TEAM JAVELIN

ON SITE
CONSTRUCTION WORKER HOUSING

FINAL DESIGN REPORT

APRIL - 2022

Academy of Architecture, Mumbai
VNIT, Nagpur
SPA, Bhopal

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EXECUTIVE SUMMARY

Observant of the disparity between architecture and the audience it serves, 11 architecture students along with engineering students, decided to come together and use Solar Decathlon India as an opportunity to create for the marginalised community of construction workers a better standard of living. The platform gave us an opportunity to address our concerns for the construction workers with solutions that strive for efficiency and resilience.

With the said vision, Team Javelin approached Shapoorji Pallonji and Company Private Limited, a globally diversified institution that focuses on good governance and sustainable development to engineer a better planet, to be their project partner. The company runs projects across India and even abroad providing a wider exposure to the team regarding workers and their conditions. The project Kaari - Ghar thus is a joint attempt to provide a dignified living space for the workers and become a model for worker-housing and allied net-zero solutions across the country.

With the increasing infrastructure development projects and faster construction, the construction workers have to work day and night with no proper standards of living, the team engaged in research and site visits to identify problems of the workers, grasp their behavioural patterns and understand the system that caters to their needs. The solution was therefore intended to address, comfort, quality and experience for the user, efficiency in resource-management viz.water, electricity for the community and affordability, scalability, flexibility, and low-maintenance ability for the developer.

The project proposal comprises of 9 clusters of 3-storey blocks, each containing 9 modular units for the workers to live in. The massing involved operations of subtraction, addition and stacking to create a solid and void composition, that fits maximum within minimum, creating thermally comfortable interior spaces, shaded semi-open spaces that provide for interaction, recreation and minimized circulation that save space. This also provides with vertical visual axis throughout the structure. The housing specifically caters to warm and humid climatic zone, but is flexible in terms of construction.

The design aims to serve all the factors of thermal comfort, water efficiency, net-zero electricity, within minimum budget and using maximum of the solutions as transportable modular units. The construction system is a modular system composed of structural steel and light weight eco friendly panels. This system could be easily dismantled and reconstructed. The stacking, overhangs, planning of windows, use of storage as fins, and providing louvres give the user thermal comfort with around 23 to 27 degree celsius of indoor temperature across the year in all living modules, with reduced need for mechanical ventilation, thus reducing electric loads. The EPI for the project was reduced to 13.10KWh/m2 from 27.38kWh/m2 by employing various techniques and approaches, including adoption of efficient lighting systems such as LEDs, use of solar heaters instead of geysers, elimination of exhaust fans by providing with sufficient ventilation and on-site power generation. Also the use of bio-digester instead of an STP has reduced the energy consumption by about 22%. Efficient water usage is ensured by implementing strategies that reduce per capita demand, treating as much wastewater as possible, and ensuring a replenishable source of water (since storage is not feasible) to meet the maximum demand on site were key considerations in making the facility water efficient without compromising affordability. 97.3% of the total water demand is met by recycled greywater, harvested rainfall, and water from a borewell recharged by harvested rainwater. The remaining 2.7%is obtained from outside sources during the monsoon season, when water is available readily and cheap.

The project not being a commercial establishment had many restrictions regarding budget, availability of space and resources. Team Javelin has tried to find out affordable solutions that root from the constraints.

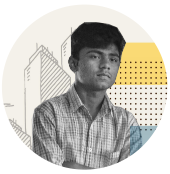
TEAM SUMMARY

Team Name : JAVELIN

Lead Institution : Rachana Sansad Academy Of Architecture

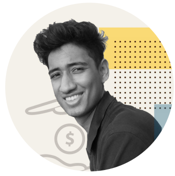
Partner Institutions : VNIT, Nagpur; SPA Bhopal

Division : On Site Construction Worker Housing

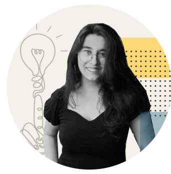


Abhishek Suryawanshi
3rd yr, B.arch
Team Leader

Harsh Tank
3rd yr, B.arch
Resilience



Harshwardhan Shirpurkar
3rd yr, B.arch
Affordability



Jigisha Soni
3rd yr, B.arch
Innovation

Krishna Khurusane
3rd yr, B.arch
Communication

Laxaree Sawant
3rd yr, B.arch
Research

Prajakta Pai
3rd yr, B.arch
Structural Scalability

Shakti Jadhav
3rd yr, B.arch
Water Performance

Sharvil More
3rd yr, B.arch
Arch. Design

Siddhi Shinde
3rd yr, B.arch
Health & Wellbeing

Vaishnavi Siddhapara
3rd yr, B.arch
Energy Performance

Aditya Patil
3rd yr, B.Tech
Structure and timeline

Satyam Lalchandani
3rd yr, B.Tech
Electrical Energy

Avani Shikare
2nd yr, M.Plan
Passive Solutions

INSTITUTIONS

LEAD: Rachana Sansad's Academy of Architecture, Mumbai

Established in 1955, Academy is a leading architecture institution in India continuing its 65 year old legacy to promote creativity and innovation in the fields of design and architecture. The institute offers undergraduate programmes in architecture, students are encouraged to look into environment friendly, context relevant solutions under the Design, Construction, Landscape, EVS and Building services studios throughout the course.

Visvesvaraya National Institute of Technology (VNIT), Nagpur

VNIT is a public engineering and research institution established in 1960, It has been designated as an institute of National importance.

School of Planning and Architecture (SPA), Bhopal

Established in 2008, this school is committed to producing Architects and Planners to take up the challenges of physical and socio- environmental development of global standards. Programmes in Architecture, Urban design, Environmental planning, conservation, etc. are offered here.

FACULTY GUIDES

Ar. Amey Ghosalkar - Design faculty at AOA, specialising in Urban Design.

Ar. Shekoba Sanap - Architect, academician and alumni of AOA and also the founder and CEO of studio UD+AC.

Ar. Pranav Bhavsar - Construction Faculty at AOA who has worked with Larsen & Toubro, Hafeez Contractor and Hiten Sethi Architects.

Ar. Rohit Shinkre - Former Principal at AOA with expertise on Interior, Architectural & Urban design projects.

INDUSTRY PARTNERS

Shubhra Biotech (DRDO Bio-digester technology)) :

Biodigester technology has been developed by the Defence Research Development Organisation (DRDO) and licensed to Shubhra Biotech Pvt. Ltd for resolving the problems of un-decomposed human waste. The innovation degrades and converts the human waste into usable water and gases in an eco-friendly manner.

SHUBHRA BIOTECH
PRIVATE LIMITED

Ricron Panels (Eco-Friendly building sheets) :

Awarded the coveted 'Climate Solver Award 2019' from World Wildlife Foundation (WWF), Ricron panels converts plastic scrap into products that are used as building materials.

RicronPanels

TEAM APPROACH

The team approach is to :
Discuss, **D**elegate, **S**tudy, **A**nalyse and **D**ecide
to ensure a smooth design process of efficient knowledge exchange.

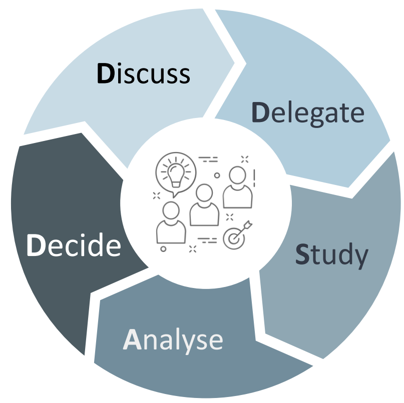


Fig.01. Team approach

DESIGN MANAGEMENT

1. The team consists of like-minded architecture students who joined together to collaborate with students from diverse sectors of sustainable design and engineering to address social and ecological challenges through architecture. To achieve a thorough design plan, each member has been assigned a specific goal.

2. We all agreed on the On-site construction worker housing division since it presented us with an opportunity to serve the underserved while also addressing social and environmental challenges.

3. We approached Shapoorji Pallonji, a company with a worldwide presence in infrastructure and building to be our Project Partner, in order for us to work on an existing project.

4. Site visits and documentation helped us collect data and form our inferences in order to begin our preliminary design, conceptual ideation and preliminary simulations. With the guidance of our faculty leads and project partner, we identified the problems of construction workers and formulated our goals and strategies accordingly.

5. Post the above process, the preliminary report was formulated and submitted which included the initial prelude design approach and ideas.

DESIGN MANAGEMENT

6

We then looked for industrial partners and began learning the technical aspects of the software needed to create the requisite simulations.

7

Moving on to the conceptual design concepts, we posed questions about the workers' challenges and devised solutions while providing a user-defined spatial experience.

8

To support our design in terms of sustainability, research was conducted about the possible materials with features such as durability, cost effectiveness, and heat resistance, among others.

9

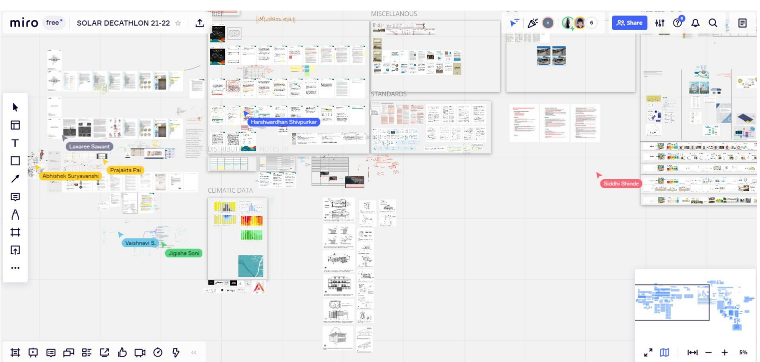
Innovation with respect to material and the usage of bio toilets led us to collaborate with industry partners mentioned previously.

10

Following the completion of the design, material, and space requirements, structural study was carried out in order to develop a distinctive, intriguing facade that serves several functions in terms of storage and passive shading.

11

All of the preceding processes lead to the creation of this intermediate report, which includes a full design process.



Img .01. Miro board ideation

Img .02. On site documentation

Img .03. Poster for collaboration with engineers

Img .04. Design discussion

Img .05. Conversing with the contractor

PROJECT SUMMARY

Project Name : **Kaari-Ghar**

Project Partner :

Shapoorji Pallonji and Company Private Limited is a globally diversified institution with a leading presence in Engineering & Construction, Infrastructure, Real Estate, and Water, Energy and Financial Services. Established in 1865 in India, they build megastructures, develop multifaceted iconic landmarks, drive innovative technologies in water management, renewable energy, oil & gas and power. Focusing on good governance and sustainable development, they invite motivated and talented individuals to collaborate with their impeccable engineering to engineer a better planet.

Key Individuals :

Mr. Davinder Manghi	**Mr. Harishprasad Mishra**
General Manager (Projects)	Project Head, Khandeshwar site

Brief description of Project :

Carrying forward a trusted 154-year old legacy of excellence, Shapoorji Pallonji and Company Private Limited aim at providing a **suitable lifestyle for the On-Site Construction Workers**, by creating dignified living quarters with a holistic community space where they will have a sense of belonging. The proposal shall be **net-zero energy and net-zero water design** to resolve problems concerning lighting, ventilation, and sanitation with precautionary fire safety measures.

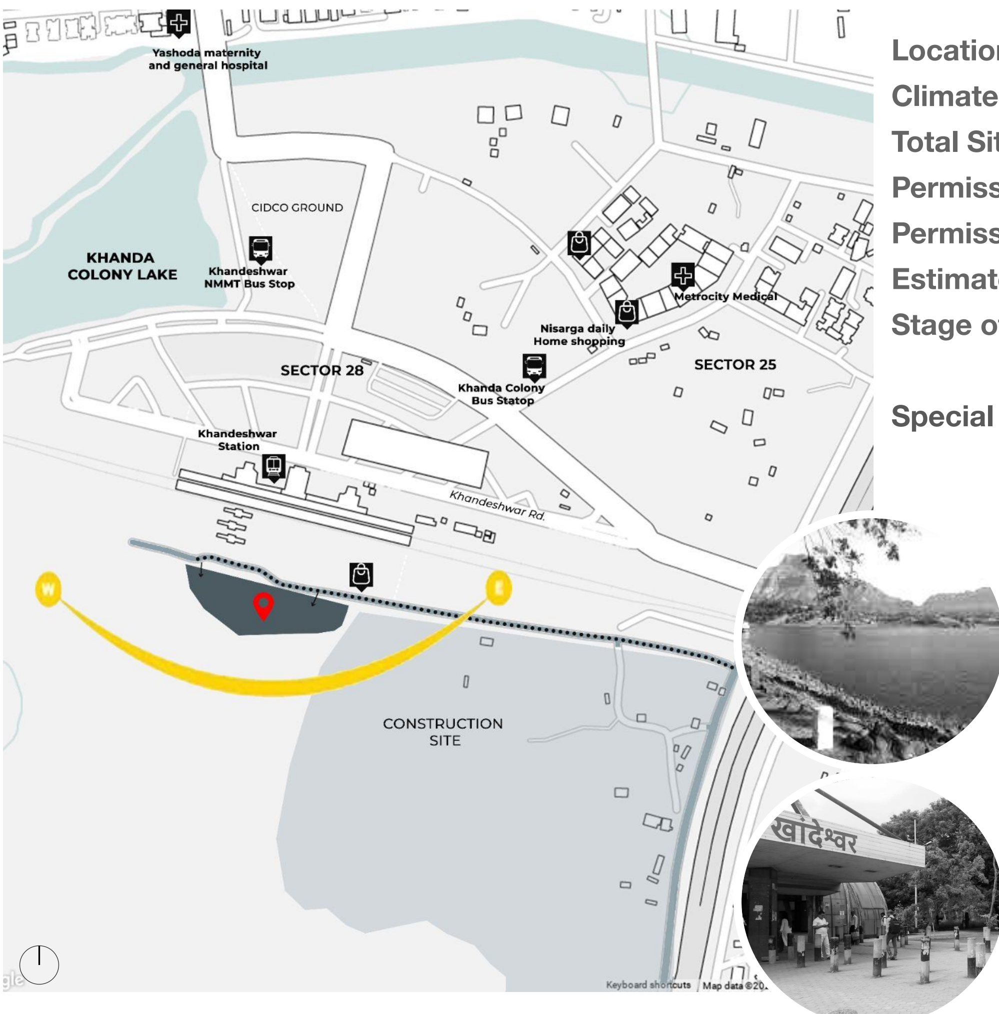


Fig.02. Project site & Context

Location : Khandeshwar, Navi Mumbai.
Climate : Warm and Humid
Total Site Area : 6500 m^2
Permissible built up : 7150 m^2
Permissible ground coverage : 3155 m^2
Estimated Built up area : 5355 m^2
Stage of project : Future Phase of Existing Project
Special Requirements of Client :

- Reusing construction site waste
- Community space
- Proper light and ventilation
- Proper storage space for workers

Legend :

Railway Station
Hospital
Shopping Area
Approach road

PROJECT SUMMARY

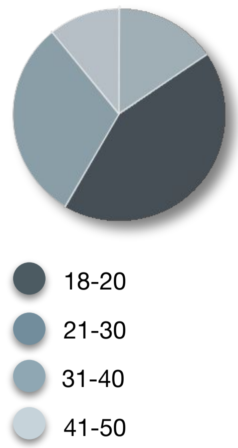
Profile of Occupants :

Day Workers

Night Workers

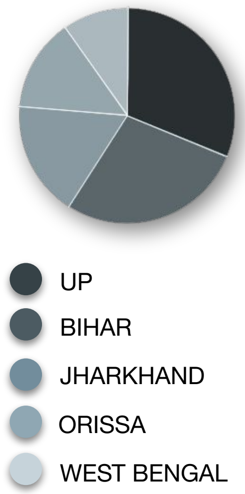
Hours of operation : 24hrs

AGE GROUP

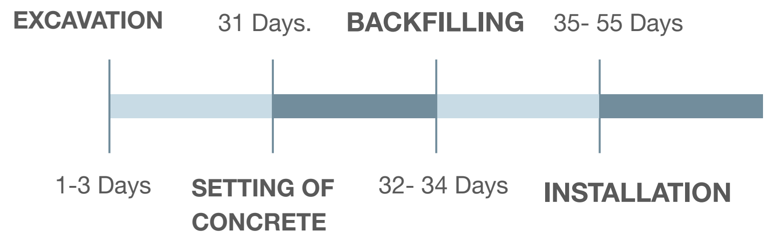


Graph.03.User mapping - age

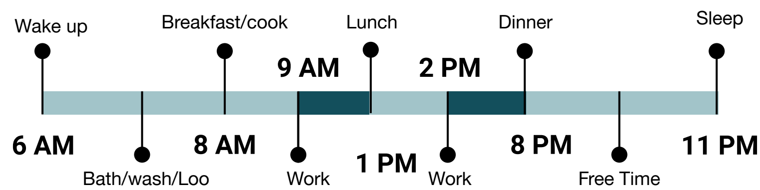
HOMELAND



Graph.04.User mapping - homeland



Graph.01.Construction Timeline



Graph.02. User mapping - routine

Sr. No.	Particulars	Baseline Estimate (Project Partener/ SOR Basis)		Proposed design estimate	
		Amount (Rs Millio	%	ount (Rs Millio	%
1	Land	78.84	71.80%	78.84	71.80%
2	Civil Works	18.25	16.60%	20.55	18.70%
3	Internal works	0.04	0.00%	0.09	0.10%
4	MEP services	3.93	3.60%	3.5	3.20%
5	Equipment and Furnishing	3.41	3.10%	8.94	8.10%
6	Landscape and site developmen	0.03	0.00%	0.9	0.80%
7	Contingency	5.23	5.00%	5.64	5.00%
	Total hard cost	**109.73**	**100.20%**	**118.45**	**107.80%**
8	Pre-Operative Expenses	-	0.00%	-	0.00%
9	Consultants	-	0.00%	-	0.00%
10	Interest During Construction	-	0.00%	-	0.00%
	Total Soft Cost	**0**	**0.00%**	**0**	**0.00%**
	Total Project cost	109.73	100.00%	118.45	107.90%
	Total Project Cost per Sq.m of Built-up Area		**20,492**		**22,120**

Table.01. Construction budget

Preliminary Construction Budget per m^2 : ₹22,120

GOALS

ARCHITECTURAL DESIGN

Different user groups (by region and religion) should be encouraged to socialise in order to create a sense of belonging, despite their differences, in order to foster a more welcoming atmosphere.

Strategies :

- Planning small niches and semi open spaces for to cultivate a healthy relationship
- Solid-void/staggered modular layout improves visual connection

Achievements :

- Voids act as an indoor recreational place for various user groups to enjoy, boosting social contact on a variety of scales and levels.

ENERGY PERFORMANCE

Reducing electricity usage and having a total on-site generation of electricity

Strategies :

- Use of Solar PV panels on rooftops to utilise strong solar radiation

Achievements :

- 100% renewable energy generation from solar PV.
- Net Zero energy efficiency with an EPI 13.10 kWh/m^2

THERMAL COMFORT

To achieve thermal comfort using 60% passive ventilation and 40% active ventilation according to the India model for adaptable comfort (I-MAC)

Strategies:

- Use of passive strategies to provide with better indoor environment.
- Using materials with a low U-value to insulate from conductive heat transfer.

Achievements :

- A central courtyard planning creates a volume of cooler air around the modules.
- Size and type of window opening allows for better wind flow

WATER PERFORMANCE

Net-zero water efficiency by calculating the consumption, generation and storage capacity

Strategies:

- Maximising rainwater harvesting and engaging in greywater management
- Using water efficient fixtures and reuse, recharge and reduce wastage of water

Achievements :

- 49% reduction of Target water performance index (WPI) now valued to 68.1LPD
- 9% Increase in recycled water, by use of bio-digesters and reed beds.
- 100% net rainwater harvested without any additional storage
- 97.3% net zero water cycle achieved

HEALTH, SAFETY AND SECURITY

To eliminate the potential risks of mosquito borne diseases.

Strategies:

- Planning covered sanitation system and strategic waste disposal.

Achievements :

- Use of bio-digester toilets reduces the odour

GOALS

AFFORDABILITY

The use of ricron panels instead of traditional porta cabins decreases building cost and time

Strategies :

- Bringing together functions and services to reduce material consumption and costs
- Modular constructions make it simple to construct, reducing labour costs.

Achievements :

- The use of recycled plastic (ricron panels) helps to reduce costs
- Reduced construction timeline

RESILIENCE

The design must be able to resist natural disasters and still function independently and effectively

Strategies :

- Strong structural design that can resist earthquakes
- Net zero energy and water design will make it retain its functionality during hazards

Achievements :

- In the event of a disaster, net zero energy and water design aids in maintaining functionality.
- Modular designs allow easy and quicker assembly, disassembly, and transportation

ADAPTABILITY

The design proposal must be adaptable in varied site scenarios to be reused after a construction project is over.

Strategies:

- Strong modular structural system will ensure durability, easy assembly/ disassembly.
- Separate structural and partition/ envelope system, uniform sizes of members will allow combinations in varied forms and scales easily.

Achievements :

- Since the structure is modular, it is adaptable to to different site constraints

INNOVATION

The design proposal should be composed of independent systems to ensure flexibility.

Strategies:

- Composition of different functions together to address multiple issues.

Achievements :

- Cantilever storage block providing with barrier free circulation space in the interior
- Using recycled material provided with properties such as geat resistant, fire retardant, etc. thus eliminating the use of insulating materials

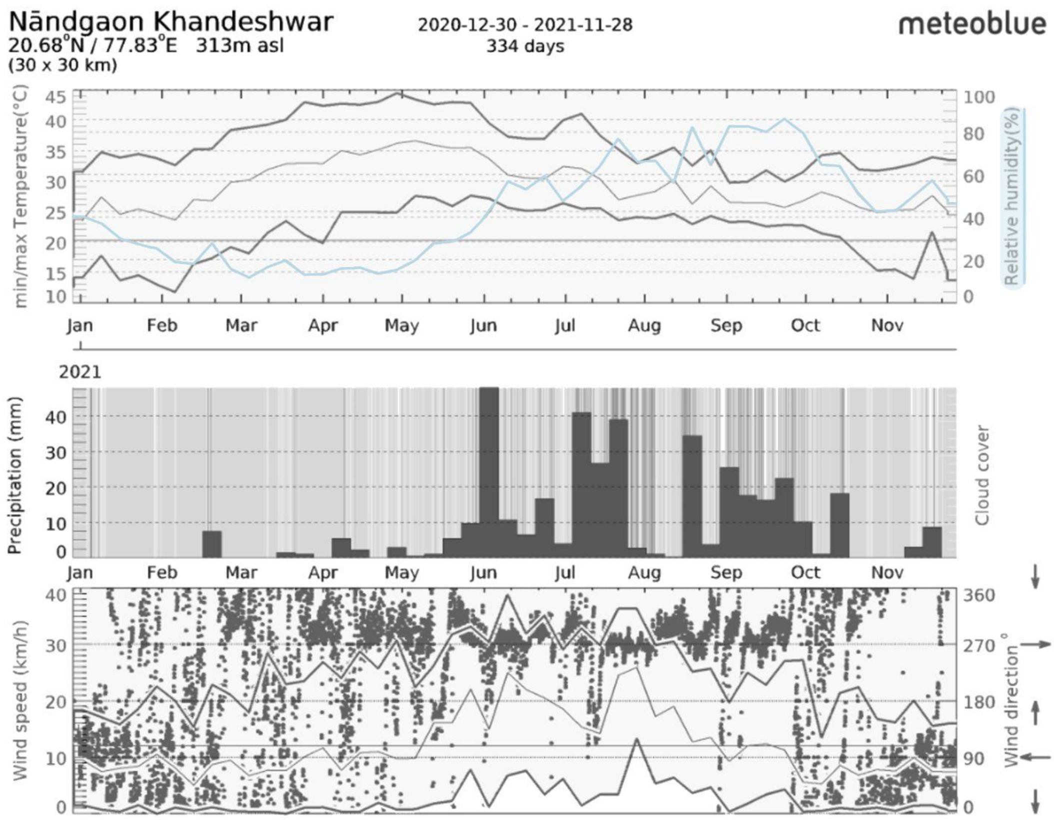
SCALABILITY AND MARKET POTENTIAL

The design shall be able to cater to all sites within the Mumbai-metropolitan region and have scope to be replicated within the warm & humid climatic zone

Strategies:

- Increased scalability across similar climatic zones aided by simple solutions.
- Planning a modular structure aid in scalability since it is adap

PERFORMANCE SPECIFICATIONS



Graph.05.Climate Zone Specifications

Climate Analysis :
The site lies in the Warm and Humid climatic zone.
Average temperature on site is 30 to 40°C.
The presence of creek near the site contributes to higher humidity levels .

Precipitation will aid in rainwater harvesting.
Use of light-weight insulating materials in hot and humid climates helps in creating thermal comfort.

Wind analysis helped in understanding the orientation of openings towards South-West direction for better passive ventilation.

Building Envelope			
Element	Wall	Roof	Window
Specifications	Recycled plastic	Recycled plastic	Single pane 30%glazed
U - value (W/m²K)	6.66	6.66	5.557

Table.02. Specifications and U-value of materials

Product	Output	Flow type	Operating pressure	Cost	Percentage reduction in consumption from base case
4 LPM Water Saving Aerator for Taps Foam flow	4 LPM	Shower/Spray	0.8 bar to 4 bar	Rs.89/Piece	50%
6 litre pour flush bucket for toilet	6 L	N/A	N/A	Rs. 150/Piece	73%
20 Litre bucket for bucket bath	20 L	N/A	N/A	Rs. 230/Piece	50%

Table.03.Specifications of Water efficient applications

DESIGN DOCUMENTATION - ENERGY PERFORMANCE

The **energy performance index (EPI)** is a significant indicator for comparing building energy usage. Energy used per unit area, defined in KWh/m2/yr or KWh/person/yr, is referred to as EPI.
The EPI for the project was reduced to 13.10KWh/m2 from 27.38kWh/m2 by employing various techniques and approaches, including adoption of **efficient lighting systems such as LEDs**, use of **solar heaters** instead of geysers, **elimination of exhaust fans** by providing with sufficient ventilation and **on-site power generation.** Also the use of bio-toilets has reduced the energy consumption by about 22%.

Baseline EPI : 27.38 kWh/m^2
Achieved EPI : 13.10 kWh/m^2

SR NO	FUNCTION	AREA IN SQ.M (PER UNIT)	Appliances	Wattage	Average Working Hours (Anually)	Total Energy Consumption (kWh)
	Living Zone					
1	**Sleeping Units**					
	Type A	30	3 LED Tubelight	3 x 18 = 54	5x365≈1800	5400
			2 56 " Fans	2 x 75=150	10x365≈3650	27000
	Type B	20	2 LED Tubelight	2 x 18 = 36	5x365≈1800	1890
			2 56 " Fan	2 x 75=150	10x365≈3650	13500
2	**Breakout Voids**					
	Type A	9	1 LED Bulb	1 x 9 = 9	4x365≈1500	405
	Type B	18	1 LED Bulb	2 x 9 = 18	4x365≈1500	810
	Type C	12	2 LED Bulb	2 x 9 = 18	2x365≈750	405
3	**Bathrooms and Washing Area**					
	Bathroom Units	1.425	1 LED Bulb	1 x3 = 3	3x365≈1000	108
			Geysers(12 Units)	1x1500	1x365=365	6600
4	**Toilets**					
	Toilet Units	1.425	1 LED Bulb	1 x3 = 3	3x365≈1000	108
	Passage (Toilet and Bathroom)	60	10 LED Light	10 x 18 = 180	4x365≈1500	600
	Common Zone					
5	**Dining Unit and Multifunctional Space**	655	35 LED Light	35 x 18 = 630	4x365≈1500	1000
			15 56" Fans	15 x 75=1125	5x365≈1800	1820
			1 Ro Plant	1 x 60 = 60	5x365≈1800	110
6	**Kitchen Unit**	9	1 LED Light	1 x 18 = 18	5x365≈1800	840
			1 Exhaust Fan	1 x 31 = 31	5x365≈1800	1540
7	**Canteen / Pantry**	19	2 LED Light	2 x 18 = 36	2x365≈750	30
			1 56 " Fan	1 x 75=75	2x365≈750	65
			1 Exhaust Fan	1 x 31 = 31	2x365≈750	25
			1 Mini Fridge	1 x 220 = 220	15x365≈6000	1320
8	**Shop**	9	1 LED Light	1 x 18 = 18	10x365≈3650	65
			1 48 " Fan	1 x 75=75	10x365≈3650	250
			1 Mini Fridge	1 x 220 = 220	10x365≈3650	792
9	**Washing Area**	19	1 LED Light	1 x 18 = 18	2x365≈750	30
10	**Indoor Games**	38	4 LED Light	4 x 18 = 72	1x365≈350	60
			2 56" Fan	2 x 75= 150	1x365≈350	110
	Well-being Zone					
11	**Medical Room**	10	2 LED Light	2 x 18 = 36	100	5
			1 48" Fan	1x75=75	100	10
	Services					
13	**Common Storage**	17	1 LED Light	1 x 18 = 18	1x365≈350	10
			1 Exhaust Fan	1 x 31 = 31	2x365≈350	10
14	**Electrical Service Room**	10	1 LED Bulb	1 x 9 = 9	500	5
15	**Pump**			1x750=750	1x365=365	280
16	**Borewell**			1 x 3750	107.5	403.125
	Circulation					
17	**Staircases**	21.4	2 LED Light	2 x 18 = 36	5x365≈1800	585
18	**Passage**	700	40 LED Light	40 x 18 = 720	5x365≈1800	1300
19	**Open Spaces**		30 Flood Light	30 x 50 = 1500	5x365≈1800	2700
					TOTAL	70191.125
						EPI=70191/5355=13.10 kWh/sq m

Table.04. Total Energy Consumption and EPI Calculation
**For detailed calculation refer page __ of annexure*

DESIGN DOCUMENTATION - ENERGY PERFORMANCE

The structure's net zero energy architecture allows it to be **self-sufficient,** allowing it to function even in the event of a calamity. On the roofs of the clusters, **solar PV panels** are intended to be installed. The panels are installed on the roof of the dining and **oriented according to the sun path.** The excess renewable energy is either **stored and used later** in the event of a disaster or **supplied back to the grid.**

The consumption percentages of the various electricity-using fixtures add up to a total of 175 solar panels as power generators. In a hot and humid climate, ventilation is the most significant feature to provide for thermal comfort, therefore fans use the majority of the energy produced, and the panels necessary for the same are more than half of the total, as shown in Fig 03. Then there's the lighting and other power-hungry fixtures.
The 175 panels, each with a capacity of 70kWh, produce a total of 1200-1500kWh each year.

Energy Consumption by Lights	**16153**
	23.14%
Solar Panels Required	**35**
Energy Consumptions for ventilation	**44330**
	63.52%
Solar Panels Required	**90**
Misccllaneous Consumprion	**9708**
	13.33 %
Solar Panels Required	**25**
Excess Production panels	**25**
Excess electricity produces	**11250kWh**

Table.05. Total Energy Consumption and detailed quantity of solar panels required

Solar Water heater calculations	
Heated water required	**125L/Unit**
Net Requirement	**4500L**
heater Capacity	**500L**
No Of Heater Required	**9**
Model	**Kenbrook ETC 500 Liter SWH**
Cost	**55000/unit**
Total Cost	**495000INR**
Area Required	**6m2**
Net Area required	**80m2**

Table.06. Detailed Solar Water Heater Calculations

System	Equipment	Brand	Total Cost (INR)
Lighting	LED Tube Lights	SYSKA	84,040
	LED Bulbs		16,640
	Flood Lights	Nelson	5,700
Fans	Ceiling Fans	CROMPTON	2,34,000
	Exhaust Fans		46,500
Heating	Water Heater	JONES	51,600
	Solar Water heater	kenbrook	4,95,000
Water	RO Purifier	WaterQ	13,000
	Pump	Havells	4,590
	Borewell Pump	Havells	17,795
Storage	Mini Fridge	CROMA	20,000
Energy Source	Solar Panels	KENBROOK SOLAR	35,00,000
		TOTAL	**44,88,865**

Table.07. Technical Specifications of lighting fixtures

Solar panel production/kWh	**3.5-4.5 kWh/day**
Annual Production/kWh	**1200-1500kWh**
Capacity of Solar Panel required	**70kWp**
Area required for Installation	**700m2**
Type	**ON GRID**
Cost	**35,00,000INR**
Model	**Kenbrook Solar 75kW On Grid**

Table.08. Solar Panel calculations

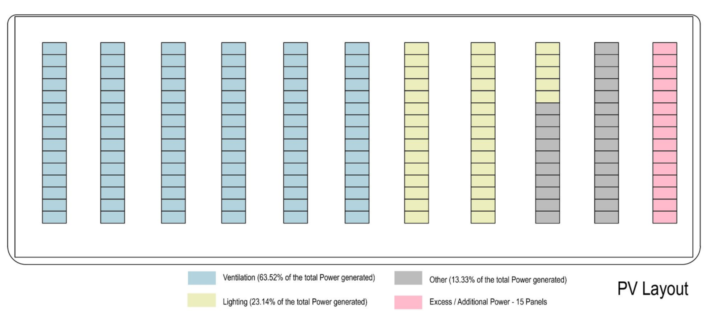


Fig.03. Solar Panel layout on dining block rooftop

DESIGN DOCUMENTATION - WATER EFFICIENCY

The facility intends to house a large number of workers (880), so efficient water usage by implementing strategies that reduce per capita demand, **treating as much wastewater as possible**, and ensuring a replenishable source of water (since storage is not feasible) to meet the maximum demand on site were key considerations in making the facility water efficient without compromising affordability. **97.3% of the total water demand is met by recycled greywater, harvested rainfall, and water from a borewell recharged by harvested rainwater**. The remaining 2.7%is obtained from outside sources during the monsoon season, when water is available readily and cheap.

We achieved this by, **R**eduction in per capita consumption by 49.5%
Recycling 83.5% of the water consumed
Providing a borewell to pump out an amount less than what has been recharged into it.

		CONSUMPTION				WATER SOURCES						
Month	Days in month	Domestic Use (L)	Irrigation Use %	Irrigation Use (L)	Total Consumption (L)	Borewell supply (L)	External supply (L)	Rainwater harvested	Rainwater used	Rainwater recharged to borewell	Greywater (L)	Blackwater (L)
Jul	31	1,857,768	5%	1,786	1,859,554	-	200,000	2795081	499483	2295598	1,160,070	311,008
Aug	31	1,857,768	5%	1,786	1,859,554	-	200,000	2062608	499483	1563125	1,160,070	311,008
Sep	30	1,797,840	50%	17,280	1,815,120	-	200,000	1285198	492471	792727	1,122,649	300,975
Oct	31	1,857,768	30%	10,714	1,868,482	420,814	-	287597	287597	0	1,160,070	311,008
Nov	30	1,797,840	90%	31,104	1,828,944	688,320	-	17975	17975	0	1,122,649	300,975
Dec	31	1,857,768	90%	32,141	1,889,909	729,838	-	0	0	0	1,160,070	311,008
Jan	31	1,857,768	90%	32,141	1,889,909	729,838	-	0	0	0	1,160,070	311,008
Feb	28	1,692,966	90%	29,290	1,722,256	665,095	-	0	0	0	1,057,161	283,418
Mar	31	1,857,768	90%	32,141	1,889,909	729,838	-	0	0	0	1,160,070	311,008
Apr	30	1,797,840	90%	31,104	1,828,944	706,295	-	0	0	0	1,122,649	300,975
May	31	1,857,768	90%	32,141	1,889,909	639,964	-	89874	89874	0	1,160,070	311,008
Jun	30	1,797,840	90%	31,104	1,828,944	-	-	1882860	706295	1176565	1,122,649	300,975
Total	365	21,888,702		282,730	22,171,432	5,310,004	600,000	8421194	2593179	5828015	13,668,249	3,664,371
Total water demand = 22,171,432			Water reused = 13,668,249		Rainwater used = 2,593,179	Water taken from Borewell = 5,310,004		Rainwater recharged into borewell = 5,828,015			External water demand = 600,000	

Table.09. Water Cycle

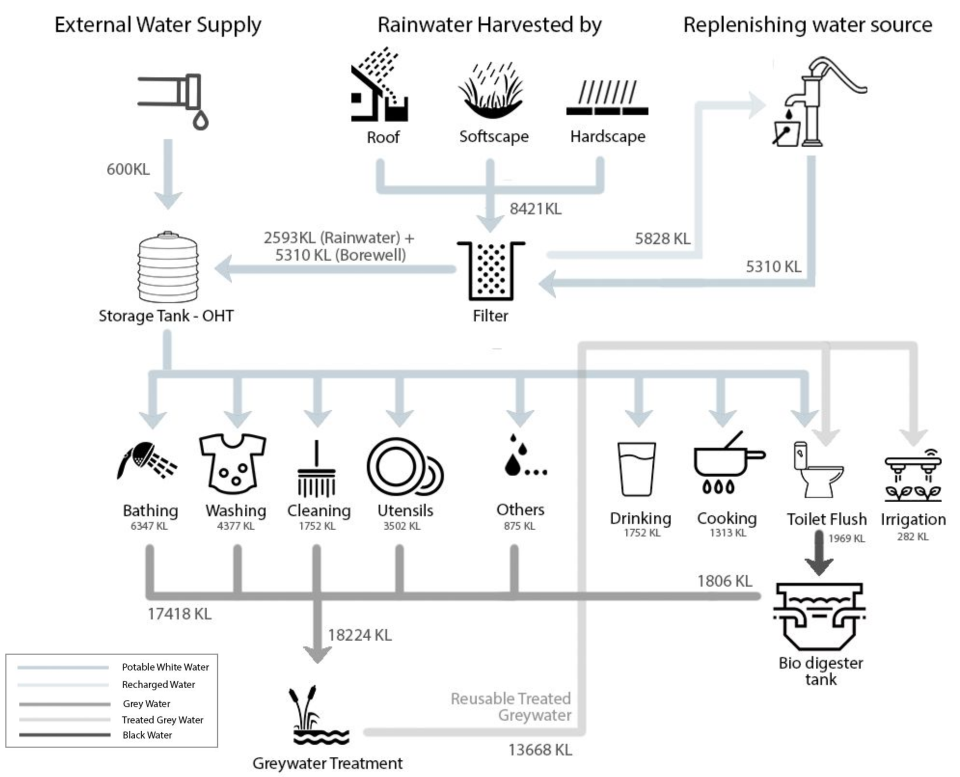


Fig 04. Water Cycle Diagram

DESIGN DOCUMENTATION - WATER EFFICIENCY

Minimizing water usage

Since we are dealing with construction workers from rural India, we decided to take advantage of their lifestyle practices. Using a **bucket bath r**educes bathing water demand by **50%**, and using a **pour flush system in squatting pan toilets** reduces flushing water demand by **75%.** In addition, using **foam flow/shrink** reduces the per minute water flow from taps in the kitchen and wash basin areas by 50% (from 8 LPM to 4 LPM).

Use	Consumption	Base case	Efficient case	Percentage	Grey water (LPD)	Black water (LPD)	Notes
Bathing	30%	40.5	20	29%	20		Bucket bath with a 20L bucket
Washing	20%	27	13.5	20%	13.5		Low flow taps
Cleaning House	8%	10.8	5.4	8%	5.4		Low flow system; typology has high density reducing per capita demand
Washing Utensils	16%	21.6	10.8	16%	10.8		Low flow taps
Others	2%	2.7	3	4%	1.5	1.5	Indirect usage
Drinking	4%	5.4	5.4	8%		5.4	Necessary consumption
Cooking	3%	4.05	4	6%		4	Necessary consumption
Toilet Flushing	17%	22.95	6	9%	5.7	0.3	Pour flush with a 6 ltr bucket. Bio-digester converts waste into reusable water with 95% efficiency
Total		**135**	68.1	100%	56.9	**11.2**	
Recyclable					**56.9**		

Table.10. Efficiency in water consumption

Water use	Nos	Quantity	Total (LPD)
Domestic Use (LPD/ Head)	880	74	**65120**
Irrigation (max) : {m2 x l/m2}	1152	1	**1152**
Cooling tower (max) : {Ton x l/Ton}	0	0	
Other			
Total			**66272**

Table.11. Total water consumption

Wastewater treatment.

DRDO-Bio digester tanks Biodigester technology has been developed by Defence Research Development Organisation (DRDO). In an environmentally responsible manner, the innovation degrades and **turns human waste into useable water and gases.** The technique involves bacteria feeding on faeces inside the tank, which then destroys the waste and releases methane gas through an **anaerobic process.** After secondary treatment of effluent utilising Reed bed or other treatment methods, the generated gas can be used for electricity, cooking, and water for irrigation or flushing back the toilets. This system does **not require electricity, requires no maintenance, is inexpensive, modular, and delivers reusable water.** The rootzone treatment is used to treat the generated greywater when partnered with a reed bed and has a 75% efficiency. As a result, 83% of the water consumed may be recycled, meeting 61% of the water demand. A landscape buffer between the toilet zone and the living zone is created by a constructed reed bed strategically placed between the two zones.

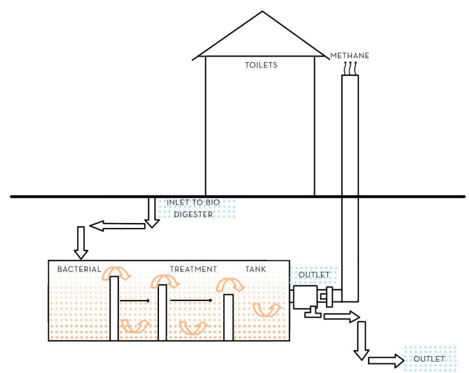


Fig 05. Bio-digester treatment

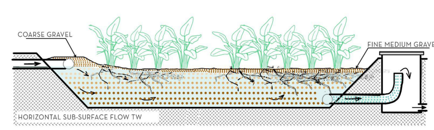


Fig 06. Root zone treatment

Rainwater harvesting

The plan aims to **capture 100% of the rainwater** that can be collected. Because our scheme is a temporary, low-footprint facility, storing so much rainwater is not possible due to space and expense constraints. As a result, we've designed a way for **digging a borewell with a recharging facility on site.** During the monsoon months, rainwater will be collected and used as needed, with the remainder being refilled into the borewell. The borewell will then only operate during non-monsoon months, pumping a fraction of the restored water.

Rainwater harvesting surfaces	Area m2	Runoff coeffecient	Effective catchment area m2
Roof Surfaces	3155	0.90	2839.5
Hardscape area	1446	0.75	1084.5
Softscape area	1899	0.30	569.7
Total Effective catchment area			**4493.7**

Table.12. Effective catchment

DESIGN DOCUMENTATION - RESILIENCE

The design and planning strategies aim to provide resilience on a variety of levels, including hazard/disaster type, environmental circumstances and retaining functionality.

Adaptability

A. Changing environmental conditions

- Given the location and characteristics of the site, variations in weather conditions- would be increase in heat and relative humidity, for which the courtyards aids in stack effect creating a cool environment not only at the cluster level but also throughout the masterplan.
- A solid-void composition helps in development of a microclimate within each cluster.
- Multiple windows and the variations in their type and size provide ample amount of light and comfort through natural ventilation.
- A manual mode of operation through mechanical fans can be used in case of increasing heat and glare.

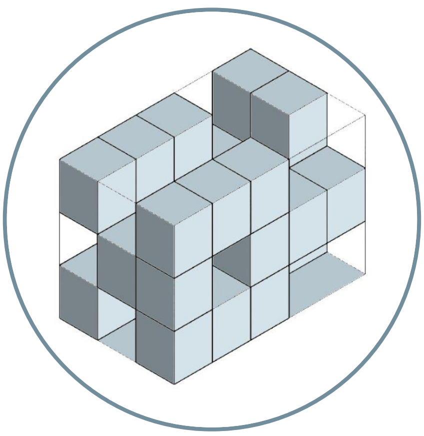


Fig.07. Stack effect

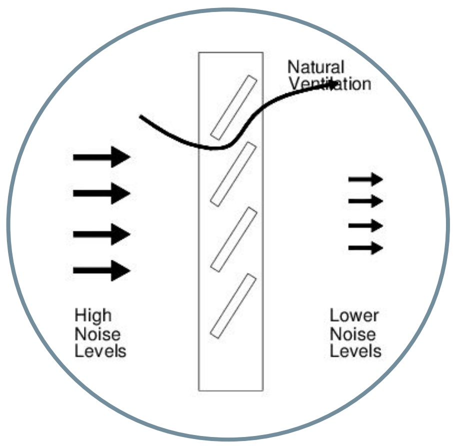


Fig.08. Passive Techniques

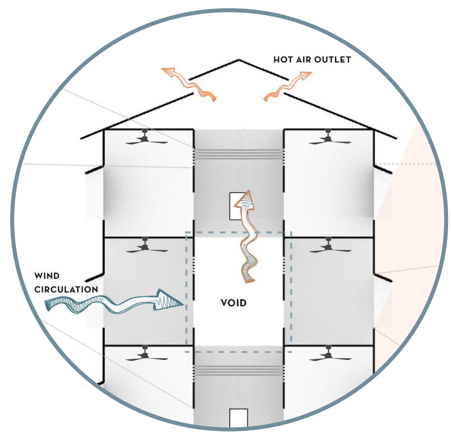


Fig.09. Natural Light and Ventilation

B. Risk due to earthquake and its solution

- Guiding the workers beforehand for the possible disasters and initiating social concerns for the same will help in reduced risk to the hazards
- Because of the flexibility provided by the grid, framed structures are more resilient to earthquakes than load-bearing structures, allowing for easier recovery after a catastrophe. The use of a grillage foundation contributes to the construction's robustness.
- In the event of a tragedy, the dining and recreational space serve as a refugee are

Fig.10. Increased Awareness and caution

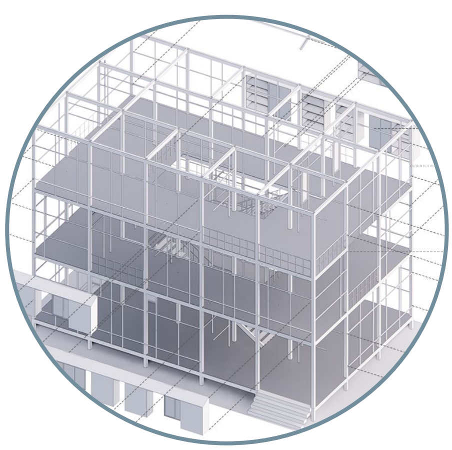


Fig.11.Framed structure - strong foundation

Fig.12. Open space as refugee area

DESIGN DOCUMENTATION - RESILIENCE

Ability to maintain functionality - in terms of energy, water and assembly :

Energy performance :

1. **Installing PV panels** on the roof to use solar radiation as the primary source of electricity helps during grid outages and disturbances.
2. The generated energy is used in the building, and the **excess energy is either fed back into the grid or stored for future use.**

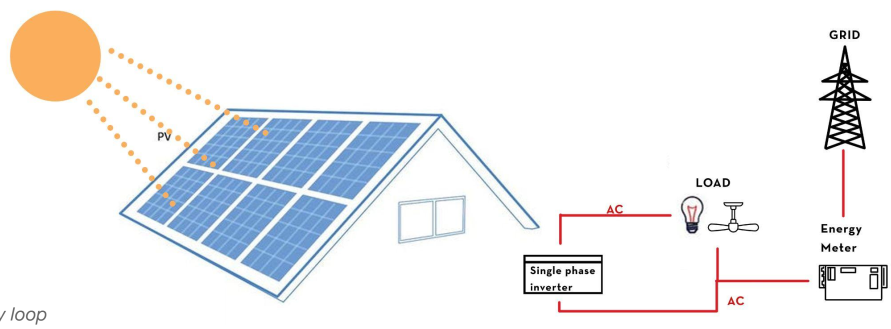


Fig.13. Energy loop

Water performance :

1. **Rainwater harvesting** is a technique for collecting, storing, and utilising rainwater for a variety of uses.
2. Rainwater falls on roofs and hard surfaces on the ground from which it gets collected
3. **Bio-digester toilets** treat human waste matter and converts it to safe water fit for irrigation and gardening

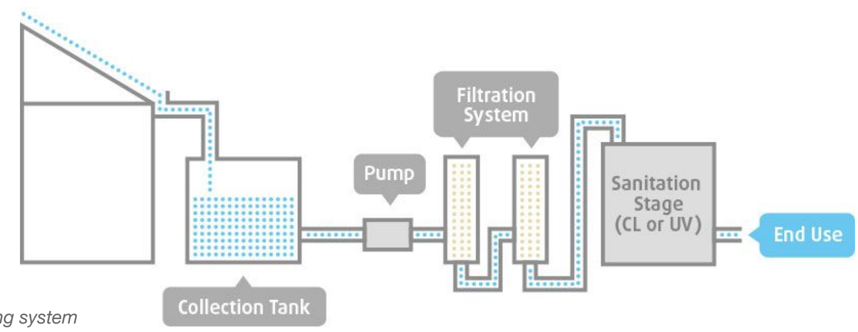


Fig.14 Rainwater harvesting system

Modularity :

1. The **architecture is modular**, with functional partitioning to build separate, scalable, and reusable components.
2. Modular construction projects take **30-50% lesser time to complete** as compared to traditional construction methods. The indoor construction process can run simultaneously with site and foundation work.
3. This also allows for **easy assembly, disassembly, and transportation.**
4. The modules can be **repeated** and changed in various ways to accommodate and **match the given constraints in the event of diverse site areas** and boundaries.

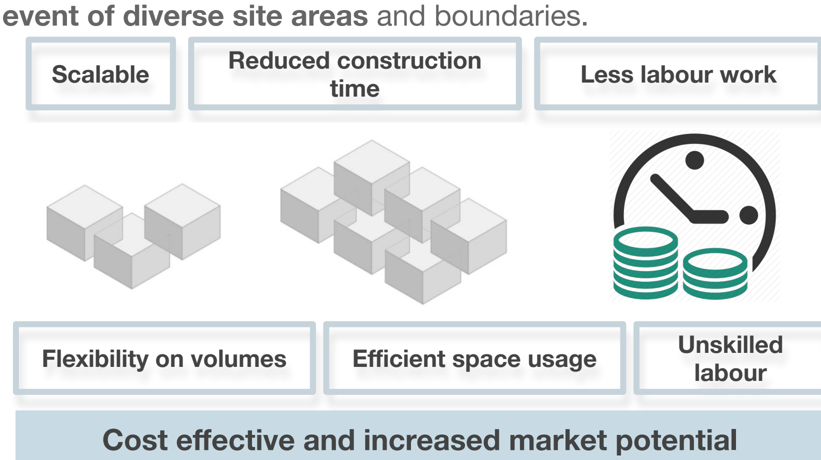


Fig.15. Modularity as a tool for scalability and affordability

DESIGN DOCUMENTATION - INNOVATION

As per the need/ problems of the workers an innovative solution is provided which has a potential for market and is scalable.

- ## Improved storage facility

  When we went to an on-site construction worker housing, we saw that the workers didn't have enough storage space and kept their belongings under the bed or strewn around like a jumble. To address this, cantilevered blocks have been added to the outer facade, providing adequate room for workers to store their belongings while also providing a barrier-free inner circulation space. This also provides for a lower FAR (Floor Area Ratio), resulting in a smaller built-up area. The blocks also act as a fin for the nearby windows, reducing heat intake and glare.

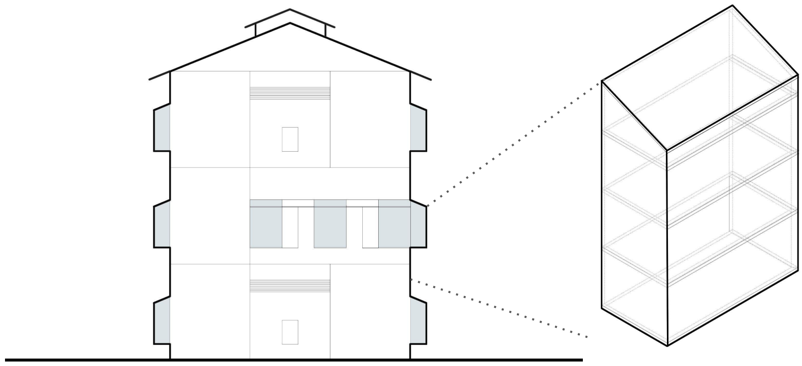


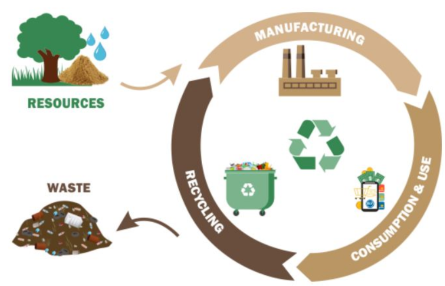
Fig 16. Storage facility in residential units

- ## Material innovation

  Ricron Panels recovers non-recyclable garbage and converts it into sheets that may be used as building materials using unique technology. It's light, recyclable, termite-proof, water-proof, heat-resistant, fire-resistant, and, most significantly, a green product, making it environmentally beneficial. The amount of heat in the interiors will be reduced by using these in the modular design while generating voids and enabling sufficient cross ventilation.

Img 06. Ricron Panels

Img 07: Ricron panel



Img 08 : Waste reduce and recycle

- ## Toilet innovation

  When we analysed the energy requirements for STP, we discovered that they are 30% more than those for Bio-digester toilets. Human waste is treated in bio-digester toilets and converted to clean water suitable for irrigation and gardening. They require less maintenance than STP, and STP requires more fixtures to separate solid waste, which can be readily accomplished by including wetlands as a landscape element as well as for solid waste treatment in Bio-digester toilets.

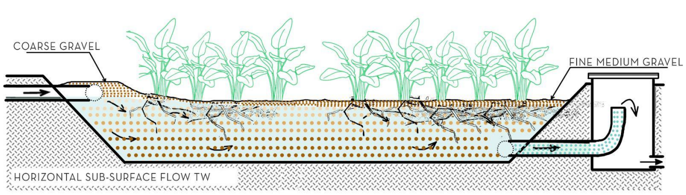


Fig 17. Root zone treatment

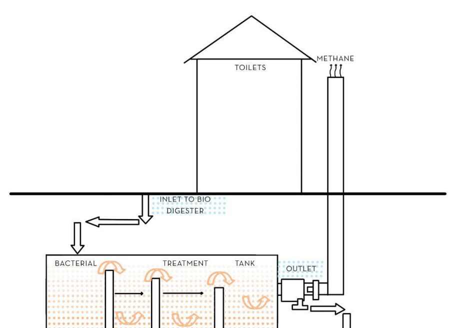


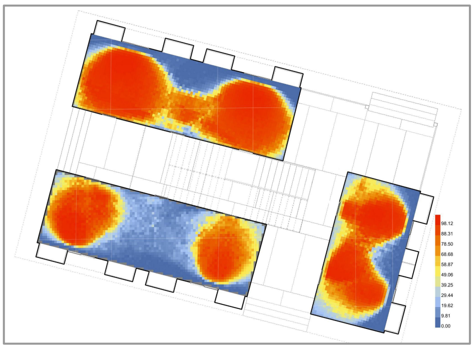
Fig 18. Bio digester system

DESIGN DOCUMENTATION - HEALTH AND WELL BEING

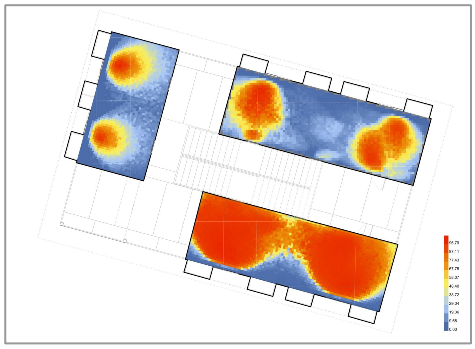
As the site is located in Khandeshwar, Mumbai, it lies in the hot and humid climatic zone. This makes it important to make the building efficient by maximum utilization of natural ventilation while providing thermal comfort.

DAYLIGHT FACTOR

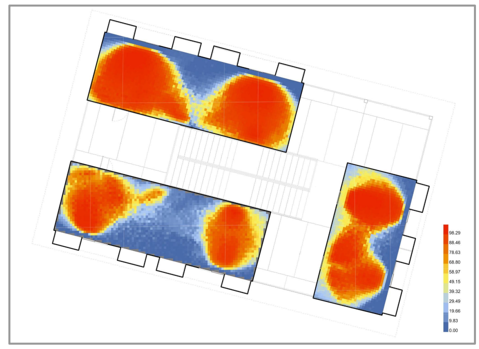
The daylight factor has been modelled to comprehend the ratio of inside Lux level to exterior Lux level, with an optimal ratio for an internal room being in the range of 2% to 5%, indicating balance between lighting and thermal aspects.



Graph.06.Daylight factor chart for ground floor

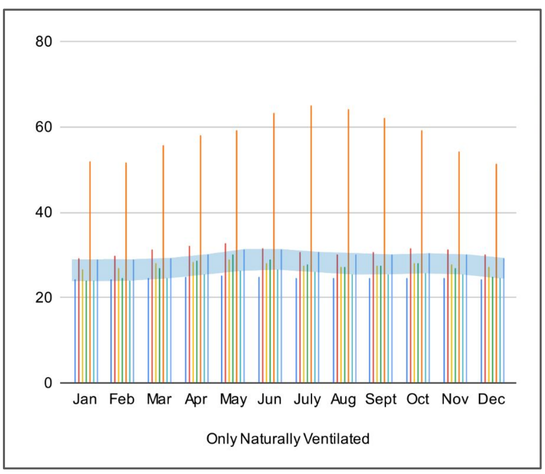


Graph.07.Daylight factor chart for first floor

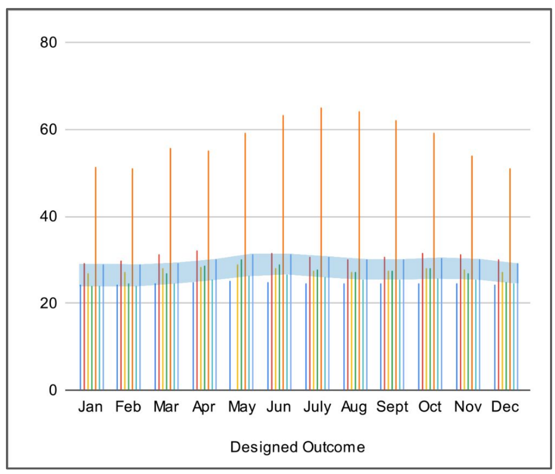


Graph.08.Daylight factor chart for second floor

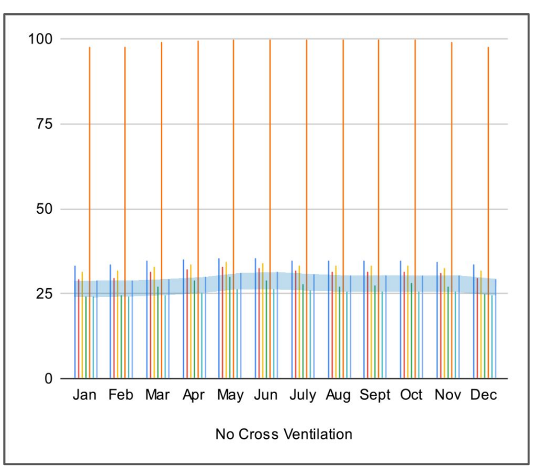
The window wall ratio has been taken as 1:15 so to bring down the internal temperature. By using fans, the indoor temperature can further be brought down.



Graph.09.Thermal comfort achieved with natural ventilation



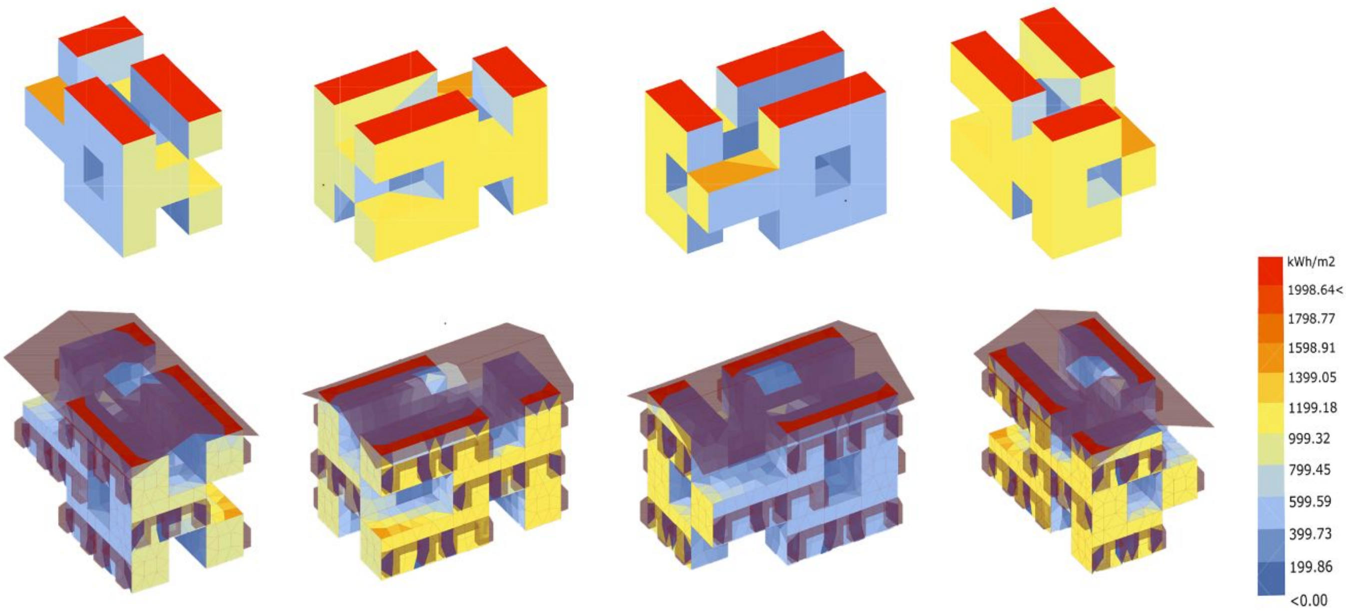
Graph.10.Thermal comfort achieved with mechanical means and natural ventilation



Graph.11.Thermal discomfort in the absence of natural ventilation.

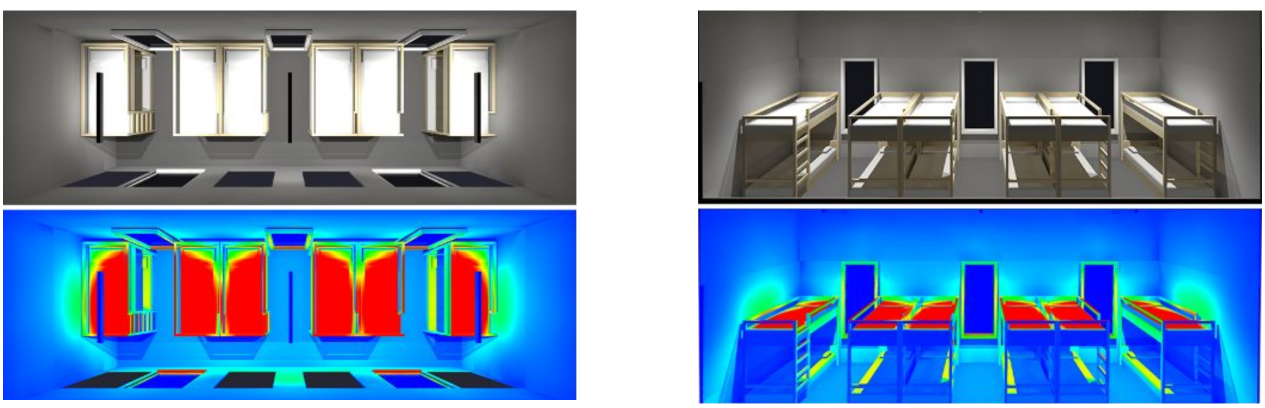
Graph.12 .Thermal comfort achieved in kitchen and dining area

DESIGN DOCUMENTATION - HEALTH AND WELL BEING



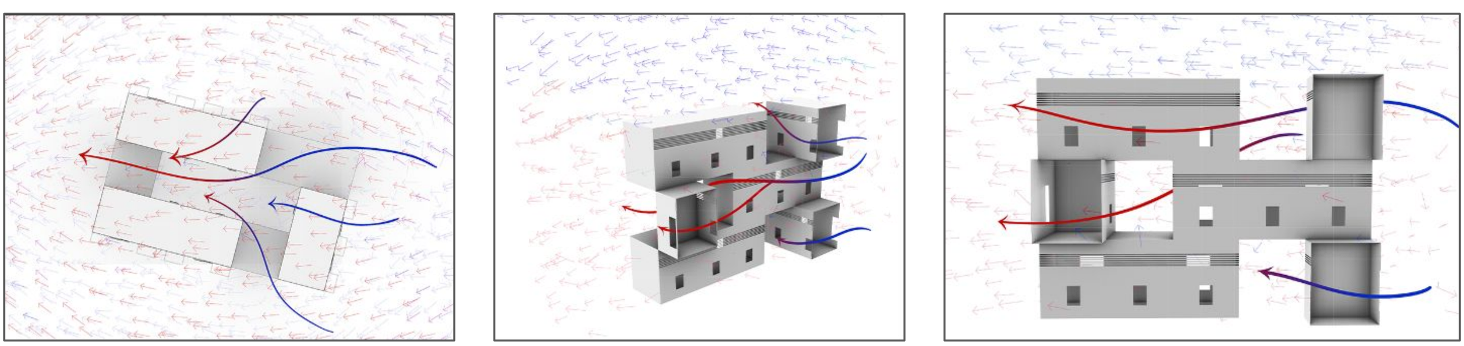
Graph 13: Heat gain simulation

The **high heat gain** by the modules without any facade modulation is shown in the first row of simulation data. To combat this, the protruding storage blocks on the facade and roof act as **fins and overhangs** respectively, **minimising heat gain and boosting thermal comfort.**



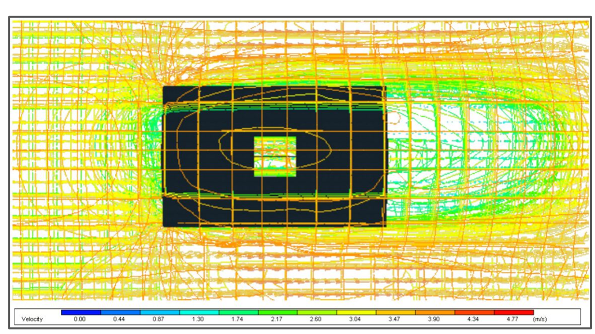
Graph 14: Illumination simulation

Within the modules, the given number of **LED lamps provide the amount of lighting required** for clear vision at night.



Graph 15: Wind flow simulation

The wind simulation demonstrates how the windows, as well as their size and placement, contribute to increased ventilation within the modules. Thus, using passive technologies and orienting the building maximum wind flows through the clusters.



Graph 16: Wind flow simulation

DESIGN DOCUMENTATION - HEALTH AND WELL BEING

The design and planning strategies increases the number of thermal comfort hours via the use of strategies falling under various categories:

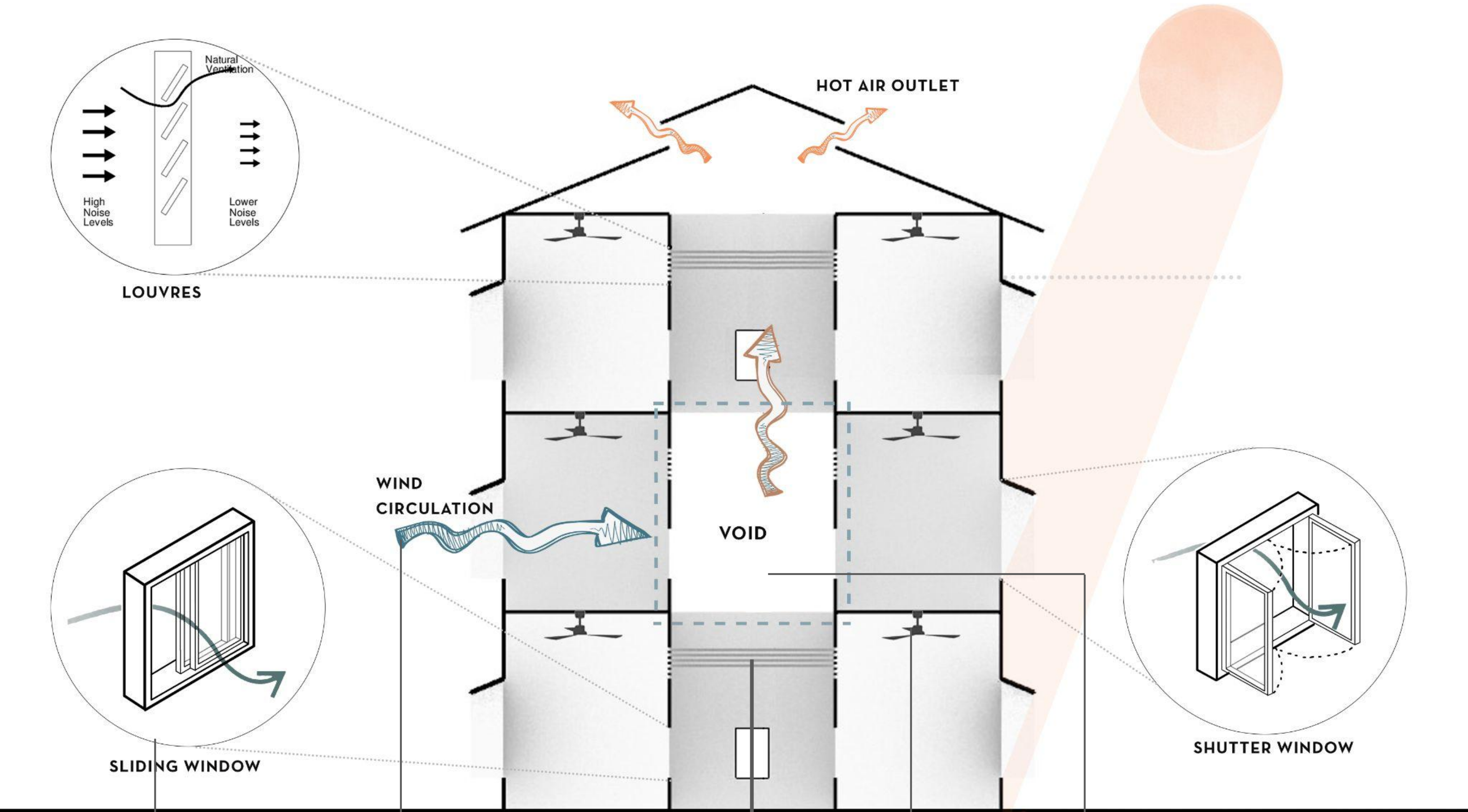


Fig 19. Thermal comfort strategies

CONSTRUCTIVE MECHANISM

Louvres :

INDUCED VENTILATION

Voids : The voids created due to the placement of the modules ensures cross ventilation through the clusters.
Low Sill Level : Because of the relatively low sill height of 600mm, colder air from the surroundings enters the modules.
Courtyards : Every cluster has a central courtyard, which provides a volume of cooler air around the modules as a result of the layout.

NATURAL VENTILATION

Cross Ventilation : Windows on each modules are on opposite walls, allowing for better airflow through cross ventilation.

TYPE OF OPENING

A combination of shutter and sliding windows aids with the ventilation process with the shutter windows providing 100% wind inlet and sliding windows providing 50% wind flow

MECHANICAL MEANS

Fans : Use of fans additionally increases the number of comfortable hours.

DESIGN DOCUMENTATION – ARCHITECTURAL DESIGN

INITIAL CONCEPTUAL DESIGN IDEAS

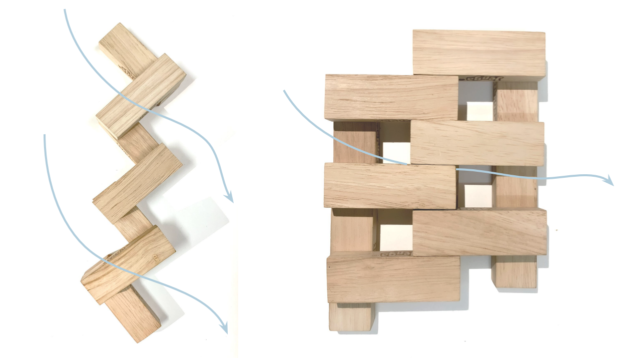


Fig 20. Playing with Jenga blocks to create interesting indoor and outdoor experiential spaces

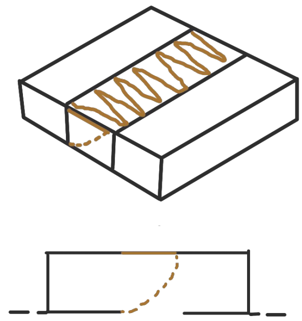


Fig 21. Exploration done in terms of foldable modules and took out inference from it - paving our way back to modular design

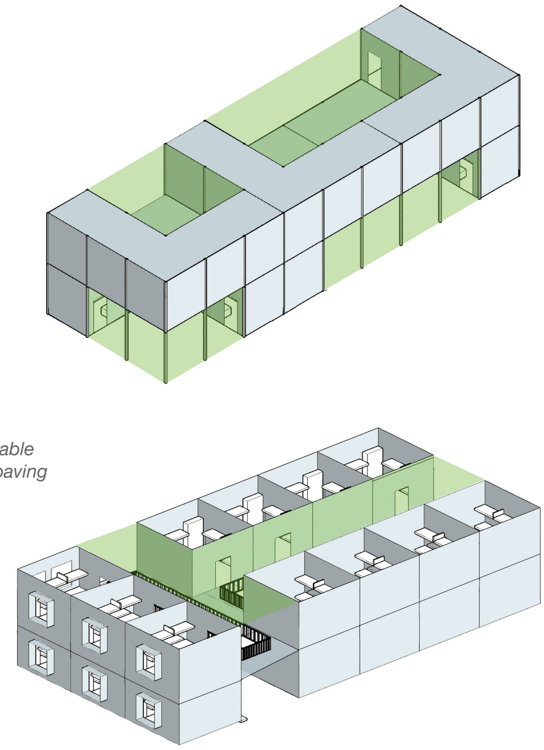


Fig 23. Modular design with central Courtyard and stilt design creating a different user experience

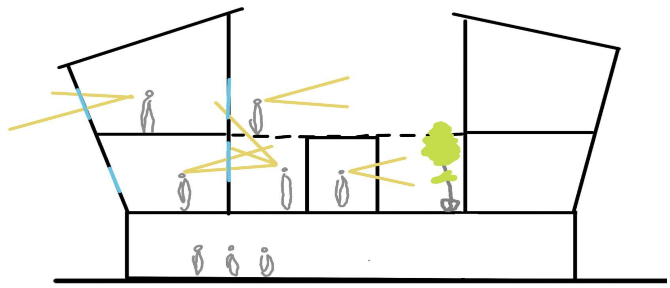
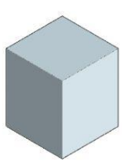
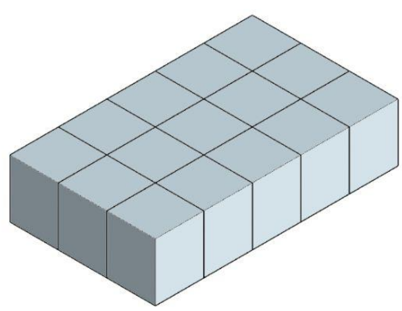


Fig 22. Sectional manipulation done keeping in mind the visual axis and innovation in roof design

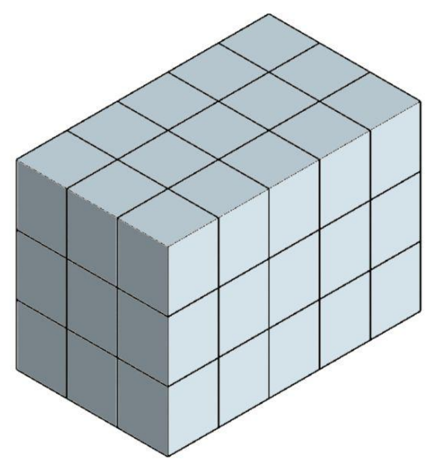
FORM EVOLUTION



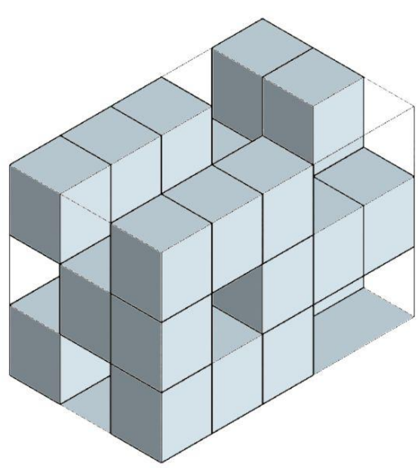
3x3x3.6m modular unit



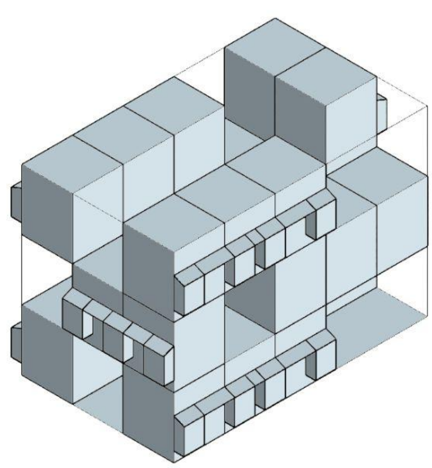
Repetition along X- & Y- axis to maintain the structural grid



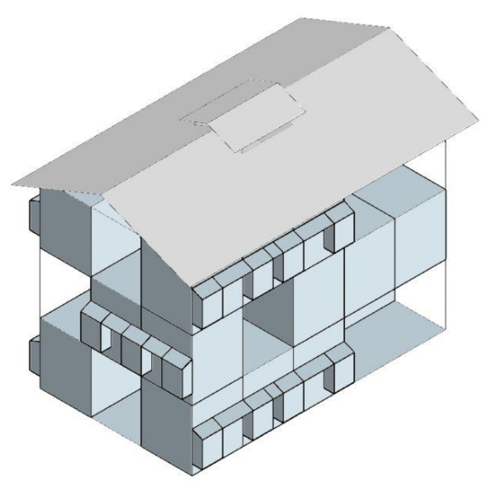
Repetition along Z- axis for vertical accommodation (G+2)



Blocks are removed to form a solid void composition that allows for light and ventilation.

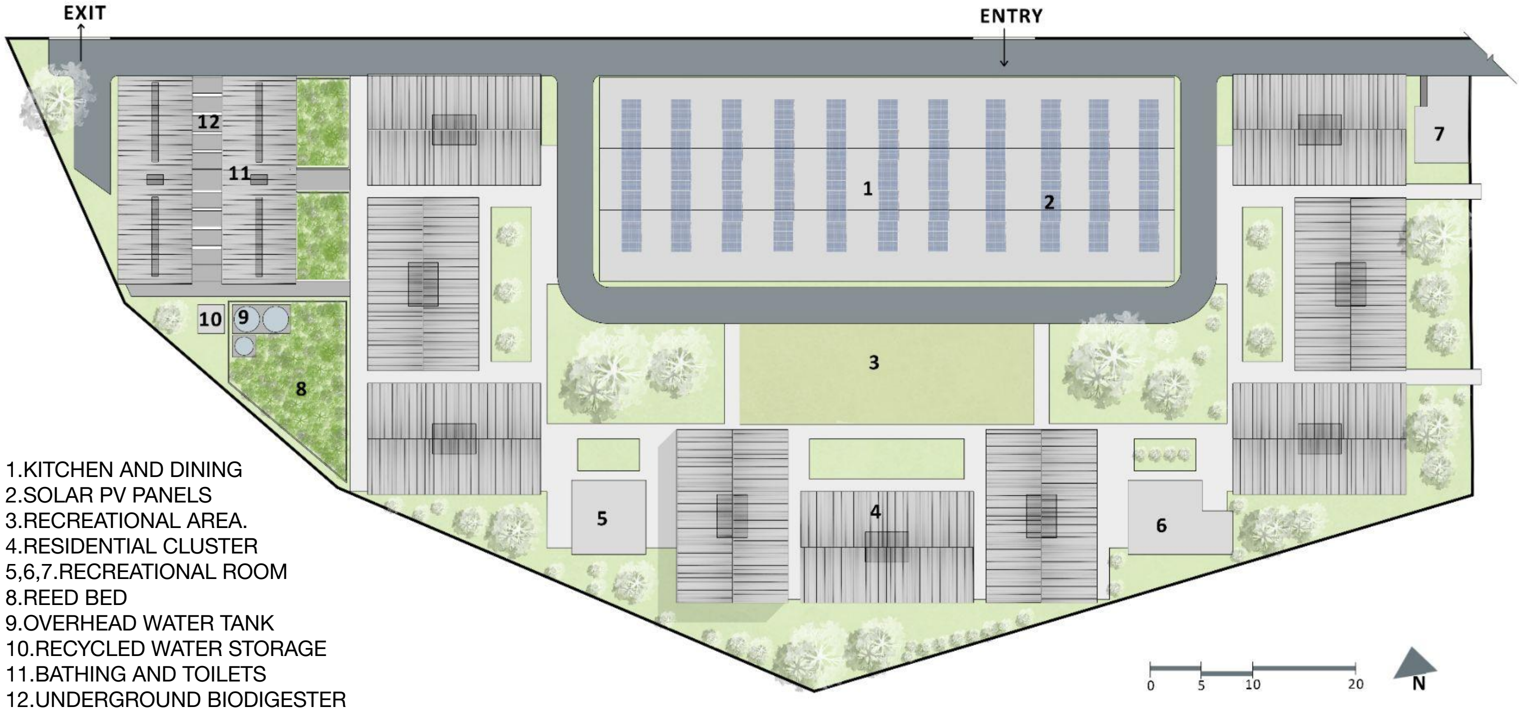


The addition of storage blocks on the exterior to allow for barrier-free interior circulation.

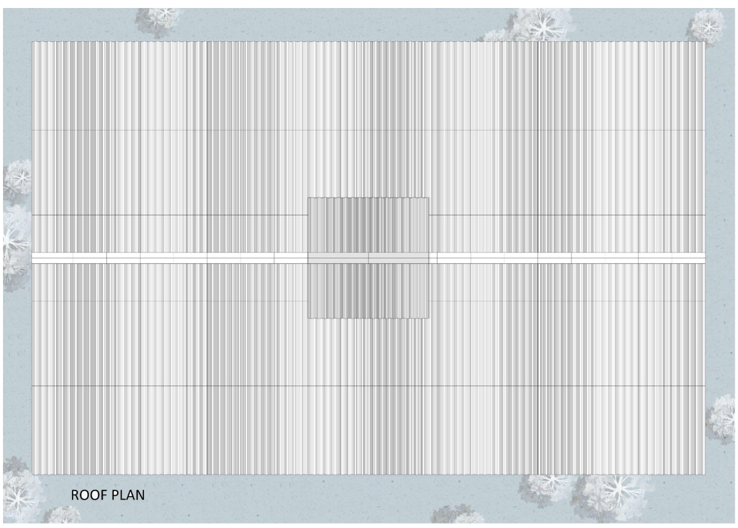


Addition of ___ roof with a skylight to create a stack effect

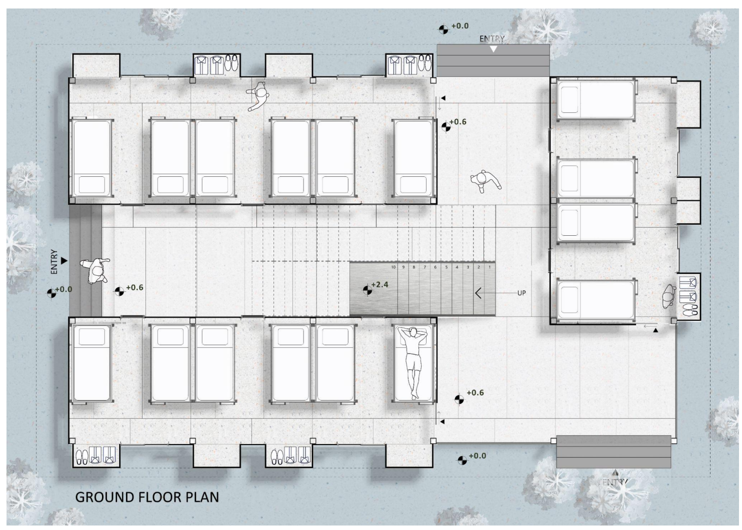
MASTER PLAN



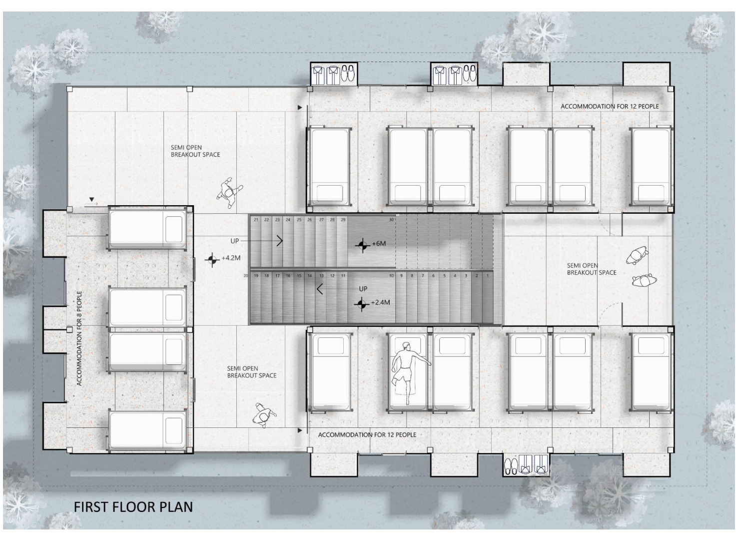
1.KITCHEN AND DINING
2.SOLAR PV PANELS
3.RECREATIONAL AREA.
4.RESIDENTIAL CLUSTER
5,6,7.RECREATIONAL ROOM
8.REED BED
9.OVERHEAD WATER TANK
10.RECYCLED WATER STORAGE
11.BATHING AND TOILETS
12.UNDERGROUND BIODIGESTER



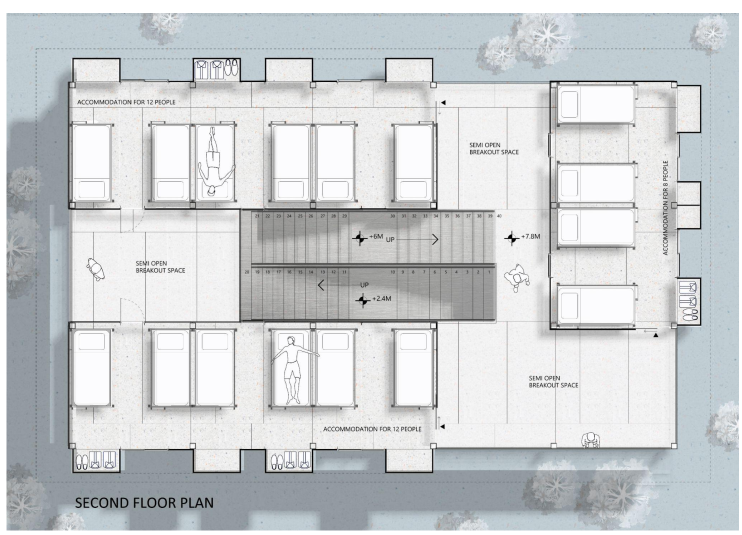
ROOF PLAN



GROUND FLOOR PLAN

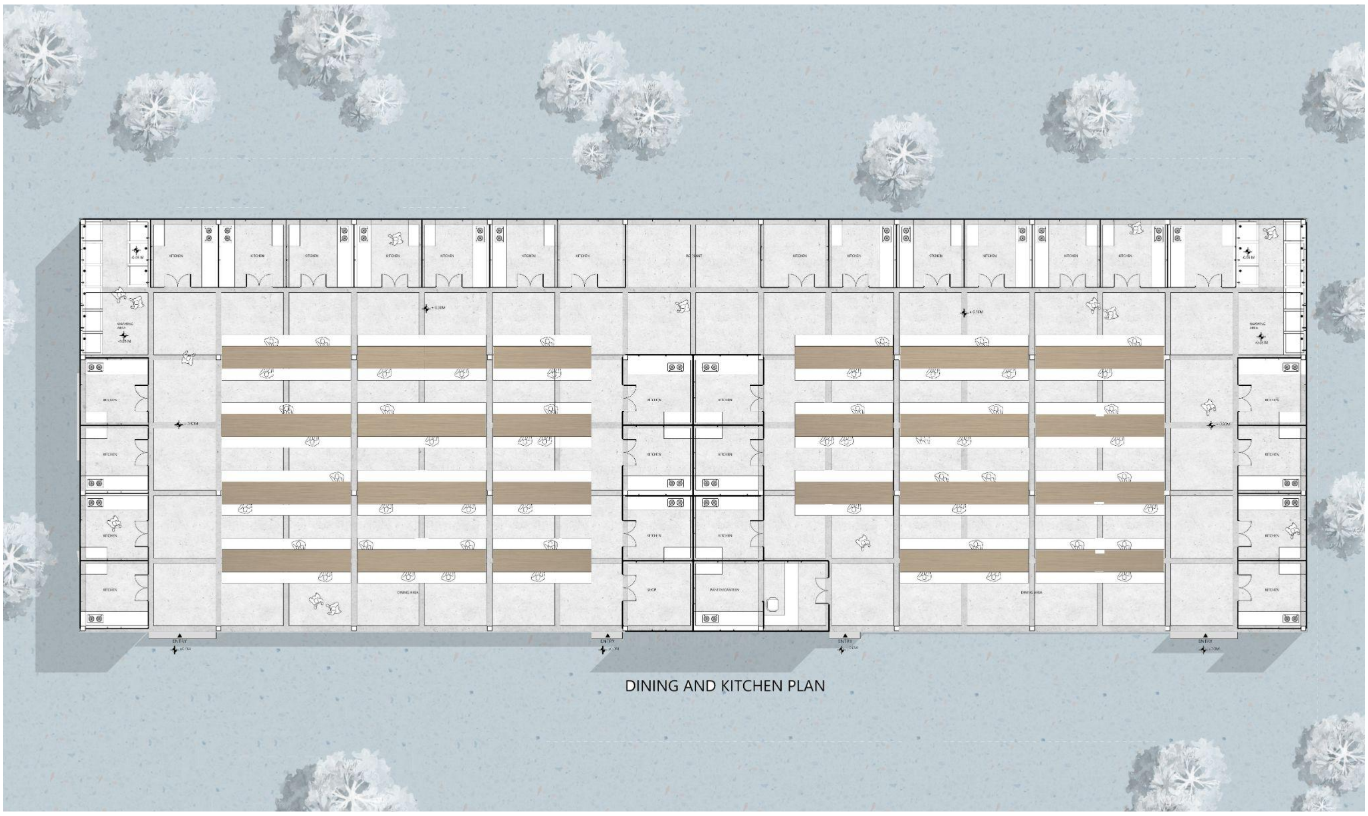


FIRST FLOOR PLAN

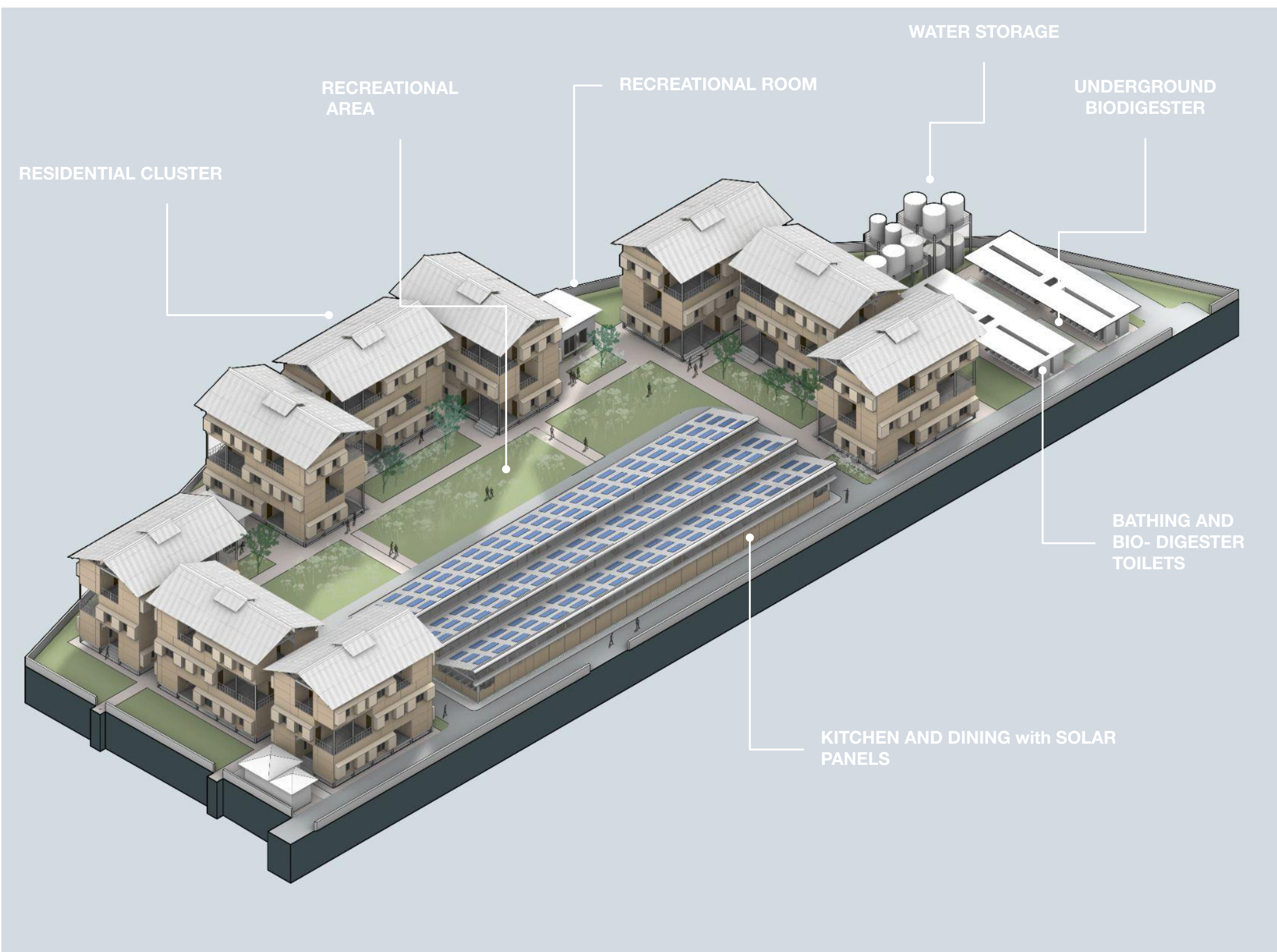


SECOND FLOOR PLAN

DESIGN DOCUMENTATION - ARCHITECTURAL DESIGN

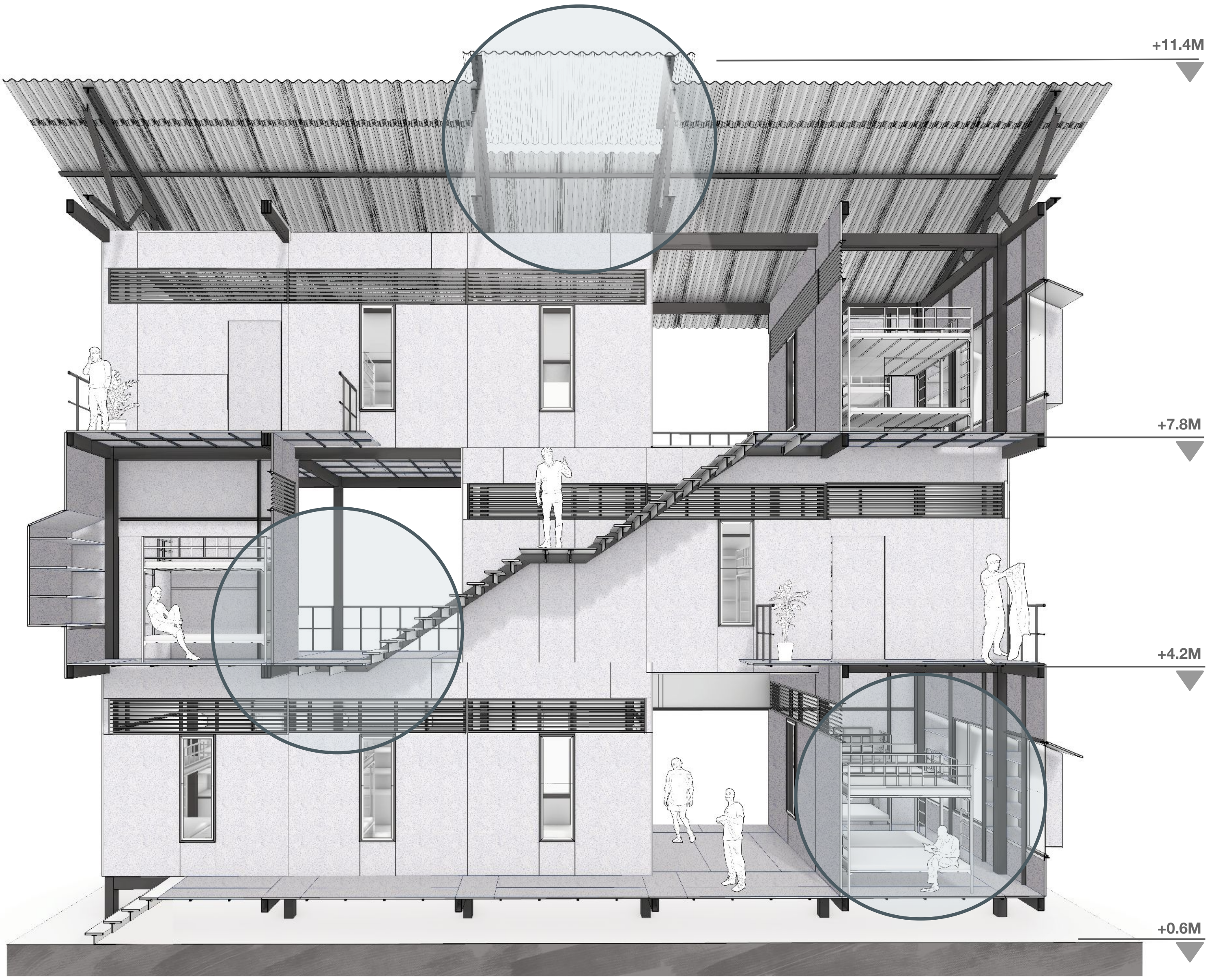


PLAN OF KITCHEN AND DINING



ISOMETRIC VIEW OF THE PROPOSED DESIGN

DESIGN DOCUMENTATION - ARCHITECTURAL DESIGN



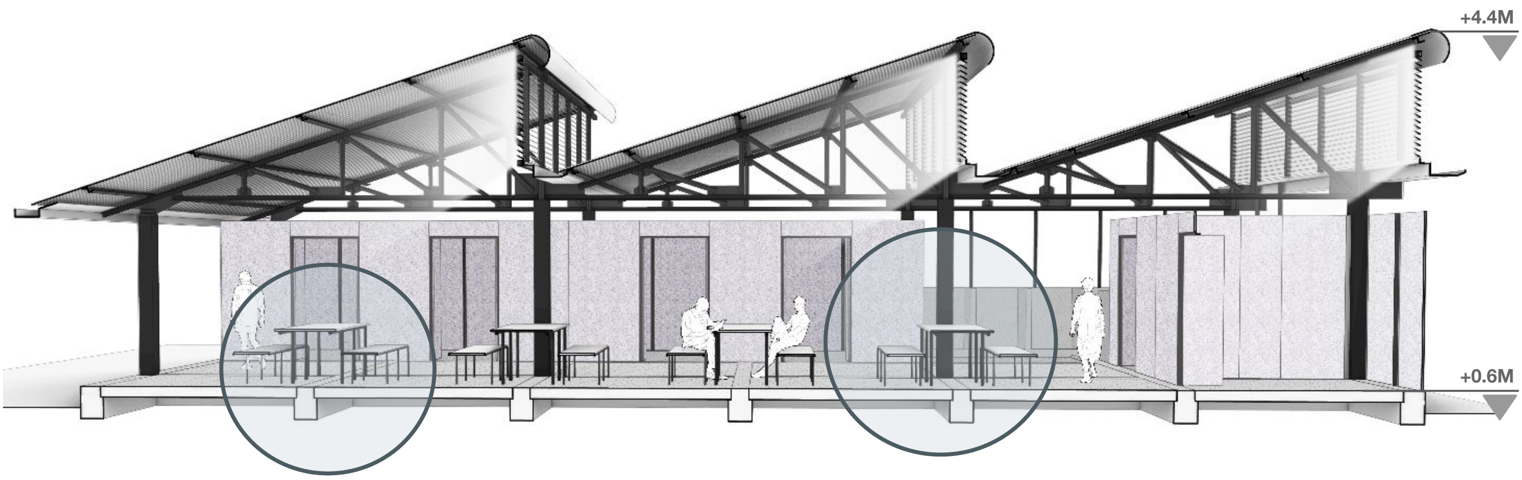
SECTIONAL PERSPECTIVE THROUGH HOUSING CLUSTER

View through the central void with the skylight

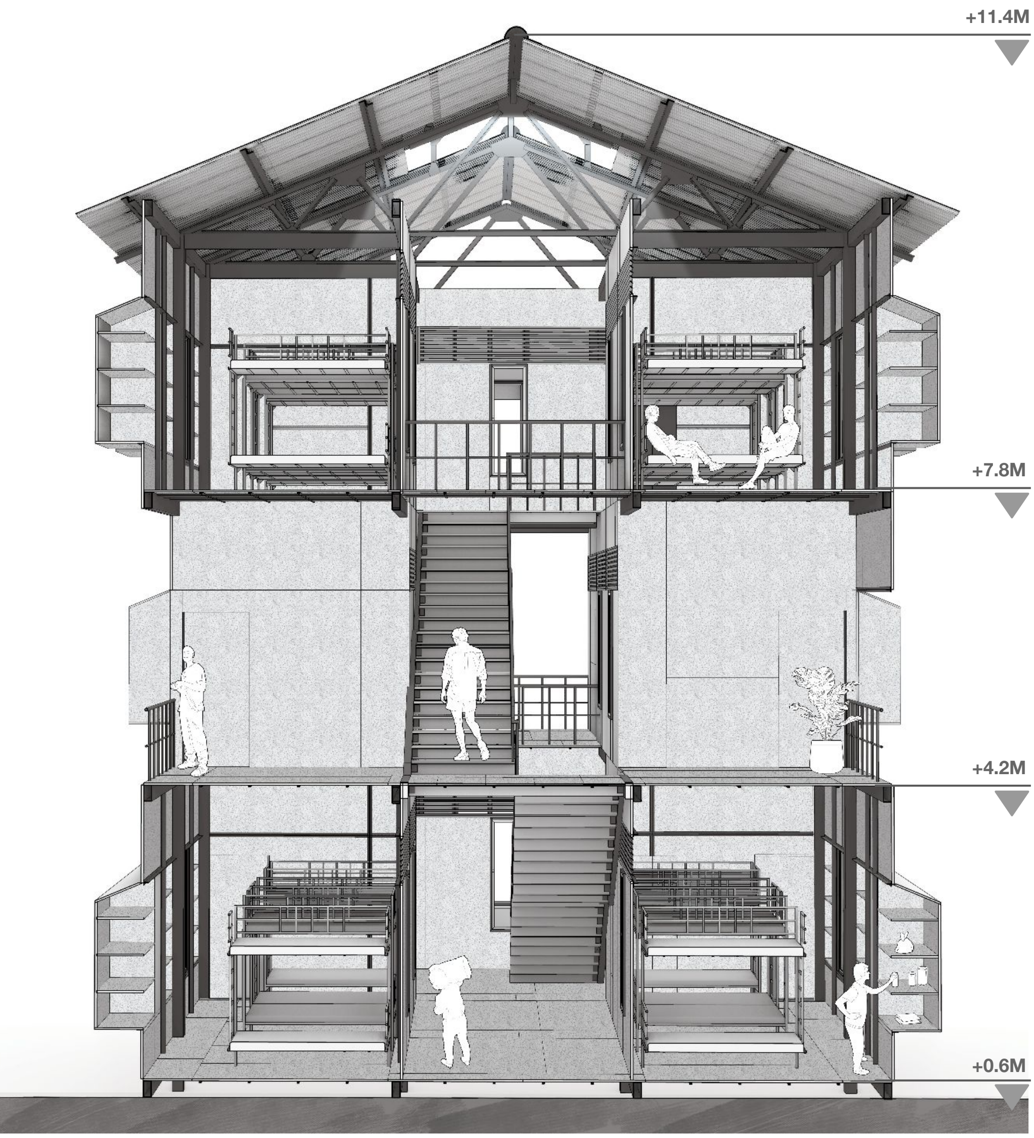
View through the staircase

View through the interior of the cluster showcasing bunk beds and storage

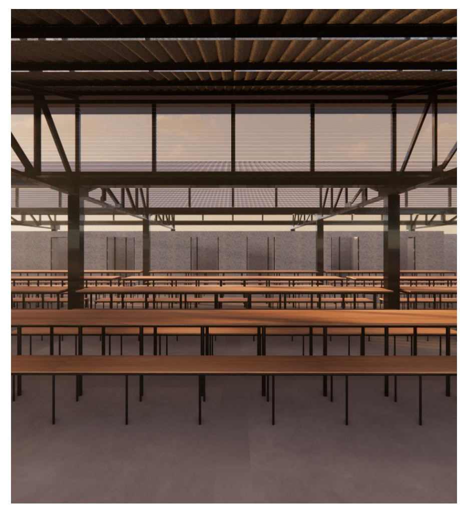
DESIGN DOCUMENTATION - ARCHITECTURAL DESIGN

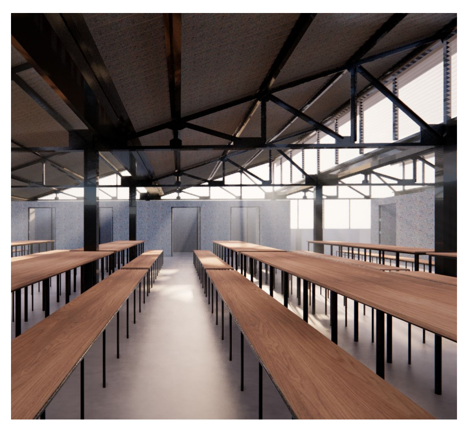


SECTIONAL PERSPECTIVE THROUGH KITCHEN AND DINING



SECTIONAL PERSPECTIVE THROUGH ACCOMODATION CLUSTER

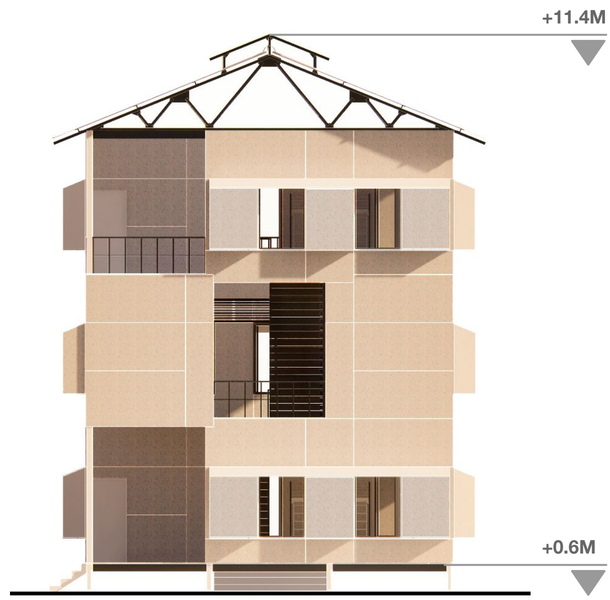




Kitchen and dining space highlighting the north light roof truss

DESIGN DOCUMENTATION - ARCHITECTURAL DESIGN

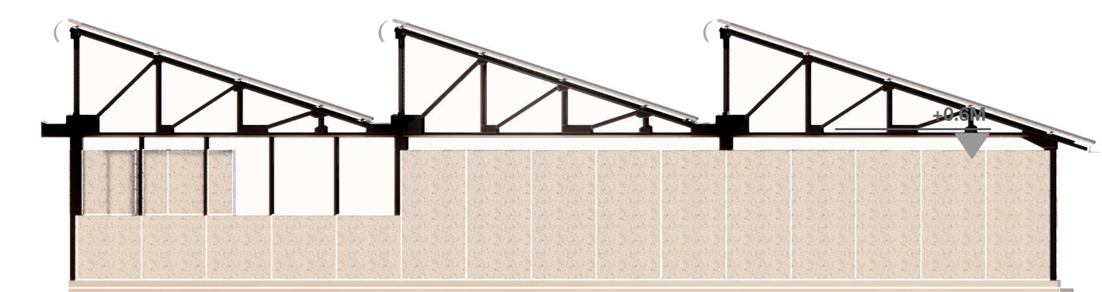
FRONT ELEVATION



RIGHT ELEVATION

LEFT ELEVATION

BACK ELEVATION

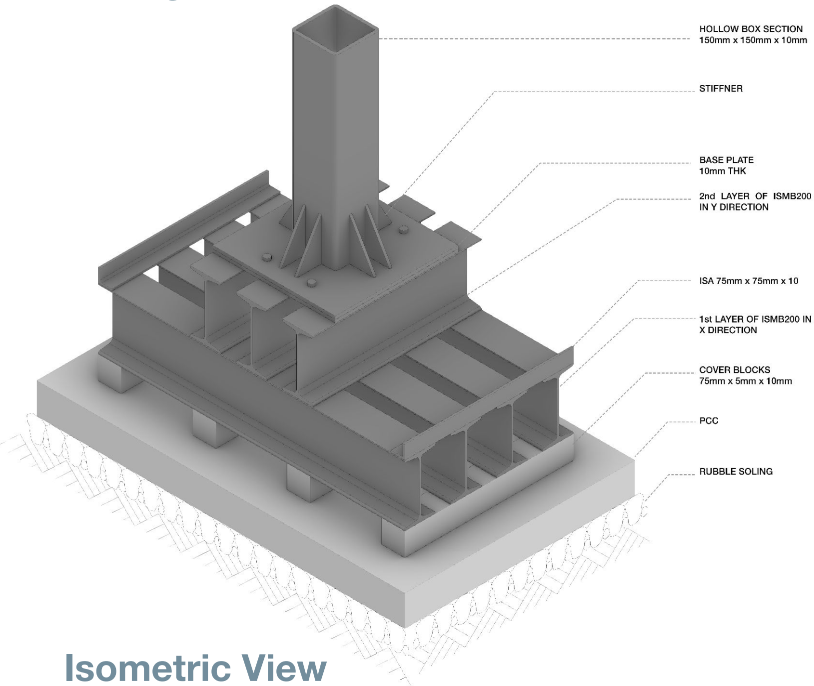


ELEVATION OF KITCHEN AND
DINING

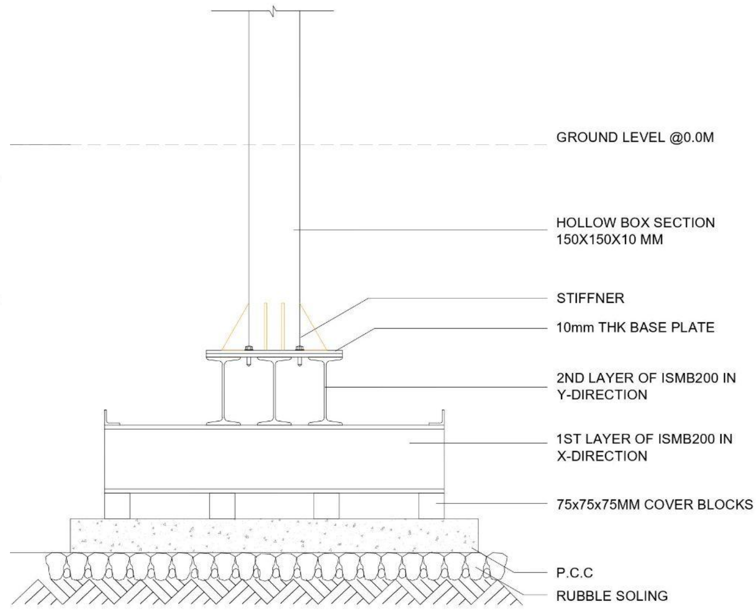
Key Plan

DESIGN DOCUMENTATION - ENGINEERING DRAWINGS

Grillage foundation



Isometric View

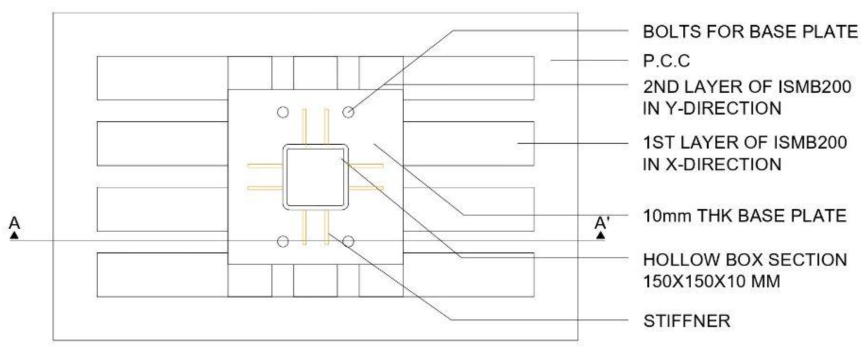


Section AA'

The load is distributed uniformly across a vast area using a **two-tier grillage foundation** with beams arranged at right angles. Steel and timber are the two forms of grillage foundations.

Steel grillage foundations range in depth from 1 to 1.5 metres, with a minimum of 25 millimetres between beams. It can simply removed and reused at a later date, making it cost effective.

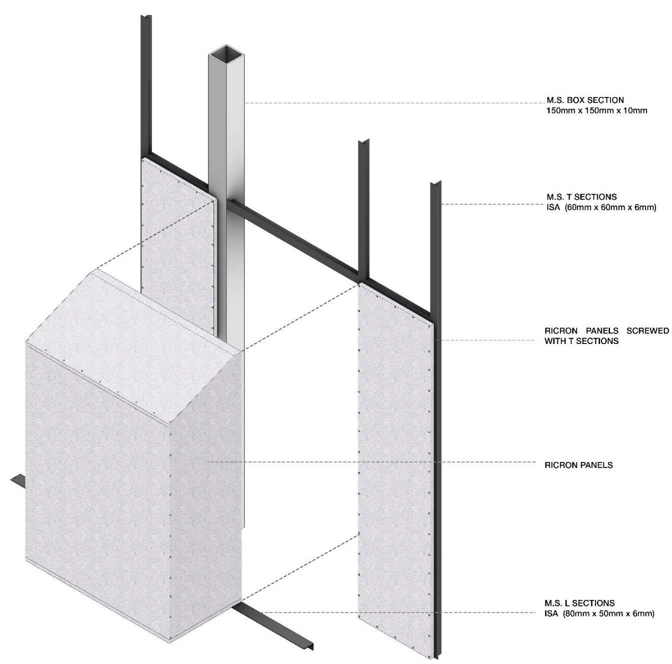
Thus, this makes it more efficient than the traditional concrete foundation.



Plan

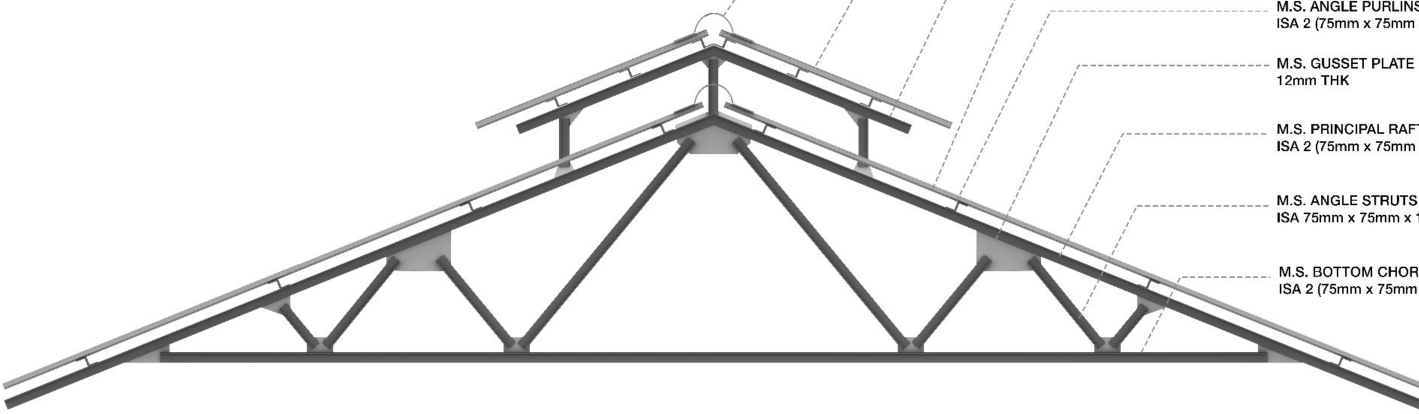
Storage block joinery details

After the placement of structural grid, cantilevered storage blocks are attached on the M.S. Angle Sections



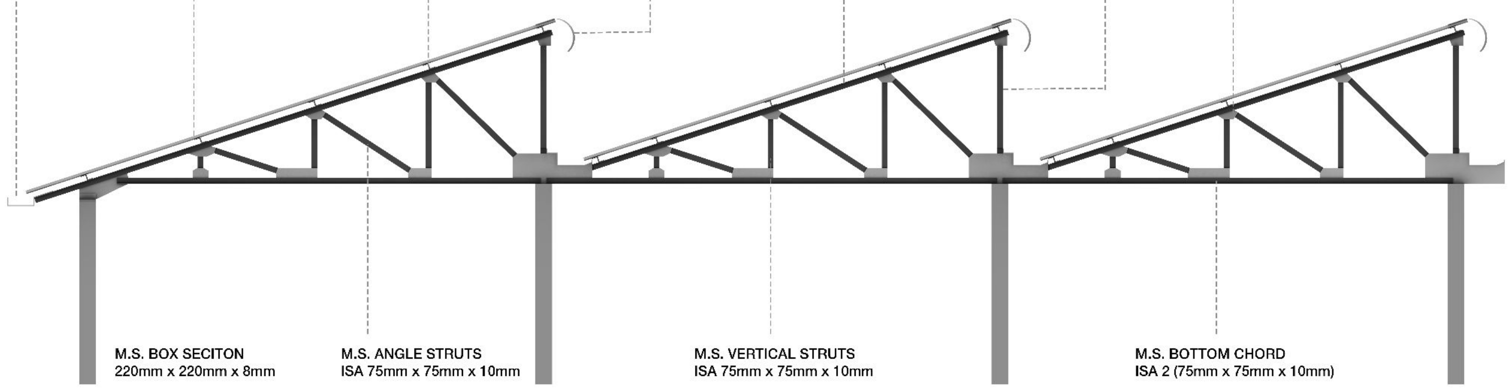
Exploded isometric view

FINK TRUSS
OVER ACCOMMODATION UNITS

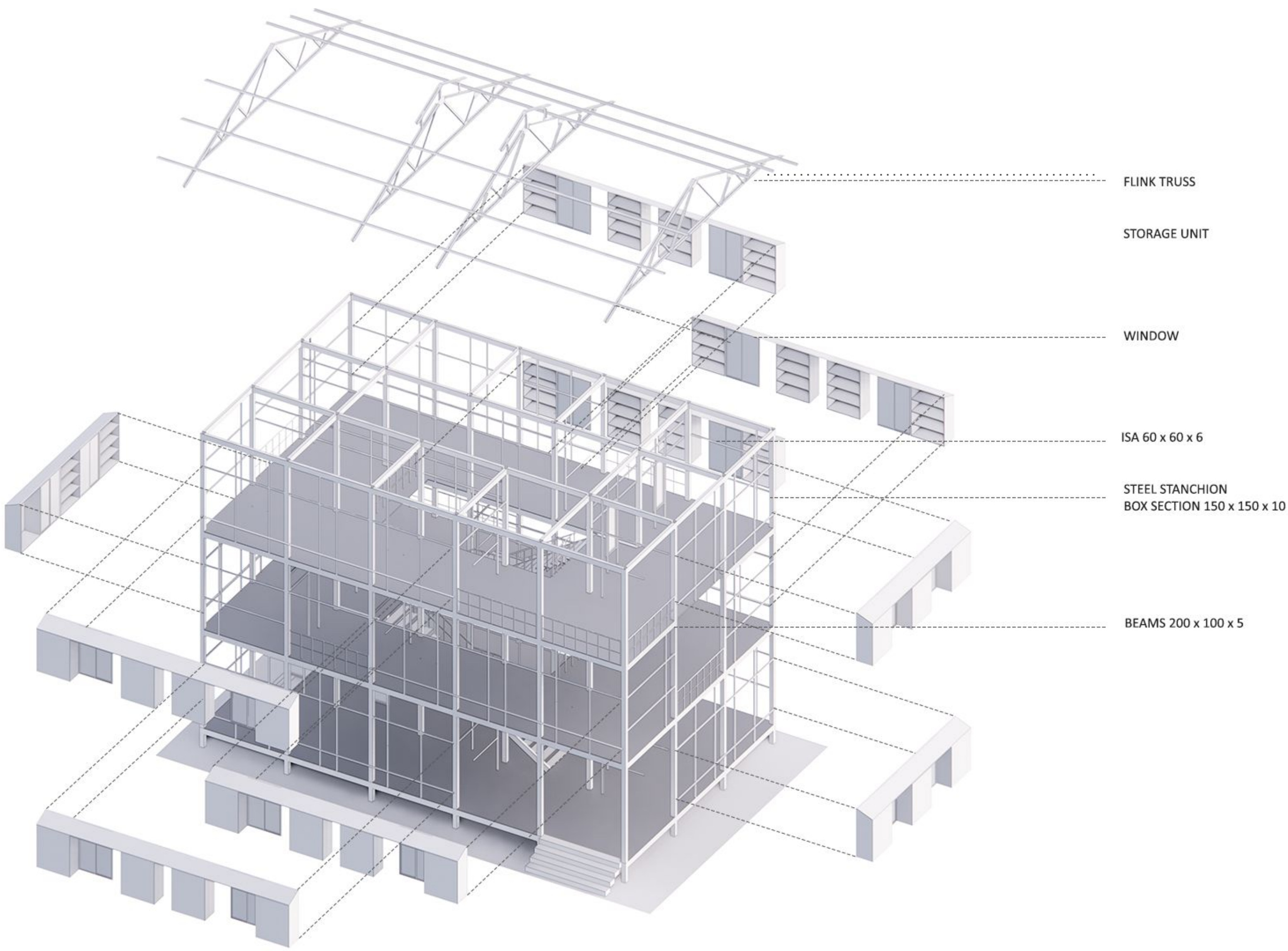


Fink truss is identified by the presence of **multiple diagonal members projecting down from the top of the end posts at a variety of angles.** These diagonal members extend to the bottom of each of the vertical members of the truss with the longest diagonal extending to the center vertical member.

NORTH LIGHT TRUSS



North light trusses are traditionally used for short spans in industrial workshop-type buildings. They allow maximum benefit to be gained from natural lighting by the use of glazing on the steeper pitch which generally faces north or north-east to reduce solar gain. The use of north lights to increase natural daylighting can reduce the operational carbon emissions of buildings.



ISOMETRIC VIEW SHOWING THE STRUCTURAL GRID

DESIGN DOCUMENTATION – AFFORDABILITY

Since our design is mostly dependent on a one-time investment in materials and fixtures, we wanted to ensure that it was reasonable in terms of other considerations such as health and wellness, scalability, market potential, and so on, thus **offsetting the cost increase to 3.4Cr**.

The members utilised are larger and more than the previous housing due to the supply of G+2 clusters and a greater number of dining, kitchen, and toilet units, as well as staircase units. A stronger grillage type foundation has been used to support the same structural structure. As the number of modules of each type grows, so does the amount of fixtures and other requirements.

DESIGN DOCUMENTATION - SCALABILITY AND MARKET POTENTIAL

Construction workers sector is the second largest employment sector in India. It attracts migrant workers from different states like Uttar Pradesh, Jharkhand, Bihar, West Bengal, and Maharashtra. Housing is an essential need for them.

Following extensive research, the **primary target market for our project is construction employees and their connected contractors.** Construction workers who are provided with this type of housing by contractors are possible users. They reside on site for the duration of the construction process, and it is vital and a basic condition for them to feel at home. Being members of the **economically disadvantaged group,** they find it **challenging to maintain their own housing** as they move from one location to another on a regular basis.

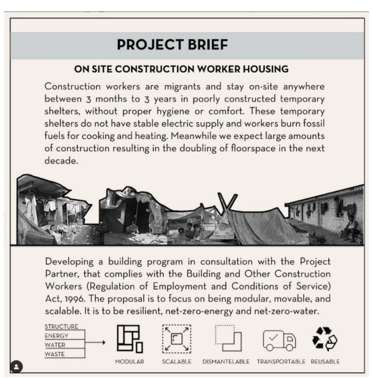
By establishing a **user experience and a spatial quality**, this worker housing solution aims to give them a more homely feeling. The fact that the intervention is net zero in quality has its own set of advantages, such as acting as a **hedge** for building owners against f**uture energy price hikes**, increased **tenant comfort**, health, well-being, and productivity; **decreased energy consumption and expenditures**; and so this **increases the market potential** of the iteration.

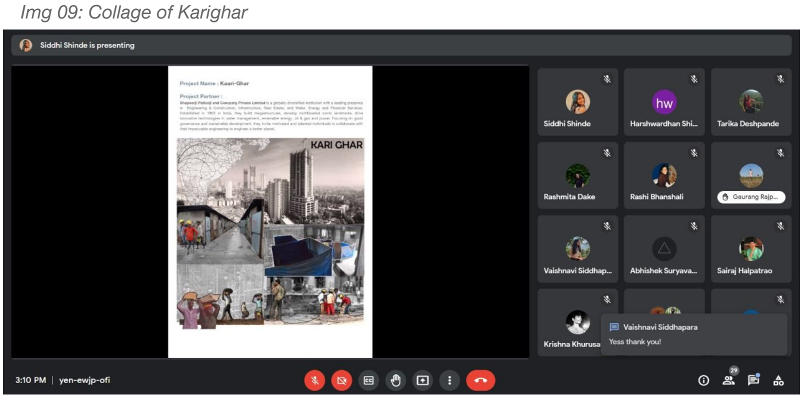
The scalability of the solution is due to its **modularity**, which makes it **flexible, repeatable,** and **replicable.** The chosen materials and building construction techniques save money and time while boosting quality and productivity. The structure can easily be assembled at varied site constraints like slope, contour, flat, etc.

DESIGN DOCUMENTATION – COMMUNICATIONS

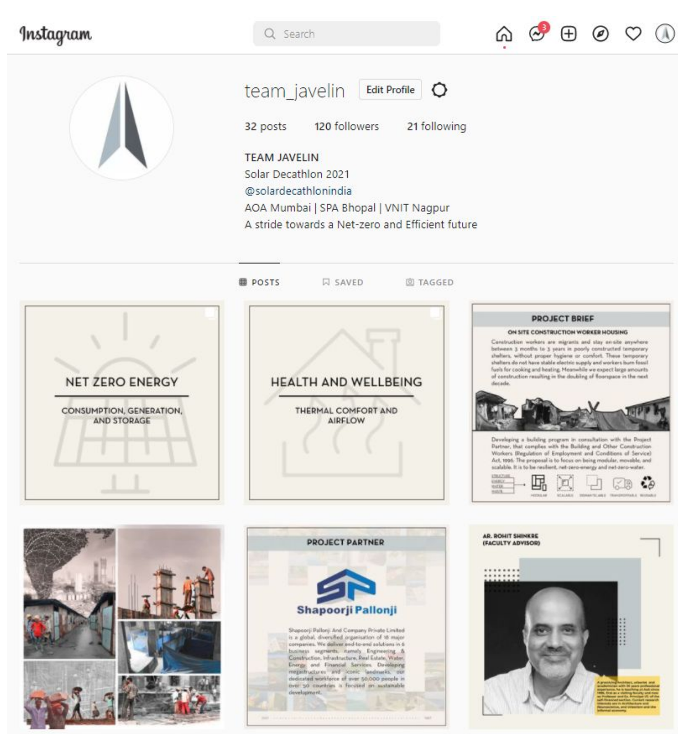
Team Javelin engaged with the public using the social media platform-instagram. From introducing the team members, guides, project and contest strategies, we also generated awareness with respect to the issues faced by workers presently

Img 09: Collage of Karighar





Img 10: Meeting for spreading awareness of the issues faced by workers and our project brief



Img 11: The official instagram page of team javelin

REFERENCES

- National Building Code (NBC) 2016
  https://www.bis.gov.in/index.php/standards/technical-department/national-building-code/
- Net Zero Energy Building (NZEB) :
  https://nzeb.in/
- Ricron panels - for materiality :
  https://www.ricron.com/
- Shubhra Biotech - for biodigester toilets
  https://shubhrabiotech.com/

APPENDIX A : BONAFIDE LETTER

रचना संसद

RACHANA SANSAD'S
ACADEMY OF ARCHITECTURE

MUMBAI FOUNDED IN 1955, AFFILIATED TO UNIVERSITY OF MUMBAI, RECOGNISED BY COUNCIL OF ARCHITECTURE AND GOVERNMENT OF MAHARASHTRA.

Ref. No. Stu-06/ 305 /0921 Date :16/09/2021

TO WHOMSOEVER IT MAY CONCERN

This is to certify that the below mentioned are bonafide students from the Academy of Architecture studying in the Third Year Architecture during the academic session 2021-2022 of the Five years full-time Bachelors Degree Course in Architecture, affiliated to the University of Mumbai.

This certificate is issued for the purpose of **Competition.**

(Suresh M. Singh)
Principal
Academy of Architecture

ACADEMY OF ARCHITECTURE रचना संसद MUMBAI-25

Students Names:
Aided Section

1. Mr Abhishek Suryavanshi
2. Mr Harsh Tank
3. Mr Harshwardhan Shirpurkar
4. Ms Jigisha Soni
5. Mr Krishna Khurusane
6. Ms Laxaree Sawant
7. Ms Prajakta Pai
8. Mr Shakti Jadhav
9. Mr Sharvl More
10. Ms Siddhi Shinde
11. Ms Vaishanvi Siddhapara

278,Shankar Ghanekar Marg, Prabhadevi, Mumbai, 400 025, Tel : 2430 1024 / 2431 0807 Fax : 2430 1724
Email : contact@aoamumbai.in website : www.aoamumbai.in

योजना एवं वास्तुकला विद्यालय, भोपाल
(राष्ट्रीय महत्व का संस्थान, मानव संसाधन विकास मंत्रालय, भारत सरकार)

School of Planning and Architecture, Bhopal
(An institution of National Importance, MHRD, Govt. of India)

मानव संसाधन विकास मंत्रालय के स्थान पर "शिक्षा मंत्रालय"
Ministry of Human Resource Development renamed as
Ministry of Education w.e.f. 17.08.2020

क्रमांक :यों.वा.वि.भो/एओ/२०२०-२१
No. SPAB/AEO/2020-21/819

दिनांक : सितम्बर २१, २०२१
Date : September 21, 2021

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Ms. Avani Shivaji Shikhare, Sch. No. 2020MEP013**, is a bonafide student of 2nd Year, Master of Planning (Environmental Planning) programme at School of Planning and Architecture, Bhopal. As per the student records held in the office, her identity is certified.

This certificate is being issued to her for facilitating the purpose of Solar Decathalon Competiton 2021-2022.

Amit Khare
Asst. Registrar (Academics)

नीलबड़ रोड, भौंरी, भोपाल (म.प्र.)–462 030 (भारत)
Neelbad Road, Bhauri, Bhopal (M.P.) - 462 030 (INDIA)
Phone no. 0755 - 2526800 (Reception)
Website : www.spabhopal.ac.in

APPENDIX A : BONAFIDE LETTER

विश्वेश्वरय्या राष्ट्रीय प्रौद्योगिकी संस्थान, नागपूर - ४४००१० (भारत)

VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR (India)

Ref : BC/2021-22/24017
Date : **06-Oct-2021**

TO WHOMSOEVER IT MAY CONCERN

Certified that Mr./Ms. **PATIL ADITYA DHANRAJ (BT19CIV076)** is a bonafide student of this Institute studying in **III** Year/ **V** Sem **BTech CIVIL ENGINEERING** program **(Duration 4 Years/8 Semesters)** during the session **2021-22** .

To The best of my knowledge, his/her conduct is good.

This certificate Issued for **null.**

Visvesvaraya National Institute of Technology,Nagpur is a Institute of National Importance by the NIT Act of 2007 (29 of 2007) declared by Govt. of India Ministry of Education.

VNIT NAGPUR

Dy. Registrar (Acd.)

I/c Deputy Registrar (Acd.)
VNIT, Nagpur

विश्वेश्वरय्या राष्ट्रीय प्रौद्योगिकी संस्थान, नागपूर - ४४००१० (भारत)

VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR (India)

Ref : BC/2021-22/24290
Date : **07-Oct-2021**

TO WHOMSOEVER IT MAY CONCERN

Certified that Mr./Ms. **SATYAM LALCHANDANI (BT19EEE095)** is a bonafide student of this Institute studying in **III** Year/ **V** Sem **BTech ELECTRICAL & ELECTRONICS ENGINEERING** program **(Duration 4 Years/8 Semesters)** during the session **2021-22** .

To The best of my knowledge, his/her conduct is good.

This certificate Issued for **null.**

Visvesvaraya National Institute of Technology,Nagpur is a Institute of National Importance by the NIT Act of 2007 (29 of 2007) declared by Govt. of India Ministry of Education.

VNIT NAGPUR

Dy. Registrar (Acd.)

I/c Deputy Registrar (Acd.)
VNIT, Nagpur

APPENDIX B : PROJECT PARTNER LETTER

To, Date: 13th Oct.2021

The Director,

Solar Decathlon India

Dear Madam/ Sir,

This is to inform you that our organization **Shapoorji Pallonji Engineering & Construction** has agreed to be project partner with the team **Javelin** led by **Rachana Sansad's Academy of Architecture** for the Solar Decathlon India 2020-21 to work on construction labour camps at our ongoing and upcoming projects in the Mumbai Metropolitan region. i.e. Thane & Navi Mumbai.

As a Project Partner to this team for the Solar Decathlon India 2020-21 competition, we are interested in seeing the Net-Zero-Energy, Net-Zero-Water, resilient and affordable solution this student team proposes and the innovation that results from this. We intend to have a representative from our organization attend the Design Challenge Finals event in April, if this team is selected for the finals.

We would like our organization's logo to be displayed on the Solar Decathlon India website, recognizing us as one of the Project Partners for the 2020-21 Challenge.

With regards,

Name of Representative: Davinder Manghi.

Designation: General Manager (Operations)

Email: davinder.manghi@shapoorji.com

Phone: 9619899505

Shapoorji Pallonji And Company Private Limited

Corporate Office: SP Centre, 41/44, Minoo Desai Marg, Colaba, Mumbai, Maharashtra, India-400005.
(T) 67490000 (F) 6633 8176 www.shapoorji.in
Regd. Office: 70 Nagindas Master Road, Fort Mumbai 400023
CIN: U45200MH1943PTC003812

Shapoorji Pallonji ENGINEERING & CONSTRUCTION

APPENDIX B : INDUSTRY PARTNER LETTER

RicronPanels

MANUFACTURERS OF REGENERATED PLASTIC SHEETS

Certified Green Product

Date: 21.02.2022

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organisation, Deeya Panel Products Pvt.Ltd. Under our brand Ricron Panels, is collaborating with the participating team led by Team Javelin on a Office / Educational / Residential / Community Resilience Shelter Building project for their Solar Decathlon India 2020-21 competition entry.

The nature of our collaboration will be as a suppliers of our eco friendly Ricron Products.

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

We would like our organisation logo to be displayed on the Solar Decathlon India website, recognising us as one of the Industry Partners for the 2020-21 competition.

With warm regards,

Rahul Chaudhary
Director
Deeya Panel Products Pvt. Ltd.
Email: rahul@ricron.com

DEEYA PANEL PRODUCTS PVT LTD

6108/6109 G.I.D.C., Ankleshwar - 393002, Gujarat | info@ricron.com | www.ricron.com

SHUBHRA BIOTECH
PRIVATE LIMITED

21/02/2022

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organization, Shubhra Biotech Pvt. Ltd Hyderabad, is collaborating with the participating team led by ACADEMY OF ARCHITECTURE, MUMBAI on a On Site Construction worker housing Building project for their Solar Decathlon India 2021-22 competition entry.

The nature of our collaboration will be service of our product – DRDO Bio-digester tanks and allied reed bed system for Water Recycling.

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 Industry Partners for the 2020-21 competition.

With warm regards,

Shubhra Biotech Pvt. Ltd ★ Hyderabad ★

Krishna Pabsetti
Chief Operating Officer
Shubhra Biotech Pvt. Ltd Hyderabad
krishna.pabsetti@shubhrabiotech.com
+ 91 9866243835

Regd. Office : Plot No. 47(A), Biotech Park, Phase III, (V) Karkapatla, (M) Mulugu, Siddipet Dist. Telangana - 502 281. Tel : +91-40-23552825

THANK YOU