Solar Decathlon India™

DIVISION - SINGLE FAMILY HOUSING
PROJECT PARTNER – TERRA CONSULTANTS

FINAL DESIGN REPORT

FEBRARY 2022

AAYAM
ADDING A SUSTAINABLE DIMENSION

SJB SCHOOL OF ARCHITECTURE AND PLANNING
SJB INSTITUTE OF TECHNOLOGY

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EXECUTIVE SUMMARY

We intend to propose a design that is as efficient as possible to the challenges of site and climate. We as a team of architecture and engineer background have coherently worked for months with help and guidance from faculty. Most meetings were through online meeting and some were in person.

We have worked considering climate and how to provide thermal comfort an extreme climate where humidity is more and to some extent intolerable condition for some months of the year.

TEAM SUMMARY

A. **TEAM NAME:** TEAM AAYAM

B. **INSTITUTION NAME:** SJB SCHOOL OF ARCHITECTURE AND PLANNING
SJB INSTITUTE OF TECHNOLOGY

C. **DIVISION:** SINGLE-FAMILY HOUSING

D. **TEAM MEMBERS:**

Vibha G Rao(team lead)
7th sem, B.Arch.
SJBSAP
Affordability

Pragathi C
7th sem, B.Arch
SJBSAP
Architecture design

Vignesh RK
7th sem, B.Arch
SJBSAP
Renewable ener

Param V Rathod
7th sem, B.Arch
SJBSAP
Energy Simulation

Harish Bhat
9th sem, B.Arch
SJBSAP
Technical specification

J Preetham Royal
9th sem, B.Arch
SJBSAP
Construction details

Harshitha L
7th sem, B.Arch
SJBSAP
Resilience

Prajwal.M
7th sem, B.Arch
SJBSAP
Water Performance

Kruthika Krishna
7th sem, B.Arch
SJBSAP
Innovation

Deeksha Satheesh
7th sem, B.Arch
SJBSAP
Market potential

Anisha HK
5th sem, B.Arch
SJBSAP
Comfort

Ruksar Rahman
5th sem, B.Arch
SJBSAP
Scalability

S Harditha
5th sem, B.Arch
SJBSAP
Structure

Rakshith R
5th sem, B.Arch
SJBSAP
lighting specification

Sagar S R
researcher
Civil engineer
SJBIT
Engineering & Project timeline

Figure 1: team profile

E. **APPROACH:**
Our approach to design started with understanding sustainability and thorough research on the concept of a net-zero house. The team is divided into 3 sub-groups based on research, energy, and technical.

We intend to work as a collaborative team with a common goal, we understand and solve issues to come up with designs that give justice to the context, concept, and vision of the competition.

F. **SJB SCHOOL OF ARCHITECTURE AND PLANNING, BANGALORE:**
The institution is affiliated to the Visvesvaraya Technological University (VTU), Belgaum. The 5-year B. Arch course has been approved by the Council of Architecture, New Delhi. Encompassing 2 undergraduate programs- (B. Arch and Planning), specialized disciplines such as Urban Design, Landscape Architecture, Interior Design and Construction Management.

TEAM SUMMARY

G. FACULTY LEAD AND FACULTY ADVISORS:

Faculty Lead:

Ar. Deepti Gupta
Associate Professor
M.Arch., B.Arch.
Sustainable concepts in Architectural Design

Faculty Advisors:

M.V. Arundathi
Assistant Professor
MTech, BE (civil)
Urban green cover, urban gardens, Green Infrastructure planning, Wastewater treatment

Ar. Shilpa Madan Gopal
Professor
M. Arch (UD), B. Arch
Areas of interest: Holistic approach to Architecture

Figure 2: Faculty team

H. INDUSTRY PARTNERS:

GRIHA India

C-BALANCE

MALIK'S DESIGN

NELE ARCHITECTURE & PLANNING

Figure 3: Industry partner

PROJECT SUMMARY

A. PROJECT NAME: GREEN ABODE

B. PROJECT PARTNER: Dr. M.N. Chandrashekar
(Terra consulting, property advisory due diligence and development) Dean & Professor (SJBSAP), PhD, MS (NYU), MURP, B.Arch., an Architect- Urban Planner, based in Bangalore.

C. BRIEF DESCRIPTION OF PROJECT:

- **Building type:** single family housing
- **Location:** kumaragiri, foothills of chikmagalur
- **Profile of occupants:** min 4(adults-2, children-2)
- **Hours of operation:** 20-24hrs
- **Climate zone:** moderate to cool climate
- **Land Area**: 8 acres
- **Neighbourhood:** surrounded by coffee estates.
- **FAR:** 2

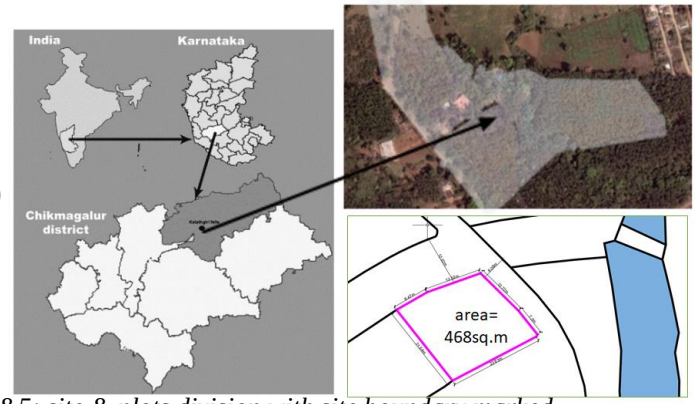
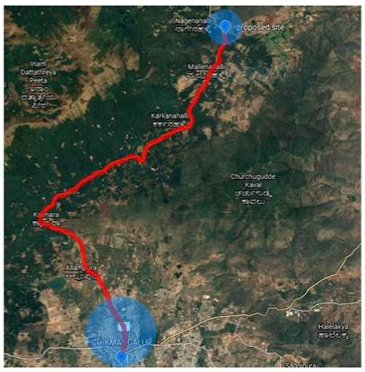


Figure 4&5: site & plots division with site boundary marked

JUSTIFICATION TO THE PLOT SELECTION: The selected site is in the hills of Chikmagalur, Karnataka, away from the hustle and bustle of the town. That helps us create an off-grid project that's self-sufficient and celebrates the natural topography.
It serves as a perfect destination for our client to visit with his family on a nature's retreat and later retire to. The site has Road on two sides with Views
- Since it is a corner plot, there is a lot of scope for good ventilation.
- As the site is steep, we can achieve levels with interesting forms.
- The contour gets dropped down to the road level and lots of cut and fill of soil reduces.

D. SITE:

- Area: 468 SQM
- Permissible ground coverage: 55% & Permissible built-up area: 244 m^2
- Estimated built-up area: 140 m^2 & Height restrictions: 15m



NEAREST TOWN TO THE SITE IS AT 2OKM DISTANCE - CHIKMANGALUR

KARNATAKA STATE HIGHWAY 57 CONNECTS CHIKMANGALUR TO THE SITE CROSSING VILLAGES IN BETWEEN.

Figure 6: site context

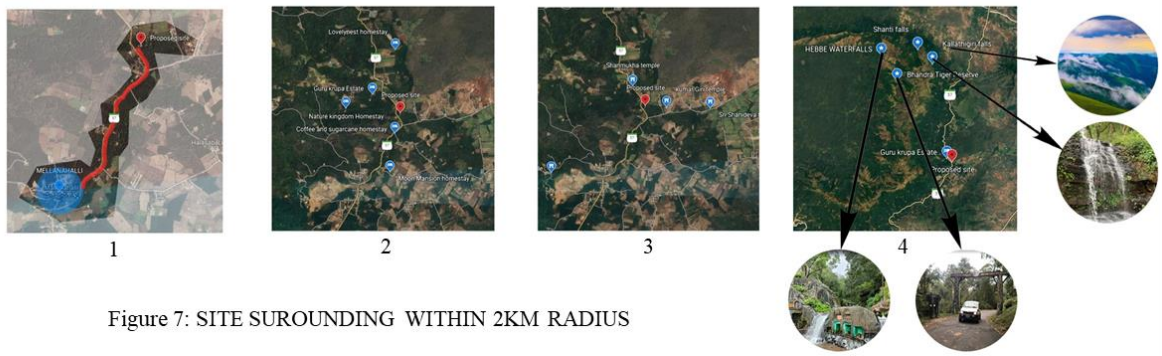


Figure 7: SITE SUROUNDING WITHIN 2KM RADIUS

1.Basic amenities can be accessed from the nearest village mellanahalli - 1.5 km from site

2 Site is surrounded by tourist homestays- users as tourists can be found nearby.
Also, there are many rich estates nearby- social and economic conditions can be inferred as mixed demography

3 Site having surrounded by ancient temples

4 Map shows the known tourist spots from the site.

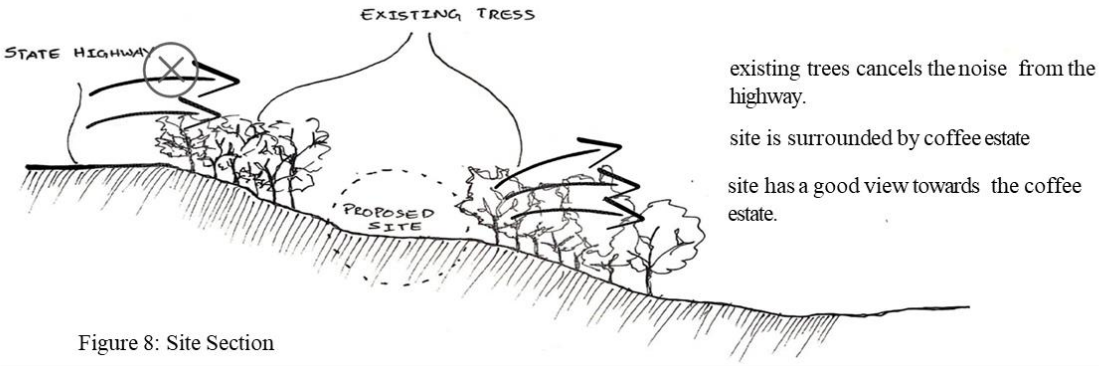


Figure 8: Site Section

E. BUDGET (INR/m2) AND TIMELINE: 35,714 INR/m^2 (thirty-five thousand seven hundred and fourteen INR/m^2) and timeline is not specified.

F. SPECIAL REQUIREMENTS:

This project intends to build a second house for clients, The project aims to achieve a sustainable living environment and to create a better lifestyle particularly keeping in mind the type of users, their age group etc. while having a minimum impact on nature and its surroundings. It also aims to create a net zero energy-built form which is self-reliant for energy requirements along with innovative means of energy production and efficient use of the energy produced. It considers the vernacular aspects of the region in a way to preserve the identity of the locality while showcasing the natural beauty of the place to the incoming visitors.

Outdoor spaces – barbeque, kitchen garden, patios, courtyards, and terrace gardening.

PERFORMANCE SPECIFICATION

Characteristics of warm and humid climate
• high humidity, strong sun, glare from the sky and horizon.
• there are long monsoon periods with heavy rain.
• the breezes, especially in coastal area, can alleviate discomfort considerably.
• precipitation – high generally in excess of 1200mm/yr
• solar radiation-
usually, defused radiation due to cloud cover or vapour in air.

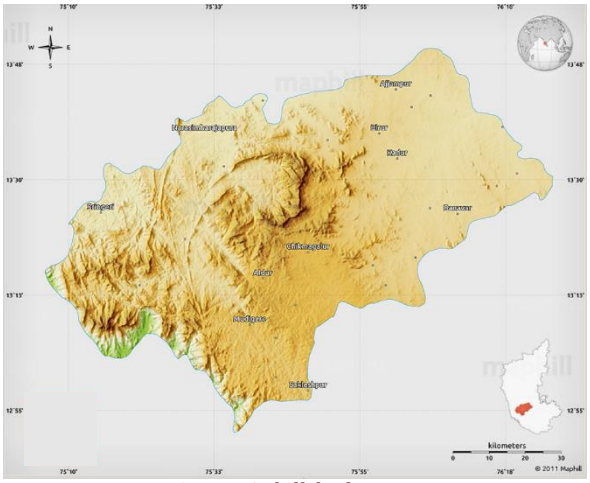


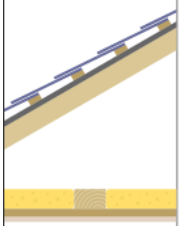
Figure 10: hillshade map

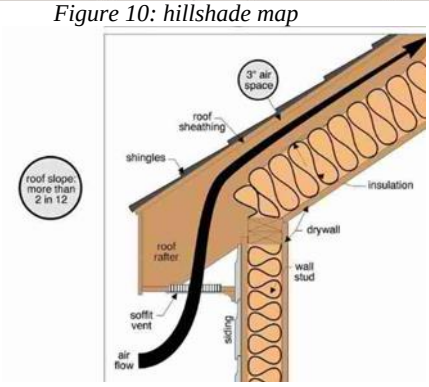
Design objectives

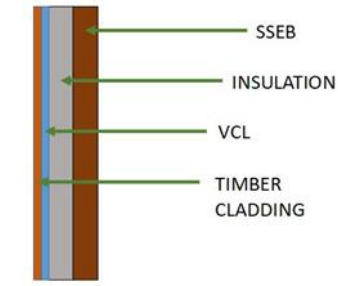
resisting heat gain
• decreasing surface area of building exposed to outside.
• using that material which take long time to heat up/reflect heat.
• increasing shading of building in general.

Promoting heat loss
• appliances used are well ventilated.
• proper ventilation occurs throughout the day.
• humidity levels are reduced as much as possible

Table 1:u value chart

Standard 30° Pitched Roof		U-Value
	Slates or tiles, sarking felt, ventilated air space, 9.5mm plasterboard, insulation between joists	no insulation
		2.51
		50mm
		0.60
		100mm
		0.34
		200mm
		0.18
		300mm
		0.12
Windows With Wood Or PVC-U Frame		**U-Value**
	Single-glazed	4.8
	Double-glazed	2.8
	Double-glazed, low-E glass	2.3
	Double, low-E glass, argon filled	2.1
	Triple-glazed	2.1
	Triple-glazed, low-E glass 1.7	1.7
	Triple, low-E glass, argon filled	1.6





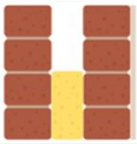
WALL PROFILE (SCHEMATIC) *Figure 11*

- The materials with higher U value would be be suitable for the rainy and winter seasons as the temperature drops to 11 to 25 degree celsius during these seasons.
- (Comfortable temperature range being 18 to 27 degree celsius)
- The materials and methods of construction with higher U value essentially means that the thickness of walls and roof would be minimal to increase thermal transmittance.
- The other factor influencing the building material selection would be the humidity which is usually as high as 80% major parts of the year.

- The window openings towards the south and the west use –DOUBLE GLAZED, LOW – E GLASS, to help avoid too much heat gain from the exterior.
- The windows to the east and north use – SINGLE GLAZED GLASS, to help facilitate heat gain through the windows.

PERFORMANCE SPECIFICATION

Table 2: typical u value

Solid Brick Wall		U-Value
	102mm brick with dense plaster	2.97
	228mm brick with dense plaster	2.11
	343mm brick with dense plaster	1.64
Cavity Wall		**U-Value**
	102mm brick with 13mm plaster, no insulation	1.37
	102mm brick with 13mm plaster, 50mm insulation	0.56

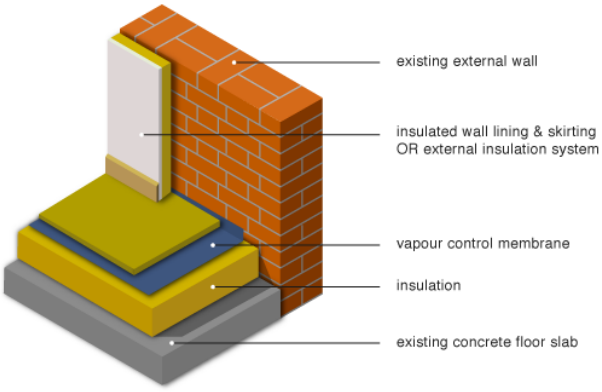


Figure 12:View showing layers required in the walls and floors.

- The pitched roof used requires 50mm insulation to protect from the cold and in addition requires a Vapour Control Layer.

- The south and west walls are – CAVITY WALL: 102mm BRICK WITH 13mm PLASTER, NO INSULATION, to avoid too much head gain during the summer.

- The north and east walls are – SOLID BRICK WALL: 343mm BRICK WITH DENSE PLASTER – to allow heat gain during the winters.

GOALS AND STRATERGIES

➢ **ENERGY PERFORMANCE**

-to achieve target EPI

-net zero energy house with uses of renewable energies

➢ **RESILIENCE:**

design will resist to heavy rainfall, floods

aiming for off grid housing

-Reliance on abundant local resources

-redundant systems for such needs as electricity, water, and transportation, to improve resilience

➢ **WASTE AND WATER MANAGEMENT:**

-sustainable management of water and sanitation

-sewage treatment plant, and rainwater harvesting, and sewage is treated to be used for biomass

-water optimization through low flow fixtures

➢ **COMFORT**

-thermal comfort by regulating indoor temperature and passive, active strategies

-provide proper daylit spaces for visual comfort

➢ **HEALTH AND WELLBEING**

-as users are in the age group of 40s-50s, spaces will be designed keeping in mind about their safety

-with proper daylit and features to promote fitness

➢ **ARCHITECTURE**

-connecting indoor and outdoor with easy transition spaces

-breathable structure with good ventilation

-vernacular style that is in accordance with context, vegetation etc

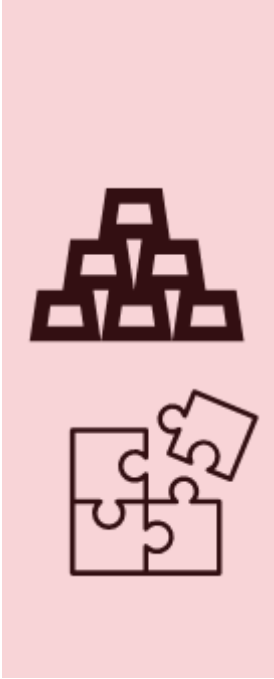
-aims to build a home amidst plantations

-aim to provide a community environment to older adults later in their 40s so that there is safe surrounding for them in their later years of life

➢ **SUSTAINABILITY**

-Ensure sustainable consumption and production patterns

-Shared natural resources should be managed efficiently, and toxic waste and pollutants disposed of carefully.



➢ **AFFORDABILITY AND INNOVATION**

-Carbon negative building envelops maximising use of local materials and hence reducing carbon footprint, embodied energy.

-a ventilation strategy in summer and solar gain strategy in winter.

-Innovation in architecture and structural details

➢ **SCALABILITY**

-It should be scalable and be as modules

-Designing a prototype that can be duplicated and adapted to include people from all economic strata in a similar climatic context

Figure 9: goals

DESIGN DOCUMENTATION

A. ENERGY PERFORMANCE

ENERGY PERFORMANCE INDEX (EPI): target EPI = <30

GriHA specification for EPI for residential building = 70kWh/sq.m/year

Goal is to achieve less than or equal to 50% reduction in the EPI.

25% of total annual energy consumed is deducted considering all the appliances may not be working at the same time. So 75% X 11255.6 = 8441.8

ENERGY PERFORMANCE INDEX = ANNUAL ENERGY CONSUMPTION (kWh/sq.m/yr) = BUILD UP AREA (sq.m)

$$\textbf{EPI} = \frac{8441.8}{140} = \textbf{60kWh/sq.m/year}$$

SL NO:	AREA	WATTS	NO-OF FIXTURES	TOTAL WATTS(w)	HOURS	W*H	DAYS(D)	W*H*D	energy consumed annually (kWh)
1	LIGHTING LED FIXTURE	10	15	150	4	600	365	219000	219
2	1200mm CELLING FAN	32	4	128	6	768	150	115200	115.2
3	EXHAUST FAN	30	4	120	4	480	365	175200	175.2
4	AIR CONDITONER	1440	1	1440	5	7200	90	648000	648
5	5A SOCKETS	200	10	2000	3	6000	365	2190000	2190
6	5/15A SOCKETS	1000	5	5000	1	5000	365	1825000	1825
7	REFRIGERATOR	400	1	400	24	9600	365	3504000	3504
8	MICROWAVE OVEN	800	1	800	0.3	240	365	87600	87.6
9	AQUA GUARD	20	1	20	3	60	365	21900	21.9
10	RICE/COOKER/KETTLE	400	1	400	2	800	365	292000	292
11	MIXER grinder	500	1	500	1	500	365	182500	182.5
12	CHIMNEY	200	1	200	4	800	365	292000	292
13	CALLING BELL	5	1	5	0.1	0.5	365	182.5	0.1825
14	LED LIGHT FIXTURE II	6	8	48	8	384	365	140160	140.16
15	washing machine(6kg)	360	1	360	1	360	365	131400	131.4
16	lighting fixture tubelights	18	5	90	3	270	365	98550	98.55
	EXTERIOR								
17	LIGHTING FIXTURE	10	15	150	8	1200	365	438000	438
18	BULKHEAD LIGHT	40	4	160	6	960	365	350400	350.4
	OTHERS								
19	BORE WELL PUMP (2HP)	1492	1	1492	1	1492	365	544580	544.5
	TOTAL ENERGY CONSUMED	6963	80	13463	84.4	36714.5		11255672.5	11255.5925

Table 3: Energy Performance Index (EPI) calculation

ESTIMATE:

	On site renewable energy	Generation amount in kwh/yr	Cost (rs)	Life span expected (years)
1	solar PV system	7000	2L	15-25
2	bio gas	550	3.3L	10-15

Substrate	Volume of produced biogas m^3	Volume of produced methane m^3
Cattle manure	17 280	10 368
Pig manure	2 867	1 720.2
Hen manure	64.8	38.88
Slurry	1 899.78	1 215.86
Maize silage	5 601.96	3 025.06
Uneaten particles (grass silage)	666	366.3
Rejected potatoes	1 020	479.4
Potato sprouts	10.7	5.03
Kitchen waste	61.25	33.69

Table 4: Preliminary estimate of on-site renewable energy generation potential

ORIENTATION

The above spaces are primary spaces which are frequently used and to help reduce the energy consumed during the winter for heating, these spaces are places towards the west.
The less frequented spaces like the kitchen and dining which are used only at certain times of the day are placed towards the east.
The library is towards the south with a huge window to help capture the heat from the sun via the greenhouse effect and warm the space.

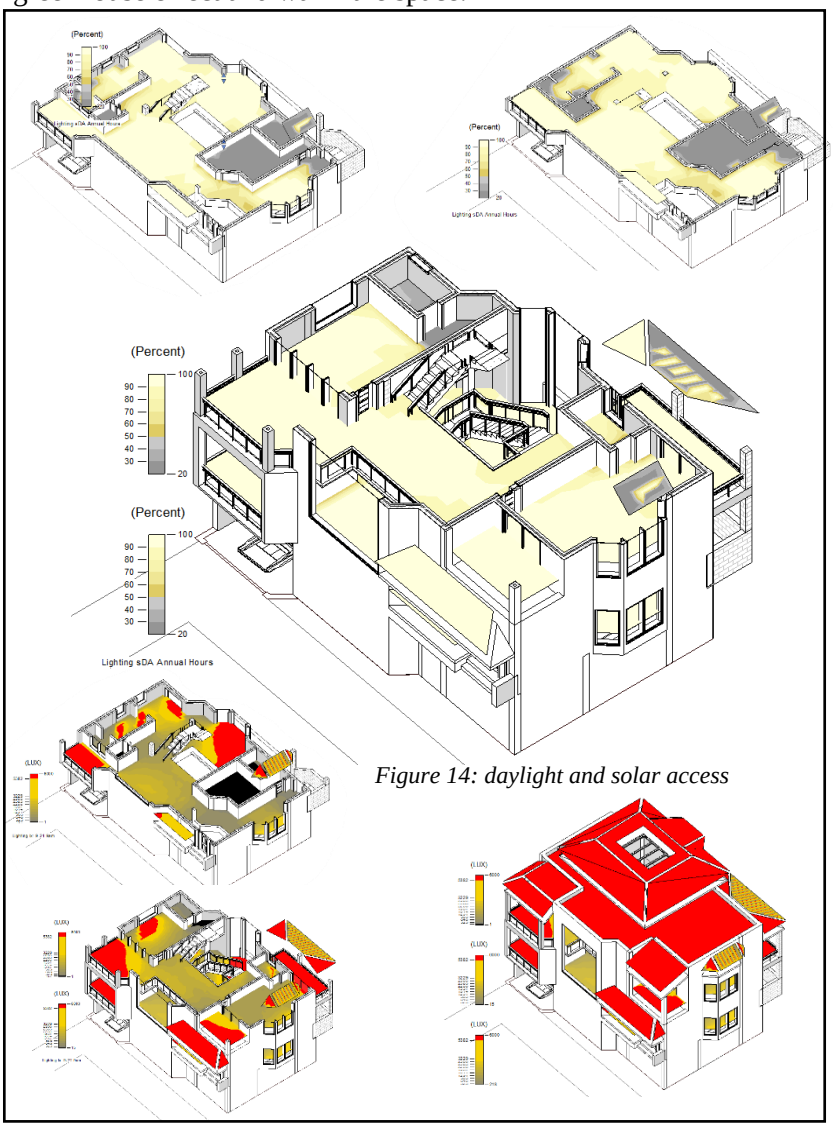
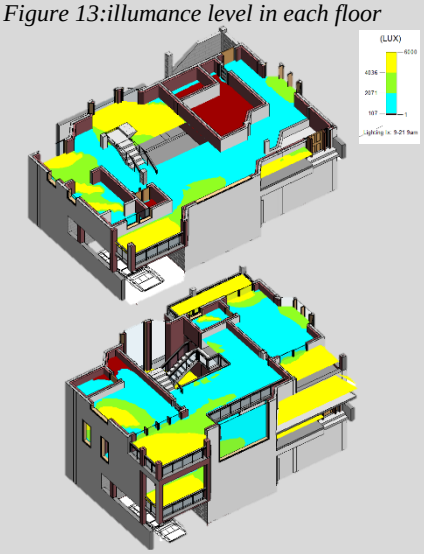


Figure 14: daylight and solar access

Figure 13:illumance level in each floor



SHADING-Horizontal shading over balconies and terraces are slopped to avoid water logging, since this area receives heavy rainfall.
Since the site is situated on a coffee plantation, the trees grown to shelter the coffee plants also shade the building. This helps reduce the amount of solar radiation incident on the walls of the building, hence helps in keeping the building cool during the summers. There is no requirement for vertical shading or any additional building skin.

HVAC equipment (Efficient appliances) for interior comfort -Air-Source Heat Pumps - Heat pumps move air in and out of the home to both heat and cool it. Heat pumps are one of the most energy efficient heating systems around, but do not work as well in colder climates.

Standard Split Heat Pump System - Standard split heat pump system is the most affordable HVAC system in the market. It works by circulating the refrigerant through an indoor and outdoor unit. The indoor unit handles the air cooling and heating of the house, but one can add a gas furnace if needed for additional heating during the winter season.

For **lighting**, LED lights are the most efficient types of lighting system available, whereas energy efficient appliances for cooking, washing (clothes and utensils), and water heating would further reduce the energy consumption.

B. WATER PERFORMANCE

LITRES PER PERSON (CAPITA) PER DAY

The standard norm for domestic water usage in India is **135 liters per capita per day**(lpcd), prescribed by the Central Public Health and Environmental Engineering Organization.

Table 5: water consumption

Per Capita daily consumption	Number of occupants	Total daily consumption	Grey water filter efficiency
135	4	540	75%

End Use	Percent use	Use in LPD	Greywater in LPD	Blackwater in LPD
Bathing	30%	162	162	
Washing	20%	108	108	
Cleaning house	8%	43	43	
Washing Utensils	16%	86	86	
Others	2%	11	5	5
Drinking	4%	22		22
Cooking	3%	16		16
Toilet Flushing	17%	92		92
Total		540	405	135

Martials/fixtures used to reduce water consumptions:-

***ALL THE PRODUCTS ARE FROM** HINDWARE company ,which is one of the India's top company and also all products are five star rated are used.

**Low flow* toilets *and dual flush*(3 or 6 liters per flush) *toilets save considerable amounts of water.*

* Install water tap aerators or more efficient fixtures.

*Aerated shower heads can increase the pressure and reduce water usage making the shower as pleasant as before.

*Newer energy and water efficient washing machines can use up to 20% less water.

LOW PER CAPITA WATER DEMAND

The water consumption was brought down to 80 lpcd from 135 lpcd through water saving fixtures, front load washing machine and efficient water supply system etc. Thus, the total occupant water demand was calculated to be 320L for 4 users.

Domestic Use	
Use LPD/Head	80
Number of people	4
Total LPD	320

End Use	Percent use	Use in LPD	Greywater in LPD	Blackwater in LPD
Bathing	30%	96	96	
Washing	20%	64	64	
Cleaning house	8%	26	26	
Washing Utensils	16%	51	51	
Others	2%	6	3	3
Drinking	4%	13		13
Cooking	3%	10		10
Toilet Flushing	17%	54		54
Total		320	240	80

Water efficient fixture	Conventional	High efficiency/ Water saving
Water closet	6lpf full flush	4.5/3lpf dual flush
Shower heads	10lpm	5.7 lpm 43%lpm savings
Taps/faucets	8lpm	Aerators ,flow fixtures with 5lpm
Washing machine	Top loading	Uses 40%less water

Table 6: domestic water consumption

PROPOSED WATER SYSTEM FLOW CHART

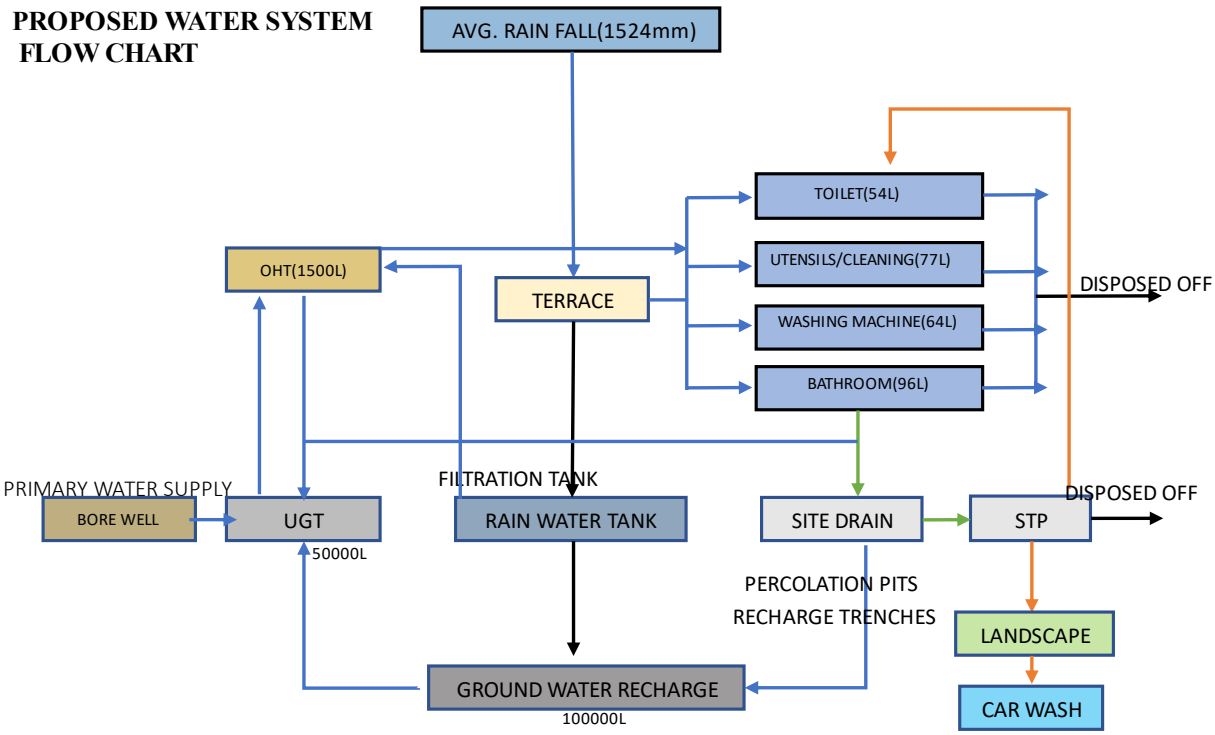


figure 15: flow chart water consumption

Pura and Sringeri taluks are SAFE for ground water development. **More than 50% of the area** of Chikmagalur taluk is SAFE and only a small portion towards eastern part of Kadur taluk is SAFE. < 50% of Kadur taluk falls in OVER EXPLOITED category and the remaining portion is SEMI – CRITICAL.

Rainwater harvesting surfaces	Area m^2	Runoff coeffecient	Effective catchment area m^2
Roof Surfaces	162	0.85	137.7
Hardscape areas	100	0.70	70
Softscape areas	206	0.30	61.8
Total Effective catchment area			**269.5**

Table 7: rainwater harvest

AS,OUR SITE IS LOCATED NEAR TO CHIKKMANGALURU,IT'S A MORE OF RAINNY REGION,SO NO NEED TO WORRY MORE ABOUT RAINFALL AND ALSO RAIN WATER IS THE BASIC SOURSE OF WATER TO THE SITE..

CONSUMPTION						WATER SOURCE			
MONTH	DAYS IN MONTH	DOMESTIC USE (L)	IRRIGATION USE %	IRRIGATION USE (L)	TOTAL CONSUMPTION (L)	RAINWATER	GREYWATER (L)	BLACKWATER (L)	TOTAL STORED
Jul	31	9,920	5%	496	10,416	84893	7,440	2,480	92333
Aug	31	9,920	5%	496	10,416	64411	7,440	2,480	71851
Sep	30	9,600	50%	4,800	14,400	42851	7,200	2,400	50051
Oct	31	9,920	30%	2,976	12,896	42851	7,440	2,480	50291
Nov	30	9,600	90%	8,640	18,240	50936	7,200	2,400	58136
Dec	31	9,920	90%	8,928	18,848	18596	7,440	2,480	22352
Jan	31	9,920	90%	8,928	18,848	3504	7,440	2,480	5984
Feb	28	9,040	90%	8,136	17,176	1617	6,780	2,260	8397
Mar	31	9,920	90%	8,928	18,848	5121	7,440	2,480	12565
Apr	30	9,600	90%	8,640	18,240	17518	7,200	2,400	24718
May	31	9,920	90%	8,928	18,848	36113	7,440	2,480	43553
Jun	30	9,600	90%	8,640	18,240	68453	7,200	2,400	75653
Total		116,880		78,536	**1,95,416**	436860	87,660		**5,24,520**

Table 8: consumption and water source

NET ZERO

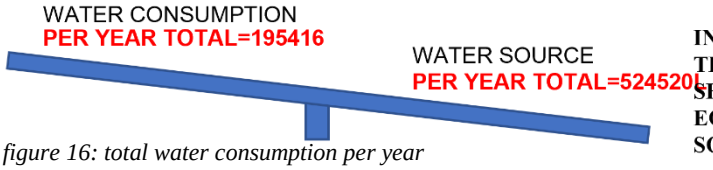
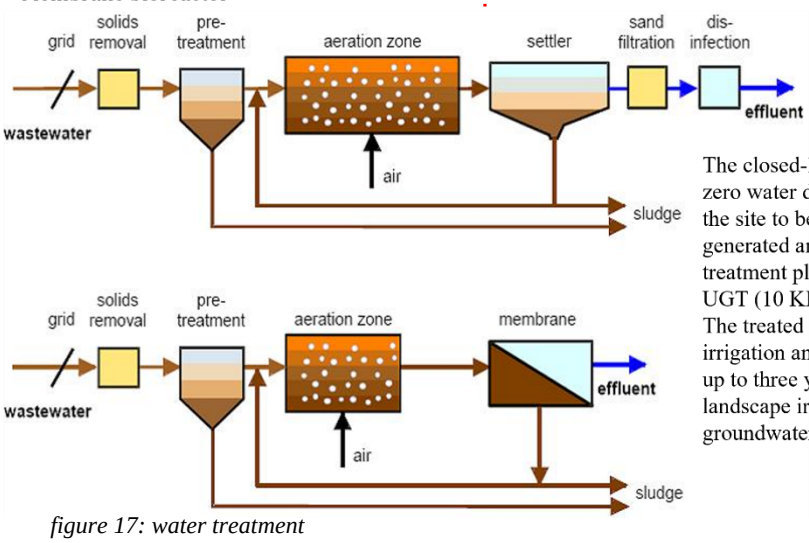


figure 16: total water consumption per year

IN A NET-NET ZERO WATER BUILDING THE TOTAL WATER CONSUMPTION SHOULD BE EQUAL OR LESS THEN WATER SOURCE. SO ACCORDING TO THE CALCULATION WE ARE ACCHIVING THE NET ZERO.

WATER TREATMENT

Membrane bioreactor



The closed-loop design aims to achieve the target of zero water discharge by allowing water produced on the site to be returned to the site. Greywater is generated and filtered at a 75 percent efficiency treatment plant before being sent to the non-potable UGT (10 KL) to be reused for flushing.
The treated grey water is used for xeriscaping irrigation and flushing (1KL/day) (366 KL annually up to three years after which water used for landscape irrigation will be discharged for groundwater table replenishment).

figure 17: water treatment

C. RESILIENCE

Some of the potential risks faced in Chikmaglur which needs to be tackled in designs are as follows:

- Heavy rainfall
- Landslides
- earthquake

Water resistant materials

Plasterboards, plywood's, carpets, vinyl, ceramic tiles and fibreglass are all non-water-resistant materials. Instead, use water-resistant materials such as:

- closed cell foam for insulation
- concrete or clay tile floors, or durable or treated timber floorboards for flooring
- fibre-cement, concrete, or PVC brick for walls.

Roofing is a key risk for weather impact. Ensure roofs are designed to cope with high intensity rainfall, without increasing their complexity (which could worsen the risk of impact in the event of another extreme weather event, bushfires, should embers become lodged). Ideally you want the roof design to be simple with minimal exposure to embers and intense rainfall. Storms and hailstorms can also inflict real damage to roofs, guttering and windows. All these features should be able to withstand once-in-100-year rainfall events. Ensure all aspects of your design are solid, including detailing of:

- roof edges
- open decks and balconies
- walls and joinery
- retaining walls
- wall-proof junctions

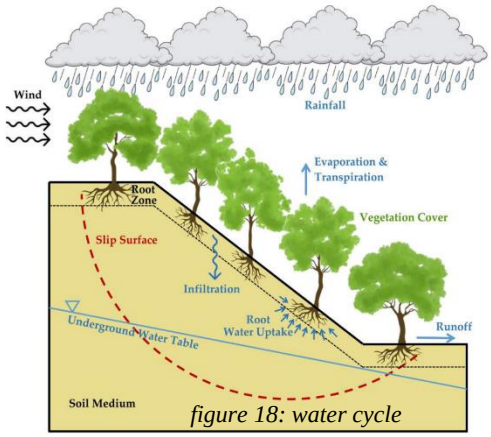


figure 18: water cycle

landslides

Proper site selection is critical to reducing the risks of landslides. Working with the contours of a place, vegetation and its root systems stabilise soil and prevent erosion. Adding barriers will help in landslides.

Earthquake

As there was a recent earthquake in Chikmagalur, preventing building from earthquake will be an important factor.

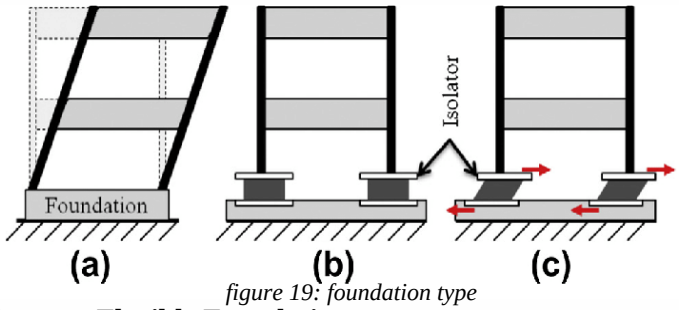


figure 19: foundation type

Create a Flexible Foundation

Base isolation involves constructing a building on top of flexible pads made of steel, rubber, and lead. When the base moves during the earthquake, the isolators vibrate while the structure itself remains steady.

Onsite Energy Production

Prime onsite power generation is also needed in remote locations with no utility power available, or where the available utility power feeds or the supporting grid are undersized and cannot be quickly or cost-effectively upsized. Data centres and other large power-demanding construction projects sometimes face this challenge.

Prime power has also been cost-effective in limited cases with large, onsite gas turbines or small micro-turbines, especially when the otherwise wasted heat is re-purposed for other uses in the facility.

Keep in mind that most gas generator, turbine, and fuel cell prime power deployments effectively replace one utility, which has largely above-ground transmission and distribution, with another utility (natural gas), which has largely more reliable underground transmission and distribution. Natural gas increasingly can be stored onsite, but costs, runtime limitations, space requirements, and other challenges exceed those of diesel fuel storage.

Water Treatment and Storage

Water treatment is any process that improves the quality of water to make it appropriate for a specific end-use. The end use may be drinking, industrial water supply, irrigation, river flow maintenance, water recreation or many other uses, including being safely returned to the environment. Water treatment removes contaminants and undesirable components or reduces their concentration so that the water becomes fit for its desired end-use. This treatment is crucial to human health and allows human

Elimination of hazardous chemicals from the water, many treatment procedures have been applied. The selection of wastewater treatment systems is contingent on a number of factors:

(1) The degree to which a method is necessary to raise the wastewater quality to a permissible level.
(2) The control method's flexibility.
(3) The process's cost
(4) The process's environmental compatibility.

The processes involved in removing the contaminants include physical processes such as settling and filtration, chemical processes such as disinfection and coagulation, and biological processes such as slow sand filtration.

Food Storage

Storing food the right way can be a great help in ensuring a household's food security. This section discusses the importance of food storage and the different ways in which households can rightly store different types of foods.

Food storage broadly refers to the different means through which food can be kept for longer . periods without the food spoiling. The shelf life of a food is the length of time a food remains.

General guidelines for food storage

Foods should be stored differently on the basis of how fast they will spoil or develop off flavours. Foods can be categorised into 3 groups:

1. Perishable (e.g. milk, meat, raw fish)
2. Semi-perishable (e.g. vegetables and grains)
3. Non-perishable foods (tinned or dried food)

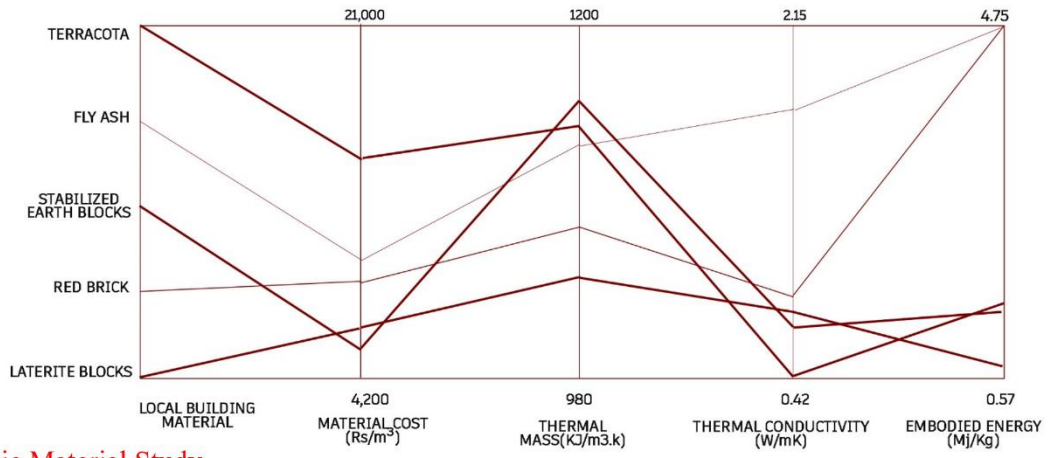
Constructing a clay pot fridge

This is made of a clay pot, a basin of water and a clean cloth. Place the pot in the basin of water. Put the vegetables inside it and cover the pot with a clean wet cloth. Place one corner of the cloth in the basin of water so that water is continuously sucked into the cloth as it dries out.

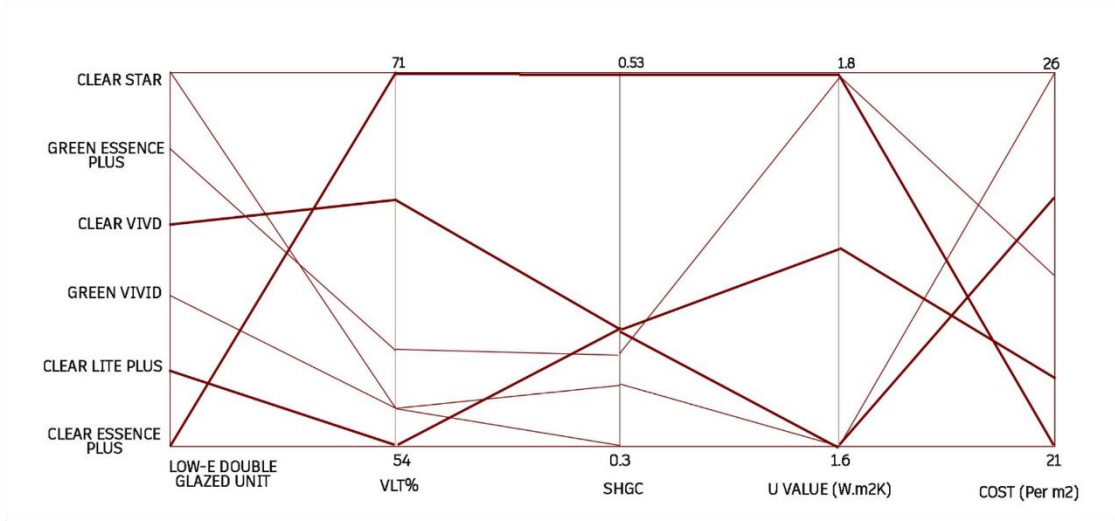
D. AFFORDABILITY

ENVELOPE SELECTION

To narrow down the selection process for the envelope design, a list of local materials was studied based on different criteria. One of the key governing factors for the decision was cost and local availability.



Basic Material Study *figure 20*



Basic Window Study *figure 21*

The prime objective was to use the cheapest construction materials available in the area and build an envelope that could withstand thermal transmittance.

The properties of site soil for lime stabilization are very similar to those of optimum soil. As a result, SSEB was selected as one of our primary building materials.

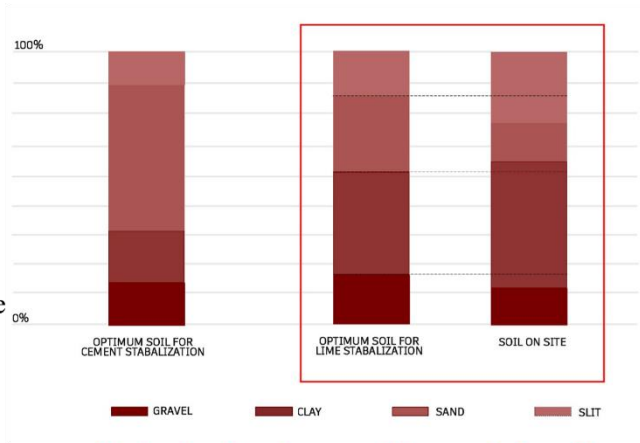
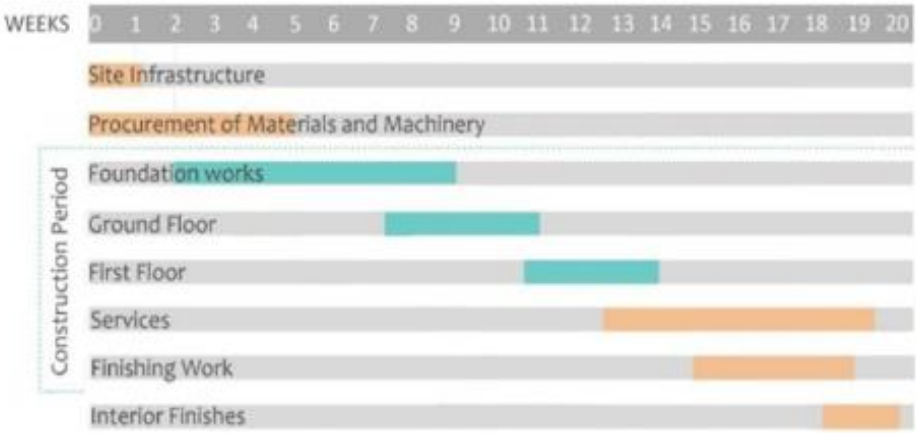


figure 22 Study showing the resemblance of site soil with Optimum soil for Lime Stabilization

figure 23 CONSTRUCTION TIMELINE



E. INNOVATION

PASSIVE STRATERGIES

- Inspired by vernacular style – sloping roof and a contemporary attempt to include a courtyard that lets daylight and illuminates all space and giving a sense of different volumes

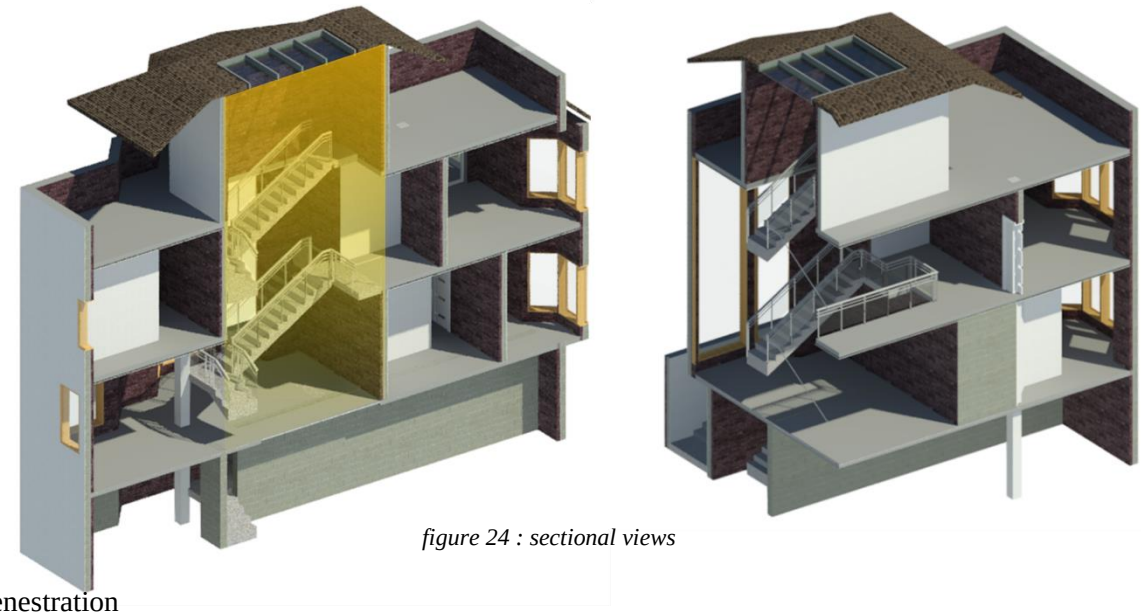
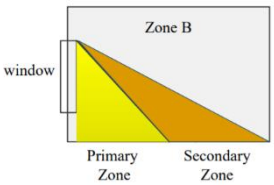


figure 24 : sectional views

Fenestration

• cross ventilation is most important in warm and humid climatic regions.
• windows must be provided with venetian blinds to shelters the rooms from the sun and rain , as well as for control of movement.
• the opening should be shaded by external overhangs
• outlets at higher level Seve to vent hot air

ACTIVE STRATERGY



Subdivision of Zone B according to the distance to the window.

Table Specifications of the light-emitting diodes (LED) luminaires in the comparison experiment.

Subzone	Type	Power (W)	Number of Luminaires
1	Grille light	16×	10
2	Grille light	16×	13

figure 25 Comparison of energy consumption.

Table 9 . Energy consumption and energy saving.

Zone	Time	Energy Consumption (KWh)		Energy Savings (%)
		Normal CONTROL	Smart Control	
Subzone 1	5 h	1.25	0.97	22.4%
	3 days	14.72	7.87	46.54%
	23 days	103.14	87.28	15.38%
Subzone 2	5 h	1.72	0.91	47.09%
	3 days	19.34	6.43	66.75%
	23 days	199.07	56.72	71.51%

to reduce energy consumption by implementing a smart lighting system that integrates sensor technologies, a distributed wireless sensor network (WSN) using ZigBee protocol, and illumination control rules. A sensing module consists of occupancy sensors, including passive infrared (PIR) sensors and microwave Doppler sensors, an ambient light sensor, and lighting control rules. The dimming level of each luminaire is controlled by rules taking into consideration occupancy and daylight harvesting.

F. HEALTH AND WELLBEING

To truly enhance the client's well-being, the building design has moved beyond optimizing single parameters such as temperature and humidity, to more holistic approaches that take their cues in health-supporting human behaviours.

The design takes the following aspects into consideration that have all been shown to impact the health and wellbeing of building occupants and are therefore important building design, construction and operational considerations:

• Indoor air quality and ventilation
• Thermal comfort, temperature and humidity
• Visual comfort, daylighting and artificial lighting
• Noise and acoustics
• Safety and security
• Interior layout, active and inclusive design, and look and feel
• Connections to nature
• Location and access to amenities and outdoor spaces

<u>Building Orientation with respect to the Sun -</u>

- Designing buildings that are climate responsive and use as less energy as possible to provide comfort and is sustainable is the way forward . The goal is to maximize the amount of sun that heats space (resulting in using less energy to mechanically heat)
- The structure is based on the cardinal directions.

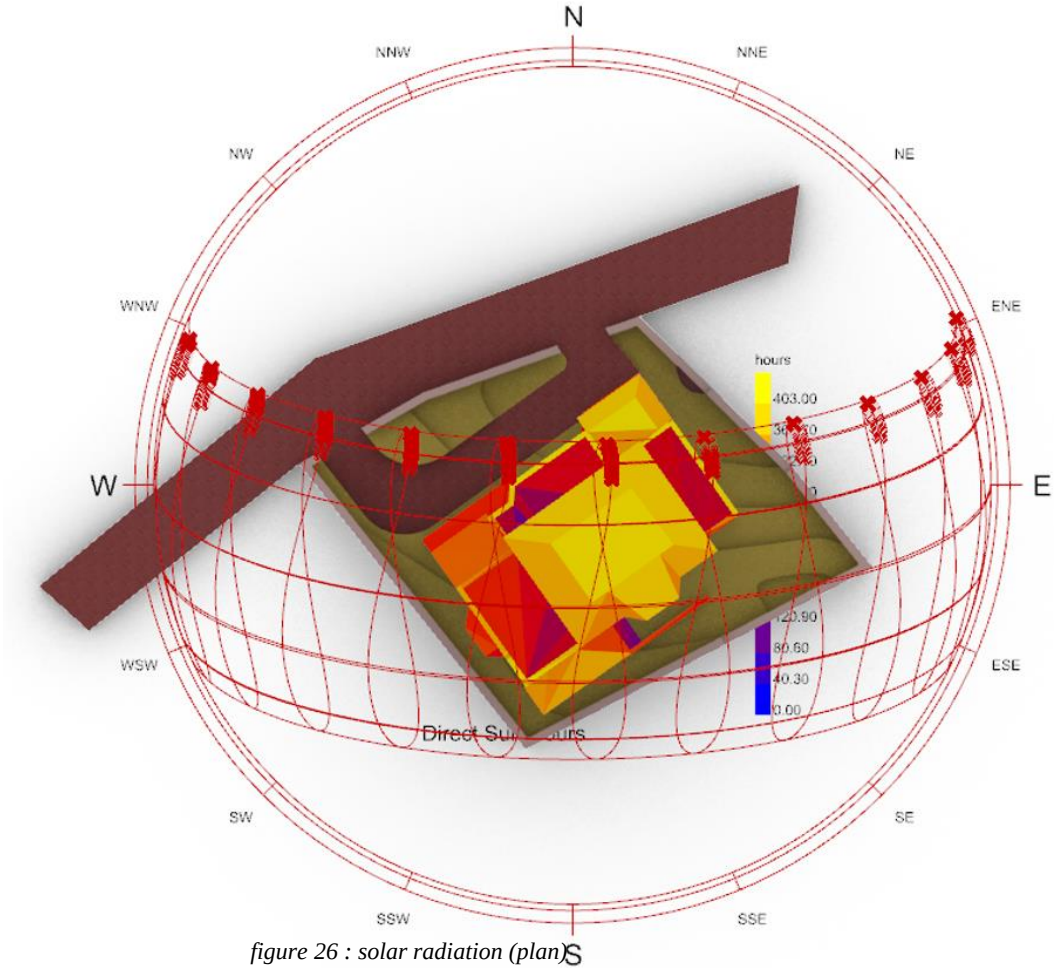


figure 26 : solar radiation (plan)

The Building is oriented NW-SE, to improve ventilation in the warmer weather and improve thermal comfort and humidity in the building.

The winters in Chikkamagaluru, where the site is located, tend to drop to very low temperatures, and in order for the sun to favour the building, it has been oriented to receive maximum sunlight since, the Earth's tilt causes the Sun to rise and set slightly south of east and west in the winter.

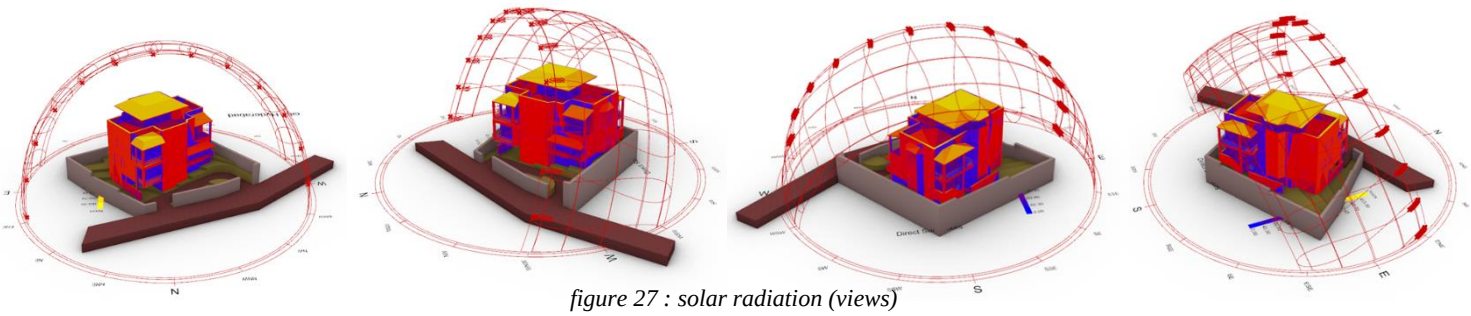


figure 27 : solar radiation (views)

Climatic modification strategies:

The project makes use of passive design that uses natural energy through the microclimate, macroclimate, topography, building form and fabric. A result of which is a minimum non renewable energy.

figure 28 : Climatic modification strategies

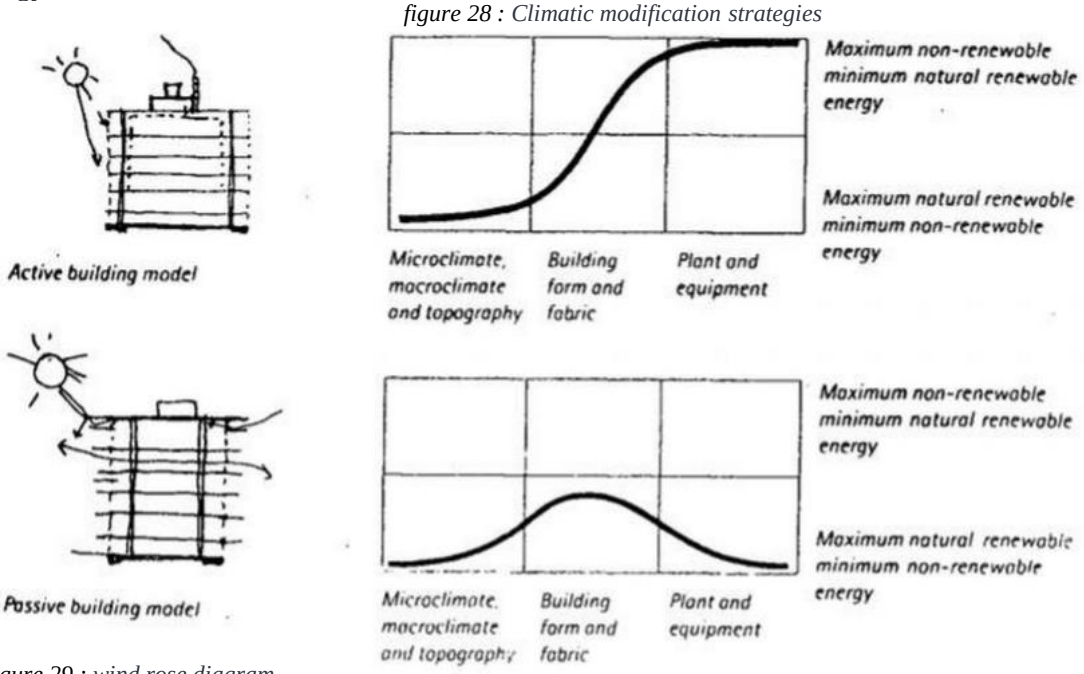
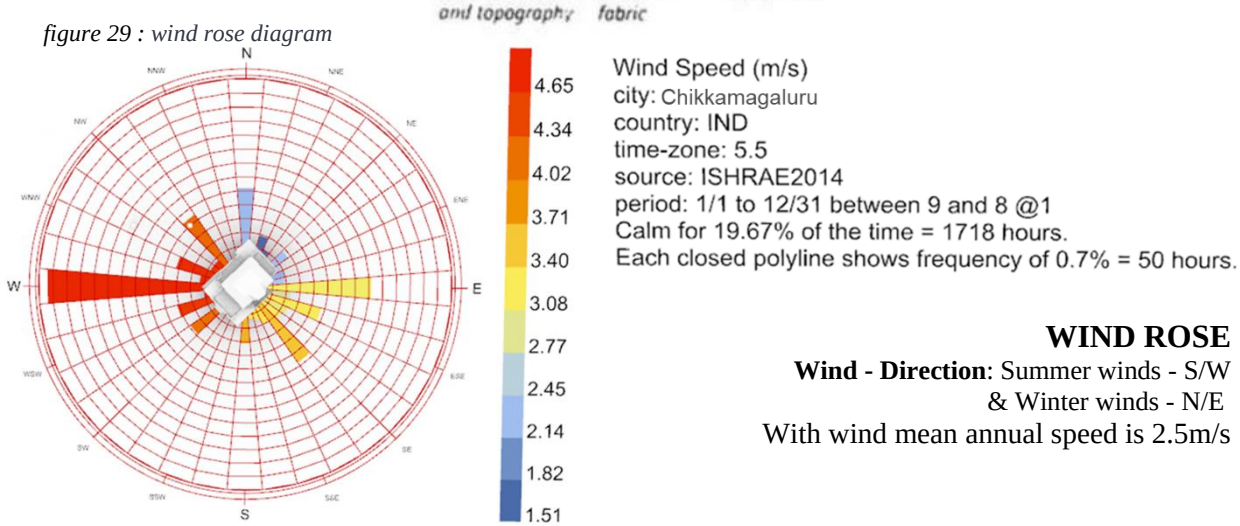


figure 29 : wind rose diagram



WIND ROSE

Wind - Direction: Summer winds - S/W
& Winter winds - N/E
With wind mean annual speed is 2.5m/s

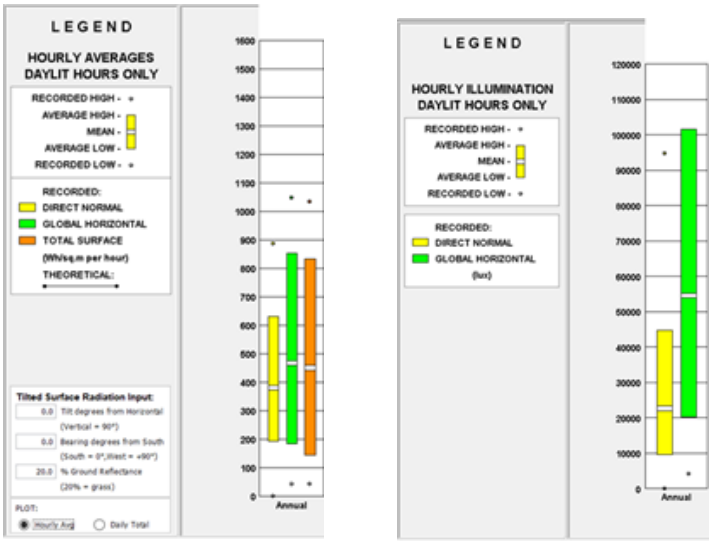


figure30 radiation and illumination range resp

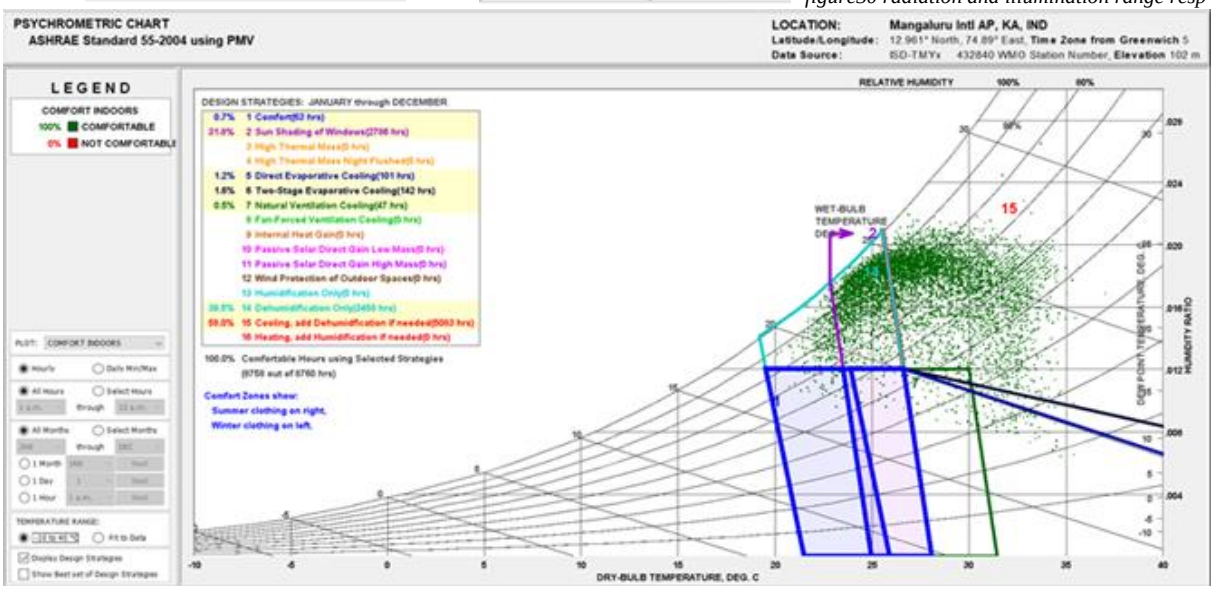


figure 31 : comfort zone shown in psychometric chart

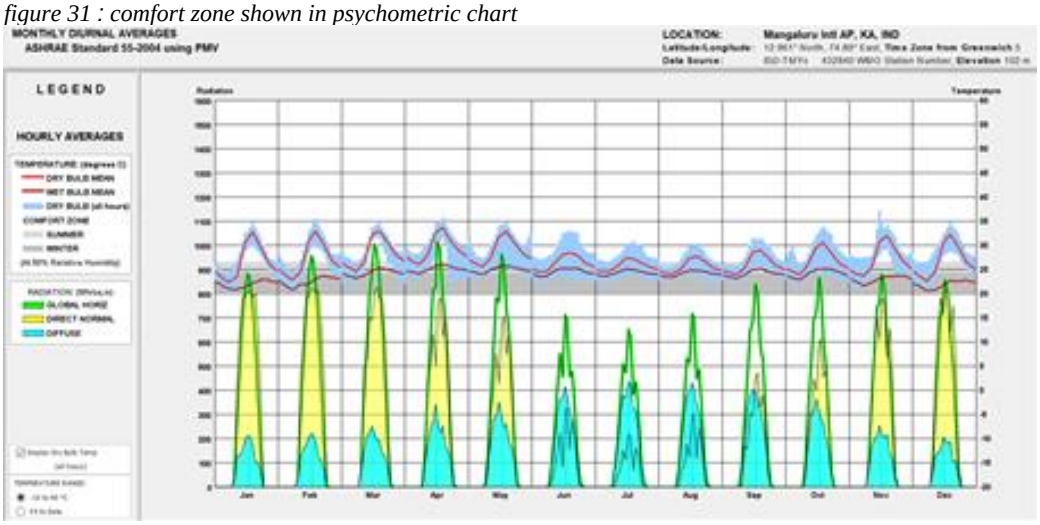
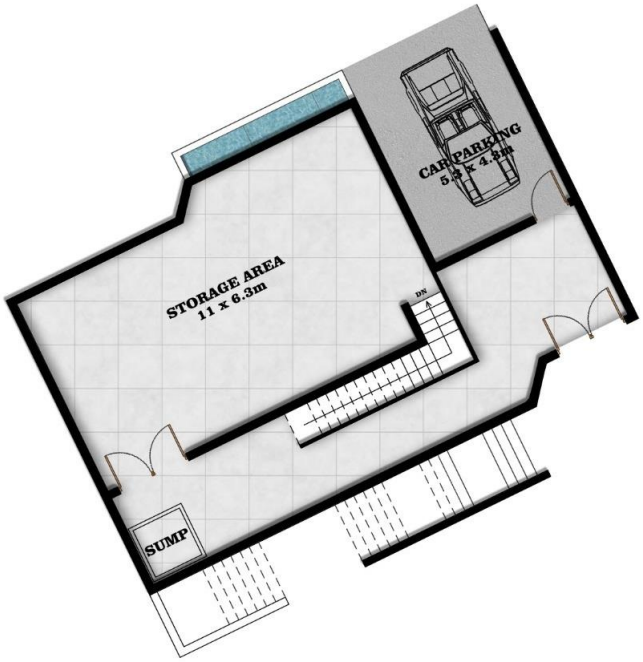


Figure 32:Thermal lag of solar radiation is seen from June to September, but humidity is high as seen in July

G. ARCHITECTURAL DESIGN

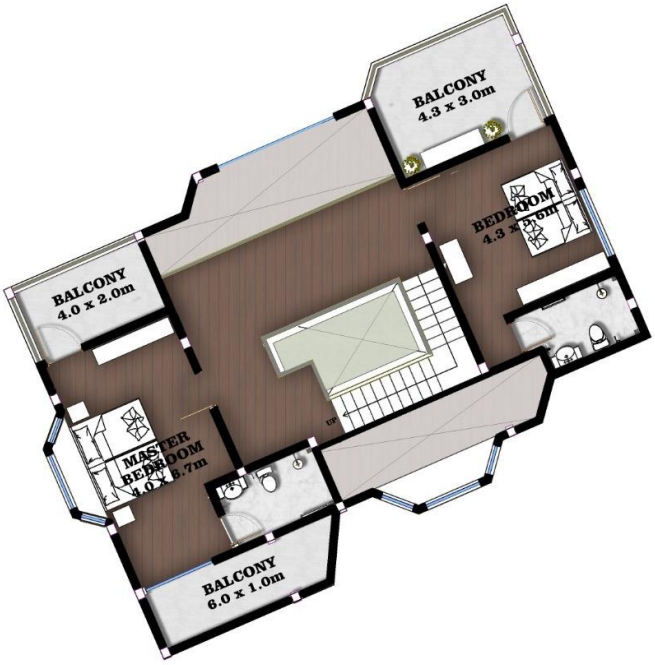
Figure 33 :



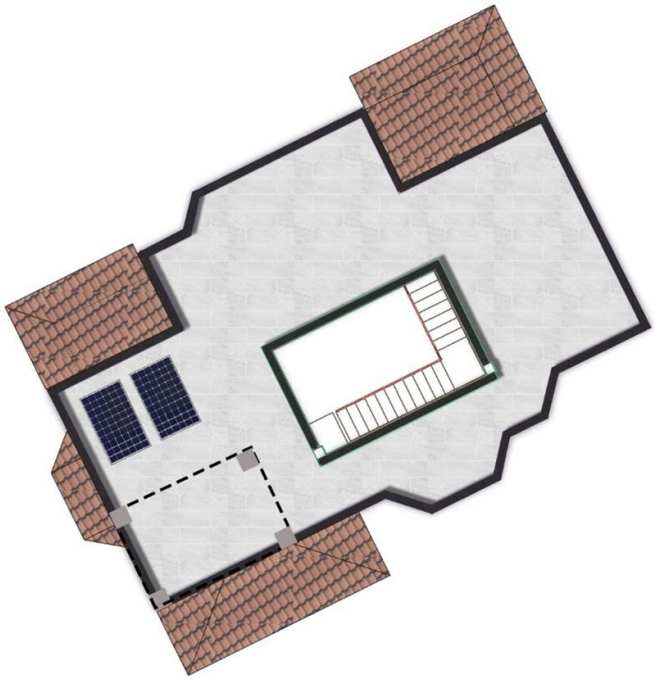
BASEMENT PLAN

BASEMENT FLOOR PLAN

GROUND FLOOR PLAN



FIRST FLOOR PLAN



ROOF PLAN

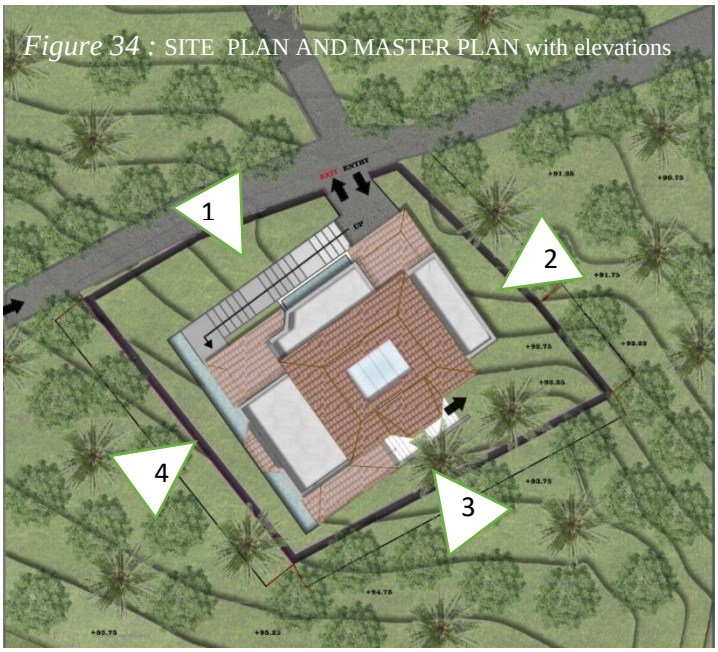
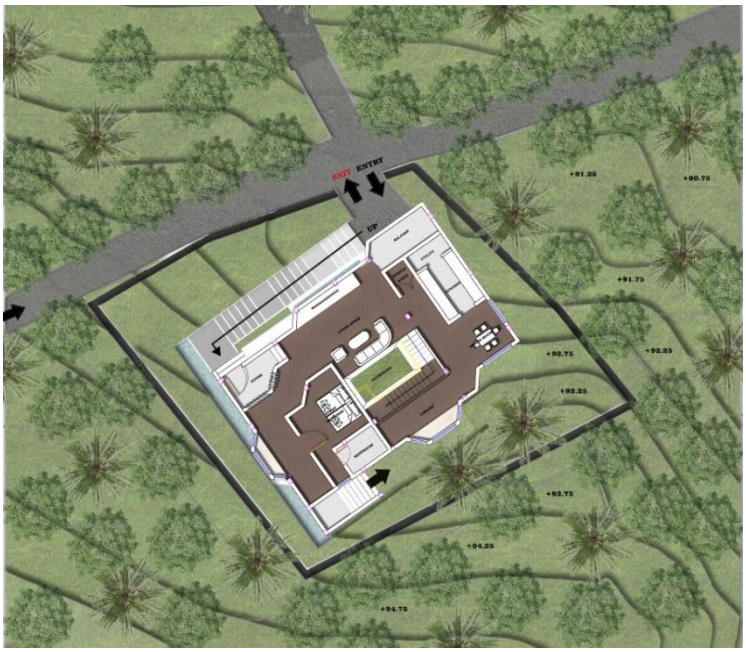
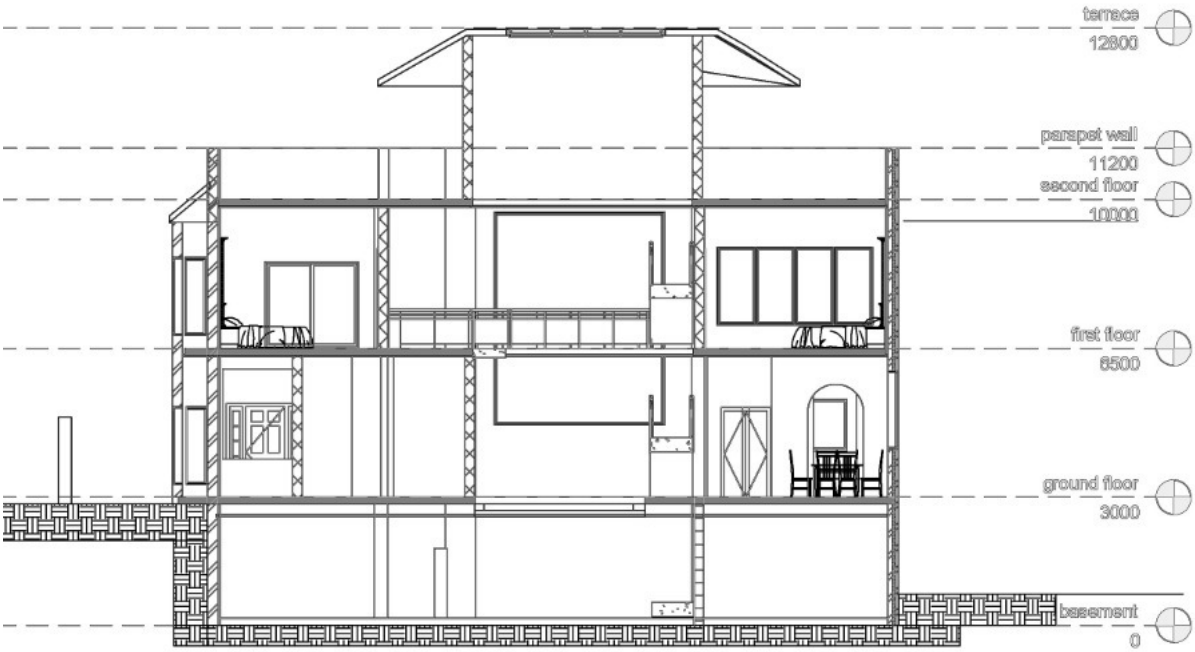


Figure 34 : SITE PLAN AND MASTER PLAN with elevations





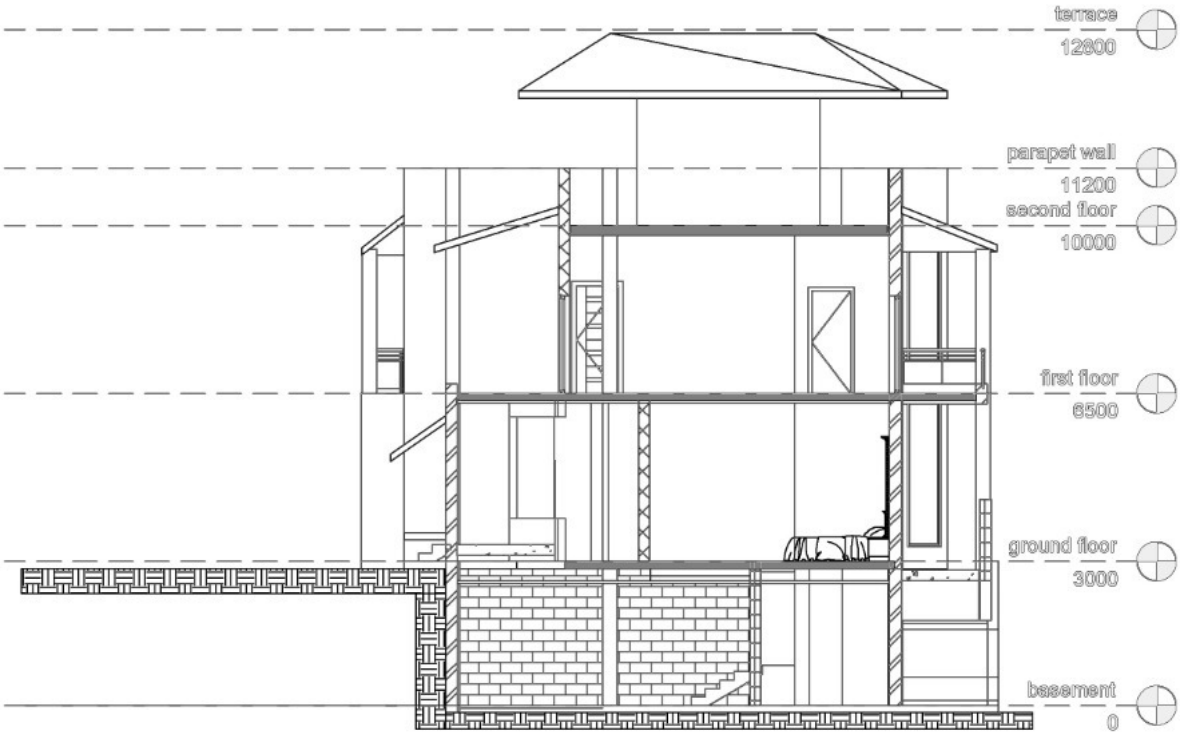


Figure 35 : section

H.

ENGINEERING DESIGN AND OPERATION:

STRUCTURAL DETAILS

- The grids of steel reinforcement rods (6mm or 8mm dia.), and concreting is done over them.
- The concrete mix used is 1:2:4.The grid size depends upon the design, span, and the material used. For Mangalore tiles (size 23cm by 40cm), the grid size is 33cm by50cm.
- The filler slab can be designed like a conventional RCC slab as per IS 456-2000 design guidelines,
- The thickness of filler material should not exceed the depth of the neutral axis.
- Generally speaking, for a slab thickness of 125mm, the filler material depth should not exceed 60mm.
- The terrace is an active community area since it is paved with solar PV panels raised on trusses and has terrace gardening spaces. *figure 36 :*

PLANS :

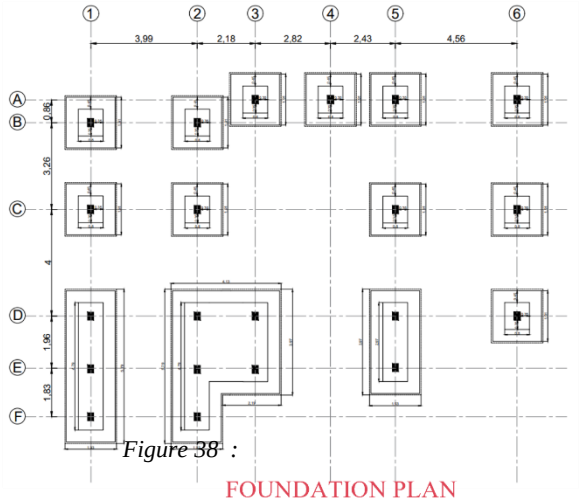


Figure 38 :

FOUNDATION PLAN

CONSTRUCTION DETAILS :

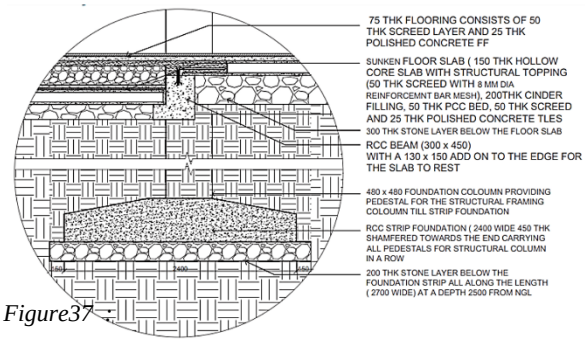
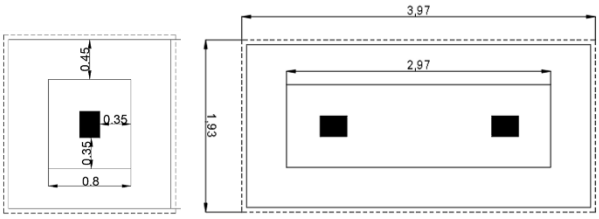
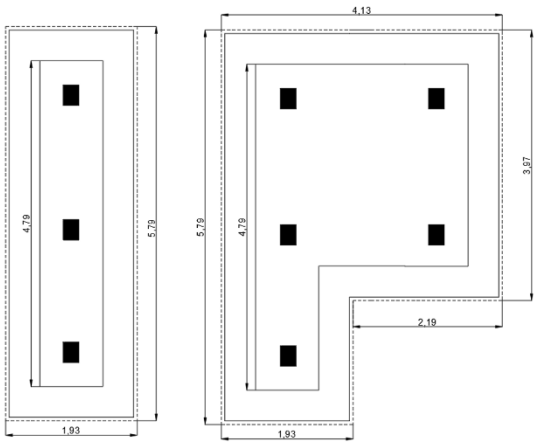


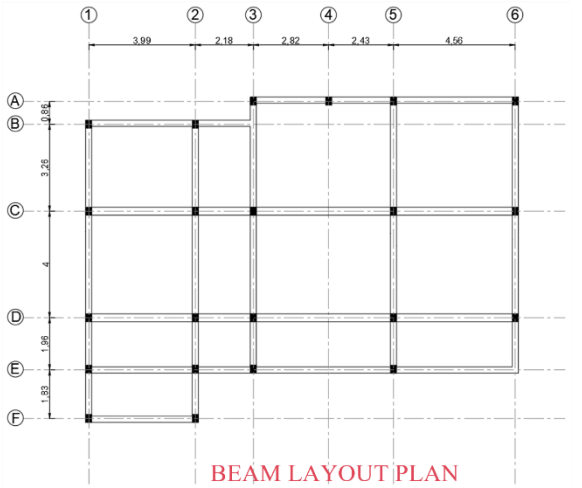
Figure37 :

FOUNDATION SECTION AND DETAILS

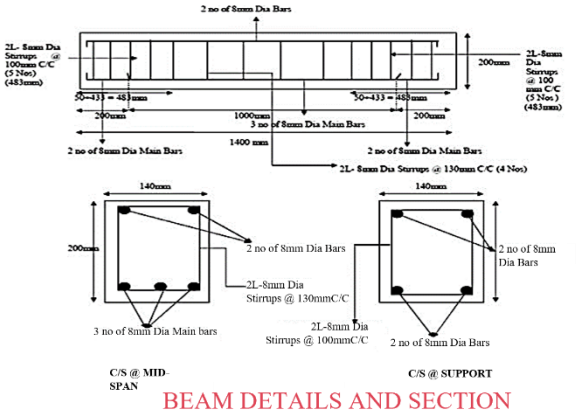
TYPES OF FOOTING IN THE FOUNDATION :





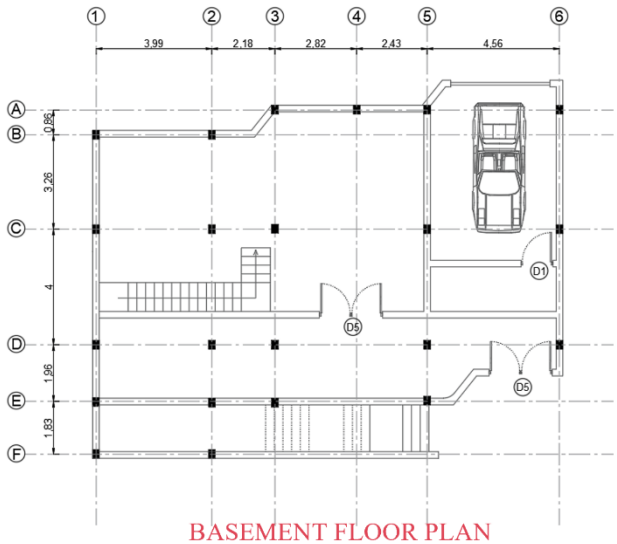


BEAM LAYOUT PLAN

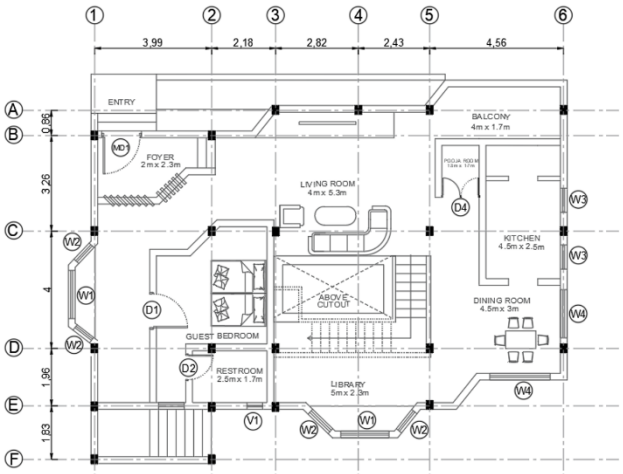


BEAM DETAILS AND SECTION

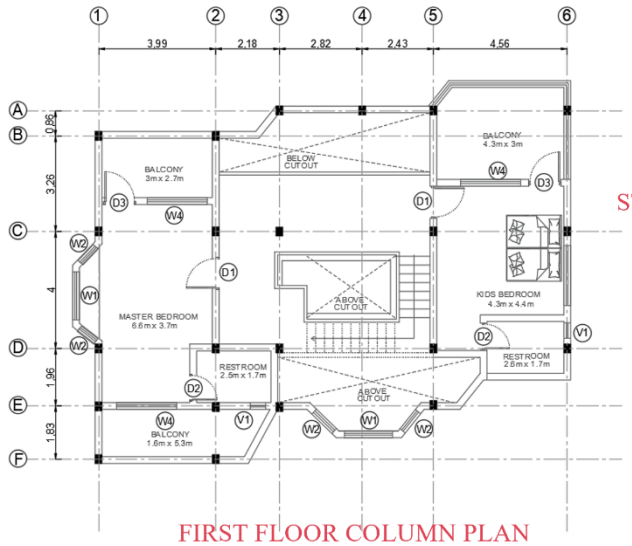
Figure 39 :column plans



BASEMENT FLOOR PLAN

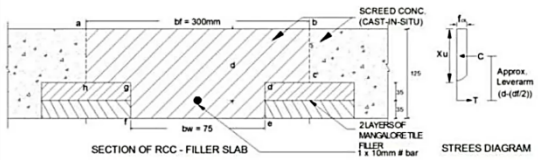


GROUND FLOOR COLUMN PLAN

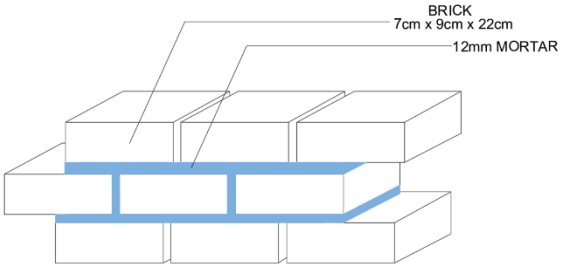


FIRST FLOOR COLUMN PLAN

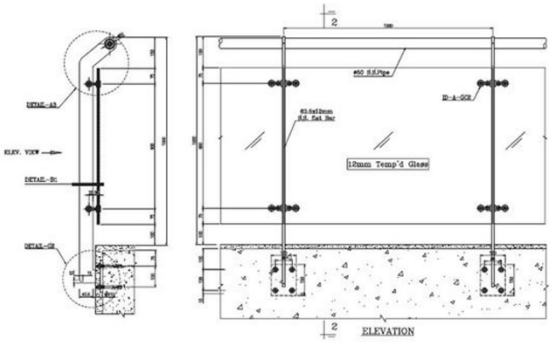
figure 40 :staircase and flooring details



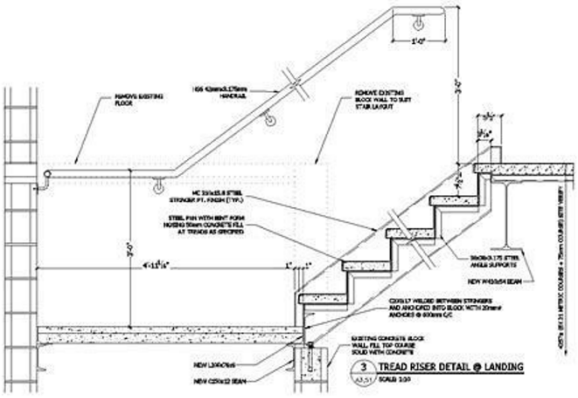
Section @ the filler slab



BRICK WORK DETAIL



BALCONY GLASS RAILINGS DETAIL

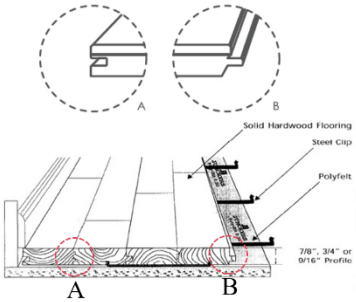


STAIRCASE DETAIL AND GLASS RAILINGS DETAIL

SCHEDULE OF OPENINGS

TYPE	DESCRIPTION	DIMENSION	Location
DOOR			
MD1	MAIN DOOR	830X2100	
D1	DOOR	800X2100	
D2	DOOR	610X2100	
D3	DOOR	760X2100	
D4	DOUBLE DOOR	600X2100	
D5	DOUBLE DOOR	760X2100	
WINDOW			
W1	WINDOW	1600X1200	
W2	WINDOW	850X1200	
W3	WINDOW	1500X1200	
W4	WINDOW	2000X1200	
FW1	FIXED WINDOW		
V1	VENTILATOR	500X1200	
V2	VENTILATOR	250X1200	

LEGENDS



WOODEN FLOORING DETAIL

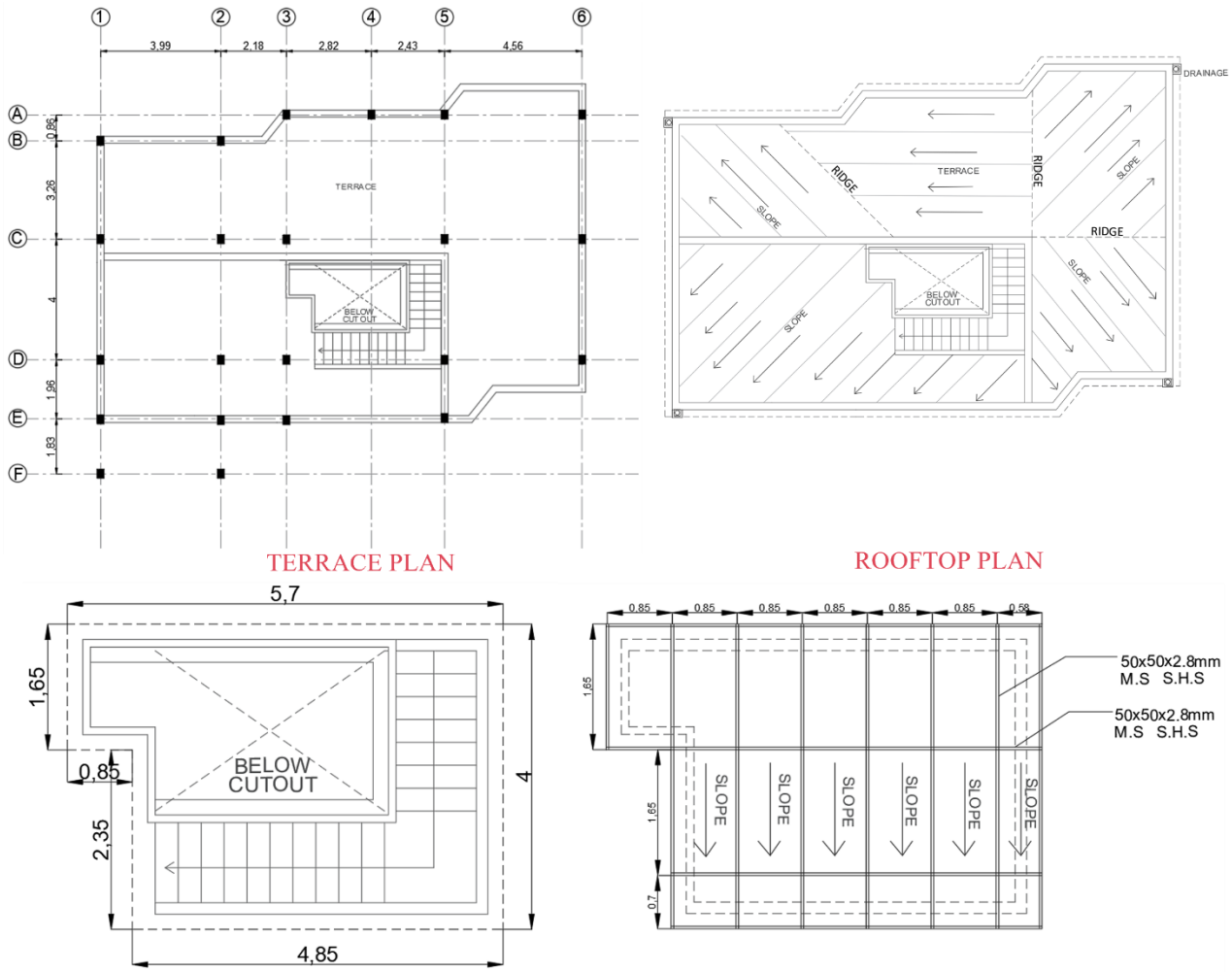


figure 36 : PLAN SHOWING STAIRCASE IN SKYLIGHTPLAN SHOWING SUPPORT FRAME FOR SKYLIGHT

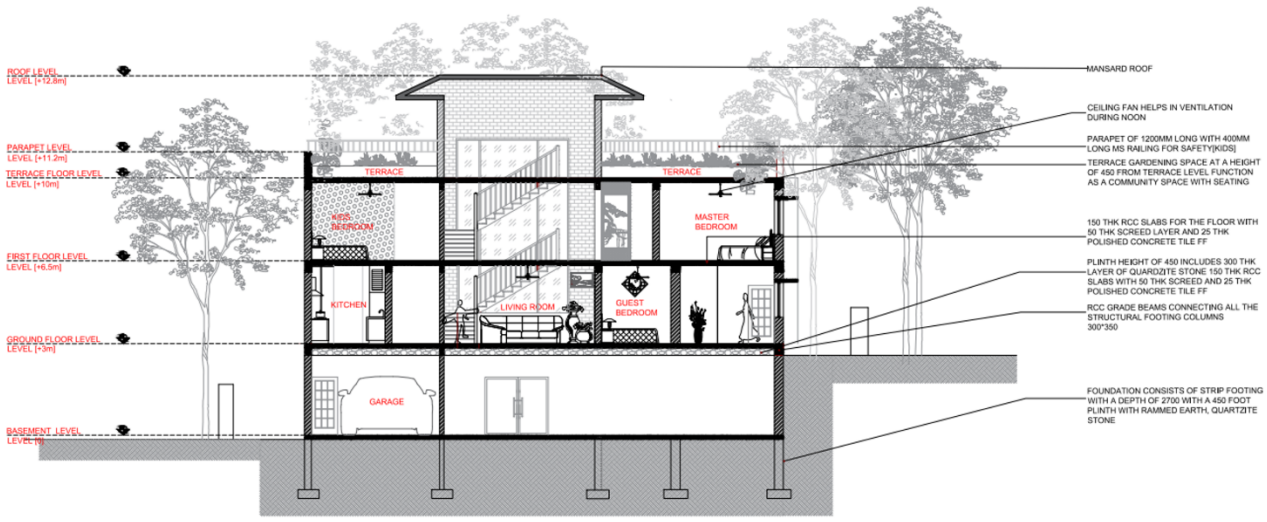


figure 41 DETAILED SECTION

OPERATIONS AND SPECIFICATIONS

EQUIPMENT : SELECTION AND OPERATIONAL SCHEDULE

The main goal was to choose appliances that were energy efficient, low maintenance, and had a long lifespan. The equipment was chosen using the Government of India's Bureau of Energy Efficiency's (BEE) Star Labeling software.

Equipment EPI was reduced from 14 kWh/m2/yr to 8.5 kWh/m2/yr by optimizing equipment range. (NOTE: Calculations and sizing for optimal HVAC systems are covered under Energy and Comfort.)

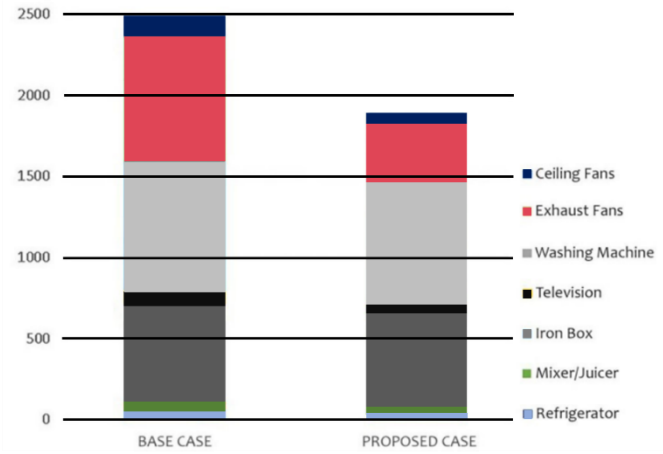


figure 42 :Equipment power comparison before and after Optimization

- Kitchen and Living room are a part of Day space. However, bedroom although being a night space, functions for 24hrs considering comfort of the residents.

Table 10 :**Equipment selected & Description**

TV : **Company :** LG **Model :** LG C1 48 (121.92cm) 4K Smart OLED TV **Power :** 40W **Cost : Rs.137190**	**MIXER GRINDER :** **Company :** HAVELLS **Model :** HAVELLS GENIE **Power :** 500W **Cost :** Rs.: ₹ 2848	**LED TUBE LIGHT :** **Company :** Syska **Model :** Syska T5 **Power :** 18W **Cost : Rs.834**	**REFRIGERATER :** **Company :** LG **Model :** GL-D241APZD **Power : 68**W **Cost : Rs.17990**
CEILING FAN : **Company :** HAVELLS **Model :** EFFICIENCIA NEO **Power :** 26W per hour **Cost :** Rs.: ₹ 5395.00	**IRON BOX :** **Company : HAVELLES** **Model :** Insta Dry Iron **Power :** 750W **Cost :** Rs.: ₹ 850	**WATER PURIFIER :** **Company :** Cuckoo **Model :** King Top 7L **Power : 1**00W **Cost :** Rs.: ₹ 21800	**WATER PUMP :** **Company :** KIRLOSKAR **Model :** TINY-180 **Power :** 180W **Cost :** Rs.: ₹ 3440
WASHING MACHINE: **Company : LG** **Model :** FHM1006ADW 5 STAR **Power : 450W** **Cost :** Rs.: ₹ 23990	**VENTILATION FAN :** **Company :** ORPAT **Model :** AXIAL FAN **Power :** 20W **Cost :** Rs.: ₹ 727	**LED PROFILE LIGHT :** **Company :** SYSKA **Model :** PROFILE LIGHT **Power :** 4W **Cost :** Rs.: ₹ 110/FEET	**LED :** **Company : PHILIPS** **Model :** BASE B22 **Power :** 2.7W **Cost :** Rs.: ₹ 447

I.SCALABILITY AND MARKET POTENTIAL

The project's ability to adapt to different demands makes it unique, as it has been designed to acclimatize to steep terrain, absence of sunlight and extreme monsoons and winters. Most suitable for regions with warm and humid climate

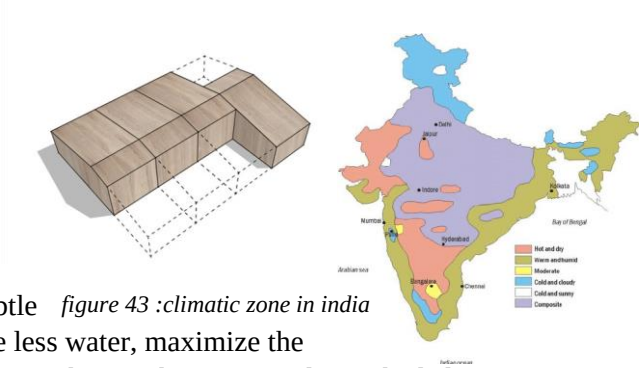


figure 43 :climatic zone in india

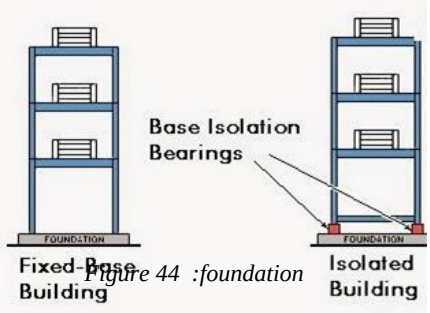


Figure 44 :foundation

It makes use of subtle technologies to use less water, maximize the amount of solar energy that can be conserved in a shaded region, use passive techniques to retain heat during winters, all while making the project 28 % sustainable.

It is resistant to the damages caused by earthquakes and other calamities, through effective methods used in the foundation and building construction.

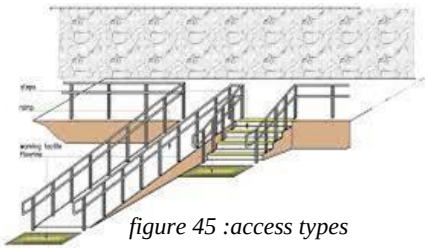


figure 45 :access types

The structure can also be used as a retirement bungalow for the market catering to the older generation and is designed for the differently abled.

The project being off-site, provides opportunity to create similar modules at any given site, thereby increasing the opportunities in the market.

Through careful consideration of effective but affordable strategies and technologies, the project is made greatly profitable.

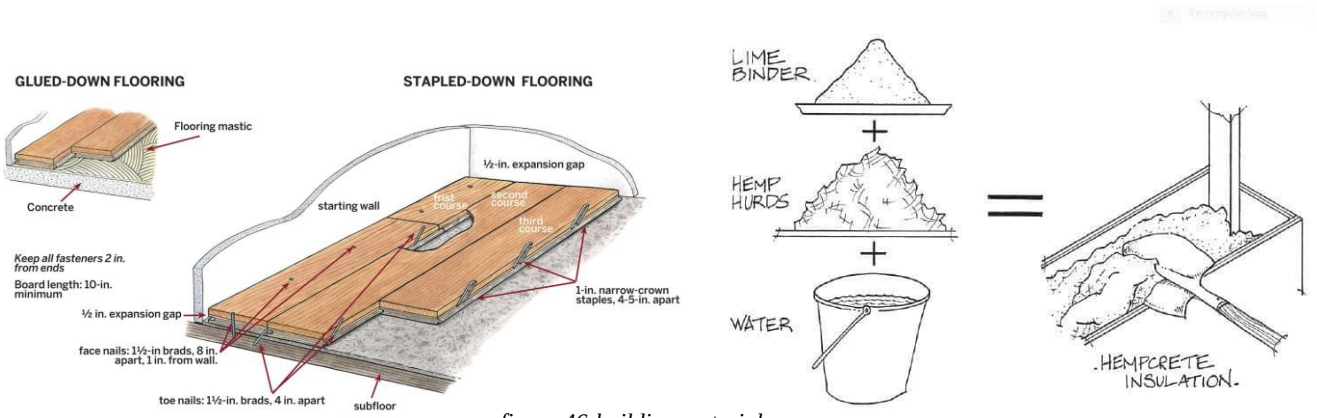


figure 46:building materials

Materials of interest: Wood and Hempcrete to reduce cost as well as acclimatize to temperature change.