Solar Decathlon India™

ARVINDBHAI PATEL INSTITUTE OF ENVIRONMENTAL DESIGN

Anand, Gujarat

NOVEMBER 2022

Final Design Report
April - 2023

COMPETITION DIVISION

SINGLE FAMILY HOUSING

TEAM ZENITH

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5. EXECUTIVE SUMMARY

No house should ever be on a hill or on anything. It should be of the hill. Belonging to it. Hill and house should live together each the happier for the other.
-Frank Llyod Wright

Net-Zero is how nature operates, everything that comes from it harmoniously merges back with it, a complete cyclic process, nothing linear like our today's construction industry that is struggling to maintain a very delicate balance with nature. This very thought inspired our team, to take up this challenge of designing not only a net zero energy building but an environment that people connect to, cherish, and value.

Given the multi-disciplinary approach required for this challenge presented by the Solar Decathlon India, we formed a team comprising students of Architecture and Civil, Mechanical, and Structural Engineering to ensure a holistic design solution that addresses the concerns of affordability, value proposition, Emotional and Aesthetical Response, Functional efficiency, Socio-Economical Response along with being a net zero energy building. Passive cooling strategies are used to ensure a spacious, open and environmentally integrated dwelling called home. Keeping in mind the value of local people for their cultural and traditional aspects, the use of traditional architecture methods and materials available in near vicinity are taken in consideration.

Our project is SUKHADHAM-2, at Anand-Vidyanagar-Gujarat, a Single-Family Housing Scheme, by renowned developers Radha-Saomi Corporation.

Working our way out, constantly juggling through things that harness the best of nature while ensuring seamless integration with technology through sensor based and automated building systems. As we promised on achieving an **EPI of 20kWh/m2/year**, we have successfully reduced it to **19.49kwh/m2/year**. Considering on reflecting the best UDI, we've achieved **56.63%.**

This ensures that all five senses of humans are treated by optimizing thermal comfort, indoor air quality and sensory comfort. This indicated as living here is a therapy. Considering the sight of 5 elements of Ayurveda, we've treated a **building as a living human itself.**

Few strategies which ensures that:

1. Automated fresh air system of earth-air tunnel chimney.
2. Using indoor air purifying plants
3. Using lime plaster resulting in humidity and co2 reduction.
4. Sensory based automated home systems that operates automatically when thermal environment reaches the optimum mark.

6. RESPONSE TO REVIEWER'S COMMENTS

SECTION	REVIEWER'S COMMENT	OUR RESPONSE
	Reviewer 1	
Energy Performance	The Strategies selected for Load reduction like- Energy efficient Envelop, Natural ventilation strategies and shading design are explained well. However, the demonstration showing the cooling reduction for each strategy through energy simulation is missing. For Example, you have suggested U value of 0.7 w/sq m k for wall. However, why it was selected – the colling load reduction it offers and the reduction in annual EPI as compared to U value.	We have addressed this on page 19
Water Performance	The calculations for this section are done well. However, the Graphics for the water cycle can be improved with the Litres for each stage for a better explanation. Treated water cannot be used for washing cloths in washing Machine, capacity and related cost of 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	We have addressed on pg no : 23
Embodied Carbon	Embodied carbon calculations for the Roofs are shown with the baseline. However, Embodied carbon calculations for each Comparative analysis with the baseline case is missing for Walls, floor and super structure. Also, please cite sources for all embodied carbon specifications.	We have citated all source at the end of the report. We have addressed on pg no : 26
Resilient Design	This section is explained well. However, it can be detailed in the final deliverable	We have addressed on pg no : 28
Engineering and Operations	The Structural load calculations are explained well. However, HVAC system design with drawings, narratives, and calculations should be incorporated. How Radiant colling will be incorporated with the filler slab needs to be explored. Further, Constructability in terms of availability of material, technology, and labour, should be explained with analysis and narratives	We are not going for radiant Cooling or chilled beam systems We are not using any HVAC systems. Availability of material is addressed on pg. no.:29
Architectural Design	This section is well documented	

6. RESPONSE TO REVIEWER'S COMMENTS

SECTION	REVIEWER'S COMMENT	OUR RESPONSE
Reviewer 1		
Affordability	This section is explained well. However, the team can work on a better graphical representation of this section. Also, please mention the source of the Rates used for calculations	We have addressed this on page 33 We have citated all source at the end of the report.
Innovation	This Section is Explained well	
Health and wellbeing	This section focuses on design for achieving thermal comfort; which should be supported through a detailed analysis of annual simulations. It is mentioned in the report that the building is going to be operated in Mixed mode ventilation. However, evidence-based design through simulation is missing- which would show the thermal comfort will be achieved across all hours. For Example Annual Energy simulation can be done providing the window operation scheduled and Hours the temperatures are in the thermal comfort range (As per IMAC)can be extracted to show compliance. Further, Air quality analysis is missing in this section and active mitigation measures if required during certain hours needs to be checked based on the AQI.	We have addressed thermal comfort on pg no: 35. We have addressed air quality analysis on pg no: 35
Value Prop-osition	This section is explained well	

6. RESPONSE TO REVIEWER'S COMMENTS

SECTION	REVIEWER'S COMMENT	OUR RESPONSE
Reviewer 2		
Energy Performance	A whole-building approach for better performance is very well done. Included strategies for integrating daylighting and passive systems, building envelope, efficient electric lights, and appliances. Focus on reducing heating and cooling loads with supportive data. Please work on demonstrating annual energy analysis against the baseline scenario using low-energy comfort systems. RE integration from the final calculation is missing.	We have addressed on pg no : 19
Water Performance	The team has clearly defined strategies for domestic consumption, irrigation, and utilities demonstrated through comprehensive annual water calculations and comparison with baseline usage. Strategies to achieve Net-zero annual water performance are also mentioned but lack clarity on the water cycle diagram.	We have addressed on pg no : 23
Embodied Carbon	A good attempt; however, the team need the put together a clear list of materials used in the building design and its comparative embodied carbon reduction from the baseline case. Also, the team needs to add courses of embodied energy/ carbon values.	We have compared embodied carbon reduction of basecase and praposed case.
Resilient Design	Good attempt to find out current weaknesses. However, potential risks resulting from climate change has to be assessed through qualitative and quantitative Analysis Interventions in design and infrastructure to tackle the risks demonstrated through drawings and narratives are also to be added.	We have addressed this on page 28
Engineering and Operations	Appreciate the sizing drawings and load calculations. Constructability at scale in terms of availability of material, technology, and operational needs are to be clearly mentioned.	We have addressed on pg no : 29
Architectural Design	Functionality and efficiency in terms of circulation, space allocation, servicing, Adjacencies should be presented through drawings. Specific passive design features adopted can be added to the drawings.	the passive design stretagies have been addressed through 10 contests.
Affordability	Construction cost analysis for local or repurposed materials and other strategies of the proposed design needs to be compared with a baseline design needs to be worked out.	We have addressed on pg no : 33

6. RESPONSE TO REVIEWER'S COMMENTS

SECTION	REVIEWER'S COMMENT	OUR RESPONSE
Reviewer 1		
Innovation	Urging the team to innovate by using new materials and ready-made products and how these materials and technologies are used.	We have addressed on pg no : 34
Health and wellbeing	This section focuses on design for achieving thermal comfort, which should be supported through a detailed analysis of the mode of operation. Annual simulations demonstrating thermal comfort achieved in key spaces are missing during occupied hours and for each mode of operation.	We have addressed on pg no : 35
Value Proposition	This section focuses on design to achieve thermal comfort, which should be supported through a detailed analysis of annual simulations. Approach the same through passive design strategies	We have addressed on pg no : 39

7. TEAM SUMMARY

7.1 TEAM NAME : ZENITH

7.2 INSTITUTION(S) NAME :

1. Arvindbhai Patel Institute of Environmental Design, Anand, Gujarat
2. Maulana Azad National Institute of Technology, Bhopal, M.P.
3. Centre for Environmental Planning and Technology, Ahmedabad
4. Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal, MP.
5. Chitkara University

7.3 DIVISION : Single-Family Housing

7.4 TEAM MEMBER :

Saksham Choudhary
B.Arch 3rd year I APIED
(Simulation & Designing)
(Team Lead)

Jainil Shah
B.Arch 5th year I APIED
(Innovation & Designing)

Aagam Shah
B.Arch 5th year I APIED
(Simulation & Designing)

Trisha Shah
B.Arch 5th year I APIED
(Composition & Designing)

Siddhartha Jain
B.Arch 5th year I APIED
(Innovation & Designing)

Samved Patel
F.T 5th year I CEPT
(Structure & Calculations)

Siddhi Patel
B.Arch 3rd year I APIED
(Material & Sustainablity)

Akshita Shrivastav
B.Arch 4th year I APIED
(Designing)

Akshada Choudhary
B.Arch 4th year I MANIT
(Energy Performance)

Pratiksha Prapti Pathak
B.Arch 4th year I MANIT
(Indoor Environment)

Rahul Kumar Rathore
B.Arch 4th year I MANIT
(Indoor Environment)

Naman Karla
B.Des 2th year I CEPT
(Simulation)

Sudesh Morey
M.Tech 2nd year I RGPV
(Energy Efficiency)

Prateek Saini
B.Arch 4th year I Chitkara University
(Structure & Calculations)

Fig. 1 : Team Profile

7.5 APPROACH

Our goal is to integrate architectural expression, health, and affordability with a net-zero-energy-building design. Our team includes architecture and engineering students who will work individually on specific tasks, but also integrate their efforts for a holistic design process. We partner with practicing architects and technical consultants for assistance and market-tested solutions in green building design and renewable energy.

7.6 LEAD INSTITUTE - APIED, GUJARAT

APIED, a 42-year-old institute in Gujarat, offers undergraduate and graduate degree courses in architecture and design with a focus on environmental and societal concerns.

7.7 FACULTY LEAD

Asst. Prof. Harsh Sharma, working at APIED for 6 years. Areas of interest include Climatology, Indigenous, Regenerative, and Resource Efficient Habitat Designing, and Human-Centric Designing.

Fig. 2 : Faculty Lead

7.8 INDUSTRY PARTNER

Grid architects(Architectural solutions)
Shashwat green consultant(Green building)
Abhay Data (MEP)
Kesarjan Building Centre (for material and structural system)

7.9 DESIGN PROCESS

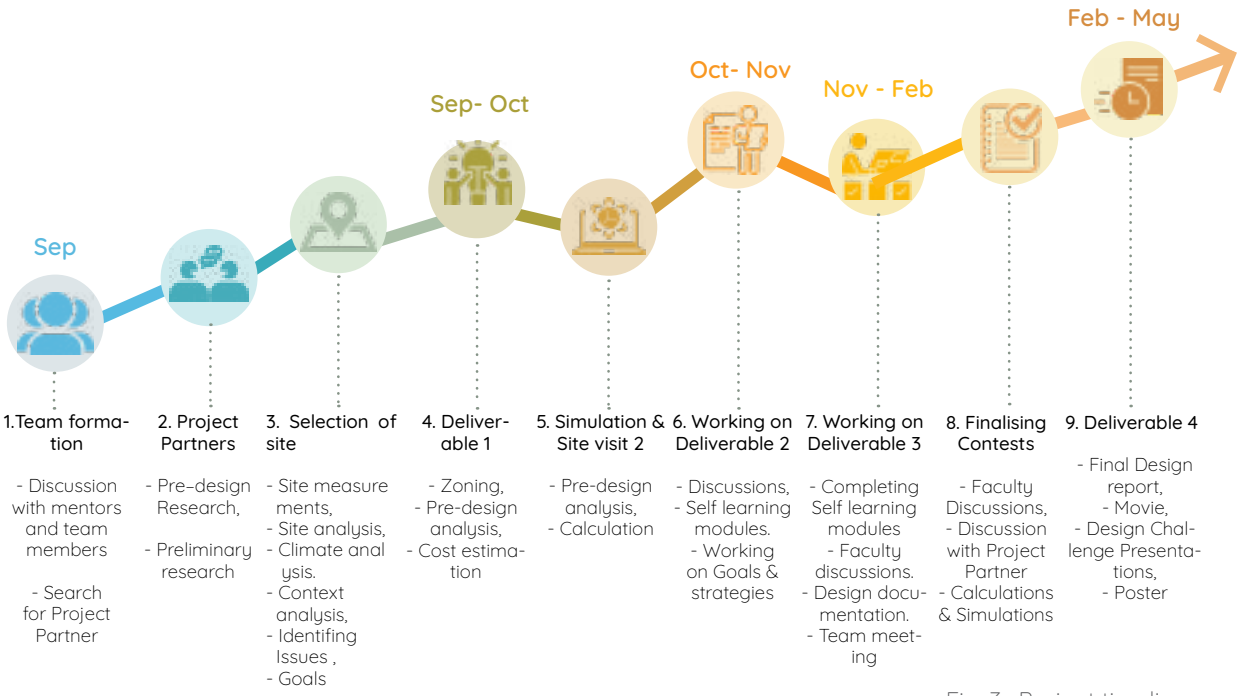


Fig. 3 : Project timeline

7.10 TEAM DISCUSSIONS

Fig. 4 : Team Discussion

7.11 SITE VISIT

Fig. 5 : Site Visits

7.12 CHALLENGES

1. It was difficult to understand new software, so calculating EPI was difficult. As a result, we had apporach Seniors and TRG members.
2. Reducing the use of unsustainable conventional methods increased the cost.
3. We found it hard to balance college and moving forward with the competition at multiple times.

7.13 SOFTWARE USED

AUTOCAD, AUTODESK REVIT, Excel, CLIMATE CONSULTANT, SketchUp, DesignBuilder, Light Stanza, Ps, Ai, Id

Fig. 6 : Software used

8. PROJECT BACKGROUND

8.1 PROJECT NAME : SUKHDHAM (PHASE-2)

8.2 PROJECT PARTNER : Radhasoami Construction (R.S. Corporation)

The R.S. Corporation is located in Anand, Gujarat. Currently owned by Mr. Jignesh shah a civil engineer. The company has over four decades of experience behind it. They focus on fulfilling the dreams of the middle class of society. They have earned goodwill as one of the most trustworthy real estate developers and have developed several successful residential as well as commercial projects.

8.3 PROJECT DESCRIPTION :

Single-family detached housing scheme on the **Northern fringes of Anand city**, following the **Hot and Dry climate zone.** The project is the second phase of an ongoing scheme, with phase one already completed and phase two in the works.The targeted occupants are primarily from the **middle and upper middle classes.** NRI clients own a significant amount of property in the area. The purpose of the project is to **built & sell**. Being residential type it remains operational for **24 hours.** The project is under construction.

8.5 SPECIAL REQUIREMENTS OF PROJECT PARTNER :

Marketable, affordability, time of construction, and little scope of customization of spaces are the main requirements of the project partner.

8.6 Cost Estimation :

Sr. No.	Particulars	Baseline Estimate (Project Partner / SOR basis)			Proposed Design Estimate		
		Amount	%	Amount	Amount	%	Amount
1	Land	3973368.00	45.0%	17,068	3973368.00	42.4%	17,068
2	Civil Works	1662126.11	18.8%	7,140	1546221.28	16.5%	6,642
3	Internal Works	578758.86	6.6%	2,486	439537.08	4.7%	1,888
4	MEP Services	354600.00	4.0%	1,523	563300.00	6.0%	2,420
5	Equipment & Furnishing	253650.00	2.9%	1,090	574400.00	6.1%	2,467
6	Landscape & Site Development	85268.18	1.0%	366	109068.18	1.2%	469
7	Contingency	570581.00	6.5%	2,451	605295.14	6.5%	2,600
	TOTAL HARD COST	7,478,352.2	85%	32,124	7,811,189.7	83%	33,553
8	Pre Operative Expenses	224,350.56	2.5%	964	224,350.56	2.5%	964
9	Consultants	373,917.61	4.2%	1,606	546,783.28	6.2%	2,349
10	Interest During Construction	747,835.22	8.5%	3,212	781,118.97	8.9%	3,355
	TOTAL SOFT COST	1,346,103.4	15%	5,782	1,552,252.8	18%	6,668
	TOTAL PROJECT COST	8,824,455.5	100%	37,906	9,363,442.5	100%	40,221
	DIFFERENCE	538,986.95	6%				

refurbished

Table 1 : Cost Estimate

Every room will have mix-mode ventilation, offering people more option to use the air conditioning however they see fit. The windows and doors are made of refurbished wood and green glass from the area, where there is a substantial demand for such products, in the project. We will grout the floor while leaving the top of the R.C.C. slab exposed, giving the impression of a tile pattern, in order to prevent cracks.

8.3 PERFORMANCE SPECIFICATION

GENERAL	
Built up area	233 m^2
Electricity Rate	5.5-6 INR/kwh
Number occupant density	6 - 8 person
Buiding Occupany Hours	24 hrs
ENVELOPE	
Wall assembly U value	0.7 W/m^2K
Roof Assembly U value	1.2 W/m^2K
SHGC	0.4
Glazing	2.7
Exterior Shading Device	Horizontal and vertical walls with earth insulation method
System Type	Mix mode ventilation augmented with Earth air tunnel and solar chimney
Mixed Mode Strategy	Windows are open when operative temperature lies with-in the IMAC thermal comfort band below 25 deg. This is possible during the months of November, December and January
Operative Hours	24 hrs
RENEWABLE ENERGY	
Type	Monocrystalline Photovoltaic Panels
Efficieny	18 -22 %
No. of units generated through 1kw	4-5.5 units/day
Annual generation Capacity	8,760-12,045 units
Installed Capacity	6 kW
EPI	
Proposed EPI	20 kWh/m^2/ year
WATER SYSTEM	
Total Daily Consumption	124173 litres (for 6 occupants)/day
Domestic Requirement	63 litres per capita per day
Flushing Requirement	72 litres (for 6 occupants)/day
Treated Grey - water	268 litres/day
Total Rainwater Harvest	121879 litres (Anually)
Annual volume from flow & flush fixtures (Grey + Black water) **(Baseline)**	244185 litres
Annual volume from flow & flush fixtures (Grey + Black water) **(Design)**	124173 litres
Percentage of water saved through applied techniques	49%
Annual volume from flush fixtures (Black water)	26280 litres
LIGHTNING	
Interior Lighting power density (LPD)	1.9
Exterior Lighting power density (LPD)	0.5

Table 2 : Performance Specification

9. GOALS

1. ENERGY PERFORMANCE

- To minimize total energy consumption by optimising daylight and ventilation.

- **EPI** target : up to 20KWh/m2/yr.
- Net zero energy design with up to 6KW Monocrystalline solar panels with **22% efficiency**.

2. WATER PERFORMANCE

- To recharge the ground water table.
- To reduce water consumption.

- 1. Recycled grey water for landscaping.
- 2. Utilizing low flush fixtures can cut water usage by up to **40%** compared to standard fixtures

3. ARCHITECTURAL DESIGN & VALUE PROPOSITION

- Achieve functionality, adaptability, and aesthetic for an optimal user experience.

- To integrate Architectural Expression, Health, and Affordability with a Net-Zero-Energy Building Design.

9. INNOVATION

- Come up with innovative techniques to maximise water and energy efficiency.

- Installing a **biofiltration system**, using **14 patterns of biophilia**
- Using **Miyawaki technique** to get better productivity.

4. HEALTH AND WELLBEING

- To achieve indoor comfort both visually and thermally.

- **80%** indoor area will be day light with minimum 200-400 or above lux.(source:MIT lab.)
- **Therapeutic landscape**, use of mediational aromatic plantation.

6. ENGINEERING AND OPERATIONS

- Usage of innovated devices for optimum thermal comfort

- Use of Sensors to determine the set point of A.C considering the **IMAC** band of thermal comfort & latest 5star rated products as per **BEE norms.**

7. RESILIENCE

- Disaster management ,Sustainable planning
- The structure can withstand up to 2000mm of rain for 3 to 4 days & High plinth level for high rain flooding conditions.

- **3 -5 Days** of autonomy.
- On site small scale **agricultural activity** to ensure food supply for minimum 3-5 days (including techniques like **hydroponics**, **aquaponics** and **aeroponics**)

5. AFFORDABILITY

- Cost optimization strategies.
- Life cycle costing of average strategy materials as per LEED **ergonomy standards**.

- **Cost payback period** : **5-7yrs**
- The average cost increase for green building measures is **15-20%**, which can be mitigated by using affordable innovative materials.

8. LANDSCAPE

- To create a quality of an environment and provide a conducive living space.

- **100%** Indigenous Species & native Vegetation
- Drought tolerant Plants – Companion planting, xeriscaping & 50% of the total paved area on site are shaded.

10. EMBODIED CARBON

- To lessen the carbon footprints on building material
- Use of **GRIHA** or **LEED** rated materials.

- Use of **20%** recycled product & 50-70% of the products used will be sourced locally with in a **500km radius.**
- Utilize carbon-sequestering materials, such as green roofs and walls.

Fig.7 : Goals

10. DESIGN DOCUMENTATION

10.1 CONTEXT ANALYSIS

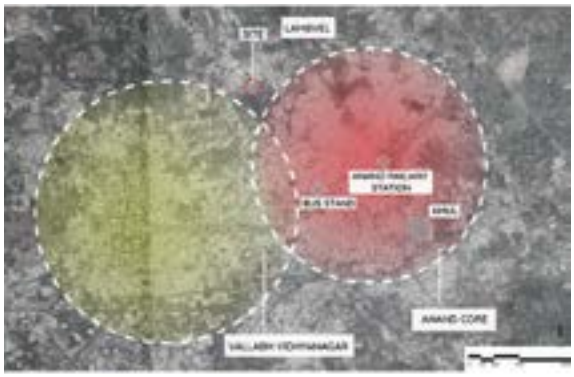


Fig. 8 : City Analysis

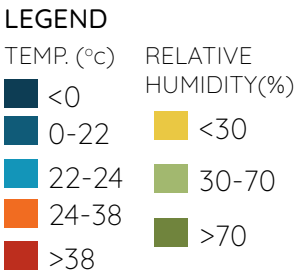
Fig.9 : Site Connectivity

- The site lies in between the fringe area of Anand & Vallabh Vidhyanagar.
- The user group who invest here are upper middle class and high income group people. Who generally travel through their own vehicle rather than using any public transportation facility.
- The Plot size varies of 4 BHk varies from 1700 - 3500 sq.ft., with average being 2,600 sq.ft.
- Hence, per Sq. ft. price varies from 2,500 - 5,700/- INR (selling price including construction cost, profit & other charges), with average being 4,100/- INR, as per facilities and amenities provided to the user.
- This solution is intended for 20-22 houses on this land parcel (with 6 members in each house).
- The material that is locally used and available in good quantity is brick.
- The earlier houses used to be a linear/row house kind of system. which would include an open-to-the-sky backyard at the back of the house for cross ventilation.

10.2 CLIMATE ANALYSIS

Fig. 10 : Summer wind

Fig 11 : winter wind



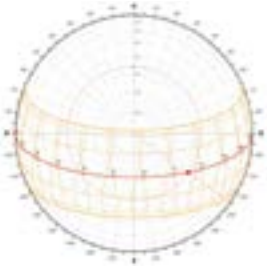


Fig 12 : Sun Path

DIRECTION	NORTH		NORTHWEST 327°	
AVERAGE DAY IN	SUMMER	WINTER	SUMMER	WINTER
OVERALL FORM	1205	1050	1309	972
NORTH SURFACE	124	57	325	65
SOUTH SURFACE	102	274	223	263
EAST SURFACE	122	109	207	173
WEST SURFACE	112	80	247	43
TOP SURFACE	588	346	698	346

Table 3 : Thermal Analysis (values in kwh)

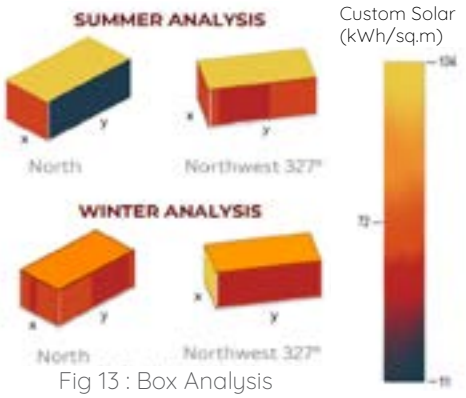


Fig 13 : Box Analysis

10.3 MASTER PLAN

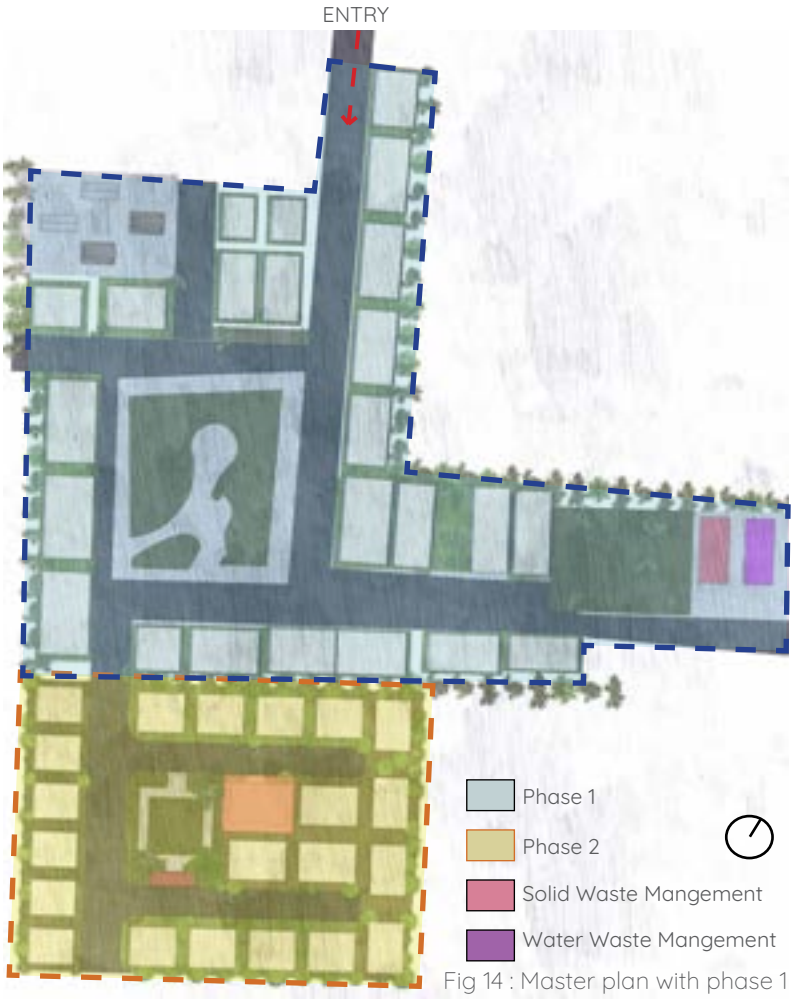


Fig 14 : Master plan with phase 1

Number of Units :
3BHK: 06
4BHK: 16

Road Area : 1298 sq.m.
Open space : 590 sq.m.

Fig 15 : Master plan

Rainwater collected on the roads and common plot will be collected collectively at the centre open space.

We have planned a waste water treatment plant on the site that will use a natural slope to collect all of the grey and black water from both phases at the distinctive phase 01 corner.

Vermicomposting system:

Vermicomposting is the process of using worms to transform organic materials (typically trash) into vermin-compost, a humus like substance.

Fig 16 : Vermicomposting

Vermicomposting of sieved blackwater using the Rottebehalter system:

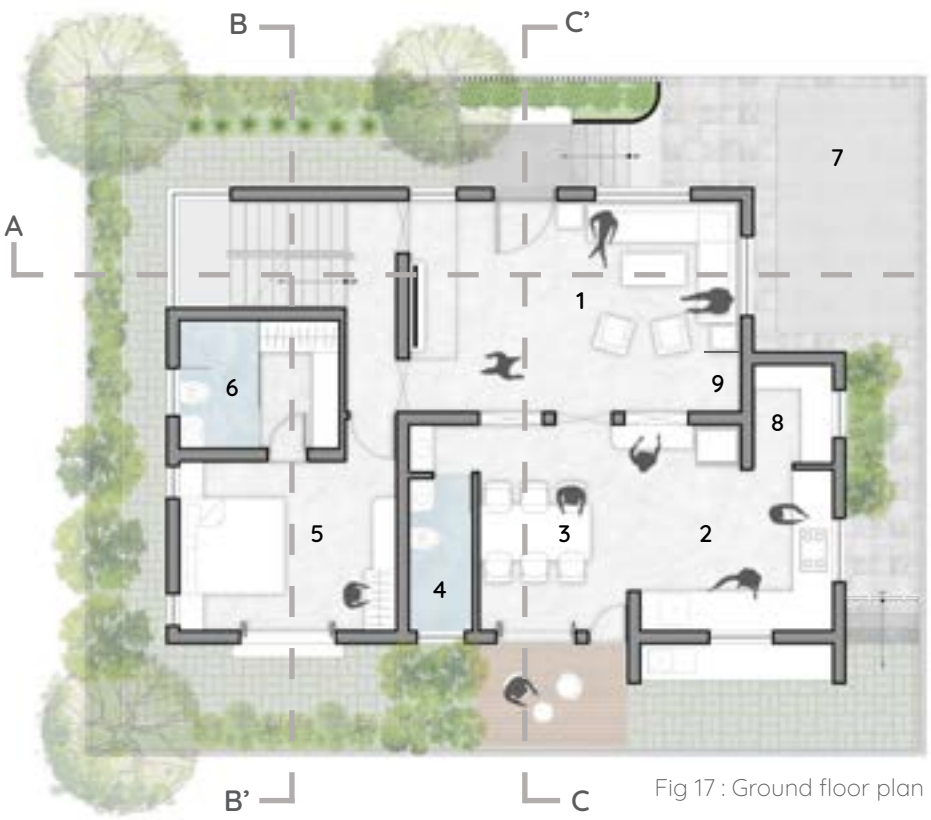
The plant consists of three major parts:

1) Intermediate tank

2) Three tanks connected to the intermediate tank in parallel, within each tank a filter bag of dimensions (50 cm*50 cm*80cm).

3) A mobile crane for weighting the filter sacks.

10.4 DESIGN ANALYSIS



1. Living Room - 6.2 x 3.9m
2. Kitchen - 3.8 x 3.8m
3. Dinning - 2.8 x 3.8m
4. Powder toilet - 1.2 x 2.8m
5. Bedroom- 1 - 4.0 x 3.2m
6. Toilet & Dressing Area 1 - 3.0 x 2.4m
7. Parking - 3.2 x 5.2m
8. Store Area - 1.5 x 1.8m
9. Pooja Space - 1.8 x 1.1m
10. Cut-out Above covered with glass

Fig 17 : Ground floor plan

- Ground Floor Plan

1. Bedroom-2 - 4.0 x 3.2m
2. Toilet & Dressing Area -2 - 3.0 x 2.4m
3. Bedroom-3 - 3.4 x 4.0m
4. Toilet & Dressing Area-3 - 1.5 x 4m
5. Balcony - 3.1 x 1.2m
6. Bedroom-4 - 3.6 x 3.8m
7. Toilet & Dressing Area-4 - 1.5 x 4m
8. Lounge area - 4.1 x 3.8
9. Earth coupling
10. Cut-out Above covered with glass

Fig 18 : First floor plan

- First Floor Plan

The approach for architecture is based on the climatic parameters and considering hot and dry climate of Anand. The approach is to promote heat loss and reduce heat gain.

We have tried to incorporate it to connect users with the greens in most parts of the house in order for them to live a healthy lifestyle.

Fig 19 : Tthirdfloor plan

Our goal is to design environments that promote meditation by being as peaceful and pleasant as possible.

Because the plot is oriented 30° north-south, we aimed to reduce the amount of time spent in the west and south suns.

To help customers lead healthy lives, we have made an attempt to connect them with greenery in most areas of the home.

- Third Floor Plan

For shading design, the building geometry was imported into the Andrew Marsh software to understand areas that require shading and areas that fall under mutually shaded spaces.

Fig 20 : Section AA'

SECTION AA'

SECTION BB'

Fig 21 : Section BB'

Fig 25 : Views

We have designed each space to be closed or opened in a mix-mode system based on the needs and comfort of the occupants.We have designed the structure and electric points in such a way that there would be no need for a false ceiling.

SECTION CC'

Fig 22 : Section CC'

Fig 23 : Front Views

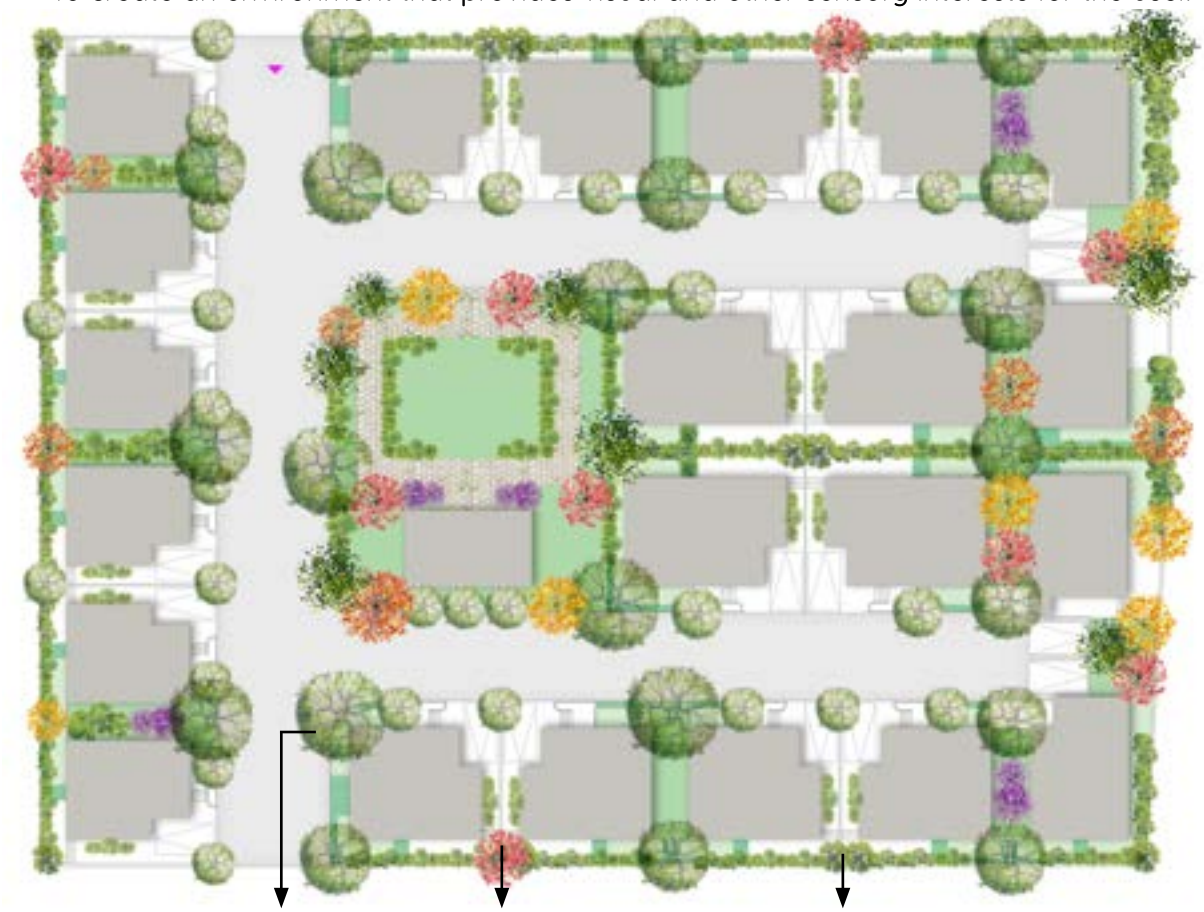
Fig 24 : Views

Choosing to live in a net-zero residence does not only mean choosing an energy efficient space but also an energy efficient lifestyle. When occupants make this decision, it is critical that the project provide them with flexibility in areas such as open kitchens and dining areas in the winter and outdoor gatherings in the backyards.

10.5 LANDSCAPE

"Bringing Nature to Built"

- In a hot and dry region, vegetation is crucial because it absorbs radiation and, with precise plant arrangement, vegetation may direct and increase airspeed.
- To create an environment that provides visual and other sensory interests for the user.



Landscpae master plan

Fig 26 : Landscpae master plan

- 68% - Hardscape , 52% - softscape, 50% of the total paved area on site are shaded.
- Creating all-season interactive spaces deeply rooted with nature by all-season flowering trees and vegetation.
- 100% Indigenous Species & native Vegetation and creating enviornment which attract bird species on site.

Landscape plant directory for masterplan


1. Gulmohar


2. Yellow Flame


3. Kadamba


4. Bauhinia (Kachnar)

Medicinal trees


1. Neem tree


2. African tulip plant


3. Ranwara plant

Fig 27 : Landscape plant directory for masterplan

Therapeutic Landscape by using medicinal trees for better health and well-being, through healthy air, water and food.

- Vegetation is planned on east and west sides to minimize the heat gain.
- The determining climatic factors are Air movement, Radiation, Relative Humidity, and Daylight.
- 50% of the Paved area are shaded by trees which decreses the urban heat island effect by 20%.
- Low/No Maintenance green spaces, that maintain themselves naturally and don't require an excess water supply, cleaning of shredded leaves and trimming.

Fig 28 : Landscape Ground Floor plan

GROUND FLOOR PLAN

FIRST FLOOR PLAN

Fig 29 : landscape First floor plan

Strategies :

1. Use of Native Plants and tress
2. Drip Irrigation
3. Earth Coupling
4. Planters on 1 floor
5. Terrace garden
6. Use of Seasonal Plants
7. Meditional Plants(Thera-putic Landscape)
8. Use of Flowering, Smelly Plants which are use for air purification

1. Green Area : 27.5Sq.m
2. 50% of the total paved area on site are shaded.

Landscape plant directory

- Herbs

- Indoor air purifier

- Smelly flowering plants

- Trees

Champa tree

Terminalia metallica

- Herbs like such Basil, mint and thyme act as insect repellants

Fig 30 : landscape plant directory

Earth Coupling :

- Earth coupling of thermal mass protected from external temperature extremes (e.g. floor slabs) can substantially lower temperatures by absorbing heat.
- Passively shaded areas around earth-coupled slabs keep surface ground temperatures lower during the day and allow night-time cooling.

Fig 31 : Earth Coupling

Companion Plant within A Square Foot Garden

- Companion planting is the technique of growing various plant species close to one another so that they can mutually benefit.
- Square foot gardening makes it possible to grow a wide range of species in a little area.
- A 4 feet by 4 feet rectangle can be divided into a grid of 16 square feet. Each square foot is treated as a separate patch, and a specific number of plants are planted per square foot.

Fig 32 : square foot farming

Drip Irrigation System

- It's a very efficient way to use water because the water goes straight to the plants without evaporation or runoff.
- Drip irrigation delivers water slowly immediately above, on or below the surface of the soil. This minimizes water loss due to runoff, wind and evaporation.

Fig 33 : Drip Irrigation

Aeromatic herbs and medicinal plants

- Plants with medicinal benifits like amla, Aloe vera, grass lemon, Dhavana, Ashwagandha, Coleus, Mints, etc

Fig 34 : Aeromatic Plants

- Use of **Mosquito-Repelling Plants** like Rosemary, Basil, Lemon balm

10.6. ENERGY PERFORMNACE

Energy Efficient Building Envelope:

- The project must ensure that the overall U-value of the wall assembly shall meet the baseline criteria mentioned in IGBC Green Aordable Housing guidelines for climate zone

Building Elements	Maximum 'U'-Value IGBC Guidelines(W/m2K)	'U'-Value (W/m2K)
Wall	<=2.5	0.7
Roof	<=1.2	1.2
Glass	<=5.7	2.7

Table 4 : U value of Building Elements

1. Wall Window Ratio(WWR) of the residence is overall 15.1%.

Glass : We are using

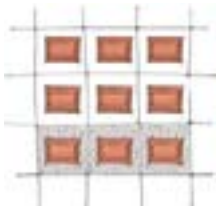
- ASAHI Ecosense Necta
- Double Glazed 6mm with air cavity
  U'-Value: 2.7 W/m²K
- SHGC: 0.4

SHGC of the Glazing of all windowsis 0.4 is meeting with the baseline criteria (IGBC Green Aordable Housing) less than 0.5 if WWR is less than 20% in hot and dry climate.

2.Overall 'U'-value factor is reduced to 0.7 W/m²K by using fly ash bricks and Rat-trap bond.

3. By using filler slab overall 'U' value is r educ ed t o 1 . 2 W/m² K from 1. 4 W/m²K

4. We have also used earth insulation to increase thermal conductivity reduce overall EPI.



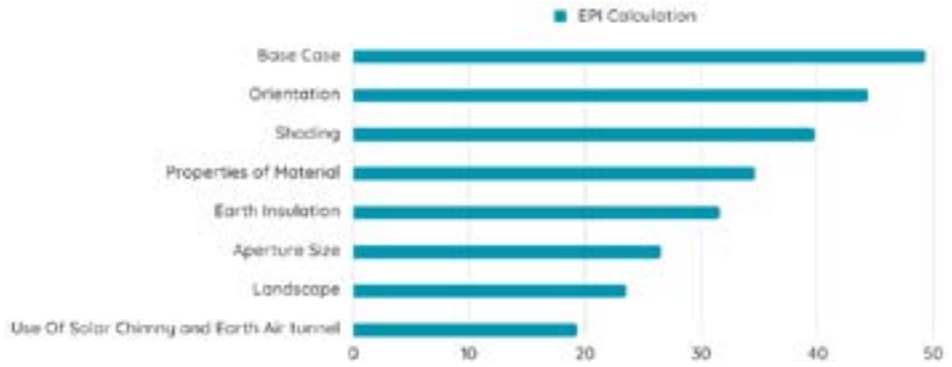


Fig 35 : Strategies

Base Case EPI: 49.31
Orientation- 4.9
Shading- 4.6
Properties of Material- 5.2
(Lime plaster, rat trap, fly ash bricks)
Earth Insulation-3
Aperture Size- 5.1
Landscape-3
Use of solar chimney & Earth air tunnel- 4.02

Proposed design EPI 19.46 KWh/Sq.m & Base case EPI 49.31 KWh/Sq.m

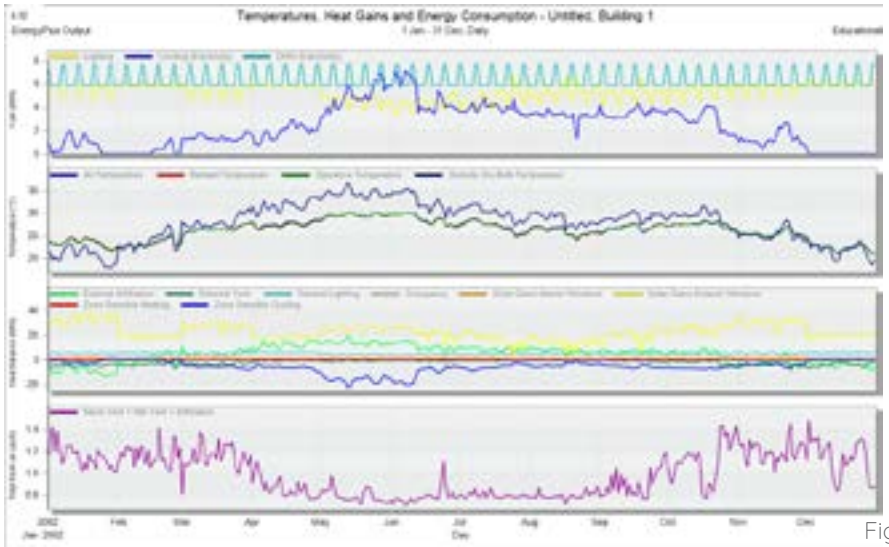


Fig 36 : Design Builder module

	Total Energy [kWh]	Energy Per Total Building Area [kWh/m2]	Energy Per Conditioned Building Area [kWh/m2]
Total Site Energy	3907.00	19.49	
Net Site Energy	3907.00	19.49	
Total Source Energy	13256.86	66.14	
Net Source Energy	13256.86	66.14	

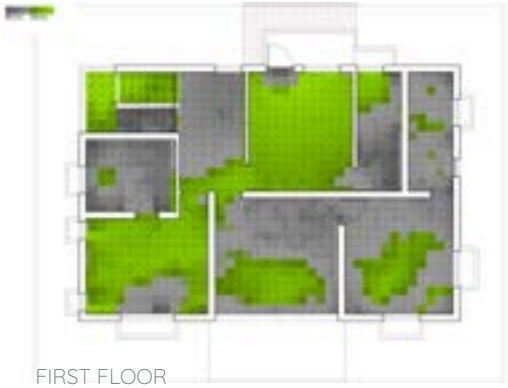
Table 5 : EPI

EPI achieved through Design builder simulation is 19.49 KWh/Sq.m

10.7 DAYLIGHTING OPTIMISATION

1. Useful Daylight Illuminance

GROUND FLOOR



FIRST FLOOR

Fig 37 : Simulation of UDI

Averages = UDI-a (100 - 2000 lux): 86.26%
UDI-s (<100 lux): 10.59%
UDI-e (>2000 lux): 3.15%`

Period: 1/Jan/2023 - 31/Dec/2023
Occupancy: 8:00 AM - 6:00 PM
We achived 86.26% of UDI were minimum requirement is 50%

2. Spatial Daylight Autonomy

GROUND FLOOR

FIRST FLOOR

Fig 38 : Simulation of SDA

Overall Score = 57.88%
Period: 1/Jun/2023 - 31/Dec/2023
Occupancy: 8:00 AM - 6:00 PM

Percentage of analysis points ≥ 300 lux for ≥ 50% of the hours.
Occupancy: 8:00 AM - 6:00 PM
We achived 57.88% of SDA were minimum requirement is 50%

3. Annual Sunlight Exposure

GROUND FLOOR

FIRST FLOOR

Fig 39 : Simulation of ASE

Overall Score = 3.38%
Period: 1/Dec/2022 - 31/Dec/2023
Occupancy: 8:00 AM - 6:00 PM
Time Threshold: 250 hours

Percentage of analysis points ≥ 1,000 lux for ≥ 250 hours per year.
We achived 3.38% of ASE were it prefer to be less then 3% (we are reducing it using finance)

10.8 ARTIFICAL LIGHT OPTIMIZATION

- Interior Lighting

Room	No. of Rooms	Lighting Equitments	Quantity per Room	Wattage per equipment	Energy Consumed
Living Room	1	LED Batten (Tubelight)	2	20	40
Bedroom normal	3	LED Batten (Tubelight)	1	20	60
	3	LED Lamp	1	10	30
	3	Night Lamp	1	0.5	1.5
South Side Bedroom	1	LED Batten (Tubelight)	1	20	20
	1	LED Lamp	1	10	10
	1	Night Lamp	1	0.5	0.5
Dressing room	4	LED Lamp	1	10	40
Toilet	6	LED Lamp	1	10	60
Kitchen	1	LED Lamp	2	10	20
Dinning Room	1	LED Lamp	1	10	10
Store	2	LED Lamp	1	10	20
Staircase	2	LED Lamp	1	10	20
Balcony	1	LED LAmp	1	10	10
Family Area	1	LED Lamp	1	10	10
Open Area	2	LED Lamp	1	10	20
Toilet open area-1	1	LED Lamp	1	5	5
Toilet open area-2	1	LED Lamp	1	5	5
Circulation	2	LED Lamp	1	10	20
Pooja	1	LED Lamp	1	5	5
Total Wattage					407
Gross Area					213
LPD					**1.9**

- E x t e r i o r i o r

Gate	1	Outside Lights	2	3	3
	1	Name Plate Light	1	5	5
Parking Area	1	LED Batten (Tubelight)	1	5	5
	1	Night Lamp	1	0.5	0.5
Garden	1	Outside Lights	6	5	30
Total Wattage					43.5
Gross Area					84
LPD					**0.5**

Table 6 : LPD Calculation

Light power density
Interior= =1.9 W/m²
Exterior=0.5 W/m²
Complies with IGBC Green Affordable Housing (Efficient Lighting

Equipment Optimization

Appliances selected are **5- star BEE rated in order reduce energy consumption**.Energy savings has been achieved by using the most energy efficient appliances and a comparison
to NBC base line has also been done.

10.9 Renewable Energy

1. Solar Energy

Size of solar panel = 1956x992 mm
(Tata solar power TP 72 series)
Area of a panel - 1.9 m^2

Efficiency of a panel - 19.6 %
1000x 19.6%x1.9=0.36Kw/panel

At 22° N, Anand experiences around 6-8 hrs of sunshine per day throughout the year.
This panel will produce 361x7=2.5 kwh/day.
Anand has approx. 280-320 sunny days/yr.

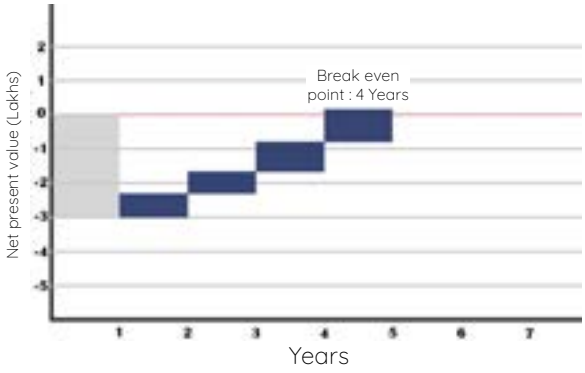


Fig 40 : Pay back period of Solar Panel

So, we need to install plant of 6KW(As per solarrooftop.gov.in)
Total Electricity generation from solar plant : 7hrs x 300days x 6kw = 12,600 Kwh
Toatal generation of electricity for Life-Time (25 Years) = 3,15,000 Kwh

Total Energy Consumption

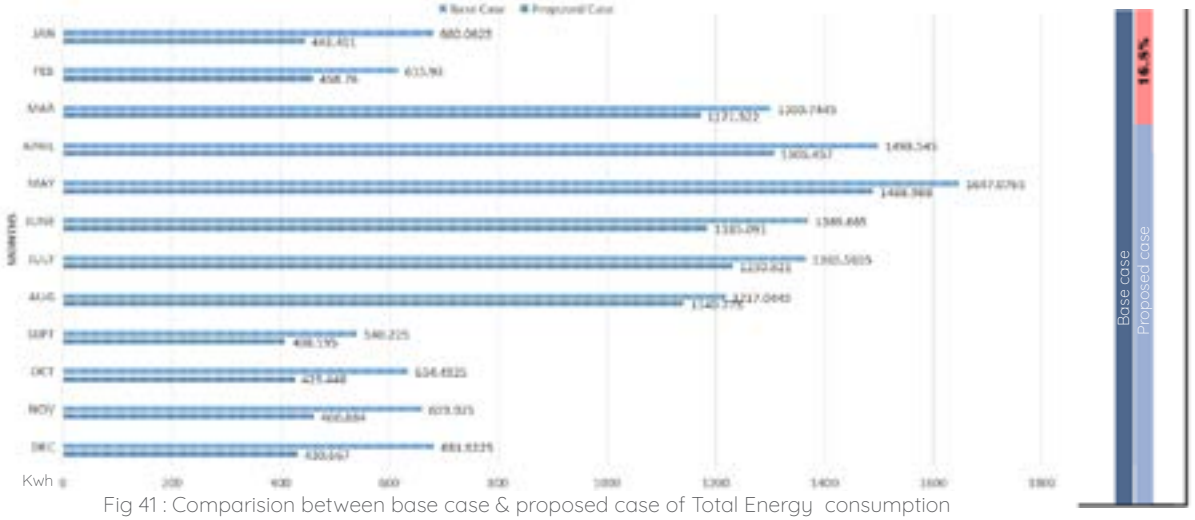


Fig 41 : Comparision between base case & proposed case of Total Energy consumption

Through various strategies related to thermal comfort every year we save 16.8% of energy consumption.

2 Energy through superior Plumbing

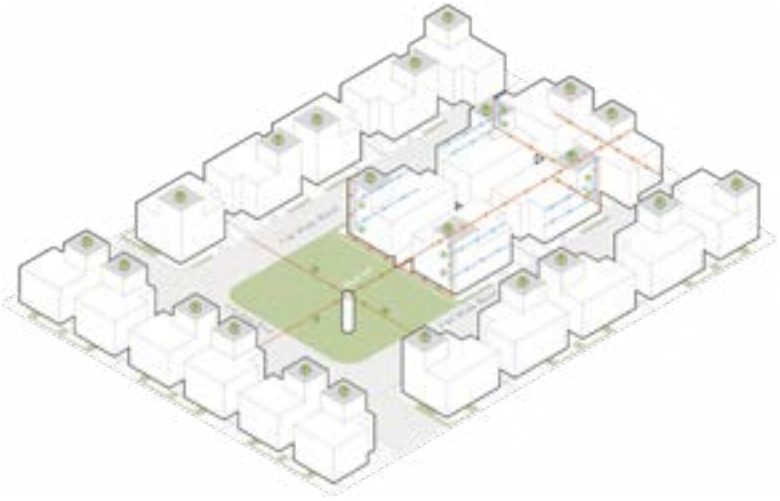


Fig 42 : Energy produced through superior Plumbing

The energy produced will be used to power street lights.

The energy needed to pump water through a society's plumbing can be captured and put to good use by replacing ordinary pipes with a network of pipes that contain turbines that produce power. Moving water is essential, similar to conventional hydroelectric power, however this use does not use turbines.


Credits : Lucide pipes
In the LucidPipe, water flows through, spinning hydrodynamic turbines to generate electricity.

10.10 WATER PERFORMANCE

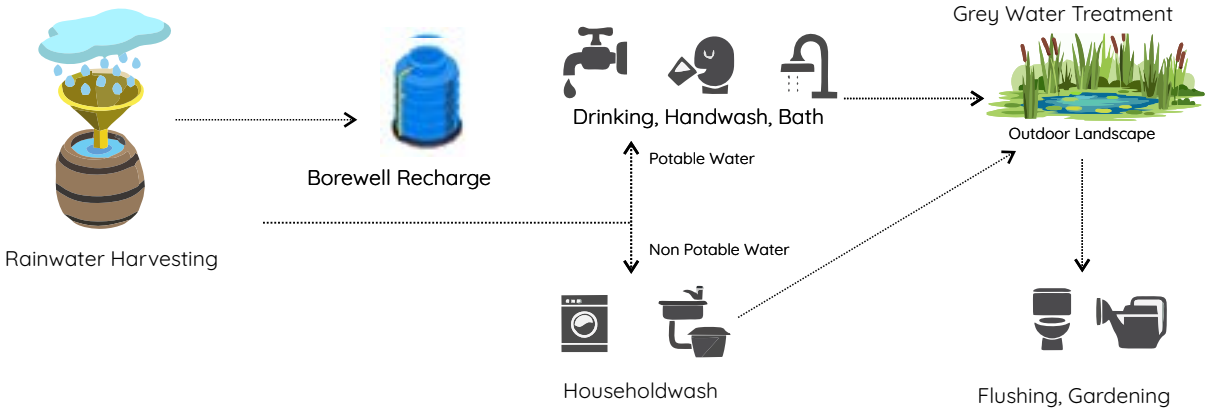
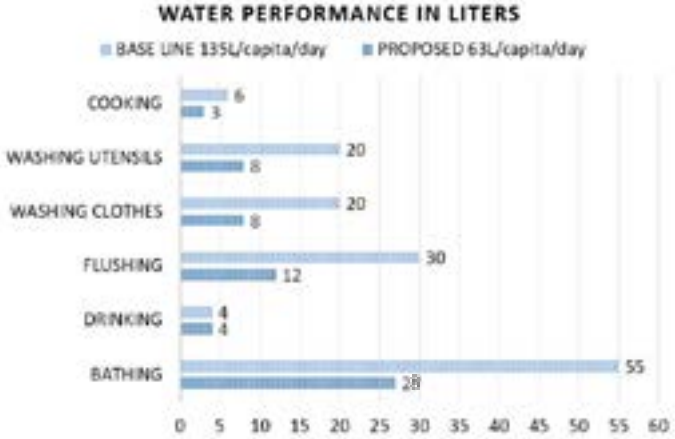


Fig 43: Water cycle

First step to minimize water wastage is to use water efficiently by using water efficient fixtures.



(SOURCE : IMD)

Fig 44 : Water efficiencient fixtures

By using such efficient fixtures we can save upto 72L per capita per day from baseline standards.

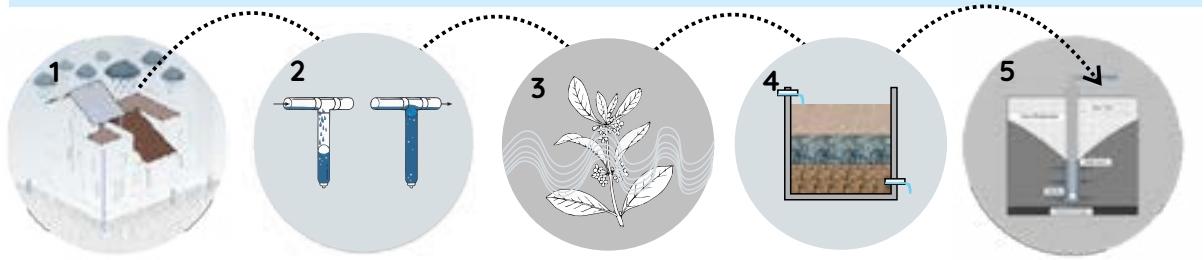
Dual Flush Systems	Duration (Flush/Minutes)	Daily Use	FTE Occupancy	Baseline		Design	
				Flow rate	Daily Use	Flow rate	Daily Use
Water Closets (Full Flush)	1	1	6	6	36	4	24
Water Closets (Half Flush)	1	4	6	3	72	2	48
Showerhead	8	1	6	10	480	5	240
Kitchen Faucets	0.25	4	3	8	24	2.5	7.5
Faucets/ Taps	0.25	4	6	8	48	2.5	15
Health Faucets	0.25	1	6	6	9	3.8	5.7
Daily Volume Generated from Flush Fixtures (Black Water)					108		72
Daily Volume Generated from Flow Fixtures (Grey Water)					561		268.2
Annual Working Days							365

Description	Baseline (Liters)	Design (Liters)
Annual Volume from Flush Fixtures (Black Water)	39420	26280
Annual Volume from Flow Fixtures (Grey Water)	204765	97893
Annual Volume from Flow & Flush Fixtures (Black + Grey Water)	244185	124173
Percentage Saving	49%	

Table 7 : Rainwater calculation

1. We are saving upto 60% water having 2.5 LPM flowrate in faucets by low flow using aerators.
2. For water closets we are using dual flush systems for Large Volume Flush we are using 4 LPF while for small Volume Flush we are using 2 LPF which can save upto 33% water.

Second step is provide rainwater harvesting system to capture maximum run-off volumes from roof and non-roof areas.



Rooftop Collection | First Rain Seprator | Aromatic/ Medicinal Plants | Filteration | Borewell Recharge

Fig 45 : Rain water harvesting system

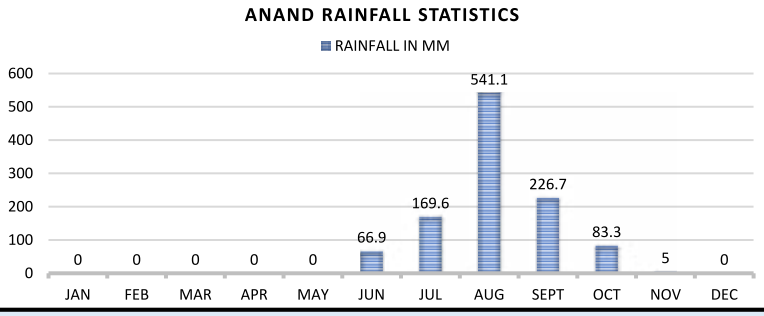
Catchment and then pipes/gutter direct to harvesting structure

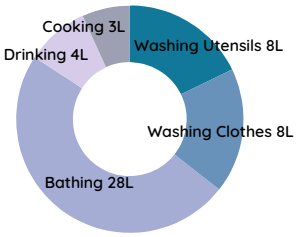
Separates first rain with impurities from RWHS

Rainwater will pass through aromatic plants which will add medicinal value

Prevents sediments, impurities to enter in harvested

Borewell will be recharged through rainwater





Rainwater Usage per Capita per day is 51L

Roof Surface Type	Run off Coefficient	Area (sq.m)	Impervious area (sq.m)
Cemented roof	0.95	60	57
Manglore Tiles	0.8	16	12.8
Hardscaping	0.8	38	30.4
Grass Pavers	0.4	23	9.2
Gardens/Farms	0.1	15	1.5
Total Impervious Area			110.9

Table 8 : Total impervious area

- Anand typically receives about 1099 millimeters of precipitation annually.

(src. Rainfall Statistics of India – 2019)

So , **Groundwater Recharge Potential Yearly,**

POTENTIAL = Rainfall In 12 Months X Total Impervious Area

= 1.099 x 110.9 m2

= 121.879 m3

No. Of days harvested water can be used = Potential/ daily usage

= 121879/51X6

= 121879/306

= 398 days

Hence, Our site could harvest rainwater for more number of days than required.

Our area has fairly Groundwater Level which is available for disposal and consumption. Hence invention of storage capacities is burden on costing.

Third step is to reduce consumption of potable water and waste water generation for flushing and gardening purposes.

- Daily grey water generation from low flow fixtures for 6 member family 268L.
- Daily grey water generation from low flow fixtures for 22 units 5896L.
- Annual grey water generation from low flow fixtures for 6 member family 97893L.
- Annual grey water generation from low flow fixtures for 22 units 2,153,646L.
- Weekly grey water generation from low flow fixtures for 6 member family 1876L.
- Weekly grey water generation from low flow fixtures for 22 units 41,272L.

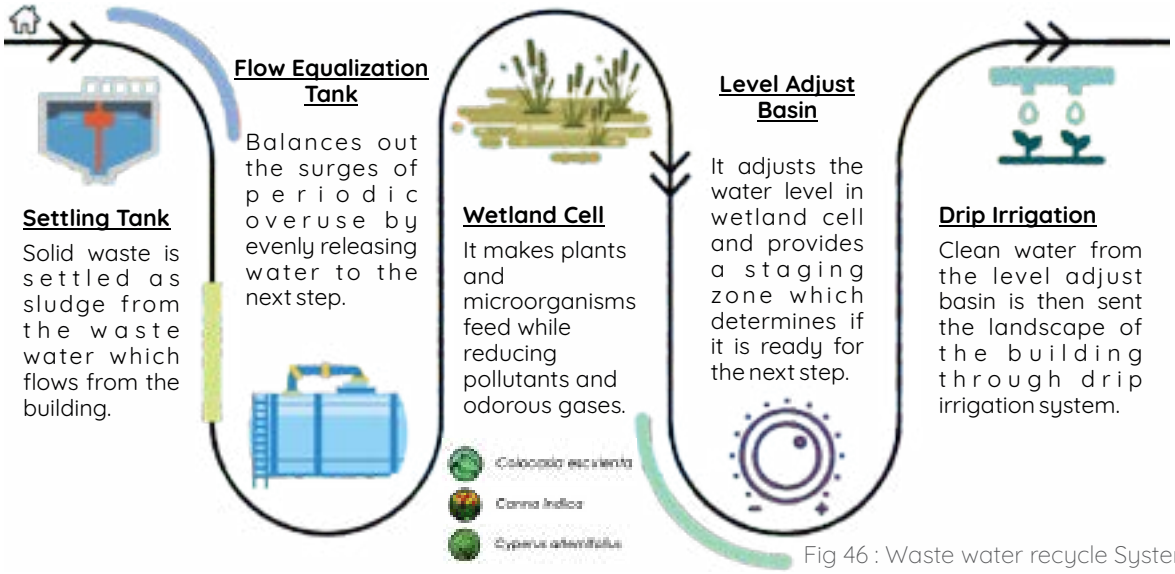


Fig 46 : Waste water recycle System

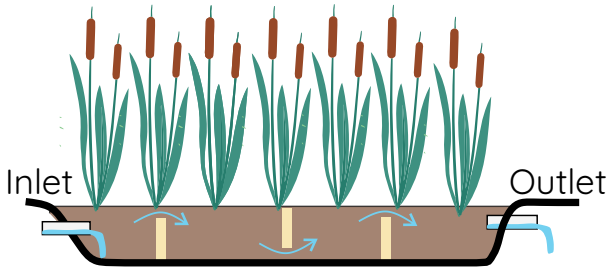


Fig 47 : Wetland cell

Wastewater enters this gravel-filled basin that is planted with wetland plant species and has a cement bottom, keeping the water in the container rather than seeping into the ground. To ensure maximum contact with the plant roots, the water is compelled to travel up and down through the system.

Daily water consumption of 6 member family is 378l

Fig 48 : Master plan

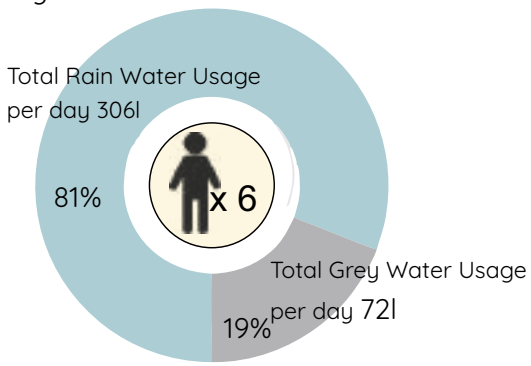


Fig 49 : Daily Water comsuption per unit

The remaining amount of treated greywater will be used for gardening .

10.11 EMBODIED CARBON - MATERIAL PERFORMANCE

All the materials which will be used in the buildings are :-
a) More affordable conventional materials
b) Locally available or within 500km radius & c)Having low embodied & U-values

Materials	U-Value (W/mK)	Embodied Energy (MJ/kg)	Market Price	Compressive Strength (N/mm sq)	Water Absorption (% of mat. weight)
WALLS					
Fire Brick	1.2(ECBC)	4.4	6 -8 RS	3.5	12-15%
Flyash Brick	0.8(ECBC)	0.5	4-6 RS	3.5	12.50%
AAC Blocks	0.18(ECBC)	3.7	17 RS	5	35-40%
kesarjan Bricks	NA	NA	12 RS	7.5	12-15%
ROOF					
Concrete	1.41(ECBC)	1.3	6000/cu.m.	15-30	1%
FINISHES					
Stone Dhaulpuri	3(ECBC)	0.44	40-45 Rs	112	12-15%
Green Glass	1.05(ECBC)	17	70/sq.ft.	3.9	NA
Lime Plaster	0.12	4.5	7.5/kg	NA	NAw
Cement Plaster	1.2(ECBC)	0.44	550/sq.m.	NA	
Manglore Tiles	0.6(ECBC)	7.5	40-45/piece		
ceramic Tles	1.5(ECBC)	8.2	35-60/sq.ft.		18-20%
kota stone	3(ECBC)	0.44	18-25/sq.ft.		
Bamboo	0.19(ECBC)	2.3	55-70/piece	13.9	

Not used(As a base case) Used in Design

Table 9 : Material Performance

Fig 50 : Material Availability

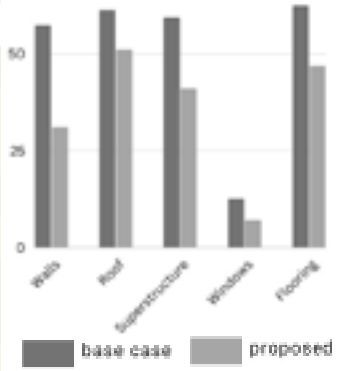


Fig 50 : Embodied carbon

Rat-Trap Bond - For better thermal performance & material saving.

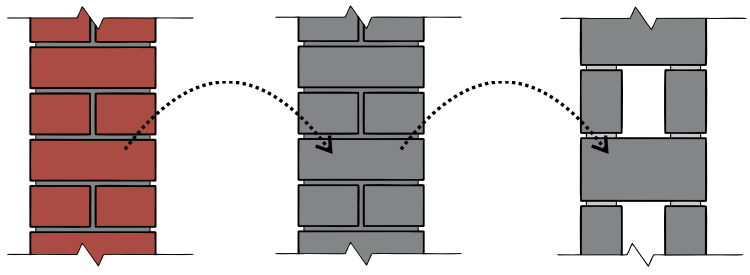


Fig 51 : Rat- Trap Bond Section

The main features are:
(a) Strength is equal to standard 230mm thick brick wall, but savings in consumption of materials. The overall saving on cost of materials used for construction compared to the traditional 9" wall is about 20% (b) the air medium created in between the brick layers helps in maintaining a good thermal comfort inside the building.

Sr. No.	Item	Conventional Wall (with 1:4 Cement : Sand Mortar)	Rat-trap Bond (with 1:4 Cement : Sand Mortar)	Savings
1.	Brick	389	280	28%
2.	Sand	0.34 m^3	0.20 m^3	37%
3.	**Cement**	**119.5 kg**	**75 kg**	**40%**

Table 10 : Material consumption in conventional Masonary wall & Rat-trap bond wall (For 1 cu m. of brickwork)

WINDOWS- As site lies in hot and dry climate, we are operating windows in following sequence:

SUMMER

Closed- 10 A.M. - 5 P.M. Open- 5 P.M. -10 A.M.

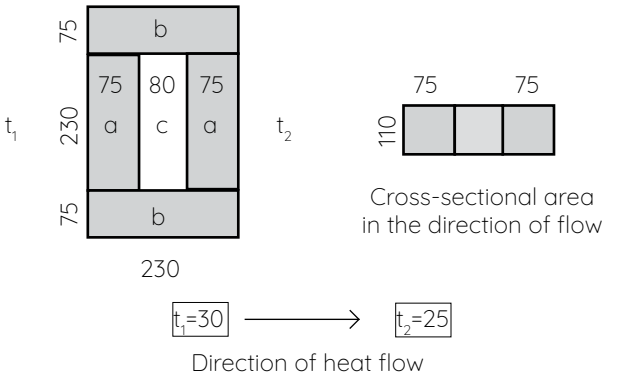
(a) windows are closed to reduce inflow of heat from outside into the rooms and those are kept open to facilitate circulation of air inside the room and dissipation of the accumulated internal heat.

WINTER

Open- 7 A.M. - 5 P.M. Closed- 5 P.M. - 7 A.M.

(b) windows are kept open to get maximum warmth from sunlight and kept closed to reduce loss of heat from inside of the room and protect the interior from rapid cooling.

WALLS- To coincide with the practice, we had constructed building with rat-trap bond, filler slab, earth insulation, etc. which are capable of reducing convection of heat through building envelop. Heat transferred through per square meter of 0.23 m thick rat-trap bond masonry walls in still air condition and for a temperature difference of 5° c.



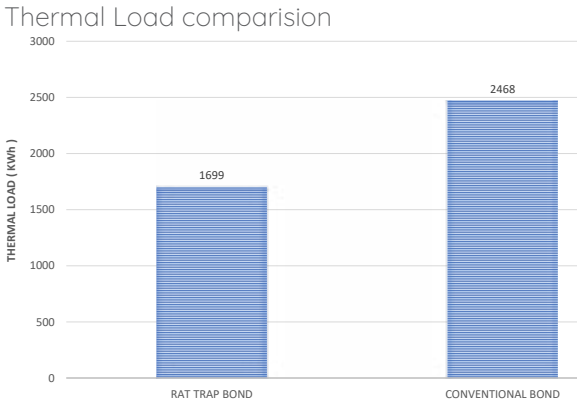


Fig 52 : Thermal Load comparision of Brick bond type

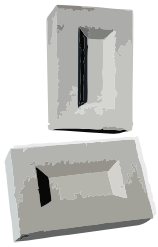
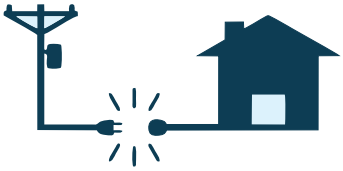
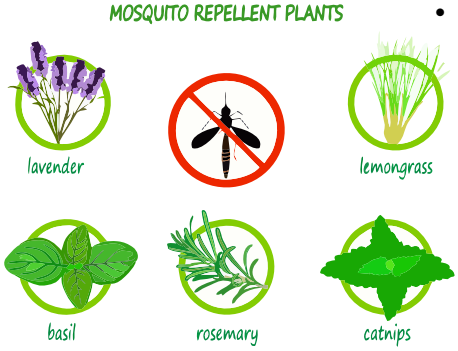
ROOF/ SLAB -

Embodied Energy for 226 sq.m. RCC slab vs Filler Slab						
Sr. No.	**Material**	**Embodied Energy (MJ)**	**CONVENTIONAL ROOF**		**FILLER SLAB ROOF**	
			Quantity consumed	**Total Embodied Energy (MJ)**	**Quantity consumed**	**Total Embodied Energy (MJ)**
1	**Concrete**		33.9		22.6	
	Cement (kg)	6.4	18794.16	120282.624	12529.44	80188.416
	Coarse Aggregate(m^3)	108	37588.32	4059538.56	25058.88	2706359.04
	Fine aggregate(m^3)	87.5	18794.16	1644489	12529.44	1096326
2	**Reinforcing Steel (kg)**	42	6575	276150	4383	184086
3	**Mangalore Tile**	7.5	0	0	867	6499.634
Total Embodied Energy(MJ)				6100460.184		4073459.090
Difference in Energy						2027001.094
Percentage of saving energy						33%

Table 11 : Comparision of Emboded enegy btv. RCC & Filler Slab

A decrease in concrete volume results in a 49% decrease in cement, sand, and crushed stonechip usage, as well as a 13% decrease in steel usage. Costing about 23% less than a conventional RCC slab. We utilise the top of the slab as the floor, much to how we don't use tiles for flooring. In addition, the house's doors and windows are constructed of refurbished wood. The embodied carbon for super structure will be same as walls as our structure is load bearing.

10.12 RESILIENCE

POTENTIAL RISKS ON SITE	SOLUTIONS
1.  Our site lies in zone 3 where there is a moderate risk of earthquakes.	• Our site lies in the moderate seismic zone, still the precautions had to be taken. Concrete frame structure have been given with beam size of 230mm width , 450mm height and the column size of 230mm by 450mm. Filling material is fly ash bricks which also have less dead load than conventional bricks  weight of flyash bricks: 2.6 kg weight of conventional bricks: 3.5 kg
2.  Site is prone to floods due to heavy rainfall in the monsoon months which leads to substantial risks of the following :- I) Power Failure for 3-5 days  ii) Lack of food Accessiblity 	• We will provide sufficient plinth level as per high flood level • We are using Luminous Eco Volt + 1650 Pure Sine Wave Inverter 1500va 24 Volt for battery backup in case of power cut. • By square foot farming we are growing variety of species in a limited space, this method requires 80% lesser space. We are also doing companion farming a practice of planting different species in close proximity so that they can offer benefits to one another. We will achieve this by doing terrace farming/ gardening on the roof of semi-private & private spaces
3.  Presence of high number of mosquitoes results high chances of diseases.	 Fig 53 : Mosquito Repellent plants • Various mosquito repellent plants are used in the landscaping of site and unit both which would not only repel mosquitoes but also attract pollinators.

S. No.	Equipment	Quantity	Watt	Total Watt	Hours	Days	Total Watt hour
1	Fan	3	35	105	12	3	3780
2	LED	6	20	120	5	3	1800
3	Plug	6	100	600	1	3	1800
			Grand Total	825		Grand Total	7380
			VA	1031.25		Round Total	10000

Table 12 : total watt hour consumption in case of calamities

Fig 59 : Square foot farming

Basil x Tomatoes
Cucumber x Sunflower
Lettuce x Garlic
Peas x Mint
Carrot x Onion

10.13 Engineering Design & Operations

1. Structure

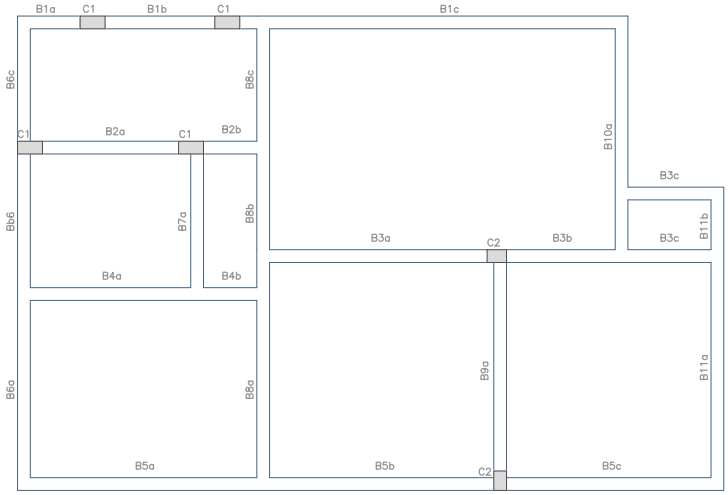


Fig 54 : Beam & column Layout

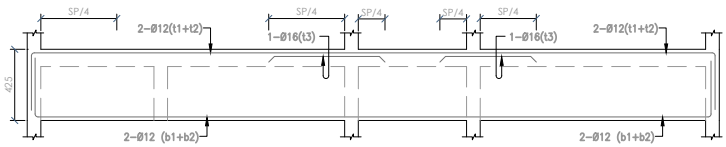
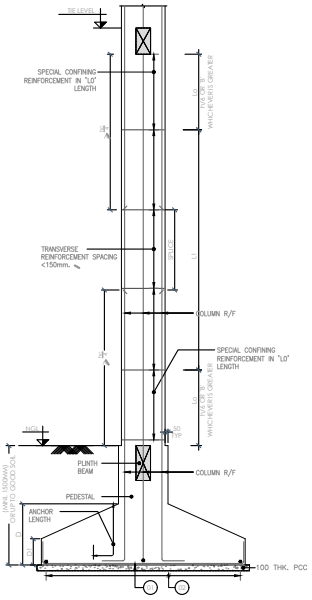


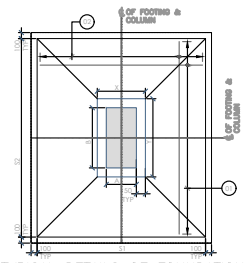
Fig 55 : Longitudinal section of Beam

	B1a			B2b			B3c		
DIA	8	8	8	8	8	8	8	8	8
LEGS	4	4	4	4	4	4	4	4	4
SPACING	150	200	150	150	150	150	150	200	150
DIST	1280	REST	1280	450	REST	450	950	REST	950

B1 (230X425)
(SCALE–1:60)



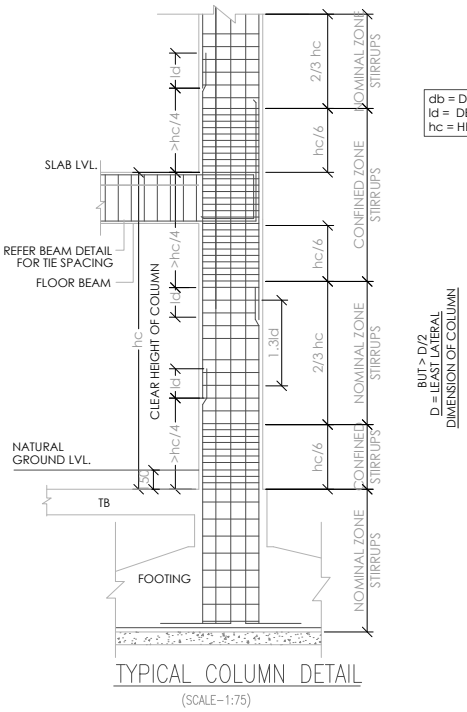
Cross Section



Detailed Plan

Fig 56 : Foundation detail

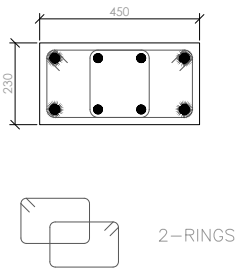
This design approach utilizes load-bearing in the most effective way possible and serves several purposes, including supporting weight, dividing the area, and insulating the structure thermally and acoustically. The walls considerable weight aids in keeping the building intact and secure against external elements like wind and earthquakes for low-rise structures.



TYPICAL COLUMN DETAIL
(SCALE–1:75)

Fig 57 : Typical column detail

SCHEDULE OF COLUMNS
(FOR ORIENTATION OF COLUMNS REFER LAYOUT)

MAIN STEEL	• Ø12–8NOS.
TIES	Ø8–250 C/C
FROM LEVEL	PEDESTAL
TO LEVEL	FIRST FLOOR SLAB
SECTION	
COLUMN Nos.	C1

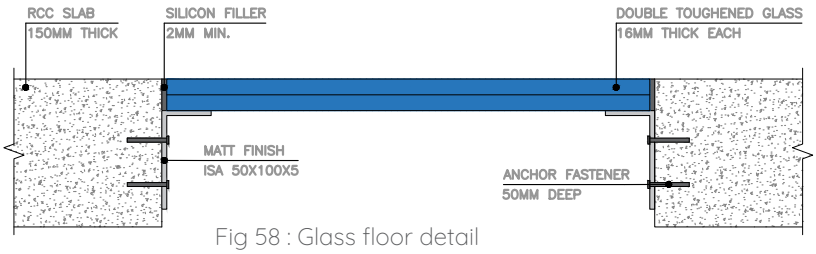


Fig 58 : Glass floor detail

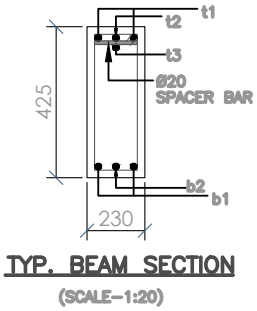


Fig 59 : Beam cross section

The Structural Design has been done in compliance with the soil condition and the Earthquake loads of Anand, using STAAD.Pro software. The Design is an IS-456 Code complaint and has been done for M-25 Grade of concrete and Fe-500 Reinforcement Bars. The design employs 2 types of structure, load bearing walls & R.c.c. columns for the staircase & water tank.

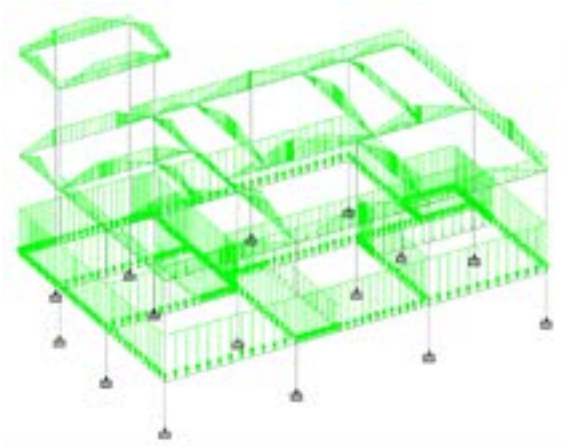


Fig 60 : Load Analysis

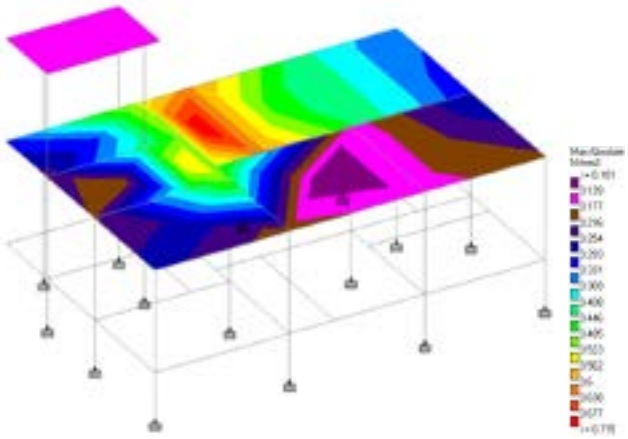


Fig 61 : Stress Analysis of slab

Filler slab Details -

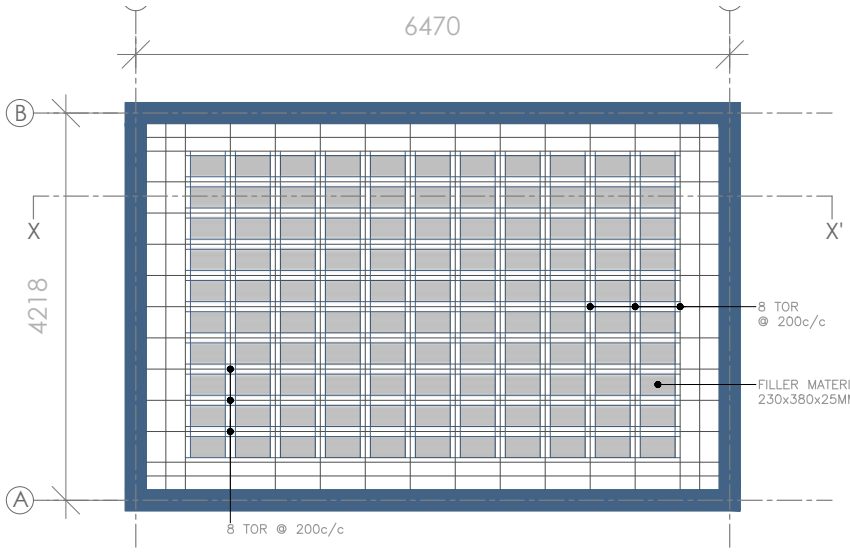


Fig 62 : Detail Plan of Filler slab of Living room

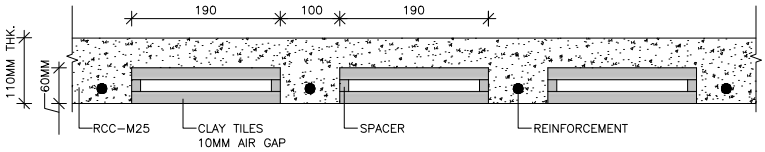


Fig 64 : Detail section

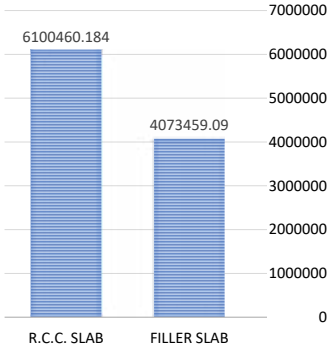


Fig 63 : Comparision Analysis

Consumes less concrete and steel due to the reduced weight of the slab achieved by replacing concrete with light weight filler.

Filler slab reduces heat flow through roof in the building due to heat resistant qualities of the filler materials and the gap between two burnt clay tiles. The inner temp. of room drops by 5° C then compared to coventional R.C.C. slab

2. Smart Electrical Solution

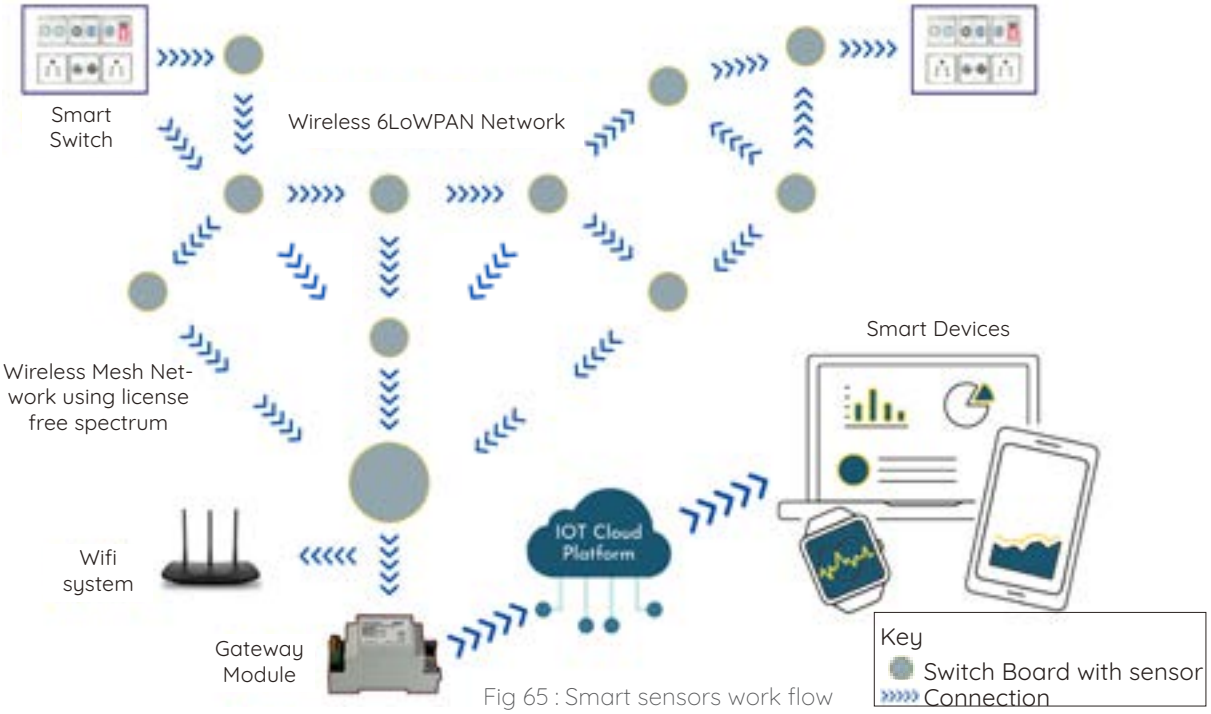


Fig 65 : Smart sensors work flow

Sensors will be installed in each area to help with understanding how the building systems operate on a daily basis and to raise awareness. a programme that keeps track of the user's buildings and has different modes like :- Air quality, lux Meter, etc as follows

1) MQ135 & PM2.5 Sensor Module measures CO_2, HCHO, PM2.5, PM10

2) PIR Motion Sensor Detector manages Lux Control through changing aperture size of openings

3) DHT22 Sensor Module measures Heat Stress Value Sensor (Humidity, Air Temperature, MRT (Mean Radiant Temperature), Air Speed)

4)MH-Z19E NDIR sensor for Indoor Air Quality monitoring, Earth Air tunnel & Air conditioner

5) Sensor for water meter, Electrical consumption & will recommend the best saving techniques

Fig 66 : Software Page

The building will operate as living organisms while keeping the central idea of health and wellbeing in mind. Through sensors, data will be produced, and necessary actions will be conducted or users will carry out suggested actions in accordance with their needs. The electrical system can be controlled manually or with the help of smart devices like smartphones, smart watches, google assistant, and applications from Amazon and Alexa. We could consume energy in this manner, and the best possible living conditions would result.

Fig 67 : Facilities provided to building

3. Earth Air Tunnel & Solar Chimney

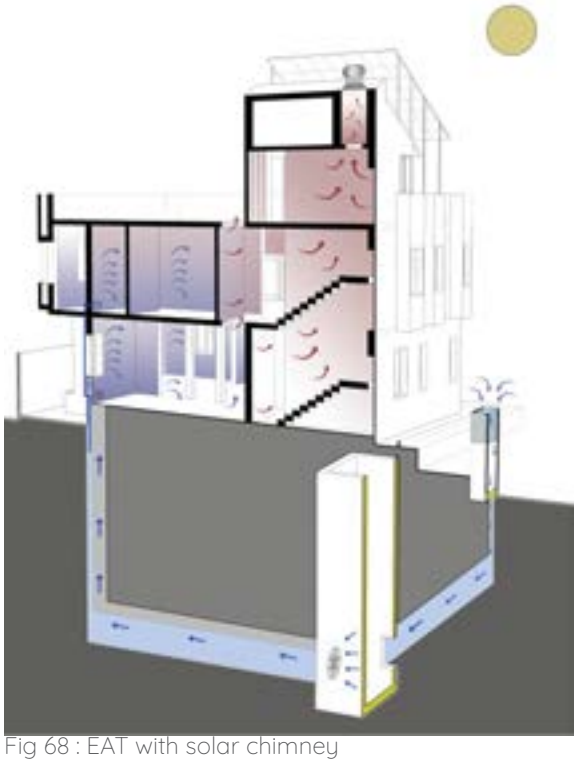


Fig 68 : EAT with solar chimney

A solar chimney is a passive ventilation sy-sytem that uses natural convection to circu-late air and creates an upward draft of air by heating a vertical shaft with the sun's energy.

The Earth air tunnel method is a comple-mentary technique used with the solar chimney to make it more efficient. An un-derground pipe (1.2-2.0m below ground level) to bring cool air from the earth into the base of the solar chimney , where it is heated and rises up through the chimney.

Cool air enters the space through intake vents on the ground and is naturally cooled by the earth. The air is heated in the solar chimney and rises up through the chimney by natural convection, creating ventilation.

This combination is an efficient way to ven-tilate buildings in hot and humid climates.

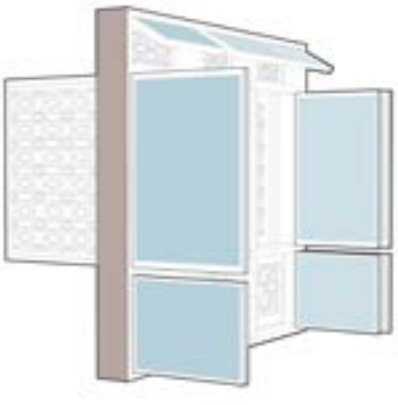
4 Shading Optimization through Sensors

Sensors detect air quality & thermal conditions to determine whether an opening should be closed/partially opened/fully opened according to matrix.These rules can be pro-grammed into the system & adjusted as needed to optimize energy efficiency & comfort.

Open- 5 P.M. -10 A.M.

Closed- 10 A.M. - 5 P.M.

Closed- 5 P.M. - 7 A.M.



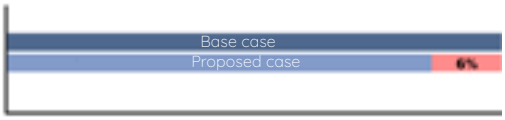
Open- 7 A.M. - 5 P.M.

Fig 69 : Operational Matrix fo windows for proposed system

10.14 AFFORDABILITY

One of the primary challenges with sustainable development & construction is the cost of construction for developing nations. It can be challenging to decide how to achieve sustainable construction using cost-effective & efficient methods, but it can be effective in the long run.

The average selling price in this area is 44,200/ m^2 and our proposed design is 46,800/m^2 which is 6% higher than the average cost.



Use of Local Materials

Materials used for construction are locally available like fly ash bricks, Lime, refurbished doors and windows, manglore tiles, bamboo

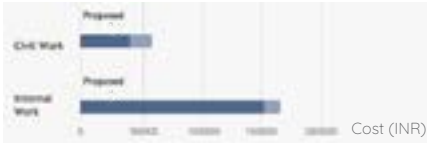


Fig 32 : Civil work cost Analysis

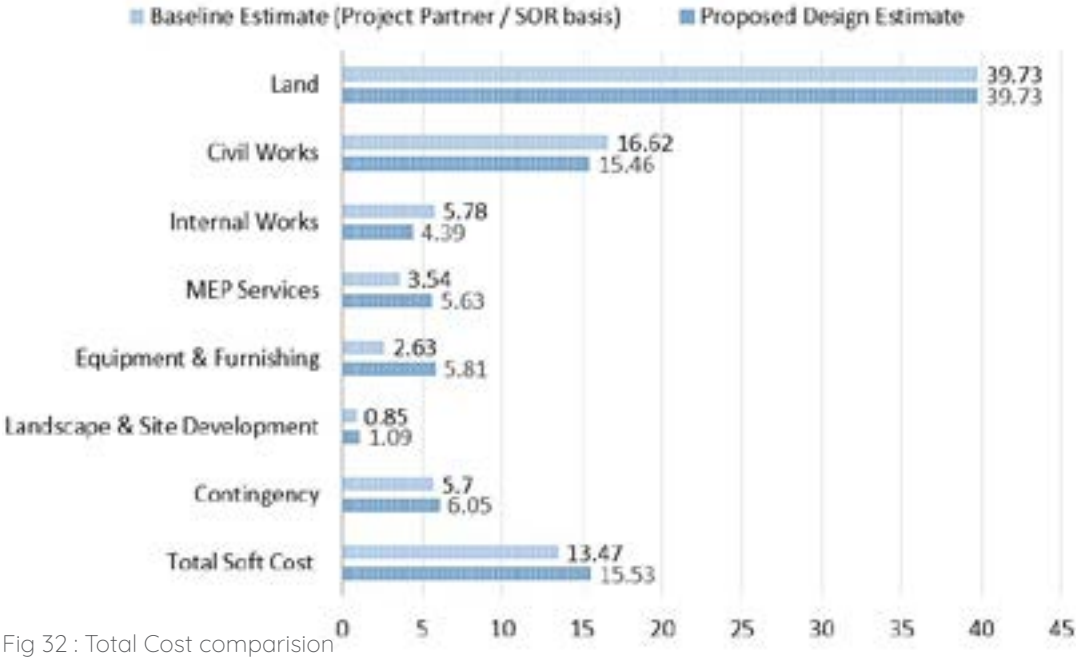


Fig 32 : Total Cost comparision

Reduction in Labour Cost

Instead of carrying out floor bedding and tiling, we are using slab for the flooring, leaving the ceiling exposed and not using paint and plaster on it, and using exposed brickwork for the exterior. eliminating false ceiling costs while keeping the ceiling aesthetically pleasing. Additionally, the workers are going to come from the vicinity. Therefore, this will result in cost savings.

Reduction in Energy

Buildings that use less energy have lower financial risks since they are more cost-effective to operate, which promotes stakeholder confidence.

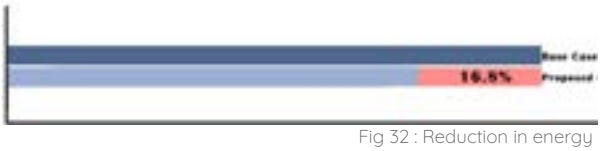


Fig 32 : Reduction in energy

Reduction in Operational Cost

The return on investment - Any additional passive design strategies used in building namely EAT & solar chimney based thermal & air control system can be paid of in approximately 7yrs. by reducing electrical loadConsidering the fact that the project's proposed cost is higher than the baseline cost, the project's overall operational cost is considerably lower.

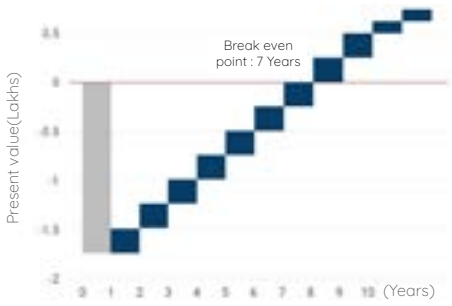


Fig 33 : Payback period for proposed case

10.15 INNOVATION

1. Earth Air Tunnel - Solar Chimney

Fig 74 : Earth air tunnel

Purpose :- Earth air tunnel is a pre-cooling which consists of network of pipes buried at reasonable depth below the ground. It cools the air by rejecting heat to the ground. A solar chimney is a vertical shaft that uses sun energy to improve natural stack ventilation in a structure.

Outcome:- EAT matches the internal temperature with the ground temperature There is a temperature difference of 8 to 10 degrees between surface and the ground but it is largely dependent on soil type, location.

2. Filler Slab

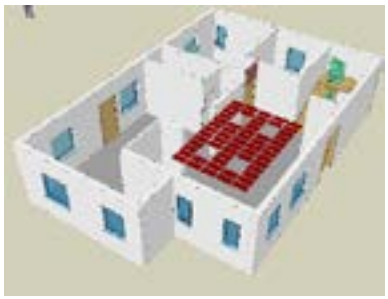
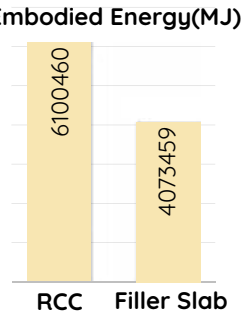


Fig 75 : Filler Slab

Purpose :- R.C.C slab consumes more amount of materials , But a filler slab usually consumes less amount of building materials as the voids in reinforcement are filled with manglore tiles.

Outcome:- As compared to conventional slab we can save upto 33% of embodied energy consumed in the material for 226 sq m total RCC slab construction.



3. Earth Insulation

Fig 76 : Earth Isulation

Purpose :- Earth Insulation essentially uses the earth around the home as your insulation, helping to provide ambient and constant temperatures in the building. The method involves piling earth around the external walls of the building so that the earth provides protection.

Outcome:- This technique has significantly reduce the overall EPI , we have tried to use earth insulation on both the floors

4. Rat-Trap Bond

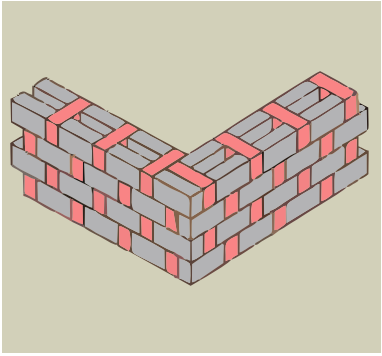
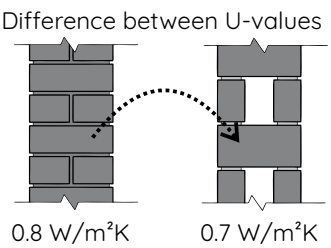


Fig 77 : Rat- trap bond

Purpose :- The Rat-Trap bond , is a double-wall technology that dramatically **lowers building costs, decreases material and mortar consumption**, and **aids in increased thermal efficiency** without compromising wall strength.

Outcome:-
By introducing Rat-Trap bond U-Value of the wall is significantly reduced by 55%, hence we will get more thermal efficiency.



10.16 HEALTH AND WELLBEING

Thermal Comfort Model

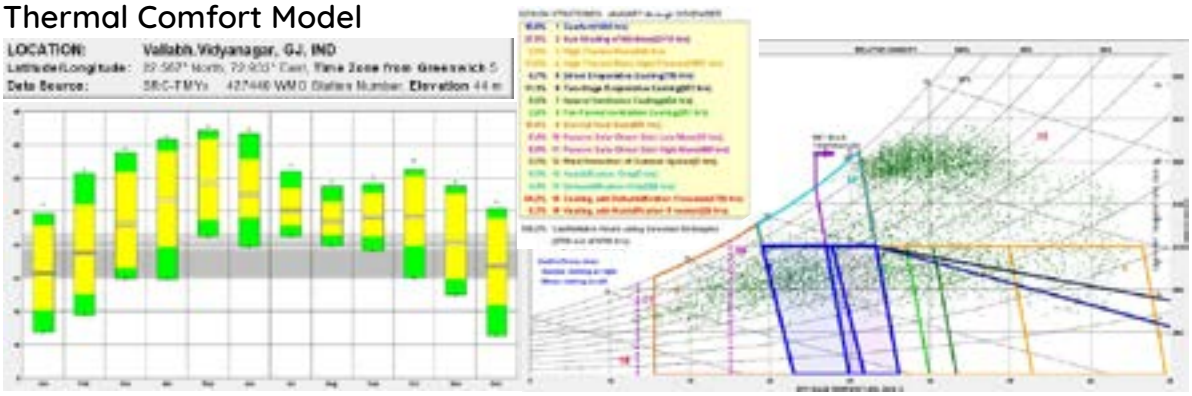


Fig 78 : Thermal Comfort Model

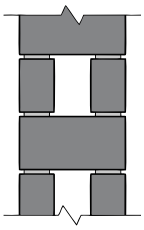
Strategies to achieve Thermal Comfort

We can achieve thermal comfort by controlling the following five factors:-

1. Radiant Temperature

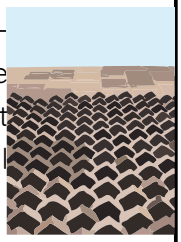
a) Building Envelope

U-value of Fly ash brick along with the rat trap bond is 0.7 W/m²K which is quite lesser than the normal conventional bricks.



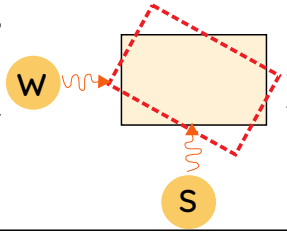
b) Microshading through wall texture

Bricks are arranged in a criss-cross pattern that will reduce the impact of direct sunlight result into better thermal comfort.



c) Orientation

Building is tilted 33° NW which avoids perpendicular radiations of sun on the surfaces.



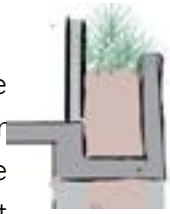
d) Shading Devices

Building also get better shading through box chajjas, trees, fenestration solar panels in maximum number of hours.

2. Air Temperature

a) Earth Insulation

Earth Insulation will keep the indoor air temperature cooler than the outside temperature blocks the conductive heat gain.



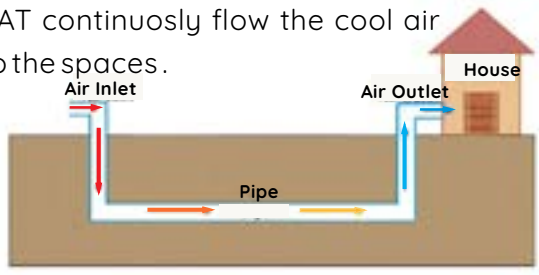
b) Sensor based openings

Sensor based openings take live feedback about air quality and thermal conditions to operate accordingly.

3. Air Movement and speed

a) Earth Air Tunnel

EAT continuosly flow the cool air to the spaces.



b) Solar Chimney

Solar Chimney sucks out warm stagnant air through stack ventilation allow fresh air to draw in

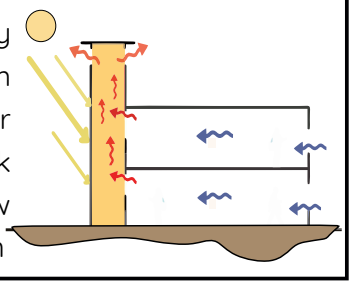
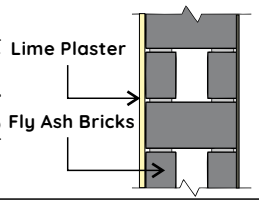


Fig 79 : Strategies to achieve Thermal comfort

4. Humidity

a) Lime Plaster

Lime plaster is good at absorbing moisture. And also produce O2 for good health



b) Dehumidifier Plants

Indoor plants like English Ivy, Bamboo Palm etc are use. They will act as natural dehumidifiers.

Bamboo Palm

5 Metabolic Heat

a) Ergonomic Design

Ergonomics can be summed up simply as making people more comfortable so they will release less metabolic heat.

acc.to human anthropometry

2H+G=640mm

Proposed design has:-

2(166)+298=630

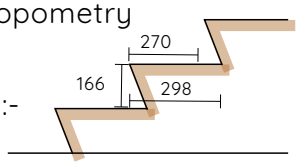


Fig 80 : Strategies to achieve Thermal Comfort

AYURVEDA

Air/Vayu | Ether/Akash | Fire/Agni | Earth/Prithvi | Water/Jal

Fig 81 : Elements of Ayurveda

1. Air/Vayu

- Air becomes contaminated by Co_2 & O_2 content decreases due to metabolic processes. In a mixed gathering the per capita output of Co_2 is taken as 0.6 c. ft. per hour.
- Volatile organic compounds (VOCs) such as formaldehydes, benzen etc. are the most common contaminants that are often present in enclosed spaces.
- Health Aspects: Chronic bronchitis, lung cancer, bronchial asthma, emphysema and respiratory allergies.

(src. SWASTHAVRITTA(Book) by Dr. Bargale Sushant Sukumar)

a. Fresh Air Ventilation

In all regularly occupied spaces of each dwelling unit, openable windows or doors and ventilators to the exteriors must be provided as shown in the table below.

(src. IGBC Green Affordable Housing)

Space Type	Net Openable Area (IGBC Baseline)	Net Openable Area (Proposed)
Living Spaces	10%	20%
Kitchen	8%	25%
Bathrooms	4%	10%

It increases the quality of life and health.

c. Indoor Plants

Use of indoor plants to enhance indoor air quality, thereby improving the health and wellbeing of occupants. The requirement is to have atleast one plant in every 100 sq.ft .

(src. IGBC Green Interiors)

b . Cross Ventilation

Provide openable doors / windows ventilators to the exteriors in all regularly occupied spaces in atleast two of the orientations.

70% of regularly occupied spaces complies with the above statement, It Enables good circulation of fresh air and provide a better indoor environment.

(src. IGBC Green Affordable Housing)

Lady Palm | Peace Lily | Gerbera Daisy

Resistant to pathogens. | Removes formaldehydes | Absorbs Co_2, Benzene

Fig 82 : Indoor plants

An experiment is done by our team to minimize Co2 level from the confined space through planters (Areca palm).

Time Duration		No. of Occupants	No. of times door opens	Readings	
9:15 AM-12 PM	Day 1	2	0		without plants
12 PM-1 PM	Day 1	3	1		
1 PM- 3 PM	Day 1	Empty	1		
3 PM- 5 PM	Day 1	3	2	**1251 ppm CO2 level**	
5 PM-6:30 PM	Day 1	3	2		with plants
6:30 PM-12 AM	Day 1	Empty	1		
12 AM- 8:40 AM	Day 2	Empty	0		
8:40 PM- 10 AM	Day 2	2	1	**712 ppm CO2 level**	

Hence through we got to know about the change in Co2 level through the planters(No. of times door opened and its duration might also affect the reading.)

2. Water/Jala

a)Rainwater Harvesting

Rain water is having taste is like Amruta (nectar), relieves fatigue, exhaustion, thirst, toxicity, fainting, sleepiness, burning sensation, conquers the abnormal Vata and Kapha and suitable for health.

b)Purification of Water (Jal Shodhana)

Sand or stone filteration are used to purify contaminated water. Rainwater will pass through flowers such as Utapala, Patala etc into water which removes bad smell and also through the aromatic plants which will increase its medicinal value.

Utpala Patala

(src. SWASTHAVRITTA(Book) by Dr. Bargale)

Fig 83 : Water purifying plants

3. Fire/Agni

Fire represents light, heat, energy, metabolism, and the power of transformation.

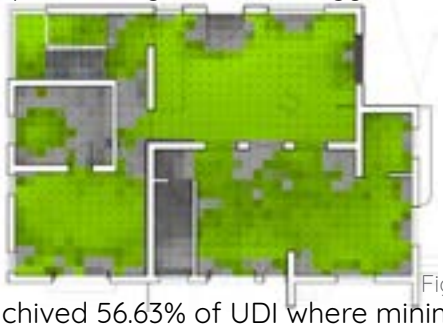


Fig84:UDI

We achived 56.63% of UDI where minimum requirement is 40% considering threshold 90%

Biological effects of light: The observation that daylight could cause the in vitro degradation of bilirubin. Other biologic effects of light include effect on and the stimulation of melanin synthesis, the activation of precursors of vitamin D, adrenocortical secretion.

(src. SWASTHAVRITTA(Book) by Dr. Bargale)

4. Earth/Prithvi

a. Aeromatic herbs and medicinal plants

Plants with medicinal benifits like amla, Aloe vera, grass lemon, Dhavana, Ashwagandha Coleus, Mints are grown.

Fig 85 : Aeromatic herbs

Fig 86 : Ground Floor Plan

Fig 87 : First floor plan

Gathering spaces

Aeromatic Plants

N

5. Space/Aakash

a. Gathering spaces

Design has well-being facilities of appropriate size covering about 15% of total builtup area as gathering space and common seating spaces. This would enhance social connectivity and promote health & wellbeing of occupants

(src. IGBC Green Affordable Housing)

b. Overcrowding

Overcrowding is a health problem in human dwellings. It may promote the spread of respiratory infections such as tuberculosis, influenza and diphtheria. The accepted standards with respect to overcrowding are as below 110 sq. ft.-2 persons

(src. SWASTHAVRITTA(Book) by Dr. Bargale)

The 5 elements and their associated organs and Chakras

These 5 elements originate from “Pancha Tanmatra” :-sound (shabda), touch (sparsha), vision (roopa), taste (rasa), and smell (gandha).

Fire is manifested as sight. Fire fuels enzyme functions, intelligence, digestive system and the metabolism.

Earth element is manifested as smell. The earth element is found in the bones, nails, teeth, muscles.

Ether/Space element manifests as sound. Relates to mouth, nostrils ,thorax, respiratory tract.

Air elementis manifested as touch. Is connected to the muscles, lung action andintestines, movement.

Water element is manifested as taste. Water governs plasma, the blood, saliva, digestive juices and mucous membranes.

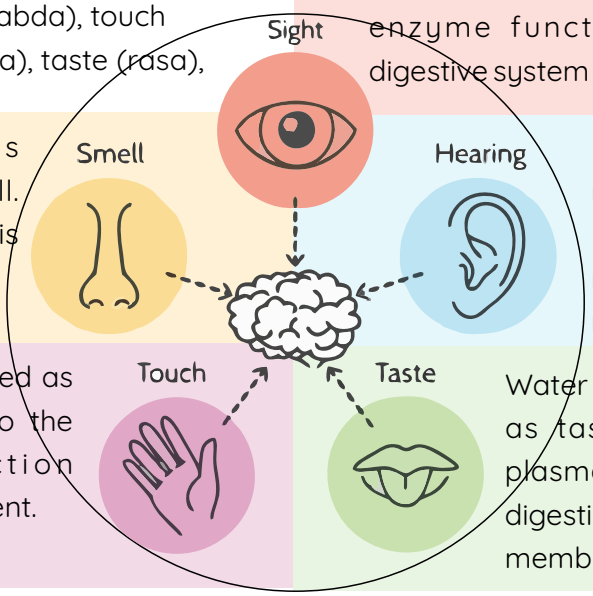


Fig 88 : 5 Senses

10.17 VALUE PROPOSITION

The five elements (Earth, Fire, Light, Wind, and Water), traditional techniques, net zero energy buildings, fresh air, and designing buildings like a body—so that it senses what is needed and then takes the necessary step—are all used to support our focus on health, happiness, and well-being.

Better space quality is the consequence, and being a part of a particular area can be therapeutic as well as green and net zero.

Sensor-based systems provide physio-psychological comfort by maintaining the human's senses at the highest levels.

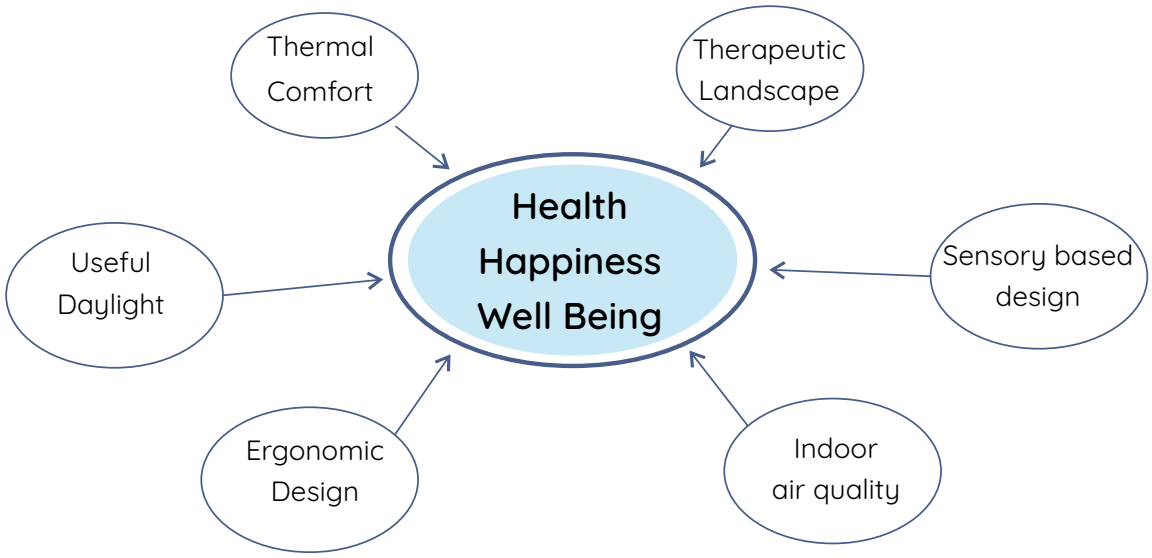


Fig 32 : Value Proposition

We have developed methods like the Earth Air Tunnel, the Solar Chimney, the Earth Insulation Method, and the use of lime as a plaster that exhales CO2 and inhales O2 to offer all of these. The house has been furnished with plants, and the landscaping has been well done on the edges. The link between the ground and the sky has been thoughtfully created. On the ground, one can feel construction.

Therefore, if someone is willing to pay 6-9% more than the running cost, they can also reduce their entire medical bill spending. Such design interventions can increase one's productivity and creativity.

As a net zero building, it then occasionally operates on its own. The structure functions like a living thing. Taking energy from nature from all the way.

Narrative For Project Partner

This form of housing which is centred around human, health and well being confront, cherish by adapting 2 Natural system within marginal increases cost is a untapped market. Which can be provided to end users ensuring high sellability and better habitat.

Narrative For End User

We can sell this scheme as tagline "Being here is therapy". User stay here and become healthy with nature and integrating natural system which was a way of living in our traditional systems, being close to nature.

11. REFERNCES

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12. LETTERS OF CONFIRMATION

12.1 PROJECT PARTNER CERTIFICATE - RS CORPORATION

306, Radhasoami Sumil, Opp. Gopi Cinema, Anand - 388 001
Tel. 02692 247737
Email : rscorporation_1972@yahoo.co.in
www.rscorporation.com

RS CORPORATION

Date:- 29-09-2022

To,

The Director,

Solar Decathlon India

Dear Sir,

This is to inform you that our organization RS Corporation has provided information about our Radhasoami Sukhdham project to the participating team led by APIED, so that their team 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 fo Representative: Jignesh Shah
Designation: Proprite
Email:rscorporation_1972@yahoo.co.in
Phone: 9825089084

R. S. Corporation

Proprietor

12.2 INDUSTRY PARTNER CERTIFICATE - THE GRID

tHE gRID

Date 21-09-2022

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organization, (tHE gRID Architects), is collaborating with the participating team led by Arvindbhai Patel Institute of Environmental Design on a Residential Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will include guidance and resource sharing on:

1. Integrated design approach.
2. Setting up a benchmark and scope of the project.
3. Narrowing down of technology, material, form and design expression.
4. Initial estimation & pay-back considerations.
5. Identifying stages of design development and execution.
6. Performance monitoring during design stage and preparation of final drawing set.
7. Integrating legal forces in the design.
8. Client engagement nuances.
9. Scheduling activities on site.

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 2022-23 competition.

Bhadri Suthar

With warm regards,

tHE gRID
ARCHITECTS

Name (Snehal Suthar, Bhadri Suthar,
Vishvajit Hada)
Designation **Co-Founder and Co principal designers and vishvajit senior Architect**
Name of the Organization **tHE gRID Architects**
Email **Info@thegrid-arch.com**
Phone 9427418225

Ganesh Meridian, C-1008, Opp New Gujarat High Court, SG Highway, Ahmedabad 380060
T: 079 40027009 I E: info@thegrid-arch.com I www.thegrid-arch.com

12.3 INDUSTRY PARTNER CERTIFICATE - AD CONSULTANT

Date 14-10-2022

To,

The Director,
Solar Decathlon India

Dear Sir,

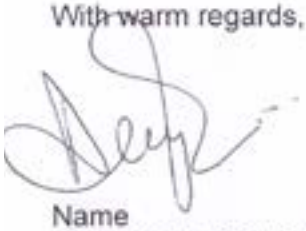
This is to inform you that our organization, A.D.CONSULANTS , is collaborating with the participating team led by Arvindbhai Patel Institute of Environmental Design on a Residential Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will include guidance and resource sharing on:
1. Selection of heating/cooling mechanism or system for township-based detached single-unit housing.
2. Software integration in the design process.
3. Pointers for Architects and Designers to keep in mind while designing.
4. Life Cycle Costing/Payback Period for higher energy efficient systems
5. Cost Implications of various systems.
6. Knowledge of Building Management Systems/ Building Information Modelling (if applicable).
7. Latest innovations in the MEP sector.

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 2022-23 competition.

With warm regards,



Name
PRINCIPAL CONSULTANT
A.D.CONSULTANTS
Adc.1366@gmail.com
9099916140

12.4 INDUSTRY PARTNER CERTIFICATE - KESARJAN BUILDING CENTER

KESARJAN
BUILDING CENTRE
PVT. LTD.

January 10, 2023

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organization, Kesarjan Building Center Pvt Ltd is collaborating with the participating team led by Arvindbhai Patel Institute of Environmental Design on a Residential Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will include guidance and resource sharing on:

1. Integrated design approach.
2. Setting up a benchmark and scope of the project.
3. Narrowing down of technology, material, form and design expression.
4. Initial estimation & pay-back considerations.
5. Identifying stages of design development and execution.
6. Performance monitoring during design stage and preparation of final drawing set.
7. Integrating legal forces in the design.
8. Client engagement nuances.
9. Scheduling activities on site.

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 2022-23 competition.

With warm regards,

Keyur Sarda
Director
Kesarjan Building Center Pvt Ltd
98250 4576

Regd. Office : 303, Aryavrat Residency, Nr. Suyojan Tower, B/h. H.L. Commerce College, Hotel President Lane, Ahmedabad -
Factory : Plot No. 1207-8, Kerala GIDC, Near Bavla District, Ahmedabad - 382 220.
E-mail : kesarjan@hotmail.com | **Web :** www.kesarjan.com | **Mobile :** 98250 45768

12.5 INDUSTRY PARTNER CERTIFICATE - SHASHWAT

SHASHWAT
720/15, Flat no.5, Nalini Apartment, LBS road,
Navi Peth, Pune-411030
E-mail: gaurang@shashwatgbc.com
Website: www.shashwatgbc.com

Ahmedabad Pune Indore

Date: 2nd Jan 2023

To,
The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organization, **SHASHWAT Green Building Consultants** is collaborating with the participating team led by **Arvindbhai Patel Institute of Environmental Design** on a **Residential** Building project for their Solar Decathlon India 2022-23 competition entry. The nature of our collaboration will include guidance and resource sharing on:

1. Integrated design approach.
2. Setting up a benchmark and scope of the project.
3. Narrowing down of technology, material, form and design expression.
4. Initial estimation & pay-back considerations.
5. Identifying stages of design development and execution.
6. Performance monitoring during design stage and preparation of final drawing set.
7. Integrating legal forces in the design.
8. Client engagement nuances.
9. Scheduling activities on site.

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 2022-23 competition.

With warm regards,

SHASHWAT

Name: **Gaurang Govind Lele**

Designation: **Director**

Name of the Organization: **SHASHWAT Green Building Consultants**

Email: gauang@shashwatgbc.com Phone: **9823103563**