Final Design Report
[April 2021]

Multifamily Housing

Institution: 1. Balwant Sheth School of Architecture, NMIMS, Mumbai
2. KJ Somaiya College of Engineering, Mumbai
3. Manipal Institute of Technology, Manipal
4. Indian Institute of Technology- Bombay, Mumbai
5. Mukesh Patel School of technology Management and Engineering, NMIMS, Mumbai

TEAM NEXUS

A "Nexus" is a series of connections linking two or more things

We believe that a good design is an amalgamation of various fields, arranged and proportioned to achieve its most efficient form. The primary colours represent the different fields, and the various tints and fragments are a collage of each member's individuality. The "X" is to symbolise intersection (or" bringing in"), growth (or "reaching out") and equality (balance of form). The way different colours, when mixed in equal proportions, form the stable colour white, Team Nexus aims to amalgamate all our knowledge, learnings, and passions to create a result that is coherent in nature.

Project Partners: Agami Realty

Industry Partner: Ecofirst Services Ltd.

2. CONTENT OUTLINE

3. LIST OF TABLES

4. LIST OF FIGURES

4. LIST OF FIGURES

4. LIST OF FIGURES

5. EXECUTIVE SUMMARY

Team Nexus from the Balwant Sheth School of Architecture and other leading institutes, comprising of 7 architecture students and 4 engineering students, aims at enhancing the quality and standard of living of the existing **multi-family housing** schemes prevalent in **Boisar** today.

In the fast-developing Boisar, Mumbai region, the increasing urban population is putting a lot of pressure on the housing sector, especially on low-income housing. The target population is mainly the **Economically Weaker Sections (EWS), Lower Income Groups (LIG) and Middle-Income Groups (MIG**), mostly employed in industrial corporations or manufacturing units. Referring to the Pradhan Mantri Awaas Yojana guidelines, we chose to take a back-end approach by understanding the market in Boisar and designing compact housing suited to the clientele and their upgrading lifestyles.

Our proposal sits on **5.65 acres of fragmented land**, as part of the Agami Eco Eden City complex, comprising of **7-storey** blocks containing **5 apartments in each wing (totally eight 1-BHK and two 2-BHK per block)**. **Connecting bridges** join the two wings at alternate levels, providing vertical recreational spaces as well. The ground floor consists of various spaces for social, recreational, administrative and commercial use, as well as provisions for parking and services.

Our goal was to provide housing solutions that **save, produce and store water and energy** by implementing reliable and **cost-effective measures** that harness the natural potential of site, as well as improve the conditions of the local community and ecology of the area. We aimed at achieving **self-sufficiency of the structure,** considering energy efficiency in all aspects of planning and operation, in order to create housing solutions that will achieve a higher value than conventional ones, and is catered specifically to the **tropical warm and humid climate** of the region.

The client's main objective was to create an **affordable housing solution** designed to attract the target market. Affordability and keeping operational cost at a minimum to ensure **maximum occupancy and financial sustainability** as a long-term goal is key to our proposal. Through these principles and design and energy simulations, as well as referring to the newly sanctioned Unified Development Control Regulations (UDCR), we reached an optimized building massing that **fulfilled the total FSI potential of site,** providing a better standard of living at low costs. By deriving a typology specifically for these users, keeping in mind certain cultural and societal aspects, we aim at making the spaces less like “units” and more like a collective neighborhood.

By targeting a **self-sufficient community cycle, reduction in the consumption of households** and **taking advantage of the solar potential of site,** we have achieved a **net zero energy model** for the common spaces and common infra and a nearly net zero operation daytime residential usage. With an **EPI of 18.4,** panels and solar water heaters generate electrical energy on site. We formulated an **integrated water system** that did not rely on the erratic grid supply of Boisar, but made use of 30% efficient faucets and multiple sources of water to reduce the general water consumption. The used water will be recycled on site by using **bio technological plants, filtration systems and rainwater harvesting.** Our waste recycling system **recycles 100% of the organic waste generated on site** and by using **precast** and modular unit designs, we have **cut down the construction cost by nearly 20%** and **increased the speed of construction by 40%**. Passive design interventions were made to harness the potential of climate, as well as attempting to create a microclimate to make the exterior and interior conditions comfortable and favourable for the user. As a call to innovation, we have provided vertical cycle stands in a bid to promote a **green transport system** that is affordable and promotes health and well-being.

Our design process was primarily data driven, backed by site visits by our team, consultations with our clients and technical support from our Industry partners. Through this integrated approach, Team Nexus presents “Agami Jewels”:

6. TEAM INTRODUCTION

Team name: Team Nexus

Division: Multifamily housing

Faculty Lead and Advisors:

Arti Daga [Faculty Lead}]: Arti Daga is an Assistant Professor with 18 years of professional and academic experience. She holds interest and expertise in Construction Management and Sustainable Architecture.

Shriya Bhatia [Faculty Advisor}: Shriya Bhatia is an Associate Professor with 11 years of professional, academic and research experience in the field of urban environment management and sustainable habitat planning.

Industry Partners:

1. Ecofirst Services Limited: Rakesh Bhatia Karim Panjwani A 100% subsidiary of Tata Consulting Engineers Limited is a leading multi-disciplinary Integrated Sustainable Design Consulting firm for the built environment.
2. Chetan Consultants: Chetan Consultants in Mumbai is one of the leading businesses in the Structural Auditors. They are also known for Structural Auditors, Certificate Consultants, Structural Engineers, RCC Consultants, Building Consultants, Structural Stability Certificate Consultants, etc.
3. Zest Smart Solutions Private Limited: Zest Smart Solutions Private Limited is a Government of India (DIPP) approved startup. rideZEST is a green transport solution designed to provide adaptive and affordable public bike sharing system in the country and around the globe.

Background of the lead institution:

BSSA, NMIMS

The NMIMS's Balwant Sheth School of Architecture (BSSA) focuses on various modes of architectural education, research, and practice. It emphasizes on the ever-changing ethos, behavioural sciences, tools, and techniques, and assimilates all in contemporary design expression. The students are offered holistic exposure and understanding through Art, History, Technology, Architectural Design and Construction process.

The Council of Architecture has recognized the course offering a full-time five-year B.Arch. Degree.

Approach:

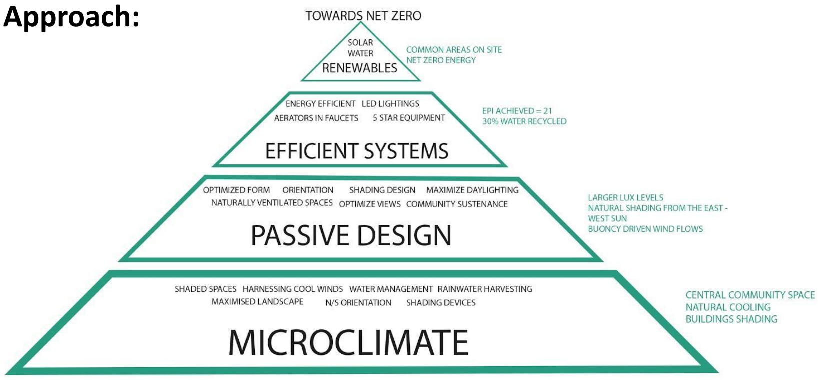


Fig 01

The team members and their roles:

Table 1

7. PROJECT BACKGROUND

Project Name: Agami Jewels, Boisar, Mumbai

Project Partner: Agami Realty

Their vision is to build homes that are affordable, comfortable, and sustainable, all at the same time. Affordability is the DNA of the company and is embedded in all their projects

1. Prashant Khandelwal
Founding team member (B. Tech Civil Engineering; MTech Structural Engineering, IIT-Bombay)

PROJECT BRIEF

Designing residential complex keeping **affordability** and **operational cost** at a minimum to ensure maximum occupancy and financial sustainability as a long-term goal.

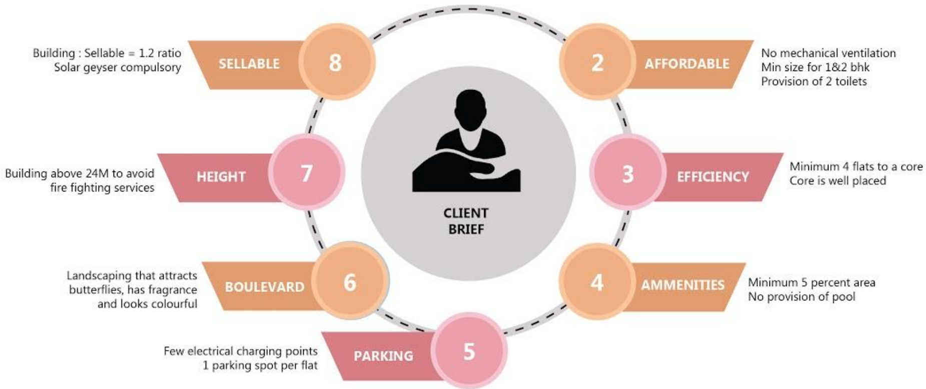


Fig 02

SITE INTRODUCTION : BOISAR , MAHARASHTRA, INDIA

Rapid industrialisation has led to the growth of Boisar as an industrial town, and has made it a potential real estate hub due to the growing demand in low cost housing .

Location: Boisar, Palghar, Maharashtra
Coordinates : 19° 48' 13N 72° 45' 22E
Altitude : 45ft at the base of the eastern slopes of the Sahyadri.
Proposal Typology : Multifamily Housing
Site Area: 22,000 SQ. M
Climate Zone: tropical, very humid, and warm.
Stage of Project Currently: Preconceptual Design Phase
Profile of Occupants: Middle income group

INVOLVEMENT OF THE PROJECT PARTNER POST PROJECT COMPLETION

The project partner maintains the sits for 2 to 3 years, post this time period a welfare society is formed and handed over to the Residents.

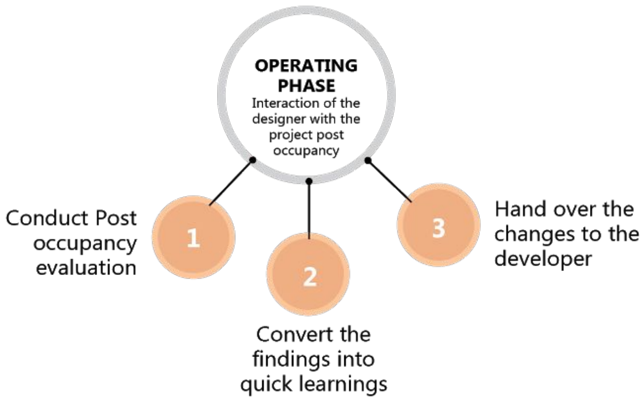
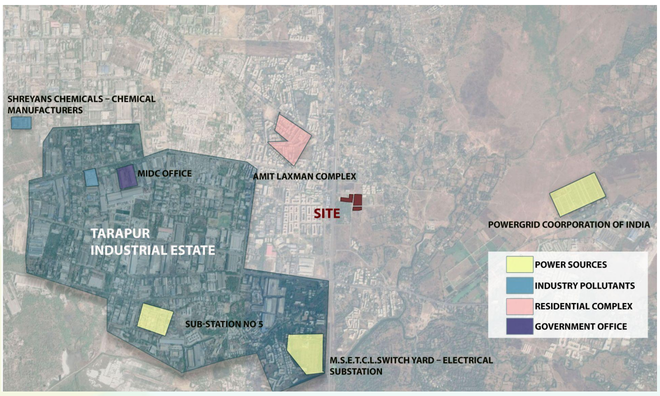
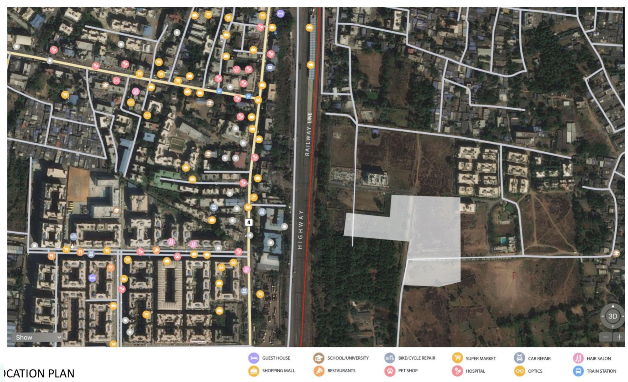


Fig 03

LOCATION PLAN



Boisar Context : Industries located near the site Fig 04



Location Plan : Land Use Fig 05

7. PROJECT BACKGROUND

UPCOMING DEVELOPMENT IN BOISAR

1. The upcoming Mumbai-Ahmedabad bullet train having a stop at Boisar.
2. The upcoming Delhi–Mumbai Industrial Corridor Project (DMIC) being planned to pass via Boisar.
3. The upcoming Mumbai-Vadodara expressway.
4. The expansion of sea transport project.

ENVIRONMENTAL ISSUES : HYDROLOGY

There are no Rivers, lakes, ponds within the radius of 2.0 km. River Surya is the closest water source used for industrial purposes.

1. Industrial effluents from the Nuclear Power plant resulted in a decrease of dissolved oxygen content in the Dandi creek from 4.5mg/litre to 1.2mg/litre
2. Comprehensive Environmental Pollution Index (CEPI) for Boisar area:

   Water: 56 | Air: 60.75

Fig 06

GOVERNANCE

Boisar is governed by the Palghar Municipal Council (PMC). It is home to the largest Maharashtra Industrial Development Corporation (MIDC).

ECONOMIC ACTIVITY : REAL ESTATE BOOM

Rising industrialisation has led to the creation of more than one lakh jobs over the past 10 years and thereby, fuelled the need for housing. In the past, Boisar lacked quality supply of residential real estate, leading to a huge demand-supply mismatch. Hence, the real estate market in Boisar is a rising industry.

Apartments in Boisar include 1-RK, 1-BHK and 2-BHK configurations. The starting price for 1-BHK apartments is Rs 16.41 lakhs.

BOISAR : USER ANALYSIS

Boisar is an industrial town consisting of migrants who are either **industry workers, officers, or government services employees**. The factory workers get paid through their daily wages due to which they cannot afford expensive, lavish houses. It caters to the lower middle class section of society.

DETAILED PROGRAM LIST

	PROGRAMME	AREA (sq. m)
1 BHK	HALL	17.8
	KITCHEN	4.8
	BATHROOM	5.6
	BEDROOM	10.2
	PASSAGE	1.4
1 BHK TOTAL		425.86
2 BHK	HALL	18
	KITCHEN	4.8
	BATHROOM	5.6
	BEDROOM 1	11
	BEDROOM 2	13
	PASSAGE	2.5
2 BHK TOTAL		587.43
ONE FLOOR AREA		428.2
TOTAL BUILT UP FOR ONE BUILDING		950.6

Table 2.1

ZONE	PROGRAMME	AREA (sq. m)	TOTAL
RESIDENTIAL	1 BHK	425.86	22144.72
	2 BHK	587.43	53456.13
RETAIL	No OF RETAIL SHOPS	45	
	AREA PER SHOP	25	1125
AMENITIES	MULTIPURPOSE HALL	530	
	GYM	70	
	LECTURE ROOM/LIBRARY	120	
	GAMES ROOM	60	
	CAFE	55	
	SOCIETY OFFICES	152	987
LANDSCAPE	SOFTSCAPE	6870	
	HARDSCAPE	161,030	167900

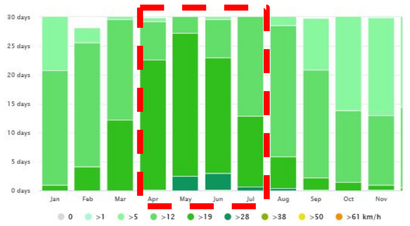
Table 2.2

TOTAL SITE AREA : 22,900 SQ. M   **FSI :** 1.1   **TOTAL BUILT UP :** 25,190 m sq

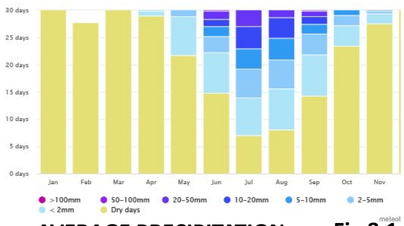
8. PERFORMANCE SPECIFICATIONS

CLIMATE ZONE

Warm and Humid Climate



WIND SPEED Fig 07

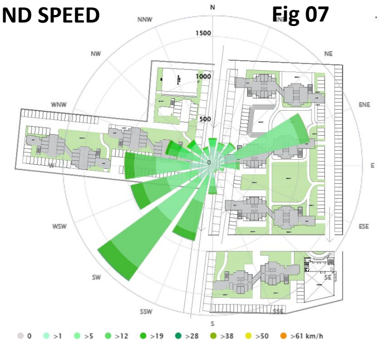


AVERAGE PRECIPITATION Fig 8.1

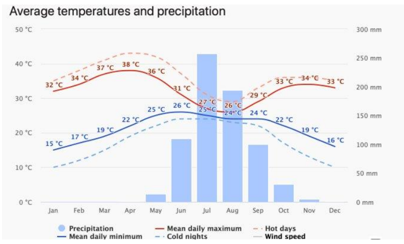
	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	22.6	23.2	25.9	28.1	29.8	29.2	27.3	26.9	26.9	27.6	26.1	24
Min. Temperature (°C)	17.1	17.8	21.1	23.9	26.6	26.3	25	24.7	24.2	23.2	20.3	18.1
Max. Temperature (°C)	28.1	28.6	30.7	32.3	33.1	32.1	29.7	29.2	29.7	32	31.9	29.9
Avg. Temperature (°F)	72.7	73.8	78.6	82.6	85.6	84.6	81.1	80.4	80.4	81.7	79.0	75.2
Min. Temperature (°F)	62.8	64.0	70.0	75.0	79.9	79.3	77.0	76.5	75.6	73.8	68.5	64.6
Max. Temperature (°F)	82.6	83.5	87.3	90.1	91.6	89.8	85.5	84.6	85.5	89.6	89.4	85.8
Precipitation / Rainfall (mm)	1	0	1	1	10	437	856	466	289	68	9	1

There is a difference of 856 mm | 34 inch of precipitation between the driest and wettest months. The variation in annual temperature is around 7.2 °C | 45.0 °F.

TEMPERATURE Fig 09



WIND ROSE
SW MAX WINDFLOW Fig 10



PRECIPITATION CHART
ANNUAL RAINFALL 1584mm Fig 8.2

SUN PATH Fig 11

Input Parameters	Units	Proposed Design Values
General		
Building Area (Built up)	m2	25190
Conditioned Area	m2	0
Electricity Rate	INR/ kWh	8
Building Occupancy Hours	-	24/7
Interna; Loads		
Interior Average Lighting Power Density	W/m2	3.6
Average Equipment Power density	W/m2	12.8
Envelope		
Roof Assembly U value	W/m2.K	1.5
Average Wall Assembly U value	W/m2K	2.2
Window to Wall Ratio (WWR)	%	22
Window U Value	W/m2.K	5.8
Windows SHGC		0.75
Windows VLT	%	87

Table 3

9. GOALS

SR. NO.	GOALS	STRATEGIES	ACHIEVEMENTS
1.Architecture	To design an environment that leads to a heightened sense of community, and facilitates interaction and inclusion among residents.	-Creating various ‘pockets’ of green space - Vertical community bridges within the buildings	Various instances of interaction and activity created within the site
2.Comfort and Environment quality	Completely negate the use of HVAC	Epd - no use of HVAC LPd - USe of leds	No reliance on HVAC systems
3. Energy Performance	Baseline Epi 35 and Target Epi 26	Epd - no use of HVAC LPd - USe of leds	EPI Achieved 18.4
4. Water Management	- To reduce the water consumption by 30%. -To be independent of the grid on a day to day basis. -To recharge the groundwater in order to facilitate regular tapping.	-Rainwater harvesting -Groundwater recharge and tapping -Water treatment on site	Creating a net positive water system when compared to how it functions on a yearly basis
5. Waste Management	To collect, segregate and recycle waste generated on site.	Introducing an Organic Waste Converter on site	- Using the manure on site for the landscaped areas -Designing a specialised garbage network
6. Affordability	-Cost of unit reduce -Affordable luxury	Faster construction faster possession more returns	Reduced the price per sq. ft from Rs 2586 to Rs. 2189.
7. Scalability and Market potential	To create living situations that cater to the target margaret, with flexibility of use	-Modular and flexible design -Precast construction	Creation of a ‘plug-in’ design where the typology of units can be changed as per the user group
8. Resilience	- Community resilience -Disaster Management preparedness	-Stilt Plan -Efficient drainage through the central landscape spline	-Resilient structure during natural disasters and a strengthened community preparedness
9. Engineering Design and Operation	To make the construction process Functionally efficient in response to speed, capital and material.	Use of Precast concrete exterior walls, with AAC interior walls.	Reduction of the construction process, completion in 24 - 36 months.
10. Innovation	-Creating a user manual that influences behaviour -Creating a facade system that responds to the climate	-User Manual App interface Design - Facade Design - Wonsoon windows, pivot windows and louvers	-Created an app interface to influence the resident. -Created a facade that responds to the seasonal changes of the site

Table 4

10. DOCUMENTATION OF DESIGN PROCESS

SITE VISIT AND DOCUMENTATION

On visiting the site we observed its fringe conditions, the roads bisecting the site and the nearby residential complex developed by the same developer. Their aim was to create a mini township with housing solutions catering to different markets starting from the affordable range to the luxury range.
Boisar being an industrial town , emits toxic gasses and substances into the air and water, creating an eco friendly design as a prototype to multiply in such a locality would be very beneficial to its users in the long run.

STRATEGIES AS PER CLIENT REQUIREMENTS

Creating a commercial edge on the road abutting side of the site

Creating a landscaped pocket in the center, unhindered by the vehicular access

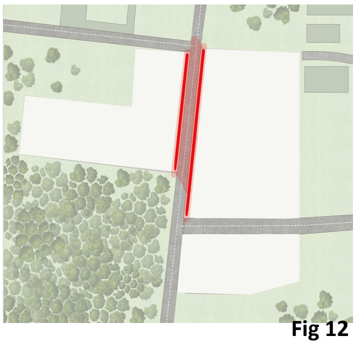


Fig 12


Fig 13


Fig 14.1


Fig 14.2


Fig 14.3


Fig 14.4


Fig 14.5


Fig 14.6

OBSERVATIONS ON SITE

The site abuts a highway and a railway; the west side of the highway is more commercialised, serving different functions like hospitals, schools, salons, guest houses and malls. The residential housing is on the east side of the highway. There is a club called the Eden Club on the right side of the site and multi-family housing typologies adjacent to the site.

The site has a 9 m road passing through it, this forms the access point for the site. It connects the site to the main road and the railway line. The south west portion of the site is filled with dense vegetation providing a natural green zone and shading to the area.

Access to the site is through the 9m wide road that passes through it. This road runs parallel to the Boisar-Palghar Road and connects to the J.K. Irani Road.

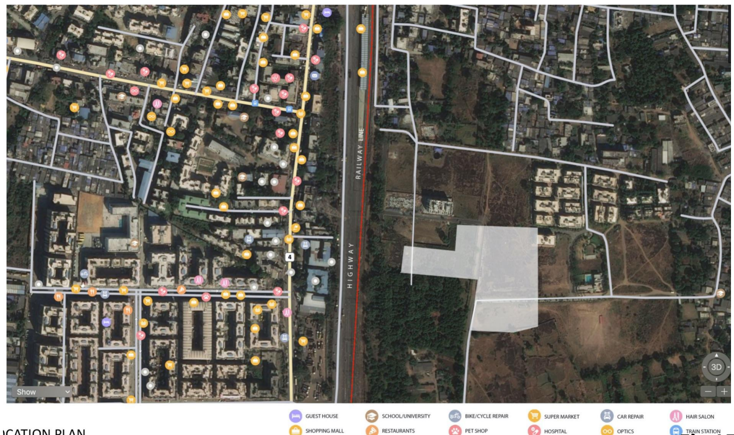


Fig 15

Fig 16

10. DOCUMENTATION OF DESIGN PROCESS

ORGANISATION AND DESIGN PROCESS THROUGH MIND MAPPING

The mind map on the right shows how we divided the team into smaller sections with each person responsible for a particular contest. This was a strategy used to overcome the communication barrier we faced initially and helped in making sure all the participants were equally involved in the competition.

We would meet thrice a week to discuss each person's progress in their respective topics and meet the industry partner every Sunday for a weekly evaluation.

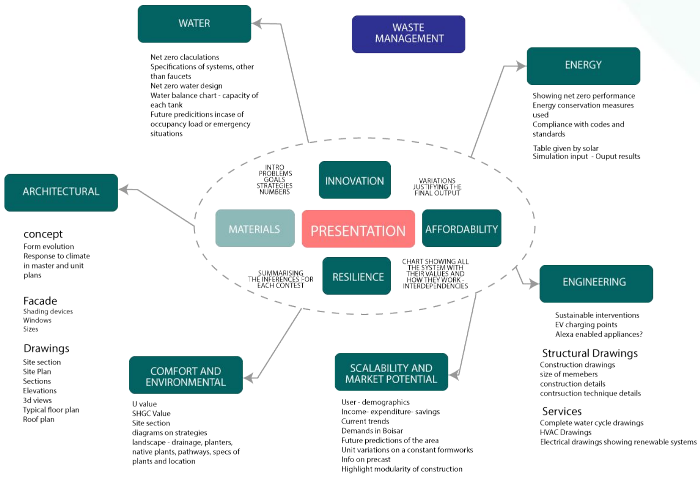


Fig 17

CONCEPTUAL IDEAS

1.

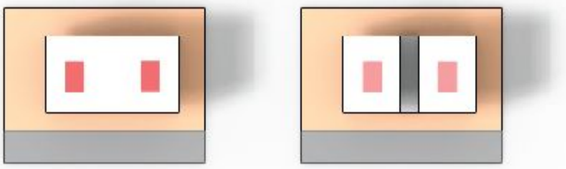


Fig 18.1

Starting from a mass, a tower form was split into two to accomodate for wind flow as well as break space within the mass on site

2.

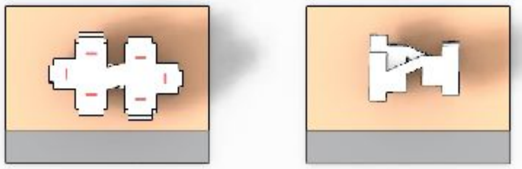


Fig 18.3

Introduction of a connector at alternate levels to provide a space for interaction and instill a sense of community, along with addition of commercial spaces.

3.

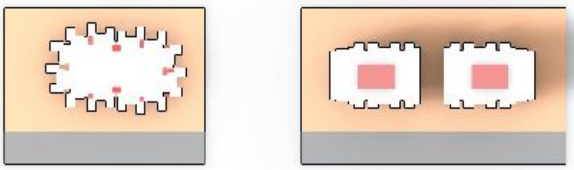


Fig 18.2

4.

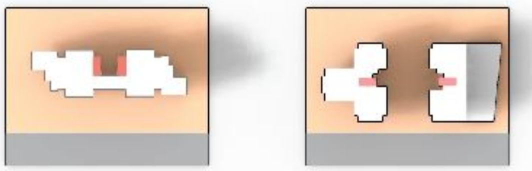


Fig 18.4

The final form has connector shifted at an angle of 45 degrees as a response to the wind direction, which ensures continuous air flow within the structure.

5.

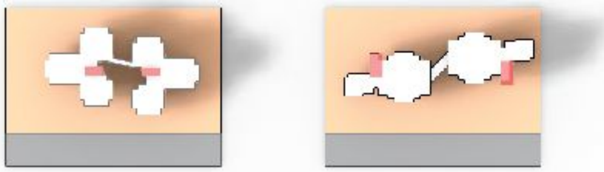


Fig 18.5

MASTER PLAN ITERATIONS

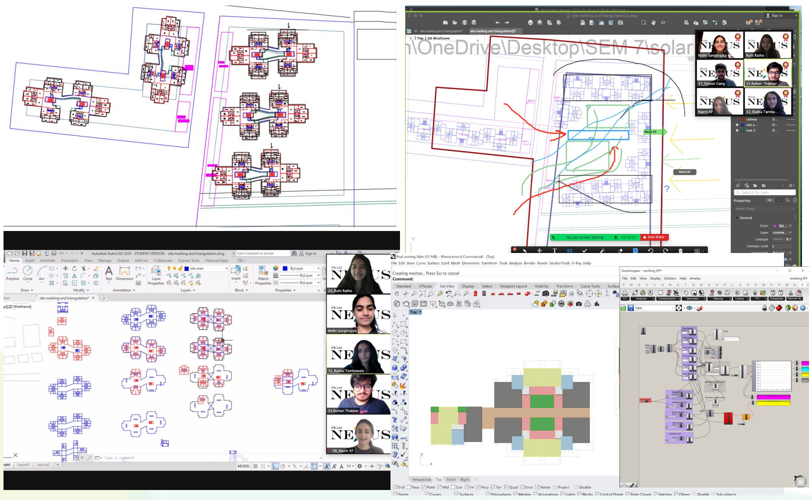


Fig 19

UNIT ITERATIONS

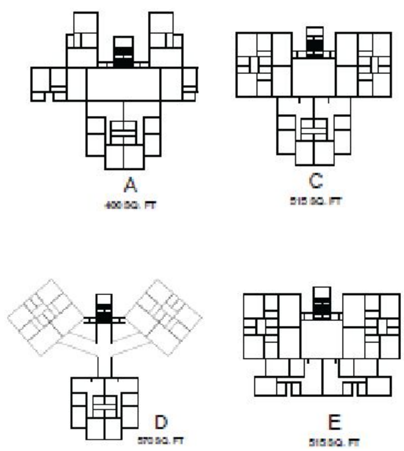


Fig 20

10. DOCUMENTATION OF DESIGN PROCESS

3D PRINTED MODELS

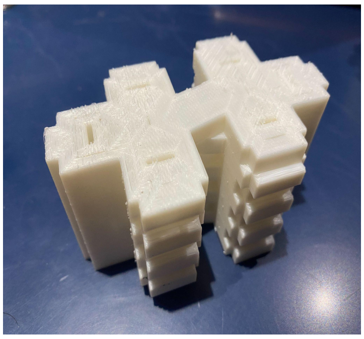


Fig 21.1

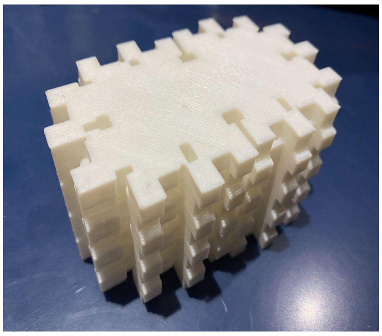


Fig 21.2

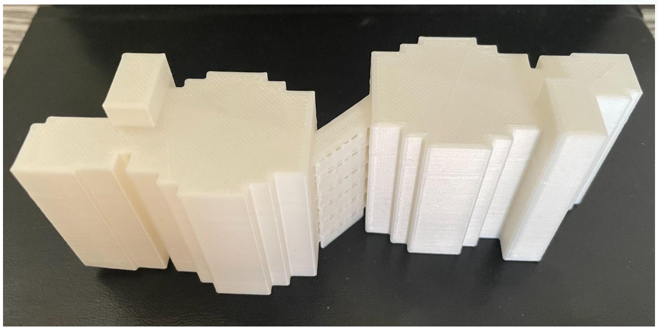


Fig 21.3

3D Printed Process Models

SOFTWARES USED

Autocad - 2d Drafting - Architectural and structural design

Ecotect Analysis - daylighting

Climate Studio - EPI, Radiation and comfort

Ladybug - Sky Dome, Site Radiation

Honeybee - Sky Dome, Site Radiation

Grasshopper - Ladybug - Sky Dome, Site Radiation

Rhino - 3D Rendering and Form development

Flow Design - Wind simulations

Revit - Quantity survey , daylight and BIM

Photoshop - Rendering Plans

Illustrator - Schematic Diagrams

In Design - Compilation of the Report

EXPECTED CHALLENGES IN DESIGN DEVELOPMENT

CHALLENGES
Net Metering Restriction of 10 KWP per meter
Awaiting confirmation on the proposal of allowing 500 kwp additional net metering as on 9th April 2021 by Ministry of Power (Draft stage).
Energy - the peak consumption of Energy is during the night, when the solar panels are not active
Ground water - we have achieved to make the building net 0 by tapping equal amounts of water being recharged. However this water is hard and for it to be utilised and potable, it needs expensive filtration equipment.
Fragmented site- The site gets divided into three parts due to one main road and another private road. The challenge lied in creating a sense of community and engagement as a cohesive whole.
Providing a sense of comfort and luxury within the constraints of affordable living

Table 5

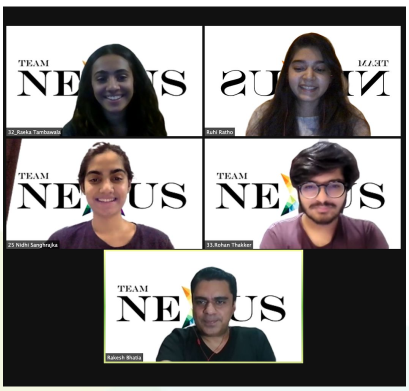
10. DOCUMENTATION OF DESIGN PROCESS

REVIEW LIST

.	Name of Facilitator	Area of Expertise
1.	Arti Daga	Mentor
2.	Shriya Bhatia	Mentor
3.	Rakesh Bhatia, Eco first	Energy, Environmental comfort, Water and Waste Management
4.	Karim Panjwani, Eco First	Architectural Design, Market Potential
5.	Prashant Khandelwal, Agami Developers	Market Potential, Affordable Design
6.	Chetan Tolia, Chetan Consultants	Structural and Mechanical Engineering
7.	Kartik	MEP Consultant
8.	Gautam Bhasin	Facade Consultant
9.	Pavitra Laxmi	Simulations - Energy and Environmental comfort
10.	Gunveer	Simulations - Energy and Environmental comfort
11.	Dhanashree Sawant	Landscape Design
12.	Nitin Killawala	Multifamily Housing Design
13.	Ami Mangaldas	Cost Estimation, Specifications

Table 6

PROJECT PARTNER AND CLIENT MEETINGS



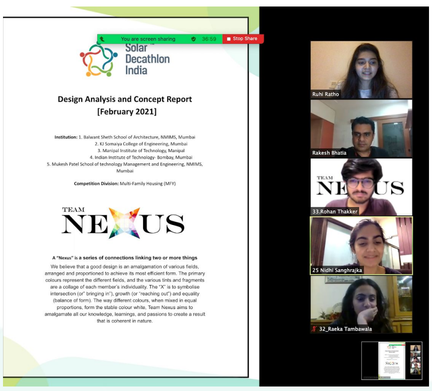


Fig 22

11. A) ARCHITECTURE: INTENT ON SITE

CLIMATE ANALYSIS FOR SITE

Inferences from sun study

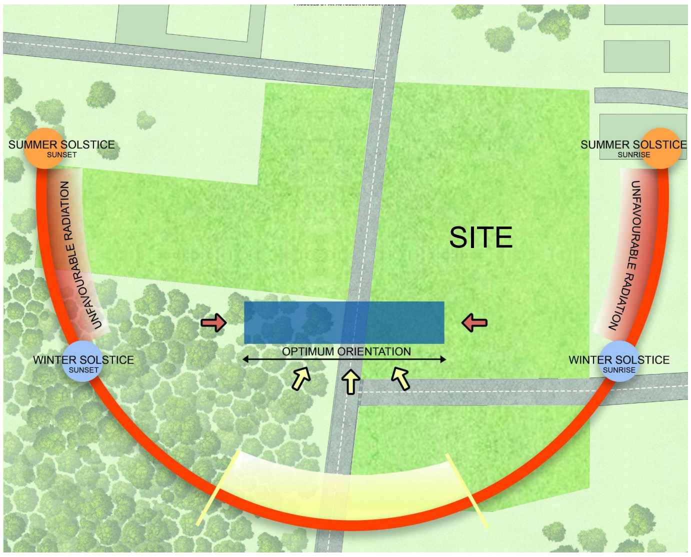
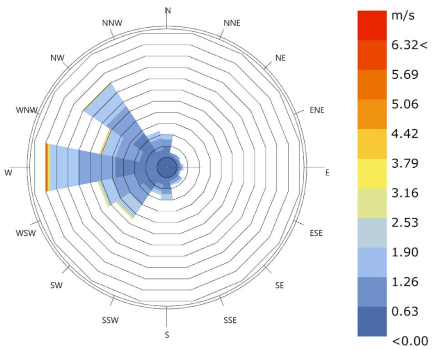


Fig 23

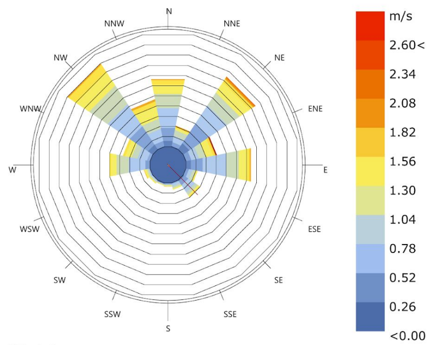
Inferences from wind study

Fig 24



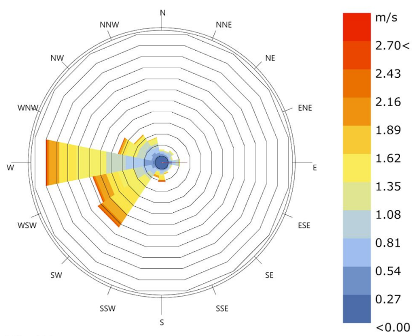
Wind-Rose
MUMBAI_IND
1 MAR 1:00 - 30 JUN 24:00
Hourly Data: Wind Speed (m/s)
Calm for 23.91% of the time = 700 hours.
Each closed polyline shows frequency of 1.7%. = 49 hours.

Fig 25



Wind-Rose
MUMBAI_IND
1 NOV 1:00 - 28 FEB 24:00
Hourly Data: Wind Speed (m/s)
Calm for 34.69% of the time = 999 hours.
Each closed polyline shows frequency of 1.2%. = 35 hours.

Fig 26



Wind-Rose
MUMBAI_IND
1 JUL 1:00 - 31 OCT 24:00
Hourly Data: Wind Speed (m/s)
Calm for 20.80% of the time = 614 hours.
Each closed polyline shows frequency of 2.2%. = 64 hours.

Fig 27

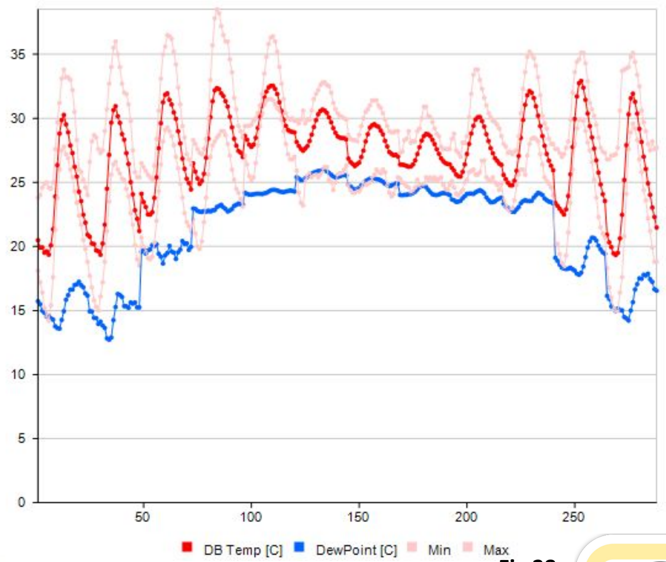


Fig 28

Diurnal Temperature

-Low to moderate difference in maximum and minimum daily temperature.
- Months from May to Aug have high temperature.
- Passive strategies would result in lower temperature in internal spaces.

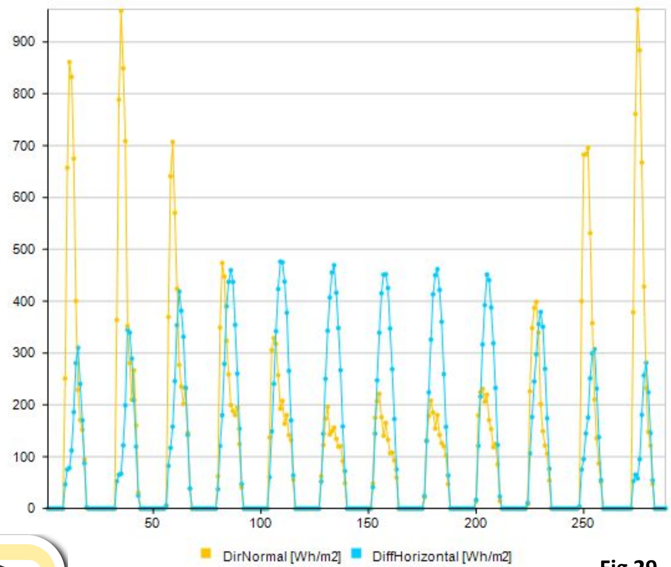


Fig 29

Radiation Graph

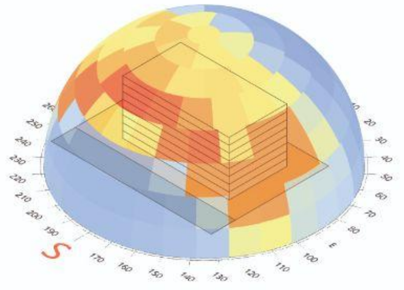
Scan Me

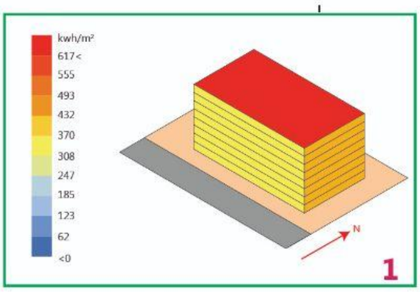
Monthly Windrose

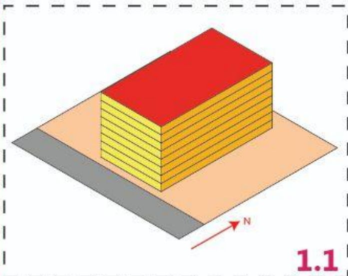
Fig 30

11. A) ARCHITECTURE: FORM DEVELOPMENT

Orientation



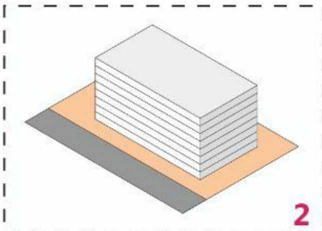




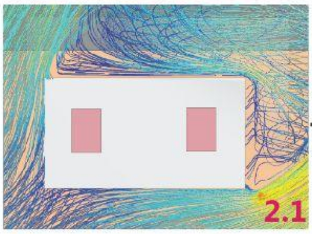
According to the sky dome analysis, there is maximum solar radiation on the east and west side and some even from the south side. Hence the building is oriented in a way inwhich the longer facade is facing towards the north-south side and smaller faces towards the east and west side with minimum openings

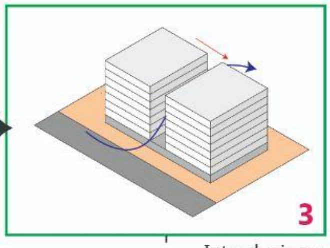
Fig 31

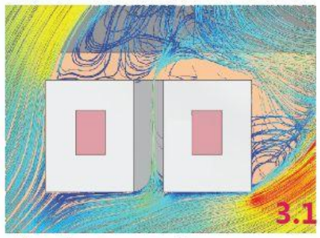
Form Development



Looking at the structure as a mass on site



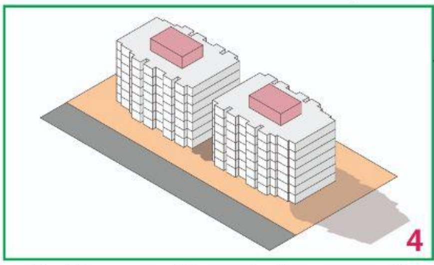




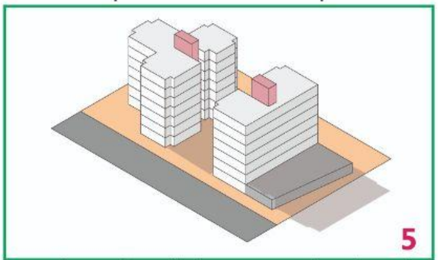
Introducing a break in the mass to allow continuous flow of wind through the buildings and hence provide a cooler environment and better natural ventilation.

Split of mass

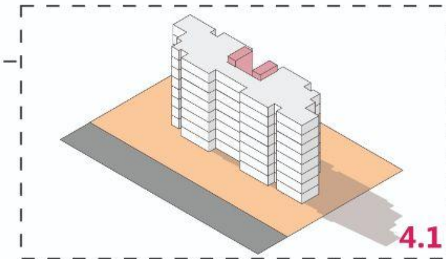
The masses were the splited to provide internal shading along with placement of core to provide ventilation.



Split mass with central cores and offsets for self shading



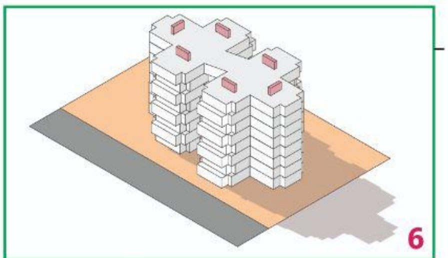
Retail shops attached at the front of the split mass



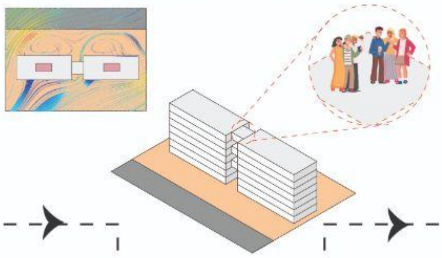
Cores on both ends with connectors at alternate levels

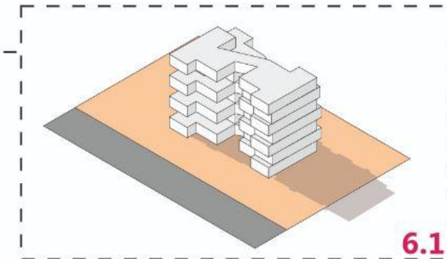
Connection

Connections are made at certain floors to provide a community space for the residents.

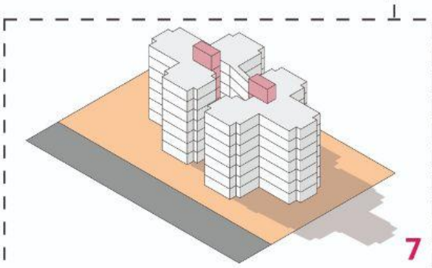


Core in lobby with connectors

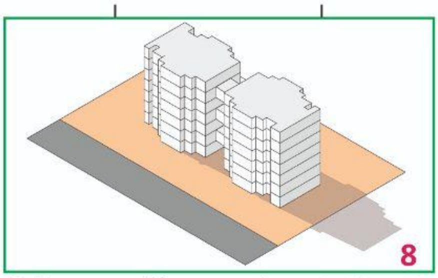




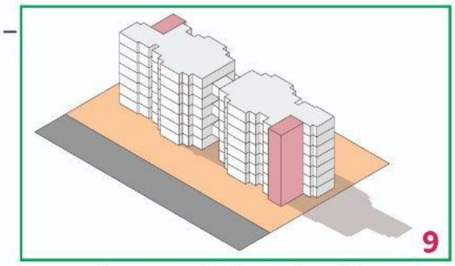
Connectors with staggering floor plates



Connectors with central atrium and central cores



Spit mass with connectors at alternate levels



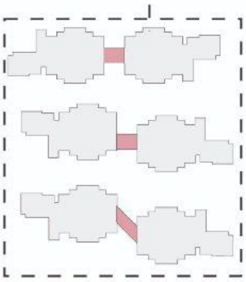
Cores on both ends with connectors at alternate levels

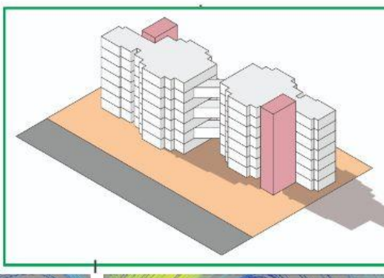
Fig 32

Green boxes are selected strategies

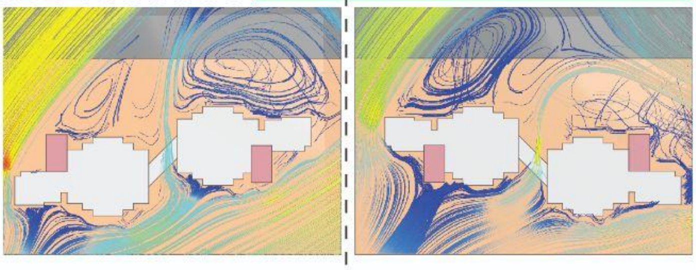
11. A) ARCHITECTURE: FORM DEVELOPMENT

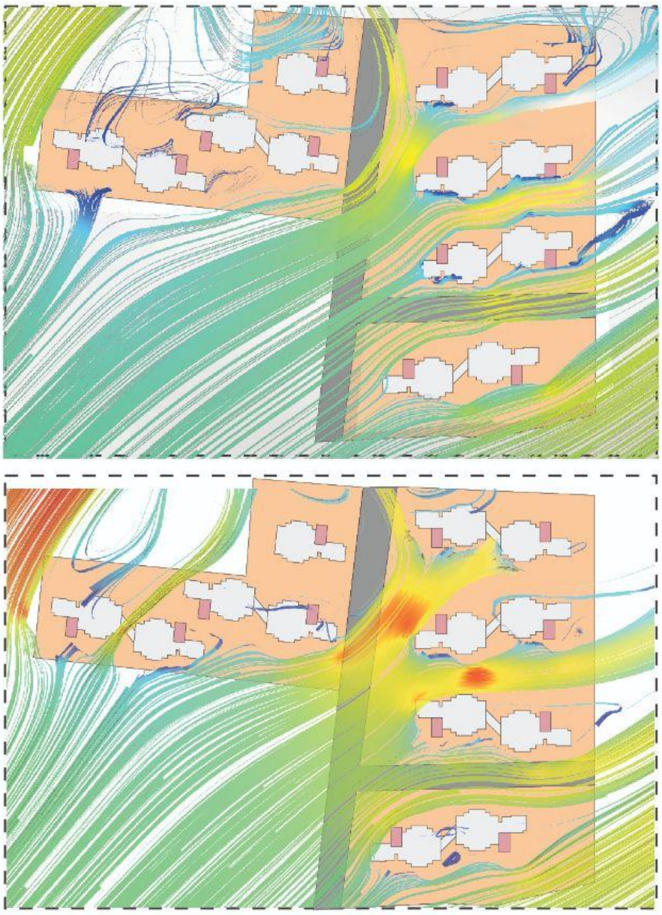
Shift



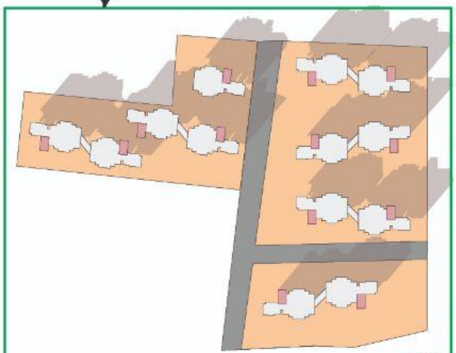


10





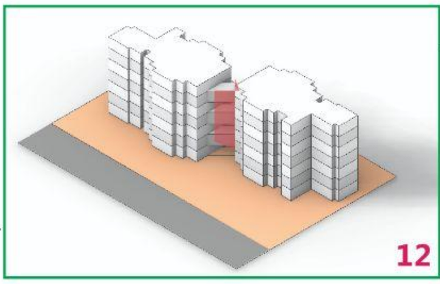
According to the wind analysis and shade and shadow analysis the master plan is designed to allow maximum windflow and wind funneling. The placement of buildings is planned in such a way where the recreational space and green spaces are shaded by the nearby buildings so create a favourable microclimate.



11

By deriving a typology specifically for these users, keeping in mind certain cultural and societal aspects, we aim at making the spaces less like “units“ and more like a collective “township”

Community building

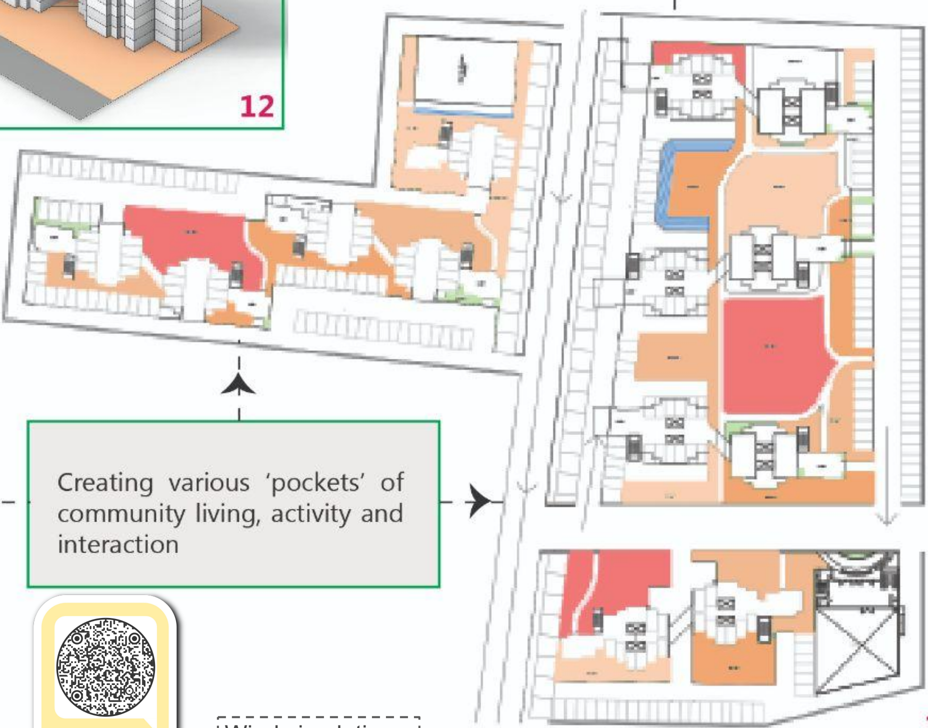


12

Making high density an advantage rather than a downside by creating a sense of community:

Our design aims at developing a sense of community and unity not just between the various residents of the area, but with the site and surrounding areas well. “Community” is not just limited to our immediate neighbours. We aim at bringing together people of the area and truly integrating this structure into its surroundings, as well as with nature and its surrounding environment.

Creating various ‘pockets’ of community living, activity and interaction



13

Scan Me

Fig 33

Wind simulation on master plan.

Green boxes are selected strategies

11. A) ARCHITECTURE: FINAL FORM AND ANALYSIS

View of Site

Fig 34

Zoning Plan

Fig 35

Activity Plan

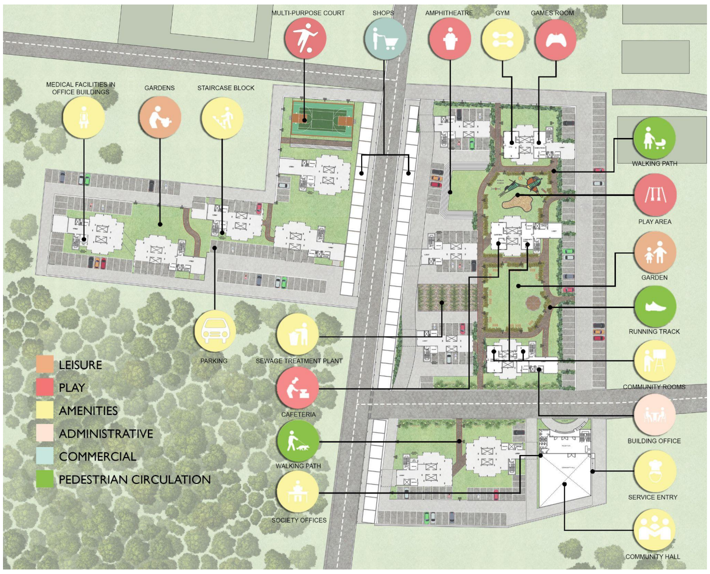


Fig 36

Vehicular Circulation Plan

Fig 37

Pedestrian Circulation Plan

Fig 38

11. B) COMFORT AND ENVIRONMENT QUALITY: WIND FLOW

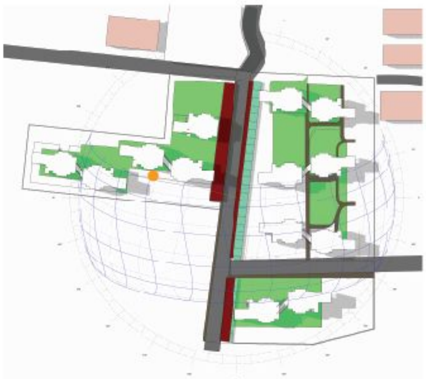
As the site is located in an industrial town we targeted to provide a comfortable environmental quality for the users hence used sun shading and wind analysis to work out the best orientation and planning for better comfort.

Winter Solistice
Time: 9:00 AM

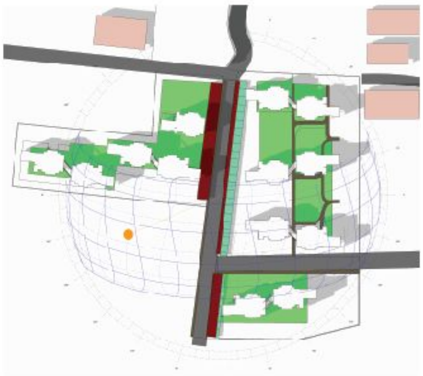
Summer Solistice
Time: 9:00 AM

Autumnal Equinox
Time: 9:00 AM

Winter Solistice
Time: 3:00 PM



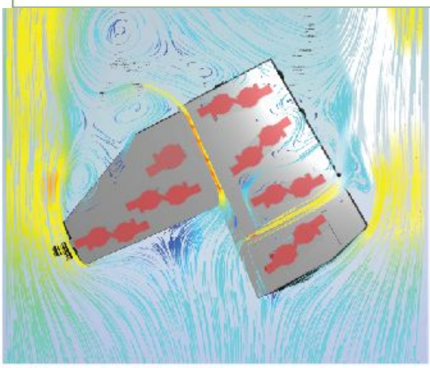
Summer Solistice
Time: 3:00 PM



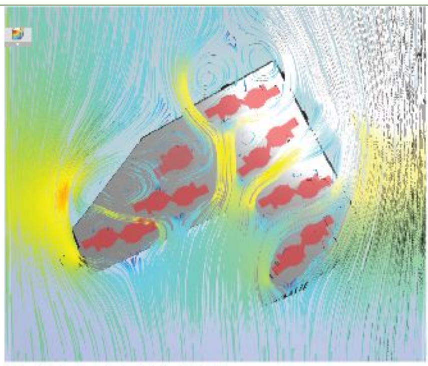
Autumnal Equinox
Time: 3:00 M

FIG 39

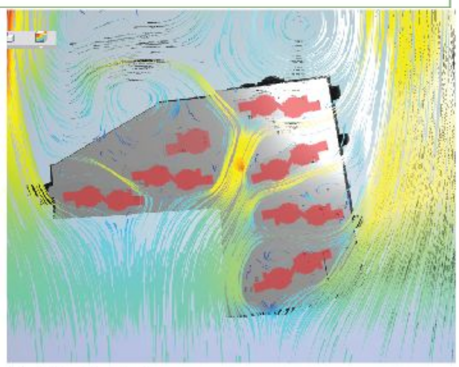
Inference
- Orientation of buildings in N-S Direction helps in reducing solar heat gain.
- The arrangement of buildings in master plan creates self-shaded green spaces between the buildings, hence making it comfortable for people to occupy throughout the day.
- Floor plan with multiple offsets provide shading from the east and west sun. and in turn reduces the need of larger shading devices.



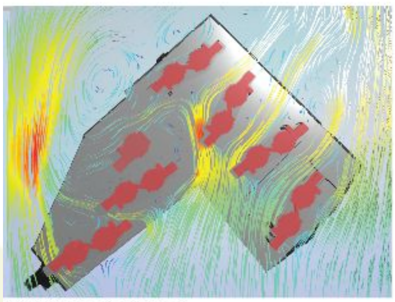
Wind direction- South South West
Wind plane - Ground



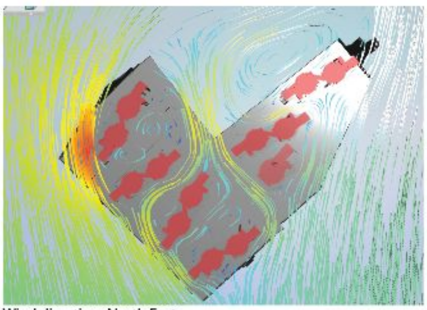
Wind direction- South South West
Wind plane - Middle



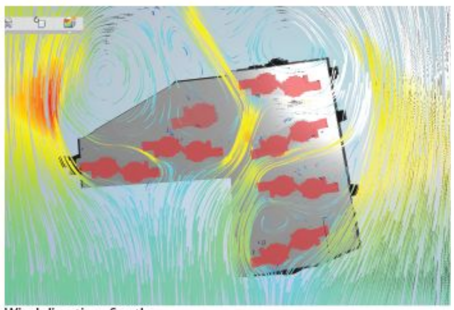
Wind direction- South
Wind plane - Middle



Wind direction- South West
Wind plane - Middle



Wind direction- North East
Wind plane - Ground



Wind direction- South
Wind plane - Ground

FIG 40

Inference
- The two wings of a building are shifted at 45 degree angle to allow easy flow of wind through central connector, hence helping to cool down the interior temperarure of the buildings.
- As the wind flows from W and S-W side majorly, the green pockets designed in master plan trap the wind and help create a micro- climate.

11. B) COMFORT AND ENVIRONMENT QUALITY: SHADING DESIGN

The goal is to reduce the requirement of artificial lighting and using maximum the potential of daylighting
Here we have worked out different options for the most efficient and affordable solution.

TIME - TABLE PLOT
According to IMAC Standards

Comfort level range	
Month	Range (in ºC)
Jan	21.50 to 28.88
Feb	21.50 to 28.42
Mar	21.70 to 28.62
Apr	22.13 to 29.05
May	22.66 to 29.58
Jun	22.74 to 29.66
Jul	22.44 to 29.36
Aug	22.20 to 29.12
Sep	22.20 to 29.12
Oct	22.28 to 29.2
Nov	22.19 to 29.11
Dec	21.73 to 28.65

Table 7

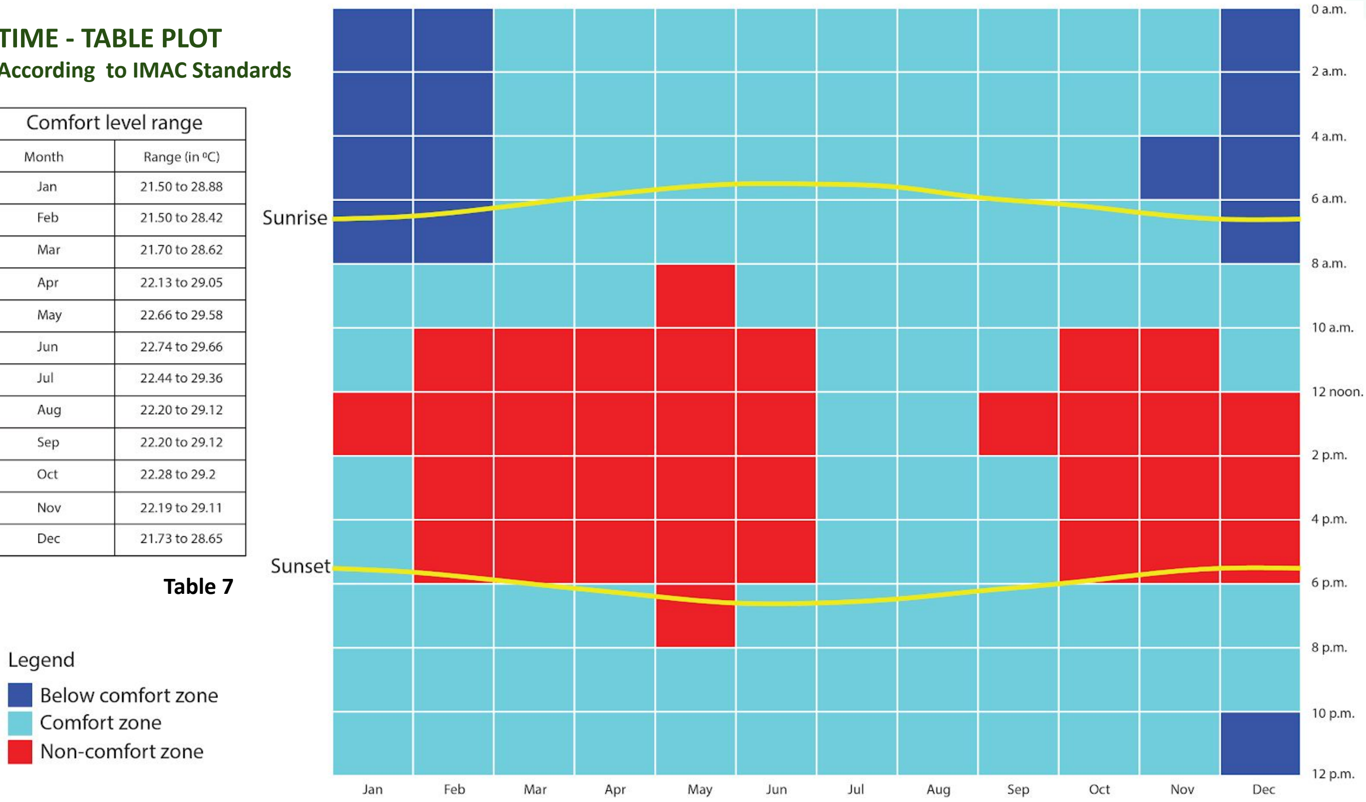


FIG 41

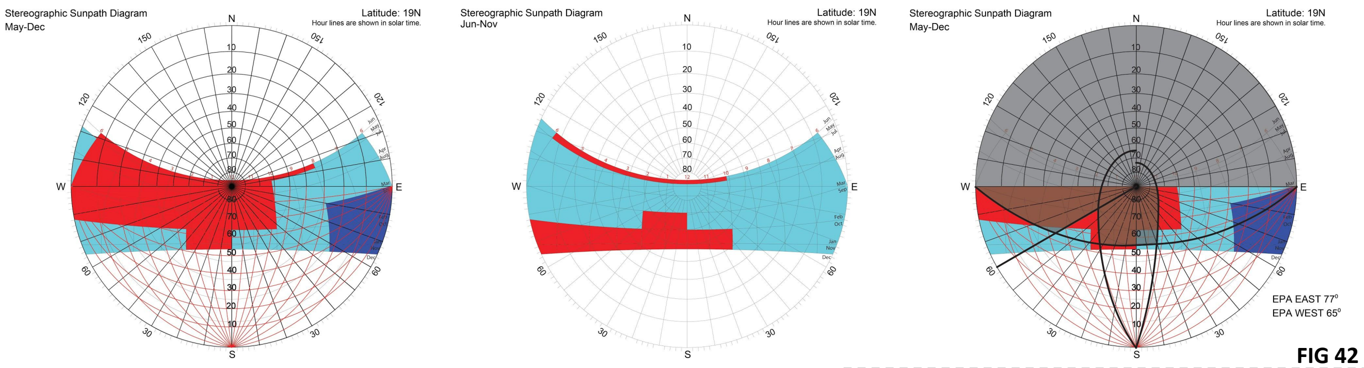
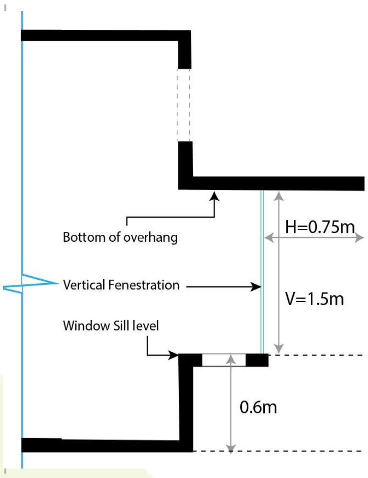


FIG 42



Section through window

FIG 43.1

PF = H/V
PF = 0.5

SEF = (C3 X PF3) + (C2 X PF2) + (C1 X PF) + C0
= (-1.01 X 0.125) + (1.91 X 0.25) + (0.24 X 0.5) + 1.12
= (-0.126) + (0.475) + (0.12) + 1.12
= 1.589

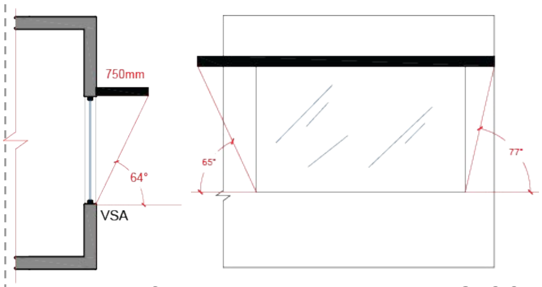
SHGC = 0.75
EQUIVALENT SHGC = 0.7/1.589
In compliance with maximum allowed value in table 4-11, ECBC+ buildings 2017

Base Case SHGC = 0.5
Proposed SHGC = 0.47

The SHGC is lowered by using a large overhang to reduce the solar heat gain and help in thermal comfort.

Effective SHGC due to shading devices

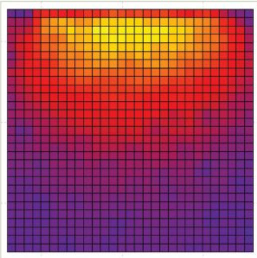
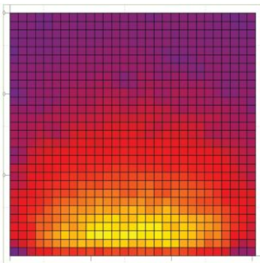
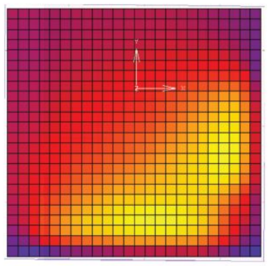
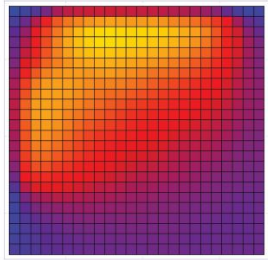
INFERENCES
For shading devices on the south facade,
Vertical Shadow Angle = 64°
End Profile Angle (East) = 77°
End Profile Angle (West)= 65°
Horizontal Shadow Angle = 60°

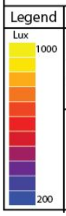


VSA EPA FIG 43.2

Chajja design

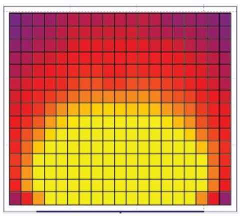
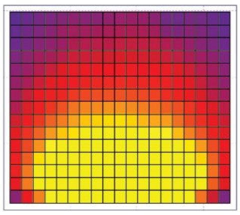
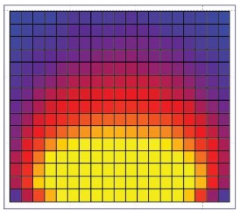
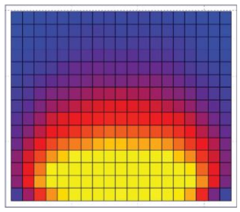
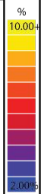
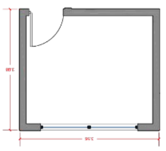
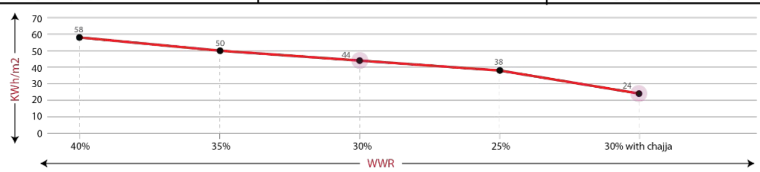
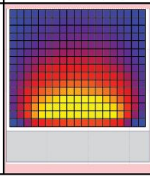
11. B) COMFORT AND ENVIRONMENT QUALITY: WWR RATIO

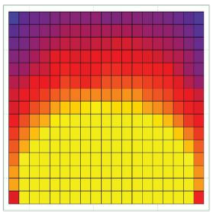
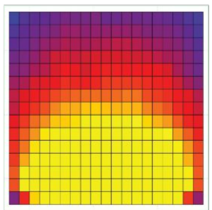
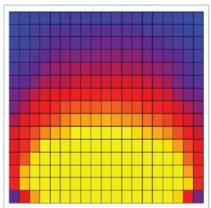
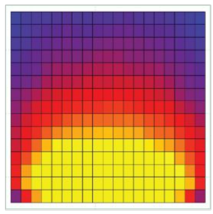
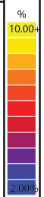
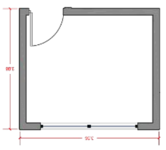
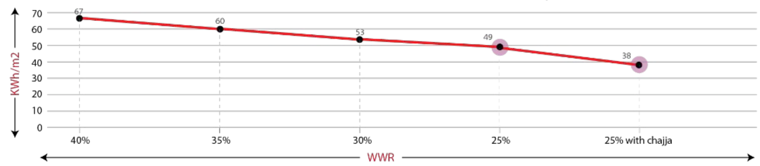
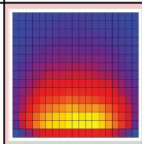
Model Parameters	North Facing Window	South Facing Window	East Facing Window	West Facing Window
Adjacency- ground adiabatic, roof adiabatic and 1 Wall exposed. Window Visual Light Transmission value = 0.8 Effective Solar heat gain potential value = 0.37				

Legend	Notes
	Simulations done for hot and warm climate for summer time 

Observations
- Windows openings on North wall enable adequate amount of light to enter.
- Windows on South facade receive good amount of light.
- Windows on East facade and West Facade gain maximum heat.

Inferences
- Maximum windows to be provided on North and South facade.
- The excessive heat received on south facade can be curtailed by chajjas and tinted glass.
- Windows on East and West facade require shading devices.

BEDROOM | 2BHK		WWR-40%	WWR-35%	WWR-30%	WWR-25%	
For South facing facade Adjacency- ground adiabatic, roof adiabatic Window Visual Light Transmission value = 0.87 Solar heat gain potential value = 0.75 Effective SHGC = 0.47	DAYLIGHT FACTOR	Window size- 2.8 x 1.5  Avg. Daylight Factor- 7.75%	Window size- 2.5 x 1.5  Avg. Daylight Factor- 7.00%	Window size- 2 x 1.5  Avg. Daylight Factor- 5.85%	Window size- 1.75 x 1.5  Avg. Daylight Factor- 5.00%	
	HEAT GAIN				 Selected Window WWR-30% Window size- 2 x 1.5 With Overhang 0.75m Avg. Daylight Factor reduced to 4.2%	

BEDROOM | 1BHK		WWR-40%	WWR-35%	WWR-30%	WWR-25%	
For South facing facade Adjacency- ground adiabatic, roof adiabatic Window Visual Light Transmission value = 0.87 Solar heat gain potential value = 0.75 Effective SHGC = 0.47	DAYLIGHT FACTOR	Window size- 2.5 x 2.1  Avg. Daylight Factor- 9.50%	Window size- 2.5 x 1.84  Avg. Daylight Factor- 7.98%	Window size- 2.5 x 1.5  Avg. Daylight Factor- 6.97%	Window size- 2 x 1.5  Avg. Daylight Factor- 6.31%	
	HEAT GAIN				 Selected Window WWR-25% Window size- 2 x 1.5 With Overhang 0.75m Avg. Daylight Factor reduced to 4.2%	

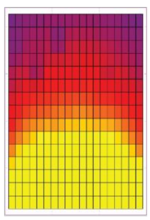
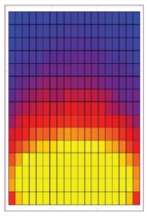
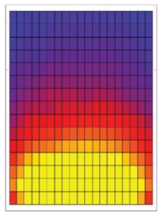
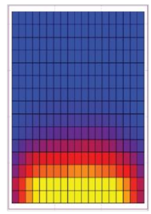
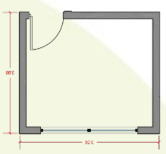
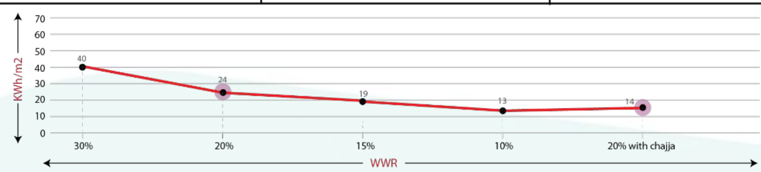
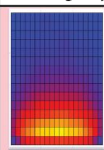
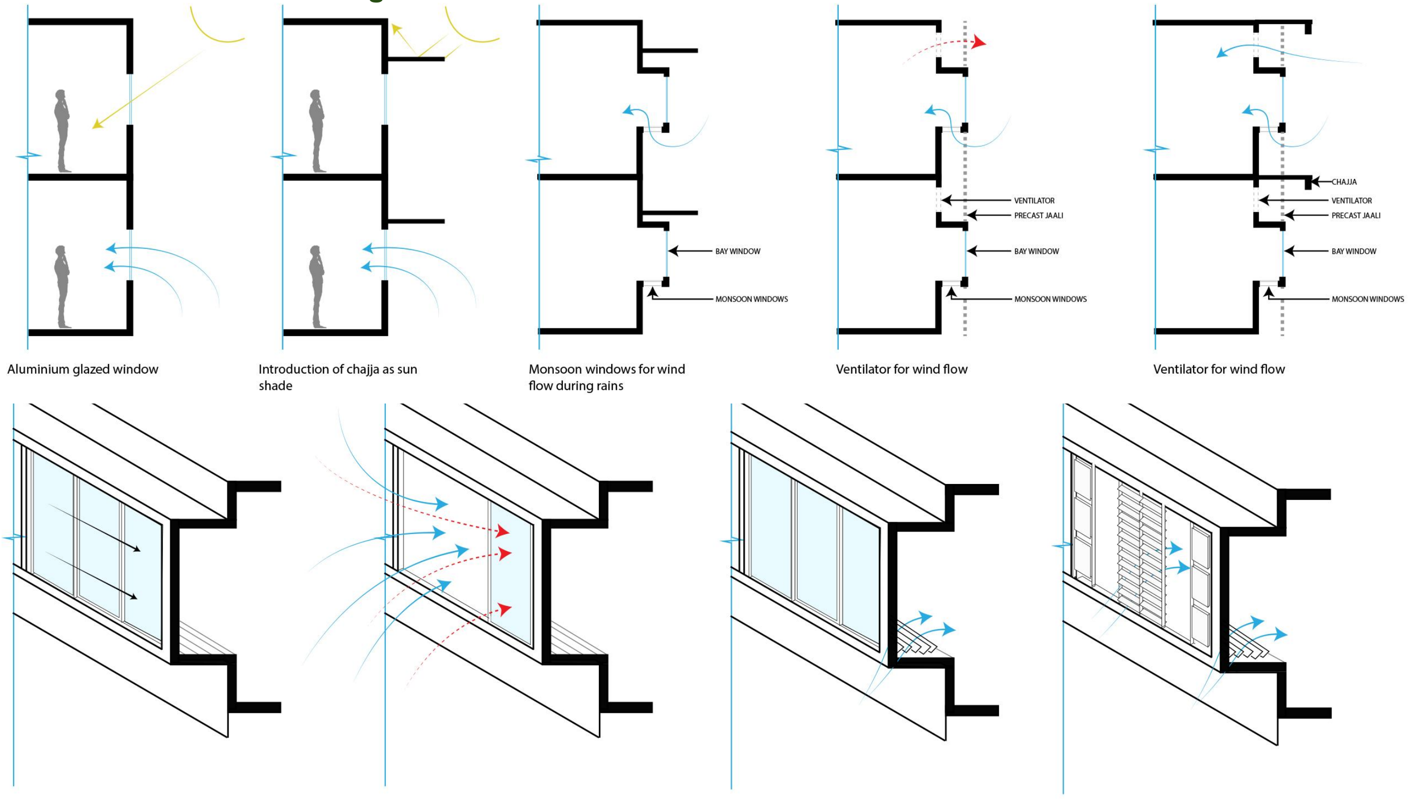
LIVINGROOM		WWR-30%	WWR-20%	WWR-15%	WWR-10%	
For South facing facade Adjacency- ground adiabatic, roof adiabatic Window Visual Light Transmission value = 0.87 Solar heat gain potential value = 0.75 Effective SHGC = 0.47	DAYLIGHT FACTOR	Window size- 2.5 x 1.9  Avg. Daylight Factor- 9.49%	Window size- 2 x 1.5  Avg. Daylight Factor- 6.79%	Window size- 1.6 x 1.5  Avg. Daylight Factor- 6.00%	Window size- 1x1.5  Avg. Daylight Factor- 3.56%	
	HEAT GAIN				 Selected Window WWR-20% Window size- 2 x 1.5 With Overhang 0.75m Avg. Daylight Factor reduced to 3.88%	

FIG 44

11. B) COMFORT AND ENVIRONMENT QUALITY: FACADE DESIGN

Evolution of window design.



Aluminium glazed window

Introduction of chajja as sun shade

Monsoon windows for wind flow during rains

Ventilator for wind flow

Ventilator for wind flow

Sliding window

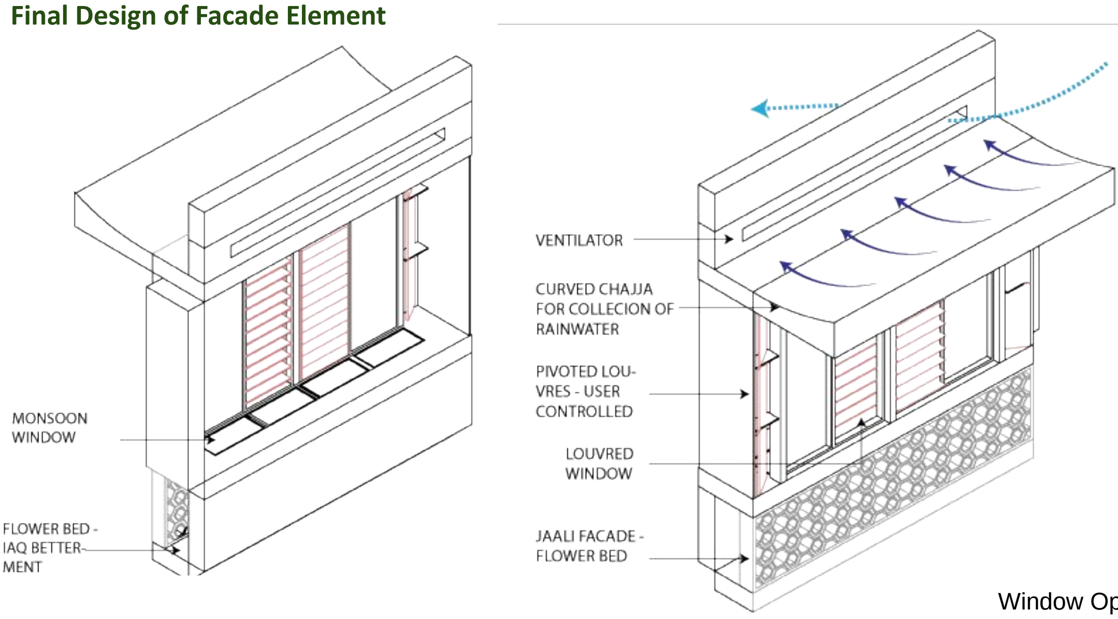
Air circulation

Monsoon behaviour

Louvred panelling

FIG 45.1

Final Design of Facade Element



The jaali and flower bed under the monsoon window, allows for fresh filtered air to flow into the space and the ventilator expels the hot air, creating a stack effect within the space.

FIG 45.2

Window Operation

Scan Me

Facade Elements

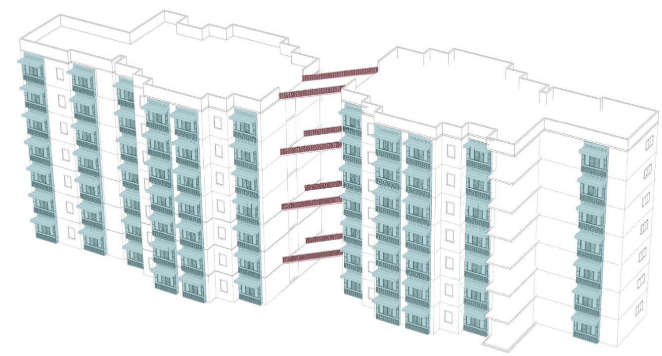


FIG 46.1

Potential Wind Flow

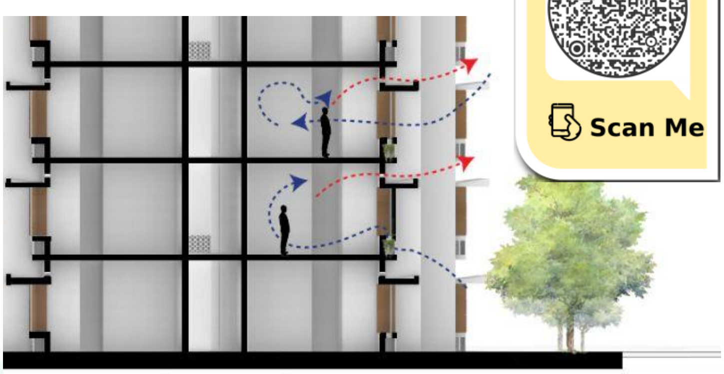


FIG 46.2

DAYLIGHT FACTOR

This simulation is done to understand the ratio of internal lux level to external lux level.
For an internal space ideal ratio should be in the range of 2%-5%.
Source: CLEAR(Comfortable Low Energy Architecture).

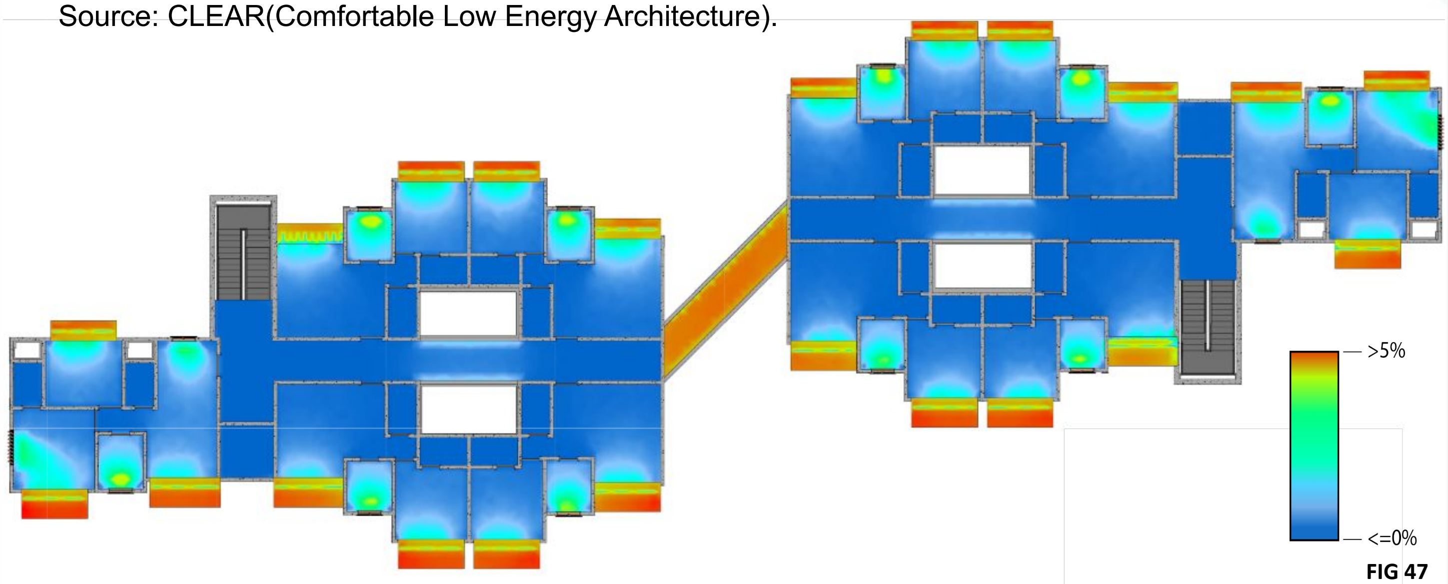


FIG 47

INFERENCES
The Average Daylight factor ranges between **2-5%**, which indicates the balance between lighting and thermal aspects.

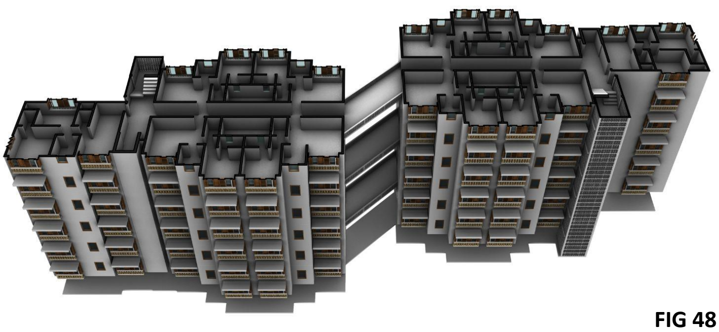
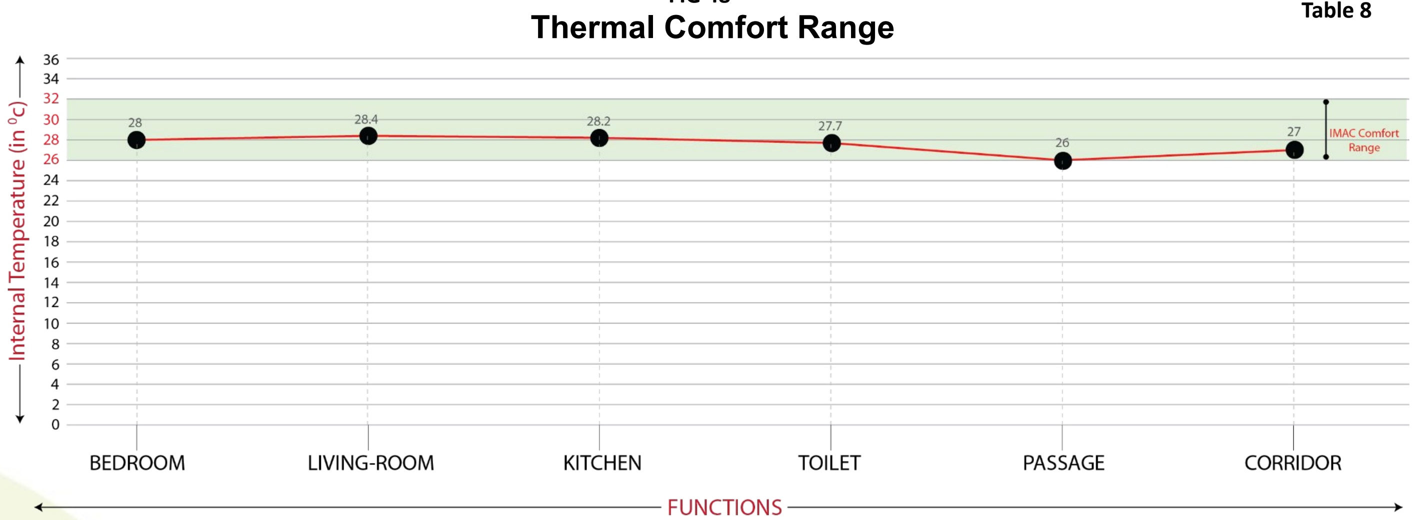


FIG 48

Windows with large openings are preffered due to the warm and humid climate of Boisar. Adequate ventilation is required for humidity control and to provide comfortable interior environment.			IGBC GH (ECBC - R & ECBC 2017)	DESIGN CASE
PARAMETER	ITEMS	Units	SI	SI
Envelope	Wall U (external)	W/ sq. m	2.5	2.2
	Roof U		1.5	0.5
	Floor		2.55	2.2
	Glass U		5.7	5.8
	Glass SHGC		0.5	0.6
	Glass VLT	%	90	87
	WWR		<40%	22%

Table 8



INFERENCES
The average temperatures of the zones lie within the IMAC comfort band and hence all the zones have comfortable indoor air temperatures.

11. B) COMFORT AND ENVIRONMENT QUALITY: EXTERNAL SITE

BOTANICAL NAME	COMMON NAME	CHARACTERISTIC	Water Req.
TREES			
T1 Neolamarckia cadamba	Kadambuam	Dense Noise Barrier	1600mm rainfall
T2 Ficus benghalensis	Banyan Tree	Garden Center	500 to 1500mm annual rainfall
T3 Wrightlia religiosa	Water Jasmine	Ornamental , Smell	800 to 1000 mm annual rainfall
T4 Azadirachta indica	Neem Tree	Mosquito repellant	450 to 1200 mm annual rainfall
T5 nyctanthes arbor-tristis	Parijatak	Flowering, at entrances	1000 to 1200mm annual rainfall
T6 Magnolia champaca	Champa	Flowering at amphitheatre	500 to 1500 mm annual rainfall
T7 Peltophorum pterocarpum	Yellow Flame	Shade, flowering	1500mm annual rainfall
SHRUBS			
BOTANICAL NAME	**COMMON NAME**		
S1 Rhaphiolepis indica	Pink Indian Hawthorne	Walkway periphery	
S2	Ratrani	Fence	
S3 Ficus Nitida	Indian Laurel Fig	Shaped hedges, Defining spaces	450 - 600mm annual rainfall
S4 Bougainvillea glabra	Paperflower	Ornamental, Flowering	600 mm annual rainfall
GRASS			
BOTANICAL NAME	**COMMON NAME**		
G1 Pennisetum setaceum	Fountain Grass	Fence Density	
G2 Chloris gayana	Rhodes Grass	Non Accessible Areas	500-1500 mm annual rainfall
Ground Cover			
C1 Arachis glabrata	Perennial forage peanut	Ground cover	100-200 mm annual rainfall
Community Farming			
F1 Cymbopogon pendulus	Lemon Grass	Farming	250-330 cm rainfall per annum
F2 Solanum lycopersicum	Tomato	farming	600mm annual rainfall
F3 Phyllanthus emblica	Indian gooseberry	farming	630 - 800mm annual rainfall
F4 Ipomoea batatas	Sweet Potato	farming	500-1300mm annual rainfall
F5 Basella Alba	Malabr Spinach	farming	60 - 100mm annual rainfall
Potted Plants			
P1 Hyacinth	Hyacinth	Ornamental	Partial Shade needed, well drained soil
P2 Bougainvillea	Bougainvillea	Ornamental	Less water, drained soil
P3 Syngonium	Arrowhead vine	Ornamental	Bright light, Medium water req.
P4 Dracaena Marginata	Dragon Tree	Ornamental	Low sunlight, minimal water

Table 9

The wind coming from the Industrial areas around the site are blocked by the vegetation barrier on site, thus creating a **microclimate.** The external environment air quality is improved by filtration through vegetation.
We have planted trees on the periphery of our site in order to reduce heat gain generated by the concrete vehicular pathways

FIG 49

11. C) ENERGY PERFORMANCE : ENERGY CYCLE

The EPI is optimised according to the custom occupancy schedule and parameters created for the users to reduce energy usage and in return reduce maintenance cost. We have targeted to achieve nearly net zero energy in common areas and the residential units. We have worked the solar PV required as per the guidelines of net metering by the government.

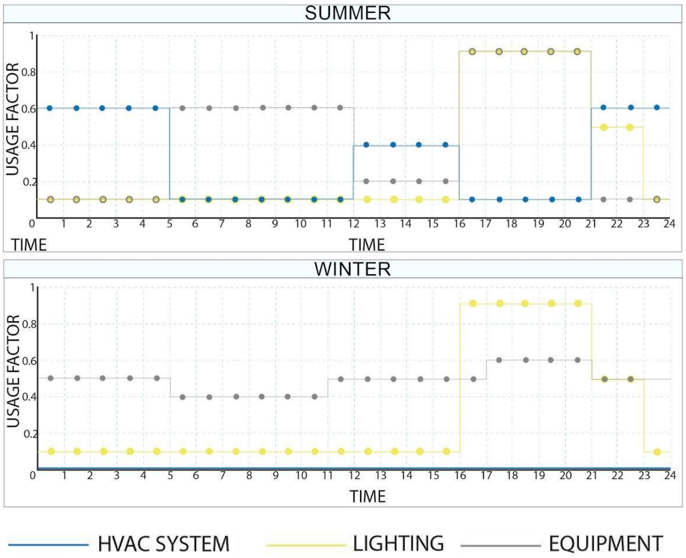
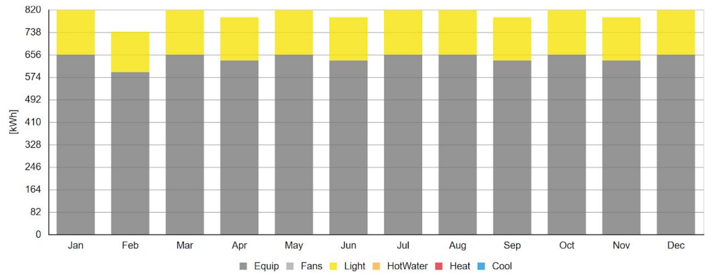
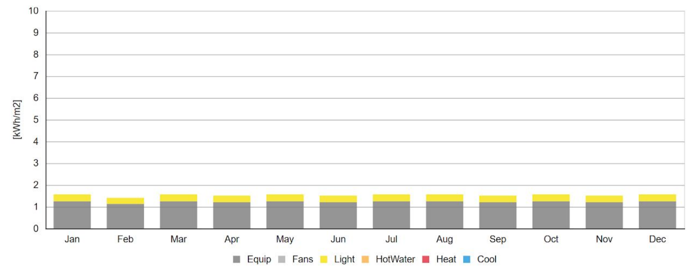


FIG 50



Energy Use



Energy Use Intensity

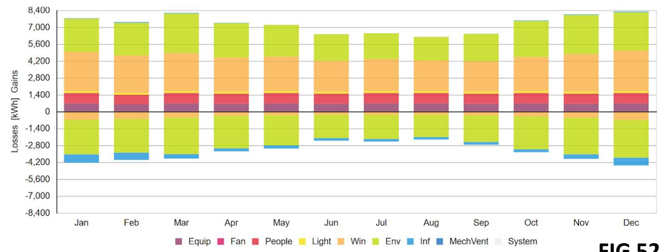


FIG 52

Energy Flows

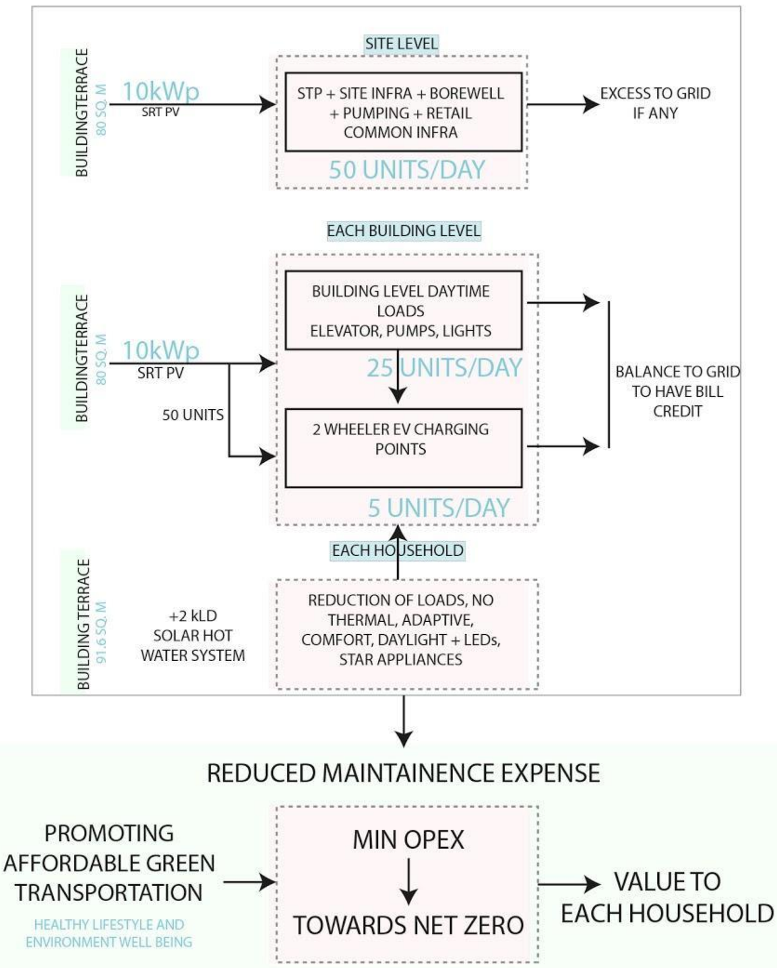


FIG 51

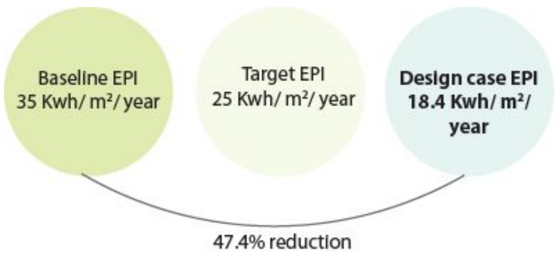


Table 9

<u>Solar PV calculations for one building.</u>

Required solar PV system = **10KWP**
Area for 1KW PV system = **8 sq.metres.**
Therefore, total area required = **80 sq.metres.**
Annual energy generation for 1 kwP = **1500KW.**
Total energy generation = **15000 KWh** from NREL

FIG 53

TERRACE MASTER PLAN

11. C) ENERGY PERFORMANCE : ENERGY CYCLE

	BEDROOM	LIVING ROOM	KITCHEN	DINING	TOILETS	STORAGE	PASSAGES	EXT. PASSAGE	STAIRCASES	AMENITIES
ENVIRONMENTAL										
DAYLIGHT										
NATURAL VENTILATION										
SOLAR ACCESS										
GLARE CONTROL										
THERMAL COMFORT										
OTHER										
PRIVACY										
VIEW										

Table 10

OCCUPANCY HOURS	6:00AM-12:00PM	12:00PM-6:00PM	6:00PM-12:00AM	12:00AM-6:00AM
BEDROOM				
LIVING ROOM				
KITCHEN				
DINING				
TOILETS				
EXT.PASSAGE				
STAIRCASES				
AMENITIES				

Table 11

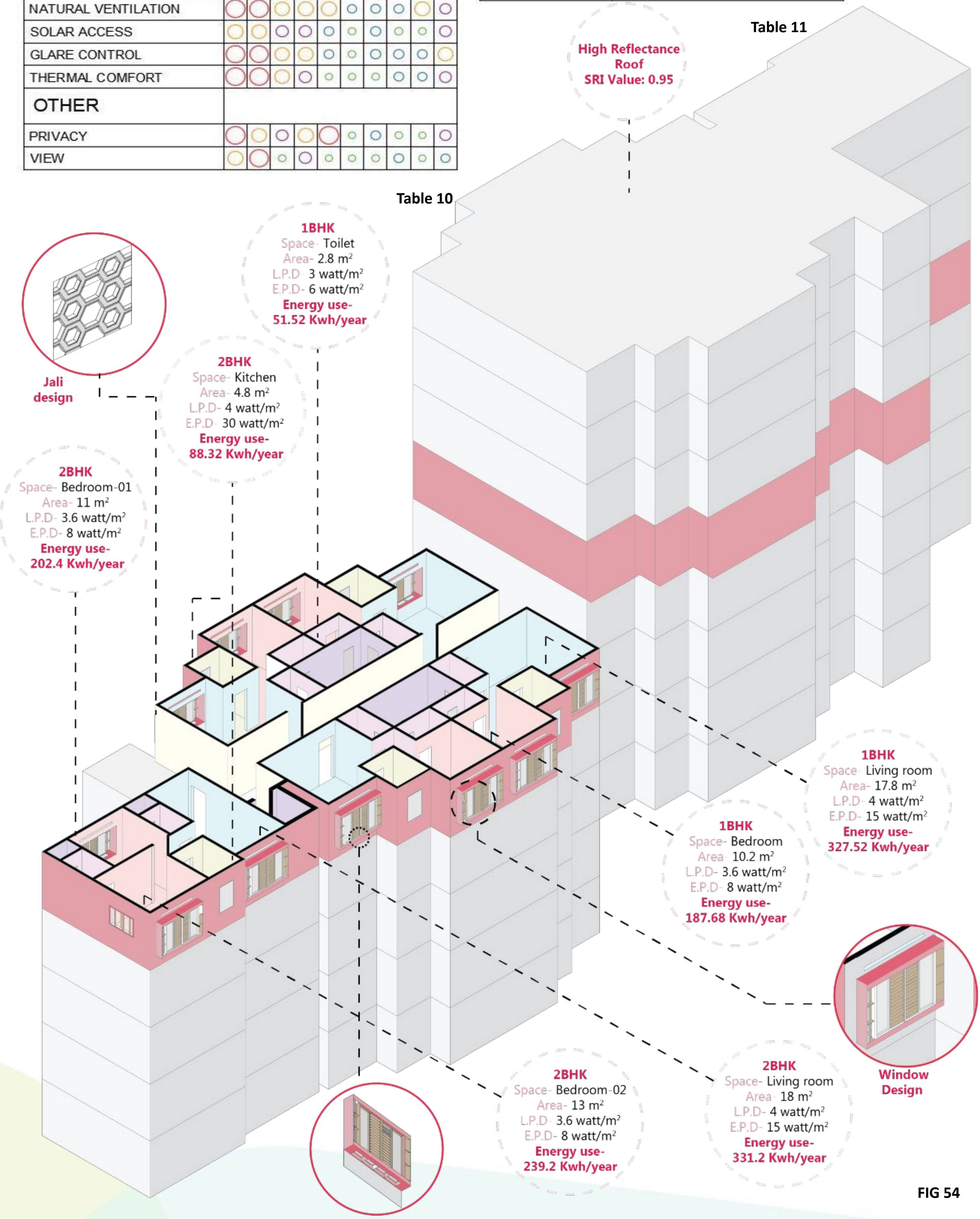


FIG 54

11. D) WATER MANAGEMENT : WATER CONSUMPTION

Due to high industrial activity in Boisar, the water source (River Surya) is polluted by the effluents from the factories. Hence, most of their sources are either groundwater or manmade lakes.

Once they source the required amount of water, it undergoes a strict treatment process before being supplied to customers. It is supplied from the Municipal corporation to site but this source is erratic and uncertain.

REDUCE the general water consumption
REUSE Onsite greywater
RECYCLE the water on site

FIG 55

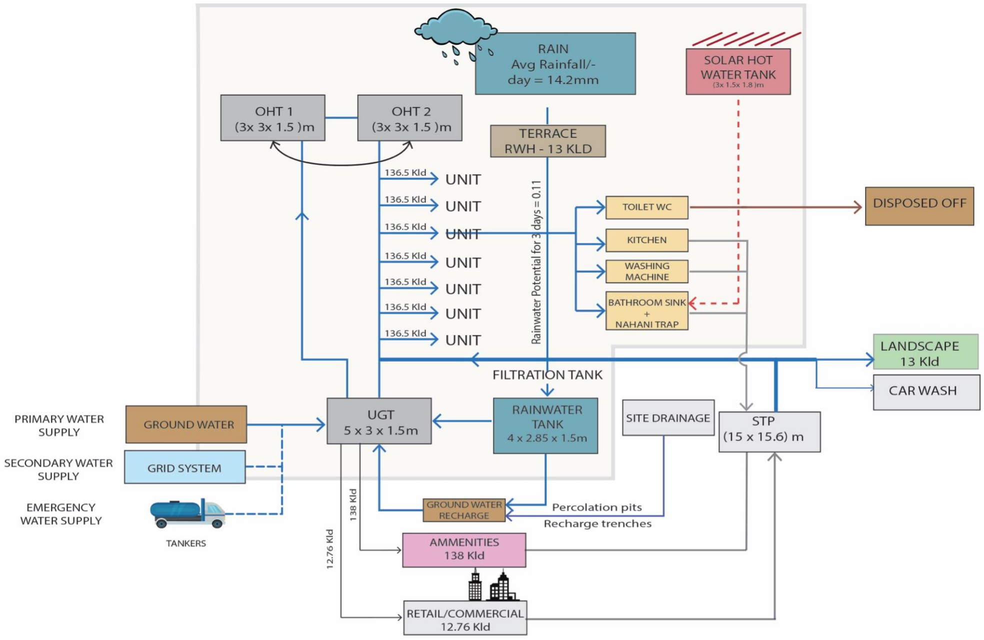


Diagram showing the integrated water cycle

FIG 56

The main challenge faced in Boisar are the erratic water supply systems, they get water for an average of 2 to 3 hours a day. Taking this into consideration we aimed at formulating an integrated water system that was self sufficient and independent in nature, taking all the programmes into consideration.

To limit dependency on external sources for onsite water usage, we propose an integrated water cycle as a promoter of self-reliance.

DAILY CONSUMPTION : BASE CASE VS DESIGN CASE

30% EFFICIENT FAUCETS

We have proposed Jaguar Aerators that decrease the base consumption by 30 %.

MANUELS: USER AWARENESS

Handing out manuels that spread the awareness of water scarcity and influence user behavior in turn.

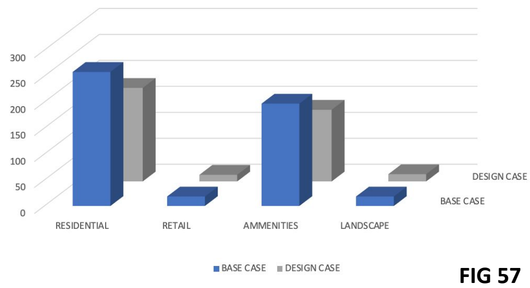


FIG 57

		OCCUPANCY LOAD	BASE CASE	DESIGN CASE
RESIDENTIAL	1BHK = 8 on a floor			
	PER PERSON	1	135	94.5
	PER UNIT	4		
	PER FLOOR	32		
	PER BUILDING	224	30240	21168
	2BHK = 2 on a floor			
	PER UNIT	5		
	PER FLOOR	10		
	PER BUILDING	70	9450	6615
	PER FLOOR	42	5670	136.5
	TOTAL PER BUILDING	294	39690	27783
	TOTAL SITE	1911	257.985	180.5895
RETAIL	No OF RETAIL SHOPS	45	135	94.5
	OCCUPANCY / SHOP	3		
	TOTAL OCCUPANCY	135	18.225	12.7575

	PROGRAMME	AREA	OCCUPANCY COEFF	NO OF PEOPLE	BASE CASE	DESIGN CASE
AMMENITIES	MULTIPURPOSE HALL	530	0.6	318	135	94.5
	GYM	70	2.5	175		
	LECTURE ROOM	120	2.5	300		
	GAMES ROOM	60	2.5	150		
	CAFE	55	2.5	137.5		
	SOCIETY OFFICES	152	2.5	380		
	TOTAL BUILTUP FOR AMMENITIES			1460.5	197.1675	138.01725

	TYPE OF VEGETATION	PLANT FACTOR	EVAPOTRANSPIRATION RATE (M/DAY)	AREAS(M SQ)	IRRIGATION SYSTEM EFFICIENCY	WATER REQUIREMENT
LANDSCAPE	LAWNS	1	0.0065	1000	0.75	8666.6667
	NATIVE PLANT	0.4	0.0065	1500	0.85	4588.2353
	NATIVE TREES	0	0.0065	1370	0.75	0
	Drought tolerant species			3870	TOTAL	13.254902

	BASE CASE	DESIGN CASE	
TOTAL WATER CONSUMPTION	486.6324	344.61915	Kld

Table 12

TOTAL WATER CONSUMPTION :

Base Case = 486 Kld

Design Case = 345 Kld

11. D) WATER MANAGEMENT : TREATMENT PLANT AND RAINWATER HARVESTING

SOIL BIOTECHNOLOGY PLANT

Instead of using a conventional STP Plant, we have proposed to use the Soil Biotechnology plant due to its advantages of - reduction in energy consumption, no smell, no sound, no process down time and 90 percentage of water recovery.

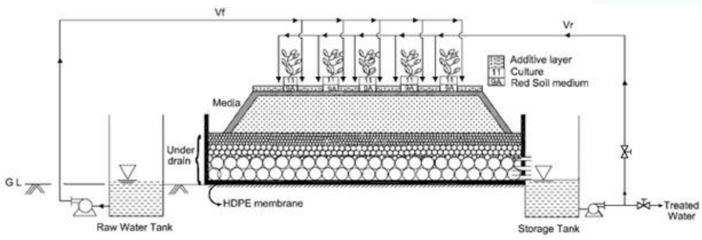


FIG 58

WASTE WATER GENERATED ON SITE = 345 Kld
GREY WATER= 85% OF WASTE WATER
WATER GOING TO STP = 290 kld
WATER TREATED BY STP = 265 kld
TOTAL WATER TREATED BY SBT - 234 Kld
STP SIZE = 23 M SQ

SBT CAPACITY : 100 TO 500 Kld Model

WATER REUSED : 265 Kld

ROOF AREA FOR ONE BUILDING	558.4
TOTAL TERRACE AREA	3629.6
AVERAGE RAINFALL/DAY (M)	0.014232877
NO. OF RAINY DAYS	172
RAINFALL PER DAY	8.27493E-05

		CATCHMENT AREAS	RUNOFF COEFF	RAINFALL/DAY (M)	RWH POTENTIAL	3 DAYS
RAINWATER HARVESTING	TERRACE	558.4	0.8	8.275E-05	0.03696576	0.1108973
	SOFT SCAPE	6870	0.2	8.275E-05	0.113697515	
	HARDSCAPE	1,61,030	0.8	8.275E-05	10.66009366	
					10.81075694	
	RAINWATER HARVEST TANK FOR ONE BULDING = (4x2.85x1.5) m					

Table 13

RAIN WATER HARVESTING

Boisar gets an average annual rainfall of 110 lpd, we have proposed the roof of every building to be a catchment area. A filtration system is added to the water pipelines that removes the dirt and impurities, making the water suitable to discharge into the ground or redirect it into the rainwater harvesting tank for further use.

RAINWATER HARVESTING CAPACITY : 430 Kld

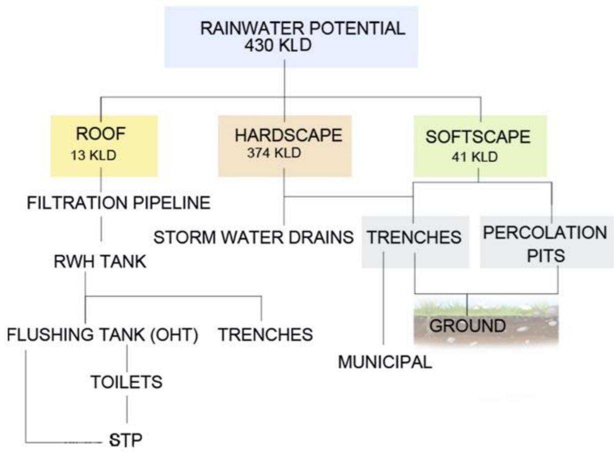


Diagram showing the rainwater harvesting cycle

FIG 60

SITE DRAINAGE

Softscape : The landscape area dips down to form a bowl, directing the water to flow towards the bioswales

Hardscape : The peripheral vehicular system has storm water drains laid out on either side at a slope covered with a grill on top.

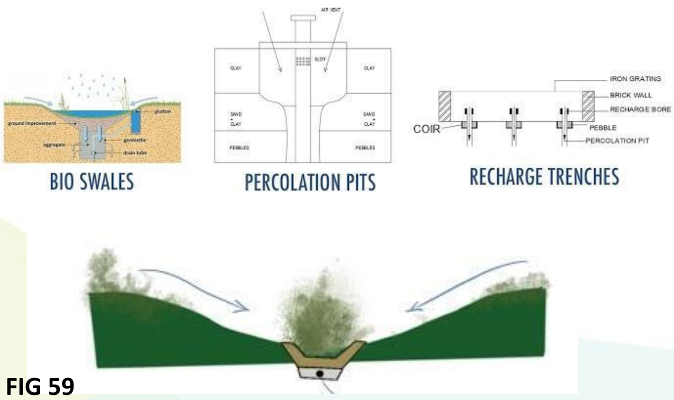


FIG 59

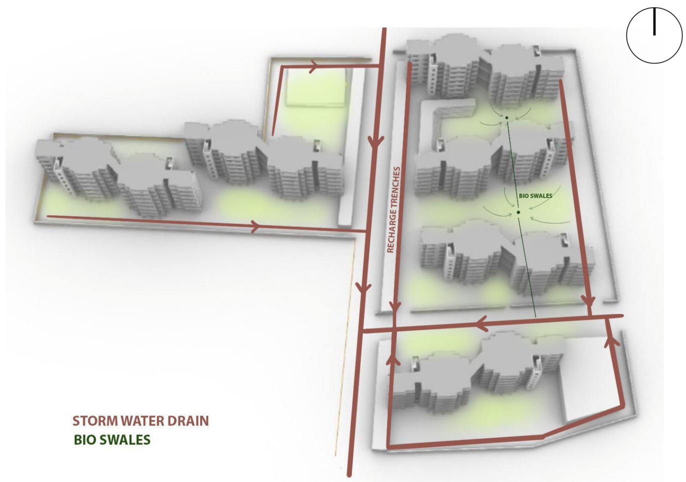


Diagram showing a conceptual site drainage plan

FIG 61

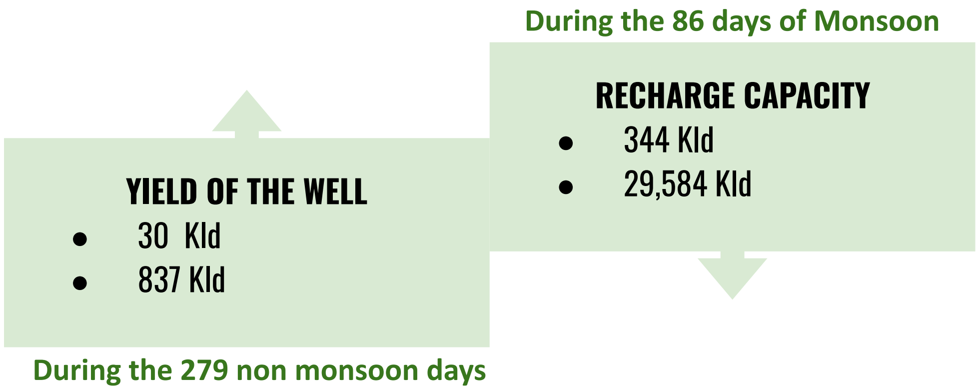
11. D) WATER MANAGEMENT : GROUNDWATER TAPPING AND CONCLUSION

GROUND WATER BALANCE

The ground water level in Boisar is at 60 to 80 ft. In order to create a balance between the tapping and recharging amount, we let all the excess rainwater recharge into the ground during the 86 days of Rainfall and tapped the 30 Kld on the remaining non monsoon days.

We have therefore introduced more water into the ground than what we proposed on tapping.

This not only increases the water table but also dilutes the harmful toxins disposed off by certain industries in and around the area.



Comparison between groundwater tapping and extraction **FIG 62**

BUILDING SERVICES : WATER

UGT

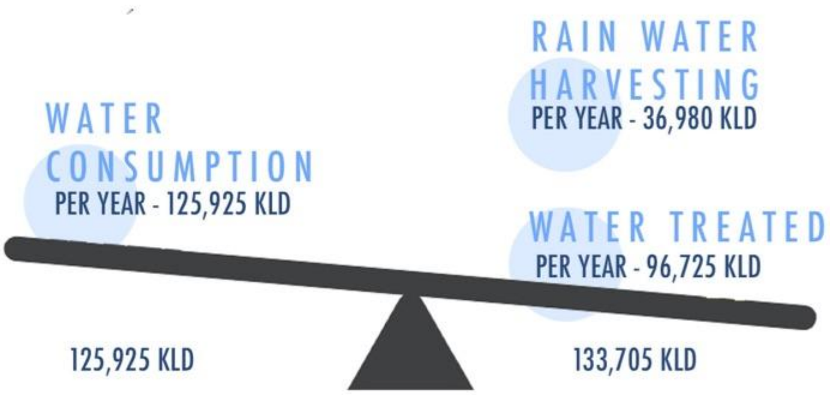
TOTAL WATER CONSUMPTION PER BUILDING = 27783 Lpd
1 M CU = 1000L
UGT VOLUME OF WATER = 28 M. CU
UGT PER BUILDING = (5x3x1.5) m

OHT

TOTAL WATER CONSUMPTION PER BUILDING = 27783 Lpd
HALF A DAY REQUIREMENT = 13891.5 Lpd
OHT AREA = 14 M sq
OHT Dimensions = (3x3x1.5) m

SOLAR WATER HEATER

1 BHK = 100 l
2 BHK = 125 l
TOTAL PER BUILDING = 7350 l
AREA OF TANK = 7.4 m cu.
TANK SIZE = (3 x 1.5 x 1.8) m



We aim at moving towards a net positive water cycle **FIG 63**

11. E) WASTE MANAGEMENT : ORGANIC, INORGANIC AND E-WASTE

Boisar being an Industrial town generates a lot of waste that is usually disposed off into dumping grounds or water bodies. We wanted to inculcate a sense of responsibility within the residents where they take charge of the waste generated on site..
The organic waste is 100 % recycled, its manure is utilised for the landscape and excess is sold of, while the inorganic waste is recycled or disposed off

WASTE INFRASTRUCTURE

Providing necessary infrastructure that enables the smooth transition of waste on site.

Providing a 2 bin system at the source of disposal - for organic and inorganic waste → Providing housekeeping that relocates and distributes the waste → Providing a common station on site for inorganic waste disposal and organic waste recycling

FIG 64

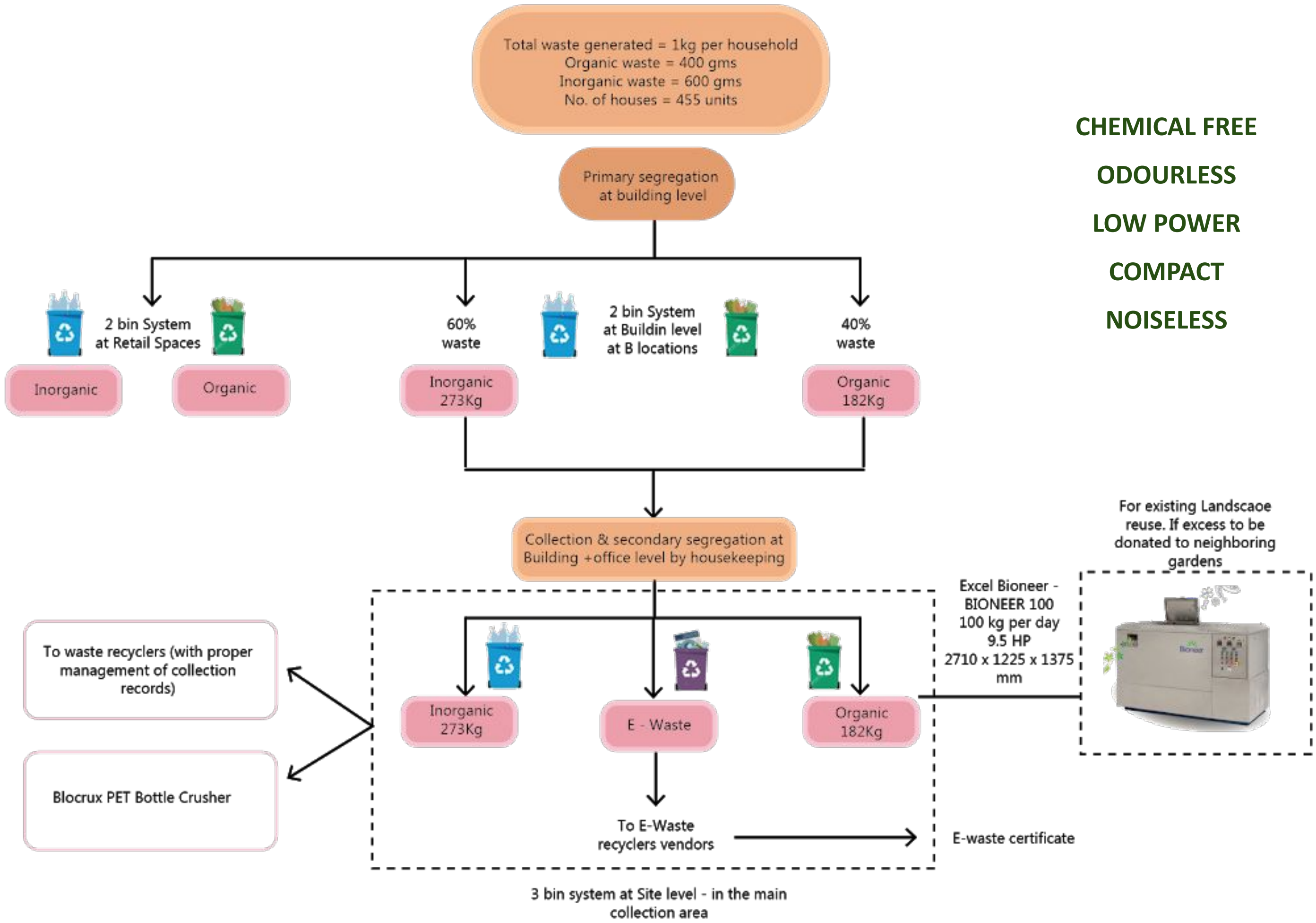


Diagram showing the waste cycle

FIG 65

CHEMICAL FREE

ODOURLESS

LOW POWER

COMPACT

NOISELESS

ORGANIC WASTE CONVERTER : AUTOMATIC WASTE CONVERTER SYSTEM

- Brand : Excel Bioneer 100
- Time ; 24 hrs
- Size : 2.7 by 1.3 m

WASTE CONVERSION PROCESS

Segregate | Input wet waste | Switch On Bioneer | Output in 24 hours | Application

FIG 66

TOTAL ORGANIC WASTE RECYCLED ON SITE : 182 Kg/day

11. F) AFFORDABILITY : PRECAST METHOD OF CONSTRUCTION

Challenge: The clientele we are catering to has an average income of 1.5 lakh per year making it impossible for them to afford a house more than 16.-4 lakhs. Hence, the aim was to adopt measures to ensure the **post operative costs are lowered.**
With a large population and clientele belonging to the LIG, meeting a fair price point is a challenge in the locality.

Strategies: Multiple strategies were used to ensure minimal cost and maximum durability for ensuring the cost is lowered in post occupancy.
The structure aims at building in low-tech means and processes using low-cost green features (such as rainwater capture for irrigation, etc.) as well as materials, to ensure the efficiency of the structure's life cycle.

PRECAST METHOD OF CONSTRUCTION

MODULARITY AND NO SHUTTERING WORK

By analysing the advantages and disadvantages of various construction methods, and keeping material costs in mind, we propose a ***precast method of construction*** that allows cost reductions through eliminating shuttering costs and ***saves valuable time,*** hence reducing the interest rates for the overall project cost and the sales prices.

FLEXIBLE UNIT CONFIGURATION

For middle class housing, often the number of occupants is high compared to the area of the house. We aimed at keeping our ***units compacts but efficient*** at the same time: the living room was made in a way that it could accommodate a sofa-cum bed and we decided to provide two toilets in both, the 2BHKs and 1BHKs to cater to the high occupant-per-flat number

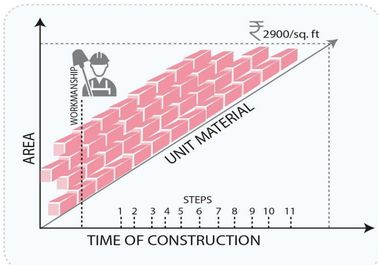
SIZING OF ELEMENTS

By repeating the same units, we have ensured that the sizing of structural systems and fixtures are maintained and is the same, thus allowing ***repetition of same mould*** and ease of construction.

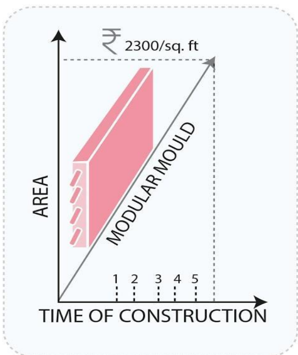
Having 5 apartments to a common core

	CONVENTIONAL	PRECAST	3D VOLUMETRIC
TIMELINE OF CONSTRUCTION	1 Excavation (2 Weeks) 2 Foundation Laying (5 Weeks) 3 Shuttering Installation (1 week) 4 Level wise concrete pouring (7 weeks) 5 Structural frame (3 weeks) 5 Removal of shuttering (1 week) 7 Curing (4 weeks) 8 Brick/ block laying (4 weeks) 9 Roofwork (1 week) 10 MEP conduiting (10 weeks) 11 Plastering (8 weeks) 50	1 Excavation – Moulding (2 Weeks) 2 Foundation – Casting (5 Weeks) 3 Transportation (3 Weeks) 4 On site assembly Grouting and fixing 5 Services Finishing (10 Weeks) 20	1 Excavation – Moulding (2 Weeks) 2 Foundation – Casting (5 Weeks) 3 Transportation (2Weeks) 4 On site assembly 5 Services Finishing (5Weeks) 19
QUALITY	Require skilled worksmanship Labour intensive Quality compromised due to human error	Manual fixing Balanced labour and technology Factory quality - no compromise	Cranes for fixing Technology intensive Factory quality - no compromise
WASTE	Site wastage - storage Clean up Disposal Water wastage - curing	Directly propped on site - no site wastage	Directly propped on site - no site wastage Material use minimal
ENERGY	Column, beam, slab, infill, plaster Material fabrication waste Overall U value - 2.5 approx (layers)	Prefabricated panels with cavity Modular fabrication Overall U value - 2	RCC infill walls Modular fabrication Overall U value - 2
COST	Individual cost for each process Shuttering costs Labour cost MEP cost Overall rate approx 2900/sq. ft	Fabrication cost including MEP Installation Overall rate approx 2300/sq. ft	Fabrication cost including MEP Installation Overall rate approx 2000/sq. ft
		Design flexibility and variation in alignments catering to climate	Restrictive rectangular grid design as per standard mould

Table 14



CONVENTIONAL BLOCKWORK CONSTRUCTION



PROPOSED PRECAST METHOD **FIG 67**

BASE CASE COST = Rs. 2586/sq. ft

PROPOSED COST = Rs. 2189.9/ sq. ft

11. F) AFFORDABILITY : SAVINGS

SAVINGS ON CONSTRUCTION

NO BASEMENT CONSTRUCTION

We managed to hit the minimum parking requirements by providing only stilt and surface parking, making sure that we eliminated the use of stack parking, something that would have drastically added onto the cost of the project

NO FIREFIGHTING COMPLIANCE REQ.

The structure was limited to a height of 24 m so that, as per the bye-laws, we would not have to provide any fire-fighting systems, which would add on to the cost of the structure.

ANNUAL SAVINGS ON INTEREST BY CONSTRUCTION TIME REDUCTION

By using a precast construction method, the client is saving time and hence he meets his loan repayment faster.

RATIO OF BUILT UP TO CARPET

While designing the floor plans, we made sure to keep the carpet to built up ratio minimum.
Base case - 1:1.45
Design Case - 1:1.2

PASSIVE DESIGN - SAVINGS ON POWER

DAYLIGHT AND NATURAL VENTILATION

The plan was designed in such a way that all the habitable areas got daylight and natural ventilation, thus reducing the electrical consumption and cost.

ZERO HVAC LOAD

By providing no HVAC systems and relying solely on natural ventilation and passive design methods throughout the units, we have managed to bring down the cost of the HVAC equipment and loading.

SAVING 5% ANNUALLY BY CHOOSING LED AND RELYING ON DAYLIGHTING

SAVINGS ON ANNUAL MAINTENANCE AND ELECTRICITY LOAD

LOWERING OPEX : WATER, ENERGY AND WASTE

By employing sustainable solutions to lower the post occupancy costs, the aim was to make the unit self sufficient and non expensive to maintain in the long run.

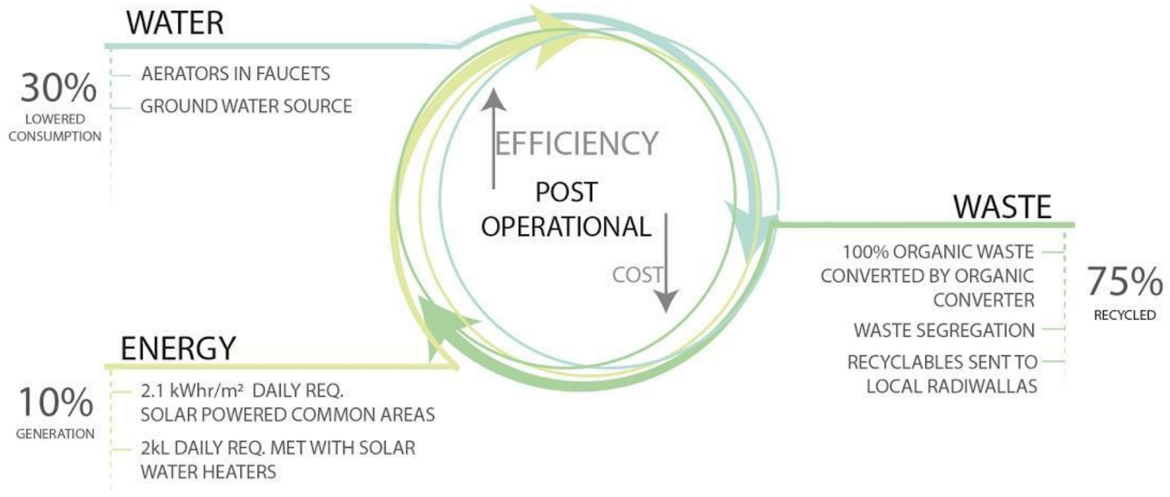


FIG 68

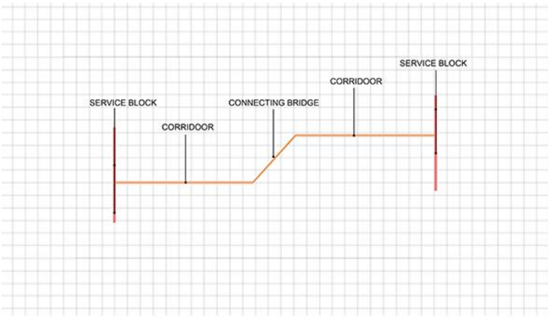
CAM CHARGES = Rs. 2/ Sq ft

PROPOSED CAM CHARGES = Rs. 1.2/ sq. ft

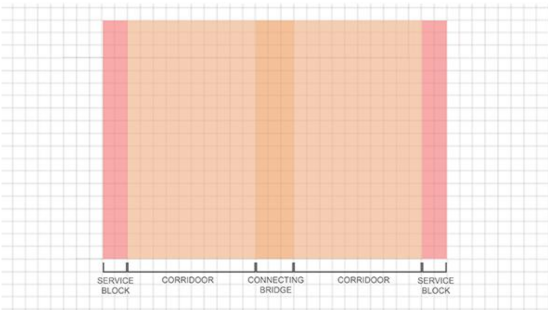
11. G) SCALABILITY: FLEXIBILITY AND MODULARITY

- **Flexibility: Adapting to their changing requirements and providing different sources of income**

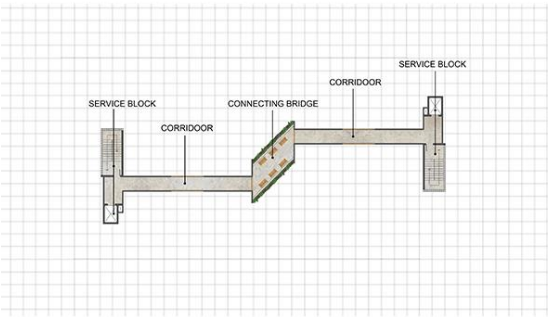
Over-determination of functions reduces the potential of a structure, as well as its usability. Over time, especially since there is a lot of development potential in the areas surrounding the site, there may be a change in the immediate requirements of the residents. By providing an adaptability in its form, we enable the structure to be capable of discharging its duties in various situations. In situations such as natural disasters or a pandemic, certain spaces may be in high demand and it is essential for the structure to be



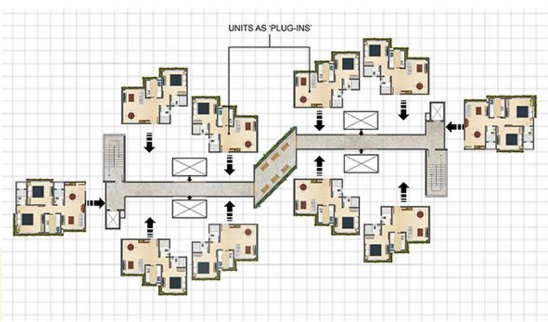
LOOKING AT THE VARIOUS SPACES AS A HOMOGENOUS ENTITY



SPATIAL DISTRIBUTION OF THE VARIOUS SPACES IN RELATION TO THE GRID

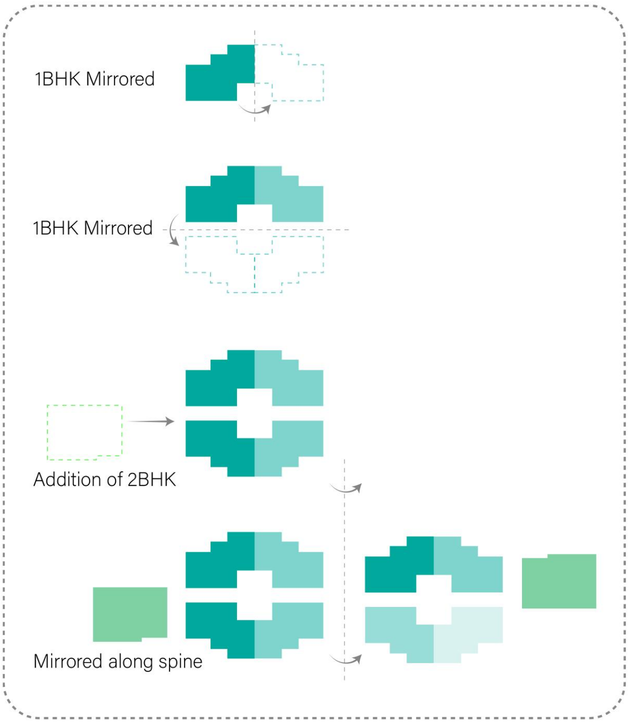


THE 'SPINE' COMPRISES OF THE SERVICE BLOCKS, CORRIDOORS AS WELL AS THE CONNECTING BRIDGE AT ALTERNATE LEVELS. THESE CIRCULATION PATHS FORM THE CONSTANT BACKBONE THAT CAN BE REPLICATED ON SITE

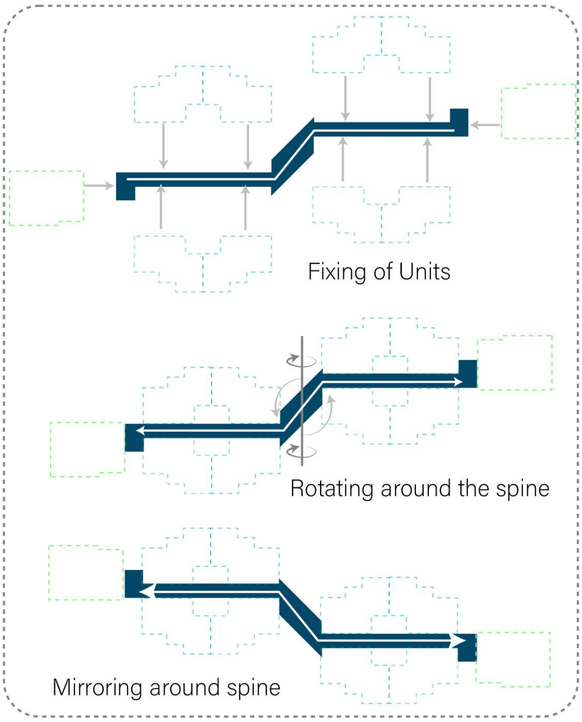


THE CONCEPT OF A 'PLUG-IN': LOOKING AT THE VARIOUS FLATS AS UNITS THAT GET INSERTED INTO THE SPINE AS PER THE MARKET POTENTIAL AND REQUIREMENTS OF THE SITE

FIG 69



The **modular** configuration of 1BHK is **replicated and multiplied** throughout the entire form.



The central core acts as a **spine for the replicated units** to be placed around.

FIG 70

11. G) SCALABILITY : CONFIGURATION OF UNITS

SCALABILITY OF UNITS:

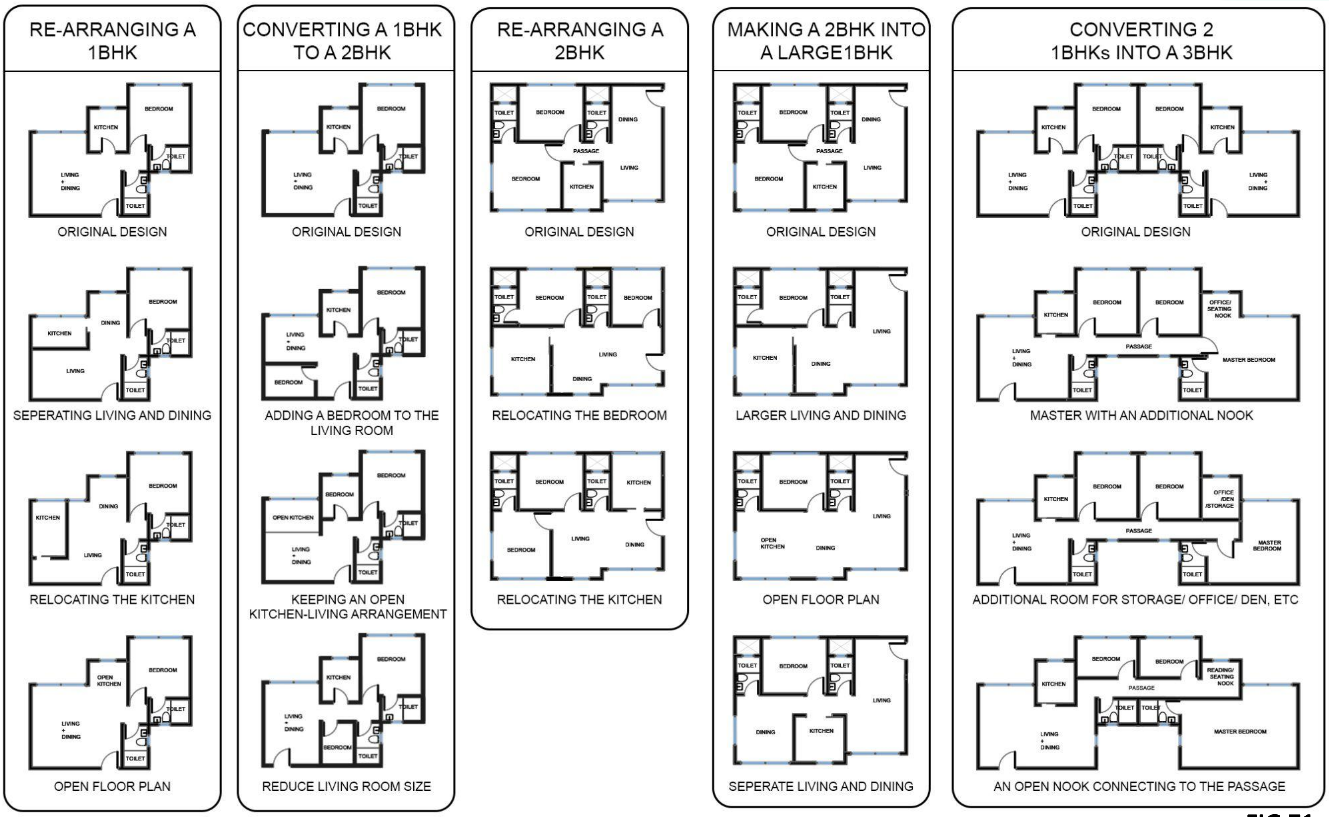
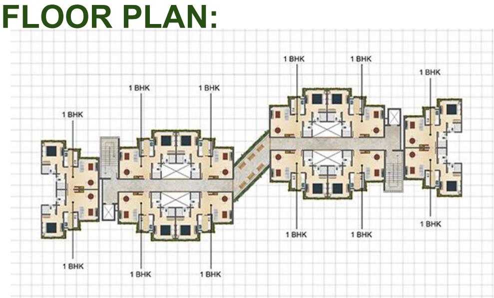
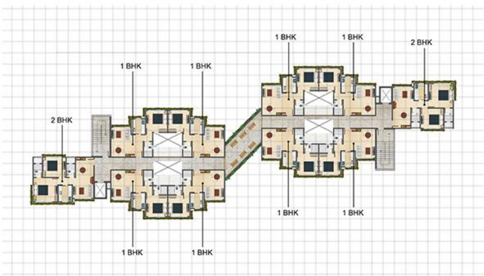


FIG 71

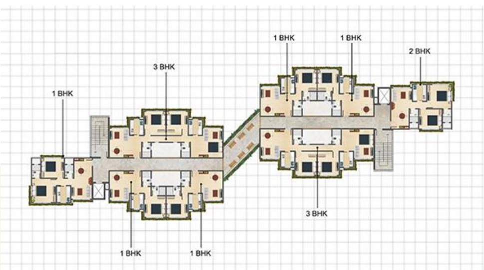
SCALABILITY OF THE BUILDING FLOOR PLAN:



IN BOISAR THERE IS A HIGHER MARKET FOR A 1BHK. IN ADDITION, PROVISIONS HAVE BEEN MADE TO ALLOW THE NUMBER OF FLATS PER FLOOR TO BE REGULATED THROUGH THIS 'PLUG-IN' MECHANISM, AS PER THE REQUIREMENTS OF SITE



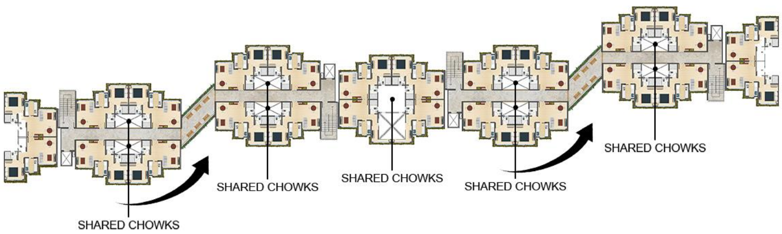
IN SITES WHERE THERE IS A MARKET POTENTIAL FOR A 2BHK, PROVISIONS CAN BE MADE TO 'PLUG-IN' THOSE UNITS



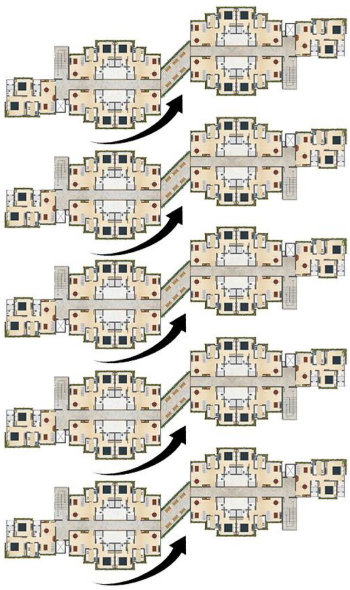
IN SITUATIONS WHERE THERE IS A DEMAND FOR EVEN LARGER SPACES, THE UNITS HAVE BEEN PLACED IN SUCH A WAY THAT 2 UNITS CAN BE CONVERTED INTO A LARGER FLAT, SUCH AS A 3BHK

FIG 72

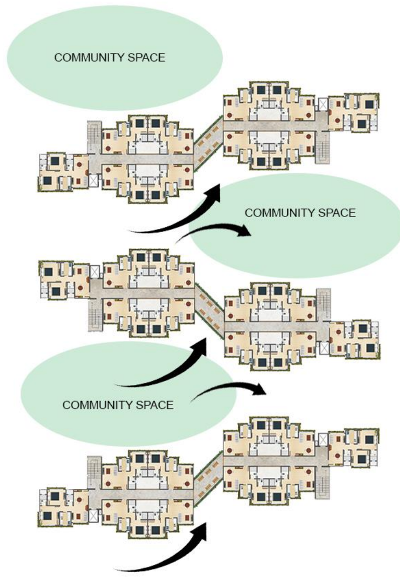
SCALABILITY OF THE MASTER PLAN:



THE LINKING ARRANGEMENT: IN SITES THAT ARE EXTREMELY LINEAR, CONTINUOUS LINKS CAN BE CREATED, ENSURING THAT EACH FLAT GETS ADEQUADE LIGHT AND VENTILATION, AS WELL AS AN EFFICIENT DISTRIBUTION OF SHARED SERVICE CHOWKS,CIRCULATION SPACES, CONNECTING BRIDGES, ETC.



THE PARALLEL ARRANGEMENT: THE ORIENTATION OF BUILDINGS CAN BE DONE PARALLEL TO EACH OTHER, WHICH ALLOWS FOR EQUAL SPACES BETWEEN THE



THE MIRROR ARANGEMENT: BUILDNGS CAN BE MIRRORED TO FACE EACH OTHER, CREATING COMMUNITY SPACES IN BETWEEN. IN THIS CASE, SUCH AS OURS, THE SHARED SPACES GET SHADED AND THE CONNECTING BRIDGES ALLOW FOR A SMOOTH WIND FLOW THROUGH SITE

FIG 73

11. G) MARKET POTENTIAL : TARGET GROUP

MARKET GROWTH

In the fast-developing Boisar, Mumbai region, the increasing urban population is putting a lot of pressure on the housing sector – especially on low-income housing. The target population is mainly the ***working class, mostly employed in industrial corporations or manufacturing units.***

SIZING OF UNITS

As per the Pradhan Mantri Awaas Yojana guidelines, the size of a house for Economically Weaker Section (EWS) could be up to 30 sq. meters carpet area which is around 320sq ft. Keeping in mind the middle-income group (LIG and MIG), the interest loan subsidy availed on housing loan on acquisition and construction of house depending on their household income. The scheme offers an option of 1, 2 BHK units having sizes ranging from 350 to 550 sq. ft and it offers homes at prices in the range of 18 lakhs to 25 lakhs.Most of their monthly incomes range from Rs. 25,000-35,000, translating into an annual income of Rs.3,00,000-4,20,000. Considering the definition for affordable housing in case of LIG and MIG, the affordability of the housing unit is not lost if it is priced within the range of Rs. 15,00,000 to Rs 21,00,000.

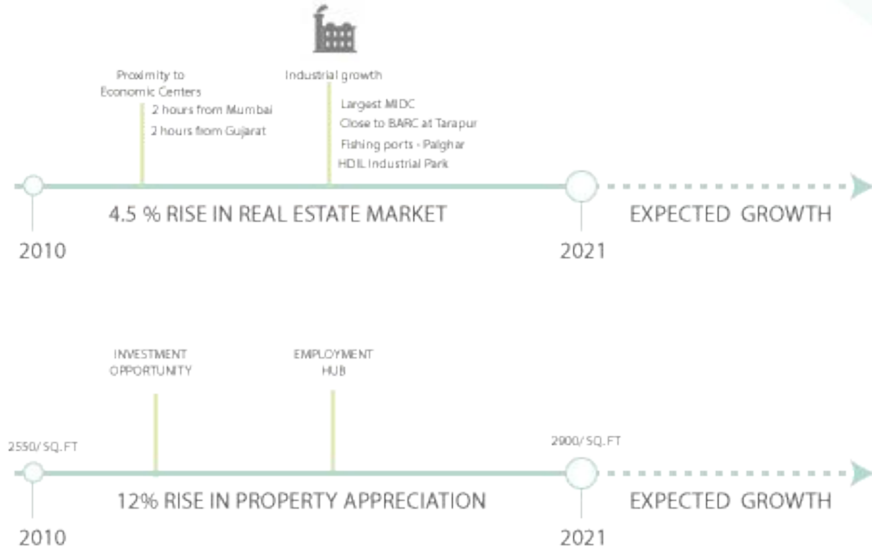


FIG 74

TARGET GROUP

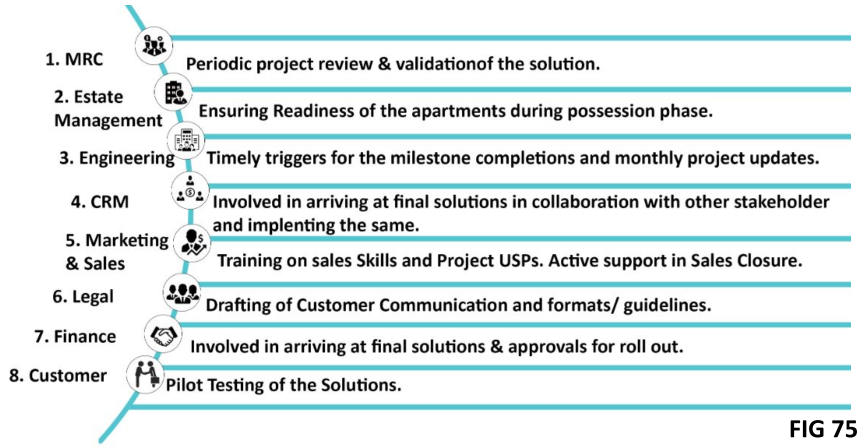


FIG 75

FLAT AREA	USER INCOME	PREDICTED COST OF SALE
350 SQ. FT	3 LAKHS P.a	18 Lakhs
550 SQ. FT	4.2 lakhs P.a	25 Lakhs

FIG 76

CONSTRUCTION TIMELINE

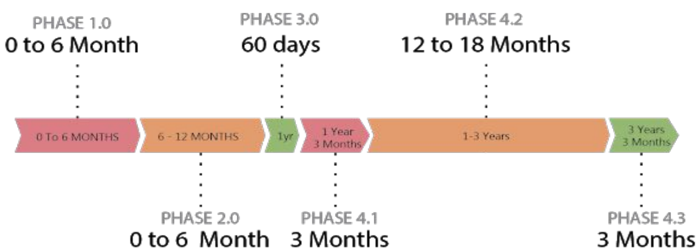


FIG 77

FIG 78

BASE COST
Rs. 2586/ SQ. FT

PROPOSED COST
Rs. 2189.9/ SQ. FT

11. H) RESILIENCE : DISASTER MANAGEMENT - COMMUNITY

By resilient design we strive to achieve **environmental, social, and economic sustainability,** along with the ability of the structure to **adapt to known and unknown risks and vulnerabilities** through immediate as well as long-term measures. The aim is to make the structure **liveable and durable in every circumstance** that counter an unprecedented situations (such as the CoVid pandemic) and other impacts that are expected to result from a warming climate. Located in an industrial district, the structure should **cater to the fluctuations in the air quality index**.

DISASTER MANAGEMENT

The designed units aim to sufficiently adapt to natural disasters, provide efficient power supply on site along with on-site waste disposal to ensure smooth functioning. We also aim to incorporate the changing life conditions caused by the CoVid-19 pandemic

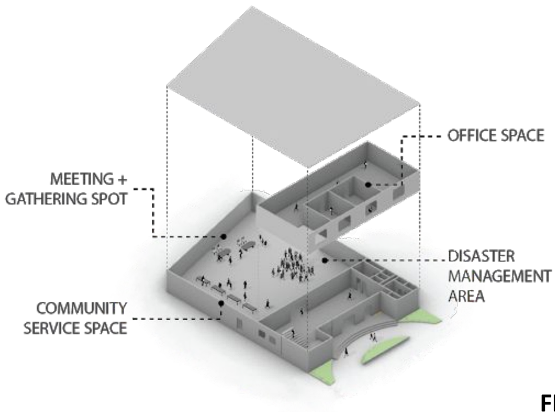


FIG 79

COMMUNITY RESILIENCE	
1 COMMUNITY SPACES	2 COMMUNITY ACTIVITIES
HALL FOR LARGE GATHERINGS	URBAN FARMING
OPEN AMPHITHEATRE	SEASONAL GATHERINGS
PLAY SPACES	FESTIVAL CELEBRATIONS
PLAY SPACES	

Table 15

RESILIENCE THROUGH COMMUNITY INTERVENTIONS

Providing a community hall that is flexible in use and can be used as a multipurpose hall as per the changing requirements. A common congregation space add to the public sense of community and can be transformed into spaces of relief during times of crisis such as a natural calamity, pandemic, etc.

COMFORT AND ENVIRONMENT

FACADE - The facade openings are designed in such a way that they adapt to the seasonal changes with time.

MONSOON - During the monsoon the openings re shit but a grill at the lower edge of the protruding window can be left open so that the wind flows in but the rain stays out.

SUMMER - During the summer the planters cool the hot dry air coming into the house

WINTER - During the winter the window can fully open up so that the cool air flows in

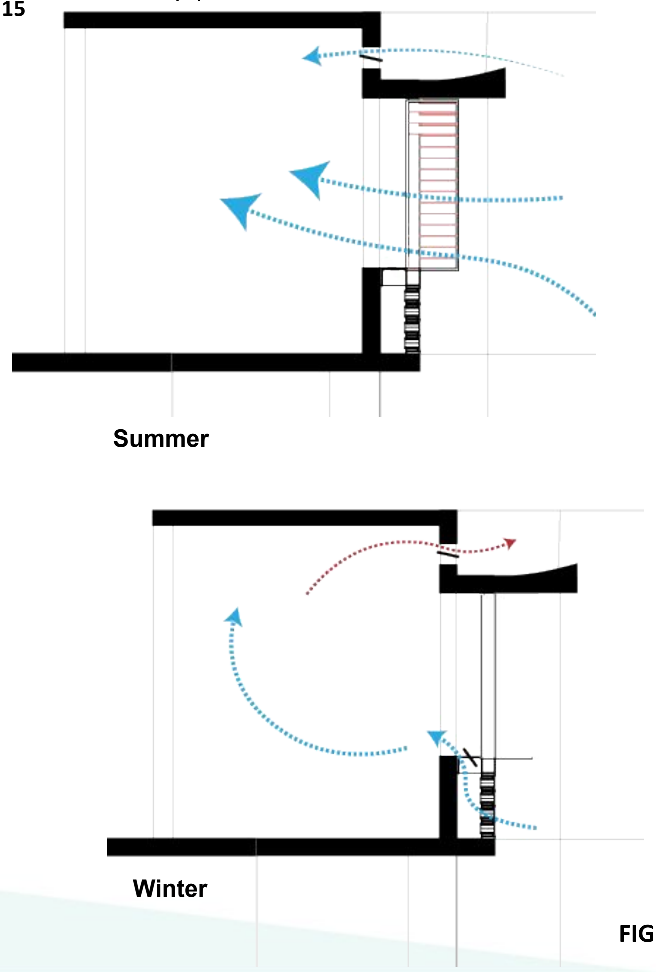


FIG 80

11. H) RESILIENCE : DISASTER MANAGEMENT- WATER AND POWER

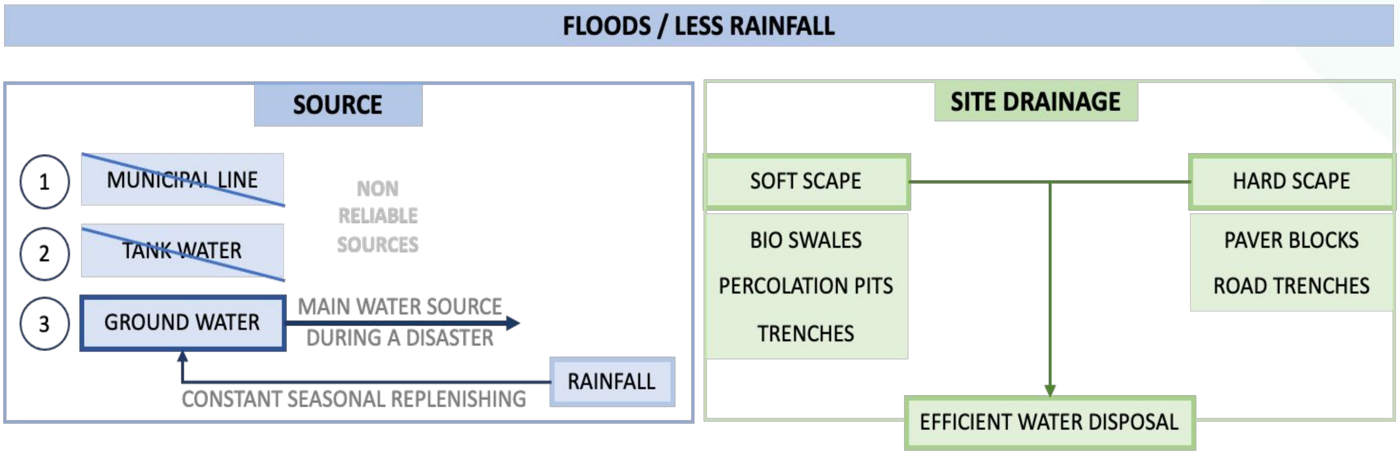


FIG 81

RESILIENCE DURING FLOODS

Boisar is a flood prone area that experiences flooding due to its irregular heavy rainfall. We have landscaped our site in such a way that the central landscaped spline percolates the water through borewells, grass swales and percolation pits while the peripheral hardscape has recharge trenches all around to take care of the hardscape drainage. This ensures efficiency of the site and the various mechanisms act in coherence with each other.

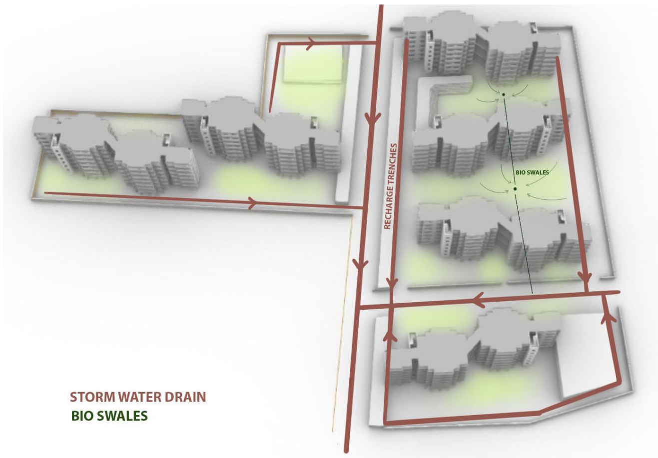


FIG 82

RESILIENT WATER SUPPLY SYSTEM

Making use of multiple sources of water and hence not being dependent on only one single source of supply. In terms of uncertainty where one form of supply fails, such as the erratic grid supply of Boisar, provisions such as bio technological plants, filtration systems and rainwater harvesting can be used to maintain the smooth operation of the site

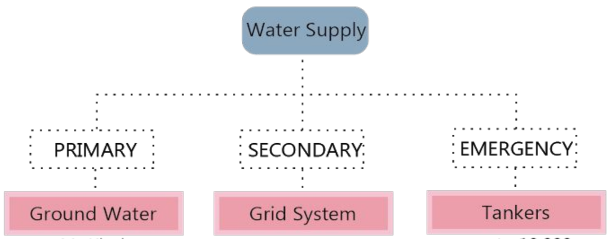


FIG 83

ENERGY PERFORMANCE

By using Solar PVS we have managed to create alternate sources of electricity during a power cut adding to teh resilience of our structure.

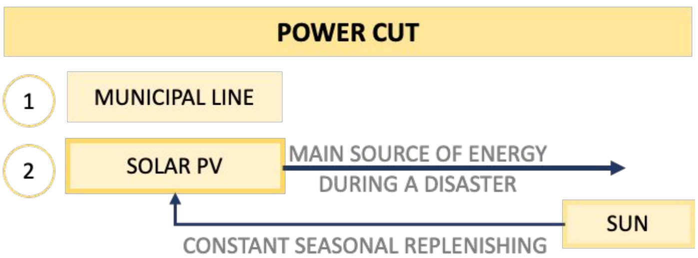
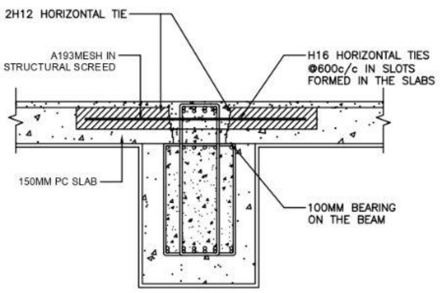


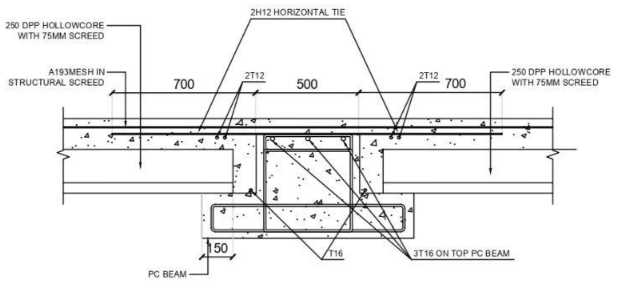
FIG 84



SECTION DETAIL
SCALE 1:20

PRECAST COLUMN TO SLAB CONNECTION DETAIL

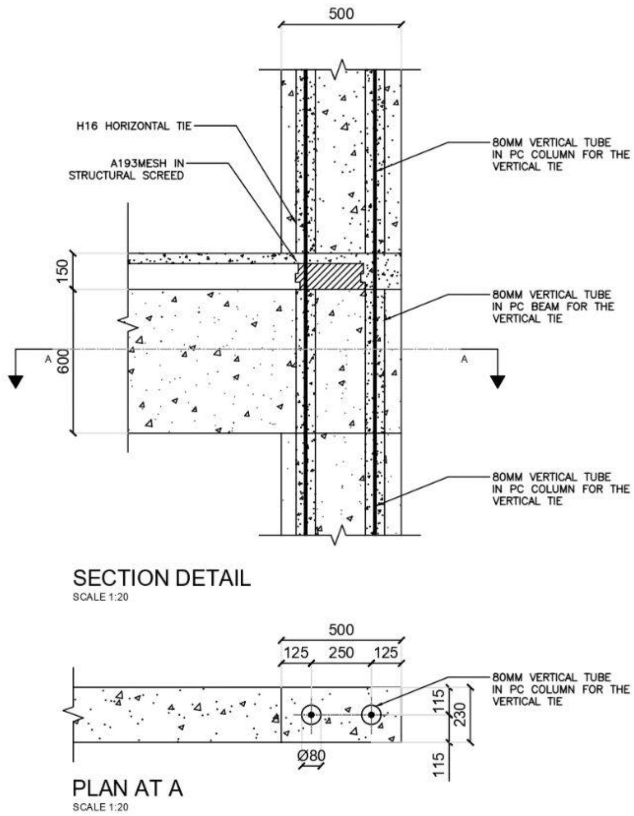
FIG 85



SECTION DETAIL
SCALE 1:20

PRECAST SLAB TO BEAM CONNECTION DETAIL

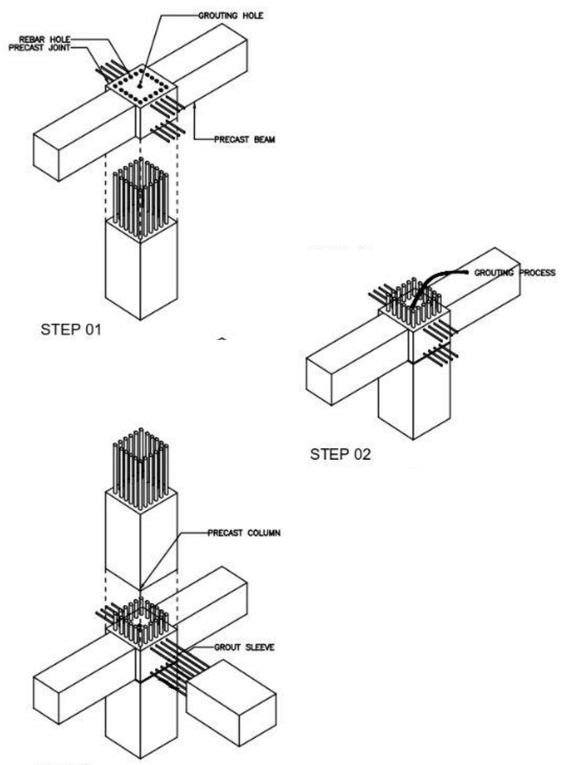
FIG 86



PLAN AT A
SCALE 1:20

PRECAST COLUMN TO BEAM CONNECTION DETAIL

FIG 88



STEP 3
GROUTING PROCESS
SCALE 1:20

FIG 87

STRUCTURAL DETAILS

Various connections have been developed to connect different types of structural elements like beam to column connection and panel to panel connection. In this manner, the imposed loads are transferred from superstructure to the foundation.

STRUCTURAL ELEMENT	MATERIAL FINISH
Precast Columns	230MM * 500MM THK "As cast" finish that results in a smooth, hard finish.
Precast Beams	230MM * 600MM "As cast" finish that results in a smooth, hard finish.
Precast Slab	150MM THK depth

Table 16

11. I) ENGINEERING DESIGN : FACADE WINDOW DETAILS

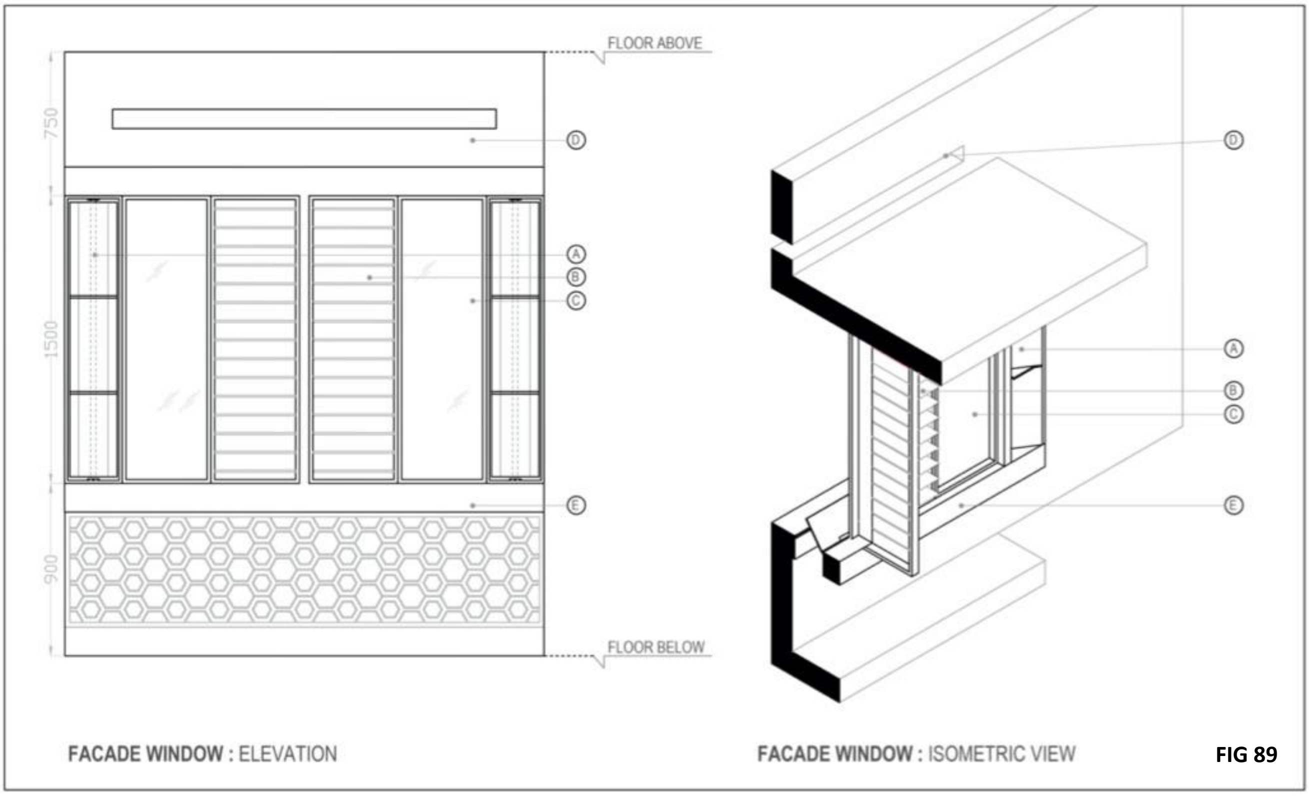


FIG 89

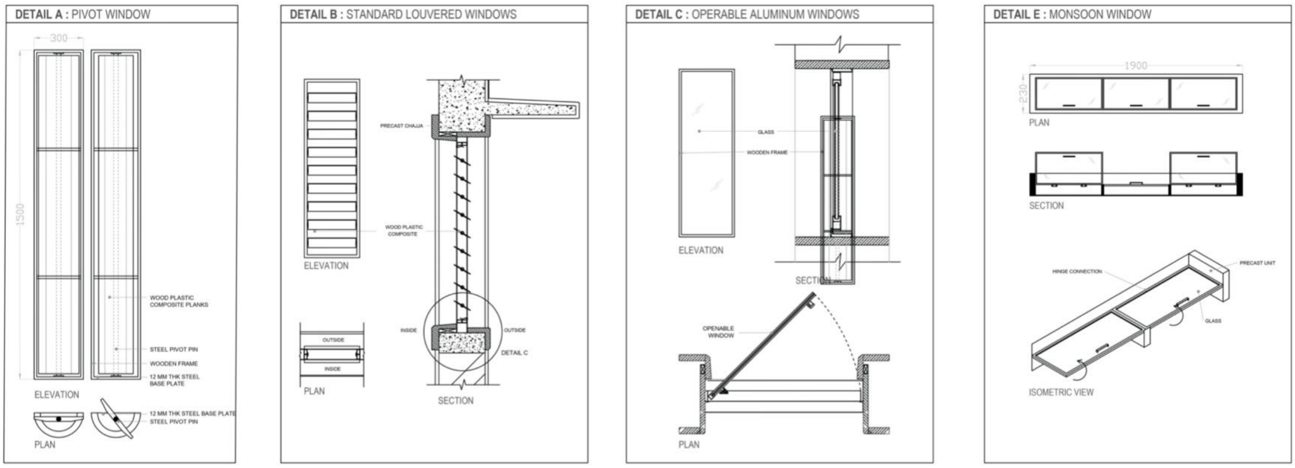


FIG 90

DESIGN ELEMENT	MATERIAL SPECIFICATION
Pivot Window frame	WPC frame, 300 x 1500 x 30 mm
Pivot Window flap	WPC Fins, 250 x 600 x 20 mm
Louvered window	WPC louvres. 420 x 170 x 20 mm
Openable window	WPC frame 450 x 1500 x 30 mm Single Glazed Glass 8mm
Monsoon window	WPC frame 230 x 600 x 30 mm Single glazed glass 8mm

Table 17

11. J) INNOVATION : DESIGN INTERVENTIONS

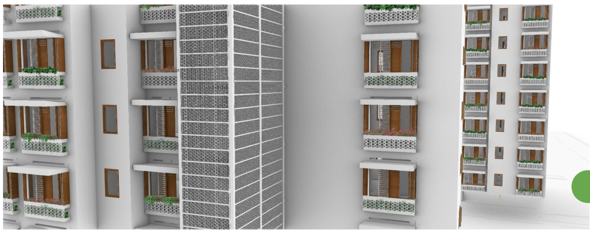
Use of Innovative Building materials that improve the performance of the building, benefit the local climate, reduces cost, and are sustainable and recyclable. In addition to our design elements, we have integrated certain systems into the functionality of the site in order to make it more sustainable, economic and usable.

CONNECTOR BRIDGE
Creation of the **connecting bridges between the two wings of the building**, which acts as a wind tunnel on site as well as vertical relief space. This also improves the security of the space by creating vantage points and brings the corridor (traditionally an 'interior' space) outside.

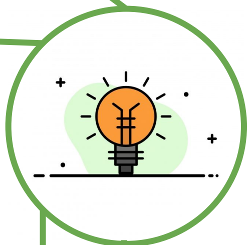
Drip irrigation system

Flower beds integrated into the facade design

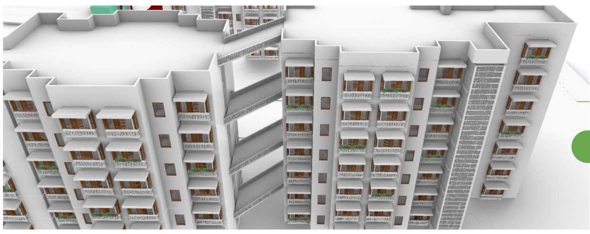
FACADE OF DESIGN
Creating a customised facade to create a comfortable indoor environment allowing maximum windflow and filtering the quality of air



'Jali' around the staircase block



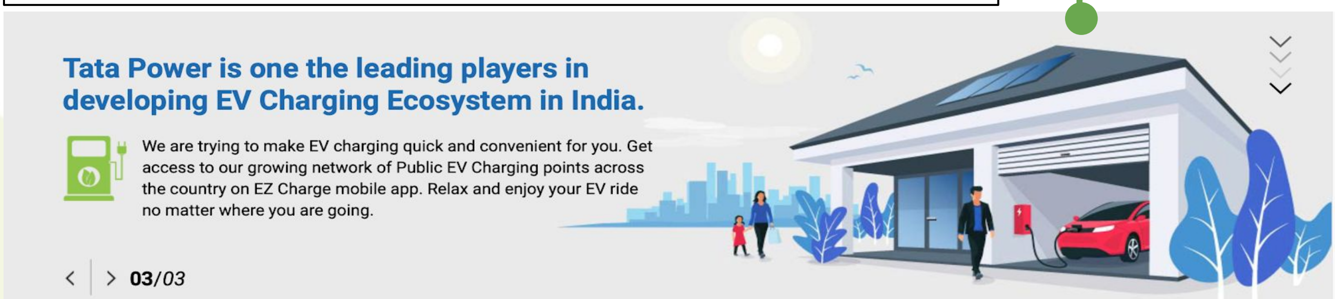
TEMPORALITY IN A TRANSITIONAL SPACE
The jaalis that create the staircase block ventilate the space and allow for smooth transition of the wind channels through the site and into the structure. It also draws in light to the staircase block throughout the day, reducing the need for artificial lighting. The jhali is envisioned to be a temporal space that adapts to different seasons at different times. During the monsoon it would be filled with greens while in the summer it could grow colourful flowers.



Recreational connecting bridge between two wings

A Green Transport system

EV POINTS
Energy charging stations for the vertical cycle stands in a bid to promote a green transport system. This system reduces dependency on fossil fuels, produces no emissions, is beneficial for overall health and makes use of solar power to recharge the cycles.



11. J) INNOVATION: APPLICATION INTERFACE

USER CONSUMPTION APP
Provisions for user-influenced behaviour, awareness campaigns and information centres-
Creating an App that informs the users of their daily consumption and suggestions for improvement. Provide the owner/occupants or visitors with brochures, CDs, information leaflets or manuals on environmental education and concerning issues. Integrate the community with the environment and make them aware and responsible for their consumption cycles.

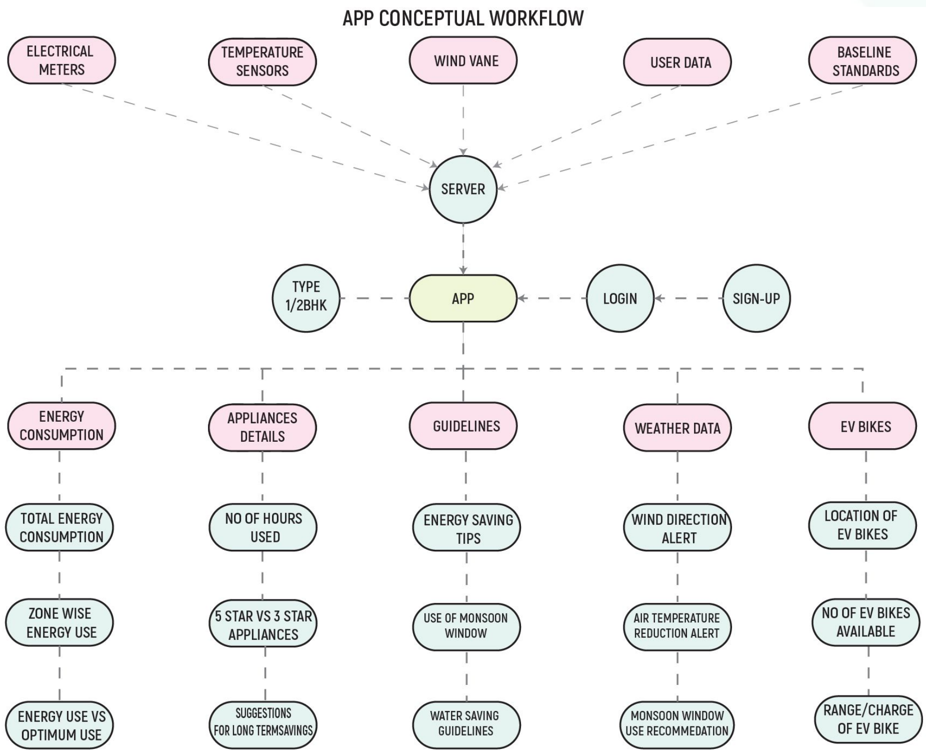


FIG 91

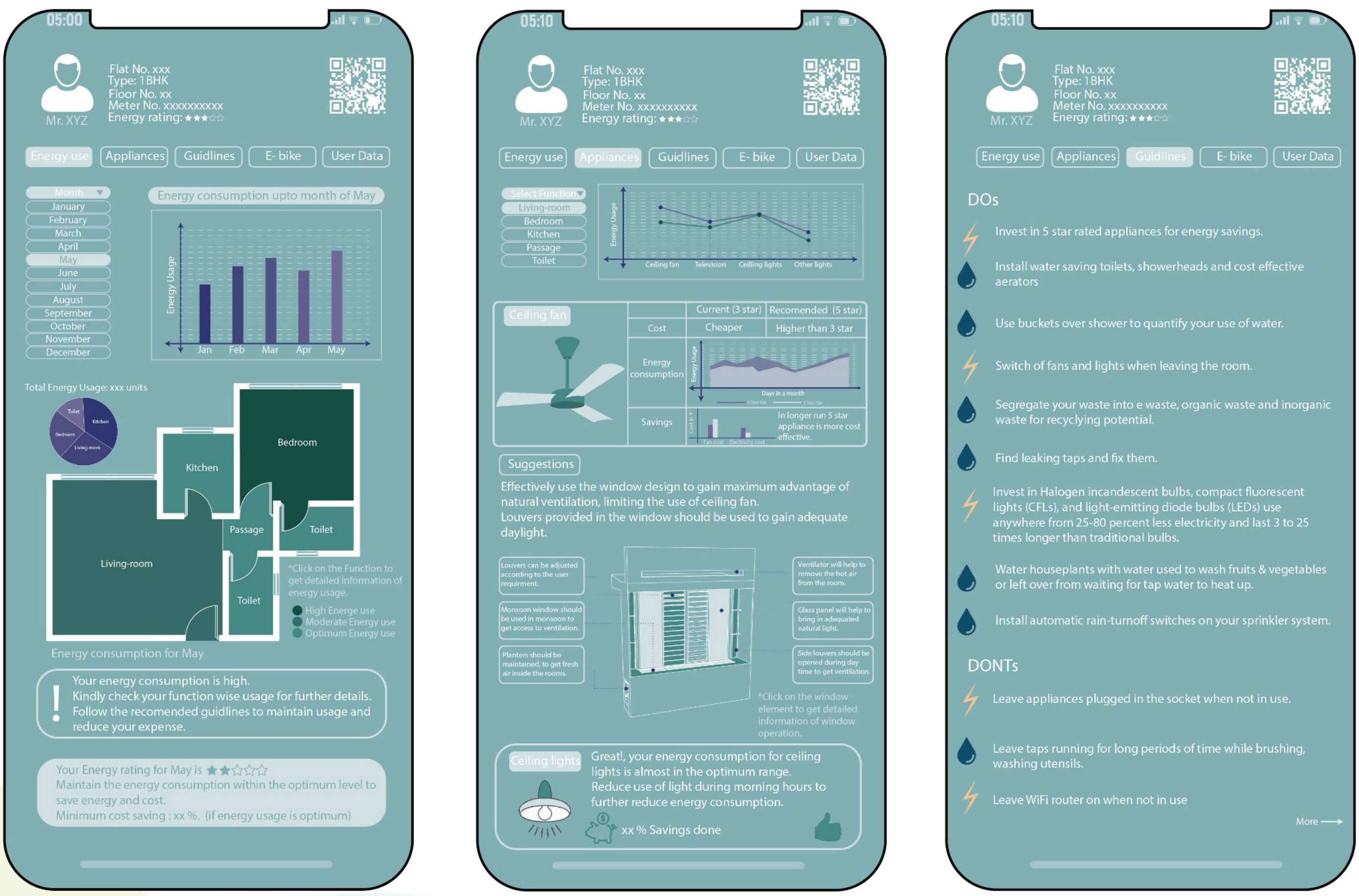


FIG 92

12. PITCH TO PROJECT PARTNER

An **integrated water management solution** that takes into account the rainwater harvesting potential, **treats 90% of the grey water** and reduces the base consumption to create a **net 0 water management solution**

A **customised**, prefabricated facade that can be used as a **market ready solution** for a comfortable indoor environment in a warm and humid climate.

A waste management system that **recycles 100 percent** of the organic waste and promotes segregation of waste at the household level.

An architectural design that **fosters community living**, offers a multitude of **various amenities**, as well as a design that results in **multiple landscaped and recreational areas**.

The use of **innovative** systems, applications, as well as design characteristics specific to the project

A **resilient** structure designed to withstand the hard summers and heavy monsoon, as well as a **flexible use of space**

An **'everyday luxury'** provided to the clientele at **affordable prices** and a **lower maintenance cost**, without the disadvantages and notions typical to mass housing projects.

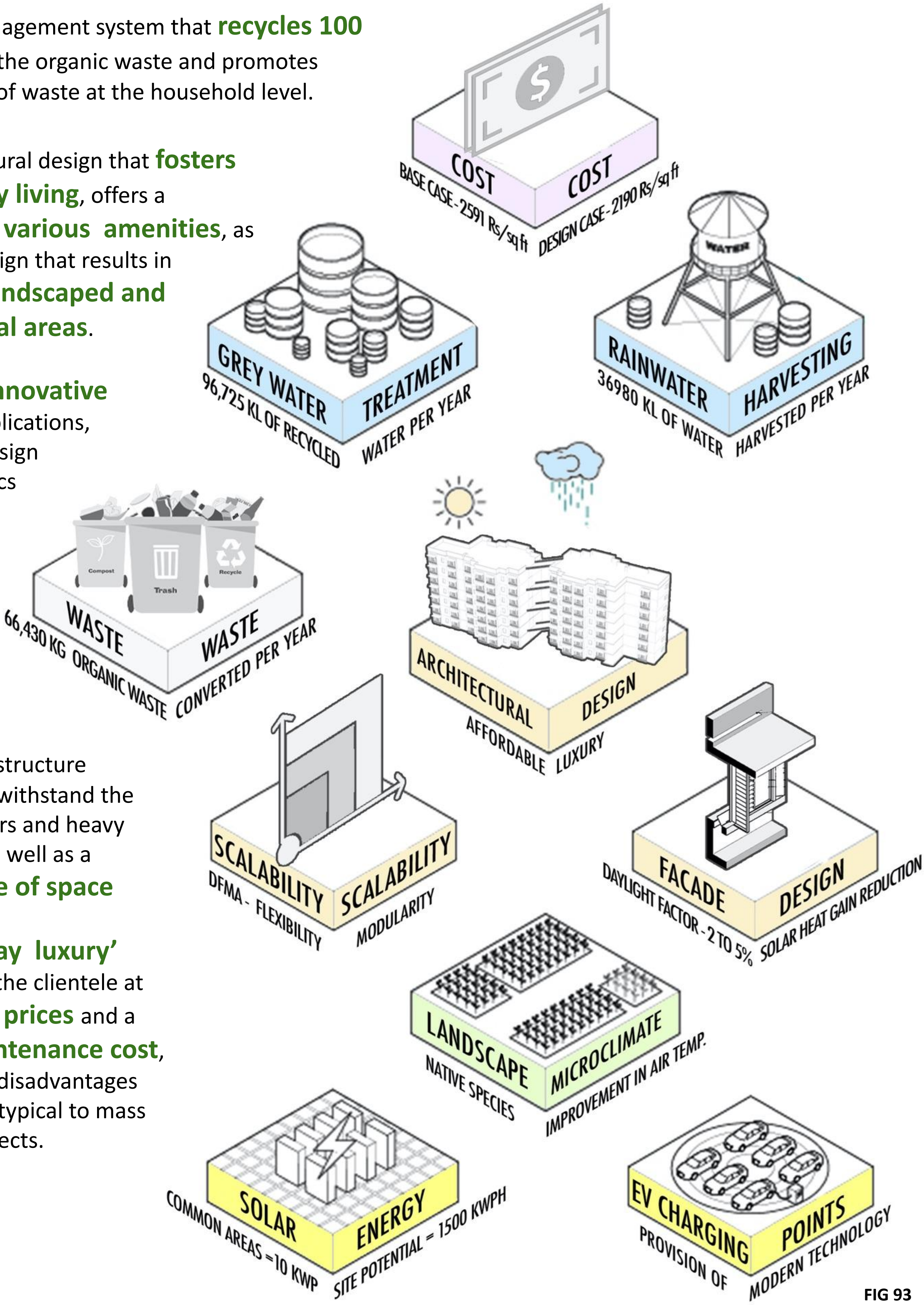
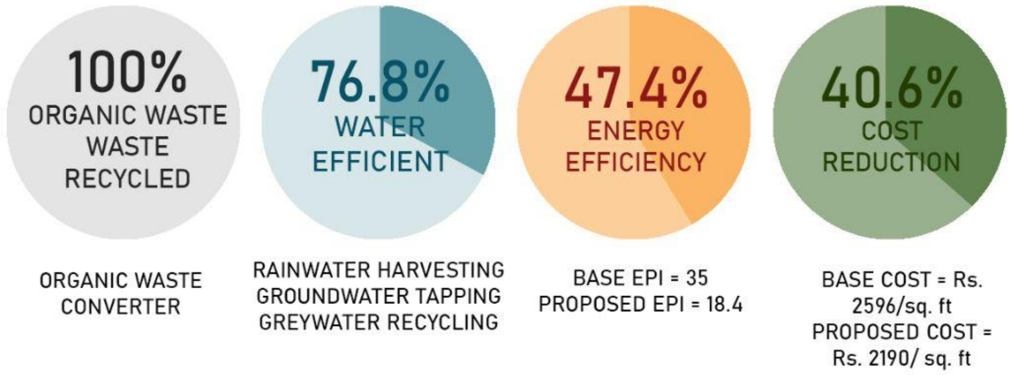


FIG 93

12. PITCH TO PROJECT PARTNER

The design proposes **net zero water, net zero energy in the common areas** along with reliance on passive design methods to create a comfortable environment. .This, along with rapid construction through **prefabricated modular elements** defies conventional mass housing and makes it affordable, scalable, accommodative and sets it apart in the growing real estate market of Boisar.



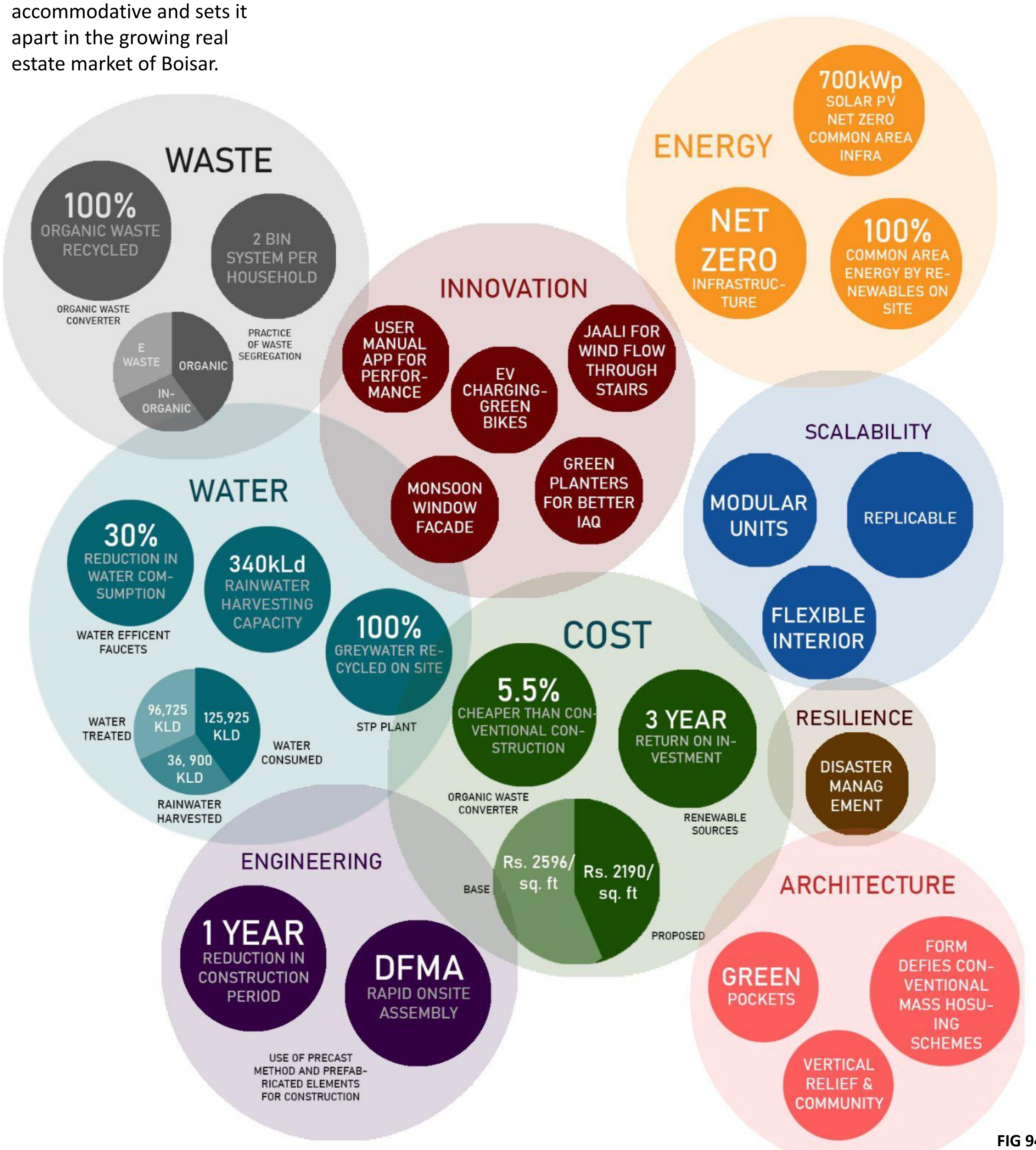


FIG 94

13. REFERENCES

Standard Documents::

1. NBC - National Building Code of India - Volume 1 and Volume 2
2. Energy Conservation Building Code - User guide
3. Energy Conservation Building Code - as a tool for energy efficiency
4. IGBC Green Homes Rating System - Version 3.0 - For Multi-dwelling Residential Units
5. IMAC standards

Books:

1. McKay, W. B., & Mckay, J. (1965). Building Construction, vol. 1.
2. Neufert, E., & Neufert, P. (2012). Architects' data. John Wiley & Sons.
3. Ching, F. D. (2014). Architecture: Form, space, and order. John Wiley & Sons.
4. Heschong, L. (1979). Thermal delight in architecture. MIT press.
5. Gordon, J. E. (2009). Structures: or why things don't fall down. Da Capo Press
6. Barber, D. A. (2020). Modern Architecture and Climate: Design Before Air Conditioning. Princeton University Press..