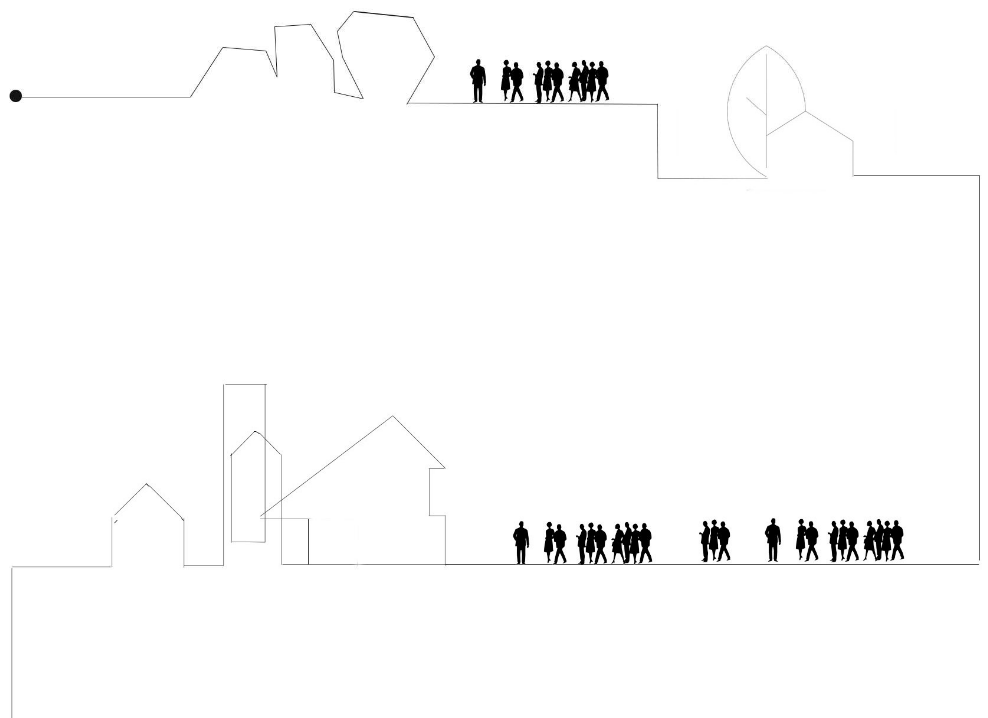
Solar™ Decathlon India



TEAM SWAYAM

SINGLE FAMILY HOUSING

FINAL DESIGN REPORT –
APRIL 2023

SJB SCHOOL OF ARCHITECTURE AND PLANNING

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NOTE: Response to reviewer's comments have been given under each topic to make it easier to read the report.

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NOTE: Response to reviewer’s comments have been given under each topic to make it easier to read the report.

EXECUTIVE SUMMARY:

'Mainstreaming Sustainable Development and Climate Resilience for Collective Action.'
- critical theme of Sustainable development and climate resilience to be the focus areas for global leaders at the World Sustainable Development Summit 2023.

The Paris Agreement, the G20 Sustainability Summit, and countless other international and government initiatives, schemes and policies involving multiple governments, NGOs, and individuals- that's how many people who are involved in the ensuring the sustainable development of the world.

The building sector contributes to a significant portion of the global emissions. We, the Team Swayam as a competitors of Solar Decathlon India are using this opportunity to design a net zero-energy housing in the city of Basavakalyan, Karnataka.

This G+1 story build-own-operate dwelling complex, called Udachan Mansion, is designed for a single family. Our goal was to integrate the project's diverse infrastructure requirements by working on various parts of design, production, and execution. This would result in the most affordable net-zero energy-water solution.

We created an optimised building massing with a significant potential for obtaining thermal comfort through natural lighting and operating the building on mixed-mode ventilation by performing pre-design comfort & energy simulation with careful consideration of all the building science principles and affordability.

With a built-up area of 424 sqm, our final building design has been able to achieve an EPI of 26.11 kWh/sqm per year, which is 35% less than the original proposal.
The design is also Net-zero water, combining efficient water consumption measures coupled with rainwater harvesting and wastewater recycling systems. Thus, the proposal is able to achieve a 22% consumption reduction from the base case.

The focus has been to reduce not only energy and water consumption but also to address the well-being of users and the challenges of affordability & marketability. Through the constant back and forth process, an initial search and exploration of all possible options, and setting the goals right, the focus has been to address these issues. The use of local construction materials and techniques have made it easier for construction and more affordable.

The site offers opportunities in the availability of daylight which we have tried to harness in our design.
This was done through an intense study and analysis of daylight which helped reduce the overall energy consumption.

REVIEWER'S COMMENTS

Section	Reviewer's Comment	Our Response
Reviewer 1		
Energy Performance	It is mentioned in the report that the building is going to be Naturally ventilated. However, evidence-based design through simulation is missing- which would show the thermal comfort will be achieved across all hours.	The comment has been updated and addressed in this deliverable.
Water Performance	The calculations for this section are done well. Capacity and related costs of the tank to be mentioned and taken into consideration. This cost could be intelligently justified by designing the tank to be used in the future development of the main project.	The capacity and cost calculation and design of water tank is considered. This has been explained further in the report.
Embodied Carbon	Embodied carbon calculations for each Comparative analysis with the baseline case is missing for Walls, Roofs, floor and superstructure. Also, please cite sources for all embodied carbon specifications.	The comment has been updated and addressed in this deliverable.
Resilient Design	Increased physical integrity through design and infrastructural changes that address the above hazards, should be demonstrated.	The comment has been updated and addressed in this deliverable.
Engineering and Operations	The Structural load calculations and HVAC system design should be explained well with drawings, narratives, and calculations. Further, Constructability in terms of availability of material, technology, and labour, should be explained with analysis and narratives	The comment has been updated and addressed in this deliverable.
Architectural Design	The Plans and the sections should be detailed with the passive design features for a better explanation	The comment has been updated and addressed in this deliverable.
Affordability	This section needs to be explained in detail	The comment has been updated and addressed in this deliverable.
Innovation	In the report, Passive design strategies are mentioned as innovation. Urging the team to innovate through the use of new materials, ready-made products and technologies.	The comment has been addressed and elaborated on the same.

REVIEWER'S COMMENTS

Section	Reviewer's Comment	Our Response
Reviewer 1		
Health and Wellbeing	This section focuses on design for achieving thermal comfort; which should be supported through a detailed analysis of annual simulation. It is mentioned in the report that the building is going to be Naturally ventilated. However, evidence-based design through simulation is missing- which would show the thermal comfort will be achieved across all hours.	We are still working on it. We will be presenting it with the presentation.
Value Propositio n	This Section should be explained well. The team should substantiate economic value addition with detailed calculations and specifications (with materials, rates and quantities) of the baseline scenario and the team's project.	The comment has been addressed and supported with necessary graphics.
Reviewer 2		
Energy Performance	Elaborate calculations for energy consumption and EPI targets given. Solar potential calculations need to be more elaborate in terms of how the numbers are arrived at.	The detailed calculations have been done further in the report.
Water Performa nce	Calculations and techniques for water conservation and harvesting are given. It is not clear how the conservation, rainwater harvesting ad recycling has met zero water requirements. You can elaborate on this.	The comments have been considered and elaborated further in the report.
Embodi ed Carbon	Calculations and techniques for reducing carbon footprint of building materials are given. CSEB, rat trap bond and structure are provided. You can improve this by adding for windows, floors, etc.	The comment has been updated and addressed in this deliverable.
Resilient Design	Durability of structure and materials has been identified as the main principle for resilience. Other aspects include comfort, water, emergency care and energy. These can be elaborated on.	Resilient design for drought and other aspects to be considered have been updated.
Engineering and Operations	Plans and structural details have been provided. You can add electrical layout.	The comment has been updated and addressed in this deliverable.

REVIEWER'S COMMENTS

Section	Reviewer's Comment	Our Response
Reviewer 2		
Architectural Design	Well done. Integration of locally available materials with planning constraints is achieved.	-
Affordability	This is inferred from section on Project Description. A 20% saving is commendable. You may elaborate on the same.	The comment has been updated and addressed in this deliverable.
Innovation	Integration of locally available and innovative materials, solar passive techniques and construction techniques is achieved. This section is well done.	-
Health and Wellbeing	Khus curtains for evaporative cooling, Jaali walls for ventilation and thermal comfort and indoor plants of various properties are proposed.	-
Value Proposition	Value proposition in terms of water consumption, energy performance, design, engineering and embodied carbon are provided.	-

TEAM INTRODUCTION

TEAM NAME: SWAYAM

INSTITUTION NAME: SJB School of Architecture and Planning

COMPETITION DIVISION: SINGLE FAMILY HOUSING

TEAM MEMBERS:

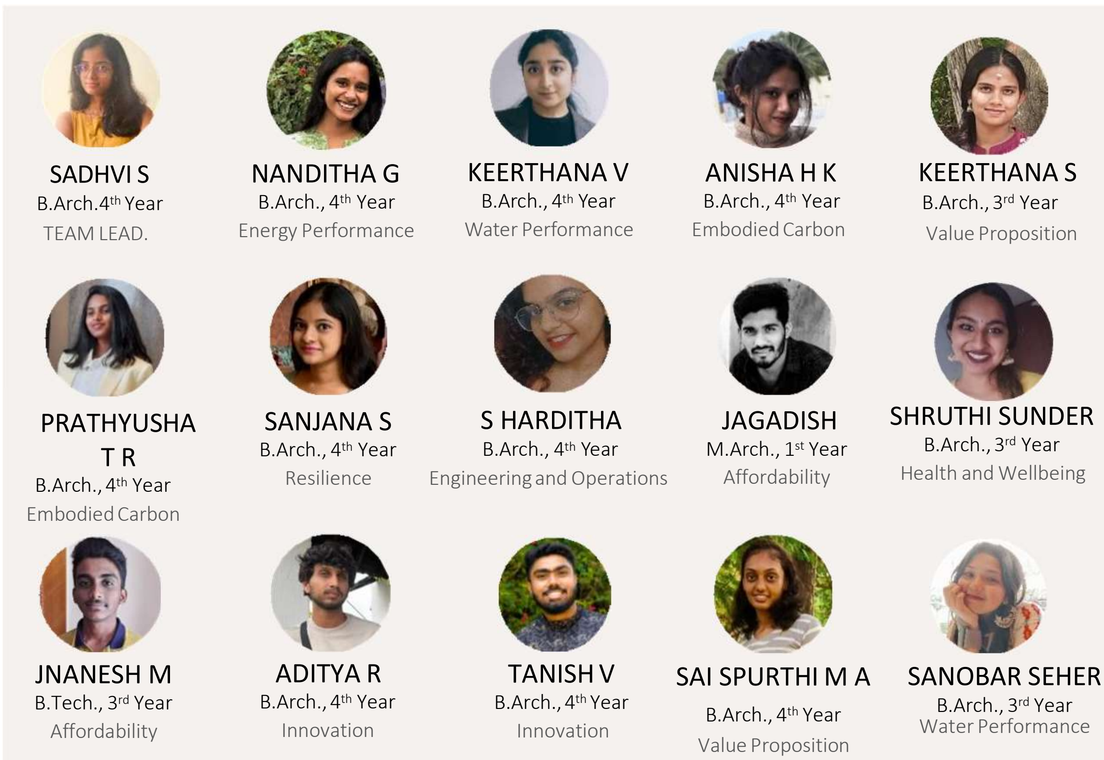


Figure 1: Team Details

APPROACH:

The team was divided based on the 10 contests, where each team member was designated, a task based on their skill set. In addition, each team member will be assisting in two other contests to establish better team co-ordination in design. The team was further divided into groups of 3-4 people each, who would come about their ideas focusing on passive strategies to develop a design based on the ideas implemented by each group, eventually sort out a design that would meet all the specifications and further go ahead with detailed design development process. We will be exploring & learning new concepts in coalition with our industry partners as we have no prior experience designing a net-zero energy and water buildings.

INSTITUTE PROFILE:

SJB School of Architecture and Planning aspires to provide a pragmatic and sensitive focus to a profession that is otherwise perceived to be elitist and urban. The school offers courses of Bachelor of Architecture and Planning, Masters of Architecture and Interior Designing.

FACULTY PROFILE:

Ar. PRAVEEN DONGARE
FACULTY LEAD
Associate Professor
I am a practicing architect and associate professor pushing the idea of sustainable future both in profession and teaching.

Ar. SUPREETH K S
FACULTY ADVISOR
Assistant Professor
A practicing Architect and also an assistant professor teaching interior design students, how a design is decision making process, So is a life.

Ar. SHILPA MADAN GOPAL
FACULTY ADVISOR
Holistic approach to Architecture

Ar. DEEPTI GUPTA
FACULTY ADVISOR
Associate Professor
Sustainable concepts in architectural design

Figure 2: Faculty Profile

INDUSTRY PARTNERS:

teri THE ENERGY AND RESOURCES INSTITUTE

NELE Architecture & Planning

MdS Malik's Design Studio www.maliksdesignstudio.com

Figure 3: Industry Partners

PROJECT BACKGROUND

PROJECT NAME: UDACHAN MANSION
PROJECT PARTNER: VISHWA UDACHAN is a practicing architect from Basvakalyan, Karnataka who wishes to go back to his roots and build a home in the place he grew up in. He and his father are the primary individuals we are dealing with in the design of this project. The project is to be used in a build-own-operate.

DESCRIPTION OF THE PROJECT:
1. Name: *Udachan Mansion*
2.Building Type: *Residential Building (Single-family housing)*
3. Location: *Basavakalyan, Karnataka*
4. No. of Occupants: *7 users*
5. Climatic Conditions*: Hot and dry climate*
6. Site Area: *50' * 80' (4000 sq.ft ≈372 sq.m)*
7.Neighborhood: *Near Tahsil Office, Mahadev Temple Road, Basavakalyan*
8.Applicable Building Regulations: *Bengaluru bye-laws*
Allowed FAR: 1.2
Permissible Ground Coverage: 70%
Actual ground Coverage: 230 sq.m
Permissible Built-up Area: 432 sq.m
Estimated Built-up Area: 410 sq.m
Height Restrictions: 15m

The original goal to make the affordable :

The current construction cost at Basavakalyan is 1800/sqft , but according to our preliminary budget calculations it is 1250/sqft. , achieved through open spaces and locally available materials.
The achieved construction cost is 1450 per square feet which is 20% less than the typical construction cost.

S. No	USER	AGE-GROUP	PROPOSED ACTIVITY SPACE
1.	Grandparents (2)	>60	• Common Area that serves as multi-function spaces to serve as a gathering space for people of all ages- front porch and primary courtyard. • Bedroom at the bottom
2	Parents (2)	30s	Common Areas- primary courtyard and secondary courtyard near the office.
3	Children (3)	<18	Common Areas- primary courtyard and secondary courtyard.
4	Guests	-	Common Area- front porch and primary courtyard.
*Areas are primarily divided based on gender to suit their lifestyle.			

Table 1: User Study

S.NO	PARTICULARS	BASELINE ESTIMATE (PROJECT PARTNER/ SOR BASIS)		
		AMOUNT	% of the total	AMOUNT (INR PER SQM.)
1.	Land	32,00,000	34.97%	7550
2.	Civil Works	28,85,910	47.64%	5885
3	Internal Works	16,75,650	27.66%	3210
4.	MEP Services	11,32,000	18.68%	4280
5	Equipment and Furnishing	0	0%	2140
6	Landscape and Site Development	75,000	0.02%	1070
7	Contingency	3,31,133	0.05%	1070
TOTAL HARD COST (WITHOUT LAND)		60,56,988	83.19% (taken against 60,56,988)	-
TOTAL HARD COST		92,56,988	89.07%	-
8	Pre Operative Expenses	2,50,000	2.73%	890
9	Consultants	2,50,000	2.73%	890
10	Interest During Construction	5,00,000	5.46 %	166.66
TOTAL SOFT COST		10,00,000	10.92 %	-
TOTAL PROJECT COST (WITHOUT LAND)				60,56,988
TOTAL PROJECT COST				92,56,988

Table 2: Construction Budget

GOALS

Architectural Design Goals

- *Architectural style: Critical regionalism*
- To design a residence that responds to the cultural context, and diversity of present-day Basavakalyan. This is to be achieved through the use vernacular architectural elements and techniques.
- The chosen material is a combination of laterite and brick for the outer walls; ferrocrete walls for the inner partition walls; and a combination of mud rolls and country tile roofing (has been further explained in design ideas pros and cons)

Energy Performance

- Energy reduction of 30% by use of renewable energy systems (solar panels) and additional reduction of 10% (in the use of lighting and artificial cooling systems through passive techniques)
- Achieve an EPI > 30 kWh/m2. (According to the baseline energy estimates the most energy used is through)
- It can be concluded from the baseline energy estimates that the most amount of energy is consumed in lighting and cooling. The strategies proposed against these are- increase the daylighting to negate the use of artificial lighrtig during the day; and passive cooling strategies like evaporative cooling.

Water Performance

- Design will achieve water efficiency by recycling and reusing greywater for non-potable uses.
- Engage in systems that reduce unnecessary wastage of water.
- The daily consumption right now comes up to 721l. The goal is to reduce water consumption by 20% through the use of water saving equipment like double sink with diverter valves.

Engineering and Operations

- The depth of a building foundation altered to around 2 feet in depth for typical soils.
- Usage of Load Bearing Structure instead of using Frame structure is preferable.
- Create an integrated façade system and roofing system to harness the incoming winds and reduce heat gain of the building by 40%.

Value Proposition

- Energy efficient
- Low cost house (minimal budget)
- Getting 10% of the initial investment back in 6 years.

Resilience

- Providing resilient design in the aspect of water and energy conservation.
- by encouraging use of renewable sources of energy

Embodied Carbon

- Reducing the carbon emission level by either choosing the material having lower embodied carbon (laterite in this case since it can be locally sourced).
- Also using active energy efficient methods to gain negative operational emissions higher than -0.6 tonnes of CO_2 a year.

Health and Wellbeing

- Use elements like vetiver curtains or khas tati -provides thermal comfort by cooling down the interiors. Emits a subtle fresh smell, keeping the space fresh.
- To achieve 50% of the operational hours in the comfort range without the use of refrigerant cooling.

Passive Techniques

- The objective of the use of passive techniques in this case are directed at increasing the livability of the house by increasing humidity, achieving thermal comfort and increasing water efficiency.
- Use elements like vetiver curtains or khas tati -provides thermal comfort by cooling down and humidifying the interiors.
- The use of vernacular construction materials and techniques to reduce the overall embodied carbon.

Affordabilty

- Lowered initial investment: The current construction cost at Basavakalyan is 1800/sqft , but according to our preliminary budget calculations it is 1250/sqft. , achieved through open spaces and locally available materials.

Electricity and EPI Calculations

SL.NO.	LOCATION	APPLIANCE	NUMBERS (N)	NO. OF HOURS (H)	DAYS (D)	IND. WATTAGE (W)	TOTAL WATTAGE (N*H*D*W)	ANNUAL ENERGY CONSUMTION (kWh)
LIGHTING								
1	Gate	Ceiling Light (Low intensity, warm lighting)	2	2	365	12	17520	17.520
2	Porch	Ceiling Light (Low intensity, warm lighting)	3	2	365	12	26280	26.280
3	Living Area	Ceiling Light (Med. Intensity, warm lighting)	6	6-8	365	24	315360	315.360
4	Dining	Ceiling light	4	2	365	24	70080	70.080
5	Kitchen	Ceiling Light (Med. Intensity, warm lighting)	2	3	365	24	52560	52.560
6	Toilet	Ceiling Light (Med. Intensity, cool lighting)	1	1	365	24	8760	8.760
7	Bedroom	Ceiling Light (Med. Intensity, warm lighting)	2	4	365	12	35040	35.040
8	Circulation space	Wall Light	2	2	365	8	11680	11.680
		Wall Scones	2	2	365	5	7300	7.300
9	Utility Garden	Wall Light	1	2	365	8	5840	5.840
10	Office	Ceiling Light (High intensity, cool lighting)	3	4	365	24	105120	105.120
		Task light	3	4	365	12	52560	52.560
11	Pooja Room	Wall light	1	2	365	10	7300	7.300
12	Bedroom2	Ceiling light (Med. Intensity, warm lighting)	2	4	365	12	35040	35.040
13	Bedroom3	Ceiling light (Med. Intensity, warm lighting)	2	4	365	12	35040	35.040
14	Master Bedroom	Ceiling Light (Med. intensity)	2	4	365	12	35040	35.040
15	Common toilet	Ceiling Light (Med. Intensity, cool lighting)	1	2	365	24	17520	17.520
16	Attached Toilet	Ceiling Light (Med. Intensity, cool lighting)	1	2	365	24	17520	17.520
17	Common area/library	Ceiling Light (Med. Intensity, warm lighting)	1	2	365	24	17520	17.520
18	Circulation	Ceiling light	2	2	365	5	7300	7.300
TOTAL LIGHTING LOAD								880.38

ENERGY PERFORMANCE

Electricity and EPI Calculations

OTHER APPLIANCES								
19	Bedroom	Ceiling fan	4	6	300	35	252000	252.000
20	Living Room	TV	2	6	365	100	438000	438.000
		Ceiling fan	2	6	300	35	126000	126.000
21	Office	Computer	3	12	365	200	2628000	2628.000
		Ceiling fan	2	8	330	35	184800	184.000
22	Service Area	Washing Machine	1	1	365	750	273750	273.750
23	Kitchen	Mixer	1	0.5	150	100	7500	7.500
		Grinder	1	0.5	150	500	37500	37.500
		Oven	1	0.5	150	1000	75000	75.000
		Chimney	1	3	365	60	65700	65.700
		Refrigerator	1	24	365	400	3504000	3504.000
		Ceiling Fan	1	4	300	35	42000	42.000
		Aqua guard	**1**	**1**	**365**	**100**	**36500**	**36.500**
24	Toilet	Exhaust Fan	3	2	365	40	87600	87.600
7757.55`								
25		Pump	1	1	365	750	273750	273.750
26		Doorbell	1	0.5	365	5	43800	43.800
27		Miscellaneous load	-	-	-	1000		
TOTAL LOAD (OTHER APPLIANCES)								8075.1
TOTAL LOAD								8075.1 + 880.38 = 8955.5
FINAL LOAD AFTER ACCOUNTING FOR A DIVERSITY OF 45%								4029.97

Table 3 : Achieved Energy Consumption Table

Achieved EPI $= \dfrac{\textbf{Annual energy consumption}}{\textbf{Estimated built-up area}}$

$= \dfrac{8955.5}{424.65\ m^2}$ = **20.18 kWh**

Original Total Load = 40 kwh/sqm per year
Achieved Total Load = 20.18kwh/sqm per year

The original proposed EPI was 40 kWh and the **achieved epi is 20.18 kWh.**

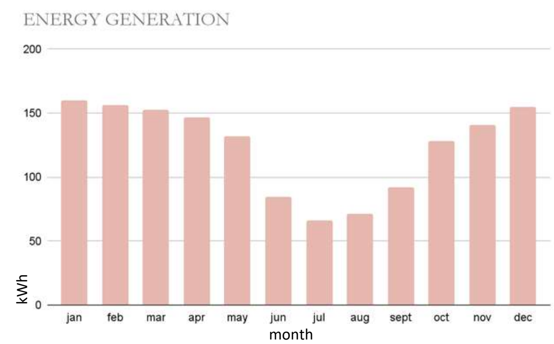


Fig 4 : Renewable Energy generation chart

According to data extracted from climate studio

Techniques used for energy conservation

- solar panels installation - active energy.
- Use of natural ventilation appropriately to decrease the usage of artificial energy.
- Comfortable micro-climate will be created (Stack effect, Cross ventilation).
- Perforated facades helps in reducing the direct sun glare.

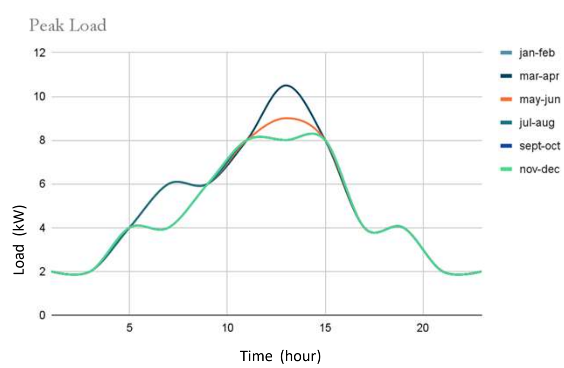


Fig 5 : Peak Energy supply graph

ENERGY PERFORMANCE

INTERNAL Heat Gain by Building
Heat gain by human = 250 btu/hr
Heat gain by appliances = 2460.75 btu/hr

EXTERNAL Heat Gain by Building
The materials used in the building envelope have low U-value and high thermal mass that help reduces the heat transfer into the interiors by creating a thermal lag.

SL NO.	LOCATION	APPLIANCE	HEAT OUTPUT (Btu/hr)
1	KITCHEN	MICROWAVE	600-1400
		REFRIGERATOR	690
		MIXER	15
		KETTLE	10
		OVEN	1170
2.	OFFICE	MEDIUM MONITOR(400-460mm)	280 (70 each)
		PRINTER	130
3.	LIGHTING	12W LED	30.69
		24W LED	225.06
TOTAL HEAT GAIN			2460.75

Table 4 : Heat gain by appliances

Model Name and Brand	SHARK Bi-Facial solar panel – LOOM SOLAR
Inverter	3500w efficiency @ 80%
Battery	150AH (8 no.)
output power	4023.76 kwh
area covered	38.4 sqm (32% of total area)
panel dimension	2.1m x 1.0m
number of panels	16 panels
Panel type and efficiency	Mono PERC Bifacial , >22%

Table 5 : Solar module specifications

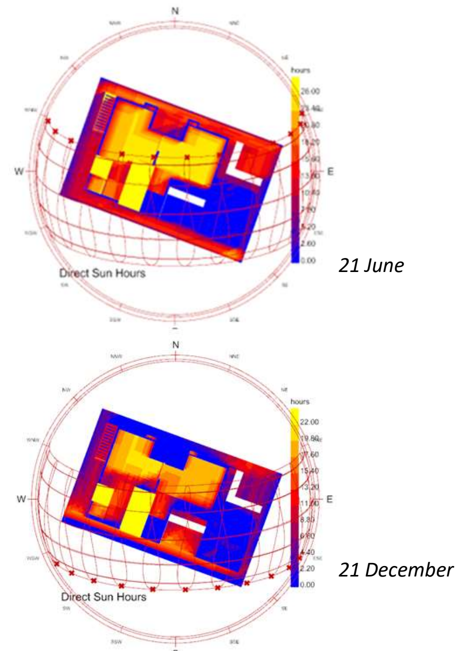


Figure 6 : Solar Radiation on Floor

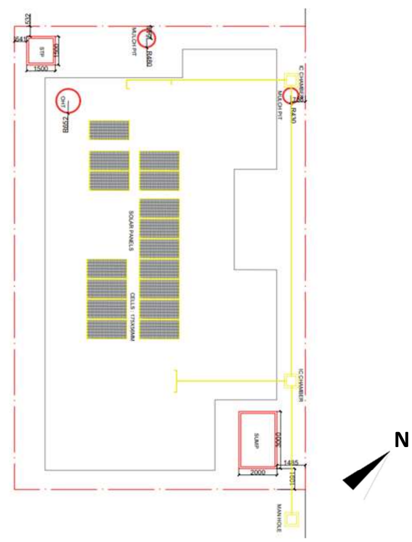


Figure 7 : Solar PV Layout

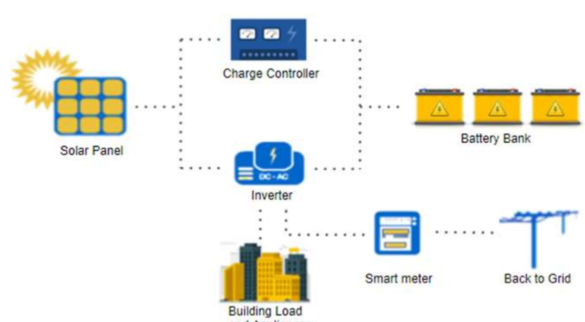


Figure 8 : Schematic Working Diagram of PV Panels – Grid tied system

WATER PERFORMANCE

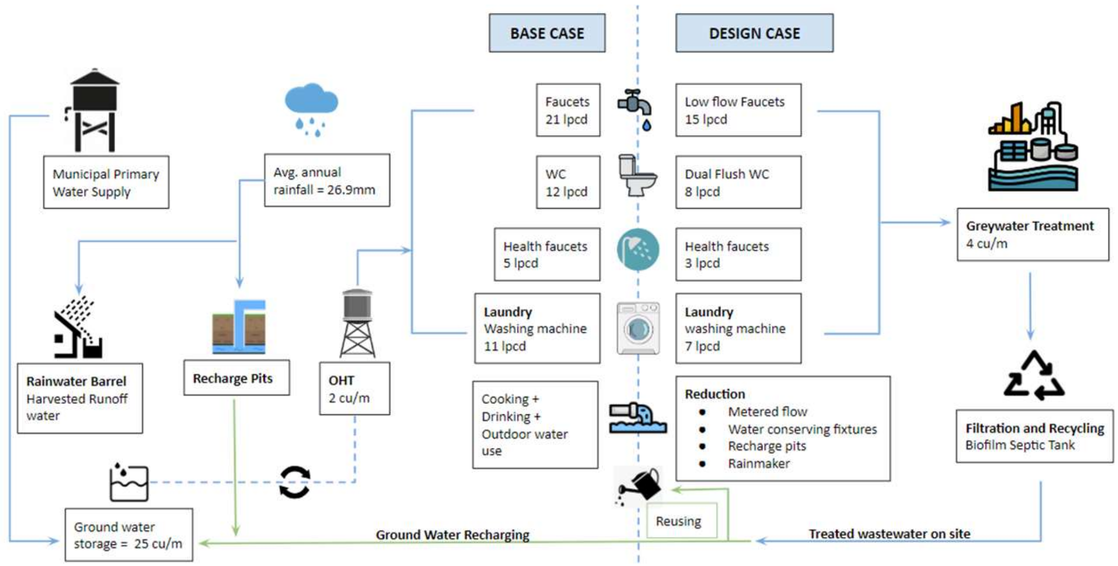


Figure 9 : Water Cycle Table

(Refer to ---- for water tank capacity and design)

Expected water consumption-

ACTIVITY	PER DAY USAGE (IN LITERS)	GREY WATER PER DAY (IN LITERS)	BLACK WATER PER DAY (IN LITERS)
BATHING	320 (33LTS/PERSON)	320	
TOILETS	75		75
FAUCETS	150 (5/MINUTE)	150	
WASHING DISHES	50	50	
LAUNDRY	80	80	
OUTDOOR WATER USE	10	5	5
OTHER USE	50	30	20
DRINKING	40		
COOKING	20	20	
TOTAL	**720**	**655**	**100**

Daily Consumption (per Capita)	Number of Occupants	Daily Consumption (In Litres)	Grey Water Efficiency	Grey Water Saved (In Liters)
103	7	721	36 %	236

Note:
Total water usage = 720
Total Grey water produced = 655
Total Black Water Produced = 100

Therefore; 655+100 = 755

Difference is a result of drinking usage.

Table 6 : Expected Water Consumption

Techniques used to reduce water consumption :

- Installing low flow water conserving fixtures and dual flush toilets.
- Reusing greywater for non-potable uses such as toilet flushing, landscape irrigation and car washing.
- Reducing fresh-water usage for utility purposes by using collected rainwater.

Techniques used for water conservation :

- Recharge pits / shafts, mulch basins and permeable pavers in landscaped area to recharge ground water.
- Conserving received rainwater in rainwater barrels for non-potable uses.

WATER PERFORMANCE

A detailed study on the energy and water consumption have been carried out so thereby calculating the efficiency achieved through each technique.

Rain Water Harvesting
RWH Potential = Annual rainfall x roof area x runoff factor
RWH Potential = 26.96 mm x 170.65 sq.m x 0.75 = 3450.54 lpc/yr
RWH Potential = 3450.54 lpc/yr

Figure 10: Rain-water barrels

Techniques used to reduce water consumption :

- Installing low flow water conserving fixtures and dual flush toilets.
- Reusing greywater for non-potable uses.
- Reducing fresh-water usage for utility purposes by using collected rainwater.

Figure 11: Permeable pavers

Techniques used for water conservation :

- Recharge pits / shafts, mulch basins and permeable pavers in landscaped area to recharge ground water.
- Conserving received rainwater in rainwater barrels for non-potable uses.

Figure 12: Mulch Basins

Conclusive Report :

Total demand (lpcd) = 721 Liters
Total demand per year = 721 x 365 = 2,63,165 Liters
Total demand per year = 263 cu/m

Total demand achieved (lpcd) = 566 Liters
Total demand achieved per year = 566 x 365 = 206590 Liters
Total demand achieved per year = 206 cu/m
Reduction by 22% = 57896 Liters

Achieved water consumption after the use of innovation-

Sl.No.	Activity	Per Day Use (In Liters)	Grey Water/day (In Liters)	Black Water/day (In Liters)
1.	Bathing	231 (33lts/person)	231	
2.	Toilets	56		56
3.	Faucets	75 (2.5/min)	75	
4.	Washing Dishes	45	45	
5.	Laundry	49	49	
6.	Outdoor Water Use	10	5	5
7.	Other Use	40	25	15
8.	Drinking	40		
9.	Cooking	20	20	
Total		566	450	76
Daily Consumption (per Capita)	**Number of Occupants**	**Daily Consumption (In Litres)**	**Grey Water Efficiency**	**Grey Water Saved (In Liters)**
81	7	567	55.5%	315

Table 7 : Achieved Water Consumption

Note:
Total water usage = 566
Total Grey water produced = 450
Total Black Water Produced = 76

Therefore; 450+76 = 526

Difference is a result of drinking usage.

WATER PERFORMANCE

Grey Water Treatment

Greywater recycling with Biofilm Septic Tank

Greywater or sullage is all wastewater generated in households or office buildings from streams without fecal contamination. It is far more easy to treat greywater due to its low level of pollutants, contaminants and pathogens. This type of septic tank uses aerated filters and aqua septic bio film inside it to recycle the waste water. It relies on microbes to use oxygen and grow inside plastic intermediaries present inside, the microbes form like a mucus inside by feeding off the waste inside the tank and cleans the impurities. These type of tanks can recycle both black and grey water.

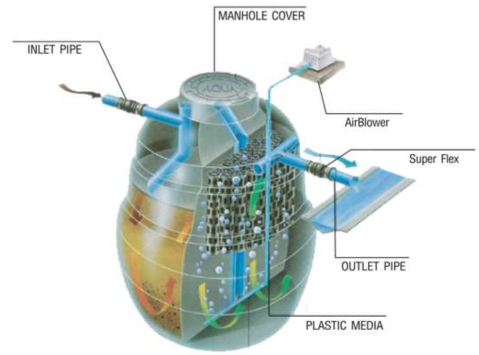


Figure 13 : Biofilm Septic Tank

It is done by filling the air distributed through the air duct and distributed to the aeration pipe in the tank, increasing the amount of oxygen to the system, which, after treating the wastewater with aqua septic biofilm.

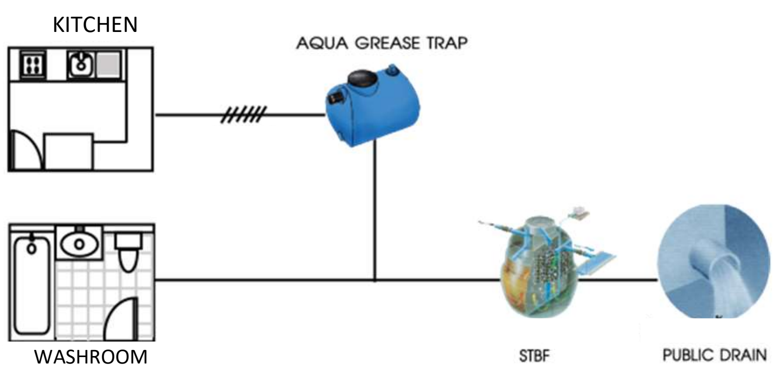


Figure 14 : Grey Water Recycling Process

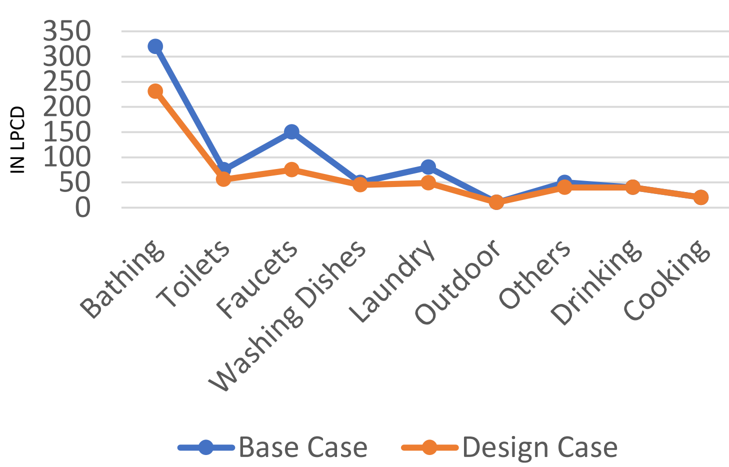


Figure 15 : Water consumption Graph

EMBODIED CARBON

METHODS IMPLIMENTED IN DESIGN, CONSTRUCTION OF ELEMENTS, AND SELECTION OF MATERIALS TO EMBODIED CARBON OF THE BUILDING

- Reducing the carbon emission level by either reducing the mass of the material or choosing the material having lower embodied carbon.
- Using active energy efficient methods to gain negative operational emissions higher than -0.6 tones of CO2 a year.
- Designing the residence to have shorter circulation to reduce floor area which will reduce the amount of materials used.
- Designing the residence to have shorter spans to reduce the use of structural materials.

USE OF CSEB BLOCKS FOR CONSTRUCTION OF EXTERNAL WALLS

- CSEB are a mix of soil, sand a stabilizer (often 5% of cement) and water.
- They are compressed in a press and they are not fired.
- CSEB are also called as E-block, economical, earth block.
- 52% less carbon emission than normal brick wall.

USE OF RAT TRAP BOND

- Rat trap bond uses 25% lesser bricks and 40% lesser mortar than traditional masonry, reducing the amount of materials required
- The air gap and the thickness of the brick course also helps promote thermal lag and the air gaps can further be filled with straw sourced locally to promote heat lag

REDUCING THE EMBODIED CARBON BY USING LOCAL MATERIALS, HENCE REDUCING THE CABON EMITTED WHILE TRANSPORTING THEM

- Laterite a locally available stone is used for the construction of external walls
- Innovative roof construction uses locally sourced timber and mud rolls
- Use of local Kota and Shahabath stone for floor tiling

NO PLASTER USED FOR THE EXTERNAL SURFACE OF WALLS PLASTER USED ONLY FOR THE INTERNAL SURFACE OF LATERITE WALLS

Internal surface is plastered as per the requirement mentioned by the client

BY USING LESSER AMOUNT OF RCC FRAME WORK THE EMBODIED CARBON OF THE CONSTRUCTION PROCESS HAS BEEN REDUCED

RAILINGS MADE OF RECYCLED TIMBER

CALCULATION OF EMBODIED CARBON:

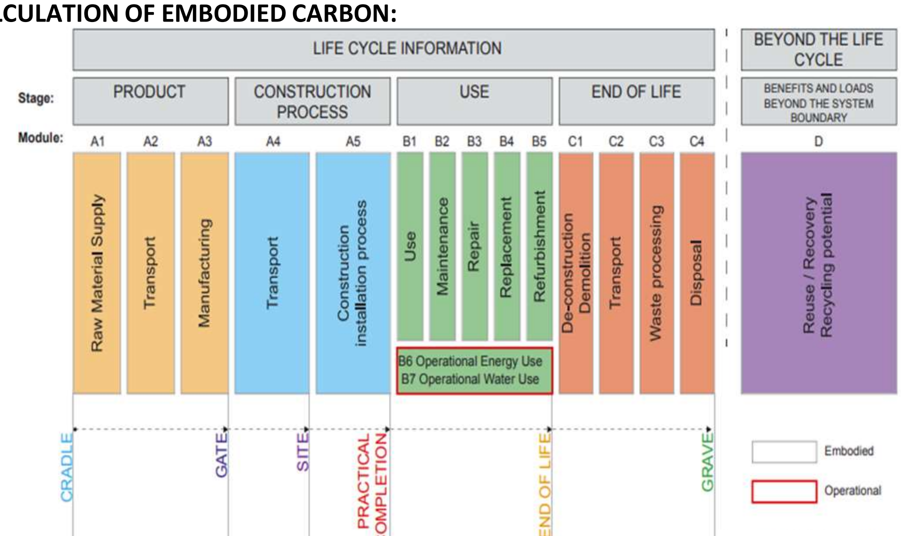


Figure 16 : Life cycle of Embodied Carbon

EMBODIED CARBON

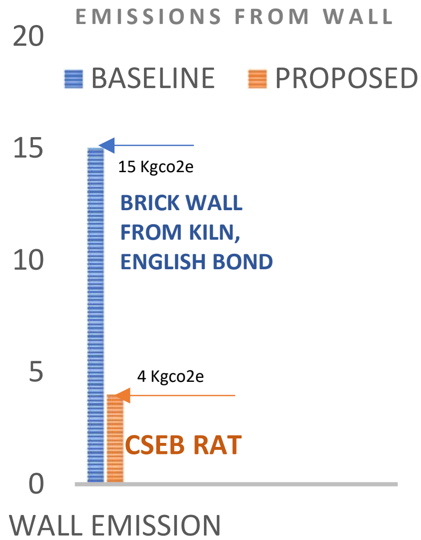


Figure 17 : Emissions from wall

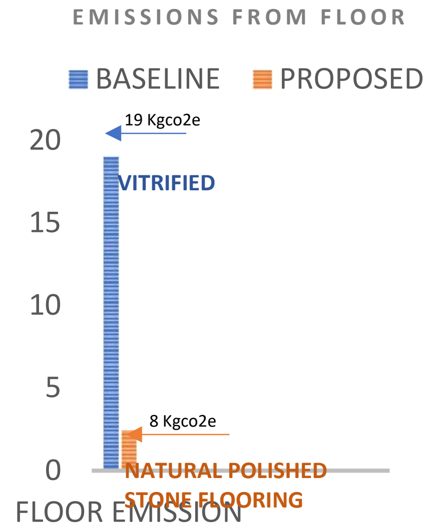


Figure 20 : Emissions from floor

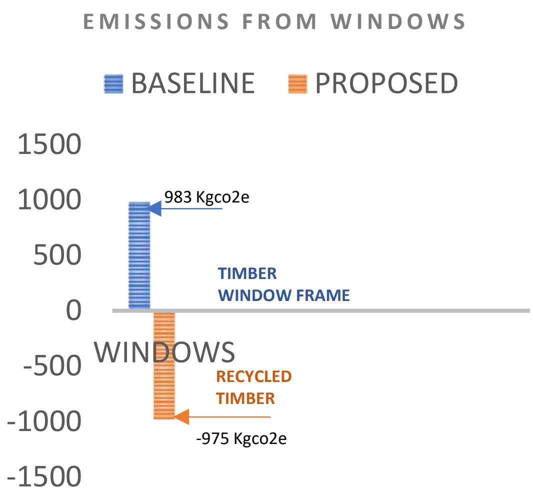


Figure 18 : Emissions from windows

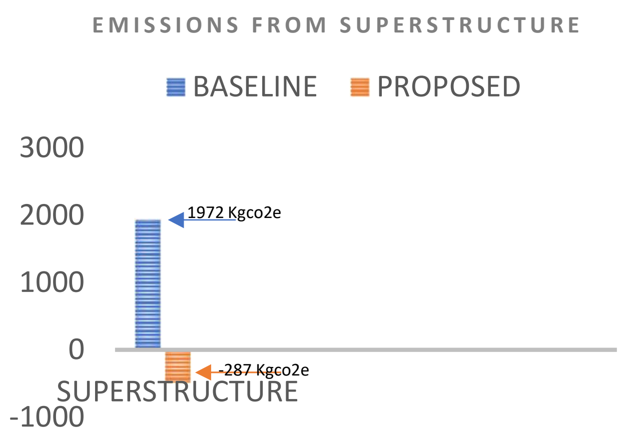


Figure 19 : Emissions from superstructure

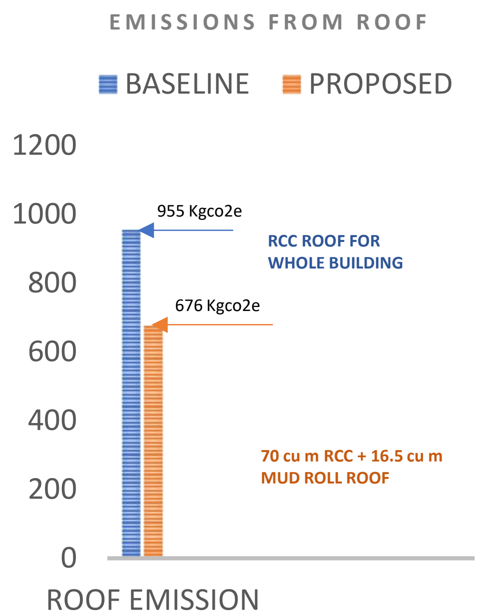


Figure 21 : Emissions from roof

(Refer to ---- for embodied carbon tool for calculations)

RESILIENCE

BUILT FORM AND RESILENCE

• One of the most importantly parts of providing a resilient design is durability. The built structure must be durable, lasting further generations. Form and materials must be chosen in accordance.
•Simple systems - to make sure the occupants are comfortable inside, simple passive strategies are applied. This increases durability and saves the cost.
• Diversity in electric and water systems. Diversity brings out aspects to withstand change and improves resilience.
• Visual comfort- open sky courtyard and openings are to be provided bringing in natural light in order to lessen the depend on artificial light during the day. These openings also provide visual connectivity through out the space.

1.WATER-The primary idea are dual flush toilets , low flow fixtures and reduce water usage. Attempts to use recharge pits to replenish the groundwater

Daily Consumption (per Capita)	Number of Occupants	Daily Consumption (In Litres)	Grey Water Efficiency	Grey Water Saved (In Liters)
81	7	567	55.5%	315

Reusing greywater to flush toilets can reduce home indoor water use by 24 percent, on average. Using treated greywater to meet water demand for toilet flushing and laundry has the potential to reduce demand by nearly 36 percent.

Total demand (lpcd) = 721 Liters
Total demand per year = 721 x 365 = 2,63,165 Liters
Total demand per year = 263 cu/m

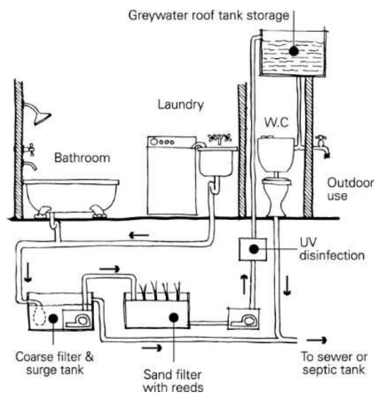


Figure 22 : Recycling of grey water

2.EMERGENCY RELIEF AND MEDICAL AID

Man made disasters like COVID-19 has made us aware of the need to have immediate access to hospitals and medical centres. Local medical facilities have been highlighted in case there is ever a need of them.

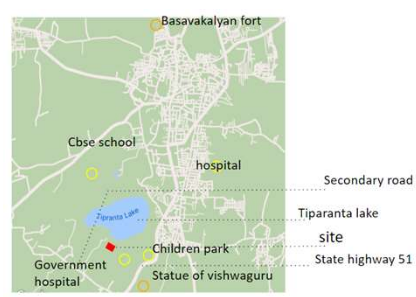


Figure 23 : Site Surrounding Context

3.ENERGY-Active and passive energy methods are used in the building. Solar energy is the driving force behind the energy in the site. This is because the large amount of solar ration that the site receives due to its location.

ROOFING TECHNIQUES

Figure 24 : Mud roll

Materials	Max. internal roof surface temp.(in c)	Time lag (in hours)	Temp. reduction of surface (in c)	Night heat(In c)
Lime roll with country tiles	37	6	12.8	26.7
Mud roll with country tiles	36.7	6	13	26.7

White Roofs :

Figure 25 : White roof

it can significantly cool the roof's temperature by reflecting the sun's rays away from the house, keeping the interior of the home cooler as well. This reduces summer energy bills.

During the maximum internal temperature increase hours of 7:00am – 5:00pm, a white roof is 6.97% cooler (more energy efficient) than a non-white roof.

Solar Roofs :

Figure 26 : Solar Panel on roof

Panel dimension	1.3x1.6 m
Number of panels	5
output	1,27,500 kw/y

912.5 kwh- 1 month
30.416 - 1 day

LED becomes heat rather than light (about 70% heat and 30% light).

- With an estimated energy efficiency of **80-90%** compared to conventional light bulbs, LEDs significantly reduce energy consumption

4. DROUGHT - Water conservation and water reuse methods have been used in the design to overcome the water scarcity . Recharge pits have been planted to recharge the ground water table.

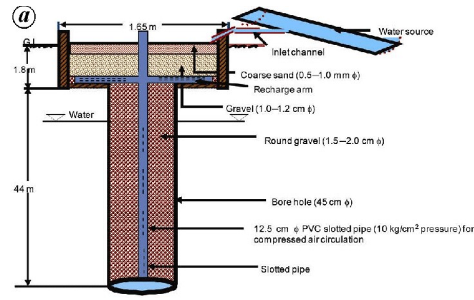


Figure 27 : Mulch Basin

Techniques used for water conservation :

- Recharge pits / shafts, mulch basins

i) Recharge pits are suitable for recharging ground water table

.ii) These are constructed at 2 m wide and 3m deep

iii) After excavation, the pits are refilled with pebbles and boulders.

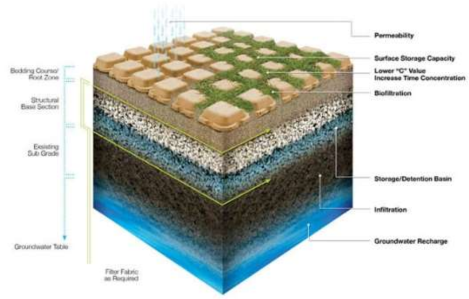


Figure 28 : Permeable paver

- Permeable pavers in landscaped area to recharge ground water.

Permeable pavement catches precipitation and surface runoff, slowly allowing it to infiltrate into the soil below

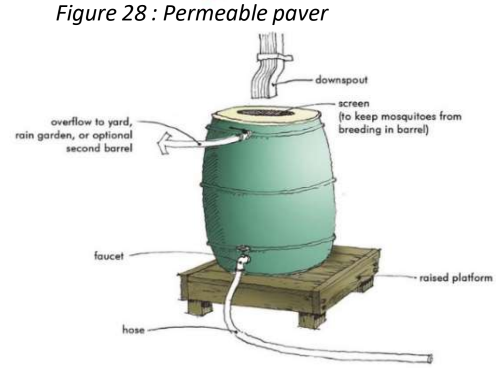


Figure 29 : Rainwater Barrel

- Conserving received rainwater in rainwater barrels for non- potable uses.

Rainwater barrels involves setting out large barrels that can greatly help drought by collect rain for potable use.

XERISCAPE:

Prolonged droughts have led water to be regarded as a limited and expensive resource.

Thus xeriscape helps residents to use less of the water for their lawns and gardens.

Xeriscaping is the practice of designing landscapes to reduce or eliminate the need for irrigation. This means xeriscape landscapes need little or no water beyond what the natural climate provides.

As a result xeriscaping can reduce water use by 50 to 65 percent.

ALOE VERA

SAGO PALM

Drought tolerant, does not require lot of water.

Figure 30 : Plants for xeriscaping

ENGINEERING AND OPERATING SYSTEMS

Figure 31 : *Floor Plans*

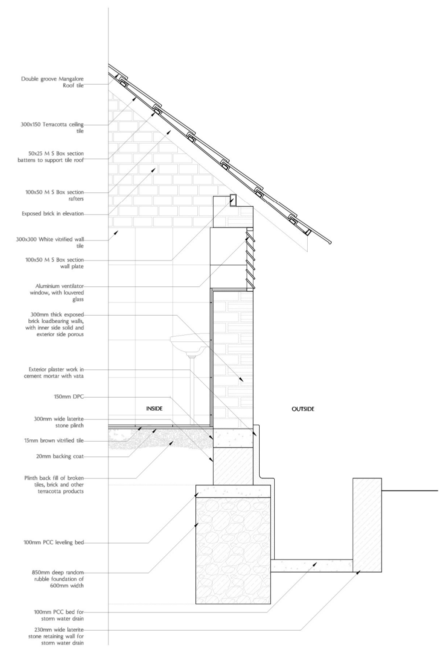


Figure 32 : Laterite wall section

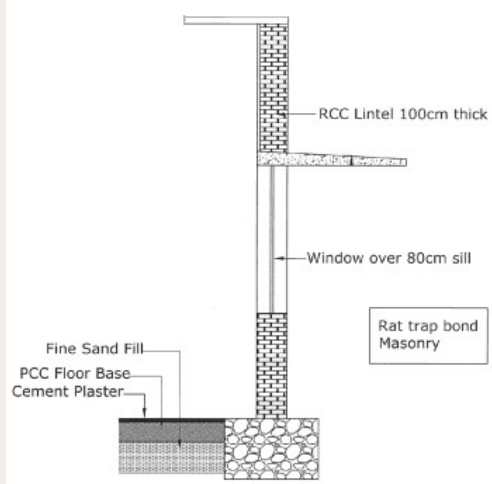


Figure 33 : Rat trap bond section

The roofing of the house is made from Mangalore tiles and is at an angle of 11-15 degrees.

(Refer to ---- for engineering drawings)

ENGINEERING AND OPERATING SYSTEMS

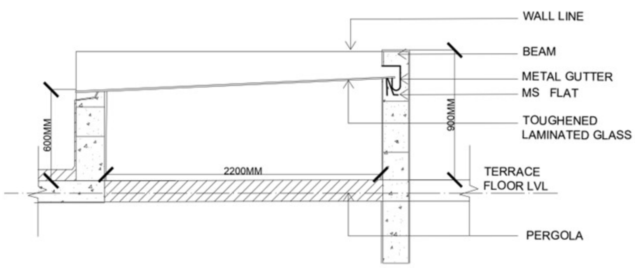


Figure 34 : Skylight

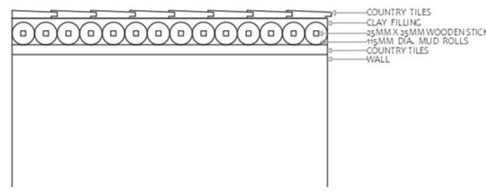


Figure 37 : Mud Roll Roof

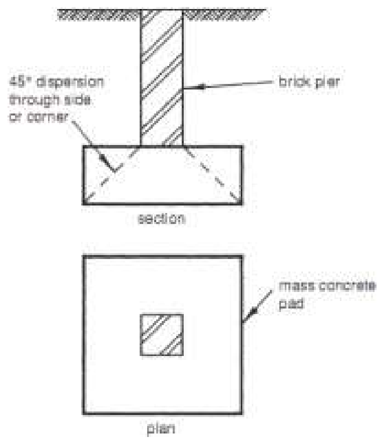


Figure 35 : Pad footing

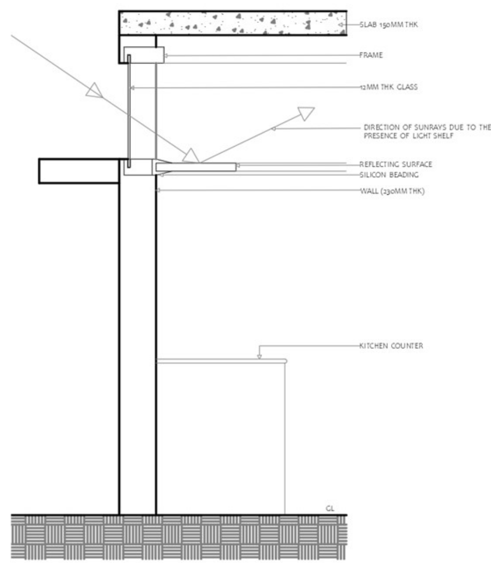


Figure 38 : Light Shelf
above Kitchen Cabinets

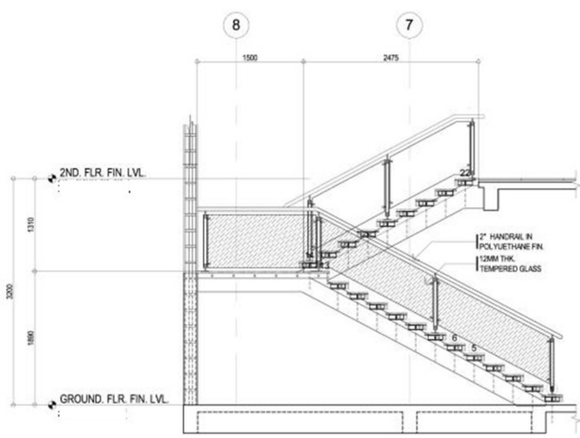


Figure 36 :
Cantilevered staircase

The structural design of the house has pad footing and load bearing walls. Most of the openings in the walls are the jalli walls.

Pooja room has jalli opening on the first floor, next to load bearing walls attached to cantilevered staircases.

ARCHITECTURAL DESIGN

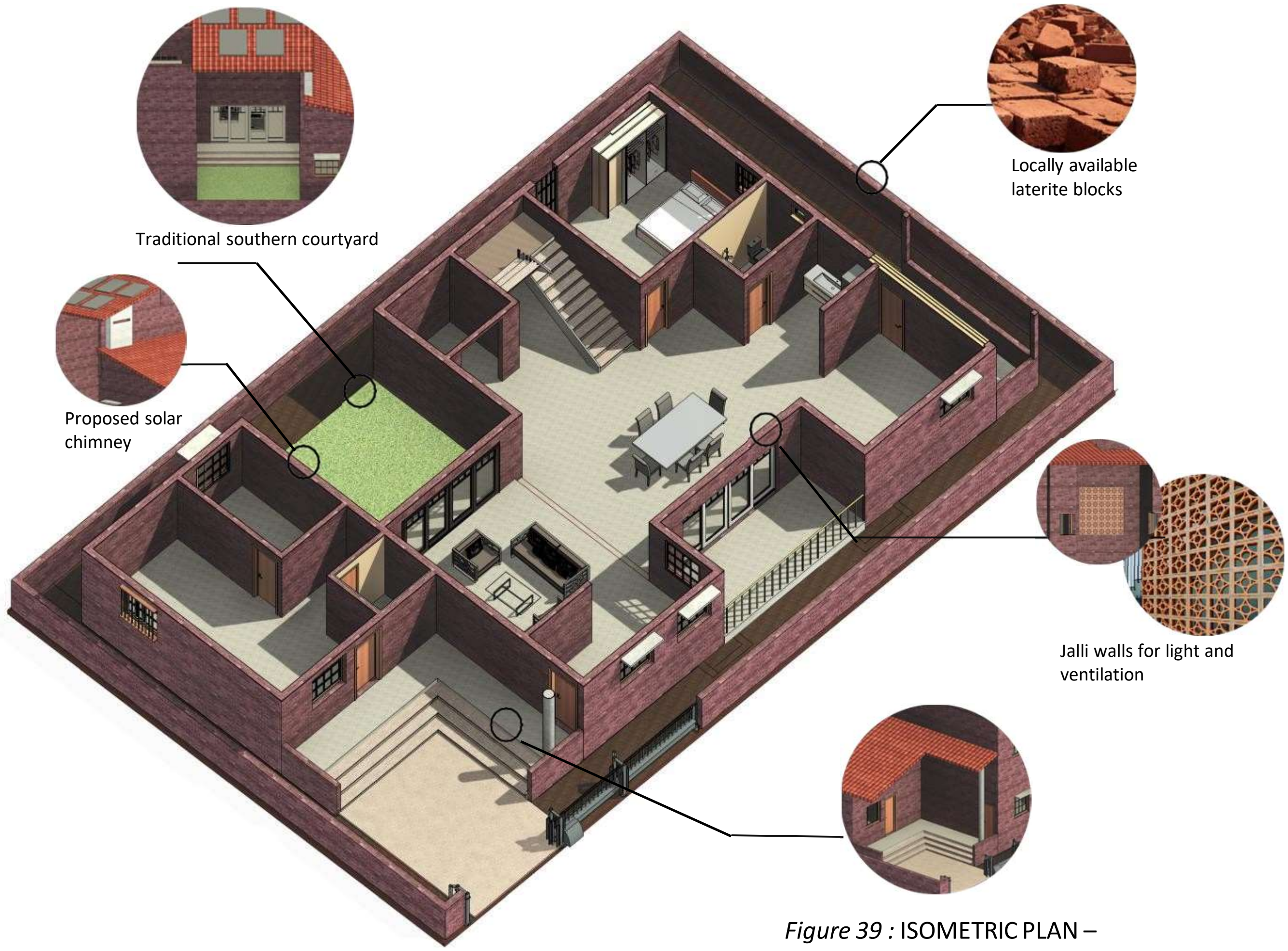


Figure 39 : ISOMETRIC PLAN – GROUND FLOOR

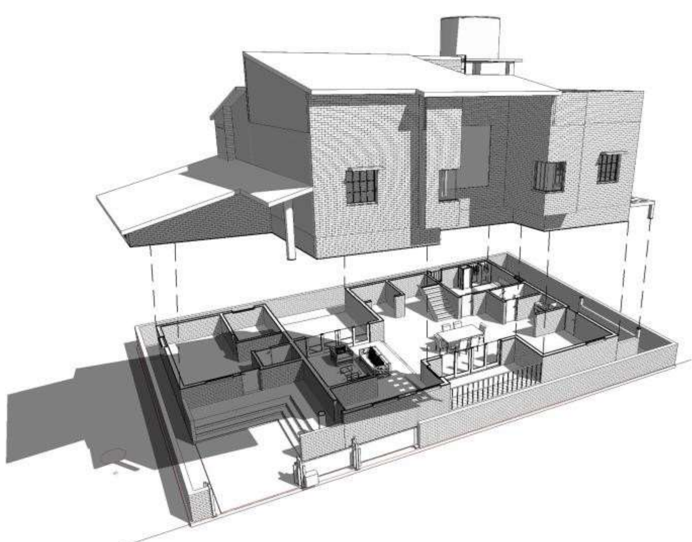
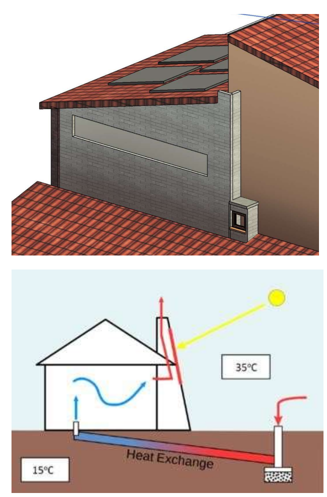


Figure 40 : ISOMETRIC EXPLODED VIEW



Solar chimney that uses a secondary vent that travels below ground. This helps to cool intake air when the chimney is used for cooling.

ARCHITECTURAL DESIGN

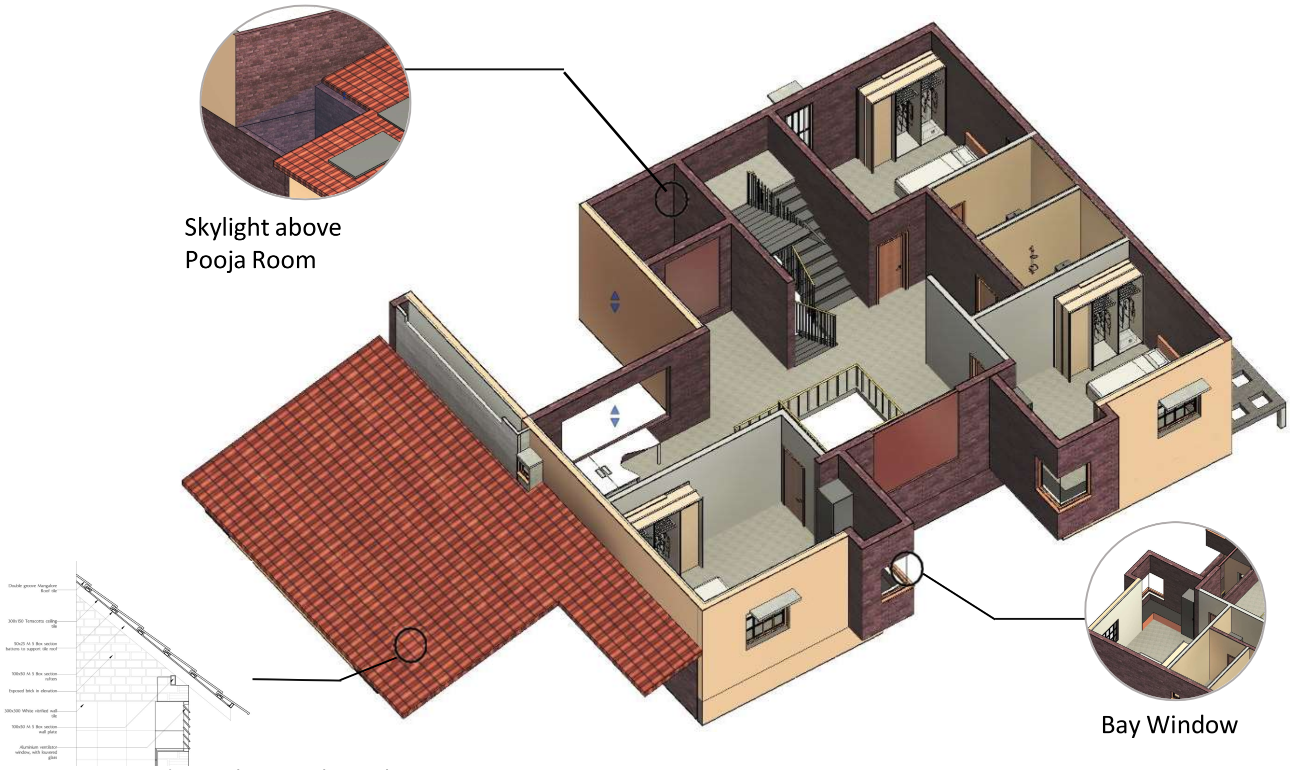


Figure 41 : ISOMETRIC PLAN – FIRST FLOOR

SECTIONAL VIEW

AFFORDABILITY

What makes the building affordable?

Primary cost reduction is happening in CAPEX:

- Use of local building materials: laterite and brick
- Reduced use of RCC and therein reducing the use of steel- one of the most expensive building materials
- Size of laterite is bigger making laying of the blocks quicker thereby reducing the labor cost.

Primary reason for cost reduction in OPEX:

- Solar Panels reducing the electricity bill.
- Optimized daylight reduces the need for electrical lighting which converts to 5.6% reduction in lighting power density.
- Electrical Appliances- The electrical appliances are energy efficient, which are generally costlier, but this in turn reduced our energy demand.

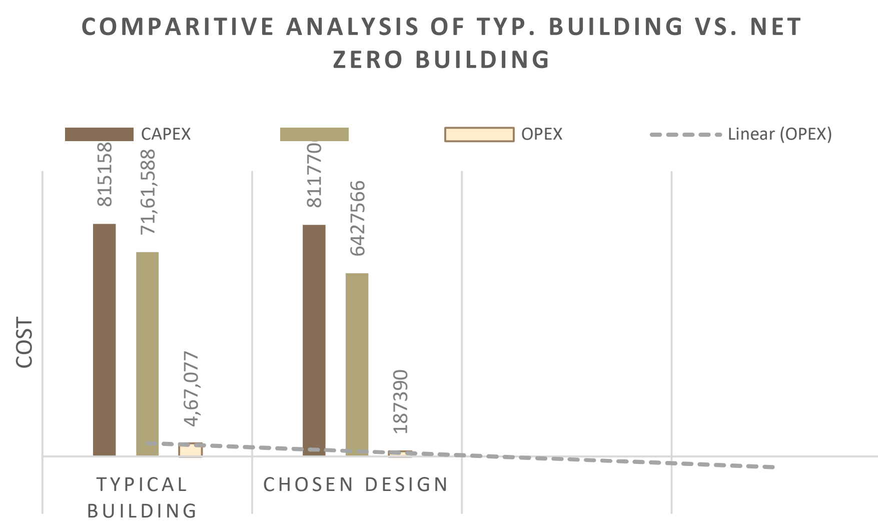


Figure 42 : Comparative Analysis of Building Typ. VS. Net Zero Building

Note:

- *Factors like gas cost and maintenance cost remains the same and hence isn't mentioned.*
- *The subsidies available in tax for solar panels have been accounted under electricity bill.*

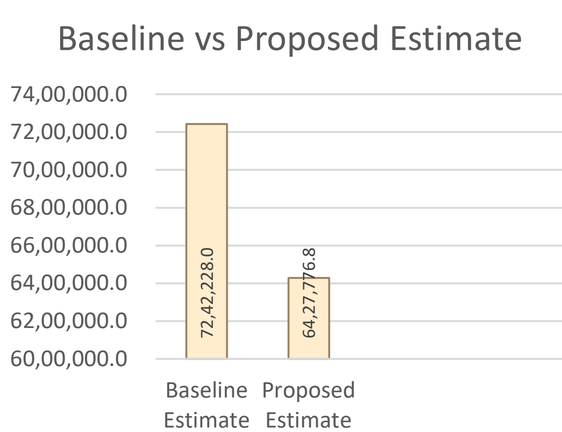


Figure 43 : Baseline vs Proposed Estimate

(Refer to ---- for water cost estimation)

AFFORDABILITY

Electricity:

		Number	Cost
CAPEX/ Installation Cost	Cost of Solar panels	16	16*21000 = 336000
	Solar Tubular Battery 150AH*8	8	8*7800 = 62400
	Inverter	1	46530
	Installation kit	1	45000
	Total Cost	-	489930
Lifecycle Cost	Battery replacement once in 3 years	7 times in 25 years	436800
	Total Lifecycle cost in 25 years		926730

Table 8: Cost of solar panel system

Electricity Bill

Minimum charges	**255**
0-50 Unit @ 4.10 Paise	205
Above 200 Unit @8.15Rs (335.75-50)	2328.8625
Total Tariff / Month	2788.8625
Annual amount	33,466.35
Average cost increase / year is 7.2% Total for 25 years	21,78,483.68

Table 9: Breakdown of electricity bill

Between the years 2009-2020, the electricity bill was observed to have doubled. If we assumed that the same condition is true for the future, then this means that an increase of 7.2% a year will be observed.

Note: In reference to - India: cost of state electricity supply | Statista

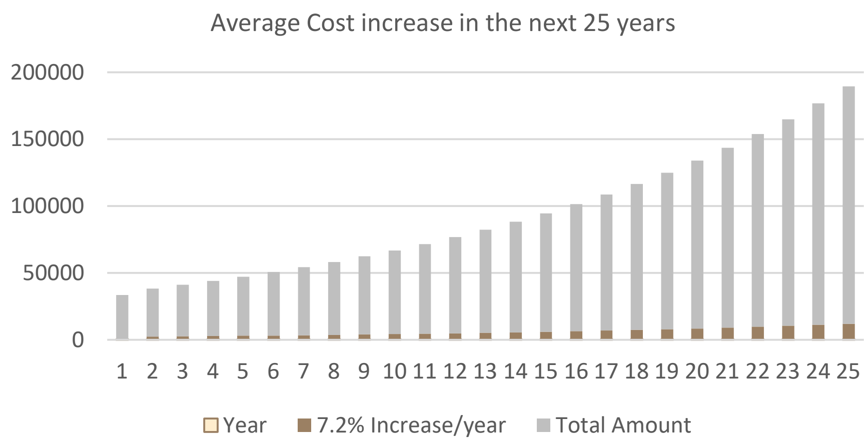
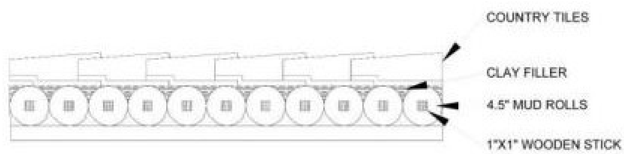


Figure 44 : Avg. Cost Increase

Based on this it can be understood that we will start receiving **return on investments** (just in terms of electricity) from the **10th year**.
From the 10th year for the entire 25 years, the ROI just through the electricity sector is **Rs. 17,11,710.0.**

INNOVATION

Figure 24 :Mud roll



Mud roll with country tiles

Image reference and source- Comparative Analysis of Thermal Performance of Roof Component using Alternative Materials Taking case of Hot and Dry Climatic Condition of Bhuj-Kutch by Veerendranath Satrasala and Nikita Manvi

1. Roofing pattern-

Idea: Thermal performance becomes one of the most important elements in determining the general level of comfort for any building. Roofs are that part of a structure that have the most sun exposure; as a result, they are the main source of heat acquisition during the day and heat loss during the night, which has a higher impact on the ambient temperature.

Goal & Objective: Using Basavakalyan as an example, the goal is to innovate and analyze the thermal performance of roof components in a hot, dry climate. The goal was to create a roofing component using a variety of locally available materials while also identifying and investigating the material's potential for inexpensive thermal performance.

Traditional construction systems have always given us learning. They have worked excellent in terms of comfort and environmental aspects. But these construction systems are not applicable in the present context; and to make the systems and materials work out in present scenario alterations and innovations needs to be done.

Development of Mud rolls with Lime, Surkhi and Flyash –

Mud rolls have high weight due to high density, hence the structural members which carry these materials to be thickened. So the mean aim was to reduce the density of mud roll and hence that aspect became the main criteria for material innovation. Combinations of mud roll with rice straw, lime, fly-ash and Surkhi is recommended, and for final experiment mud roll with rice straw and mud roll with lime where selected as these two had relatively low densities.

The creation of new materials and different combinations also involved innovation. It was thought vital to lower the density of Mud-Roll, and this was done by reducing the density by 50% in comparison to the regular Mud-roll. The temperature difference between the external and internal roof surfaces is 13°C, and the time delay obtained is six hours. Heat index at night is 26.7 °C.

2. RAT TRAP FOR OUTER WALLS-

Rat trap bond is laid in such a way that it creates a cavity in the wall. Fig shows the rat trap bond placed on edge forming the inner and outer face of the wall with cross bricks bridging the two faces. Rat trap bond is considered to be the cost- saving construction it has many advantages than only the cost saving. In this method, the bricks are laid in a vertical position and formed the cavity which maintains the interiors cooler in summer and warmer in winter. Innovation is achieved by using locally available straw placed in the gap.

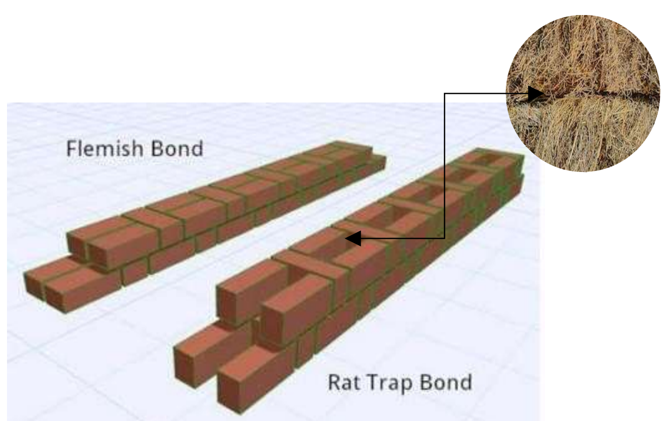


Figure 45 : Rat trap Bond for outer walls

INNOVATION

4. SOLAR CHIMNEY

A solar chimney is a type of passive solar heating and cooling system that can be used to regulate the temperature of a building as well as providing ventilation. Like a Trombe wall or solar wall, solar chimneys are a way to achieve energy efficient building design. A diagram of a solar chimney that uses a secondary vent that travels below ground. This helps to cool intake air when the chimney is used for cooling.

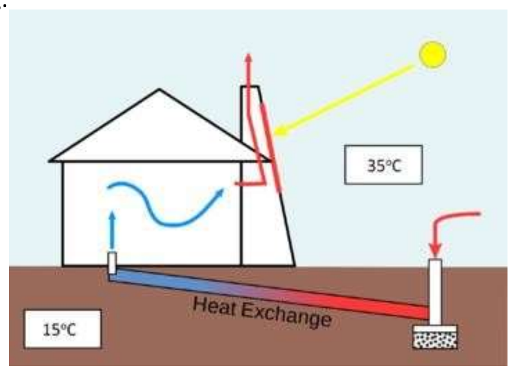


Image reference-Energy Education, Solar chimney

Figure 46 : Solar Chimney

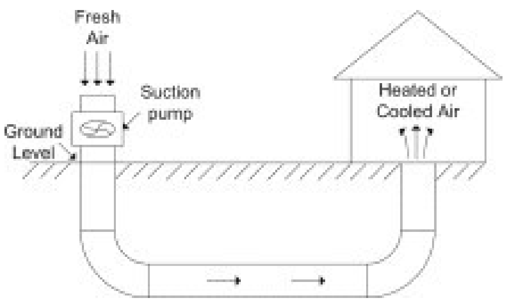


Image reference-Ground coupled heat exchangers: A review and applications by Suresh Kumar Soni via Science Direct.

Figure 47 : Skylight

5. GROUND COUPLED HEAT EXCHANGER

A ground-coupled heat exchanger is an underground heat exchanger that can capture heat from and/or dissipate heat to the ground. They use the Earth's near constant subterranean temperature to warm or cool air or other fluids for residential uses. It is suggested to use a suction pump right outside the office. This is used to draw in the natural air. The Earth's nearly constant subsurface temperature is used to chill the air as it travels down the earth tube. By including a solar chimney, the office is transformed into a straightforward loop. Throughout the day, heat is generated inside the workplace, which makes the air lighter and transportable outside through the solar chimney.

5. SRI (SOLAR REFLECTIVE INDEX) AND EMISSIVITY MATERIALFOR ROOF CONSTRUCTION (FOR FLAT ROOF)

The Solar Reflectance Index (SRI) is an indicator of the ability of a roof surface to return solar energy to the atmosphere. Roofing material surfaces with a higher SRI will be cooler than surfaces with a lower SRI under the same solar energy exposure, especially on a sunny day. Using materials with higher SRI values can enhance building occupant comfort and reduce air conditioning use. Lighter-colored materials generally have a higher solar reflectance, so they reflect heat from the sun and do not warm the air as much. Light colored paint is used on the flat roof to achieve the concept of SRI.

Emissivity is a measure of how well the roof surface emits thermal radiation energy — heat. The recommended emissivity for roof coatings is at least 66 percent, which means 66 percent of the thermal energy striking the surface is emitted, reducing the building’s heat load and lowering cooling costs.

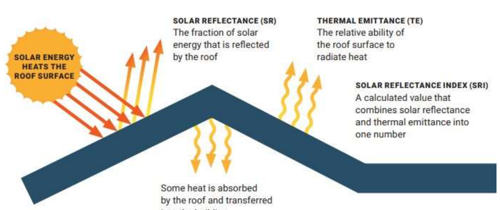


Image reference- Continuing Education center, Architecture and Construction- Cool roofs for Hot projects

Figure 48 : SRI for roof construction

HEALTH AND WELLBEING

Our aim is to utilize natural elements for cooling and ventilation in the project.

Figure 49 : Khus Curtain

1. Use of Vetiver / Khus Curtains

Vetiver / Khus curtains are made of the native Indian grass called 'vetiver', which has been used as a coolant for many years. Using these curtains in the west and east windows (in the direction of wind), while sprinkling water thrice a day, will decrease the temperature, and allow the passage of cool air through the house.

Figure 50 : Jaali Wall

2. Use of Jaali Walls

The wall facing the courtyard in the library is a jaali wall. This provides ample space for cross ventilation, thus increasing the thermal comfort of the space.

3. Use of Indoor Plants

SAGO PALM
Drought tolerant, does not require lot of water. Believed to bring success, prosperity and peace.

ANTHURIUM
Reduces formaldehyde, ammonia and xylene from indoor air, reduces cigarette smoke and toxins from organic solvents, helps remove microbes from air easing allergies.

PHILODENDRON
Boosts humidity: reduces dry air, grows in water, removes formaldehyde, toluene, trichloroethylene and xylene from indoor air, along with several other VOCs.

TULSI
A sacred plant. It is a natural immunity booster, reduces stress, cures respiratory diseases, has anti-cancer properties and has many more health benefits.

WEEPING FIG
Prevents the growth of deadly microbes and fungus, removes toxins emitted from home appliances and gadgets.

ALOE VERA
Has antibacterial and antioxidant properties, easy to maintain, has many skin benefits, accelerated wound healing, lowers blood sugar levels, reduces constipation.

BOSTON FERN
Improves the humidity by helping to restore moisture to the air naturally, removes harmful toxins from air, benefitting those suffering from dry skin or irritable nose and throat.

STRINGS OF PEARL
Removes indoor air pollutants and purifies the air, fights against infectious bacteria and cancer.

Figure 51 : Indoor Plants

WATER PERFORMANCE

- The goal was to reduce water consumption by 20% through the use of water saving equipment like double sink with diverter valves.

Techniques used for water conservation :

- Recharge pits / shafts, mulch basins and permeable pavers in landscaped area to recharge ground water.
- Conserving received rainwater in rainwater barrels for non- potable uses.

By using the water conservation techniques, we reduced water consumption by 22%.

ENERGY PERFORMANCE

- Solar panels are truly renewable energy source that significantly reduces energy bills. It has low maintenance costs and reduces impact on the environment and it improves energy security and independence.

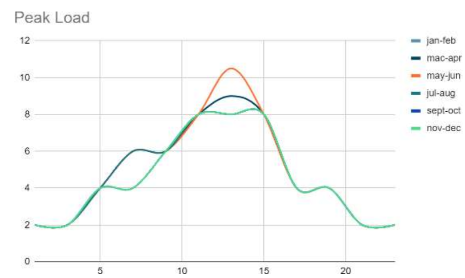


Fig 52 : Typical energy consumption for a single family housing in basavakalyan

ARCHITECTURAL DESIGN

- Courtyards introduce cross ventilation into a building, using the courtyard design to break the house into smaller, more manageable areas, with more walls opening onto the outdoors, so it's much easier to encourage a gentle breeze into the home.
- Jaali allows light and air while minimizing the sun and the rain, as well as providing cooling through passive ventilation.
- Light shelves can enhance daylight quality and reduce the need for artificial lighting and so reduce energy consumption. It also reduces cooling loads. It increases occupant comfort and productivity. It enhances design aesthetics

ENGINEERING AND MECHANICS

- Addition of load bearing walls instead of columns to reduce the construction costs and time.
- Reduction of glass as a construction material to avoid heat radiation in the building.
- Solar chimney is introduced in the building for proper air circulation and to regulate room temperature.

EMBODIED CARBON EMISSION

- By using local materials, the carbon spent in transporting the materials has been reduced .
- Materials that use lesser carbon during their manufacturing process have been used.
- Using materials to consciously reduce the initial carbon content in the building construction stage.

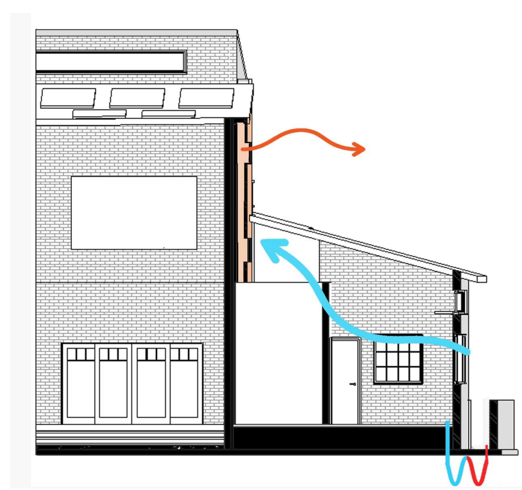


Figure 53 : Cross Ventilation Through Courtyard

REFERENCES

- CPWD DSR vol. 1 2018
- CPWD DSR vol. 2 2018
- CPWD Plinth Area Rates 2020
- CPWD DAR vol. 1 2018 Civil
- CPWD DAR vol. 2 2018 Civil
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- IS456:2000
- IS 13920:2016
- Solar Lighting System (HIMAWARI) by La Forêt Engineering Co.,Ltd.
- Treatment and effective utilization of greywater by Dhanu Radha Samayamanthula. Chidambaram Sabarathinam. Harish Bhandary
- Energy Efficient&Cost Effective Sewage treatment using Phytorid ISSN: 2231 –5721 • Pan Climatic Humans by Chris Mackey

BUILDING AREA PROGRAM

Space	Specifications	Area (Sq.m)	Active (Menchanically ventilated)	Passive (Unconditioned)
Ground Floor				
Parking	-	25		●
Living Room	-	33	●	
Kitchen	-	21	●	
Dining Room	-	38		●
Bedroom	-	21	●	
Office	-	35	●	
Pooja Room	-	8		●
Toilet	-	3.5		●
First Floor				
Master Bedroom	1 no.s,	21	●	
Bedroom	2 no.s,	21.3*2=42.6	●	
Toilet (Attached)	1 no.s,	3.2		●
Toilet	1 no.s,	3.2		●
Other Areas	Family Room, Utility Room	20		●
Circulation Areas	Staircase, 10% of each floor	45		●
Total Built-up	424			
Total Area of Site	371.5			
FAR	1.2			
Ground Coverage	52%			

Table 10: Building Area Programme

Fig 54 : ***GROUND FLOOR PLAN***

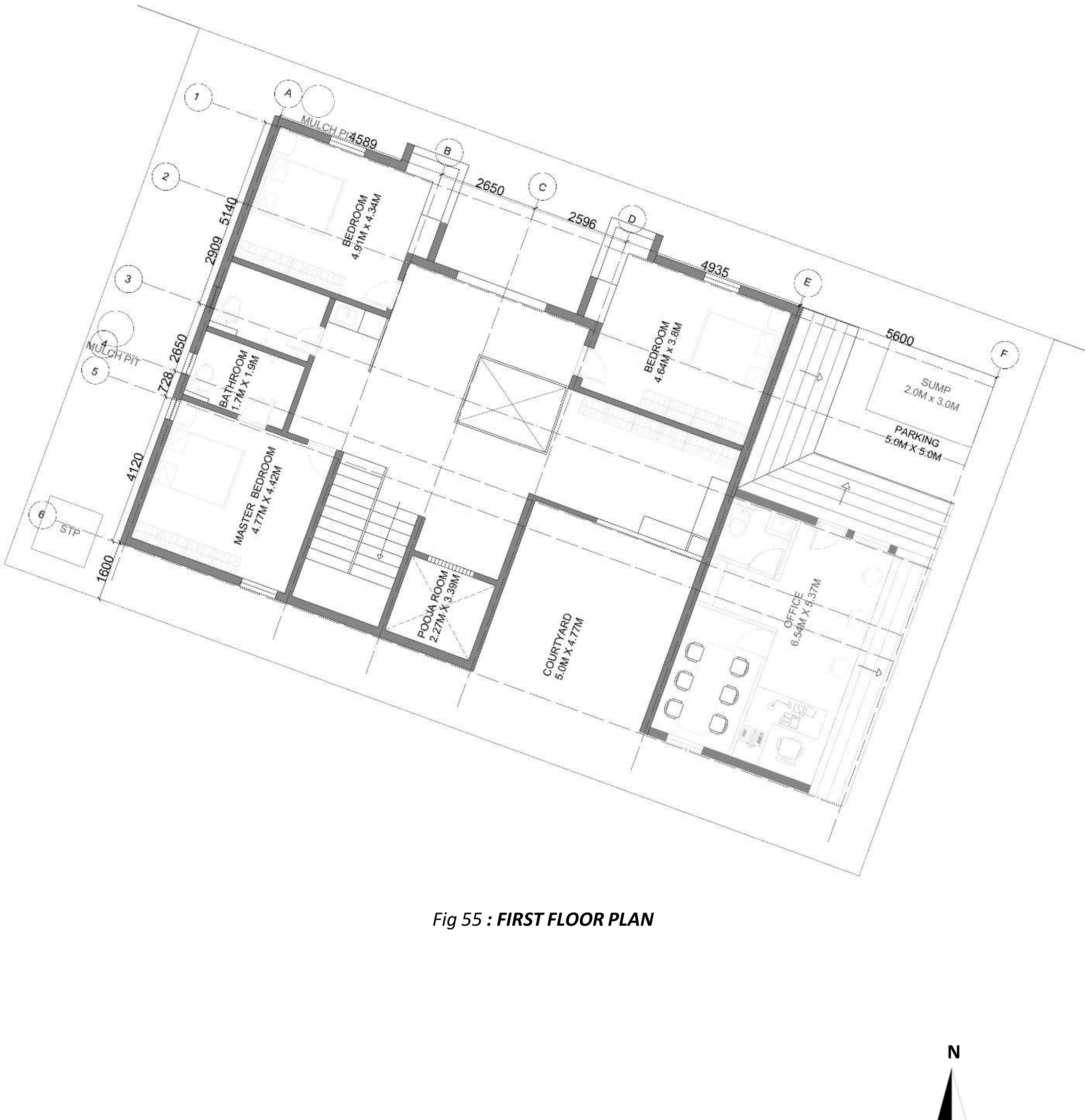


Fig 55 ***: FIRST FLOOR PLAN***

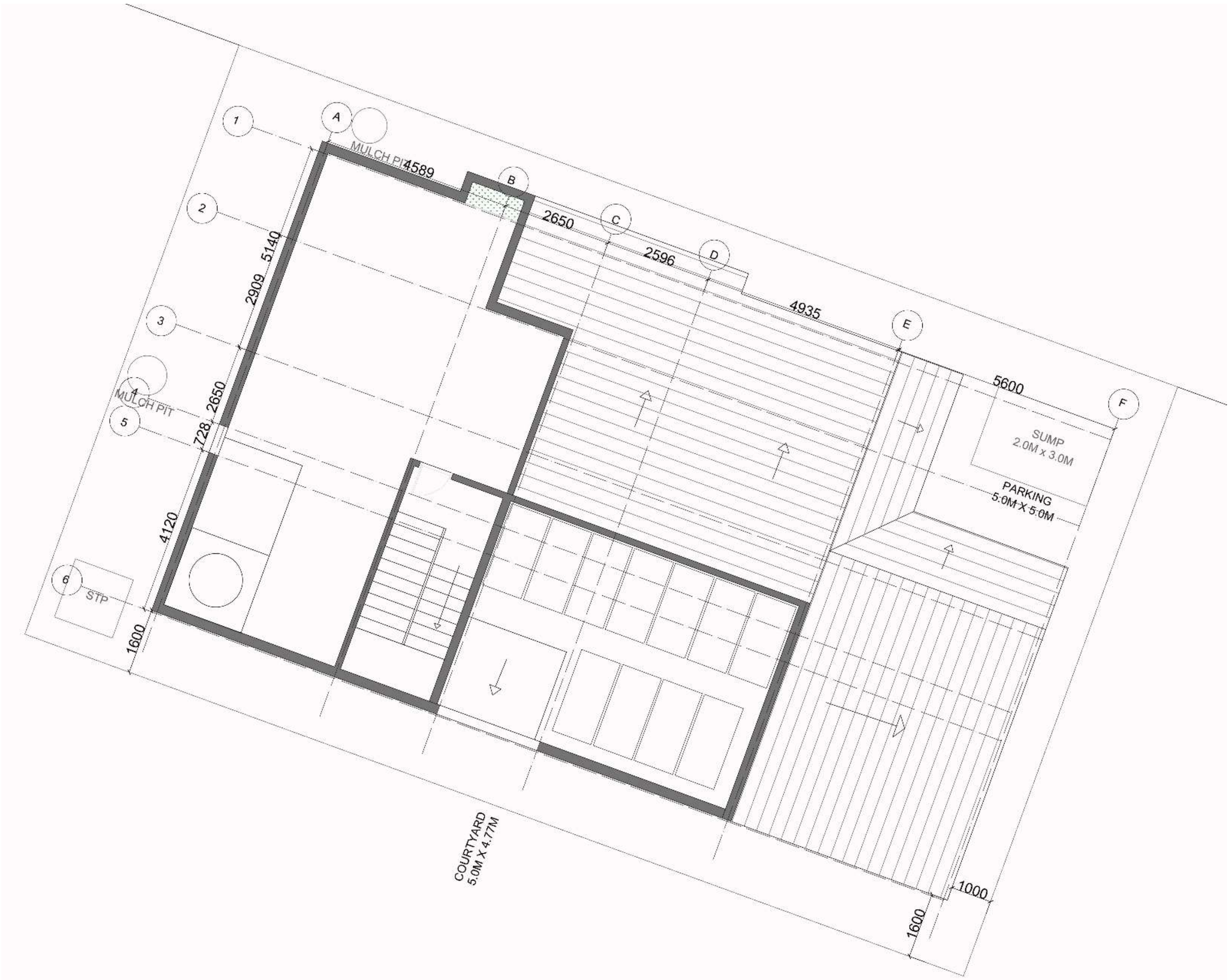
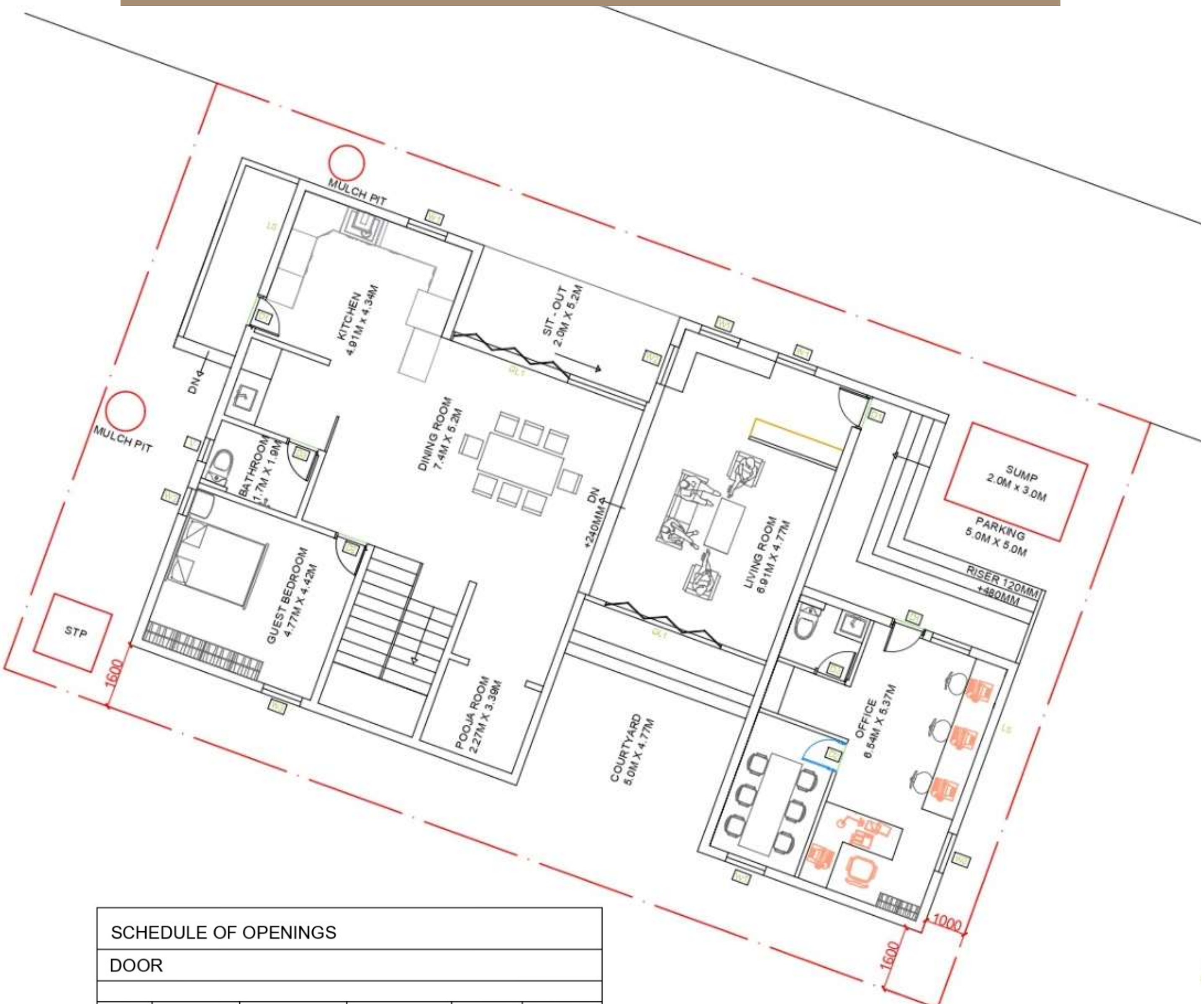


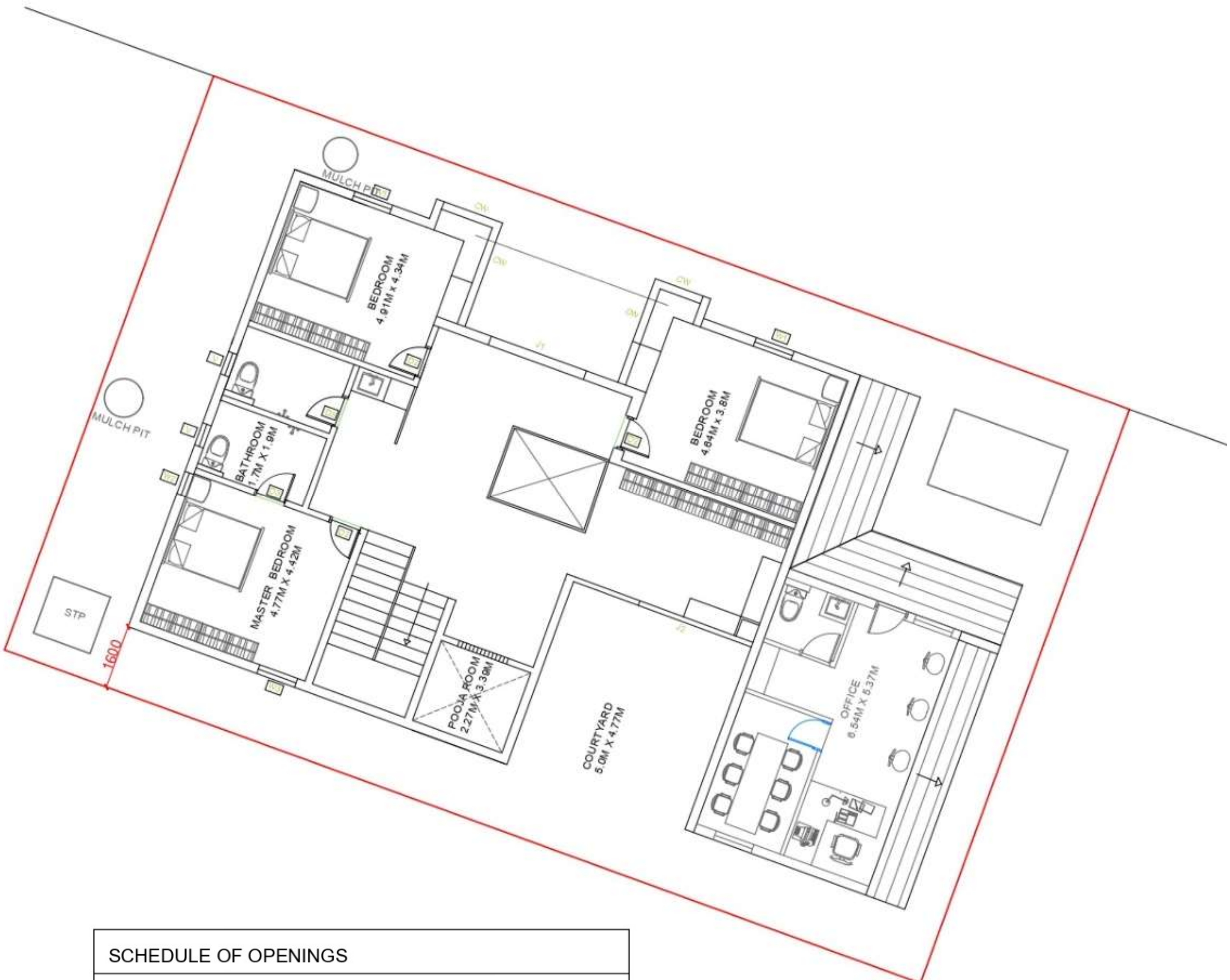
Fig 56 ***: TERRACE LEVEL PLAN***



SCHEDULE OF OPENINGS					
DOOR					
SL NO.	OPENING NO.			CILL (MM)	LINTEL (MM)
1					
2	D1	1050 X 2100	1000 X 2050	0	2100
3	D2	950 X 2100	900 X 2050	0	2100
4	D3	750 X 2100	700 X 2050	0	2100
GLASS SLIDING WINDOW					
6	GL1	3050 X 2150	3000 X 2100	0	2100
WINDOW					
SL NO.	OPENING NO.			CILL (MM)	LINTEL (MM)
1	W1	1200 X 1200	1150 X 1150	900	2100
2	W2	790 X 2400	740 X 2350	300	2700
3	W3	840 X 1200	790 X 1150	900	2100
4	CW4	910 X 1200	860 X 1150	600	1800
5	LS5	3500 X 600	3450 X 550	2100	2700
6	V	450 X 450	400 X 400	2400	2850
7	J1	2500 X 1500	2500 X 1500	600	2100
8	J2	3000 X 1500	3000 X 1500	600	2100

Fig 57: **GROUND FLOOR FURNITURE PLAN**

N



SCHEDULE OF OPENINGS					
DOOR					
SL NO.	OPENING NO.			CILL (MM)	LINTEL (MM)
1					
2	D1	1050 X 2100	1000 X 2050	0	2100
3	D2	950 X 2100	900 X 2050	0	2100
4	D3	750 X 2100	700 X 2050	0	2100
GLASS SLIDING WINDOW					
6	GL1	3050 X 2150	3000 X 2100	0	2100
WINDOW					
SL NO.	OPENING NO.			CILL (MM)	LINTEL (MM)
1	W1	1200 X 1200	1150 X 1150	900	2100
2	W2	790 X 2400	740 X 2350	300	2700
3	W3	840 X 1200	790 X 1150	900	2100
4	CW4	910 X 1200	860 X 1150	600	1800
5	LS5	3500 X 600	3450 X 550	2100	2700
6	V	450 X 450	400 X 400	2400	2850
7	J1	2500 X 1500	2500 X 1500	600	2100
8	J2	3000 X 1500	3000 X 1500	600	2100

Fig 58: **FIRST FLOOR FURNITURE PLAN**

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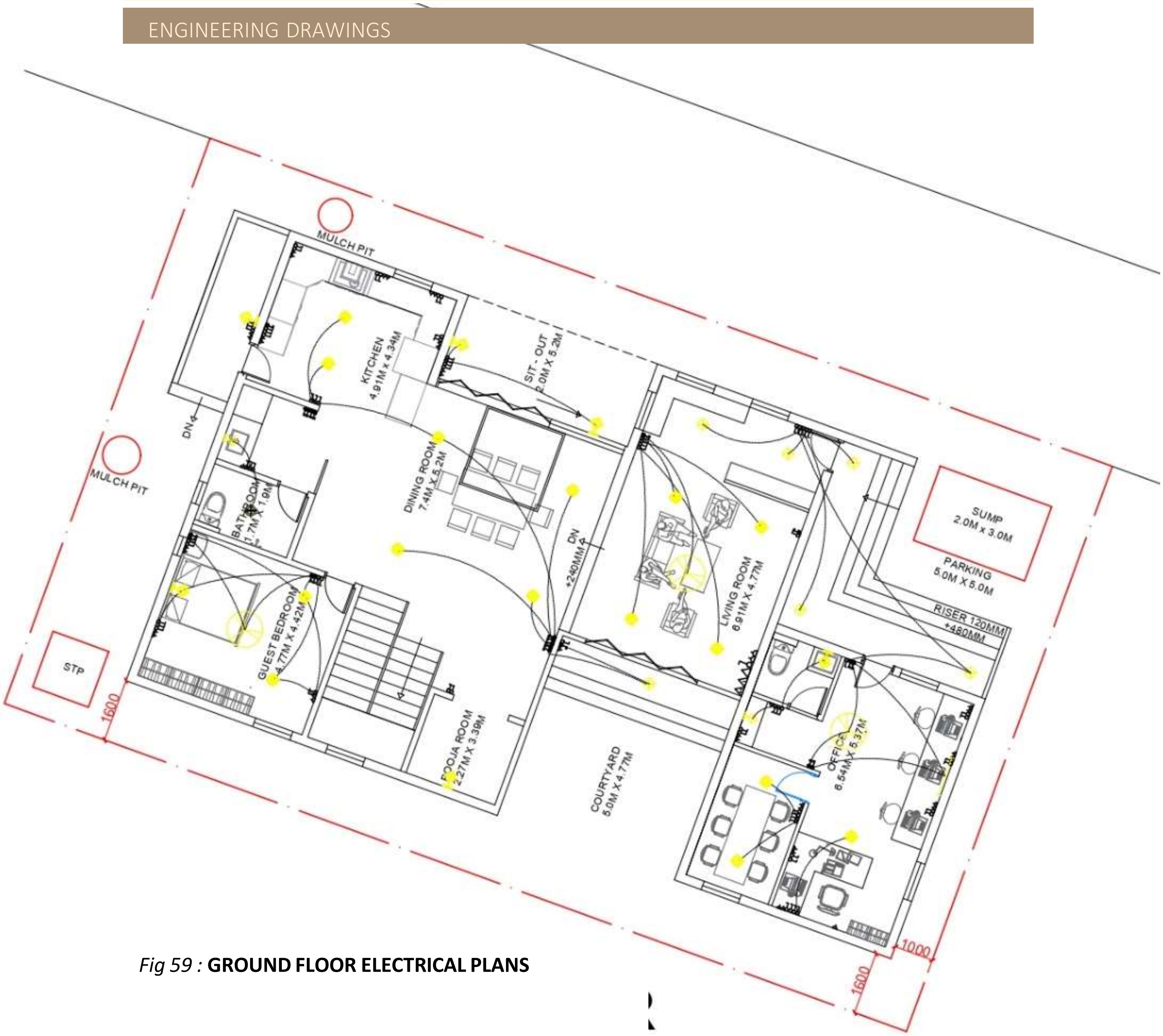

Fig 59 : **GROUND FLOOR ELECTRICAL PLANS**

SYMBOLS LEGEND

PLAN	NAME	PLAN	NAME	PLAN	NAME
	SINGLE GANG SWITCH		SINGLE SOCKET		TELEPHONE SOCKET
	DOUBLE GANG SWITCH		SINGLE SOCKET FOR LAMP		INTERNET SOCKET
	TRIPLE GANG SWITCH		DOUBLE SOCKET		TV SOCKET
	SINGLE TWO WAY SWITCH		FLOOR SOCKET SINGLE		WEATHERPROOF SOCKET
	DOUBLE TWO WAY SWITCH		FLOOR SINGLE SOCKET FOR LAMP		DECT BASE STATION
	TRIPLE TWO WAY SWITCH		FLOOR SOCKET DOUBLE		WALL BRACKET
	SWITCH CROSS		FLOOR SOCKET SINGLE, TELEPHONE		PICTURE LAMP
	SWITCH SERIAL		FLOOR SOCKET DOUBLE, TELEPHONE		ELECTRIC FAN
	LIGHT POINT - PENDANT HOLDER (6 INC				LUMINAIRE

	18
	22
	32
	18
	22
	32
	22

ENGINEERING DRAWINGS

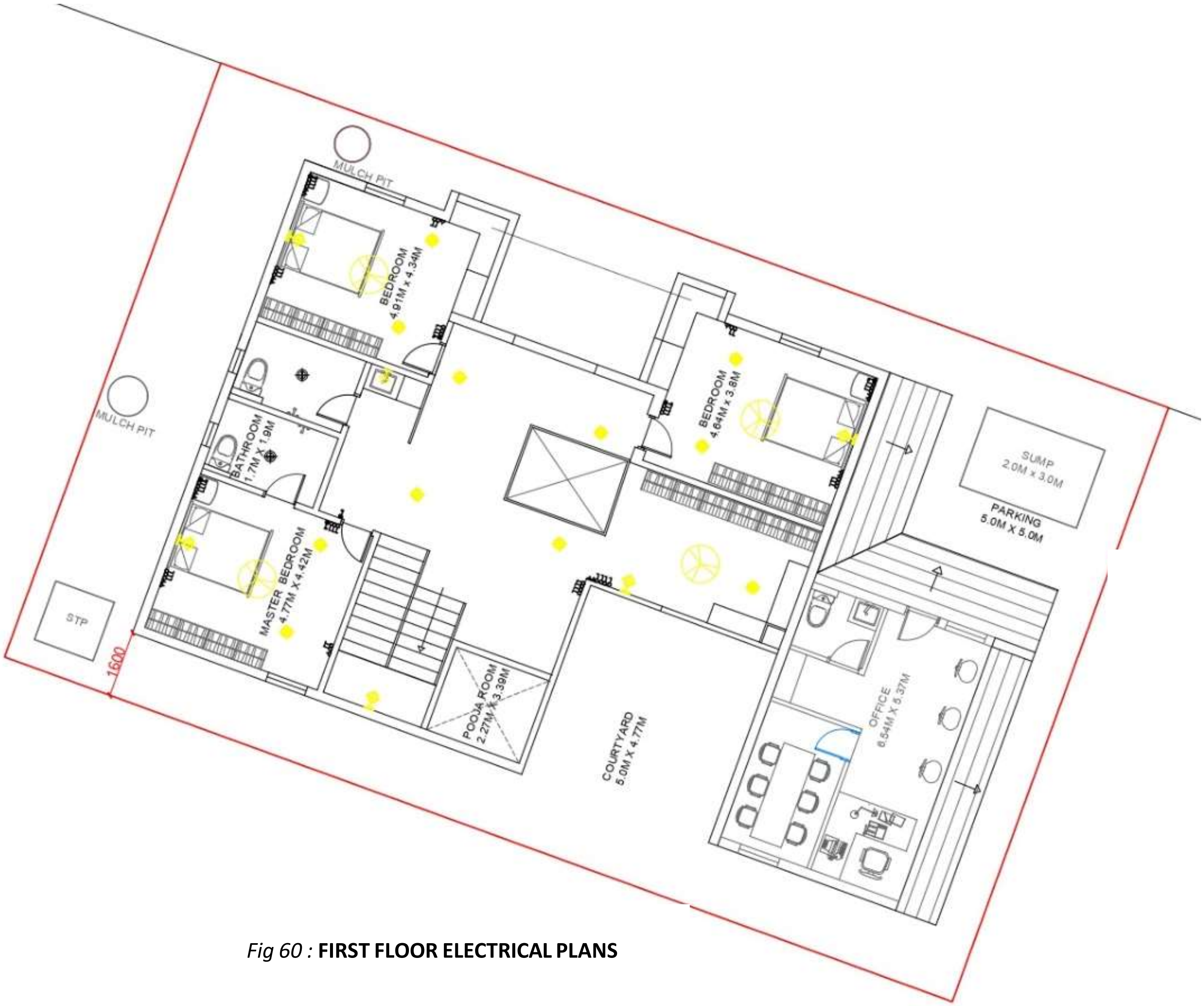

Fig 60 : **FIRST FLOOR ELECTRICAL PLANS**

SYMBOLS LEGEND					
PLAN	NAME	PLAN	NAME	PLAN	NAME
	SINGLE GANG SWITCH		SINGLE SOCKET		TELEPHONE SOCKET
	DOUBLE GANG SWITCH		SINGLE SOCKET FOR LAMP		INTERNET SOCKET
	TRIPLE GANG SWITCH		DOUBLE SOCKET		TV SOCKET
	SINGLE TWO WAY SWITCH		FLOOR SOCKET SINGLE		WEATHERPROOF SOCKET
	DOUBLE TWO WAY SWITCH		FLOOR SINGLE SOCKET FOR LAMP		DECT BASE STATION
	TRIPLE TWO WAY SWITCH		FLOOR SOCKET DOUBLE		WALL BRACKET
	SWITCH CROSS		FLOOR SOCKET SINGLE, TELEPHONE		PICTURE LAMP
	SWITCH SERIAL		FLOOR SOCKET DOUBLE, TELEPHONE		ELECTRIC FAN
	LIGHT POINT - PENDANT HOLDER (6 INC				LUMINAIRE

	18
	22
	32
	18
	22
	32
	22

N

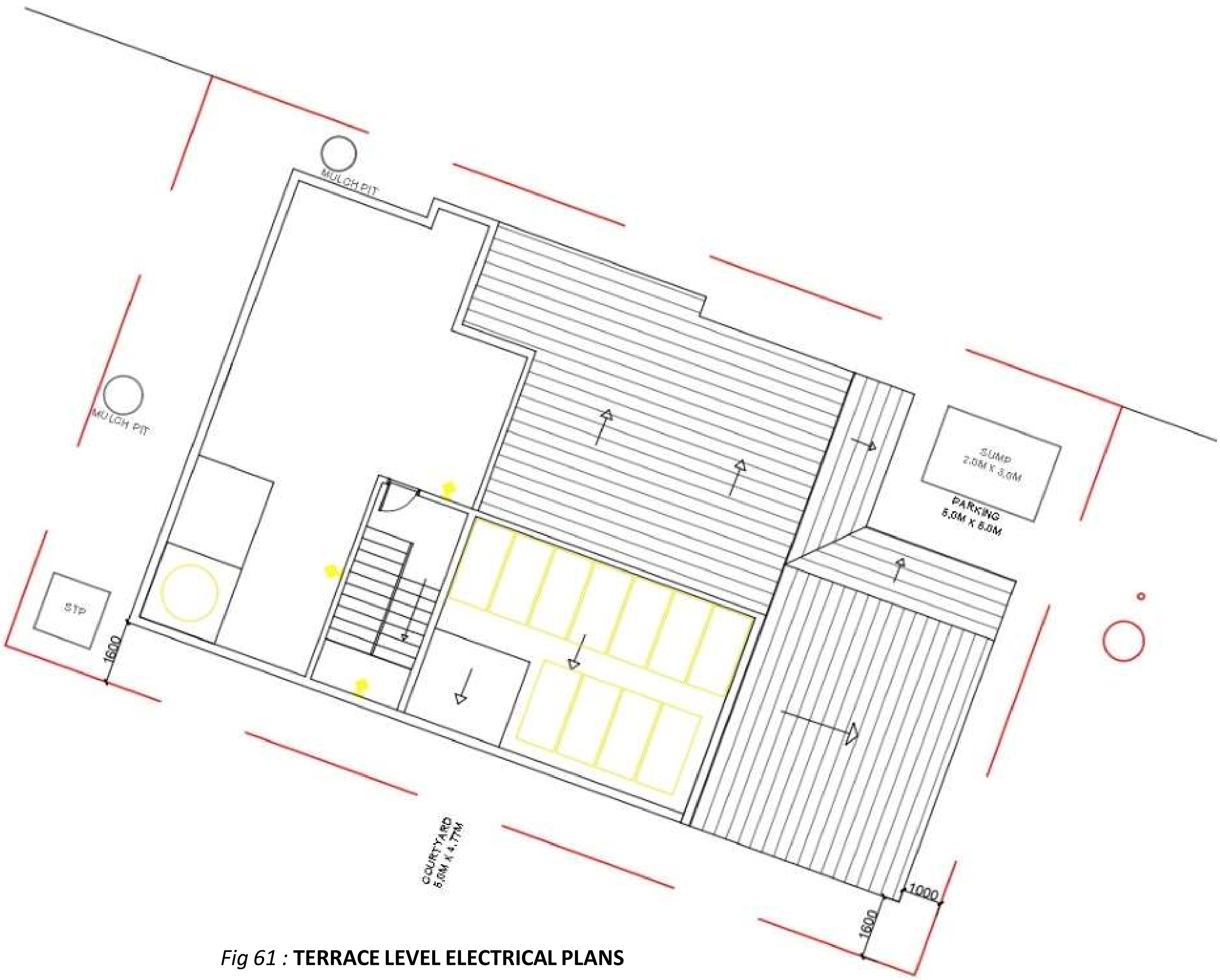

Fig 61 : **TERRACE LEVEL ELECTRICAL PLANS**

SYMBOLS LEGEND					
PLAN	NAME	PLAN	NAME	PLAN	NAME
	SINGLE GANG SWITCH		SINGLE SOCKET		TELEPHONE SOCKET
	DOUBLE GANG SWITCH		SINGLE SOCKET FOR LAMP		INTERNET SOCKET
	TRIPLE GANG SWITCH		DOUBLE SOCKET		TV SOCKET
	SINGLE TWO WAY SWITCH		FLOOR SOCKET SINGLE		WEATHERPROOF SOCKET
	DOUBLE TWO WAY SWITCH		FLOOR SINGLE SOCKET FOR LAMP		DECT BASE STATION
	TRIPLE TWO WAY SWITCH		FLOOR SOCKET DOUBLE		WALL BRACKET
	SWITCH CROSS		FLOOR SOCKET SINGLE, TELEPHONE		PICTURE LAMP
	SWITCH SERIAL		FLOOR SOCKET DOUBLE, TELEPHONE		ELECTRIC FAN
	LIGHT POINT - PENDANT HOLDER (6 INC				LUMINAIRE

	18
	22
	32
	18
	22
	32
	22

PLUMBING PLANS

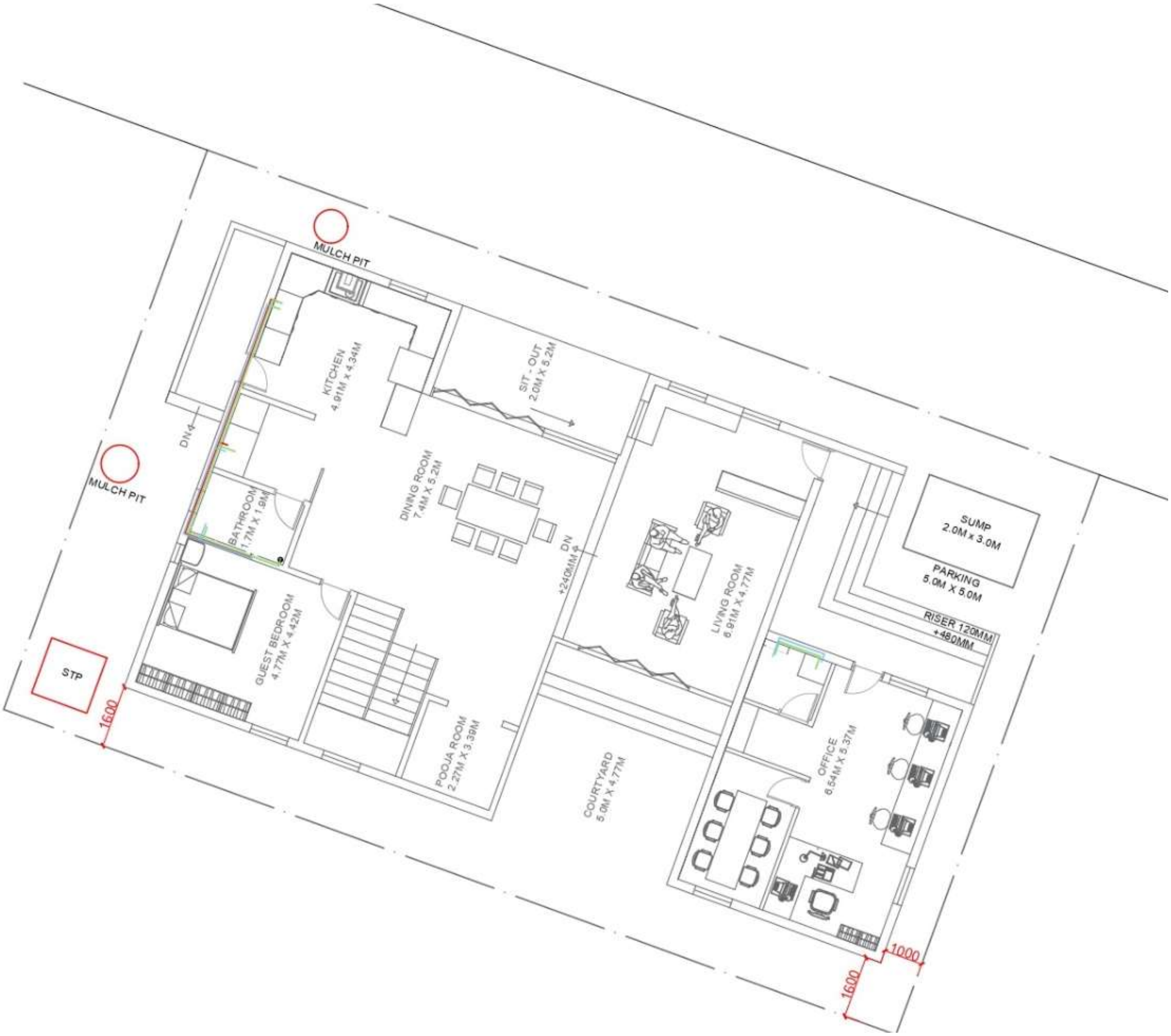

Fig 62 : **GROUND FLOOR PLUMBING PLANS**

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ENGINEERING DRAWINGS

PLUMBING PLANS

Fig 63 : **FIRST FLOOR PLUMBING PLANS**

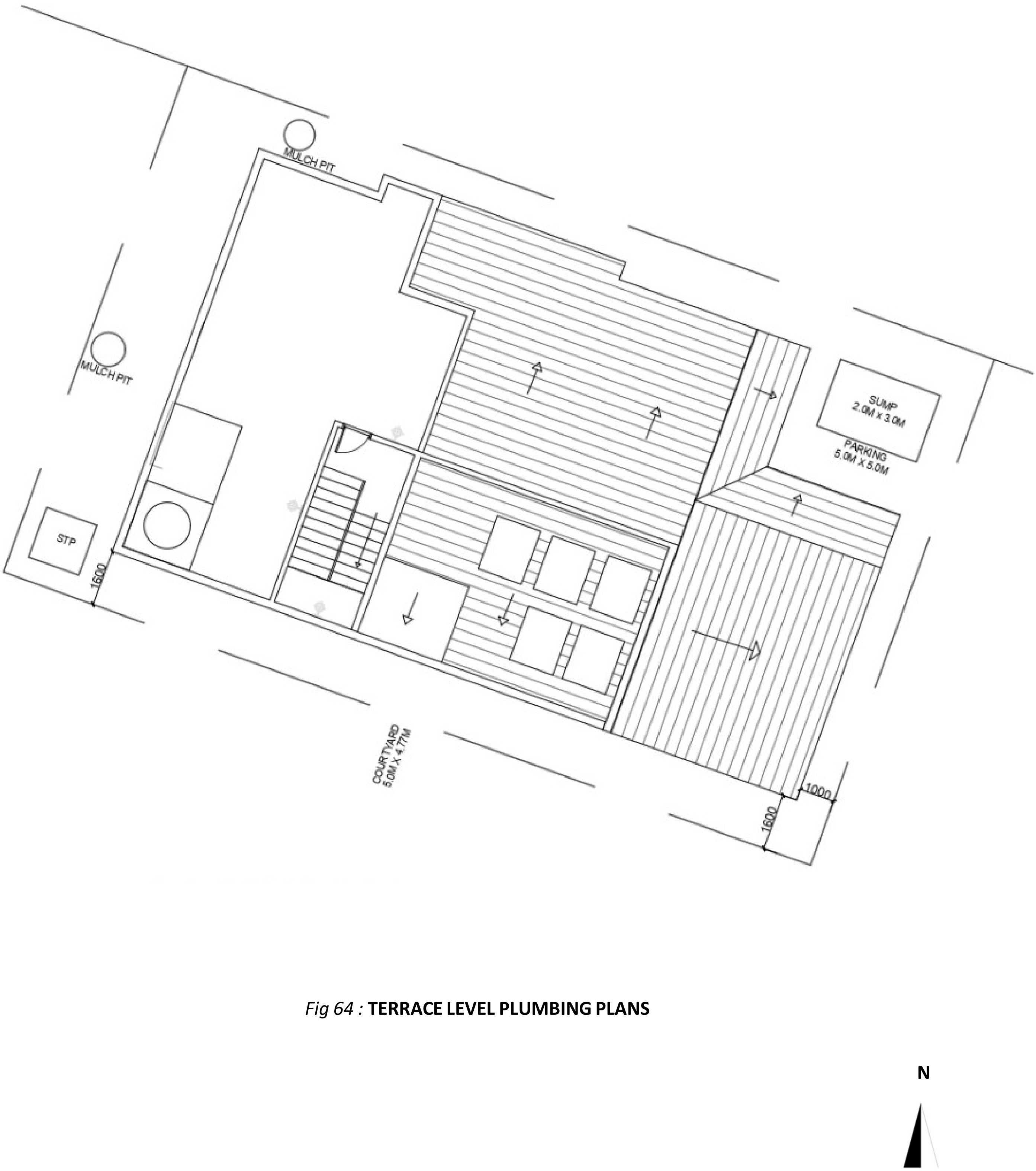


Fig 64 : **TERRACE LEVEL PLUMBING PLANS**

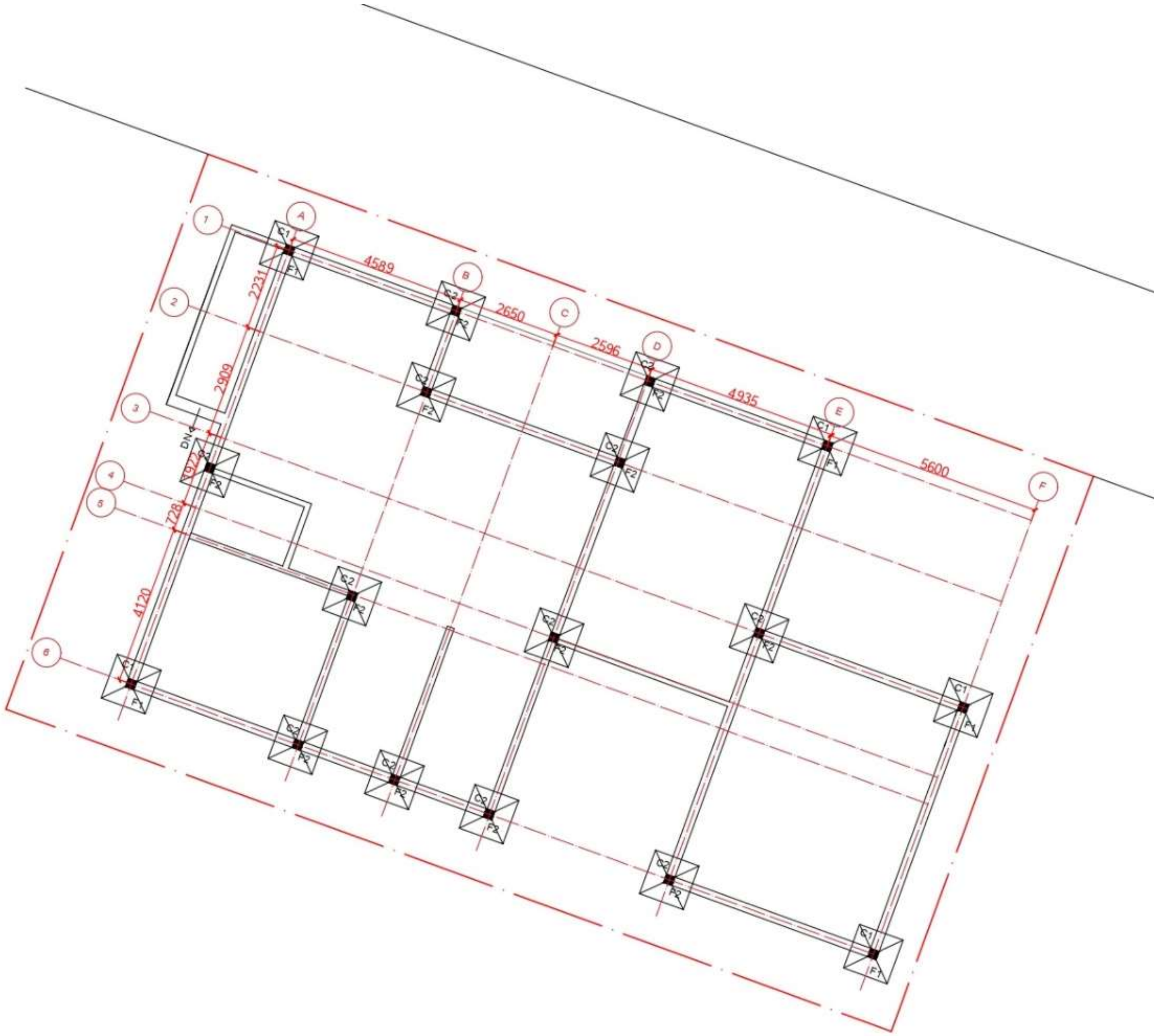


Fig 65: **FOOTING PLAN**

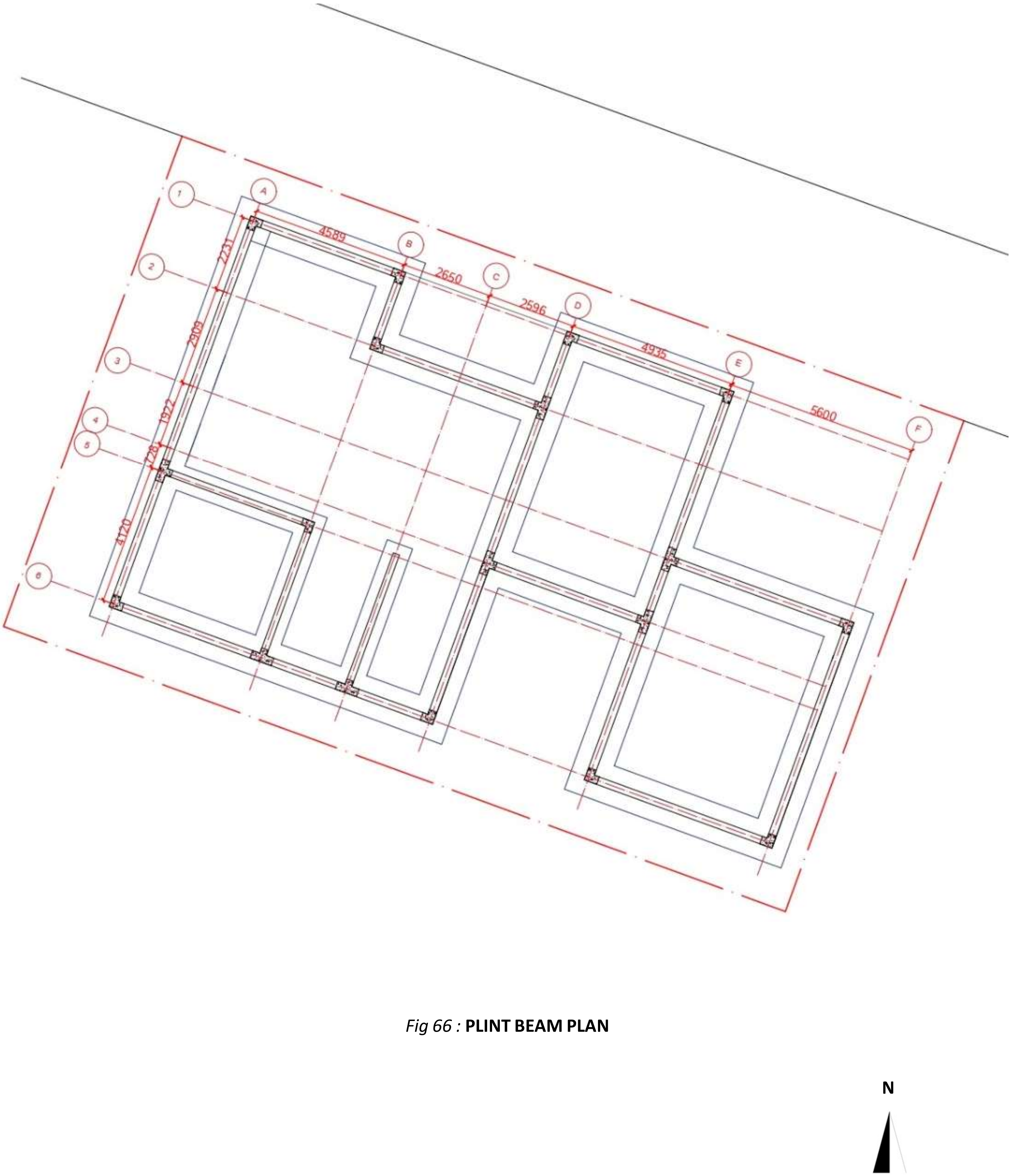


Fig 66 : **PLINT BEAM PLAN**

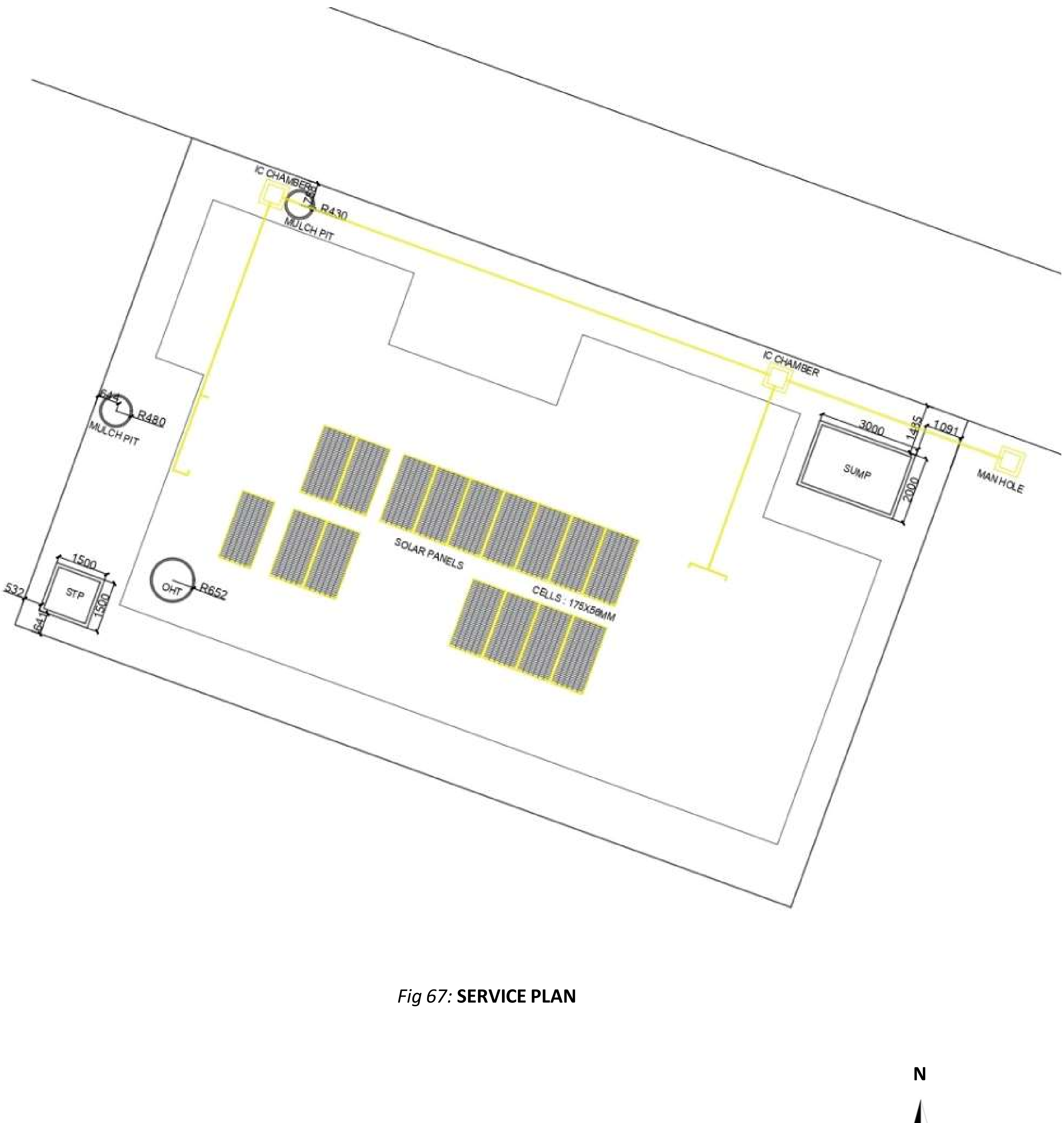
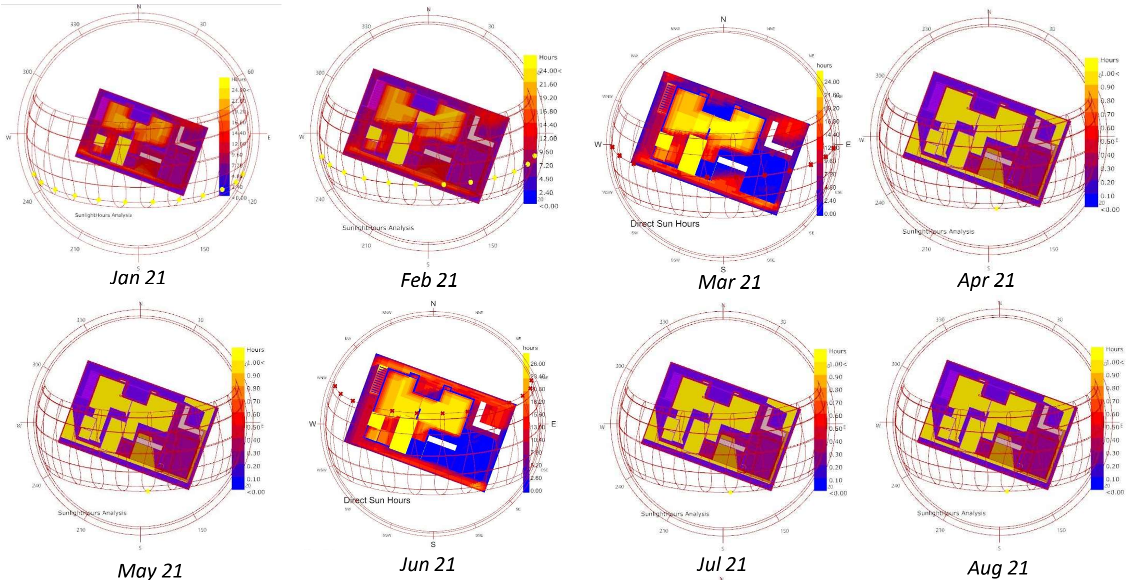


Fig 67: **SERVICE PLAN**

SPECIFICATION OF RELVANT BUILDING SYSTEMS

SOLAR PANEL



Model Name and Brand	**SHARK Bi-Facial solar panel – LOOM SOLAR**
Inverter	3500w efficiency @ 80%
Battery	150AH (8 no.)
output power	4023.76 kwh
area covered	38.4 sqm (32% of total area)
panel dimension	2.1m x 1.0m
number of panels	16 panels
Panel type and efficiency	Mono PERC Bifacial , >22%

Table 5 : Solar module specifications

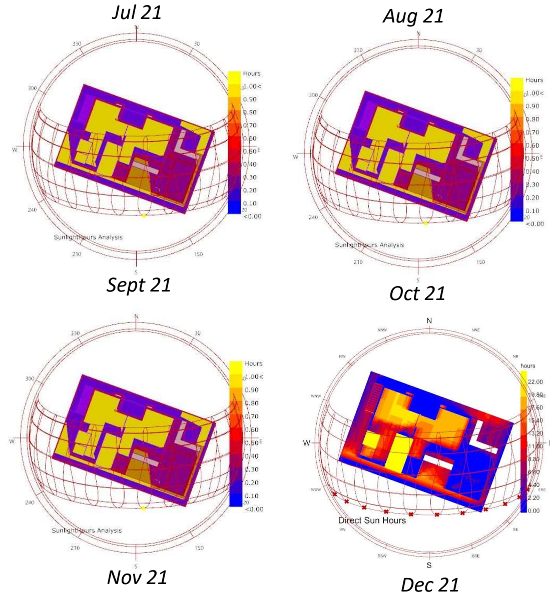


Fig 68 : Solar radiation on floor

WATER TANK

- CCWS – 200.02 – Model (Sintex)

Capacity – 2000 lts
Diameter – 1400 mm
Length – 1560 mm
Manhole diameter – 520 mm

- Refilling of tanks at least twice a week
- Total Daily Water Usage – 566 Lts

7 days a week
566 x 7 = 3962 ~ 4000 lts/week

Fig 69 : Water Tank

ENERGY SIMULATION INPUT AND OUTPUT PARAMETERS

Input Parameters	Units	Proposed Design Values
General		
Building Area	m^2	424
Conditioned Area	m^2	0
Electricity Rate	INR/kWh	8.2 per unit
Natural Gas Rate	INR/GJ	If Applicable
Building Occupancy Hours	–	24 hours
Average Occupant Density	m^2 / person	63.37
Internal Loads		
Interior Average Lighting Power Density	W/m^2	1.98
List of Lighting Controls	–	Mentioned in Energy Performance Section
Average Equipment Power Density	W/m^2	20.18
Minimum OA Ventilation (Building Average)	$l/sec.m^2$	0.30
Envelope		
Roof Assembly U value (rcc + white mosaic)	$W/m^2.K$	10.53
(mud rolls + country tiles)	$W/m^2.K$	5.59
Roof Assembly SRI (rcc + white mosaic)		94
(mud rolls + country tiles)		
Average Wall Assembly U value (cseb + straw)	$W/m^2.K$	4.33
(laterite + plaster)	$W/m^2.K$	3.56
(Agrocrete)	$W/m^2.K$	3.33
Window to Wall Area Ratio (WWR)	%	0.0172
Windows U value (double glazed, low-e glass, filled with argon)	$W/m^2.K$	3
Windows SHGC		0.32
Windows VLT	%	0.55
Infiltration Rate	ac/h	-
Describe Exterior Shading Devices		Described in D2
HVAC System		
HVAC System Type and Description	–	–

Table 11 : List of input and output parameters for energy simulation

ENERGY SIMULATION INPUTS

Output Parameters	Units	Proposed Design Values	
Proposed EUI (Total)	kWh/m²/ yr	**20.18** kWh/m²/ yr	
EUI Breakdown by End Use		No HVAC	
Heating	kWh/m²/ yr	0	
Cooling	kWh/m²/ yr	0	
Fans	kWh/m²/ yr	**3.55** kWh/m²/ yr	
Pumps	kWh/m²/ yr		
Heat Rejection	kWh/m²/ yr	0	
Service Hot Water	kWh/m²/ yr	0 (We have Solar water heater)	
Lighting	kWh/m²/ yr	**1.98** kWh/m²/ yr	
Equipment	kWh/m²/ yr	**1.87** kWh/m²/ yr	
Total Envelope Heat Gain (Peak)	W/m²	-	
Cooling Load of Conditioned Area	SF/ Tr	0	
Building Electric (Peak)	W/m²	**10.8** kWh/m²/ yr	
Annual Operating Energy Cost	INR/m²	0 (Explained in cost estimation section)	
Annual Unmet Hours	–	0	
Cooling Capacity	Tr	0	
Annual Hours of Comfort without Air Conditioning	Hours	8760	
Monthly Energy Performance		**Generation**	**Consumption**
Jan	kWh	32,144.17	-
Feb	kWh	37,914.99	-
Mar	kWh	39,652.50	-
Apr	kWh	37,418.56	-
May	kWh	34,998.45	-
Jun	kWh	34,127.70	-
Jul	kWh	33,074.78	-
Aug	kWh	32,950.67	-
Sep	kWh	34,005.59	-
Oct	kWh	35,556.94	-
Nov	kWh	33,819.43	-
Dec	kWh	30,406.46	-

Table 11 : List of input and output parameters for energy simulation

NET ZERO WATER CYCLE DESIGN AND CALCULATION

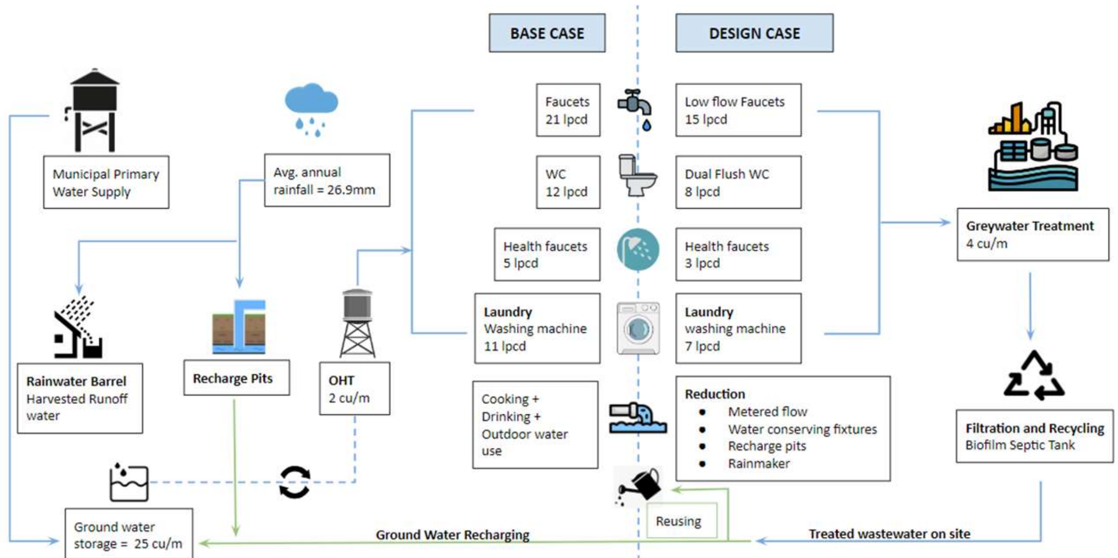


Fig 9 : Achieved Water Cycle Table

Daily Consumption (per Capita)	Number of Occupants	Daily Consumption (In Litres)	Grey Water Efficiency	Grey Water Saved (In Liters)
103	7	721	36 %	236

Table 6: Expected Water Consumption table

Daily Consumption (per Capita)	Number of Occupants	Daily Consumption (In Litres)	Grey Water Efficiency	Grey Water Saved (In Liters)
81	7	567	55.5%	315

Table 7 : Achieved Water Consumption table

Total demand (lpcd) = 721 Liters
Total demand per year = 721 x 365 = 2,63,165 Liters
Total demand per year = 263 cu/m

Total demand achieved (lpcd) = 566 Liters
Total demand achieved per year = 566 x 365 = 206590 Liters
Total demand achieved per year = 206 cu/m
Reduction by 22% = 57896 Liters

Note:
Total water usage = 566
Total Grey water produced = 450
Total Black Water Produced = 76

Therefore; 450+76 = 526

Difference is a result of drinking usage.

SUMMARY OF COST ESTIMATION

Project Summary

Proj Project Information

Team:	Swayam		
Division:	Single Family Housing	**Land Cost:**	10 Million INR
Site Area (sqm)	360	**City:**	Basavakalyan
Built-up Area (BUA) (sqm)	720	**State:**	Karnataka
Ground Coverage (Plinth Area) (sqm)	216		

Project Summary

S.No.	Particulars	Definition	Baseline Estimate (Project Partner / SOR basis)			Proposed Design Estimate		
			Amount in Million	%	Amount (INR per sqm)	Amount in Million	%	Amount (INR per sqm)
1	Land	Cost of land purchased or leased by the Project Partner	10.00	0.0%	13,889	10.00	0.0%	13,889
2	Civil Works	Refer Item A, Civil works in Cost of construction worksheet	3813910.00	52.7%	5,29,70,97,222	3032910.00	41.9%	4,21,23,75,000
3	Internal Works	Refer Item B, Civil works in Cost of construction worksheet	1679650.00	23.2%	2,33,28,47,222	1616650.00	22.3%	2,24,53,47,222
4	MEP Services	Refer Item C, Civil works in Cost of construction worksheet	1328800.02	18.3%	1,84,55,55,589	1516000.04	20.9%	2,10,55,55,609
5	Equipment & Furnishing	Refer Item D, Civil works in Cost of construction worksheet	0.00	0.0%	-	0.00	0.0%	-
6	Landscape & Site Development	Refer Item E, Civil works in Cost of construction worksheet	75000.00	1.0%	10,41,66,667	75000.00	1.0%	10,41,66,667
7	Contingency	Amount added to the total estimate for incidental and miscellaneous expenses.	344868.00	5.0%	47,89,83,335	187216.80	5.0%	26,00,23,335
	TOTAL HARD COST		#######	**100.2%**	**10,05,86,63,924**	#######	**91.2%**	**8,92,74,81,722**
8	Pre Operative Expenses	Cost of Permits, Licenses, Market research, Advertising etc	5.00	0.0%	6,944	5.00	0.0%	6,944
9	Consultants	Consultant fees on a typical Project	5.00	0.0%	6,944	5.00	0.0%	6,944
10	Interest During Construction	Interest paid on loans related to the project during construction	3.75	0.0%	5,207	2.21	0.0%	3,063
	TOTAL SOFT COST		**13.75**	**0.0%**	**19,096**	**12.21**	**0.0%**	**16,951**
	TOTAL PROJECT COST		#######	**100.0%**	**10,05,86,83,020**	#######	**88.8%**	**8,92,74,98,673**

Table 12: Cost Estimation – Project Summary

Primary cost reduction is happening in CAPEX:

1. Use of local building materials: laterite and brick
2. Reduced use of RCC and therein reducing the use of steel- one of the most expensive building materials
3. Size of laterite is bigger making laying of the blocks quicker thereby reducing the labour cost.

Primary reason for cost reduction in OPEX:

1. Solar Panels reducing the electricity bill.
2. Optimized daylight reduces the need for electrical lighting which converts to 5.6% reduction in lighting power density.
3. Electrical Appliances- The electrical appliances are energy efficient, which are generally costlier, but this in turn reduced our energy demand.

ROOF – BASELINE CASE(RCC ROOF)

MATERIAL	QUANTITY IN KG	EMISSION FACTOR	MATERIAL EMISSION	VEHICLE USED FROM FACTORY TO SHOP	DISTANCE	NUMBER OF TRIP	VEHICLE USED FROM SHOP TO SITE	DISTANCE	NO OF TRIPS	SOURCES AND NOTES
Brick kiln	12040	0.57	6863	-	-	-	HGV truck	8	1	EMBODIED CARBON TOOL
Sand	24680	0.009	222	-	-	-	HGV truck	6	1	EMBODIED CARBON TOOL
Cement	4084	0.91	15488	mini truck	3	3	Mini truck	5	3	EMBODIED CARBON TOOL
Plaster	35200	0.44		HGV truck	3	1	Hgv lorry	5	1	EMBODIED CARBON TOOL
TOTAL MATERIAL EMISSION PER FUNCTIONAL UNIT = 15 Kgco2e										

Table 13: Wall –Base line case (Brick Kiln)

MATERIAL	QUANTITY IN KG	EMISSION FACTOR	MATERIAL EMISSION	VEHICLE USED FROM FACTORY TO SHOP	DISTANCE	NUMBER OF TRIP	VEHICLE USED FROM SHOP TO SITE	DISTANCE	NO OF TRIPS	SOURCES AND NOTES
CSEB	4980	0.056	279	-	-	-	HGV lorry	5	1	AUROVILLE EARTH INSTITUTE https://www.buildupnepal.com/wp-content/uploads/2018/04/Embodied-Energy-of-Various-Materials-and-Technologies-S-Maini-V-Thautam-Auroville-Earth-Institute-2009-1.pdf
Sand	16042	0.009	144	-	-	-	HGV lorry	6	1	EMBODIED CARBON TOOL
Cement	2654	0.91	2415	Mini truck	3	2	Mini truck	5	2	EMBODIED CARBON TOOL
straw bale	3636	-1.4	-5090	-	-	-	Mini truck	4	3	EMBODIED CARBON TOOL
Agrocrete blocks	21360	-0.14	-6622	-	-	-	HGV lorry	500	1	https://greenjams.org/worlds-first-verified-carbon-negative-construction-block/
laterite	25194	0.056	1411	-	-	-	HGV lorry	5	1	https://www.buildupnepal.com/wp-content/uploads/2018/04/Embodied-Energy-of-Various-Materials-and-Technologies-S-Maini-V-Thautam-Auroville-Earth-Institute-2009-1.pdf
Lime plaster	35200	0.27	9504	-	-	-	HGV lorry	5	1	EMBODIED CARBON TOOL
TOTAL MATERIAL EMISSION PER FUNCTIONAL UNIT = 4 Kgco2e										

Table 14: Wall – Proposed case (CSEB rat trap bond)

SUMMARY OF COST ESTIMATION

MATERIAL	QUANTITY IN KG	EMISSION FACTOR	MATERIAL EMISSION	VEHICLE USED FROM FACTORY TO SHOP	DISTANCE	NUMBER OF TRIP	VEHICLE USED FROM SHOP TO SITE	DISTANCE	NO OF TRIPS	SOURCES AND NOTES
Steel reinforcement	26753	2.6	69558	HGV ORRY	80	1	HGV LORRY	8	1	EMBODIED CARBON TOOL
Sand	35525	0.009	320	HGV LORRY	3	1	HGV LORRY	6	1	EMBODIED CARBON TOOL
Cement (opc)	17568	0.91	15987	HGV LORRY	3	3	Mini truck	5	3	EMBODIED CARBON TOOL
Aggregate in cu.m	49.1	0.009	0.441	-	-	-	HGV LORRY	80	1	. EMBODIED CARBON TOOL
TOTAL MATERIAL EMISSION PER FUNCTIONAL UNIT = 955kg-co2 e										

Table 15: roof base line case (RCC roof)

Steel reinforcement	16275	2.6	42315	HGV LORRY	80	1	HGV LORRY	8	1	EMBODIED CARBON TOOL
Sand	29000	0.009	261	-	-	-	HGV LORRY	6	1	EMBODIED CARBON TOOL
Cement (opc)	14400	0.91	13104	-	-	-	HGV LORRY	5	1	EMBODIED CARBON TOOL
Aggregate in cu.m	40	0.009	0.36	-	-	-	HGV LORRY	80	1	EMBODIED CARBON TOOL
Sand	29000	0.009	261	-	-	-	HGV LORRY	6	1	EMBODIED CARBON TOOL
Mud rolls	6650	0.064	426	-	-	-	Mini truck	4	5	Auroville earth institute https://www.buildupnepal.com/wp-content/uploads/2018/04/Embodied-Energy-of-Various-Materials-and-Technologies-S-Maini-V-Thautam-Auroville-Earth-Institute-2009-1.pdf
Clay tile roof	3260	0.69	2249	-	-	-	Mini truck	10	3	EMBODIED CARBON TOOL
TOTAL MATERIAL EMISSION PER FUNCTIONAL UNIT = 676kg-co2 e										

Table 16: roof – proposed case (RCC + mud roll roof roof)

SUMMARY OF COST ESTIMATION

MATERIAL	QUANTITY IN KG	EMISSION FACTOR	MATERIAL EMISSION	VEHICLE USED FROM FACTORY TO SHOP	DISTANCE	NUMBER OF TRIP	VEHICLE USED FROM SHOP TO SITE	DISTANCE	NO OF TRIPS	SOURCES AND NOTES
Vitrified ceramic floor tile	7440	0.68	5059	MINI TRUCK	70	6	MINI TRUCK	4	6	EMBODIED CARBON TOOL
Sand	8630	0.009	78	-	-	-	HGV LORRY	6	1	EMBODIED CARBON TOOL
Cement	2142	0.91	1949	MINI TRUCK	3	2	MINI TRUCK	5	2	EMBODIED CARBON TOOL
TOTAL MATERIAL EMISSION PER FUNCTIONAL UNIT = 19Kgco2 e										

Table 17: Floor – baseline case (vitrified tiles)

MATERIAL	QUANTITY IN KG	EMISSION FACTOR	MATERIAL EMISSION	VEHICLE USED FROM FACTORY TO SHOP	DISTANCE	NUMBER OF TRIP	VEHICLE USED FROM SHOP TO SITE	DISTANCE	NO OF TRIPS	SOURCES AND NOTES
Stone floor tile	16740	0.056	937	-	-	-	HGV LORRY	15	1	EMBODIED CARBON TOOL
Sand	8630	0.009	78	-	-	-	HGV LORRY	6	1	EMBODIED CARBON TOOL
Cement	2142	0.91	1949	MINI TRUCK	3	2	MINI TRUCK	5	2	EMBODIED CARBON TOOL
TOTAL MATERIAL EMISSION PER FUNCTIONAL UNIT = 19Kgco2 e										

Table 18: Floor – proposed case (kota stone)

MATERIAL	QUANTITY IN KG	EMISSION FACTOR	MATERIAL EMISSION	VEHICLE USED FROM FACTORY TO SHOP	DISTANCE	NUMBER OF TRIP	VEHICLE USED FROM SHOP TO SITE	DISTANCE	NO OF TRIPS	SOURCES AND NOTES
Timber window frame	30000	2.4	72000	-	-	-	HGV LORRY	10	1	EMBODIED CARBON
Float glass	1460	1.2	1752	-	-	-	Mini truck	5	1	EMBODIED CARBON
TOTAL MATERIAL EMISSION PER FUNCTIONAL UNIT = 983 Kgco2 e										

Table 19: windows (base line case)

MATERIAL	QUANTITY IN KG	EMISSION FACTOR	MATERIAL EMISSION	VEHICLE USED FROM FACTORY TO SHOP	DISTANCE	NUMBER OF TRIP	VEHICLE USED FROM SHOP TO SITE	DISTANCE	NO OF TRIPS	SOURCES AND NOTES
Recycle timber	30000	-2.9	-87000	-	-	-	HGV lorry	700	1	https://www.researchgate.net/publication/262369187_Carbon_Footprint_of_Recycled_Products_A_Case_Study_of_Recycled_Wood_Waste_in_Singapore
ORAE glass	1460	0.7	1022	-	-	-	HGV lorry	700	1	https://www.glassonweb.com/news/oraer-worlds-first-low-carbon-glass
TOTAL MATERIAL EMISSION PER FUNCTIONAL UNIT = -975 Kgco2 e										

Table 20: windows – proposed case

LETTERS OF CONFIRMATION- PROJECT PARTNER

29th September 2022

To,

The Director,

Solar Decathlon India

Dear Sir,

This is to inform you that our organization (individual) Vishwa Udachan has provided information about our Udachan Mansion project to the participating team led by SJB School of Architecture and Planning, so that their team Team Swayam may use this information for their Solar Decathlon India 2022-23 Challenge entry.

As a Project Partner to this team for the Solar Decathlon India 2022-23 competition, we are interested in seeing the Net-Zero-Energy, Net-Zero-Water, resilient and affordable solution this student team proposes and the innovation that results from this. We intend to have a representative from our organization attend the Design Challenge Finals event in April, if this team is selected for the finals.

We would like our organization's logo to be displayed on the Solar Decathlon India website, recognizing us as one of the Project Partners for the 2022-23 Challenge.

With warm regards,

Name of Representative: Vishwa Udachan

Designation: -

Email: vishwaudachan5@gmail.com

Phone: +91 9538620178

LETTERS OF CONFIRMATION- INDUSTRY PARTNER

MdS
Malik's Design Studio

5th October'22

To,
The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organization M/s Malik's Design Studio is collaborating with the participating team led by SJB School of Architecture and Planning on a Single-Family Housing (Residential) Building project for their Solar Decathlon India 2022-23 competition entry.

As an industry partner, we will be providing our participants with knowledge on existing technology, techniques and a better understanding on the feasibility of their design. We will be doing so by reviewing their work through periodic reports and analysis.

We would like to have a representative from our organization attend the Design Challenge Finals event in April / May if the same is held online and the team is selected for the Finals. If the said event will be held offline, we would like to be informed about the venue and exact dates a month before we make the decision.

We would like our organization's logo to be displayed on the Solar Decathlon India website, recognizing us as one of the Industry Partners for the 2022-23 competition.

With warm regards,

Name: Vijetha Malik
Designation: Design Director - Landscape
Name of the Organization: Malik's Design Studio
Email: vijetha@maliksdesignstudio.com
Phone: 080 41229185

ADDRESS: #529/C, 2ND FLOOR, SVT PLAZA, K R ROAD, SHASTRINAGAR, BANGALORE 560 028
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LETTERS OF CONFIRMATION- INDUSTRY PARTNER

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Dr. G. R. Narsimha Rao
Director
Southern Regional Centre

email: grnrao @teri.res.in

10th October, 2022

To,
The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organisation, **The Energy and Resources Institute**, is collaborating with the participating team led by **SJB School of Architecture and Planning, Bangalore** on a Residential Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be for expert guidance to the student team, **"Swayam"**.

We would like to have a representative from our organisation to attend the Design Challenge Finals event in April/May, if this team is selected for the Finals.

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

With warm regards,
G. R. Narsimha Rao

TERI BANGALORE

Name: **G.R. Narsimha Rao**
Designation: Senior Fellow & DIRECTOR
Name of the Organisation: The Energy and Resources Institute
Email: grnrao@teri.res.in
Phone: 9448083750

LETTERS OF CONFIRMATION- INDUSTRY PARTNER

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+91 73489 39231
email : info@nele.in
website : www.nele.in

19/02/2022

To,

The Director,

Solar Decathlon India

Dear Sir,

This is to inform you that our organization, NELE is collaborating with the participating team led by SJB SCHOOL OF ARCHITECTURE & PLANNING on an Educational Building project for their Solar Decathlon India 2020-21 competition entry.

The nature of our collaboration will be an educational supervision of the progress, support & guidance required to the team throughout the competition period.

We would like to have a representative from our organization attend the Design Challenge Finals event in April/May, if this team is selected for the Finals.

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

Ar. MANU SRIDHARA KASHYAP
COA REG.No. CA/2012/55690

Yours Faithfully,
MANU SRIDHARA KASHYAP
LicenseNo.: CA/2012/55690
Address: NELE ARCHITECTS, Shankarpura
Contact No.: 7348939231
Email id: manuskashyap@nele.in

Place: Bangalore
Date: 19/02/2022

ARCHITECTURE & PLANNING NELE

Ar. MANU SRIDHARA KASHYAP
COA REG.No. CA/2012/55690

LETTERS OF CONFIRMATION- INDUSTRY PARTNER

||Jai Sri Gurudev||
Sri Adichunchanagiri Shikshana Trust ®

SJB School of Architecture & Planning

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E-mail:dean@sjbsap.edu.in
URL : www.sjbsap.edu.in

Date: 23.02.2023

BONAFIDE CERTIFICATE

This is to certify that below mentioned students are bonafide students of this institution of 3rd & 4th year for Solar Decathlon 2022-23.

1.Sadhvi Sankaranarayan
2.S Harditha
3.Anisha Hemanth Kumar
4.Sai Spurthi Meda Ashok
5.Sanjana Sadananda
6.Prathyusha TR
7.Keerthana V
8.Tanish V
9.Aditya Rajendra
10.Nanditha G
11.Jagadish Sirgapur
12.Jnanesh M
13.Keerthana S
14. Shruthi Sundar
15. Sonobar Seher

Prof. Dr.M N Chandrashekar

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