Solar™ Decathlon India

Orphans in Need

JINDAL SCHOOL OF ART & ARCHITECTURE
India's First Interdisciplinary School of Built Environment

SUNERGON

FINAL DESIGN REPORT- APRIL 2023

EDU

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EXECUTIVE SUMMARY 03

Sun Ergon is a team of students with backgrounds in engineering, architecture, and built environment studies. The team recognizes the convergence of various fields such as seismic engineering, environmental engineering, materials and making, public health, resilient design, and net-zero design. With members from diverse disciplinary backgrounds, Sun Ergon has formed a collaboration with Orphans in Need to build a self-sustaining educational institute for orphan children in the remote Mailda village in Nuh district, Haryana, India

Over the course of three months, the team has diverged into smaller teams to explore the different aspects of the school program before coming together to make final design decisions. The team aims to build an institute that focuses on self-sustenance, quality educational systems, holistic wellbeing, and community service. The Springhills International School provides a transformative environment that fosters a strong sense of situated environmental and community-oriented awareness.

The school offers educational programs to orphan children and vocational training programs that open avenues for people in surrounding villages to seek education and employment, creating a community in itself. By offsetting operational energy needs of the inhabitants, the team aims to become net positive through on-site renewable energy generation. The use of rainwater and on-site waste water treatment allows for net-zero water consumption without having to depend on fossil, municipal, and ground water sources.

As part of their commitment to supporting philanthropic causes, the team supplies the harvested rainwater to nearby villages every month as part of their commitment to giving back to the community. By helping the locals to meet the local, they achieve sustainability, carbon efficiency, and resilience by using locally sourced rammed earth and CSEB (compressed stabilized earth block). The integration of locally produced materials makes the project more affordable to scale up and implement compared to those with conventional construction methods and materials.

The design strategies employed provide for a conducive and comfortable environment for social activity and learning. Through various design interventions, the site's natural climate, hydrometeorological conditions, water management, and projected stresses from climate change have been assessed and addressed. The team's goal is to create a school building that is economically feasible over the course of its lifecycle while benefiting the local community through educational and social empowerment and nurturing natural ecosystems.

Overall, Sun Ergon's aim is to create a sustainable and inclusive educational environment that serves as a model for future development projects that seek to have a lasting positive impact on the local community and its inhabitants. The Springhill International School is not just a school, but a community development project that will serve as a beacon of hope and empowerment for generations to come.

RESPONSE TO REVIEWER'S COMMENTS 04

SECTION	REVIEWER'S COMMENTS	HOW DID WE WORK ON THEM
REVIEWER 1		
TEAM SUMMARY	You could add your teammates pictures here. You could elaborate your approach more in terms of your design process. Also tie up with any relevant industry partners if possible. It would help the practicality of your project	This has been addressed on page 8 of the document.
GOALS	It seems that you are now heading forward with a clear aim. There are some spelling mistakes all through this segment, please rectify those. Aim for embodied carbon seems to be incomplete.	This has been resolved on page 12 of the document.
RESILIENCE	You have identified the potential risks in the region. You could elaborate it more in terms of how does it impact your project. How would it disrupt your services like energy, food, waste etc. .?	This has been addressed on page 22 & 23 of the document.
ENERGY AND WATER CONSUMPTION	Very well done calculations on both the headers. You could add you plan to reduce your energy demand	This has been addressed on padge 13 & 16 of the document.
REVIEWER 2		
GOALS	Energy Performance -Provide information for installed PV capacityfor the given roof area. Show breakup of reduction in EPIs with each strategy implemented. Add plans/ sections to enlist the passive strategies you plan to use.	This has been addressed on page 13-15 of the document.
	Water Performance - Good work, clear & concise. How will vary/help in times of water scarcity	This has been addressed on page 16 & 17 of the document.
	Embodied Carbon - Enlist examples of what materials you plan to use & how.	This has been addressed on page 19 & 20 of the document.
	Operations -It is interesting to note alternate HVAC modes. Provide the working schematic of the system in the next deliverable, to demonstrate how these will work in your case.	This has been addressed on page 25-27of the document.

Table 1. Reviewer's Comments

TEAM INTRODUCTION 05

Team Name : **SunErgon**
Team Division : Educational

Institutions Name : Jindal School of Art and Architecture (Lead Institute)
Jamia Milia Islamia

TEAM MEMBERS

Tharun CM
BArch 4th year

Team Lead

Mani Chandra Prabha
BArch 4th year

Architectural Design

Ishita Mittal
BArch 4th year

Architectural Design

Manis Kumar Kosam
BDes. U&CD 4th year

Energy Performance
Health & Well Being

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BArch 4th year

Resilience
Report Editor

VL Nikhil Reddy
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Energy Performance
Health & Well Being

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Architectural Design

Shan Mary SajiBArch
3rd year

Innovation & Value
Proposition

Tanvi Varma Indukuri
BArch 3rd year

Water Performance
Report Editor

Yash Dahiya
BArch 3rd year

Engineering & Operations

Anuraag Jauhari
BArch 2nd year

Engineering & Operations

Ananya Agrawal
BArch 2nd year

Architectural Design
Report Compilation

Anum Wani
BArch 2nd year

Architectural Design
Video Editor

Uwais-Ul-Hassan
MTech Earthquake
Engineering 1st year

Earthquake Resilience

Yasir Hamid
MTech Environmental
Engineering 1st year

Water Performance &
Resilience

FACULTY LEAD

Abu Talha Farooqi, Assistant Professor, JSAA

Abu Talha Farooqi has practiced and taught architecture for 10 years and has headed design studios, theory & research courses, as well as sustainability related courses in his teaching career. He is also an ECBC Master Trainer.

LEAD INSTITUTION

The Jindal School of Art and Architecture was established with the goal of being one of the top educational institutions for the study of the built, natural, and visual environments. The school offers 3 major programs Bachelor of Architecture, Bachelor of design, and Bachelor of Arts (Hons). Being a part of O P Jindal Global University, students at JSAA have the privilege to interact with peers and faculties from different disciplines.

INDUSTRY PARTNERS

SMH Adil (Director)
GEED Simulation Pvt. Ltd.
The nature of our collaboration will be Design assistance.

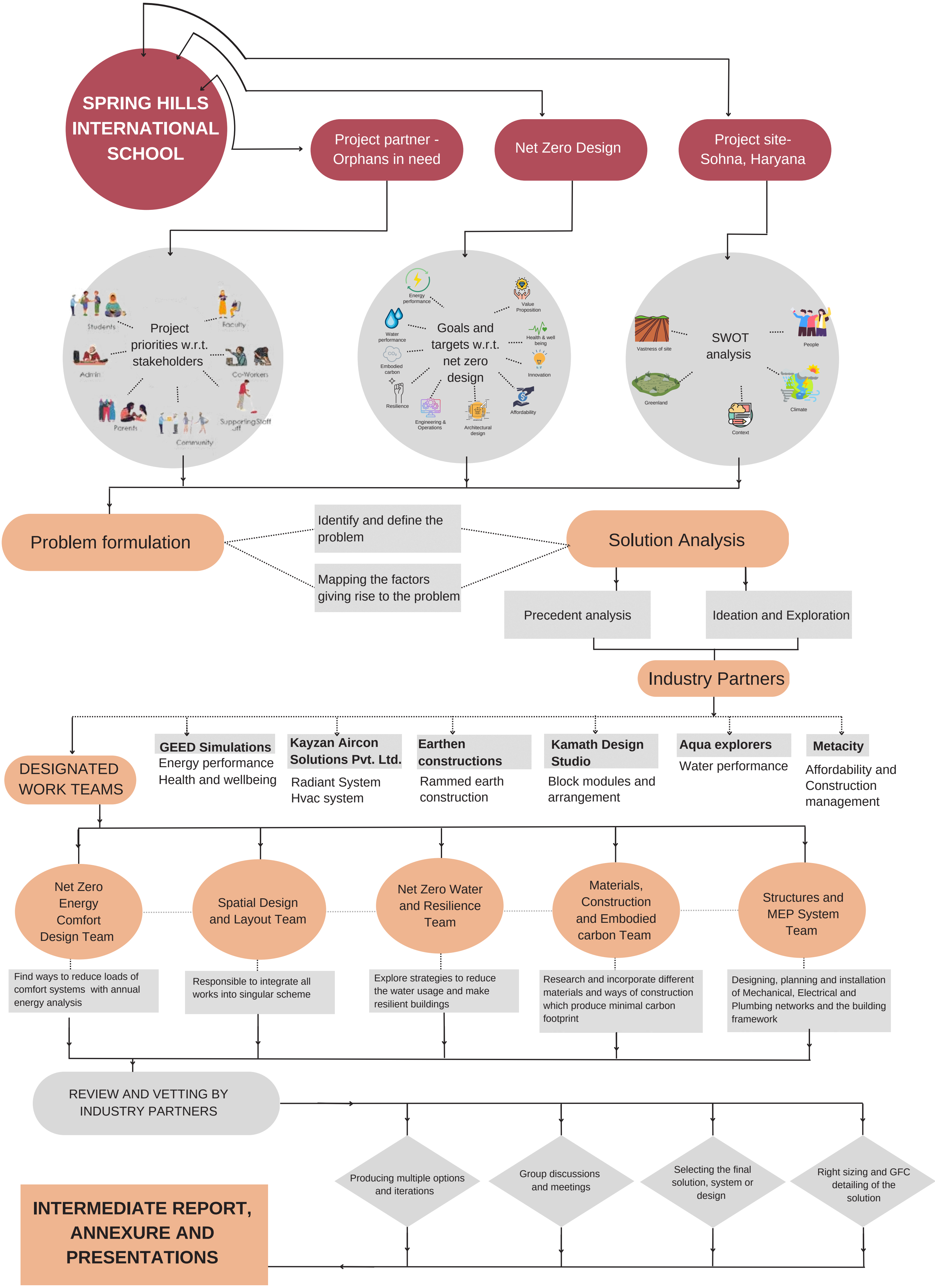
Pankaj Rathore (Director)
Kayzan Aircon Solutions Pvt. Ltd.
The nature of our collaboration will be Design assistance.

Mudassir Ahmed Khan (Director)
Metacity
The nature of our collaboration will be assisting the participating team in construction details, materiality and affordability of the overall project. We shall be working on ways to reduce the construction costs, using products which requires lesser maintenance and energy usage.

Earthen Construction
Mainak Das
The nature of our collaboration will be Earthen Construction Consultancy.

Kamath Design Studio
Ayodh Kamath
The nature of our collaboration will be architectural research.

Aqua Explorers
Mariyam Zakiah
The nature of our collaboration will be Water Performance calculations .



SPRING HILLS INTERNATIONAL SCHOOL
Project partner - Orphans in need
Net Zero Design
Project site- Sohna, Haryana
Students
Faculty
Project priorities w.r.t. stakeholders
Admin
Co-Workers
Parents
Community
Supporting Staff
Energy performance
Value Proposition
Water performance
Goals and targets w.r.t. net zero design
Health & well being
Embodied carbon
Innovation
Resilience
Engineering & Operations
Architectural design
Affordability
Vastness of site
SWOT analysis
People
Greenland
Climate
Context
Problem formulation
Identify and define the problem
Mapping the factors giving rise to the problem
Solution Analysis
Precedent analysis
Ideation and Exploration
Industry Partners
DESIGNATED WORK TEAMS
GEED Simulations
Energy performance
Health and wellbeing
Kayzan Aircon Solutions Pvt. Ltd.
Radiant System
Hvac system
Earthen constructions
Rammed earth construction
Kamath Design Studio
Block modules and arrangement
Aqua explorers
Water performance
Metacity
Affordability and Construction management
Net Zero Energy Comfort Design Team
Find ways to reduce loads of comfort systems with annual energy analysis
Spatial Design and Layout Team
Responsible to integrate all works into singular scheme
Net Zero Water and Resilience Team
Explore strategies to reduce the water usage and make resilient buildings
Materials, Construction and Embodied carbon Team
Research and incorporate different materials and ways of construction which produce minimal carbon footprint
Structures and MEP System Team
Designing, planning and installation of Mechanical, Electrical and Plumbing networks and the building framework
REVIEW AND VETTING BY INDUSTRY PARTNERS
Producing multiple options and iterations
Group discussions and meetings
Selecting the final solution, system or design
Right sizing and GFC detailing of the solution
INTERMEDIATE REPORT, ANNEXURE AND PRESENTATIONS

PROJECT BACKGROUND 06

Project Name : Springhills International School
Partner Organisation : Orphans in Need

Orphans in Need

BACKGORUND

Orphans in need is a non-governmental organisation based in UK, dedicated to providing long term, consistent support to orphans and their families in need access to high-quality care and excellent facilities. They have partnered in 13 countries including Somalia, Mali, Pakistan, Bangladesh, Sierra Leone, Sriv Lanka, and Palestine. Established in 2005, the organisation focusses on sustainable solutions to support the neediest around the world.

NAME & DESIGNATION OF KEY INDIVIDUALS INVOLVED

Mr. Umer Wani
Facilitation Manager, orphans in need.

BRIEF DESCRIPTION OF PROJECT

The Springhills International School is a part of the Orphans in Need project to further expand the support towards the community and orphans. This is an institutional project that would accommodate student capacity of approximately 2000 including additional 100 faculty and admin staff. The project is located near in Maindla Village in Taoru Tehsil in Nuh district of Haryana (Co-ordinates: 28.25°N 77.07°E). The project site area falls under the composite climate condition as per ECBC. The school building will be occupying students, faculty, and employee for an 5 days a week during a single 7-hour working hour from 7:00 am to 2:00pm.

SITE DETAILS AND BUILT UP AREA

Location: Maindla Village, Nuh
Land cost: 150 million INR
Site and proposed Built up area-

1. Site Area: 25734 sq.mt
2. Permissible Ground Coverage: 35%
3. Derived Landscape Area: 7618 sq.mt
4. Permissible FAR: 1.5
5. Achieved Built-up Area: 20407 sq.mt

GRIHA EPI Benchmark (Composite-Institutional)	: 90 kWhr/m2/year
Target Energy Performance Index (EPI)	: 45 kWhr/m2/year
Achieved EPI	:47 kWhr/m2/year
Operational Hours	:7 hours/per day
Total Roof surface Area	:7025 sq.mt
Feasible Plan size as per roof top area	:6606 sq.mt

fig.1. Site Context

I- ENERGY PERFORMANCE:
Reducing the EPI as much as possible, even below Super ECBC benchmarks, and offsetting operational energy needs and become net positive through on site renewable energy generation.

II- WATER PERFORMANCE:
To achieve zero dependency on fossil and municipal water sources, while maximizing the reduction of freshwater demand and recycling wastewater to have a net positive impact on the community through water and sharing initiatives.

III-EMBODIED CARBON:
To reduce embodied carbon in each component of the building, ranging from the structure as a whole to masonry to subcomponents and accessories. To place a special focus on reducing structural steel and concrete by 50%.

IV- RESILIENCE:
To design a self-sustaining building that can embody pre-disaster and post-disaster preparedness in terms of extreme scenarios.

V- ENGINEERING AND OPERATIONS:
All engineering systems on site, plumbing, electrical, lighting services, as well as structural systems are rightly sized and follow the highest energy efficient standards, and are thereby cost effective.

VI- ARCHITECTURAL DESIGN:
To ensure that the program, the site, its materials and inhabitants, and the co mmunity meet, sustain and work for each other, articulating teh necessary cod es of practice, guidelines.

VII- AFFORDABILITY:
To ensure the program, the site, the materials, and the inhabitation/dwelling meet and work with each other.

VIII- INNOVATION:
To make mainstream, industrialise and scale the construction up through alternative materials for a large site, low rise big school projects in the suburban regions in a time-efficient way.

XI- HEALTH & WELL BEING:
To maintain the optimum environment for the users to function effieciently in.

X- VALUE PROPOSITION:
To design a school building that is economically feasible over its life cycle, while benefiting its inhabitants and the local community through educational and social empowerment and nurturing natural ecosystems.

I. ENERGY PERFORMANCE

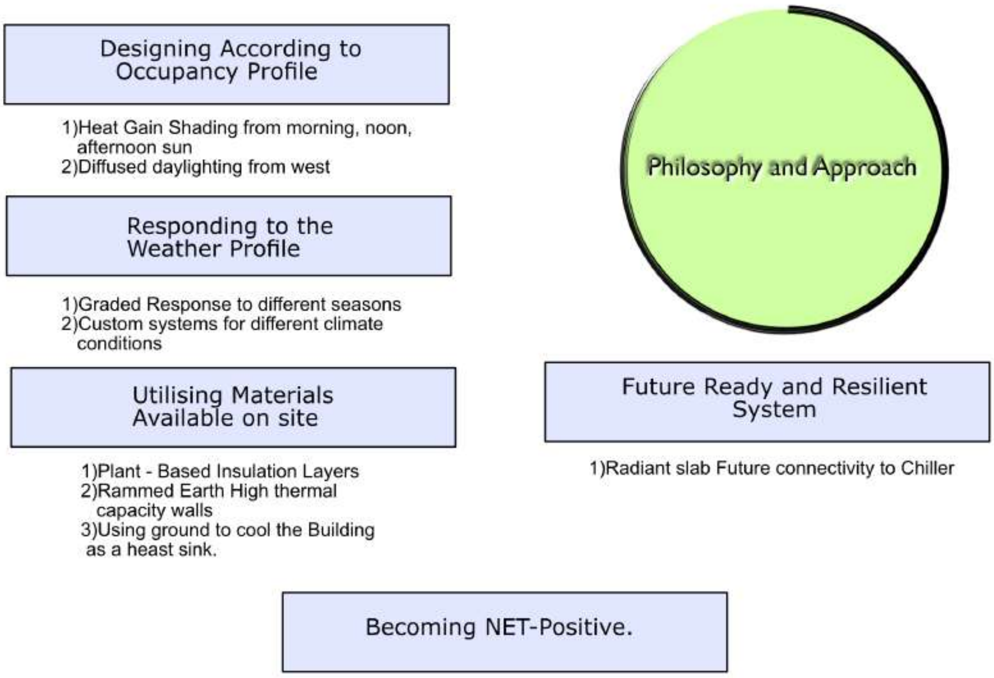


fig.2. Philosophy and Approach

Reduction of Thermal Loads

Passive Strategies

Several steps have been taken to optimise our building and achieve the recommended EPI. Using optimum orientation and using efficient materials we tried to reduce the thermal load on the building. We have also optimized the envelope as well as maximized daylighting through passive strategies. Design builder v.7.0.2.004 has been used to run the simulations.

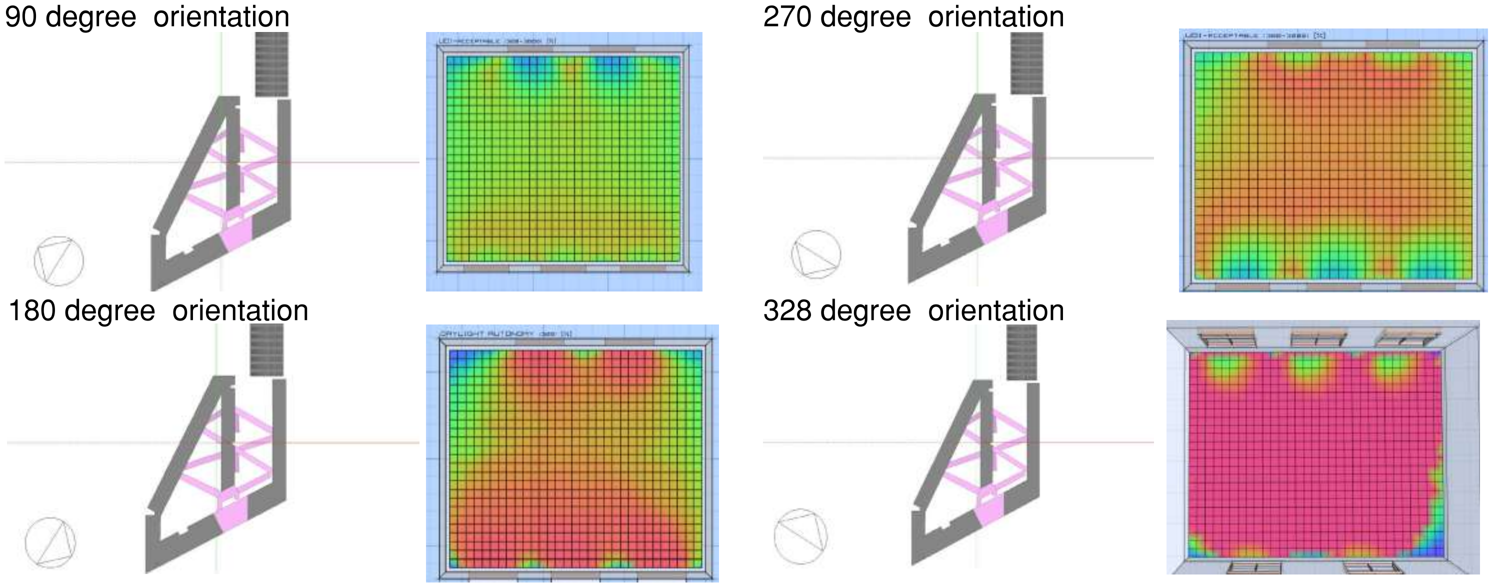


fig.3. Orientation and UDI

Integration of low energy comfort system

To achieve the Net-zero goal the HVAC system plays a major role. We could not use any of the natural HVAC systems due to the Sheer size of our building. So we have to use a system which would have fewer carbon emissions and provide us with a flexible heat/ cooling system throughout the year.

We came up with a low-energy thermal comfort system that will be installed to ensure the building is maintained in the recommended thermal band. We will install a ground source slab radiant cooling system to cater to thermal comfort over the year.

Integration of Active System

We propose a ground Source Heat Pump with AHU coupled with Air Cooled Chiller. The Chiller uses refrigerant gas -1IRCR ZE gas-R1234 HFO.

Added chiller with a dedicated outdoor air system for the dehumidification of air during the monsoon months (July to September). The system operates on water pumped from the ground

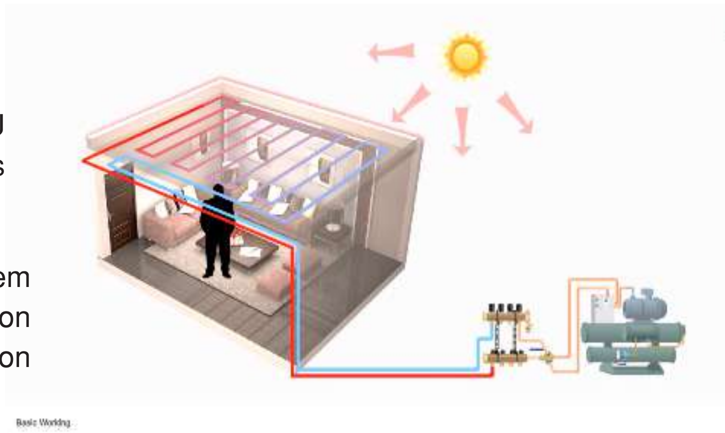


fig.5. Radiant cooling sch

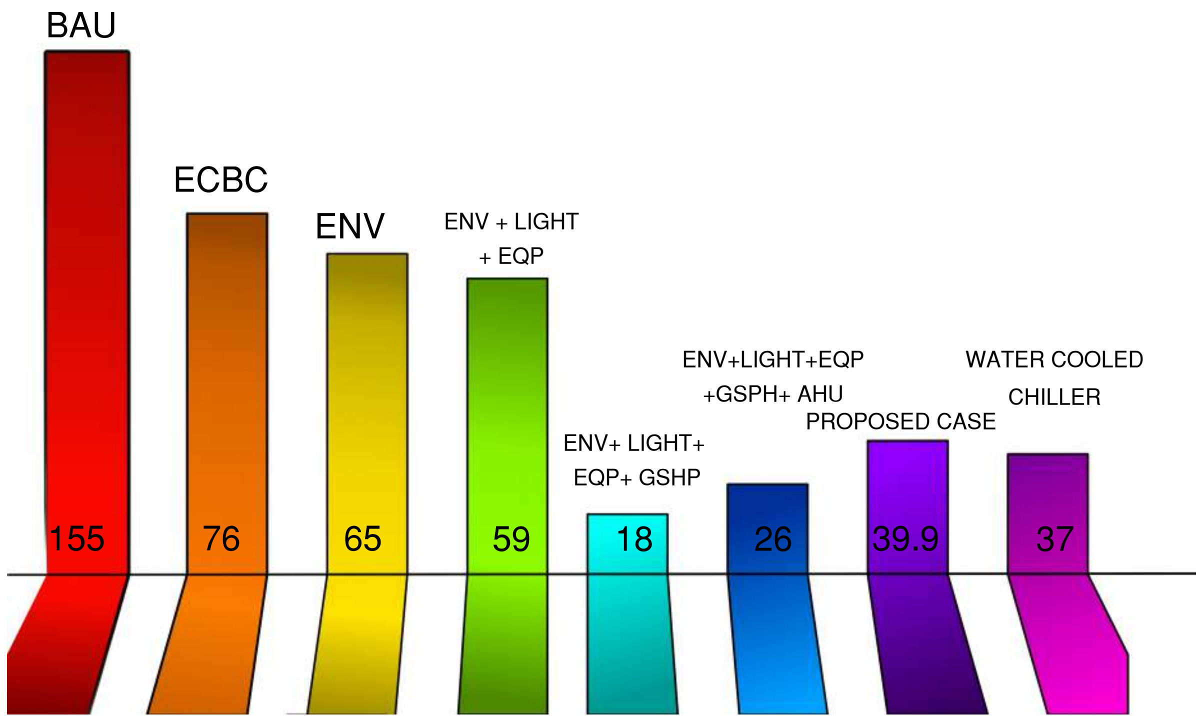
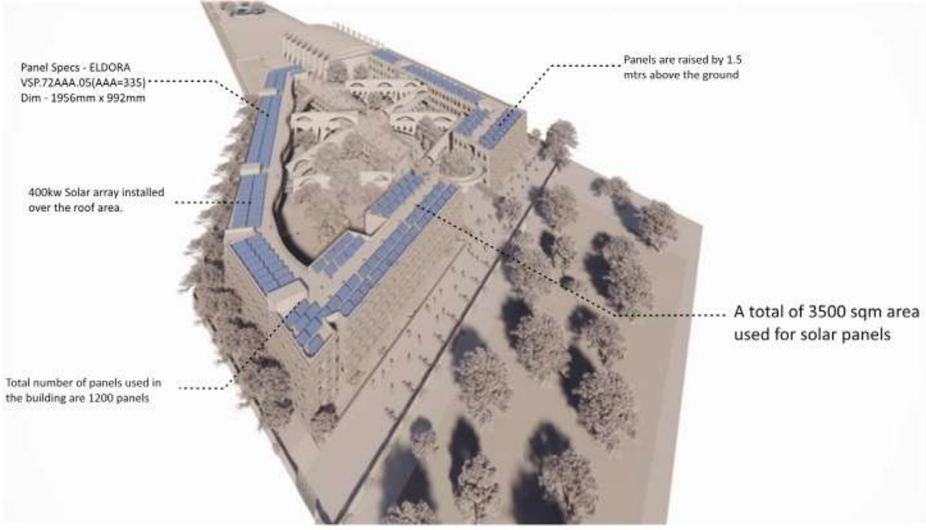


fig.4. EPI Chart

fig.6. Solar PV render

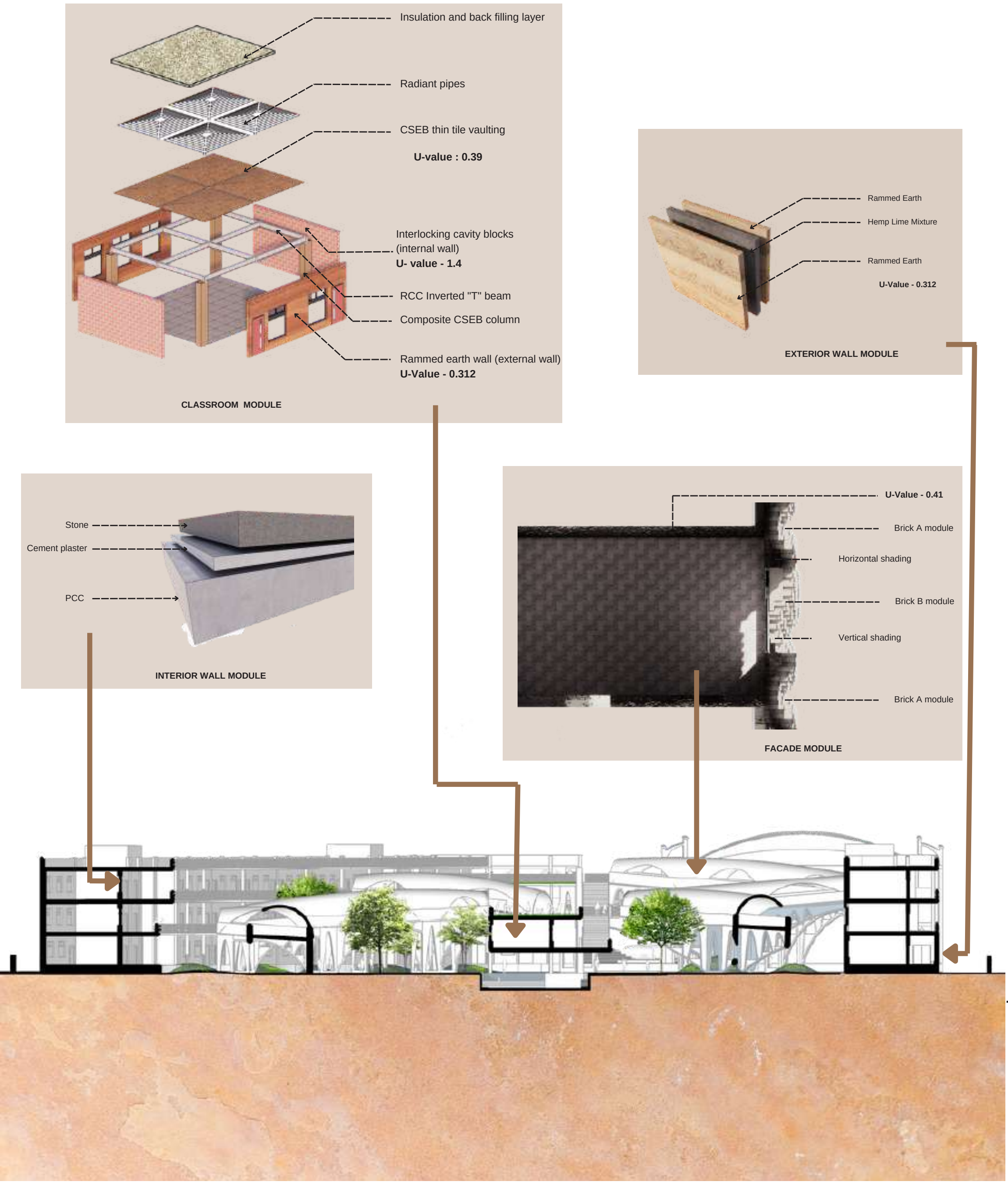


Renewable Energy Generation.

Energy generation and consumption:

Total energy consumption		Total energy generation	
507137 kwh	<	580,000 kwh	Net Positive Achieved!

Surplus energy will be directed towards Net metering of the electricity grid.



7. Envelope assembly

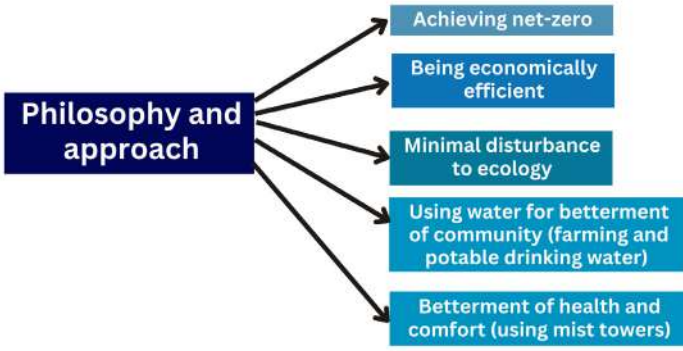
II. WATER PERFORMANCE

Our Philosophy and Approach

The earth has a cyclic balance where various natural cycles and processes occur that help maintain an overall balance and a state of equilibrium. One such cycle is the water cycle where there is a continuous movement of water which help carry out processes like evaporation, condensation, precipitation, runoff, and groundwater recharge. Human intervention has disrupted this balance by polluting and overusing groundwater, especially with construction, which reduces the amount of water recharged in the ground. Our goal should be to minimize disturbance to the ecosystem and restore this balance to maintain a timeless cycle.

1) Rainwater collection and filtration:

According to the Central Ground Water Board (CGWB), the Mewat district has an annual rainfall of about 572 mm (as mentioned in the Ground Water Yearbook of Haryana State 2021-22), with the peak rainy months being July (167.2 mm), August (194 mm), and September (99.3 mm). Through the collection of rainwater, we are able to successfully collect about 3611 kL from the rooftop area and about 4496 from the site surface area annually. In order to utilise this resource to its fullest potential, we have sorted the water collected according to its designated purpose on site.



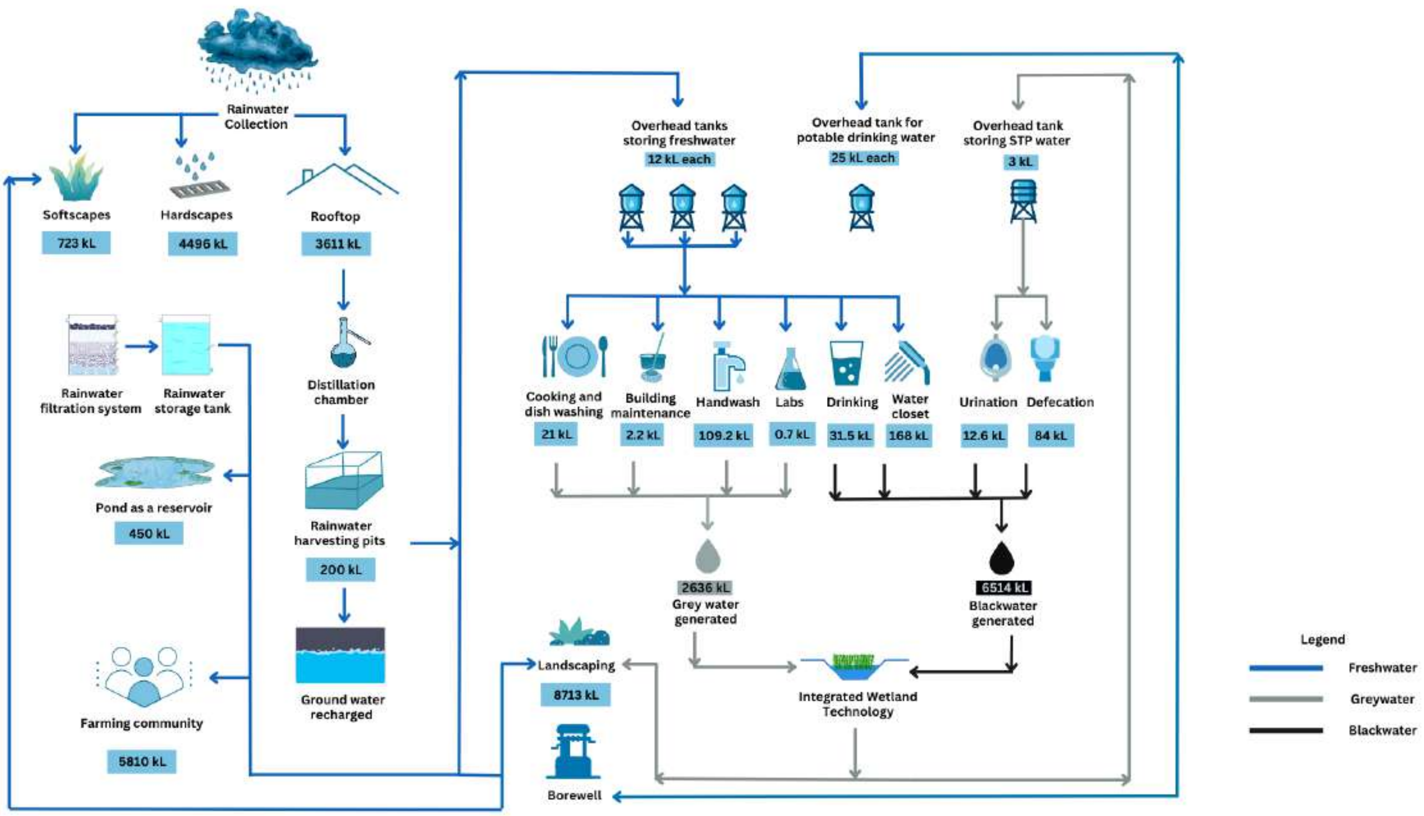


fig.8. Water Cycle Diagram

The freshwater supply in the building will be sourced entirely from the water collected through the rooftop area. As for the water collected from the site surface area, it will be channelled out to serve various needs. . About 722 kL of the rainwater is collected directly in the horticulture area. Following from consultations with our industry partner, Aqua Explorers, Prof, Gauhar Mahmood we have constructed a parapet wall along the landscaped areas. This helps in collecting the necessary water required to fulfil their irrigation demand. About 2339 kL of site surface water will cater to the irrigation demand for landscaping. Prof. Mahmood further indicated that rainwater is free from heavy metals, and that the use of charcoal, aids in the elimination of any undesirable odours. Therefore, the rest of the site surface water is being sent through a filtration system consisting of four tanks, gravel pre-filtration unit, slow sand biofiltration system, biochar adsorption filter and the storage tank (refer to fig 7).

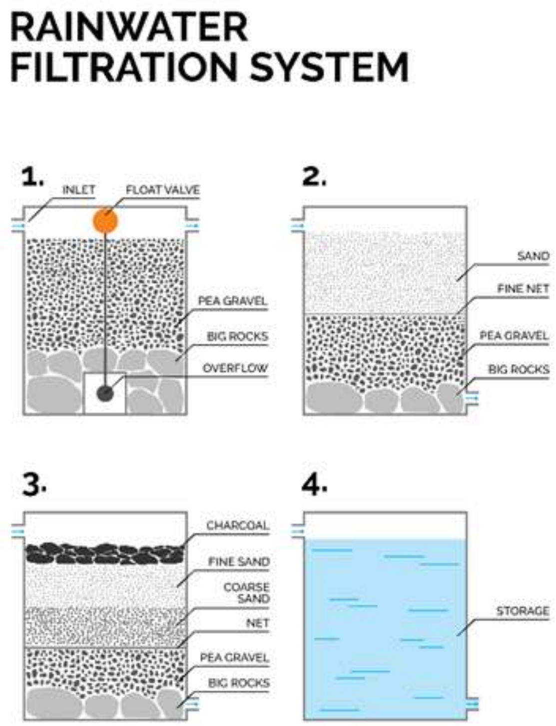


fig.9. Process of rainwater filtration through each tank

2) Recycling Water :

In order to reduce the freshwater demand in the building, the grey water and black water generated are treated on site using the Integrated Wetland Technology (IWT) based green STP. The design for IWT has been proposed in collaboration with SINE IIT Bombay Company: Emergy Enviro Pvt. Ltd, and goes beyond the need for electricity powered mechanical pumps. The technology is based on sub-surface flow, which consists of a basin or a channel with barriers called baffles with a defined depth of porous media. The porous media also supports the root structure of emergent vegetation.

The design of the Integrated Wetland system assumes that the water level in the cells will be beneath the surface of the filter media. The system is noise free, odour free, sustainable, uses minimal energy and is also economical. Various components of the Integrated Wetland System and the schematic process of treating the wastewater is depicted in Fig. 3.

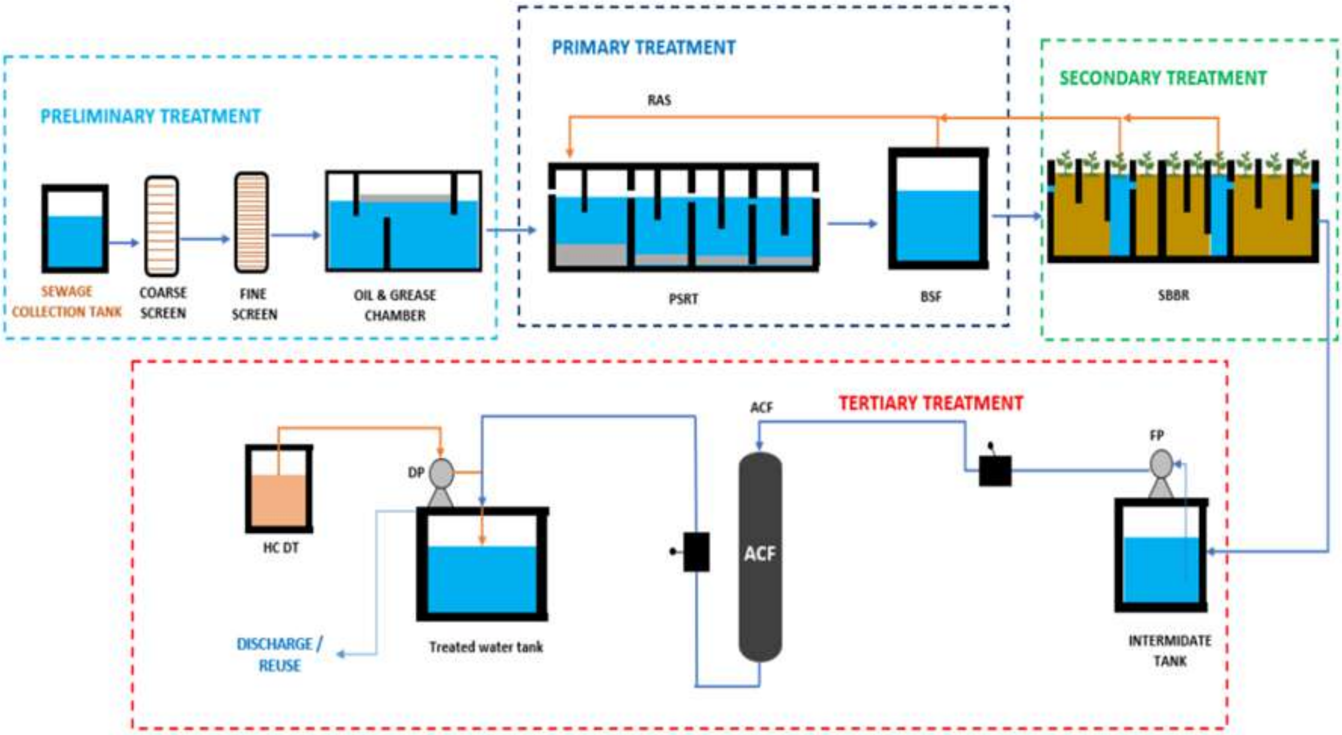


fig.10. Process flow diagram of IWT

3) Behavioural changes in consumption:

Apart from bringing forth a net zero solution, it is also important to manage the demand in the building. At our school we wish to cultivate a water-conservation mindset among its occupants by altering consumption patterns. Our approach involves installing fishbowls at all wash basins and drinking water dispensers (see fig. 5) that gradually empty while the tap is running but automatically refill to their original level once the tap is turned off. The Poor Little Fish basin system is an emotionally-driven way to promote water conservation. Additionally, we're planning to connect hydroponic plants in jars to water dispensers, providing another interactive way for occupants to learn about responsible water use. Overall, our aim is to foster sustainable behaviors and promote water conservation within our school community.

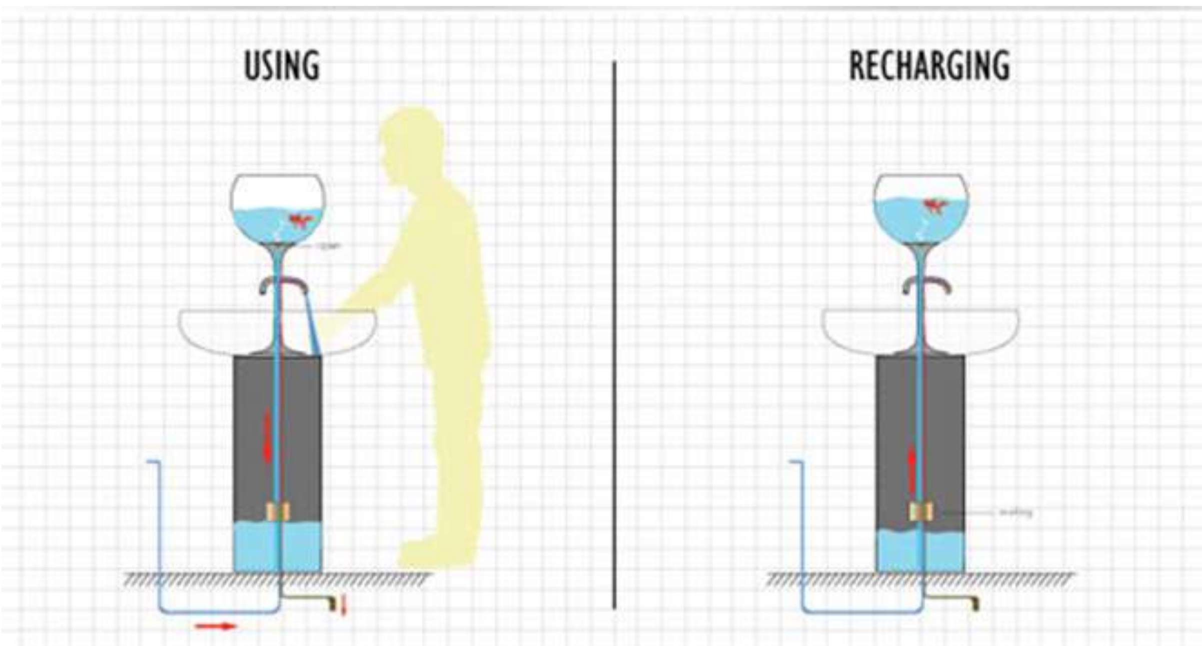


fig.11. Functioning of the poor little fish basin

III. EMBODIED CARBON

Reducing the Embodied Carbon of our project stands among one of our foremost goals. Our approach has bene guided, primarily by locating and sourcing local materials, leveraging indigenous skillsets and harnessing human resource. We will utilise Rammed Earth and CSEB bricks that will be prepared on site. This will further help in reducing the embodied carbon of the project. Our strategies have helped us reduce the Carbon Emissions from 33,000 tonnes of Carbon to 16,000 tons of Carbon. We are also using R12344ze as refrigerant gas and chiller, which has approximately zero GWP.The Embodied Carbon Simulations and calculations were done on OneClick LCA and on the Embodied Carbon Tool.

Below are the materials used in our projects for all the elements that a building is composed of:

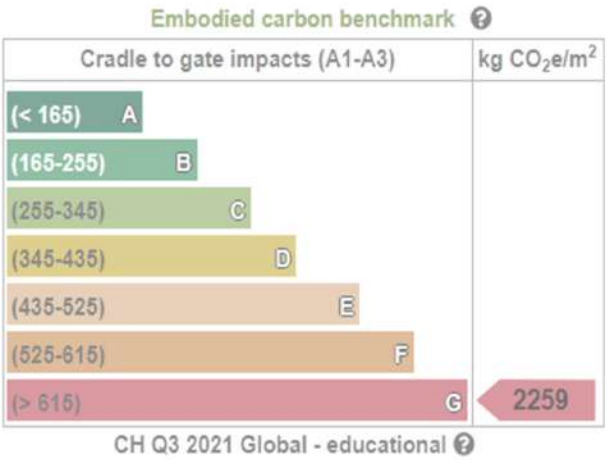


fig.12. Baseline Results- Carbon Heroes Benchmark

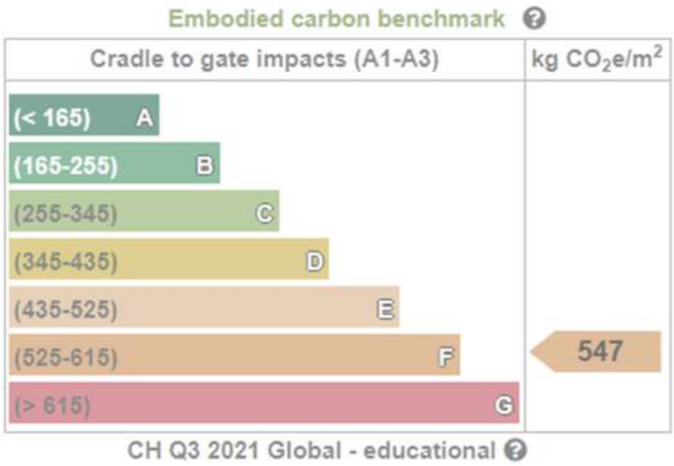


fig.13. Proposed Results- Carbon Heroes Benchmark

Walls

Our external walls are 300mm thick, made of Rammed earth bricks instead of customary clay bricks baked in brick kilns. The soil for the bricks is locally sourced from the construction site hence reducing the transportation cost and the emissions caused from it. The bricks are not required to be baked in fire which further reduced the embodied carbon of the material.

For Interior walls, we use Compressed Stabilized Earth Block (CSEB) bricks, also largely sourced from the site. These bricks cut costs and enable us to economize on the energy spent from making conventional clay bricks.

Columns

We have opted for the use of CSEB columns for our structure, than conventional RCC columns of an M25 grade and steel rebar reinforcement. All steel reinforcements used are 70 % recycled and salvaged, further reducing water consumption from construction. The steel rebar will be incorporated through CSEB blocks derived from the site.

Foundations

Foundations are built using M25 concrete with 25% GGBS content, than regular concrete. GGBS is Ground Granulated Blast-furnace Slag, a by-product from blast-furnaces used to make iron. The steel used for the reinforcement is 70% recycled, as mentioned.

Roofing

School building and multipurpose hall roofs are vaulted using CSEB tiles, replacing the usual RCC slabs. RCC is only used in beams running alongside the vaulting.

Bridges

Locally sourced Quartzite stone and CSEB blocks are used instead of steel and concrete to build bridges connecting the various parts of the school building. The stones were found as boulders on site, while CSEB blocks were used for the bridge vaults.

Flooring

Quartzite Stone, which was abundant on site, was used for flooring instead of ceramic or other natural stones that need to be stored and transported. This reduces emissions caused by transportation. (refer to embodied carbon annexure)

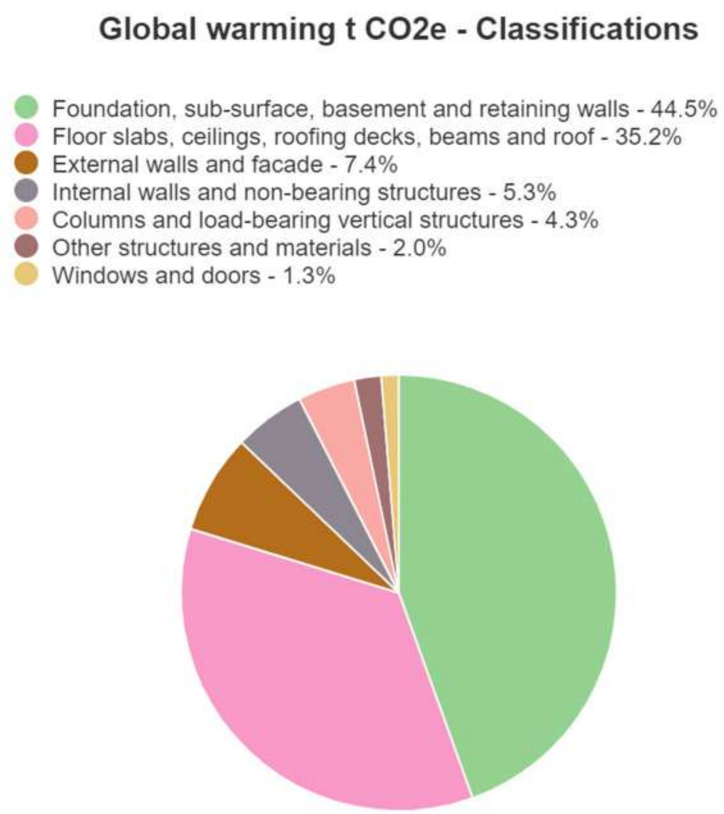


fig.14. Global Warming Potential Classifications Baseline

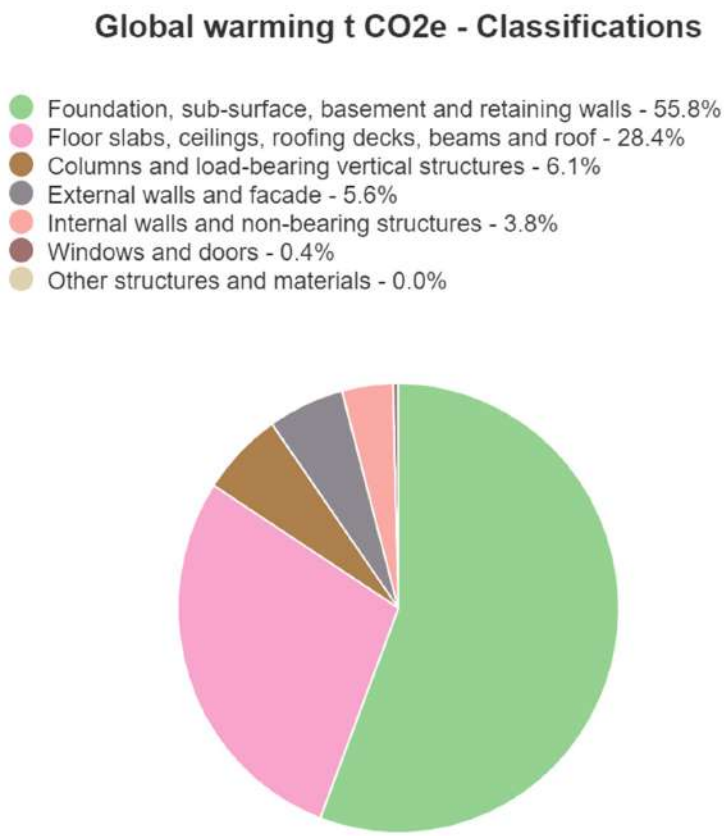


fig.15. Global Warming Potential Classifications Proposed

Our project is centred on minimizing carbon emissions throughout the building process. We have implemented several measures to achieve this goal, starting with the use of excavators for excavation. Further, we use electric concrete mixers for building the foundation and beams as opposed to diesel-run concrete mixers to lower carbon emissions. Natural materials salvaged from and prepared on site reduce carbon emissions that would have been accounted for due to transportation. Further, CSEB blocks, and rammed earth are utilised for construction due to not only their low embodied carbon, but also because they accommodate the use of certain machinery such as a vibrating conveyer belt, a weighing machine, a pneumatic rammer (used for the construction of rammed earth walls), all of which run entirely on renewable solar electricity from solar panels. We will be using this electrical energy through net-metering during construction, using the Municipal's power supply and returning them the excess electricity. Further, we aim to strike a balance between human labour and machines to reduce not only emissions, but to further contribute to the local community by providing employment opportunities. Our holistic approach ensures sustainability, carbon efficiency, without compromising on quality or efficiency.

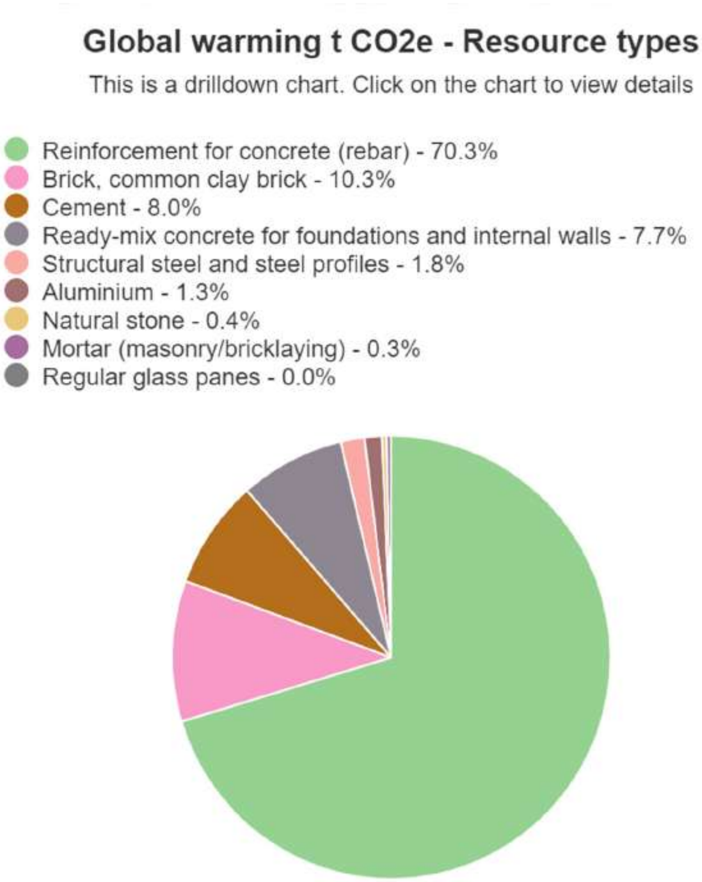


fig.16. Global Warming Potential Resource Types Baseline

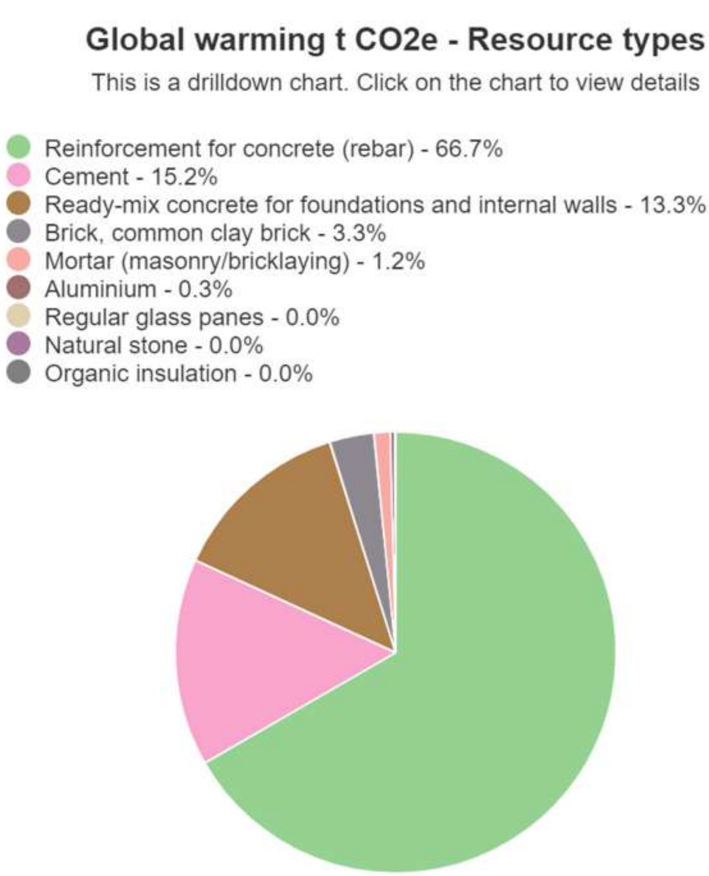


fig.17. Global Warming Potential Resource Types Proposed

IV. RESILIENCE

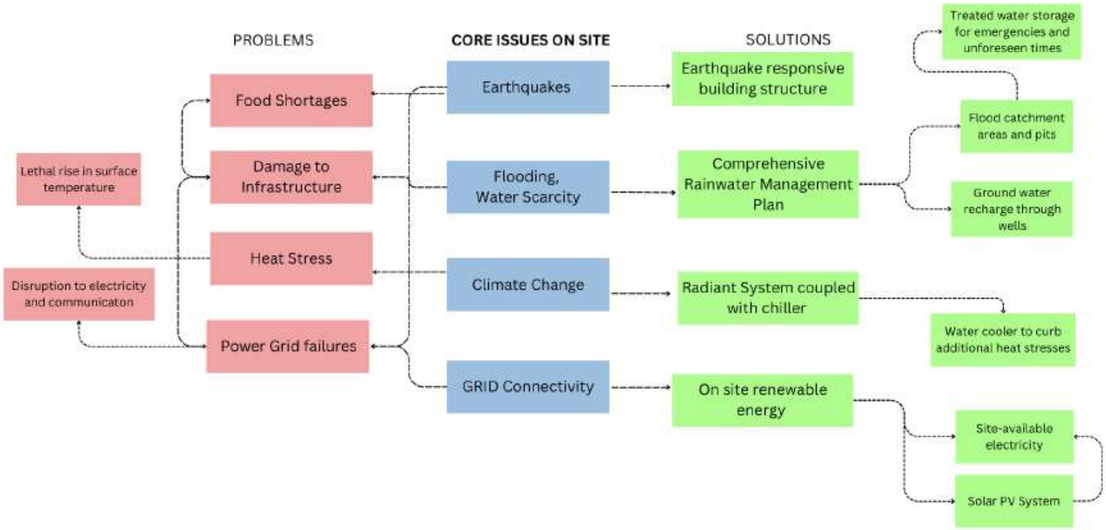


fig.18. Disaster Proofing and Preparedness

1.EARTHQUAKE RESILIENCE

Nuh, Haryana falls near the Gurgaon district within the NCR of Delhi, which is an intense seismic risk zone, exhibiting a high to severe seismic hazard in case of M 6.0 at the Sohna Fault (Sharma et al., 2020). The site is directly impacted by several active tectonic features such as the Himalayan Main Boundary Thrust, the Main Central Thrust, The Aravali-Delhi Fold, and the Sohna Fault (Sandhu et al., 2020). Thus, Sohna lies in Zone IV of earthquake intensities as per the Seismic Zone Map of India [IS 1893], with I Factor of 1.5. It is described by the BIS as High Damage Risk Zone, corresponding to Intensity VIII (Scale of I-XII) on the Modified Mer- calli (MM) scale, and a reading of 5-5.9 on the Richter scale.
Design and Construction Interventions-
i) CSEB blocks for construction of columns can bear loads up to three storeys. [NBC 2016, Part 11, 9.2.1.3.1 (c)]
ii) Using steel reinforced CSEB can ensure optimal structural stability.

STEEL REINFORCEMENTS	
10 – 12 MM	All columns of the main academic block, library, kitchen, cafeteria, health-center, etc.
16 – 20 MM	All columns of the multipurpose hall

iii) A study in Spain by Santis et al. (2018) tested masonry vaults with steel reinforcements chords and plaster. They noticed the reduced effect of lateral forces and increased the deflection capacity and stability of the vault by twice (Santis et al., 2018).
iv) The school structure utilizes an RCC framework, consisting of horizontal (plinth, roof and floor, lintel, gable) bands and vertical reinforcing bars (HSD Bar Diameter - 10mm and 12mm) at all openings wider than 600 mm. [IS 4326: 1993 clause 8.4.1, 8.5.7.1]
v) The recommended mortar mix for construction is cement:sand 1:4 [IS 426:1993] than a ratio of 1:6.

DISASTER PREPAREDNESS

Given the climatic and hydrometeorological risks posed on site, it is essential for the school to provide for the safety and wellbeing of its inhabitants after the disasters onset:

a) Energy

i) The school is sustainable in its energy consumption, using a 0.335 kWp Solar Photo-Voltaic system installed to offset the annual energy consumption.

ii) Energy that is not used is returned to the grid. In the event of a prolonged power outage brought forth by a disaster, the school will still have functioning electricity and hot water supply in times of distress.

b)Community Resilience Shelter

i)The school campus integrates the surrounding community with itself, by converting the multi-Purpose Hall as a space to live in, sleep, eat and avail primary healthcare.

ii)The solar PV system will continue accommodating for all energy, ventilation, and food needs. The installed rainwater harvesting system will serve all consumption, sanitation, and cooking needs.

c)Food, Health, and Wellbeing

i)The school also has a 120 sqm kitchen for the provision of meals, with dedicated storage pantry spaces, and a freezer room within the floor area program. Additionally, there is a 150 sqm kitchen farm and garden provided to grow kitchen essentials, translating as a fun and collaborative activity for children.

ii)The school also has a fully functioning and equipped health center, where inhabitants can avail general check-ups, treatments for common ailments, counselling and guidance services for students, as well as health education resources.

iii)Overall, the school provides 1300 hours of thermal comfort, and 2449 hours of visual comfort each year without relying on mechanical services for all our critical functions (lights, lifts, communications, pumping for water supply, and sanitation).

d) Resisting Grid Failure: -

i) The total energy consumption - 507137.62 kw/h

Maximum energy need- 507137.62/1500 = 338.09 kwh/year

ii)The school also employs a system of net metering, which returns all unused energy back to the grid.

e)Resisting Heat Stress

For future heat stress and global warming threats, the radiant system is so designed to be coupled with a chiller system to offset the additional thermal load.

IT WILL BECOME RESILIENT WITHOUT SIGNIFICANT CAPITAL EXPENDITURE!

Even for present heat stress, the play areas and gardens are well-shaded with buildings and trees, protecting children from harsh direct sun.

RESISTING WATER SCARCITY, FLOODING, AND MANAGING WASTEWATER HANDLING

In 2020, the Integrated Water Resources Management of Sohna published a report on the state of ground water depletion within Sohna in the last 15 years. It highlights excessive extraction of water through private borewells, for residential, agricultural, and industrial purposes. Moreover, rapid urbanization has further exacerbated the issue, generating large amounts of untreated wastewater, which still awaits adequate management.

A circular system of recharge and consumption that does not rely on municipal water services, and one that treats and recycles wastewater is essential. Refer to the details in Annexure 4, A.4.2 (i) (ii) (ii) (iv), for more details.

i) Rainwater Harvesting

These rooftop and on-site recharge systems collect and store rainwater that falls on rooftops, pavements, and other surfaces, to use as freshwater following filtration and treatment.

ii) Rainwater Recharge Harvest Pits and Microinjection wells.(refer to annexure)

iii) Hydro-Abstraction Wells

iv) Integrated Wetland Technology Green-STP system (refer to fig.13)

v) Pond/Kund

We use all rainwater from the rooftop and treated surface water for building needs. Excess water is stored in a pond, after which any excess remaining water is supplied to the local community. The pond design allows us to store over 750KLD of rainwater, with two sections measuring 10m in radius and 1.3m and 2m in depth, respectively. The pond also features steps as part of its design features, where students can sit together. We keep the overall depth low for the safety of students.

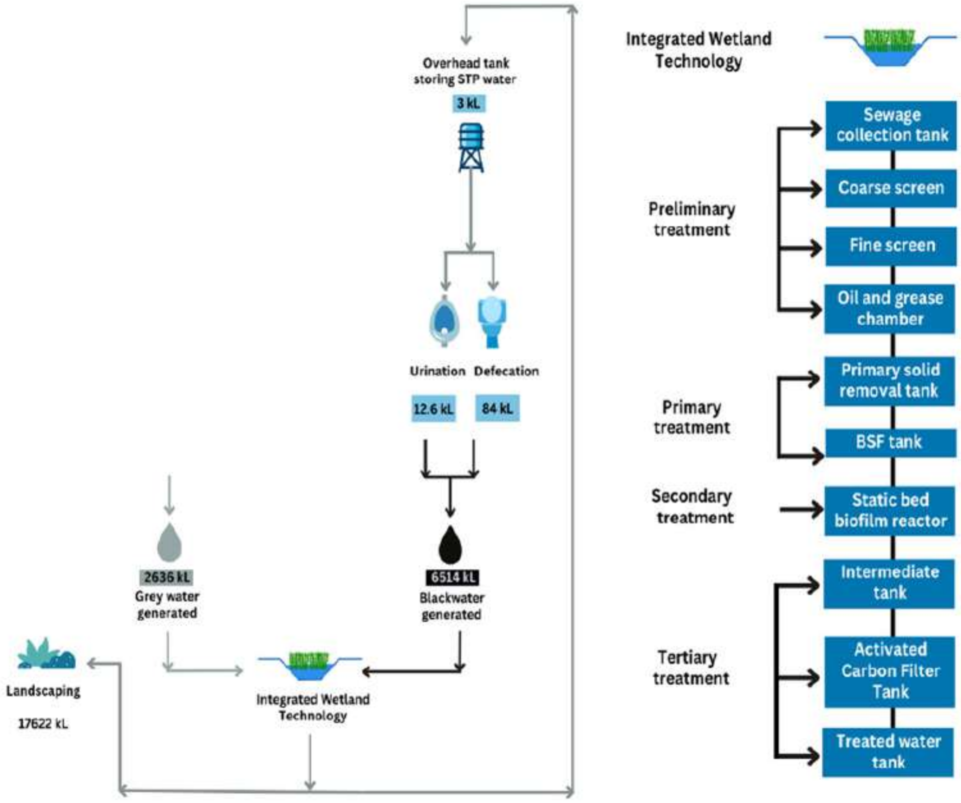


fig.19. Flow diagram of IWT and the usage of this treated water in the building

V. ENGINEERING & OPERATIONS

The school's engineering systems and services are seamlessly incorporated into the building's overall structure, and they function as intended to provide a comfortable and convenient living experience for its inhabitants. This requires designing the systems and services to align with the school's spatial, architectural, and material characteristics.

Structural Systems

The classrooms have four cross vaults with beams running between them. The cross vaults are made of CSEB tiles and are independent of steel and concrete, thanks to its structure. The structure can take the compression very well, so the vertical loads from top are distributed on the vaulting in the form of compressive forces. There are T-shaped beams placed, with steel reinforcing at the bottom to take the tension that will be caused when the loads from the vaults are transferred.

The bridges work on the same principle as the cross vaults in the classrooms. The only difference is that the bridge has small parabolic arches to reduce the self-weight of the structure. The bridges are a combination of the locally sourced Quartzite stone, that form the arch while CSEB and Rammed Earth fill the rest of the structure.

For the Multipurpose Hall, we have used a parabolic shape for the roof which works on the same principle as the vaulting in the classrooms. There are buttresses which support the lateral loads of the Multipurpose hall due to the height and width of the building and the roof. These Buttresses consist of composite columns and beams, that distribute the load through the buttress. These composite beams and columns are made of CSEB with steel reinforcement while the internal walls are made of Rammed earth.

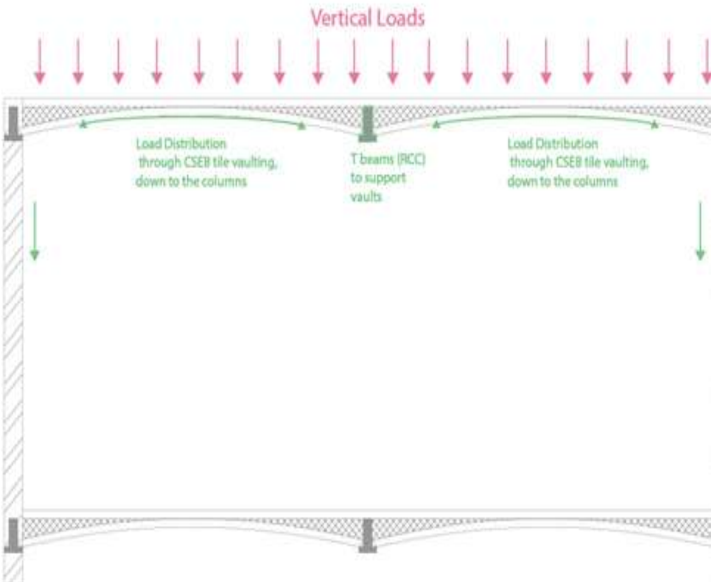


fig.20. Load Distribution for Classrooms

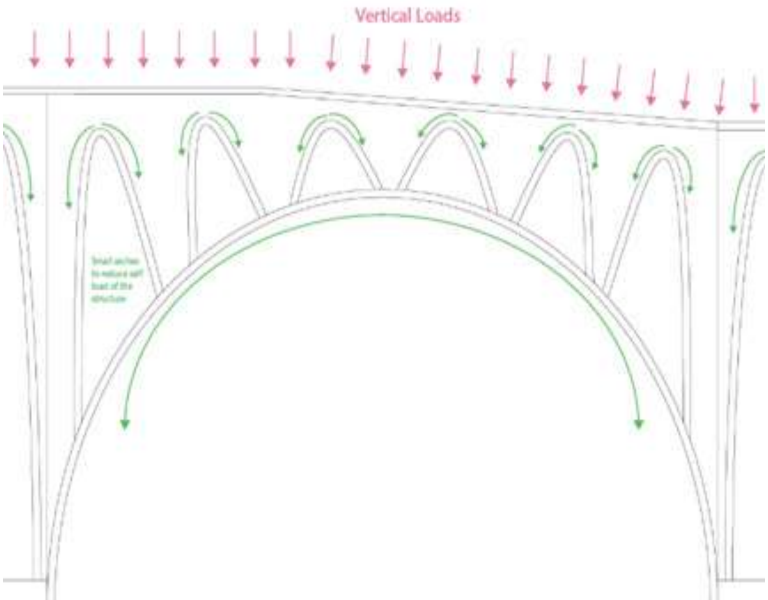


fig.21. Load Distribution for Bridges

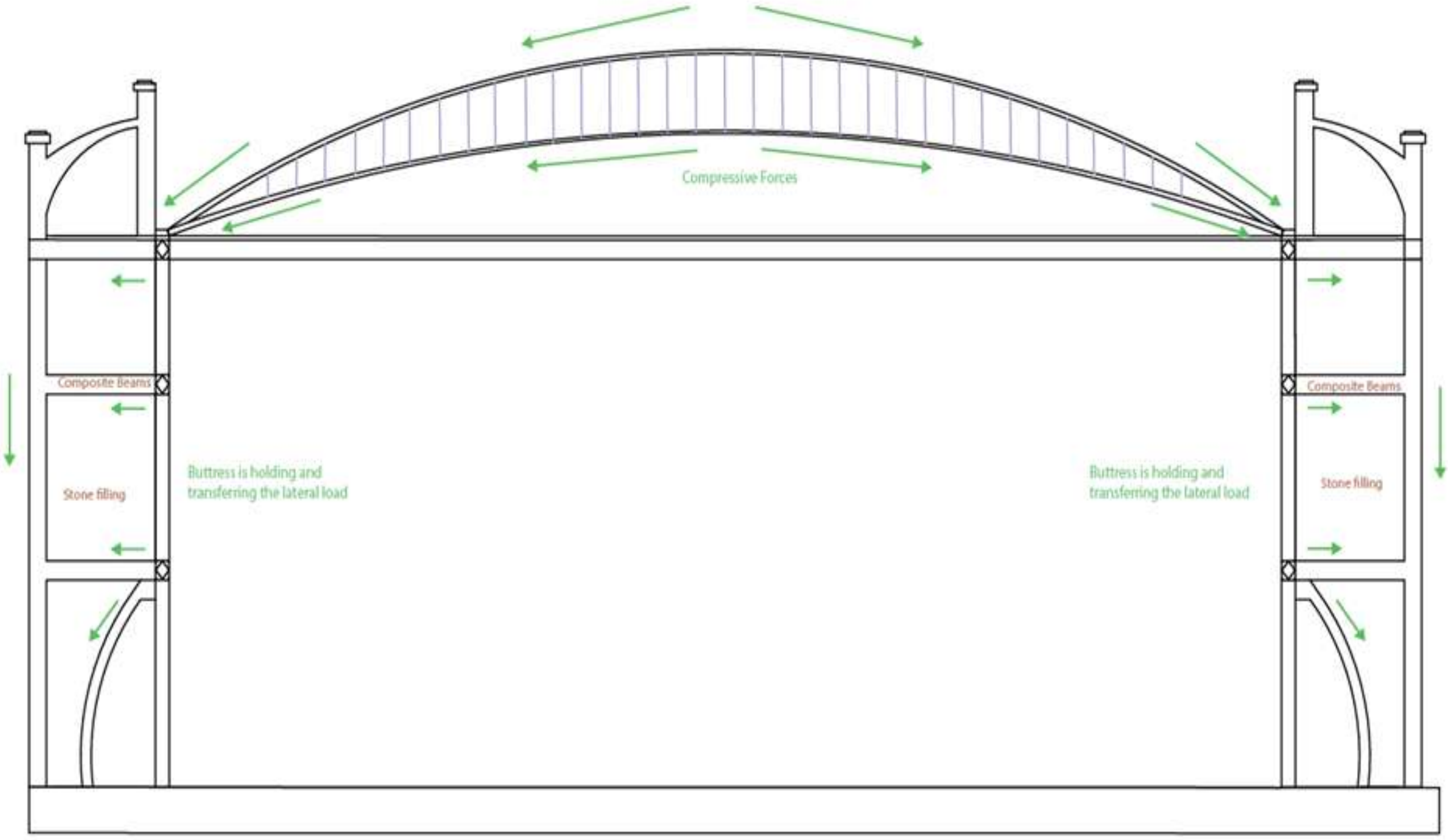


fig.22. Load Distribution for Multi Purpose Hall

Plumbing Systems

The plumbing systems have been designed to minimize water usage, collect rainwater, and recycle the used water. The goal was to adopt eco-friendly and energy-efficient methods to manage water usage and waste. The various systems have been defined and combined to ensure optimal performance and functionality.
Black water, grey water, rainwater collected through the rooftop and ground have their own dedicated waste systems. Each of these systems has a dedicated serviceable plumbing shaft and inspection chambers for effective maintenance. The rainwater is collected from the rooftop and site's catchment area, which is then passed through a desilting chamber where the water is cleaned using rapid sand filtration. This water is further used to fulfil the freshwater demand in the building and the rest of the water is recharged in the pond. For an elaborate breakdown of the amount of water collected and used, refer to Water Performance.

Flow rate calculation for a Soil and Water waste Pipe-
Maximum Flow Rate through the pipe using the Hazen-Williams equation, which is commonly used for water flow calculations: Q = 0.849 C D^2.63 S^0.54 where, Q = flow rate in gallons per minute (GPM) C = Hazen-William's coefficient (a value that depends on the roughness of the pipe), D = inside diameter of the pipe in inches, S = slope of the pipe (assuming a level pipe, S = 0).

HVAC System

All major details have been covered in energy performance and health and well being section.
Refer to Enginnering and Operation Annexure for system details and SLD

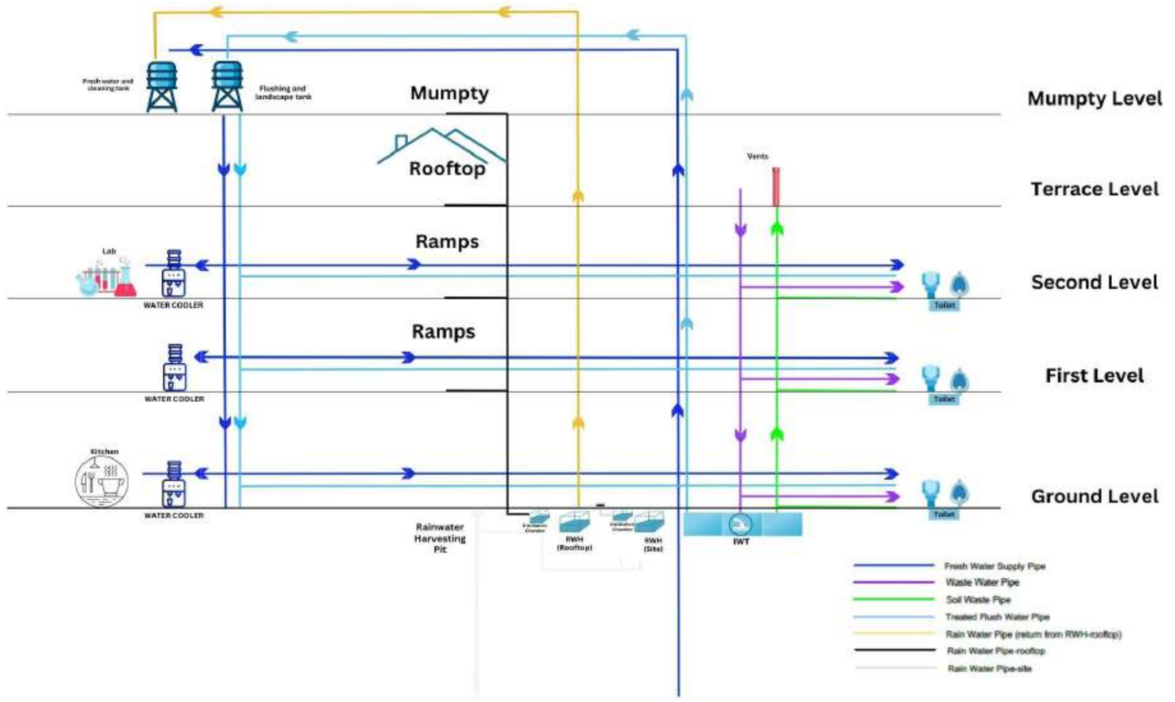


fig.23. SLD explaining the plumbing systems of the building

Rightsizing of Plumbing Systems

The diameter and length of the pipe, the viscosity of the water, the existence of any blockages, and any changes in direction, all affect the terminal velocity of water in a plumbing system. In general, faster flow rates and higher terminal velocities are possible with bigger pipes while slower flow rates and lower terminal velocities are common with smaller pipes.

Following formulae may be used for calculating the terminal velocity and terminal length:

Vt = 3.0 (Q/d) 2/5

Lt = 0.052 Vt

For elaborate rightsizing calculations refer to Annexure.

Right sizing of lighting

Efficiency in the systems, maintaining the required lux level in the classrooms and other areas where optimal lighting is required, were our primary objectives while designing the lighting system. According to the NBC guidelines, a minimum of 300-500 lux levels is required in areas such as classrooms to maintain uniform lighting across the space in order to provide optimal visual comfort. We have achieved this by using 18W lights that have a luminous efficacy of 116 lm/W, through the most efficient design possible.

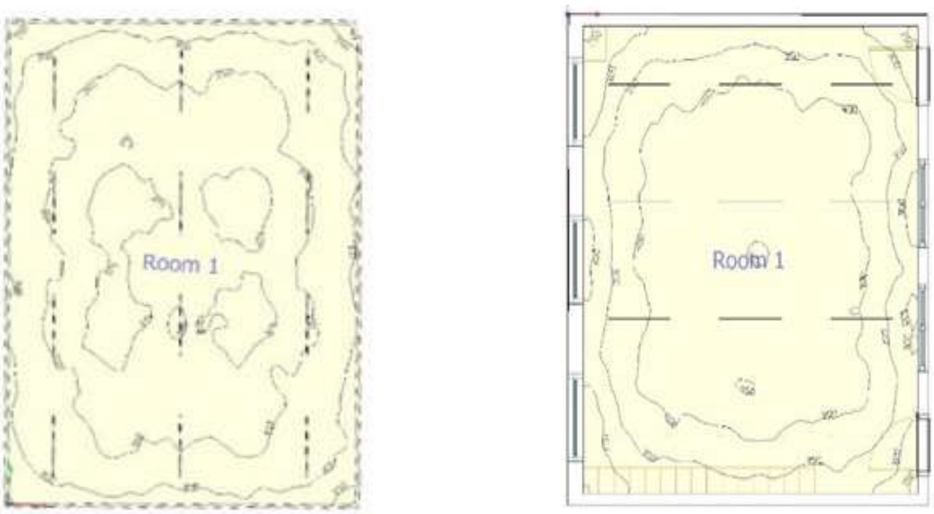


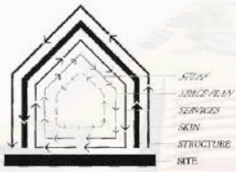
fig.24. Lux Level calculations from two different classrooms

VI. ARCHITECTURAL DESIGN

PHILOSPHY AND APPROACH

Build the layers, the building will build itself

- Site
- Space
- Skin
- Structure
- Services
- Stuff



Read and Respect

- Local issues and needs
- Why go far when you have everything on the site
- Tree as the epicentre of design
- Geography and geology
- Matter and materiality
- Land and substrata
- History and heritage

ETHICS of design is the AESTHETHICS of design

- For people, for environment; with people, with environment
- Ecology and environment priority
- Landscape and vegetation as beauty

GOD lies in details, but so does the DEVIL

- Integration of systems and services
- Vaulting integrated design details
- Façade integrated design details
- Stuff layouts
- Columns, walls, and circulation

REAL IS BEAUTIFUL

- Real community, real issues
- Real stakeholder empowerment
  1.Girl child education
  2.CWSN
  3.Vocational Training Centre
  4.Sports Academy
  5.Exhibition
  6.Community Centre
  7.Primary Health centre

BUILD LESS, only where necessary

- Spatial Efficiency
- Multipurpose spaces
- Connecting ramps
- Multi-purpose systems
- Tree also provides Shelter

EASE AND CONVENIENCE

- Universal access
- Zoning and stacking of areas
- Circulation and movement

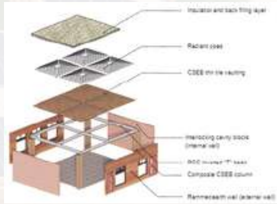
VALUE OF ITERATION

- Design, analyze, improvise, repeat.

Tree as Epicenter

Multipurpose spaces

Timbral Vaulting



Classroom Detail

Exhibition Spaces

Exhibition Spaces

Landscape as beauty

SITE

"*Site is eternal*," cries architect Duffy .

Guided by Stewart Brand's HOW BUILDINGS LEARN, our site analysis and scientific data made us realize the need of communal and experiential spaces that will help build the school by weaving a fabric that would bind the community and school together

We work 'with' the site- use of excavated earth for construction, the incorporation and retention of natural forms, such as the tree on the front facade of the building, or the boulders for landscape seating.

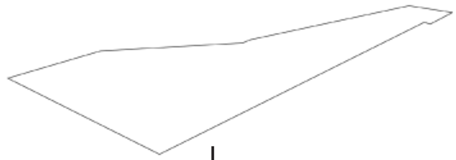


fig.25. Site

SPACE

"Interiors change radically", as Brand says.

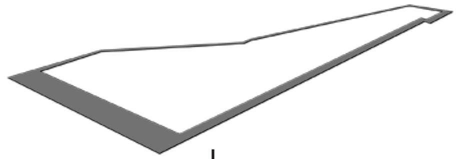
The space plan and design efficiency for the Springhills International School was achieved through several iterations of rearranging different programs- both, vertically and horizontally- through several attempts at circulation diagrams.

The central block was designated for fun, recreation and togetherness, with the music, art, dance rooms, and library bringing students and teachers together for cultural encounters.

The classrooms and corridors were placed to counter dead ends and comply with the National Building Codes for fire-fighting.

Nodes of centrality are an important theme in our design, with the academic block centering around The Tree, with all bridges coming together at the central block.

Further, the school is entirely accessible by wheelchair, ensuring inclusivity for all students. The design reflects our commitment to creating a welcoming and functional space that fosters learning, growth, and community.



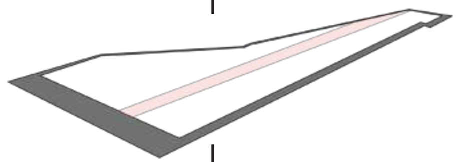


fig.26. Central path

SERVICES

Circulation- building circulation was strategically designed to optimize solar gain from the east, south-east, south, and south-west direction, in response to school occupancy hours.

we have oriented all our corridors in this direction to ensure a comfortable and healthy environment for our occupants.

The traditional "piyaoo" provides drinking water to outsiders through the boundary wall of the school.

The porous and liminal nature of the school boundary wall exemplifies our commitment to social responsibility, extending beyond the school's boundaries to benefit members of the extended community. (Refer to Engineering and Operations for further details)

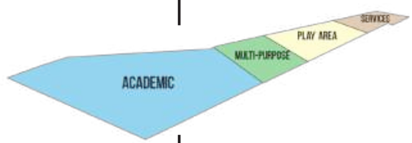


fig.27. Zoning

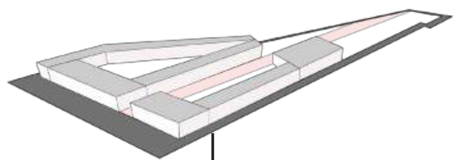


fig.28. Massing

fig.29. Bird's eye render

SKIN

"Skin is mutable", Brand says.
Our aim was to create a project that feels like it has always been there, while at the same time offering a fresh and contemporary take on the existing landscape.
Our building, up till the final stage, derives its skin from the colors and textures found on site, utilizing only raw materials and their organic finishes, without the need for external finishes to create an experience of familiarity and warmth.
FRONT FACADE :
The front faCade modules and system thoughtfully designed to provide essential shading on the front of the building, reducing heat gain from the Southern sun. (Please refer to annexure 6 for further details)
INTERNAL WALLS
All internal walls made with interlocking bricks, of custom shapes, a different kind for each junction of the wall, iterated under the leadership of Kamath Design Studio who helped us integrate our earthen materials with the composite molds as discussed.

STRUCTURE

"Structure persists and dominates", as Brand puts.
Let the FORM of the structure participate in LOAD distribution; incorporation of arcuated systems
THE VAULTING SYSTEM
Incorporating local and timeless timbrel vaults for the roofing system, with a reduction in steel and concrete. This was designed iteratively under the leadership of our industry partner Architect Mainak Das, an expert in alternate construction technology.
1. Classrooms,
2. Corridors,
3. Bridges,
4. Multipurpose Hall
THE COLUMN-BEAM
Composite CSEB Columns with inverted T Shaped RCC Beams

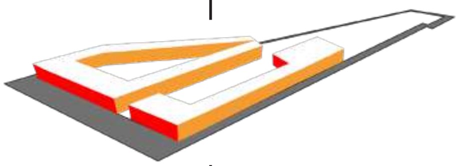


fig.30. Radiation

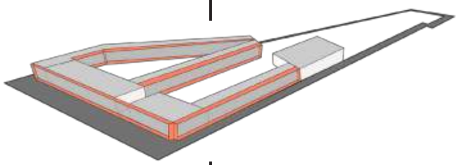


fig.31. Shading

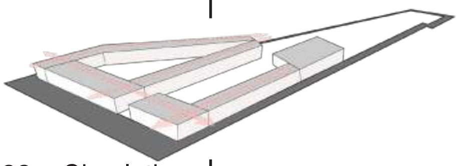


fig.32. Circulation

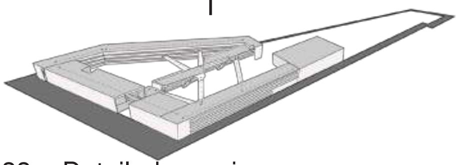
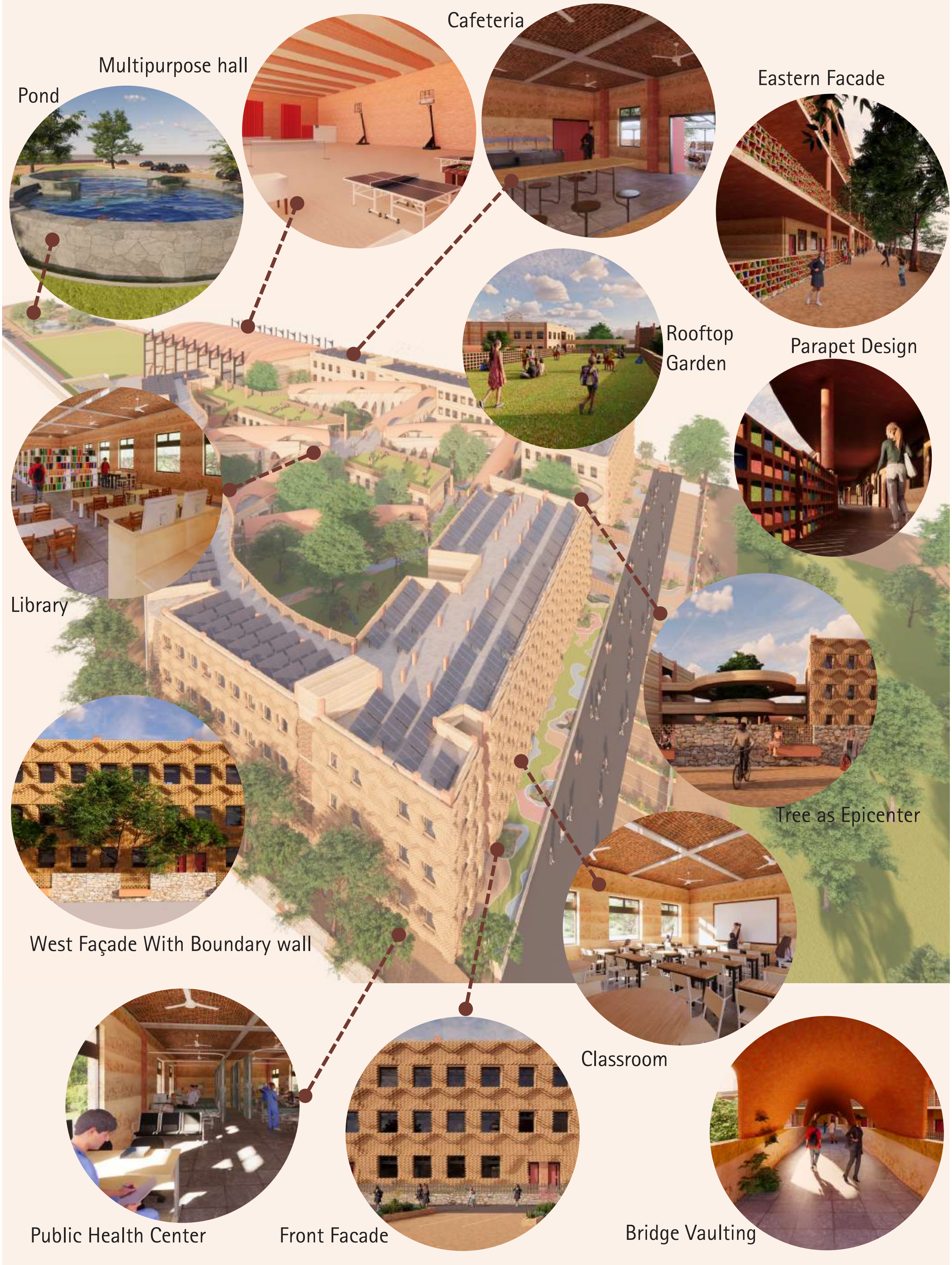


fig.33. Detailed massing


fig.34. Facade render

BUILDING AT A GLANCE



LANDSCAPE DESIGN

Landscaping of the site was done in a holistic way. The aim was not to disturbed the ecosystem of the site but to maintain it. This was done by planting all local species, keeping in mind the birds, insects and animals of the site. The entire system was designed in a way to ensure a symbiotic relation between all the inhabitants of the space. Undulations, as an element, were used to create interesting interactive spaces .

The process of covering the open surface of the ground by a layer of some external material is called mulching. It ensures moisture retention and higher yields.

The entire soil for landscaping area will be inoculated with Mycorrhiza. Mycorrhiza occurs naturally in soils and if left undisturbed will spread throughout the soil, linking plants together with a common root system.

For further details refer Architecutre design annexure

VII. AFFORDABILITY

The level of affordability is a clear indicator of the effectiveness of sustainable measures taken in a project. It should not only consider the initial capital investment, but also the time and operational obstacles that may arise in the process of achieving net zero costing.

Proposed Case vs Base Case

The costs have been weighed against various factors as shown in Fig 19, in order to determine the optimum case. Through the proposed design estimate, we have achieved more than 13.1% cost reduction as compared to the baseline estimate.

Cost Breakdown

The cost of installation and maintenance is reduced by right sizing the various MEP services components, using different design methodologies. Labour procurement will be done locally, so their transportation cost will help in reducing the final construction cost of the project. The use of locally sourced materials enabled us to cut down the construction costs. For example- Mountain cut rocks are available in abundance on site, which will be used to make the foundation and the boundary wall of our building. Hence, the dependency on other material to be sourced from the market is significantly reduced.

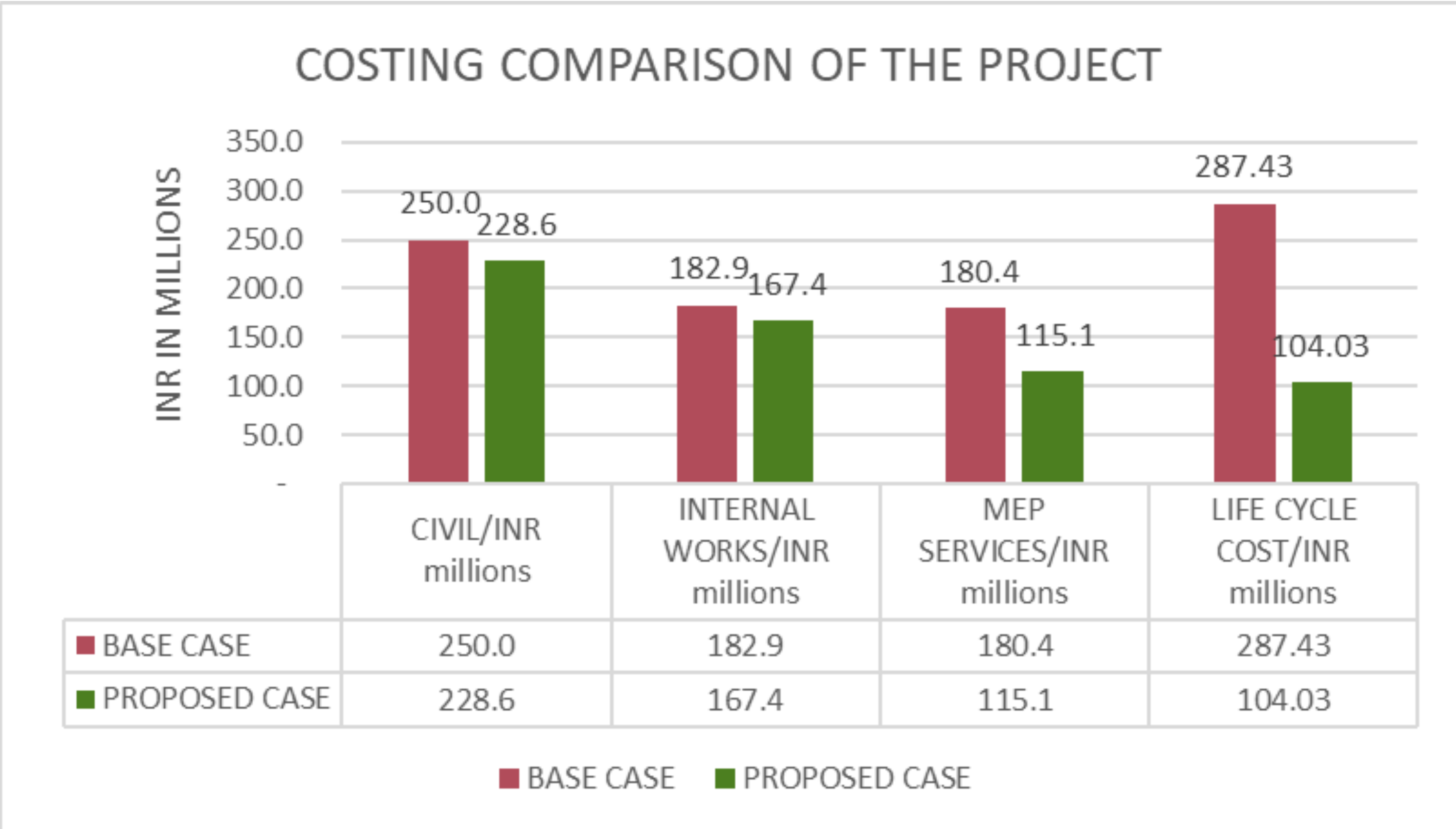


fig.36. Baseline Design Cost vs Proposed Design Cost

Civil Works

The materials used in the construction of the school is rammed earth, CSEB blocks and tiles, 100% recycled steel reinforcement, M25 grade concrete with 50% GGBS content. The amount of concrete used is very less, as it is used only in foundation and beams. Most of our construction is being done using CSEB and rammed earth. All the columns are constructed using CSEB and the walls (exterior and internal) are made of rammed earth and CSEB blocks. Both the materials and labour are locally sourced. The rammed earth walls are made from the earth, that has been excavated for the purpose of constructing the foundation, underground water storage tanks, pond. The doors and windows are made of single glazed reflective glass with recycled aluminium frames. These methods of working have decreased the costing of the civil work where, the base case was costing INR 25 crores and the proposed case will cost INR 22.856crores.

MEP

The piping for plumbing services in the building is designed in such a way that it is less likely to collide with the structural components. These types of conflicts raise construction costs because they frequently necessitate the installation of offsets in pipes, which will then require additional expenses for coordination, materials, and labour.

The wastewater generated in the building is treated using the Integrated Wetlands Technology (IWT), which is then collected and reused for irrigation and flushing purposes. By using IWT, both construction and operational costs are reduced as compared to the base case of a Sewage Treatment Plant (STP) having higher operational and maintenance costs.

Efficient selection of reused sanitary wares and piping helps in optimizing the use of materials, thereby reducing construction costs.

We have gone with BLDC fans, which are very efficient and have a 5-star ISEER rating. These fans consume 65% less energy as compared to an induction motor fan being used (as a base case). The same has been followed for the exhaust fans. While keeping the fixtures as efficient as possible we have not compromised on ACH standards, as all the exhaust fans fulfil that demand too.

fig.37. The various kinds of fans used

The costing for the MEP in the base case is INR 18.04 crores and for the proposed case is INR 11.51 crores.

Life Cycle Cost

The HVAC system used in the proposed case is that of a radiant cooling system, which is connected to the ground source heat pump. This system is installed in all the conditioned spaces such as the classrooms, laboratories, vocational classrooms, and activity rooms. The AHU system is also another system being used, by coupling it with an air-cooled chiller. The sensible heat is generated more in the computer labs because of the electronic equipment present in this space. Here, a 5-star efficiency rating split ACs is proposed, where-as, in the base case, the VAV system on the air side is connected to the plant side water cooled chiller coupled with cooling tower, along with electric boilers.

The capital cost of the base case is INR 4 crores, where-as, the capital cost of our proposed case is INR 6.5 crores. The annual maintenance cost for the base case is INR 0.7 crores and the proposed case is INR 0.35 crores. The utility cost per year for both, the base case and the proposed case are INR 1.6 crores and INR 0.8 crores respectively. The life of the base case and proposed case is 6 & 25 years respectively which means over 4 life cycles of the base case system, 1 life cycle of the proposed case system will be over, i.e., life of base case is 6 years and proposed case is 25 years. Life Cycle Cost (LCC) of our base case and the proposed case are INR 28.74 crores & INR 10.4 crores respectively. The difference in capital cost is recovered in approximately 2 years and 3 months.

VIII. INNOVATION

The only thing standing between low energy materials and their large-scale application is time and labor. Can we fill this gap? How can we scale up their usage? Below mentioned ideas could be the ways to achieve so-

1. By introducing mechanization
2. By efficient construction management system

Problems identified-

1. Delay in construction time
2. Increased labour costs
3. Scalability of project
4. Misconception of natural materials as alternative materials
5. Lower efficiency and quality control

Technology used-

Our system uses rammed earth with the advanced technology of pneumatic rammer instead of the manual ramming process. Pneumatic rammer works by converting compressed air into mechanical force to create an impact, similar to a jackhammer. The main components of a pneumatic rammer are the air compressor, the air hose, the air valve, and the rammer itself. Compressed air is supplied to the rammer through the air hose, and when the air valve is opened, the compressed air rushes into the rammer's cylinder. Inside the cylinder, the compressed air pushes a piston, which then strikes the bottom of the rammer's foot. This creates a downward force that is transferred to the ground, causing the material to become compacted. The rammer is typically designed with a heavy-duty foot, which is often made of steel, to withstand the repeated impacts. We use a custom-made rammer which tends to be cheaper than the available rammers in the market.

What sets us apart is that we aim to increase the scalability of the usage of rammed earth by adoption of this system. The use of pneumatic rammers is a more labor oriented system as it helps to finish the tedious manual process of ramming in a much efficient manner with uniform compression throughout the wall.

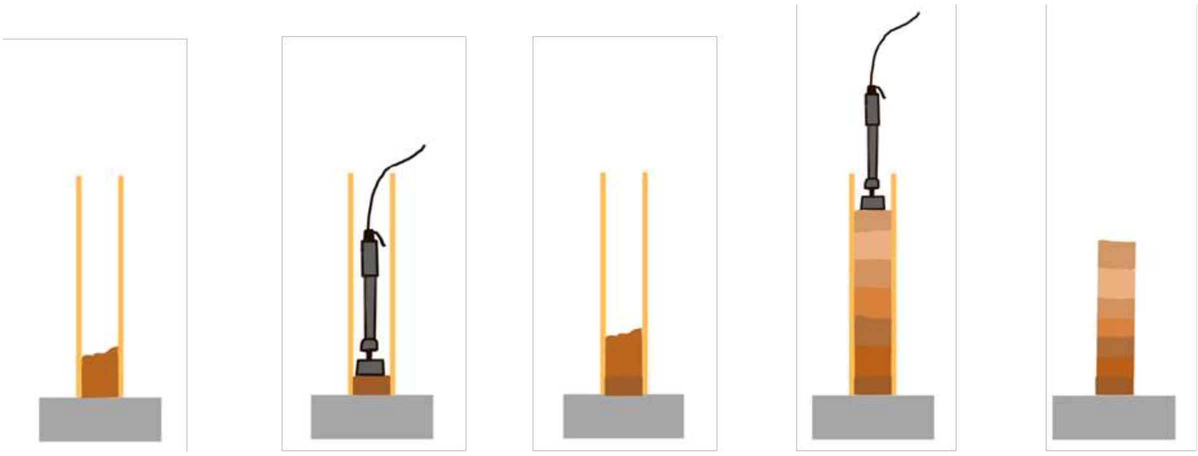


fig.38. The process of ramming

The preliminary testing of the technology is done and feasibility is established in a field environment. The proposed innovation has been endorsed by the industry partner and is ready to be used on sit. The environmental impacts and greenhouse gas emissions for the same have also been taken into account.

Market-

In the current market, rammed earth construction has a limited scope and is not as widely used as other building techniques such as brick, concrete, or timber. However, it is growing in popularity as people become more interested in sustainable building methods and the use of natural materials. The limited scope in the current market is due to the limitations of the existing techniques which our system aims to overcome. The target group for this system could be:

1. Low density areas
2. Low FAR building
3. Business oriented projects
4. Community Organisations

Cost implications-

Since the conventional earth ramming method uses longer duration for the completion of project, the cost of labor is more in this case. Also, in our project, the materials are procured locally from the site and hence the cost of procurement of raw materials is minimal. In order to build an elevation of a 8x8 sqft. wall, the manual earth rammering will take upto 622Rs. per sq.ft. whereas our proposed system will take upto 322.18Rs. per sq.ft., inclusive of the transportation, labour and material cost.

Cost estimation	Material	Labour	Framework*	Rammer*	Total Cost
Conventional Method	7020	34000	77	1.9	41098.9
Our method	7020	13600	57.8	154.1	20831.9

Table 2. Cost Estimation for one wall panel of 64sq.ft. area

Benefits and Impacts-

1. Time efficient- The manual earth ramming takes up to 6-8 days to construct a wall of dimension 8ft x 8ft which delays the overall project. However, this method of using pneumatic rammer can help produce the same work within just 1.5 days, as this method takes help of advanced technology to finish the task.

Time taken to build 1 wall panel	Shuttering and preparation	Material making	Ramming	Other works
Conventional Method	0.04	0.03	5	1.93
Our Method	0.04	0.08	0.3	1.08

Table 3. Time taken to build a wall panel of size 64sq.ft

2. Stronger- The Pneumatic rammer compacts the earth layer much more than manual ramming. The amount of compaction is 30%- 40% more in pneumatic rammer than that of manual ramming. This increased compaction makes the raw soil act as a stone which strengthens the entire building structure.

STRENGTH COMPARISON	Manual ramming	Clay Brick	Pneumatic Rammer
Compressive strength	7	11.2	12

Table 4. Compressive strength of materials used

3. Ecological- The pneumatic rammer used requires 10Hp power supply. The same will be provided through the electricity generated by solar panels. This reduces the dependence on fossil fuels and limits the carbon emissions. The material used in rammed earth consists of lime which absorbs CO2.

Lime used (kg)	Absorption of co2 by lime per kg	Total absorption of CO2 by lime
111.49	0.01	1.47

Table 5. CO2 absorption in making one wall panel

ENERGY VALUE	Clay Brick	Rammed earth
Global warming potential (kg COe)	0.57	-0.0084

Table 6. Energy Consumption of different materials

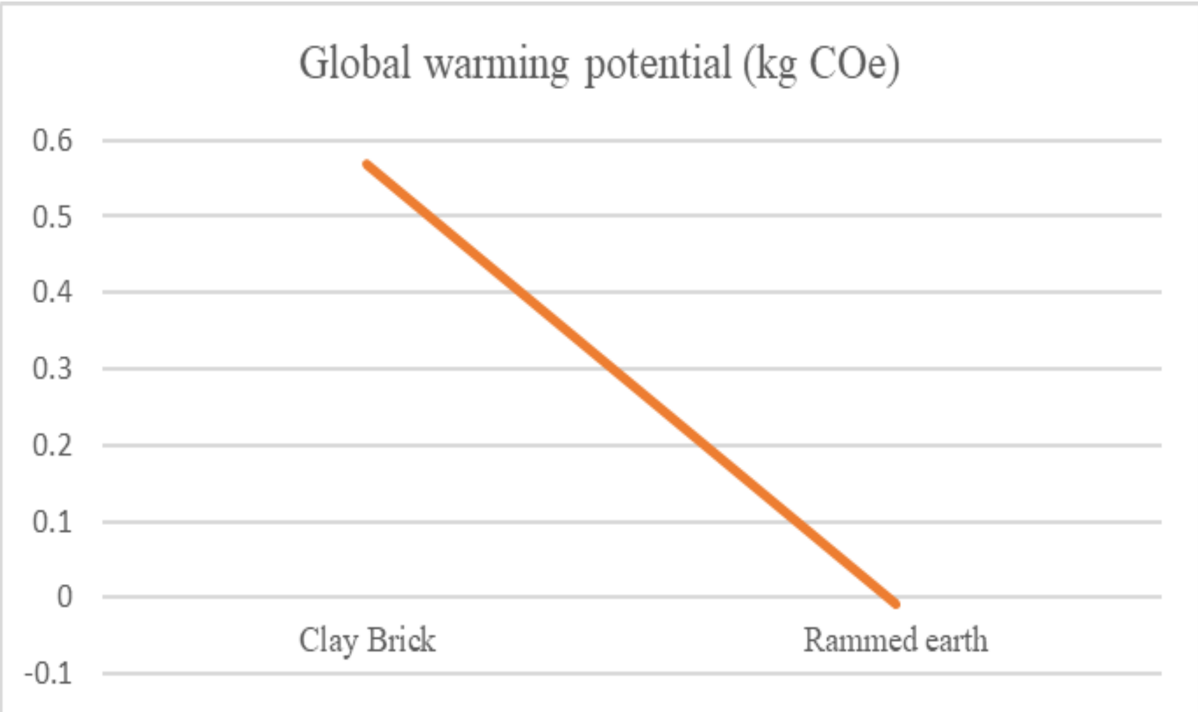


fig.39. Global warming potential of clay bricks vs rammed earth briicks

IX. HEALTH & WELL BEING

ENSURE LIGHT & VISIBLE COMFORT

- 90% + UDI
- Artificial Lighting conforming to NBC-2016
- Uniform design distribution of daylight and artificial light

ENSURE ENVIRONMENTAL QUALITY

- Regulation of indoor Fresh Air

ENSURE EXPERIENTIAL COMFORT

- Regulating surface Temperature
- Regulating Air Temperature
- Regulating RH when air temperature exceeds 30 C

Thermal Comfort

The school building is designed to incorporate natural ventilation for fresh air requirements according to ASHRAE 55 Standard, while being 100% conditioned during operation hours. We have followed ASHRAE and ECBC model for Adaptive comfort models for reduction in energy use as buildings that can be operated at more moderate temperatures.

For Air Conditioned Buildings.Indoor operative Temperature= (0.078 x outdoor temperature) + 23.25. In our case, Indoor Operative Temperature for an air-conditioned building during summer days, =(0.078 x 35) + 23.25

= 25.98 degree Celsius

Where indoor operative temperature (degree C) is neutral temperature & outdoor temperature is the 30-day outdoor running mean air temperature (degree C) ranging from 13 to 32 C. Neutral Temperature ranges from 24.5-28.5C for the building observed outdoor range with 90% acceptability range for the adaptive models for conditioned buildings is 1.5 degree C.

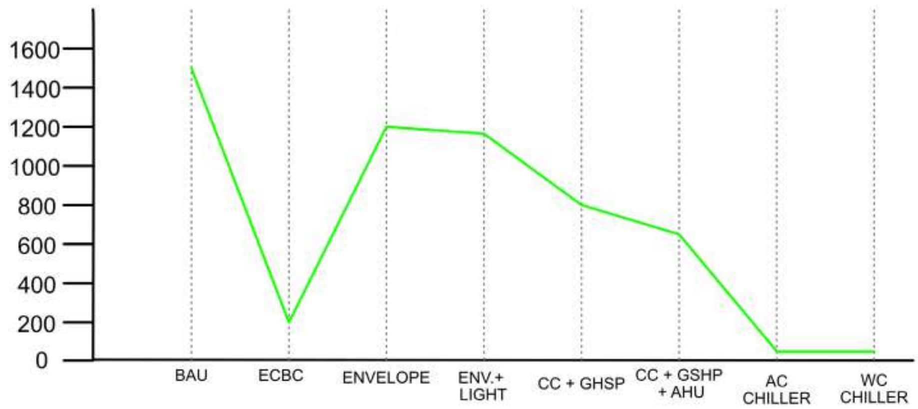


fig.40. Unmet Hours

fig.41. Ventilation Diagram - Section

The typical space types such as classrooms, activity labs, staffrooms etc. are naturally ventilated coupled with DOAS and Chiller System. All the spaces are designed (refer fig.26) for cross-ventilation through windows and ventilators on both sides of the classroom in the longer stretch of the room (opening towards naturally ventilated corridor) to provide minimum fresh air requirement (5-7 ACH) as per Section 5.2.21 NBC 2016. All the mechanically conditioned spaces such as computer room and conference hall are fitted with exhaust fans to provide the minimum fresh air required as per ASHRAE 62.1-2016.

IAQ

For maintaining acceptable ASHRAE indoor air quality from any internal and external air pollution, a misting tower is added that evaporates water as mist and reduces dust PM 10 indoors.

VOC

The building walls emit near zero to low VOC as it is made up of organic components and Earth.

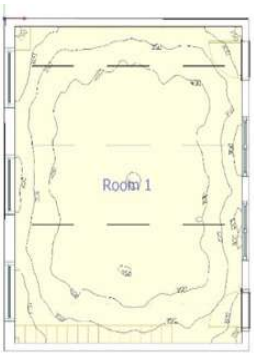


fig.42. Lux Level Calculations for a room

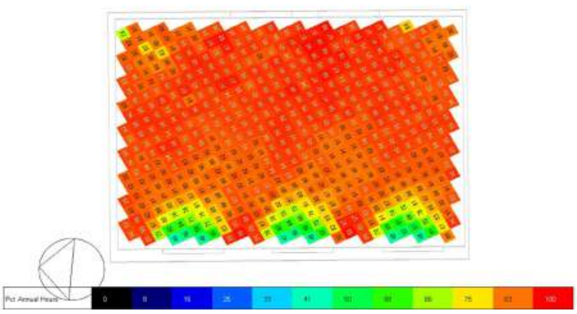


fig.43. UDI

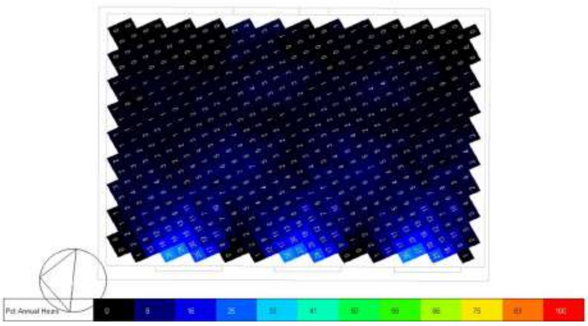
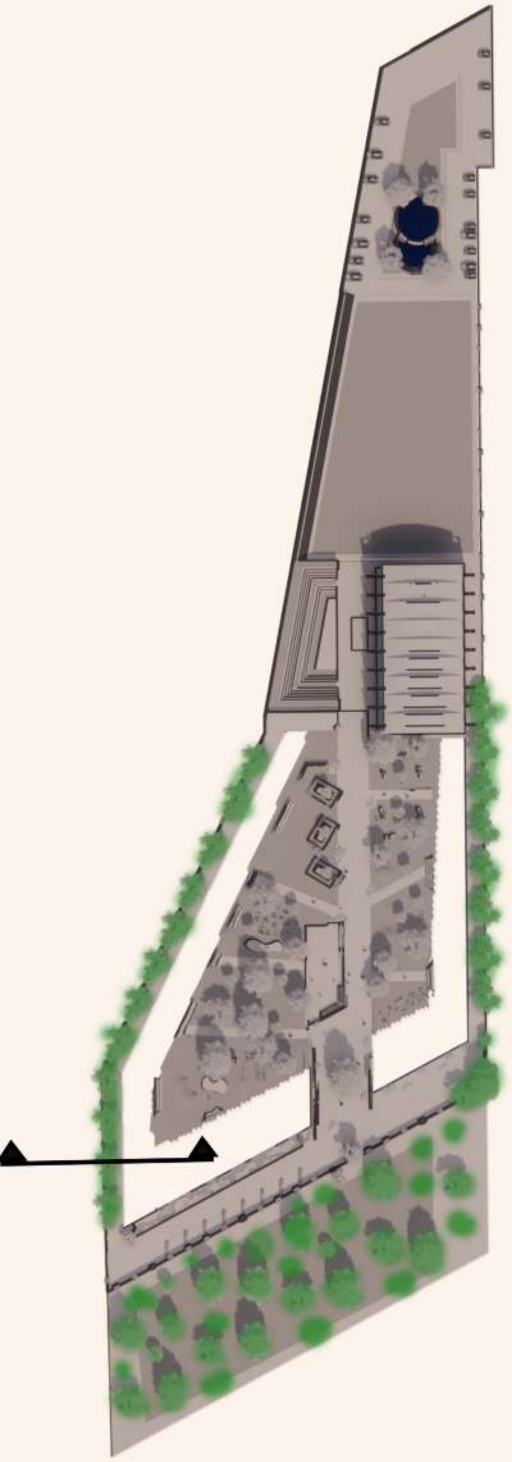


fig.44. ASE



MOSQUITO REPELLENT PLANTS


Rosemary


Lavender


Mint


Basil


Scented geranium/ Citronella

GREEN BARRIER

SETBACK

GREEN BELT

Deciduous trees help in reducing summer heat, therefore have been planted wherever there is direct exposure to sunlight. (setbacks, green belt)

MEDICINAL PLANTS

Liquorice

licorice root is promoted as a dietary supplement for conditions such as digestive problems, cough, and bacterial and viral infections.

Neem Tree

Neem preparations are reportedly efficacious against a variety of skin diseases, septic sores, and infected burns.

Jatropha

Used to fight against skin diseases, rheumatism and as a curative for sores on domestic livestock.

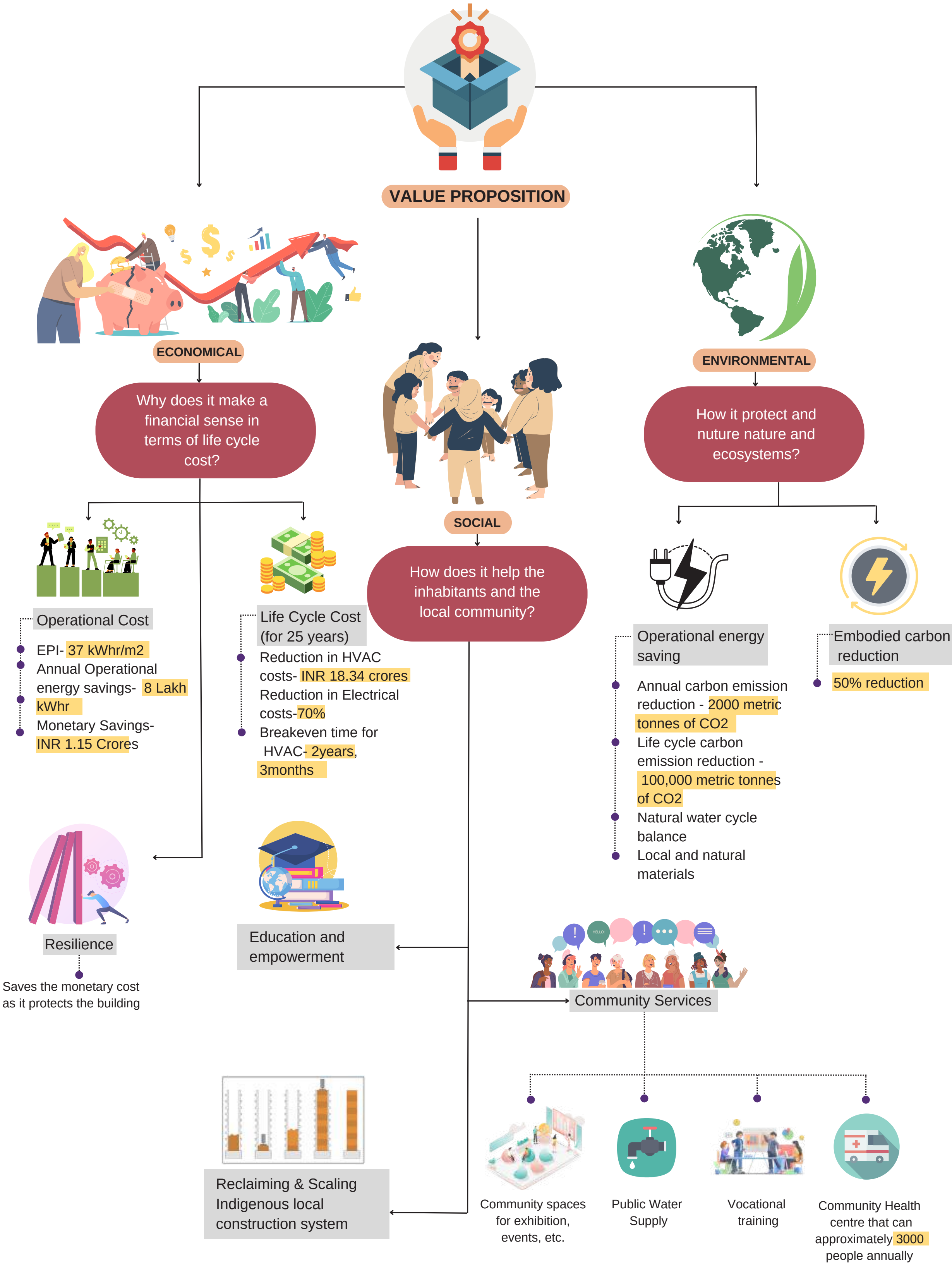
Aloevera

Aloe vera is gel from the leaves of aloe plants is used for healing and softening the skin. Aloe has also long been a folk treatment for many maladies, including constipation and skin disorders.

Mulberry

Mulberries may lower cholesterol levels, help prevent fatty liver disease, and improve blood sugar control.

X. VALUE PROPOSITION



Our project, Spring hills international school, is more than just any educational institution. Embedded within the trinity of cause, community, and clientele, it is a transformative experience that empowers children and nurtures a deep sense of environmental and community-oriented awareness. To bridge the gap between economic marginalization and a geographically remote site, we integrate our vision to uplift our students with(in) nature, existence, people, and resources. To achieve this, we use sustainable materials such as rammed earth and earth blocks, foraged and produced on site. By involving members of nearby villages and training them in skill-based professions, we create a community that benefits from the school's educational and social programs. Our school provides a unique and vocational-centric environment that instills purpose and responsibility in young people, giving them the chance to learn about their place in the world while adding life to the remoteness of Sohna, Haryana. Our sustainable, cost-effective, and community-centric practices serve as a model for other schools and organizations, proving that sustainability is an accessible and equitable approach.

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Orphans in Need

JINDAL SCHOOL OF ART & ARCHITECTURE
India's First Interdisciplinary School of Built Environment

SUNERGON

FINAL DESIGN REPORT- APRIL 2023

EDU

ANNEXURE

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ARCHITECTURAL DESIGN

Zoning	Space	NFA (sq metres)	Units	Total NFA (sq m)	Conditioned
Teaching	Classroom	51	60	3060	Y
		61	6	366	Y
		81	1	81	Y
Labs	Biology	85	1	85	Y
	Chemistry	138	1	138	Y
	Physics	117	1	117	Y
	Stem	110	1	110	Y
	Robotics	52	1	52	Y
	Math	90	1	90	Y
	Computer	73	2	146	Y
	Library	251	1	251	Y
Extra curriculars	Music room	65	1	65	Y
	Vocational School	67	1	67	Y
		52	3	156	Y
		91	1	91	Y
	Dance room	62	1	62	Y
	SUPW	45	3	135	Y
	Art room	50	2	100	Y
Admin	Vice principal's office	28	1	28	Y
	Principal's office	31	1	31	Y
	Admission office	17	1	17	Y
	Manager's office	23	1	23	Y
	Account's office	82	1	82	Y
	Conference room	58	1	58	Y
	Staff room	43	2	86	Y
		29	3	87	Y
		31	2	62	Y
		37	1	37	Y
		69	1	69	Y
		62	1	62	Y
Sports	Storage room	34	1	34	N
Entrance zone	Reception	50	1	50	N
	Waiting	30	1	30	N
Primary Health Centre	Beds	91	1	91	Y
Dining	Cafeteria	74	1	74	N
	Kitchen	70	1	70	N
Washrooms	Boys	22	9	198	N
	Girls	22	9	198	N
	Accesible	5	9	45	N
Parking	For cars	14	72	1008	N
Play Field	Open air sports area	3387	1	3387	N
	Courtyard Gardens	5887	1	5887	N
	Skating Field	254	1	254	N
MPH	Hall Area	1000	1	1000	N
	Green Room	60	1	60	N
	Store room	40	1	40	N
	Stage	150	1	150	N
			Total carpet area	7854	

Table 1. Detailed Building Area program

fig.1. Ground floor rendered plan

fig.2. Ground floor plan

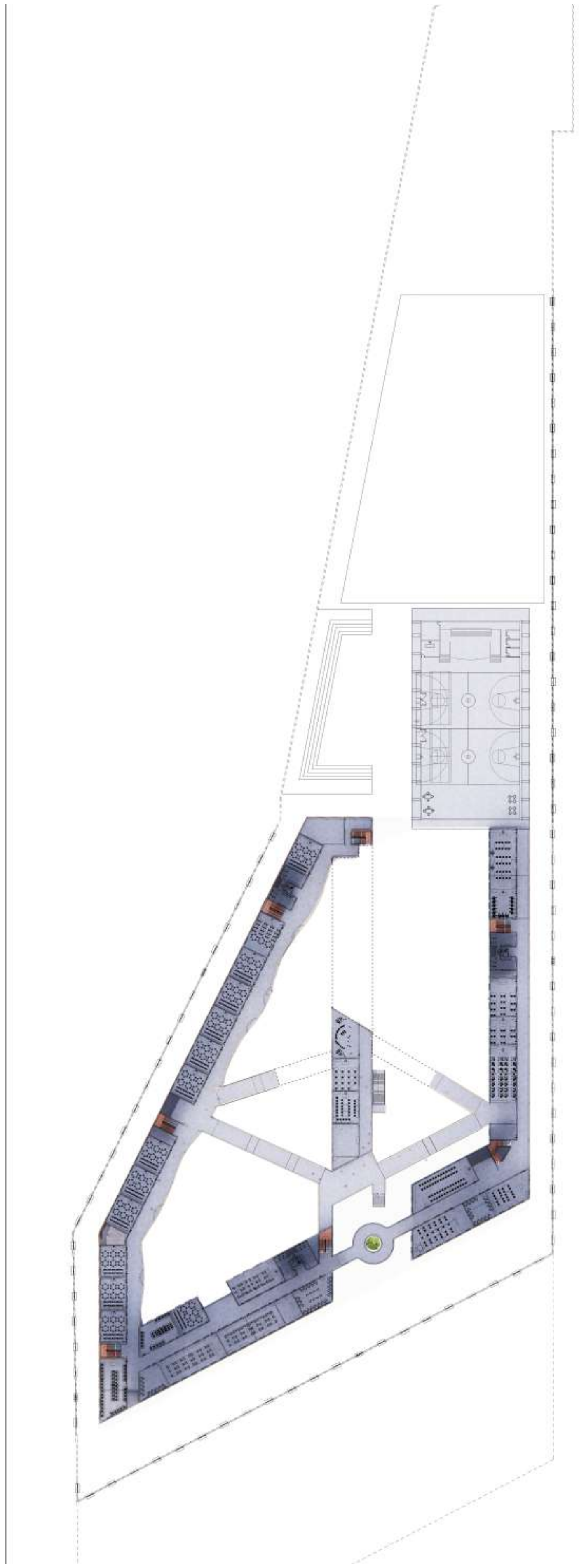


fig.3. First floor rendered plan

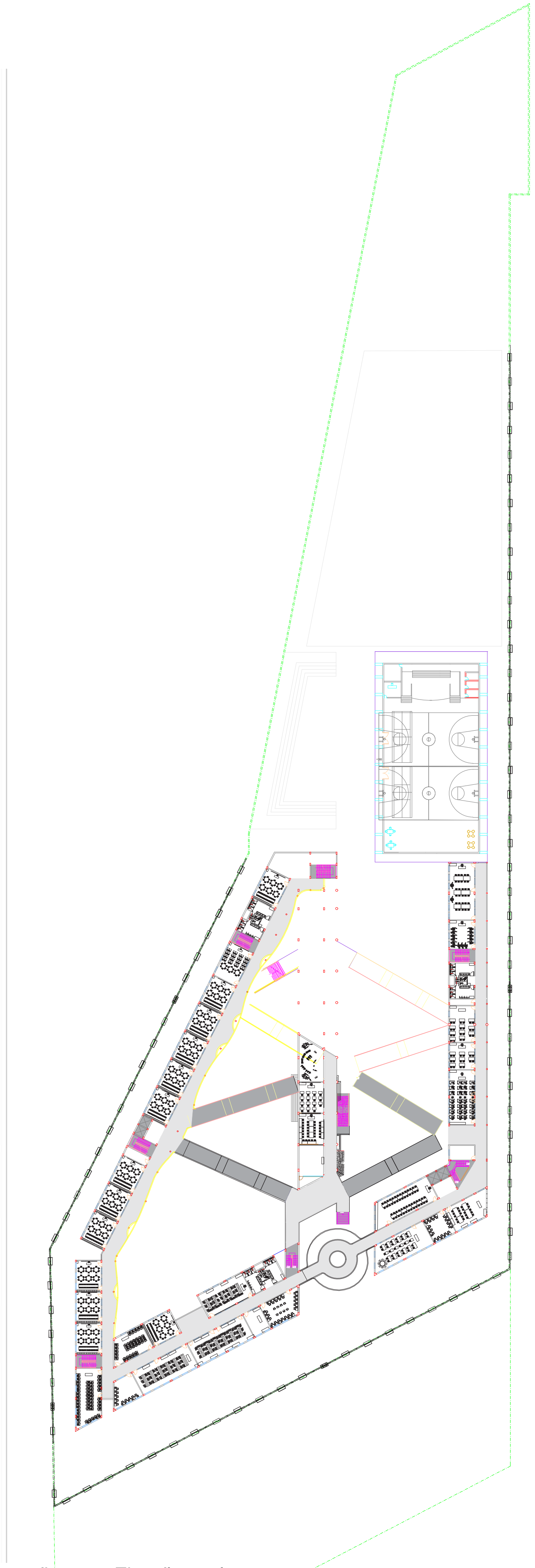


fig.4. First floor plan

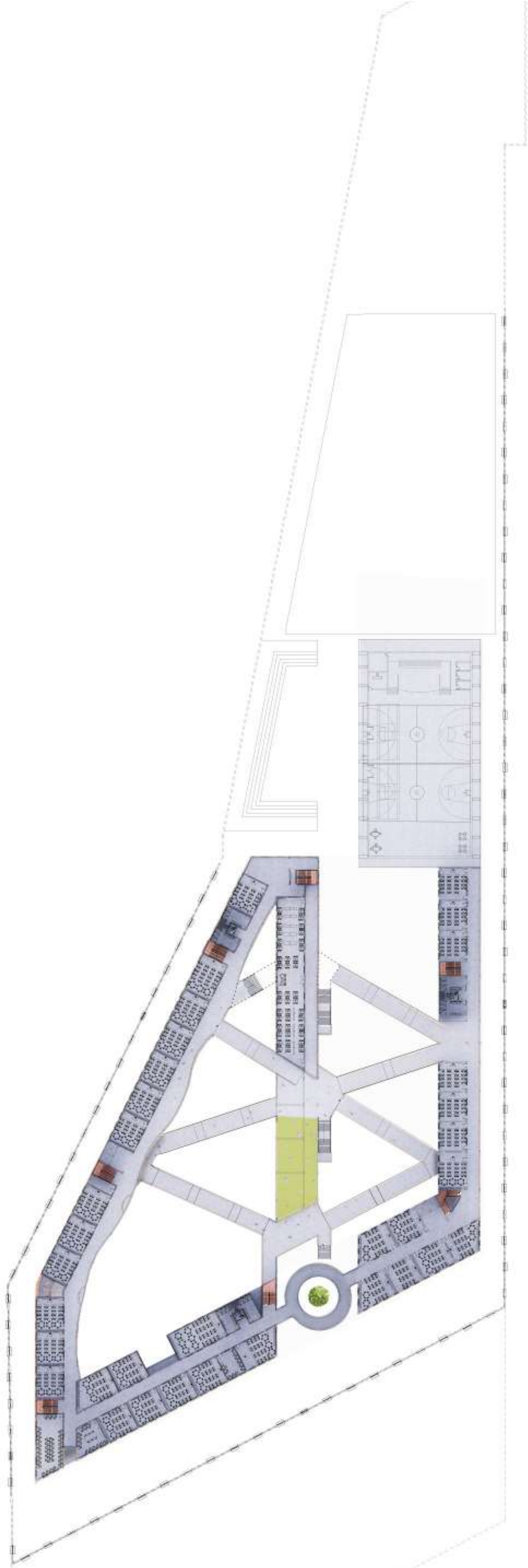


fig.5. Second floor rendered plan

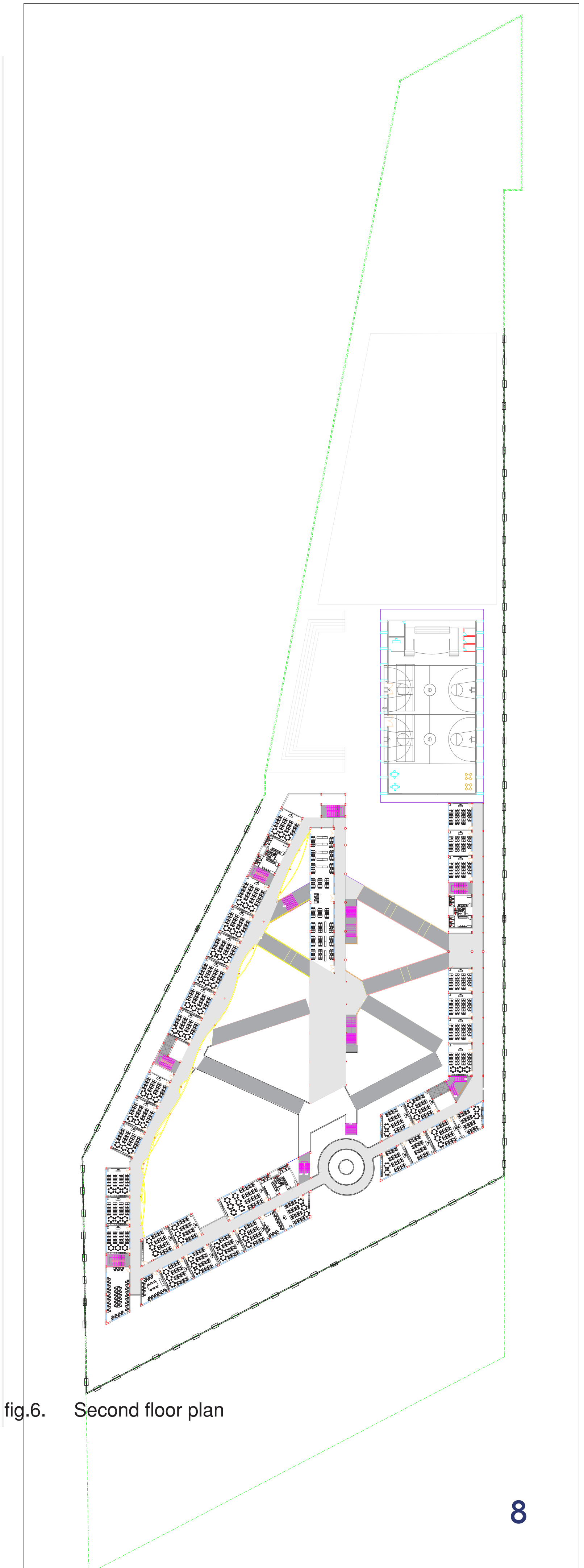


fig.6. Second floor plan

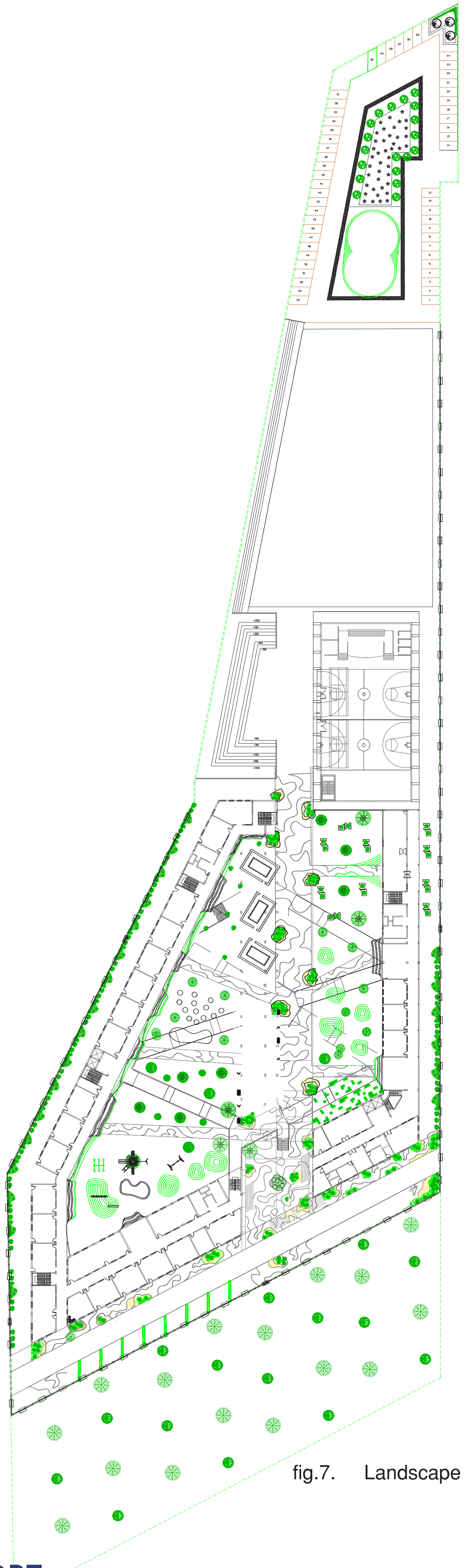


fig.7. Landscape plan

PARAMETRIC FRONT FACADE DETAIL

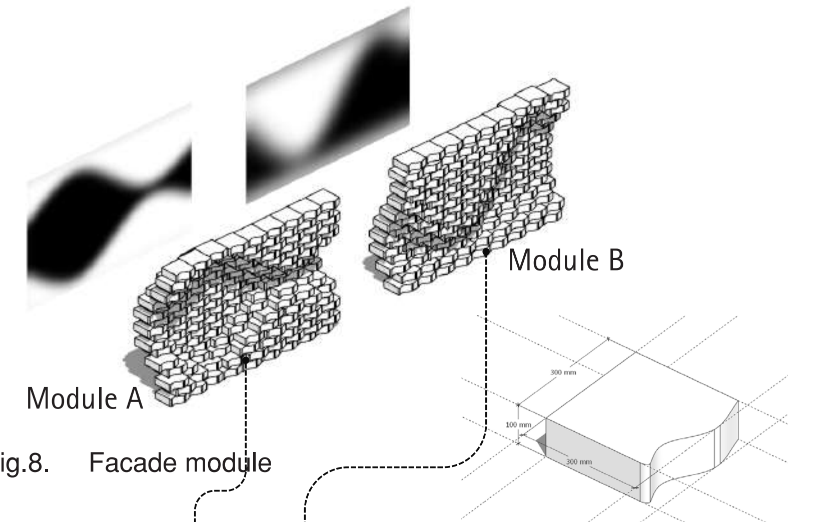


fig.8. Facade module

We have developed a façade system for the southern part of the building that helps in reducing solar heat gain while also providing shading to the windows through its parametric arrangement.

To accomplish the same, we have divided the system into a combination of two repetitive modules - Module A (2750x1800mm) and Module B (2750x1800).

Module A provides horizontal shading while Module B provides vertical shading to the windows.

Furthermore, we have customized the brick block to minimize the terracing of blocks on the façade.

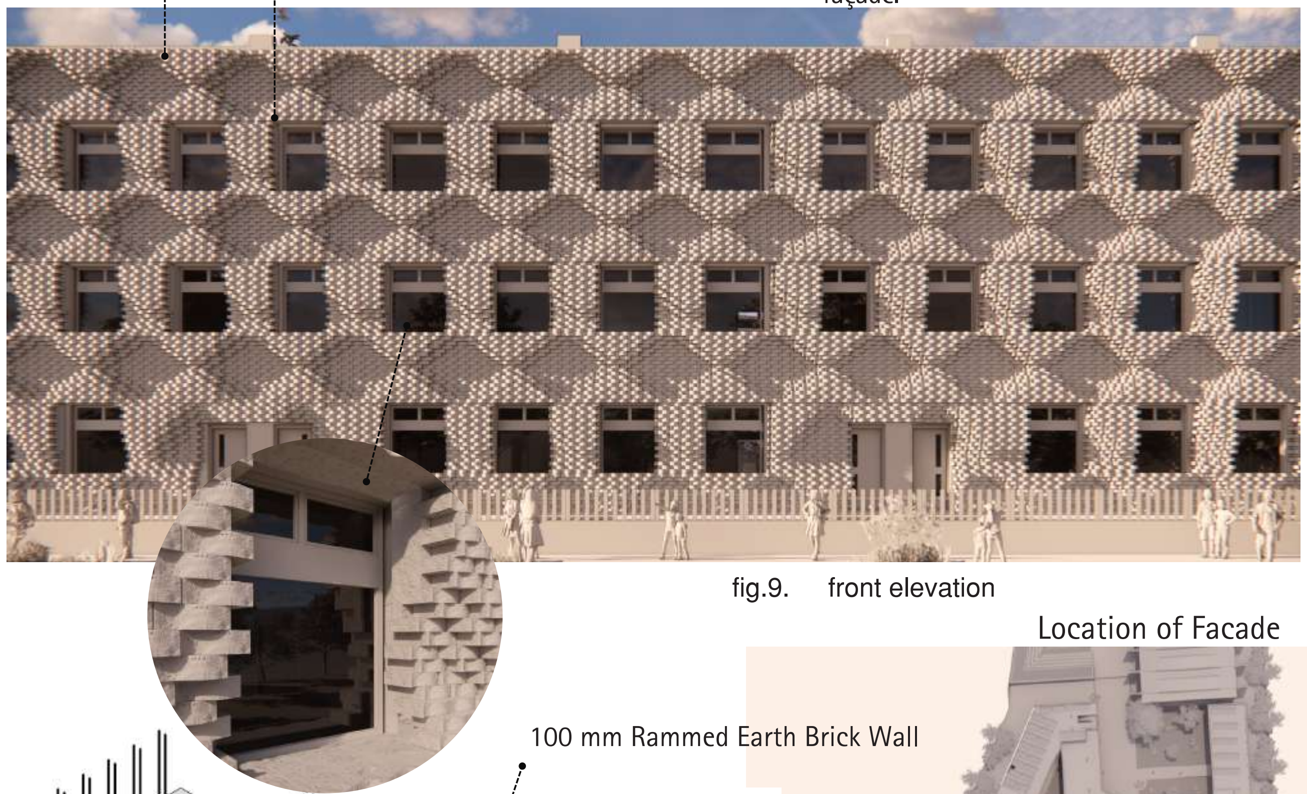
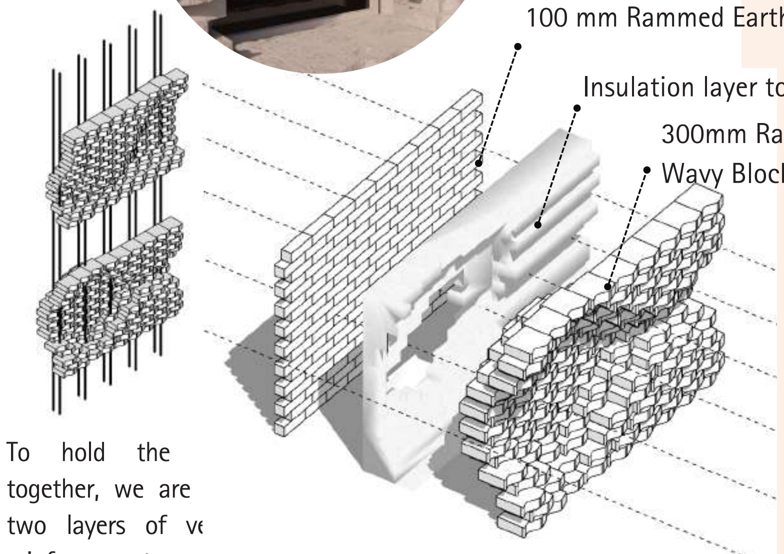


fig.9. front elevation



To hold the together, we are two layers of ve reinforcement.

Exploded Layers of the Wall

Location of Facade

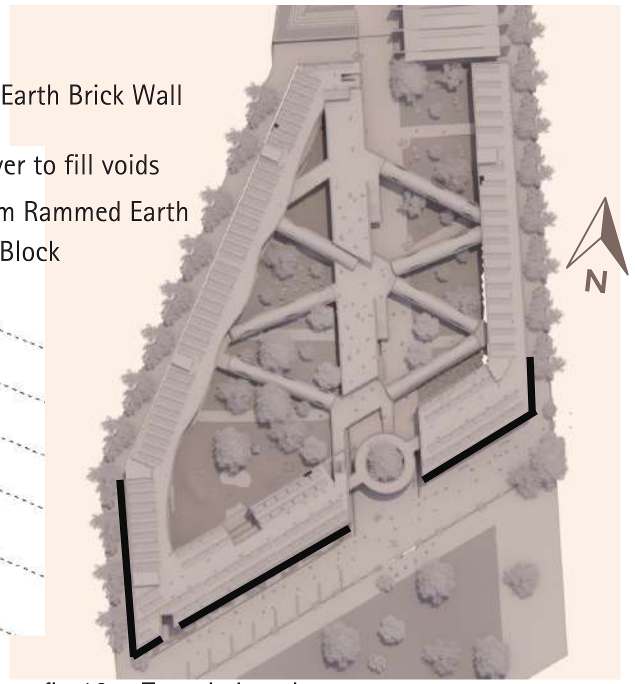


fig.10. Facade location

3D RENDERS

fig.11. 3-D renders 1/2

3D RENDERS

fig.12. 3-D renders 2/2

ENGINEERING AND OPERATIONS

Electrical Layouts

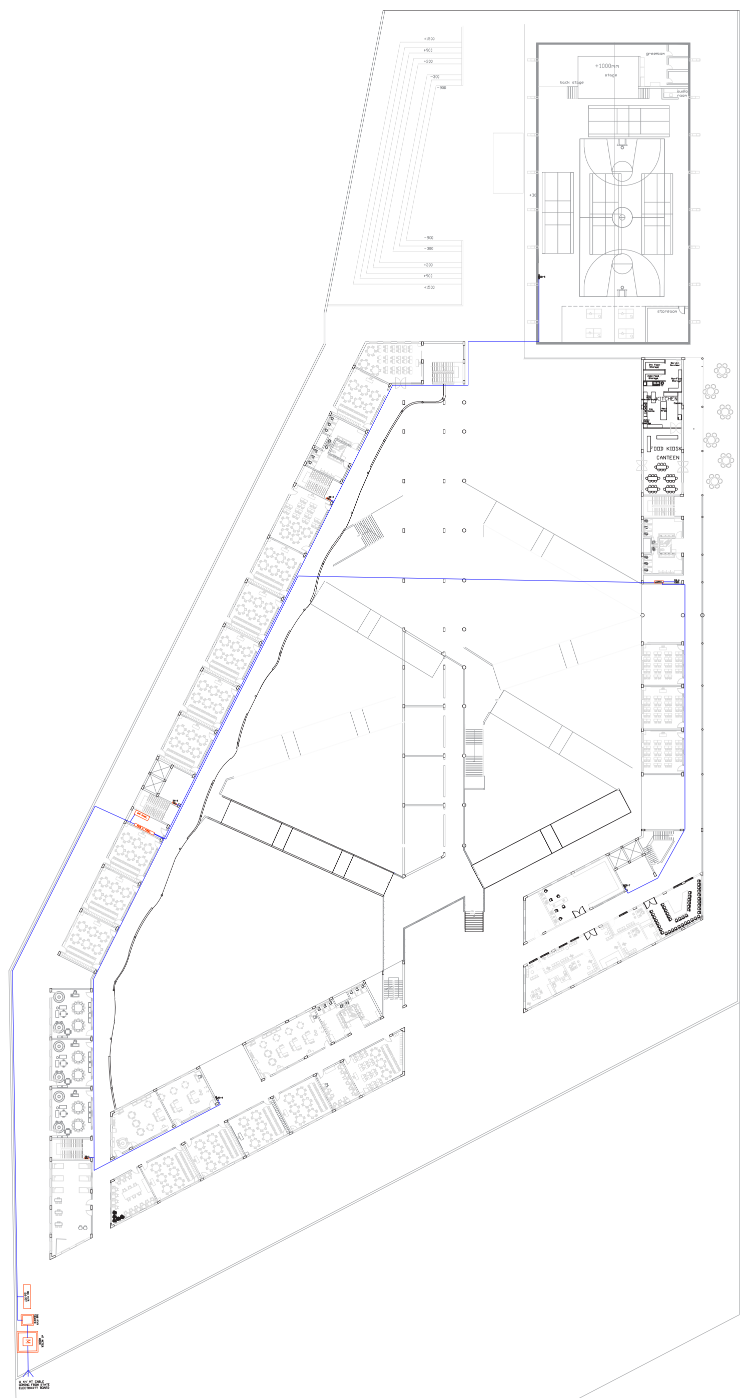


fig.13. Ground floor HI side layout

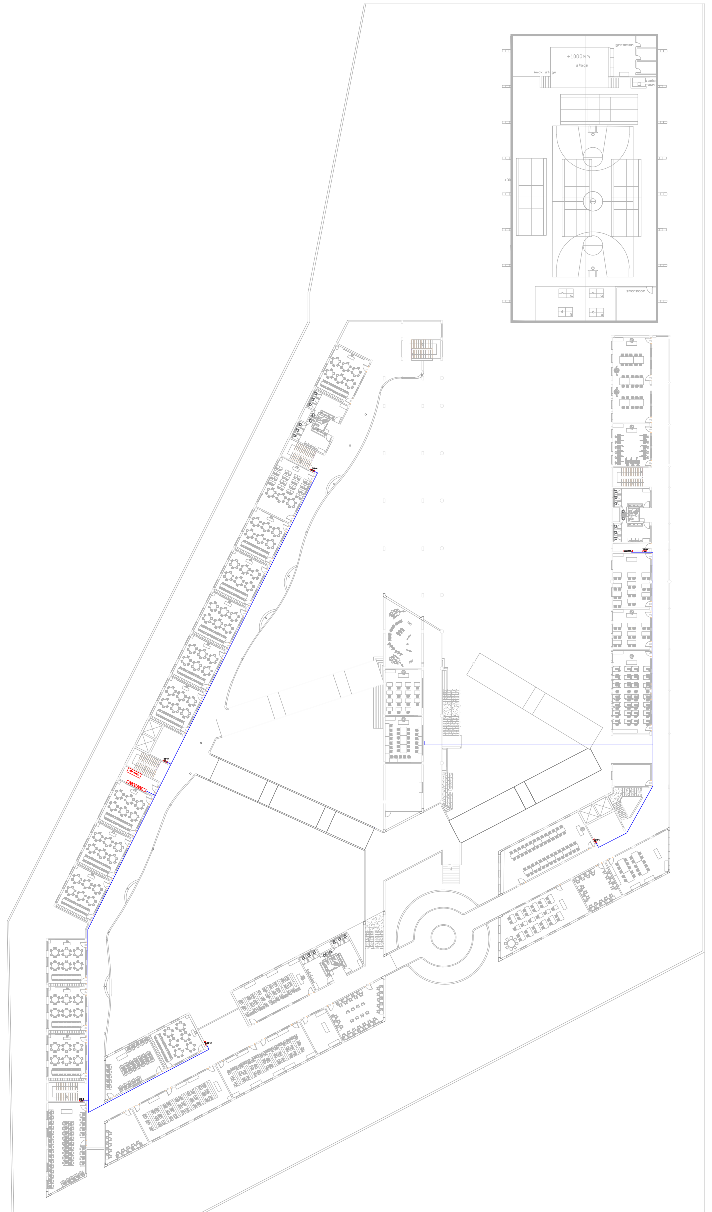


fig.14. First floor HI side layout

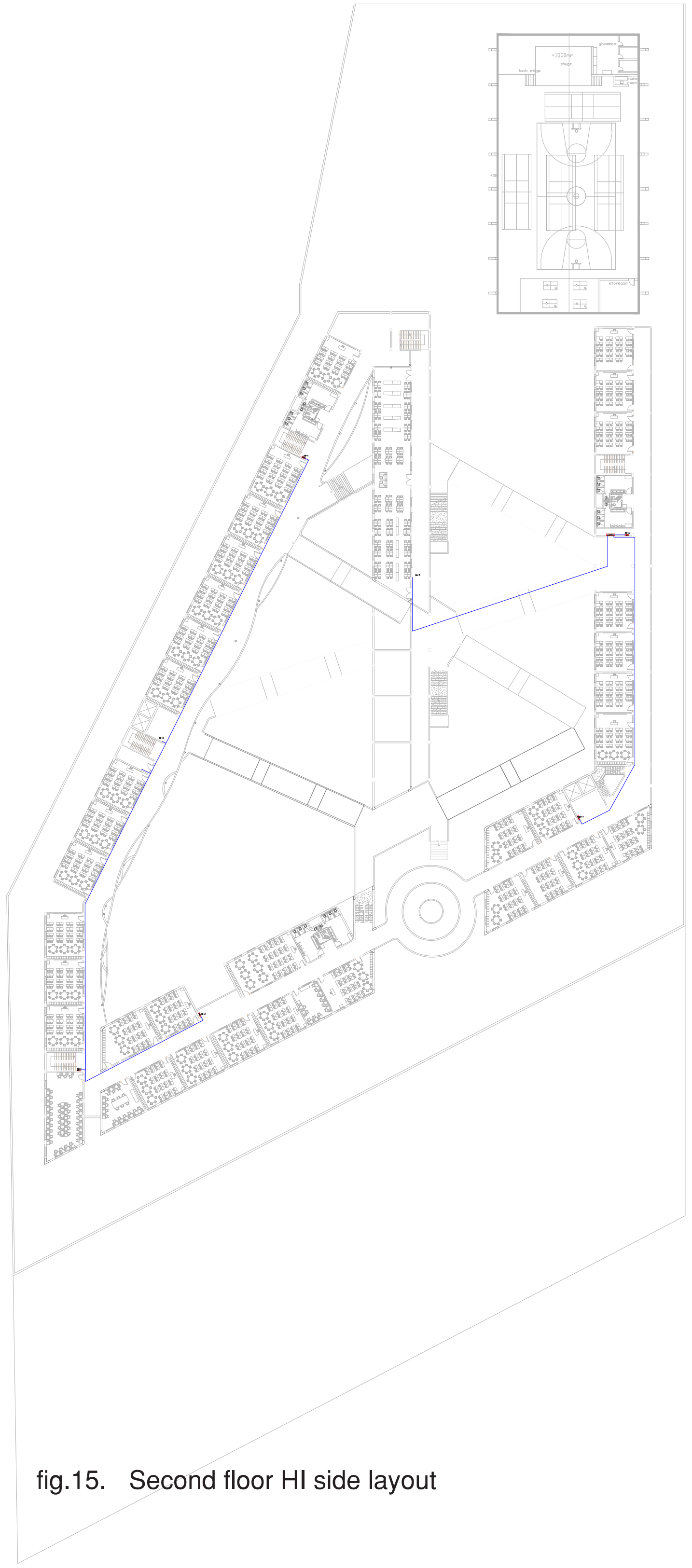


fig.15. Second floor HI side layout

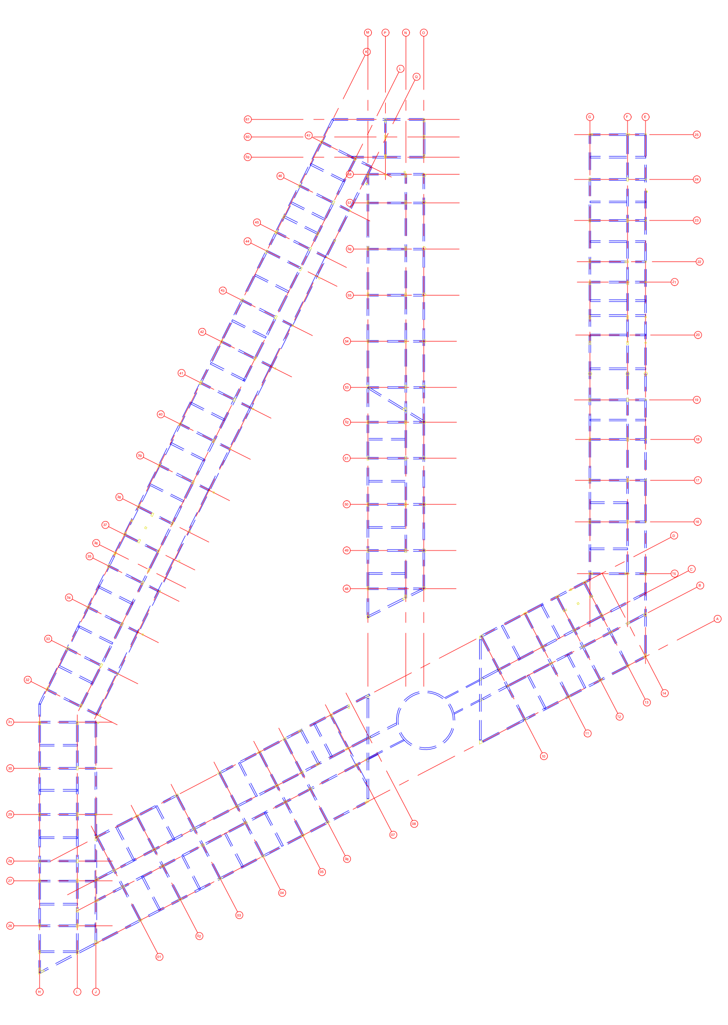


fig.16. Typical structural layout

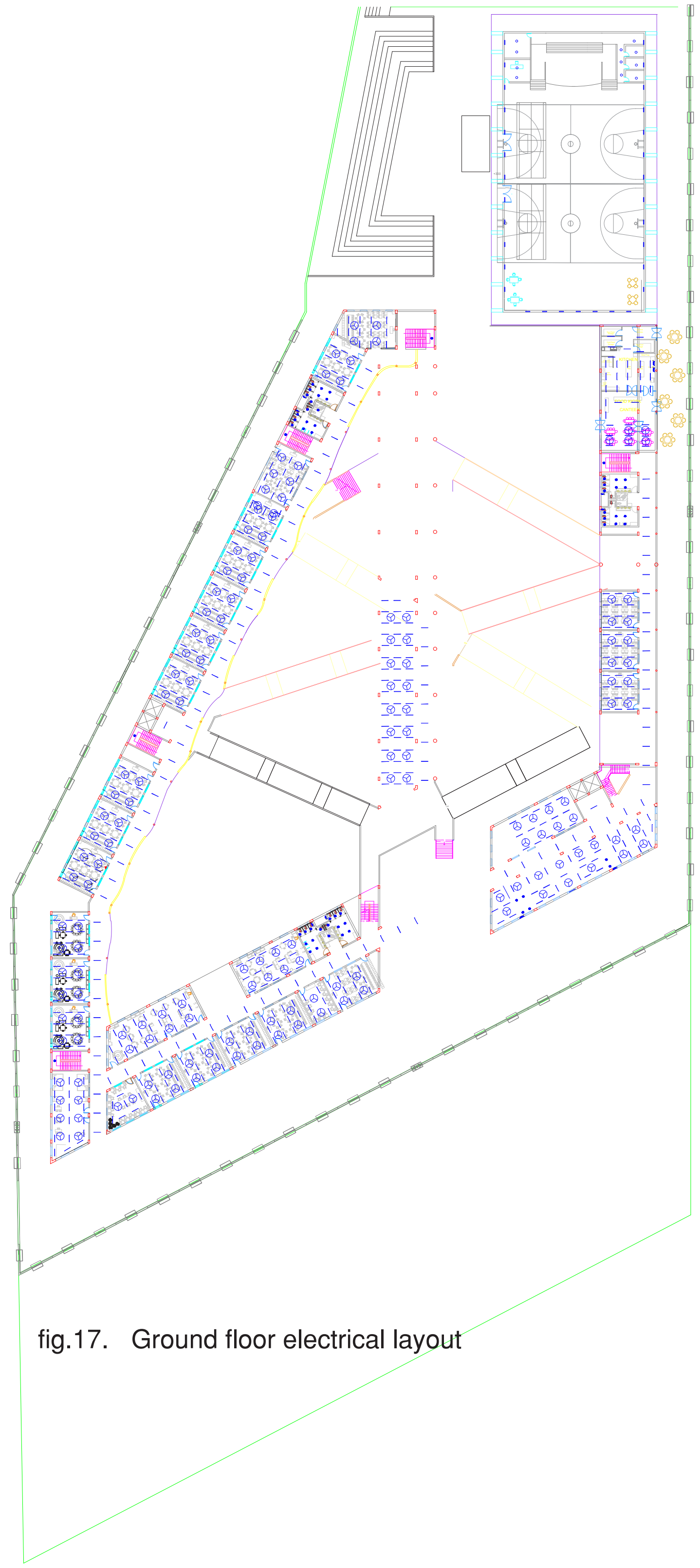


fig.17. Ground floor electrical layout

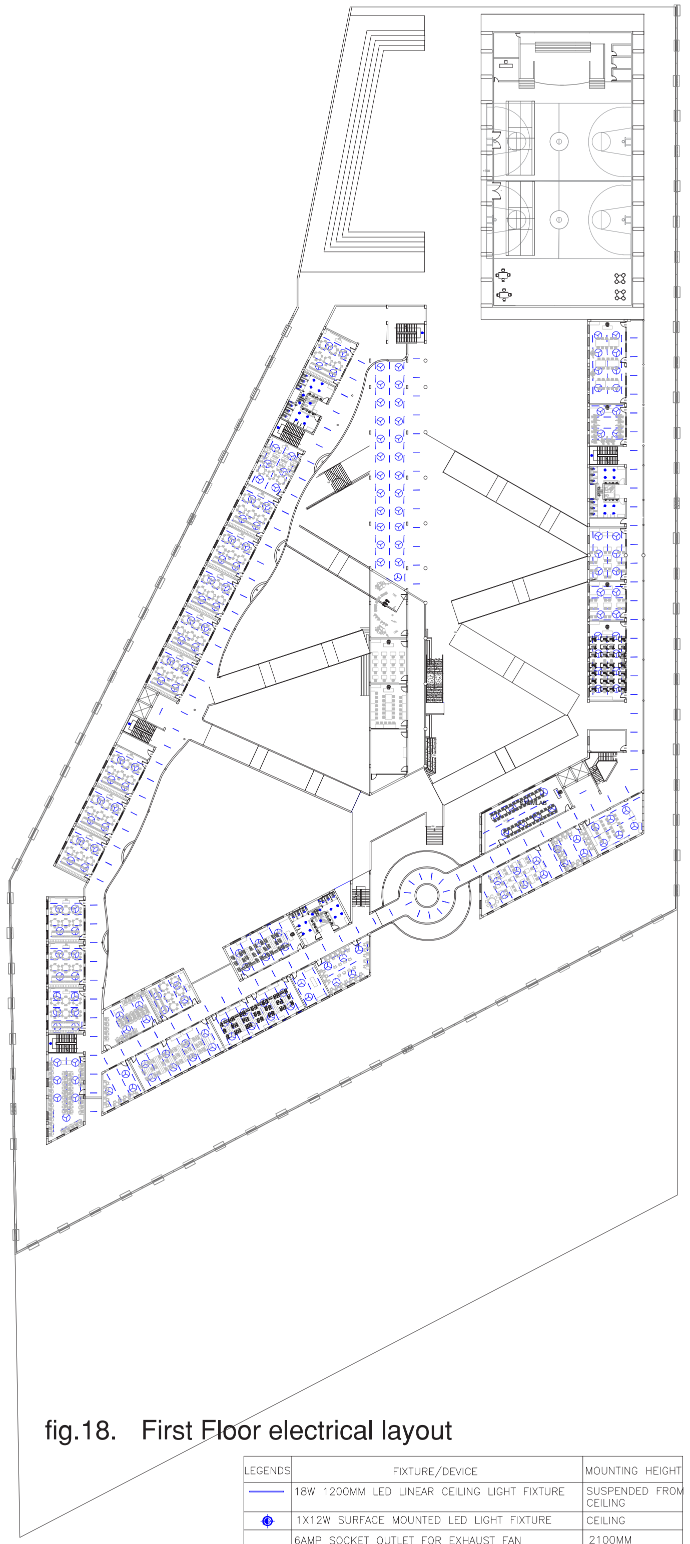


fig.18. First Floor electrical layout

LEGENDS	FIXTURE/DEVICE	MOUNTING HEIGHT
	18W 1200MM LED LINEAR CEILING LIGHT FIXTURE	SUSPENDED FROM CEILING
	1X12W SURFACE MOUNTED LED LIGHT FIXTURE	CEILING
	6AMP SOCKET OUTLET FOR EXHAUST FAN	2100MM
①	EXHAUST FAN LABORATORIES/KITCHEN –1150 CMH	2100MM
②	EXHAUST FAN W.C.s – 356 CMH	2100MM
	CEILING FAN 1200MM	CEILING
	SWITCH BOARD FOR LIGHTS/EXHAUST FAN/CHIMNEY	
	1x6/16A POWER OUTLET (RAW) WITH 1x16A SWITCH FOR GENERAL PURPOSE	1050MM

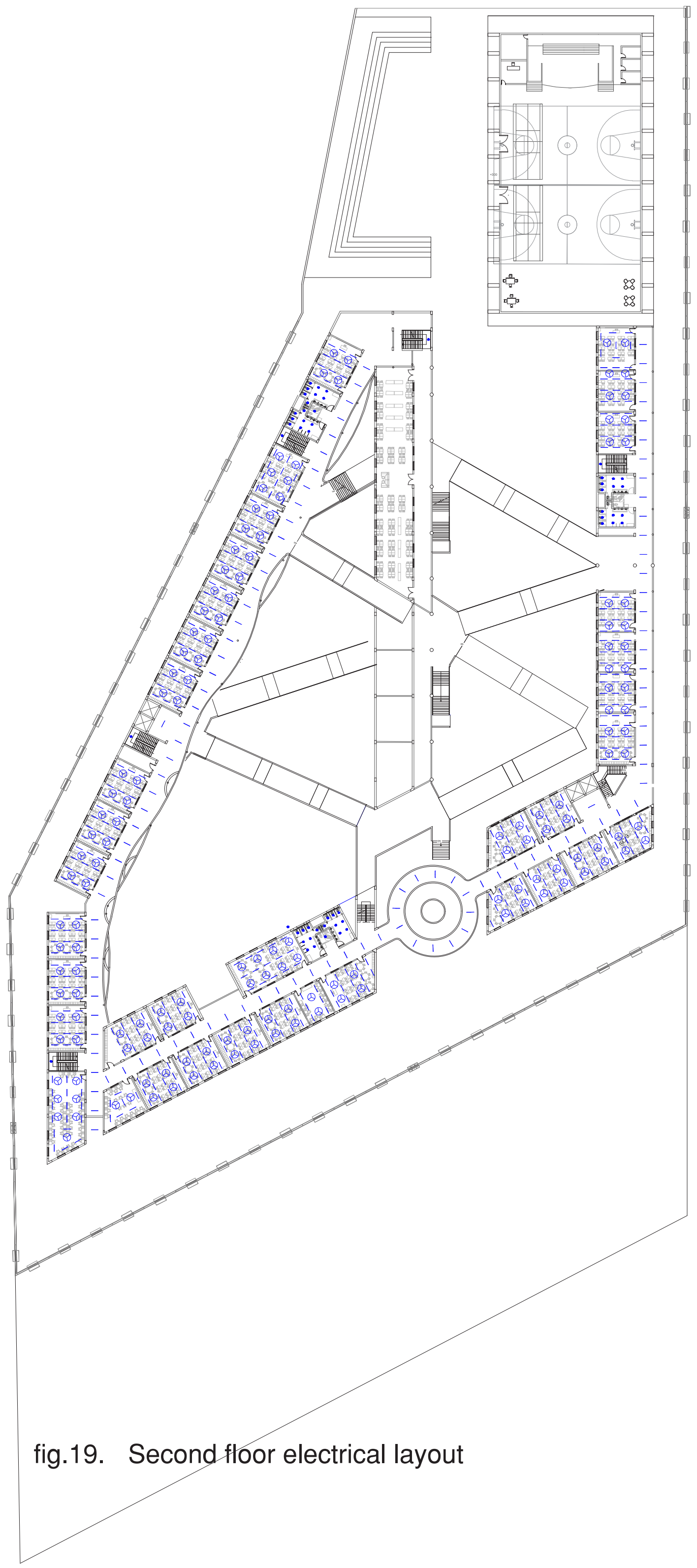


fig.19. Second floor electrical layout

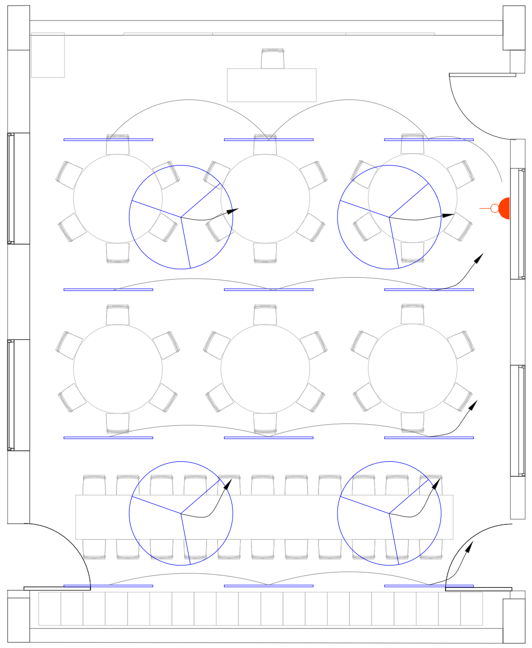
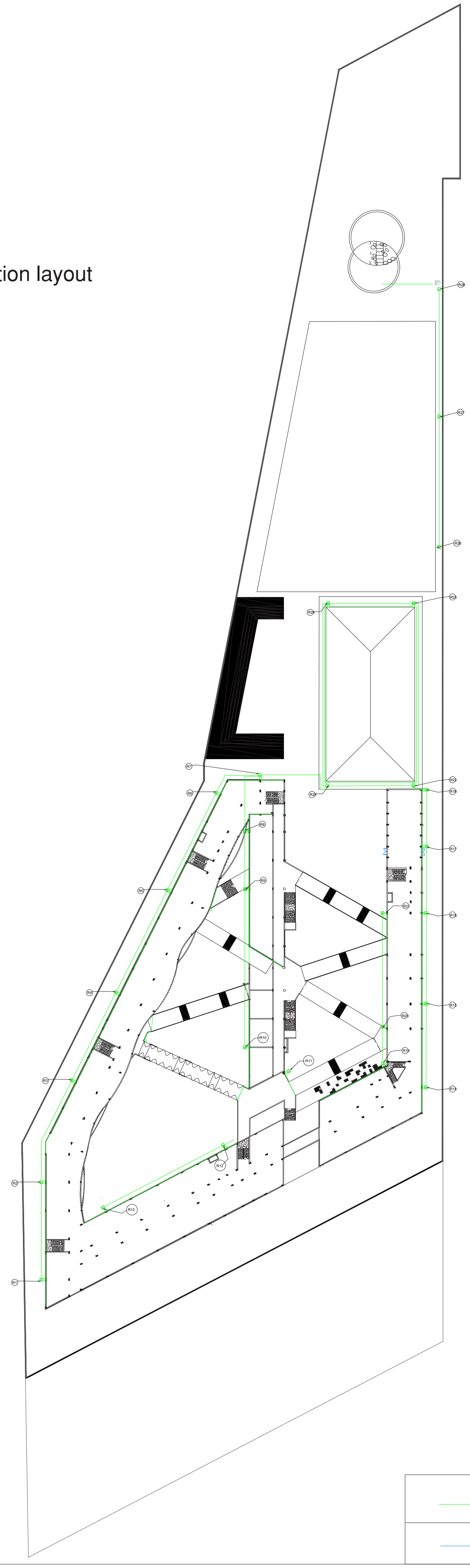


fig.20. Typical classroom electrical layout

LEGENDS	FIXTURE/DEVICE	MOUNTING HEIGHT
	18W 1200MM LED LINEAR CEILING LIGHT FIXTURE	SUSPENDED FROM CEILING
	1X12W SURFACE MOUNTED LED LIGHT FIXTURE	CEILING
	6AMP SOCKET OUTLET FOR EXHAUST FAN	2100MM
1	EXHAUST FAN LABORATORIES/KITCHEN –1150 CMH	2100MM
2	EXHAUST FAN W.C.s – 356 CMH	2100MM
	CEILING FAN 1200MM	CEILING
	SWITCH BOARD FOR LIGHTS/EXHAUST FAN/CHIMNEY	
	1x6/16A POWER OUTLET (RAW) WITH 1x16A SWITCH FOR GENERAL PURPOSE	1050MM

Plumbing layouts

fig.21. Roof - rainwater collection layout



	Rain Water Pipe-rooftop
	Rain Water Pipe-site

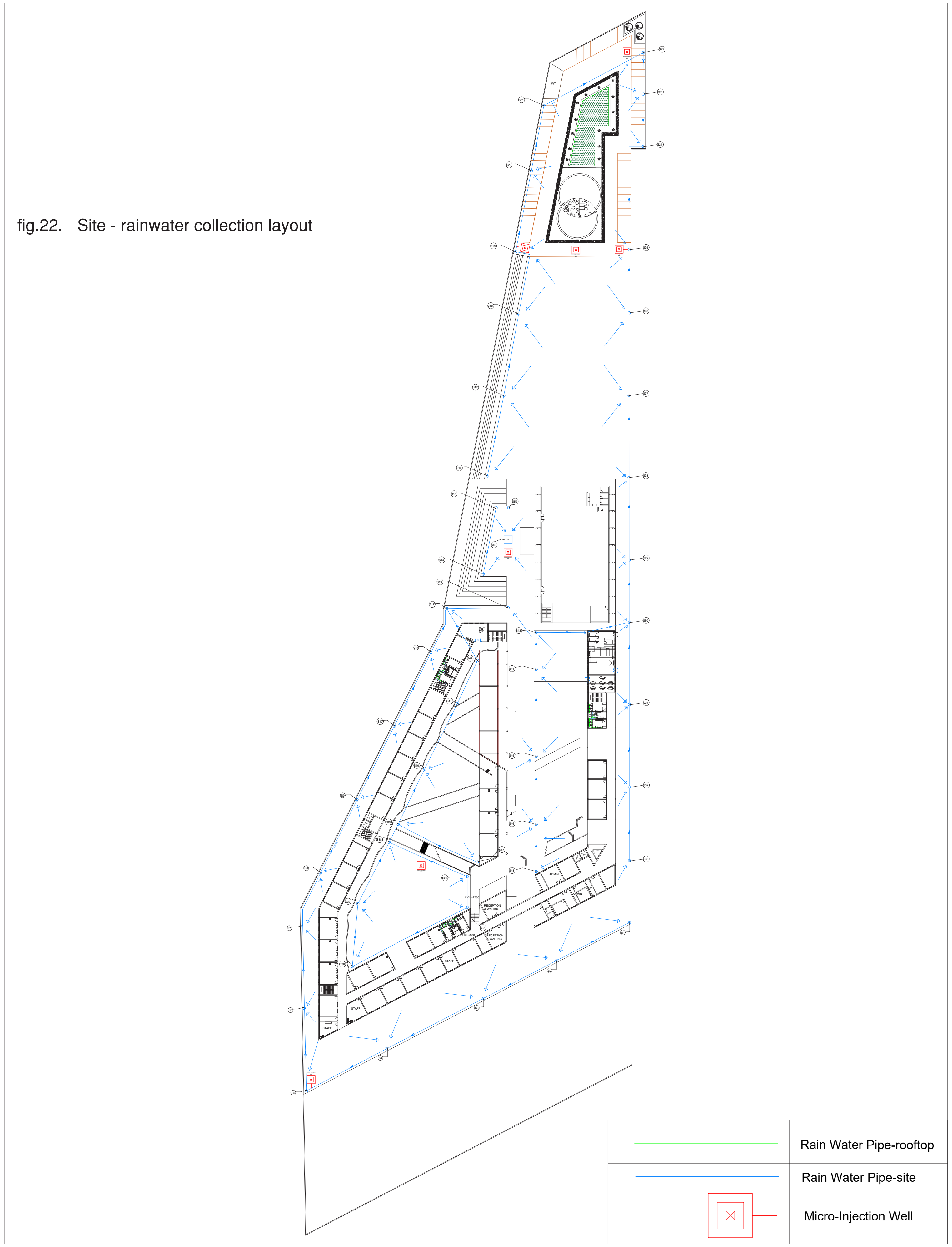


fig.22. Site - rainwater collection layout

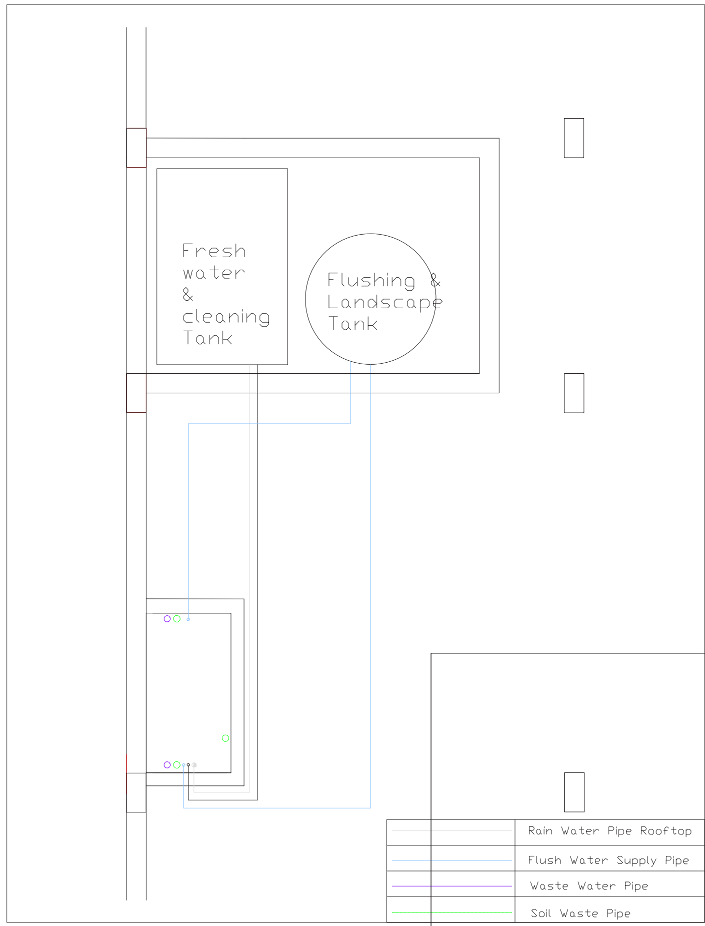


fig.23. Mumty level plumbing layout

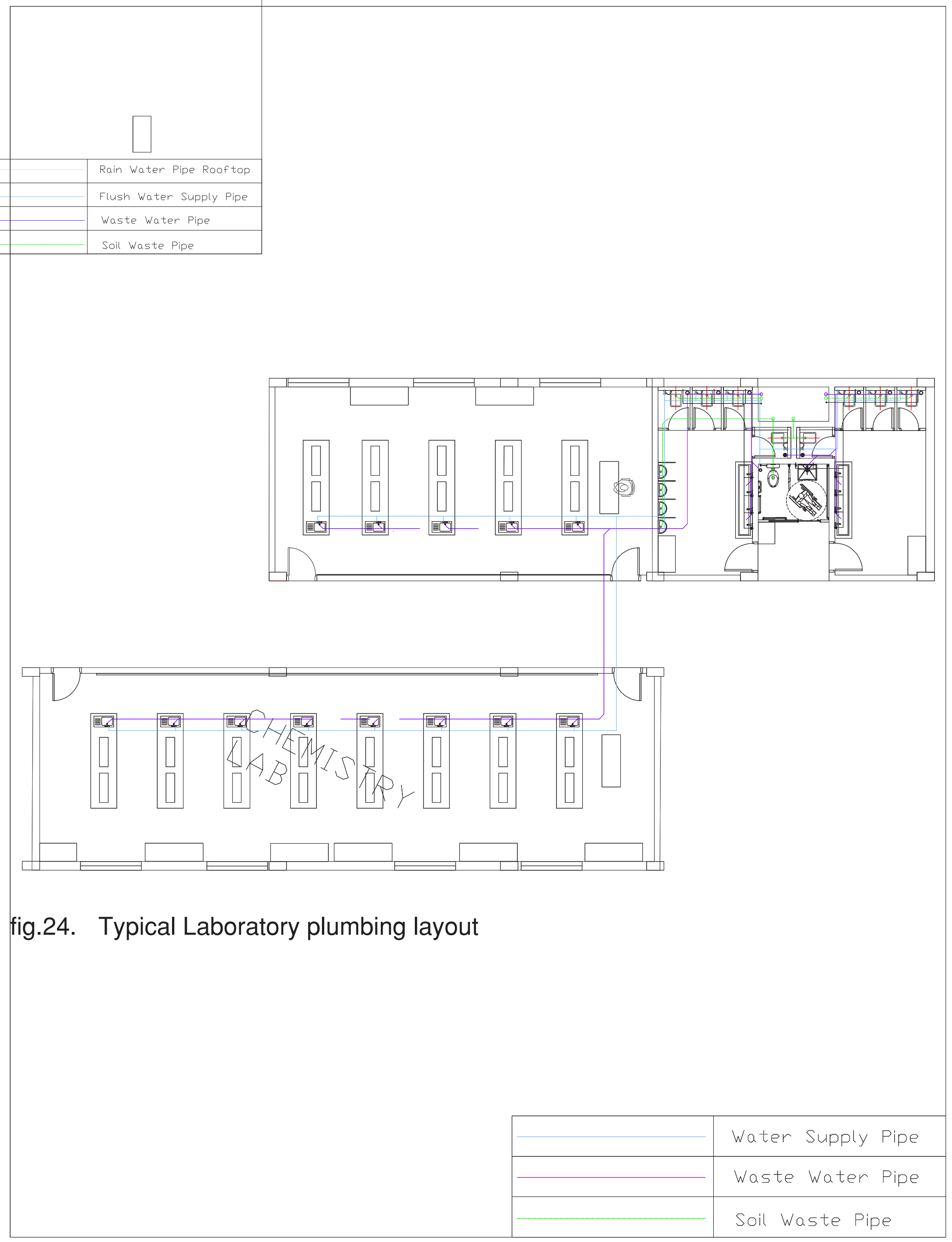


fig.24. Typical Laboratory plumbing layout

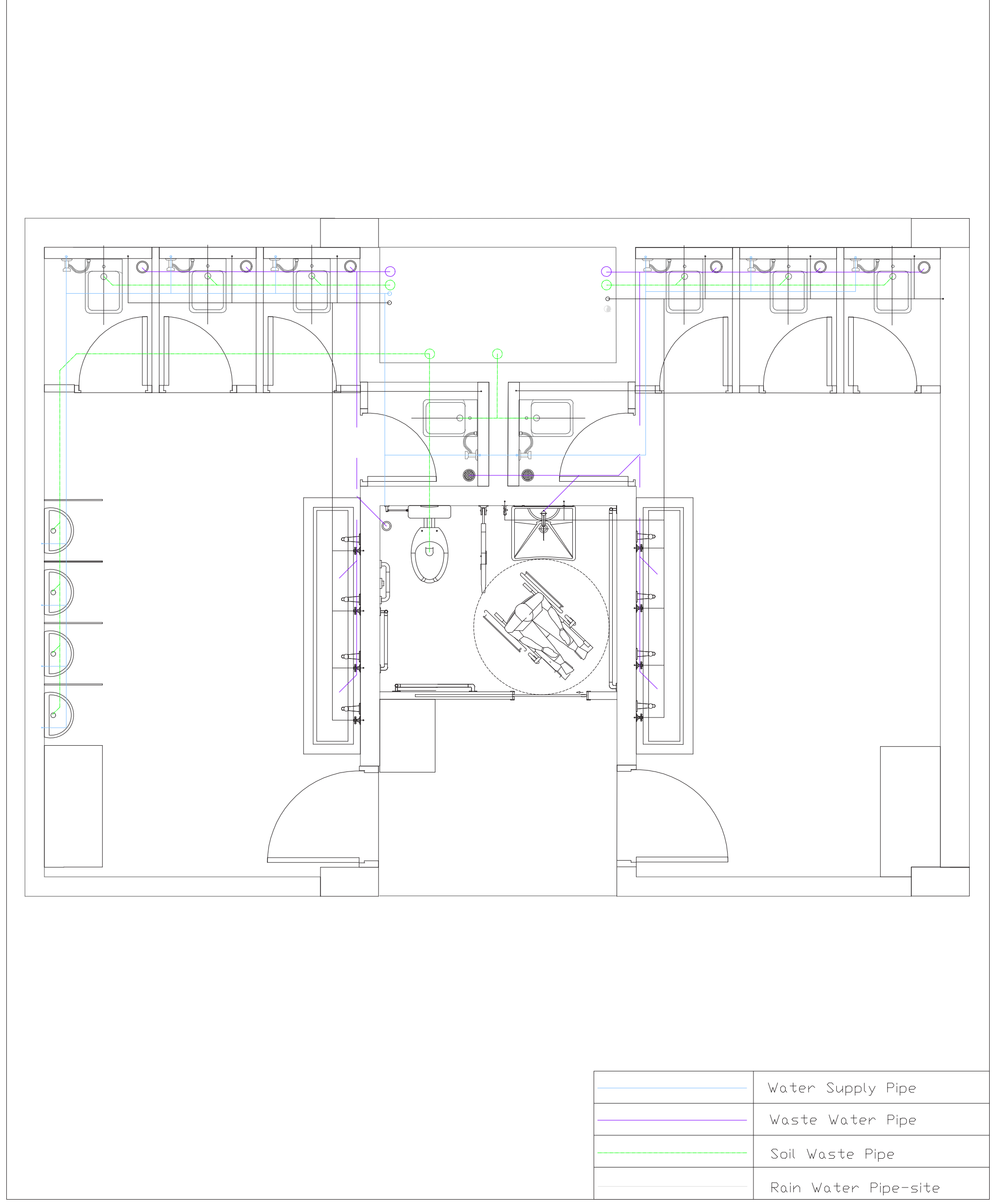
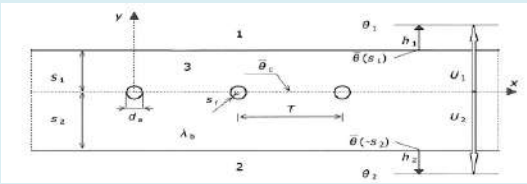


fig.25. Typical washroom Plumbing layout



Calculations based on EN 15377, valid for type E (Pipes embedded in massive concrete))

Input details

		Unit	Data
Pipe details			
Pipe spacing	T	M	0.15
Outside diameter of pipe	da	M	0.02
Pipe wall thickness	Sr	M	0.002
Thermal conductivity of pipe	λp	W/MK	0.35
Layer above Pipe			
Thickness of Ist conductive layer above the pipe	S1	M	0.075
Thermal conductivity of the Ist conductive layer	λ1	W/MK	2.1
Thickness of 2nd conductive layer	S2	M	0.045
Thermal conductivity of the 2nd conductive layer	λ2	W/MK	1.2
Thickness of 3rd conductive layer	S3	M	0.01
Thermal conductivity of the 3rd conductive layer	λ3	W/MK	1
Thickness of 4th conductive layer	S4	M	0
Thermal conductivity of the 4th conductive layer	λ4	W/MK	0
Layer below pipe			
Thickness of Ist conductive layer	S1	M	0.075
Thermal conductivity of the 1st conductive layer	λ1	W/MK	2.1
Thickness of 2nd conductive layer	S2	M	0.01
Thermal conductivity of the 2nd conductive layer	λ2	W/MK	1.2
Thickness of 3rd conductive layer	S3	M	0
Thermal conductivity of the 3rd conductive layer	λ3	W/MK	0
Thickness of 4th conductive layer	S4	M	0
Thermal conductivity of the 4th conductive layer	λ4	W/MK	0
Design conditions			
Over all transfer co-efficient for surface above	h1	W/M2K	22
Overall transfer co-efficient for surface below	h2	W/M2K	7
Length of one loop	L	M	100
Inside design temperate in room above surface	θ1	°C	30
Inside design temperate in room below surface	θ2	°C	30
Chilled water inlet temperature, Twi	θv	°C	22
Chilled water outlet temperature, Two	θR	°C	25
Specific heat of heating or cooling fluid	Cp	KJ/Kg K	4.2

Output details

		Unit	Data
Cooling Capacity			
Heat flow upwards	q1	W/Sqm	-36.77
Heat flow downwards	q2	W/Sqm	-25.32
Total heat flow	q	W/Sqm	-62.09
Flow details			
Sp.design heating/cooling fluid mass	MHsp	Kg/Hr Sqm	17.82
Mass flow rate	Mw	Kg/Hr	267.36
Fluid velocity	w	M/s	0.37
Reynolds number	Re	-	5335.15
Temperature of surfaces			
Temperature of upper surface	θsm1	°C	28.33
Temperature of lower surface	θsm2	°C	26.38
Heat transfer co-efficient's			
Heat transfer co-efficient above pipe	U1	W/M2K	7.77
Heat transfer co-efficient below pipe	U2	W/M2K	5.35

fig.26. Radiant Output

Radiant Cooling System

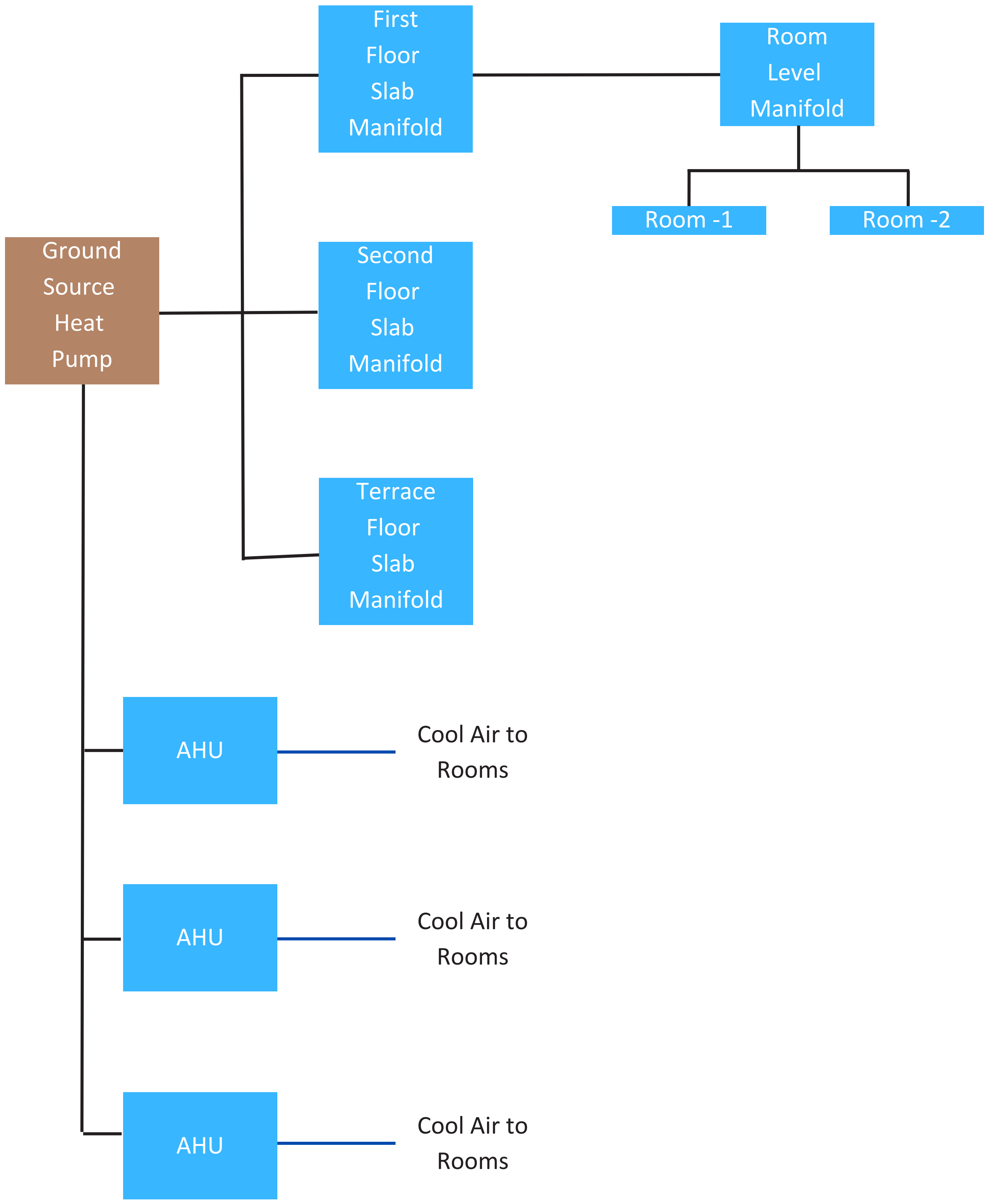


fig.27. Radiant System SLD

Building System Specifications

S. No.	Fixture Description	Unit	Nos	Watt/ Fixture	Light load Watt	Total Connected Load(kW)	Diversity Factor	Total Demand Load (kW)
	PROJECT:- Springhills International School							
	SUBJECT:-LIGHT AND POWER LOAD CALCULATION							
1	LIGHT & POWER LOAD GROUND FLOOR							
1.1	18W 1200MM LED LINEAR CEILING LIGHT FIXTURE	Nos	599.00	18.00	10,782.00	10.78	1.0	10.78
1.2	Ceiling Fan	Nos	153.00	28.00	4,284.00	4.28	1.0	4.28
1.3	1X12W SURFACE MOUNTED LED LIGHT FIXTURE	Nos	48.00	12.00	576.00	0.58	1.0	0.58
1.4	Exhaust Fan (Kitchen)	Nos	2.00	20.00	40.00	0.04	0.5	0.02
1.5	Exhaust Fan (Bathroom)	Nos	8.00	11.00	88.00	0.09	0.5	0.04
1.6	6A Socket outlet for Chimney (Kitchen)	Nos	1.00	150.00	150.00	0.15	0.5	0.08
1.7	6A Switch socket outlet for R.O. (Kitchen)	Nos	3.00	150.00	450.00	0.45	0.5	0.23
1.8	16A KitchenSocket outlet for Oven	Nos	3.00	500.00	1,500.00	1.50	0.5	0.75
1.9	2 Ton Split AC	Nos	7.00	1200.00	8,400.00	8.40	0.5	4.20
2	1.5 Ton Split AC	Nos	3.00	520.00	1,560.00	1.56	1.0	1.56
2	2.5 Ton Split AC	Nos.	3.00	1600.00	4,800.00	4.80	0.5	2.40
2.1	16A Switch socket outlet for General Purpose	Nos	15.00	500.00	15,500.00	15.50	0.3	4.65
2.2	2x6A Switch socket outlet for Classroom	Nos	30.00	200.00	6,000.00	6.00	0.3	1.80
2.3	16A Kitchen Socket outlet for Tea/Coffee	Nos	2.00	500.00	500.00	0.50	0.3	0.15
2.4	16A Kitchen Socket outlet for Fridge	Nos	2.00	500.00	500.00	0.50	0.3	0.15
	Total Light & Power Load					55.13KW		31.67KW
2	LIGHT & POWER LOAD FIRST FLOOR							
2.1	18W 1200MM LED LINEAR CEILING LIGHT FIXTURE	Nos	574.00	18.00	10,332.00	10.33	1.0	11.68
2.2	Ceiling Fan	Nos	169.00	28.00	4,732.00	4.73	1.0	4.73
2.3	1X12W SURFACE MOUNTED LED LIGHT FIXTURE	Nos	42.00	12.00	504.00	0.50	1.0	0.50
2.4	Exhaust Fan (Laboratories)	Nos	7.00	20.00	140.00	0.14	0.3	0.04
2.4	Exhaust Fan (Bathroom)	Nos	6.00	11.00	66.00	0.07	1.0	2.25
2.5	16A Switch socket outlet for General Purpose	Nos	30.00	500.00	15,000.00	16.00	0.3	4.80
2.6	2X6A Switch socket outlet for Computer Lab	Nos	85.00	70.00	5,950.00	5.95	0.3	1.79
2.7	2X6A Switch socket outlet for Classrooms/Offices	Nos	30.00	200.00	6,000.00	6.00	0.3	1.80
	Total Light & Power Load					43.72KW		27.59KW
3	LIGHT & POWER LOAD SECOND FLOOR							
3.1	18W 1200MM LED LINEAR CEILING LIGHT FIXTURE	Nos	538.00	18.00	9,684.00	9.68	1.0	9.68
3.2	Ceiling Fan	Nos	158.00	28.00	4,424.00	4.42	1.0	4.42
3.3	1X12W SURFACE MOUNTED LED LIGHT FIXTURE	Nos	16.00	12.00	192.00	0.19	1.0	0.19
3.4	Exhaust Fan (Bathroom)	Nos	6.00	11.00	66.00	0.07	1.0	2.25
3.5	16A Switch socket outlet for General Purpose	Nos	9.00	500.00	4,500.00	16.00	0.3	4.80
3.6	2X6A Switch socket outlet for Classrooms/Offices	Nos	30.00	200.00	6,000.00	6.00	0.3	1.80
	Total Light & Power Load					36.37KW		23.15KW
4	LIFTS	Nos.	4.00	7500.00	30,000.00	30.00	0.5	15.00

Table 2. Light and power load calculation

S.No.	Floor Description	Units	Qty	Connected Load (kW) Each Floor	Total Demand Load (kW) Each Floor
	PROJECT:- Springhills International School				
	SUBJECT:-ELECTRICAL LOAD CALCULATION				
1	Ground Floor	No.	1	55.13	31.67
2	First Floor	No.	1	43.72	27.59
3	Second Floor	Nos.	1	36.37	23.15
4	**Common Area Load**				
4.1	Plumbing Load	No.	1	40.00	20.00
4.2	Shop /Kiosk Load (Assumed)	No.	15	1.00	15.00
4.3	Lift	No.	4	30.00	15.00
4.4	External Lighting			5.00	5.00
4.5	Radiant Cooling and AHU			150.00	150.00
	Total Load Load				**287.41kW**
	Maximum Demand Load @ 80% Overall Diversity				**229.93kW**
	TRANSFORMER SELECTION				
	MAX DEMAND LOAD **@ 80% Overall Diversity**				**229.93kW**
	Transformer Power factor @ 0.9				0.90
	Transformer Loading @90%				0.9
	Net KVA Required				**284kVA**
	Suggestions Transformers Capacity				**1 Nos 300kVA**
	Hence Proposed 1 No. 300 KVA 11/0.415 KV TRANSFORMER				
	D.G SELECTION				
	Total Connected Load				**81.67kW**
	Maximum Demand Load @ 80% overall Diversity				**65.33kW**
	D.G Power factor @ 0.8				0.80
	D.G Loading @80%				0.80
	Net KVA Required				**102kVA**
	Suggestions D.G Capacity				**1No. 100KVA**
	CAPACITOR SELECTION				
-	TOTAL EXPECTED DEMAND				230 KW
-	INITIAL PF (Assumed)				0.80
-	TARGETED PF (Assumed)				0.95
-	CORRECTION FACTOR				0.421
-	REQUIRED KVAR				97 KVAR
	REQUIRED KVAR				**100 KVAR**
	SELECTED KVAR				**100 KVAR**

Table 3. Electrical load calculation

ENERGY PERFORMANCE

Input Parameters	Units	Proposed Design Values
General		
Building Area	m²	12707.8
Conditioned Area	m²	6262.96
Electricity Rate	INR/kWh	7.1
Natural Gas Rate	INR/GJ	Nil
Building Occupancy Hours	–	7:30 am–14:30pm
Average Occupant Density	m² / person	0.4
Internal Loads		
Interior Average Lighting Power Density	W/m²	4.1
List of Lighting Controls	–	
Average Equipment Power Density	W/m²	6.9
Minimum OA Ventilation (Building Average)	l/sec.m²	0.0083
Envelope		
Roof Assembly U value	W/m².K	0.426
Roof Assembly SRI		0.4
Average Wall Assembly U value	W/m².K	0.312
Window to Wall Area Ratio (WWR)	%	27.52
Windows U value	W/m².K	3.7
Windows SHGC		0.72
Windows VLT	%	0.811
Infiltration Rate	ac/h	0.2
Describe Exterior Shading Devices		Front Façade (South facing) has a parametric layer that acts as a shading, the shading layer has become a part of the wall assembly
HVAC System		
HVAC System Type and Description	–	Ground Sourced Heat Hump with Radiant Chilled Ceiling coupled with AHU and Air cooled Chiller.
Describe Mixed mode strategy in operation/controls of AC and windows	–	Building HVAC system is 100% conditioned during occupied hours to achieve maximum thermal comfort hours.
Heating Source	–	Ground Sourced Heat Pump
Heating Capacity	kW	
Heating COP		
Cooling Source	–	Electric
Cooling Capacity	kW	2312.1
Cooling COP		5.5
Operation Hours		7
Heating Set Point	°C	18
Cooling Set Point	°C	26
Relative Humidity Setpoint		

Table 4. List of input output parameters 1/2

Service Hot Water			
SHW Type and Description	–	If Applicable	
Output Parameters	**Units**	**Proposed Design Values**	
Proposed EUI (Total)	kWh/m²/ yr	39.91	
EUI Breakdown by End Use			
Heating	kWh/m²/ yr		
Cooling	kWh/m²/ yr	11.3	
Fans	kWh/m²/ yr	16	
Pumps	kWh/m²/ yr	0.16	
Heat Rejection	kWh/m²/ yr		
Service Hot Water	kWh/m²/ yr	NIL	
Lighting	kWh/m²/ yr	3.2	
Equipment	kWh/m²/ yr	9	
Total Envelope Heat Gain (Peak)	W/m²	74.315	
Cooling Load of Conditioned Area	SF/ Tr	168.53	
Building Electric (Peak)	W/m²	5525.4	
Annual Operating Energy Cost	INR/m²	283	
Annual Unmet Hours	–	188	
Cooling Capacity	Tr	400	
Annual Hours of Comfort without Air Conditioning		1340hrs	
Monthly Energy Performance		Generation	Consumption
Jan	kWh	41804	39097.05
Feb	kWh	46314	30349.11
Mar	kWh	56218	33195.06
Apr	kWh	56364	34019.43
May	kWh	54544	26851.52
Jun	kWh	47268	48495.93
Jul	kWh	45270	70216.81
Aug	kWh	47212	69511.03
Sep	kWh	50248	62762.56
Oct	kWh	49433	34935.15
Nov	kWh	43874	32425.17
Dec	kWh	42137	28334.57
	Total	580686	510193.39

Table 5. List of input output parameters 2/2

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

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The energy output range is based on analysis of 30 years of historical weather data, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

580,685 kWh/Year*

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	4.51	41,804
February	5.65	46,314
March	6.51	56,218
April	6.83	56,364
May	6.56	54,544
June	5.71	47,268
July	5.21	45,270
August	5.34	47,212
September	5.87	50,248
October	5.54	49,433
November	5.00	43,874
December	4.55	42,137
Annual	**5.61**	**580,686**

Location and Station Identification

Requested Location	sohna
Weather Data Source	Lat, Lng: 28.25, 77.05 1.5 mi
Latitude	28.25° N
Longitude	77.05° E

PV System Specifications

DC System Size	400 kW
Module Type	Premium
Array Type	Fixed (roof mount)
System Losses	14.08%
Array Tilt	22°
Array Azimuth	180°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4%
Albedo	*From weather file*
Bifacial	No (0)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Monthly Irradiance Loss	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Performance Metrics

DC Capacity Factor	16.6%

https://pvwatts.nrel.gov/pvwatts.php 1/1

Table 6. Solar PV potential calculation

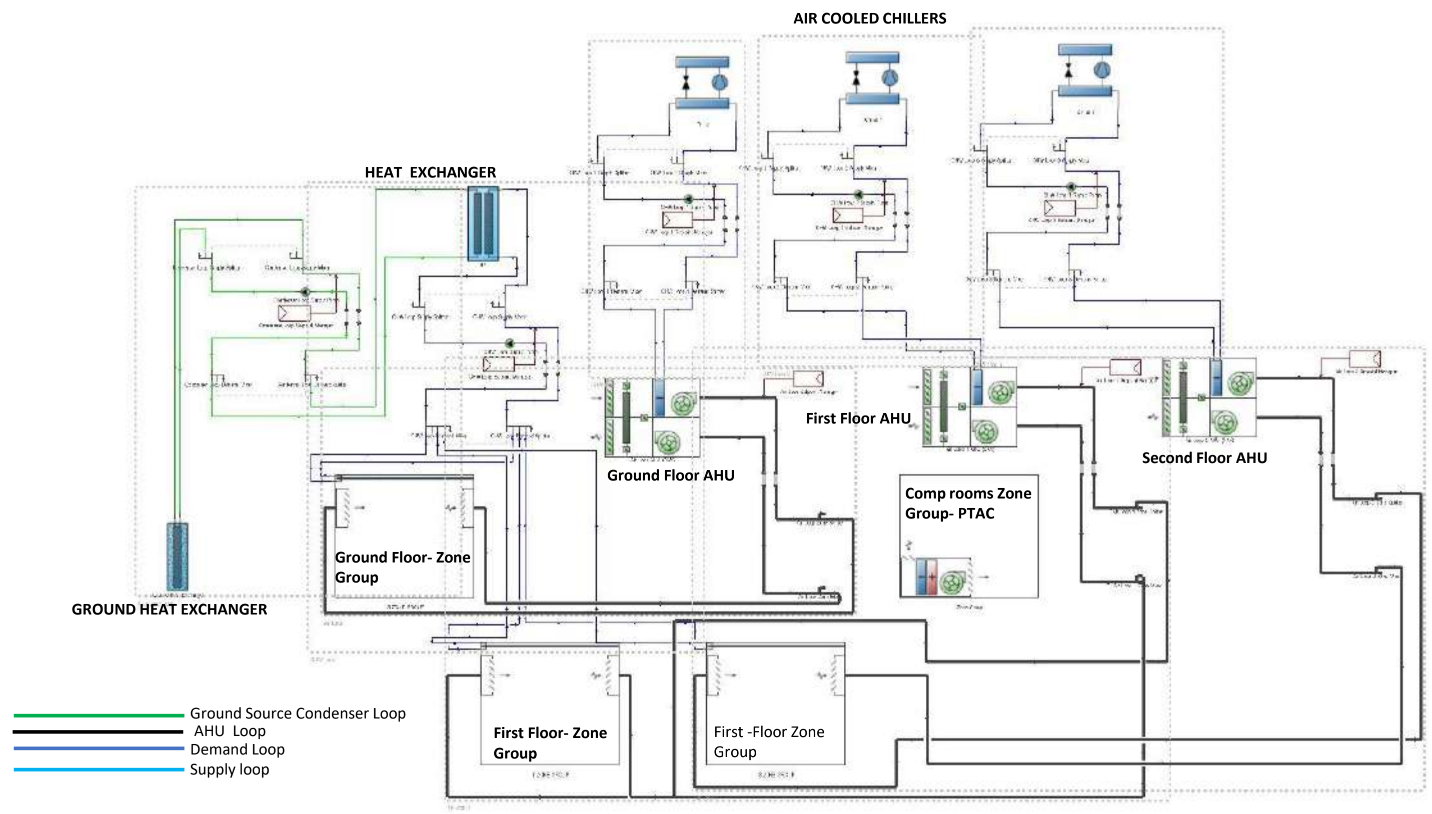


Table 7. HVAC schematic

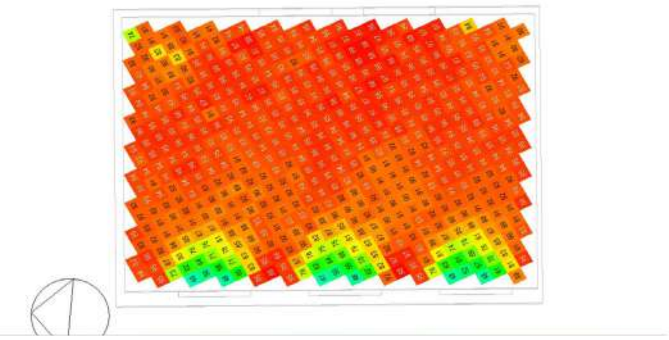


fig.29. UDI schematic - Typical Classroom

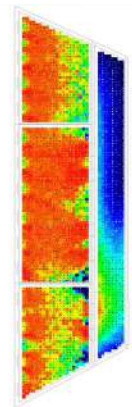


fig.28. UDI schematic - central block

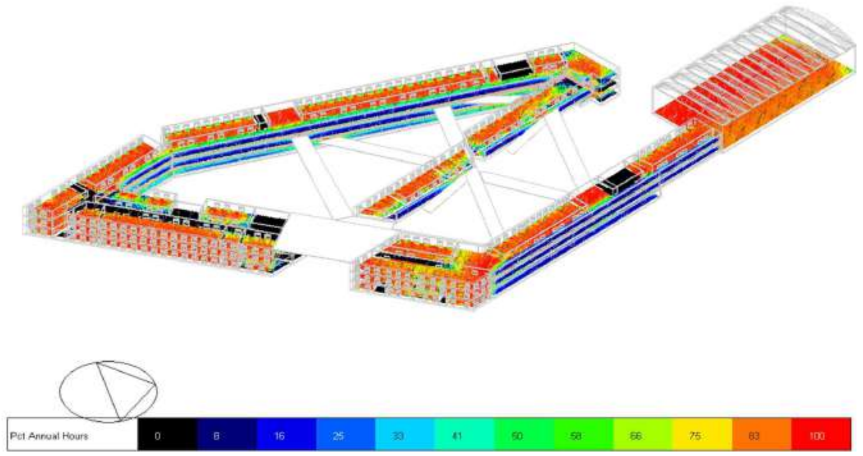


fig.30. UDI schematic - Isometric

WATER PERFORMANCE

Occupant activity	Percent usage	Quantity (ltrs)	Grey water	Black water
Drinking	7.3	3150	0%	100%
Cooking and dishwashing	4.9	2100	100%	0%
Building maintenance	0.5	224.512	100%	0%
Flushing (urination)	2.9	1260	0%	100%
Flushing (defecation)	19.6	8400	0%	100%
Handwash	25.4	10920	100%	0%
Water closet	39.1	16800	0%	100%
Labs	0.2	70	100%	0%
Total (in Litres)		**42924.51**		
Total (in KL/day)		**42.92451**		

Table 8. Baseline occupant water consumption

Occupant activity	Percent usage	Quantity	Grey water	Black water
Drinking	4.4	4144.9	0%	100%
dishwashing	2.9	2763.2	100%	0%
maintenance	4.7	4431.3	100%	0%
Flushing (urination	11.7	11053.0	0%	100%
Flushing (Defecatic	17.5	16579.5	0%	100%
Handwash	35.1	33159.0	100%	0%
Water closet	23.4	22106.0	0%	100%
Labs	0.3	263.2	100%	0%
Total (in Litres)		**94500**		
Total (in kL/day)		**94.5**		

Table 9. Proposed occupant water consumption

Net Zero Water cycle calculation

Months	No of days	No.of working days	Occupant demand (kL) [A]	Rainwater harvested (in kL) [B]	Net rainwater available monthly (kL) [A-B=C]	Irrigation Demand (kL) [D]	Generated grey water (kL) [E]	Generated black water (kL) [I]
January	31	14	1323	145.4	-1177.6	1521.7	568.6	754.4
February	28	20	1890	144.9	-1745.1	1386.7	812.3	1077.7
March	31	20	1890	96.2	-1793.8	1521.7	812.3	1077.7
April	30	19	1795.5	85.0	-1710.5	1472.6	771.7	1023.8
May	31	20	945	183.3	-761.7	1521.7	812.3	1077.7
June	30	20	945	765.5	-179.5	1472.6	812.3	1077.7
July	31	19	1795.5	2609.7	814.2	1521.7	771.7	1023.8
August	31	19	1795.5	2900.6	1105.1	1521.7	771.7	1023.8
September	30	18	1701	1454.1	-246.9	1472.6	731.1	969.9
October	31	18	1701	302.9	-1398.1	1521.7	731.1	969.9
November	30	18	1701	64.3	-1636.7	1472.6	731.1	969.9
December	31	15	1417.5	78.8	-1338.7	1521.7	609.3	808.2
		220	**18900**	**8831**	**-10069**	**17929**	**8936**	**11046**

Table 10. Baseline water consumption pattern

Months	No of days	No.of working days	Occupant demand (kL) [A]	Rainwater harvested (kL) [B]	Net rainwater available monthly (kL) [A-B=C]	Sustaining demand for the next month	Irrigation Demand (kL) [D]	Generated grey water (kL) [E]	Treated grey water available (kL) [E*90%=F]	Treated grey water used for flushing (kL) [G]	Treated grey water left (kL) [F-G=H]	Generated black water (kL) [I]	Treated black water available (kL) [I*90%=J]	Total recycled water available from STP (kL) (after flushing) [H+J=K]	Freshwater demand for irrigation (kL) [D-K=L]	Total water required for mist towers to eliminate SPM (kL) [M]
January	31	14	465.7	145.4	-320.3	-320.3	708.5	186.4	167.8	135.2	32.5	414.5	373.1	405.6	302.9	0.0
February	28	20	665.3	144.9	-520.4	-840.7	645.6	266.3	239.7	193.2	46.5	592.2	533.0	579.4	66.2	0.0
March	31	20	665.3	96.2	-569.1	-1409.8	1416.9	266.3	239.7	193.2	46.5	592.2	533.0	579.4	837.5	0.0
April	30	19	632.0	85.0	-547.0	-1956.8	1371.2	253.0	227.7	183.5	44.1	562.6	506.3	550.5	820.8	60.0
May	31	20	665.3	183.3	-482.0	-2438.8	1416.9	266.3	239.7	193.2	46.5	592.2	533.0	579.4	837.5	60.0
June	30	20	665.3	765.5	100.2	-2338.6	1371.2	266.3	239.7	193.2	46.5	592.2	533.0	579.4	791.8	30.0
July	31	19	632.0	2609.7	1977.7	-360.9	320.0	253.0	227.7	183.5	44.1	562.6	506.3	550.5	-230.5	30.0
August	31	19	632.0	2900.6	2268.5	1907.7	289.5	253.0	227.7	183.5	44.1	562.6	506.3	550.5	-261.0	27.0
September	30	18	598.8	1454.1	855.4	2763.1	335.2	239.7	215.7	173.9	41.8	533.0	479.7	521.5	-186.3	0.0
October	31	18	598.8	302.9	-295.8	2467.2	152.4	239.7	215.7	173.9	41.8	533.0	479.7	521.5	-369.1	0.0
November	30	18	598.8	64.3	-534.4	1932.8	685.6	239.7	215.7	173.9	41.8	533.0	479.7	521.5	164.1	0.0
December	31	15	499.0	78.8	-420.2	1512.6	708.5	199.7	179.7	144.9	34.8	444.2	399.7	434.6	273.9	0.0
		220	**7318**	**8831**	**1513**		**8713**	**2929**	**2636**	**2125**	**511**	**6514**	**5863**	**6374**	**3048**	**207**

Table 11. Proposed water consumption pattern

Rainwater harvesting surfaces	Area m^2	Runoff coeffecient	Effective catchment area m^2	January (9.4 mm)	February (9.6 mm)	March (6.3 mm)	April (5.2 mm)	May (9.8 mm)
Roof top area	7016	0.9	6314.4	59.4	60.6	39.8	32.8	61.9
Roads	4275	0.8	3420	32.1	32.8	21.5	17.8	33.5
Pathways & hardscape	3447	0.7	2412.9	22.7	23.2	15.2	12.5	23.6
Horticulture part	4211	0.3	1263.3	11.9	12.1	8.0	6.6	12.4
Lawn Area	3407	0.3	1022.1	9.6	9.8	6.4	5.3	10.0
Ground (earth)	3378	0.3	1013.4	9.7	6.4	5.3	9.9	41.9
Total Site Area (in m2)	25734		Total (in KL/month)	145.4	144.9	96.2	85.0	183.3

Rainwater harvesting surfaces	June (41.3 mm)	July (167.2 mm)	August (194 mm)	September (99.3 mm)	October (20.7 mm)	November (4.1 mm)	December (5.1 mm)	Total water collected at every surface (KL/surface)
Roof top area	260.8	1055.8	1225.0	627.0	130.7	25.9	32.2	**3611.8**
Roads	141.2	571.8	663.5	339.6	70.8	14.0	17.4	**1956.2**
Pathways & hardscape	99.7	403.4	468.1	239.6	49.9	9.9	12.3	**1380.2**
Horticulture part	52.2	211.2	245.1	125.4	26.2	5.2	6.4	**722.6**
Lawn Area	42.2	170.9	198.3	101.5	21.2	4.2	5.2	**584.6**
Ground (earth)	169.4	196.6	100.6	21.0	4.2	5.2	5.2	**575.3**
Total Site Area (in m2)	765.5	2609.7	2900.6	1454.1	302.9	64.3	78.8	8830.8

Table 12. Rainwater Harvested calculation

AFFORDABILITY

Project Summary							
Projec Project Information							
Team:	Sunergon						
Division:	Educational Building			Land Cost:	150	Million INR	
	Site Area (sqm)	25,734		City:	Nuh		
	Built-up Area (BUA) (sqm)	20,407		State:	Haryana		
	Ground Coverage (Plinth Area) (sc	7,025					

Project Summary

S.No.	Particulars	Definition	Baseline Estimate (Project Partner / SOR basis)			Proposed Design Estimate		
			Amount in Million INR	%	Amount (INR per sqm)	Amount in Million INR	%	Amount (INR per sqm)
1	Land	Cost of land purchased or leased	150.00	17.9%	7,350	150.00	17.9%	7,350
2	Civil Works	Refer Item A, Civil works in Cost	249.98	29.8%	12,250	228.58	27.3%	11,201
3	Internal Works	Refer Item B, Civil works in Cost	182.91	21.8%	8,963	167.39	20.0%	8,202
4	MEP Services	Refer Item C, Civil works in Cost	180.42	21.5%	8,841	114.47	13.7%	5,610
5	Equipment & Furnishing	Refer Item D, Civil works in Cost	0.06	0.0%	3	0.06	0.0%	3
6	Landscape & Site Development	Refer Item E, Civil works in Cost	19.07	2.3%	935	19.08	2.3%	935
7	Contingency	Amount added to the total estimate for incidental and miscellaneous expenses.	31.62	5.0%	1,550	26.48	5.0%	1,298
	TOTAL HARD COST		**814.07**	**98.4%**	**39,892**	**706.06**	**86.1%**	**34,599**
8	Pre Operative Expenses	Cost of Permits, Licenses, Marke	10.00	1.2%	490	10.00	1.2%	490
9	Consultants	Consultant fees on a typical Proje	10.00	1.2%	490	10.00	1.2%	490
10	Interest During Construction	Interest paid on loans related to t	3.75	0.4%	184	2.21	0.3%	108
	TOTAL SOFT COST		**23.75**	**2.8%**	**1,164**	**22.21**	**2.7%**	**1,088**
	TOTAL PROJECT COST		**837.82**	**100.0%**	**41,055**	**728.27**	**86.9%**	**35,687**

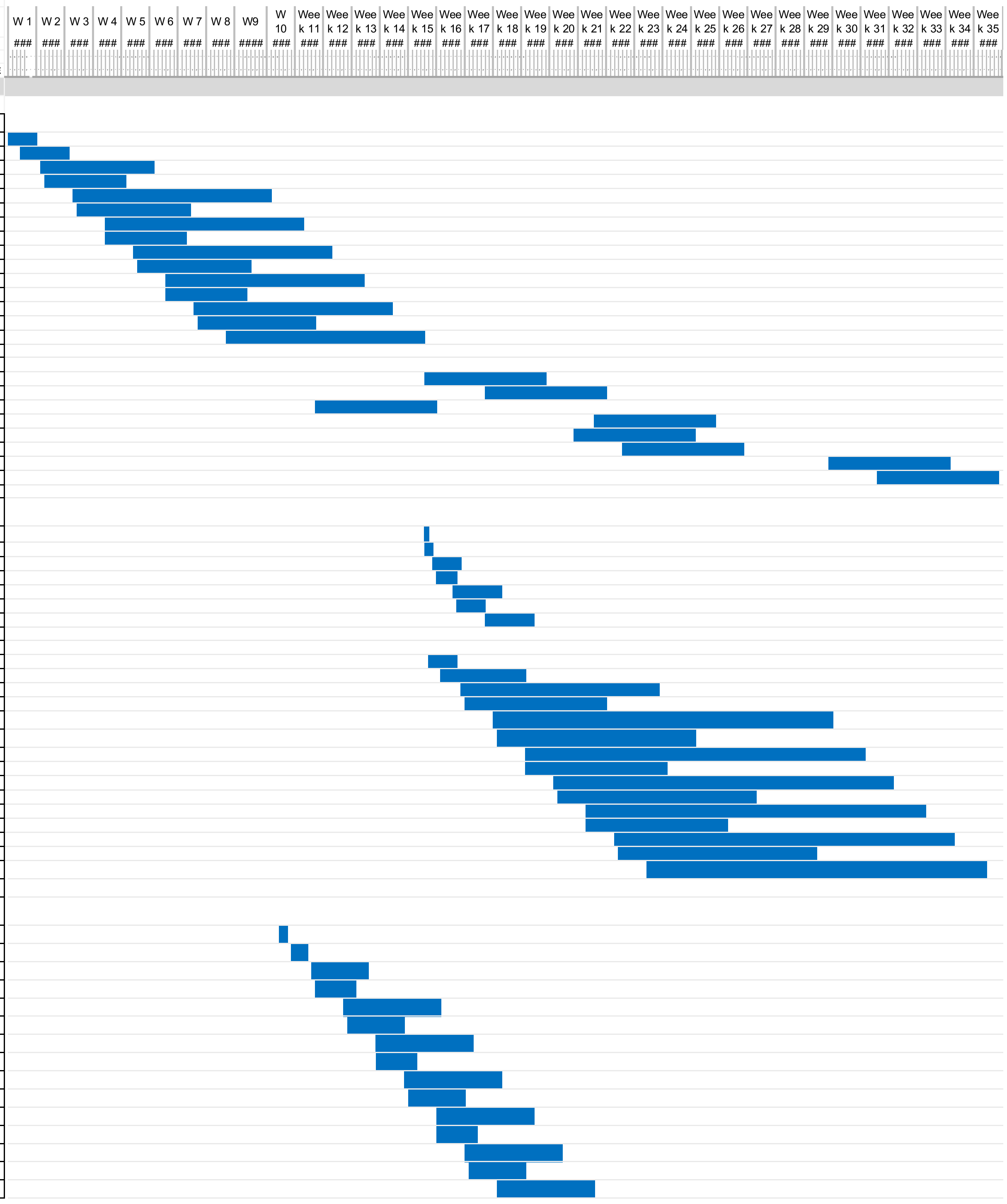
Table 13. Cost estimation summary

INNOVATION

Spring Hills International

	Project Start Date	Monday, 5 June 2023		Display Week	1
	Proejct End Date	Saturday, 3 February 2024		Total work days	243

WBS	TASK	START	END	DAYS	% DONE
1	**EAST WING CONSTRUCTION**				
	Excavation	Mon 5/Jun/23	Sun 11/Jun/23	7	0%
	Foundation	Thu 8/Jun/23	Mon 19/Jun/23	12	0%
	Plinth beam	Tue 13/Jun/23	Mon 10/Jul/23	28	0%
	Stone composite column	Wed 14/Jun/23	Mon 3/Jul/23	20	0%
	Rammed earth wall	Wed 21/Jun/23	Mon 7/Aug/23	48	0%
	Ring beam	Thu 22/Jun/23	Wed 19/Jul/23	28	0%
	Roof	Thu 29/Jun/23	Tue 15/Aug/23	48	0%
	1st floor column	Thu 29/Jun/23	Tue 18/Jul/23	20	0%
	1st floor Rammed earth wall	Thu 6/Jul/23	Tue 22/Aug/23	48	0%
	1st floor Ring beam	Fri 7/Jul/23	Thu 3/Aug/23	28	0%
	1st floor Roof	Fri 14/Jul/23	Wed 30/Aug/23	48	0%
	2nd floor column	Fri 14/Jul/23	Wed 2/Aug/23	20	0%
	2nd floor Rammed earth wall	Fri 21/Jul/23	Wed 6/Sep/23	48	0%
	2nd floor Ring beam	Sat 22/Jul/23	Fri 18/Aug/23	28	0%
	2nd floor Roof	Sat 29/Jul/23	Thu 14/Sep/23	48	0%
2	**BRIDGE CONSTRUCTION**				
	Ramp1	Fri 15/Sep/23	Sat 14/Oct/23	30	0%
	Ramp 2	Sat 30/Sep/23	Sun 29/Oct/23	30	0%
	Ramp 3	Sat 19/Aug/23	Sun 17/Sep/23	30	0%
	Ramp 4	Fri 27/Oct/23	Sat 25/Nov/23	30	0%
	Ramp 5	Sun 22/Oct/23	Mon 20/Nov/23	30	0%
	Ramp 6	Fri 3/Nov/23	Sat 2/Dec/23	30	0%
	Ramp 7	Sun 24/Dec/23	Mon 22/Jan/24	30	0%
	Ramp 8	Fri 5/Jan/24	Sat 3/Feb/24	30	0%
3	**MULTI PURPOSE HALL CONSTRUCTION**				
	Excavation	Fri 15/Sep/23	Fri 15/Sep/23	1	0%
	Foundation	Fri 15/Sep/23	Sat 16/Sep/23	2	0%
	Plinth beam	Sun 17/Sep/23	Sat 23/Sep/23	7	0%
	Stone composite column	Mon 18/Sep/23	Fri 22/Sep/23	5	0%
	Rammed earth wall	Fri 22/Sep/23	Tue 3/Oct/23	12	0%
	Ring beam	Sat 23/Sep/23	Fri 29/Sep/23	7	0%
	Roof	Sat 30/Sep/23	Wed 11/Oct/23	12	0%
4	**WEST WING CONSTRUCTION**				
	Excavation	Sat 16/Sep/23	Fri 22/Sep/23	7	0%
	Foundation	Tue 19/Sep/23	Mon 9/Oct/23	21	0%
	Plinth beam	Sun 24/Sep/23	Sat 11/Nov/23	49	0%
	Stone composite column	Mon 25/Sep/23	Sun 29/Oct/23	35	0%
	Rammed earth wall	Mon 2/Oct/23	Sun 24/Dec/23	84	0%
	Ring beam	Tue 3/Oct/23	Mon 20/Nov/23	49	0%
	Roof	Tue 10/Oct/23	Mon 1/Jan/24	84	0%
	1st floor column	Tue 10/Oct/23	Mon 13/Nov/23	35	0%
	1st floor Rammed earth wall	Tue 17/Oct/23	Mon 8/Jan/24	84	0%
	1st floor Ring beam	Wed 18/Oct/23	Tue 5/Dec/23	49	0%
	1st floor Roof	Wed 25/Oct/23	Tue 16/Jan/24	84	0%
	2nd floor column	Wed 25/Oct/23	Tue 28/Nov/23	35	0%
	2nd floor Rammed earth wall	Wed 1/Nov/23	Tue 23/Jan/24	84	0%
	2nd floor Ring beam	Thu 2/Nov/23	Wed 20/Dec/23	49	0%
	2nd floor Roof	Thu 9/Nov/23	Wed 31/Jan/24	84	0%
5	**CENTRAL BLOCK CONSTRUCTION**				
	Excavation	Thu 10/Aug/23	Fri 11/Aug/23	2	0%
	Foundation	Sun 13/Aug/23	Wed 16/Aug/23	4	0%
	Plinth beam	Fri 18/Aug/23	Thu 31/Aug/23	14	0%
	Stone composite column	Sat 19/Aug/23	Mon 28/Aug/23	10	0%
	Rammed earth wall	Sat 26/Aug/23	Mon 18/Sep/23	24	0%
	Ring beam	Sun 27/Aug/23	Sat 9/Sep/23	14	0%
	Roof	Sun 3/Sep/23	Tue 26/Sep/23	24	0%
	1st floor column	Sun 3/Sep/23	Tue 12/Sep/23	10	0%
	1st floor Rammed earth wall	Sun 10/Sep/23	Tue 3/Oct/23	24	0%
	1st floor Ring beam	Mon 11/Sep/23	Sun 24/Sep/23	14	0%
	1st floor Roof	Mon 18/Sep/23	Wed 11/Oct/23	24	0%
	2nd floor column	Mon 18/Sep/23	Wed 27/Sep/23	10	0%
	2nd floor Rammed earth wall	Mon 25/Sep/23	Wed 18/Oct/23	24	0%
	2nd floor Ring beam	Tue 26/Sep/23	Mon 9/Oct/23	14	0%
	2nd floor Roof	Tue 3/Oct/23	Thu 26/Oct/23	24	0%



Since the conventional earth ramming method uses longer duration for the completion of project, the cost of labor is more in this case. Also, in our project, the materials are procured locally from the site and hence the cost of procurement of raw materials is minimal

Cost estimation for 1 Wall panel of 64sq.ft.area

Cost estimation	Material	Labour	Framework*	Rammer*	Total Cost
Conventional Method	7020	34000	77	1.9	41098.9
Our method	7020	13600	57.8	154.1	20831.9

Time taken to build a wall panel of size 64 sq.ft.

Time taken to build 1 wall panel	Shuttering and preparation	Material making	Ramming	Other works
Conventional Method	0.04	0.03	5	1.93
Our Method	0.04	0.08	0.3	1.08

Time taken to construct the entire walls of the building

CONSTRUCTION OF WALLS	Conventional Ramming	Pneumatic rammer
Total wall area	166155.50	166155.50
Area of 1 wall panel (in sq.ft.)	64	64
No. of wall panels required	2596.18	2596.18
Days taken to make 1 wall panel	7	1.5
Days taken to make entire panels	18173.26	3894.27
Total Days taken if 10 panels are worked on simultaneously	1817.33	389.43
Total time taken in years	4.98	1.07

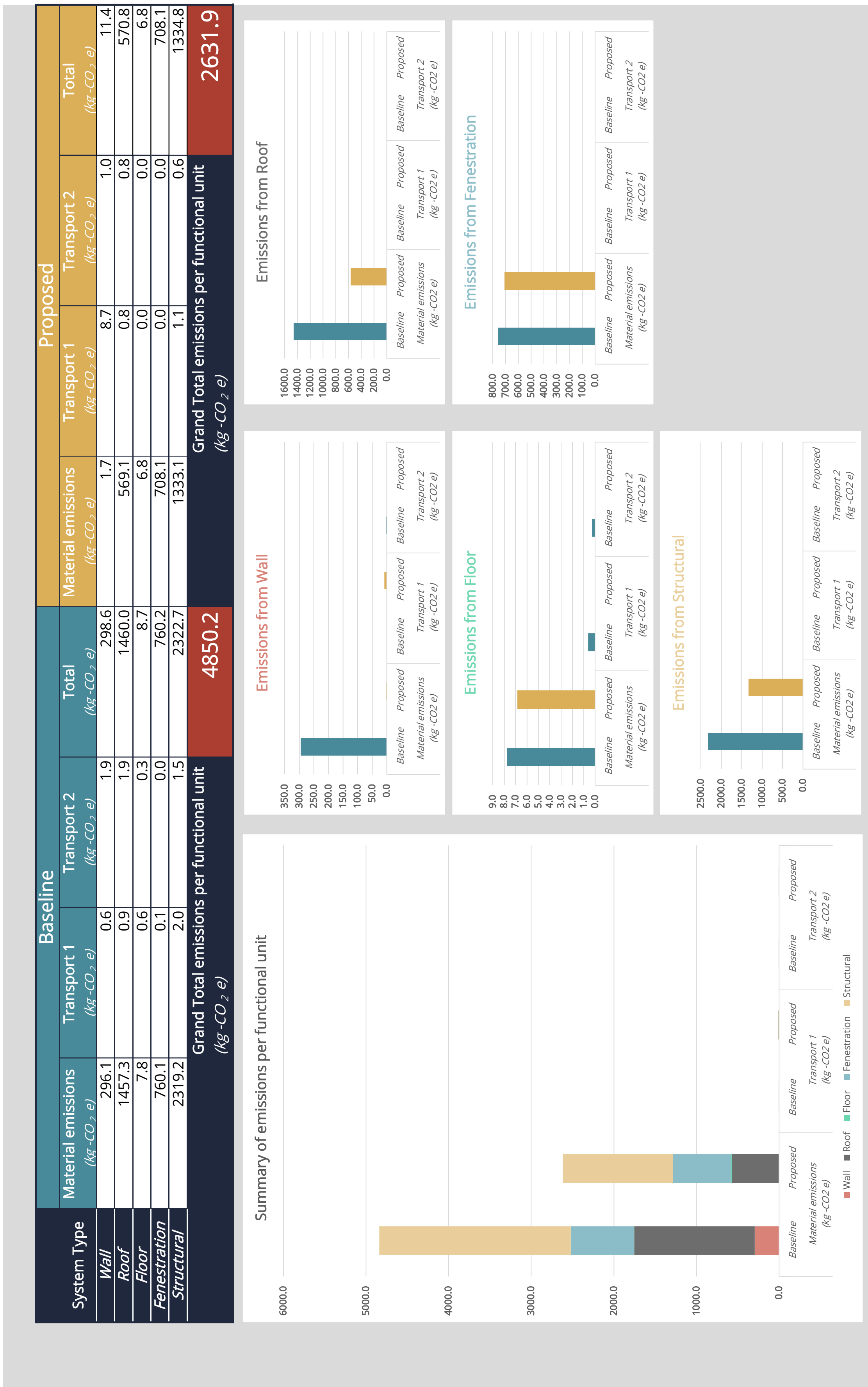
Compressive strength of the materials used

STRENGTH COMPARISON	Manual ramming	Clay Brick	Pneumatic Rammer
Compressive strength	7	11.2	12

Energy consumption of different materials

ENERGY VALUE	Clay Brick	Rammed earth
Global warming potential (kg COe)	0.57	-0.0084

EMBODIED CARBON



System Type	Baseline Material emissions (kg -CO₂ e)	Baseline Transport 1 (kg -CO₂ e)	Baseline Transport 2 (kg -CO₂ e)	Baseline Total (kg -CO₂ e)	Proposed Material emissions (kg -CO₂ e)	Proposed Transport 1 (kg -CO₂ e)	Proposed Transport 2 (kg -CO₂ e)	Proposed Total (kg -CO₂ e)
Wall	296.1	0.6	1.9	298.6	1.7	8.7	1.0	11.4
Roof	1457.3	0.9	1.9	1460.0	569.1	0.8	0.8	570.8
Floor	7.8	0.6	0.3	8.7	6.8	0.0	0.0	6.8
Fenestration	760.1	0.1	0.0	760.2	708.1	0.0	0.0	708.1
Structural	2319.2	2.0	1.5	2322.7	1333.1	1.1	0.6	1334.8
Grand Total emissions per functional unit (kg -CO₂ e)				4850.2				2631.9

fig.31. Embodied Carbon tool summary

fig.33. Abundance of quartzite on site

RESILIENCE

Key Parameters for earthquake resilience

Seismic and Structural Analysis - Resisting disasters brought by earthquakes

Locations within the built structure that are especially susceptible to failure upon immediate contact with ground motions/seismic vibrations define the building's Critical Zones. IS 1893 recommends the L/T section of the building as its critical zone, and the identification of one such zone is simulated below, existing on the eastern side of the campus. Given the large scale of Springhills International School, as well as its existing re-entrant corners and asymmetries, seven critical zones have been identified and studied for seismic analysis, ensuring the building's stability in relatively safer zones.

The structure was evaluated for the dynamic method by Response-Spectrum method. The results obtained are on STAAD Pro V8 and are as enlisted below:-

Stress Diagram

A stress combination is shown in two complementary axes. The variation of the stresses in the structure are within the allowable permissible limits of the materials used. The combination induces compressive stresses by majority which is quite safe for the design.

The design loads lie within the safe range with a maximum of 3 Km/m2.

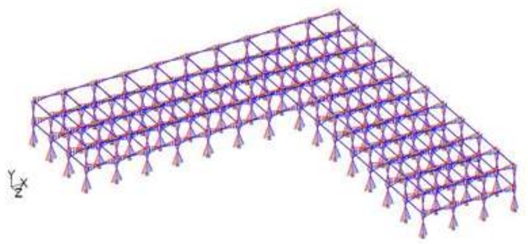


fig.32. Stress Diagram

MODE	PERIOD	FX
1	0.0404	23.99
2	0.396	945.90
3	0.374	98.87
4	0.340	23.99

Table 14. Structural dynamic properties(modes and frequencies)

Bending moment Diagram

The structural frame is subjected to the loads provides adequate moment of resistance. The moments produced provide the suitable restoring action in the structure for its stability. The beam dimensions provided are 300 mm*500 mm which makes it suitable for shear resistance. The overall design shear comes out to be less than 60% and hence nominal shear reinforcement is provided with adequate application of shear stirrups with 135-degree hook, which increases the seismic stability and compression failure of the beam column

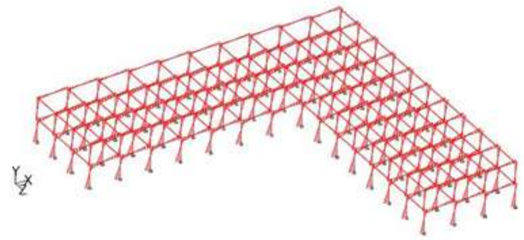


fig.34. Bending Moment Diagram

Total SSRS Shear	3147.54
Total ABS Shear	4113.62

Table 15. Shear Analysis

Axial Shear Diagram

Deflection: As per IS 456:2000 the maximum slenderness ration for a simply supported beam should not be greater than 22 and the maximum deflection produced by combined dead load, imposed load and earthquake loads neglecting the stress reversal is given by span/350 which comes out to be equal to 3000/350 = 8.57 mm (approx.)

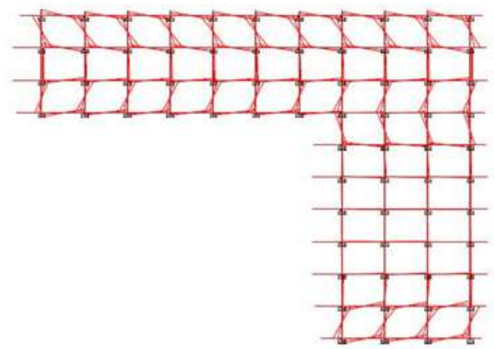


fig.35. Axial Shear Diagram

Loading	0.32276
SA/G (as per IS 1893)	2.500
Load factor	1.000
Factor V (as per IS 1893)	0.900 X 15655.53
VB MIN (based on Clause 7.2.2)	250.49

Table 16. Codal Values for X

This is significantly greater than the maximum deflection during the worst phase of action.

Axis	CRITICAL NODES (cm/Radians)
X	205
Y	241
Z	200

Table 17. Maximum Displacement

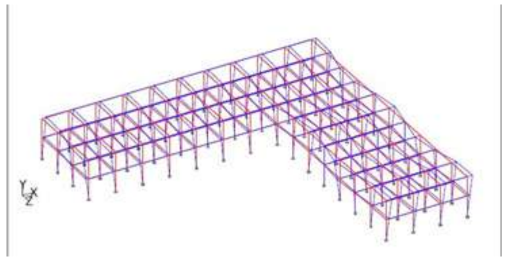


fig.36.   Displacement at X axis

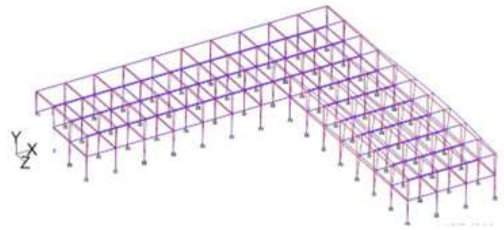


fig.37.   Displacement at Y axis

Using CSEB for columns ensures optimal structural stability. A seismic study in Nepal, one of the most seismically active regions in the world, says that reinforced CSEB displays a very low absolute displacement of less than 0.024% (0.83 mm) even under structural and wind loads (Thuden and Toivonen, 2018). The composite is extremely ductile, possessing a high energy dissipation capacity, and can center itself upon the application of trauma. (Thuden and Toivonen, 2018)

Water resilience

i) Rainwater Harvesting Efficiency

The rainwater harvesting collection infrastructure has been devised to accommodate an additional capacity beyond the customary 50 kL/d, to efficiently manage up to 150-200 kL/d.

RAIN WATER HARVESTING SITE (Pathways, Green Area, Roads, Hardscapes)												
Location of drain		Length in M	Area covered in sq.M	Area in Hec.			run-off in LPS		Design			
Drain from	Drain to			Self	Add.	Total	per hectare	total run-off	Slope 1 in	Drain Size DIA (M)	Velocity in m/s	Discharge in lps
S1	S2	30.00	469.20	0.05	0	0.047	125.0	5.9	100	0.15	0.85	100.50
S2	S3	29.90	543.10	0.05	0.05	0.101	125.0	12.7	150	0.10	0.53	41.69
S3	S4	39.90	530.10	0.05	0.10	0.154	125.0	19.3	150	0.10	0.53	41.69
S4	S5	32.70	413.20	0.04	0.15	0.196	125.0	24.4	150	0.10	0.53	41.69
S5	S6	30.00	560.90	0.06	0.20	0.252	125.0	31.5	150	0.10	0.53	41.69
S6	S7	30.00	468.50	0.05	0.25	0.299	125.0	37.3	150	0.15	0.70	82.06
S7	S8	12.30	430.90	0.04	0.30	0.342	125.0	42.7	150	0.15	0.70	82.06
S8	S9	30.00	462.40	0.05	0.34	0.388	125.0	48.5	200	0.25	0.85	166.78
S9	S10	30.00	557.90	0.06	0.39	0.444	125.0	55.5	150	0.30	1.11	261.12
S10	S11	30.00	570.70	0.06	0.44	0.501	125.0	62.6	150	0.30	1.11	261.12
S11	S12	16.60	694.10	0.07	0.50	0.570	125.0	71.3	150	0.30	1.11	261.12
S12	S13	22.30	544.10	0.05	0.57	0.625	125.0	78.1	450	0.40	0.78	243.74
S13	S14	21.30	523.50	0.05	0.62	0.677	125.0	84.6	450	0.40	0.78	243.74
S14	S15	24.50	473.80	0.05	0.68	0.724	125.0	90.5	450	0.40	0.78	243.74
S15	S16	23.30	458.80	0.05	0.72	0.770	125.0	96.3	450	0.40	0.78	243.74
S16	S17	30.00	805.10	0.08	0.77	0.851	125.0	106.3	450	0.40	0.78	243.74
S17	S18	30.10	675.60	0.07	0.85	0.918	125.0	114.8	450	0.40	0.78	243.74
S18	S19	27.50	571.00	0.06	0.92	0.975	125.0	121.9	450	0.40	0.78	243.74
S19	S20	30.00	481.70	0.05	0.98	1.023	125.0	127.9	450	0.40	0.78	243.74
S20	S21	28.40	560.90	0.06	1.02	1.080	125.0	134.9	450	0.40	0.78	243.74
S21	S22	39.60	414.00	0.04	1.08	1.121	125.0	140.1	450	0.40	0.78	243.74
S22	S23	16.50	402.70	0.04	1.12	1.161	125.0	145.2	450	0.40	0.78	243.74
S23	S24	19.10	329.00	0.03	1.16	1.194	125.0	149.3	450	0.40	0.78	243.74
S24	S25	35.50	462.00	0.05	1.19	1.240	125.0	155.0	450	0.40	0.78	243.74
S25	S26	30.00	506.60	0.05	1.24	1.291	125.0	161.4	450	0.40	0.78	243.74
S26	S27	30.00	616.00	0.06	1.29	1.353	125.0	169.1	450	0.40	0.78	243.74
S27	S28	30.00	679.40	0.07	1.35	1.421	125.0	177.6	450	0.40	0.78	243.74
S28	S29	30.00	647.20	0.06	1.42	1.485	125.0	185.7	450	0.40	0.78	243.74
S29	S30	22.90	519.60	0.05	1.49	1.537	125.0	192.2	450	0.40	0.78	243.74
S30	S31	30.00	454.80	0.05	1.54	1.583	125.0	197.8	450	0.40	0.78	243.74
S31	S32	30.00	567.20	0.06	1.58	1.639	125.0	204.9	450	0.40	0.78	243.74
S32	S33	26.80	630.20	0.06	1.64	1.702	125.0	212.8	450	0.40	0.78	243.74
S33	S34	26.80	530.20	0.05	1.70	1.755	125.0	219.4	450	0.40	0.78	243.74
S34	S35	26.80	670.20	0.07	1.76	1.822	125.0	227.8	450	0.40	0.78	243.74

Table 18.   Site harvesting potential

ii) Rainwater Harvest Pits and Microinjection Wells

To ensure that water seeps into deeper layers, micro-Injection wells facilitate the injection of water to bottom layers. This creates a closed loop system of recharge and consumption. This program, designed for a capacity of 15 cubic meters, has 9 to 10 pits directly to collect rainwater. Each tip has a retention time of 15 minutes, after which any remaining water is absorbed back into minutes, after which any remaining water is absorbed back into the top layer of the soil. To ensure water seeps into deeper layers, micro-injection wells facilitate the injection of water to bottom layers. The depth of each microinjection well is 5m.

RWH Pit drawing

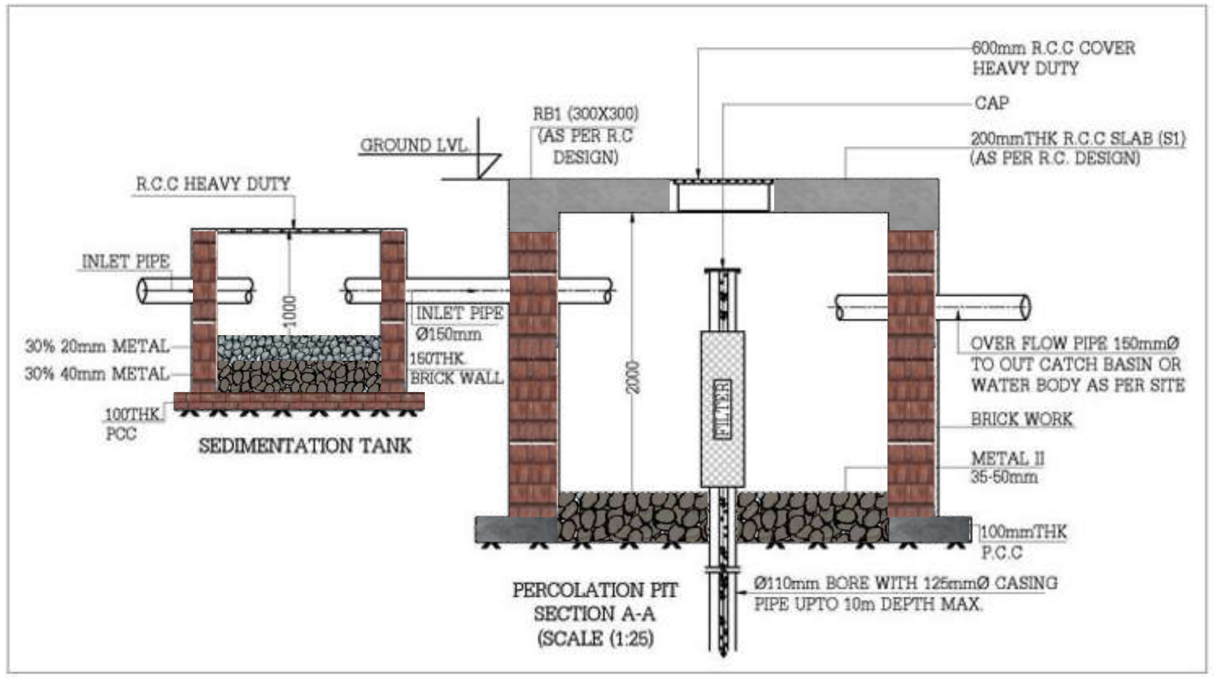


fig.38.   Rainwater Collection and underground recharge through Microinjection Wells

ii) Integrated wetland technology

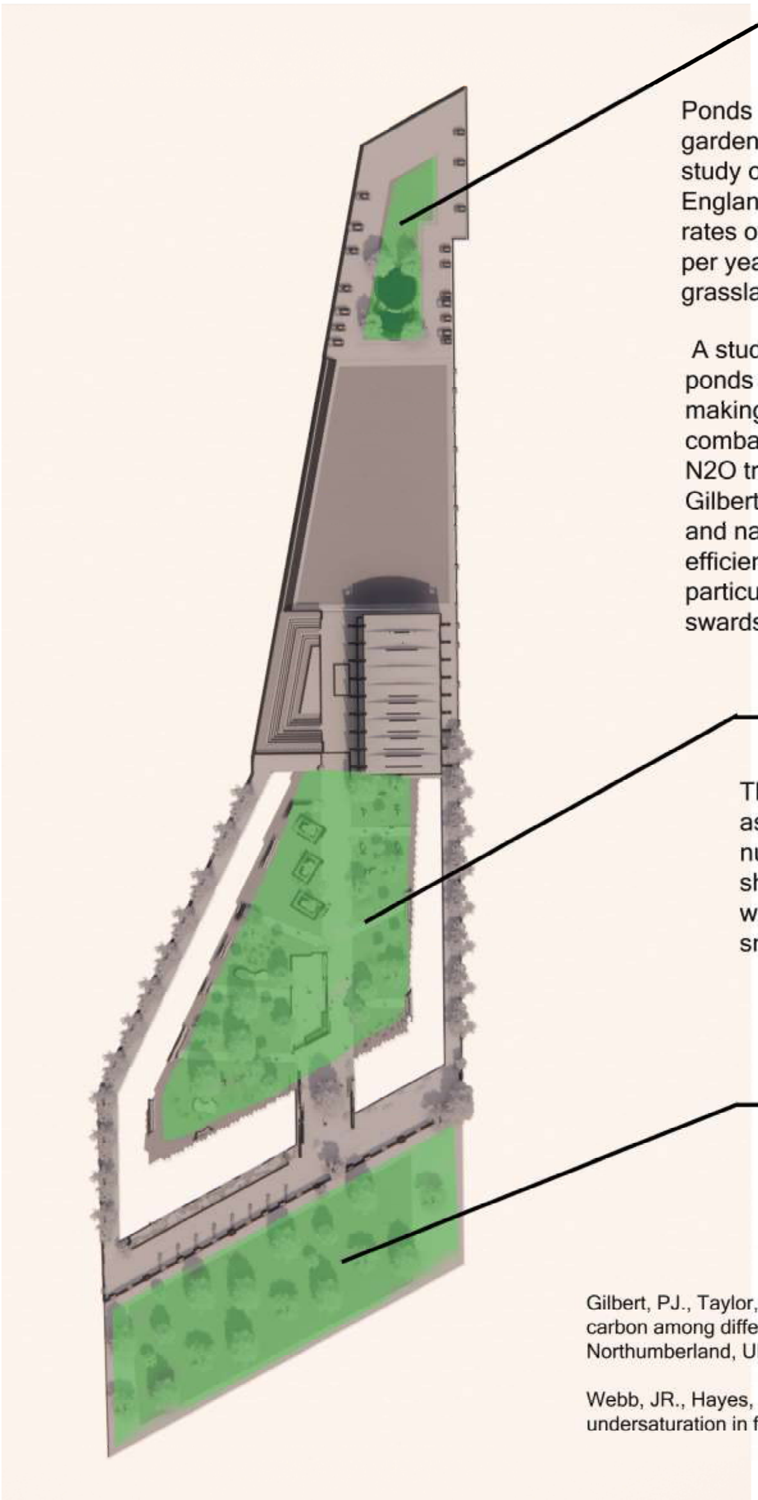
Capacity of STP - 35.0 KLD

Treatment efficiency of the system in terms of pollutants removal is extremely important to ensure the overall health and wellbeing of inhabitants.

PARAMETERS	% REMOVAL
Total suspended solids	80-98
Biochemical oxygen demand	80-97
Chemical oxygen demand	85-95
Total Nitrogen	60-75
Phosphorus	70-90

Table 19.   STP treatment potential

CARBON SINK



POND

Ponds may also play an important role in gardens' fight against climate change. One study of small, lowland ponds in north-east England found that they stored much higher rates of carbon (79 to 247g) per square metre per year) compared to surrounding woodland or grassland (2-5g).

A study has found that two thirds of farm ponds act as N2O sinks (Webb et al., 2019), making them an important contributor to combating climate change, particularly as N2O traps heat at 300x the rate of CO2. Gilbert et al., (2014) found that permanently and naturally vegetated ponds were the most efficient at sequestering carbon dioxide, particularly those dominated by thick moss swards and aquatic grasses.

COURTYARD

The courtyard and greenbelt also act as carbon sinks because of the diverse number of species planted. Trees and shrubs absorb more carbon dioxide with their trunks and branches than smaller plants.

GREEN BELT

Gilbert, PJ., Taylor, S., Cooke, DA., et al. (2014) Variations in sediment organic carbon among different types of small natural ponds along Druridge Bay, Northumberland, UK. Inland Waters. 4(1), 57-64.

Webb, JR., Hayes, NM., Simpson, GL. et al. (2019) Widespread nitrous oxide undersaturation in farm waterbodies creates an unexpected greenhouse gas sink.

fig.39. Carbon Sink

HEALTH AND WELLBEING

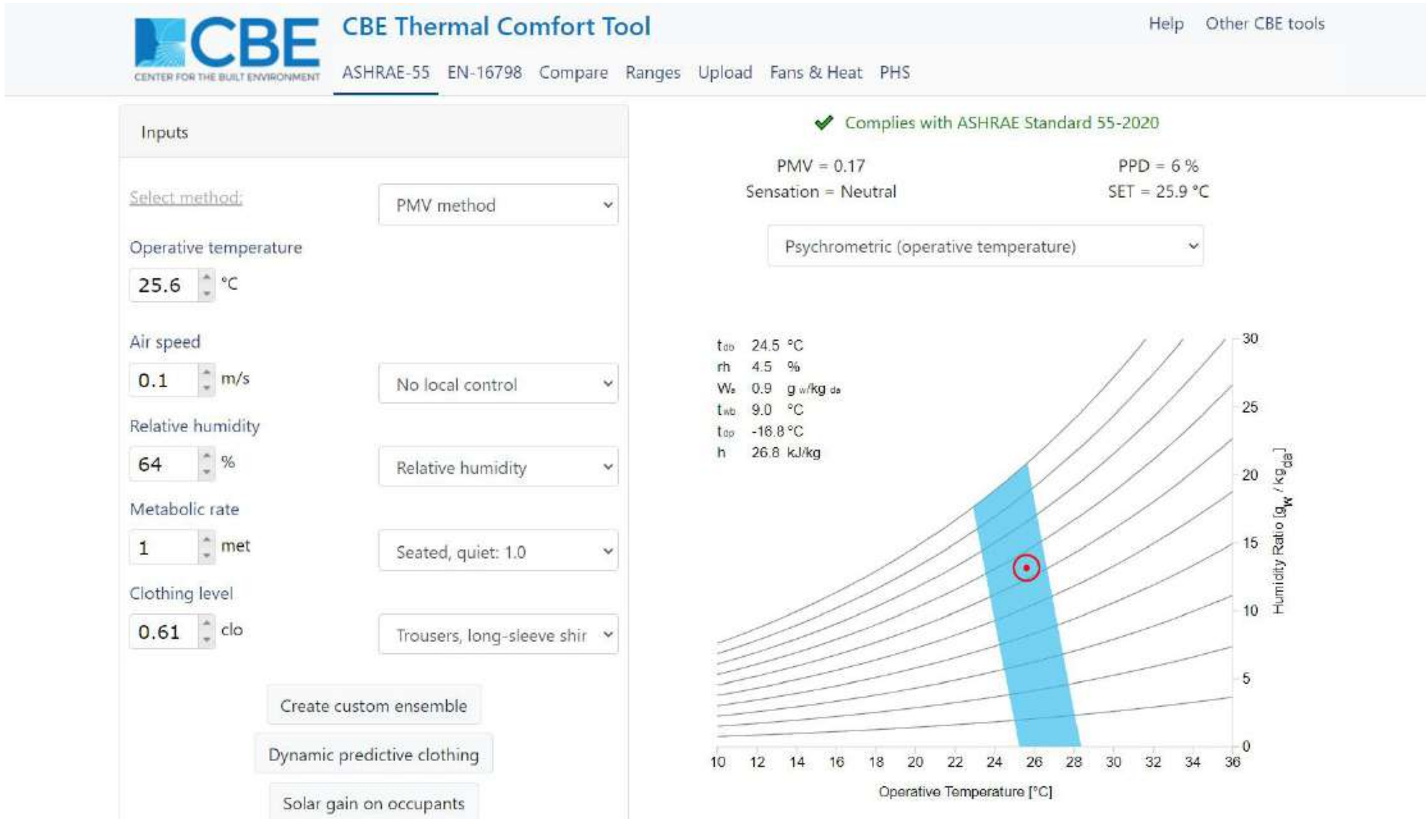


fig.40. Psychrometric chart for a typical classrooms

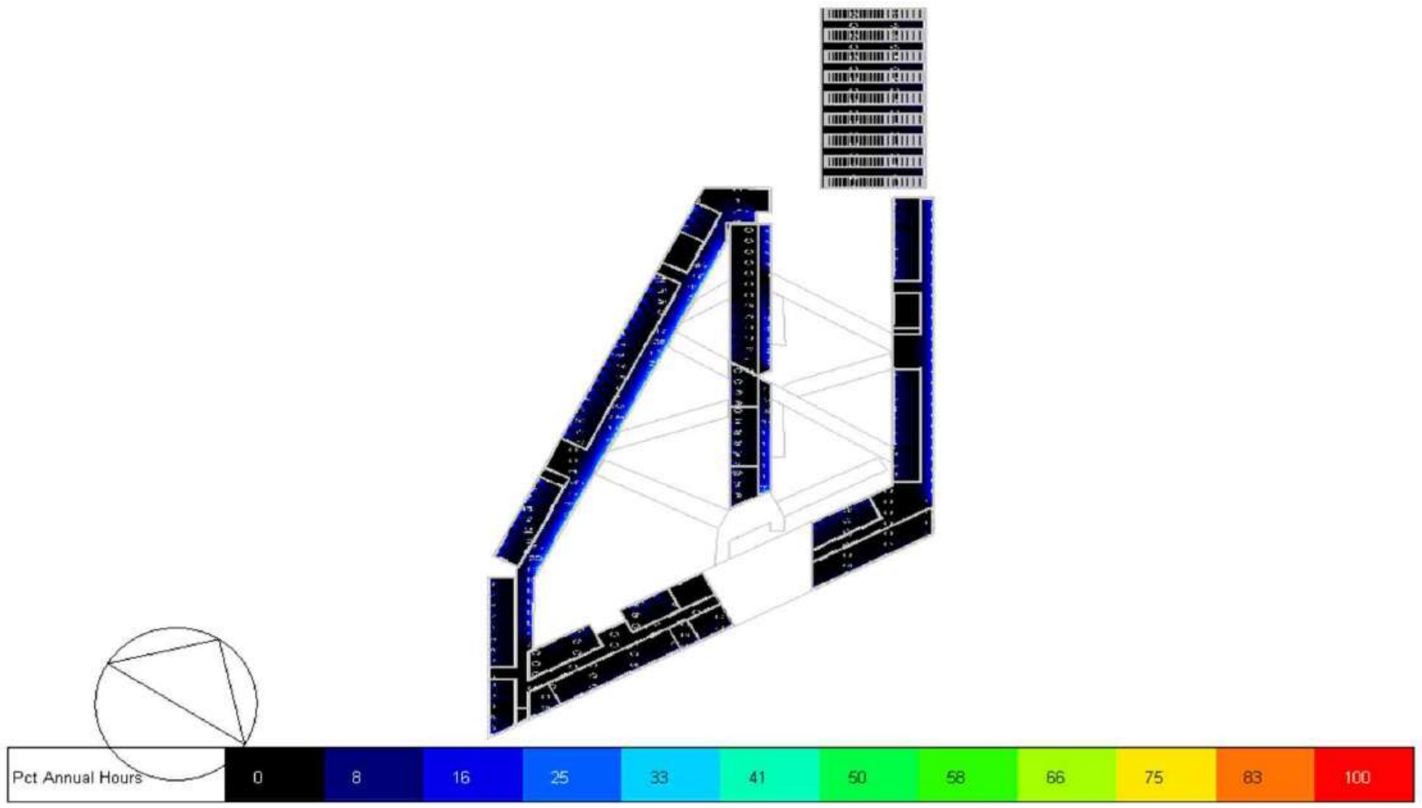


fig.41. Annual Sunlight Exposre Analysis - Overall site

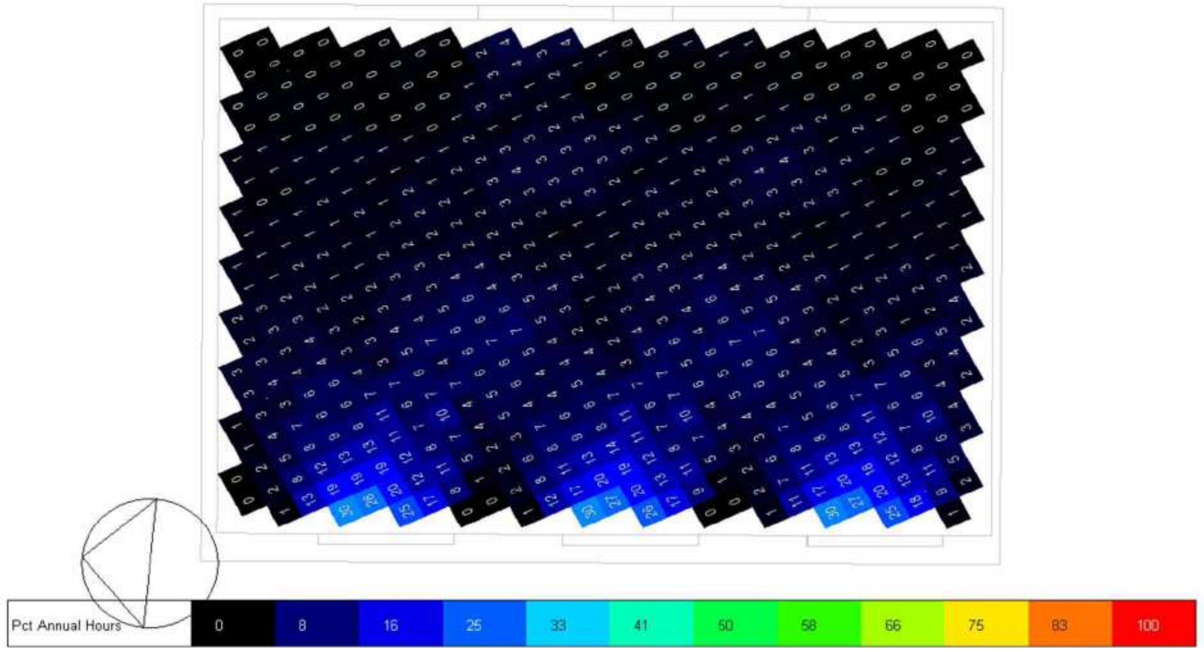


fig.42. Annual Sunlight Exposre Analysis - Classroom

Zone Sensible Cooling

	Calculated Design Load [W]	User Design Load [W]	User Design Load per Area [W/m2]	Calculated Design Air Flow [m3/s]	User Design Air Flow [m3/s]	Design Day Name	Date/Time Of Peak {TIMESTAMP}	Thermostat Setpoint Temperature at Peak Load [C]	Indoor Temperature at Peak Load [C]	Indoor Humidity Ratio at Peak Load [kgWater/kgDryAir]	Outdoor Temperature at Peak Load [C]	Outdoor Humidity Ratio at Peak Load [kgWater/kgDryAir]	Minimum Outdoor Air Flow Rate [m3/s]	Heat Gain Rate from DOAS [W]
GFL:CLASS2	3932.38	4522.23	13.81	0.274	1.237	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01931	41	0.01517	1.237	0
GFL:CLASS1	1927.71	2216.87	14.14	0.134	0.592	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.0192	41	0.01517	0.592	0
GFL:HC1	2364.52	2719.2	21.15	0.165	0.485	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.98	0.016	41	0.01517	0.485	0
GFL:CLASS8	1679.41	1931.32	12.62	0.117	0.578	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01967	41	0.01517	0.578	0
GFL:CLASS4	945.1	1086.87	13.06	0.066	0.314	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01958	41	0.01517	0.314	0
GFL:STAFF2	138.85	159.67	5.16	0.01	0.117	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 13:00	zzzzzzzzzzzzz	25.92	0.02129	40.55	0.01517	0.117	0
GFL:CLASS6	671.87	772.65	11.38	0.047	0.256	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.0201	41	0.01517	0.256	0
GFL:CLASS7	1204.67	1385.37	15.82	0.084	0.331	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01825	41	0.01517	0.331	0
GFL:STAFF1	578.36	665.12	15.96	0.04	0.157	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01757	41	0.01517	0.157	0
GFL:CLASS5	2102.3	2417.65	11.77	0.146	0.776	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01994	41	0.01517	0.776	0
GFL:CLASS3	1357.91	1561.59	13.44	0.094	0.439	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01938	41	0.01517	0.439	0
GFR:ADMIN2	1562.36	1796.71	13.87	0.109	0.489	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01882	41	0.01517	0.489	0
GFR:ADMIN1	611.69	703.45	12.79	0.043	0.208	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01929	41	0.01517	0.208	0
GFR:ADMIN3	1590.1	1828.62	16.72	0.111	0.413	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01797	41	0.01517	0.413	0
GFR:SUPW1	1828.54	2102.82	15.11	0.127	0.525	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.0185	41	0.01517	0.525	0
FFR:VOCT2	9463.17	10882.65	74.78	0.658	0.757	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01089	41	0.01517	0.549	0
FFR:VOCT1	12955.79	14899.16	73.84	0.901	1.036	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01091	41	0.01517	0.762	0
FFR:LAB3	6060.95	6970.1	64.11	0.422	0.485	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01119	41	0.01517	0.411	0
FFR:LAB5	3369.26	3874.65	59.74	0.234	0.269	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 09:00	26	25.99	0.01123	36.1	0.01516	0.245	0
FFR:STAFF5	1721.43	1979.64	50.77	0.12	0.147	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01171	41	0.01517	0.147	0
FFR:LAB4	5904.41	6790.07	69.77	0.411	0.472	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 10:00	26	25.99	0.01104	37.62	0.01516	0.367	0
SFR:CLASS23	7274.19	8365.32	76.78	0.506	0.582	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01084	41	0.01517	0.411	0
SFR:CLASS22	12211.41	14043.12	69	0.849	0.976	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 09:00	26	25.99	0.01097	36.1	0.01516	0.768	0
SFR:CLASS25	9518.84	10946.67	75.64	0.662	0.761	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01087	41	0.01517	0.546	0
SFR:CLASS24	13259.9	15248.89	76.6	0.922	1.061	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01085	41	0.01517	0.752	0
CF:ACT1	4357.02	5010.57	76.3	0.303	0.349	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01086	41	0.01517	0.248	0
CF:ACT2	6757.39	7771	74.17	0.47	0.541	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01091	41	0.01517	0.396	0
CF:ACT3	3852.97	4430.92	70.08	0.268	0.308	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01102	41	0.01517	0.239	0
SFL:CLASS16	7915.6	9102.94	78.05	0.55	0.633	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 10:30	26	25.99	0.01083	38.29	0.01516	0.44	0
SFL:CLASS15	12490.55	14364.13	70.01	0.868	0.999	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 09:30	26	25.99	0.01102	36.86	0.01516	0.775	0
SFL:STAFF8	2386	2743.9	90.98	0.166	0.191	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 09:30	26	25.99	0.01057	36.86	0.01516	0.114	0
SFL:CLASS18	4235.63	4870.97	86.05	0.295	0.339	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 09:30	26	25.99	0.01066	36.86	0.01516	0.214	0
SFL:CLASS17	6026.96	6931	83.22	0.419	0.482	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 10:30	26	25.99	0.01072	38.29	0.01516	0.314	0
SFL:STAFF7	2522.31	2900.66	70.45	0.175	0.202	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.011	41	0.01517	0.155	0
SFL:STAFF6	5139.71	5910.67	68.01	0.357	0.411	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01107	41	0.01517	0.328	0
SFL:CLASS14	10888.25	12521.49	81.73	0.757	0.871	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01074	41	0.01517	0.579	0
SFL:CLASS19	10851.21	12478.89	79.61	0.754	0.867	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUN	05-06-2015 17:30	26	26	0.00907	43.78	0.01107	0.592	0
SFL:CLASS20	21268.2	24458.43	74.58	1.479	1.701	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.0109	41	0.01517	1.238	0
SFL:CLASS21	4723.42	5431.93	98.12	0.328	0.378	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 10:30	26	25.99	0.01047	38.29	0.01516	0.209	0
FFL:COMP2	7148.24	8220.48	128.42	0.497	0.572	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 11:00	26	25.99	0.01013	38.95	0.01517	0.242	0
FFL:CLASS12	3028	3482.2	67.82	0.211	0.242	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 11:00	26	25.99	0.0111	38.95	0.01517	0.194	0
FFL:LAB1	11109.52	12775.94	53.91	0.772	0.895	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) SEP	01-09-2015 09:30	26	25.99	0.0115	33.41	0.01398	0.895	0
FFL:STAFF4	2584.59	2972.28	52.44	0.18	0.214	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) SEP	01-09-2015 09:00	26	26	0.01149	32.54	0.01398	0.214	0
FFL:CLASS13	3766.42	4331.39	79.51	0.262	0.301	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01079	41	0.01517	0.206	0
FFL:CLASS9	18656.33	21454.78	64.77	1.298	1.492	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01117	41	0.01517	1.253	0
FFL:CLASS10	8964.06	10308.67	65.73	0.624	0.717	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01114	41	0.01517	0.592	0
FFL:CLASS11	8908.6	10244.89	66.66	0.62	0.713	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.0111	41	0.01517	0.58	0
FFL:LAB2	4711.01	5417.66	65.05	0.328	0.377	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.01115	41	0.01517	0.314	0
FFL:COMP1	9120.41	10488.47	119.98	0.634	0.73	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 14:00	26	25.99	0.0102	41	0.01517	0.33	0
FFL:STAFF3	2137.07	2457.64	59.56	0.149	0.171	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) SEP	01-09-2015 09:00	26	26	0.01122	32.54	0.01398	0.156	0
CS:LIB1	18207.78	20938.95	82.6	1.266	1.456	SUMMER DESIGN DAY IN ENERGY SIMULATION (01-01:31-12) JUL	01-07-2015 11:00	26	25.99	0.01074	38.95	0.01517	0.957	0

The Design Load is the zone sensible load only. It does not include any system effects or ventilation loads.

Table 20. Heat load calculation

LETTERS OF CONFIRMATION

Orphans in Need

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organization Orphans in Need, has provided information about our proposed school project to the participating team led by Jindal School of Art and Architecture, so that their team Sun Ergon 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,

Name of Representative: Umer Wani

Designation: Facilitation Manager

Email: umer.wani@orphansinneed.in

Phone: +91 6006222690

+91-11 416 77770
info@orphansinneed.in
orphansinneed.in

Orphans in Need | E- 16 Lower Ground Floor
South Extension Part 1 | New Delhi - 110049

India Charity Registration No. 2213/2005-2006

Date

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organisation, Ar. Mainak Das, is collaborating with the participating team led by Jindal School of Art and Architecture on an Educational Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be Earthen Construction Consultancy and Contract.

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,

Mainak Das

Name Mainak Das
Designation Chief Architect
Ar. Mainak das
Email mainakdas2001@gmail.com
Phone 9871251104

Date 23-04-2023

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organisation, Kamath Design Studio, is collaborating with the participating team led by Jindal School of Art and Architecture on Educational Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be architectural research.

We would not be able to 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,

Ayodh Vasant Kamath

Ayodh Vasant Kamath

Principal, Kamath Design Studio

22-02-2023

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organization, METACITY Projects, is collaborating with the participating team led by Jindal School of Architecture on a Educational Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be assisting the participating team in construction details, materiality and affordability of the overall project. We shall be working on ways to reduce the construction costs, using products which requires lesser maintenance and energy usage.

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

With warm regards,

Mudassir Ahmed

Mudassir Ahmed Khan
Director
Metacity Projects LLP
Mudassir@metacity.in
+91- 9990640217

Simulation Specialist – Built Environment

22-02-2023

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organisation, Globa Evolutionary Energy Design, is collaborating with the participating team led by Jindal School of Art and Architecture on an Educational Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be Design assistance.

We would like/ would not be able to 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 / do not want 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,

For Global Evolutionary Energy Design

Proprietor

Smh Adil
Princiapl Consultant
Global Evolutionary Energy Design
adil@geedindia.org
9873588571

Certified Energy Managers (CEM), Board Member, IBPSA (I) INDIA, Email: info@geedindia.org, Web: www.geedindia.org.

Global Evolutionary Energy Design, Consulting Engineers, Scientific & Technical Consultancy, GSTIN No.: 07AHJPA5402C1Z2
D-15, A. F. Enclave, Jamia Nagar, New Delhi, INDIA (PIN) 110025, Office: (Tel) +91 1129948146, (Mob) +91 9873588571

KAYZAN
CREATING HEALTHY SUSTAINABLE ENVIRONMENT

Kayzan Aircon Solutions Pvt. Ltd.

157, Prakash Industrial Estate, Sahibabad, Ghaziabad (U.P.) - 201005, INDIA
Ph : 9811708798/ 9871135795 |Web.: www.kayzanaircon.com

Date: 20/02/2023

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organization, M/s Kayzan Aircon Solutions Pvt. Ltd., is collaborating with the participating team led by Jindal School of Art and Architecture on an Educational Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be DESCRIBE IN A FEW SENTENCES.

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

With warm regards,

Name: Pankaj Rathore
Designation: Director
Name of the Organisation: Kayzan Aircon Solutions Pvt. Ltd.
Email: pankaj@kayzanaircon.com
Phone: +91 98711 35795

Mobile: 9810670782/9643266906 GSTIN: 07AAVPZ0732D1ZE

AQUA EXPLORERS

Eco-Inventory, Tubewell site, Geo-Environmental, Geological and Hydro-Investigations

Date 23-04-2023

To,

The Director,

Solar Decathlon India

Dear Sir,

This is to inform you that our organisation, Aqua explorers, is collaborating with the participating team led by Jindal School of Art and Architecture on Educational Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be water performance calculation.

We would like to 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,

Mariyam Zakiah

Director

Aqua explorers

aquaexplorers@yahoo.com

+91 9810670782

Registered Office:First Floor,Kh NO. 414/237, H.NO.9/2, Abul Fazal Enclave-I, Okhla, New Delhi, 110025

Office: D-149/10, Milli Times St., Abul Fazal Enc., Okhla, Jamia Nagar, New-Delhi-110025; Email id:aquaexplorers@yahoo.com