, you would need more area to put solar panels. There is some mistake with the EPI; 151 kWh/m2 per year is too much. In the project description you have written 60 kWh/m2 per year (page10).In D2, I highlighted that the EPI could be less than 50 kWh/m2 per year, but you misunderstood and considered it a net reduction. EPI of 151 is too high; how have you created this number? Please try to correct this and talk to TRG and your guides; this is a significant mistake that you should cater.	The EPI has now been reduced to 80 kWh/m2-year. And the solar panel calculations has been updated and the reference for the same has been given in the appendix.
WATER PERFORMANCE	You have correctly highlighted the water requirements, usage, reclamation and recharge. Though	Firstly the typo has been corrected.

	there are a few typos it seems 35 kilolitres per day (page-19) How much reduction were you able to make per capita is not mentioned, i.e. how much lpcd was baseline and how much was design?	Secondly, the graphs has been included highlighting the per capita consumption.
EMBODIED CARBON	I guess you have correctly pointed out the reduction in carbon, but you can use a good representation through sectors.	Noted.
RESILIENT DESIGN	Seems fine.	Thank you.
ENGINEERING & OPERATIONS	Only few tables I can see in the appendices, though a whole complete section should be included.	A whole new section has been added in the report.
ARCHITECTURAL DESIGN	It is good that you have put in plans to understand but views and write is equally important. Site could have been generated in a better way. Would love to see some furniture in the section.	The mentioned corrections have been done in the report. We have tried to represent site in a better way. And have also added some furniture in the section.
AFFORDABILITY	It is good that you have mentioned the cost-benefit as per materials but cost benefit analysis could have be shown for all materials even window glass.	The same has been updated in the report.
INNOVATION	Seems fine.	Thank you.
HEALTH & WELL BEING	You have well highlighted that passive strategies and its benefits to occupants. But these strategies should be tested through calculations, simulations as per indoor thermal comfort, thermal standards and visual comfort standards.	We have provided the cross ventilation calculations in the appendix which is very well taking care of thermal comfort.
VALUE PROPOSITION	Seems fine, although pictures could be used to pitch.	We have tried to represent value proposition graphically.
ADDITIONAL COMMENTS:	You have presented the work very well though you must keep an eye on the details and technicalities.	Thank you.

Table 2: Response sheet to Reviewer's 2 comments

EXECUTIVE SUMMARY

The team "**TEAM GET THEM GREEN**" from D Y PATIL SCHOOL of Architecture aims to design **Net Zero-energy-water** and **climate-resilient buildings**, contributing to live projects by partnering with leaders in real estate development.

It consists of young architects and civil engineer from a range of age groups. The project "**AKASA**'', which means **ether or atmosphere** is the expanse in which everything lives and operates (that which allows space) and is surrounded by elements such as water, wind, and fire.

Team Get Them Green has created a **net zero, locally sourced, environmentally friendly, better thermally comfortable, and universally accessible multifamily housing solution**. The structure will offer improved livelihood options as well as a refuge of safety during difficult times.

As a team, we are incredibly appreciative of the competition for broadening our perspectives. Every step of the way, we try to learn something new while providing each service with honesty and care.

Due to limited space, unique geometry and terrain, and the ongoing need for housing, Mumbai has been experiencing the reconstruction of old buildings over the past 15 years.

To understand this better we did a **socio-economic background of users and people**. Mumbai is also facing the **prominent environmental issue of air pollution**. And since the site is in close proximity to Link Road, the **air quality is deteriorating**. Another issue is **Solid Waste Management** which causes diseases in the vicinity of the site.

We considered these as a means of getting ready for this impending catastrophe. Borivali West, a developed residential neighborhood in Mumbai's north, mostly serves the upper-mid market. Because of the high density and emphasis on profitability in Mumbai, redeveloping multifamily housing in a sustainable fashion has been a challenge for Team Get Them Green.

1. TEAM INTRODUCTION

1.1 Team Name - Team GET THEM GREEN

1.2 Institute Name - D Y Patil School of Architecture, Lohegaon.

1.3 Division- Multi - Family Housing

1.4 Team Members-

Figure 1: Team members, Qualifications and Roles

1.5 Approach-

The Team GET THEM GREEN participated in Solar Decathlon India (SDI) 2022-23 as it gives an opportunity for student teams to design Net Zero-energy-water and climate-resilient buildings, contributing to live projects by partnering with leaders in real estate development. The team members involved are from multi-disciplinary fields as mentioned in the team list adopting a multidisciplinary approach for effective decision-making and enhanced building performance, right from the conceptual stage till the completion of the project.

We as a team along with our faculty lead and the faculty advisor sought from the beginning to grasp and have a clear concept of what the solar decathlon India 2021–2022 intends us to accomplish. We aim to improve our teammates' experiences and skills in order to win the competition and fulfill the ten contests, as well as their requirements, successfully.

To move further, we fragmented the tasks depending on our teammates' areas of interest and aptitude. Design meetings and work discussions among team members are held daily. Any doubts or ideas are discussed with the faculty lead and advisor. These meetings with the faculty lead and advisor are held at least twice a week. Any corrections or suggestions are discussed to carry out the work further. This helps the team work together, gain more confidence and minimize errors.

1.6 About Institute-

D Y Patil School of Architecture was established in August 2011 under Savitribai Phule Pune University (SPPU). Within a short span of 10 years the school has established itself as one of the top 5 institutes in the Pune region.

The Master's in environmental architecture (M. Arch) program was started in the year 2013. The learning environments fosters research and creativity, honing environmentally conscious professionals, exposure to essential and new issues in the construction industry, and technically sound versatile personalities ready to take their place in the world.

1.7 Faculty Lead and Faculty Advisors-

FACULTY LEAD
Prof. Prathama Jhaveri
Associate Professor
B.Arch & M.Arch
(Environmental Architecture)

FACULTY ADVISOR
Prof. Shubhada Chapekar
Principal, Professor in Architecture
B.Arch (Hons) & M.Arch
(Environmental Architecture)

FACULTY ADVISOR
Prof. Aparna Rahul Mhetras
HOD (M.Arch Env. Arch.)
Professor B.Arch & M.Arch
IGBC Accredited Faculty

Figure 2: Faculty lead and Faculty advisors, Qualifications

1.8 Industry Partner - Samuchit Enviro Tech, Pune

1.9 Design Process

As Team **Get Them Green** from completing SLMs to distributing tasks, we had gone through various design discussions and innovative ideas to have solutions to cater to our passive design needs. We have assigned the team members on basis of individual expertise and understanding of the parameters enlisted in the design brief to achieve our required goals for the proposed design project.

Figure 3 Process through the Deliverables

DELIVERABLE 1

From choosing a site in Mumbai vicinity to curating a building area program we got knowledgeable about the byelaws & space planning as for muti-family housing typology. On understanding the goals through watching the comprehensive & well-crafted SLM's, we got to know about various parameters that contribute towards designing an environment friendly structure.

DELIVERABLE 2

It was a holistic experience doing the hustle for gathering people having expertise in architecture, engineering & environmentalists on the same page to put forward a collaborative effort towards collecting data for the proposed redevelopment project.

DELIVERABLE 3

During this phase we explored various software related to climate analysis, energy simulation & daylight analysis to gather data related to EPI & design our fenestration accordingly.

2. PROJECT INTRODUCTION

a	**Name of project**	Sheetal CHSL
b	**Project partner**	M/S C.H. Patil and son's LLP, Borivali, Mumbai
	C H Patil & Sons entered into the realty business in the year 1975, as a family conglomerate, with the purpose of providing meticulously planned apartments to discerning customers at affordable prices. Currently, C H Patil & Sons is one of the few Indian Real Estate Development Company to get an ISO 9001 - 2008 certification. Key Persons - Rohit Patil , Amit Patil (Partner at C. H. Patil & Sons)	
c	**Brief description of project**	
1	Location	Borivali, Mumbai
2	Co-ordinates	19.22 N, 72.84 E
3	Altitude	14m MSL
4	Climate zone	Warm and humid as per ECBC 2017
5	Typology	Multifamily
6	Current Stage	Planning
7	Hours of Operation	24 hrs
d	**Site area**	1489.75 sqm
	Approx Bup area	4806 sqm
	Total carpet area	4005 sqm
e	**EPI**	60 kWh/sq.m approx (GRIHA 2015)
f	**Preliminary budget of onsite SPV system**	
	Terrace area	350 sq.m
	60% available for renewable energy	210 sq.m
	Energy generation approx	1,94,910 kwh/year
	Cost	40 lakhs
g	**Project preliminary Budget -** Rs.41000 / sq.m	
h	**Project partner requirements**	
1	Affordability	
2	Comfort	
3	Sustainable measures	
4	Saving energy/ electricity	

Table 4: Project Summary

3. GOALS AND STRATEGIES

3.1 ARCHITECTURAL DESIGN

Aim: Design a building with better thermal comfort and accessible to all.
Strategy:

1. Design using passive strategies for improved ventilation, lighting and thermal comfort.
2. Associate universal design principles to make the space functional for everyone.

3.2 ENERGY PERFORMANCE

Aim: To reduce the EPI
Strategy:

1. Equipping the building with energy efficient fixtures.
2. Proposing maximum daylight and thermal comfort to minimize energy consumption.
3. Generation of on-site renewable energy like Solar PV.

3.3 WATER EFFICIENCY

Aim
Achieving Net Zero Water Building by reducing water consumption by 44%. Harvesting the potential rainwater on-site and reusing treated water for applications such as flushing, landscaping etc.

Strategy:
1. Use of efficient plumbing fixtures and reduced water consumption by 44%.
2. Avoiding and limiting the use of lawn areas and instead planting native trees.
3. Harvesting Rainwater as the alternate water source by designing slopes.
4. Water recycling by installing the on-site Sewage Treatment Plant and reusing treated water for applications such as flushing, landscaping etc.

3.4 RESILIENCE

Aim: Withstand the earthquakes and heat waves.
Strategy:
Although earthquake occurrence is not very severe (site falls under Zone III, in case of a high-rise building, we aim to work on designing an earthquake resistant structure.

3.5 CARBON NEUTRALITY

Aim: To reduce embodied carbon of building materials with respect to roof, walls, windows and floor by 70%.
Strategy:

1. Replacing conventional concrete roof slab with green cement and adding stone wool insulation to it reduces carbon factor by a difference of 19.96tco2e value.

2. Replacing conventional RCC wall with lower co2 factor emitting material which is AAC blocks, embodied carbon is reduced to 0.6tco2e.
4. Installation of double wooden glazing window embodied carbon is reduced to 0.0004tco2e which is carbon neutral.
5. Instead of using cement as in conventional buildings, we tried to replace it with use of green unreinforced C40/50 cement which is 75% cement replacement, embodied carbon is reduced to 1.73tco2e.

3.6 HEALTH & WELL-BEING

Aim: To enrich the lifestyle of residents by providing an environment that is comfortable for its occupants.

Strategy:

1. Green corridors & existing vegetation.
2. Use of passive architecture to increase cooling hours.
3. Naturally ventilated passages.
4. Low VOC materials.
5. Physical exercise amenities.
6. Connection to nature.

3.7 INNOVATION

Aim: To collect organic waste from each house and convert into compost.

Strategy: We can provide an Organic waste composter at a particular floor which will convert the organic waste generated from households for which the tenements will get some rebate in their monthly maintenance bill.

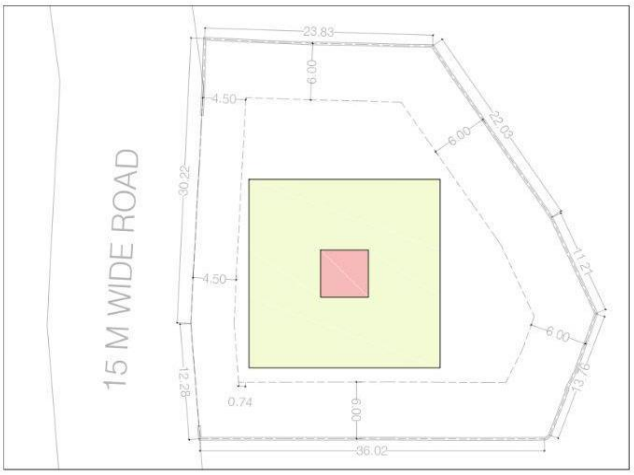
3.8 AFFORDABILITY

Aim: To make the project economically viable for project proponents by curtailing the financial costs of the execution and the operations of the project.

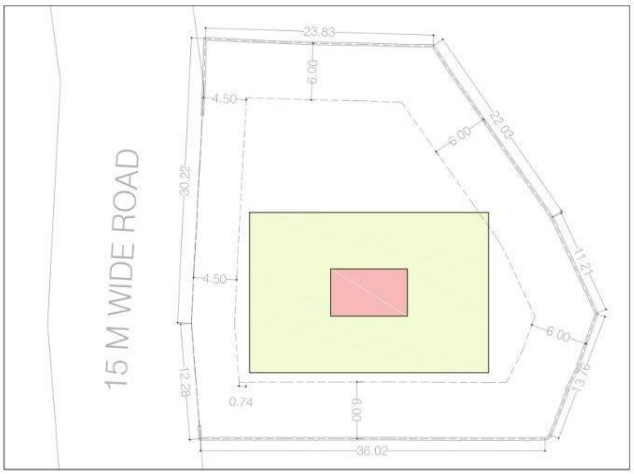
Strategy:

1. Use of local materials and cast In-situ construction.
2. Preferring hollow beams and hollow slabs.
3. Reducing the steel bar diameter with each succeeding floor.
4. These options help to ensure less usage of materials and hence the investment.

4. DESIGN PROCESS

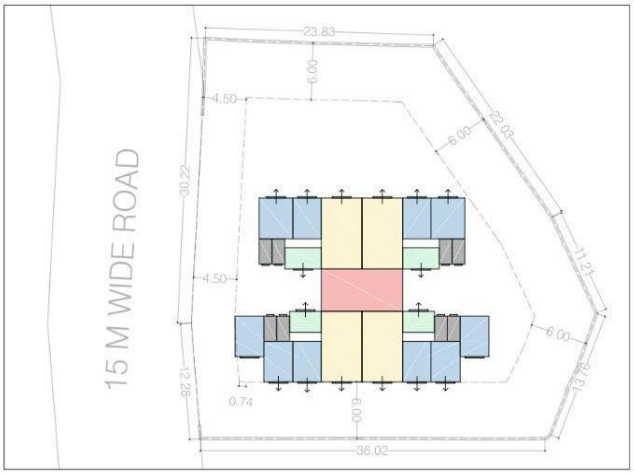


A BASE MODEL WITH THE CORE WITHIN LEAVING THE SITE MARGINS AS PER REGULATIONS.

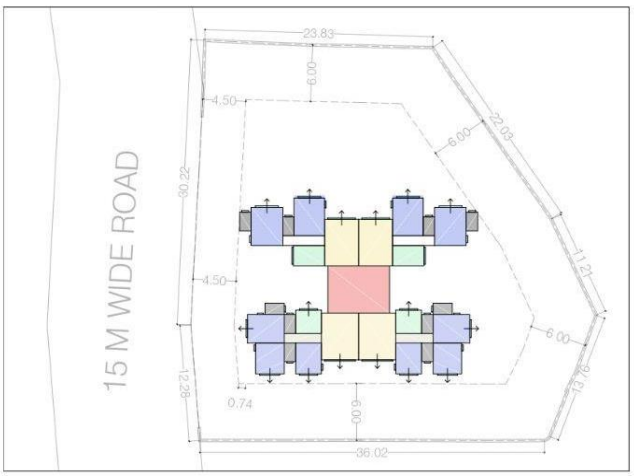


ORIENTED THE STRUCTURE N-S (E-W LONG AXIS) TO RECEIVE LOWER ANGLES OF SUN

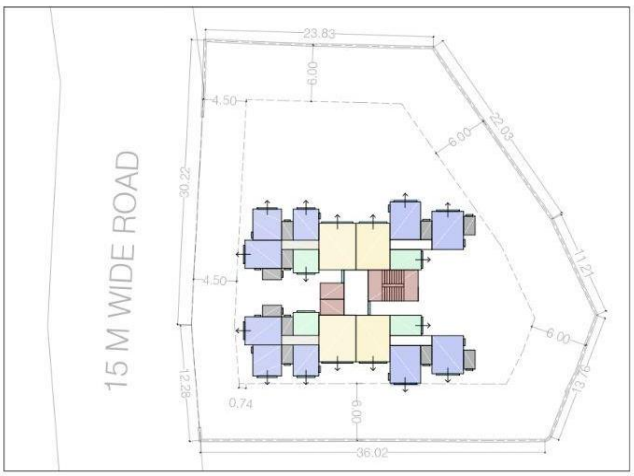
ENHANCE WIND CIRCULATION ACROSS THE SITE AND WITHIN THE BUILDING BY CREATING PUNCTURE WITHIN THE BUILDING.



MAXIMUM OPENINGS TOWARDS NORTH AND SOUTH



STAGGERING THE SPACES SO THAT EVERY ROOM HAS 2 OPENINGS, THUS ENHANCING CROSS VENTILATION.



OPTIMIZING THE COMMON LOBBY SPACES TO REDUCE MATERIAL WASTAGE AND PROVIDING CROSS VENTILATION IN THE LOBBY.

PARAMETERS	DESIGN PROBLEM	STRATEGY
MASSING	Due to site constraints and setback, the building footprint is small.	A rectangular block having only four apartments on each floor with one service core.
ORIENTATION	Higher radiation on East and West façade due to lower sun angles. Buildings surrounding the site with height more than 32 m, affecting the wind flow.	Maximum openings towards north and south, and minimum on the east-west façade. Puncture in the service core on the east-west side so that wind flows through the building.
FLOOR LAYOUT	Efficient consumption and no wastage of FSI in lobby area. Provide 2bhk and 3bhk apartments as per project proponent's requirement.	The common lobby area is optimized and planned fully free of FSI. Plan is mirrored to improve the area efficiency.
UNIT LAYOUT	Optimizing FSI Adequate day lighting Maximize cross ventilation and natural ventilation	The area designated is optimized by providing larger rooms and smaller areas for passages. Ideal fenestration for ample daylight is proposed. Every room has openings on 2 walls to increase cross ventilation.
SHADING / FENESTRATION	Cater to the rain, wind and radiation Use shading device as per the orientation of the window.	Material of the window and glass with low U – value and SHGC value, and high VLT for light transmission. Green window proposed to reduce radiation. Open-able windows instead of sliding to ensure maximum ventilation

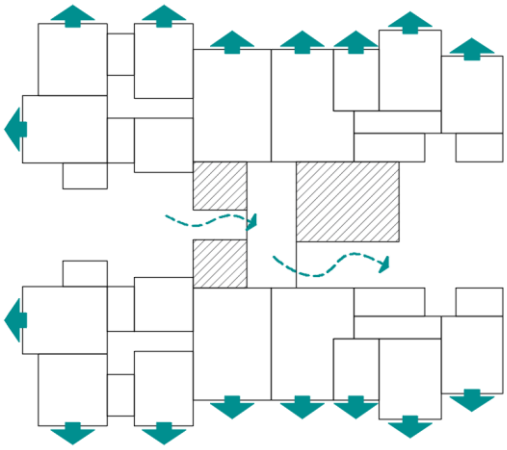
5. DESIGN DOCUMENTATION

Figure 4: FRONT ELEVATION VIEW

ENERGY PERFORMANCE

Passive Strategies

The first step towards designing a net zero building is to implement passive strategies wherever apt for the project, right from the site zoning to building form and orientation to designing shading devices. Passive strategies lead to the form and design of a building. Sun, wind, light and the micro-climate has been taken into consideration while designing the building.



a. Orientation

The orientation of the building is North-South. There are minimum openings towards East and West direction, thus avoiding the lower altitude angles of sun.

b. Cross Ventilation

Since Mumbai has a Warm and Humid climate, every room has been designed with openings on two sides. This will promote cross ventilation and provide thermal comfort. Wind circulation through the building is proposed by designing openings in the core.

Figure 5: ORIENTATIONAND OPENINGS

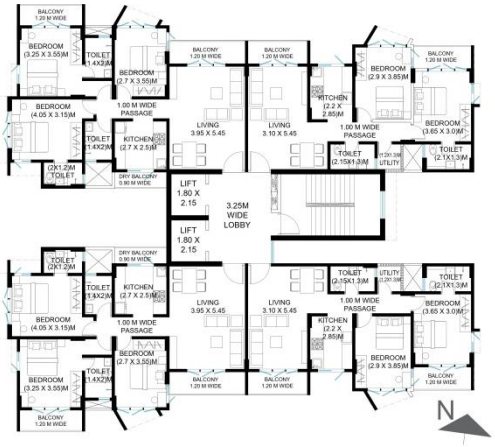


Figure 6: UNIT PLAN SHOWING CROSS VENTILATION

ENVELOPE:

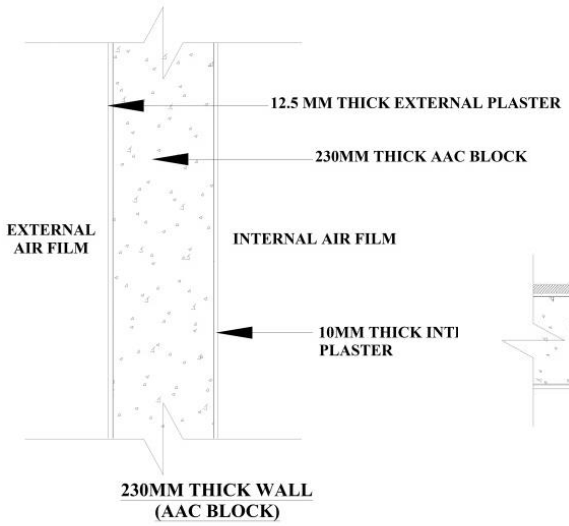


Figure 7: PROPOSED WALL ASSEMBLY

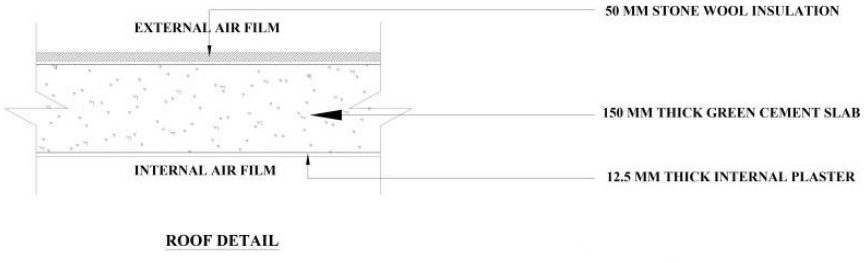


Figure 8: PROPOSED ROOF ASSEMBLY

	WALL	ROOF	WINDOW
BASE CASE	RCC Wall **U-value = 1.95 W/m²K**	Concrete slab with no insulation **U-value = 3.92 W/m²K**	Triple wooden glazing **U - value = 5.7** **SHGC = 0.67**
PROPOSED CASE	230mm thick AAC block **U-value = 0.4 W/m²K**	Green Cement with stone wool insulation **U-value = 0.83 W/m²K**	Double wooden glazing **U - value = 1.3** **SHGC = 0.3** **VLT=60%**

SOLAR PHOTOVOLTAIC SYSTEM CALCULATION

SOLAR PV CALCULATION

As a thumb rule, we require 8 sq meter area to 20 sq meter area for a 1 kW capacity of electricity production in 1 hr. from 1 solar pv panel. (REGION SPECIFIC)

Solar window for Mumbai = 10.00 am to 15.30 pm	5.5	Hours
TOTAL AREA	367.6	SQ. M
40 % CIRCULATION SPACE	147.04	SQ. M
60 % AREA AVAILABLE OF SOLAR PV INSTALLATION	220.56	SQ. M

Average solar irradiation in MAHARASHTRA state is 1266.52 W / sq.m
1kWp solar rooftop plant will generate on an average over the year 5 kWh of electricity per day (considering 5.5 sunshine hours)
Assuming 16 sq meter area for a 1 kWH capacity of electricity production in 1 hr. from 1 solar pv panel.
So 5 kWH capacity of electricity production in 5.5 hrs. from 1 solar pv panel.

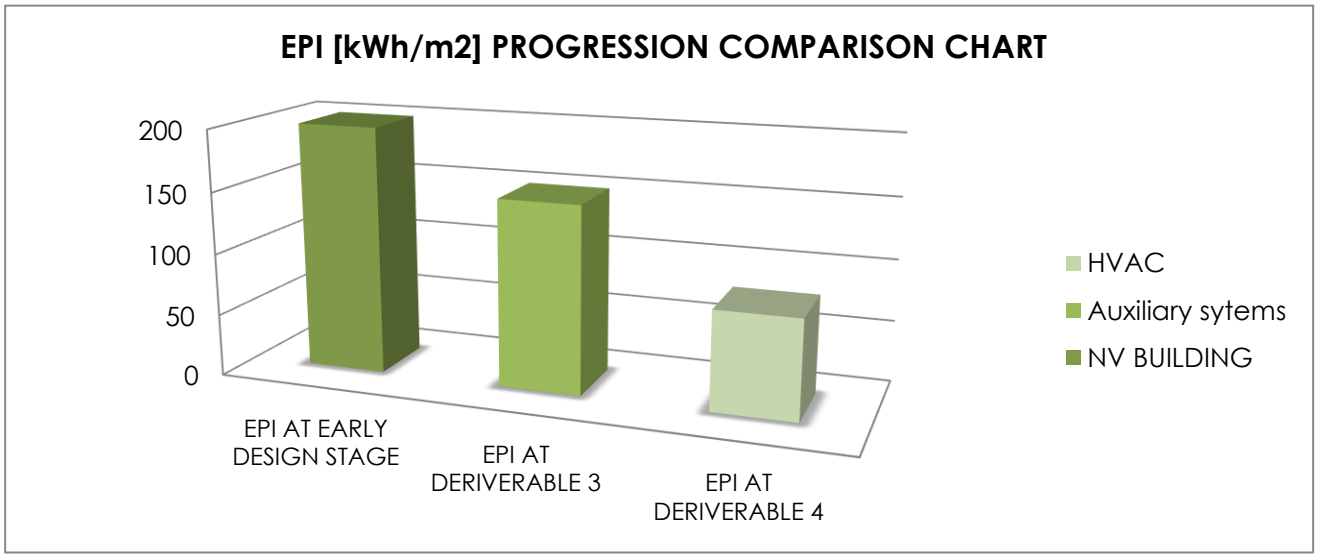
AS PER MNRE, PROJECT ROOF GENERATES 22KW PER DAY CONSIDERING 20% EFFICIENCY FROM THE CURRENTLY AVAILABLE SOLAR PV TECHNOLOGIES AVAILABLE

TOTAL NUMBER OF SOLAR PANELS REQUIRED TO GENERATE 22KW ELECTRICITY PER DAY = 22 PANELS

TOTAL ELECTRICITY GENERATION ANNUALLY CONSIDERING 300 SUNNY DAYS = 33000 kWH

Refer appendix B for detailed calculation

EPI PROGRESSION COMPARISON CHART



Refer Appendix D for output calculations.

PROPOSED DESIGN CASE					
	Building Envelope	**Values with units**	**Total Energy [kWh]**	**Mode of data collection**	**BUP area in sqm**
1	Wall	0.4 [W/m2-K]	120853.76	SIMULATION	**5131**
2	Windows	1.3 [W/m2-K]			
	SHGC / VLT	0.3 / 0.6			
3	Floor	1.5 [W/m2-K]			
4	Roof	0.83 [W/m2-K]			
5	WWR	17%			
6	LPD	5 [W/m2]			
7	EPD	0.5[W/m2]			
8	ELPD	5 [W/m2]			
9	Lift & Pump	Lumsum	50000	ASSUMPTION	
10	1 Ton Split AC unit		245280	PRESCRIPTIVE	**81.01**
	No. of units = 140 (All bedroom Living) Daily avg usage = 8 uncomfortable hours per day as per simulation (4593) EC by 1 ton AC = 0.6 Kwh NET EC by overall AC = 140 X 8 X 0.6 X 365				
	EPI [kWh/m2]		**416133.76**		

Refer Appendix D for output calculations.

DAYLIGHT ANALYSIS

According to the daylight simulation, **75% of the floor area is naturally lit as shown in the diagram.**

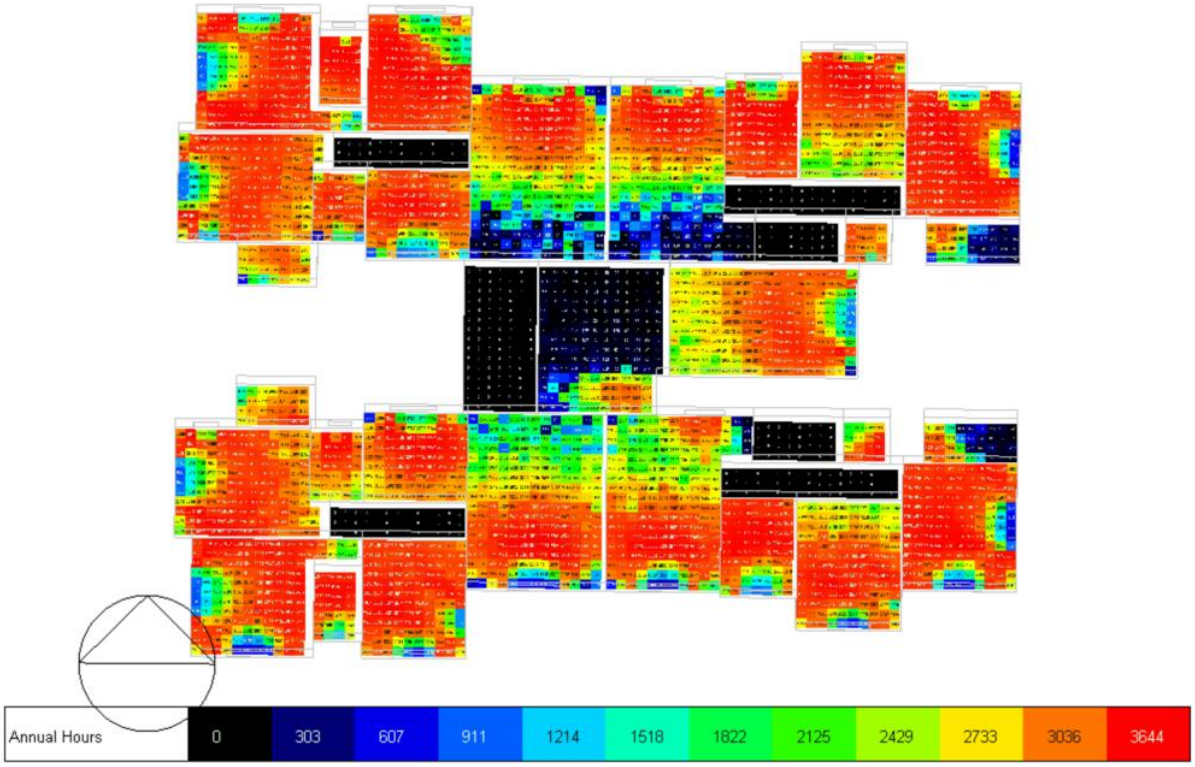


Figure 9 DAYLIGHT SIMULATION ANALYSIS

ENERGY PERFORMANCE INDEX:

We incorporated components on demand side with lower operation hrs estimations like Refrigerator and TV. Besides we have captured the highest energy consuming appliances like AC and Geysers. While the developer may not be providing it but the User will still be installing it and it needs to be estimated which will have its impact on Supply loads as well and hence an impact on Net Zero calculations. Considering all these changes and running the simulation the preliminary result for EPI we obtained now is **80 kWh/m2-year.**

WATER PERFORMANCE

A. PRELIMINARY WATER CYCLE DIAGRAM ON-SITE

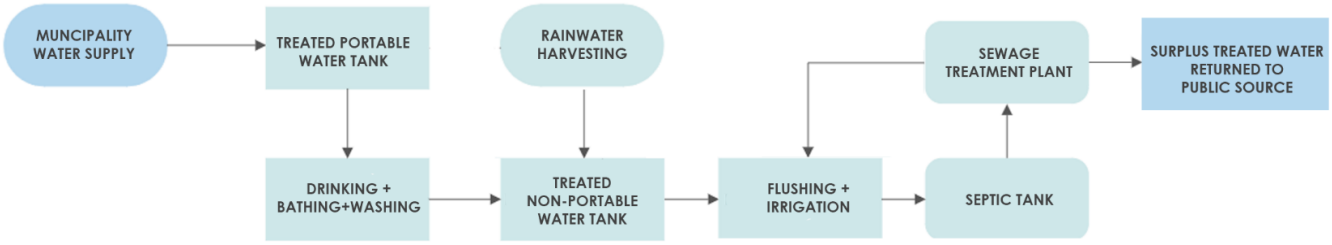


Figure 10: Diagram showing water cycle

B. WATER CONSUMPTION- REDUCE

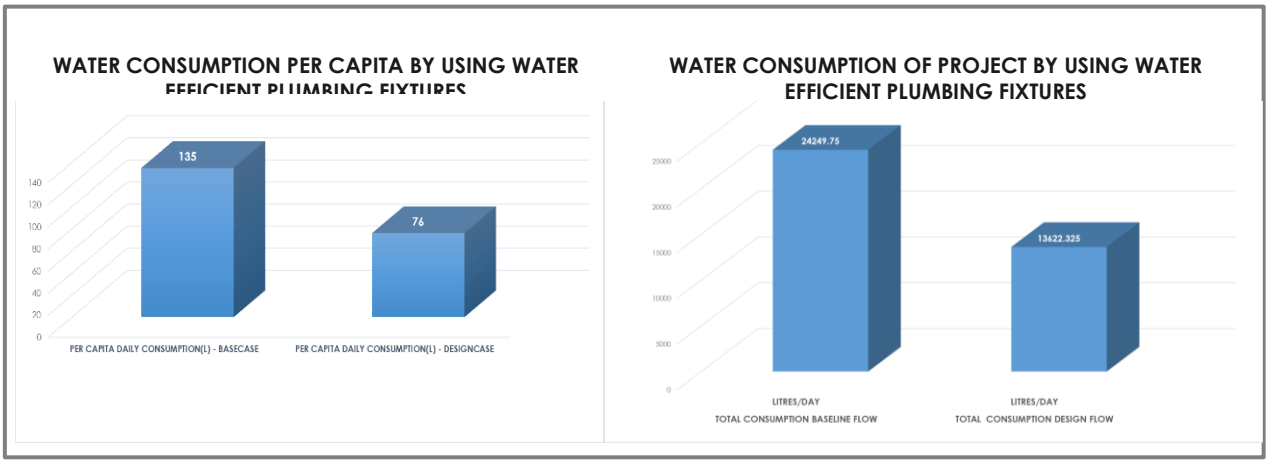
Water Consumption by using Water Efficient Plumbing Fixtures						
		Baseline	Design Case	Duration	Baseline Flow	Design Case Flow
Water Closet (Full Flush) - Baseline	LPF	6	3	1	1341.00	670.50
Water Closet (Half Flush) - Baseline	LPF	3	1	1	2011.50	670.50
Faucets / Taps - Baseline	LPM	6	3.8	0.15	1609.20	1019.16
Health Faucets - Baseline	LPM	6	3.8	0.15	201.15	127.40
Shower	LPM	10	5.8	8	17880.00	10370.40
Kitchen Sink	LPM	6	3.8	0.15	1206.90	764.37
Total Occupants (including visitors)	Numbers	224				
Occupants - Male	Numbers	112				
Occupants - Female	Numbers	112				
Daily Usage		**Men**	**Women**			
Water Closet (Full Flush)	Numbers	1	1			
Water Closet (Half Flush)	Numbers	3	3			
Faucets / Taps	Numbers	8	8			
Health Faucets	Numbers	1	1			
Shower	Numbers	1	1			
Kitchen Sink	Numbers	6	6			
Total Consumption Baseline Flow	**Litres/Day**	**24249.75**				
Total Consumption Design Flow	**Litres/Day**	**13622.33**				
Total Consumption Design Flow	**KL/Year**	**4972.15**				
Total Consumption % savings	**%**	**44**				

Table 1: Water consumption reduction by using water-efficient plumbing fixtures.

Source of baseline LITRES PER FLUSH (LPF) / LITRES PER MINURE (LPF) -

1. National building code of India 2016- vol 2 part 9 - water supply 4.7.3.3
2. Uniform plumbing code – India, 2016

Irresponsible usage of water and overexploitation of groundwater sources has led to water shortage in Mumbai. Therefore, **water consumption is brought down by 44 %.**



WATER-EFFICIENT PLUMBING FIXTURES

Figure 11: Grohe Water Care Tempesta II Showers

New GROHE WaterCare Tempesta II Showers, features a reduced flow rate of only 5.8 l/min. **Kohler kumin kitchen sink cock tap** features a reduced flow rate of only 3.8 l/min.

Figure 12: Kohler Kumin Kitchen sink cock tap

C. RAINWATER HARVEST- RECYCLE

Stage 02 - Calculation of Rainwater Harvesting Potential				
Title	**UoM**	**Number**	**Run off Coefficient**	**Pervious Area**
Cemented/ Tiled Roof (terrace)	sqm	367.60	0.95	349
Flat Vegetation (on Ground - motherearth)	sqm	560.00	0.20	112
Pavement area (Hardscape Area)	sqm	561.70	0.95	534
Vehicular road	sqm	0.00	0.95	0
Total Site Area	sqm	1489.30		995
Total Impervious area Roof	sqm	367.60		883
Total pervious area Non Roof	sqm	1121.70		112
Total Rainwater Harvesting Potential onsite per day	**Cu.m**	**35.71**		

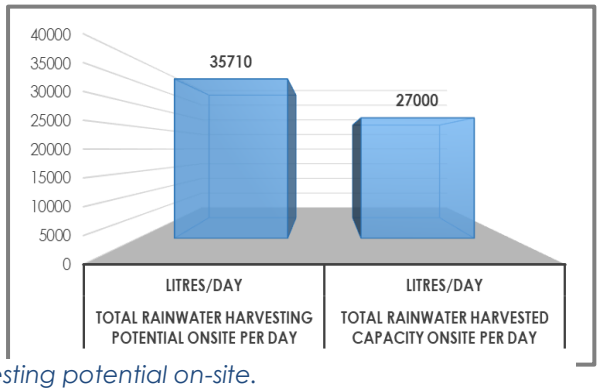


Table 2: Calculating average rainfall & rainwater harvesting potential on-site.

Rainwater potential on-site is around **35710 Liters/day** which is recycled by filtering and **27000 Liters/day** of rainwater is stored in rainwater harvesting tank & reused for flushing and landscaping.

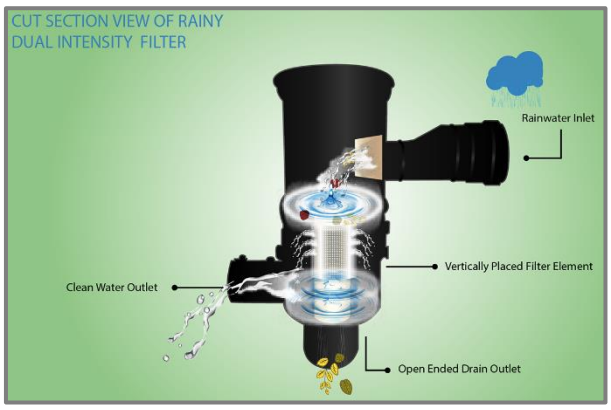
D. WATER TREATMENT – RECYCLE & REUSE

Waste water treatment Reuse & Recycle		
Total Volume of waste water generated	litres/day	**13622**
Flow from flush fixtures (black water)	litres/day	1468
Flow from flow fixtures (grey water)	litres/day	12154
Capacity of Sewage Treatment Plant	litres/day	12000
Percentage	%	88%
Efficiency of STP	%	0.95
Volume of treated waste water available daily	litres/day	**11400**
Percentage	%	**84%**
Available Total Rainwater Harvested onsite	litres/day	**27000.00**
Total Water Recycled onsite in Monsoon days	litres/day	**38400.00**
Total Water Reused onsite daily during Dry days	litres/day	**11400.00**

Application	Vol of water required (ltrs)	Volume of Water Reused			Landscape Water Calculations	
		Treated Waste Water (ltrs)	Surplus Treated Water in dry season	Surplus Treated Water in monsoon season	Landscape area (sq.m)	560.00
Flushing	1468	1468			daily water (ltrs/sq.m/day)	1.20
Landscaping	672	672			Total water daily required (ltrs/day)	672.00
Total	2140.40	2140.40	9260	36260	Annual Requirement (litres/yr)	161280.00
Total volume of water required (for landscaping & flushing)					2140	
Total volume of treated waste water water used (for					2140	
Surplus Treated water returned to the source in dry season					9260	
Surplus Treated water returned to the source in monsoon season					36260	

Table 9: *Calculating Wastewater recycled & reused on-site.*
Table 10: *Calculating Surplus treated water returned to the municipality.*

The main challenge faced in Borivali is the unpredictable water supply systems; they get water for an average of 4 to 6 hours a day. Considering this, we aimed to formulate an integrated water system that is self-sufficient and less dependent on nature. Considering everything, we have proposed the roof of the building and site slopes be a catchment area.

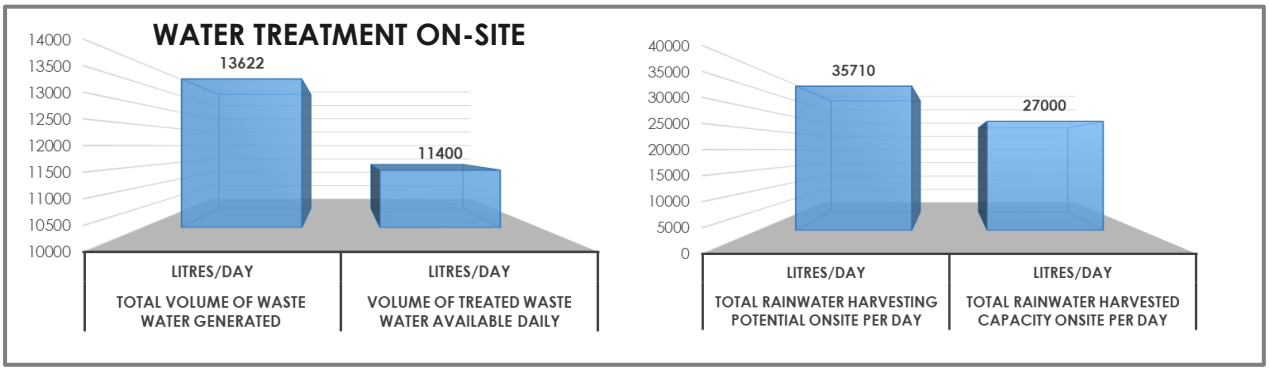


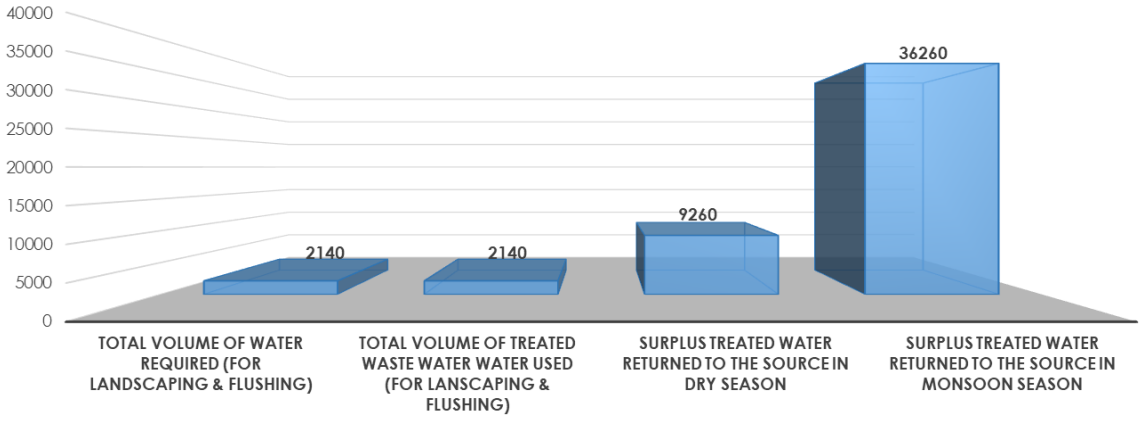
Source- allegianceindia.in/products/rainy-filters-fl-500-/25

Refer Appendix C for detailed calculations.

Rainy FL-500 filtration system is used to remove the dirt and impurities with more than 90% efficiency, making **27000 liters/day of harvested rainwater** suitable to use on monsoon days & further redirected for reuse for domestic purposes like irrigation and flushing.

Additionally, the 13622 liters/day outflow of wastewater in form of grey water and black water is treated in a **sewage treatment plant on site making efficient 11400 liters/day of treated water** available for use in flushing and irrigation purposes in dry days.





ARCHITECTURAL DESIGN

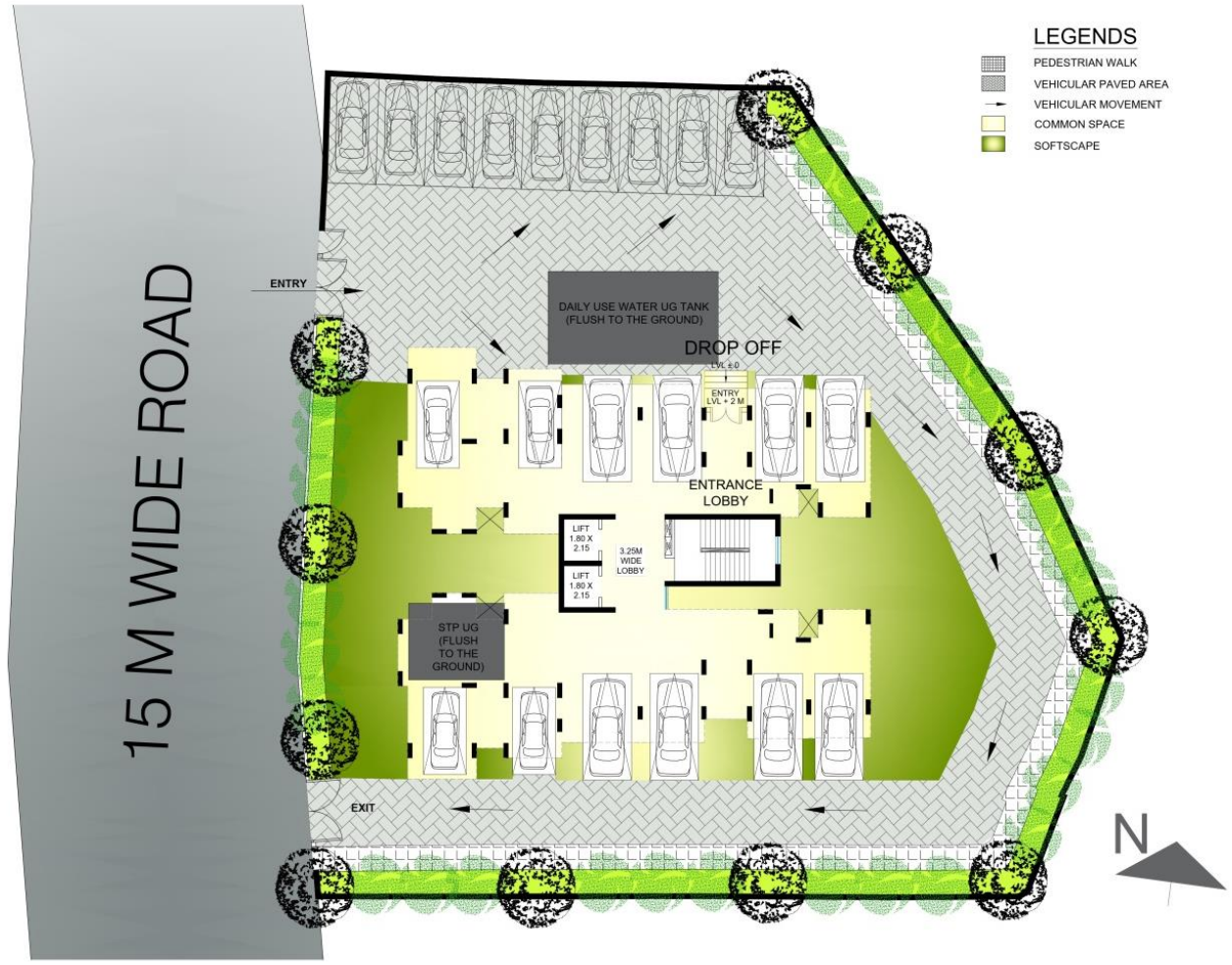


Figure 13: SITE PLAN

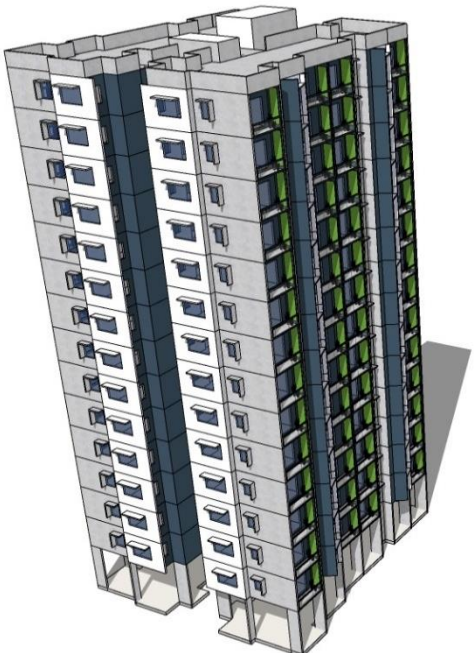


Figure 14: Bird's Eye View

Figure 15: Fenestration design

Figure 16: TYPICAL FLOOR LAYOUT

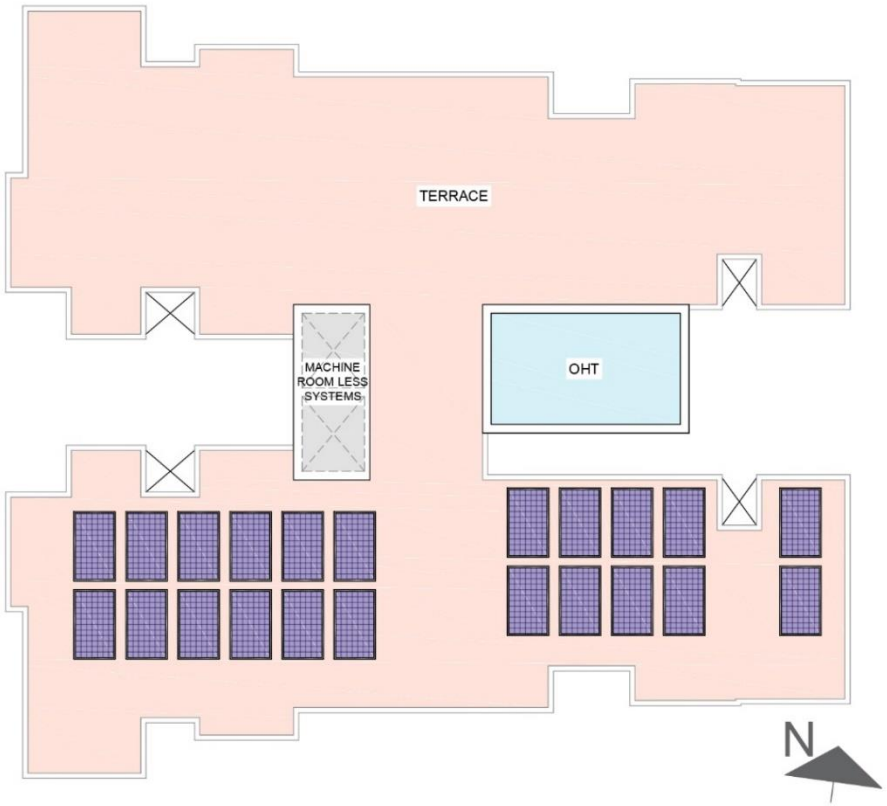


Figure 17: TERRACE FLOOR LAYOUT

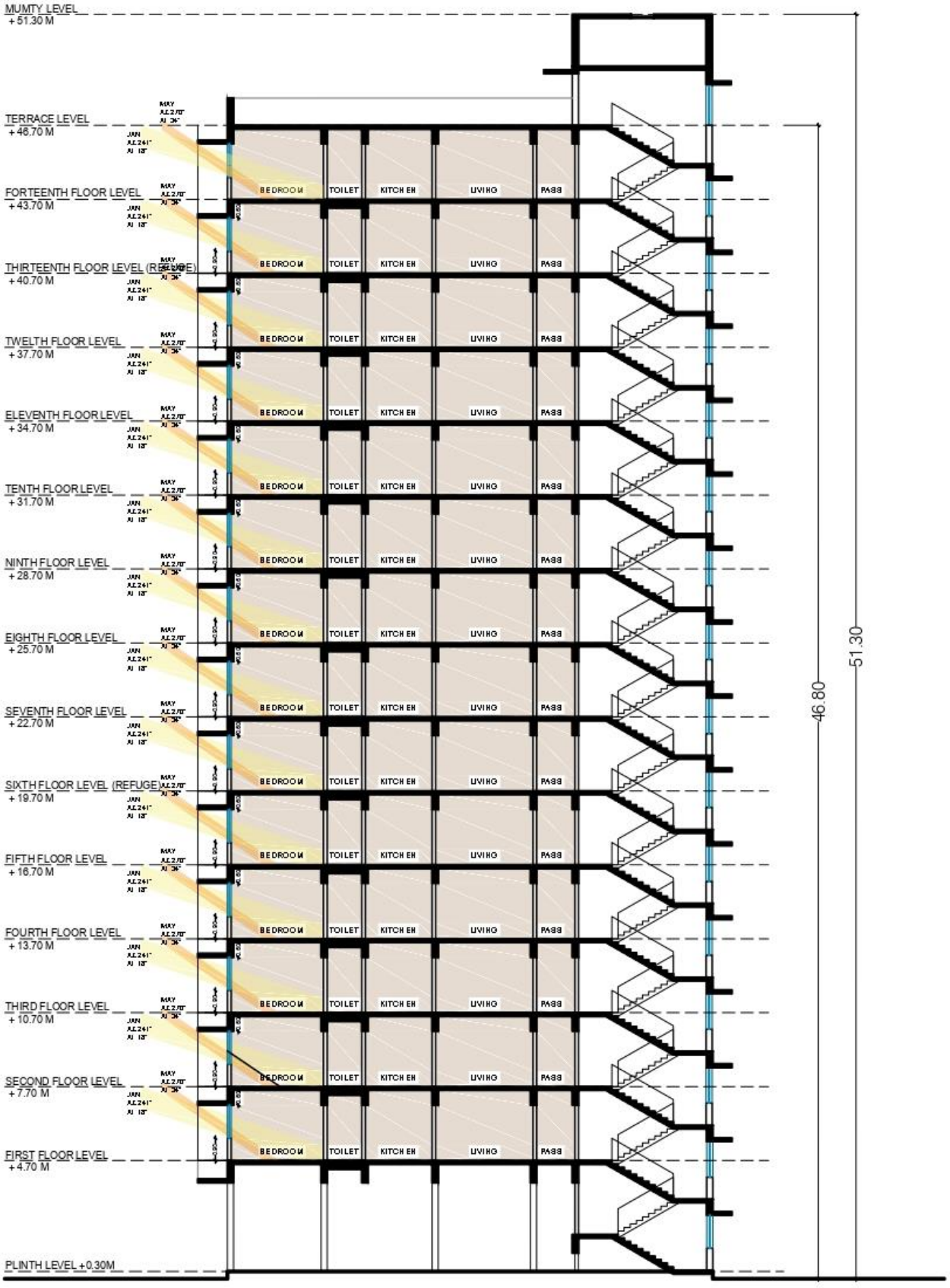


Figure 18: SECTION AA'

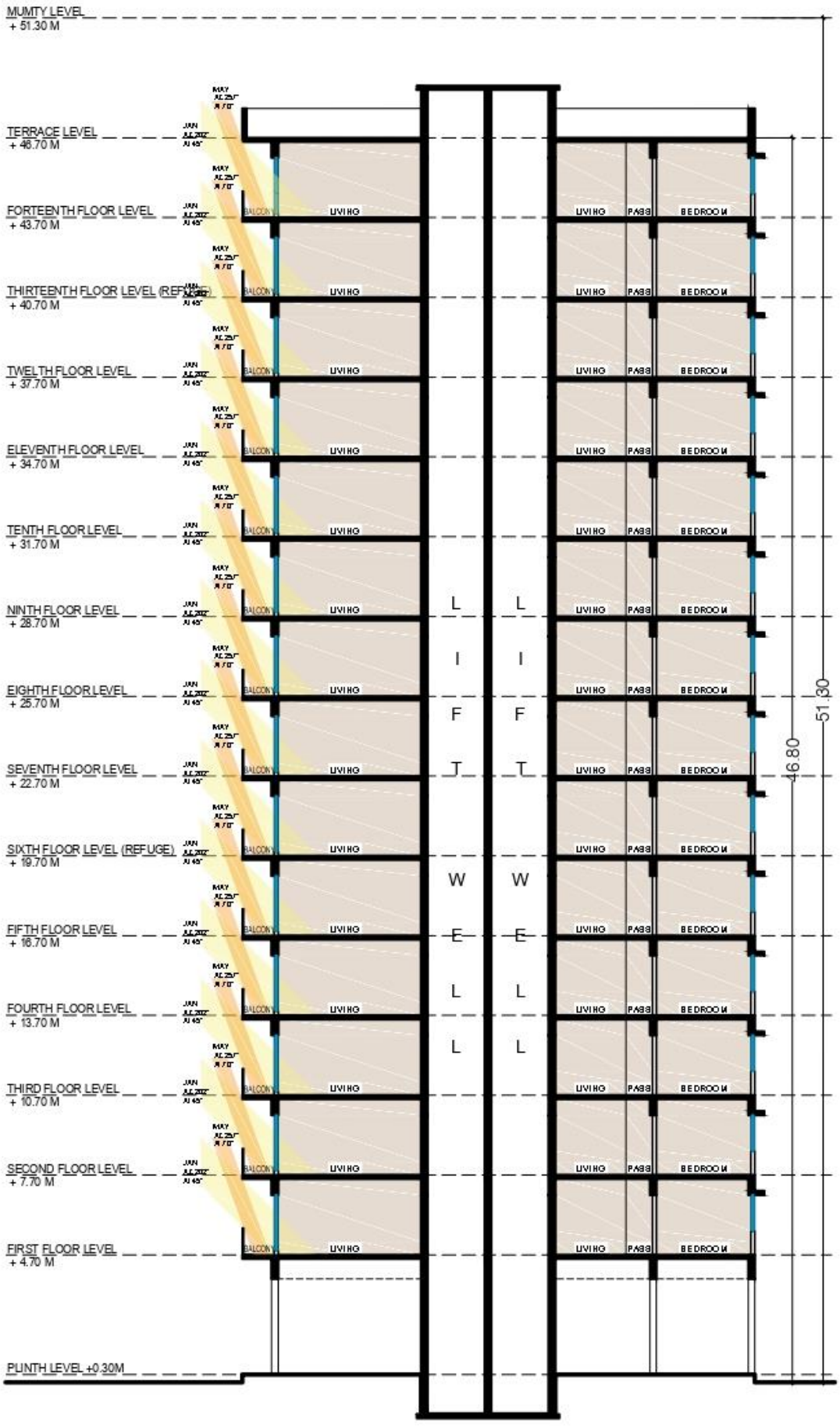


Figure 19: SECTION BB'

EMBODIED CARBON

System	Base case	Material spec.		Proposed case	Material spec.	
	Total carbon emission (tco2e)	**U-value (w/m²*k)**	**Co2 factor (t)**	**Total carbon emission (tco2e)**	**U-value (w/m²*k)**	**Co2 factor (t)**
A. ROOF	**21.69** (Concrete roof slab with no insulation)	3.92	0.9	**3.136** (Green cement with stone wool insulation)	0.83 (Green cement) + 0.038 (Stone wool insulation)	0.072 (Green cement) + 0.74 (Stone wool insulation)
B. WALL	**1.532** (RCC wall + Reinforcement bars)	1.95	O.42 (RCC wall) + 1.5 (Reinforcement bars)	**0.6** (230mm thick AAC block + Reinforcement bars)	0.4	5.2 (AAC wall) + 1.5 (Reinforcement bars)
C. WINDOW	**0.002** (Triple wooden glazing)	U-value = 5.7 SHGC = 0.67	0.052	**0.0004** (Double wooden glazing)	U-value = 1.3 SHGC = 0.3 VLT=60%	0.04
D. FLOOR	**24.78** (RCC Flooring)	1.67	0.9	**1.73** (Green cement)	0.83	0.072 (Green cement)

Refer Appendix E for detailed calculations, sections and values given and their references.

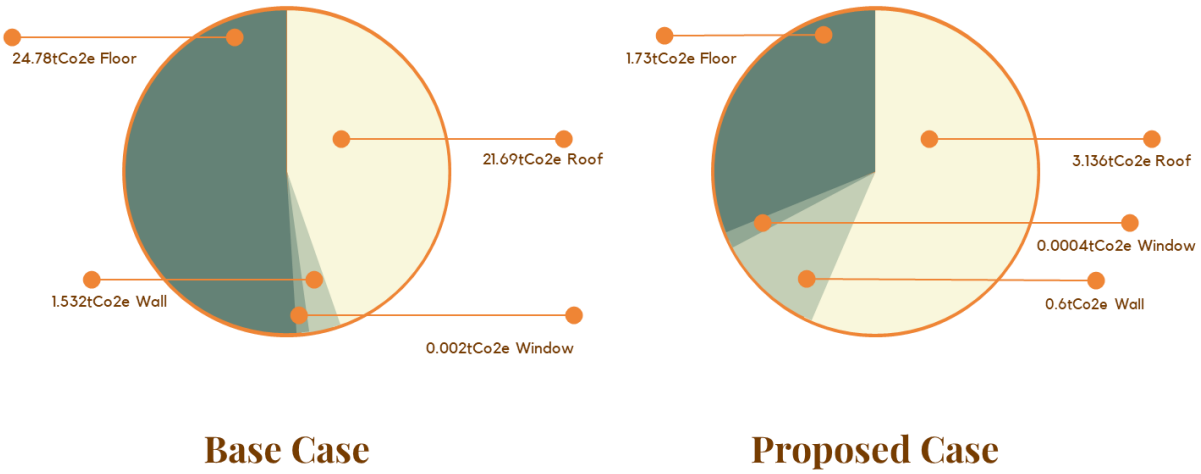


Figure 20: Chart showing total carbon emission from systems used in proposed case compared to base case

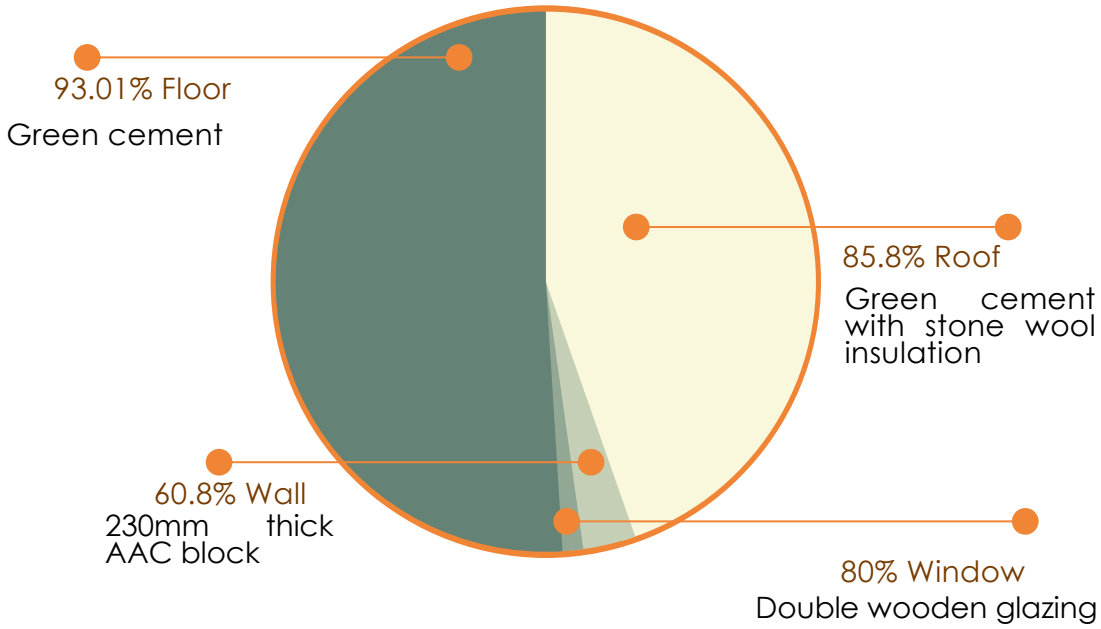


Figure 21: % Reduction achieved in carbon emission from various systems

CONCLUSIONS

A. **ROOF WITH STONE WOOL INSULATION-** the CO_2 emission of green concrete for 80% replacement is 36% less, 70% replacement is 32% less, 60% replacement is 28% less when compared to Normal concrete. So we concluded that 80% replacement is adoptable for the usage as the replacement of the normal concrete since there is less emission of CO2.

B. **WINDOW-** The latest research by Inspired Efficiency, a new energy, sustainability and carbon consultant, and resource-efficiency and footprint expert Circular Ecology shows that triple-glazed windows aren't necessarily the lowest carbon option. Triple glazing have an additional layer of glass, but also a second pocket of gas in between the glazing panes. This results in lower emissions in operation, but comes at the price of increased embodied carbon.

C. **FLOOR-** Rammed Earth is used as flooring. (Refer Appendix)

RESILIENCE

RESILIENCE FOR STRUCTURAL STABILITY

The structure is included with a shear wall system for the core as this system provides adequate stiffness to the structure. built rapidly using the same frame work and at a lower cost. Long columns which act as shear walls are used in between the floor plate without intrusion to maintain the lateral stability.

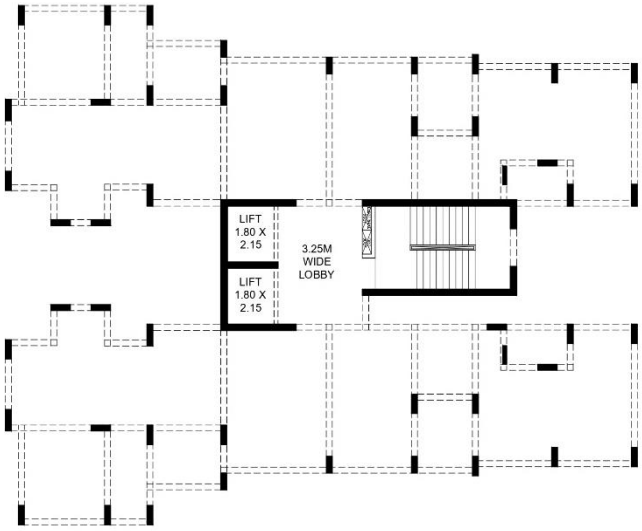


Figure 22: STRUCTURAL PLAN

RESILIENCE FOR FIRE PROTECTION SYSTEMS

- Fire Protection Systems are an integral, essential aspect of residential habitat design. The intricacy of these systems in a high-rise building is exponentially more complex than regular dwellings. The fire safety systems are designed and installed as per the 'National Building Code (NBC) of India, Part – 4, Fire and Life Safety'.
- In accordance with regulatory norms**, MULTI DETECTORS** are placed in every room across the floor plate barring kitchens.
- The core of every floor is provided with early warning fire measures like **HAND-HELD FIRE EXTINGUISHERS AND WATER HOSE REELS**. These extinguishers are recycled every year and the pressure is checked regularly to ensure effective functioning.
- The **AUTOMATED SPRINKLER SYSTEM** is provided in every room which is fed through the pressurized network of pipes.

RESILIENCE FOR HEAT WAVES

SHOCK AND STRESSES

Heat waves begin when high pressure in the atmosphere moves in and pushes warm air towards the ground. Majority of the recreational spaces are protected from these heat waves by the building shade throughout the day creating low pressure in the landscaped area. And the urban heat island effect in the future is reduced by the shaded vegetation area.

POWER FAILURE

Solar PV panels to be installed on site.

WASTE DISPOSAL

Multi-coloured bins for segregating dry & wet waste have been provided for household waste collection which will be delivered to the Material Recovery Facility in nearby vicinity.

FLOODING

To cater the flooding issue, the site has been raised from the road level. In addition to this, plinth of 300mm is proposed to avoid the water retention on the site.

INNOVATION

WASTE COMPOSTER

Excel OWC (Organic Waste Convertor) is an **easy-to-use Decentralized Waste Management System**.

It turns large amounts of organic waste such as kitchen waste, garden waste, food processing waste etc. into compost.

The system is designed to eliminate odour and also to remove the problem of irritants such as flies and rats

- Dimension: **2010 mm x 1485 mm x 1370 mm**
- Batch Size: **120kg**
- Total Connected Load in HP: **13.5HP**
- Dimensions: **2010 mm x 1485 mm x 1370 mm**

ROOM TYPOLOGY	NUMBER OF OCCUPANTS	NUMBER OF DAYS IN A WEEK	TOTAL WASTE GENERATED DAILY	TOTAL WASTE GENERATED DAILY /TYPOLOGY	TOTAL WASTE GENERATED DAILY /FLOOR
2 BHK	4	7	28 KG	56 KG	**98 KG**
3 BHK	5	7	35 KG	42 KG	

TOTAL NUMBER OF FLOORS	TOTAL WASTE GENERATED DAILY /FLOOR	TOTAL WASTE GENERATED DAILY BY THE BUILDING
14	98 KG	**1372 KG**

DAILY TREATMENT CAPACITY OF OCW300	1 BATCH TREATMENT CAPACITY DAILY	TOTAL ENERGY REQUIRED TO RUN 1 BATCH (120KG)
1500 KG	120 KG	**10.0656 kwh (13.5 HP)**

1 horsepower is equal to **0.74569987 kilowatts**

TOTAL NUMBER OF BATCHES REQUIRED DAILY(KG)	TOTAL ENERGY REQUIRED TO RUN 12 BATCHES
1440 KG (12 BATCHES)	**120.672 kwh**

AFFORDABILITY

AAC block: Affordability Features

AAC blocks are also known as **autoclaved aerated concrete blocks**, which are one of the environment friendly and lightweight construction materials.

Color	Greyish-white
Lightweight	50% lighter than red bricks
Fire resistance	Between two and six hours, based on the thickness
Energy efficiency	25% reduction in air-conditioning costs
Thermal efficiency	Three times higher than clay bricks
Water absorption	About 10% of its weight
Sound insulation	42 dB (approximately)
Affordable cost	Nearly one-third of the cost of regular bricks

(Source: https://housing.com/)

The lightweight AAC blocks are easy to transport, which helps to save on the overall logistics and shipping costs, as compared to the costs involved in the transportation of traditional bricks. The material contains small air pockets and hydrogen is used to foam the concrete, thus, giving it an excellent heat insulation property that allows temperatures to be warm in winters and cool in summers. Therefore, it can significantly **lower your air-conditioning costs by about 25%.**

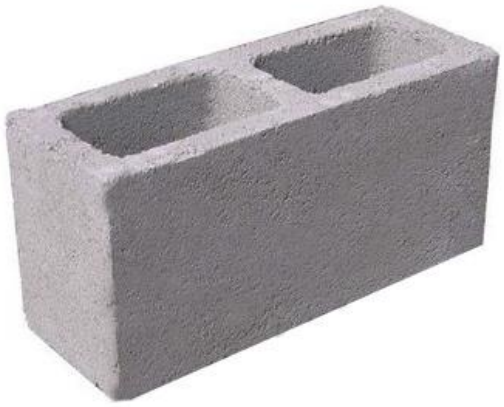


Figure 23: AAC Block

Being lightweight, energy-efficient and easy to install, AAC blocks also **minimize labor costs**. The material is lightweight and thus, contributes less to dead load and the requirement of structural steel can be minimized in RCC framed structures. Therefore, it can save on construction costs, when chosen for high-rise constructions.

Cost of Clay Brick of dimensions 0.23m X 0.11m X 0.07m = **Rs. 5/- (per piece)**

∴ Cost of 1m^3 Clay Brick = Rs. 2823. 26/-

But, cost of 1m^3 of AAC blocks used in our project = Rs. 2000/-

(Source: https://www.indiamart.com/)

Hence approximately Rs. 800/- of building units are saved behind every 1m^3 of construction.

Electricity Cost Savings

Total Generation/ Day	Cost/ 1kW	Savings/ Day
534kW	Rs. 11/-	Rs. 5784/-

Water Savings

Water Saved/ Day	Water Reused/ Day	Water Harvested/ Day
44%	11400 liter/day	35.71 cu.m

Cost-benefit analysis for materials used as per proposed case

	Wall System	Roof System	Window System	Flooring System
Base Case	230 mm thick RCC Wall U value= 1.4 W/m²K Carbon Factor: 0.42t Embodied Carbon: 1.14 tco2e Rate: Rs. 186/- per cu. ft.	Concrete roof slab with no insulation U value= 1.67 to 0.83 W/m²K Carbon Factor: 0.9t Embodied carbon: 21.69 tco2e Rate: Rs. 255/- per cu. ft.	Triple Wooden glazed window (6mm thick window glass + 28mm thick window frame) U value= 0.8 W/m²K Carbon Factor: 0.052t Embodied Carbon: 0.002 tco2e Rate: Rs. 165/- per sq. ft.	RCC Flooring U value= 0.8 W/m²K Carbon Factor: 0.9t Embodied Carbon: 24.78 tco2e Rate: Rs. 180-200/- per sq. ft.
Proposed Case	**230 mm thick AAC Block** U value= 0.7 W/m²K Carbon Factor: 5.2t – 5.9t Embodied Carbon: 0.6 tco2e Rate: Rs. 54/- per cu. Ft.	**Green concrete roof slab with Stone Wool Insulation** U value= 0.038 W/m²K Carbon Factor: 0.072t Embodied Carbon: 1.73 tco2e Rate: Rs. 90/- per cu. Ft.	**Double Wooden glazed window (4mm thick window glass + 10mm thick window frame)** U value= 2.6 W/m²K Carbon Factor: 0.04t Embodied Carbon: 0.0004 tco2e Rate: Rs. 105/- per sq. ft.	**Green Concrete Roof slab** U value= 0.16 W/m²K Carbon Factor: 0.072t Embodied Carbon: 1.73 tco2e Rate: Rs. 130/- per sq. ft.
Cost reduced by	**71%**	**65%**	**36%**	**32%**

HEALTH AND WELL-BEING

The design of our built environment affects our health and well-being, and can have long-term implications for quality of life. To truly enhance human well-being, building design needs to move beyond optimizing single parameters such as temperature and humidity, to more holistic approaches that take their cues in health-supporting human behaviors.

Our aim was to enrich the lifestyle of residents by providing an environment that is comfortable for its occupants through following strategies:

THERMAL COMFORT

Due to the orientation and placement of the windows on the plan, there is smooth circulation of wind due to cross ventilation resulting in cooling down the interior temperature of the flats thereby ensuring thermal comfort of the users.

Note: Ensuring that minimum 25% of the regularly occupied spaces (by area) in each dwelling unit shall have an opening (doors/ ventilators/ windows) to the outdoor environment, in at least two of the orientations, better option has been analyzed below.

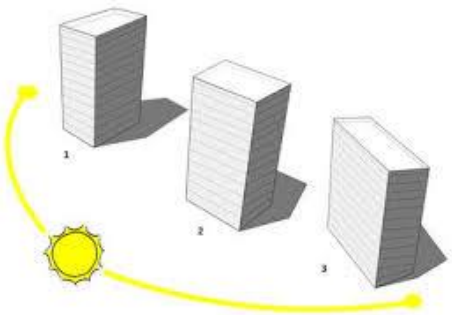


Figure 24: Analysing better orientation options of building

VENTILATION DESIGN

Since Mumbai has a Warm and Humid climate, every room has been designed with openings on two sides. This will promote **cross ventilation** and provide thermal comfort. Wind circulation through the building is proposed by designing openings in the core.

Shafts are proposed adjacent to two rooms with openings close to beam level. This ensures flow of warm air from the rooms to the shaft.

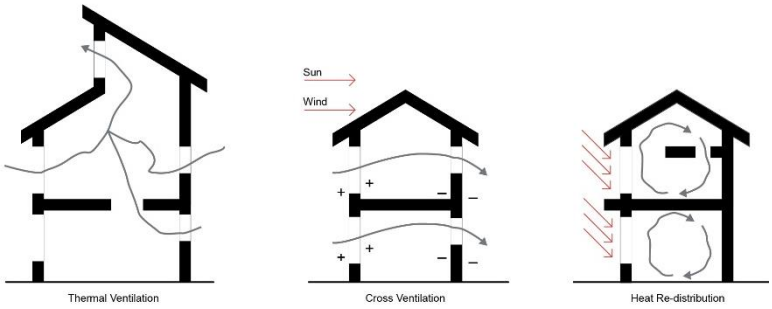


Figure 25: Analysing thermal comfort options through sketches

ADEQUATE DAYLIGHTING

Design habitable spaces to have access to natural daylight, thereby enhancing the quality of life of the occupants achieve minimum glazing factors at least 50% of the regularly occupied spaces in each dwelling unit.

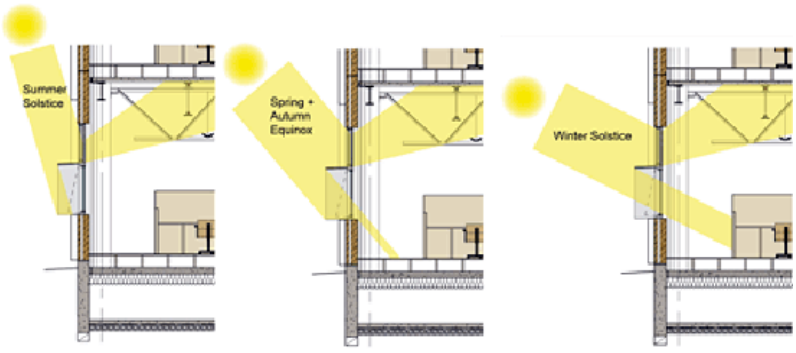
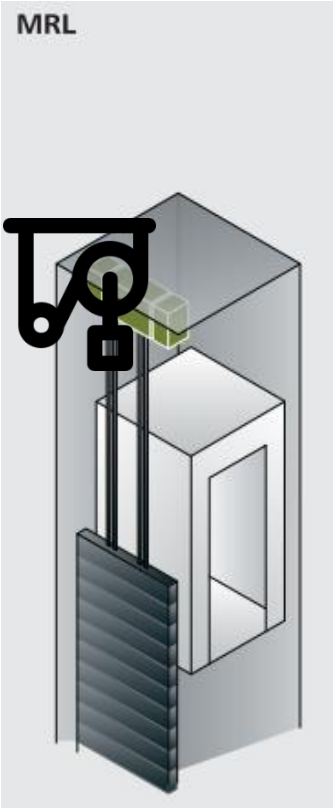


Figure 26: Seasonal performance of shading, redirection devices.

ENGINEERING AND OPERATIONS

1.LIFT SYSTEMS

We are inculcating **SCHINDLER 550 MRL** lift systems which is an energy efficient alternative that provides us with a feature of machine room less elevator design. It not only saves the space on the rooftop but also is cost effective, making it a very feasible option for residential buildings that may be struggling with space when it comes to an elevator installation. Hence, MRL elevators can be a popular choice amongst the property owners that have a strict budget.



LED lights have an extremely long service life. They last up to **20 times longer** than standard light bulbs while consuming less energy. A bright solution for passengers and the environment.

This lift system incorporates high-efficiency regenerative drives which use about **30% less energy** than comparable elevators. The drives are even able to produce energy that can be fed back into the electricity grid immediately.

The motor and traction media developments allow travel heights of up to 150 meters and speeds of up to **3 m/s** while keeping **noise and vibration levels low** and assuring a smooth ride.

2.WATER PUMPING SYSTEM

KBL (KIRLOSKAR BROTHERS LIMITED) has received Star rating from the Bureau of Energy Efficiency (BEE) for 26 models of their submersible pump-sets. This pumping system is capable of pumping water efficiently to each apartment of a highrise building. It gets water supply from the nearby municipal corporation line.

Refer the details in the appendix C attached at the end.

3. SEWAGE TREATMENT SYSTEM

Sewage treatment is a type of wastewater treatment which aims to remove contaminants from sewage generated from the apartments in order to produce an effluent that is suitable for discharge to the surrounding site environment present underground through an outlet.

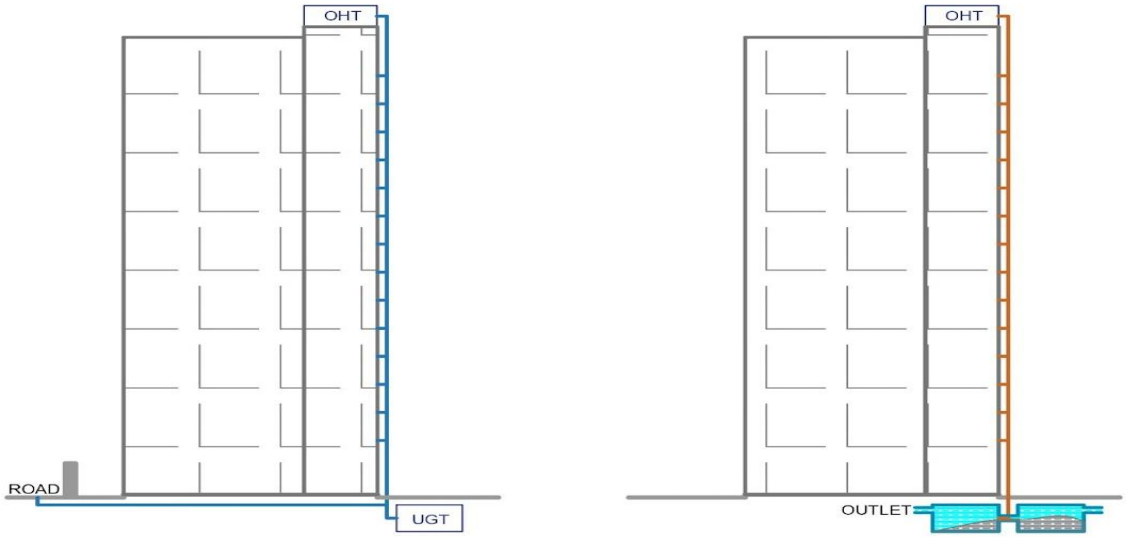


Figure 27: SCHEMATIC REPRESENTATIONS FOR PUMPING & SEWAGE TREATMENT SYSTEMS

VALUE PROPOSITION

The multidisciplinary team GET THEM GREEN from D Y PATIL University has partnered with the **C H Patil & Sons** to **redevelop** a **5131.00 sq.m residential complex in Borivali of 38 tenements**. **Situated in the northern part of Mumbai,** Borivali West is a developed residential suburb that majorly caters to the upper-mid segment. Borivali is one of the topmost developing localities with connectivity to the Western Express Highway and good infrastructure facilities such as commercial complexes, schools, and colleges hence attracting a range of tenants- from single, working occupants to expanding families.

The concept included **optimizing saleable area** and **effectively using common areas**, **preventing space wasting**, in order to produce **adaptive, flexible dwelling layouts** that **optimized FSI consumption**. In addition, Team Get Them Green worked to uphold the **social, ecological, and financial pillars of sustainability**.

The pre-existing site includes 4 stories residential building block which would be redeveloped with **60% additional FSI** and **14 saleable flats** and **38 rehoused flats**. Reduced material requirements and rapid construction make it financially and ecologically viable. One of the goals was to make it a **zero-maintenance society. Considering inferences from pre-design analysis**, modules are arranged in a spacious manner that aids in self-shading thus reducing cooling loads. The building design is focused on **reducing cooling loads**, and **allowing natural daylight** to shallow plans **filtering solar radiation**. The **roof and south façade are passively treated** due to maximum solar incident radiation. **To increase resilience** for structural stability, **a shear wall is used to construct the lift core walls** which allows the structure to be built rapidly using the same framework and **at a lower cost**.

Irresponsible usage of water and overexploitation of groundwater sources has led to water shortage in Mumbai. Therefore, **water consumption is brought down by 44%**. Rainwater collected on-site at around **35.71 KLD,** will be filtered and reused for domestic purposes **for irrigation and flushing to the rainwater harvesting tank.**

Furthermore, focus on biodiversity through the **use of native plants, landscaping strategies, green walls, and terrace farming intern** increase the thermal comfort of the building. For these reasons, the **target is to reduce the EPI of 60 kWH/m2/year by 20%.**

APPENDIX A

PARKING STATEMENT

CARPET AREA (SQ.M)	NO. OF FLATS	PARKING PERMISSIBLE AS PER DCPR 2034	PARKING REQUIRED
UPTO 45.OO	0.00	1 PARKING FOR 4 FLATS	0.00
45.00 - 60.00	0.00	1 PARKING FOR 2 FLATS	0.00
60.00 - 90.00	26.00	1 PARKING FOR 1 FLATS	26.00
ABOVE 90.00	0.00	2 PARKING FOR 1 FLATS	0.00
		TOTAL PARKING	26.00
		10% VISITOR	2.6
		TOTAL PARKING REQUIRED	28.60
		SAY.	29
		TOTAL PARKING PROPOSED	**30.00**
		NO OF BIG CARS PROPOSED	**26.00**
		NO OF SMALL CARS PROPOSED	**4.00**

PARKING SYSTEMS

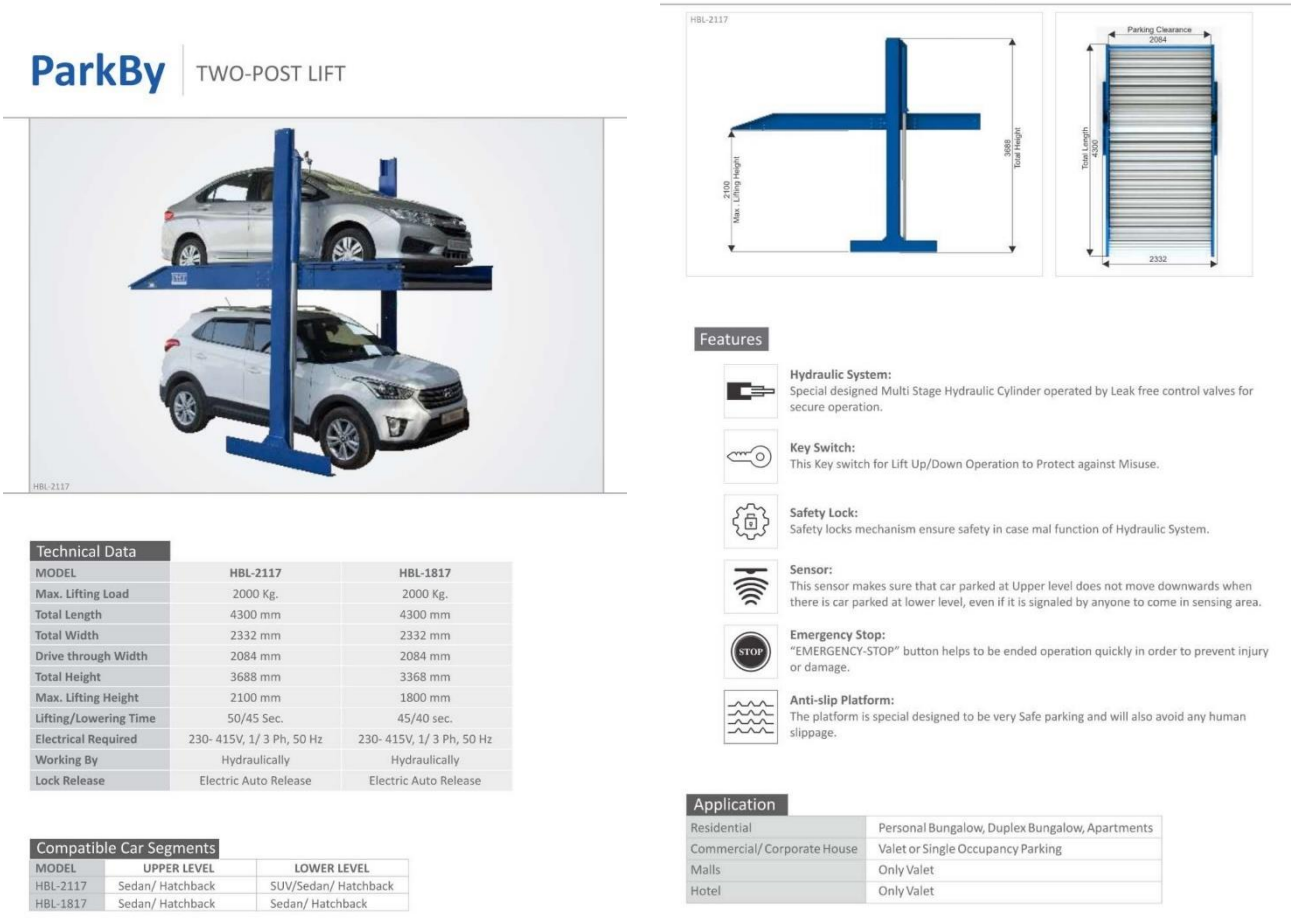
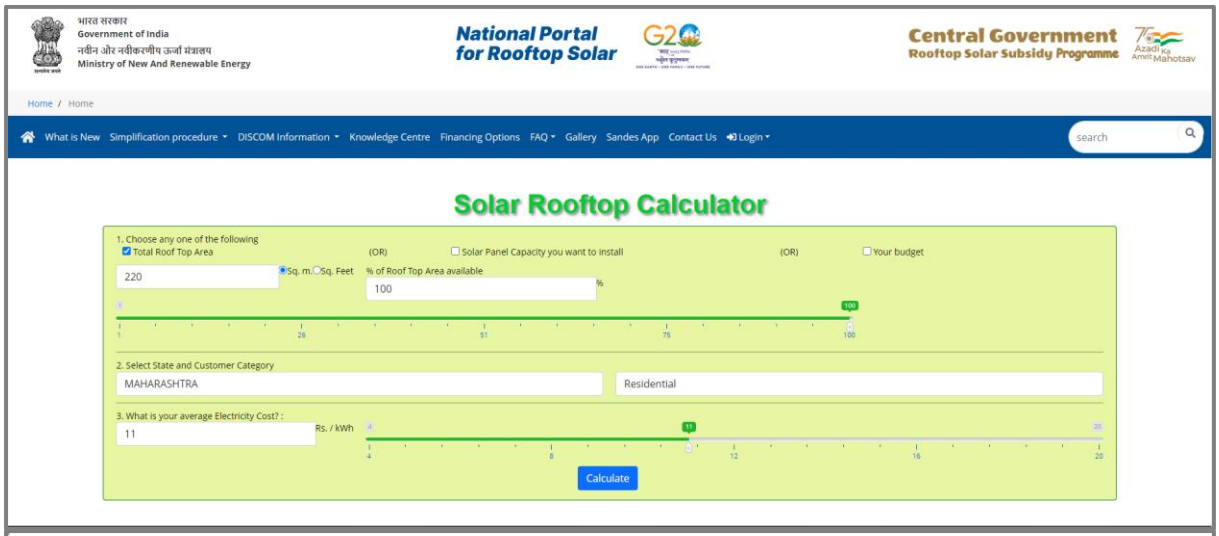
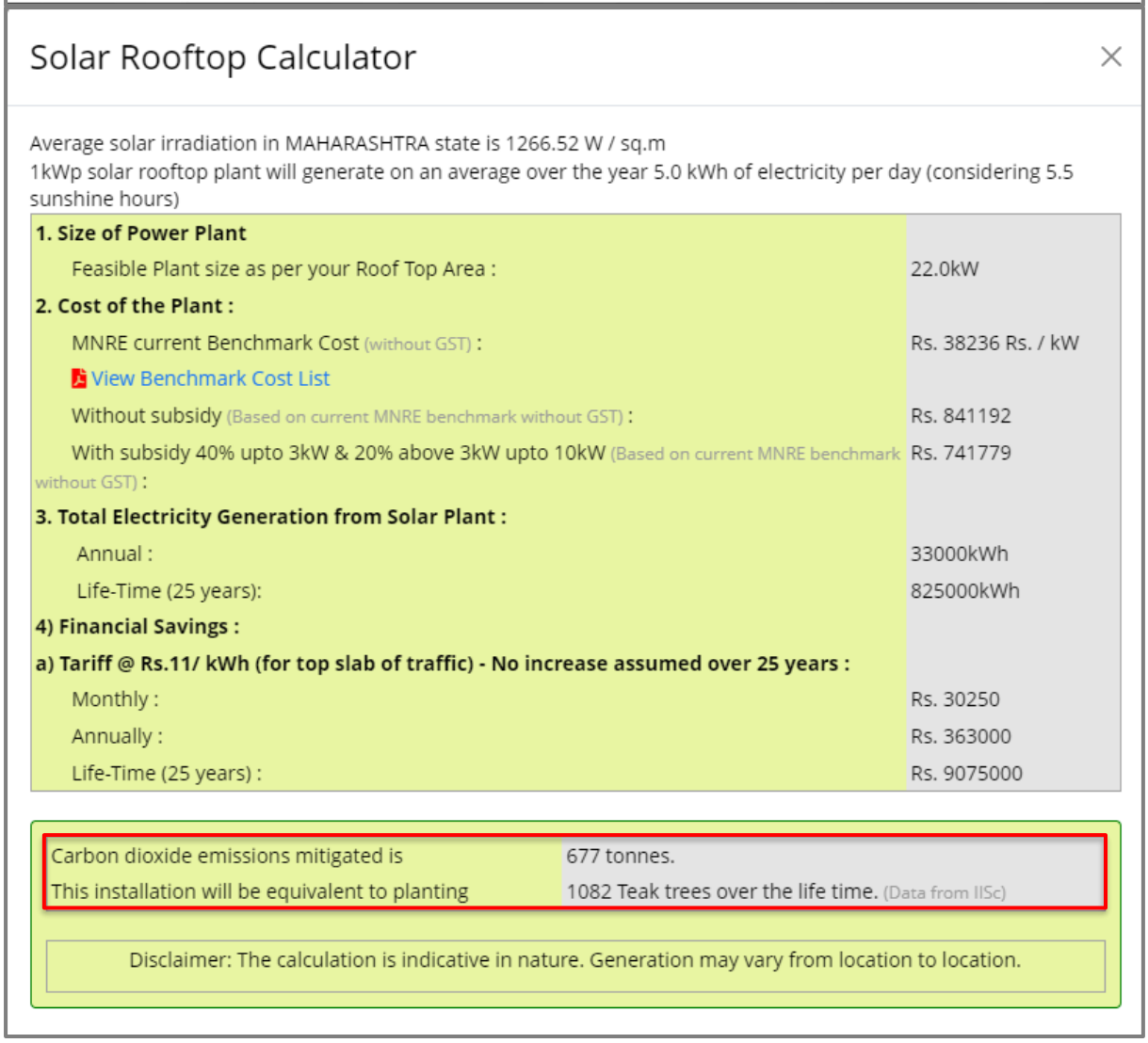


Figure 4 Parking solutions

APPENDIX B

SOLAR CALCULATIONS





Solar Rooftop Calculator

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

1. Size of Power Plant	
Feasible Plant size as per your Roof Top Area :	22.0kW
2. Cost of the Plant :	
MNRE current Benchmark Cost (without GST) :	Rs. 38236 Rs. / kW
View Benchmark Cost List	
Without subsidy (Based on current MNRE benchmark without GST) :	Rs. 841192
With subsidy 40% upto 3kW & 20% above 3kW upto 10kW (Based on current MNRE benchmark without GST) :	Rs. 741779
3. Total Electricity Generation from Solar Plant :	
Annual :	33000kWh
Life-Time (25 years):	825000kWh
4) Financial Savings :	
a) Tariff @ Rs.11/ kWh (for top slab of traffic) - No increase assumed over 25 years :	
Monthly :	Rs. 30250
Annually :	Rs. 363000
Life-Time (25 years) :	Rs. 9075000

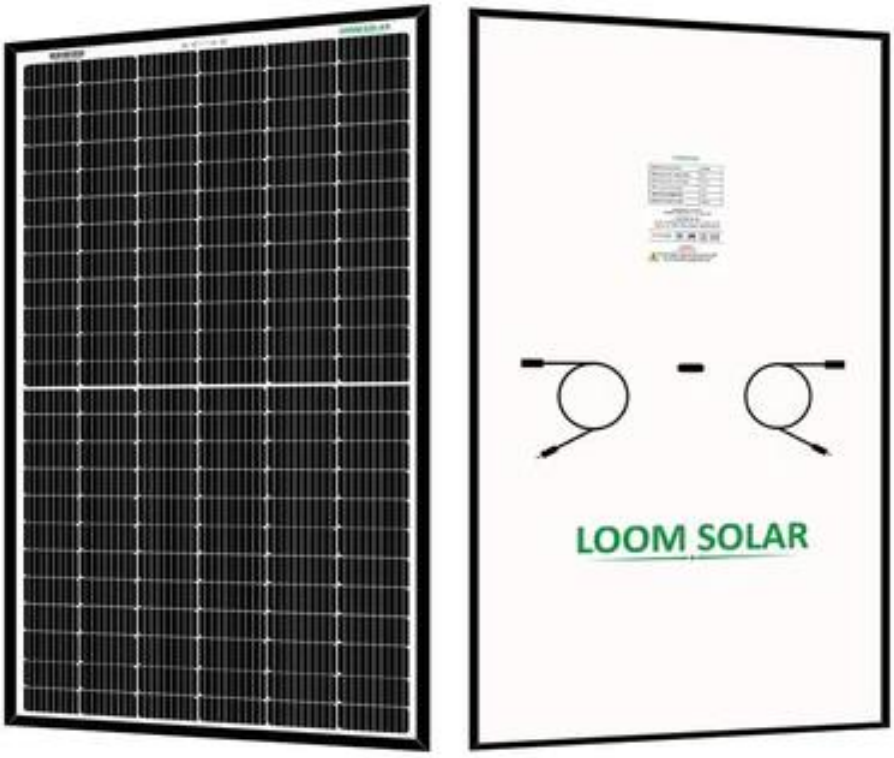
Carbon dioxide emissions mitigated is	677 tonnes.
This installation will be equivalent to planting	1082 Teak trees over the life time. (Data from IISc)

Disclaimer: The calculation is indicative in nature. Generation may vary from location to location.

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

SOLAR PANEL DESCRIPTION:

Loom Solar Panel - Shark 445 - Mono Perc, 144 Cells, Half Cut



Technical

wattage (WP)	445 Watts
voltage at Max Power	42 Volts
current at max power	10.5amps
open circuit voltage	49 volts
short circuit current	11 amps
number of cells	144

Descriptions

Brand	Loom Solar
Output Power	445 Watts
Space Requirement	24 sq. feet
Operating Voltage	24 Volt
Panel Technology	Mono Perc
Manufacturer warranty	10 year on manufacturing defects
Performance Warranty	25 Years
Additional Features 1	6th Generation Monocrystalline Solar Cell (PID FREE) from Germany
Additional Features 2	Cell Conversion efficiency > 22%
Additional Features 3	Compliance with IEC standards

APPENDIX C

Water Calculations:
WATER CONSUMPTION, WASTEWATER TREATMENT & RAINWATER HARVEST

WATER CONSUMPTION- REDUCE

Water Consumption by using Water Efficient Plumbing Fixtures						
		Baseline	Design Case	Duration	Baseline Flow	Design Case Flow
Water Closet (Full Flush) - Baseline	LPF	6	3	1	1341.00	670.50
Water Closet (Half Flush) - Baseline	LPF	3	1	1	2011.50	670.50
Faucets / Taps - Baseline	LPM	6	3.8	0.15	1609.20	1019.16
Health Faucets - Baseline	LPM	6	3.8	0.15	201.15	127.40
Shower	LPM	10	5.8	8	17880.00	10370.40
Kitchen Sink	LPM	6	3.8	0.15	1206.90	764.37
Total Occupants (including visitors)	Numbers	224				
Occupants - Male	Numbers	112				
Occupants - Female	Numbers	112				
Daily Usage		**Men**	**Women**			
Water Closet (Full Flush)	Numbers	1	1			
Water Closet (Half Flush)	Numbers	3	3			
Faucets / Taps	Numbers	8	8			
Health Faucets	Numbers	1	1			
Shower	Numbers	1	1			
Kitchen Sink	Numbers	6	6			
Total Consumption Baseline Flow	**Litres/Day**	**24249.75**				
Total Consumption Design Flow	**Litres/Day**	**13622.33**				
Total Consumption Design Flow	**KL/Year**	**4972.15**				
Total Consumption % savings	**%**	**44**				

Source of baseline lpm/lpf -

1. National building code of India 2016- vol 2 part 9 - water supply 4.7.3.3
2. Uniform plumbing code – India, 2016

Table 7: *Water consumption reduction by using water-efficient plumbing fixtures.*

Irresponsible usage of water and overexploitation of groundwater sources has led to water shortage in Mumbai. Therefore, as per the National building code 2016, Standard fresh **water consumption demand is brought down by 44 %.**

C. RAINWATER HARVEST- RECYCLE

Rain Water Harvesting Roof & Non Roof		
Stage 01 - Calculation of Daily Rainfall		
Titles	UoM	Qty
Peak Month Rainfall, July 2016	mm	926.0
Peak Month Rainfall, Aug 2017	mm	950.3
Peak Month Rainfall, July 2018	mm	1138.8
Peak Month Rainfall, July 2019	mm	1464.8
Peak Month Rainfall, July 2020	mm	1502.6
Total Rainfall in last 5 years	mm	5982.5
Average Peak Month Rainfall in 5 yea	mm	**1196.5**
	m	**1.1965**
One Day Rainfall (3 % of Average Peak Month Rainfall)	m	**0.036**
Average Normal One Day Rainfall	**m**	**0.036**

Stage 02 - Calculation of Rainwater Harvesting Potential				
Title	**UoM**	**Number**	**Run off Coefficient**	**Pervious Area**
Cemented/ Tiled Roof (terrace)	sqm	367.60	0.95	349
Flat Vegetation (on Ground - motherearth)	sqm	560.00	0.20	112
Pavement area (Hardscape Area)	sqm	561.70	0.95	534
Vehicular road	sqm	0.00	0.95	0
Total Site Area	sqm	1489.30		995
Total Impervious area Roof	sqm	367.60		883
Total pervious area Non Roof	sqm	1121.70		112
Total Rainwater Harvesting Potential onsite per day	**Cu.m**	**35.71**		

Table 8: *Calculating average rainfall & Rainwater harvesting potential on-site.*

Stage 1: Data is collected from Customized Rainfall Information System (CRIS), Hydromet Division, IMD for the peak month rainfall in the last 5 years.
Stage 2: Rainwater potential on-site is around **35710 Liters/day** which is recycled by filtering and **27000 Liters/day** of rainwater is stored & reused for domestic purposes like flushing and irrigation.

C. WATER TREATMENT – RECYCLE & REUSE

Daily Out Flow		
Flow from flush fixtures (black water)	3554	1468
Flow from flow fixtures (grey water)	20696	12154
Annual Out Flow		
Annual Flow from fixtures (black water)	1297082	535964
Annual Flow from fixtures (grey water)	7554077	4436184
Annual flow from fixtures (black & grey water)	**8851159**	**4972149**

Waste water treatment Reuse & Recycle		
Total Volume of waste water generated	litres/day	**13622**
Flow from flush fixtures (black water)	litres/day	1468
Flow from flow fixtures (grey water)	litres/day	12154
Capacity of Sewage Treatment Plant	litres/day	12000
Percentage	%	88%
Efficiency of STP	%	0.95
Volume of treated waste water available daily	litres/day	**11400**
Percentage	**%**	**84%**
Available Total Rainwater Harvested onsite	litres/day	**27000.00**
Total Water Recycled onsite in Monsoon days	litres/day	**38400.00**
Total Water Reused onsite daily during Dry days	litres/day	**11400.00**

Table 9: *Calculating Wastewater recycled & reused on-site.(LEFT)*

Rain water harvesting tank	UoM	Number
Length of tank	m	3.00
Depth of tank	m	1.50
Width of tank	m	3.00
Volume of tank	cu.m	13.50
No of tanks	no.s	2.00
Total Volume of RHW Tank	**cu.m**	**27.00**
Total Rainwater harvesting executed on site	**%**	**76%**

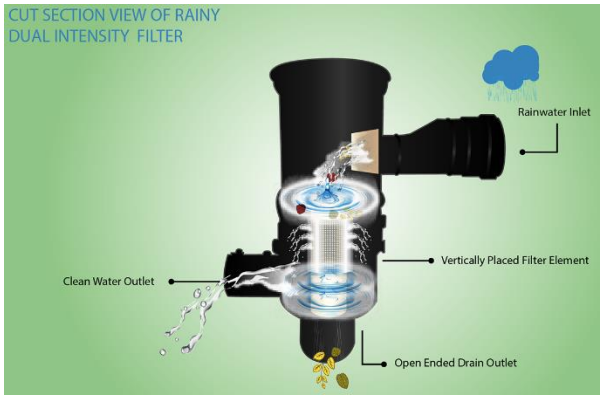
Table 10: *Calculating RHW Tank Capacity. (RIGHT)*

Application	Vol of water required (ltrs)	Volume of Water Reused			Landscape Water Calculations	
		Treated Waste Water (ltrs)	Surplus Treated Water in dry season	Surplus Treated Water in monsoon season		
Flushing	1468	1468			**Landscape area(sq.m)**	**560.00**
Landscaping	672	672			**daily water (ltrs/sq.m/day)**	**1.20**
Total	**2140.40**	**2140.40**	**9260**	**36260**	**Total water daily required (ltrs/day)**	**672.00**
					Annual Requirement (litres/yr)	**161280.00**
Total volume of water required (for landscaping & flushing)					**2140**	
Total volume of treated waste water water used (for					**2140**	
Surplus Treated water returned to the source in dry season					**9260**	
Surplus Treated water returned to the source in monsoon season					**36260**	

Table 11: *Calculating Surplus treated water returned to the municipality.*

The main challenge faced in Borivali is the unpredictable water supply systems, they get water for an average of 4 to 6 hours a day. Considering this, we aimed to formulate an integrated water system that is self-sufficient and less dependent on nature. Considering everything, we have proposed the roof of the building and site slopes be a catchment area.

Rainy FL-500 filtration system is used to remove the dirt and impurities with more than 90% efficiency, making **27000 litres/day of harvested rainwater** suitable to use on monsoon days & further redirected for reuse for domestic purposes like irrigation and flushing.



Source- allegianceindia.in/products/rainy-filters-fl-500-/25

Additionally, the 13622 liters/day outflow of wastewater in form of grey water and black water is treated in a **sewage treatment plant on site making efficient 11400 litres/day of treated water** available for use in flushing and irrigation purposes in dry days.

REFERENCES-

1. https://igbc.in/igbc/redirectHtml.htm?redVal=showGreenHomesnosign
2. Uniform Plumbing Code – India, 2016
3. http://www.imd.gov.in
4. http://nwm.gov.in/sites/default/files/1.%20National-water-mission-%20%20%20water-use-efficiency.pdf
5. https://www.grihaindia.org/sva-griha
6. allegianceindia.in/products/rainy-filters-fl-500-/25

APPENDIX D

INPUT OUTPUT PARAMETERS FOR SIMUATION

Input Parameters	Units	Proposed Design Values
General		
Building Area	m^2	5131.00 sq.m
Conditioned Area	m^2	NA
Electricity Rate	INR/kWh	5.55
Natural Gas Rate	INR/GJ	NA
Building Occupancy Hours	-	24 hours
Average Occupant Density	m^2 / person	260 /5131 = 0.05
Internal Loads		
Interior Average Lighting Power Density	W/m^2	7.5 (as per SvaGriha)
List of Lighting Controls	-	-
Average Equipment Power Density	W/m^2	11
Minimum OA Ventilation (Building Average)	$l/sec.m^2$	1.5
Envelope		
Roof Assembly U value	$W/m^2.K$	0.8
Roof Assembly SRI	-	102 (PANACHE COOL TOP ECO)
Average Wall Assembly U value	$W/m^2.K$	0.4
Window to Wall Area Ratio (WWR)	%	24.24
Windows U value	$W/m^2.K$	1.3
Windows SHGC	-	0.3
Windows VLT	%	60
Infiltration Rate	ac/h	0.70
Describe Exterior Shading Devices	-	Chajja (0.45m), Louvers (6no.s with 0.2m width at 15degree), Side fins (0.3m)

HVAC System		
HVAC System Type and Description	NA	NA
Describe Mixed mode strategy in operation/controls of AC and windows	-	-
Heating Source	-	-
Heating Capacity	-	-
Heating COP	-	-
Cooling Source	-	-
Cooling Capacity	-	-
Cooling COP	-	1.50
Operation Hours	-	8
Heating Set Point	-	-
Cooling Set Point	-	-
Relative Humidity Setpoint	-	-

Service Hot Water		
SHW Type and Description	-	-

Output Parameters	Units	Proposed Design Values
Proposed EUI (Total)	kWh/m²/ yr	151.48
EUI Breakdown by End Use		
Heating	kWh/m²/ yr	NA
Cooling	kWh/m²/ yr	NA
Fans	kWh/m²/ yr	NA
Pumps	kWh/m²/ yr	0.05
Heat Rejection	kWh/m²/ yr	NA
Service Hot Water	kWh/m²/ yr	NA
Lighting	kWh/m²/ yr	23.26
Equipment	kWh/m²/ yr	17.26
Total Envelope Heat Gain (Peak)	W/m²	-
Cooling Load of Conditioned Area	SF/ Tr	-
Building Electric (Peak)	W/m²	-
Annual Operating Energy Cost	INR/m²	-
Annual Unmet Hours	-	4530
Cooling Capacity	-	NA
Annual Hours of Comfort without Air Conditioning	-	4230

REFERENCES FOR WATER PERFORMANCE CALCULATIONS

1. allegianceindia.in/products/rainy-filters-fl-500-/25
2. https://igbc.in/igbc/redirectHtml.htm?redVal=showGreenHomesnosign
3. Uniform Plumbing Code – India, 2016
4. http://www.imd.gov.in
5. http://nwm.gov.in/sites/default/files/1.%20National-water-mission-%20%20%20water-use-efficiency.pdf
6. https://www.grihaindia.org/sva-griha

Program Version:**EnergyPlus, Version 9.4.0-217a24fc09, Y**

Tabular Output Report in Format: **HTML**

Building: **Building**

Environment: **RES AT BORIWALI (01-01:31-12) ** Mun**

Simulation Timestamp: **2023-04-24 00:04:57**

Report: **Annual Building Utility Performance Summary**

For: **Entire Facility**

Timestamp: **2023-04-24 00:04:57**

Values gathered over 8760.00 hours

Site and Source Energy

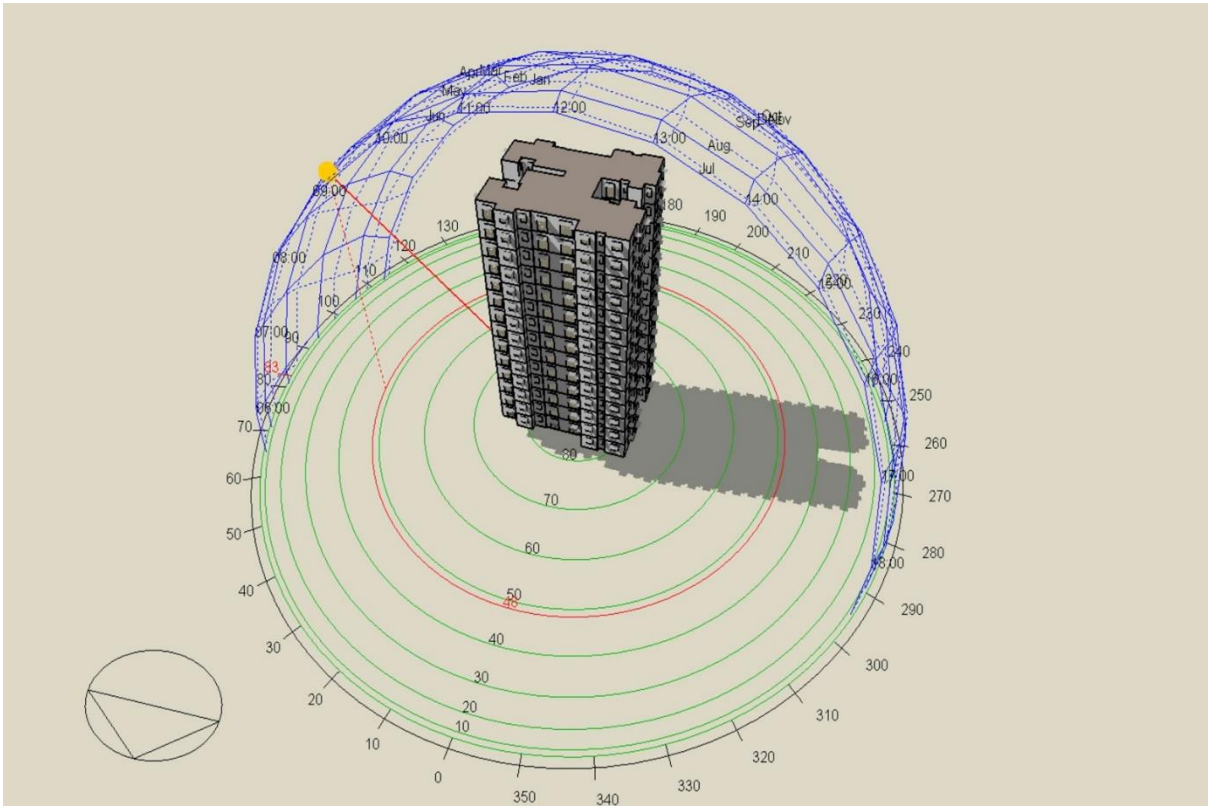
	Total Energy [kWh]	Energy Per Tota
Total Site Energy	38160.33	
Net Site Energy	38160.33	
Total Source Energy	120853.76	
Net Source Energy	120853.76	

Building Area

	Area [m2]
Total Building Area	5099.94
Net Conditioned Building Area	0.00
Unconditioned Building Area	5099.94

Comfort and Setpoint Not Met Summary

	Facility [Hours]
Time Setpoint Not Met During Occupied Heating	0.00
Time Setpoint Not Met During Occupied Cooling	0.00
Time Not Comfortable Based on Simple ASHRAE 55-2004	4593.17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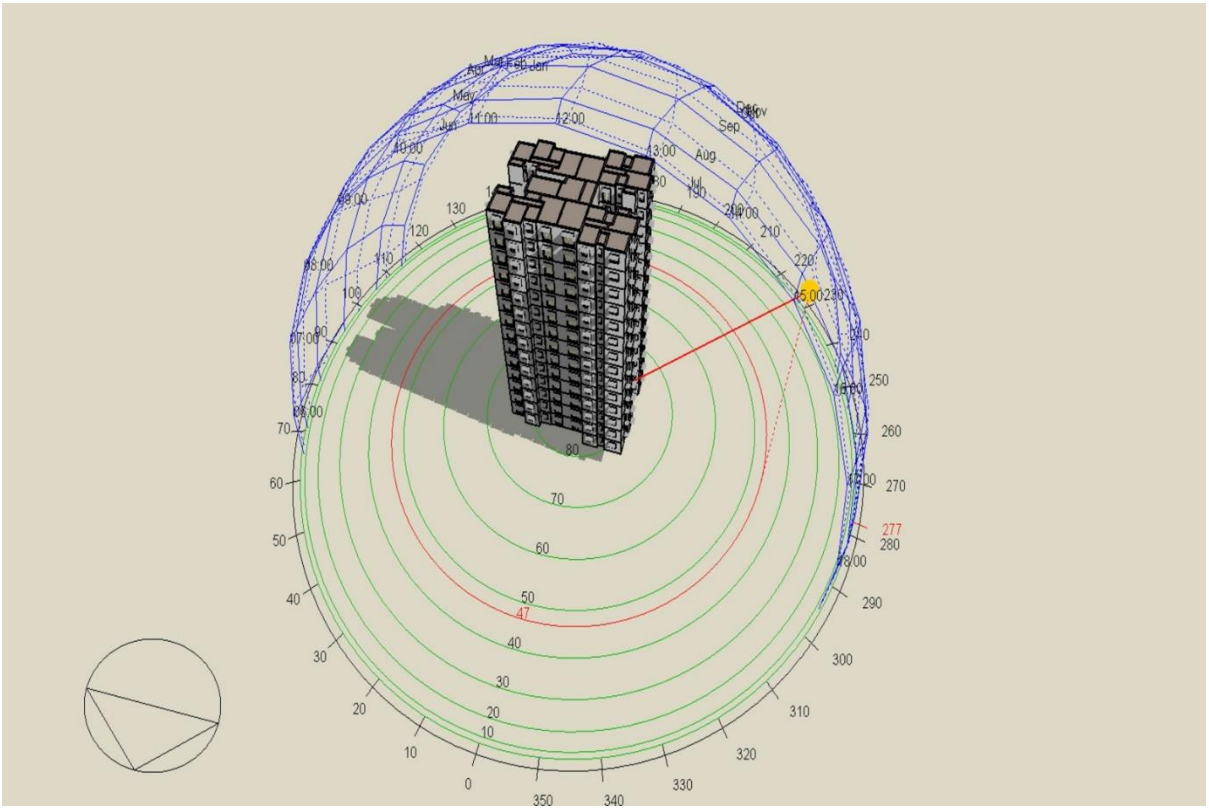
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APPENDIX E

SUMMARY OF EMBODIED CARBON CALCULATIONS

The building and construction industry is responsible for up to 30% of annual global greenhouse gas (GHG) emissions, placing it among the top seven major contributors to the enhanced global warming effect. The energy use and carbon emissions occur in all different stages of a building's life cycle(A1-A5), which may be defined as in (Figure 1). In another particular categorization, carbon emissions may be divided into two general groups, **embodied carbon** and **operating carbon emissions**. The embodied carbon, has been conventionally defined to comprise carbon emissions incurred in stages I to III of the building's life cycle (defined above), although it may be extended to include the end-of-life carbon emissions.

CALCULATING EMBODIED CARBON

The most important time to calculate embodied carbon is in the early design stages. It is crucial to have time and scope to make changes in light of your embodied carbon assessment. The most important time to calculate embodied carbon is in the early design stages. The fundamental principle of an embodied carbon calculation is typically to multiply the quantity of each material or product by a carbon factor (normally measured in $kgCO_2e$ per kg of material) for each lifecycle module being considered:

Embodied carbon = quantity × carbon factor

The **quantity** of each material or product is an estimate that improves in accuracy throughout the design process.

The **carbon factors** are split up by lifecycle module, and are estimates that improve in accuracy as more is known about the procurement process for the project.

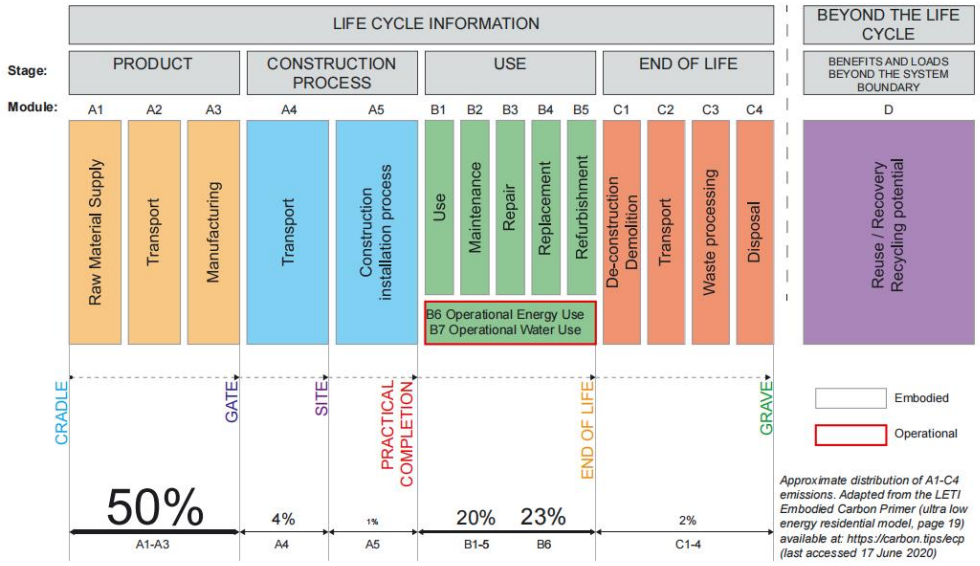

Figure 5: Different phases of a building's life cycle.

Figure 6: LIFECYCLE STAGES OF CONSTRUCTION ***Source:*** *thestructuralengineer.org*

Reference: Approximate distribution of A1-C4 emissions. Adapted from the LETI Embodied Carbon Primer (ultra low energy residential model, page 19) available at: https://carbon.tips/ecp (last accessed 17 June 2020)

TABLE 2: A1–A3 ECFs for typical structural materials

Material	Type	Specification/details	A1–A3 ECF ($kgCO_2e/kg$)	Data source
Concrete	*In situ*: piling, substructure, superstructure	Unreinforced, C30/37, UK average ready-mixed concrete EPD[1] (35% cement replacement)	0.103	MPA, 2018[2]
		Unreinforced, C32/40, 25% GGBS cement replacement[3]	0.120	ICE V3[4]
		Unreinforced, C32/40, 50% GGBS cement replacement	0.089	ICE V3
		Unreinforced, C32/40, 75% GGBS cement replacement	0.063	ICE V3
		Unreinforced, C40/50, 25% GGBS cement replacement	0.138	ICE V3
		Unreinforced, C40/50, 50% GGBS cement replacement	0.102	ICE V3
		Unreinforced, C40/50, 75% GGBS cement replacement	0.072	ICE V3
	Precast	Unreinforced, C40/50 with average UK cement mix	0.178	ICE V3
		Reinforced, 150mm prestressed hollow core slab: British Precast Concrete Federation average EPD	$50.2kgCO_2e/m^2$	BPCF, 2017[5]
Steel	Reinforcement bars	UK: BRC EPD	0.684	BRC, 2019[6]
		Worldwide: Worldsteel LCI study data, 2018, world average	1.99	ICE V3
	PT strands	Assume the same as reinforcement bars		
	Structural sections	UK open sections: British Steel EPD	2.45	BS, 2020[7]
		Europe (excl. UK): Bauforumstahl[8] average EPD	1.13	Bauforumstahl, 2018
		Worldwide: Worldsteel LCI study data, 2018, world average	1.55	ICE V3
	Galvanised profiled sheet (for decking)	UK: TATA Comflor EPD	2.74	TATA, 2018
Blockwork	Precast concrete blocks	Lightweight blocks	0.28	ICE V3
Brick	Single engineering clay brick	Generic, UK	0.213	ICE V3
Timber, excl. carbon sequestration[9], [10]	Manufactured structural timber	CLT, 100% FSC/PEFC	0.437	ICE V3
		Glulam, 100% FSC/PEFC	0.512	ICE V3
	Studwork/framing/flooring	Softwood, 100% FSC/PEFC	0.263	ICE V3
	Formwork	Plywood, 100% FSC/PEFC	0.681	ICE V3
Plasterboard	Partitioning/ceilings	Minimum 60% recycled content	0.39	ICE V2
Intumescent paint	For steelwork	Specific EPD: Amotherm steel WB, Amonn	2.31	AMONN, 2019[11]

Data taken from *CEC* Table 2, and correct at time of publication. Check data sources to verify that data presented here are valid at time of your calculation.

[1] Covers 93% of production from member companies of the British Ready-Mixed Concrete Association.
[2] MPA, 2018. *UK manufactured generic ready-mixed concrete*. Produced by members of the British Ready-Mixed Concrete Association (BRMCA), part of the Mineral Products Association (MPA). published by Institut Bauen und Umwelt e.V. (IBU). Available online at https://carbon.tips/mpa1 (last accessed 07/04/2020)
[3] Note that the ICE V3 database has a wide range of concrete mixes, including PFA (pulverised fuel ash) cements. Additionally, see CEC §2.2.2.1.3 for more information.
[4] Jones and Hammond, 2019.
[5] British Precast Concrete Federation, 2017. *Environmental Product Declaration (EPD) report of 1m2 of 150mm precast concrete prestressed hollow core flooring slab.* Published by Institut Bauen und Umwelt e.V. (IBU). Available online at: https://carbon.tips/hollow
[6] BRC, 2019. *Environmental product declaration (EPD) report of fabricated steel products produced in the UK by Eco-Reinforcement members.* Gwent, BRC Limited. Available at https://carbon.tips/brcepd (last accessed 23/02/20)
[7] BS, 2020. *Environmental product declaration (EPD) report of Steel Rails and Sections (including semi-finished long products).* Gwent, BRC Limited. Available online at https://carbon.tips/rails (last accessed 30/04/20)
[8] bauforumstahl e.V., 2018. *Environmental Product Declaration (EPD) report of Structural Steel: Sections and Plates*. Published by Institut Bauen und Umwelt e.V. (IBU). Available online at https://carbon.tips/ed6cd (last accessed 13/05/2020)
[9] The ICE V3 database also includes timber A1–A3 embodied carbon factors including sequestration.
[10] See CEC §2.2.2.1.5.
[11] AMONN, 2019. *Environmental Product Declaration, Intumescent Coating, Amotherm Brick WB - Amotherm Concrete WB - Amotherm Gyps WB Amotherm Steel WB - Amotherm Steel WB HI - Amotherm Wood WB.* Ponte nelle Alpi, J.F. Amonn Srl. Available online at https://carbon.tips/amonn (last accessed 12/06/20)

Figure 7: Reference for co2 factor of low carbon emitting materials

A. ROOF SYSTEM: -

Base Case- Concrete Roof slab with No Insulation

150mm thick slab, across $322.1m^2 = 48.3m^3$

Quantity = Mass of concrete roof slab = $500kg/m^3$ x $48.3\ m^3$ = **24.1t;** where t is tonne

Carbon Factor = 0.9t
Embodied carbon = 24.1t x 0.9t = **21.69 tco2e**

Proposed Case- Green Concrete Roof slab with Stone Wool Insulation
For unreinforced, C40/50, 75% cement replacement, carbon factor is 0.072
150mm thick slab, across 322.1m^2 = 48.3m^3
Quantity = Mass of concrete roof slab = 500kg/m^3 x 48.3 m^3 = **24.1t**
Carbon Factor = 0.072t(Refer Figure 2)
Embodied carbon = 24.1t x 0.072t = **1.73 tco2e**
Roof Insulation – Stone Wool Insulation (u-value = 0/038w/m^2k)

Features of Green Concrete:

Cement production accounts for more than 6% of all CO2 emission which is a major factor in the world global warming (Greenhouse gas). India is the third largest cement producer in the World and one of the largest consumers of cement per capita in the world. Rough figures are that India consumes about 1.2 Ton/year/capita, while as World average is 0.6 Ton/year/capita. There have been a number of efforts about reducing the CO2 emissions from concrete primarily through the use of lower amounts of cement and higher amounts of supplementary cementitious material (SCM) such as fly ash, blast furnace slag etc. CO2 emissions from 1 ton of concrete produced vary between 0.05 to 0.13 tons. 95% of all CO2 emissions from a cubic meter of concrete is from cement manufacturing. It is important to reduce CO2 emissions through the greater use of SCM.

Figure 8: RICESD-2015(Volume 4 - Issue 08)

50mm thick slab across 322.1m^2 = 0.05 x 322.1
= 16.1 m^3
Quantity = Mass of stone wool insulation = 120kg/m^3 x 16.1m^3
= **1.9t**
Embodied carbon = 0.74tco2e
Total carbon emission of Insulated Roof = 1.73t + 1.406t
= 3.136tco2e
Note:- Replacing conventional concrete roof slab and adding insulation to it reduces carbon factor by a difference of 19.96tco2e value.

B. WALL SYSTEM: -

Base Case – 230mm thick RCC wall
230mm thick wall across, 53.9m height = 0.23 x 53.9 x 0.115
= 1.42 m^3
Quantity = Mass of RCC wall = 1922kg/m^3 x 1.42 m^3 = **2.7t**
Carbon Factor = 0.42t
Embodied carbon for RCC wall = 2.7t x 0.42t = 1.142tco2e
Reinforcement bars; **Quantity =** 90kg/m^3 x 2.97m^3 = **0.26t**
Carbon factor = 1.5t
Embodied carbon for reinforcement bars
= 0.26t x 1.5t = 0.39tco2e
Therefore, **total carbon emission for 230mm thick RCC wall**

= 1.142t + 0.39t
= 1.532tco2e

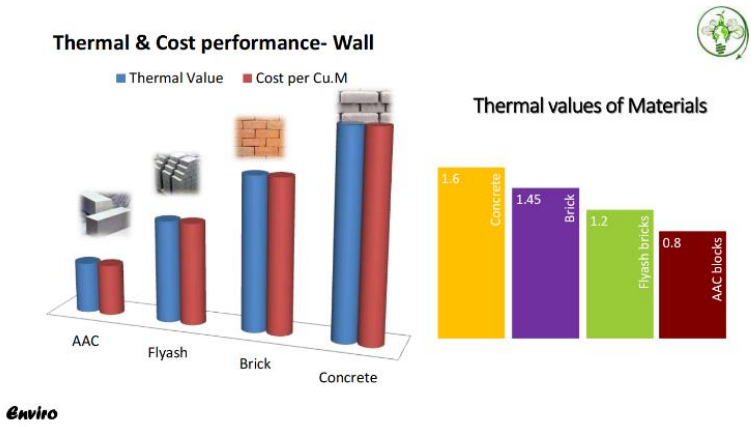

Figure 9: Thermal value of materials

Proposed Case – 230mm thick AAC block
230mm thick wall across, 53.9m height = 0.23 x 53.9 x 0.24
= 2.97 m^3
Quantity = Mass of AAC block per cubic meter = 14kg/m^3 x 2.97 m^3
= **0.041t**
Carbon Factor = 5.2t – 5.9t
Embodied carbon for AAC wall = 0.041t x 5.2t = 0.2132tco2e
Reinforcement bars; **Quantity =** 90kg/m^3 x 2.97m^3
= **0.26t**
Carbon factor = 1.5t
Embodied carbon for reinforcement bars = 0.26t x 1.5t = 0.39tco2e
Therefore, **total carbon emission for 230mm thick AAC wall**
= 0.2132t + 0.39t
= 0.6tco2e

C. WINDOW SYSTEM: -

Base Case – Triple Wooden glazed window (6mm thick window glass + 28mm thick window frame)
34mm thick window across 4m^2 = 0.34 x 4
= 1.36 m^3
Quantity = Mass of window and window frame = 30kg/m^3 x 1.36 m^3
= **0.04t**
Carbon Factor = 0.052t
Embodied carbon for triple wooden glazing= 0.04t x 0.052t = **0.002tco2e**
Proposed Case – Double wooden glazing window (4mm thick window glass + 10mm thick window frame)
14mm thick window across 4m^2 = 0.14 x 4
= 0.56 m^3
Quantity = Mass of window and window frame = 20kg/m^3 x 0.56 m^3
= **0.0112t1**

Carbon Factor = 0.04t
Embodied carbon for triple wooden glazing= 0.0112t x 0.04t = **0.0004tco2e**

D. FLOORING SYSTEM: -

Base Case- RCC Flooring
150mm thick slab across 367.20 m^2 = 0.15m x 367.2 m^2
= 55.08 m^3
Quantity = Mass of RCC slab per cubic meter = 500kg/m^3 x 55.08 m^3
= 27.54t
Carbon factor = 0.9t
Embodied Carbon = 27.54t x 0.9t
= 24.78tco2e
Proposed Case- Green Concrete Roof slab
For unreinforced, C40/50, 75% cement replacement, carbon factor is 0.072
150mm thick slab, across 322.1m^2 = 48.3m^3
Quantity = Mass of concrete roof slab = 500kg/m^3 x 48.3 m^3 = **24.1t**
Carbon Factor = 0.072t
Embodied carbon = 24.1t x 0.072t = **1.73 tco2e**

APPENDIX F

CROSS VENTILATION CALCULATIONS:

CROSS VENTILATION CALCULATIONS

BEDROOM:

A. **Occupancy:**

- Location: Bedroom
- No. of occupants: 2 persons
- Activity: Seated at rest, Light.
- Sensible heat gain: 66 to 12 watts-69 watts
- Latent heat gain: 31 to 45 watts
- Sensible Heat Gain for 2 persons: 2 X 69= 138 watt
- Heat Gain per person: 69 watts

B. **As per graph, 4 B.T.U 14 W/m² occupant Heat Gain**

- Internal Heat gain
- Electric Lighting
- Simple orientation for short= Medium= 75 (Lux)
- Stay: Lighting Heat gain= 27 w/m² = 7 B.T.U

C. Equipment's:

Heat gain from equipment

High= 6 w/m²

D. Solar Heat Gain

- As per our radiation chart for the west surface, we will consider the solar heat gain for the month of May which is 143 w/sq.m
- Glass:143 X 0.71 X0.5
- Curtain – 0.5

: 50.76 w/m²

E. Total Heat Gain:

= occupancy + Electric + equipment's + Solar heat gain

=14+27+6+50.76

=**97.76w/m²**

Size of Room= 4.05 X 3.15

= 12.75 m²

Total area of opening = 8 sq.m for bedroom

F. Window Sizes:

Inlet area/ 12.75X 100 %=8

x/12.75 X 100= 8

=**1.2 m²**

LIVING ROOM:

A. **Occupancy:**

- Location: Living Room
- No. of occupants: 6 person
- Activity: Seated at rest, Light.
- Sensible heat gain: 66 to 12 watts- 69 watts
- Latent heat gain: 31 to 45 watts
- Sensible Heat Gain for 6 person: 6X 69= 414 watt
- Heat Gain per person: 69 watts

B. As per graph, 13 B.T.U 39 W/m² occupant Heat Gain

- Internal Heat gain
- Electric Lighting
- Medium= 110 (Lux)
- Visual task, High contrast lighting of large size= 27 w/m² = 7 B.T.U

C. **Equipment's:**

Heat gain from equipment

Residential= 6 w/m²

D. Solar Heat Gain

- As per our radiation chart for the west surface, we will consider the solar heat gain for the month of May which is 143 w/sq.m
- Glass:143X 0.71 X0.5

  :50.76 w/m^2

E. Total Heat Gain:

= occupancy + Electric + equipment's + Solar heat gain

=39+35+6+50.76

=**130.76w/m^2**

Size of Room=3.95 X 5.45

= 21.52 m^2

Total area of opening = 12 sq.m for living

F. Window Sizes:

Inlet area/ Floor X 100 %=12

x/21.52X 100= 12

x=**2.58 m**

KITCHEN:

A. **Occupancy:**

- Location: Bedroom
- No. of occupants: 2 person
- Activity: Seated at rest, Light.
- Sensible heat gain: 66 to 12 watts-69 watts
- Latent heat gain: 31 to 45 watts
- Sensible Heat Gain for 2 person: 2 X 69= 138 watt
- Heat Gain per person: 69 watts

B. As per graph, 4 B.T.U 14 W/m^2 occupant Heat Gain

- Internal Heat gain
- Electric Lighting
- Simple orientation for short= Medium= 75 (Lux)
- Stay: Lighting Heat gain= 27 w/m^2 = 7 B.T.U

C. **Equipment's:**

Heat gain from equipment

High= 6 w/m^2

D. Solar Heat Gain

- As per our radiation chart for the east surface, we will consider the solar heat gain for the month of May which is 143 w/sq.m
- Glass:143 X 0.71 X0.5
- Curtain – 0.5: 50.76 w/m^2

E. Total Heat Gain:

= occupancy + Electric + equipment's + Solar heat gain

=14+27+6+50.76

=**97.76w/m^2**

Size of Room= 2.7 X 2.5 = 6.75 m^2

Total area of opening = 6 sq.m for Kitchen

F. Window Sizes:

Inlet area/ Floor X 100 %=6

x/6.75 X 100= 6 =**0.405 m^2**

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AJEENKYA D Y PATIL UNIVERSITY THE INNOVATION UNIVERSITY

D Y PATIL SCHOOL OF ARCHITECTURE

D Y Patil Knowledge City, Charoli Bk, Lohegaon, Pune-412 105

Ref. No: DYPSOA/Admin/BC/2022-23/9154 DATE: 22/02/2023

BONAFIDE CERTIFICATE

This is to certify that the students mentioned in attached list are the bonafide students of D Y Patil School of Architecture Lohegaon Pune.

List of students.

1	Aayushi Sunil Khond	Second Year M Arch
2	Amit Ashok Shirke	Second Year M Arch
3	Akanksha Suman	Second Year M Arch
4	Altamash Mushir Khan	Second Year M Arch
5	Kajal Vilas Banekar	Second Year M Arch
6	Kalpita Sanjay Petkar	Second Year M Arch
7	Siddhi Rahul Mirwankar	Second Year M Arch

These students have been allowed to participate in Solar Decathlon Competition.

SHUBHADA KEDAR CHAPEKAR

(Prof. Shubhada Chapekar)
Principal

Principal
Dr. D. Y. Patil School of Architecture
Dr. D. Y. Patil Group of Institutions
Dr. D. Y. Patil Knowledge City
Charoli (BK), Via Lohegaon
Pune-412 105

Dr. D Y Patil School of Architecture

AJEENKYA DY PATIL UNIVERSITY
THE INNOVATION UNIVERSITY

School of Engineering

No. ADYPU/ SOE / HOD / 2022 / L /346

Date: 29/09/2022

To whom soever it may concern

This is to certify that, **Mr. Darshan Sanjay Verma** is the student of 3rd year B. Tech CTIS at School of Engineering, Ajeenkya DY Patil University, Lohegaon. He is allowed to attend course by Solar Decathlon India. Institute has no objection on his participation. This Bonafide certificate is issued upon his own request.

SCHOOL OF ENGINEERING
AJEENKYA D.Y. PATIL UNIVERSITY, PUNE

Institution seal

29/9/22

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Date: 20.01.2023

To,
The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organisation, Samuchit Enviro Tech, Pune, is collaborating with the participating team led by Dr. D. Y. Patil School of Architecture on a Multifamily Housing Building Project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration with team GET THEM GREEN as Sustainability Consultant has been on assisting them with the Embodied Carbon Emission Strategy of the Building Project.

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

With warm regards,

Pournima Agarkar

Sustainability Consultant

Samuchit Enviro Tech

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