Community Resilience Shelter
Kambalakkad, Kerala

Final Design Report | 2021 April

Nil Bill

Solar™ Decathlon India

SEEDS

School of Planning & Architecture Bhopal

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5. Executive Summary

Team Nil Bill consists of 12 participants from the Departments of Architecture, Planning and Civil Engineering. With this diversity in the academic curriculums, our team tries to look at the competition's requirements through various lenses. The team is highly motivated and sensitive towards the requirements of the people of Kambalakkad and has had multiple conversations with the principal of the school and local NGO heads for information regarding the same.
The team meets twice every week for a rendezvous between the smaller teams, where all the work done during the week is discussed. This frequency increases when deadlines come closer. Full house meetings take place every week and all the smaller teams discuss their progress and work on further operations.
Project Dridh is about creating a net zero energy water community resilience shelter cum primary school in the flood and earthquake prone village of Kambalakkad, Kalpetta, Wayanad. The construction has to be such that the shelter can function without any resources during the times of unfortunate events.
The design aims to make the community resilience shelter cum school a functional model while focusing on the basic needs of the students, teachers as well as the people of Kambalakkad village who will be using the shelter during times of disaster. To make sure that the design works best for the users of the town, the team has been constantly in contact with the locals of the town and the head of the local NGO RASTA Foundation who have already worked in this direction.
Understanding the community reliance on agriculture and livestock, it was deduced that a lot of waste must be generated in terms of sewage, cow dung and biodegradable waste which can then be used as fodder for the biogas plant. Design solutions have also been made keeping in mind the usage patterns of primary school children, to make the school environment more conducive to the town's value system.

6. Team Nil Bill

6.1 Team Profile

Team Nil Bill has taken upon themselves to design a net-zero energy-water 'Community Resilience Shelter' in Kerala which will be used for emergency evacuation during extreme weather events like cyclones, floods, etc. Our team consists of a total of 12 students from School of Planning and Architecture, Bhopal (M.P.), Indian Institute of Engineering Science and Technology, Shibpur (W.B.) and Haldia Institute of Technology, Haldia (W.B.) pursuing Bachelors in Architecture, Planning, and Engineering programmes.

6.2 Approach

We intend to follow a coherent design approach whereby we have set our goals for our project, which will be succeeded by research and analysis into different directions leading to the realisation of those goals. Moreover, we will focus on Practicality, that is to make the shelter as affordable and market-ready as possible, so that a similar strategy may be practically applicable in other disaster-prone areas, and on User Experience, because we believe that even if we succeed in making a Net-Zero Energy-Water building, we will fail on the usability of the structure if we do not keep the users at the forefront of our design process.

6.3 Lead Institution Profile

The **School of Planning and Architecture, Bhopal** (S.P.A. Bhopal) is a premier institute of national importance in Madhya Pradesh, India. It was established in 2008 by the Ministry of Education, as an autonomous institute and a C.F.T.I., specializing in education and research in the fields of Planning, Architecture and Design.

The students pursuing Bachelor of Architecture are trained in Energy Efficient designing through simulation software and in Non-Conventional Building Techniques through hands-on construction exercises within the campus. Extensive studios pertaining to climate study and vernacular design are held, and students are trained in different contextual backgrounds. In addition, students are sensitized with Universally Accessible Design with the help of a fully-functional Center for Human Centric Research (C.H.C.R.) facility.

6.4 Faculty Profile

Dr. Anand Jayant Wadwekar (Faculty Lead)
Associate Professor & Head, Department of Urban Design, S.P.A. Bhopal

Mr. Govind M.P. (Faculty Advisor)
Assistant Professor, Department of Planning, S.P.A. Bhopal

Dr. Naveen Kishore, (Faculty Advisor)
Associate Professor of Architecture, S.I.T. Bangalore

6.5 Industry Partners

a) Mr. J.P. Singh- Solar Energy Consultant
Founder of J.P. Consultants- Solarizing Rooftops for a Greener Tomorrow
b) RASTA (Rural Agency for Social and Technological Advancement), Wayanad- Local Context Consultant
c) Aureka, Auroville, TN- Construction Material Consultant

7. Project Dridh- □□□□

The word *'Dridh'* (Hindi- □□□□) describes someone or something that survives through all odds with integrity and unrelenting courage. Our project has been named *'Dridh'* as we wish to instil these values into the core of the Net-Zero Energy-Water Community Resilience Shelter, thus empowering the disaster-hit communities and helping them persevere through their difficult and testing times.

7.1 Project Partner

SEEDS (Sustainable Environment and Ecological Development Society) is a non-profit voluntary organization founded in 1994. It has one ultimate goal: building the resilience of people exposed to disasters, and building practical solutions for disaster readiness, response, rehabilitation, management. The organization has invested in skill-building partnerships and advocacy to build the long-term resilience of at-risk communities.
SEEDS has constantly built for the disaster-hit.

Key individuals involved:

1. Mr. Aakash Vishwakarma- Architecture and Innovations (Architect)
2. Mr. Sumeet Agarwal- Project Management and Control (Architect)
3. Mr. Shafat Mir- Construction Management (Civil Engineer)
4. Ms. Shruti Nikhar- Social Coordination (Architect)

7.2 Description of the Project

Project Dridh aims to design a Multipurpose Community Resilience Shelter in a flood-prone district of Kerala. It would serve as a school during normal times and as a resilience shelter during disasters. The aim of this intervention is to address the long-term impact of disasters on livelihoods and help develop resilient coping mechanisms for future risks.

SEEDS INDIA

Site area and context

The site is located in Kambalakkad, a small town in Panamram,Vythiri, Wayanad, Kerala. Kambalakkad experiences a typical tropical monsoon climate. It is home to many indigenous tribes, and the town also has a few mosques, *madrassas* and schools for the communities. The entire district is vulnerable to disasters like landslides, floods, flash floods and high winds. The villagers belong to the rural and marginalised communities with poor socio-economic status and their main source of livelihood is agriculture. Their houses are built using local materials and techniques and are the most vulnerable during disasters.

The site currently has a hundred-year-old Government Upper Primary School (G.U.P.S.) with a total site area of 4493 **sqm.** Currently, the school serves the nearby population and acts as a refuge shelter as the surroundings get flooded annually. The school currently works from 10 A.M. to 4 P.M. It lies on one of the highest elevation levels in Kambalakkad.

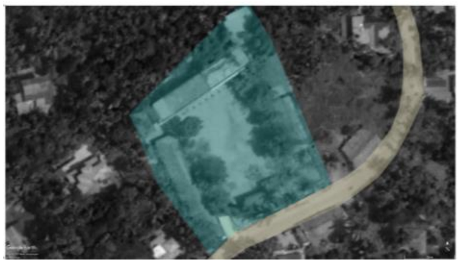


Figure-1: Site Image (Source: Google Earth)

7.3 Special Requirements of the Project Partner, SEEDS:

- The construction cost should not be more than Rs. 1400 per sqft or Rs. 15,070 per sqm. Therefore, the preliminary construction budget cap is estimated to be Rs. 2,56,19,000. (Considering built-up area= 1700 sqm.)
- The time period for construction is one year.
- 90% renewable energy to be produced to power the building should be solar energy.

- Any building shape is suitable. However, square or rectangular shapes should have their peripheral corners rounded, for improving the aerodynamics of the structure.
- The building should be above High Flood Level (HFL) and be able to withstand speedy winds and earthquakes.
- The design should adhere to all safety norms laid by the NDMA.
- Louvre type of window is suggested to be used wherever possible.
- The roof should be able to act as shelter space.

8. Performance Specifications

Climate zone- Kambalakkad lies in hot and humid climate, in Wayanad, Kerala. It experiences floods, and fast winds, which can convert to a hazardous natural disaster.

Performance specifications:

- The building envelope is made of CSEB blocks (U value 1.4 $W/m^2.K$)
- The roof has filler slab, and the roof covering has cement with SRI 40.
- The windows are Saint Gobain single panel windows with VLT 56 and SHGC 0.5
- The overall WWR is 52%
- The peak load is 13kW, at the time of a school building.
- The interior average LPD is 1.625 Watt/m2.
- The average equipment power density is 5.004 Watt/m2.
- The built up area of the building is 2332 sqm (excluding paved areas).
- Renewable energy used is solar energy. Mono-crystalltine solar panels have been raised on the roof (away from trees, mumties, etc), and a 48 hour battery backup is provided along with it, to facilitate a 2 day off grid usage. The batteries are hybrid, so that they do not die during stagnant times, when the system is on-grid. The payback period of the solar panels is approximately 6 years (excluding battery).
- Rainwater harvesting system is provided, and the roof rainwater is collected, treated and supplied for landscape irrigation and bioswales and fire safety tanks. The STP treated water supplies to the landscape as well.

9. Goals and Strategies

A total of 10 goals were identified, all having a set of measures. Further a list of strategies to be used was prepared which can help achieve these goals. Figure 2 shows the effect of each strategy on the goals

Goal 1: **Community Integration:** Having a continuous Integration of the local community

a. 50% wall area to have local arts
b. 30% locally available materials to be used

Goal 2: **Electricity:** Reducing overall electricity load and having complete onsite generation for electricity

a. 90% electricity from solar
b. Target EPI: 55 kWh/sq.m
c. Forced ventilation not more than 50%
d. 60% of day lighting will be natural.

Goal 3: **Affordability:** Reducing operational costs and capital costs of the building

a. Capital Cost of the project: Rs. 2,56,19,000/-

Goal 4: **Comfort:** Designing the building envelope to achieve optimum indoor comfort both visual and thermal

a. No use of HVAC system
b. 80% of time to be in Comfort zone

Goal 5: **Landscaping:** Using site design and landscaping for multi-fold purposes

a. 1 tree per 80 sqm
b. Distance between any tree and structure/tree should be less than its height
c. Hardscapes less than 30%

Goal 6: **Multipurpose:** Designing dynamic, adaptable and efficient multipurpose building

a. 80% built up area to be multipurpose which can be used during school as well as disaster times
b. 50% plot area to be flexible open spaces

Goal 7: **Water:** Having a Net 0 water cycle

a. 65% water from Rain Water
b. 35 LPCD of water During school use
c. 75 LPCD of water during use as CRS

Goal 8: **Accessibility:** Making the design universally accessible during all times

a. All essential areas to be universally accessible during all times

Goal 9: **Resilience:** Providing structural and functional durability and resilience

a. Full autonomous for 2 Days minimum in terms of battery, food & water

Goal 10: **Waste:** Reduce, Reuse and recycle maximum waste generated

a. 100% of Grey water to be treated and reused

STRATEGIES \ GOALS	Community Integration	Electricity	Affordability	Comfort	Landscaping	Multipurpose	Water	Accessibility	Resilience	Waste
Using vernacular techniques and materials	●		●	●						
Using local arts and murals	●		●	●						
Using naturally found binding material in maximum proportion			●						●	
Using a concrete framework for the building skeleton									●	
CSEB/ ISSB blocks, red clay bricks or AAC in-fill blocks	●		●						●	
Using ductile steel instead of high strength concrete									●	
Improving the concrete property with micro-structure design									●	
Plinth raised by 1m for all buildings									●	
Keeping an open building plan with partitions						●			●	
Keeping extra space for storage									●	
Open terrace, free from obstructions								●	●	
Curving of peripheral corners to facilitate aerodynamics			●						●	
Shaded terrace spots for surplus people during a disaster									●	
Ample open space for public gathering	●				●	●			●	
Designating space for livestock	●					●			●	
Battery storage to provide for emergency power									●	
Right sized lighting loads		●	●							
Using PV systems on walkways, rooftops, security lights etc		●	●							
Using 5* rated fixtures & appliances		●	●							
Using LED exit luminaires and high-efficiency fans		●	●							
Using photo cell controls		●	●							
Night flush ventilation		●		●						
Right-sized overhangs and fins		●	●	●						
Light filtration and controlled daylighting louvres		●	●							
Using fully-openable panelled windows		●		●						
Using louvre windows for controlled shading		●	●							
Light-coloured exterior walls, high-reflectance roofing		●							●	
Brick jaalis for semi-shaded lit-up spaces				●	●	●				
Bioswales for groundwater recharge	●				●		●			
Keeping all existing dense mature trees intact on-site					●					
Growing Vetiver grass as hedgerows					●		●			
RWH and STP at lowest point			●				●			
Reuse processed greywater for irrigation/ flushing		●			●		●			●
Sedimentation mechanism to filter and reuse rainwater							●			
Installing water-conserving fixtures			●				●			
Sewage, cow dung and biodegradable waste used in biogas plant	●	●	●		●					●
Demarcating biodegradable and non-biodegradable waste	●		●		●					●
Designing recycling receptacles										●
Creating waste monitoring system	●									●
Providing ramps, handrails, signages etc				●				●	●	

Figure-2: Strategies used for different goals (Source: Author)

10. Documentation of design process

The design process started with understanding the demand of the competition and the project partner to better work on the project. The process included professionals, locals and our team to work forward into this direction, understanding the minute details of their (locals) daily life adversities and brainstorming ways to combat them by the simplest means.

Software Used:

- Opaque, Design Builder, LadyBug for Rhino
- Revit, AutoCAD, Rhino
- Zoom, GoogleMeet, Miro, Jamboard, GoogleDocs, Google Drive, WhatsaApp, GoogleSlides

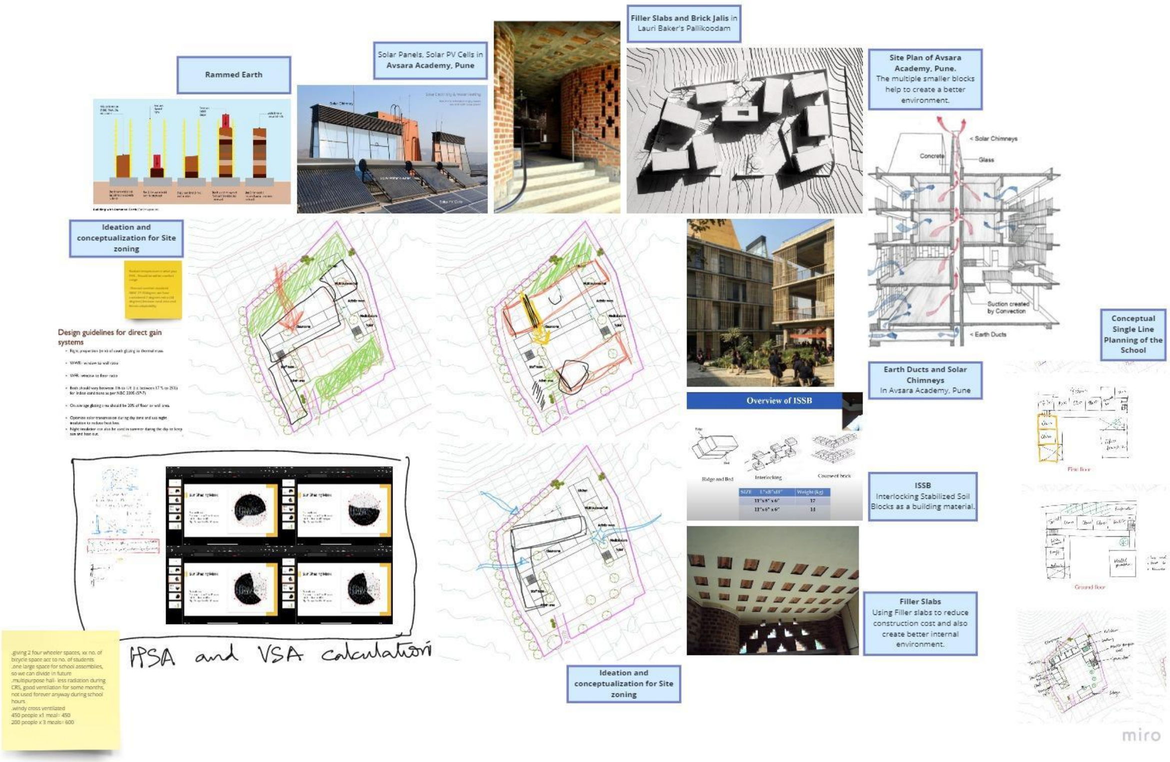


Figure 3: Work Moodboard (Source: Author)

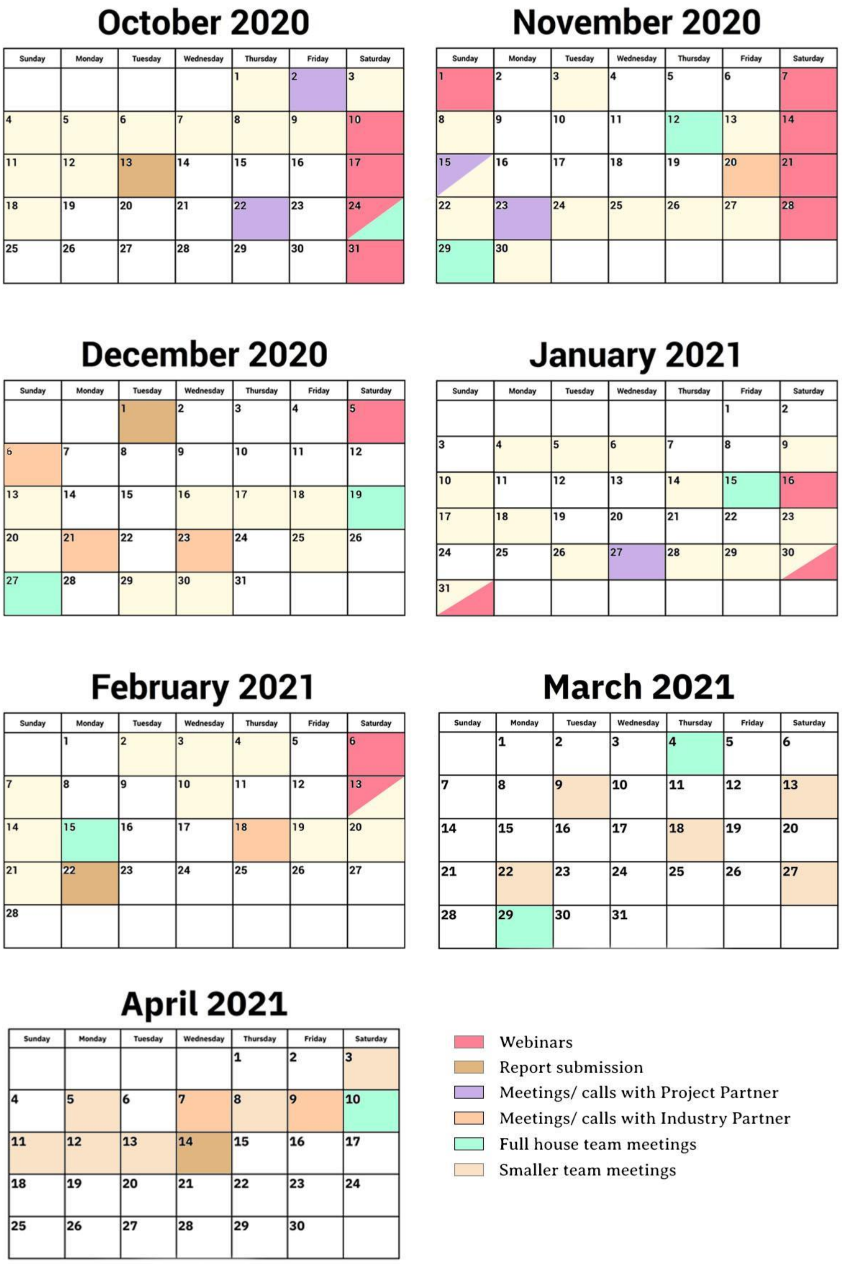


Figure 4: Schedule for team meetings, webinars and submission for the competition (Source: Author)

Our approach to a multipurpose community resilience shelter is to achieve maximum overlap between the architecture of spaces. Studying and understanding these dualities in the usage of the same building and same rooms in different situations is hence at the very core of this project. Every area, room, and function of the school building has been identified and planned to be used optimally in emergency situations, creating an ideal multipurpose building that operates in 2 very different modes with minimum changes.

The case studies gave us an understanding and applicability of passive design systems, solar panels and various construction techniques to work forward in the design process.

We started with the zoning identifying important usages for both the school and the CRS. We looked at the multipurpose aspects and explored what all can be achieved. We set up a few goals as explained in the next section, and started working upon those. The team was divided based on their experience and the softwares they knew.

Table 1 : Meeting details of team, project partner and industry partners (Source: Author)

Date	Meeting Purpose
8.09.2020	Ice breaking session between team members, SDI brief reading
26.09.2020	Project Partner Shortlisting and Contacting
2.10.2020	Finalised Kerala project by SEEDS, India
16.10.2020	Divided into 2 teams- one for studying the cultural context of Kambalakkad and the other for obtaining raw data like climate and site morphology
22.10.2020	Talked to Mr. Jinu, SEEDS for local information about Kambalakkad
24.10.2020	Full House Meet and discussion between smaller teams
29.10.2020	Industry Partner search began, created a document of probable industry partners for services, materials, cost estimation, help in simulations, etc.
3.11.2020	Meet with Dr. Naveen Kishore for progress update
12.11.2020	Full House Meet and discussion between smaller teams
13.11.2020	Design discussion and first Design Builder Simulation attempt
15.11.2020	Call to Haris from SEEDS in Kambalakkad, a native of the place
20.11.2020	Call to RASTA's Danesh, giving information about the local context of the town and school and flood situation in the area
22.11.2020	Contacted SDI Technical Resource Group for Climate, Water and Simulation consultations
23.11.2020	Received more site photographs from Haris from SEEDS in Kambalakkad
25.11.2020	Preliminary site zoning and Climate Analysis
26.11.2020	Site and Building level preliminary zoning
29.11.2020	Full House Meet and discussion between smaller teams
6.12.2020	Introductory Meeting with Industry Partner JP Consultants
19.12.2020	Full House Meet and division into smaller teams
21.12.2020	Introductory Meeting with probable Industry Partner Agrocrete
23.12.2020	Call to RASTA's Danesh, giving more information about the kinds of attempts done in the past to improve the community
27.12.2020	Full House Meet and discussion between smaller teams
29.12.2020	Meet with Anmol Mathur regarding Climate analysis and Sun-shading
15.01.2021	Full House Meet and division into smaller teams
3.11.2020	Meet with Dr. Naveen Kishore for energy simulation assistance
27.01.2021	Meet with the Principal of GUPS Kambalakkad to get information about the existing school requirements and consumptions, holidays and children's needs
30.01.2021	Design Discussion, water cycle finalisation and electrical consumption
5.02.2021	Design Discussion, site and building zoning refining
12.02.2021	Discussion on cost estimation and building design finalisation, quantities, companies
15.02.2021	Full House Meet and discussion between smaller teams
17.02.2021	Meet with Dr. Naveen Kishore for energy simulation assistance
17.02.2021	Design Discussion, site and building zoning refining
22.02.2021	Meet with Industry Partner JP Consultants for finalisation of solar renewable energy details

11. Progress on the Ten Contests

11.1 Architectural design

The following design considerations were kept while design the multipurpose community resilience shelter:

1. The building typology to be designed is a Community Resilience shelter, but the building will serve as a CRS only for 20 days in a year. Hence, the other function of the building- a primary school- is also diligently designed, to ensure maximum flexibility and design optimisation.
2. Since cattle are a primary part of the lives of our community, we have ensured that space for cattle is provided on the site, for evacuation during disasters.
3. The access to the site has slope 1:12, making it compliant with universal design guidelines.
4. The building orientation achieved due to site geometry restrictions and shading simulations, is the best possible one.
5. One large ground has been provided, instead of two smaller ones, by keeping the building towards the periphery. This ensures best conditions for a school as well as a CRS, providing ample open gathering space.
6. Two large activity rooms, a multipurpose hall and an SUPW room, have been provided for conversion to a dormitory when the building is a CRS.
7. The younger students' classrooms are kept on the Ground Floor, and a separate sandy play area has been designed for them at the rear of the site.
8. All mature trees have been preserved, and the younger bamboo trees cut have been utilized in making the parking cum cattle shed areas.
9. The peripheral corners of the building have been curved at 1500mm radius, for smooth aerodynamics, complying with NDMA disaster shelter guidelines.
10. The rooms which are least probable to be used during the time when the building functions as a CRS, like laboratories and libraries, have been given on the upper floors.
11. Ramps have been provided to climb the plinth of the building (1500mm), so that the building is accessible at all times. Also, since giving a ramp for the first floor was not feasible, arrangements have been made for the differently abled to stay on the ground floor, during a disaster.
12. Staircases have been provided at a minimum distance of 30m from each other.
13. Expansion joints for the longest building block have been provided, to facilitate material expansion/ contraction.
14. The underground and ground-level water tanks have been provided near the access, to reduce pipe length. The OHTs are provided above the toilets and kitchen areas.
15. Solar Panels are positioned at a place where no mumty or tree shade can reduce its efficiency, according to sun hours calculated from LadyBug for Rhinoceros.
16. Minimal parking space is provided, since the students and faculty come by public transport to the school. Space for 20 two wheelers and 2 four wheelers is provided.
17. Access to the terrace is free, since the roof is flat, to accommodate emergency upsurge of people during the time of a disaster.
18. The administration block is kept close to the access, for smooth functioning of the building.

Figure 5: Site Plan (Source: Author)

Figure 6: Ground Floor Plan (Source: Author)

Figure 7: First Floor Plan (Source: Author)

Architectural design that integrates climatic considerations toward achieving net-zero goals
Sun Shading Mask

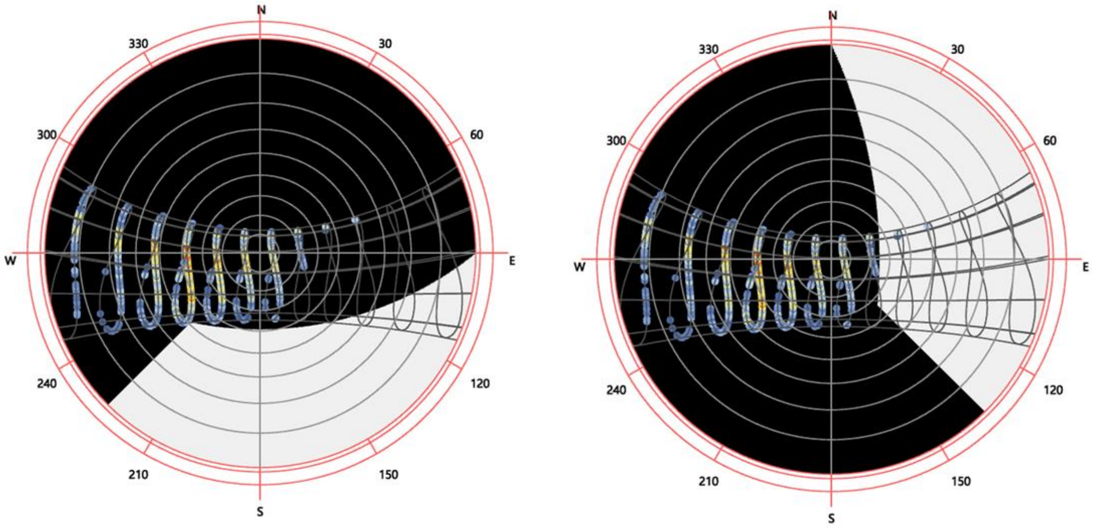


Figure 8: Sun Shading Mask- Southern Facade and Eastern Facade (Source: Author)

Southern Facade
Overhang Projection(VSA): 40°
Right fin projection(HSA): 45°

Northern Facade
Overhang Projection(VSA): 18°
Left fin projection(HSA): 20°

Eastern Facade
Overhang Projection(VSA): 25°
Right fin projection(HSA): 45°

Western Facade
Overhang Projection(VSA): 45°
Left fin projection(HSA): 70°

The Sun Mask Shading analysis has been used to design various projections around the openings to block the Sun having radiation above 500 W/m^2 from 8 a.m. to 4 p.m. only. The projections are in the form of concrete horizontal louvre systems and vertical louvre systems.

The shading projections of the openings have been individually customised to create a balanced thermal and visual comfort. The horizontal concrete louvres also serve as light shelves to reduce the glare from direct sunlight and thus providing optimum amount of daylighting.

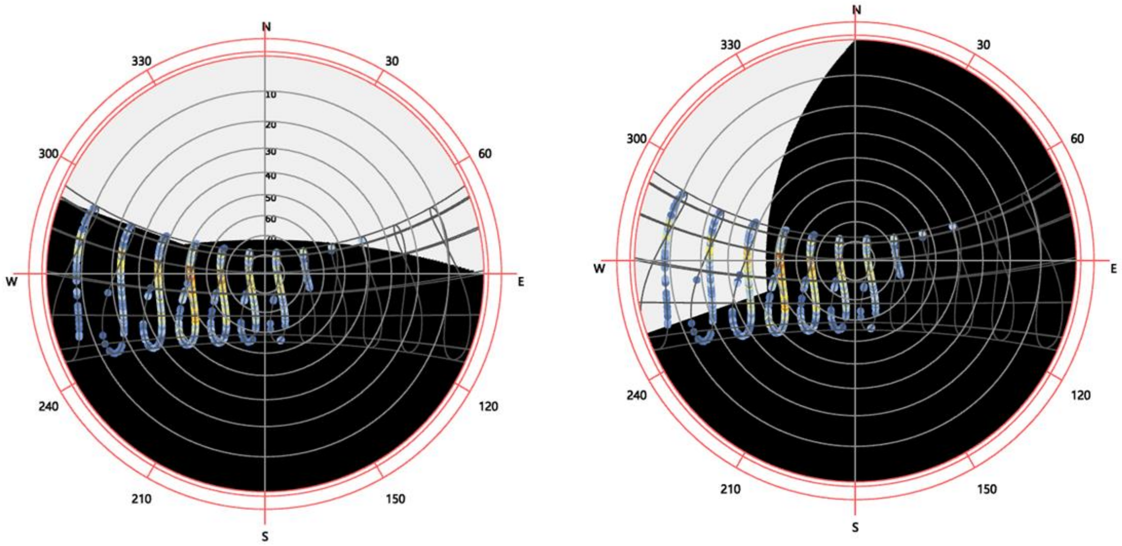


Figure 9: Sun Shading Mask- Northern Facade and Western Facade (Source: Author)

11.2 Comfort and environment quality

The energy simulations have been done on Design Builder. The main considerations kept during simulations were sun path analysis, windflow and natural ventilation, and daylighting. The eastern walls are shaded by trees, the western facade has been kept to a minimum, and almost all spaces have a corridor to provide a buffer for light as well as the glaring sun.

Using the Fanger PMV model, 4 environmental parameters (air temperature, mean radiant temperature, relative humidity, air velocity) and 2 subjective parameters (metabolic rate and clothing thermal insulation) are considered.
The comfort band from IMAC obtained is 27 to 32 degrees. We have considered a range of 27 to 34 degrees, according to the subjective conditioning of the locals of Kambalakkad.

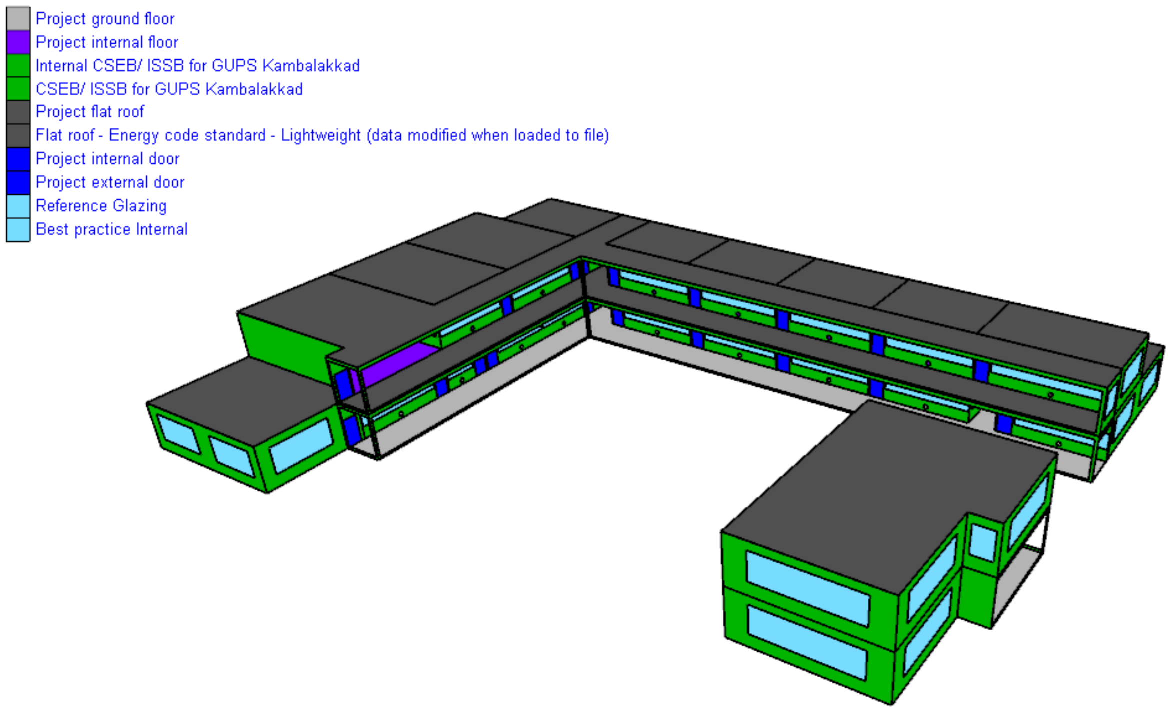


Figure 10- 3D visualisation of the building (Source: Design Builder)

- No. of discomfort hours has been reduced.
- The thermal comfort of occupants currently lies between 30 and 40 degrees. We are trying to vary the internal gain, and the openings to match it with the IMAC comfort band.
- The EPI achieved is 70.6, as the lack of HVAC creates some determined discomfort.
- The daylighting within the spaces is optimum, as derived by the Design Builder illuminance graphic.
- The spaces used for maximum times are provided with recessed windows, so as to shade the wall and provide simultaneous horizontal or vertical overhangs, protecting the building fabric from direct heat gain.
- The classrooms have large windows for maximum cross ventilation and daylighting.

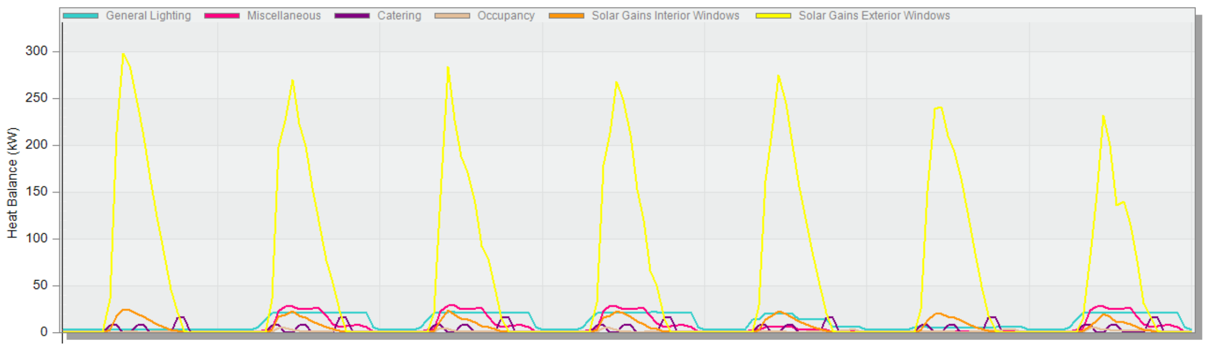


Figure 11- Internal Gains graph (Source: Design Builder)

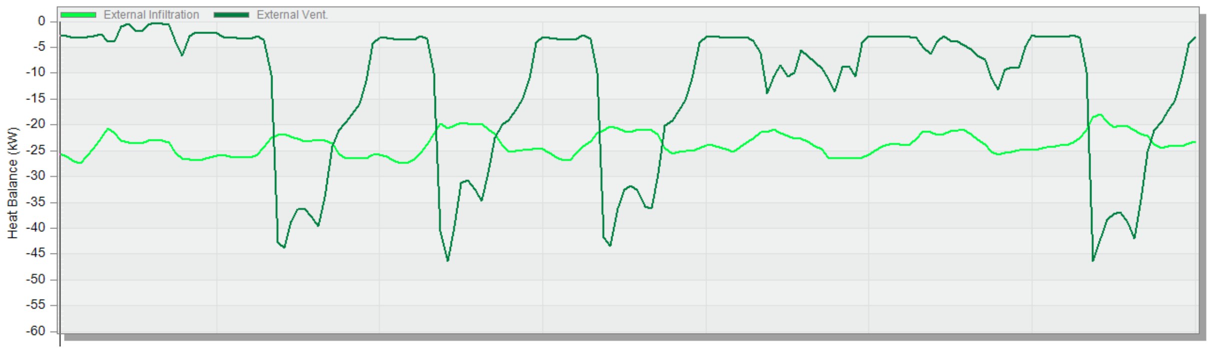


Figure 12- Fabric and Ventilation graph (Source: Design Builder)

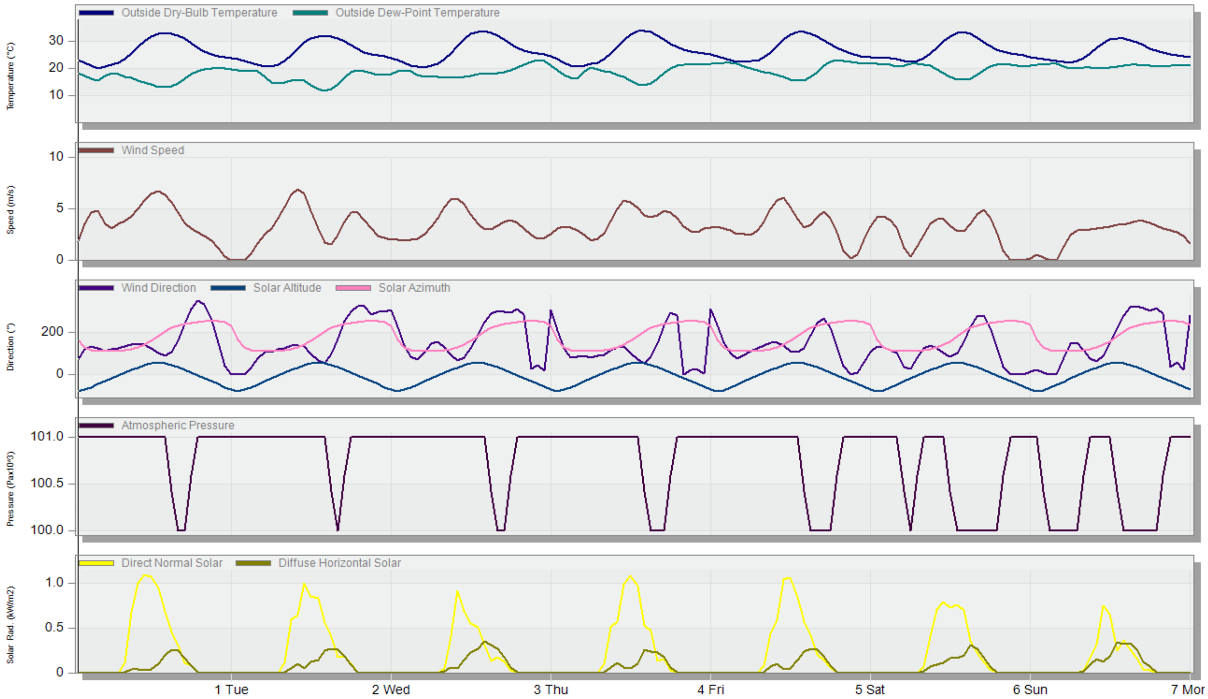
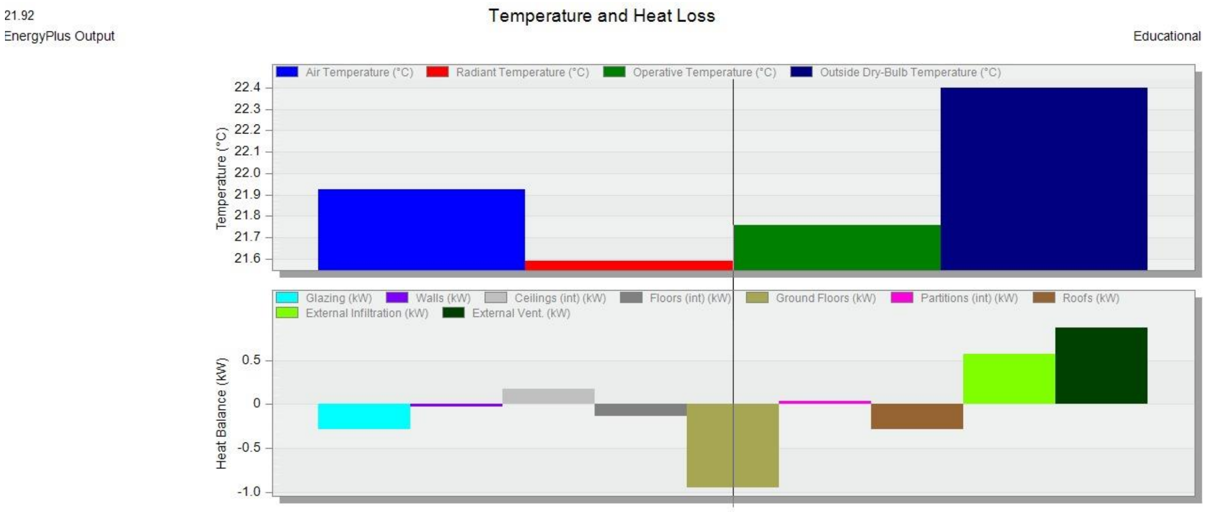


Figure 13- Site Data graphs (Source: Design Builder)



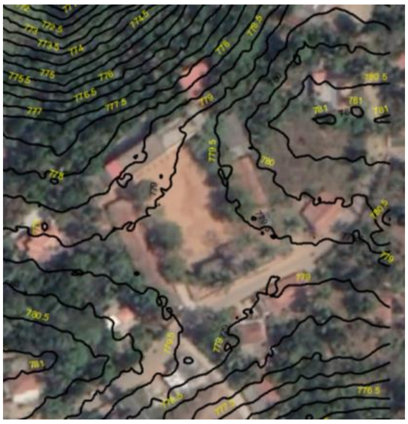
Air Temperature (°C)	21.92
Radiant Temperature (°C)	21.59
Operative Temperature (°C)	21.76
Outside Dry-Bulb Temperature (°C)	22.40
Glazing (kW)	-0.28
Walls (kW)	-0.03
Ceilings (int) (kW)	0.17
Floors (int) (kW)	-0.13
Ground Floors (kW)	-0.94
Partitions (int) (kW)	0.04
Roofs (kW)	-0.29
External Infiltration (kW)	0.57
External Vent. (kW)	0.87

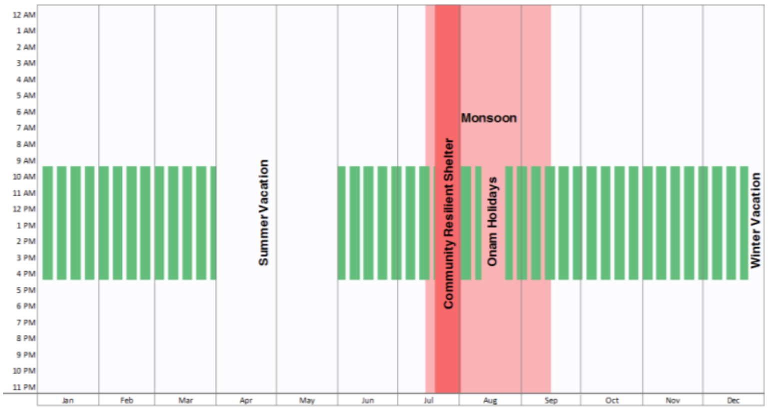
Figure 14- Temperature and Heat Loss graphs (Source: Design Builder)

11.3 Resilience

The site is located in Kambalakkad, a small town in Wayanad, Kerala. Kambalakkad experiences a typical tropical monsoon climate. It is home to many indigenous tribes, and the town also has a few mosques, madrassas and schools for the communities. The entire district is vulnerable to disasters like landslides, floods, flash floods and high winds. The situation is further aggravated by the fact that all wires go through streets and the dense trees fall during monsoon cutting off the power supply to the site. This has required the building to be strong and sturdy. The site location as shown in figure 10 shows that it is located at a higher altitude than surrounding areas and has been confirmed by primary sources that it doesn't get flooded. Flooding usually occurs in monsoon and a Tentative working of the School as a CRS is given in Figure 15

Figure 15- Site Image with contours and Usage of School as CRS (Source: Google Earth, Author)





To bring the physical durability and resilience of structure, a concrete framework will be used for building skeleton. Ductile steel will be used instead of high strength concrete and locally available soil is used to make construction blocks . The plinth for all the structures will be raised by 1.5 m to further reduce any risk of flood water ingress. The corners have been curved to increase aerodynamics in case of high winds.

Steps have as well been taken for the mental well being of the people. The walls will Incorporate local artwork and graphics on walls. As the literacy rate is very low, especially for the women, these illustrations will as well act as a guide. This will as well help educate students about environmental issues and NZEBs, and hence integrate awareness through the grass root level. Rest of the area will be coloured in light colours to give visual comfort.

For efficient functioning, it was essential for building to adapt from a school to a CRS with minimal changes and maximum overlap of spaces, so that there are minimum redundant spaces. Figure 11 shows the functional bubble diagram of the school/CRS

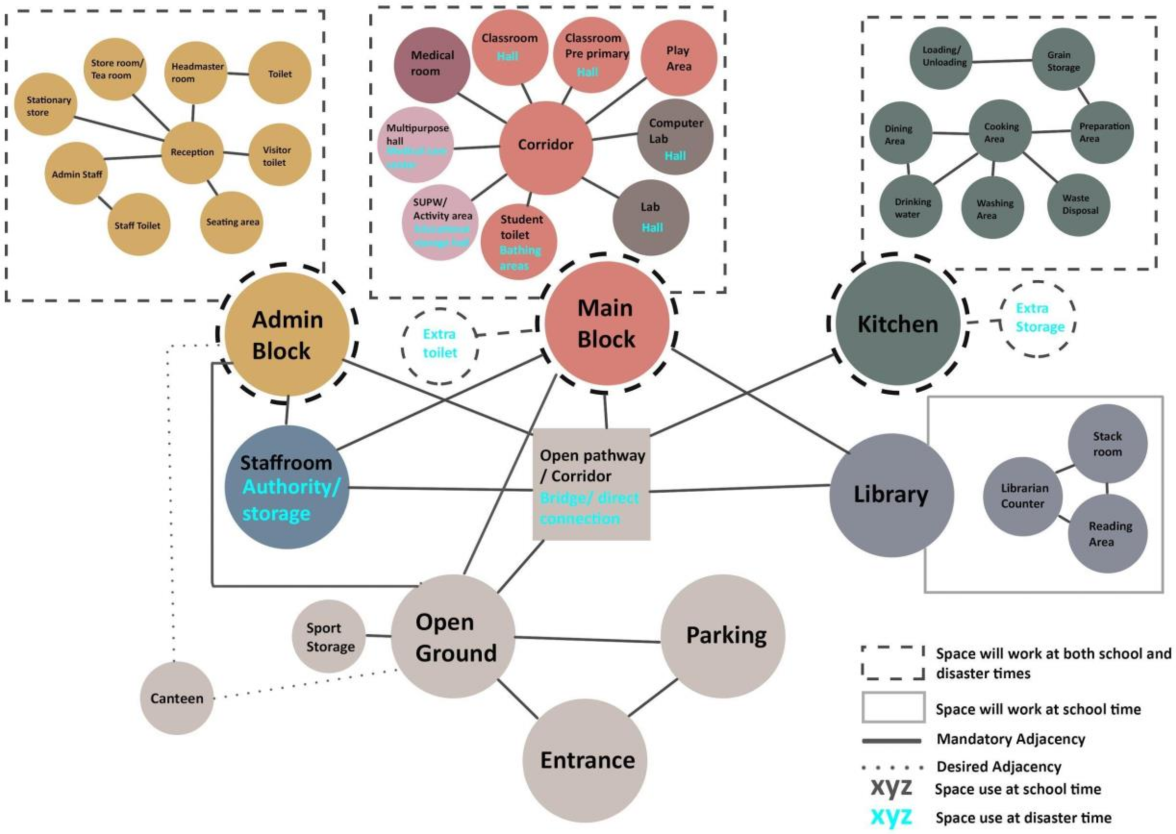


Figure 16- Bubble diagram for proximity and use of spaces (Source: Author)

Relief camps are put up here for 15-20 days, each classroom is assigned to one particular colony of the village, which keeps people who know each other together, helping in coping up during stresses. Further, extra space for storage of emergency disaster equipment, and to store clothes, sheets, shoes, grain, hay etc. A medical care centre in the multipurpose hall enhances preparedness, which is integrated with service delivery centres such as immunization programmes, feeding and educational programmes (kudumbashree) that take place in villages. This will develop this resilience shelter as the centre of relief through active participation of vulnerable communities. Cattle are an important part of village life and an inseparable part of this community. It was essential that a place was provided for them too. The Large open space at the center allows for public gatherings, as well

as for keeping cattle during floods. The terrace will be kept open, free from obstructions to allow air evacuation and keep few areas shaded to accommodate the surplus of people during a disaster. The benches are Modified a bit so that they can be used as beds as well as can be stored in a compact manner and have been detailed out in the innovation section.
Except for the library (101 sq.m), all other areas can be used in school as well as CRS. 94% of the 1700 sqm built up area , and 90% of the floor area can be used during both school hours and as CRS achieving our goal for multipurpose areas.

To Convert from A School to CRS, one needs to follow few basic Steps:

1. Lock The computer lab, library and Science lab
2. Move the Benches in the way shown in plan in Appendix to get more space
3. Allocate rooms locality wise and move people in them and Put the cattle in shaded area
4. Open Extra storage for providing essential supplies if required

To convert Back to a School, Follow the steps:

1. Clean all the rooms
2. Refill and Lock the extra storages and toilets
3. Move back the benches to their original location as set in class
4. Open the Labs and Library

11.4 Engineering design and operation

Plumbing design
The plumbing system has been designed to achieve a net-zero water consumption. The details of the plumbing have been given in section 11.6 Water Performance. The diagram for the building is given in figure X

Solar PV Grid
The Hybrid Solar PV system has been recommended by our industry partner as it is less expensive and also has the ability to connect to a grid power supply maintaining an ON- grid system during the normal working hours of the school while an OFF- grid system containing a battery is used during the times when school is converted into community resilient shelter.

Figure 17: Hybrid Solar system (left), Solar Ballast structure (right)
(Source: https://www.cleanenergyreviews.info/blog/2014/8/14/what-is-hybrid-solar, https://modernize.com/homeowner-resources/solar/solar-ballast)

The equipments that are used in the system are as follows:

1. Mono Crystalline Solar Panels - Rating 495Wp, Qty- 51 Nos
2. Hybrid Inverter - Rating 25 kW
3. Lithium Ion Batteries - Rating 800 Ah, 96 Volts

The Ballast structure system is used to install the solar panels on the roof. In this system the concrete blocks are placed throughout the roof to secure an array to the roof and prevent wind lift and other movement, all without making any penetrations in the roof slab.

The solar array has been used in the area of 250sqm thus leaving the rest of the roof surface for installing the temporary structures to accommodate larger populations during disasters and also for air rescue.

The electrical SLD for ground floor and first floor are given in Figure 19 and Figure 20
Electrical Usage details are

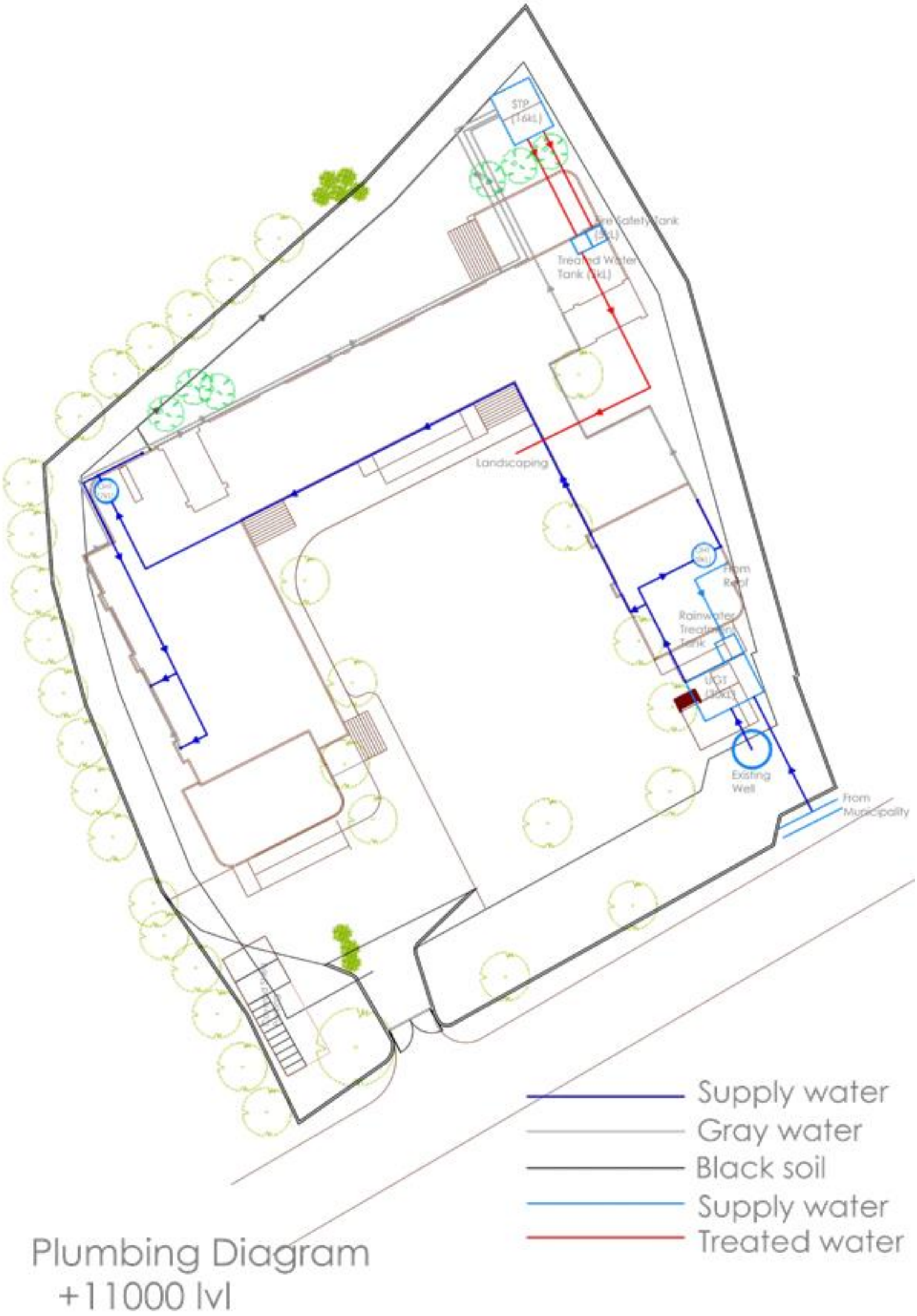


Figure 18: Plumbing SLD (Source: Author)

Figure 19: Ground floor electrical SLD (Source: Author)

Electrical Diagram First Floor

Figure 20: First floor electrical SLD (Source: Author)

ELECTRICAL LOAD WHEN BUILDING IS SCHOOL						
ROOM	EQUIPMENT	QUANTITY	NO. OF HOURS USED PER DAY	WATT	TOTAL CONSUMPTION (WATT/PER DAY)	
LOBBY	LED CEILING LIGHT	50	8	10	4000	500
	WATER COOLER	2	8	750	12000	1500
STAIR CASE	LED TUBELIGHT	2	8	18	288	36
CLASSROOM	FAN	6	8	40	1920	240
	LED BULB	0	0	0	0	0
	LED TUBELIGHT	5	8	18	720	90
KITCHEN	LED BULB	0	0	0	0	0
	LED TUBELIGHT	4	8	18	576	72
	REFRIGERATOR	1	12	25	300	25
MULTIPURPOSE AREA	FAN	8	8	40	2560	320
	LED TUBELIGHT	6	8	18	864	108
	LED BULB	0	0	0	0	0
TOILET	LED BULB	2	8	10	160	20
MEDICAL ROOM	FAN	2	8	40	640	80
	LED BULB	0	0	0	0	0
	LED TUBELIGHT	2	8	18	288	36
SUPW	FAN	8	8	40	2560	320
	LED BULB	0	0	0	0	0
	LED TUBELIGHT	14	8	18	2016	252
SEMI OPEN	FAN	0	0	0	0	0
	LED BULB	2	5	10	100	20
	LED TUBELIGHT	8	0	18	0	144
ADMIN AREA	FAN	8	8	40	2560	320
	LED BULB	0	0	0	0	0
	LED TUBELIGHT	14	8	18	2016	252
	COMPUTER	2	6	45	540	90
STAFF ROOM	FAN	8	8	40	2560	320
	LED BULB	0	0	0	0	0
	LED TUBELIGHT	14	8	18	2016	252
PUMPING STATION	PUMP	2	1	746	1492	1492
	LED BULB	2	12	10	240	20
	FAN	0	0	0	0	0
COMPUTER LAB	computer	40	8	45	14400	1800
	fan	8	8	40	2560	320
	LED TUBE LIGHT	14	8	18	2016	252
TERRACE	LED Tubelight	8	3	50	1200	400
TOTAL					60592	9281
					60.592	9.281kW
					64 units per day- daily consumption	
					64*30= 1925- monthly consumption	

TOTAL ELECTRIC LOAD	
LOBBY	32000
STAIR CASE	1728
CLASSROOM	21120
KITCHEN	876
MULTIPURPOSE AREA	3424
TOILET	800
MEDICAL ROOM	928
SUPW	4576
SEMI OPEN	100
ADMIN AREA	4576
STAFF ROOM	4576
PUMPING STATION	1732
COMPUTER LAB	18976
TERRACE	1200
CLASS 8	3424
LIBRARY	3424
READING ROOM	3424
EXTRA CLASSROOM	6848
TOTAL LOAD	113732
OTHER	5686.6
NET LOAD (IN kWh)	119418.6
NET CONSUMPTION (IN kWh)	119.4186
ANNUAL NET CONSUMPTION DURING SCHOOL	26272.092

Figure 21: Appliance details and usage during School usage (Source: Author)

ELECTRICAL LOAD WHEN SCHOOL IS CRS						
ROOM	EQUIPMENT	QUANTITY	NO. OF HOURS USED PER DAY	WATT	TOTAL CONSUMPTION (WATT HOUR/PER DAY)	
LOBBY	LED CEILING LIGHT	50	16	10	8000	500
	WATER COOLER	2	0	750	0	0
STAIR CASE	LED TUBELIGHT	2	16	18	576	36
CLASS ROOM	FAN	3	16	40	1920	120
	LED BULB	0	0	0	0	0
	LED TUBELIGHT	2	12	18	432	36
KITCHEN	LED BULB	0	0	0	0	0
	LED TUBELIGHT	4	16	18	1152	72
	REFRIGERATOR	1	12	25	300	25
MULTIPURPOSE AREA	FAN	8	16	40	5120	320
	LED TUBELIGHT	3	16	18	864	54
	LED BULB	0	0	0	0	0
TOILET	LED BULB	2	16	10	320	20
MEDICAL ROOM	FAN	2	16	40	1280	80
	LED BULB	0	0	0	0	0
	LED TUBELIGHT	2	12	18	432	36
SUPW	FAN	8	16	40	5120	320
	LED BULB	0	0	0	0	0
	LED TUBELIGHT	7	16	18	2016	126
SEMI OPEN	FAN	0	0	0	0	0
	LED BULB	2	6	10	120	20
	LED TUBELIGHT	4	6	18	432	72
ADMIN AREA	FAN	4	10	40	1600	160
	LED BULB	0	0	0	0	0
	LED TUBELIGHT	7	16	18	2016	126
	COMPUTER	2	6	65	780	130
STAFF ROOM	FAN	8	0	40	0	0
	LED BULB	0	0	0	0	0
	LED TUBELIGHT	14	0	18	0	0
PUMPING STATION	PUMP	2	1	746	1492	1492
	LED BULB	2	12	10	240	20
	FAN	0	0	0	0	
COMPUTER LAB	COMPUTERS	40	0	65	0	0
	FAN	8	0	40	0	0
	LED TUBE LIGHT	14	0	18	0	0
TERRACE	LED TUBELIGHT	8	8	50	3200	400
TOTAL					37412	4165
						4.165 kW

TOTAL ELECTRIC LOAD	
LOBBY	16000
STAIR CASE	3456
CLASSROOM	18816
KITCHEN	1452
MULTIPURPOSE AREA	5984
TOILET	1600
MEDICAL ROOM	1712
SUPW	7136
SEMI OPEN	552
ADMIN AREA	3616
STAFF ROOM	0
PUMPING STATION	1732
COMPUTER LAB	0
TERRACE	3200
CLASS 8	5984
LIBRARY	5984
READING ROOM	5984
EXTRA CLASS ROOM	11968
TOTAL LOAD	95176
OTHER	4758.8
NET LOAD	99934.8
NET CONSUMPTION (IN kWh)	99.9348
ANNUAL NET CONSUMPTION DURING CRS	1998.696

Figure 22: Appliance details and usage during CRS usage (Source: Author)

The building is made of framed concrete structure, with interlocking CSEB infill and Filler slabs. This ensures strength, flexibility, and easy assembly. The filler slabs have abundantly available Mangalore tiles as fillers, which not only increases the insulation of the slab but also decreases the amount of concrete used.

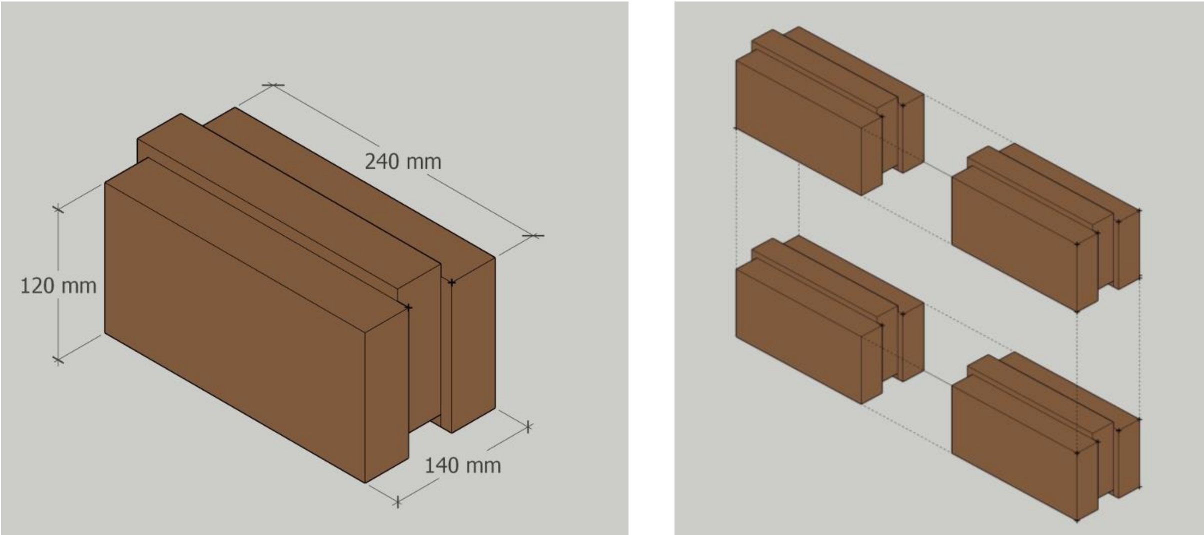


Figure 23: One CSEB block, and its interlocking technique (Source: Author)

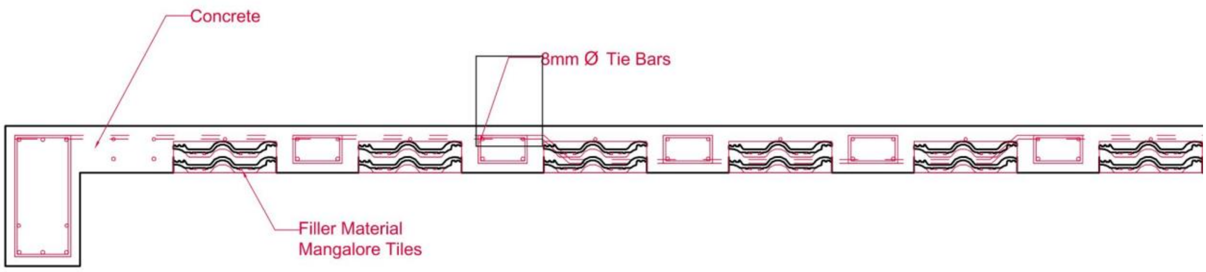


Figure 24: Section showing Filler slab detail (Source: Author)

11.5 Energy Performance

We aim to power the building mostly by solar energy, and by wind energy during times of high cloud-cover and incessant rains. For a Solar PV system, the total **solar energy potential is 1,96,605 kWh/ year.** (Assuming rooftop area= 600 sqm and 20% efficiency for fixed type solar panels). For a wind turbine system, the total **wind energy potential is 4,336 kWh/ year.** (Value may reduce due to additional yield losses.)

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	6.60	19,518	2,147
February	6.96	18,217	2,004
March	6.66	19,486	2,144
April	6.02	17,539	1,929
May	5.39	16,729	1,840
June	3.79	11,881	1,307
July	3.77	12,238	1,346
August	4.24	13,569	1,493
September	5.19	15,738	1,731
October	5.40	16,579	1,824
November	5.42	16,028	1,763
December	6.30	19,083	2,099
Annual	5.48	196,605	$ 21,627

PV System Specifications *(Residential)*	
DC System Size	132 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	10%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2
Economics	
Average Retail Electricity Rate	0.068 $/kWh
Performance Metrics	
Capacity Factor	17.0%

Potential of wind power before blades:		
Density of air:	1.23	kg/m3
Wind speed :	4	m/s
Rotor diameter:	4	m
Area covered:	12.57 m^2	
kinetic power:	495 Watt	
kinetic power (kw):	0 kW	
Annual potential wind energy:	4,336 kWh	

Figure 25: Solar Rooftop Calculator

(Source: PVWatts by NRE) *Figure 26: Wind Turbine Calculator(Source: Greencoast)*

For a biogas system, (asssuming 1 kg cow dung produces 40 litres of biogas) the total fuel generation potential is 32240MJ/Year (assuming 10 cows and each cow providing 10 kg dung per day) which is **8955 kWh/ year.** *(Source: Irena Statistics- Measuring Small Scale Biogas 2016)*

Being a rural area, Kambalakkad has a strong livestock and agriculture oriented community. Several compostable ingredients are readily available for composting, and meeting fuel needs of the families. RASTA foundation has implemented several biogas systems too.

To reduce the load on the building, numerous strategies were used. The ISHRAE Standards were used to establish right sized lighting loads within each space based on task lights, ambient lights and accent lights. The CSEB/ ISSB blocks will be used due to high time lag, low U value and it as well meets the requirements for our contextual occupants, occupancy hours, climate and comfort range. The light-coloured exterior walls, high-reflectance roofing will further reduce thermal gain. Photocell controls on lighting will be used to prevent unnecessary artificial lighting during the day. Further only 5 star rated fixtures and appliances will be used in the building. LED exit luminaires and high-efficiency fans will be provided in the rooms.

The high time lag of CSEB blocks is used with Night flush ventilation along with other natural and fan forced ventilation strategies that have allowed cooler temperature during working hours of school without the need for HVAC systems. This significantly reduces the electrical load. These have been discussed in detail in section 10.7

To understand the consumption pattern of the electricity, a time table of working hours throughout the year was prepared as can be seen in figure 7. The building is used as CRS for 20 days in a year during high flood season, and rest of the year, is used as a school with upto 200 working days.

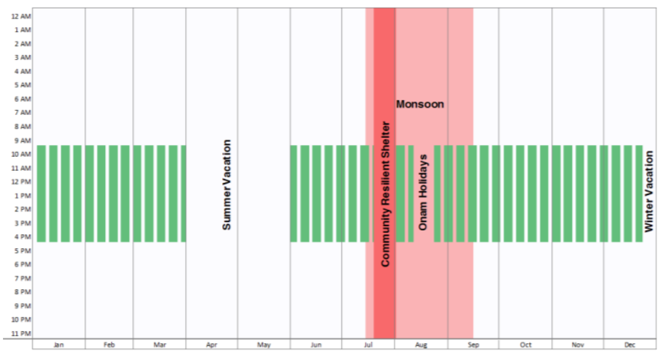


Figure 27: Yearly Working hours (Source: Author)

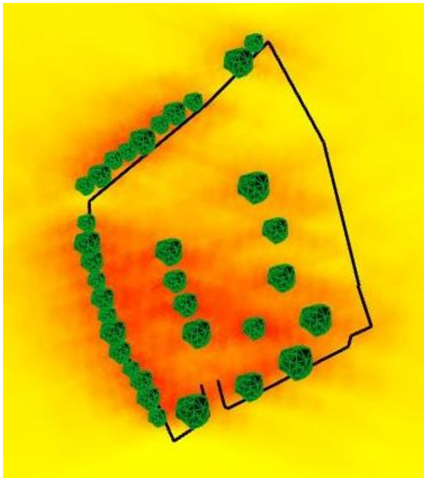
The appliances and usage hours as a school as well as CRS were listed for each space in the building and an overall consumption was calculated. The summary of the load has been given in Table 2. Hence, a total consumption per year for the same will be 28,300 kWh/year which is well below the generation potential of the site and hence 90% energy can be produced by the Solar panels.

Table 2 : Energy consumption details (Source: Author)

	Energy Load (Watt hour/ day)	
NAME OF PLACE	**School**	**CRS**
LOBBY	28000.0	8000.0
STAIR CASE	1728.0	3456.0
CLASSROOM	21120.0	18816.0
KITCHEN	876.0	1452.0
MULTIPURPOSE AREA	4224.0	5984.0
TOILET	800.0	1600.0
MEDICAL ROOM	928.0	1712.0
SUPW	4576.0	7136.0
SEMI OPEN	100.0	552.0
ADMIN AREA	4576.0	3616.0
STAFF ROOM	4576.0	0.0
PUMPING STATION	1732.0	1732.0
COMPUTER LAB	18976.0	0.0
TERRACE	1200.0	3200.0
CLASS 8	3424.0	5984.0
LIBRARY	3424.0	5984.0
READING ROOM	3424.0	5984.0
EXTRA CLASS ROOM	6848.0	11968.0
TOTAL LOAD	113732.0	95176.0
OTHER	5686.6	4758.8
NET LOAD (IN Wh)	119418.6	99934.8
NET CONSUMPTION PER DAY(IN kWh)	**119.4**	**99.9**
Maximum operational days	220.0	20.0
NET CONSUMPTION FOR FULL SESSION (IN kWh)	**26272.1**	**1998.7**

NAME OF DEVICE	NO OF UNITS
BULB	12
FAN	180
WATER COOLER	2
PROJECTOR	1
COMPUTER	41
TUBELIGHT 18 WATT	140
REFRIGERETER	1
WATER MOTOR	2
LED CEILING LIGHT	50
TUBELIGHT 50 WATT	8

For Solar generation, a hybrid system will be used as suggested by J.P. Consultants, our industry partner, as it is less expensive than a complete stand alone system, as there is no need for a backup generator. It as well provides the possibility to connect to the grid which serves as the backup power and can as well allow the excess solar energy be sent back to the grid. It provides flexibility to switch between power from the grid or power from the battery bank at will. This allows downsizing of the battery bank capacity. Mono Crystalline Panels will be used which have very high efficiency of 20% and 495 Wp. Figure 8 shows the sunlight hours which can help identify suitable areas for Solar, which will be used to place solar panels. Compared it with figure 8, the solar panels have been placed in the area on area with highest hours of sunshine



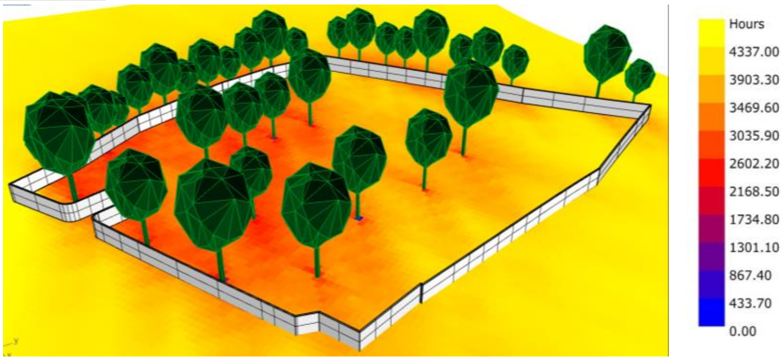


Figure 28: Sunlight Hours Analysis, Plan (left) and Perspective view (right) (Source: Author)

11.6 Water Performance

The design aims to achieve the management of on-site water as a resource as it is the need of the hour to utilize the fresh water judiciously. Rainwater harvesting, efficient plumbing fixtures and reuse of greywater for toilet flushing and gardening are the key aspects of the design to achieve a net zero water building, in turn minimizing total water consumption, maximizing the use of alternative water sources and minimizing waste water that is discharged from the building.

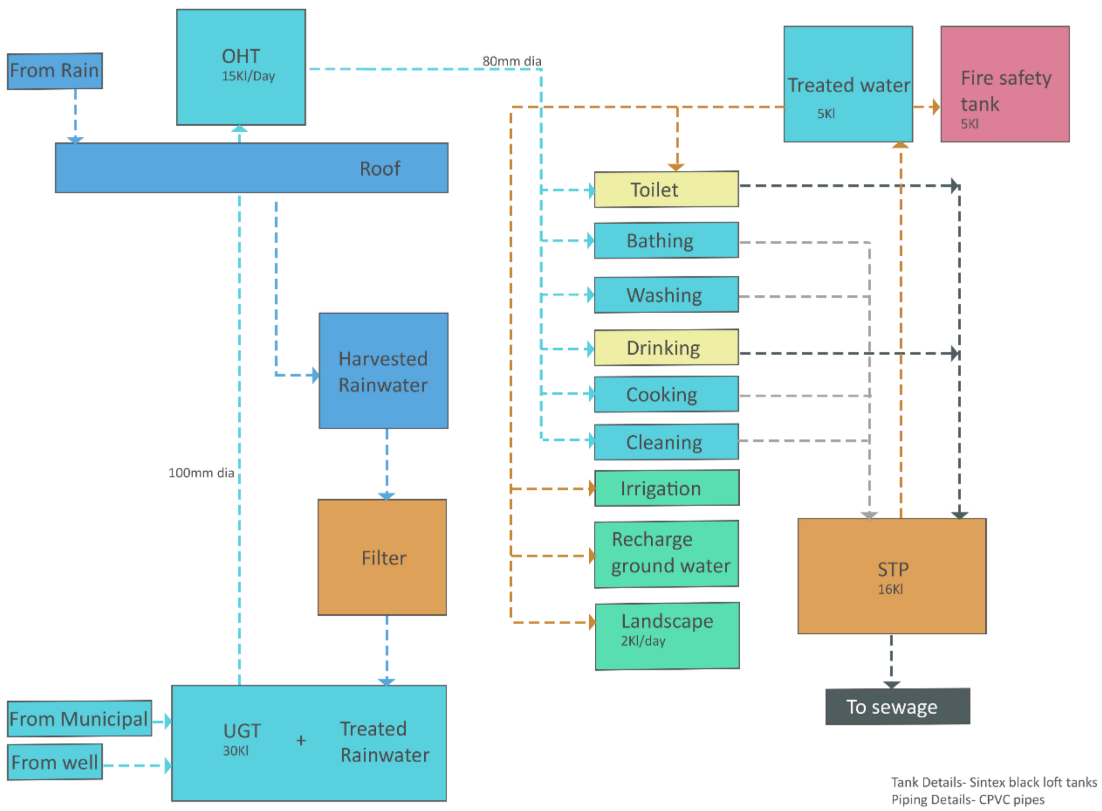


Figure 29: Net zero water cycle design (Source: Author)

***The requirement of water consumption and end uses will change for both cases**

Table 3 : Daily water consumption estimates (Source: Author)

	School use	Community Resilience use
LPD/Head	34.75	75
No. of people (including staff and others)	450	200
Total LPD/day	15637.5	15000
Grey water/day	8444.25	11400
Black water/day	7193.25	3600

Rainwater is harvested from the rooftop of the building. It is treated by a gravity fed bio sand filter and then treated with activated carbon and disinfected with chlorine so as to reuse rainwater for potable uses. The bio sand filter is adapted from the traditional slow sand filters, and has been a traditional practice of people from ages. The filter tank is made of concrete and is filled with layers of sand and gravel as demonstrated in the figure. 10.

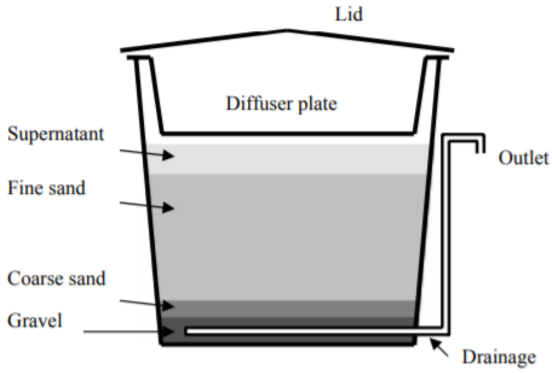


Figure 30: Schematic layout of bio- sand filter (Source: http://web.mit.edu/watsan/Docs/Student%20Reports/Ghana/2009/Group%20Report-Ghana09,%20Clair,%20Sara,%20Dave,%205-21-09.pdf)

Annual harvested rainwater after treatment with an efficiency of 75% is collected in an underground water tank which is connected to the panchayat water supply line and water supply line from a well which is present within the site. Well on an average supplies 300 - 400 litres of water per day to the school and with the addition of panchayat water supply fulfills the demand of the people of the school currently. The usage of fresh water resources is focused to be reduced in this project by mainly utilizing harvested rainwater and treated grey water. The usage of these fresh water sources are then mainly required in the months of December, January,February and March. Through this approach the dependency of building on the fresh water resources will be declined drastically.

The water stored in the underground tank is then pumped to 2 OHT of 8 Kl and 7 Kl so that each water tank can be isolated for cleaning and inspection without interfering with the supply of water. The pumps operate once a day to fill the overhead tanks. The OHT is sized 15 Kl so that it can suffice the supply of water for 1 day of water requirements of the building. This water is then used for all domestic purposes like cooking, washing, cleaning, drinking, bathing etc.

The water required for flushing (5 Kl/day) and landscape irrigation (2 Kl/day) is achieved by treating the grey water produced by the building. The greywater treatment system is sized 9Kl/day to treat greywater produced from the building through bio-sand filters with an efficiency of 75% and any excess water goes to the septic tank. Providing a well-sealed STP, with its topmost part elevated to 1m to protect from inundation during flooding, to reuse processed greywater for irrigation/ flushing. Black water from toilets is directed to the septic tank.

By using efficient plumbing fixtures with low flow faucets/showers and dual flush WC which resulted in an overall reduction in water requirement of 25% for school use and 45% during community resilience shelter.

Table-4: Reduction of water usage for school use (Source: Author)

School Use	Usage breakdown per person (in Litres)	Reduced usage by low flow fixtures (in Litres)
Cleaning	9	6.9
Washing Utensils	13.5	10.4
Drinking	3.6	2.7
Cooking	2.7	2.1
Toilet Flushing	15.3	11.8
Others	0.9	0.69
Total	45 lpcd	34.75 lpcd

Table 5: Reduction of water usage during community resilience shelter (Source: Author)

Community Resilience shelter	Usage breakdown per person (in Litres)	Reduced usage by low flow fixtures(in Litres)
Bathing	41	23
Washing	27	15
Cleaning	11	6
Washing Utensils	22	12
Drinking	5	3
Cooking	4	2
Toilet Flushing	23	13
Others	3	2
Total	135 lpcd	75 lpcd

****The annual domestic use includes both school as well community resilience shelter (for a period of 1 month).***

Table 6: Water Balance (Source: Author)

Annual Domestic use	Annual irrigation use	Annual grey water	Treated grey water	Annual harvested rainwater
38,11,425 l	2,38,300 l	20,93,541 l	15,70,156 l	24,87,567.5 l

Tank sizing is based on the average amount of water consumed per day for various activities. The overhead tank is sized 15Kl to fulfill the demand of the school; the water can be stored and used for a lockdown period of 48 hours. The tanks chosen are Sintex black loft tanks as they are low cost, maintenance free, durable, UV protected and light weight. The pipes used should be CPVC pipes with appropriate dimensions as shown in Fig 9 . CPVC pipes are highly energy efficient, cost-effective, resistant to corrosion,low bacterial growth, high fire resistance, low thermal conductivity and leak proof .

11.7 Innovation

There was 1 main issue that was faced here as a community resilient shelter. There is a high social disparity. The people are still illiterate with a literacy rate of only 79%. Women still have to cover their faces and people from different castes would not be talking to each other, which can be a major issue during disaster times. The women are financially completely dependent on their husbands since they usually don't get an opportunity to gain any kind of vocational skills or qualifications. However, the village is the venue for most of the art competitions in the district. We came up with two solutions for the case.

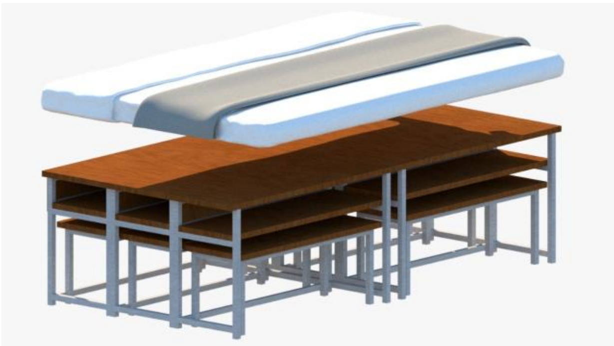
First during the functioning as a CRS, a colony was assigned 1 class. This allowed people with similar social backgrounds like castes and religion who live nearby, to as well stay together during the disaster times. Further we have, as a goal to have at least 50% of wall area to be covered with local arts. Through consultation with Raasta foundation, we can, through these illustrations on walls, raise awareness regarding the environment as well as can include illustrations of how the building can work as a CRS. This will help even the illiterate people and build upon the art pool of the village.

These illustrations will be very context specific but can be replicable in other areas with help of NGOs.
Another major issue lied in the fast conversion between CRS and school. The most time was actually consumed in moving around the benches. We needed to make the bences such that they are similar to the normal Benches so that students don't mess around with them too much but at the same time, are compact and if required could be used as beds by joining each other. The designed bench is shown in figure 31

Figure 31: School Bench Design (Source : Author)

Few of the key features include:

- The sitting bench is seperate from the table and the bench completely goes inside the table final footprint being only 70%
- Tables have a backrest on the front for the seat ahead of it providing bit more comfort for students
- The compartment slab is inset from the table columns so that while stacking side to side on longer edge, backrest interlocks with the table columns preventing any horizontal movement which creates more stable structure that can be used as a bed in emergency
- The sides of the compartment are open so that they can be accessed even when stacked and people can keep Blankets, clothes, food etc below it



There was another opportunity in terms of solar potential of the site. Of the approx. 2,00,000kWH/year potential, the CRS and school will need only 30,000kWh/year. A huge chunk of this can be given back to the local grid of the village, Creating a net energy positive building. For the same reason we opted for a hybrid system which connects with the grid too. We are also using the most efficient solar panels to minimise the area covered on the terrace (for air evacuation), Since we had ample space on the rooftop, we did not face any issues. However for smaller schools, solar panels can be placed on places like corridor roofs, light & sign poles to place these panels.

11.8 Affordability

A capital budget of Rs. 2,56,19,000/- is given by the project partner and the goal was to have the capital expenditure within the budget. The materials used in construction including CSEB/ ISSB blocks will be locally sourced. These will reduce the transport as well as material cost. Using local materials along with local techniques can allow the use of the local labour force and can as well allow for easier repair and maintenance. The efficient use of space in case of both CRS and school has allowed to minimize the use of extra material for single use spaces. Further we have aimed to not use HVAC systems, as it was not fitting in the local context, neither did the local people feel the need for it. This has reduced costs in electrical appliances along with plumbing, wiring and solar panel and battery. The preliminary cost estimation is given in Annexure 2

The operational costs were reduced by rightsizing the electrical appliances and ventilation structures. ISHRAE Standards were used to establish right sized lighting loads within each space based on task lights, ambient lights and accent lights. 5* rated appliances as well will be used to reduce the operational costs. WWR was taken from Design Builder simulations to right size the windows for ventilation and natural light. Other passive design strategies for ventilation described in section 10.7 as well reduce the electrical load and hence reduce operational costs.

However one of the major strengths of the site was its immense solar energy potential. A hybrid system connected to the grid can give back this excess energy to the grid for some revenue. There is a shortage of electricity in the village and this can help giving back to the village. However, 2 issues in this are that the roof has to be open and barrier free to allow air evacuation where solar panels cannot be placed. Further the cost of battery and solar panels is counted in capital expenditure. Even though it will reduce the operational expenditure bringing another source of revenue it will increase the capital expenditure. Hence a mid point has been reached

11.9 Scalability and market potential

Schools have been used as relief camps during disaster times at numerous times, however they are not the most well equipped with them. There are issues especially with access, storage of emergency supplies, with no power backup. Here we have tried to solve this issue by having a school be school but as well function as a Community Resilient Shelter. CRS to be a community asset needs to be very context specific and understand the social structure of the village. Here we had issues with illiteracy, cattles and caste biases working together. With the help of local NGOs, these issues can be identified and resolved in the building at the design stage itself.

A concrete framework was used for structural stability, however, other infill materials have been locally sourced like CSEB blocks which reduces the transport times and allows the use of locally skilled labour. The local arts used to paint the walls bring in the connection that connects the CRS with the community more coherently. To scale this model, it's essential to partner with local NGOs and communities to ensure that a bottom up approach requirement is met with the top down approach of expertise.

Another aspect of being a school, is the immense untapped solar potential in the government school. In India, though it is boasted that we have electrified 100% of villages, it must be noted that it's based on census definition that only 10% households need to be electrified to state that a village has been electrified. This has left a huge unseen gap in energy coverage in villages. Schools, which already act as a center of village, can hence as well act as a source of energy generation. Villages in Bangladesh already have village wise microgrids formed by solar panels at individual homes. This was taken up by SOLshare in bangladesh. This decentralization of power sources has helped the country from preventing any major blackout caused due to hurricanes and damage in infrastructure. Similar micro grids of each village can be formed with schools at the center. A hybrid solar grid can be used in government schools across Kerala and India, with enough capital expenditure.

12. Pitch to Project Partner

The aim of the project was to prepare a net zero energy building, and our team Nil Bill has designed a multipurpose Community Resilience Shelter cum Upper Primary School for the remote town of Kambalakkad. We have kept in mind that a) it is a government school and has to be maximum affordable, and b) it is a resilience shelter for the marginalised community. Hence, our design is very simple, yet very effective and practical.

SEEDs is involved with numerous projects related to both education and Resilience shelters. Our solution provides you with the opportunity of the optimal usage of land and resources with this multipurpose resilience shelter. Its result of being a Net zero building is the cherry on top. This is essential especially for the end user as they have to bear the cost of operation and maintenance. This provides SEEDs with a very compelling product to the people and administrators.

We have shown how the school can be optimally used with minimum changes to it. Over 90% of our area is used during both the CRS and as school, which is important in the cities where the land is scarce. We have shown the technology of the hybrid system for solar panels which ensures there is full capacity of battery always and at same time excess of the electricity can be traded with the municipality, to ensure revenue influx as well. For the times of disaster, a 1.5m plinth has been provided along with plinth protection. The walls are recessed, to accommodate classroom storage as well as horizontal + vertical shading of the envelope.

Also, since there is also an existing building there, we have accommodated maximum site contextual information while proposing the new design, which is why our design is worthy of implementation. All special requirements of the project partner SEEDS have been met, and it is ensured that a consistent dialogue with the Kambalakkad community (via phone or Google Meet) is established, so that the end product is accepted by the community and fits well within their financial, civil and social contexts.

Figure 32: Aerial view of the proposed School cum CRS (Source : Author)