Solar Decathlon India™

COMPETITION ORGANIZATION

Satish Misal Educational Foundation's BRICK GROUP OF INSTITUTES

LEAD INSTITUTION

VISHWAKARMA INSTITUTES VI

PARTNER INSTITUTION

LEARN
EDUCATE
NET ZERO
SUSTAINABLE

PARTICIPATING TEAM

DELIVERABLE - 4
FINAL DESIGN REPORT
APRIL 2023

TEAM LENS

LEARN
EDUCATE
NET-ZERO
SUSTAINABLE

EDUCATIONAL BUILDING

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

1. EXECUTIVE SUMMARY

The LENS team consists of eleven architecture students from SMEF's Brick School of Architecture, Pune, and two civil engineering students from Vishwakarma Institute of Information Technology, Pune. With diverse skill sets and expertise, the team is diligently working towards designing a project that contributes to the larger goal of creating a sustainable, equitable, and education-focused India for the future. The team is being guided by professionals and advisors from different backgrounds to achieve this objective.

Our ongoing project is located in Dhubri, Assam, approximately 2km from the Brahmaputra River. Dhubri faces various challenges, including a low education index, limited access to education where 1 in 3 children lack schooling. According to a study by the 'Omeo Kumar Das Institute of Social Change and Development, Guwahati,' there is an 11% gender gap in literacy, underscoring the urgent need for education, particularly for females. Unfortunately, inadequate infrastructure means that only 37% of children are currently enrolled in schools. Recent news articles from India Today NE, Pratidin Time, and The Sentinel Assam indicate that out of 1985 schools, 1087 are primary institutions, and half of them are likely to be affected by the recent floods. Additionally, Dhubri has experienced multiple earthquakes and regular flooding in low-lying regions.

Based on the SDG India Index by Niti Ayog, Dhubri is ranked the worst performer in education, gender equality, and economic growth in Assam. Therefore, the current project involves designing a modern vernacular campus for a primary education center dedicated to girls, which also serves as a flexible vocational training center for women. The project aims to accommodate over 200 students and 50 women trainees and act as a shelter during natural calamities. The school is strategically located away from flood-prone areas, providing a safe haven during floods. "Education-on-wheels" buses are utilized to transport people to the school during difficult times. It also ensures access to education to students and women during regular school days.

Our aim was to achieve a net-zero-energy building by utilizing energy-efficient fixtures and systems to minimize energy consumption. To assess our progress, we conducted several energy simulations on DesignBuilder, and the total energy consumption was determined to be **30.04 kWh/m²** per year. We also generated renewable energy on-site, with solar PV generating **1,24,200 kWh** per year, wind energy generating **36,300 kWh** per year, and hydroelectric energy generating **840 Wh** per year, which fulfilled the consumption demand. This successful approach, combined with several building services and structure specific reviews, has resulted in a feasible net-zero energy status for the campus.

RESPONSE TO REVIEWERS COMMENTS FOR DELIVERABLE 3

Section	Reviewers Comment	Our Response
Reviewer 1		
Energy Performance	It's a good effort to work through a prescriptive method for calculating annual energy consumption. However, at this stage, you should be using building energy simulation models, to understand an inform your design through performance strategies. Building simulation has informed your design for improved daylight. Similarly, use energy simulation models to demonstrate reduction of loads against baseline scenario for each strategy. Further, it is not clear how low energy comfort systems have been integrated.	We have analysed energy consumption and energy reduction using simulation models. The simulations show energy performance of the design case as compared to base case. This comparative analysis helps in determining for both the cases, the energy requirement and consumption.
Water Performance	In the water cycle diagram, depict the annual quantities of water, to show how the water balance.	The quantities are added to the water cycle diagram, which initially was only graphical.
Embodied Carbon	While carbon emissions of materials used in base and design case has been shown, detailed calculations are missing. Provide detail calculations on reduction of embodied carbon that compare the embodied carbon content in the proposed design with a baseline case.	The detailed calculations of embodied carbon of entire structure are added with the base case and design case considerations.
Resilient Design	Demonstrate assessment through both quantitative and qualitative analysis. Provide consideration to resilience for energy, water, food security and waste disposal. Demonstrate how physical integrity has been improved through integration in project drawings.	The resilience data has been reworked and the quantitative aspect of it has also been catered.
Engineering and Operations	Well Done! Include the space provisions and integrated the systems in architecture design.	The detailed data regarding these provisions have been added.
Architectural Design	Well done ! Include details on functional and efficiency in terms of circulation, space allocation and servicing.	The graphical data has been added which explains the same.

RESPONSE TO REVIEWERS COMMENTS FOR DELIVERABLE 3

Section	Reviewers Comment	Our Response
Reviewer 1		
Affordability	Construction cost is on the higher side. You may want to explore measures to improve affordability. Especially, explore measures to reduce costs of the interior works.	The calculations have been altered a bit and additions wrt HVAC and other energy efficient equipments have been done due to which the Design case is on the higher side than the base case. This also proves that in a long run, the maintenance cost would be lesser.
Innovation	Good work. The next step would be to integrate this in the architecture design.	The graphical data has been added which explains the innovative measures undertaken in the plans and sections.
Health and wellbeing	Include annual simulations demonstrating thermal comfort achieved in key spaces during occupied hours and for each mode of operation. Also include airflow network diagrams, natural and mechanical ventilation modes of operation.	Simulations for natural ventilation and natural light analysis have been added with three cases.
Value Proposition	You could also include value proposition in terms of cost-benefits, and other concepts covered above.	The value proposition data regarding cost benefits taking into account the market potential have been added in this deliverable.

RESPONSE TO REVIEWERS COMMENTS FOR DELIVERABLE 3

Section	Reviewers Comment	Our Response
Reviewer 2		
Energy Performance	A good detailed analysis of energy performance of the project. However, the deliverable requirement of demonstrating load reduction against baseline scenario for passive design, envelop, lighting and plug loads separately is missing. You have provided the energy consumption for proposed case, but not the baseline.	Load reduction is given with comparison to base case and have been added and worked upon.
Water Performance	Good detailed analysis of water reduction and it's strategies. It is a good idea to put the liters per day number in the water cycle diagram for each heading.	Values are added in the chart.
Embodied Carbon	Very nicely and succinctly captured all the required details in this section.	We have added the required succeeding calculations as well.
Resilient Design	The potential risks on the project site have been nicely narrated and captured.	We have further worked to mitigate the impact of negative risks.
Engineering and Operations	Nice and elaborate details provided under Engineering and operations. The system designs and rightsizing have been nicely explained with sufficient drawings, narratives and calculations. A little more can be discussed about the constructability at scale in terms of material, technology and labour with some basic analysis.	The constructability aspect in the affordability chart have been added
Architectural Design	A good creative and evidence based design with nice visuals. All required aspects seem to be covered in this category.	We have further detailed our design intervention.
Affordability	The construction cost analysis is brief and to the point. Good work.	We have further detailed out the project timeline and financing cost analysis.
Innovation	The innovative ideas discussed are interesting and nicely explained. The scaling up of these ideas for this marked can also be discussed for these ideas. The cost implications and cost benefit analysis are also crucial to the implementation of these ideas and should be discussed.	The costing alterations in both design and base case have been done, and, addition of cost effective items and HVAC have been added.

RESPONSE TO REVIEWERS COMMENTS FOR DELIVERABLE 3

Section	Reviewers Comment	Our Response
Reviewer 2		
Health and wellbeing	Good documentation of overall chapter. The thermal comfort graph only shows RH values within the comfort range, but the temperature values within the comfort range for the occupied hours are not clear from the given graphs. The number of hours the occupants will be comfortable is also not discussed. The team should also mention the thermal comfort standard (NBC/ECBC/ASHRAE-55/IMAC) used for assessment.	The comfort hours for the same have been added and mentioned according to the IGBC school standards and GRIHA standards
Value Proposition	The team has a good proposition for the end user. However, the team can add aspects about net-zero energy/net zero water/etc. approaches and create a narrative on these aspects as well to create additional impact to the project partner.	The net zero energy and water narratives - which were present earlier have been highlighted again.
Additional Comments	Overall, really good documentation and great work. The teams have clear understanding and thought process about the project. They can further detail and perform quantitative analysis for various other aspects of the project for making further design decisions.	Addition of simulations for comfort hours within the building, revising affordability chart and changes in project timeline.

2. TEAM INTRODUCTION

2.1. Team Name : LENS - Learn Educate Net-Zero Sustainable

2.2. Lead Institution : SMEF'S Brick School of Architecture, Pune, Maharashtra

2.3. Division : Educational Building

2.4. Team Members :

SAURABH SAHANE
Simulations

VANSHIKA PARIKH
Calculations

AKSHITA RATHI
Design & Landscape

VISHAL DAYANI
Management & Design
Team Leader

KHUSHI LOTHE
Design & Graphics

KESHAV AGRAWAL
Report Writing

OMKAR JOSHI
Structural Design

RIYA MANWATKAR
Graphics & Sketches

SHREYA BHIDE
Calculations

SHIVANI GAUTAM
Design & Graphics

VAISHNAV VINOD
Graphics

SIMRAN SOND
Report Writing

BHAGYASHREE KOKATE
Structural Calculations

2.5. Team Approach :

This competition project would be our first step towards our unified target of making a better India for tomorrow through sustainability, education and gender parity. As a team, our approach has always been simple - to start with introspection on individual levels, then, discussing with group members and brainstorming as a team, recognising plausible ideas and fixing a mission while reiterating the various steps involved. The team was divided into smaller groups with each member taking the lead in their area of expertise. The overlap and intersection of these groups ensured having an integrated approach, and everyone remained informed and involved in each stage of the design.

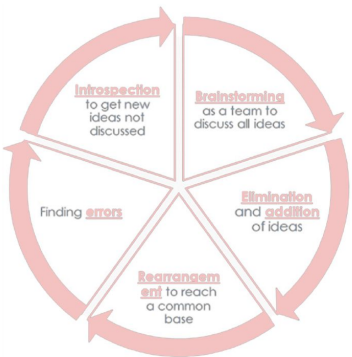


Fig. 2.5.1. Team Approach and Ideation Process

2.6. Background Of Team Institution :

SMEF's Brick School of Architecture:
This Institute provides a global approach to education that goes beyond traditional teaching methods. The undergraduate and masters programs emphasize collaboration and research, pushing students beyond their comfort zones to meet current and future industry challenges and contribute to a better-built environment.

Satish Misal Educational Foundation's BRICK GROUP OF INSTITUTES

Lead Institute

Vishwakarma Institute of Information Technology:
Its Civil department aims to provide excellent education in Civil Engineerin developing competent Civil Engineers with strong values and imparting th highest standards of knowledge and skills. They also establish a Center of Excellence in major areas of Civil Engineering to meet industry needs and support research.

VISHWAKARMA INSTITUTES VI

Partner Institute

2. TEAM INTRODUCTION

2.7. Faculty Guides :

Dr. Poorva Keskar
Principal

Dr. Poorva Keskar is an architect and a director at VK:e, environment designer, quality manager, educator and author of numerous articles on the practice of environment design.

Ar. Vinita Lulla
Faculty Lead

Ar. Vinita has flair for sustainable architecture, chases creativity minutely and adds aesthetics in everything she perceives.

Ar. Shreya Mirpagar
Faculty Advisor

Ar. Shreya is a creative and conscientious environmental architect passionate about design inclusive research towards sustainability.

Sharvari Rajwaday
Faculty Advisor

Ms. Sharvari is a graduate of architecture, with a deep interest in sustainable cities and communities. She holds IGBC AP, LEED GA, and WELL AP credentials.

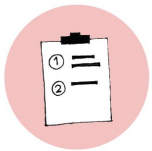
2.8. Industry Partner :

VK:e environmental is a consulting practice, consisting of a group of professionals that passionately believe in promoting Sustainability. VK:e aspires to positively transform urban growth and align it with nature through 'Better Design' approach.

2.9. Design Management Process :

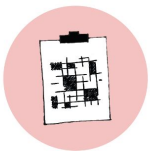
1. Pre-design research:
Research on SDG for Education Building typology (SDG 4), which aims "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all".

2. Project partner (Karunar Kheti Trust):
Brief discussions with the Project partner gave us a broad contextual description. The school is conceptualized by their ideology of " ***for the people, by the people*** ".



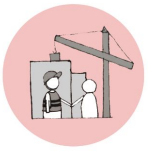
3. Site selection Criteria:
This site in Dhubri, Assam was selected on the basis of which has low literacy rates, accessibility challenges and insecurity to send females to school. Thus, the site was fit for female educational building.

4. Contacted industry partner VK:e :
Discussions about the ideation of the project. Insights on new iterations possible for the project. Provided inputs regarding passive design strategies for the project.



5. Research on climate problem and Design programming:
Climate analysis (micro, macro). Design Iterations with Conceptualization and zoning in accordance to **(IGBC school standards)** areas required for an educational building.

6. Design review from supervised consultants:
Electrical, MEP & HVAC review by Ar. Suraj Bhunje
Energy expert review by Ms. Sharvari Rajwaday (holds IGBC AP, LEED
GA, and WELL AP credentials)



7. Discussion with Experienced team, consultant Civil Engineer and Cost Consultant Review:
Internal review from previous participants. Review of Structural by Er. Gurudutt Ingale and Cost by Ar. Raghunandan A. and Civil by Er. Archana Tanawade.

8. Revisions & Final Review with Industry partner:
Changes in design due to previous review from experts. Discussion with Ar. Poorva Keskar Director at VK:e. Changes related to environmental impact and resilience had been suggested.

3. PROJECT INTRODUCTION

3.1. Project Name : Samaya Gurukul: Primary Girls School & Women's Vocational Training Centre

3.2. Project Partner : KARUNAR KHETI TRUST

3.2.1. Description : It is a start-up non-profit Trust founded on July 30, 2019, and is rooted in Boisahabi Tea Estate which is located in Assam's Jorhat district. Karuna Kheti Trust in Assamese means The Cultivation of Compassion Trust. Their objective is to work with the rural communities of Assam, in particular, its dominant social fabric spun by tea plantations and traditional village communities, for empowerment based on the interconnected areas of education, healthcare, and livelihood.

3.2.2. Inspiration from the Project Partner :

TEAM Lens has been inspired by Karunar Kheti Trust's ethos of **"for the people, by the people"** and as such its project and chosen location while being completely different from that of Karunar Kheti, is inspired by the community-participatory and education-health-livelihood interconnected development ethos of the Trust.

3.2.3. Key Individuals :

Dr. Arjun Trivedi (Ph.D., Physics) for 15 years has worked in some of the world's leading scientific and engineering institutions. He recently returned to Assam to respond to socio-economic-political-environmental challenges and found an ally in his long-time friend Mr. Mineswar Dutta. Mr. Mineswar Dutta has more than 30 years of experience working with Assam's rural communities, its tea plantations, and its villages. Their work in this region and field has inspired us to independently take up this project under their guidance.

Dr. Arjun Trivedi

Mr. Mineswar Dutta

3.3. Project Description :

Location : Dhubri, Assam, India
Climate Zone : Warm & Humid Climate
Annual Rainfall : 2363 mm
Average Annual High Temperature : 30.33° C
Average Annual Low Temperature : 22.52° C
Longitude & Latitude : 26.0207° N, 89.9743° E
Altitude : 33528 mm
Humidity Level : 64.21%

Fig. 3.3.1. Dhubri Site

The project is situated in the old town of Dhubri, in Assam's west most corner, known as the "Land of Rivers." With an area of 1,664.10 sq. km and a population of 19,48,632 (according to the Ground Water Information Booklet Dhubri District, Assam (March 2013)), it is enclosed by the Brahmaputra and Gadadhar rivers on three sides. Dhubri has experienced several earthquakes in past and also gets an average of 2363 mm precipitation and experiences flooding due to overflowing and rains, making the surrounding areas uninhabitable. While considering these issues, a school and vocational training program for women have been proposed, with a focus on "Primary Education for Girl Child" and "Vocational Training for Women."
This institute is proposed as a conceptual level economical model project.

3. PROJECT INTRODUCTION

Total Proposed Build Up Area: 2800 sq.m.
Ground Cover: 2500 sq.m.
Status of the Project : Master Planning Complete
Profile of Occupants : Total 300 occupants: 200 Young Girls between the age of 5 - 11 years as primary students and 50 Women of Dhubri above the age of 18 as vocational trainees. Additionally, 50 teaching and the non-teaching staff.
Hours of Operation: 11 - 12 hours (Primary School : 8 AM to 3 PM; Vocational Training Centre : 8 AM to 5 PM; Day Care Centre: 8 AM to 5 PM)

3.4. Site Details :

DHUBRI Site - Area Statement				
Sr.no	**F.S.I. calculations**	**In Sq m**	**In Sq ft**	**Remark**
1	Area of Plot	8832.00	95,067.65	As perdocument sent by owner
2	area under road	350.00	3,767.40	Assumed Road widening as per the governer urban development department,G.O.A.
3	**Net Plot**	**8482.00**	91,300.25	(Sr.No.1 - Sr.No.2)
5	Open Space (20%)	1696.40	18,260.05	Mandatory open space (20% of Sr.No.3)
6	Net Plot Area	8482.00	91,300.25	Net Plot Area for FAR consideration
7	Basic F.A.R.	14843.50	159,775.43	1.75 as per the governer urban development department,G.O.A.
8	**Ancillary FSI**	**12723.00**	136,950.37	50% of FSI
9	**Total Built Up Area**	**14843.50**	159,775.43	7 (including Parking)

Table 3.4.1. **Site Area Details**

3.5. Project Timeline :

Total Time Period : 4 Years
Fig. 3.5.1. **Project Timeline**

3.6. Construction budget & cost :

The base case budget (INR/sqm) = INR 45,541/sq.m as per Schedule of Rates of Dhubri, Assam.
Proposed construction cost (INR/sqm) = INR 74,201/sqm as per calculations.

3.7. EPI - Energy Performance Index :

The EPI goal according to EPI targets (2022-23) for primary school Educational Building typology in the Warm & Humid climate zone is 38 kWh/m² (ECBC standards provided by Solar Decathlon India).

For a net zero building, Total consumption = Total onsite renewable energy generation = **1,61,340 kWh** per year.

EPI = Total energy consumption / total built-up area = **30.4 kWh/m²** per year (simulations in design builder). Hence, the EPI goal calculated is less than the target EPI provided for a primary school.

4. GOALS & STRATEGIES

Energy Performance:

Goal: Achieving net-zero energy and maximizing energy efficiency in a primary school with a target EPI of 38 kWh/Sq. m per year for a built-up area of 2930 sq.m.

Strategies: Used a combination of active & passive strategies such as optimized orientation, envelope, shading, natural ventilation, and daylight, LPD, HVAC etc to optimize energy consumption. Onsite renewable energy using Solar PV, Vertical Axis Wind Turbine and Bloom (Water Collecting Pods) respectively will also be utilized.

Health and Wellbeing:

Goals: The target is to have 40% of annual daylight (IGBC Green schools) and 100% daylight in occupied hours . Maximizing indoor environmental quality metrics to improve occupant comfort, wellbeing, and productivity

Strategies: By including informal and transitional areas into passive design principles and establishing a healthy physical and mental environment for the kids. Using a north-light truss system to include efficient natural lighting during primary occupancy hours with unequal wall-to-window ratio (WWR) on windward and leeward side.

Resilience:

Goal: To construct a structure with intangible resilience for socio-cultural issues and the tangible ability to survive changing climatic circumstances, such as earthquakes and floods.

Strategies: Provisions for a programme that prioritizes women and offers financial assistance. The structure uses shock absorbers and bamboo bracings with bamcrete walls to contribute to seismic resilience and implemented disaster mitigation techniques to increase operational resilience.

Innovation:

Goals: An education and awareness campaign with flood relief potential. Install a method to collect rainwater. Have a convertible furniture arrangement and facade systems that can either generate power or contribute to one's health and well-being.

Strategies: Proposing a bus facility on regular days and times of crisis that serves as a mobile classroom. An attractive rainwater collection module that generates hydro electricity. Facades made of algae panels and wind turbines and deployable multi-use single-unit furniture.

Water performance:

Goal: To reduce overall water consumption by 50% while still meeting the water usage requirement of 45 liters per day per person (NBC 2017) in a primary school in Assam's warm and humid climate.

Strategies: Harvesting rainwater with Bloom (Water Collecting Pods) and rooftops lowers the demand for groundwater supply by up to 40%. Further, low flow fixtures reduce the water requirement by 49.55%. Use of recycled grey water for the irrigation reduces fresh water demand(by 24.41%).

Architectural Design:

Goals: To accomplish Net-zero building goals through sustainable design solutions by consideration of the climate, context, and user perspective. It would be a women education centric design development.

Strategies: A holistic framework of active and passive design methods in accordance with environmental codes, energy ratings, local bylaws, and NBC in addition to local tradition. Usage of an inclusive color scheme with user centric planning included into the design of the building, and a visibly secure atmosphere for users. An education program proposal that is inclusive of women of all ages.

Embodied Carbon:

Goals: Reduce operational and embodied carbon energy to minimize CO2 levels. Provisions for a minimum on-site offset of 20% through plantation.

Strategies: Utilize salvaged, recycled, and local resources in our material palette for the proposed design. Used materials like Bamboo, clay, GGBS and all others that are available within a radius of 200 km. 50% of cement is replaced by GGBS in proportion.

Value proposition:

Goals: To fill in the gap of women inclusivity in education realm and working environment. Propose a program that could be inherently be adopted by the women and a potential monetary vertical.

Strategies: Along with a primary education programme, the design proposes a vocational training programme inclusive of practice of traditional art & crafts like Bamboo weaving etc, making of paper and sanitary pads which could further provide them with scope of remuneration or monetary benefit.

5. DESIGN DOCUMENTATION

5.1. Architectural Design:

5.1.1. Concept:

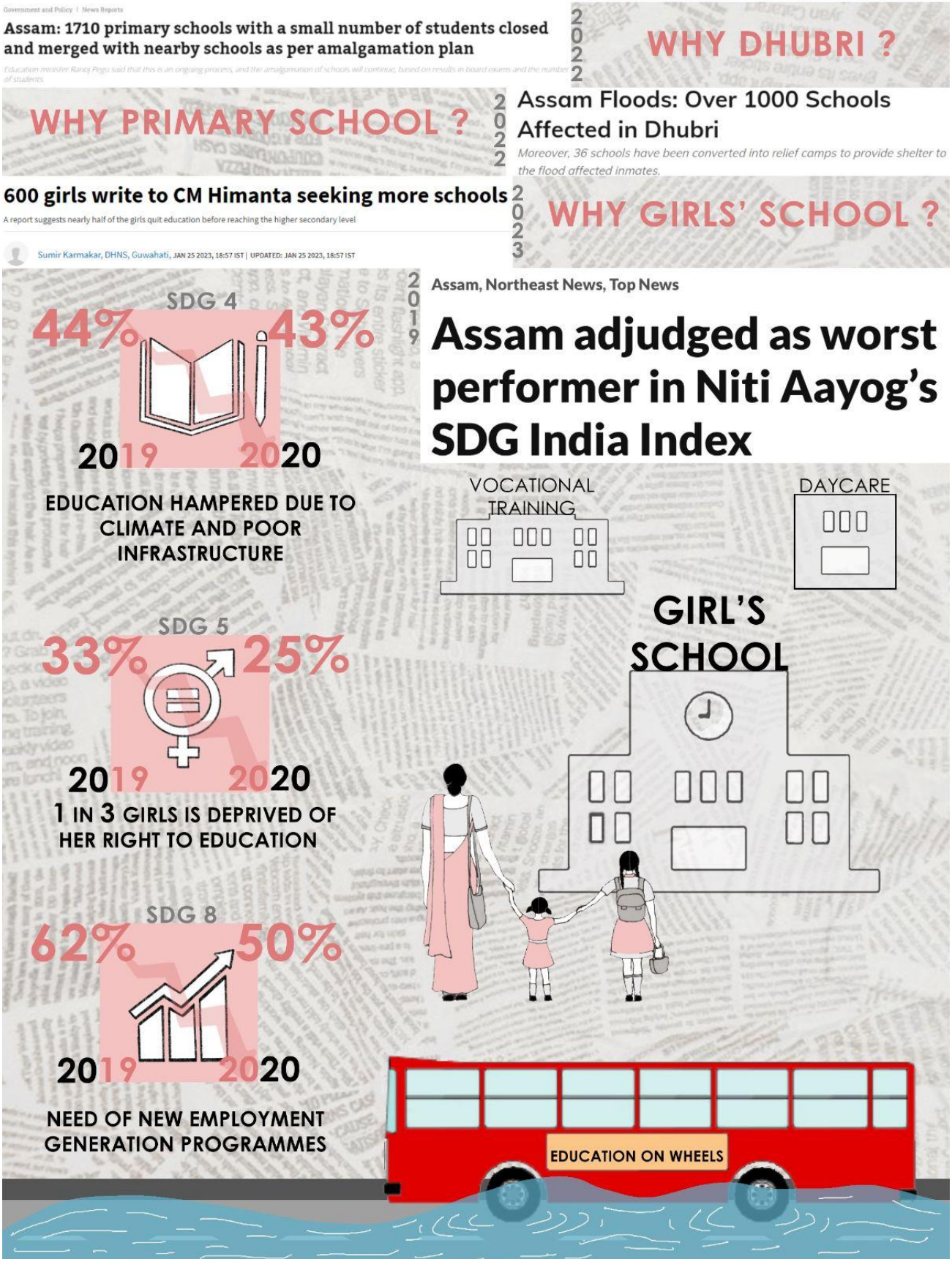


Fig. 5.1.1.1. **Concept**

5. DESIGN DOCUMENTATION

5.1.2. Design Concerns:

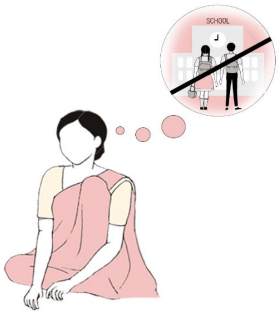


Fig. 5.1.2.1.1. **Lack of Societal Acceptance**

5.1.2.1. Concern 1 - Co-ed Schools

Parents in Dhubri are apprehensive about co-educational settings, mainly due to concerns about safety in Dhubri and religious conservatism. Therefore, the project incorporates a girl-centric design to address these concerns. In Dhubri, parents also prioritize schools that offer mid-day meal schemes for their children.

5.1.2.2. Concern 2 - Safety and Lack of Comfortable Environment

The practice of early marriages (according to a study conducted by the National Family Health Survey (NFHS-4) in 2015-16, Assam has a high prevalence of child marriage with around 35% of women aged 20-24 years being married before the age of 18)in Dhubri has resulted in women experiencing emotional distress, as parents consider it a way to enhance their financial ties with their in-laws. However, it is essential to recognize women as influential catalysts for spreading knowledge, and providing education to them would be advantageous not just for themselves but for the whole family.

Fig. 5.1.2.2.1. **Required Proper & Safe Sanitation**

Fig. 5.1.2.3.1. **Physical & Mental Wellbeing**

5.1.2.3. Concern 3 - Sanitation & Well being

The project incorporates various measures to maintain a clean and secure environment, including female-only toilets, ceramic fittings, and treated water. Furthermore, there is an on-site facility for producing and disposing of sanitary pads.

5.1.2.4. Concern 4 - Responsibility Over Siblings

The school offers a daycare for kids under five, conveniently located near the women's workplace. This supports mothers to be with their infants while promoting learning and financial independence. The daycare has feeding and dining rooms for moms and solves the issue of older siblings staying home to care for younger ones. With on-site childcare, women can balance work and parenting, and the daycare's playful design ensures a safe and enjoyable environment for children.

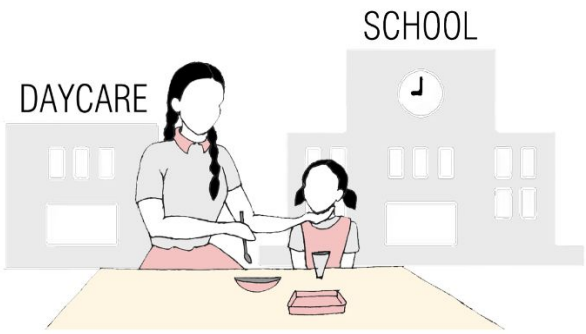


Fig. 5.1.2.4.1. **Daycare Provision**

5. DESIGN DOCUMENTATION

5.1.3. Design Development:

Considering a girl-centric design, the entire structure is divided into three distinct zones: public, semi-public, and private. Public spaces in Dhubri are designed to serve the local community, while semi-public spaces are intended for parents of students. Private spaces, on the other hand, are exclusively accessible to female students, their siblings, faculties, and mothers of students.

Public space includes the auditorium block, whereas the vocational training exhibition for women and administrative block are semi-public spaces, and the dining area and classrooms are private spaces. Considering the climate of Dhubri, the design also incorporates ample natural daylight through north-facing light trusses, providing potential for solar panels on the sloping roofs to face the south direction. The positioning of the classroom block and administrative block is intentionally designed to create a venturi effect within the campus.

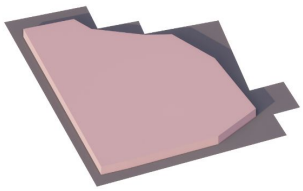


Fig. 5.1.3.1. **Demarcating Buildable area on site.**

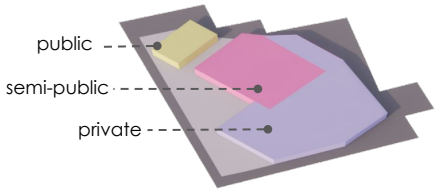


Fig. 5.1.3.2. **Zoning of Public, Semi-Public and Private zones.**

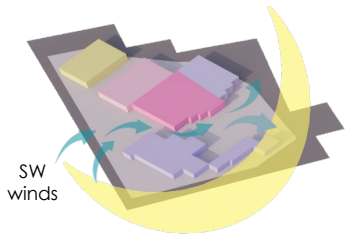


Fig. 5.1.3.3. **Modulating the form by staggering it as per the predominant wind-direction and sun-path.**

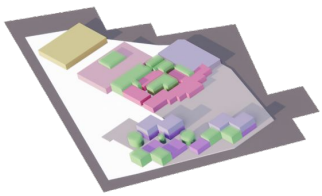


Fig. 5.1.3.4. **Inclusion of hierarchy of courtyards as per the psychology triggered by the five senses**

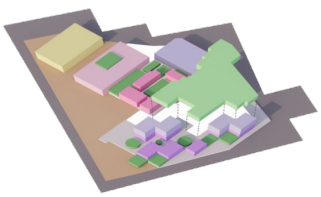


Fig. 5.1.3.5. **Scooping out of intimate multipurpose play area for girls.**

Legends-

1. Parking
2. Solar Grid
3. Drop Off
4. Education on Wheels - Bus Parking
5. Multipurpose Play Area
6. Play Area Ramp

A. Entrance for Auditorium
B. Entrance for Exhibition Area
C. Entrance for School
D. Exit for School

Fig. 5.1.3.6. **Site Plan**

5. DESIGN DOCUMENTATION

5.1.3. Design Development:

A semi-open play area (in Fig. 5.1.3.11.) has been introduced that offers glimpses of the sky and creates vibrant patterns on the ground. A green playful ramp (in Fig. 5.1.3.9.) is designed which connects the semi-open play area to the first floor. The rainwater pods i.e. Bloom (Water Collecting Pods) (in Fig, 5.1.3.8.)resemble a tree trunk, serving as a playful element for children. A wall (in Fig. 5.1.3.10.) displaying challenging mathematical tables, with recurring exposure to the wall, helps children remember them subconsciously. The walls also feature engaging games like the abacus wall and stick wall. To cater to the predominant wind direction and foster a sense of curiosity among the girls, the classrooms are arranged in a staggered manner. This design also incorporates a hierarchy of courtyards in between the classrooms, providing spaces for the girls to interact and engage with their surroundings.

Fig. 5.1.3.7. **Bloom (Water Collecting Pods)**

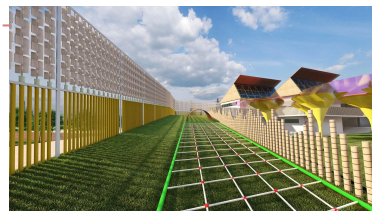


Fig. 5.1.3.8. **Playful ramp**

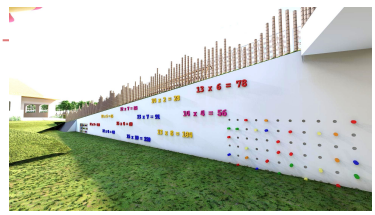
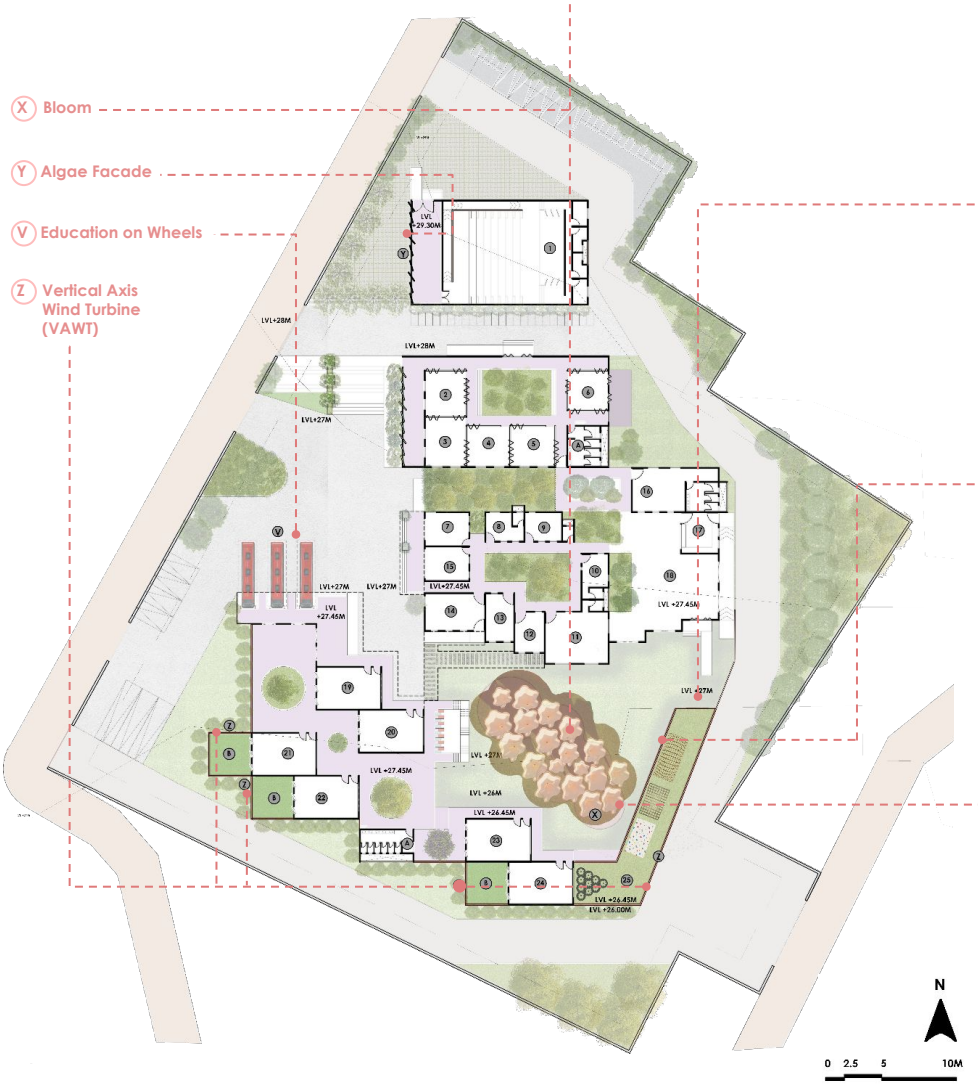


Fig. 5.1.3.9. **Interactive wall**

Fig. 5.1.3.10. **Central Play Area**



Legend -

1. Auditorium
2. Paper studio
3. Bamboo studio
4-5. Multipurpose studio
A- Toilet
6. Weaving studio
7. Accountants
8. Principal's room
9. Meeting room
10. Director's cabin
11. Staff room
12. Non-teaching staff
13. Admin
14. Infirmary
15. Stationary
16. Day care
17. Kitchen
18. Dining
19. Classroom 1
20. Classroom 2
21. Classroom 3
22. Classroom 4
23. Classroom 5
24. Classroom 6
25. Play area ramp

Fig. 5.1.3.11. **Ground Floor Plan**

5. DESIGN DOCUMENTATION

5.1.3. Design Development:

The journey to the upper floors is made enjoyable by the bamboo tubes installed along the interesting staircase (in Fig 5.1.3.13), which also generates electricity for the building. Several other playful elements such as the water-lashing wall (in Fig 5.1.3.16.) and various embedded play equipment in the central play area (in Fig 5.1.3.15) contribute to the school's recreation factor.The area between the dining zone and the central play area transforms into a shared space where girls from the school, siblings from the daycare, and mothers from the exhibition area come together to bond and connect. The shared bonding space is accessible from the playful ramp (in Fig 5.1.3.16.) and the central semi-open area.

Legend-

25. Play Area Ramp
26. Bloom (Water Collecting Pods)
27. Classroom 7
28. Classroom 8
29. Computer Lab
30. Music/ Dance Room
31. Shared/Bonding Space

A. Toilet

Fig. 5.1.3.16. **First Floor Plan**

Fig. 5.1.3.12. **Staircase**

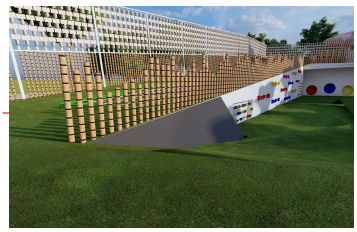


Fig. 5.1.3.13. **Water Lashing Wall**

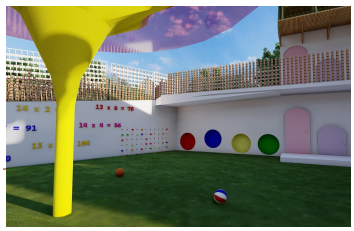


Fig. 5.1.3.14. **Central Play Area**

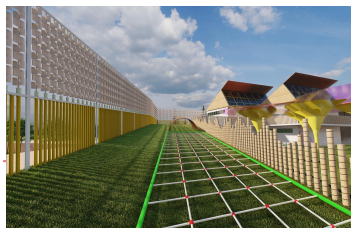


Fig. 5.1.3.15. **Playful Ramp**

5. DESIGN DOCUMENTATION

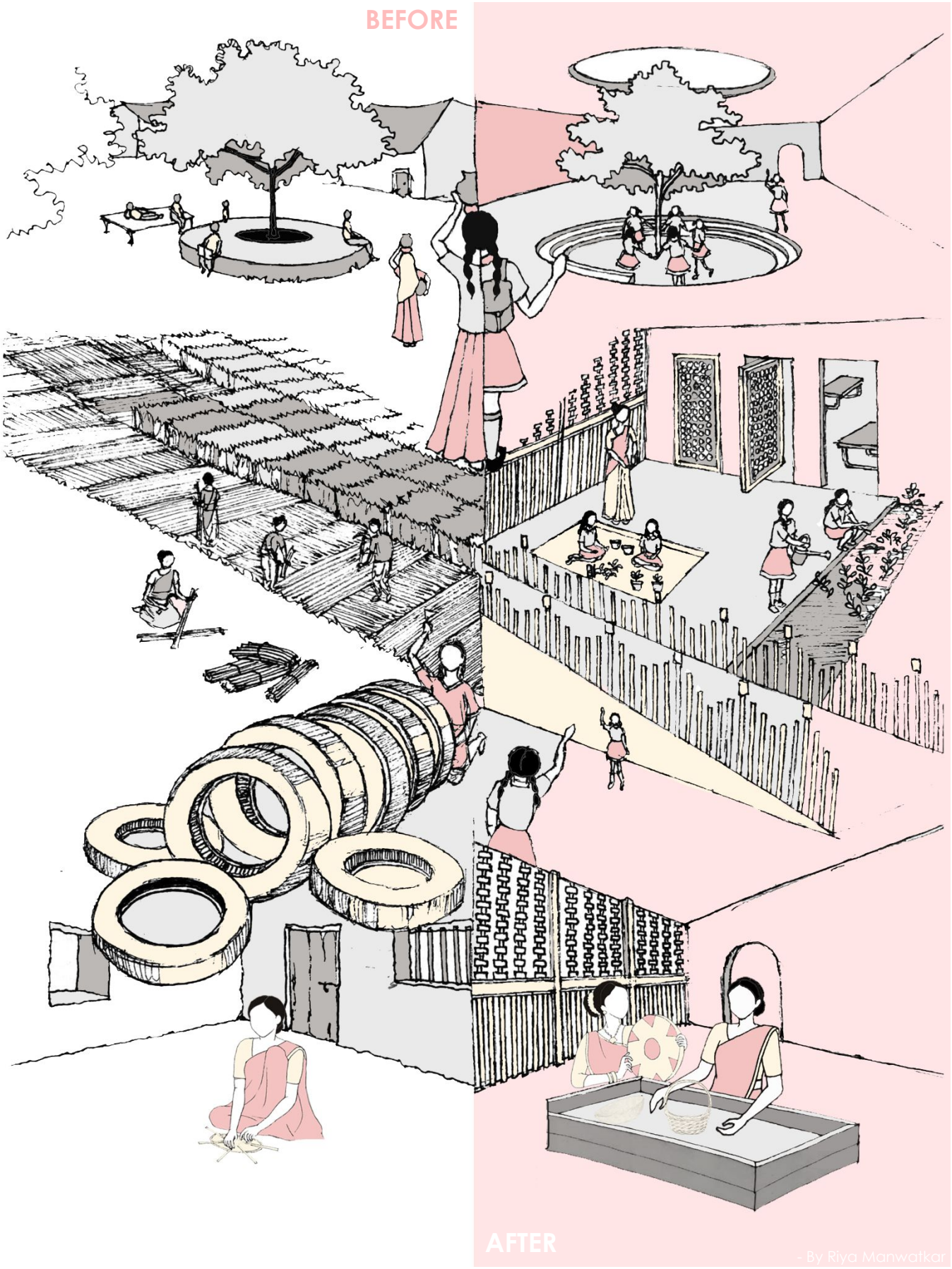


Fig. 5.1.3.17. **Incorporating ideas inspired by Dhubri**

5. DESIGN DOCUMENTATION

5.1.4. Landscape Design:

The school's surroundings consist entirely of native Dhubri trees that are intentionally arranged to engage all five senses and encourage optimal student concentration. Every native tree used can withstand severe weather conditions.

Common name :- Hollong
Height :- 45 m
Foliage :- 15-20 m

Common name :- Gurjan
Height :- 15-20 m
Foliage :- 20-30 m

Common name :- Sissoo
Height :- 15-20 m
Foliage :-10-15 m

Fig. 5.1.4.1. **Aroma inducing trees (Sense: Smell)**

Common name :- Kurta
Height :- 8-15 m
Foliage :- 5-7 m

Common name :- Nahar
Height :- 8-15 m
Foliage :- 10-15 m

Common name :- Sia Nahar
Height :- 8-10 m
Foliage :- 6-8 m

Fig. 5.1.4.2. **Fruit bearing trees (Sense : Taste & Visual)**

Common name :- Mekai
Height :- 15-20 m
Foliage :- 10-15 m

Fig. 5.1.4.3. **Trees with texture (Sense : Touch & Hearing)**

Common name :- Khair
Height :- 10-15 m
Foliage :- 5-8 m

Fig. 5.1.4.4. **Ayurvedic herb**

Common name :-
Caeserweed
Botanical name :-
Urena lobata

Common name :-
Devil's trumpet
Botanical name :-
Datura metel

Common name :-
Vasaka
Botanical name :-
Justica adhatoda

Fig. 5.1.4.5. **Shrub Palette**

Fig. 5.1.4.6. **Courtyard between admin and dining**

Fig. 5.1.4.7. **Courtyard between classrooms**

Fig. 5.1.4.8. **Landscape Plan**

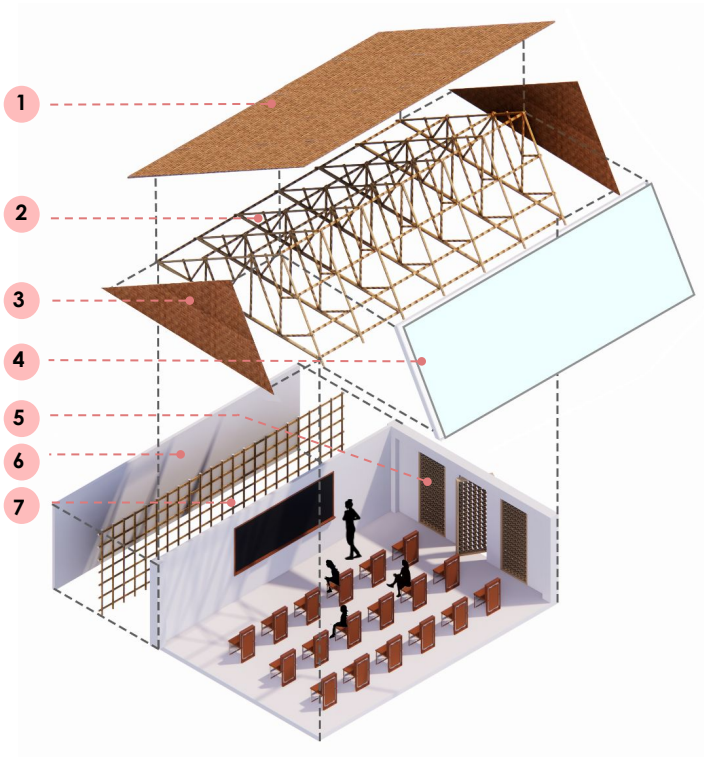


Fig. 5.1.5.1. **Exploded isometric of classroom**

1 - Bamboo Shingles (5mm thk)
2 - Bamboo truss (75mm radius & 5mm thk)
3 - Bamboo woven sheet
4 - 10mm toughened glass supported with aluminium frame
5 - Bamboo Jali Pivoted door
6 - Suntex 8 exterior plaster

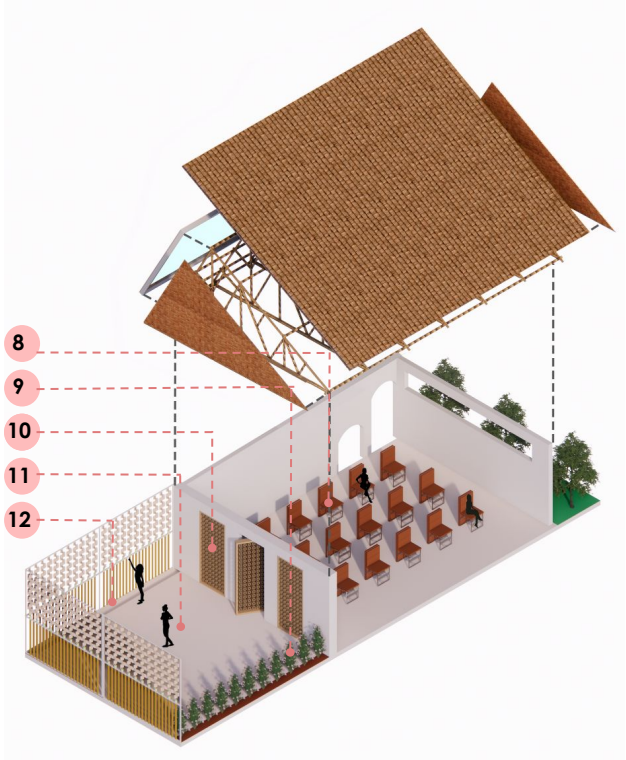


Fig. 5.1.5.2. **Exploded isometric of spillover of classroom**

7 - Bamboo reinforcement for Bamcrete wall
8 - Flexible furniture
9 - Gardening area
10 - Bamboo Jali Pivoted door
11 - Covered spill over area
12 - Wind turbine + bamboo roller facade

Fig. 5.1.5.3. **Courtyard**

Fig. 5.1.5.4. **North light truss**

Fig. 5.1.5.5. **Covered pathways**

Fig. 5.1.5.6. **Bamboo jali pivoted door**

Fig. 5.1.5.7. **Staggered planning**

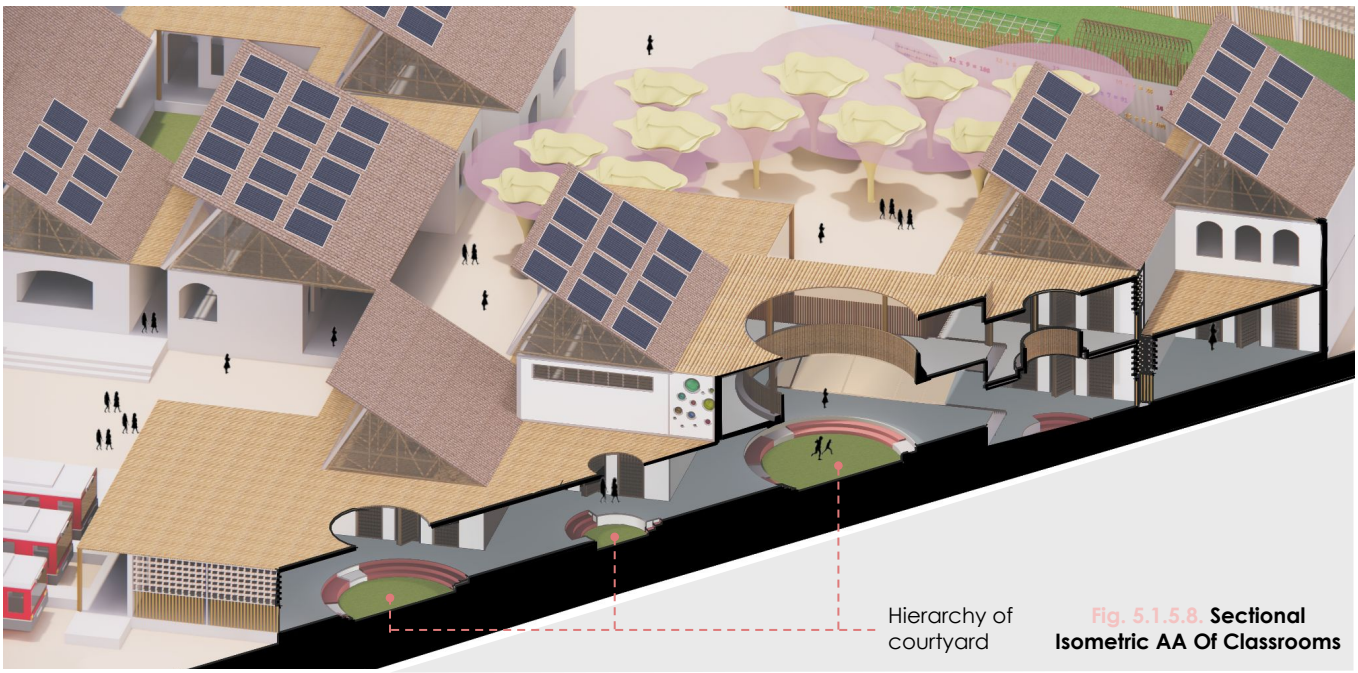


Fig. 5.1.5.8. **Sectional Isometric AA Of Classrooms**

5. DESIGN DOCUMENTATION

5.1.6. Design Details:

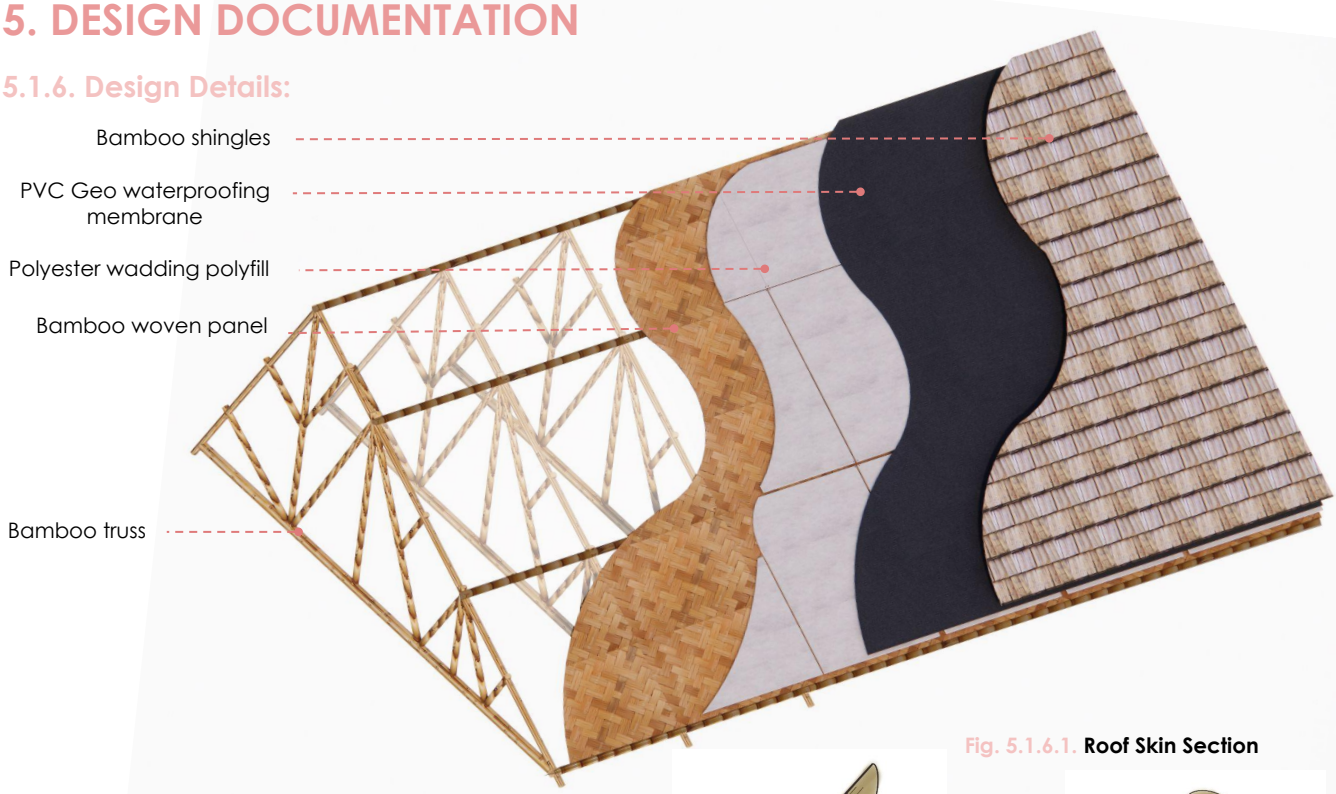


Fig. 5.1.6.1. **Roof Skin Section**

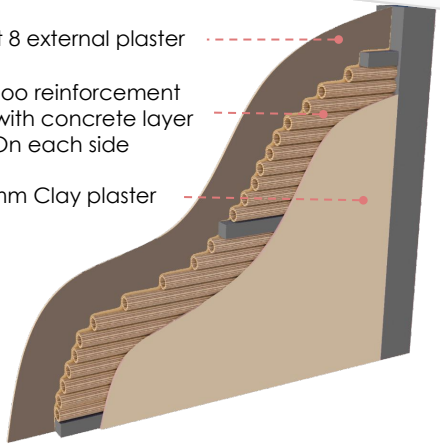


Fig. 5.1.6.4. **Bamcrete Wall Skin Section**

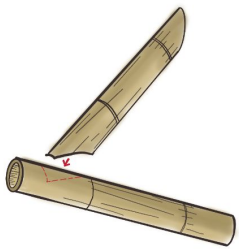


Fig. 5.1.6.2. **Bamboo Joinery- Fish Mouth**

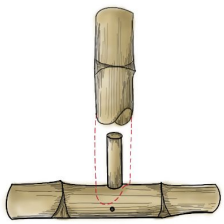


Fig. 5.1.6.3. **Bamboo Joinery**

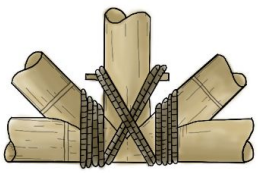


Fig. 5.1.6.5. **Bamboo Joinery**

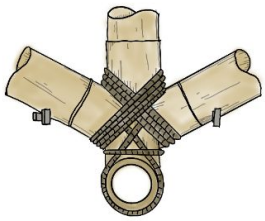


Fig. 5.1.6.6. **Bamboo Joinery**

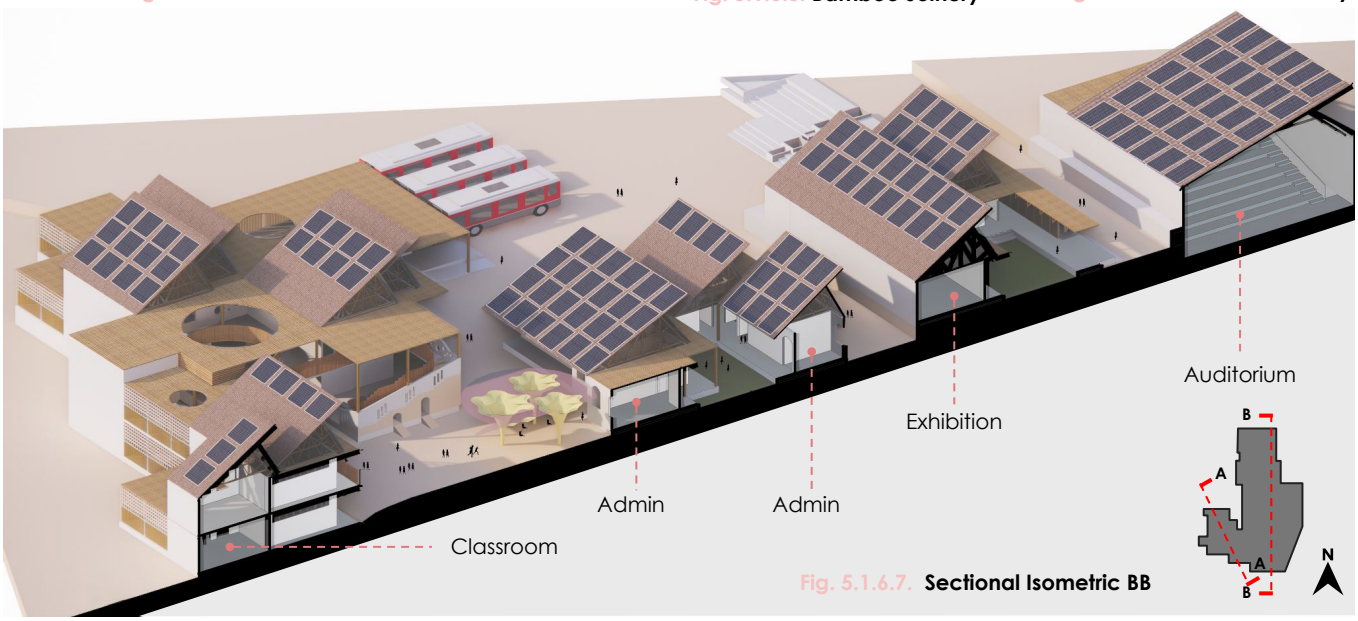


Fig. 5.1.6.7. **Sectional Isometric BB**

5. DESIGN DOCUMENTATION

5.1.7. Passive Strategies Inclusive Design:

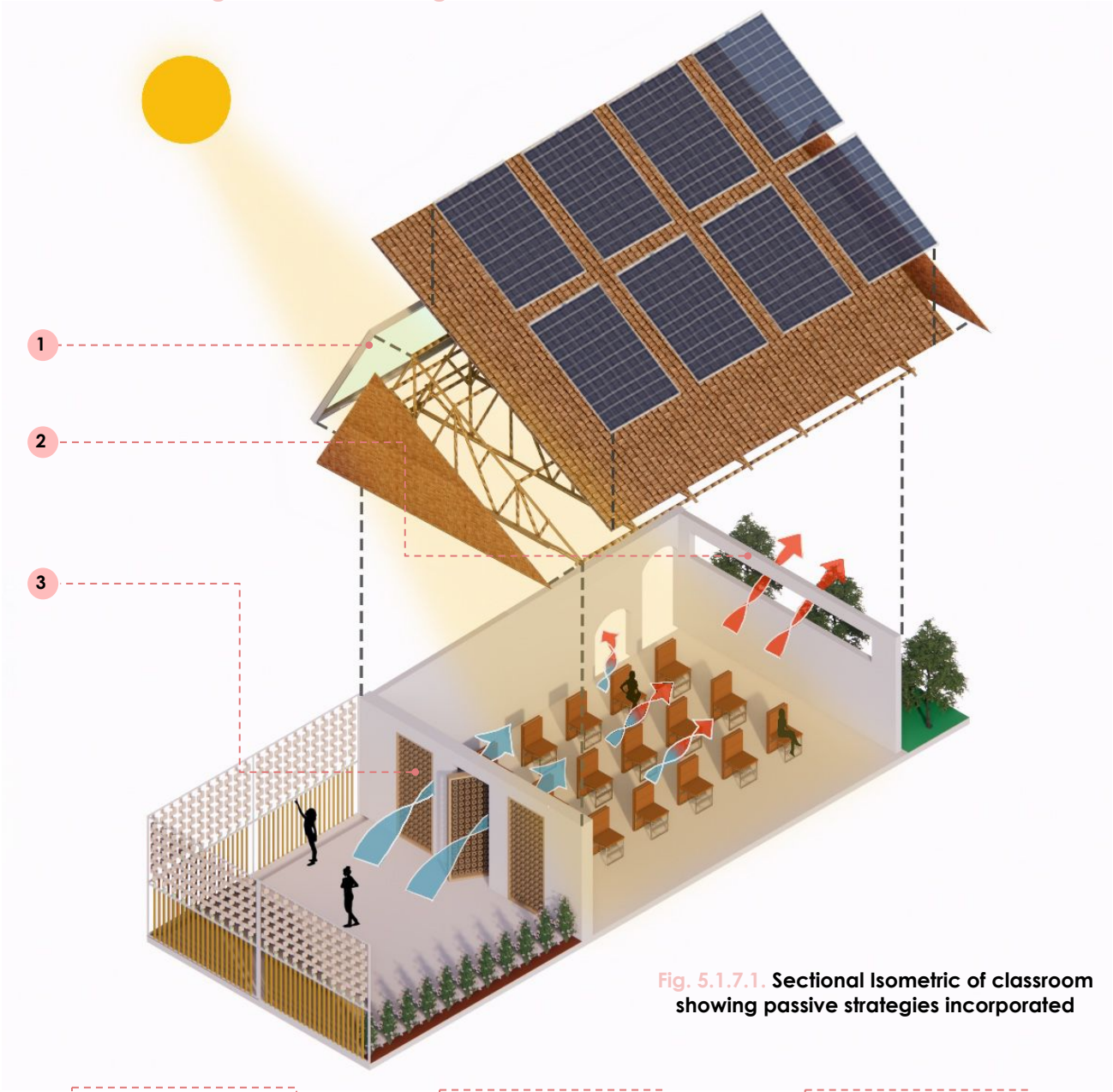


Fig. 5.1.7.1. **Sectional Isometric of classroom showing passive strategies incorporated**

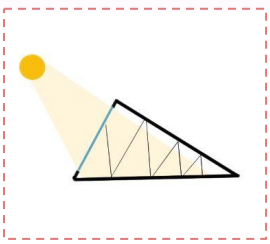


Fig. 5.1.7.2. **North Light Truss**

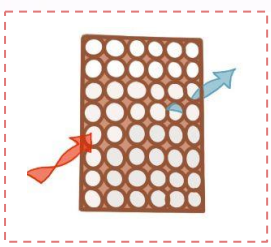


Fig. 5.1.7.3. **Terracotta Jali Wall**

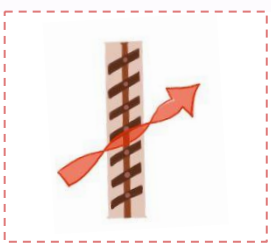


Fig. 5.1.7.4. **Louvered Opening**

In order to ensure thermal comfort in Dhubri's warm and humid climate, passive strategies such as terracotta jali walls and elevated ventilators are employed in classrooms. Mechanical ceiling fans and strategically placed openings at different levels facilitate air circulation, effectively reducing humidity.

5. DESIGN DOCUMENTATION

5.2. Innovation

5.2.1. Algae Facade

Need: A facade technology that can assist to reduce air pollution and make up for embodied carbon.

Chlorellaceae Algae, commonly found in Dhubri's lakes and ponds, can purify air through an Algae wall. This wall is created using container modules with water and algae implants and three pipes attached. Two intake pipes take in air and algae feeder while the output pipe releases oxygen. The system promotes algae breeding and also produces biomass for fuel. The Algae wall serves as an efficient and eco-friendly solution for air purification and biomass production in Dhubri.

Fig. 5.2.1.1. **Collection of Algae from Nearby Ponds/Lakes**

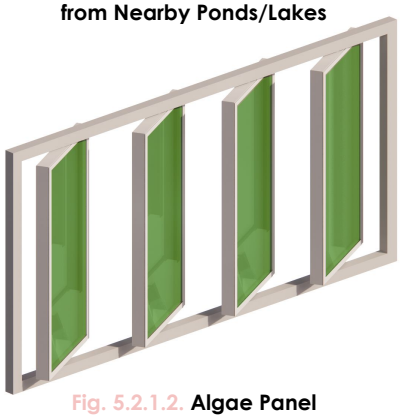


Fig. 5.2.1.2. **Algae Panel**

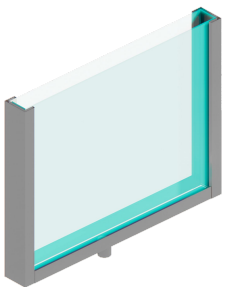


Fig. 5.2.1.3. **A Custom built panel to propagate the Algae Growth**

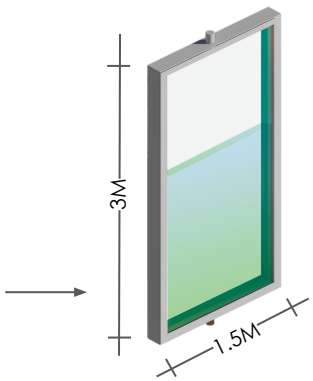


Fig. 5.2.1.4. **Water filled in Panel with Algae Particles through an Inlet and could be removed using the Outlet dispenser**

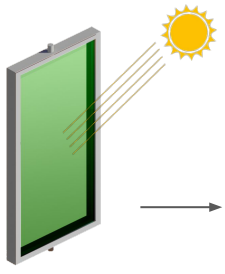


Fig. 5.2.1.5. **Growth of Algae and initiation of Photosynthesis**

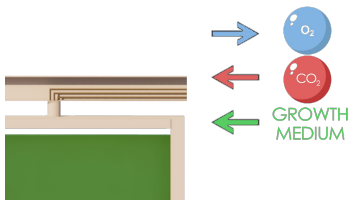


Fig. 5.2.1.6. **Photosynthesis process carried out with help of pipes & Biomass obtained as a byproduct that can be used a Fuel**

5.2.2. Vertical-axis wind turbine (VAWT) system

Need: A system that facetedly produces electricity on the premises through wind turbines and encourages children play

To generate electricity, a combination of small vertical-axis wind turbines and bamboo tubes is used to harness wind and mechanical energy, respectively. These turbines can catch wind from any direction and can be used alone or with solar panels to generate power. A bamboo tube play equipment has been designed for children to convert mechanical energy into electrical energy.

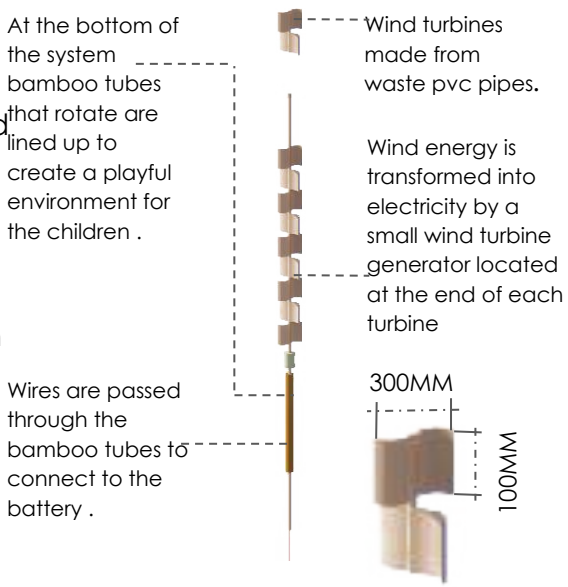


Fig. 5.2.2.1. **Wind Propelling Member Assembly**

1 WALL- 10,000 kilowatt-hours per year
1 VERTICAL ROD- 400 KWh per year
1 ROTATORY BLADE- **16 KWh** per year

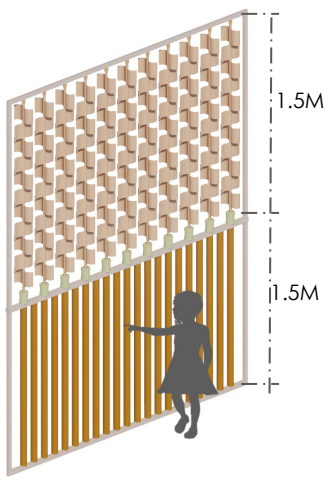


Fig. 5.2.2.2. **Wind Propelling Facade**

5. DESIGN DOCUMENTATION

5.2. Innovation

5.2.3. Rainwater Pods - Bloom

Fig. 5.2.3.1. **Form Inspiration from Foxtail Orchids, major Flower species in Assam**

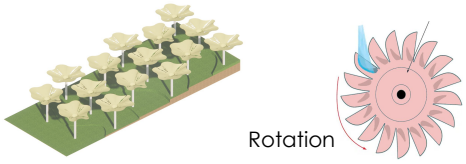


Fig. 5.2.3.2. **Runner rotates as the water moves down**

Need: A rainwater harvesting system designed to collect water during heavy rainfall, while also creating an interactive play area below.

A rainwater collection unit in Dhubri, inspired by the native Foxtail Orchid flower, serves a dual purpose of providing shelter and collecting rainwater. The structure features colored glass panels above, creating playful patterns for children to enjoy as the light disperses. The unit's asymmetrical flower pod design acts as the primary rainwater collector and filtration channel. Filtered water is pumped out through an outlet pipe and stored for future use at the school. With an average of 2363 mm of rainfall annually, this innovative system maximizes the water harvesting while celebrating the Foxtail Orchids.

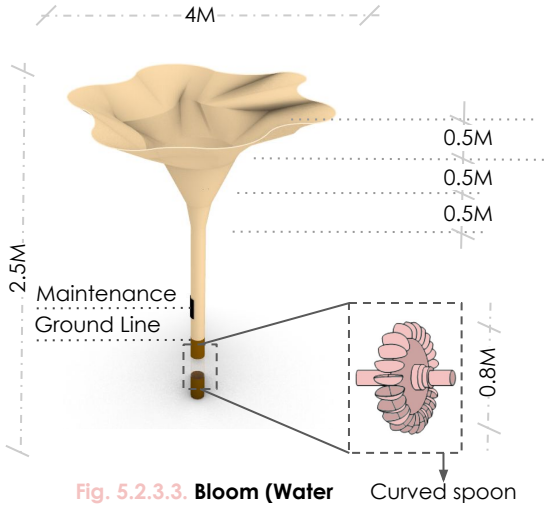


Fig. 5.2.3.3. **Bloom (Water Collecting Pods) Module**

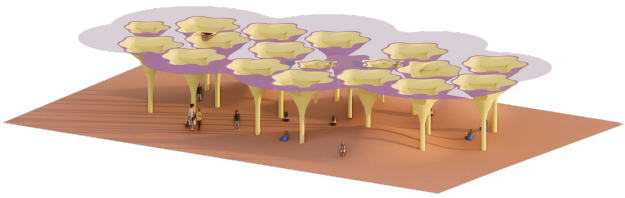


Fig. 5.2.3.4. **Bloom (Water Collecting Pods) in the playing space**

5.2.4. Flexible Furniture

Need: Stackable multipurpose movable furniture that caters to different age groups and people.

This piece of furniture serves as both an adjustable working table and a chair for people of various ages. The furniture has two panel sides that each function as a different piece of furniture and measures 60 cm X 120 cm. Two foldable legs on the backside can be folded in order to shut the table and pulled out to become a table. Pull-out panels on the opposite side can be pulled out to create a chair. Four panels, each measuring 29.5 cm X 60 cm, can be taken out separately to adjust the seating level. Axial channels are used along with a scissor joint mechanism to move the pull-out panels. As a result, the loads are handled by the metal frame mechanism. Also, since this furniture is stackable, it can be cleared out of the way to make clear space in classroom if necessary. This innovation resonates with the local idea of sitting on the ground while studying in a class and using the proposed product as a table while also providing an option of a conventional chair system when needed.

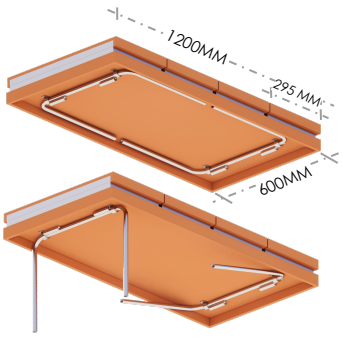


Fig. 5.2.4.1. **1. Flexible Furniture Panel 2. Openable Legs for the Foldable Table**

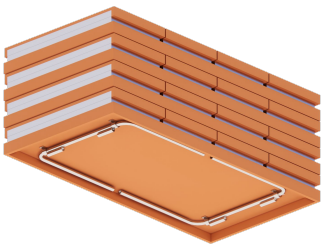


Fig. 5.2.4.2. **Stackable Furniture Panels**

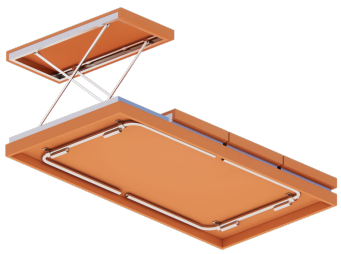


Fig. 5.2.4.3. **Openable Panels of the Furniture with Scissor Mechanism and Axial Channel**

Fig. 5.2.4.4. **Convertible Chair with Wooden Panel Placed as Seat & Visible Scissor Mechanism**

5. DESIGN DOCUMENTATION

5.2. Innovation

5.2.5. Education On Wheels

Need: A medium of bringing the children to the school premises as well as a hub for education. During calamities it would rescue and provide shelter to the victims.

The concept of "Education on Wheels" is put forth to make it easier for kids to get to school by providing transportation options and an area where they may study. The bus will transform into a mobile classroom during severe downpours and emergencies. This bus focuses on spreading awareness across Dhubri to empower "Education for Girls". Operational older buses, previously damaged by floods will be repaired and utilized. The interiors have been customized in addition to the seating, where a writing area and book storage have also been incorporated. In the event of a severe rise in flood water levels, the buses with higher suspension modification, will rescue the victims.

Fig. 5.2.5.1. **Local Buses**

Fig. 5.2.5.2. **Flood Wrecked Buses**

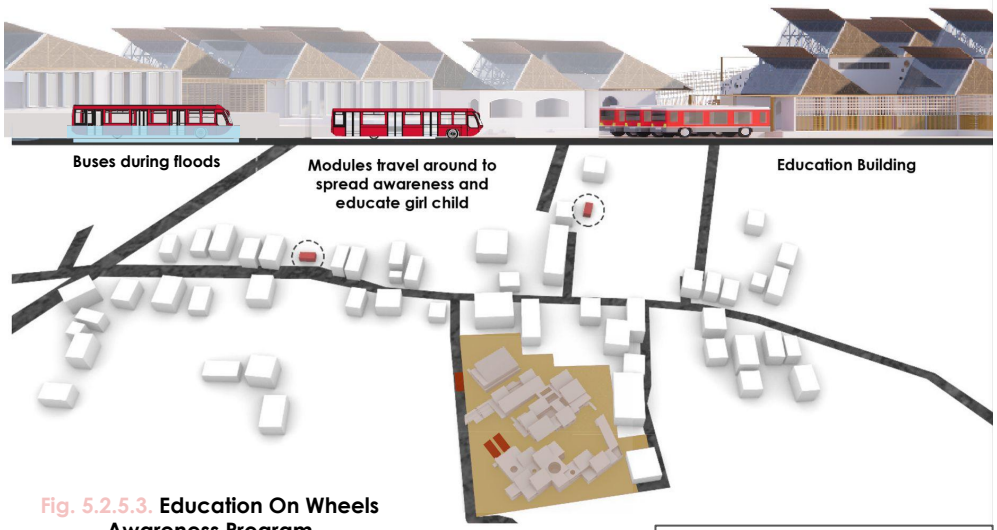


Fig. 5.2.5.3. **Education On Wheels Awareness Program**

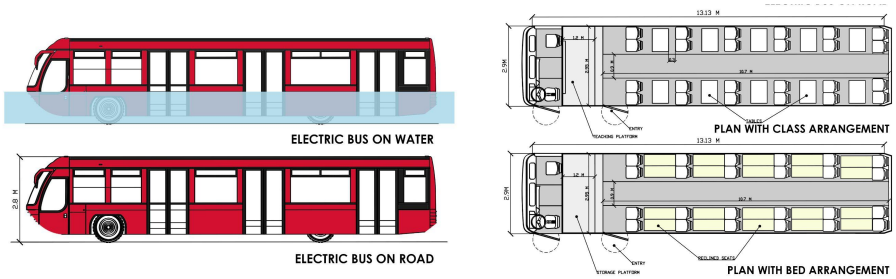


Fig. 5.2.5.4. **Design of the Buses Proposed**

5.2.6. UI/UX Designed App - Education Resilience On Wheels (EROW)

Need: A technological Intervention that would help in calling, sharing and facilitating the Education On Wheels - Buses by installing the application on their mobile phones.

This application streamlines services such as school pick-up and drop-off based on your location. It includes a calendar for school events, studio availability and seating options for women, handmade products for purchase, exhibition updates, and a calamity help call for buses. Users can access their profiles and a settings menu for basic set-up and app services.

Fig. 5.2.6.1. **EROW Interface**

5. DESIGN DOCUMENTATION

5.3. Energy Performance

5.3.1. On-site Renewable Energy Generation

5.3.1.1. Solar PV

Name: Panasonic Half-Cut, Mono-Crystalline Solar Panel
Efficiency: 20.7%
Dimensions: 2095 x 1039 x 35mm
Weight: 24.5 kg
Cost: ₹18,875 per panel.

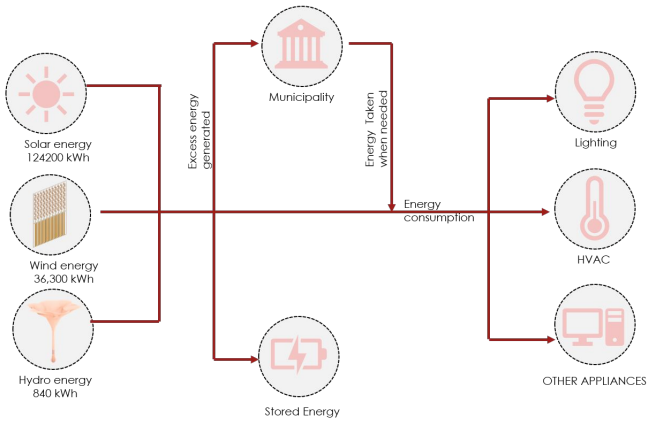


Fig. 5.3.1.1. **Energy Generation**

The school's roof has an angular profile that allows for north light openings. Solar panels can be directly placed on the roof with Panel Clamp System and without a tilted frame. The roof is angled at 30° as per the tilt needed for Solar PV panels.
The average annual radiation in Dhubri is **800Wh/m2**.

The Total Energy Generated is **1,24,200 kWh per year.**

AREA	SOLAR PANEL YIELD	ANNUAL AVG. RADIATION	PERFORMANCE RATIO	ENERGY GENERATED
A (m2)	r (%)	H (kWh/m2 annual)	PR	E (kWh per year)
1000	0.207	800	0.75	**124200 kWh per year**

Table 5.3.1.1.1. **Solar PV Energy Generation**

5.3.1.2. Wind Energy Generation

Vertical Axis Wind Turbines (VAWT) are designed to generate electricity from wind energy on the site's southwest side. The minimum wind speed required for turbine rotation is 10 kph; however, this wind speed is only available in Dhubri for 5 months per year, or 3600 hours.
Energy Generated by 1 turbine in a year(8760 hrs)= 16 kWh

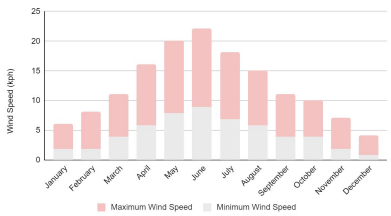


Fig. 5.3.1.2.1. **Annual Wind Speed**

Length of Facade	Height of Facade	Total Turbines in wall	Energy Generated by 1 Turbine	Energy Generated by Wall
m	m	1 turbine= 0.3 x 0.1m	3600 hrs of a year	3600 hrs of a year
132	1.5	6600	5.5	**36,300 kWh per year**

Table 5.3.1.2.1 **Wind Energy Generation**

5.3.1.3. Energy Generation From Bloom (Water Collecting Pods)

The innovation Bloom (Water Collecting Pods) can also be used to generate energy by placing a peloton wheel at the bottom of the pipe carrying water to the tank. The energy generated as a result is relatively low (only 1% of total energy generated).

Height of Pods	Surface area of a Pod	Surface area available for Pods	Total no. of Pods	Energy Generated by 1 Pod	Total Energy Generated
m	m^2	m^2		Watt	Watt per year
5.5	4.5	192	40	21	840 kWh per year

Table 5.3.1.3.1 **Hydel Power Energy Generation**

5. DESIGN DOCUMENTATION

5.3.2. Energy Consumption

Space Function	Area m²	Lumen Received	No. of Rooms	Power	No. of Lights	Hrs per day	Total Hrs	ENERGY CONSUMED
	m²	lux		Watt				kWh
Reception/ Waiting	32	200	1	18	8	9	2421	348.624
Admin	194	400	1	30	24	9	2421	1743.12
Staff Room	88	400	1	30	18	9	2421	1307.34
Classroom	54	400	10	35	100	9	2421	8473.5
Studios	47	400	4	35	24	9	2421	2033.64
Staircase	38	200	1	22	15	9	2421	798.93
Toilets	25	200	3	22	15	9	2421	798.93
Kitchen/ Dining	204	200	1	22	24	5	2421	1278.28
Auditorium	286	300	1	18	50	5	2421	2178.9
								18,961.27 kWh

Table 5.3.2.1. **Energy Consumption - Lighting**

Space Function	Area	No. of Rooms	Power	No. of Fans	Hrs per day	No. of days	Total Hrs	ENERGY CONSUMED
	m²		Watt					kWh
Reception/ Waiting	32	1	85	2	9	269	2421	435.78
Admin	194	1	85	8	9	269	2421	1743.12
Staff Room	88	1	85	2	9	269	2421	435.78
Classroom	54	10	85	20	9	269	2421	4357.8
Studios	47	4	85	8	9	269	2421	1743.12
Kitchen/ Dining	204	1	85	6	9	269	2421	1307.34
								10,022.94 kWh

Table 5.3.2.2. **Energy Consumption - Fans**

Appliances	Nos.	Power	Hrs per day	No. of days	Total Hrs	ENERGY CONSUMED
						kWh
Computers	35	300	9	269	2421	29657.25
Laptop	8	150	9	269	2421	2905.2
Projector	8	80	9	269	2421	2905.2
Printer	1	40	9	269	2421	96.84
Microwave	1	1000	9	269	2421	2421
Refrigerator	1	1500	24	269	6456	9684
Water Purifier	2	35	9	269	2421	217.89
						47,887.38 kWh

Table 5.3.2.3. **Energy Consumption - Other Equipments**

Appliances	Energy per km	Km travelled in 1 day	Total days	No. of buses	ENERGY CONSUMED
Electric bus	1.6	10	365	3	**17,520 kWh**

Table 5.3.2.4. **Energy Consumption - Electric Buses Charging**

Appliances	Nos. of 1.5 tons AC	Power	Hrs per day	No. of days	Total Hrs	ENERGY CONSUMED
HVAC	4	1500	9	269	2421	**14,526 kWh**

Table 5.3.2.5. **Energy Consumption - HVAC**

The annual energy consumption of school is **1,03,276.66 kWh**. The calculated **EPI is 30.4 kWh/m².** Target EPI for education building in a hot and humid climate is 38 kWh/m² (ECBC standards provided by Solar Decathlon).

We have used low energy fixtures and sensor lighting to reduce the energy consumption by **18.76% .**

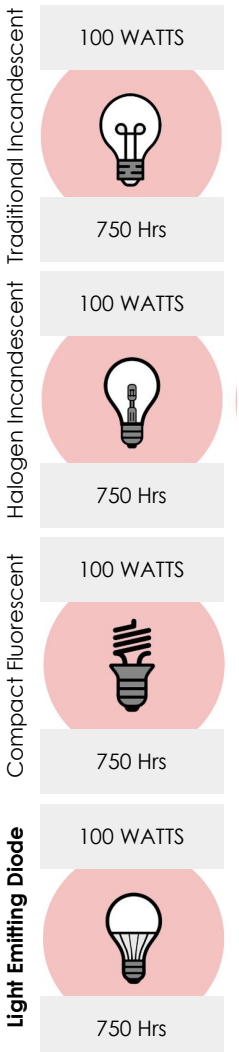


Fig. 5.3.2.1. **Comparing 1600 Lumen Light Fixtures**

5. DESIGN DOCUMENTATION

5.3.3. Energy Consumption and Energy Generation

FUNCTION	Power
Solar PV	124200
Wind Energy	36300
Hydro Energy	840
	1,61,340 kWh

Table 5.3.3.1. **Energy Generation**

FUNCTION	Power
Lighting	18,961.27
Fans	10,022.62
Other Appliances	42,246.45
HVAC	14,526
Electric Buses Charging	17,520
	1,03,276.66 kWh

Table 5.3.3.2. **Energy Consumption**

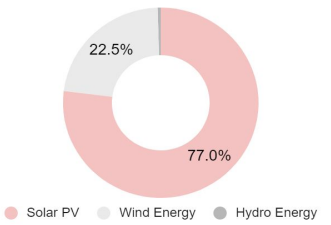


Fig. 5.3.3.1. **Energy Generation**

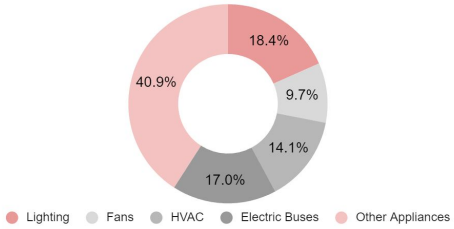


Fig. 5.3.3.2. **Energy Consumption**

The annual energy generated is **1,61,340 kWh.**

The total annual energy generated on site is greater than the annual energy consumed on site.

The energy generated is used majorly for Lighting, Fans, HVAC system and other equipments that are used in a school. The excess energy generated is sent back to the grid for electric units in return. We can utilize these units when energy generated is low.

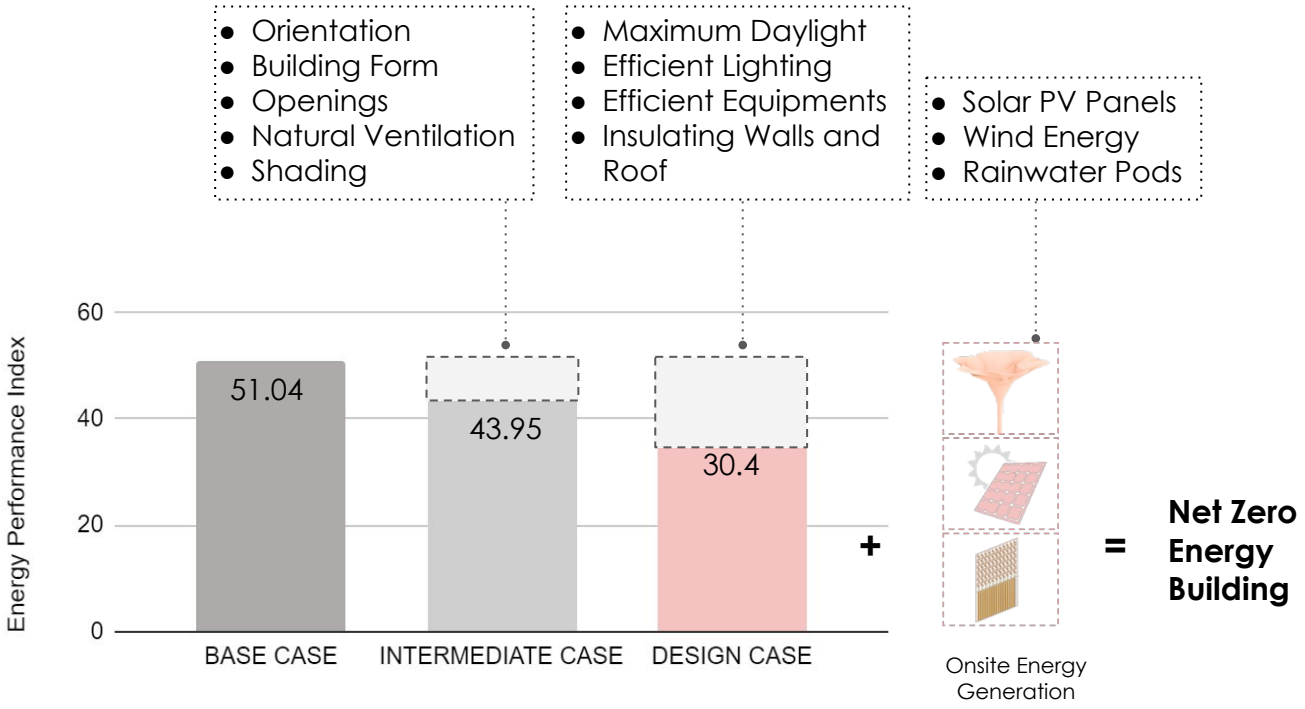


Fig. 5.3.3.3. **Reduction of EPI**

EPI is reduced from base case to design case by **30.05%.**

	Total Energy (kWh)	EPI (kWh/m2)
BASE CASE	1,49,573.57	51.04
INTERMEDIATE CASE	1,28,785.22	43.95
DESIGN CASE	1,04,616.25	30.4

Table 5.3.3.3. **EPI Calculated in different Cases**

EPI is calculated for various stages- base case, intermediate case, proposed case.
The energy load is reduced with the help of building form and orientation, natural ventilation, shading, optimum daylight, efficient lighting fixtures and efficient equipment.

5. DESIGN DOCUMENTATION

5.4. Water Performance

As per National building code 2017, Standard Water demand for one person is **45 LPD** (litres per day) for educational buildings. Proposed system aims to reduce the water usage by 49.55% with the use of low water flow fixtures.

5.4.1. Water Cycle Diagram

		CONSUMPTION						WATER SOURCES				
Month	Days in month	Domestic Use (L)	Cooling Use %	Cooling Use (L)	Irrigation Use %	Irrigation Use (L)	Total Consumption (L)	Ground Water (L)	Rainwater	Greywater (L)	Blackwater (L)	Total Stored
Jul	23	2,89,800	90%	0	50%	34,500	3,62,250	-	300000	14,490	3,47,760	77472
Aug	23	2,89,800	80%	0	50%	34,500	3,62,250	-	300000	14,490	3,47,760	99264
Sep	22	2,77,200	50%	0	50%	33,000	3,46,500	-	300000	13,860	3,32,640	133152
Oct	23	2,89,800	75%	0	30%	20,700	3,62,250	55,983	89073	14,490	3,47,760	0
Nov	22	2,77,200	20%	0	90%	59,400	3,46,500	2,66,112	0	13,860	3,32,640	0
Dec	23	2,89,800	0%	0	90%	62,100	3,62,250	2,78,208	0	14,490	3,47,760	0
Jan	23	2,89,800	0%	0	90%	62,100	3,62,250	2,78,208	0	14,490	3,47,760	0
Feb	20	2,52,000	20%	0	90%	54,000	3,15,000	2,33,986	7934	12,600	3,02,400	0
Mar	23	2,89,800	50%	0	90%	62,100	3,62,250	2,75,739	2469	14,490	3,47,760	0
Apr	22	2,77,200	90%	0	90%	59,400	3,46,500	1,51,685	114428	13,860	3,32,640	0
May	23	2,89,800	100%	0	90%	62,100	3,62,250	-	300000	14,490	3,47,760	21792
Jun	22	2,77,200	90%	0	90%	59,400	3,46,500	-	300000	13,860	3,32,640	55680
Total						**6,03,300**	**16,75,800**	**9,39,618**	**7,24,830**	**67,032**	**32,53,824**	**10,19,819**

Table. 5.4.1.1. **Water Demand, Harvesting, Usage and Gray Water Generation & Usage**

5.4.2. Water Usage

Water is majorly used for toilets and washbasins in the school for a total of 269 days. Water is also used in kitchen and for certain workshops.

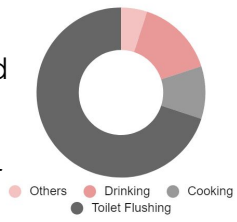


Fig. 5.4.2.1. **Water Consumption**

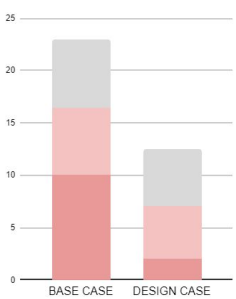


Fig. 5.4.2.2. **Water Efficiency**

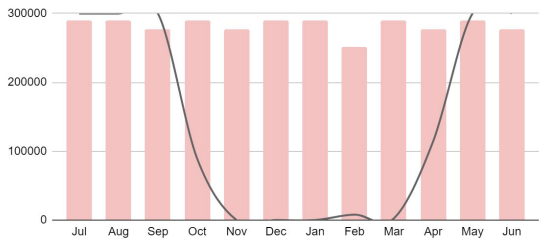


Fig. 5.4.2.3. **Water Consumption & Rainwater Harvested**

Water use	Quantity	Liters/day
Occupants : {People x l/person}	350	45
Irrigation (max) : {m2 x l/m2}	2000	1.5

Table. 5.4.2.1. **Water Usage**

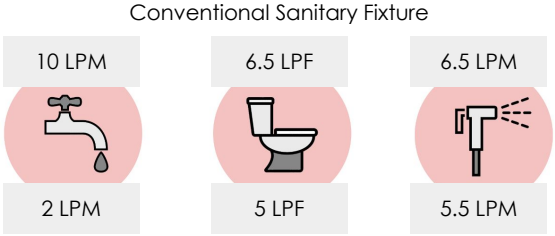


Fig. 5.4.2.4. **Flow & Flush of Sanitary Fixtures**

5. DESIGN DOCUMENTATION

5.4.3. Grey & Black Water Use & Discharge

Grey water is collected from wash basins, cooking, and other sources and directed to the grey water treatment tank. The treated grey water is then routed to flushing tanks and used to flush toilets. The wastewater from toilets is treated further and used for landscaping. Water completes its entire site cycle.

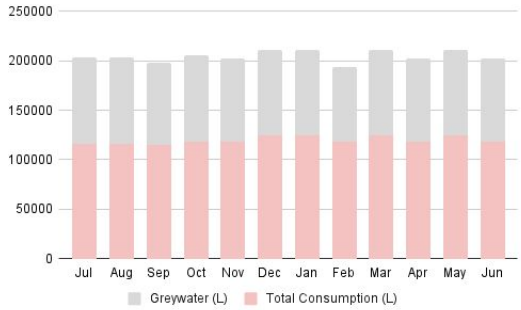


Fig. 5.4.3.1. **Water Consumption and Grey Water Treatment**

End Use	Percent use	Use in LPD	Greywater in LPD	Blackwater in LPD
Others	8%	1260	630	630
Drinking	12%	1890		1,512
Cooking	10%	1575		1,260
Toilet Flushing	70%	11025		8,820
Total		**15750**	**630**	**15,120**

Table 5.4.3.1. **Generated Grey & Black Water**

Fig. 5.4.3.2. **Schematic Section Recycling Grey & Black Water**

5.4.4. Rainwater Harvesting

Rainwater is collected from Rooftops, Flower pods, hardscape tiles is **7,24,830 L** annually. This caters to 49.55% of total water demand. This water is stored underground and utilised in non monsoon months.

Rainwater harvesting surfaces	Area m2	Runoff coefficient	Effective catchment area m2
Roof Surfaces	2630	0.85	2235.5
Hardscape areas	2100	0.70	1470
Softscape areas	200	0.0	0
Total Effective catchment area			**3705.5**

Table. 5.4.4.1. **Rainwater Harvesting Catchment Area**

5.4.5. Water Cycle System

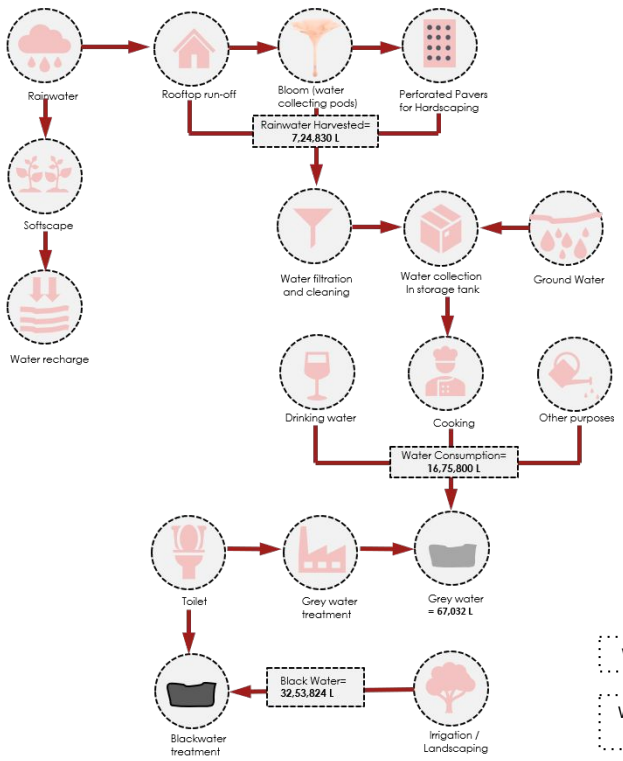


Fig. 5.4.5.1. **Water Cycle Diagram**

Fig. 5.4.5.2. **Rainwater Harvesting Layout**

5. DESIGN DOCUMENTATION

5.5. Embodied Carbon:

5.5.1. Due to Materials:

Carbon footprint of the building calculated with the help of design builder is 898.9 kg-CO2 e. To reduce the carbon footprint, we opted for unconventional low-emission materials like Bamcrete, GGBS, and Clay Plaster. We incorporated bamboo shingles and clay plaster walls, which not only absorb microbial matter and algae but also contribute to air purification by absorbing greenhouse gases. By using locally sourced bamcrete, which utilizes bamboo reinforcement, we were able to reduce the building's carbon footprint. Furthermore, we replaced steel with bamboo reinforcement and Ordinary Portland Cement with GGBS in the concrete mixture, resulting in a 78.31% reduction in carbon footprint. This reduction is a significant step towards achieving a **NET-Zero Carbon Emission** building.

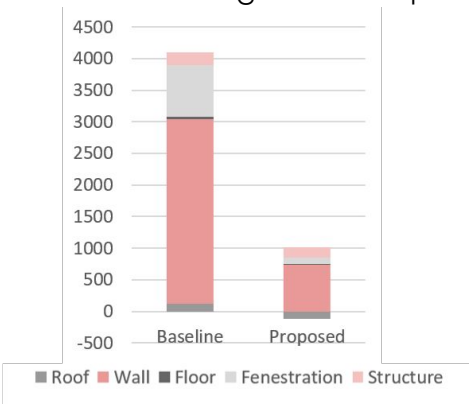


Fig. 5.5.1. **Embodied Carbon Comparison**

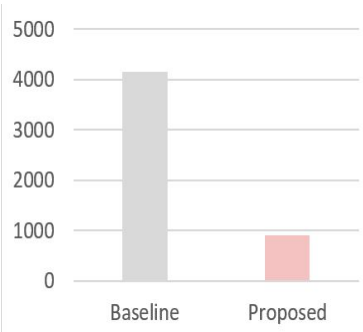


Fig. 5.5.2. **Embodied Carbon Analysis**

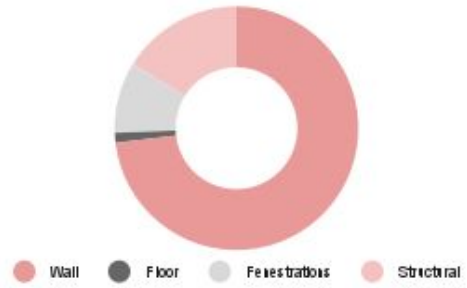


Fig. 5.5.3. **Embodied Carbon Distribution**

USE	BASE CASE		DESIGN CASE	
	Material	Carbon Emission	Material	Carbon Emission
Concrete Mixture	Portland Cement	950	GGBS	150
Reinforcement	Steel Reinforcement	870	Bamboo Reinforcement	690
Wall	Brick Wall	180	Bamcrete Wall	70
Window Frame	UPVC	110	Aluminium	160
Plaster	Gypsum Plaster	173	Clay Plaster	119

Table 5.5.1. **Carbon Emissions Of Different Materials of Both cases**

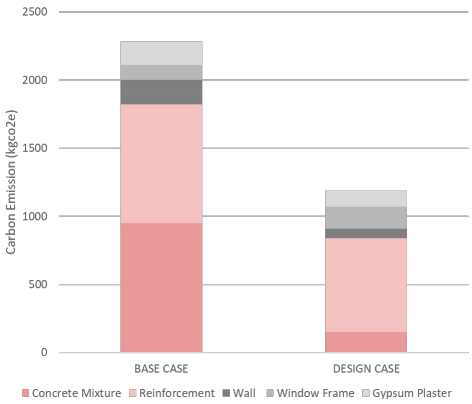


Fig. 5.5.4. **Carbon Footprint of different Material**

System Type	Baseline				Design			
	Material emissions (kg-CO2 e)	Transport 1 (kg-CO2 e)	Transport 2 (kg-CO2 e)	Total (kg-CO2 e)	Material emissions (kg-CO2 e)	Transport 1 (kg-CO2 e)	Transport 2 (kg-CO2 e)	Total (kg-CO2 e)
Wall	2910.8	6	12.3	2929.1	713.8	7	19	739.8
Roof	165.9	0.2	0.3	166.4	-114	0.2	0.4	-113.4
Floor	39.7	0.1	0.1	39.9	13.1	0.1	0.1	13.3
Fenestrations	808.8	0.1	0.1	809	95.7	0	0.1	95.8
Structural	200	0.4	1.2	201.6	161.8	0.4	1.2	163.4
	Grand Total emissions per functional unit (kg-CO2 e)			**4146**	Grand Total emissions per functional unit (kg-CO2 e)			**898.9**

Table 5.5.2. **Carbon Emissions Of Base Case and Design Case**

5. DESIGN DOCUMENTATION

5.6. Resilience:

Renewable Energy Sources

Increasing the deployment of renewable energy sources like solar, wind, and biomass can provide power even during a grid outage and increase energy resilience in flood-prone areas like Dhubri.

Raising Plinth Level

In case of flooding in future, food will not get damaged due to higher kitchen plinth level.

Rainwater Harvesting

The aim is to maximize the use of harvested rainwater in proposed case and reduce the ground water consumption.

Fig. 5.6.1. **Climate-smart interventions to enhance water, energy and food security (e.g. rainwater harvesting, solar panels, renewable energy, thermal comfort).**

Reusing Paper

Recycled paper can be made in the workshop and utilized to create stationery items related to paper, helping to conserve natural resources such as wood, water, and energy.

Energy Availability

Using energy efficient and self sufficient system which will work even during power outage.

Adaptive Thermal Comfort

The 'life-expectancy' of passively cooled design is managed by maintaining internal heat gains through courtyards.

5. DESIGN DOCUMENTATION

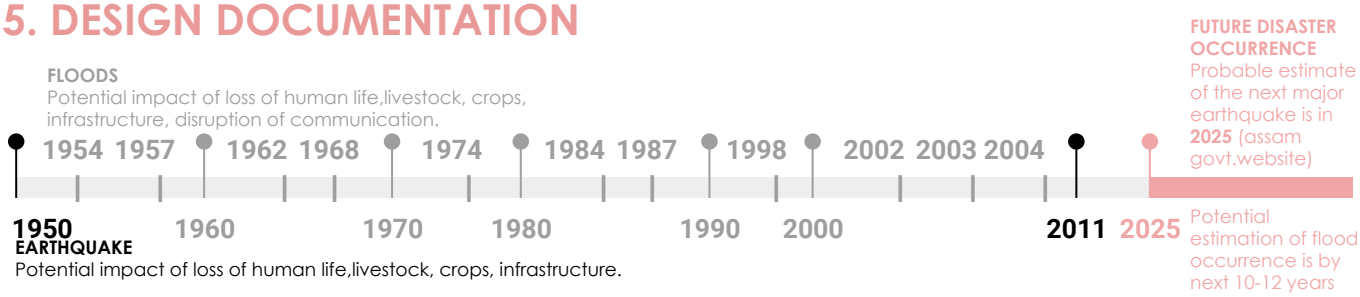


Fig. 5.6.2. **Natural Calamity Timeline**

5.6.1. Earthquake Resilience

Ground Improvement: We have used a stepped footing method, in which ground improvement is carried out around the stepped footing constructed in soft ground or ground subjected to liquefaction. This method uses a combination of stepped footing with commonly used ground improvement methods, such as deep mixing and preloading.

Isolated Base/Shock Absorbers:
We have used a base isolation system in our footing where we are protecting our structure by decoupling our superstructure from substructure. The load transfers from the column to the plinth slab and then to stepped footing through PCC Step. The shock absorbers are placed between the Plinth and the PCC Step to resist the dynamic forces by isolating the substructure from the superstructure.

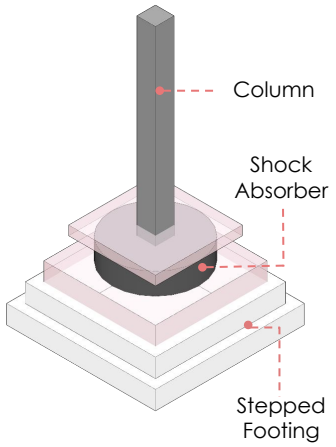


Fig. 5.6.1.1. **Shock Absorbers between Plinth and PCC Step with Stepped Footing**

5.6.2. Flood Resilience

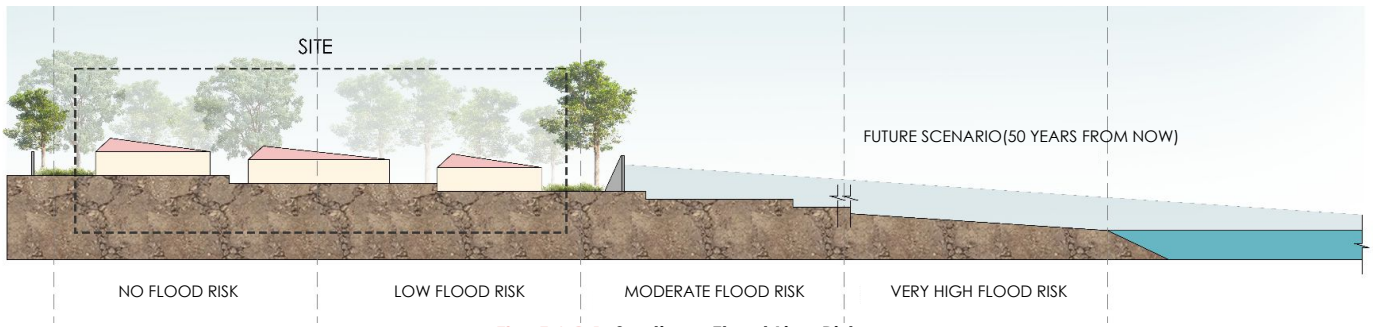


Fig. 5.6.2.1. **Section - Flood Line Risks**

This school has been proposed with the aim of educating locals on how to deal with natural calamities. The school offers shelter for flood victims in the district, together with "education on wheel" buses available for evacuation, education and awareness programs during the time of crisis. This proactive disaster management of evacuating the victims and giving them shelter during the demonstrates a commitment to community protection.

5.6.3. Fire Resilience

Compliant with Assam Fire Service Rules-1989, our building has a six-meter wide fire escape route and open ground access. Students will be trained on fire safety and follow established protocols. Fire extinguishers and sand buckets are placed at regular intervals for added safety.

Fig. 5.6.3.1. **Fire Tender Movement & Escape Layout**

5. DESIGN DOCUMENTATION

5.6.4. Community Resilience

Due to the fear of extreme circumstances, especially for women, according to population census 2011, the literacy rate in Dhubri is quite low, and parents hesitate to send their daughters to school. In order to address this issue, a proposed institution would be a primary school exclusively for girls, which would provide a multiutility space for them to engage in economic activities during non-school hours.

Additionally, the facility could also serve as accommodation during times of crisis.

The school administration would adopt a menstrual hygiene scheme called "Freedays" (National health mission) to promote better personal sanitation among adolescent girls.

This initiative helps in educating young girls about pad - making which in a future perspective would remain with them as a learning throughout their life. This would a positive impact on girls' quality of life and offers a glimmer of hope for those in rural community.

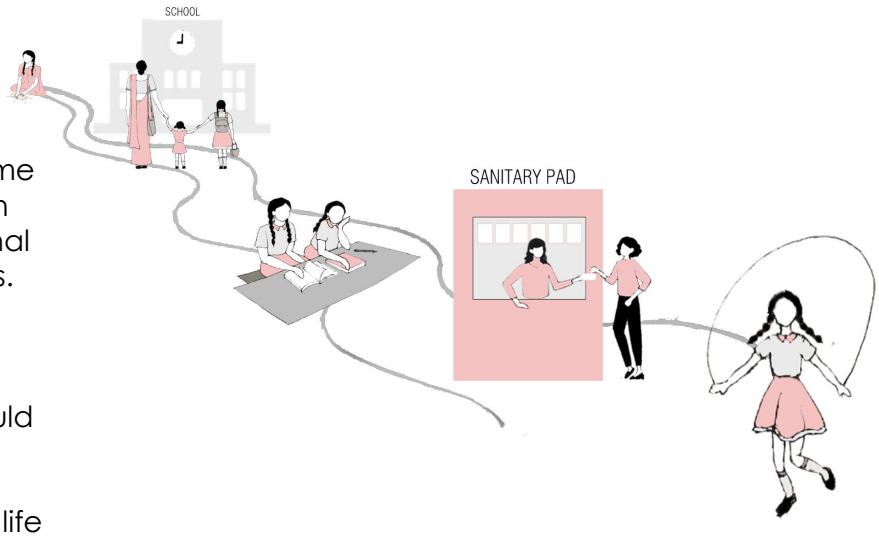


Fig. 5.6.4.1. **Community Resilience**

5.6.5. Economic Resilience

The school in Dhubri encourages traditional crafts such as cloth weaving, bamboo weaving, and embroidery. Women are given the opportunity to learn and develop their skills while achieving financial stability through pop-up stores. As a girls' education center, a program has been initiated to teach women trainees, how to make sanitary pads and spread the word to females in their homes and communities. This would also help the female community monetize these products.
This not only creates awareness and appreciation for their crafts but also empowers them, increasing their confidence, self-assurance, and resilience. The school promotes their overall personal and social development, beyond just earning a livelihood.

Fig. 5.6.5.1. **Economic Resilience**

5. DESIGN DOCUMENTATION

5.7. Engineering & Operations:

The structural design for this campus has been done in compliance with the soil conditions of Dhubri and load calculations using ETABS Ultimate. The design is an IS-456 Code complaint and has been done for two grades of concrete: M20 and M25 and reinforcement of Fe-415 according to the use in the structural element.The design employs a typical cuboidal footing and a typical column section of **300X300mm** in the entire project.

5.7.1. Structural Stability:

We have done an error-free analysis of the Bending Moment & Shear Force Analysis of our structure with zero errors and our structure is stable for basic loads and dynamic loads.

5.7.2. Material:

In footing and column we have used concrete of **M25** grade with **50% replacement of cement** by GGBS (Ground Granulated Blast Furnace Slag) which will reduce Carbon Emission level.

In Beam and Slab we have used concrete of **M20** grade with **50% replacement of cement** by GGBS (Ground Granulated Blast Furnace Slag) which will reduce Carbon Emission level.

5.7.3. Plinth Ductile Detailing:

We have given plinth ductile detailing to provide adequate toughness and ductility, to resist severe earthquake shocks without collapse.

5.7.4. Bamboo Bracing:

We have used Bamboo X-Bracing in the bamcrete walls to keep building stable during seismic events, such as earthquakes. It also limits building's lateral movement, reducing the likelihood of damage to the structure components.

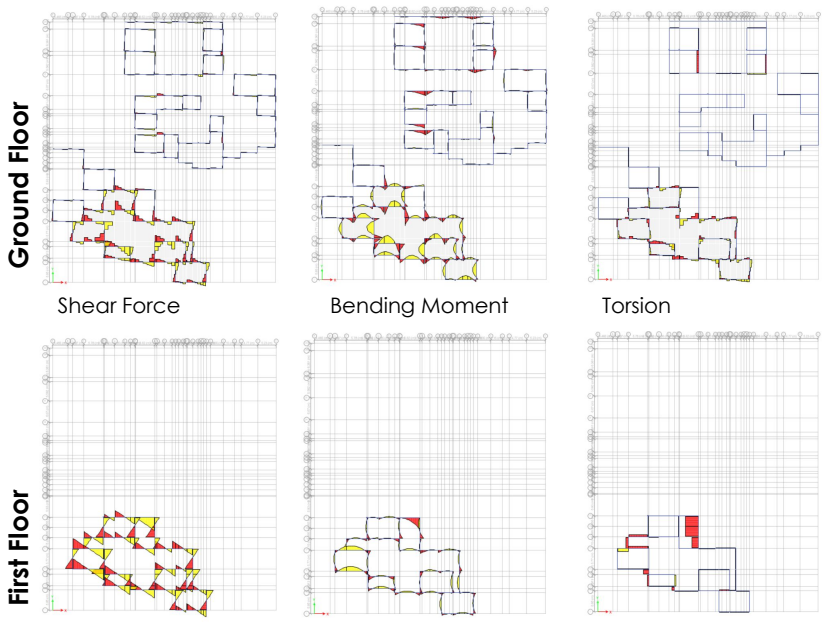


Fig. 5.7.1.1. **Stability Analysis by S.F., B.M., and Torsion for Structural Grid**

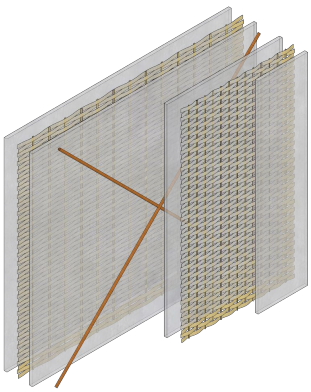


Fig. 5.7.4.1. **Bamboo Bracing**

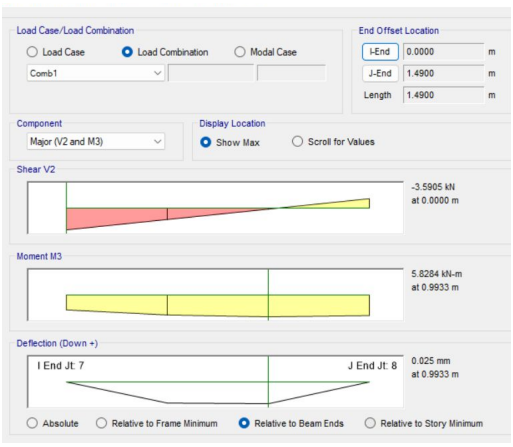


Fig. 5.7.1.2. **Stability Analysis by S.F., B.M., and Deflection for One Grid**

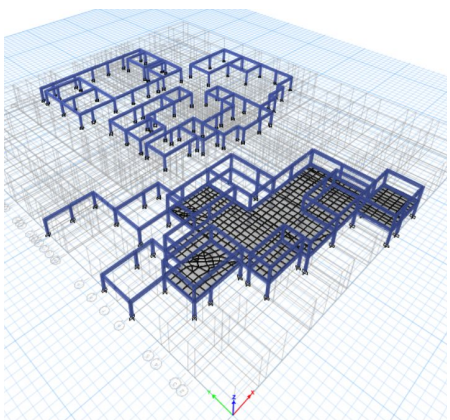


Fig. 5.7.1.3. **3D View of Framed Structure**

5. DESIGN DOCUMENTATION

5.7.5. Heating, Ventilation and Air Conditioning (HVAC)

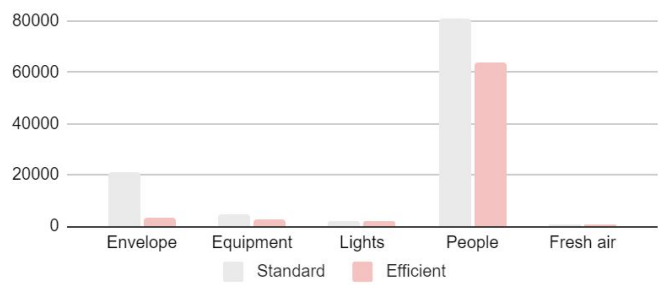


Fig. 5.7.5.1. **Heat Gain From Various Factors**

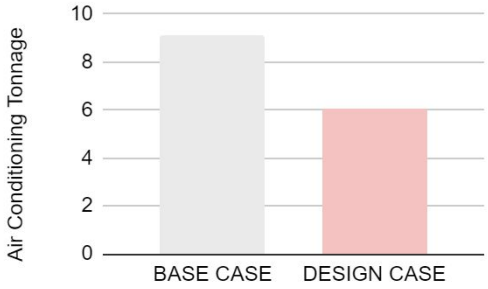


Fig. 5.7.5.2. **HVAC Load Reduction**

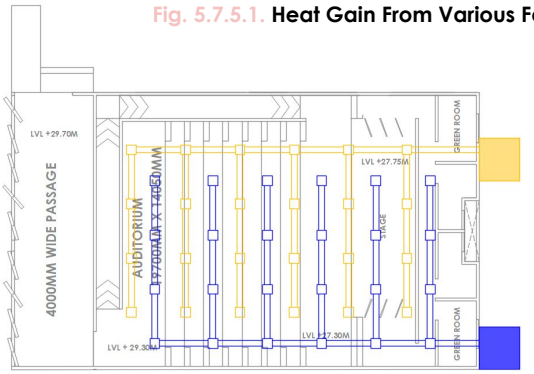


Fig. 5.7.5.3. **Auditorium HVAC Layout**

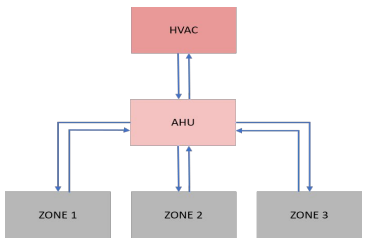


Fig. 5.7.5.4. **HVAC Diagram**

BASE CASE	
Total Room Sensible heat	45861
Total Room Latent heat	27139
Grand total heat, BTU/hr	73000
AIR CONDITIONING TONNAGE	6.08

Table 5.7.5.1. **Base Case : Cooling Load Calculations**

DESIGN CASE	
Total Room Sensible heat	72401
Total Room Latent heat	37039
Grand total heat, BTU/hr	109440
AIR CONDITIONING TONNAGE	9.12

Table 5.7.5.2. **Design Case : Cooling Load Calculations**

The cooling load of the building is being reduced by using passive design strategies and providing openings strategically. **Air-cooled HVAC** system with **MERV-13** filters is used for cooling the Admin and Auditorium.

5.7.6. Solid Waste Management System

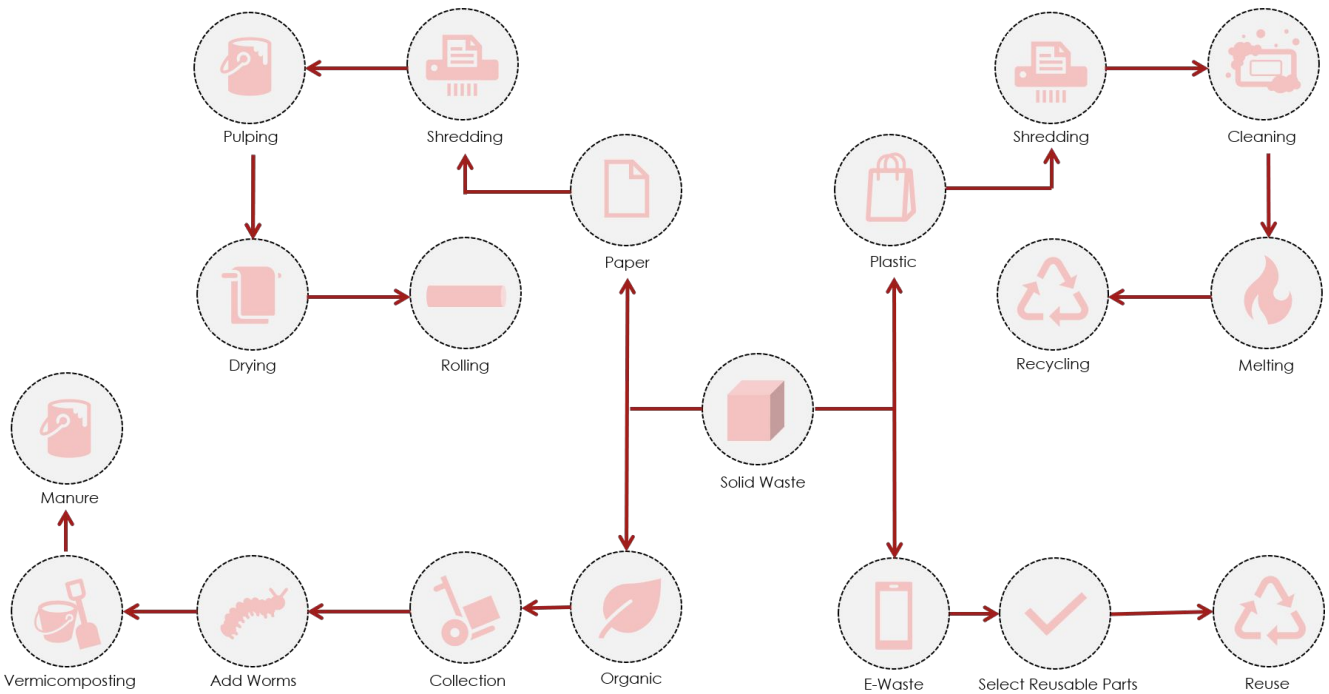


Fig. 5.7.6.1. **Solid Waste Management System**

5. DESIGN DOCUMENTATION

5.8. Health And Wellbeing

5.8.1. Thermal Comfort Optimization

The graph below confirms that the relative humidity levels fall within the established comfortable range (40% to 60%) as derived by ASHRAE guidelines during the occupied hours (8am to 5pm) of the building.

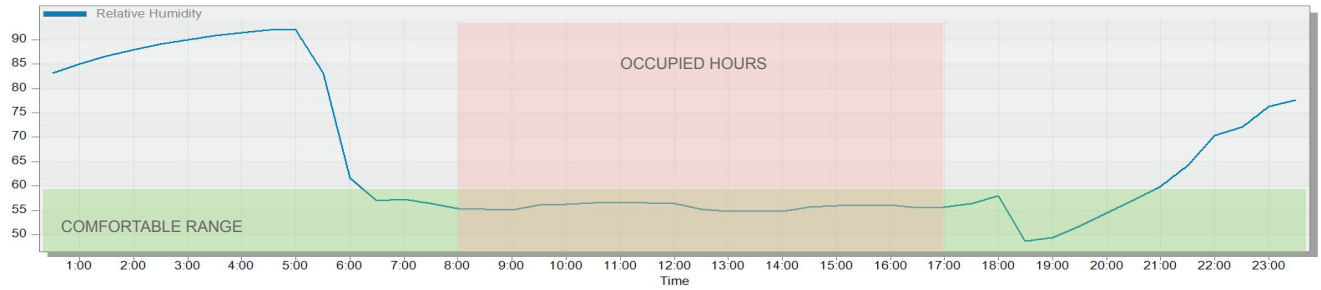


Fig. 5.8.1.1. **Relative Humidity and Occupied Hours**

A monthly thermal comfort band for the entire year was derived. This band gives a range of acceptable indoor operative temperatures.

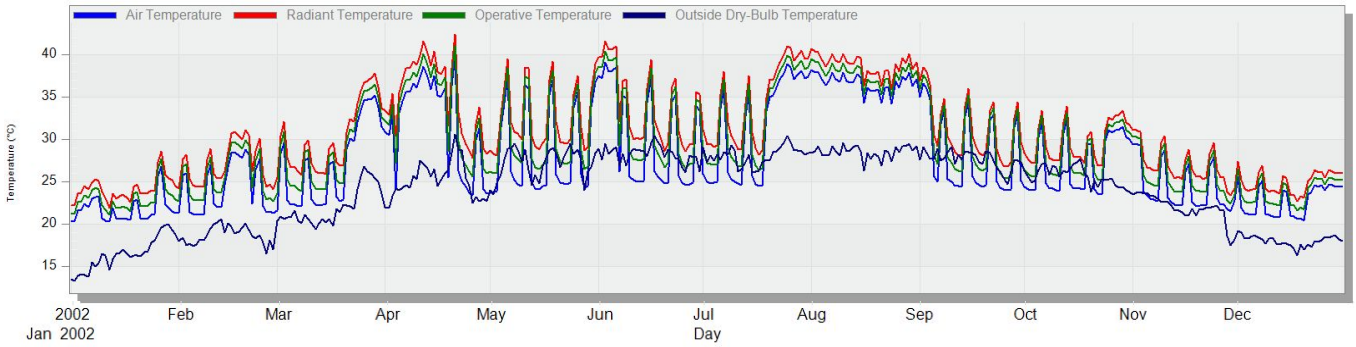


Fig. 5.8.1.2. **Simulated Temperatures**

5.8.2. Computational Fluid Dynamics (CFD) Analysis

CFD analysis was done for a typical classroom using design builder .
Due to addition of passive strategies (design case 1), exterior shading devices and using fans (proposed case) for ventilation the indoor temperatures were brought down to comfortable levels (23 to 26 degree celsius according to ASHRAE).

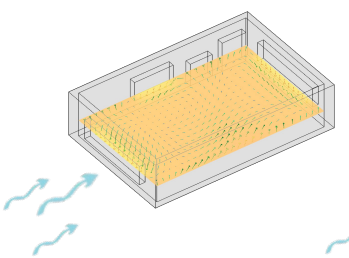


Fig. 5.8.2.1. **Base case**

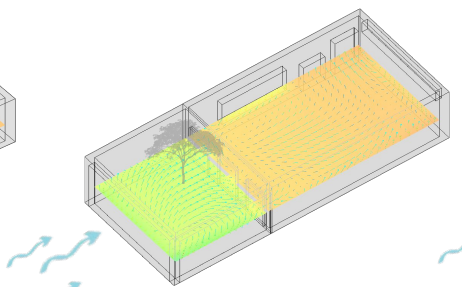


Fig. 5.8.2.2. **Intermediate Case**

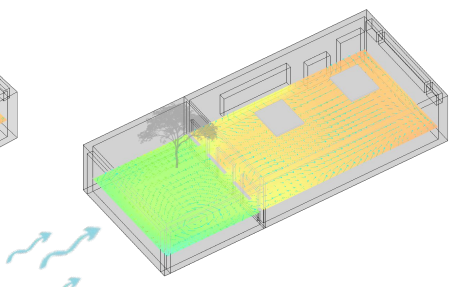
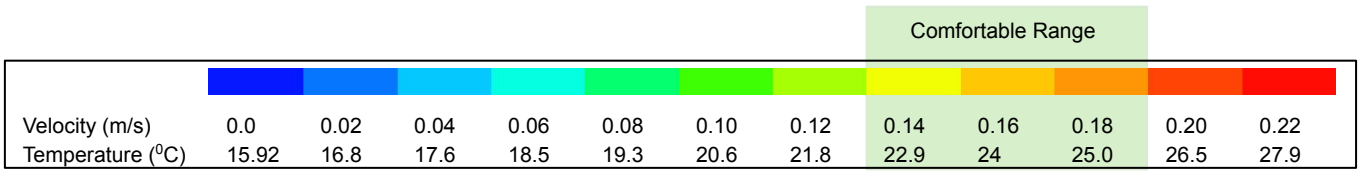


Fig. 5.8.2.3. **Design case**



5.8.3. Day-Light Analysis

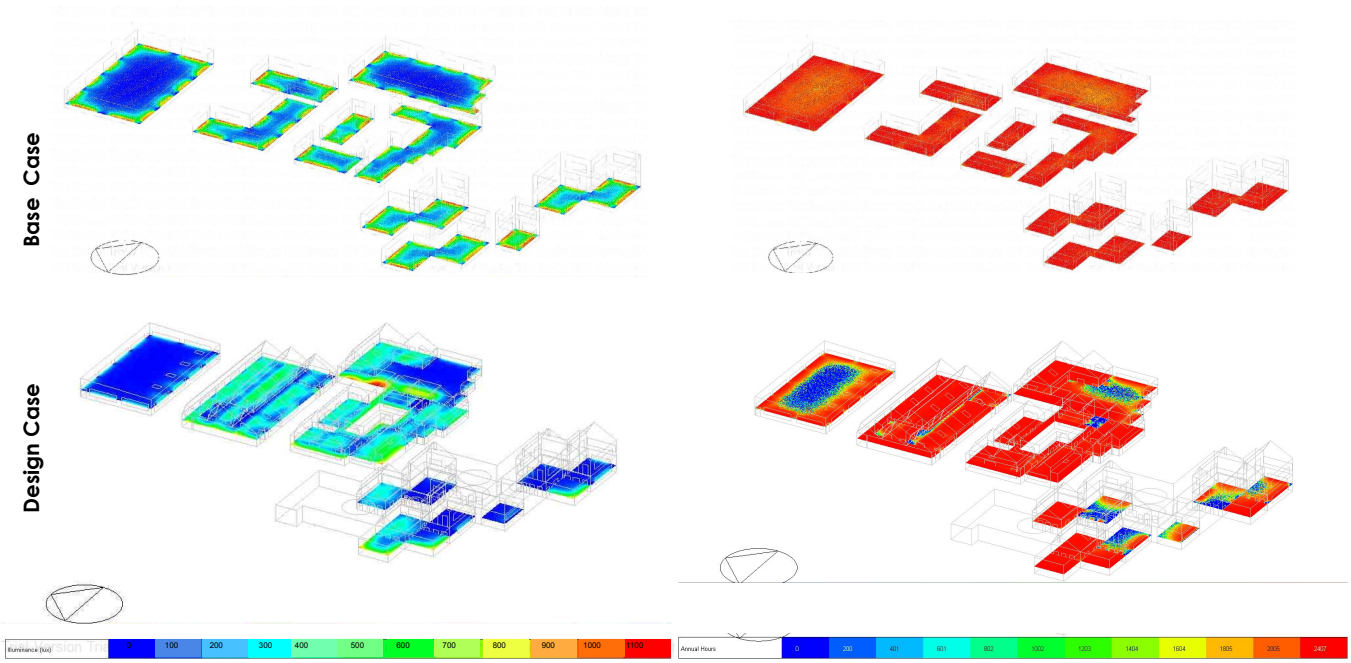


Fig. 5.8.3.1. **Daylight Factor**

Fig. 5.8.3.2. **Annual Hours - Sunlight**

Through the use of simulations in Design Builder, we were able to meet the energy performance objectives of the building. To enhance natural lighting and minimize heat loads, we made adjustments to the building envelope, enabling greater diffusion of light while reducing glare. By optimizing the window-to-wall ratio (WWR) at 30% and considering the local climate and sunlight conditions, we ensured ample daylight for reduced lighting needs while maintaining thermal comfort.

5.8.4. Solar radiation

The incident radiation analysis provided evidence for the use of solar panels on the south facing roofs .The incident radiation on the interior spaces is minimized by shading the openings , leading to a reduction in indoor temperatures.

Fig. 5.8.4.1. **Incident Solar Radiation**

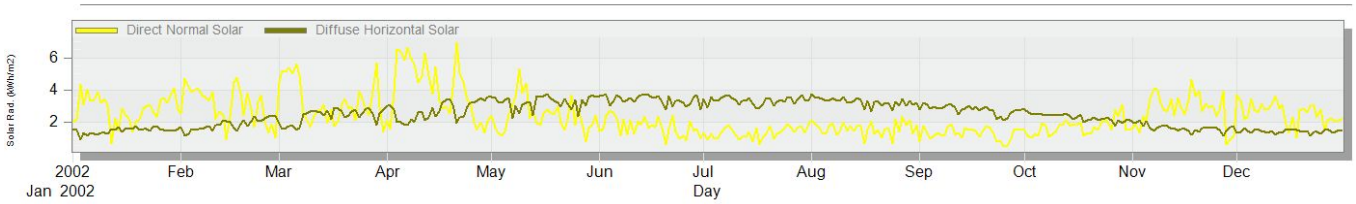


Fig. 5.8.4.2. **Solar Radiation**

5.8.5. Comfortable Annual Hours

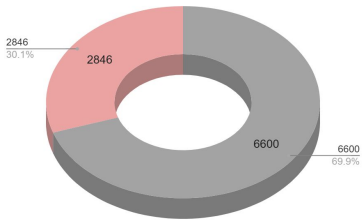


Fig. 5.8.5.1. **Base case**

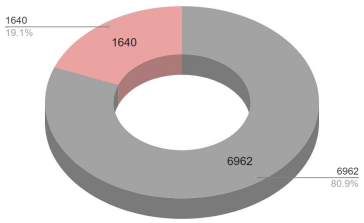


Fig. 5.8.5.2. **Proposed case**

Base case comfortable annual hours were 67% and after incorporation of the mentioned materials and passive strategies, comfortable annual hours amount to 81% (ASHRAE)

Comfortable Hours

Uncomfortable Hours

5.8.6. Comfort Optimization

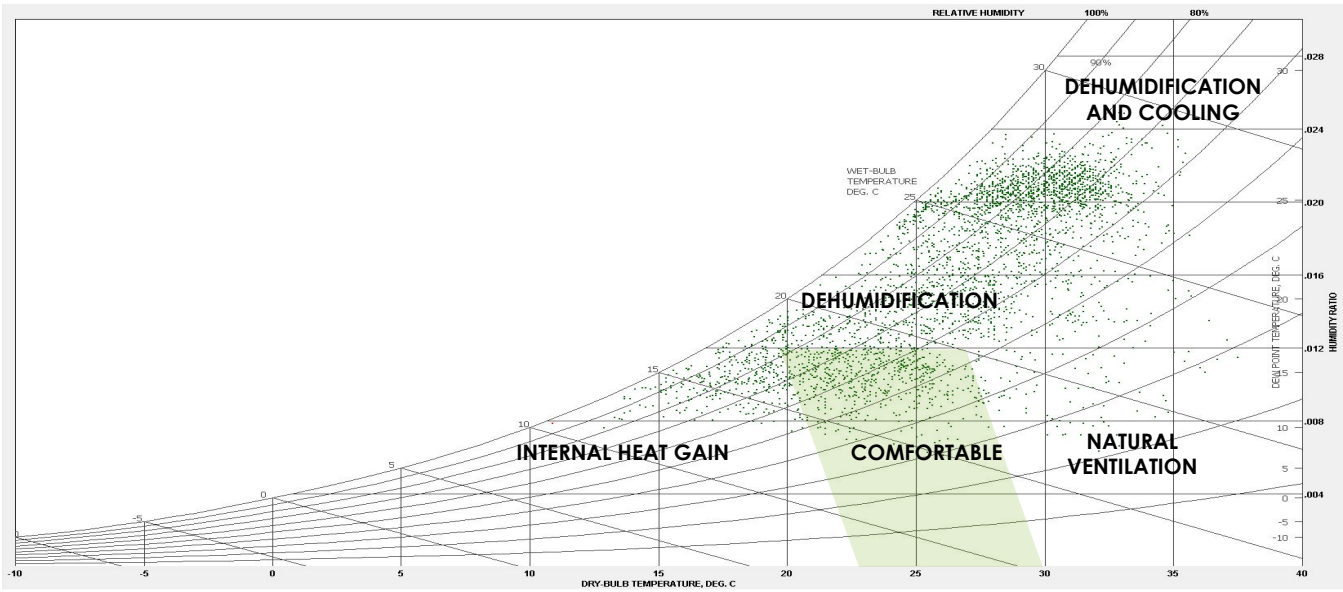


Fig. 5.8.6.1. **Psychrometric chart Base case**

An annual comfort band was derived for the occupied hours by using climate consultant .

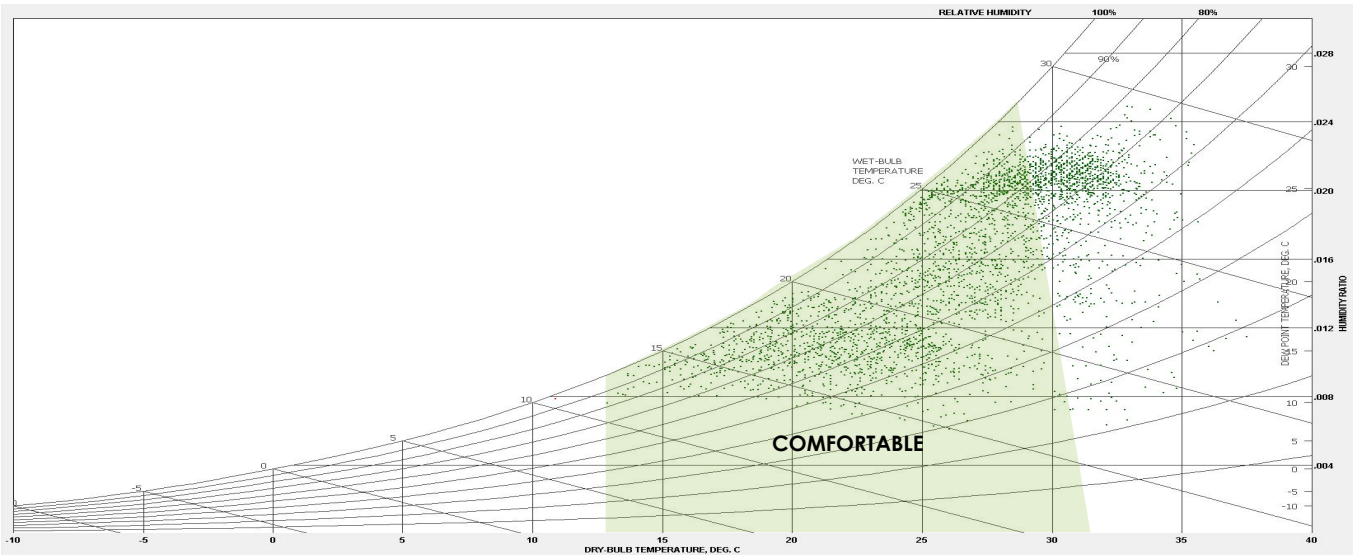


Fig. 5.8.6.2. **Psychrometric chart - Design case**

A series of passive cooling and dehumidification strategies were employed, resulting in an increase of the comfort zone from 17% to 56%.

5. DESIGN DOCUMENTATION

5.9. Value Proposition

5.9.1. Intangible Aspects

5.9.1.1. Women Inclusive Program

The entire initiative is designed to be gender-inclusive so that women who attend the Samaya Gurukul for vocational training can leave their kids in the classrooms or the daycare while they learn. In this way, the project improves the lives of the women while also giving them the chance to participate in something similar if they were unable to do so for other reasons, such as childcare duties.

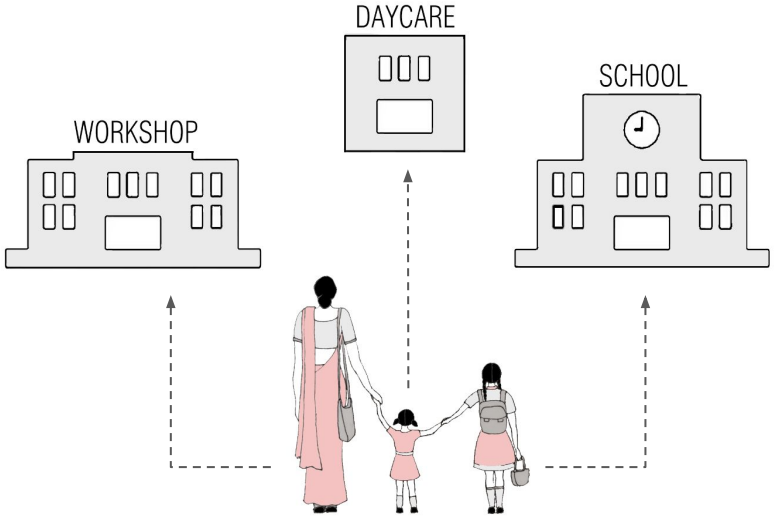


Fig. 5.9.1.1.1. **Women Inclusive Program**

5.9.1.2. Safeguarding Local Arts and Crafts

The vocational training is designed to engage women in tasks related to traditional crafts including weaving, bamboo weaving, and embroidery, among others. This would not only assist in resurrecting local crafts but also in giving them a platform where they could be produced, valued, and sold, ultimately assisting in generating income.

Fig. 5.9.1.2.1. **Embroidery & Bamboo Basket Weaving**

5.9.1.3. Recycling Paper Waste

Recycled paper is made in the workshop and utilized to create stationery items like books etc. that are made out of paper. Since it is a primary school, it is subjected to a lot of paper scraps and recyclable used paper. Making recycled paper will thereby reduce the production of dry waste and the need for new paper supplies.

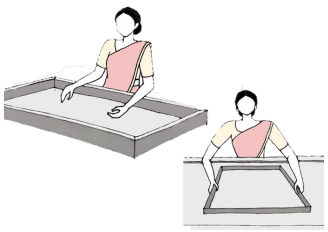


Fig. 5.9.1.3.1. **Recycled Paper Making**

5.9.1.4. Secular Interaction Space

By placing a facility of this kind nearby, it improves the likelihood of interaction between members of various communities, regardless of their religion, caste, or economic status, and so contributes to greater socio-cultural unification. Thus, induce a feeling of socio-cultural harmony and make it safer from a societal standpoint.

Fig. 5.9.1.4.1. **Socio-Cultural Harmony**

5.9.2. Tangible Aspects

5.9.2.1. Space for Appreciation & Exhibition

Along with the workshop studios, there is also an exhibition area where the goods manufactured by the women can be seen and appreciated. This platform aids in increasing women's self-assurance about their abilities and work & restitutes for the women's long overdue lack of recognition.

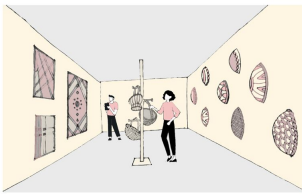


Fig. 5.9.2.1.1. **Exhibition Space**

5.9.2.2. Land Value Appreciation & Densification of Nearby Areas

After completion of this project, the nearby areas would become more inviting and the amenities in the neighborhood would start developing. As a result, the area would become safer and less remote. Also, this will eventually have an impact on land values and urban economics.

5. DESIGN DOCUMENTATION

5.10. Affordability

The design case estimate **is greater than 80.0 million / 800 lakhs** to the baseline estimate due to added cost of installations specifically innovative design such as algae panels,VAWT and energy efficient equipments and a major cost of the solar panels on the roof (after inclusion of 40% subsidy due to solar farming techniques from government) helps to increase the building performance as compared to the base case.
The base case was a 'Conventional RCC framed structure with brick walls.'

Project Summary

Project Project Information

Team:	LENS				
Division:	Educational Building		**Land Cost:**	45	Million INR
Site Area (sqm)		8,482	**City:**	Dhubri	
Built-up Area (BUA) (sqm)		2,800	**State:**	Assam	
Ground Coverage (Plinth Area) (sqm)		2,500			

S.No.	Particulars	Definition	Baseline Estimate (Project Partner / SOR basis)			Proposed Design Estimate		
			Amount (Million INR)	%	Amount (INR per sqm)	Amount (Million INR)	%	Amount (INR per sqm)
1	Land	Cost of land purchased or leased by the Project Partner	45.00	21.4%	16,071	45.00	17.1%	16,071
2	Civil Works	Refer Item A, Civil works in Cost of construction worksheet	102.96	49.1%	36,771	106.30	40.4%	37,964
3	Internal Works	Refer Item B, Civil works in Cost of construction worksheet	3.44	1.6%	1,229	4.34	1.6%	1,550
4	MEP Services	Refer Item C, Civil works in Cost of construction worksheet	6.80	3.2%	2,427		0.0%	-
5	Equipment & Furnishing	Refer Item D, Civil works in Cost of construction worksheet	5.28	2.5%	1,885	5.30	2.0%	1,893
6	Landscape & Site Development	Refer Item E, Civil works in Cost of construction worksheet	0.20	0.1%	72	60.93	23.1%	21,762
7	Contingency	Amount added to the total estimate for incidental and miscellaneous expenses.	5.93	2.8%	2,119	9.83	3.7%	3,509
	TOTAL HARD COST		**169.6**	**81%**	**60,576**	**231.7**	**88%**	**82,749**
8	Pre Operative Expenses	Cost of Permits, Licenses, Market research, Advertising etc	10.00	4.8%	3,571	10.00	4.8%	3,571
9	Consultants	Consultant fees on a typical Project	10.00	4.8%	3,571	10.00	4.8%	3,571
10	Interest During Construction	Interest paid on loans related to the project during construction	20.25	9.7%	7,234	11.72	5.6%	4,186
	TOTAL SOFT COST		**40.3**	**19%**	**14,377**	**31.7**	**15%**	**11,329**
	TOTAL PROJECT COST		**209.9**	**100%**	**74,952**	**263.4**	**100%**	**94,078**

Table 5.10.1. **Project Summary Cost Report**

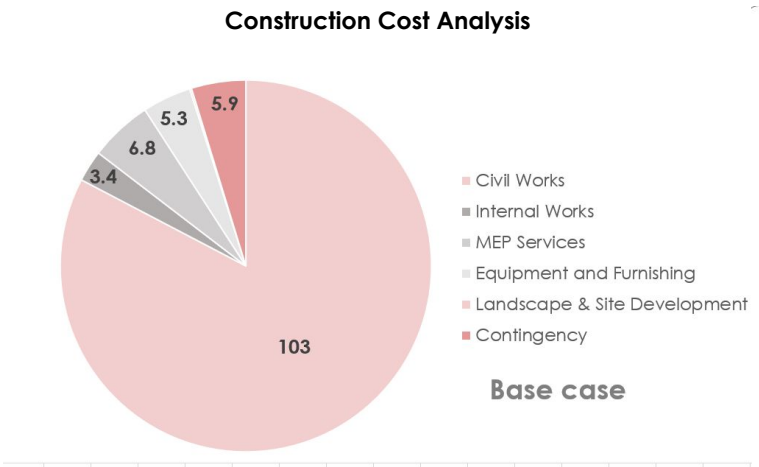


Fig. 5.10.1. **Base Case - 12.75 Crore Rupees**

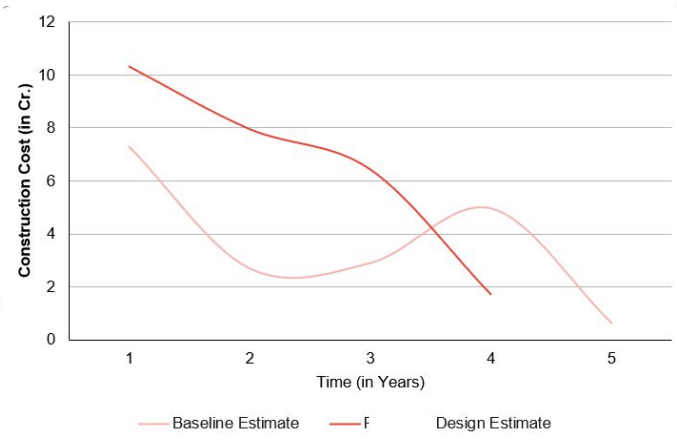


Fig. 5.10.2. **Financing Cost Analysis :**
S Chart determining cash flow during construction

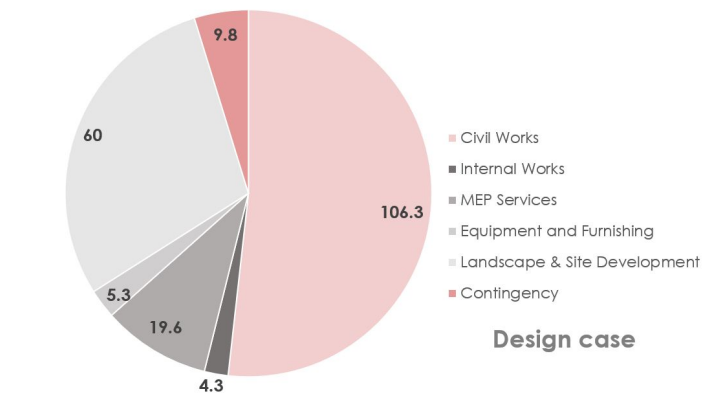


Fig. 5.10.3. **Proposed Design Case - 20.78 Crore Rupees**

Project Cost Assumptions

S.No.	Particulars	Amount (Millions)
	HARD COSTS	
1	Land Cost (Million INR)	45.00
2	Contingency (Million INR)	5%
	SOFT COSTS	
3	Pre Operative Expenses (Million INR)	10.00
4	Consultants (Million INR)	10.00
1	Debt	50.0%
2	Equity	50.0%
3	Debt to Equity Ratio	1.000
5	Interest Rate	10.0%

Table 5.10.2. **Financing Cost assumptions**

The cost of our project is initially estimated to be high, but over a period of 25 years would generate a significant amount of savings in money or energy by the Life cycle cost decrease of 143 million/ 1431 lakhs due to lower maintenance and energy costs.

5. DESIGN DOCUMENTATION

Total Time Period : 4 Years

Scope of work	Year 1				Year 2				Year 3				Year 4				Year 5			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Land																				
Base Case																				
Design Case																				
Civil Works																				
Base Case																				
Design Case																				
Internal Works																				
Base Case																				
Design Case																				
MEP Services																				
Base Case																				
Design Case																				
Equipment & Furnishing																				
Base Case																				
Design Case																				
Landscape & Site Development																				
Base Case																				
Design Case																				
Contingency																				
Base Case																				
Design Case																				
Pre-Operative Expenses																				
Base Case																				
Design Case																				
Consultants																				
Base Case																				
Design Case																				

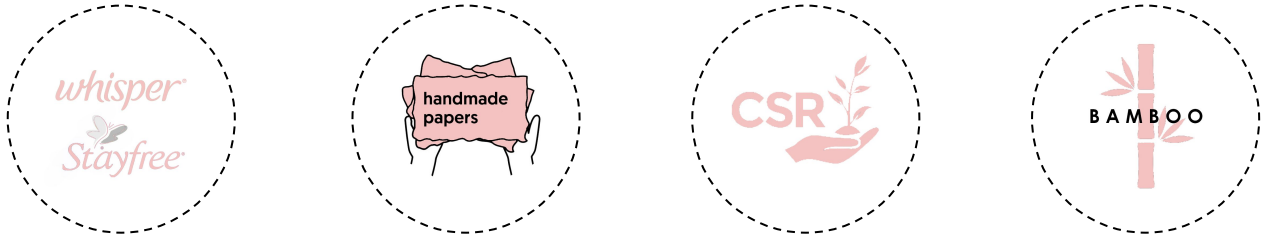
Fig. 5.10.4. **Project Timeline - Gantt Chart based on S Chart Cost analysis**

5.10.1. Market Potential

As per Amalgamation Plan 2022, 56 schools in Dhubri were amalgamated with nearby schools to achieve a standard teacher-pupil ratio of 10:1 for primary level (according to the Ministry of Education, India), optimum services of the employees, saving administrative cost and other logistic support for the schools. It is found that:

1. There are existing schools but the enrollment and attendance ratio has been poor.
2. Only about 37% of the schools have provision for desk for the students.
3. More than 50% of the schools do not have proper infrastructure, lacking basic facilities like light, benches, blackboards, workshops, skill development areas and many more.

Our local environment is still growing in terms of educational infrastructure and currently lacks basic facilities. Hence, our proposal would cater to the demands of the target population and will entice the intended market. It includes attracting - sanitary pad production (as our centre focuses on its production), other major profit making companies that require handcrafted items. Various bamboo workshops that take place in the auditorium open to all, also play an important role in attracting people from other cities or countries.



Sanitary napkin companies | Handcraft companies | Corporate social responsibility | Bamboo workshop in auditorium open to all

Fig. 5.10.1.1. **Potential Target Market**

6. APPENDIX

6.1. Detailed Area Program

BASE CASE - AREA STATEMENT		
	TOTAL AREA (sq.mtrs.)	REMARK
ADMIN SPACES	300	Unconditioned
LEARNING SPACES	750	Unconditioned
COMMON SPACES	800	Unconditioned
AUDITORIUM	350	Conditioned
TRANSITION SPACES	600	Unconditioned
TOTAL	2800	

Table 6.1.1. **Brief Area Statement**

DESIGN CASE - AREA STATEMENT					
	SPACES	NO.	AREA(sq. mtrs.)	TOTAL AREA (sq.mtrs.)	REMARK
ADMIN SPACES	WAITING AREA	-	as per design	-	Unconditioned
	ADMIN ROOM	1	25	25	Unconditioned
	PRINCIPAL'S CABIN	1	25	25	Unconditioned
	DIRECTOR'S CABIN	1	20	20	Unconditioned
	ACCOUNTANCY CABIN	1	30	30	Unconditioned
	STAFF ROOM	1	70	70	Unconditioned
	NON TEACHING STAFF ROOM	1	25	25	Unconditioned
	MEETING ROOM	1	30	30	Unconditioned
	STATIONERY SHOP	1	30	30	Unconditioned
	INFIRMARY (MEDICAL AND TREATMENT FACILITIES)	1	45	45	Unconditioned
LEARNING SPACES	CLASSROOM	8	50	400	Unconditioned
	MUSIC / DANCE ROOM	1	50	50	Unconditioned
	COMPUTER LAB	1	50	50	Unconditioned
	GARDENING AREA FOR CLASS 1,2,3	3	40	120	Unconditioned
	TOILETS	2	40	80	
COMMON SPACES	AUDITORIUM (for public and students both)	1	350	350	Conditioned
	DAYCARE	1	80	80	Unconditioned
	DINING + KITCHEN	1	250	250	Unconditioned
	EXHIBITION AREA(for 18+ women)+STUDIOS	1	450	450	Unconditioned
TRANSITION SPACES		20 % OF FSI	600	600	Unconditioned
TOTAL				2800	

Table 6.1.2. **Detail Area Statement**

6. APPENDIX

6.2. Incorporating Innovations

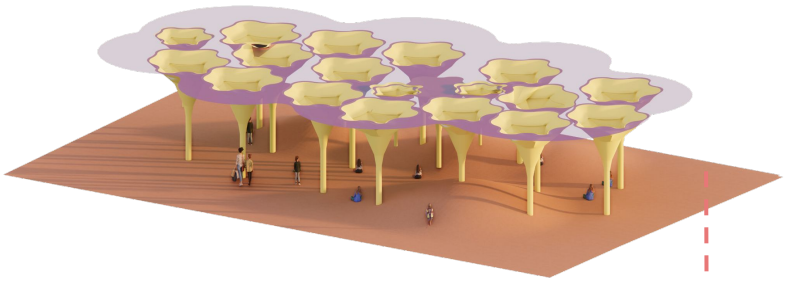


Fig. 6.2.1. **Bloom (Water Collecting Pods)**

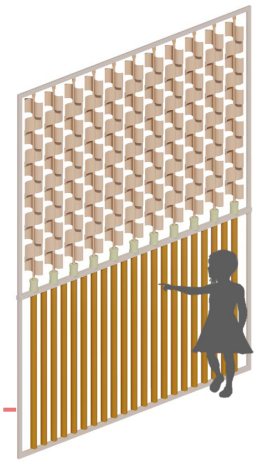


Fig. 6.2.2. **Vertical Axis Wind Turbine(VAWT)**

Fig. 6.2.5. **Isometric View**

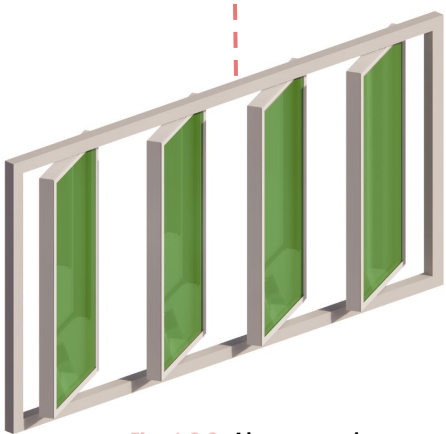


Fig. 6.2.3. **Algae panel**

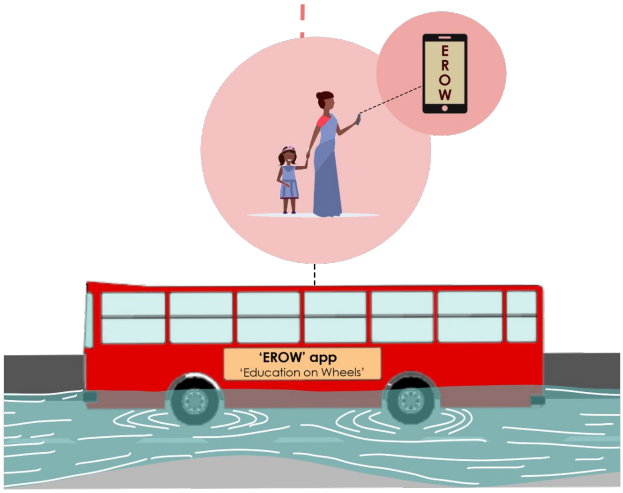


Fig. 6.2.4. **Education on Wheels with Education Resilience on Wheels App (EROW)**

6. APPENDIX

6.3. Engineering drawings

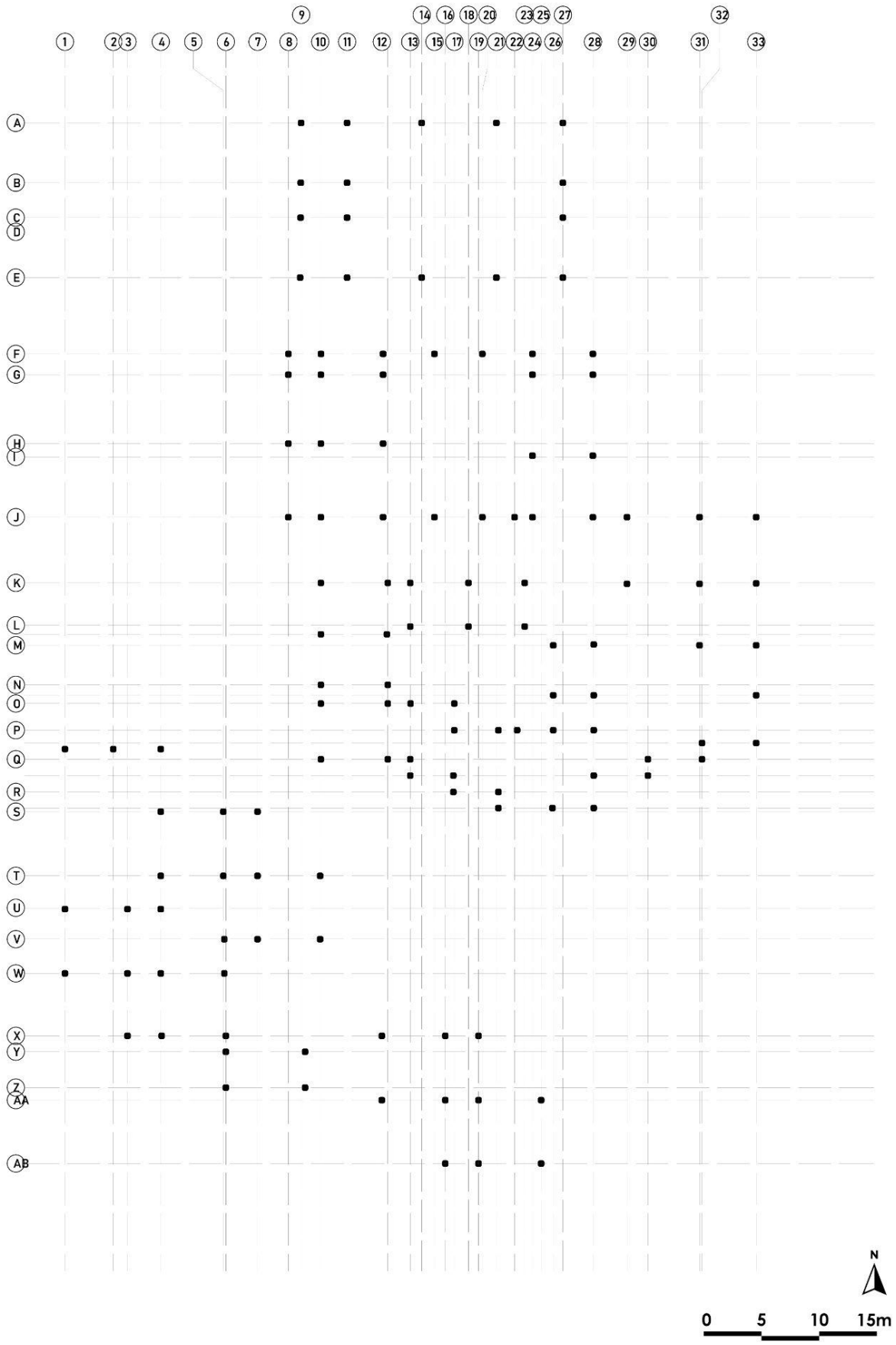


Fig. 6.3.1. **Centre Line Plan and Column Layout**

6. APPENDIX

6.4. Performance Specifications - Input & Output Parameters

INPUT PARAMETERS	Units	Proposed Design Values
GENERAL		
Building Area	m²	2930
Conditioned Area	m²	568
Electricity Rate	INR/kWh	5.3
Natural Gas Rate	INR/GJ	-
Building Occupancy Hours		9:00am to 5:00pm
Average Occupant Density	m² / person	10.46428571
INTERNAL LOADS		
Interior Average Lighting Power Density	W/m²	1172
Average Equipment Power Density	W/m²	12.23
ENVELOPE		
Roof Assembly U value	W/m².K	1.4
Roof Assembly SRI		35
Average Wall Assembly U value	W/m².K	0.143
Window to Wall Area Ratio (WWR)	%	0.23
Windows U value	W/m².K	2.5
Windows SHGC		0.25
Windows VLT	%	85
HVAC SYSTEM		
HVAC System Type and Description		Air Cooled HVAC system
Cooling Capacity	kW	47.47
Operation Hours		9
PROPOSED EUI	kWh/m²/ yr	
EUI Breakdown by End Use		
Lighting	kWh/m²/ yr	6.47
Cooling	kWh/m²/ yr	41.5
Fans	kWh/m²/ yr	3.42
Equipment	kWh/m²/ yr	5.97
Electric Buses Charging	kWh/m²/ yr	14.4
ENERGY GENERATION		
Solar PV Panels	kWh/yr	1,24,200
Wind Energy	kWh/yr	36.300
Bloom- rainwater collecting pods	kWh/yr	840

Table 6.4.1. **Input & Output Parameter**

6. APPENDIX

6.5. Cost Summary Estimate

Project Summary

Project Project Information

Team:	LENS				
Division:	Educational Building		**Land Cost:**	45	Million INR
	Site Area (sqm)	8,482	**City:**	Dhubri	
	Built-up Area (BUA) (sqm)	2,800	**State:**	Assam	
	Ground Coverage (Plinth Area) (sqm)	2,500			

S.No.	Particulars	Definition	Baseline Estimate (Project Partner / SOR basis)			Proposed Design Estimate		
			Amount (Million INR)	%	Amount (INR per sqm)	Amount (Million INR)	%	Amount (INR per sqm)
1	Land	Cost of land purchased or leased by the Project Partner	45.00	21.4%	16,071	45.00	17.1%	16,071
2	Civil Works	Refer Item A, Civil works in Cost of construction worksheet	102.96	49.1%	36,771	106.30	40.4%	37,964
3	Internal Works	Refer Item B, Civil works in Cost of construction worksheet	3.44	1.6%	1,229	4.34	1.6%	1,550
4	MEP Services	Refer Item C, Civil works in Cost of construction worksheet	6.80	3.2%	2,427		0.0%	-
5	Equipment & Furnishing	Refer Item D, Civil works in Cost of construction worksheet	5.28	2.5%	1,885	5.30	2.0%	1,893
6	Landscape & Site Development	Refer Item E, Civil works in Cost of construction worksheet	0.20	0.1%	72	60.93	23.1%	21,762
7	Contingency	Amount added to the total estimate for incidental and miscellaneous expenses.	5.93	2.8%	2,119	9.83	3.7%	3,509
	TOTAL HARD COST		**169.6**	**81%**	**60,576**	**231.7**	**88%**	**82,749**
8	Pre Operative Expenses	Cost of Permits, Licenses, Market research, Advertising etc	10.00	4.8%	3,571	10.00	4.8%	3,571
9	Consultants	Consultant fees on a typical Project	10.00	4.8%	3,571	10.00	4.8%	3,571
10	Interest During Construction	Interest paid on loans related to the project during construction	20.25	9.7%	7,234	11.72	5.6%	4,186
	TOTAL SOFT COST		**40.3**	**19%**	**14,377**	**31.7**	**15%**	**11,329**
	TOTAL PROJECT COST		**209.9**	**100%**	**74,952**	**263.4**	**100%**	**94,078**

Table 6.5.1. **Project Summary - Cost Estimate**

6. APPENDIX

6.6. Letter Of Confirmation Project Partner

Karunar Kheti Trust
Public Charitable Trust under Indian Trusts Act 1882 (serial/deed number: 3818/2470)
Registered under sections 12A and 80G of the Income Tax Act, 1961
PAN AAETK0174H
Boisahabi TE, Selenghat PO, Jorhat, Assam 785636
Website: www.karunarkhetitrust.org, E-mail: karunarkhetitrust@gmail.com
Cell Phone: +91-6000963387

8 October 2022

To,
The Director
Solar Decathlon India

Dear Sir,

This is to inform you that our organization **Karunar Kheti Trust** has provided information about our **A School For The People, By The People** project to the participating team led by SMEF's Brick School of Architecture, so that their team LENS 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 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 Project Partners for the 2022-23 Challenge.

With warm regards,

Arjun Trivedi
Digitally signed by Arjun Trivedi
Date: 2022.10.08 16:26:30 +05'30'

Name of Representative: Dr Arjun Trivedi

Designation: Founder & Executive Director

Email: arjun.trivedi@karunarkhetitrust.org

Phone: +91-6000963387

6. APPENDIX

6.6. Letter Of Confirmation Industry Partner

VK:e environmental

To,

The Director,
Solar Decathlon India

6-10-2022

Dear Sir,

This is to inform you that our organisation, VK:e environmental, is collaborating with the participating team led by SMEF's Brick School of Architecture on a Educational Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be your help regarding factors like affordability, constructability, and innovation. We would also like to have your review on our work and in decision making regarding the same.

We would like have a representative from our organisation 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,

VK:e environmental LLP
5th Floor Nextgen Avenue S. No.103 (P) Bahiratwadi. Near ICC Tower S. B. Rd., Pune-16

Name: - Ar. Kanchan Sidhaye
Designation: - Sr. Associate
Mail ID: -VK:e environmental LLP
Email: - ksidhaye@vke-environmental.com
Contact No: - 9423506729

Page 1 of 1
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5th Floor, Next Gen Avenue, Off. Senapati Bapat Rd, Pune, Maharashtra 411016 | Email: mail@vke-environmental.com Phone: +91 20 6626 8888 | www.vke-environmental.com An ISO:9001 Company

6. APPENDIX

6.7. Bonafide Certificates

Satish Misal Educational Foundation's
BRICK
SCHOOL OF ARCHITECTURE

Ref: BSA/Admin/GST/2022-23/1600
Date: 15-09-2022

To whoever it may concern

This is to certify that the following participating members from **Team LENS** participating in the Solar Decathlon, India are bonafide students of SMEF's Brick School of Architecture currently studying in 4th year B.Arch. for Academic Year 2022-23.

1. Vishal Dayani
2. Akshita Rathi
3. Keshav Agrawal
4. Khushi Lothe
5. Riya Manwatkar
6. Saurabh Sahane
7. Simran Sond
8. Shivani Gautam
9. Shreya Bhide
10. Vaishnav Vinod
11. Vanshika Parikh

Their faculty mentor is: Ar. Vinita Lulla & Ar. Shreya Mirpagar, Assistant Professor, SMEF's Brick School of Architecture.

Faculty advisor is: Dr. Poorva Keskar, Principal, SMEF's Brick School of Architecture. This certificate is being issued on their request to be able to participate in the Solar Decathlon competition.

SMEF's Brick School of Architecture Undri Pune 411028

Dr. Poorva Keskar
Principal in Charge
SMEF's Brick School of Architecture

6. APPENDIX

BRACT's

Vishwakarma Institute of Information Technology

(An Autonomous Institute Affiliated to Savitribai Phule Pune University)

(Approved by AICTE, New Delhi, A.I.S.H.E. Institute Code : C-41497)

NAAC Accredited with 'A' Grade, An ISO 9001:2015 Certified Institute

S.No. 3/4, Kondhwa Bk., Pune - 411 048. MAHARASHTRA, INDIA

Tel.: +91 - 20 - 26950200 / 26950400, Fax : +91 - 20 - 26950450

Email : director@viit.ac.in Website : www.viit.ac.in

Ref. No.- DATE:10/10/2022

TO WHOMSOEVER IT MAY CONCERN

This is to certify that the following participating members from **Team Lens**participating for Solar Decathlon India are bonafide students of**BRACT's Vishwakarma Institute of Information Technology, Pune** currently Studying in Third Year of Civil Engineering for Academic Year 2022-2023.

1. **Samruddhi Ravindra Londhe (PRN-22120175)**
2. **Bhagyashree Ashok Kokate (PRN-22120209)**
3. **Omkar Ravi Joshi (PRN-220102**58)

Their faculty mentor is **Dr. Archana Tanawade**, BRACT's Vishwakarma Institute of Information Technology, Pune. This certificate is being issued on their request to be able to participate in the Solar Decathlon Competition.

Dr. (Mrs). Vaishali Patil,
Registrar.

B.R.A.C. Trust
Dept. of Civil Engg.
Vishwakarma Institute of Information Technology

Dr. S. T. Shinde
Head of Department,
Civil Engg., VIIT, Pune 48.

* For student recommendations only.