Final Design Report – April 2023

DHARA-TATTVA
SINGLE FAMILY HOUSING

"येथे बहुताचे हित"
Marathwada Mitramandal's
College of Architecture

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EXECUTIVE SUMMARY

A Net-zero, single-family Housing in a flood prone, high-humidity, and hot climate is a least explored area in the construction industry. Team Dharatattva from Marathwada Mitra Mandal's College of Architecture was eager to design a net zero energy and water in a highly saline region of the Mankule Village. The design process was developed considering the limitations that will be faced on the site, and an integrated design approach by a team of architecture and engineering disciplines, with the support of industry partners.

The project was ideated by the Applied Environmental Research Foundation (AERF) as a part of their aim to mainstream biodiversity issues in cross-cutting areas and to promote dialogue with diverse stakeholder groups on biodiversity concerns through capacity building, for which various research centres as well as accommodations for the researchers are being developed. The project is going to serve as a dwelling and research space for a couple of researchers studying biodiversity as well as the conservation of mangroves. Achieving a Net-zero energy and water status in such drastic conditions shows the ideological design solution that can be followed in similar climatic as well as site conditions.

With careful consideration of user circulation, passive strategies, affordability of the user and the market forces, a design solution has been proposed. Considering the climatic constraints and thermal comfort, use of CSE blocks have been used in the design. The major problem faced is scarcity of potable water. Data was collected regarding the solutions to use the site conditions to solve this problem, and use of the innovative solution of AWG (Atmospheric Water Generator), which uses the humidity in the air, and converts it into potable water is used. Considering the profession of the occupants, special provisions has been made for their research facility, which led to the creation of a user oriented design where the requirements of the occupants are given utmost importance.

The total EPI of the Unit is 28.65 kWh/m2-yr. The PV array helps to achieve the energy target by generating 9500 kWh/m2-yr of energy. Net water is attained by reducing the water usage with help of efficient fixtures, rainwater harvesting as well as wastewater treatment. Use of CSE Blocks has helped reduce the carbon embodiment as well as led to savings, which has helped us to make the house more sustainable as well as affordable.

RESPONSE TO REVIEWERS COMMENT

Section	Reviewers comment	Our response
	Reviewer 1	
Energy Performance	Give clear calculations for deriving Solar Energy Performance.	The same have been mentioned on page no. 11
Water Performance	Show rainwater harvesting calculations (amount of rainfall x runoff coefficient)	The same have been mentioned on page no. 14
Embodied Carbon	Elaborate on reduction of embodied carbon.	The same have been mentioned on page no. 31
Engineering and Operations	Add proper drawings and narratives.	The same have been mentioned on page no. 29
Affordability	Elaborate on calculations.	The same have been mentioned on page no. 24
Health and Wellbeing	Quantify the humidity reduction by the dehumidifier.	The same have been mentioned on page no. 20
Additional comments	Add the missing sections of the report.	The same have been included in their respective sections.

	Reviewer 2	
Energy Performance	Use building energy simulation software.	The simulation has been done using Design Builder Software.
	Show comparison with baseline to demonstrate reduction in loads and energy use.	
	Clearly state percentage of roof used by Solar PV system.	The Solar panels take up 11% of the total roof area.
Water Performance	Account for flow and flush fixture flow rates	The same has been taken into consideration.
	State strategies for water reduction and specify if net zero water is achieved.	The same has been mentioned on page no. 14

RESPONSE TO REVIEWERS COMMENT

Section	Reviewers comment	Our response
Embodied Carbon	Provide Assessment for roof, window and floor	The same have been mentioned on page no. 31
Resilient Design	Provide Qualitative and Quantitative analysis.	The same have been mentioned on page no. 16
Engineering and Operations	Did not attempt	The same has been attempted.
Architectural Design	Give details in terms of circulation, space allocation, servicing, adjacencies, densities for site, building and interiors.	The same have been mentioned on page no. 26 and 27
Affordability	Provide construction cost analysis.	The same have been mentioned on page no. 24
Innovation	Give cost, benefit and impact of given solution	The same have been mentioned on page no. 30
Health and Wellbeing	Provide assessment on thermal comfort, ventilation and indoor air.	The same have been mentioned on page no. 20
Value Proposition	Quantify tangible benefits.	The same have been mentioned on page no. 24

TEAM INTRODUCTION

1. Team Summary

1.1 Team Name : Dhara-tattva

Dhara-tattva as a word conveys the idea of nurturing nature of soil, where in we as a team come together with the philosophy of imbibing the essence and values of earth/soil.

1.2 Institutions Name: •Marathwada Mitramandal's College of Architecture (Lead Institution)
•Marathwada Mitramandal's College of Engineering

1.3 Division: Single Family Housing

1.4 Team Members

Chirag Mutha
T.Y.B.Arch
Water Performance

Dev Dadhania (Team lead)
T.Y.B.Arch
Energy Performance

Anish Kabra
T.Y.B.Arch
Value Proposition

Sahil Patil
T.Y.B.Tech.
Innovation

Samiksha Shinde
T.Y.B.Arch
Designing

Swapnil Karad
T.Y.B.Arch
Affordability

Gauravi Shivale Deshmukh
T.Y.B.Arch
Engineerging and Operations

Shreya Tamhankar
S.Y.B.Arch
Health and Wellbeing

Chinmayee Soman
S.Y.B.Arch
Embodied Carbon

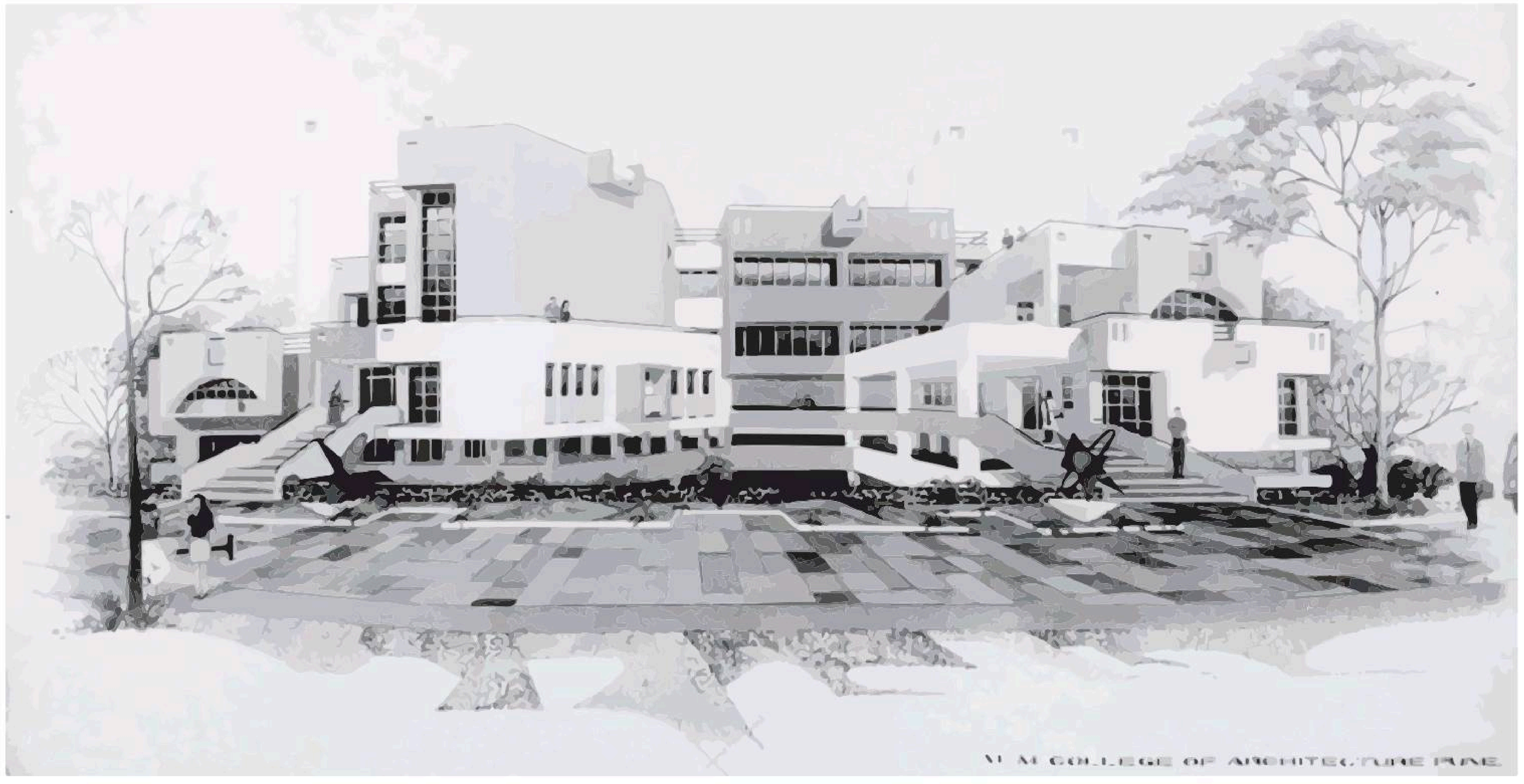
Aarya Indapwar
T.Y.B.Arch
Resilience

1.5 Approach

Dhara-tattva as a word conveys the idea of the nurturing nature of soil, where in we as a team come together with the philosophy of instilling the essence and values of earth/soil into our work. The team aspires to contribute in the field of architecture by designing an energy efficient, sustainable and climate responsive project. The team is nurtured by exceptional teachers steering the students towards achieving this goal.

The site we have chosen lies in an area that is a frequent witness to floods and cyclones with mangroves being their only defense. The coastal areas of India as a whole including our site are facing adverse effects of the rising sea level, thus we aim to make a prototype module to help reduce the disruption in the livelihood or economy of the community. The team is working with sensitive approach towards climate change that is very prominent and quickly gaining momentum, through our design process we aim to tackle the problems faced on site.

1.6 Background Of Lead Institution:



Marathwada Mitramandal's College of Architecture: a private institute in Pune, Maharashtra established in 1985 is affiliated to SPPU and is also recognized by COA and AICTE,Delhi. Located in the heart of Pune city with a thriving educational environment, amenities and facilities, the college aims towards the overall personality development of the students through exposure to extensive activities like site visits, seminars, etc. Experienced faculty specialized in subjects like energy performance, environmental architecture, urban planning, etc. provide comprehensive guidance.

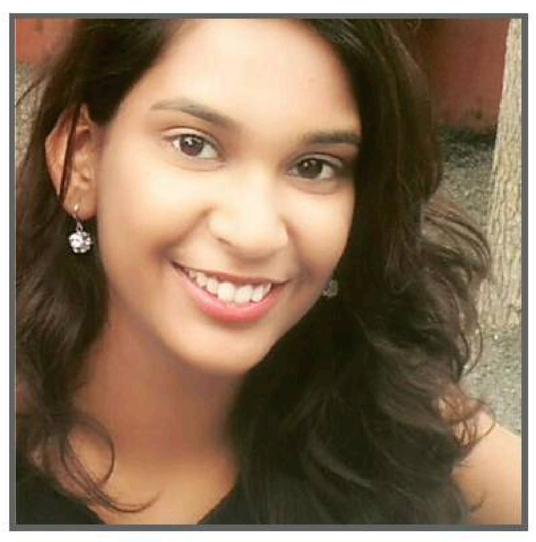
1.7 Faculty Lead

Name: Ar. Madhura Rasane
Designation: Assistant Professor
She is an IGBCAP and holds master's in Environmental Architecture and Planning, and practices for the last 6 years in projects of Urban Design, Residential design as well as green building certifications.

Ar. Madhura Rasane
Faculty Lead

1.8 Faculty Advisor

Name: Ar. Sanika Kulkarni
Designation: Assistant Professor
She has a teaching experience of 4 years. She has been a part of Solar Decathlon India since 2020 as a TRG member and a part of Solar Decathlon USA 2021 as a mentor.



Ar. Sanika Kulkarni
Faculty Advisor

PROJECT BACKGROUND

Project Partner: Applied Environmental Research Foundation

Background: AERF works on many projects that create possibilities to adapt to climate change and to develop sustainable livelihood options to the local communities. AERF is trying to bridge the gap between engaging businesses and corporate bodies through this programme by engaging them in conservation on the ground and various capacity building activities. The objective is to engage businesses in a meaningful manner in generating awareness and capital both for the cause of biodiversity conservation.

Key Individuals

Dr. Archana Godbole
(Founding director of AERF)
She has more than 20 years of experience in the field of conservation and natural resource management and is a NGO member representative of the Clinton Global Initiative and AERF's commitment on safeguarding forests and biodiversity of northwestern ghats

Dr. Archana Godbole

Mr. Jayant Sarnaik
(Founding member and joint director of AERF)
He has over 18 years of experience in biodiversity conservation and climate change. He works on developing strategies for making conservation socially sustainable and economically viable.

Mr. Jayant Sarnaik

Brief Description of Project

The aim of the design is to sustain during natural calamities, without disturbance in day-to-day life of the locals. The site we selected for our project is located in Mankule village on the banks of Amba river in taluka Alibaug district Raigad. This very region belongs to warm and humid climatic zone. This is a live project proposed under the single family housing residential unit for a couple-conducting research for the conservation of mangroves. As the locality is prone to frequent flooding,the family would be evacuating when the red alerts is issued.

Building Area Program

- Plot Area - 448 SQ. M
- Permissible floor space index (F. S. I.) - 100%
- Maximum permissible height - 24.0M
- Set backs –Front Margin - 3.0M
  Side Margin - 1.0M
  Rear Margin -1.0M
- Built up area- 310 SQ.M

Fig. No. 4.3.1: Site Location

3. Goals

3.1 Energy Performance

1. Achived a final EPI of 22.39 kWh/sq.m/yr
2. Optimised orientation, passive techniques, shading, envelope optimisation & on-site renewable energy generation have decreased EPI by 51%

3.2 Water Performance

•By improving the water fixtures 121lpd is achieved.
•75% of grey water is recycled by the eco friendly domestic greywater system
•Using recycled grey water for flushing and rain water harvesting

3.3 Embodied Carbon

•Overall CO_2 emission has been reduced by 52% using CSEB blocks.
•Bamboo has been used due to its CO_2 absorbing capacities.
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3.4 Resilience

•1900 mm stilt height is given to combat flooding.
• Pile foundations are used to sustain the structure
• Rain gardens are set up to lessen surface runoff & replenish ground water.

3.5 Architecture Design

• To lessen the quantity of heat that enters the site from the southern side, a jali wall has been installed.
• A private deck has been provided with centrally pivoted windows

3.6 Engineering & Operations

•Filler slab has been provided in the deck area to reduce the self weight & material.
• Due to the low strength of the soil, pile foundation is used.

3.7 Affordibility

•Filler slab usage lowers the amount of material required.
•Utilising locally produced materials like CSEB for general structure & ain wood for railing & internal staircase

3.8 Innovation

•There's an app for automation. Automated gates, louvers & lighting.
•A smart camera with voice connection has been given.v

3.9 Health & Well being

• In transitional areas, indoor plants like aloe vera & rubber plants have been used. Additionally, retrackable roofs have been utilised in accordance with the climate.

3.10 Value Proposition

• Creating green spaces for the user which helps them perceive sensory stimuli from the environment.
• Using material which makes the project cost effective.

ENERGY PERFORMANCE

Building orientation and form:-
The best orientation for the building was arrived upon based on the inferences received from design builder simulations.
The orientation along with the form aims at reducing Solar heat gain while maximizing the solar energy received.
The orientation along X axis facilitates natural ventilation

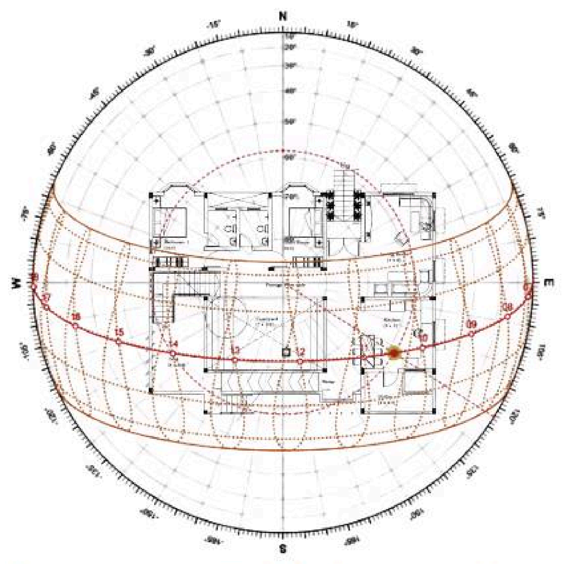


Fig. No. 6.1.1: Building orientation

Artificial Light Optimisation:-
Artificial lighting for the residence was done based on the requirements of the tasks carried out at each space. Ceiling and Wall mounted lights are used for ambient lighting, and task lighting is used for kitchen. Colour Rendering Index is between 3000-4000k.

Fig. No. 6.1.2: Artificial light optimisation

Space	Luminares	No. of Luminares	Power(W)	Total Wattage	No. of hours	W*h	Days	W*h*d	Energy Consumed Annually(kWh)
Living area	Ceiling Mounted LED	4	15	60	4	240	365	87600	87.6
Kitchen	LED Spotlight	4	8.5	34	4	136	365	49640	49.64
Courtyard	LED Spotlight	6	8.5	51	8	408	365	148920	148.92
Bedroom 1	Ceiling Mounted LED	2	15	30	3	90	365	32850	32.85
Bedroom 2	Ceiling Mounted LED	2	15	30	3	90	365	32850	32.85
Deck	LED Spotlight	4	8.5	34	5	170	365	62050	62.05
Washroom	Bulb	2	5	10	1	10	365	3650	3.65
Washroom	Bulb	2	5	10	1	10	365	3650	3.65
Bedroom 3	Ceiling Mounted LED	2	15	30	3	90	365	32850	32.85
Bedroom 4	Ceiling Mounted LED	2	15	30	3	90	365	32850	32.85
Working Area	Ceiling Mounted LED	4	15	60	4	240	365	87600	87.6
Open terrace	LED wall mounted	2	8.5	17	4	68	365	24820	24.82
Passages	LED Spotlight	12	5	60	7	420	365	153300	153.3
Staircase	LED Spotlight	6	8.5	51	7	357	365	130305	130.305
Parking	Ceiling Mounted LED	1	15	15	6	90	365	32850	32.85
Stilt Area	Ceiling Mounted LED	8	8.5		6	6	365	2190	2.19
Landscaping	Bulkhead Light	4	12	48	5	240	365	87600	87.6
	LED light	10	8.5	85	5	425	365	155125	155.125
	Total Energy Consumed	77	191.5	655	79	3180		1160700	1160.7

Table No. 6.1.1: Energy calculation based on lumanaries.

Equipment Optimization:-

Appliances were selected based on their rating by BEE energy rating scale. The appliances chosen were the most energy efficient ones with 5 star rating to reduce total equipment load.

Sr. No.	Fixtures	NO. of Fixtures	Watts	Total Watts	Hours	W*h	DAYS	W*h*d	Energy Consumed Annually(kWh)
1	Fan	8	40	320	9	2880	365	1051200	1051.2
2	Fridge	1						107000	107
3	Chinmey	1	60	60	2	120	365	43800	43.8
4	Washing Machine	1	360	360	1	360	365	131400	131.4
5	Computer	2	180	360	9	3240	300	972000	972
6	Aqua Guard	1	20	20	3	60	365	21900	21.9
7	Mixer	1	500	500	0.5	250	365	91250	91.25
8	TV							110000	110
9	Air Conditioner	1	1450	1450	5	7250	120	870000	870
10	Geyser	3						2190000	2190
	Others								
11	Water Pump	1	525	525	1	525	365	191625	191.625
	Total Energy Consumed	20	3135	3595		14685		5780175	5780.175

Fig. No. 6.1.2: Energy calculation based on appliances

Renewable Energy

Solar Potential:-

The site receives ample amount of solar radiance throughout the year, thereby making solar energy a suitable option for energy generation.

The terrace receives maximum solar irradiance compared to building façade. The solar are placed on the terrace to meet the demands of energy requirements.

A total of 8 roof mounted solar panels are installed on terrace with a tilt=18 on southern side of the building.

Solar Radiation Analysis:-

For effective efficiency we analysed from climate consultant solar radiation guides us solar radiation hour each month overall year so we got average 9.6 hr of efficiency.

We are using 8 no. modules of 640 watt each plate which generates 24 units per day and 8760 units per year. Our electricity consumption is 19 unit/day and we are generating 5 unit/day more than our consumption. The additional generation is fed to the grid from the solar panel back to the grid. Thereby making the building net zero.

Fig. No. 6.1.3:Solar Radiation analysis

PERFORMANCE SPECIFICATIONS

	Envelope Systems	
	Building Envelope Assemblies	U Value
Exterior Wall	210mm	0.3 W/m²K
	Exposed Hollow CSEB Blocks(210mm)	
Interior Wall	Exposed Hollow CSEB Blocks(210mm)	
Roof	Ferrocrete(75mm) + Clay Conical blocks(145mm)	
Floor	Green Oxide Flooring	
	Glazing	
	SHGC (Solar Heat Gain)	0.4
	VLT	0.6
	HVAC	Power
Ceiling Fan	Havells Stealth Air BLDC(1200mm) 5 star rating	40W
Air Conditioning	Voltas 1.5Ton 5 star Split Inverter AC	1450W
	Lighting	
Fixtures	Philips Astra LED Power	15W
	Philips Astra LED Spotlight	8.5W
Controls	On/Off through Smart App	Both Fixtures
	Electrical	
Appliances		Power
Refrigerator	Whirlpool 5star Inverter Direct Cool Single Door Refridgerator	107W
Water Purifier	Aquaguard Neo UV+UF+MC Water Purifier	20W
TV	Croma 40 inch Full HD LED Smart Android TV	110W
Computer	DELL Latitude 3520 Laptop	180W
Washing Machine	BOSCH 7 kg Front Load washing machine	360W
Mixer	Croma Mixer Grinder	500W
Electric Geyser	Crompton Arno Neo 15 L 5 star Geyser	2000W
	Renewable Energy	
Solar Energy	Trinasolar Vertex 645W Monocrystalline Module	
	Water Pump System	
Water Pump System	Kirloskar 0.5HP Domestic Water Motor Pump	525W

Table No. 6.1.3: Performance specifications of envelope systems

Energy Performance Index
Target Epi = <30(kWh/sq.m)
The goal is to achieve 5-star rating EPI as per BEE(ECBC) for warm and humid climate i.e.EPI≤30(kWh/sq.m)

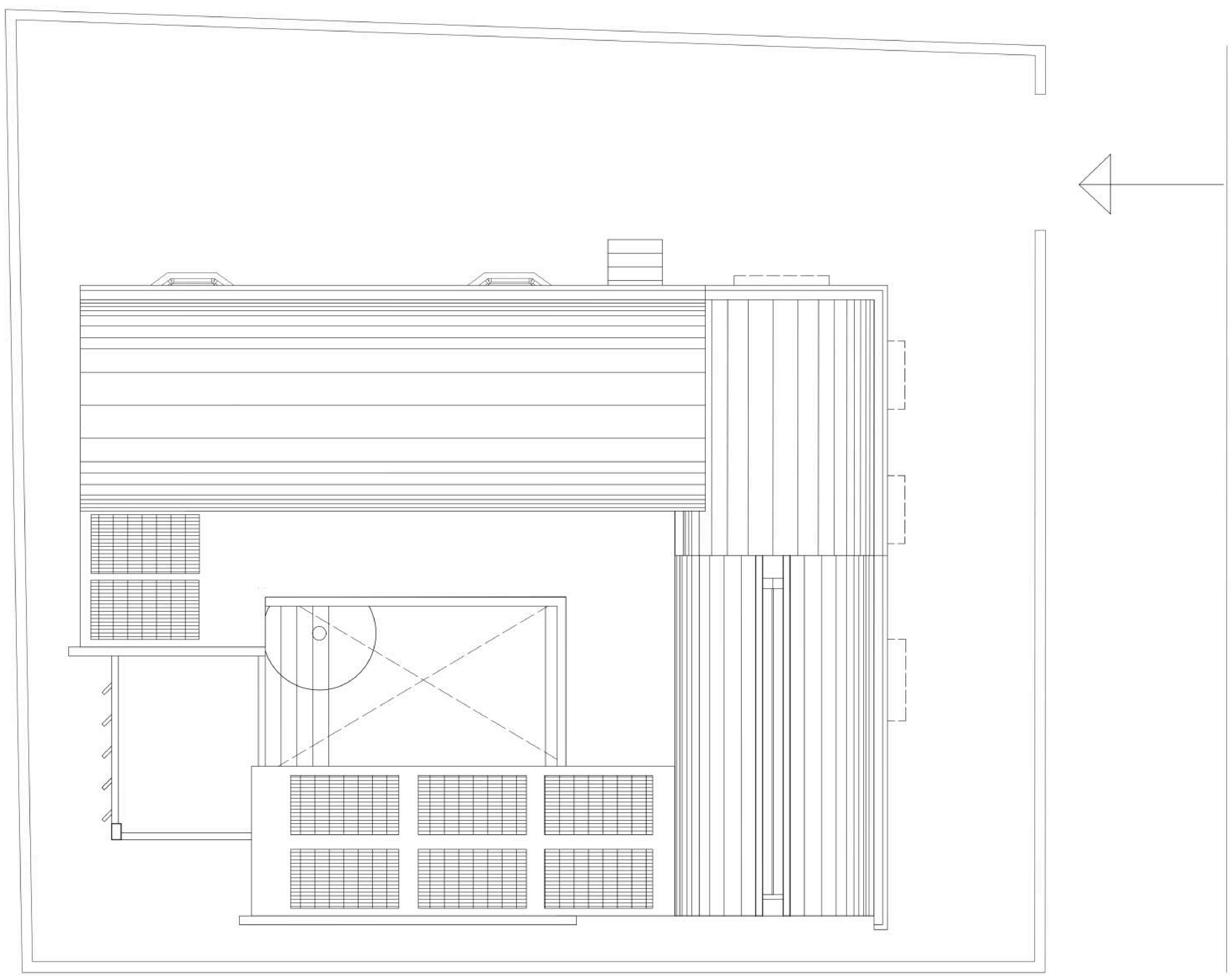
$$\text{Energy Performance Index} = \frac{\text{Annual energy consumption (kWh/sq. m./yr)}}{\text{Build up area (sq.m.)}}$$

$$\text{EPI} = \frac{6941}{310} \quad \mathbf{=22.39\ kWh/sq.m./year}$$

Feasibility of Solar Panels

Total Energy Consumed in a year	6941	kWh
Total Energy Generated in a year	8760	kWh
Degradatino of generation per year	1%	
Total energy generation considering degradation	8672.4	kWh
Excess energy that can be fed into the grid	1731	kWh
Cost of energy	7.5	INR/kWh
Cost saving per year	12982.5	INR

Table No. 6.1.4: Energy calculation based on solar panels.



ROOF FLOOR PLAN

Fig. No. 6.1.4: Placement of Solar Panels

6.2 Water Performance

As per National Building Code 2016, standard fresh water demand is 135LPHD. Proposed case aims in reduction of water consumption upto 121 LPHD by using efficient water saving fixtures, recycling of rainwater and reuse of greywater generated onsite.

Per Capita daily consumption	Number of occupants	Total daily consumption	Grey water filter efficiency
121	6	726	75%

Tab.6.2.1-Daily Consumption

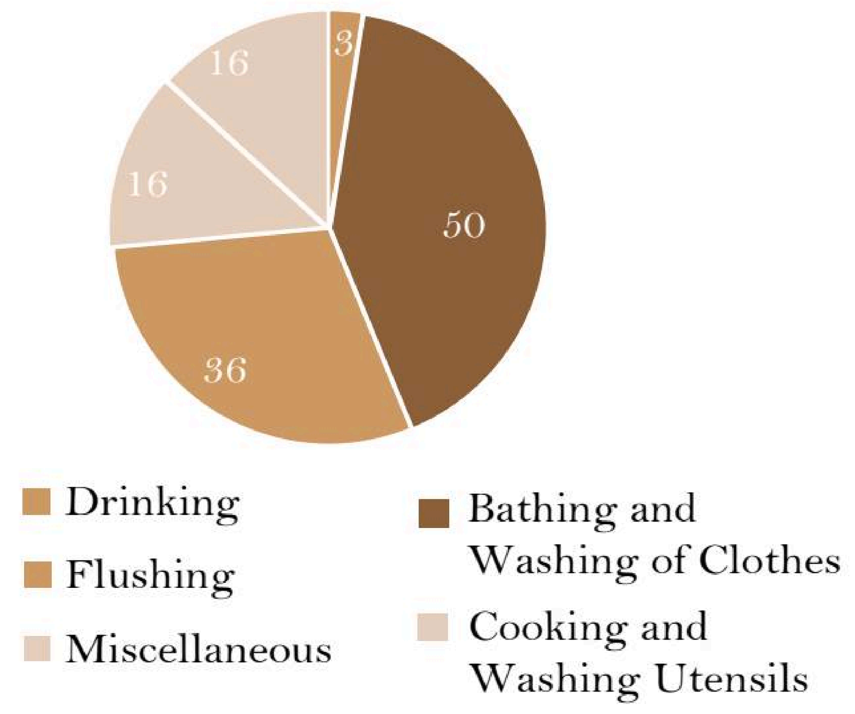


Fig. 6.2.1- Per-capita water consumption

End Use	Percent use	Use in LPD	Greywater in LPD	Blackwater in LPD
Bathing	30%	218	218	-
Washing	20%	145	145	-
Cleaning house	8%	58	58	-
Washing Utensils	16%	116	116	-
Others	2%	15	7	7
Total		726	545	182

Tab. 6.2.2- Water Consumption (lpd)

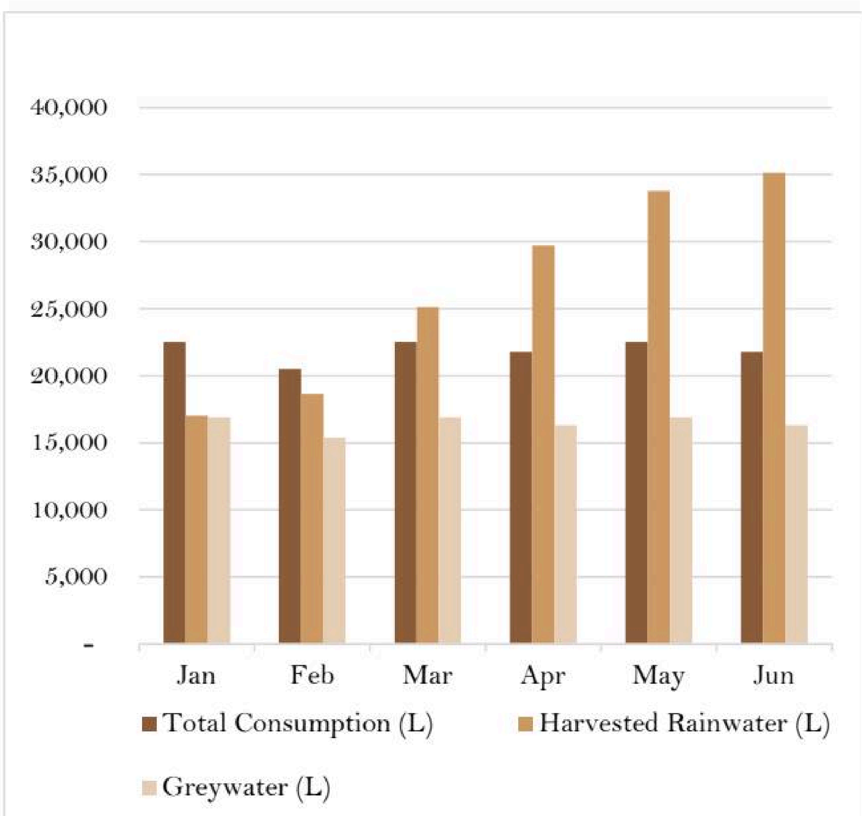
Waterharvesting Sources	Area	Runoff coefficient
Roof Surfaces	216	0.85
Hardscape areas	52	0.7
Softscape areas	167	0.3
Effective catchment area	270.25	

Tab.5 - Rainwater harvesting surfaces

Ample amount of rainfall in Mankule village, allowed to be independent on muncipial water supply by harvesting the rainwater. With reference tothe tab. 2 we collect around 960 liters of water every day which meets daily requirement water consumption.

Months	Rainfall (mm)	Effective rain (mm)	Harvested rainwater (l)
July	115	110	29,728
August	120	115	31,079
September	110	105	28,376
October	105	100	27,025
November	95	90	24,323
December	80	75	20,269
January	68	63	17,026
February	74	69	18,647
March	98	93	25,133
April	115	110	29,728
May	130	125	33,781
June	135	130	35,133
Total Harvested water (l)			3,20,246

Tab. 6.2.4- Harvested Rainwater



Tab. 6.2.3- Water Balance

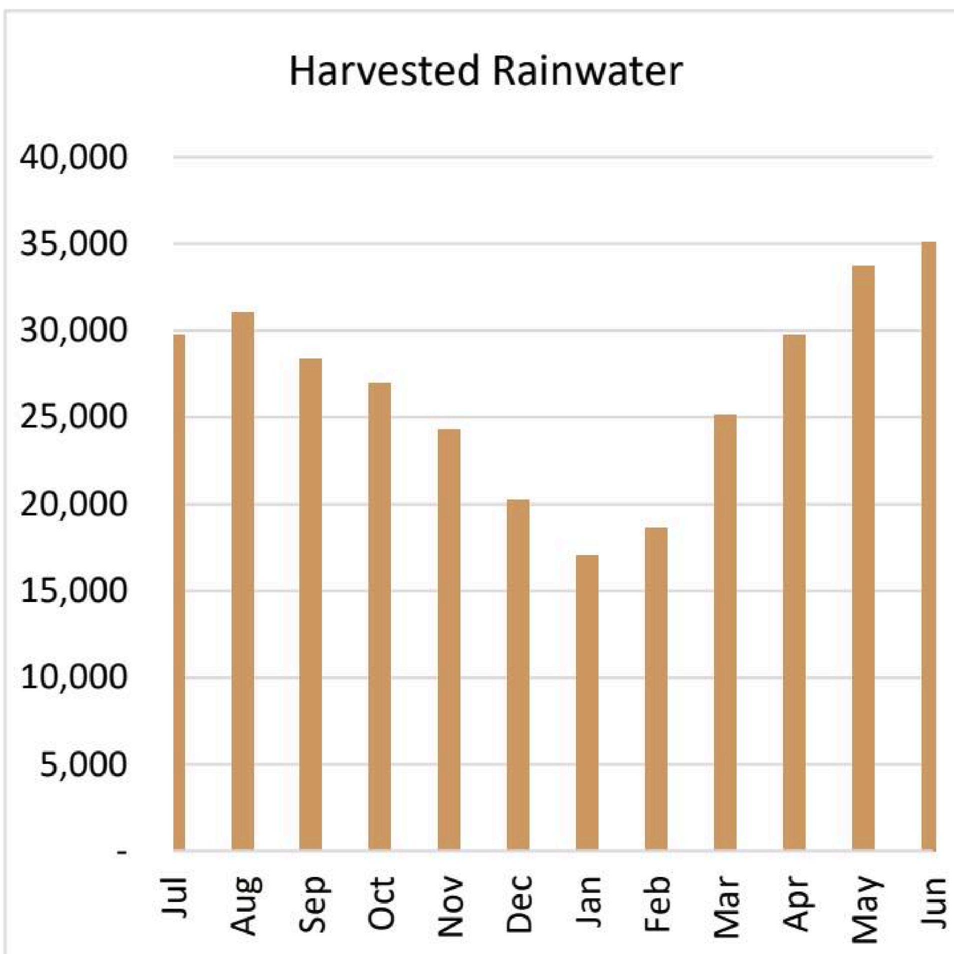
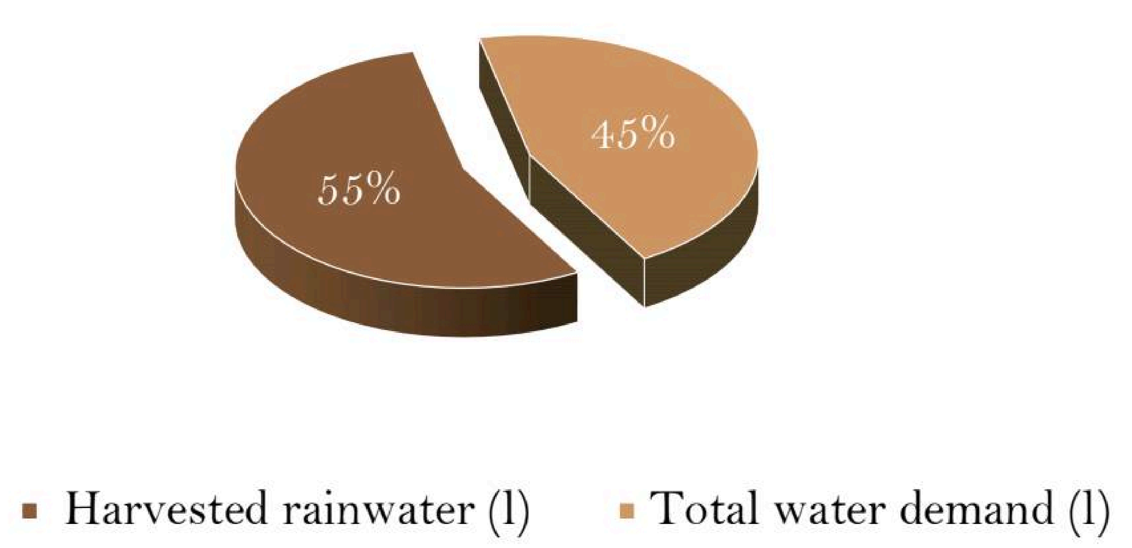
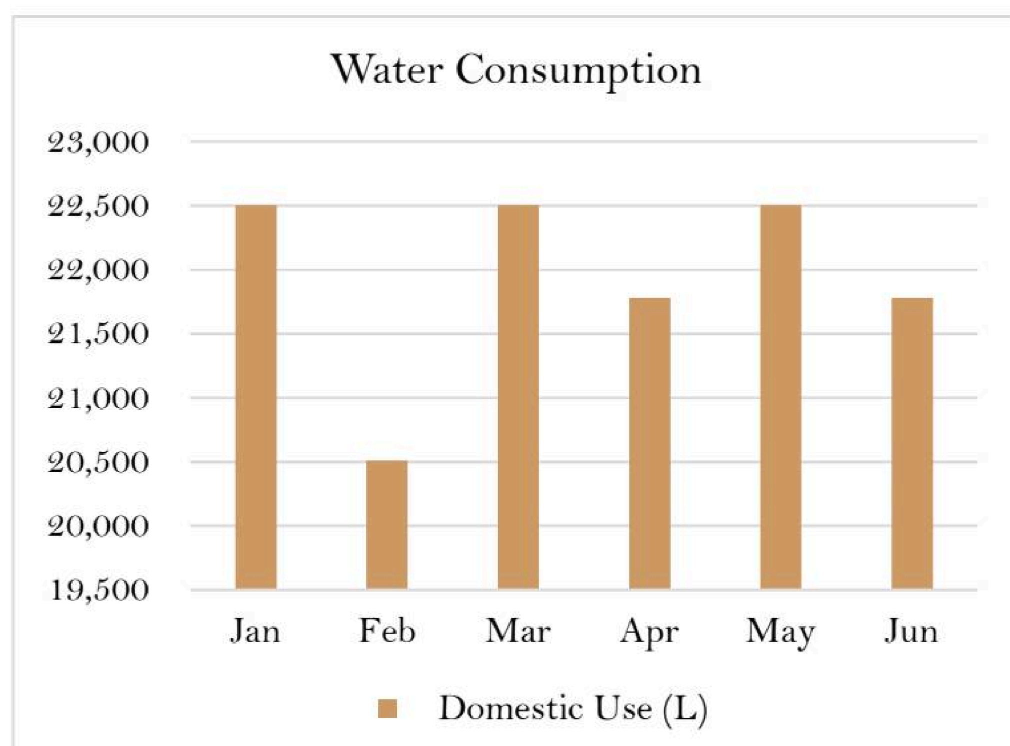


Fig. 6.2.2- Water Balance





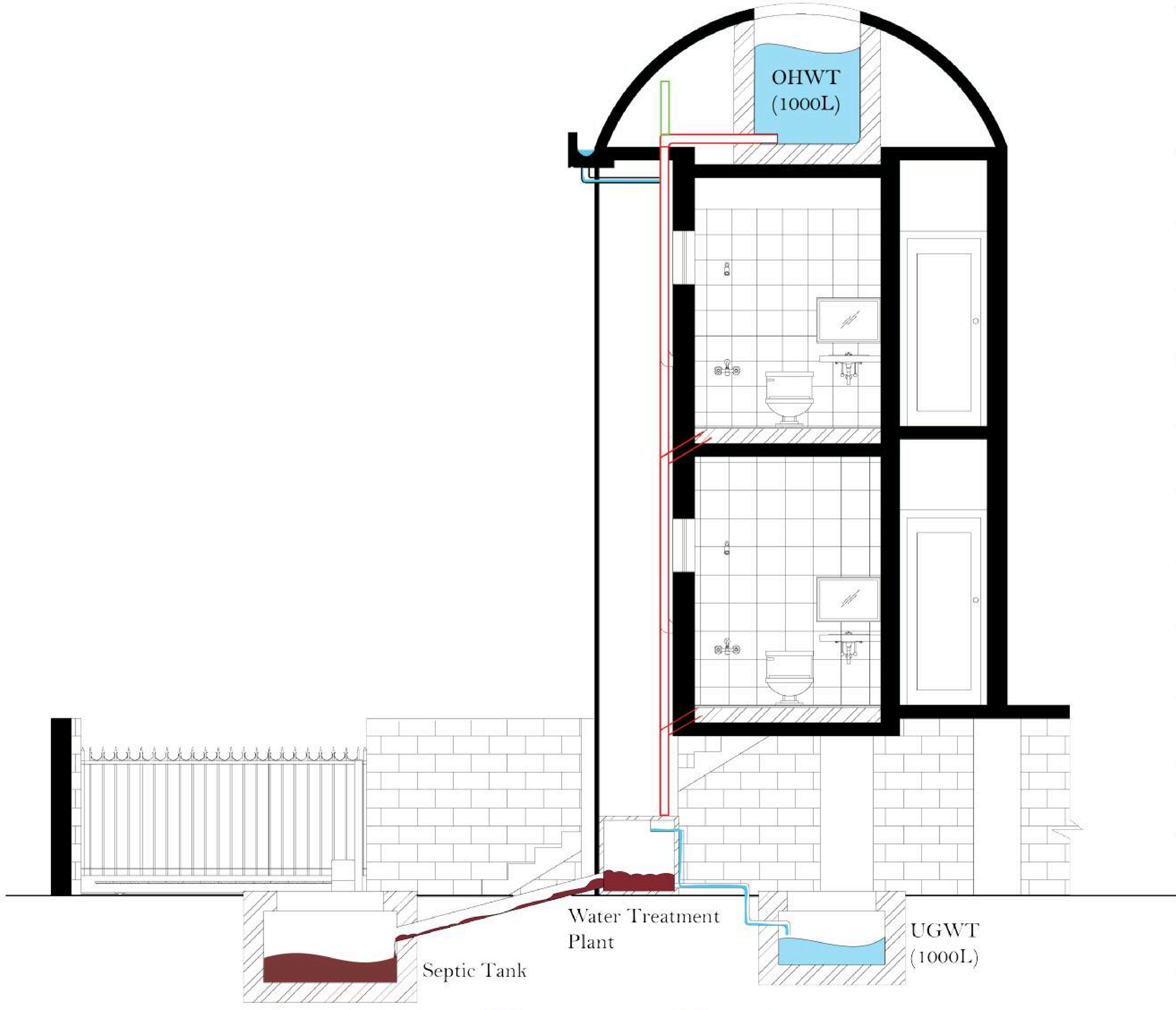


Fig. 6.2.3- Section

Month	Days in month	Occupant demand	Total water demand (l)
July	31	22,506	22,506
August	31	22,506	22,506
September	30	21,780	21,780
October	31	22,506	22,506
November	30	21,780	21,780
December	31	22,506	22,506
January	31	22,506	22,506
February	28	20,510	20,510
March	31	22,506	22,506
April	30	21,780	21,780
May	31	22,506	22,506
June	30	21,780	21,780
Total		2,65,172	2,65,172

Tab. 6.2.5- Total water Demand

Month	Days in month	Generated black water	Generated Grey water	Filtered grey water
July	31	5,717	16,789	12,592
August	31	5,717	16,789	12,592
September	30	5,532	16,248	12,186
October	31	5,717	16,789	12,592
November	30	5,532	16,248	12,186
December	31	5,717	16,789	12,592
January	31	5,717	16,789	12,592
February	28	5,209	15,300	11,475
March	31	5,717	16,789	12,592
April	30	5,532	16,248	12,186
May	31	5,717	16,789	12,592
June	30	5,532	16,248	12,186
Total			1,97,818	1,48,363

Tab. 6.2.6- Grey Water Treatment

The building aims to reuse of 1,48,363 L of filtered greywater every year through an eco-friendly greywater treatment system which filters 1,97,818L of generated greywater every year.

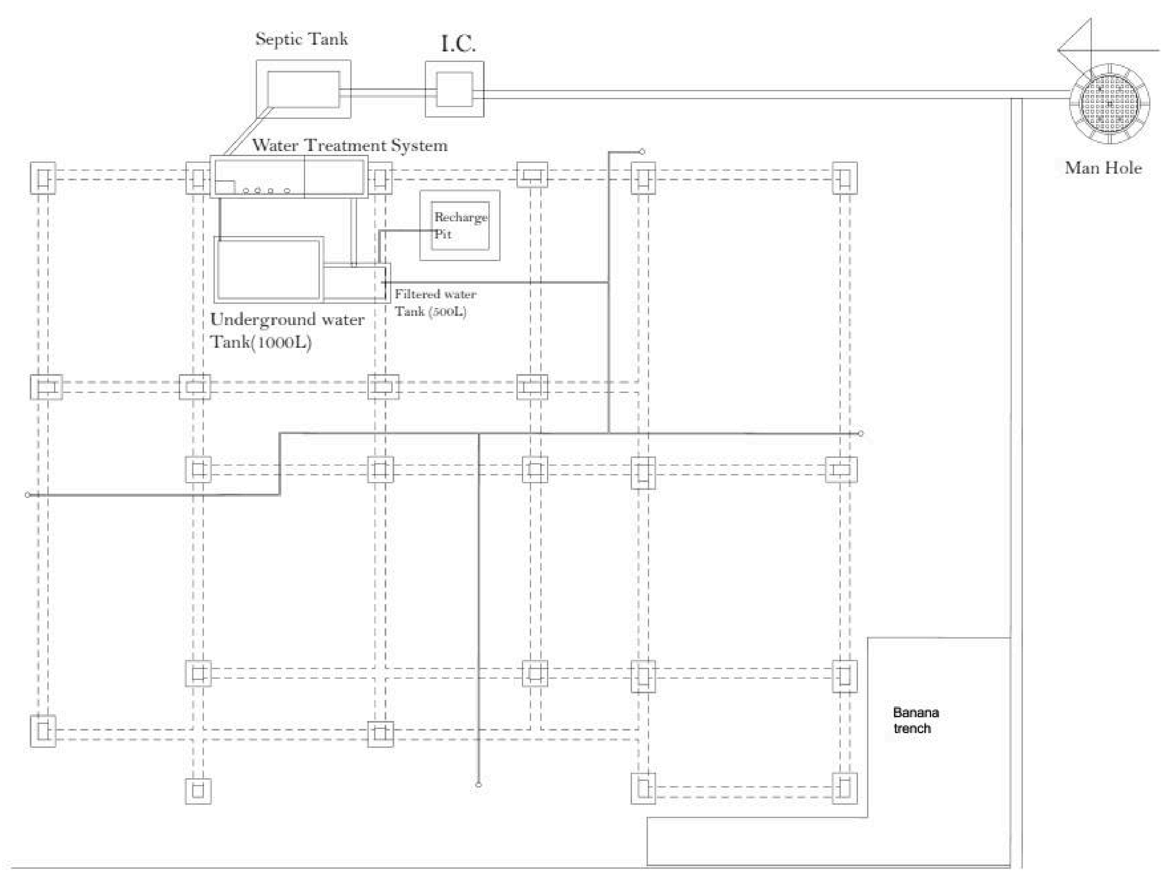


Fig. 6.2.4- Plumbing Layout

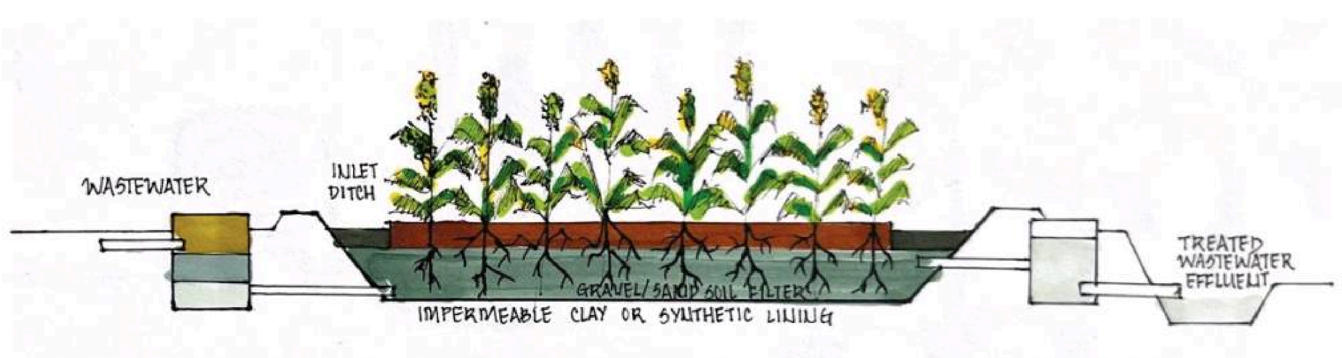


Fig.6.2.5- Banana Trench

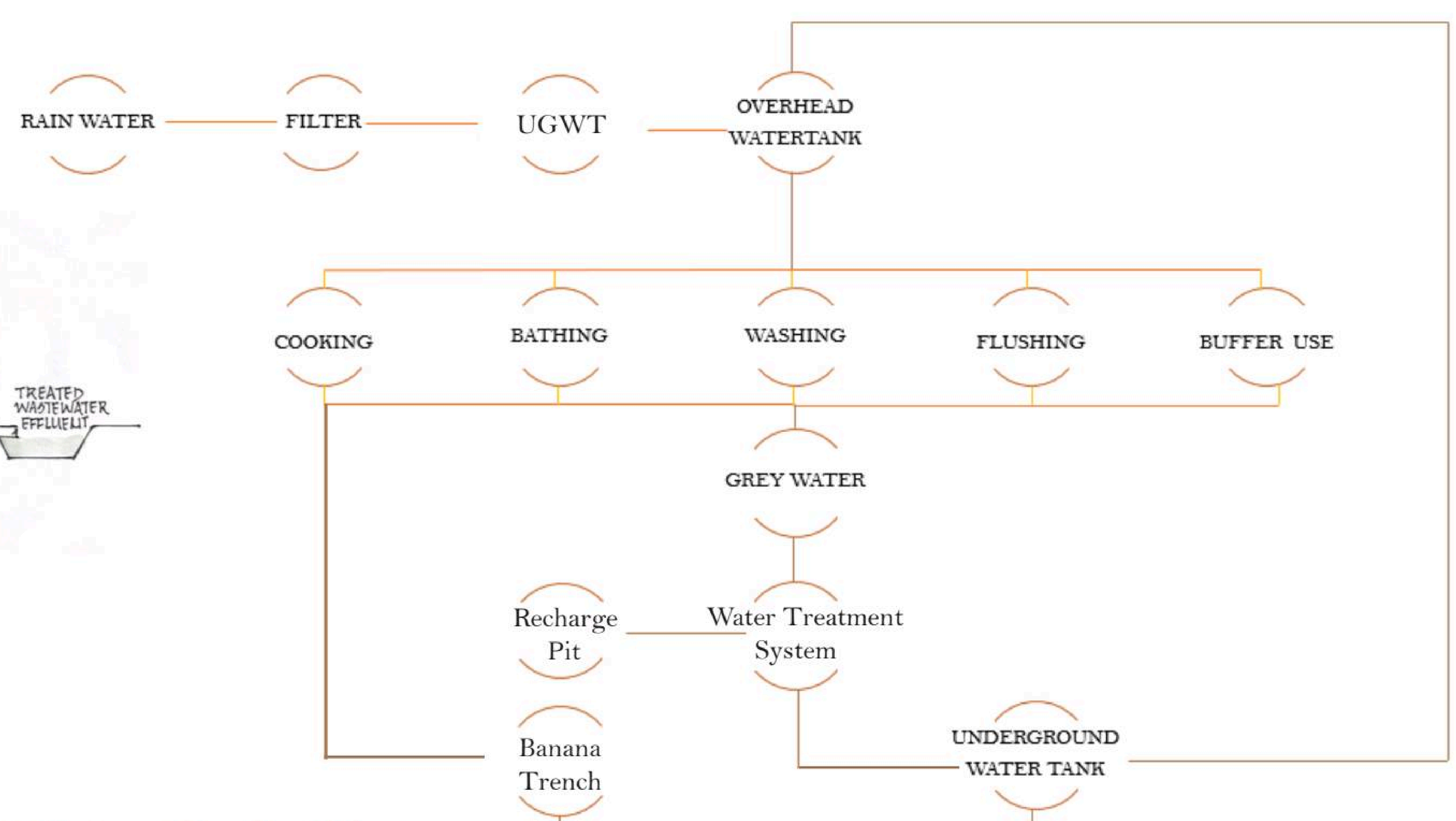
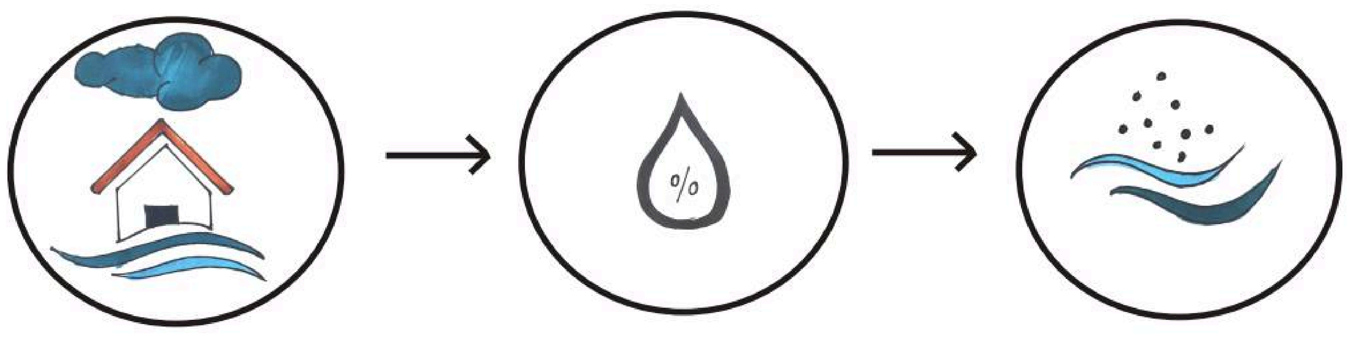


Fig.6.2.6- Water Cycle Diagram

6.3 RESILIENCE



1. Sustainability in the face of extreme weather:
• Mankule has a warm and humid environment. The climate is exceedingly humid due to the high regularity of floods. Passive strategies can be used to maintain the internal atmosphere naturally.
• A courtyard in between the houses generates courtyard effects. Hot air rises and escapes from the courtyard, keeping the interior environment naturally cool.
• Properly positioned windows opposite each other can enhance cross ventilation, which improves thermal comfort, maintains air quality, and reduces heat and pollutants.
• Installing a jali wall on the most heat gain side can avoid direct solar radiation from entering the building.
• Using natural construction materials with high thermal capacity and water vapour permeability, such as compressed stabilised earth blocks, can aid in natural cooling
• Jali work on southern side can help to prevent entering direct heat inside and also creates venturi effect to keep internal cooler.

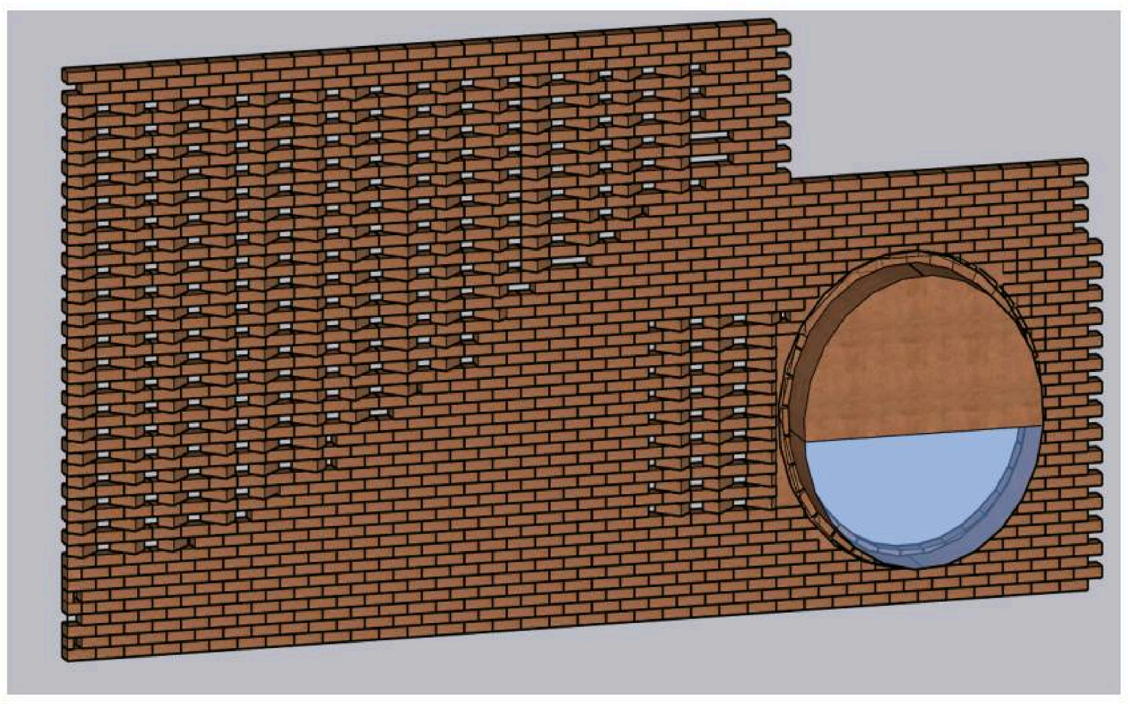


Fig. No.6.3.1: Jali Wall.

Fig. No.6.3.2. d Earth Blocks.

Soil salinity:
• The soil comes in frequent contact with salne water as flooding is common in the mankule area.
• This leads to infertility of soil eventually resulting in death of the flora.
• Due to increase in salinity content of soil its water bearing capacity reduces drastically causing higher run off rate. Hence, treatment of salinity of soil is an imporatant issue.
• There are a few speices of plants wh ich can help to tackle this problem, namely, Salicornia, a flowering plant that grows in coastal areas.
• During floods, this species collects the salt from the saline water which can be used as culinary salt in day-to-day life, effectively being named 'Saloni'.
• By collecting the salt the salt percentage in the soil is Salicornia reduced and can turn a barren land into fertile soil.

Fig. No. 6.3.3: Salicornia

1. **Flood protection:**

• Because the region is prone to flooding, as well as cyclones, earthquakes, and hurricanes, during these disasters, a significant number of houses collapse, resulting in loss of life and property damage.
• There are some measures that can be taken to mitigate such damage.
• Stilt houses are built above earth to escape flood, pest, and vermin risks. The main reason for using stilts is to protect the homes from water logging and flooding.
• Because of the elevated levels, stilts not only safeguard the house from flooding but also provide better natural ventilation.
• Another reason for raising the structure at greater height is that covered parking is included under the stilts.
• Stilts can be built from a variety of materials, including bamboo, wood, and stone.
• RCC stilts are used in this construction. Stone cladding is provided for better strength.

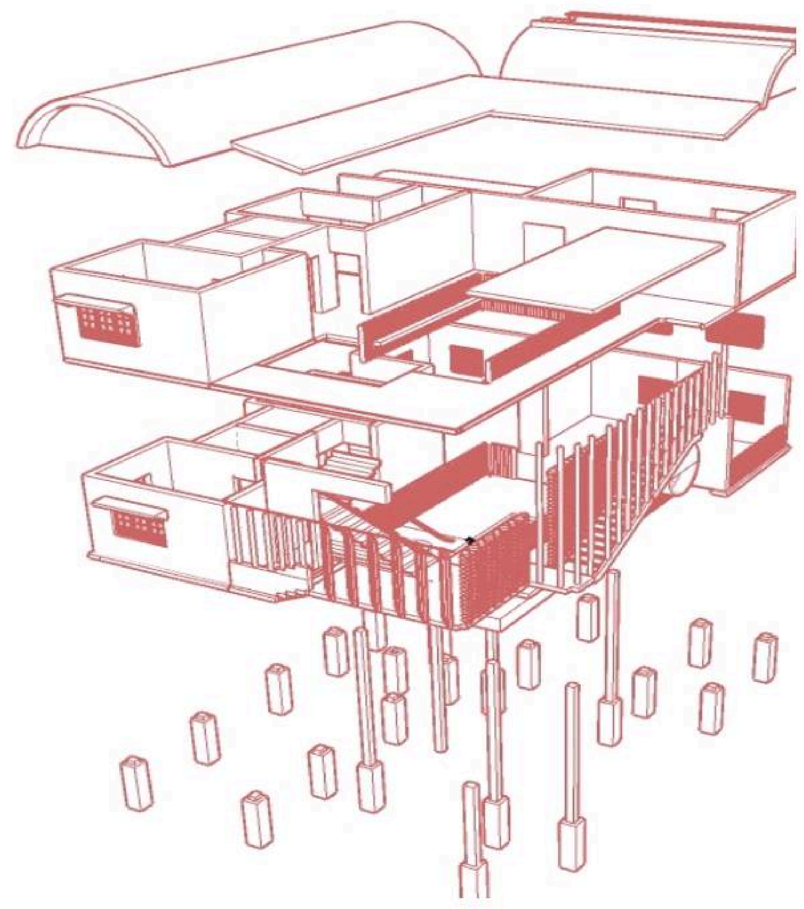


Fig-6.3.4 Stilts & exploded view

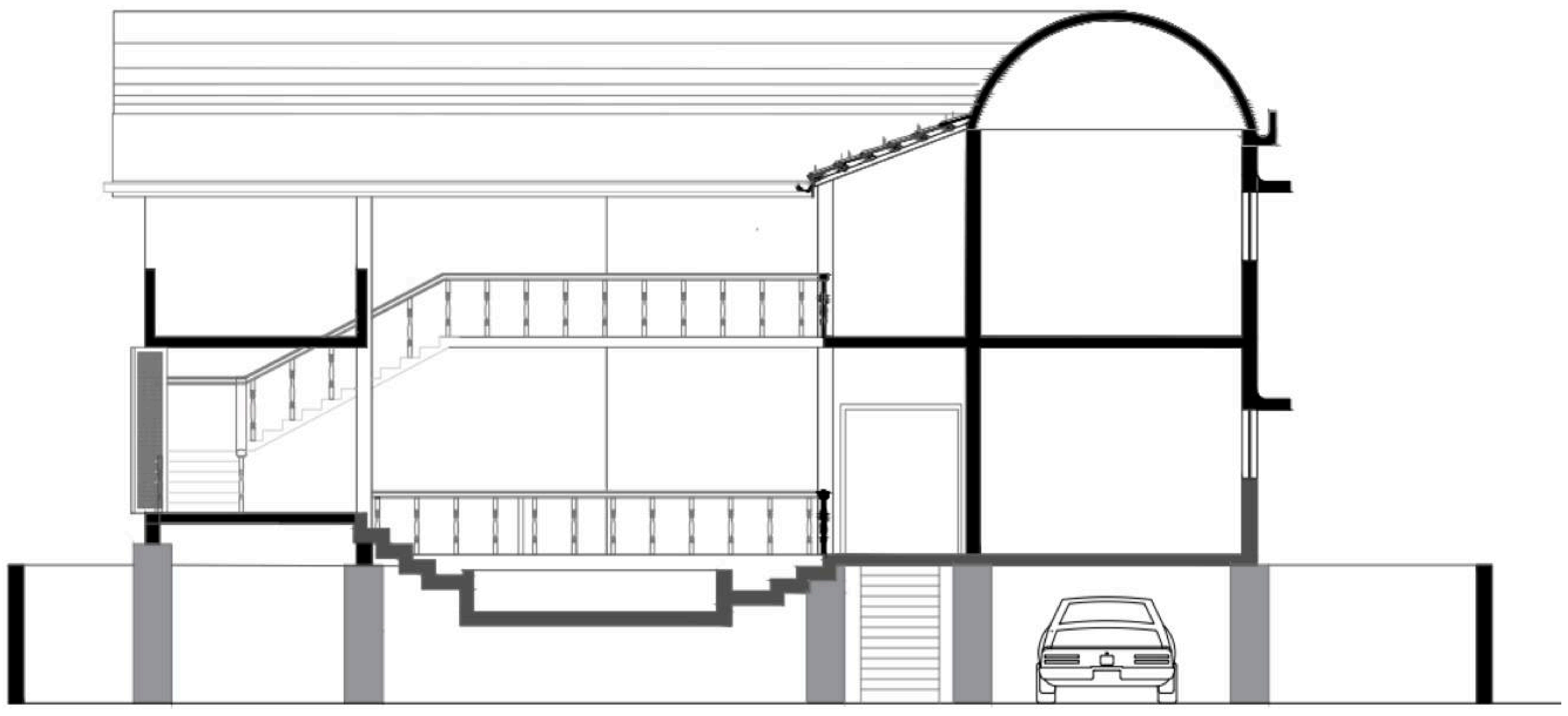


Fig-6.3.5 stilts raised at 1900mm height for parking

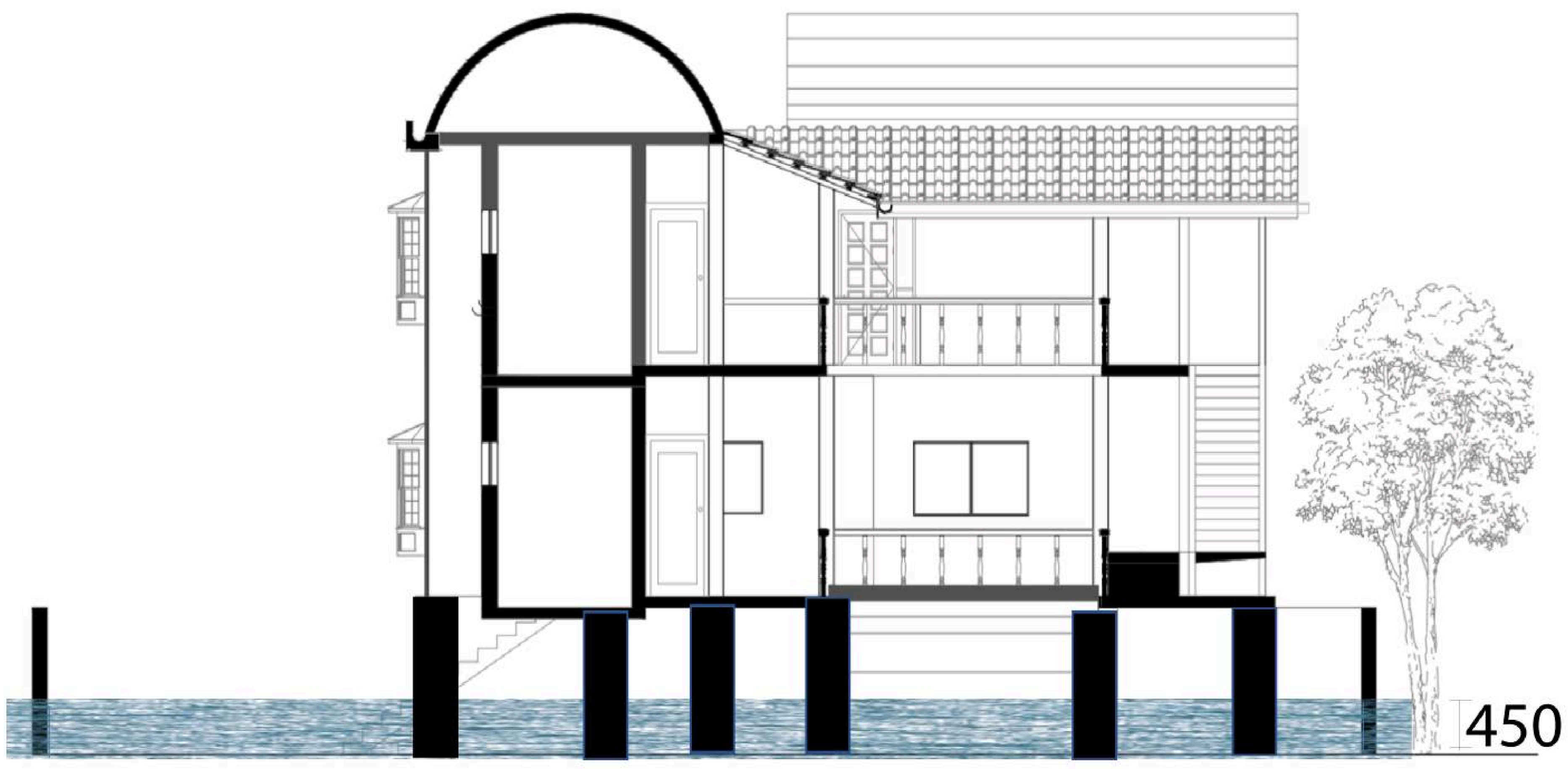


Fig-6.3.6 Flood level in present conditions (stilt height at 450mm)

Qualitative:

•Floods bring enormous damage to society. Landslides have claimed many lives and destroyed property.
•As a result, sanitation and clean water needs were addressed. Floods saline the clean water, rendering it unfit for drinking and other domestic purposes.
•As a result, a significant issue is a lack of clean water. Simple methods can be used to clean and reuse it.
•Climate change is another issue that arises as a result of inundation. The climate has changed dramatically, and it is now exceedingly hot and humid. Thermal comfort can be maintained using passive methods.
•The home should be flood resistant, which is an important consideration during floods.

Fig6.3.7- Project cost comparision of standard RCC design v/s proposed design

Mankule faces about 2400 mm average rainfall throughout the year. Flood height is around 450 mm in the year 2023. Within 20-30 years i.e., in 2080 the height will be gradu ally raised to 800 mm that means the height is almost doubled.

• Considering situation of next 50-60 years the stilt height is kept 1900mm to protect the house from flood damage

Flood level around 50 years later i.e in 2050 is 800mm which is doubled within 50 years

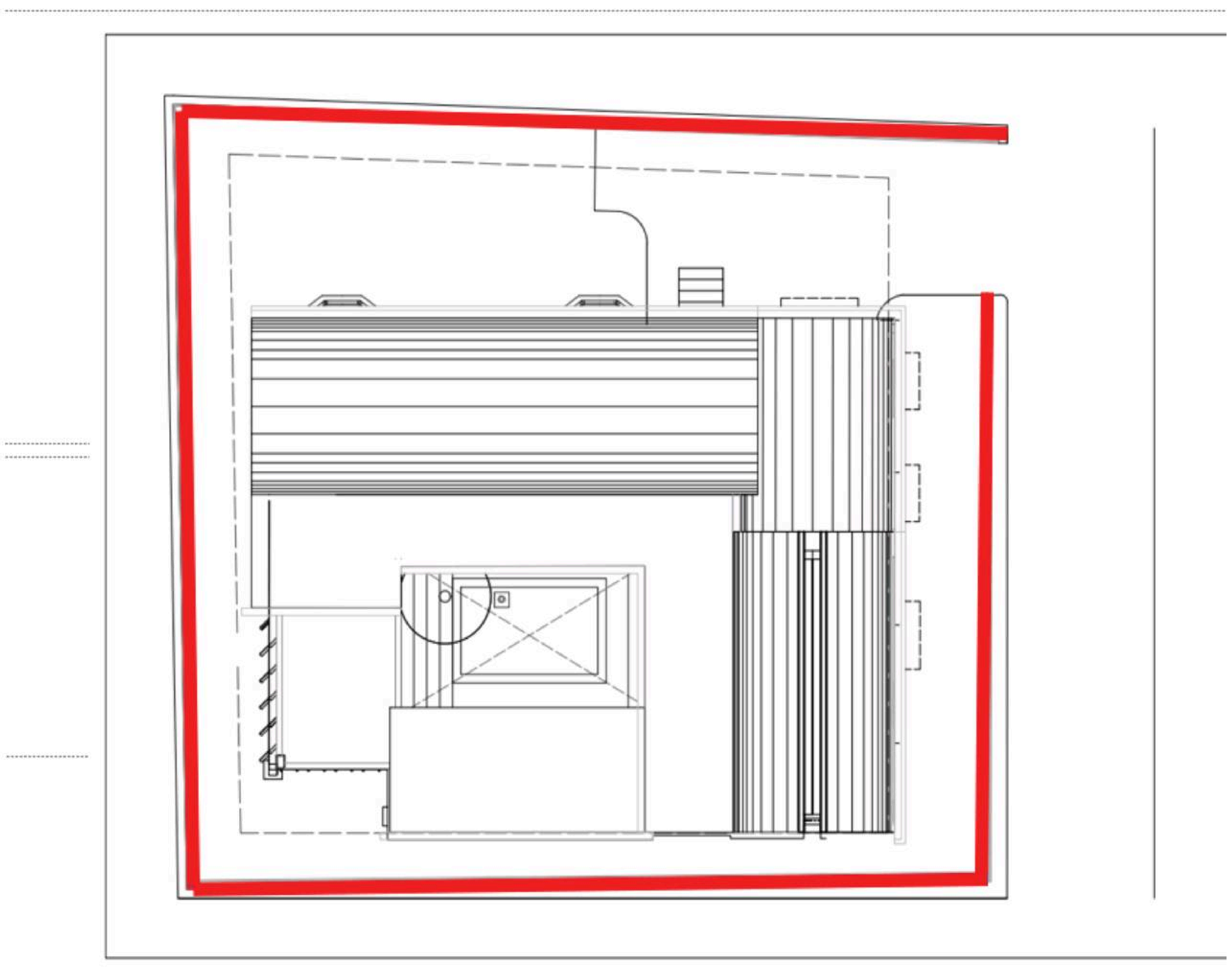


Fig 6.3.8- Channel placement around the site

The channel placement on the site's periphery, which enables simple water runoff during floods, is shown on the above-mentioned plan. The canals allow water to flow into a pit where it is collected

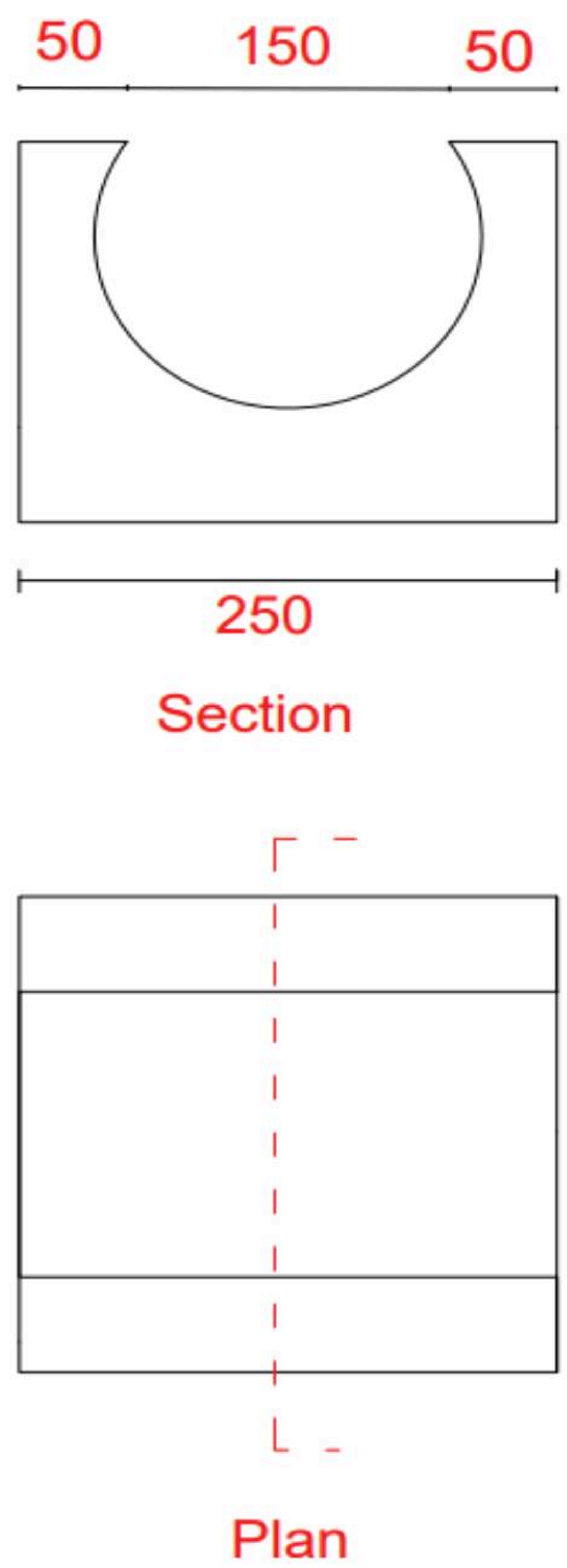


Fig 6.3.9- Channel details

Health & Well being

Fig-6.4.1 Aloe Vera Plant

Fig-6.4.2 Rubber Plant

Aloe Vera

•Has high moisture content

•They work as a dehumidifier

•They clean air

Rubber Plant

•It is an environmentally friendly when kept indoors.

•It is an air purifying agent

Fig-6.4.3 Indoor Plant View 1

Indoor plants are positioned around the perimeter of transitional space.

Fig-6.4.4 Indoor Plant View 2

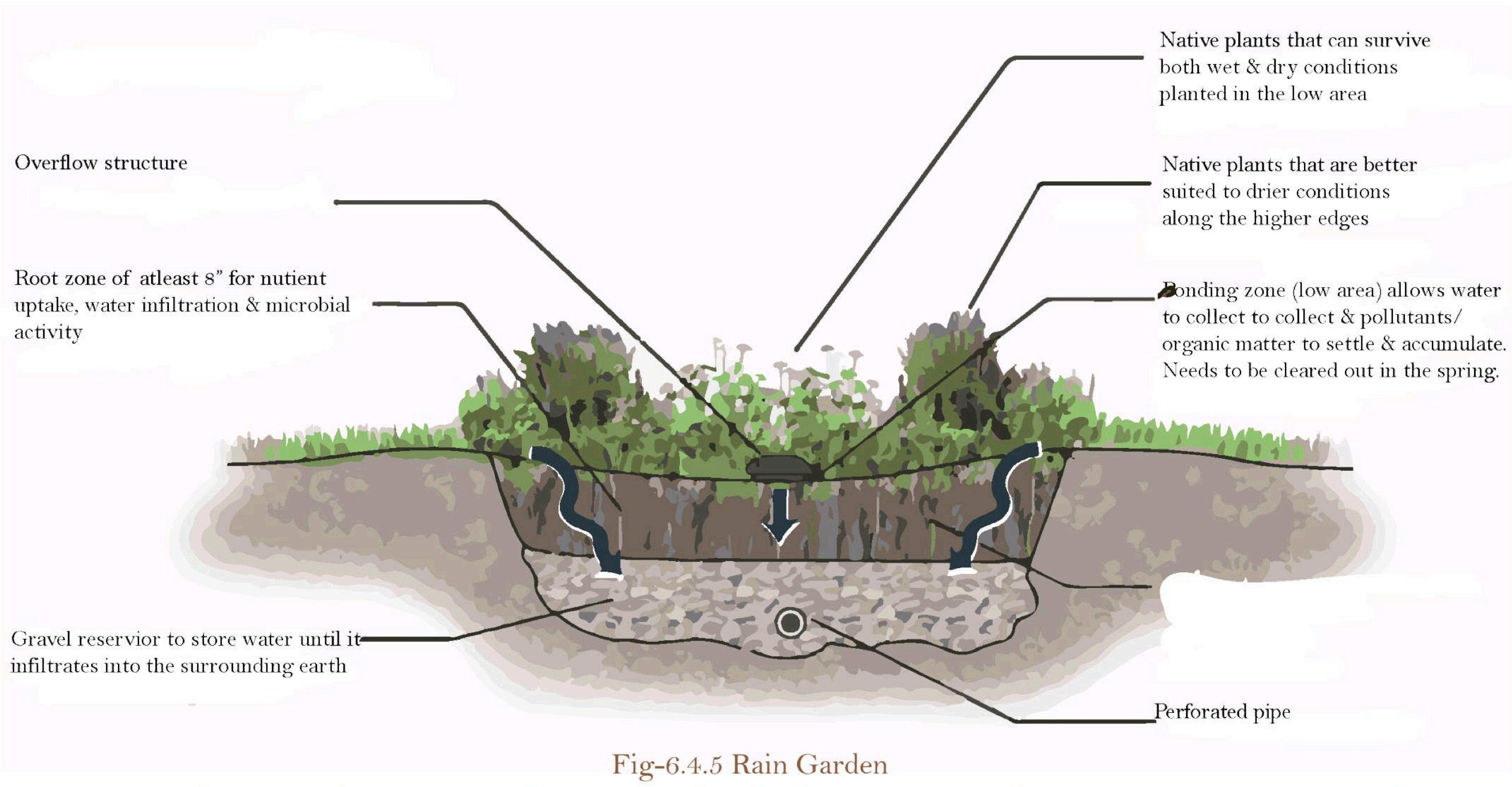


Fig-6.4.5 Rain Garden

•A rain garden is a depression shallow in depth that is planted with native plants such as croton and cacti.

•The depression allows the rainwater to collect and seep down .This prevents erosion and helps restore groundwater level.

•Rocks and sand soil help proper drainage in a rain garden.

Daylighting

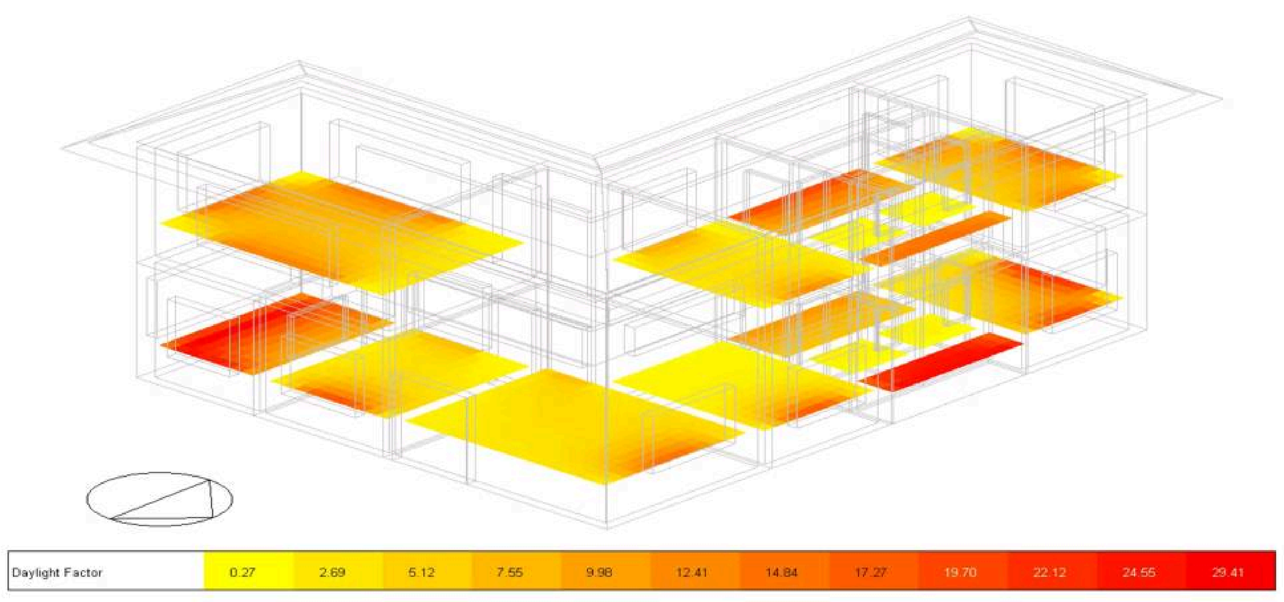


Fig-6.4.6 Daylighting Analysis

By introducing natural light through skylights in the research room and living room, daylighting has been improved in a number of spaces across the house. Centrally pivoting windows in the deck area provide a play of light and shadow as well as serve as a heat barrier.

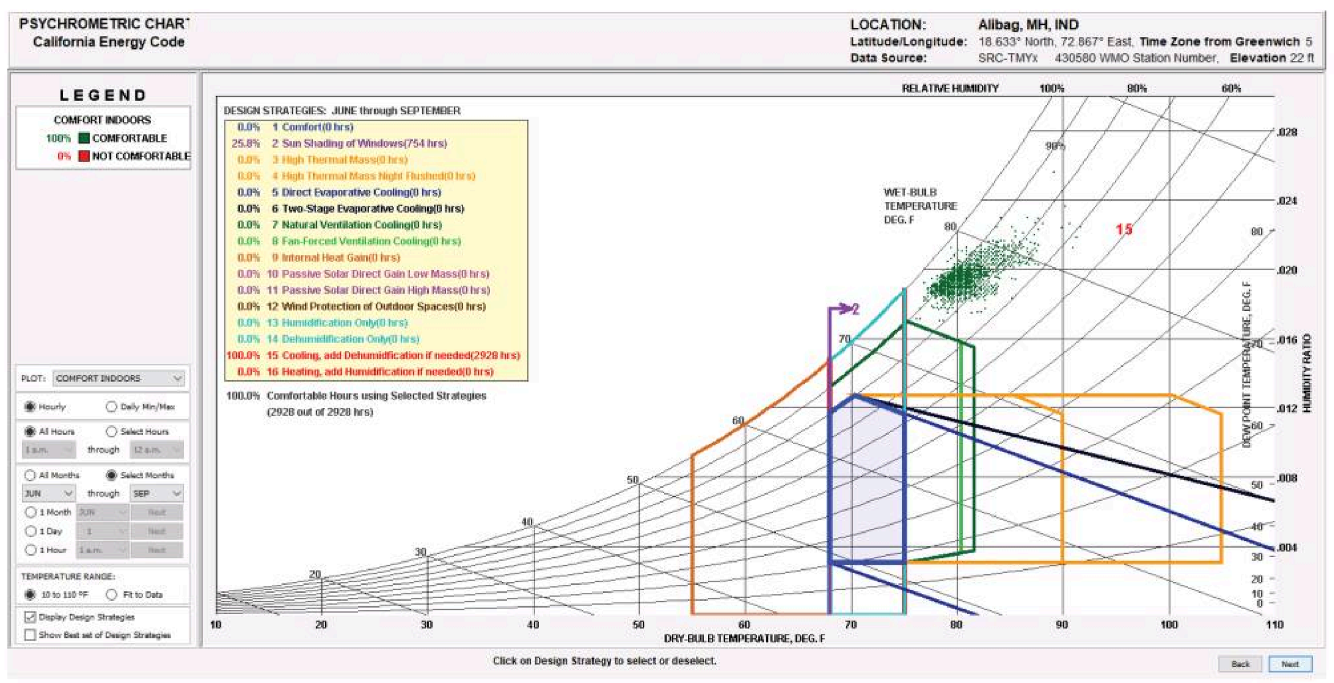


Fig-6.4.7 Psychometric Chart June- September Analysis

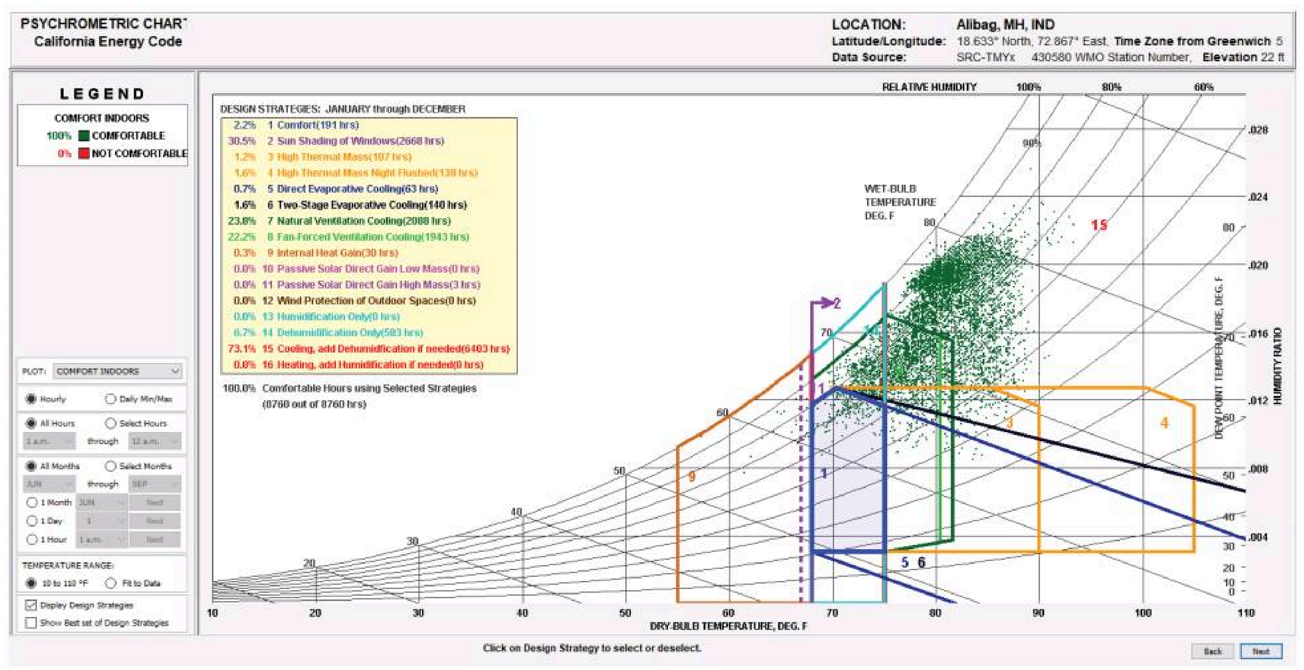


Fig-6.4.8 Psychometric Chart Yearly Analysis

For the purpose of reaching 100% pleasant operable hours, a thorough case study was done. Several tactics are used to reduce humidity levels and achieve thermal comfort at our site because it is located in a temperate zone with a humidity level of more than 70%.

Thermal Shock

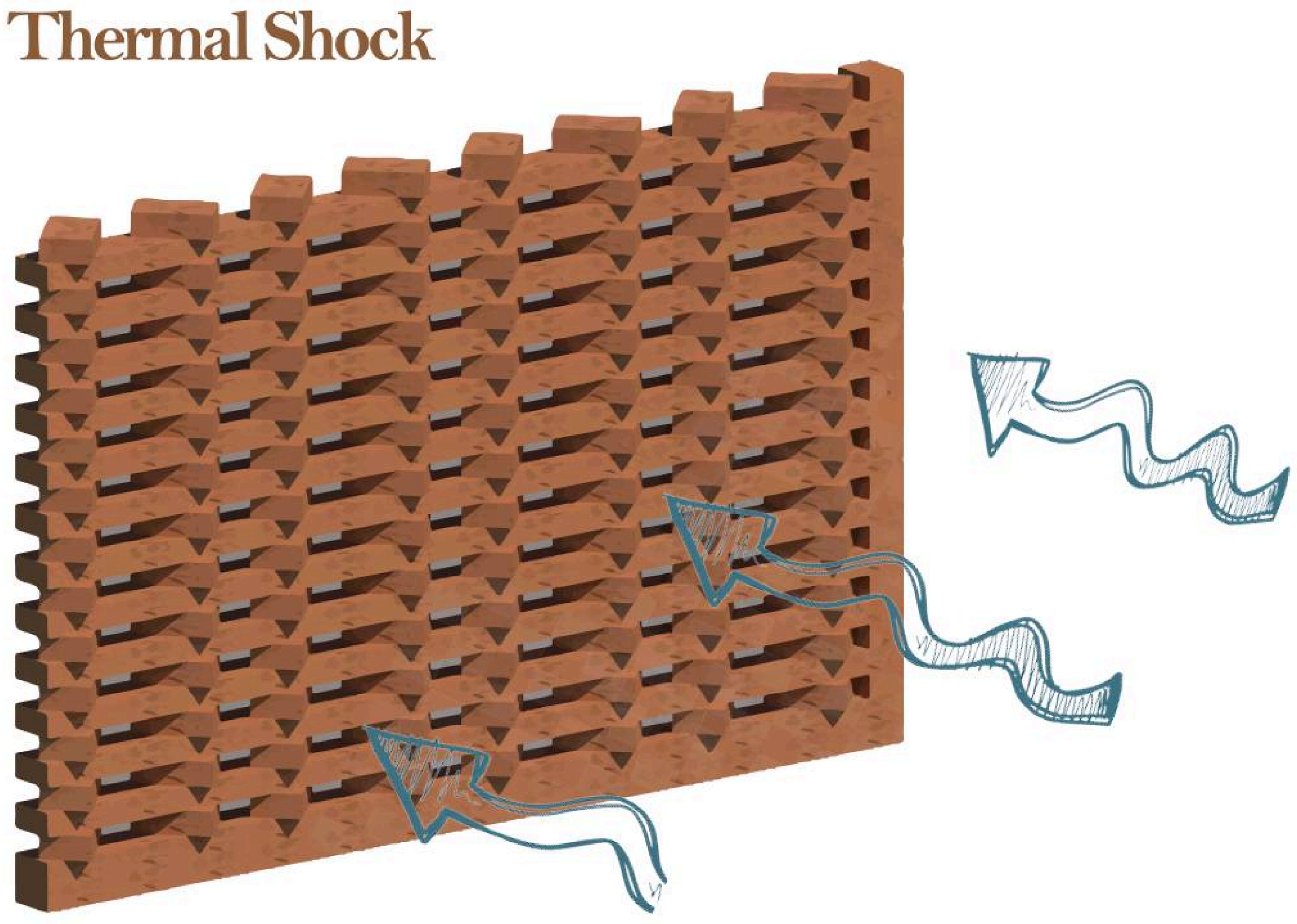


Fig-6.4.9 Jali wall elevation

Fig-6.4.11 Barriers for avoiding thermal shock

To prevent the thermal shock, numerous barriers have been built. The obstruction is the staircase, followed by the placement of the jali walls.

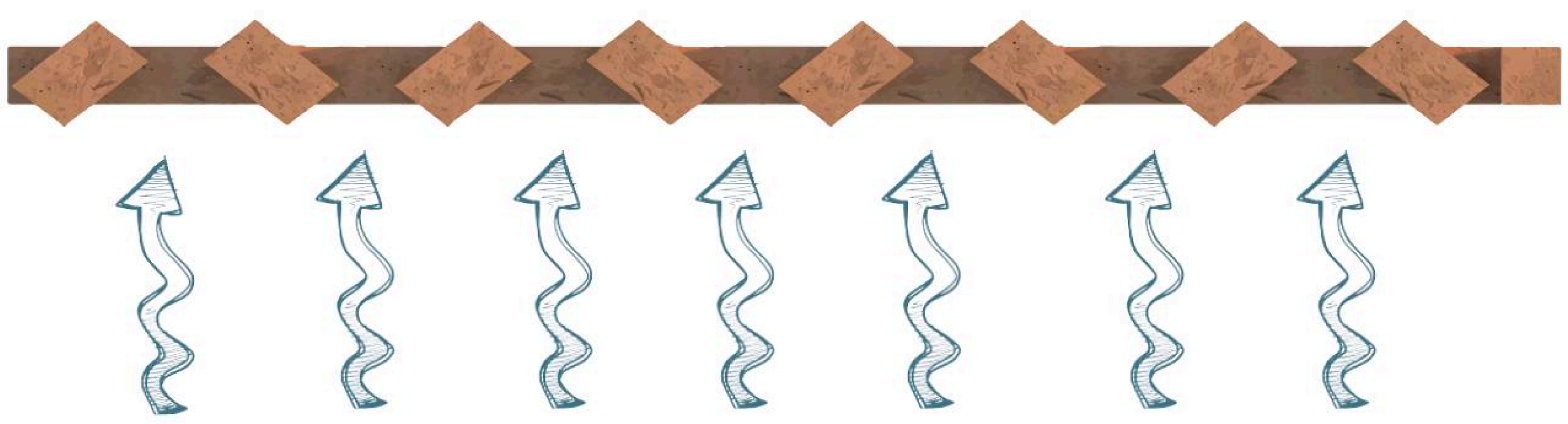


Fig-6.4.10 Jali wall Plan

The jali walls are set at a 30 degree angle to produce a venturi effect & allow the cool air to enter.

Fig-6.4.12 Centrally Pivoted windows

Centrally pivoted window winders are provided so that the user may utilise them as desired.

Landscape

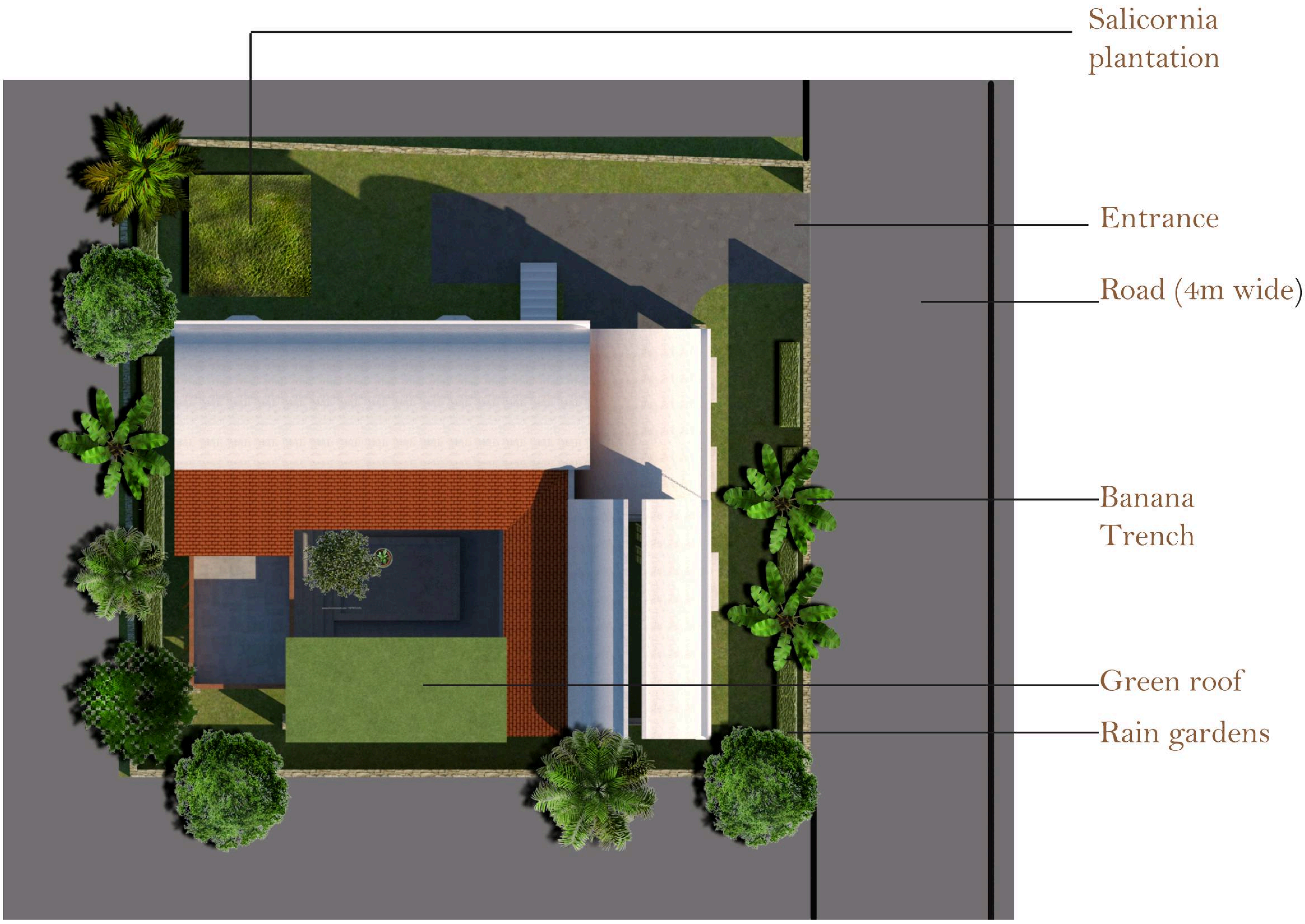


Fig-6.4.13 Site Plan

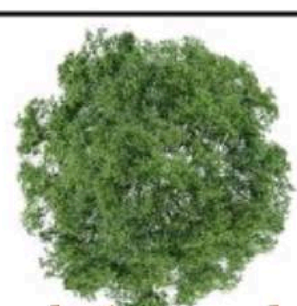
 Coconut Tree	 Tamarind Tree	 Plumeria Tree	 Banana Tree
 Sandalwood Tree	 Palm Tree	 Ocimum tenuiflorum	 Rain garden

Fig-6.4.14 Types of Plants & Trees

The key consideration when designing for the landscape was flooding. Rain gardens are positioned on the site's west and east sides in accordance with the slope. Shallow depressions called rain gardens are created to reduce excessive surface runoff. To lessen the salinity of soil,v Salicornia is planted on the site's northwestern edge. Several plants are placed on the west side of the site to shield from direct sunlight.The location also benefits from naturally occurring trees that were placed on the southern side.

Affordability

- **Hollow Compressed stabilized Earth blocks:**
- Reduce cement by 60%.
- Compressed stabilised earth blocks are inexpensive and widely accessible in the area.
- They cost 16% less than traditional brick.
- Being produced without kilns makes them environmentally friendly.
- less heat conductivity.
- compared to burned bricks, required nearly 50%–60% less mortar.
- In cseb, the mortar is 30% less expensive.
- For cseb, no plaster is necessary.
- In comparison to brunt bricks, the embodied carbon of cseb is 11–12 times lower at 548mj/m3
- reduce steel by 50%.

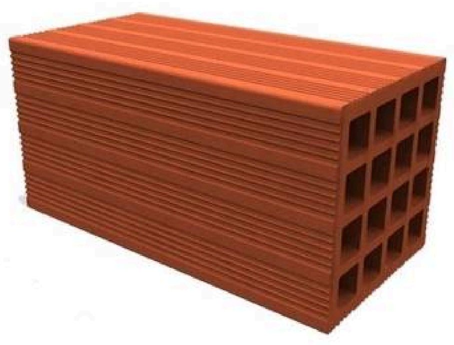


Fig 6.6.2- Hollow CSEB Block

- **Bamboo:**
- Lightweight bamboo is widely accessible.
- Compared to trees, they can produce 30% more oxygen and absorb 40% more carbon dioxide.
- The temperature tolerance of bamboo is up to 4000 degrees Celsius.
- Used in courtyard and railings.
- They are fire resistant and cost effective.

Fig6.6.1- Bamboo Railing

- **Ferrocement**
- Used in roofing.
- It weighs between 10 and 25 percent less than a similar brick building.
- It is superior to many traditional ones and can repair atmospheric harm.
- cost -

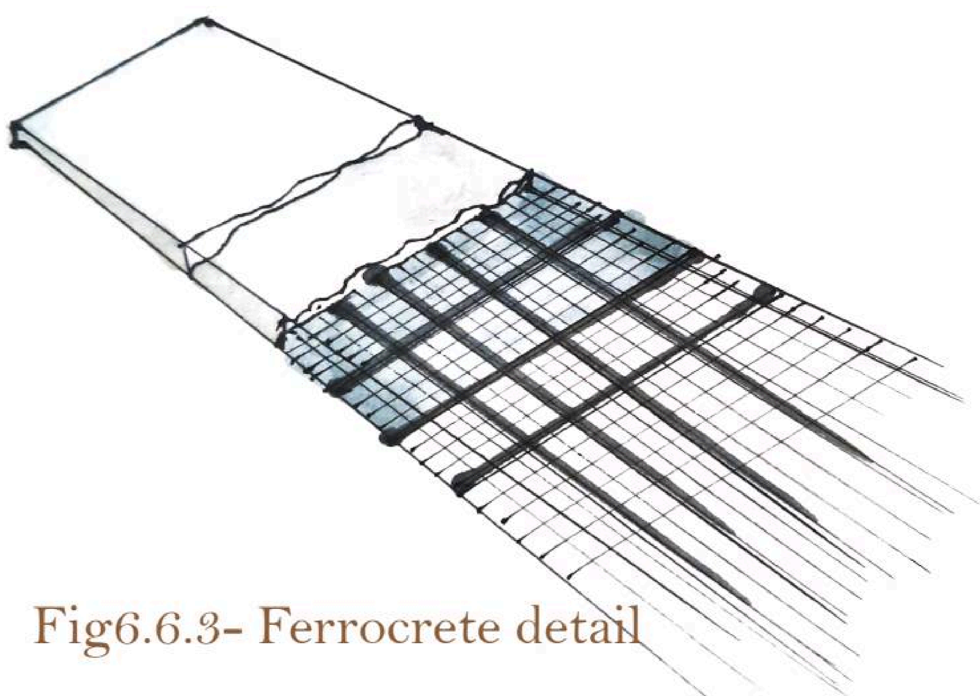


Fig6.6.3- Ferrocrete detail

Fig 6.6.5- Ferrocrete Vault

- **Oxide flooring:**
- Flooring made of oxide is quite economical.
- They are anticipated to get smoother and shinier over time.
- They are ideal for warmer locations since they are substantially cooler than other materials.
- Because they are made of natural materials, they are more environmentally friendly and sustainable.
- cost - 80-90 rs per sq ft.

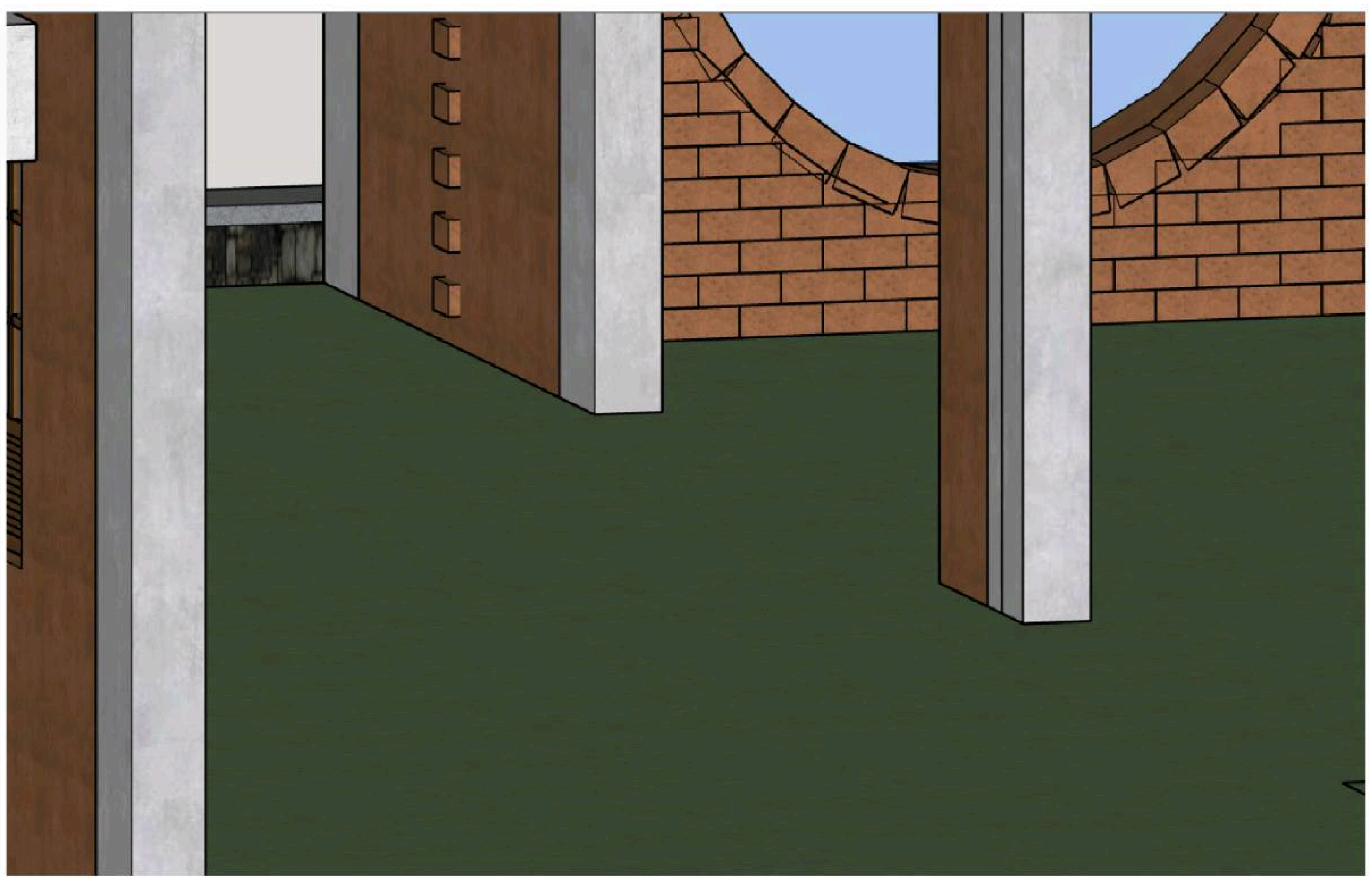


Fig 6.6.4- Green oxide flooring for interior

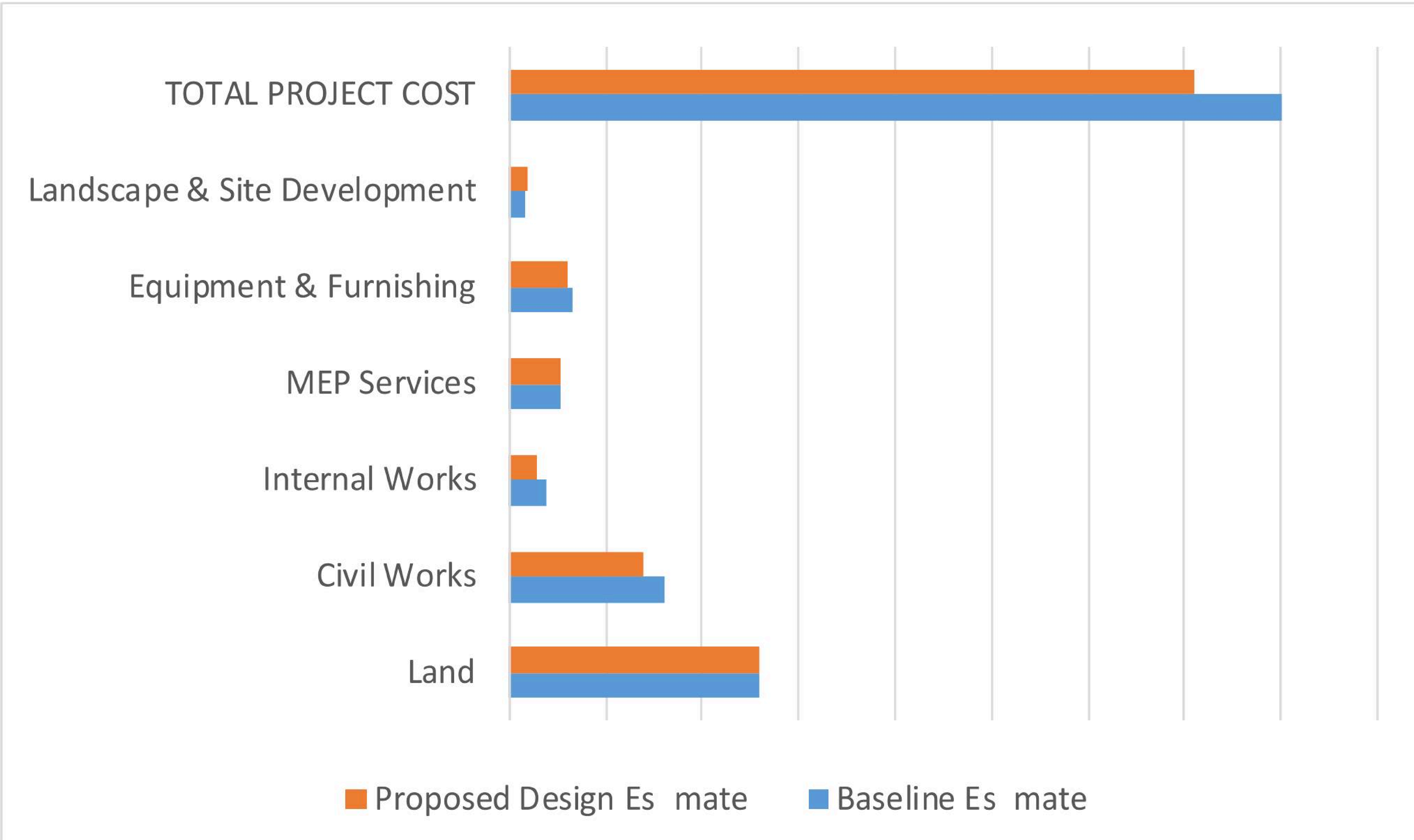
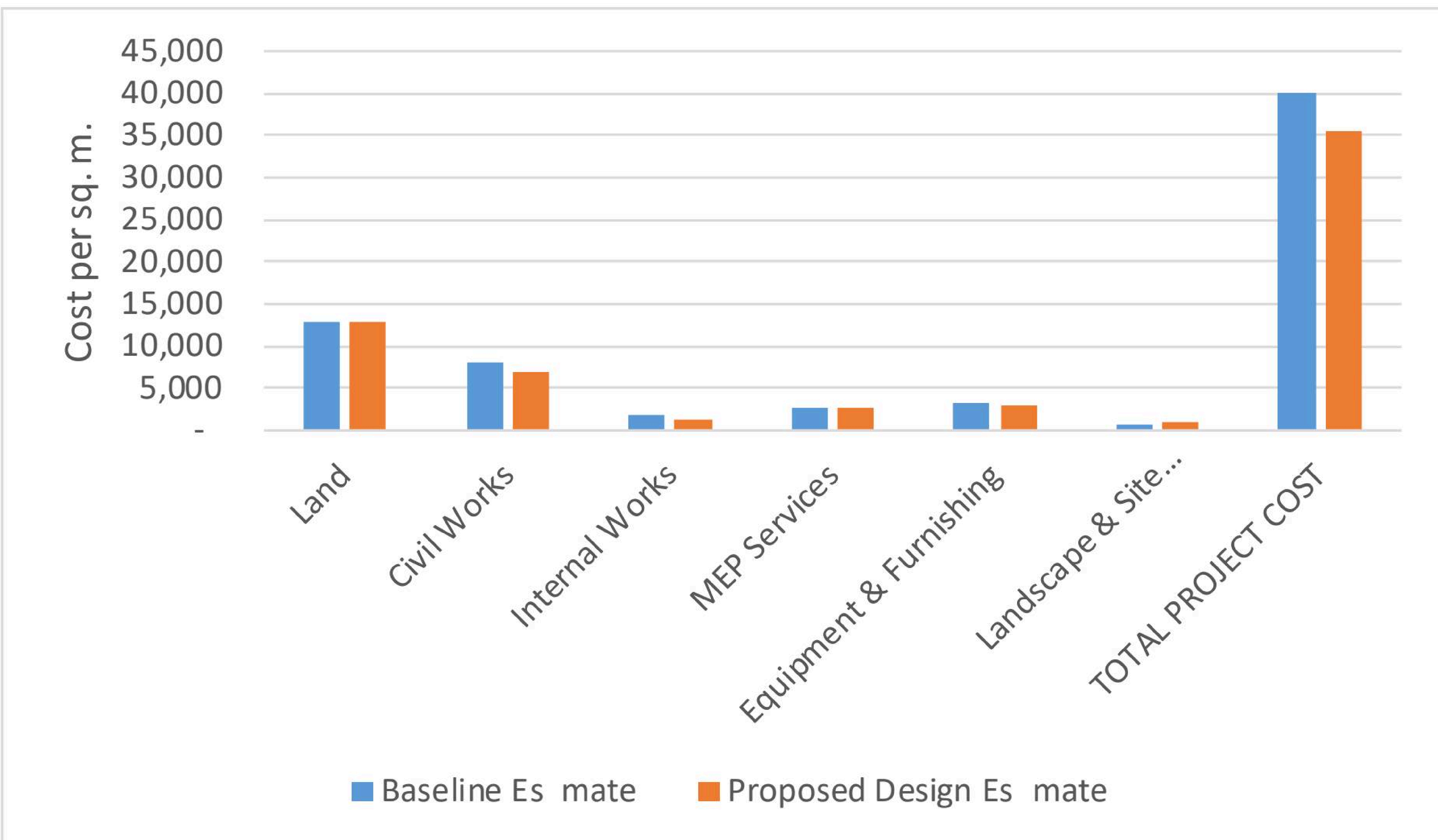


Fig- Project cost comparision of standard RCC design v/s proposed design

Value Proposition

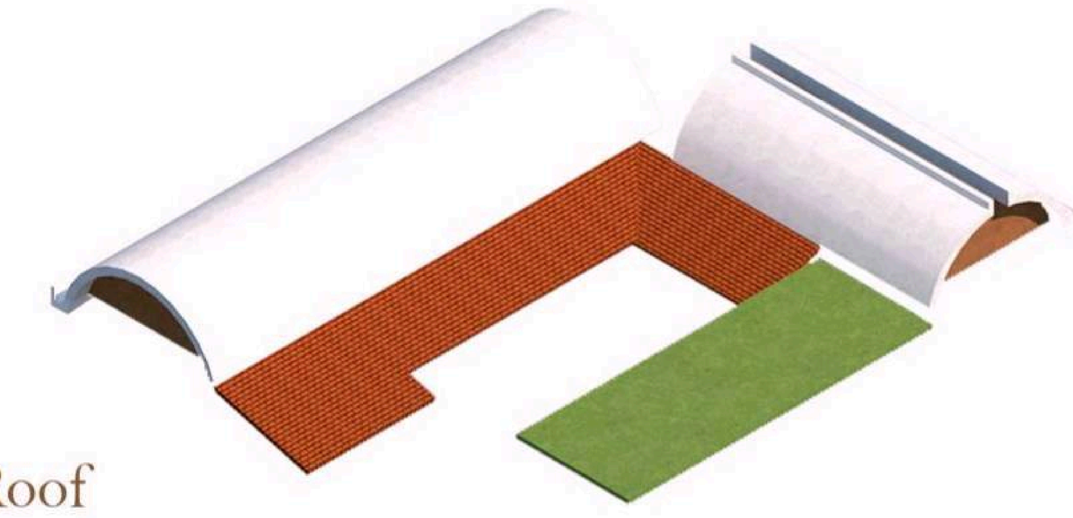
Open spaces define the design with a central courtyard acting as a multipurpose space. The courtyard is equipped with an amphitheater and can be used as an informal family room or even as a business quarter. The connection to the outside is established with open to sky deck that opens up to the western part of the site, overlooking the landscaping. The clever use of passive designs such as venturi effect makes the design energy efficient and makes it such that the insides remain cool during summers and warm during winters. The onsite harvesting of water is equal to the water demand of the site making it a net zero water cycle. Use of CSEB Blocks as primary construction material is a vernacular approach and due to the material being porous, humidity is controlled on the inside. Using the long hours of solar energy to our aid, solar panels generate electricity onsite. In addition to that, low energy comfort system is achieved by use of energy efficient fixtures.



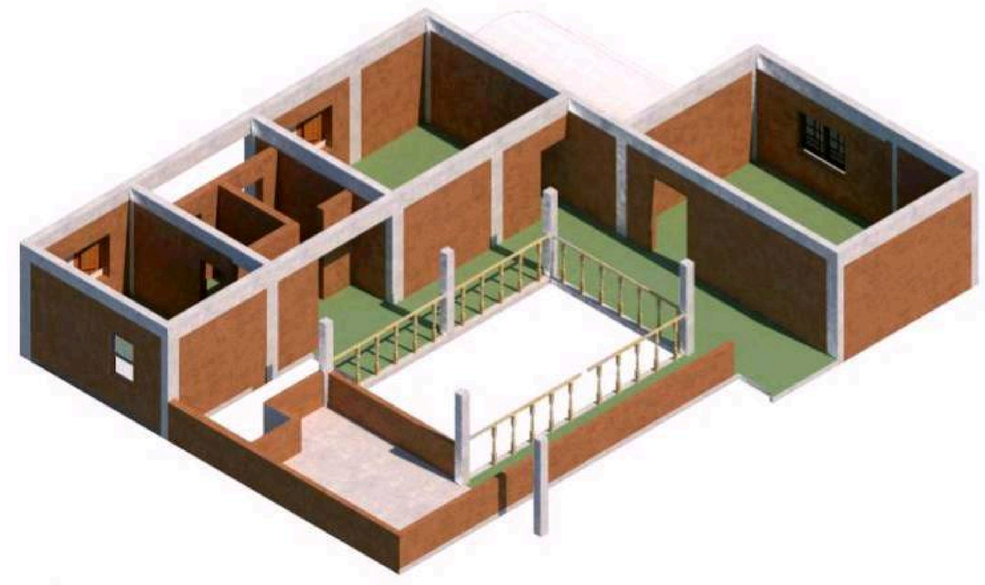
Architectural Design

Fig. 2 - Site Plan

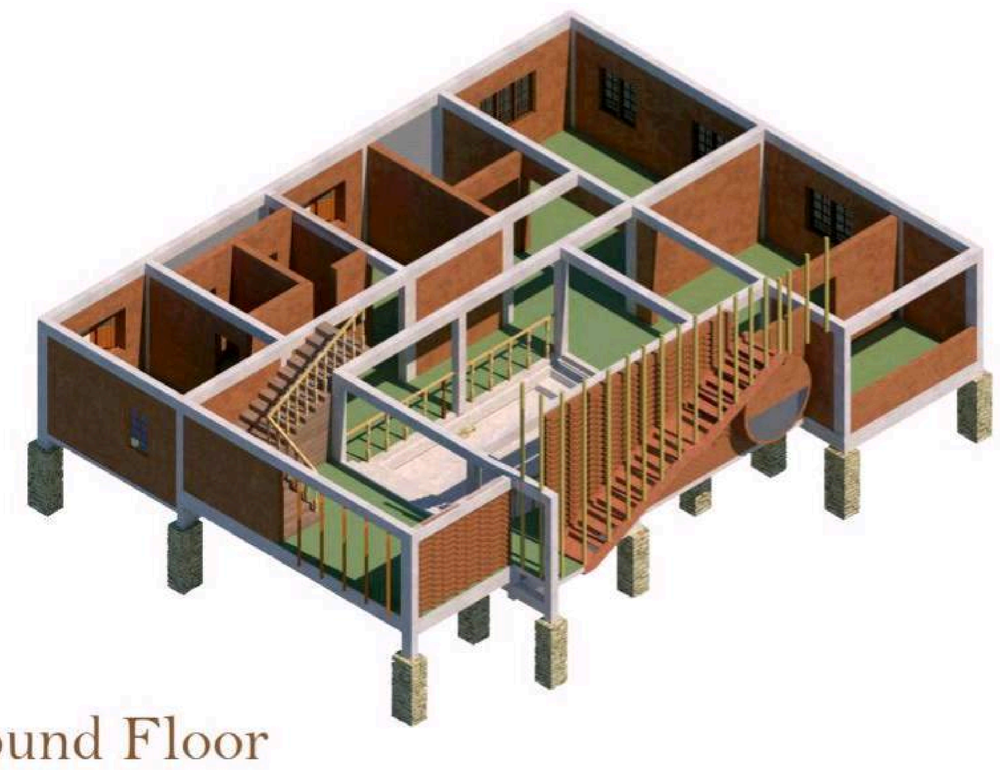
Roof



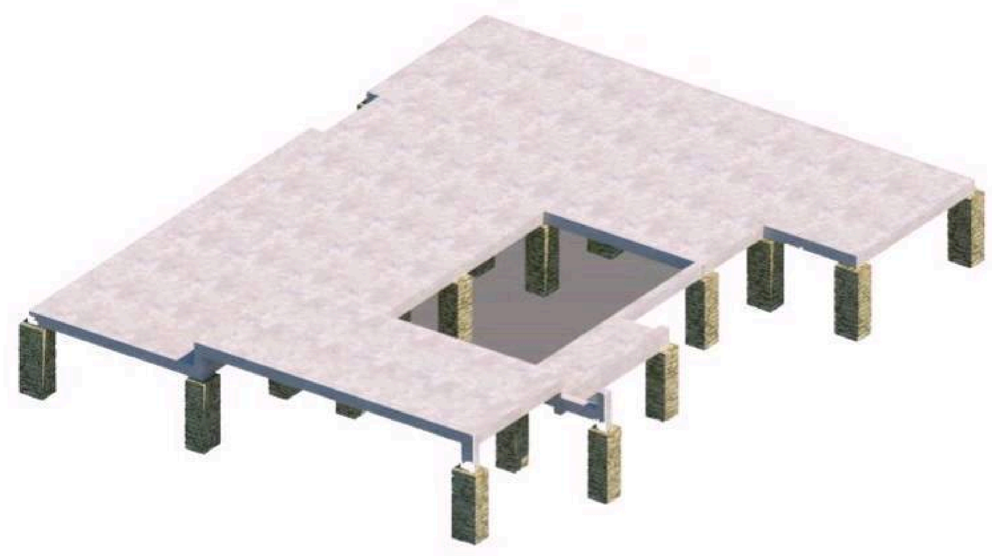
First Floor



Ground Floor



Stilt Plan



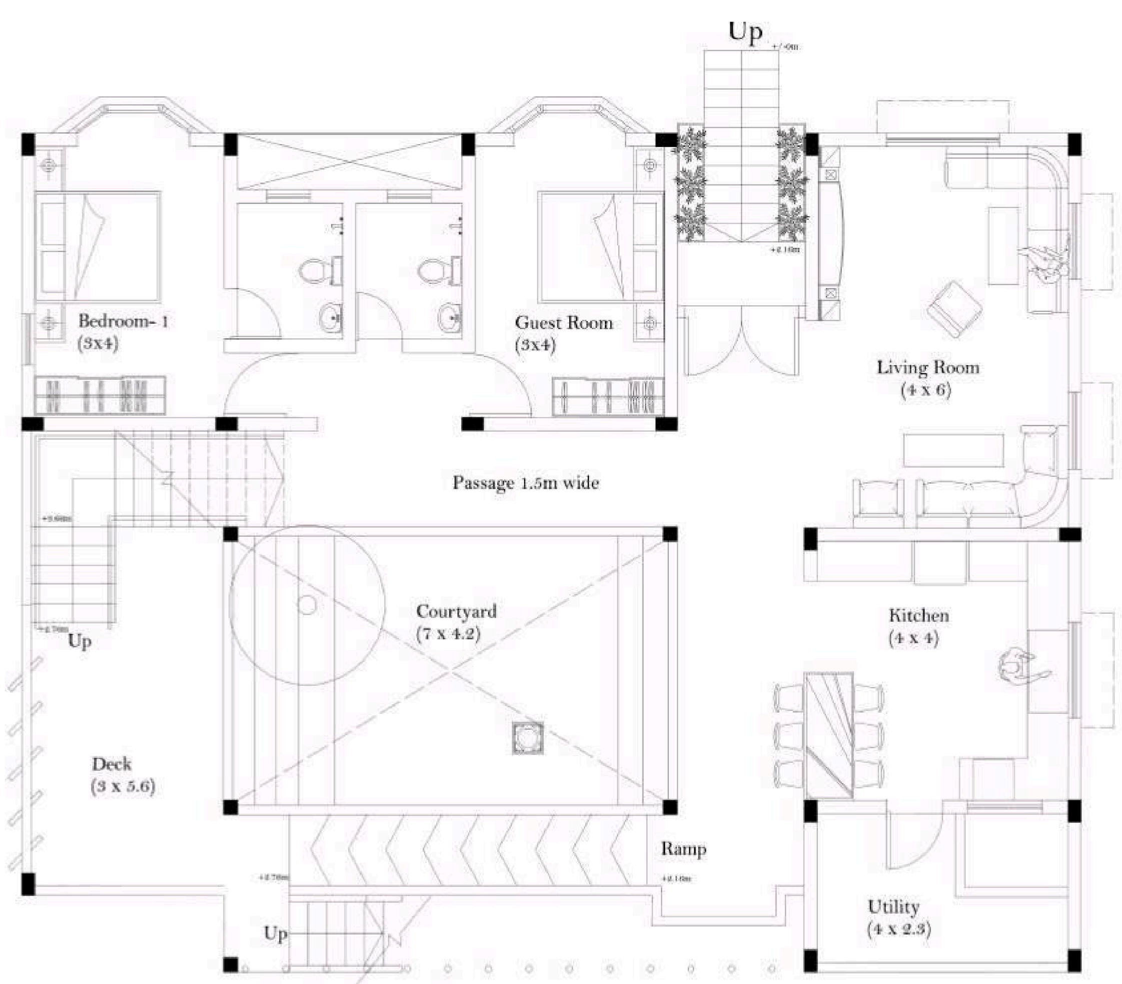


Fig.2 - Ground Floor Plan

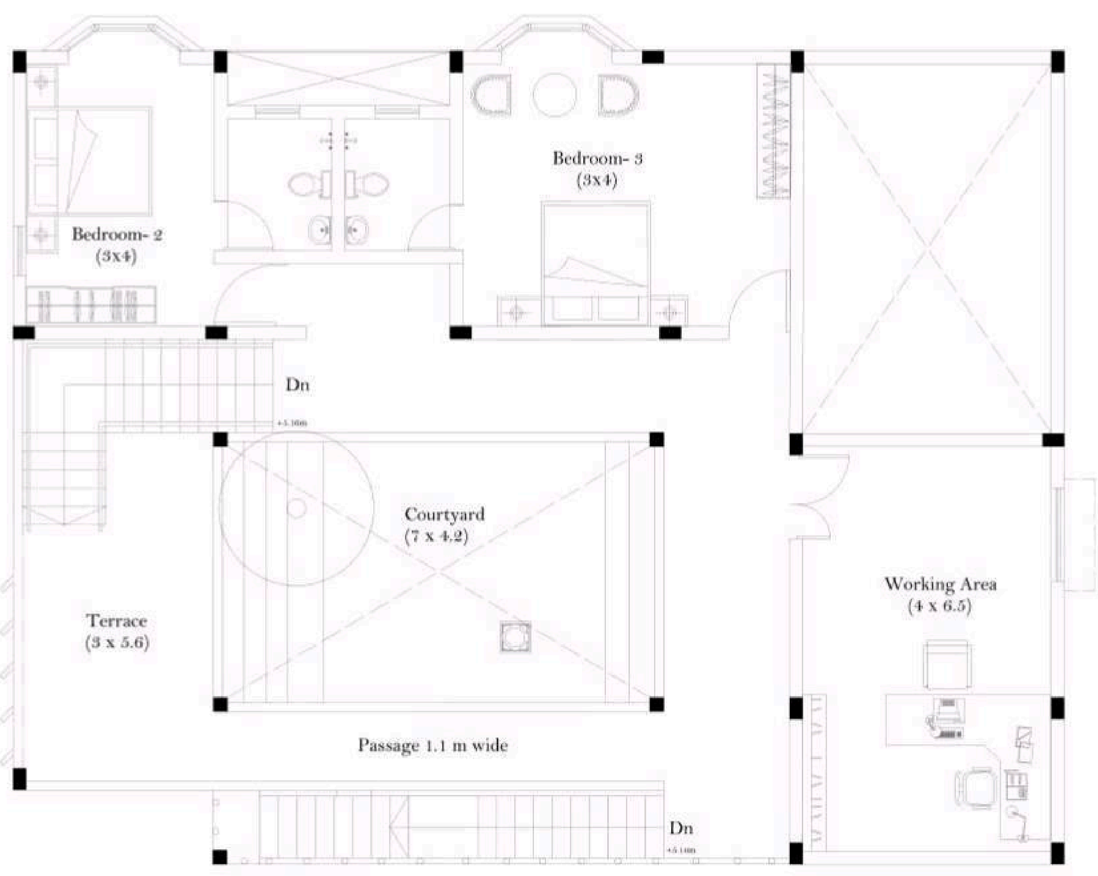


Fig.2 - First Floor Plan

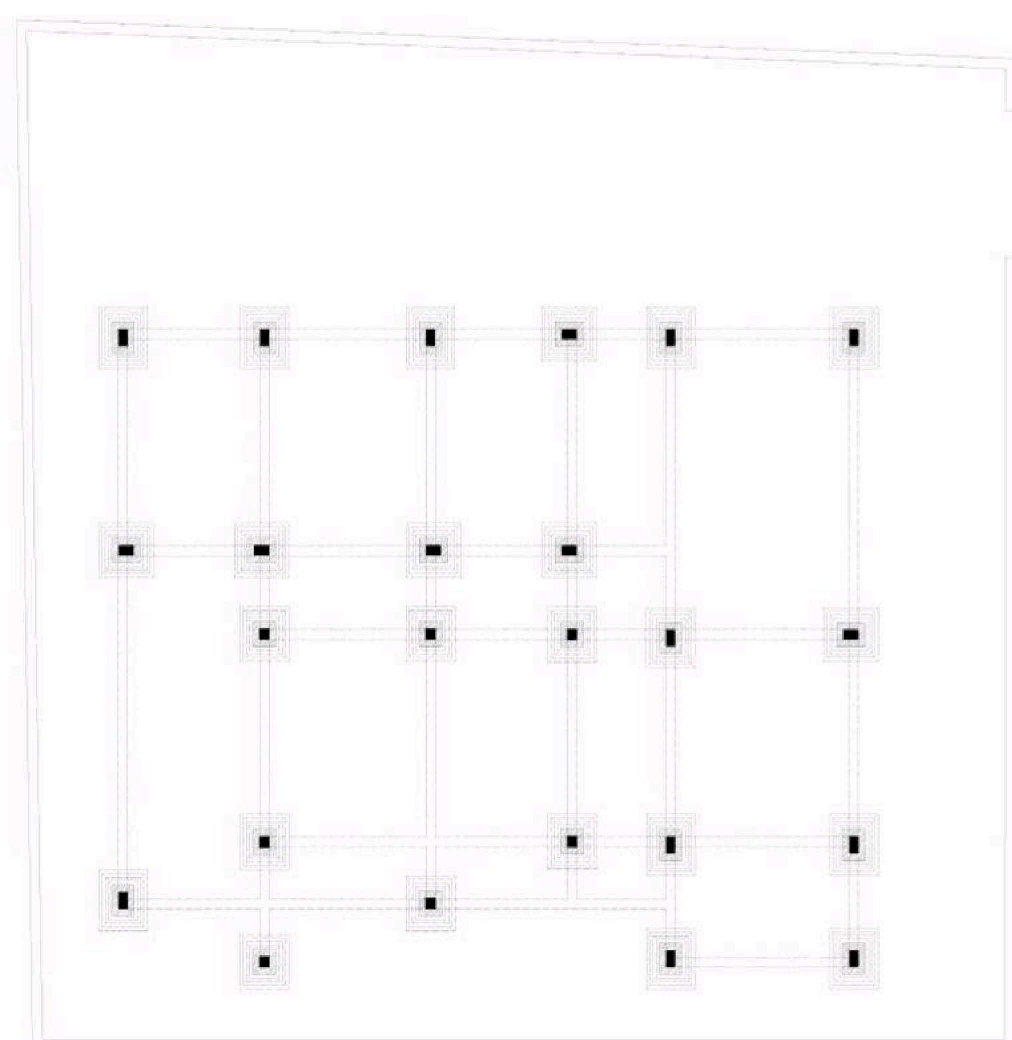


Fig.2 - Stilt Level plan

Sections

Details

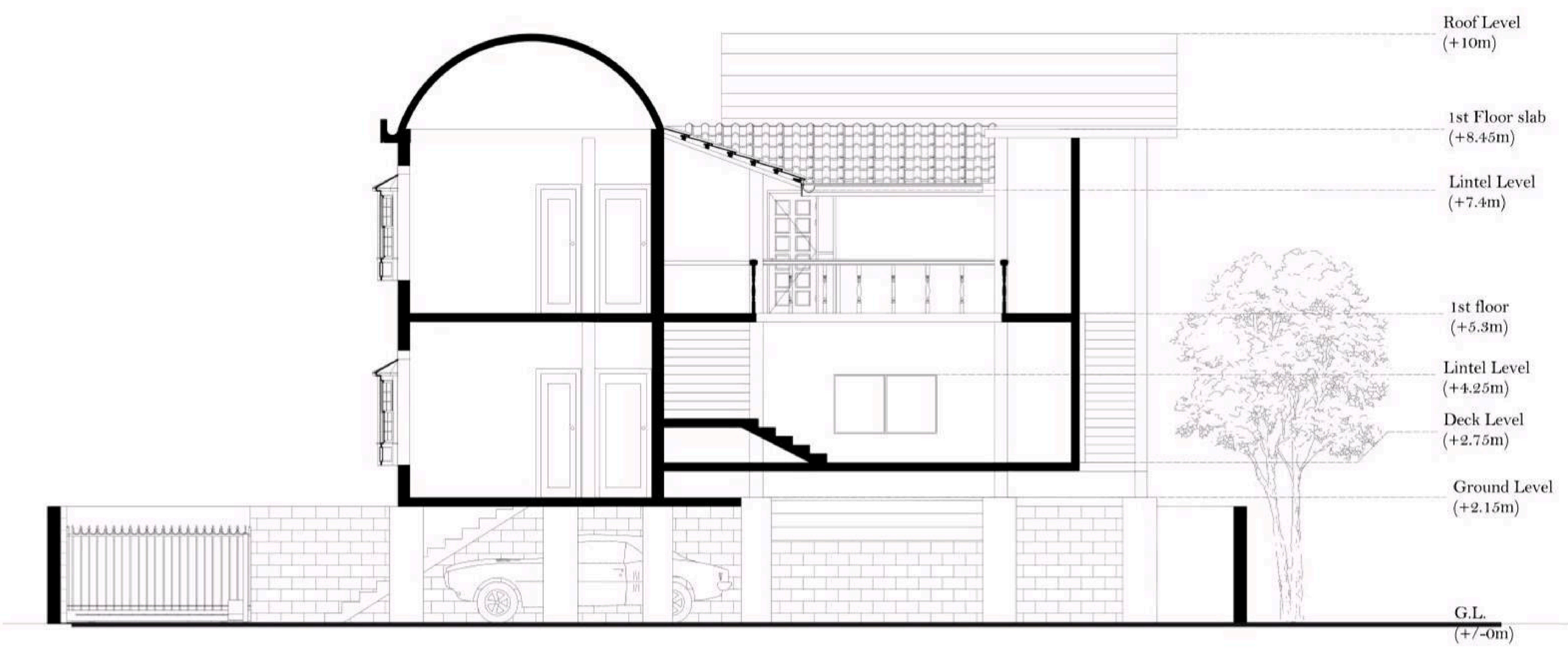


Fig. 2 - Section -AA'

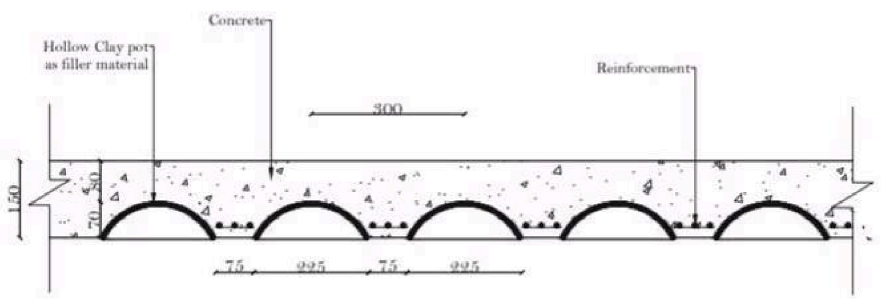


Fig. 2 - Filler Slab Detail

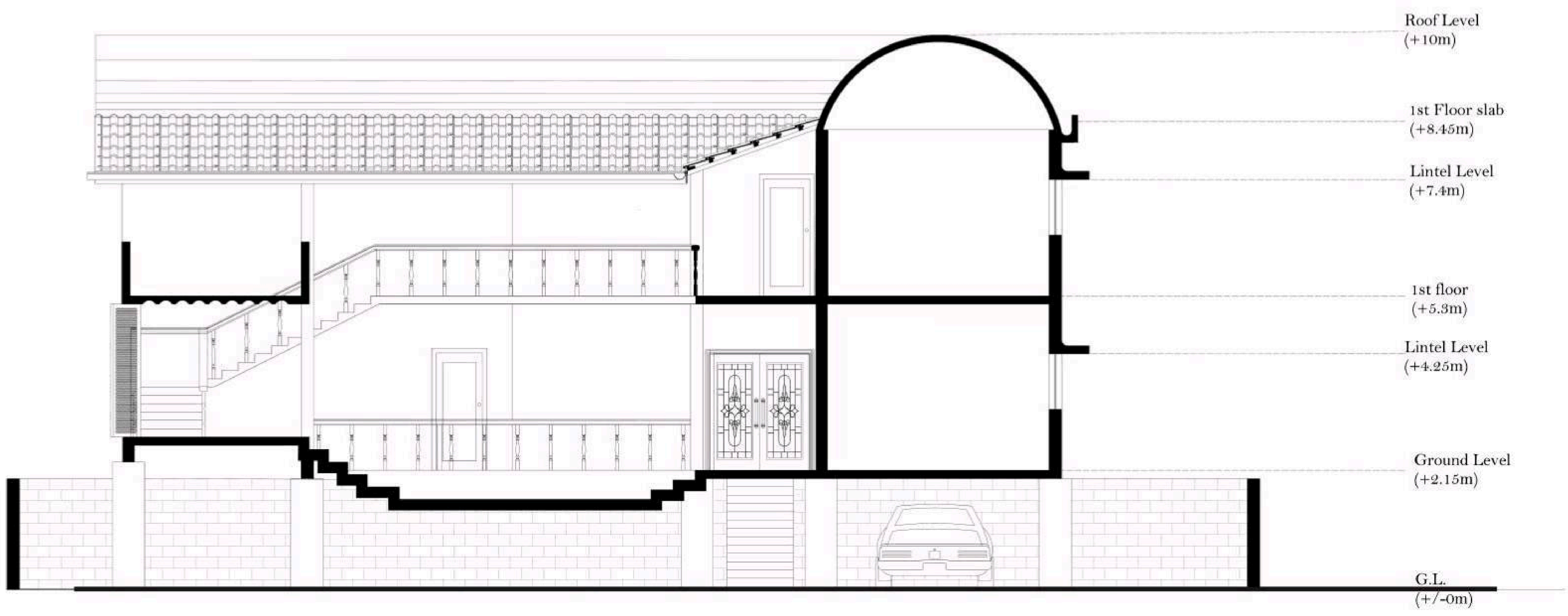


Fig.2 - Section BB'

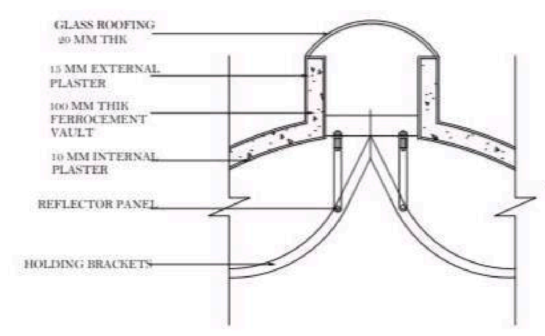


Fig. 2 - Skylight Detail

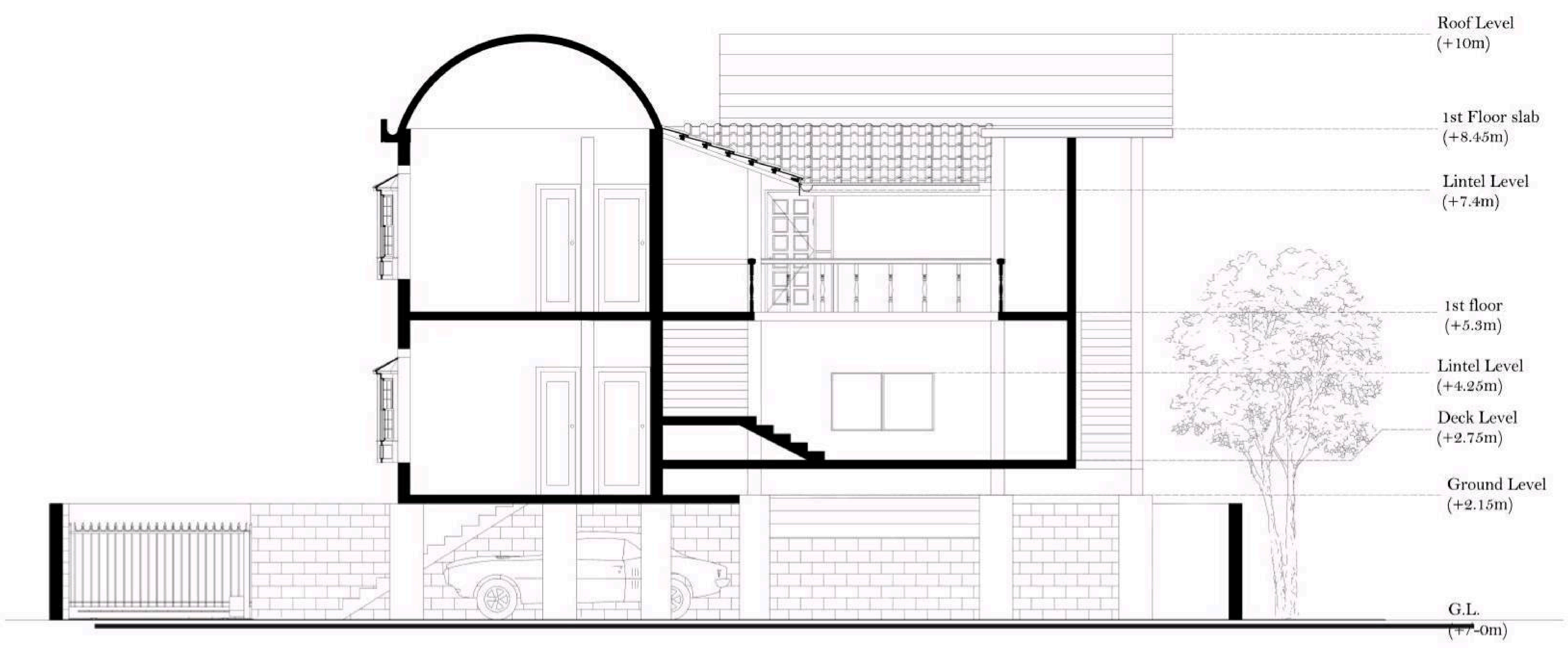


Fig.2 - Section CC'

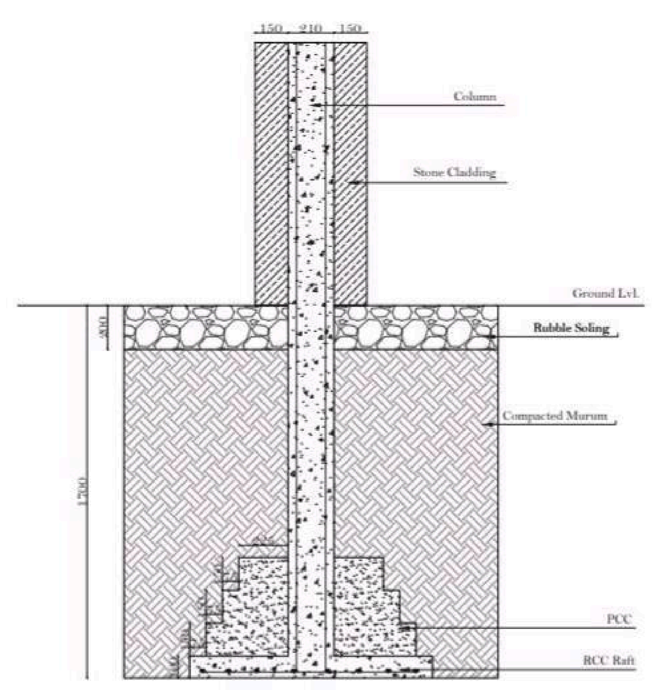


Fig. 2 - Footing Detail

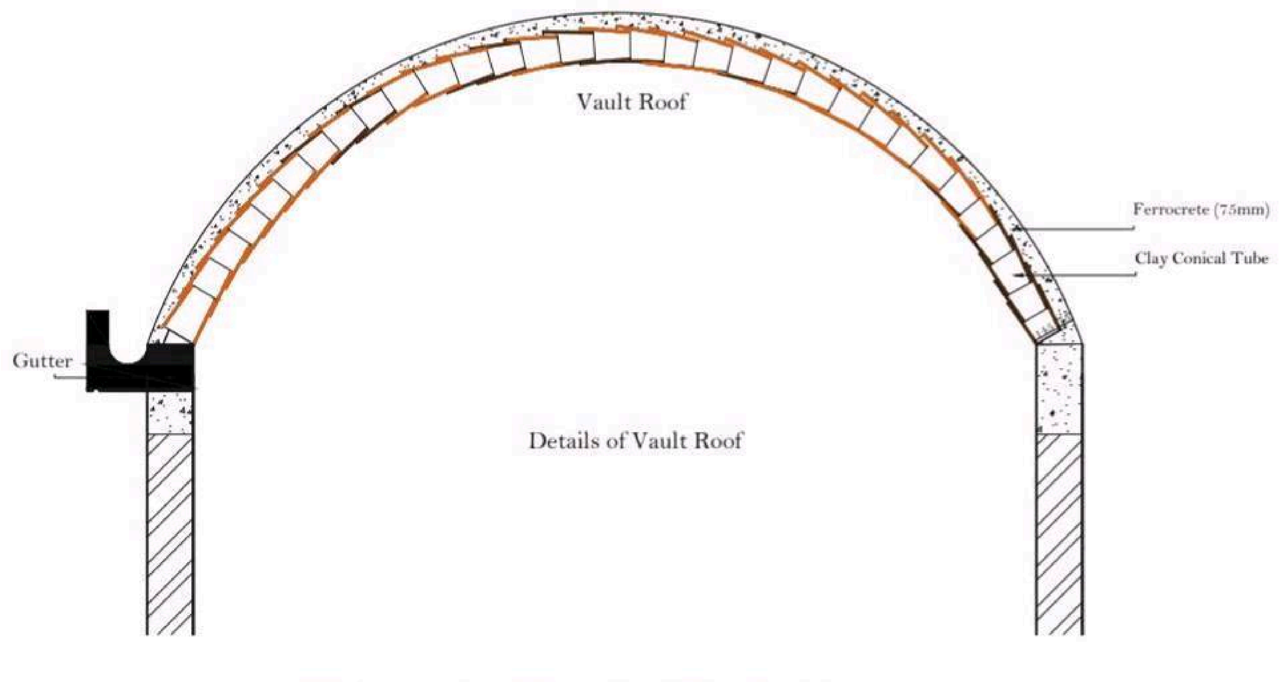
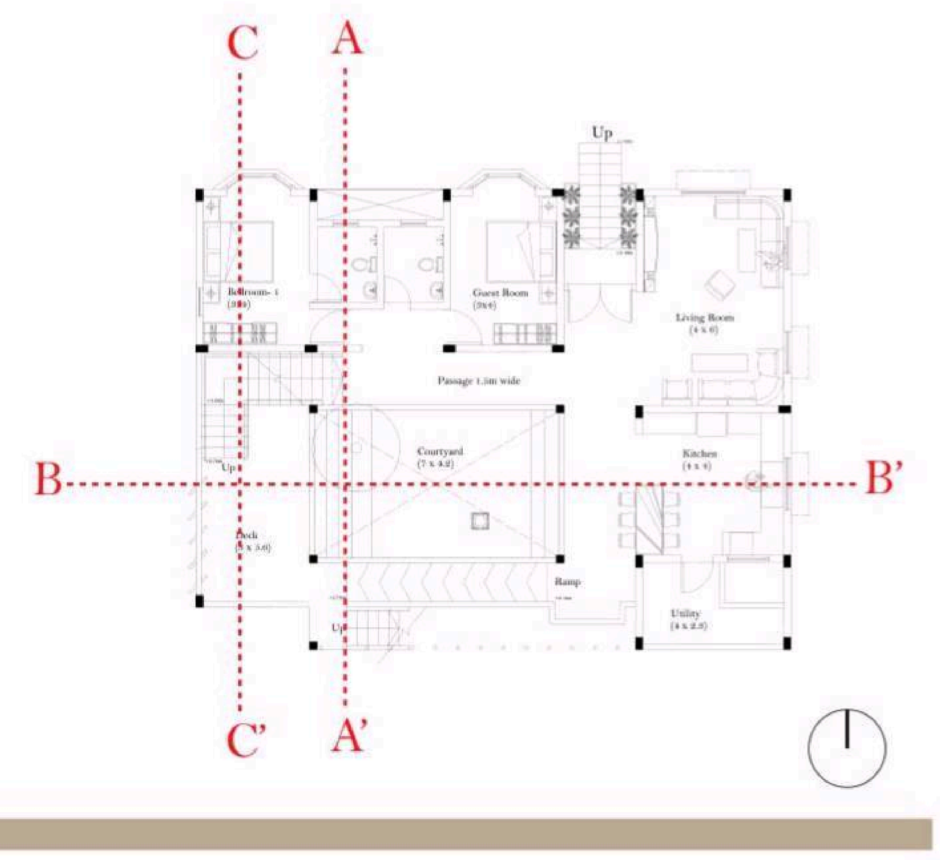


Fig. 2 - Vault Detail



Elevations

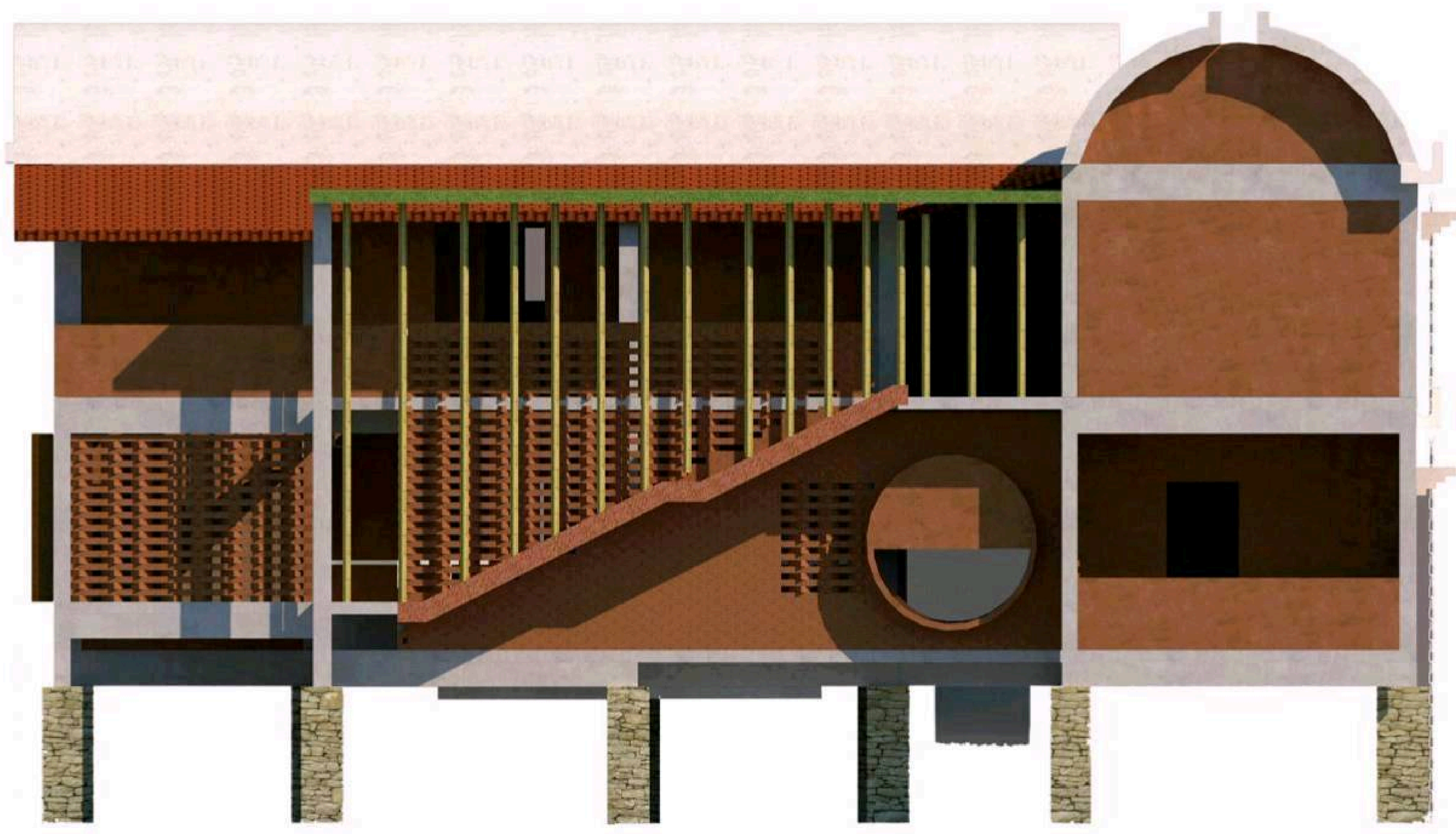


Fig.2 - South Side Elevation

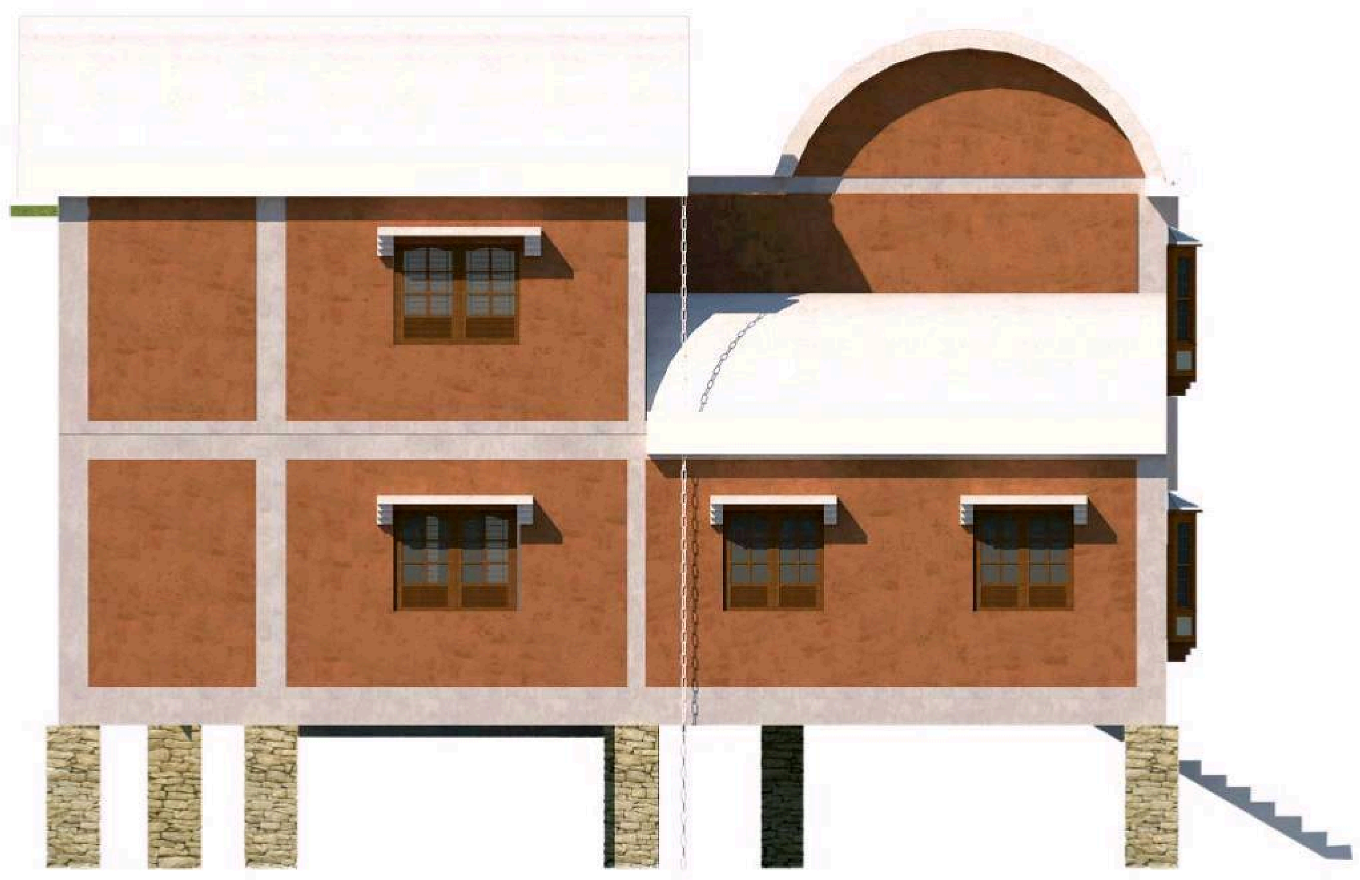


Fig.2 - East Side Elevation

Fig. 2 - West Side Elevation

Material Palette

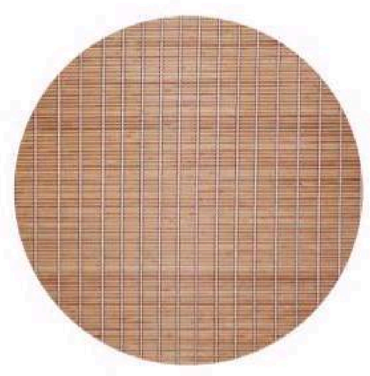
The following materials were chosen for the interior material palette. Green oxide flooring was chosen along with timber furniture due to their sustainable tendencies.

Oxide Flooring

Jute

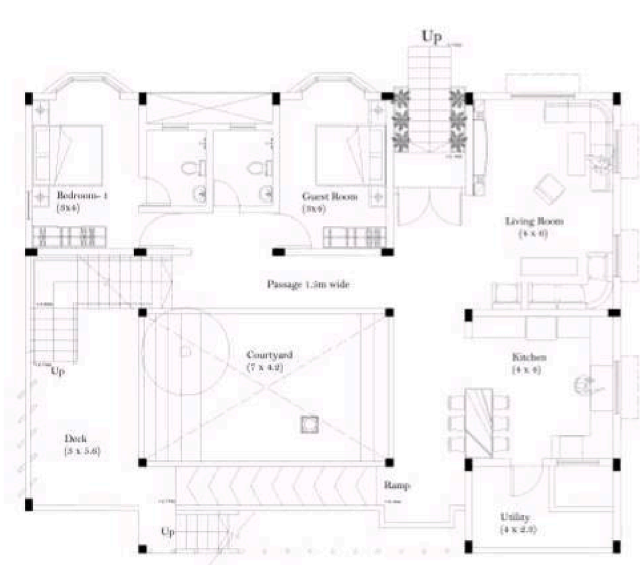
Plywood

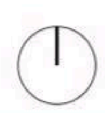
Bamboo



Bamboo

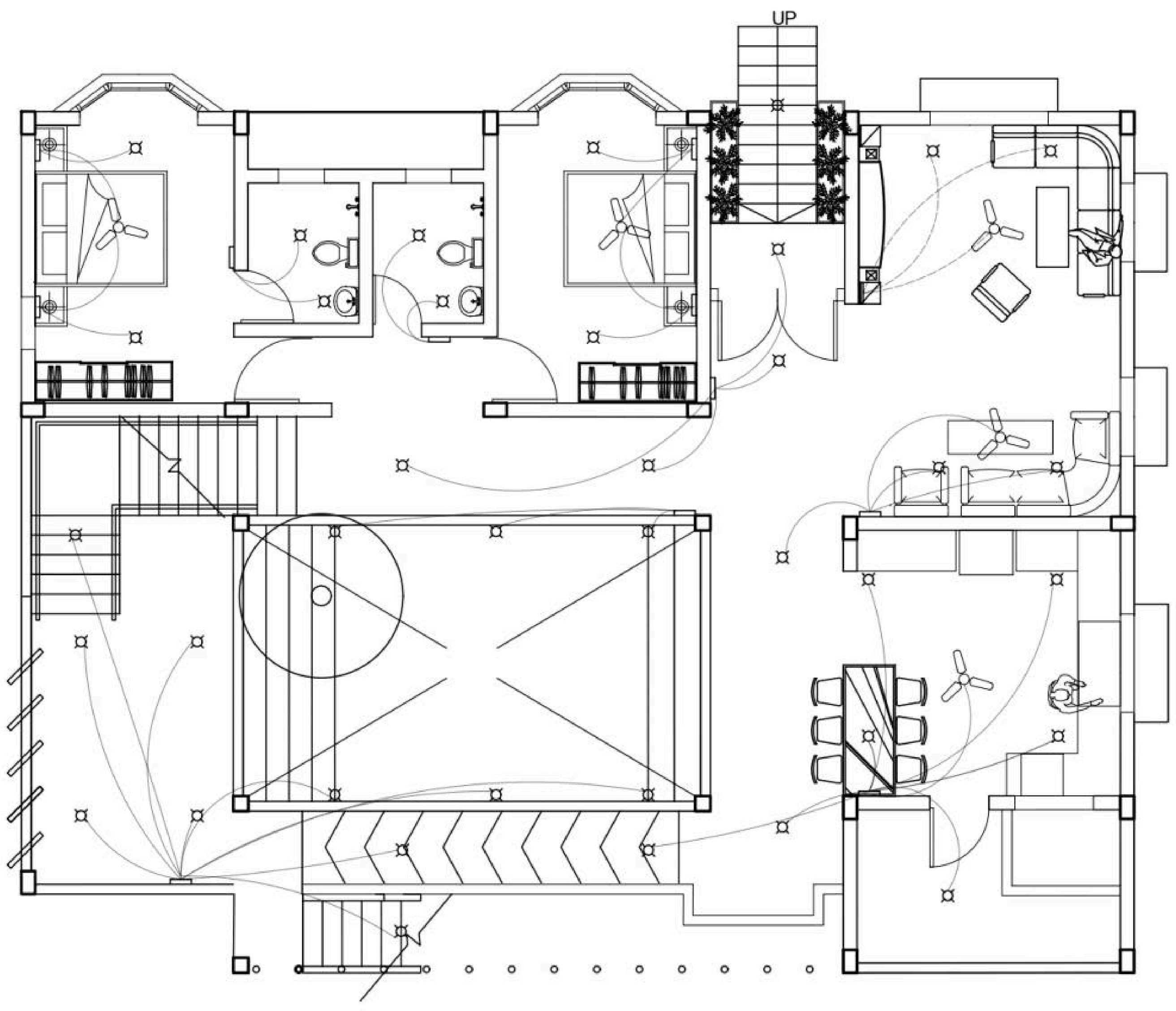
Fig. 2 - Material Palette



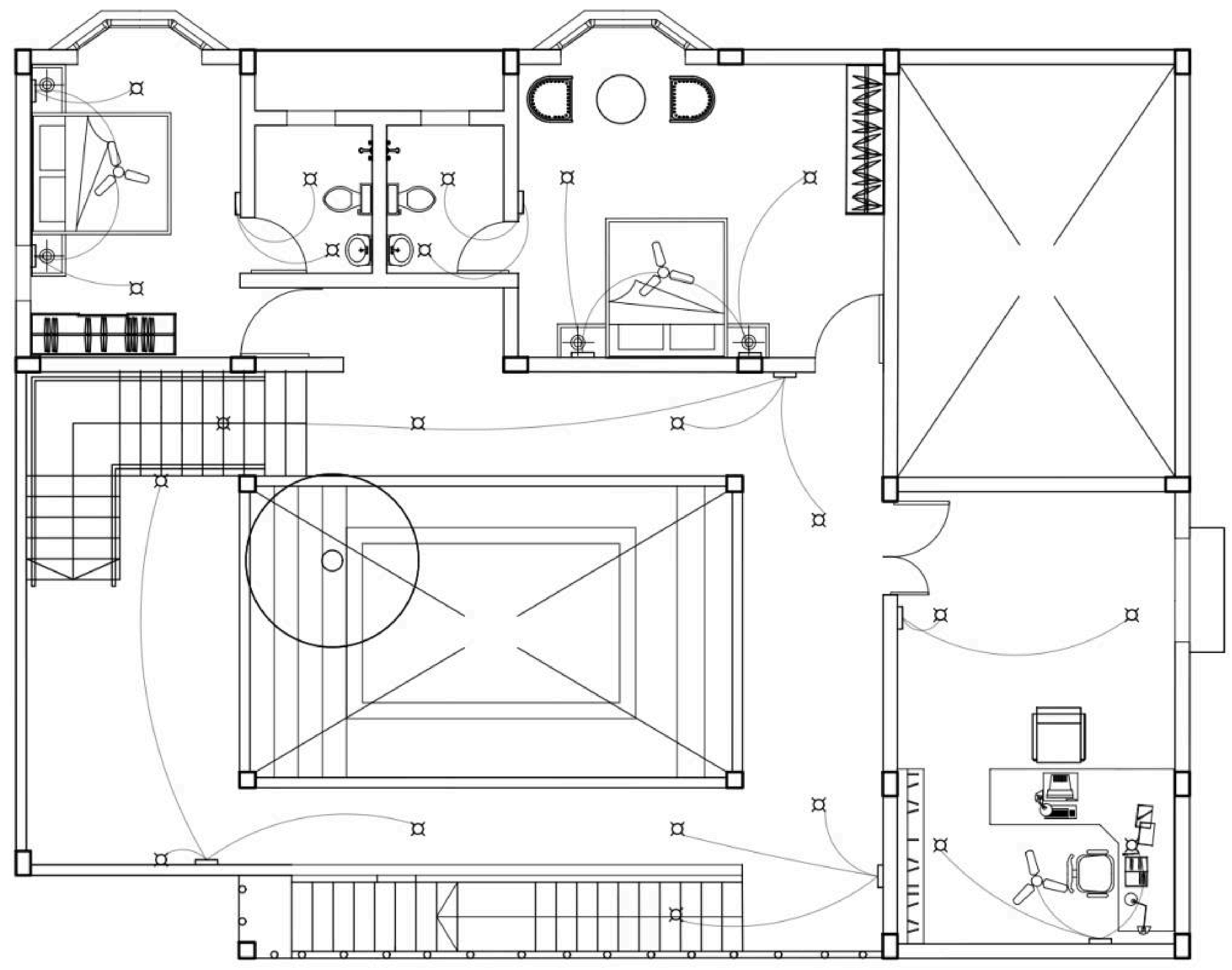


Engineering and Operations

Electrical layout:



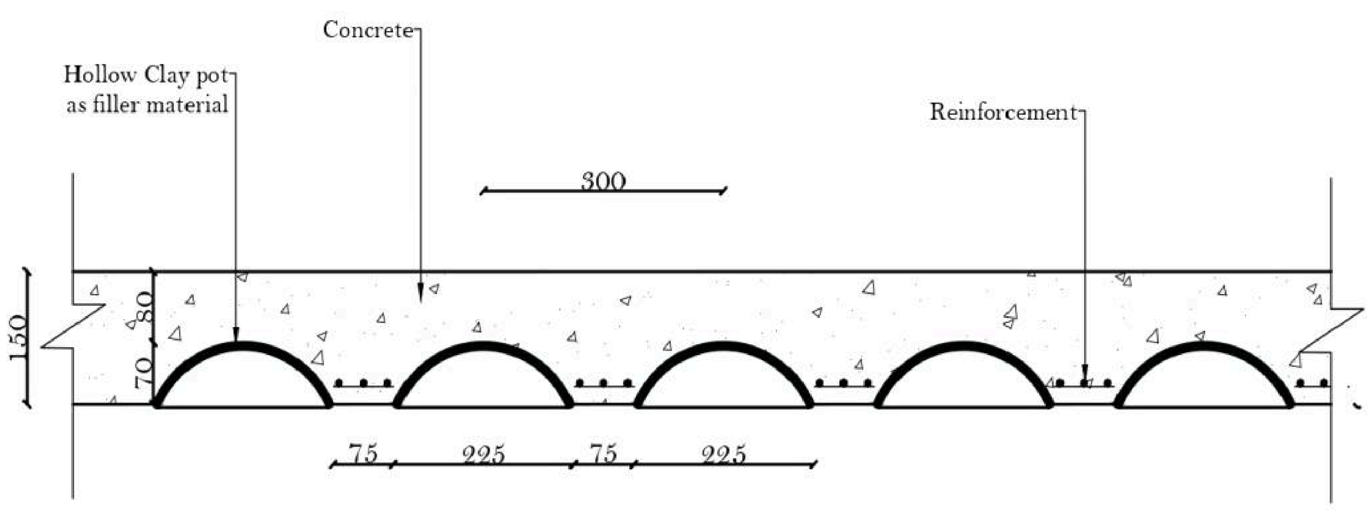
GROUND FLOOR PLAN



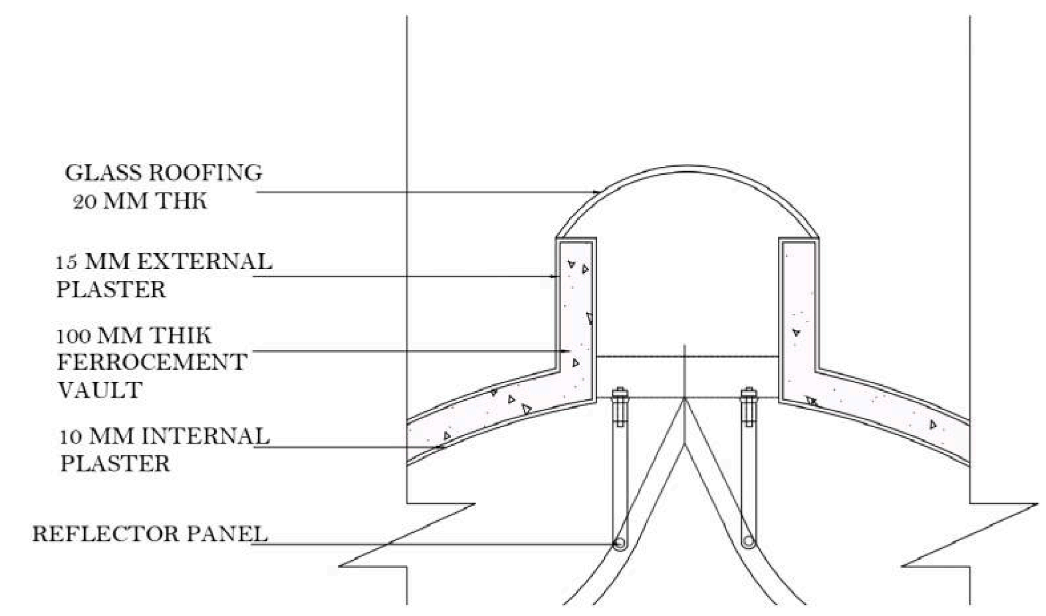
FIRST FLOOR PLAN

Structural details:

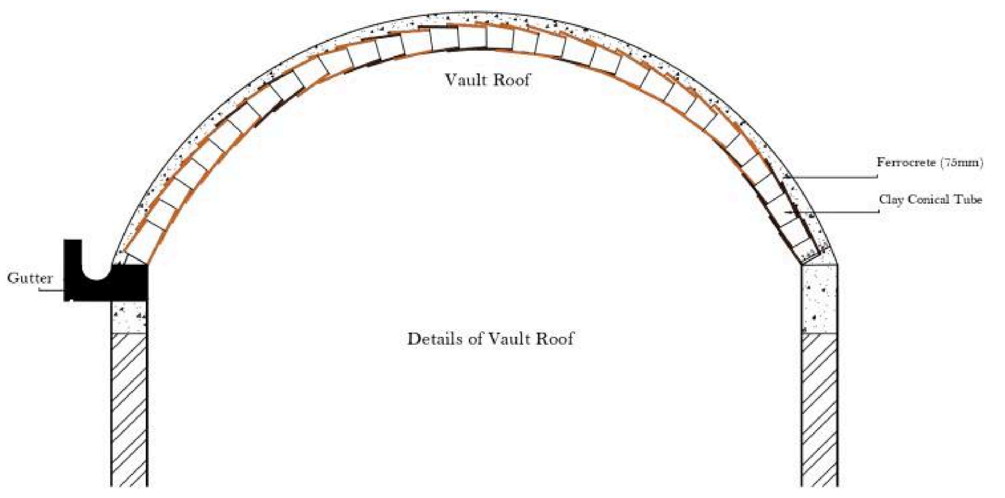
- Light weight filler slabs of 150 mm thick with earthern pots of thickness 10mm as filler materials been used which saves concrete and accounts to 15% of total cost.
- 5 mm thick green oxide flooring is above slab.
- The masonry construction is improved by using larger blocks which uses less mortar.

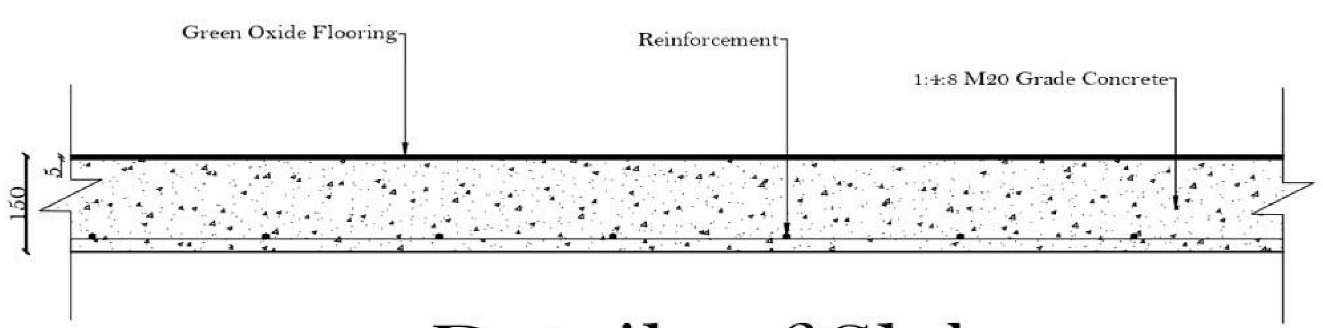


Filler slab



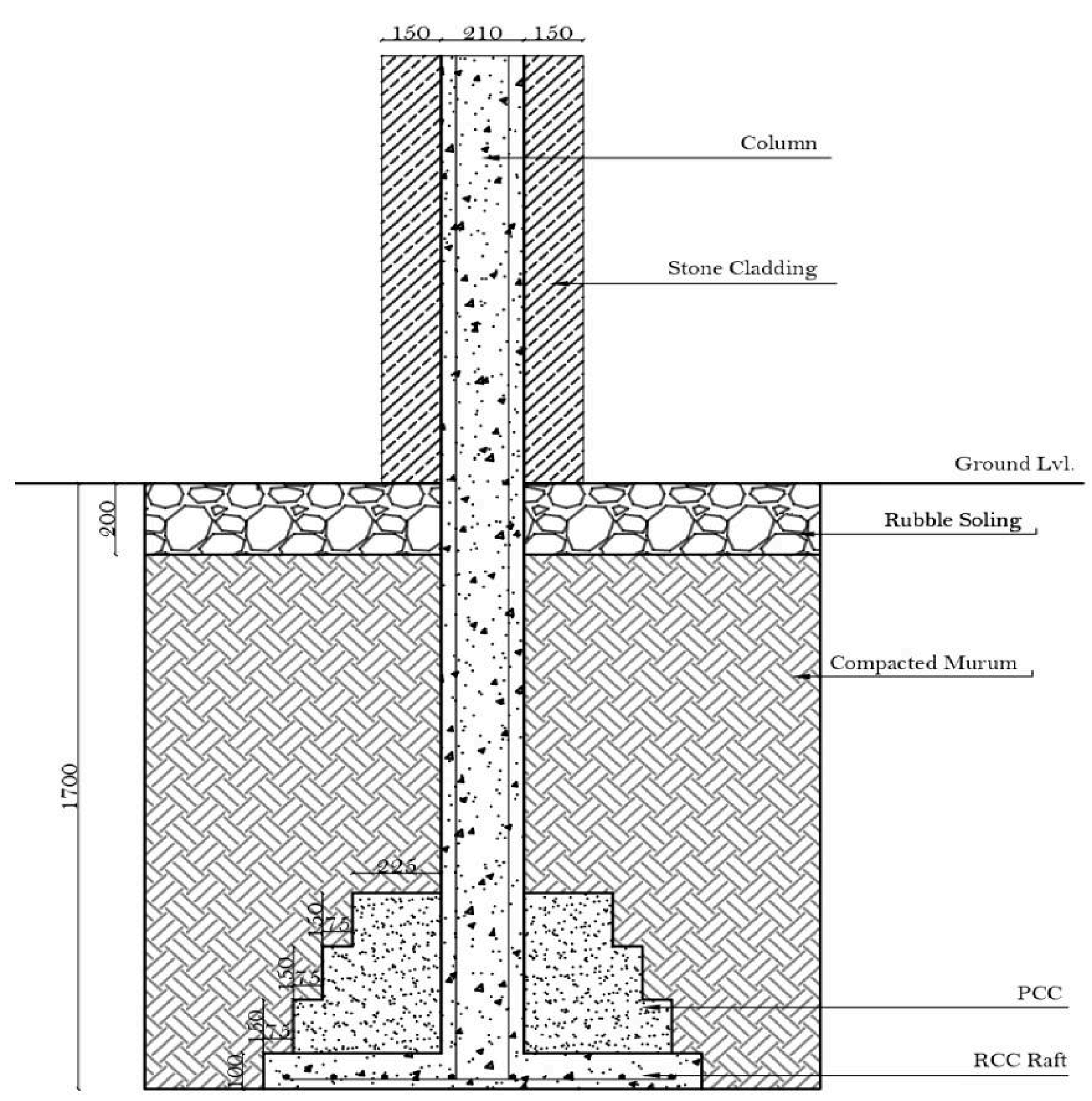
Skylight details





Details of Slab

slab details



footing details

INNOVATION

Purpose: To provide the user with detailed and real-time data reports on the performance of electricity generating and other building services. It is made available to the user through a smart app. The app helps save energy by using features like switching on and off of all the electrical appliances with ease and ensures smooth working of all building services by alerting to the need of maintenance when needed. It also educates the user about the various kinds of services and their effectiveness in saving energy and cost.

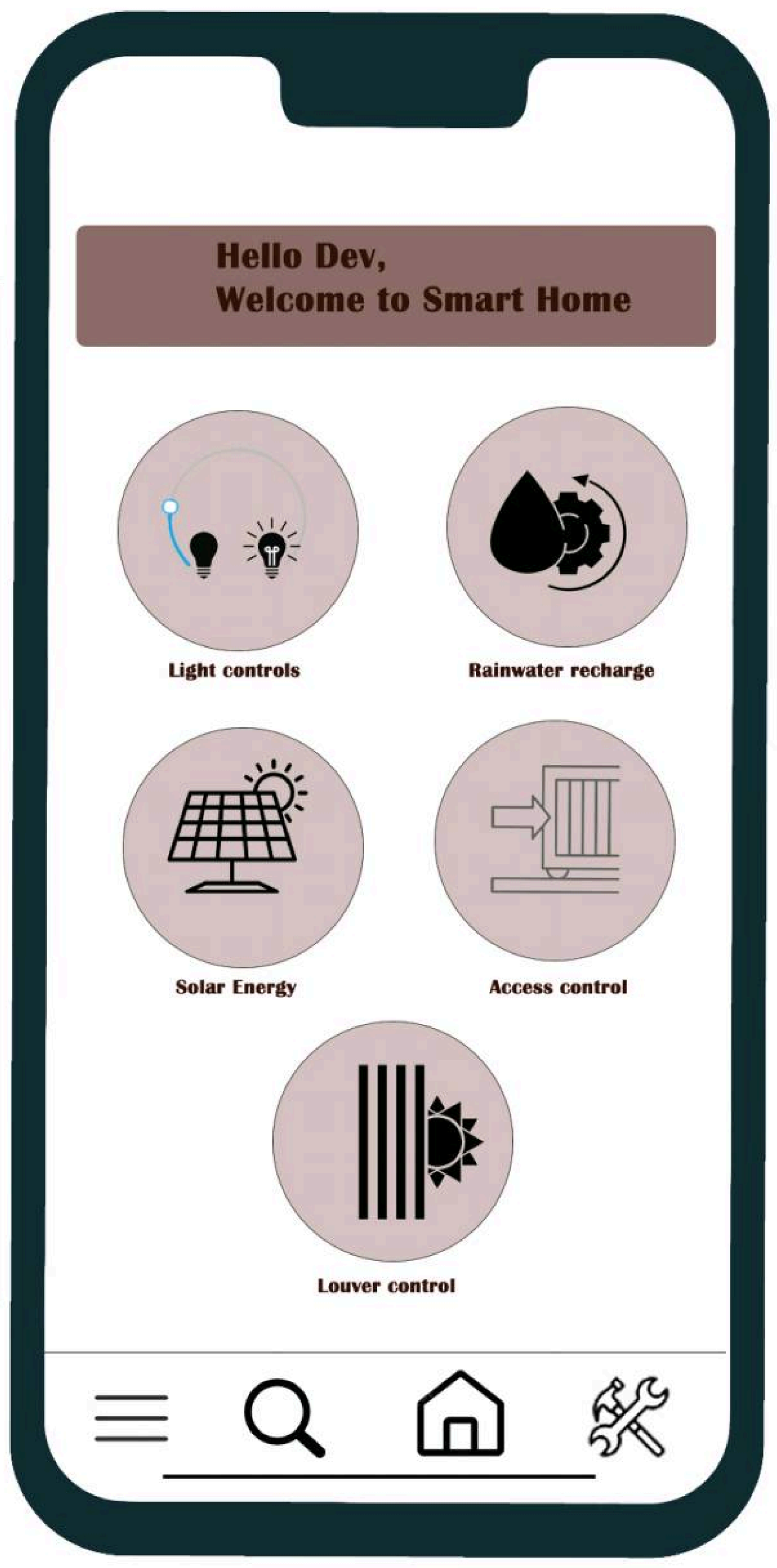


Fig. No. 00: Homescreen Interface of the Application.

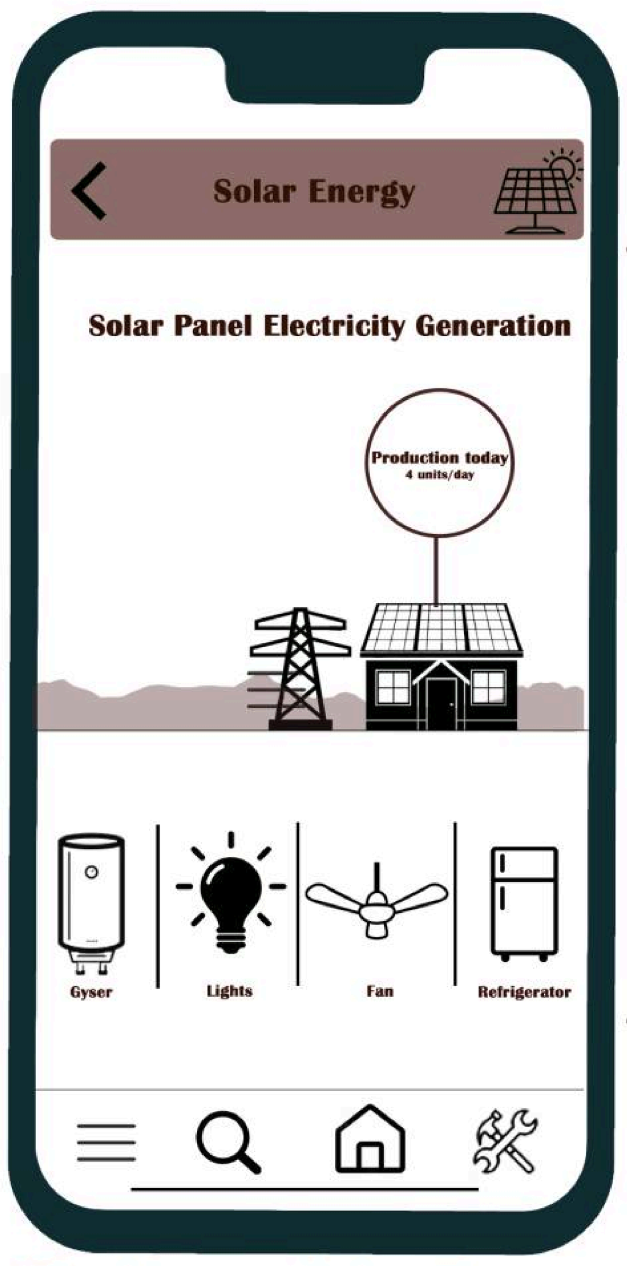


Fig. No. 00: Solar Energy Interface

The app is equipped to show up to date performance of building systems like:

- Electricity generated by solar panels
- Status of invertor on its energy capacity.
- Water levels in tanks.
- Water recharged through rainwater harvesting.

The app also allows you to control smart technologies installed in the house such as:

- Access to door cam
- Speaker and opening,
- Closing of the main gate to control access.
- Turning on and off of light fixtures in the house.
- Adjusting the angle of louvers manually or turning on the sun tracking option.

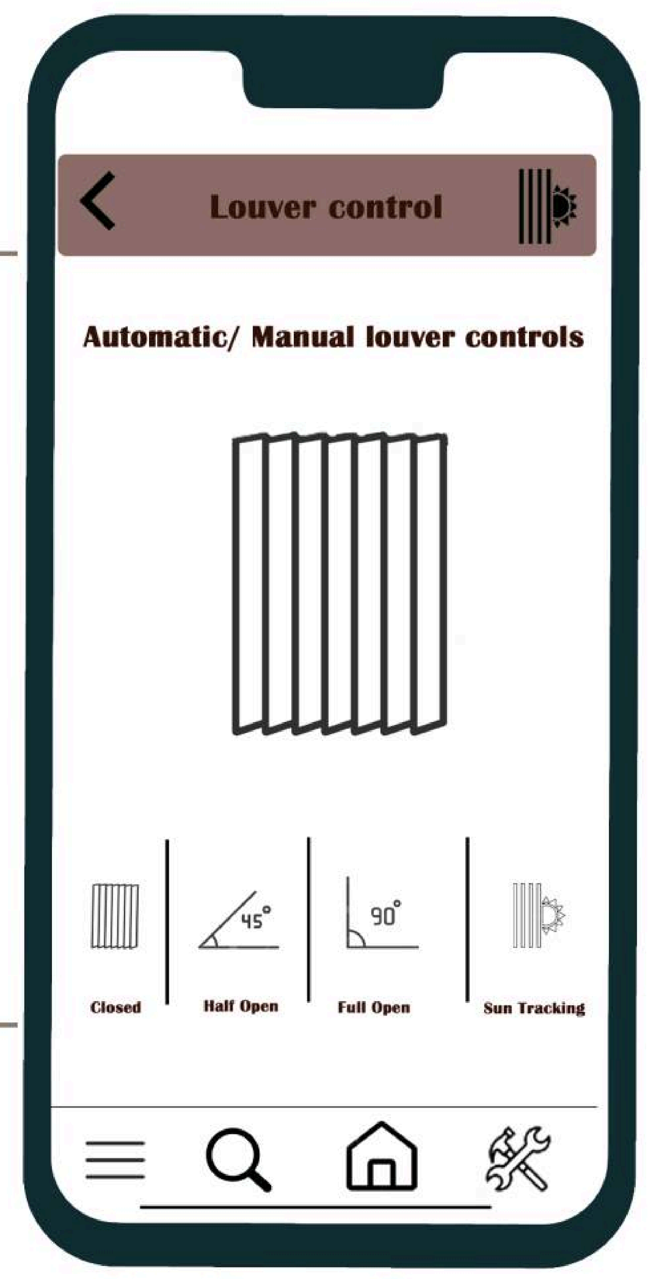


Fig. No. 00: Louver Control Interface

INNOVATION

Purpose: To provide the user with detailed and real-time data reports on the performance of electricity generating and other building services. It is made available to the user through a smart app. The app helps save energy by using features like switching on and off of all the electrical appliances with ease and ensures smooth working of all building services by alerting to the need of maintenance when needed. It also educates the user about the various kinds of services and their effectiveness in saving energy and cost.

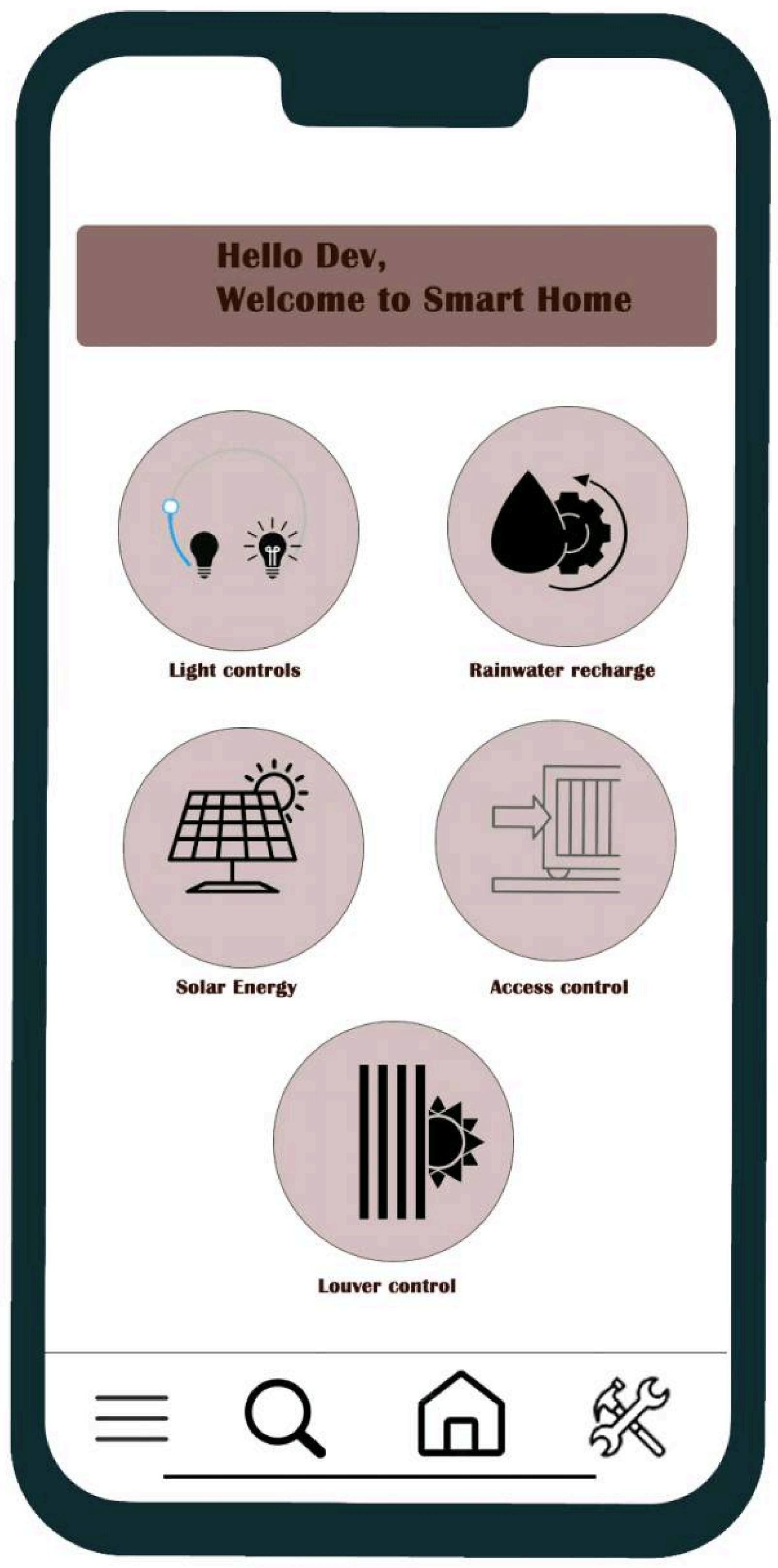
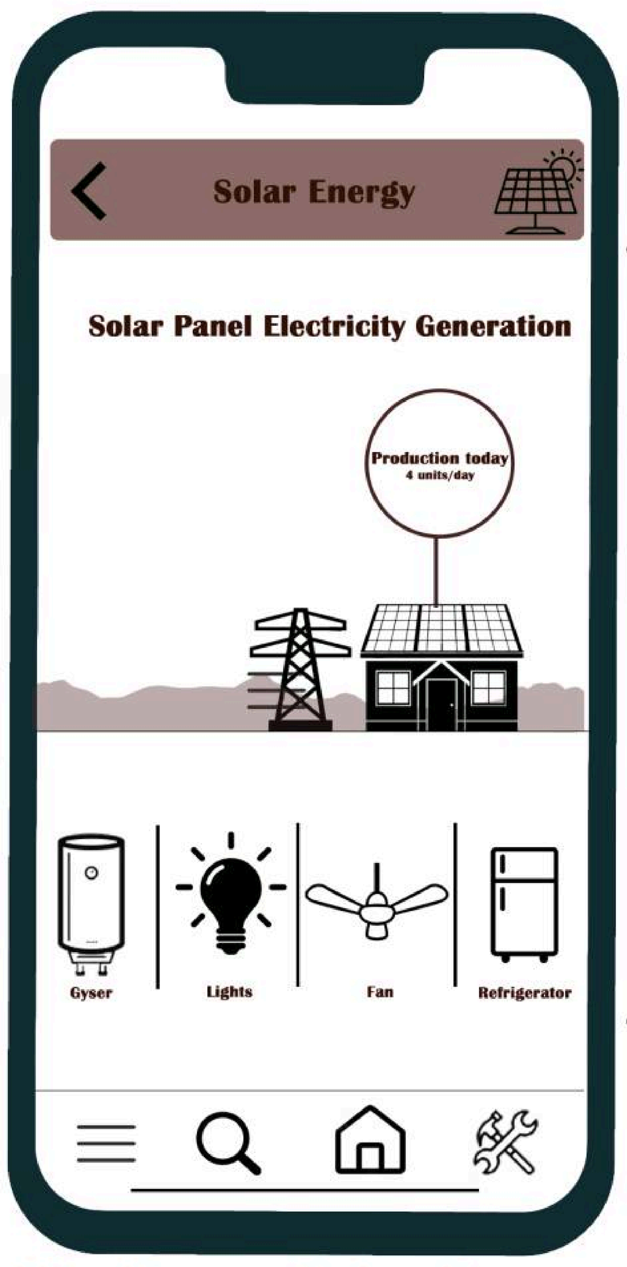


Fig. No. 00: Homescreen Interface of the Application.



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- Speaker and opening,
- Closing of the main gate to control access.
- Turning on and off of light fixtures in the house.
- Adjusting the angle of louvers manually or turning on the sun tracking option.

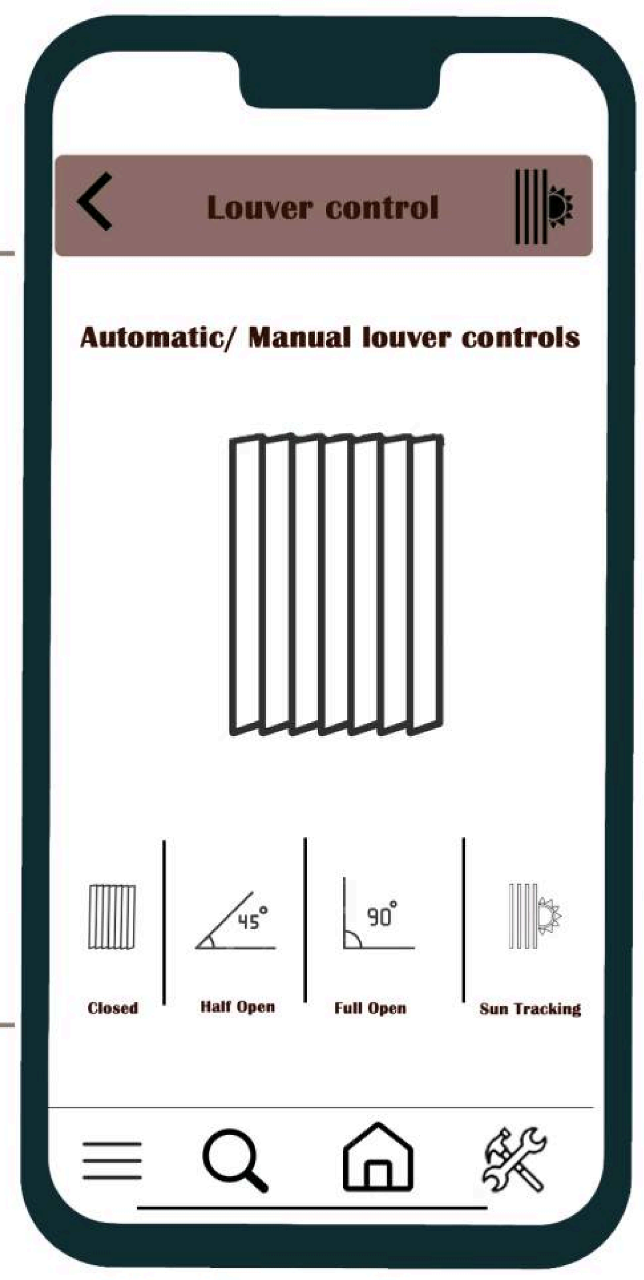
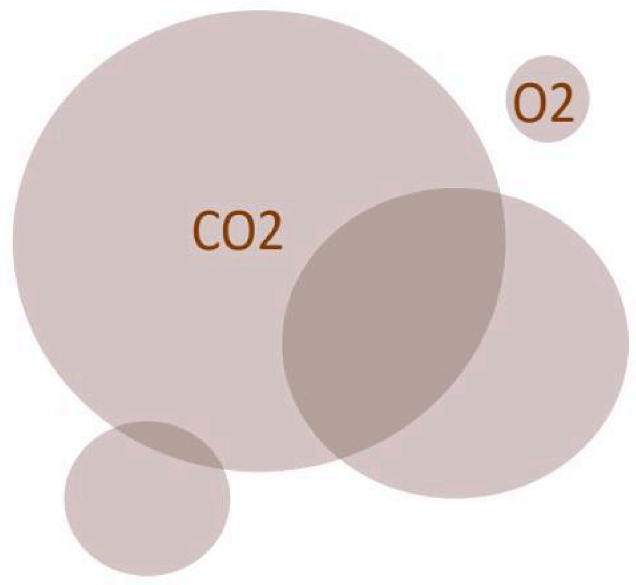
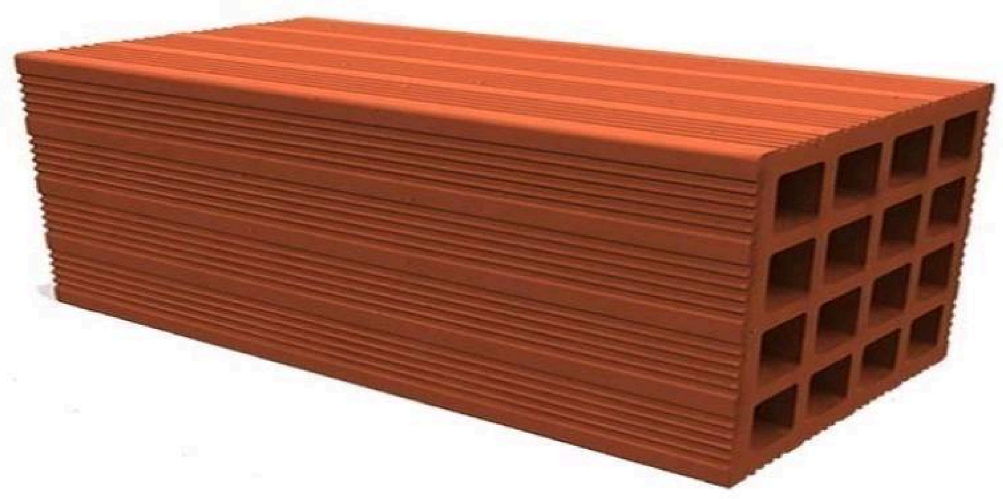


Fig. No. 00: Louver Control Interface

Embodied Carbon

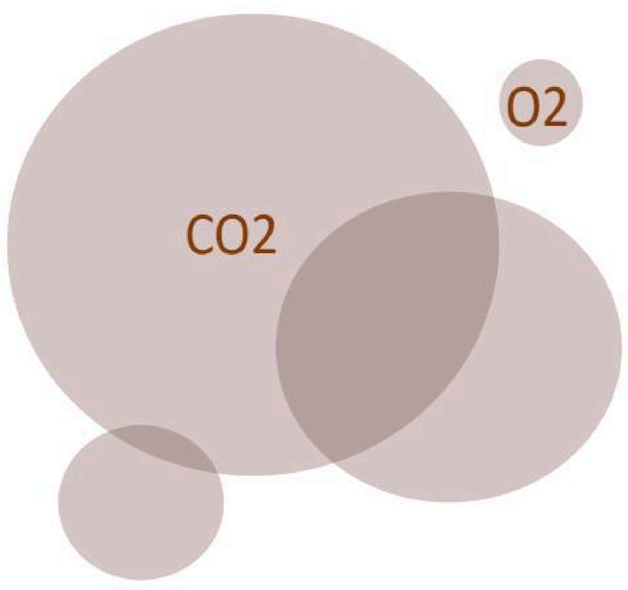


• Production of construction material, transportation of materials, plays a major role in contributing towards carbon emission.
• Concrete and burnt bricks require high energy during the process of manufacturing which releases high amount of carbon.
• To reduce the carbon emission, fly ash can be mixed with concrete.
• Normal concrete has carbon footprint around 0.25 per kg. when about 24% of fly ash is added to the cement the footprint is reduced to 0.14 per kg.
• Burnt bricks require high energy during construction and manufacturing.
• Embodied energy for one brick is 0.81 per piece, the carbon footprint per kg is 0.06 which is very high. Also, transportation of these bricks contributes towards release of carbon dioxide.
• The blocks are made with mix of fairly dry inorganic subsoil non expensive clay and aggregate along with cement binder mixed with fly ash.
CSEB is locally available in alibaug region. A shop is located 20km away from the site so average carbon dioxide emission is 1-2 kg
• As Compressed stabilized earth blocks are made from natural material, the carbon emission during its manufacturing is very less as compared to burnt bricks.
One tonne of bamboo can store around 140 kg carbon dioxide.
Around 250 kg CO_2 can be reduced from atmosphere in one cubic meter.
Carbon footprint of bamboo is 0.074



Hollow clay

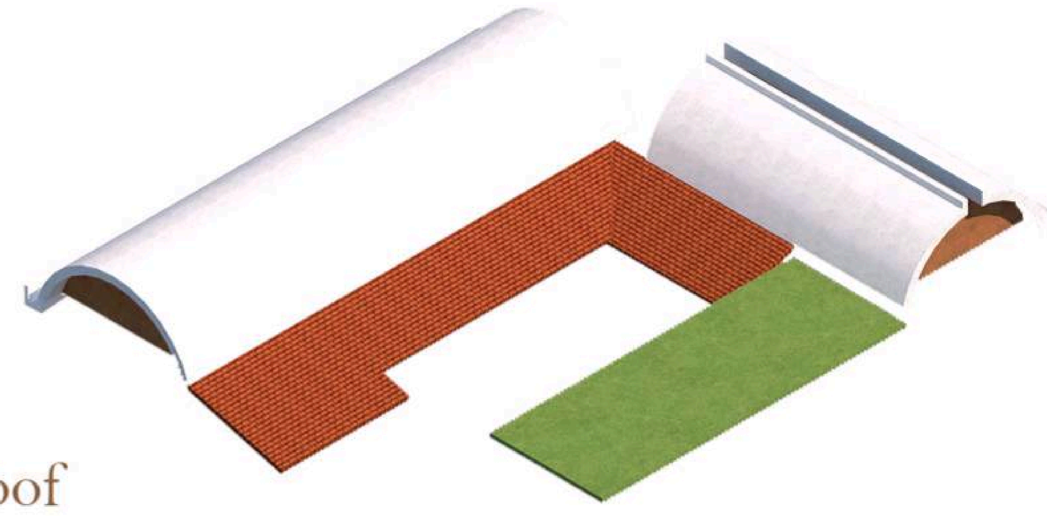
• These blocks release small amount of carbon during manufacture and for rest of the construction they release a constant amount of carbon dioxide.
• Embodied energy for compressed stabilized earth blocks per piece is 0.41 and carbon footprint is 0.026 per piece.
• The two materials are compared carbon footprint and embodied carbon are reduced by 84% and 49% respectively for compressed stabilized earth blocks.
• The overall carbon emission of the structure is reduced by 52% using sustainable compressed stabilized earth blocks.
• Using of natural building material such as compressed stabilised earth blocks which has high thermal capacity, water vapour permeability can help in natural cooling.
• The mangroves in this region store three to five times as much carbon per acre as other tropical forest.



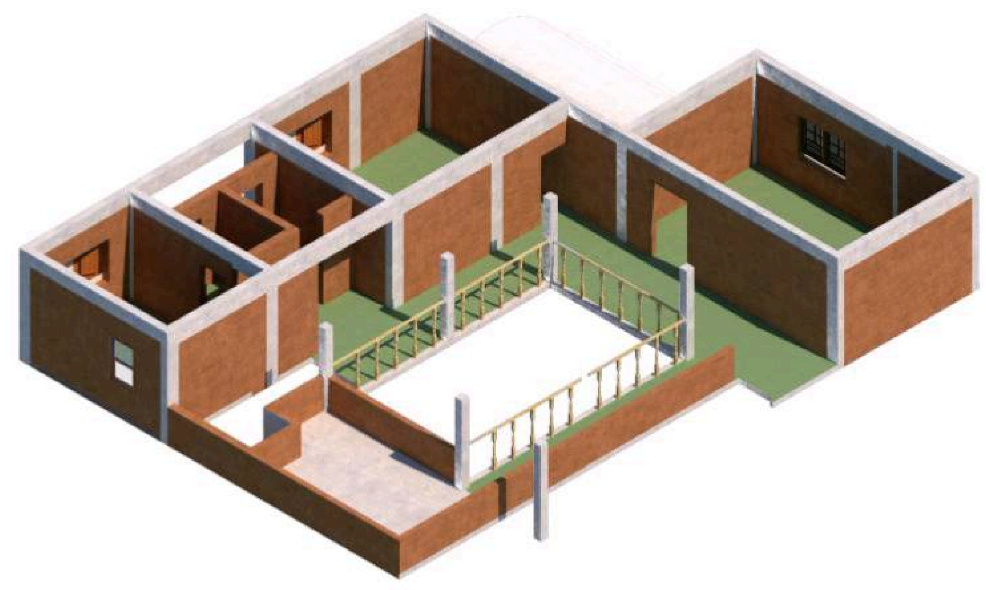
APPENDIX

Architectural Design

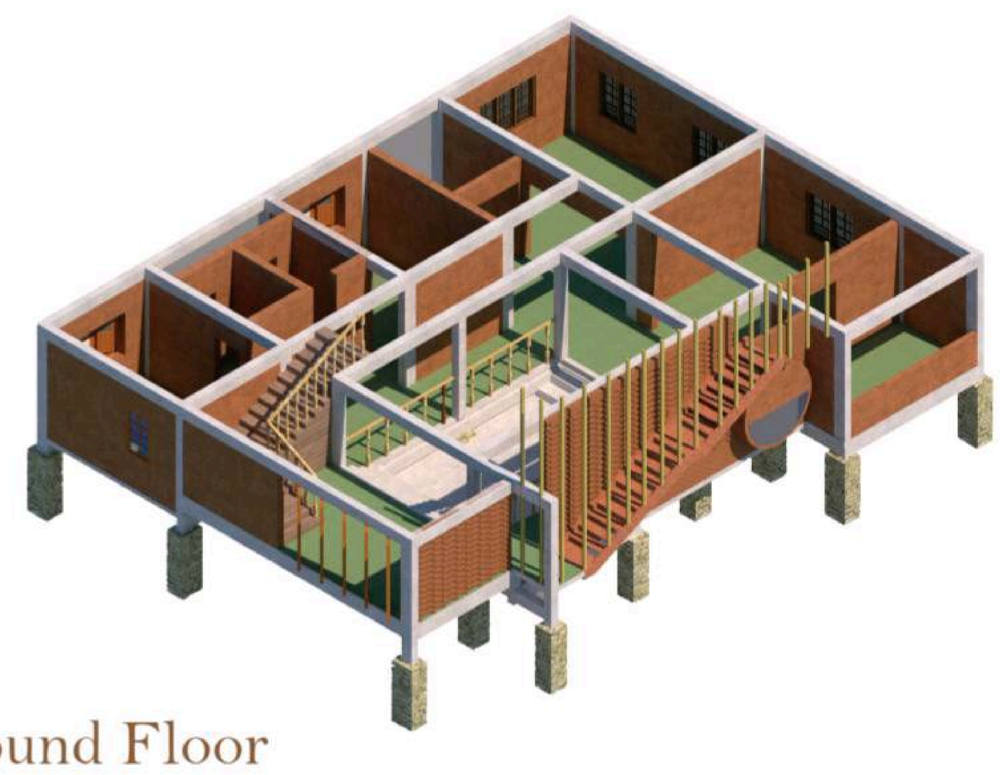
Fig. 2 - Site Plan



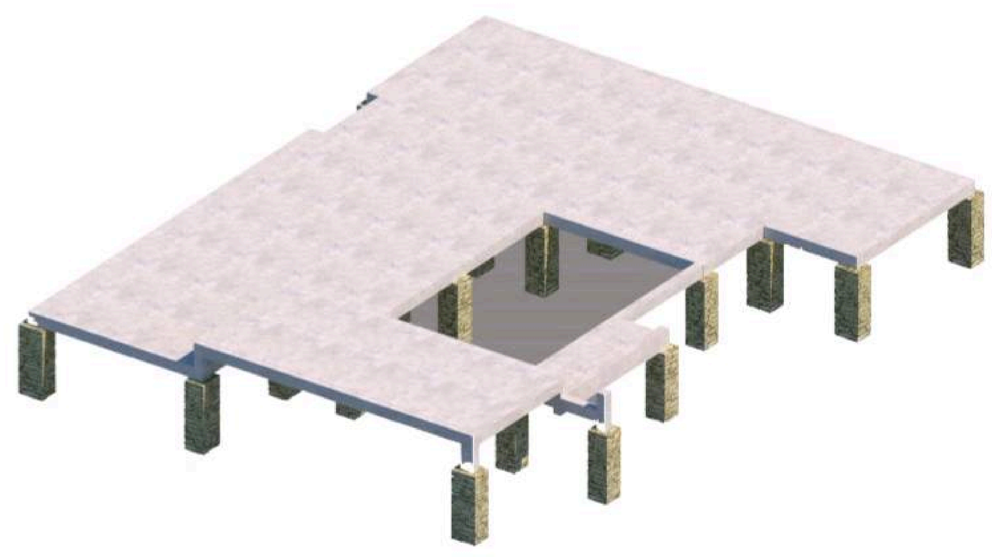
Roof



First Floor



Ground Floor



Stilt Plan

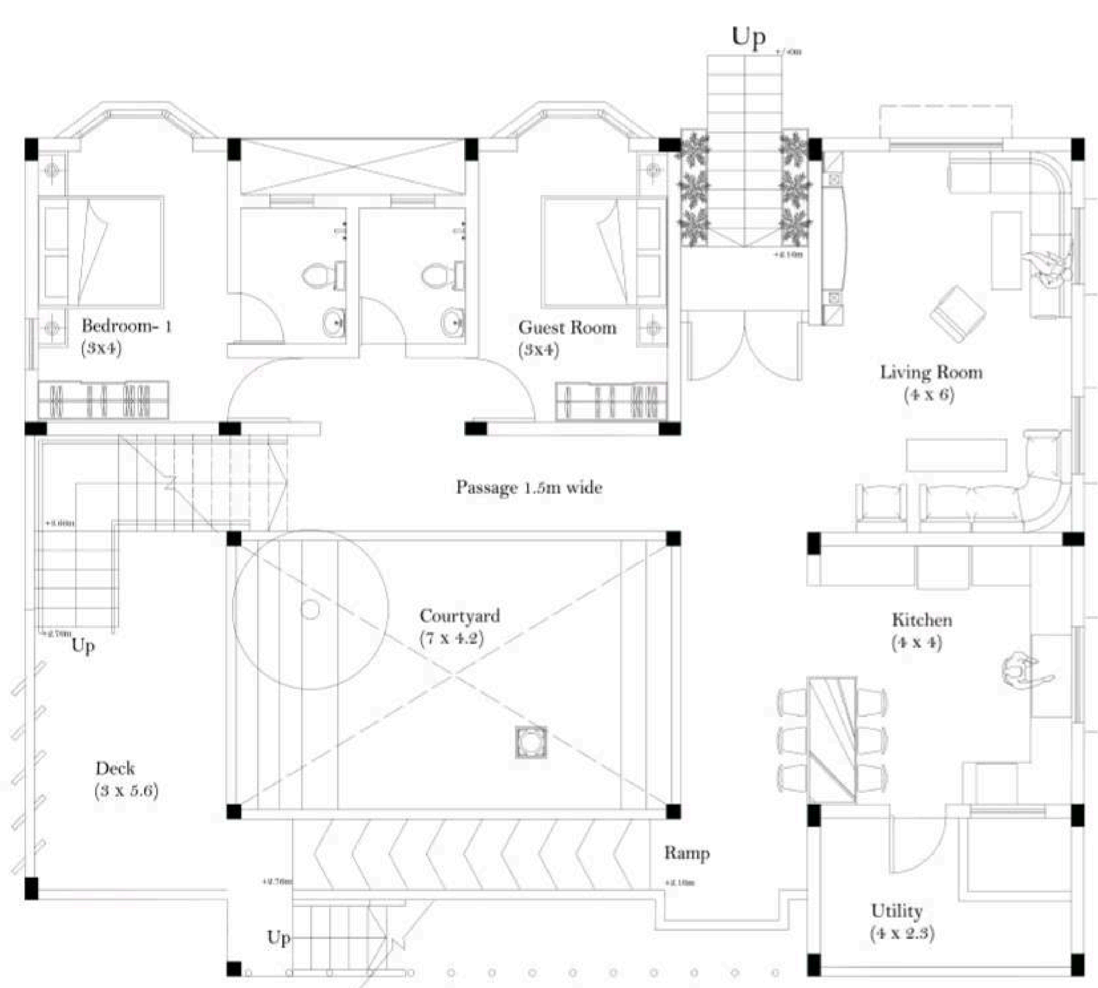


Fig.2 - Ground Floor Plan

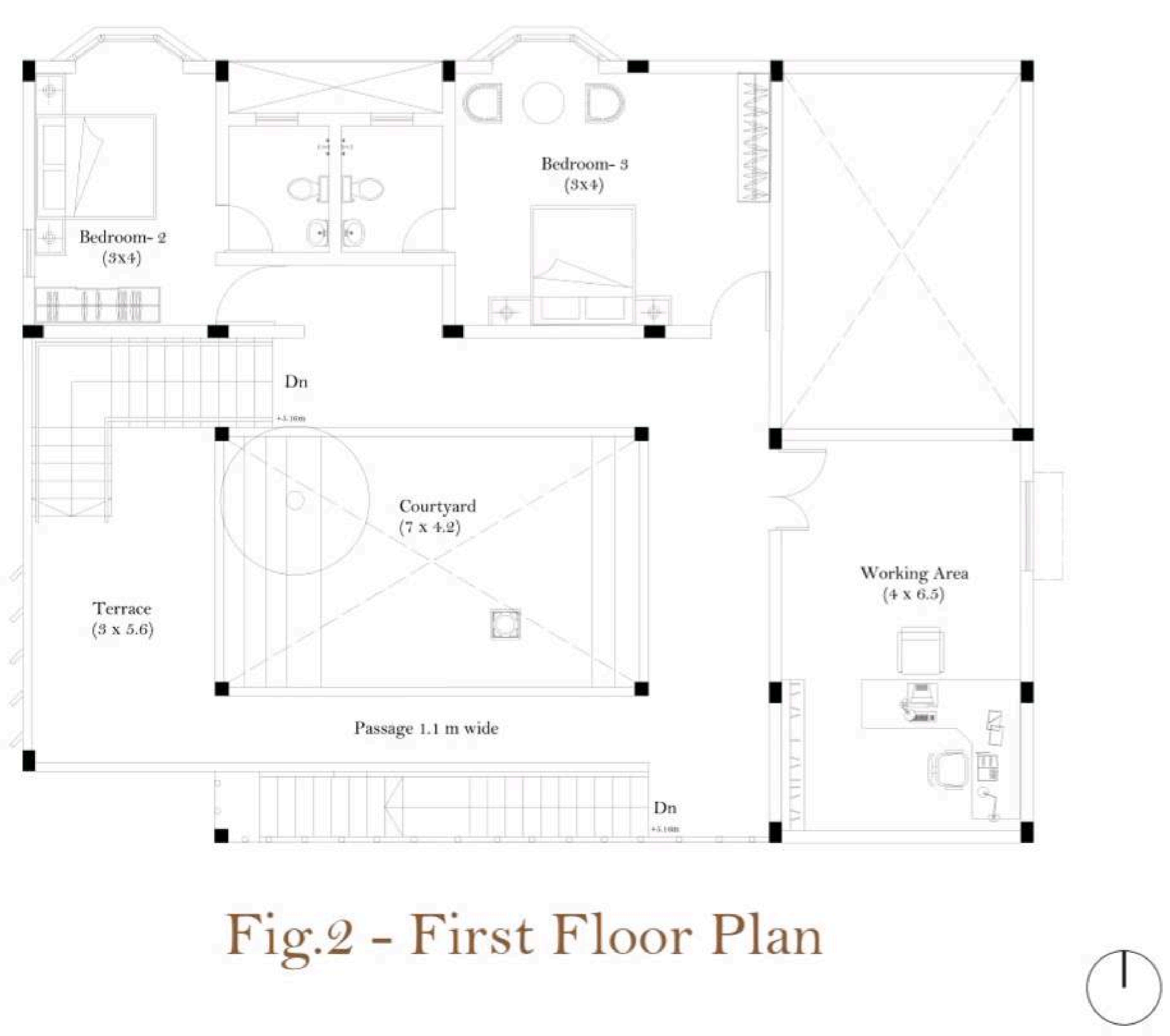


Fig.2 - First Floor Plan

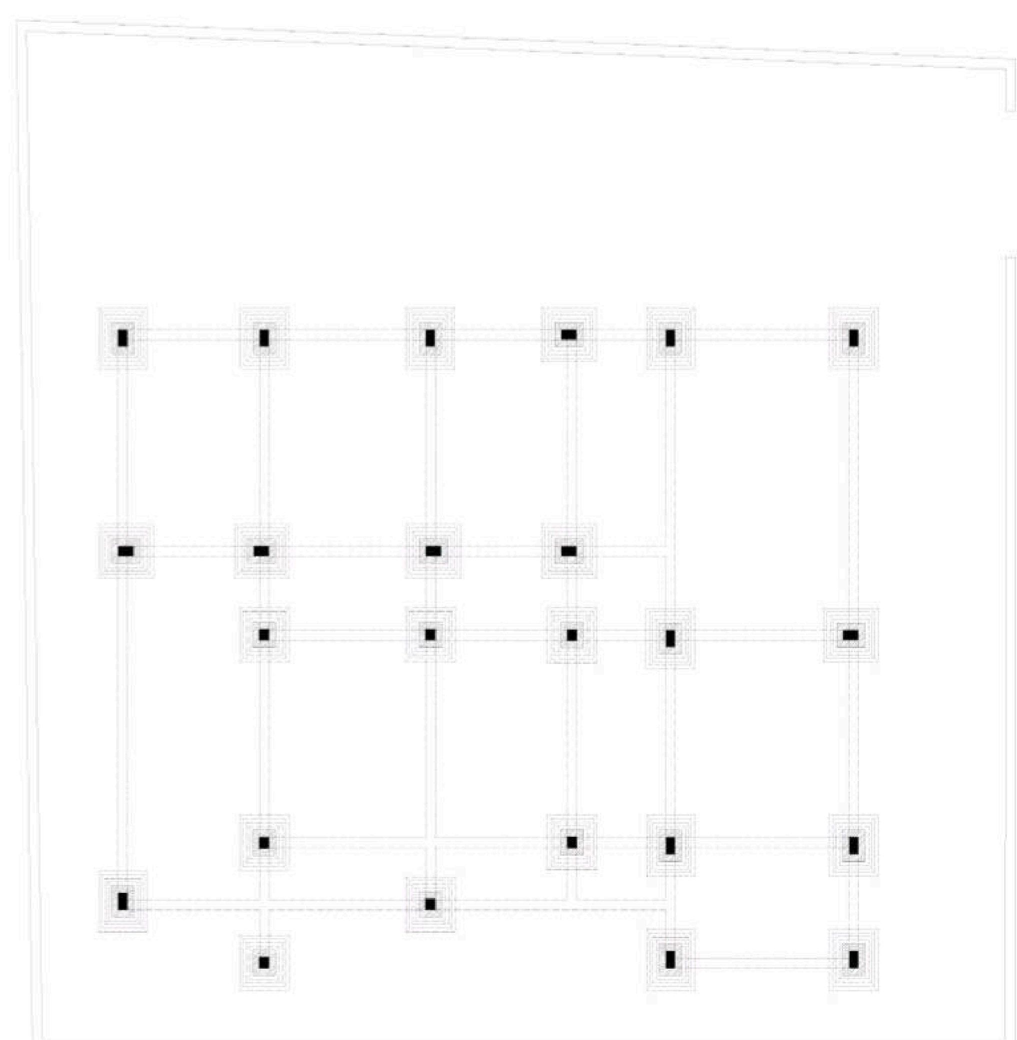


Fig.2 - Stilt Level plan

Sections

Details

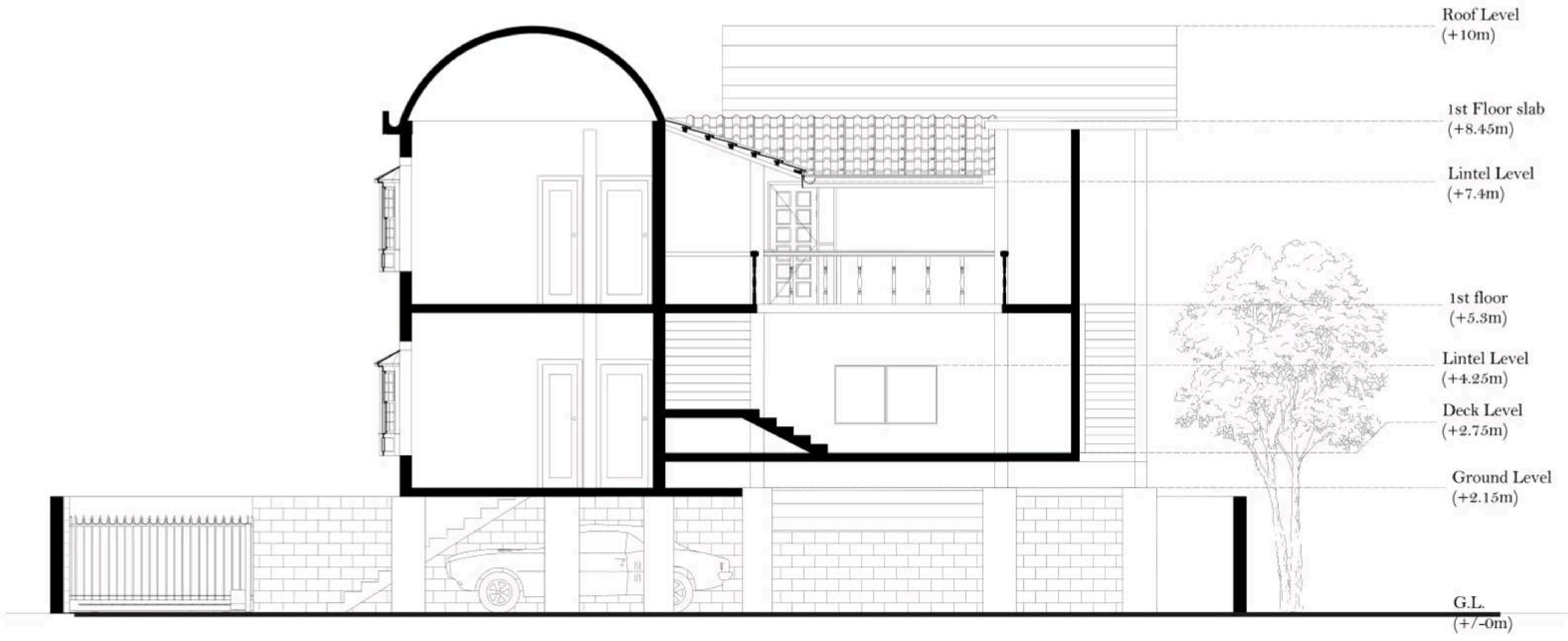


Fig. 2 - Section -AA'

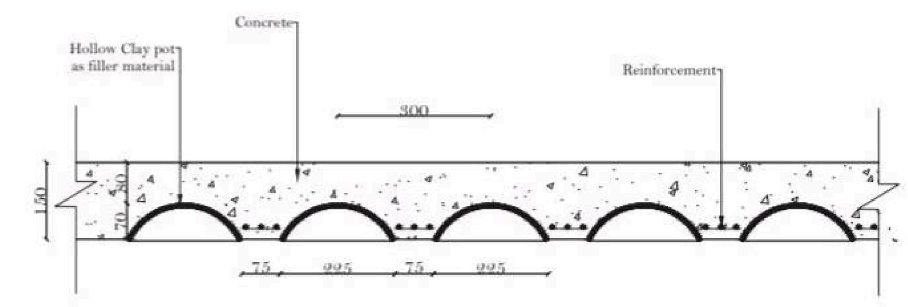


Fig. 2 - Filler Slab Detail

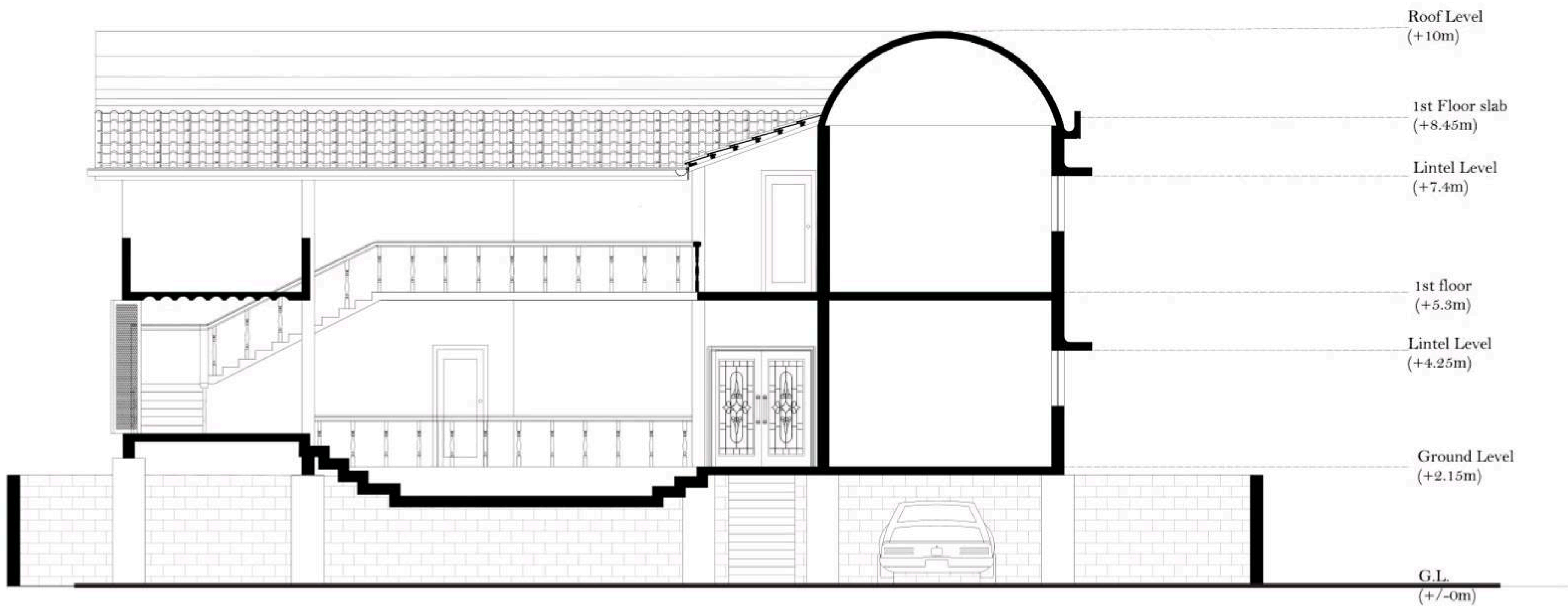


Fig.2 - Section BB'

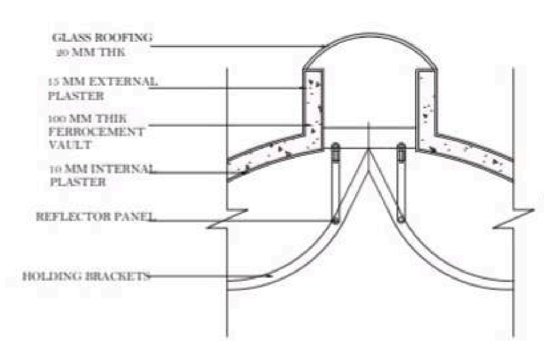


Fig. 2 - Skylight Detail

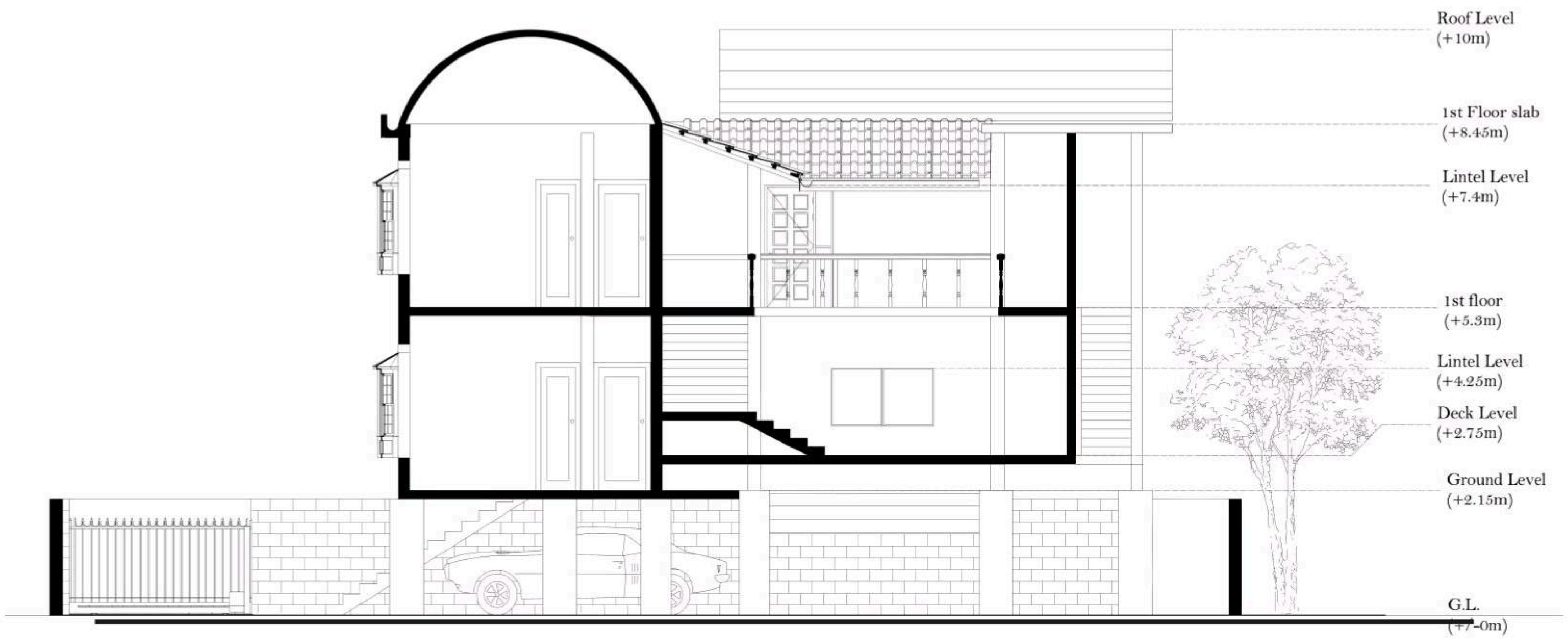


Fig.2 - Section CC'

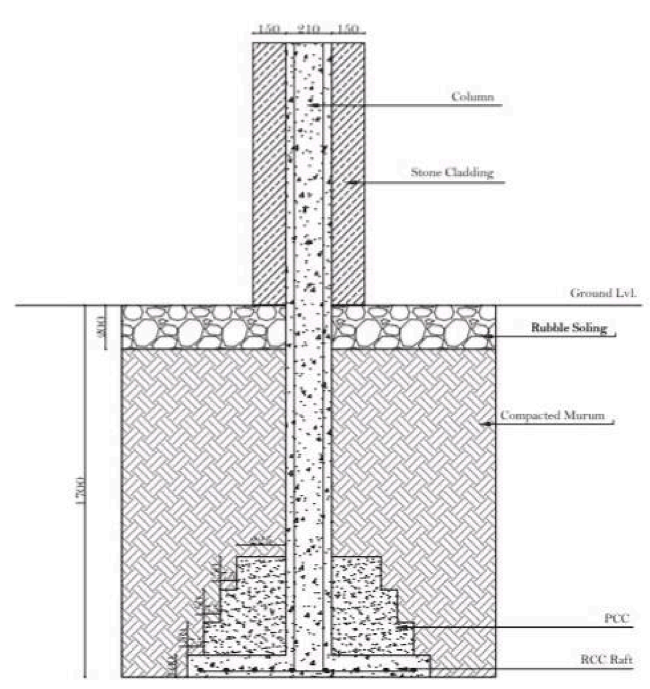


Fig. 2 - Footing Detail

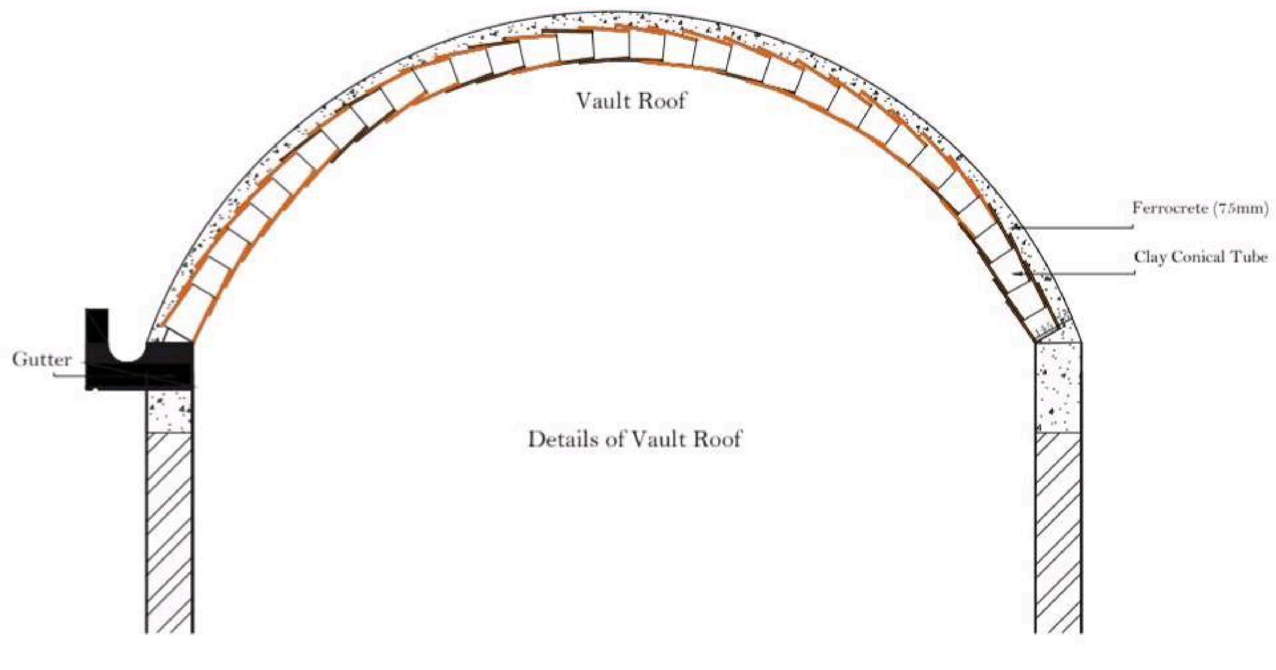
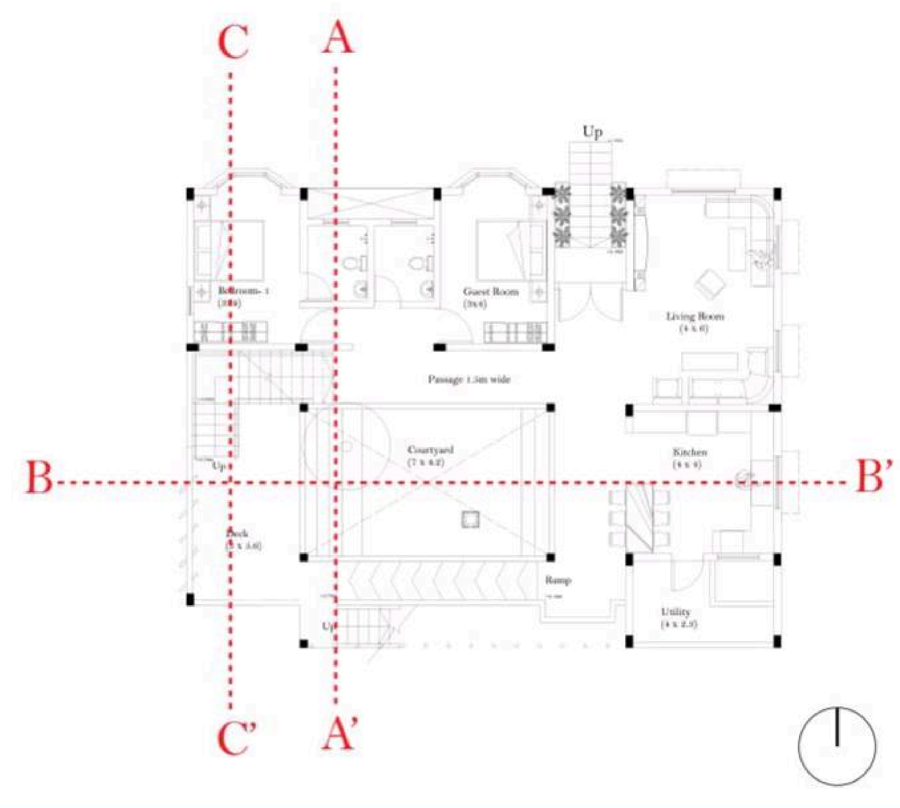


Fig. 2 - Vault Detail



Elevations

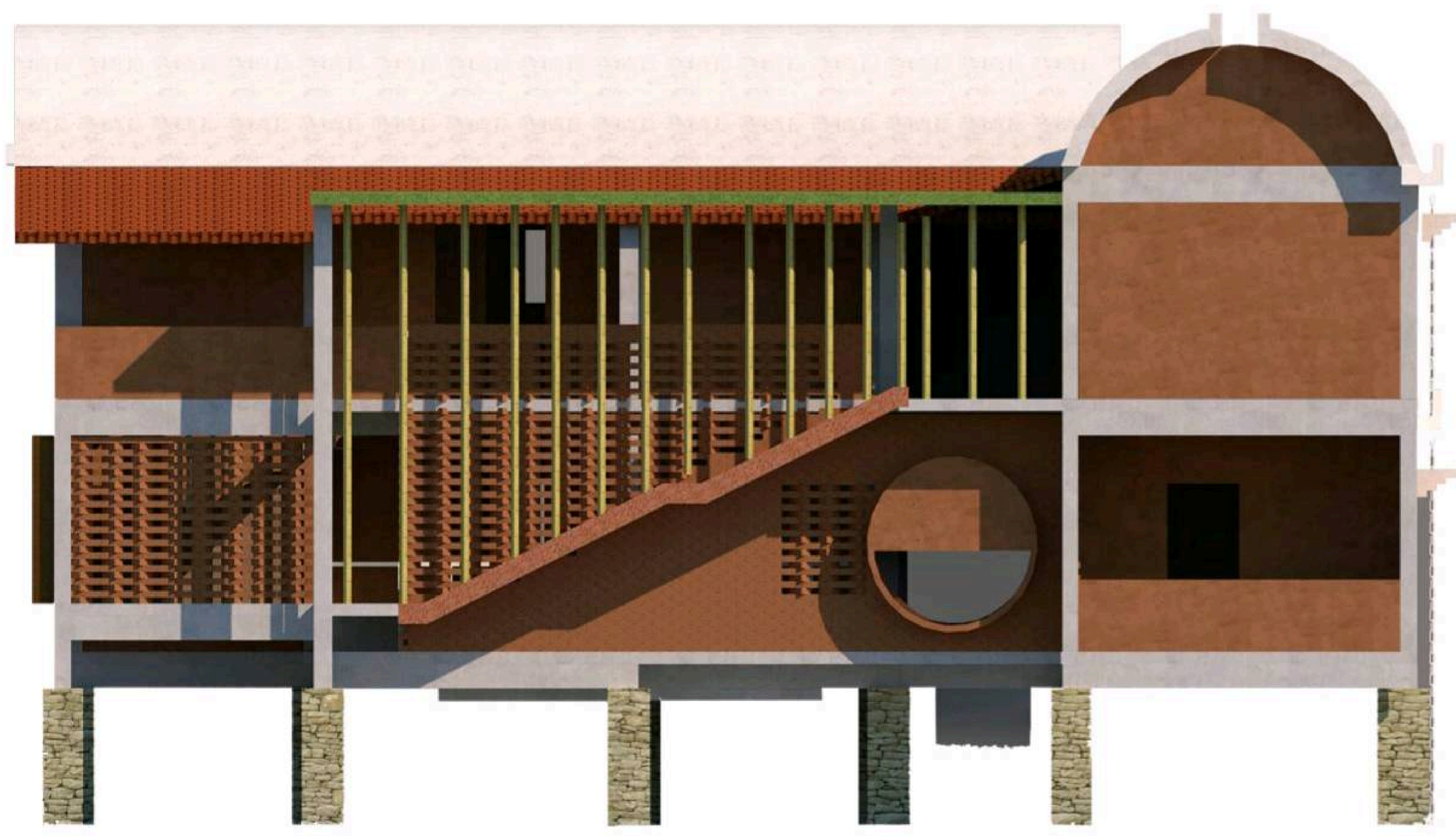


Fig.2 - South Side Elevation

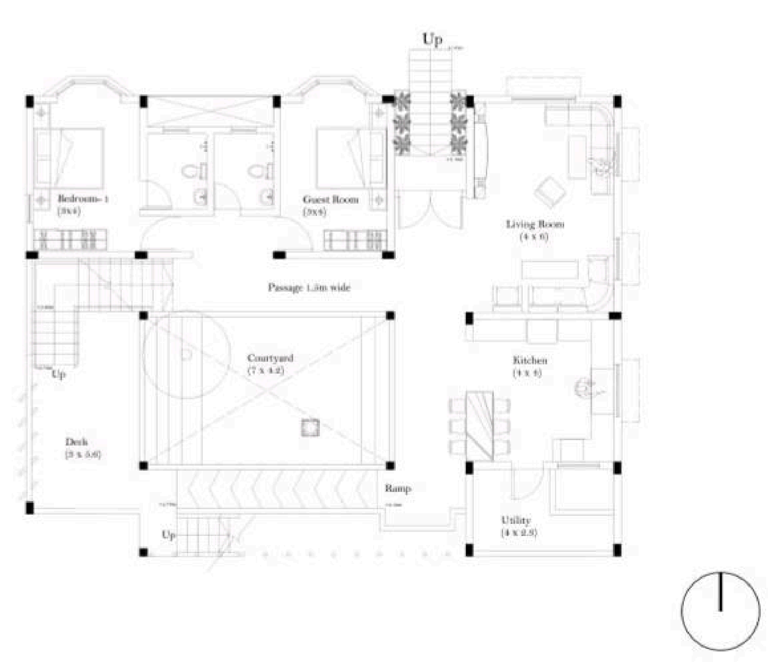
Fig.2 - East Side Elevation

Fig. 2 - West Side Elevation

Material Palette

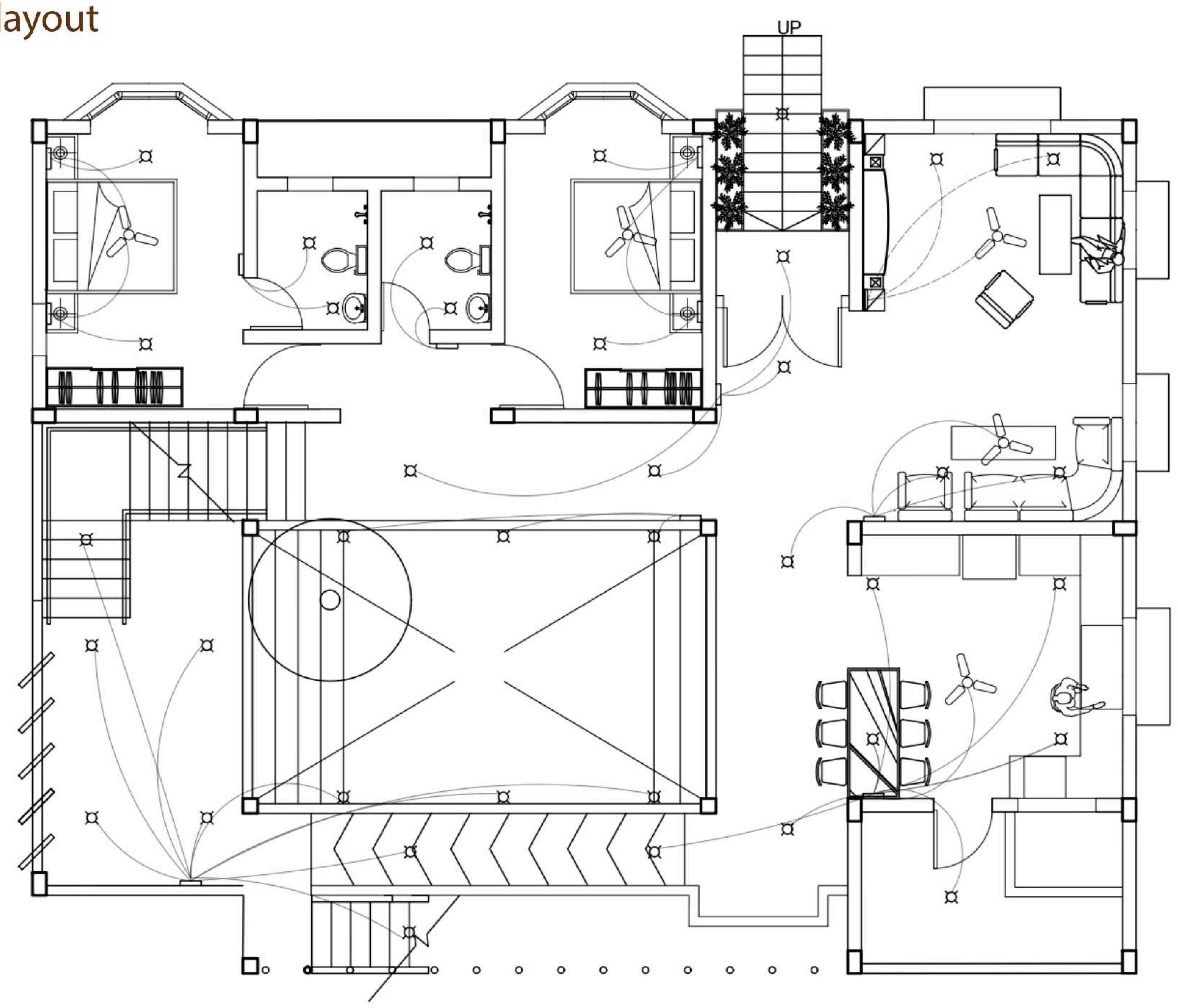
The following materials were chosen for the interior material palette. Green oxide flooring was chosen along with timber furniture due to their sustainable tendencies.

Fig. 2 - Material Palette

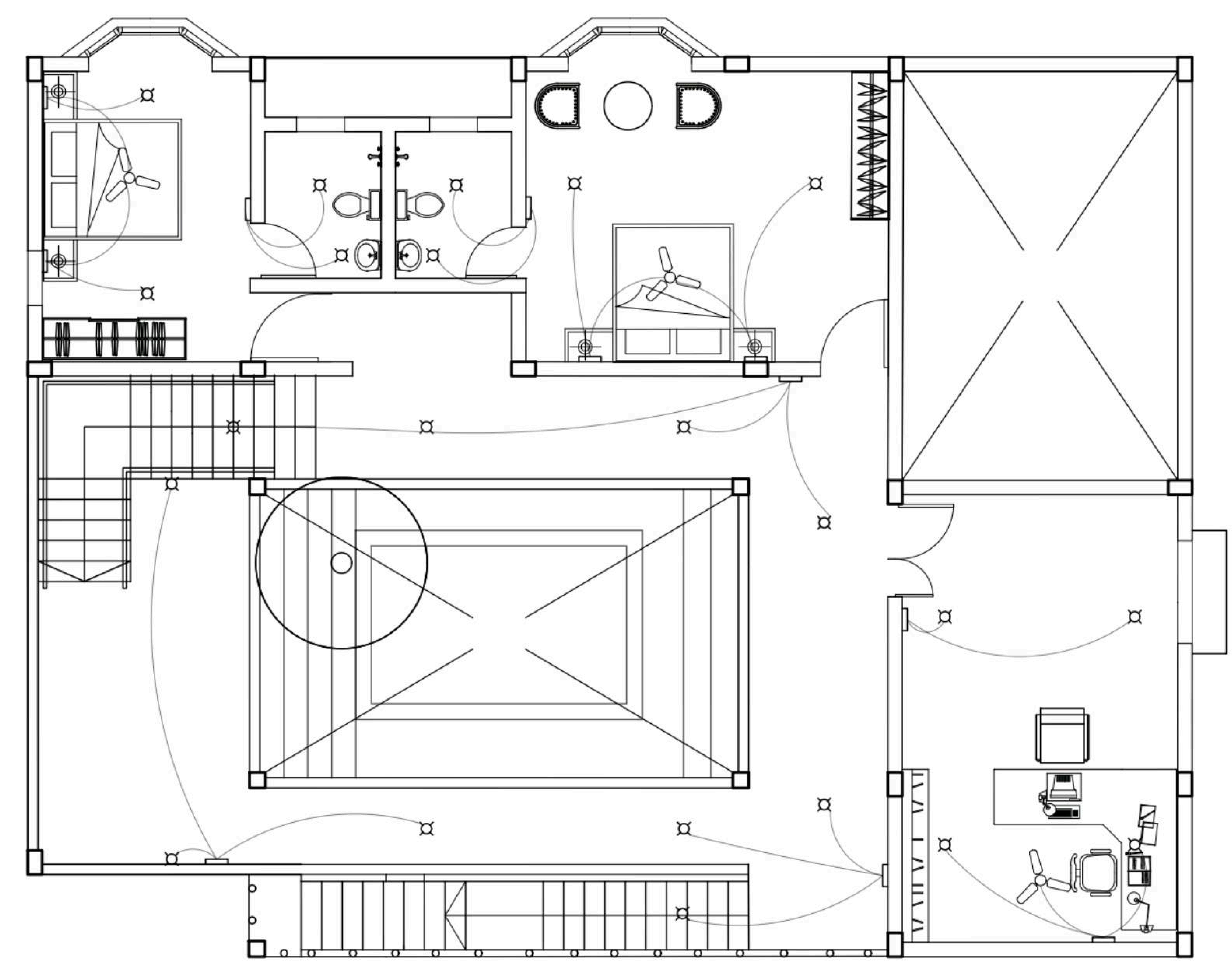


Appendix

Electrical layout



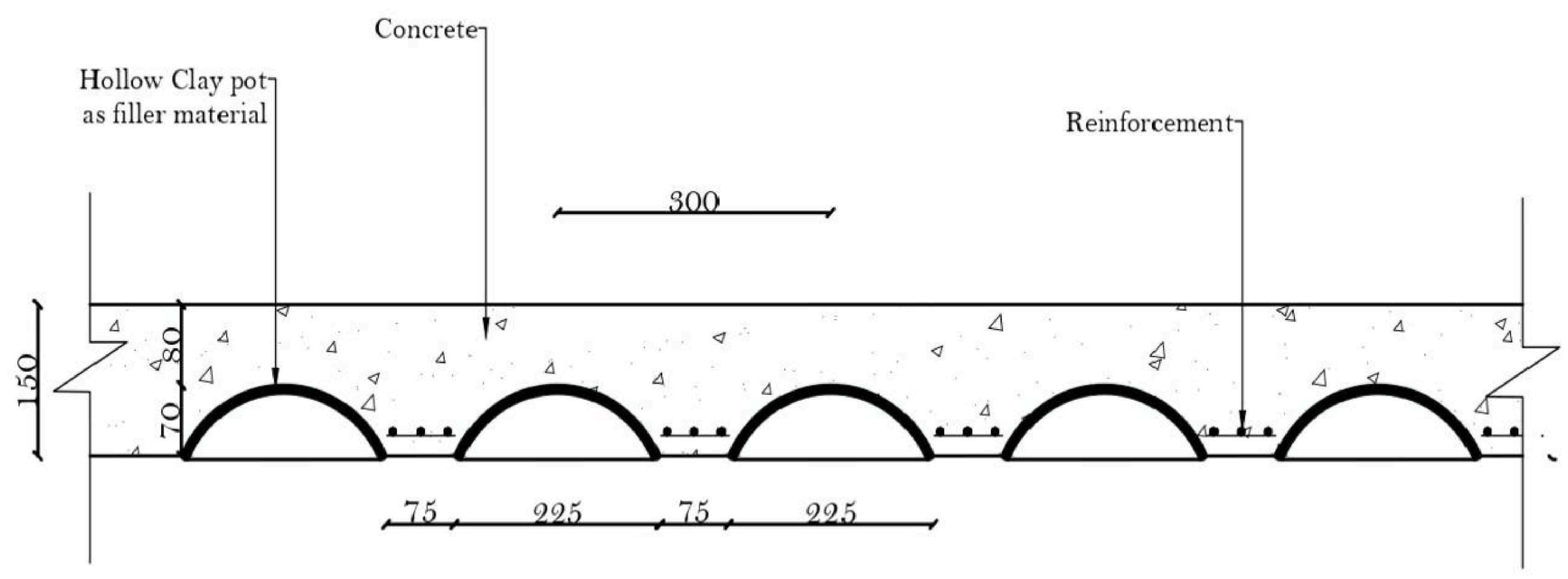
GROUND FLOOR PLAN

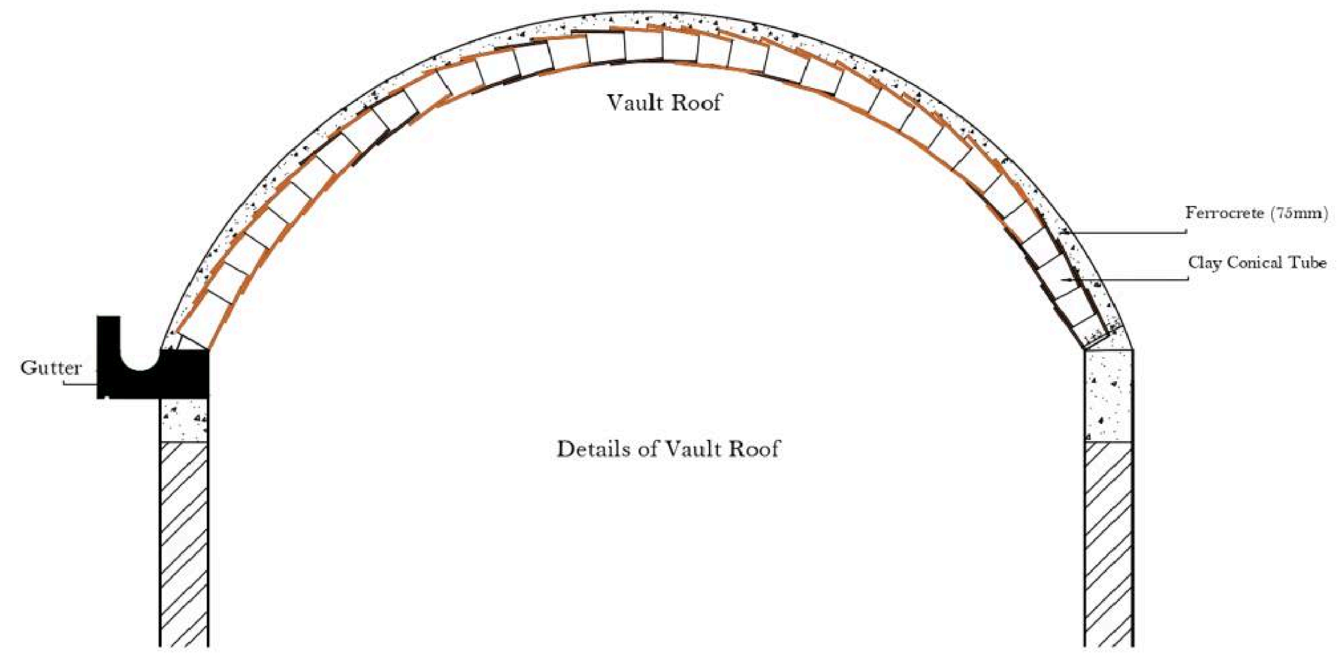


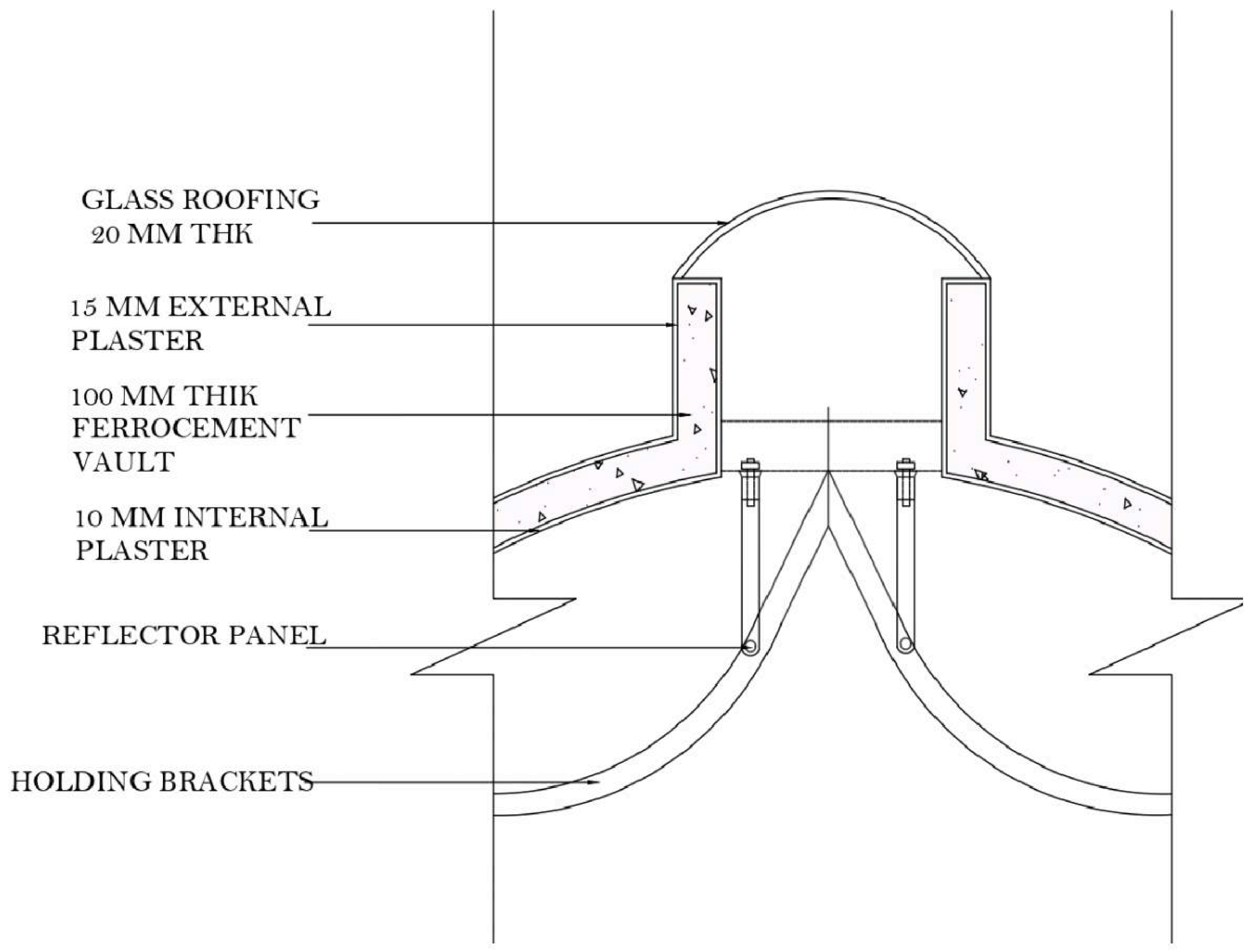
FIRST FLOOR PLAN

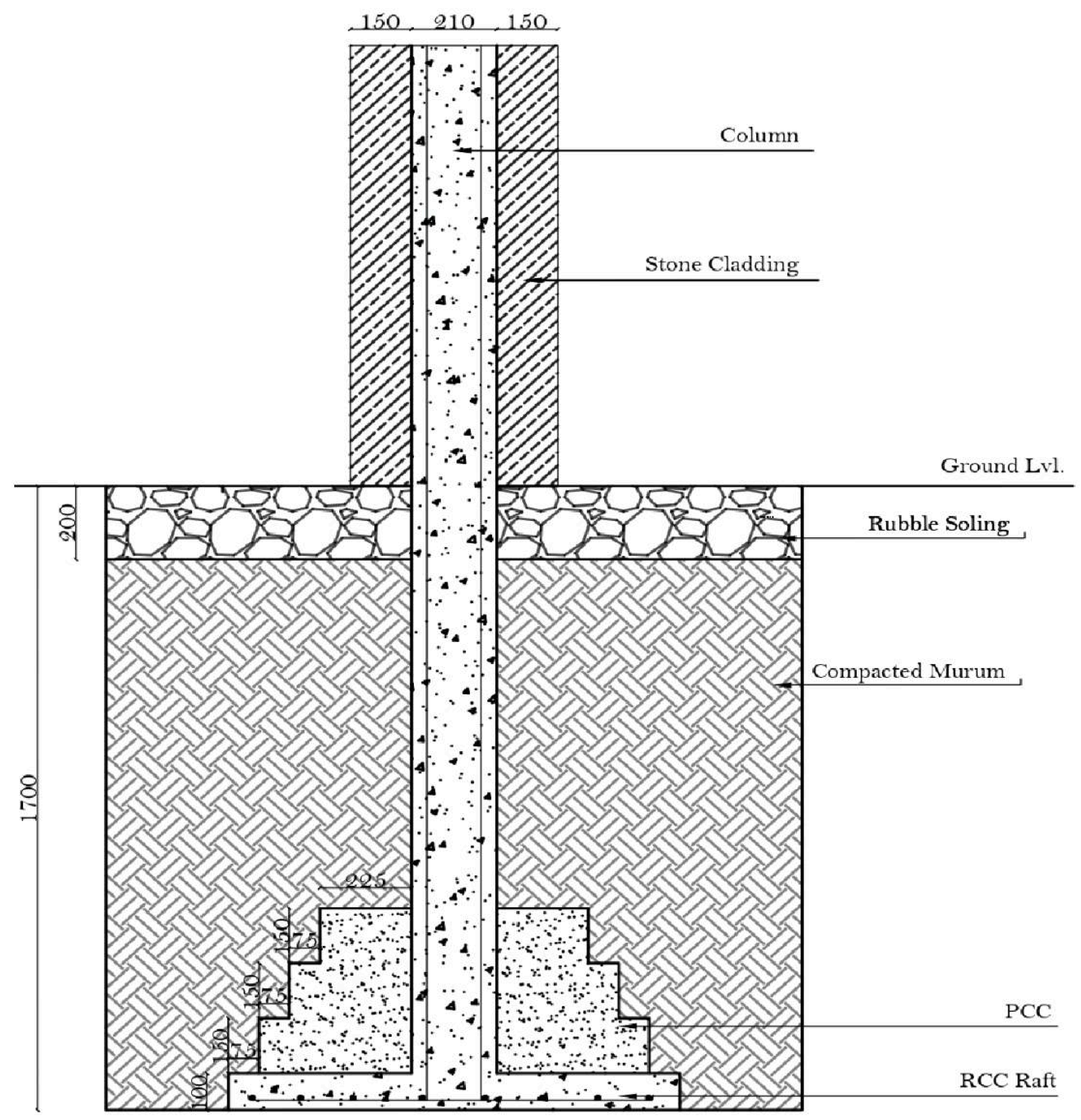
Appendix

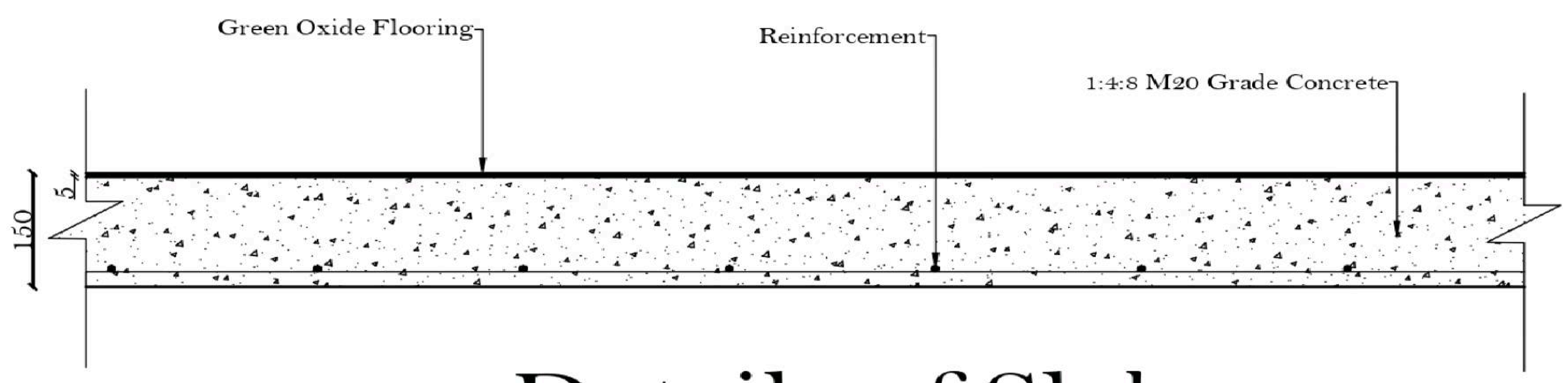
Structural Details:





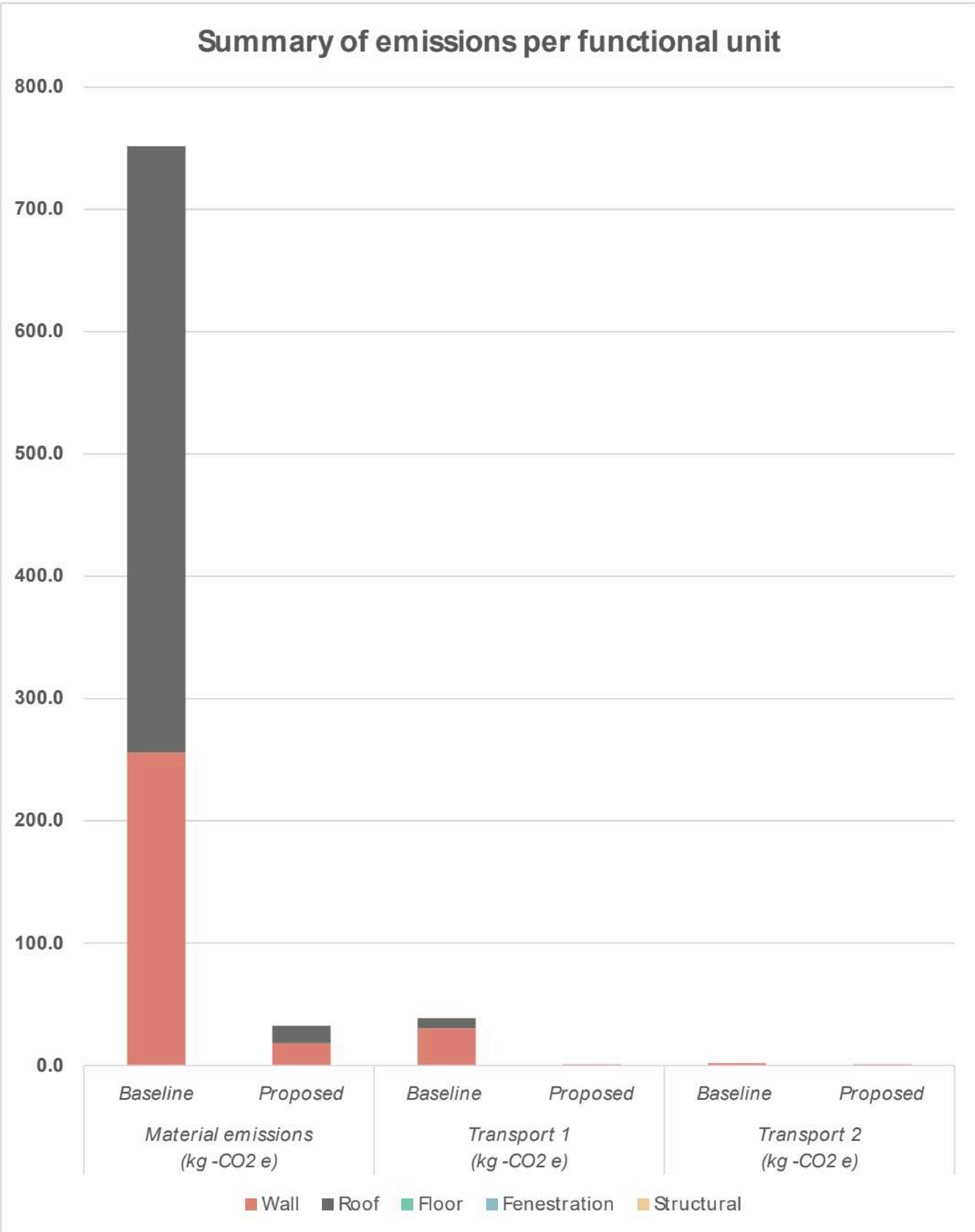


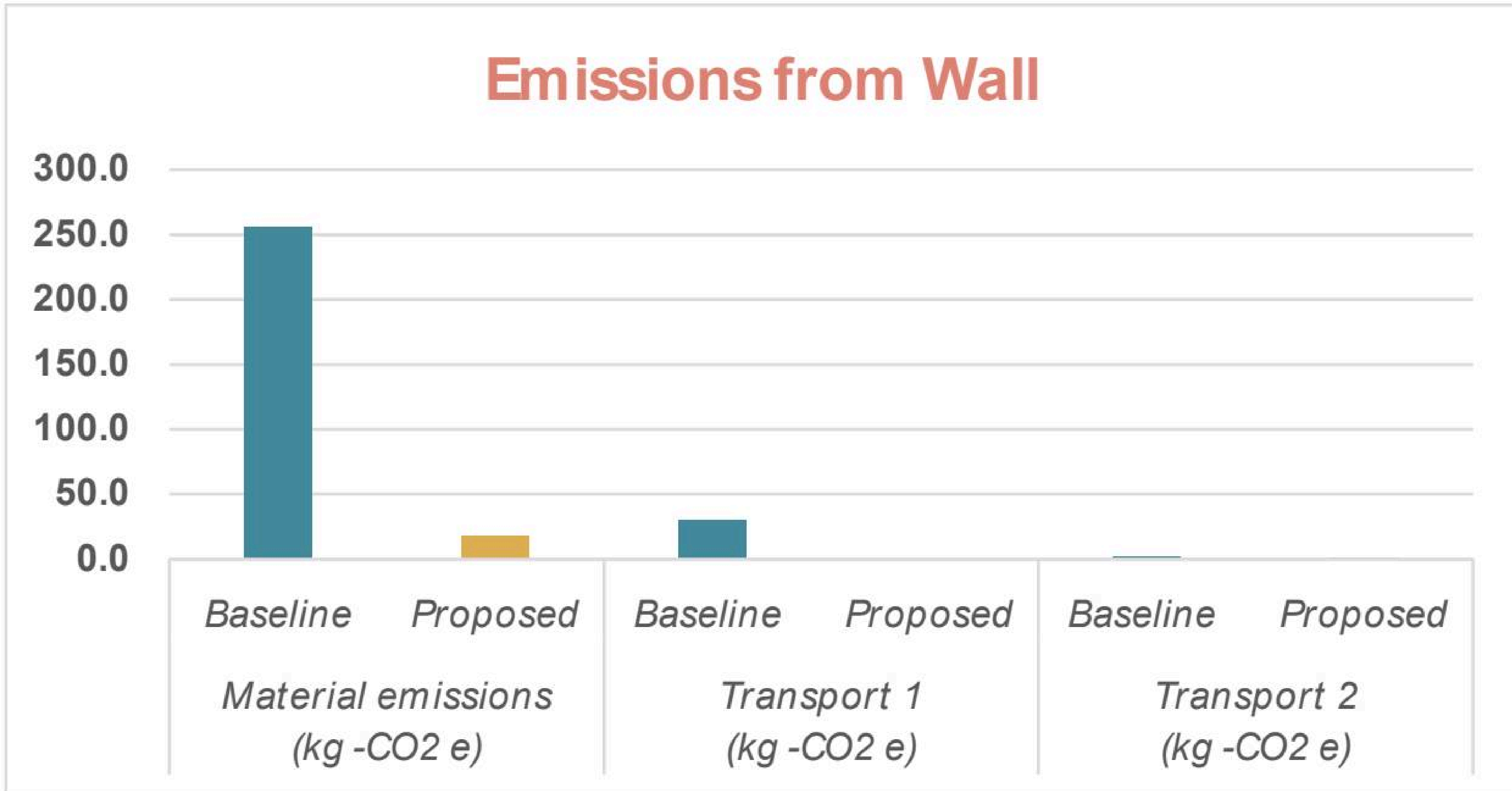


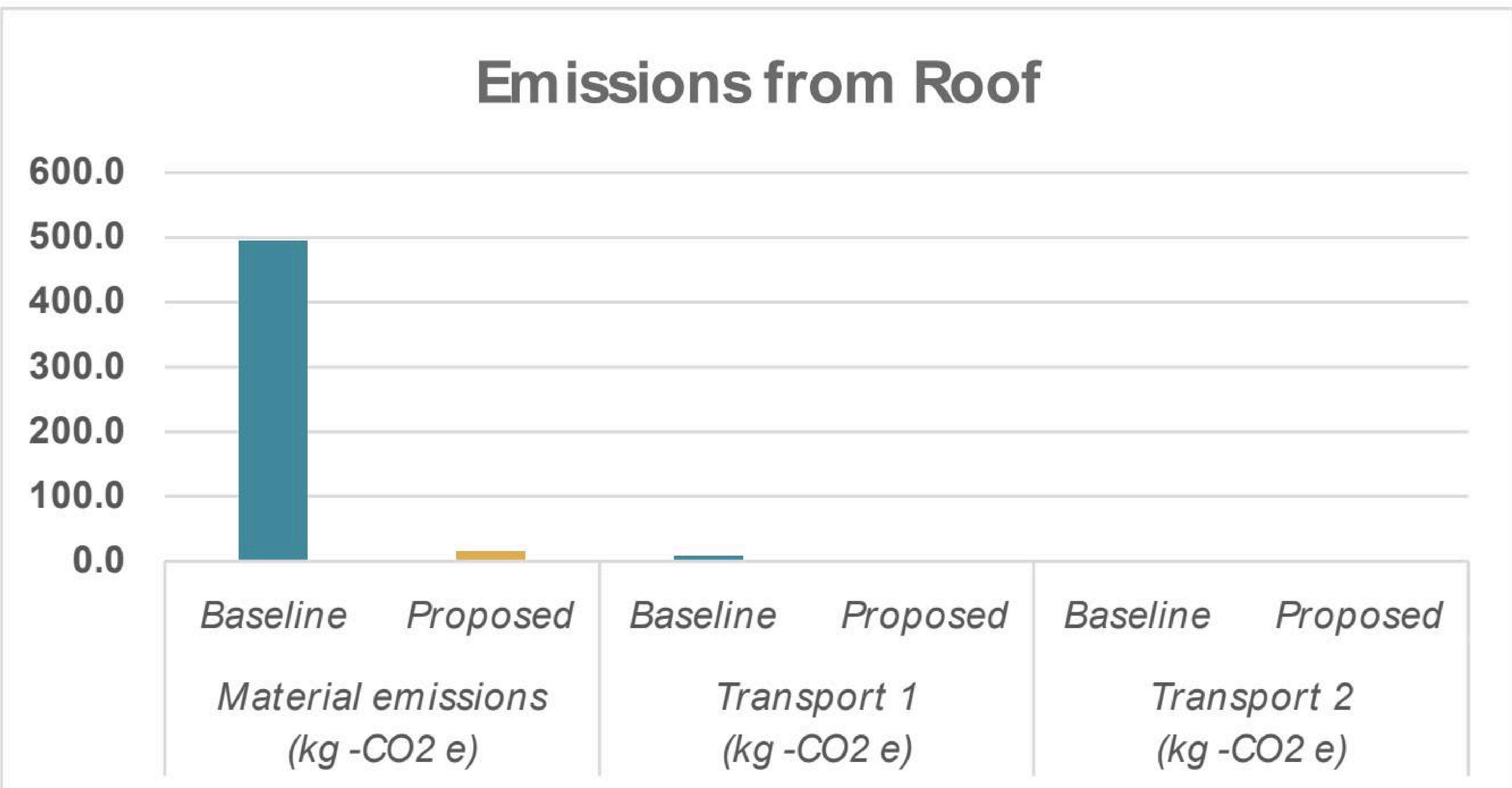


Details of Slab

Carbon Emission







Project Summary

Project Summary			
Project Information			
Team:	Dhara Tattva		
Division:	Single Family Housing	Land Cost:	4 Million INR
	Site Area (sqm) 448	City:	Mankule Village
	Built-up Area (BUA) (sqm) 310	State:	Maharashtra
	Ground Coverage (Plinth Area) (sqm) 215		

Project Summary

S.No.	Particulars	Definition	Baseline Estimate (Project Partner / SOR basis)			Proposed Design Estimate		
			Amount in Million INR	%	Amount (INR per sqm)	Amount in Million INR	%	Amount (INR per sqm)
1	Land	Cost of land purchased or leased by the Project Partner	4.00	32.2%	12,903	4.00	32.2%	12,903
2	Civil Works	Refer Item A, Civil works in Cost of construction worksheet	2.51	20.2%	8,102	2.15	17.3%	6,932
3	Internal Works	Refer Item B, Civil works in Cost of construction worksheet	0.61	4.9%	1,970	0.44	3.6%	1,429
4	MEP Services	Refer Item C, Civil works in Cost of construction worksheet	0.82	6.6%	2,638	0.81	6.6%	2,628
5	Equipment & Furnishing	Refer Item D, Civil works in Cost of construction worksheet	1.01	8.1%	3,252	0.92	7.4%	2,971
6	Landscape & Site Development	Refer Item E, Civil works in Cost of construction worksheet	0.25	2.0%	811	0.28	2.2%	892
7	Contingency	Amount added to the total estimate for incidental and miscellaneous expenses.	0.26	5.0%	839	0.23	5.0%	743
	TOTAL HARD COST		**9.46**	**79.1%**	**30,516**	**8.83**	**74.3%**	**28,498**
8	Pre Operative Expenses	Cost of Permits, Licenses, Market research, Advertising etc	0.50	4.0%	1,613	0.50	4.0%	1,613
9	Consultants	Consultant fees on a typical Project	0.70	5.6%	2,258	0.70	5.6%	2,258
10	Interest During Construction	Interest paid on loans related to the project during construction	1.75	14.1%	5,638	0.96	7.7%	3,099
	TOTAL SOFT COST		**2.95**	**23.8%**	**9,509**	**2.16**	**17.4%**	**6,970**
	TOTAL PROJECT COST		**12.41**	**100.0%**	**40,025**	**10.99**	**88.6%**	**35,468**