THE BUILDERS

FINAL DESIGN REPORT

APR . 2021

EDU

04

EXECUTIVE SUMMARY ○ TEAM INTRODUCTION ○ PROJECT BACKGROUND

PERFORMANCE SPECIFICATIONS ○ GOALS ○ DESIGN DOCUMENTATION

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

Solar Decathlon India ™

1 EXECUTIVE SUMMARY

The Builders has members from various disciplinary backgrounds – the built environment, de-sign, and engineering. Different fields of enquiry for our team members include, but are not limited to materials and making, environment and ecology, public health, and sustainable building practices. Our praxis of a connected work ecosystem is that of the team working in an integrated real-time collaborative system, where everyone is either a long-term stakeholder or a temporary one. Everyone builds, with the objective to empower themselves and their surroundings – students at the school, parents of those students, architects, engineers, residents, farmers, the flora, the fauna. Hamara School has educated and empowered a generation since its inception in 2001. Many of those whose lives were changed by the school continue to be associated with the school even today. The school exists within a community. To make it a part of the community, we use (the) building itself as a pedagogic tool and the environment as education. The students, who this school was started for, learn from their environment, and co-build their campus. The method has been to syncronise 'what we have' – Land, Earth, Matter, Humans, Non humans; with 'What our goal is'– to empower, to coexist, and to care, nurture, and nourish. Through solar energy and minimal conditioned spaces, our goals to achieve net-zero energy performance have been successful. Net-zero water consumption and zero dependency on fossil water has also been achieved by using rainwater and passive water treatment systems. Alongside this, we have ensured the multi-purpose nature and cross subsidization of the built infrastructure, while lowering construction costs by incorporating design elements with site sourced materials - rammed earth walls, terracotta blocks, bamboo-mud shelters and shading systems. Ensuring climate-appropriate construction practices has helped promote the health of not just the building but also its inhabitants. The building has also been designed as an aid to rehabilitate people suffering damage in the event of an extreme weather event. We were able to achieve all these goals by synthesizing architectural design and engineering operations prioritizing the well-being of its inhabitants as well as the environment it is embedded in. We believe our method and design has modelled a template which is replicable, has scalability potential and can create habitats of co-existence.

2 TEAM INTRODUCTION

THE BUILDERS
Division: Educational Building

TEAM MEMBERS

Saksham Khetwani *(3rd Year B.Arch.)*
Team Lead, Architectural Design, Innovation, Affordability

Aditi Agrawal *(4th Year B.Arch.)*
Architectural Design, Innovation, Affordability

Rounak Dutta *(3rd Year B.Arch.)*
Architectural Design, Innovation, Water Performance

Aastha Khatri *(4th Year B.Arch.)*
Architectural Design, Innovation, Water Performance

Ishita Mittal *(3rd Year B.Arch.)*
Architectural Design, Innovation, Communication

Maazen Ahmed *(3rd Year B.Arch.)*
Communication, Graphic Design, Report Editor

Vidipt Saroj Kalla *(4th Year B.Arch.)*
Communication, Graphic Design, Video Editor

Varnika Dalmia *(3rd Year B.Arch.)*
Communication, Scalability & Market Potential

Taha Mama *(3rd Year B.Arch.)*
Communication, Scalability & Market Potential, Resilience

Anamika Sarker *(3rd Year B.Arch.)*
Communication, Scalability & Market Potential, Resilience

Dhruv Bajpai *(4th Year B.Tech - Civil.)*
Energy Performance, Engineering & Operations, Health and Well Being

Sobia Rehan *(2nd Year M.Arch.)*
Energy Performance, Engineering & Operations, Health and Well Being

FACULTY LEAD AND FACULTY ADVISOR

Abu Talha Farooqi *(Faculty Lead)*
Assistant Professor & Assistant Dean, 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.

Sourav Banerjea *(Faculty Advisor)*
Assistant Professor, JSAA

Sourav Banerjea is a trained Urban Designer and takes interest in grooming students to participate in design competitions. He is also a strong believer of multi program typologies and sees them as the key to unlocking a sustainable future. Another domain which inspires him as a designer is community participation and deliberation at all stages of decision making - both at building and urban scale.

Samrudha Dixit *(Assistant Professor of Practice)*
Samrudha Dixit is an educator with over seven years of collective experience in design, andragogy, and research. His work ranges from structural design projects with eminent architects and engineers, teaching and research assistantships at premier organisations; now a Lecturer at Jindal School of Art and Architecture.

INDUSTRY PARTNERS

Mudassir Ahmed Khan *(Director)*
Metacity
Mudassir Ahmed Khan is an architect and partner at PMC and turnkey construction firm DEMAC Projects based in New Delhi. He has been involved in design-build projects which range from residential buildings to mixed facility buildings and involve coordination of multiple execution agencies. He has been associated with the government organisation UTTIPEC, DDA, where he worked in projects, related to urban mobility and placemaking. His proclivity lies in understanding the making of all kinds of built forms.

Akshay Goyal *(Principal)*
Architron Group
Akshay is an architect working at the intersection of design innovation, technology, and urban futures. He is the Founder of TronX Venture Studio and Managing Partner at Architron Group. He has previously worked with organizations in the US, UK, and India. His work and research has focused on reimagining the future of the built environment and cities and design innovation for sustainable habitat. Akshay is a visiting professor at SSAA, India and has taught at Harvard University, MIT, Shih Chein University & SPA, Delhi. He is an active design mentor and jury member at forums like Techstars, Microsoft Hack, AAVS amongst other places.

Gaurav Shorey *(Director)*
Psi Energy Pvt. Ltd.
Leading our team with enormous support is Mr. Gaurav Shorey from PSI (Partnerships for Sustainable India) Energy! It is a sustainable habitat and green buildings consultancy based in New Delhi. They provide sustainable habitat design solutions that are rooted in response to local contexts

SMH Adil *(Director)*
GEED Simulation Pvt. Ltd.

Incorporated in 2017, GEED Simulations Private Limited Company is a multi-disciplinary engineering and building design firm that provides building and system assessments and consultancy services. Since its establishment it has helped its customers in planning of the building while giving individuals practical and reasonable conditions. Their expertise lies in mechanical/electrical and fire protection with additional services for CFD Modeling, Building Information Modeling, Lighting Dynamic, Commissioning and Central Plants design.

DESIGN MANAGEMENT PROCESS

The Builders has members from various disciplinary backgrounds- the built environment, design, and engineering. Different fields of enquiry for our team members include, but are not limited to materials and making, environment and ecology, urban and spatial planning, public health, and sustainable building practices.

To develop and consolidate our design, we have split our team into smaller groups to work on the ten contests as set out in the Solar Decathlon competition guide, namely- energy performance, water performance, resilience, affordability, innovation, health and wellbeing, engineering and operations, architectural design, scalability and market potential, communication. The division of the contests between the members of the team has been done keeping in mind not only the disciplinary backgrounds that our team members come from but also their personal leanings and goals. We have found that adopting this approach allows for every individual member to engage with the subject matter at hand to their full potential, under the guidance of our faculty leads and industry partners. Once these are presented to the rest of the team, it is followed by fruitful discussions, with subsequent iterations of the same.

3 PROJECT INTRODUCTION

Project Name
Hamara School, Aligarh

Partner Organization
Society for Human Welfare & Education, Aligarh

BACKGROUND

Hamara School was started in 1997 by a team of young doctors for young children from marginalized backgrounds living in the urban slums doing odd jobs in and around the AMU campus. The team started giving evening tuitions to a small group of children with an aim of settling these children into main stream schools of Aligarh. They registered a society under the name – Society for Human Welfare and Education. Today, this organization runs 4 more schools in different urban-slum areas of Aligarh in collaboration with other foundations. The students once they graduate from Hamara School are placed in good schools, and supported educationally, emotionally, financially throughout their journey of studies as far as post-doctoral studies.

NAME & DESIGNATION OF KEY INDIVIDUALS INVOLVED

Mr. Shah Mohammad Shadab
Manager

Ms. Wajiha Khan
Innovation & Communication Head

Mr. Ahmad Faraz Khan
Consultant

BRIEF DESCRIPTION OF PROJECT

Located in the city of Aligarh in Uttar Pradesh, our project seeks to design and build the first completely functioning campus for the Hamara School. Aligarh has a composite climate, i.e. it displays the characteristics of hot and dry, warm and humid as well as cold climates. Therefore, temperatures can range in the extremes round the year. What becomes important is the intended hours of operation – which doubles up as a school (8 AM – 4 PM) and a counselling-coaching centre (5 PM-8 PM).

The primary intended users of the school are the children and teenagers of the surrounding areas, for whom this school is imagined as a centre for learning and growth. The project aims to enhance creative skills, environmental sensitivity and aspiration among the students by providing an environment in which the transition to a formal education system is smooth. The client is interested in adopting the NIOS (National Institute of Open Schooling) system, along with promoting an unstructured learning environment, i.e. an environment in which we seek to reduce the symbolic distance between the mentor and mentee spatially.

Following the hub and spoke model of education, this campus aims to become the Hub for various other school spread across various neighbourhoods in the city, where at present there at 4. In addition to being a regular school for students from nursery to class X, the campus also seeks to have dedicated spaces for vocational activities, coaching facilities, and community service. Some other factors that we as a design team in consultation with our client would like to employ is involvement of the local community not only in the inhabitation of the school, but also in the design and construction stages of it and turning this into a space for building professional and inter-personal relationships and skills.

S. No	Site & Proposed Built-up Areas	
1	Site Area	2880 sq.m
2	Permissable Ground Coverage	1152 sq.m
3	Actual Ground Coverage	1112 sq.m
4	Derived Landscape Area	1768 sq.m
5	Permissable FAR	1.2
6	Permissable Built-up Area	3456 sq.m

Tab. 0.1- Site and Proposed Built-up Areas | Refer to Annexure for Space Wise Breakdown

Project Summary						
S.No.	Particulars	Definition	Baseline Estimate (Project Partner / SOR basis)		Proposed Design Estimate	
			Amount (Rs Millions)	%	**Amount** (Rs Millions)	%
1	Land	Cost of land purchased or leased by the Project Partner	13.50	15.2%	13.50	15.2%
2	Civil Works	Refer Item A, Civil works in Cost of construction worksheet	30.17	33.9%	20.29	22.8%
3	Internal Works	Refer Item B, Civil works in Cost of construction worksheet	7.51	8.4%	5.65	6.4%
4	MEP Services	Refer Item C, Civil works in Cost of construction worksheet	22.65	25.4%	9.51	10.7%
5	Equipment & Furnishing	Refer Item D, Civil works in Cost of construction worksheet	5.65	6.3%	4.85	5.4%
6	Landscape & Site Development	Refer Item E, Civil works in Cost of construction worksheet	0.78	0.9%	0.47	0.5%
7	Contingency	Amount added to the total estimate for incidental and miscellaneous expenses.	4.24	5.0%	2.94	5.0%
	TOTAL HARD COST		**84.51**	**95.2%**	**57.20**	**65.9%**
8	Pre Operative Expenses	Cost of Permits, Licenses, Market research, Advertising etc	3.20	3.6%	3.20	3.6%
9	Consultants	Consultant fees on a typical Project	1.33	1.5%	1.33	1.5%
10	Interest During Construction	Interest paid on loans related to the project during construction	-	0.0%	-	0.0%
	TOTAL SOFT COST		**4.53**	**5.1%**	**4.53**	**5.1%**
	TOTAL PROJECT COST		**89.04**	**100.0%**	**61.73**	**69.3%**
	Total Project Cost per Sq.m of Built-up Area		**28,722**		**19,914**	

Tab. 0.2 - Construction Budget

4 GOALS AND STRATEGIES

The revealing word of our project is embedded in the name of the school – Hamara School (trans. Our School). 'Hamara' is not a word, but a phenomenon and a reality for us. In other words, it is not only just a way of life, but a 'way of being' for us. That is precisely how we have envisaged the new campus of Hamara School. 'School' on the other hand, means for us – a learning in-progress for us. The praxis of 'shared learning' underlines our praxis as well as goal.

What we have …. Land; earth; matter; humans; non humans;
What our goal is … to empower; to coexist; to care, nurture, and nourish …

We raised the following questions/problems while building the project, and our goals were to find answers to these in the context of our project:

What was the problem we identified:
While we make a building, how can we do away with categorisation and watertight compartmentalisation of people and things?

What we did to address it:
We began thinking of the stakeholders of the school and that of the community as one and the same. This helped us in integrating spaces for local vendors, hawkers, craftsmen to become a part of the school. The boundaries and distinctions eroded. Our school is as much a school as it is a vocational centre as it is a community centre.
Similarly, we looked at materials and systems and fused the economic with ecological by using excavated earth for walls and bricks.

What was the problem we identified:
What are the ways in which we can read the site, resources, people, available to us to build an enterprise together?

What we did to explore/achieve it:
We took a stock of all kinds of resource available to us, and attempted to build together with the matter and people together. The bamboo shelters, fenestration system, terracotta blocks, rammed earth walls, and a host of other initiatives is a result of respecting the local resource and dismantling the people-matter divide.

What was the problem we identified:
How must we learn to question the gap between building and the inhabitants? Between building and dwelling? Isn't the building and its energy, water, ecological impact intensely incumbent upon the question of dwelling, how people live and become part of the built environment?

What we did to explore/achieve it:
Our building is a template that we have provided to the inhabitants. The inhabitants have full control on how they will adapt the building and themselves. Daylight, Ventilation will be modulated by the users as per their need and comfort. The fenestration system is completely flexible – the bamboo fenestration is removable, and the brick jaalis are adjustable for transparency.

These questions and our response strategies represent the intent, method, and relevance of how our team is building Hamara School. The way we dwell is how we will build.

I - ARCHITECTURAL DESIGN

Goal – Building a campus which has the power and ability to transform and a sense of temporality, and facilitates a way of being which is in sync with the environment and ecology around – humans and non-humans.

II - HEALTH & WELLBEING

Goal - Ensuring a combination of Comfort (Thermal, Visual, Occupant control), Health (air, water, natural materials, natural environment, vegetation) and well-being (quality of spaces, diversity of spaces, community interaction)

III - RESILIENCE

Goal – Resilience against disasters and calamities, and building as a shelter during such times.

All the strategies have been discussed in detail in the section on Resilience

IV - ENERGY PERFORMANCE

Goal - Achieving Net-positive Energy Design

Strategy – High thermal mass and insulation, minimal conditioned spaces, low-WWR, shading, direct-indirect evaporative cooling and solar PV for net zero. predominant semi-open spaces, will reduce the need for air conditioning and thus ensure reduction in total energy consumption.

V - WATER PERFORMANCE

Goal - Becoming Net Positive in Water Consumption and zero dependence on Fossil Water.

Strategy – Complete grey and black water recycling through eco STP.

Complete rain water harvesting and utilisation.

Offsetting non-monsoon fresh water demand by recharging the groundwater

VI - ENGINEERING & OPERATIONS

Goal – To achieve Functionality & Integration, Responsibility & Empathy, and Affordability & Resilience in the selection and sizing of engineering services and systems.

Detailed strategies have been discussed in the section on engineering and operations.

VII - INNOVATION

Goal – Innovating materials and systems from the local resource available – site and people.

All the actual Innovative products and technologies have been discussed in detail in the section on Innovation.

VIII - AFFORDABILITY

Goal – Making net zero and ecologically sensitive building affordable; aligning the 'ecological' with the 'economical'.

All the strategies have been discussed in detail in the section on Affordability

VIII - SCALABILITY & MARKET POTENTIAL

Goal - Developing ideas and solutions which address the need of the immanent stakeholders, and also fill market gaps thereby creating newer ways of co-building and collaborations.

Detailed strategies have been discussed in the section on scalability and market potential.

VIII - COMMUNICATION

Goal - Communicating the project and what we are trying to achieve to the local and global audience through physical interaction, physical outreach as well as digital outreach and publication.

5 PERFORMANCE SPECIFICATIONS

A	Climate Zone	Composite
B	Performance Specifications	
i.	Envelope	Wall U-value 1.46 W/m2K Roof U-value 0.9 W/m2K Window to Wall Ratio – 14% + Shading Window specifications: U-Value – 5.6 W/m2K VLT -81% SHGC -0.88
ii.	HVAC	Conditioned Area – Computer Lab + Conference room- Split AC BEE 5 Star rated, COP 4.1 Classrooms, laboratories, Staff Rooms and Multipurpose Hall, etc. - Naturally Ventilated + Direct/Indirect Evaporative Cooling + Ceiling Fans (BLDC 28 W)
iii.	Lighting	Overall LPD – 4.4 W/m2K4 W/m2K 100% LED lights No Lighting Controls Space by Space LPD calculation – Refer to Annexure -ReluxDesktop_Lighting Design Analysis
iv.	Electrical	EPD – 3 W/m2K Ceiling Fans – 28 W BLDC Fans All appliances will be BEE 5 star rated as applicable RE System – 10 kWp Solar PV (Scenario 3) ECBC compliant DG set 30 KVA Transformer 50 KVA UPS 8 kW
v.	Water Systems	Eco STP 6 KLD Rainwater Storage Tank – 25 KL 25 Micro Injection wells for rainwater recharge

Tab. 0.3 - Performance Specifications

6 DESIGN DOCUMENTATION

| I - THE ARCHITECTURE AND DESIGN STORY

FUNDAMENTAL DRIVERS

"Only if we are capable of dwelling, only then can we build."

- Martin Heidegger: Building Dwelling Thinking from Poetry, Language, Thought

BUILDING AS DWELLING: DWELLING AS BUILDING

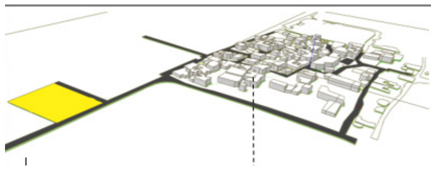
The building for Hamara School has never been understood as a concrete form that has to be constructed for the students to study. The first day of visit to the site and the community nearby had invoked a sense of humility, ridding us of our materialistic understanding of buildings. At that moment we were convinced of building a space, that had to be put to life with the co-existence of nature and human. The building would not only impart knowledge to the students but will blur the restricting boundaries between the community and the reluctant culture of education. (Refer to Annexure (1) Fig. 1, 2)

DISMANTLING THE BOUNDARIES

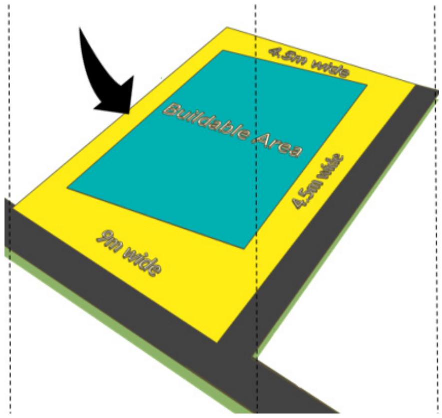
Before we wanted the inhabitants to dwell, we aimed to develop a sense of belongingness. Such connectedness had to be established by building with **what we have** and **for what we have**. While we walked through the narrow lanes of the village, we were inspired to look at their rituals and practices of living together in harmony with the animals. Roakes outside the house, concrete sitting spaces around trees, etc., all such elements had been marked to be incorporated within our design. The inspiration did not stop at the elements but extended to the craftsmanship of the people. The joy of sending their children to the schools, most people willingly volunteered to work on the school, signifying the name "HAMARA". Some had the skills of carpentry, and masonry had great hands-on metal welding, while few tremendously etched glass surfaces. (Refer to Annexure (1) Fig. 3,4,5)

BUILDING AS AN EXTENSION OF THE BODY

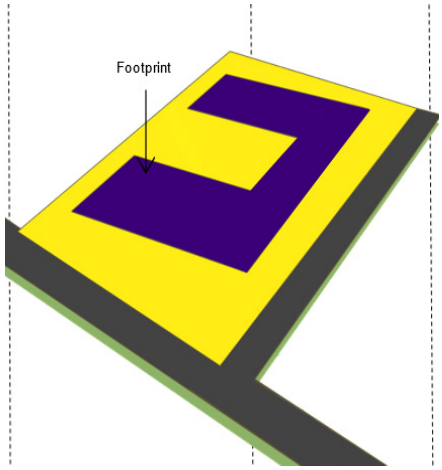
Besides, as we adapted ourselves to the understanding and environment of the village, this idea of adaptation got ingrained into our design. We incorporated design ideas that allow the students and inhabitants of the school to tweak and regulate the building and spaces as per their needs. (Refer to Annexure (1) Fig. 6 & 7)



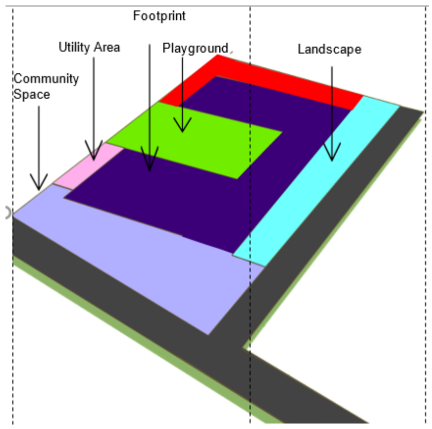
Site & Context - The site with area of 2880 sq.m. is located in Nangla Bhai Beg village, Aligarh. It is surrounded by agriculture lands on two sides with 6m road on front side and 4.8m road on the other. There are also quite a few upcoming residential projects around the site.



Buildable Area - As per Aligarh, norms, the provided setbacks for the site are 9m on the front and 4.5m on the back and rear sides.



Buildable Footprint - The building footprint was derived by mapping the existing constraints and determinants like access points, orientation, surrounding, community engagement and base level climate analysis.



Programmatic Zoning - The larger programmatic zoning considers multiple discussions with client to understand their pedagogy and anticipations towards the building, and other parameters, which could impact the approach towards co-design. As a result, all the spaces, that could be used for revenue generation were kept on the out fronts and ground floor, so that other educational and vocational spaces don't get affected.

We decided upon the use of reclaimed materials from the site that will not only reduce the carbon imprint of our site but will also reflect the vernacular practices adopted by the humans of the community in their homes (Refer to Annexure (4) Tab A4.6 for detailed Embodied Carbon Calculations and Fig 4.4., 4.5 in the Energy Performance section).

The use of compressed earth stabilized blocks as walls, terracotta tiles for parametric façades, reclaimed brick for flooring and concrete sitting spaces did not only speak for the culture of the community giving the material an agency but also did help us reduce the cost of construction for the school building.

PROGRAMMATIC DRIVER // MAKERS

PEDAGOGY (STUDIO MODEL, VOCATIONAL ACTIVITIES, ETC.)

For us, this pedagogy itself became the inspiration to define the kind of spaces we would have wanted to integrate into our design for Hamara School.

The design consists of multiple extended spaces which merge classrooms and corridors into each other and can be used in multiple ways with its temporal necessities.

Within a standardized system of education, where children are confined to an established set of rules to accomplish conventionally preferred paths, the Hamara School takes a radical turn. The kind of training that is provided within the school premises incorporates workshops such as carpentry, embroidery, cooking, etc. The underlying intentions behind this kind of approach are to provide the enrolled kids with an environment that is more experiential and experimental and to transform learning from the mere margins of a systemized book into more skillset and vocational-based development. (Refer to Annexure (1) Fig. 8,9)

ENVIRONMENT AS EDUCATION

The building with a conscious intent doesn't only take a child to the classroom but brings the whole classroom out of a box into fluid spaces through attentively strategized learning elements. It also includes a studio-based vertical class system for teaching subjects such as Language, Mathematics, Science, and Social Sciences, where design and details interact with its users to provide them a better understanding and grasp in a very specialized manner.

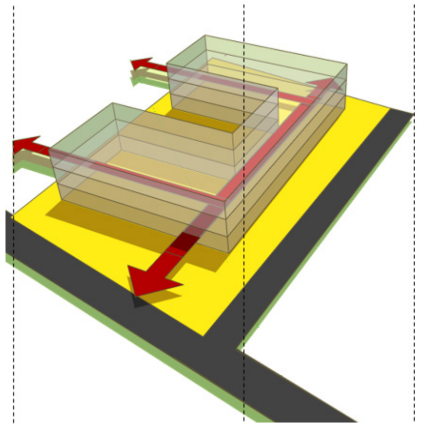
The window turns itself into an abacus allowing students to combine learning with their ordinary everyday practices.
Thus spaces thus themselves act as a learning tool for the children who inhabit them on a regular basis. For instance, the compass incorporated with the details of door design allows children to experience the principles on a real scale, instead of limiting it to a 2D plane.
*The design of the Hamara School thus becomes an interface between architecture and development, with playful learning settings. (*Refer to Annexure (1) Fig. 10,11)

UNIVERSAL ACCESS + SPECIAL NEEDS CHILDREN

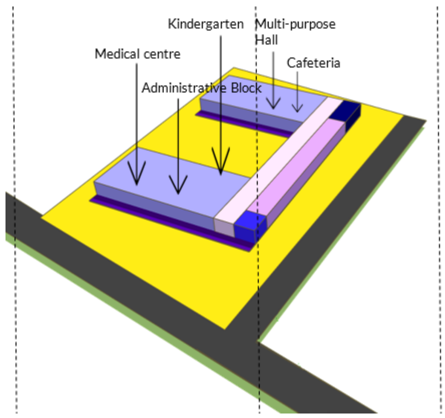
Taking into consideration the thought that it's not always the disability that makes a person divergent from the perception of objective reality, but also their physical and social environment, the building with its inclusivity for all also takes into consideration and serves the specially-abled children with elements which are user friendly and accessible to all.

SCHOOL-COMMUNITY EXCHANGE & REVENUE MODEL (CROSS-SUBSIDY, MULTI-PURPOSE, COMMUNITY KIOSKS, ETC.)

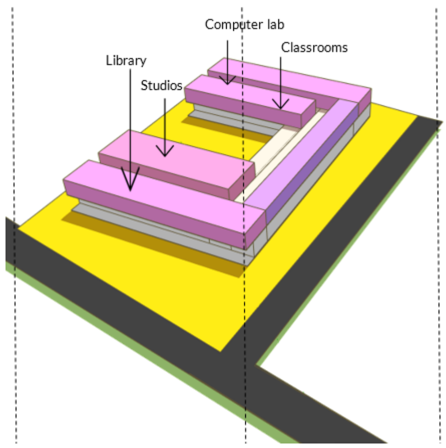
The building not only does restrict itself to function as a school but also does extend its functionality through the renting out of a multipurpose hall for socio-cultural events to the community when in need. (Refer to Annexure (1) Fig. 12,13)



Internal Spine Walkway - An internal circulation walkway runs throughout the volumes. Internally, this provides informal seating and interaction space.



Staggered stair connection - The staggered staircase cuts through the interior of the building to connect the three floors, allowing students to circulate outside and forging a stronger bond between the outside and inside environments.



In-between Spaces (First floor) - First floor entails corridors that connects front block to rear block. The front block consists of educational spaces like studios, and library with sitting spaces. The rear block consists of computer labs and classrooms. Each floor has one male and one female washroom, inclusive of differently- abled cubicle.

DESIGN PROCESS

The design process started with the context and site, and we step-by-step applied the layers of byelaws, orientation, passive design, built-open relationship, functional programmatic drivers, fenestration systems, and material and textural experiences. For a detailed understanding, refer to Fig. 1.1 to 1.10 to understand the process.

LANDSCAPE DESIGN

Our landscape design has been conceptualised with the goal to respect the triad of Flora, Fauna, and Earth. So we followed the principles of Permaculture. (Refer to landscape plan in Annexure (1) Fig.A1.15)

Permaculture

The actors in the process fuses into one another to create a seamless circle, where the humans serve the earth and the soil gifts back with medicinal plants, foods for a better livelihood, encouraging economic maturity through a socially interactive environment. *Refer to Annexure (1), Fig. A1.16 for plant guild systems and Fig 1.11 below*

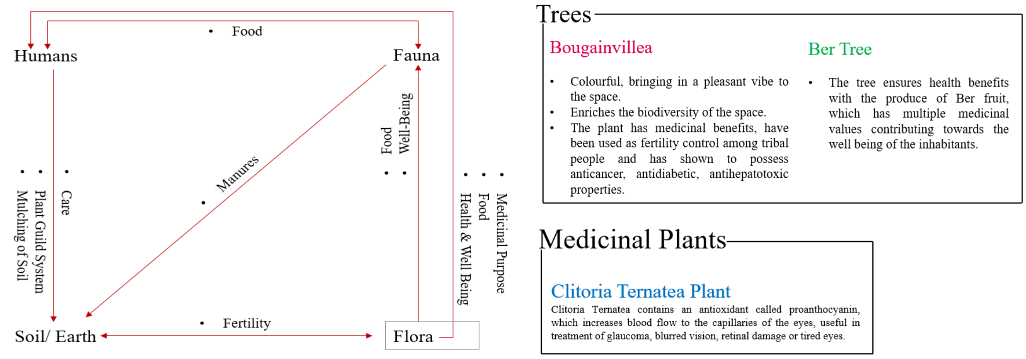
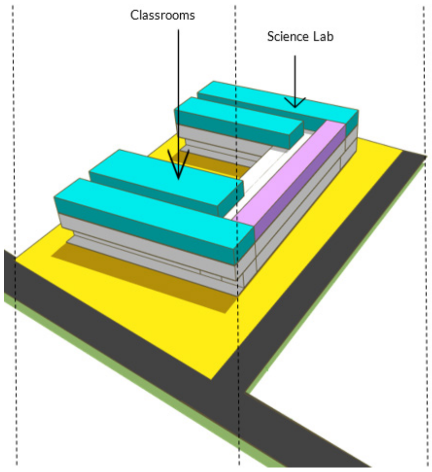
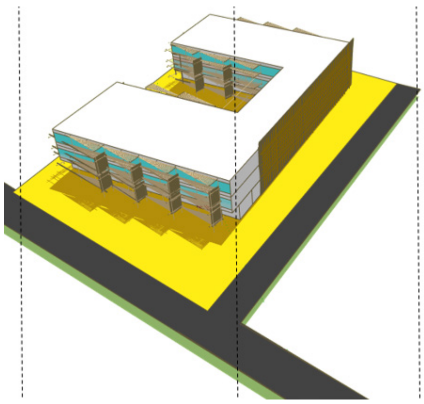


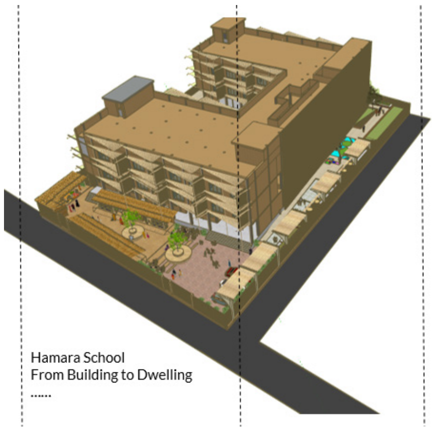
Fig. 1.11 - Permaculture Ecosystem



In-between Spaces (Second Floor) - Second floor entails a composite science lab, with classrooms and spaces for vocational activities such as embroidery workshop and model making workshop.



Fenestrations - All fenestration systems within the building intend to provide thermal comfort with an attentive adaptability and transformation to the dwellers. Local material and construction techniques provide an opportunity for co-designing and community engagement.



SYNCING THE ARCHITECTURE WITH BUILDING SYSTEMS

For meticulous detailing, we made mockup specimens of the different architectural components - for example the infiltration free MS window, rammed earth specimen, terracotta hollow block, bamboo thatched construction etc. Refer to Annexure (1), Tab. A1.1 for window mockup. Refer to Annexure (7) for other mockups

The spatial and formal design of the Hamara School has been meticulously integrated with the **structural system** – structural span, positioning of columns, layouting of beams. (Refer to Annexure (6) Structural Drawings – Fig A.1-A.4)

All the Electrical Services – electrical systems, lighting fixtures, ceiling fan points, switches, controls, high-side, and low-side systems – all have been located properly and in relation to the spatial and formal scheme. (Refer to Annexure (6) Electrical Drawings – Fig A.5-A.10)

All the Plumbing Services – location of ECO-STP, storm water drainage, rain water tank, supply and waste water network have

II - HEALTH & WELLBEING

THERMAL COMFORT

The existing Hamara School set-up in Aligarh has no mechanical conditioning, and the school faculty and students adapt to their indoor environment through clothing, natural ventilation, and ceiling fans during the peak summer months (Figure 1). In the harsh winter months, the students put on extra layers of warm clothes to keep the heat intact.

Fig. 2.1- Adaptive Thermal Comfort at existing Hamara School, Aligarh

We have followed the IMAC [1] 2014 model for thermal comfort for the project, where the occupants are able to tolerate a wider range of environmental conditions, which, in turn, helps save energy. At present, the predominant trend in India is to design airconditioned office buildings that operate at 22.5 ± 1°C all year round. The IMAC study derived a statistically significant model for buildings operated in naturally ventilated mode, throughout the year that shows Indians are more adaptive than the prevailing ASHRAE and EN models would suggest:

Neutral temperature = 0.54 x Outdoor temp. + 12.83 [2]

Where, neutral temperature is the indoor operative temperature (C), and outdoor temperature is the 30-day outdoor running mean air temperature (C) ranging from 12.5 to 31 C. The neutral temperature for NV building varies from 20.5-28.5°C for the observed outdoor range with 90% acceptability in the range of ±2.4°C of the neutral temperature.

We plotted the Indoor Operative temperature for the proposed HVAC system i.e. System 1 -Free Radiant Cooling only and System 2- Radiant Cooling +Direct Evaporative Cooling System for a typical summer day on 1st May, against the Outdoor Dry Bulb Temperature and IMAC Neutral temperature. The graph below demonstrates that System 2 brought down the Indoor Operative Temperature within the comfort zone. Refer to Annexure page no. x (Energy Performance section:Modelling the Hybrid Low energy comfort system)

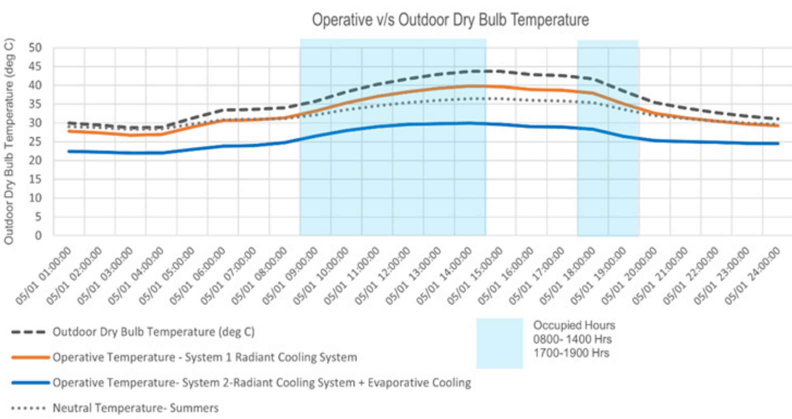


Fig. 2.2- Thermal Comfort achieved through Radiant Cooling and Evaporative cooling system

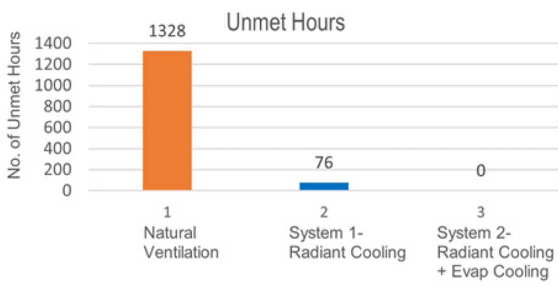


Fig. 2.3- Annual Unmet Hours

The Annual Unmet Hours (Occupied+Unoccupied) were reduced from 1328 to 76 through System 1 and Zero in System 2, which further demonstrates its efficacy in the project.

VENTILATION AND AIR QUALITY

The typical spaces like classrooms, laboratories etc are naturally ventilated coupled with Direct/Indirect evaporative cooling. All the spaces are designed (Refer Figure 3) for cross-ventilation through windows and ventilators (opening towards naturally ventilated corridor) to provide the minimum fresh air required as per Section 5.2.21 NBC 2016. The mechanically conditioned spaces i.e., computer room and conference hall are fitted with exhaust fans to provide the minimum fresh air required as per ASHRAE 62.1-2016 .

Fig. 2.4 - Cross Ventilation in Classrooms

VISUAL COMFORT

DAYLIGHTING

A Useful Daylight Illuminance [3] (UDI) and Annual Solar Exposure [4] analysis was performed for a typical floor level as well as for individual classrooms (refer to Tab. 2.1 for input parameters). The classrooms have been designed to have sufficient daylight to meet the SuperECBC compliance i.e. Useful Daylight Illuminance (100-2000 Lux) for 90% of the potential daylit time in a year for at least 60% of the floor area. Dynamic shading devices have been installed in the South-West and North-East Façade to block direct solar gains during the summer months, limiting the Annual Solar Exposure (above 1000 Lux) to 12-15%. The façade will be transformed during the winters by removing the shading devices to allow the sun inside. The UDI and ASE analysis for the critical orientation i.e. South-West front façade is shown to demonstrate the visual performance *(Refer Figure 2.5 & 2.6)*

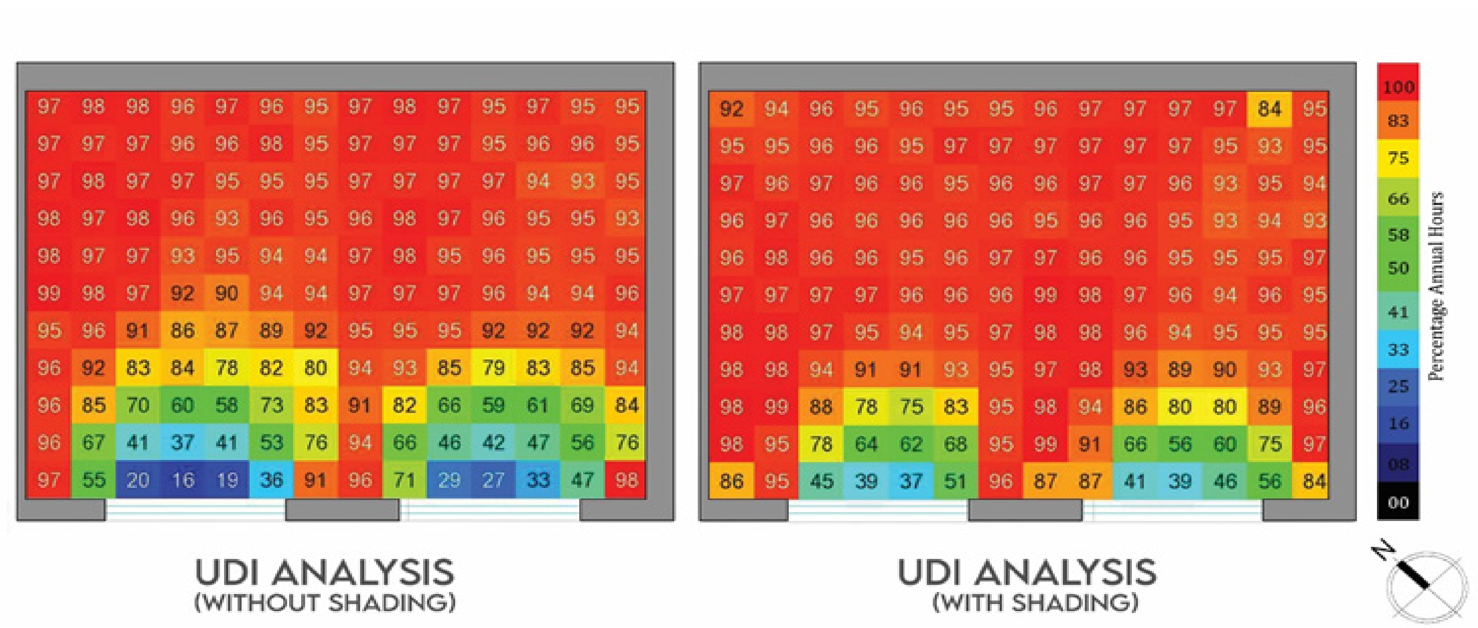


Fig. 2.5- UDI Analysis for Typical Classroom in South-West Orientation

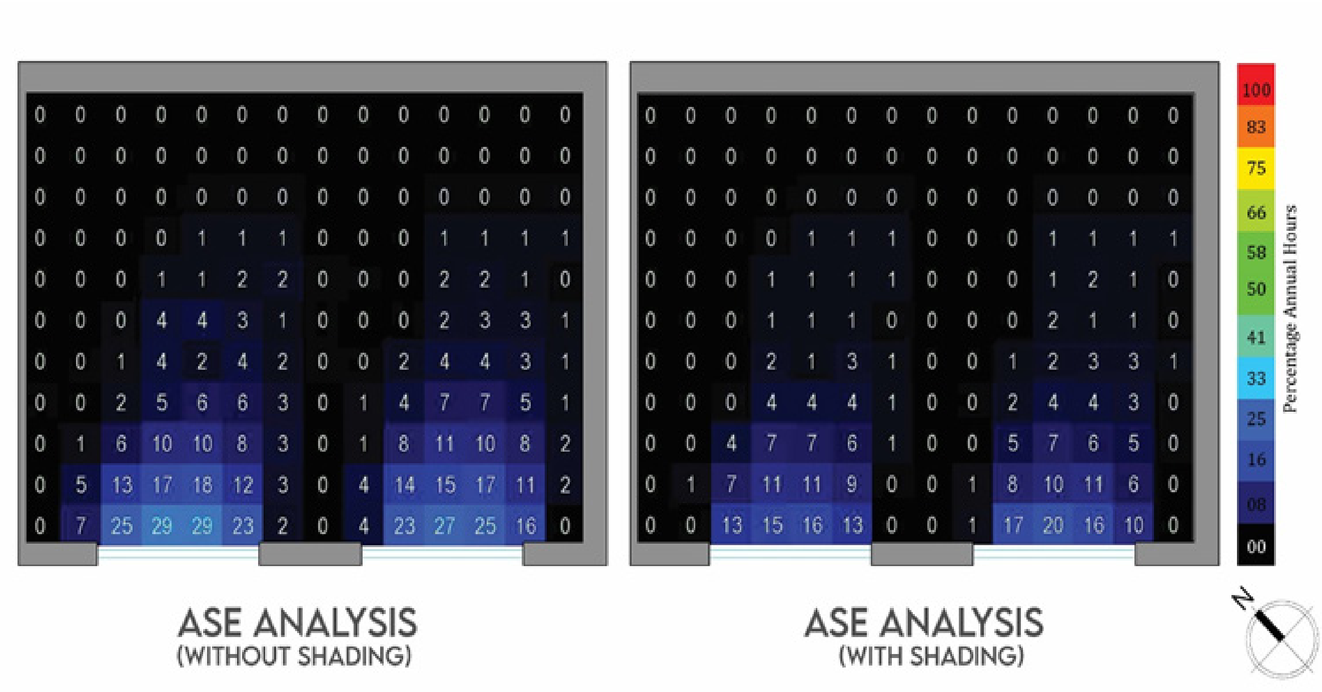


Fig. 2.6- ASE Analysis for Typical Classroom in South-West Orientation

ARTIFICIAL LIGHTING

The interior lighting has been designed to achieve the NBC 2016 levels for illumination on the work-lane for the different activities. A simulation was carried out in ReluxNet *(Annexure (2), Tab. 2.1)* to ensure all spaces meet the required Lux levels for visual comfort.

Visual Comfort for the Nocturnal beings

We are equally concerned about the visual comfort of the fauna around the site. In orderv to reduce night-time light pollution , the exterior lights are shielded and no-uplighters have been used for illuminating the landscape or boundary walls.

INTERIOR FINISHES & FURNITURE

The Interior Finishes are selected to limit the emission of Volatile Organic Compounds (VOC's) in the indoor environment. The internal walls are rammed earth, cement flooring and ceiling painted with water-based paints. The furniture will be majorly made from Bamboo and Cane to limit the VOC emissions. The IGBC standards (IEQ Credit 5) for VOC's have been followed

	INPUTS IN DAYLIGHT MODEL
Working Plane Height	0.76 m
Reflectance of Internal surfaces	Walls – 0.4 Flooring – 0.2 Ceiling – 0.6 Internal walls – 0.4
Glazing	VLT – 80% clear glass 5 mm
Shading	As designed
WWR	As designed
Glazing	VLT – 80% clear glass 5 mm
Shading	As designed
WWR	As designed

Tab. 2.1 - Inputs in Daylight Model

TYPE OF PAINTS & COATINGS	VOC LIMIT (g/L less water)
Non-flat (Glossy)	150
Flat (Mat)	50
Anti-corrosive/ Anti-rust	250
Clear Wood Finish: Varnish	350
Clear Wood Finish: Lacquer	550

Tab. 2.2 - VOC Limits for Wet Applied Products as per IGBC

REFERENCES / NOTES

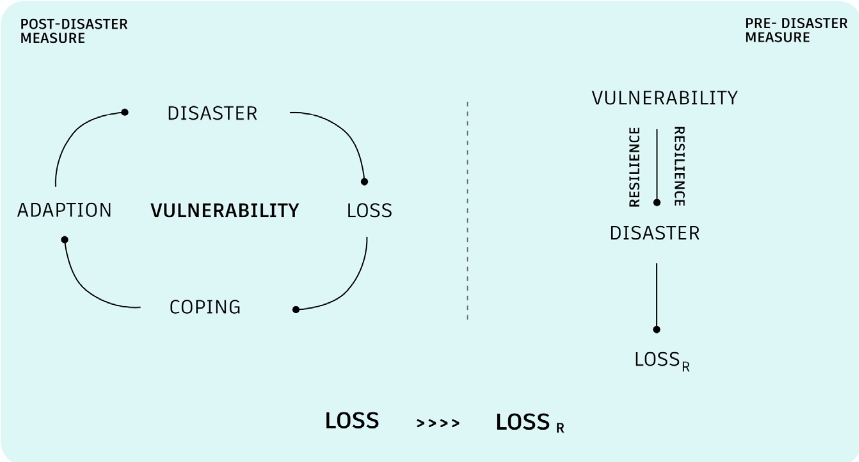
1. An Introduction to the India Model for Adaptive (Thermal) Comfort, CEPT, 2014

2. Field studies of thermal comfort across multiple climate zones for the subcontinent: India Model for Adaptive Comfort (IMAC) , Manu S, et al, 2015

3. Useful Daylight Illuminance (UDI) is the annual occurrence of illuminance distribution across the working plane that are within a range considered "useful" by occupants. It excludes any times when there is inadequate natural daylight or excessive direct sunlight which would give rise to a risk of glare. UDI therefore not only provides information about useful daylight illuminance, but also on the propensity for excessive levels of daylight that are associated with glare, occupant discomfort and unwanted solar gains. In this way the single UDI metric can be used to summarise the overall daylight performance of a space.

4. Annual Sunlight Exposure (ASE) is the number of hours per year a point on the working plane receives direct sunlight greater than a threshold value.

III - RESILIENCE



A Disaster is characterised by loss to an individual or a community. This can be in the form of material – homes collapsing during an earthquake, or immaterial – a sense of belonging associated with that home. To cope with these losses certain adaptive measures can be taken. However, not all losses are quantifiable. The damage in these cases is already done. Additionally, say the measures do recuperate all the losses, the pre-disaster state is restored i.e., the vulnerability to the disaster remains the same. Therefore, post-disaster measures just lead to a vicious cycle. To break out of this lock-in it is imperative to call upon pre-disaster measures. Resilience is one such tool. The focus is shifted to identifying the vulnerability to a disaster within a set of individuals, consequently methods to mitigate it. This practice not only minimise losses but also aids them to go beyond the status quo.

POTENTIAL INTERVENTIONS

A. EARTHQUAKE RESILIENT DESIGN

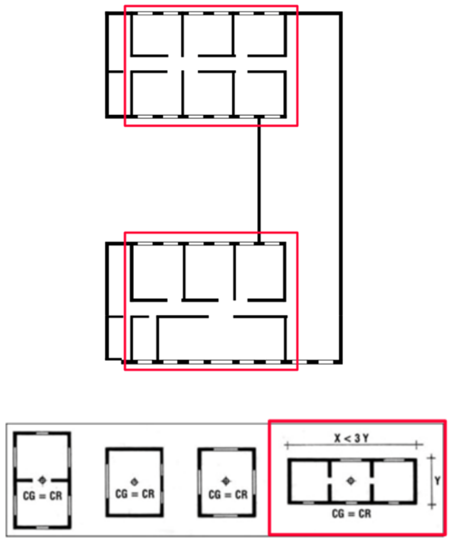
As per BIS (as revised in 2002), Aligarh is in Zone III which is classified as a Moderate Damage Risk Zone. This corresponds to Intensity VII (Scale of I-XII) on the Modified Mercalli (MM) scale, and a reading of 5-5.9 on the Richter scale.
Earthquakes between this bracket are characterised by very strong shaking with negligible damage to buildings of good design, moderate cracks. Possibility of wall failures, with old structures collapsing (Source: USGS General Interest Publication 1989)[(1)]. Hence, the design target is, "Collapse Prevention during an MCE" i.e., structures stand – do not collapse immediately – till safe escape of occupants. The Uttar Pradesh State Disaster Management Plan (2010) for earthquakes recommends a microzonation study. While this study is not feasible for the Hamara school site, a preliminary soil test was conducted which informed the foundation design of the structure.

DESIGN INTERVENTIONS

The entire structural and seismic analysis was carried out on STAAD *(refer to analysis diagrams Fig. A3.1 - A3.6 in Appendix (3)* An independent study (source) conducted concluded with a few pointers for the seismic safety on buildings in Aligarh taking IS:4326 – 1993 and IS: 1893 – 1984 into account.

Following are our design decisions informed by the study:

1. The Hamara School is a G+2 framed structure with no-load bearing walls as the fourth floor on a brick thick wall are found to make the lower floors vulnerable. Additionally, windows opening with less than 45 cm between them on a load bearing wall makes it weak. (Gupta and Singh, 2014)
2. Mortar with cement and sand ratio of 1:4 will be used as it most effective against earthquakes compared to a ratio of 1:6 by a factor of 3, which in turn is stronger than locally used surkhi (lime mortar) and clay mud mortar (Gupta and Singh, 2014)



Proper distribution of walls and openings

Fig. 3.1 - The openings in the Hamara School Plan (top) with recommended Units from BMPTC guidelines (bottom)

The following interventions were made with reference to pp. 27 of The Guidelines for Improving Earthquake Resistance Housing, 2010 by BMTPC, New Delhi: [3]

1. The Height to Perimeter Ratio of the Hamara School is has been paid consciously keep low (Perimeter of the base = 221 m, and Building Height is 12 m) to minimize a tendency to overturn.
2. Floor heights are kept equal 3600 mm to equalize column/wall stiffness.
3. Floor plans are kept symmetrical and the openings – doors and windows follow fixed units for the centre of mass of the structure to be close to its centre of rigidity to reduce torsion and balance resistance in all directions.

A geotechnical investigation was conducted for the construction of Hamara School, Aligarh by Aqua Explorers, New Delhi *(Report and soil investigation photos attached in Annexure (3) , Fig. A3.7 and Fig. A3.8)*

1. Combined footing is recommended as the net safe bearing capacity was found to be 9.60 T/m2 at a depth of 2 metres. This will take care of the differential settlement of the soil strata which is found to be loose/medium dense to stiff in nature based on the SPT values. However, precautions must be taken to avoid loose pockets such as buried dug

B. EXCESSIVE RAINFALL / FLOODING RESISTANCE

Droughts & Floods

An online tool launched by WWF, called WWF Water Risk Filter [5] can be used to help cities build resilience against water woes and risks, and to plan for sustainable futures. According to the WWF Water Risk Filter[6], Aligarh faces a severe risk of water scarcity and a moderately high risk of flooding by the year 2050.

To make the Hamara School project resilient towards extreme weather events such as floods and droughts, certain intentional interventions have been made in the site and building.

Rainwater Recharge Micro-Injection Wells

Recharge wells help build resilience towards floods, by mitigating waterlogging and flooding by taking care of excess surface run-off. In the long run these wells could help us tide over the increasingly frequent drought periods since the well itself may retain water, which can then be pumped and used.

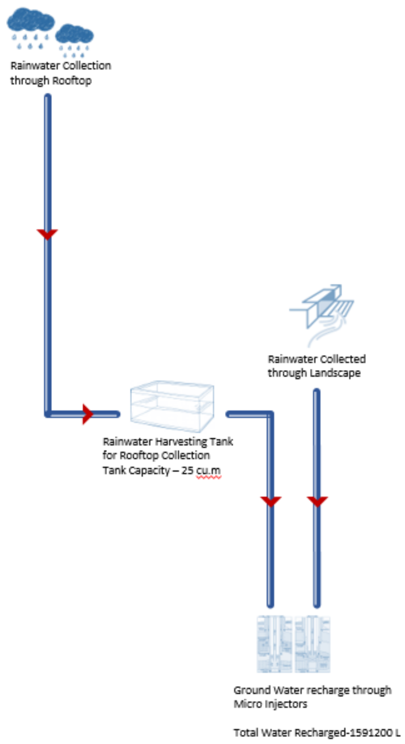


Fig. 3.2 - Rainwater Harvesting and Ground Water Recharge Diagram

A. EXCESSIVE RAINFALL / FLOODING RESISTANCE

Raised Plinths

The raised-plinth measure will become progressively more cost effective as climate change increases flood hazards. Raising the structures at the time of their construction appear to be cost-effective at all discount rates [7] (source). It also maintains with the construction practices in the immediate surroundings of the Nagla Bhaibeg village.

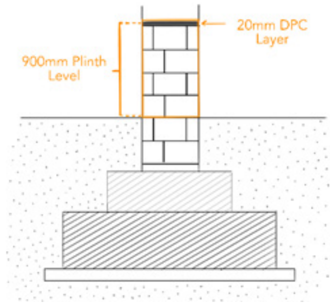


Fig. 3.2- Plinth Level & Footing

Road, Driveways and Tree Pits

Directing water off the roads and captured in the landscape, gravel and dirt roads absorb water faster and won't pollute rainwater with petroleum chemicals, install porous paving. Increasing infiltration also serves to counter the effect of floods as well as build resilience

C. ENERGY RESILIENCE

Hamara School is sustainable and net zero in its annual energy consumption and has a 10 kWp Solar PV system along with battery storage capacity of 8 kW, installed to take the electrical load of all the ceiling fans and 50% of the lighting load. Therefore, Hamara School Campus is not dependent upon the grid for lighting and ventilation. Refer to Tab. 0.3 under Techinical Specifications and electrical SLDs under Appendix (x) - Engineering and Operations

This is further supported by a 30 KVA DG set to meet the requirements of the multi-purpose hall, pumps, plug load, kitchen and the cooling system in extreme conditions. So in the case of long power outage, the school campus has the potential to become a home for the distressed communities.

D. CLIMATE RESILIENCE

The building and campus of Hamara School effectively protects the inhabitants from the harsh weathers of Aligarh. In hot summers, the building insides and open spaces are well shaded, and can be completely shut to the outside loo (hot and dry winds), and evaporative cooling system ensures ventilation and conditioning. In heavy monsoons, the rainwater is stored and given back to the ground source, avoiding any flooding of the site.
Our principle of moving towards the dwelling realm from the building realm enables the inhabitants to tailor and adjust the building and its components to their likes and needs, making them more resilient towards the extremities of the climate and weather. ***(refer to Health and Wellbeing and Energy performance sections of the report)***

F. FOOD RESILIENCE

At Hamara School, there is a dedicated kitchen to provide meals to the inhabitants. This kitchen has ample storage space for food storage of 100 sq. ft. This is coupled with a 800 sq. ft kitchen garden to grow kitchen essentials.

G. COMMUNITY RESILIENCE

Hamara School integrates the community with the school. Not only does it have spaces for everyday community welfare and exchange, but it also doubles up as a community shelter during times of distress.

During such times, the big multipurpose hall will provide shelter and sleeping space to about 50 people (with that being expandable up to 150 people if outdoor spaces are also included), and the health centre will look after their medical needs.

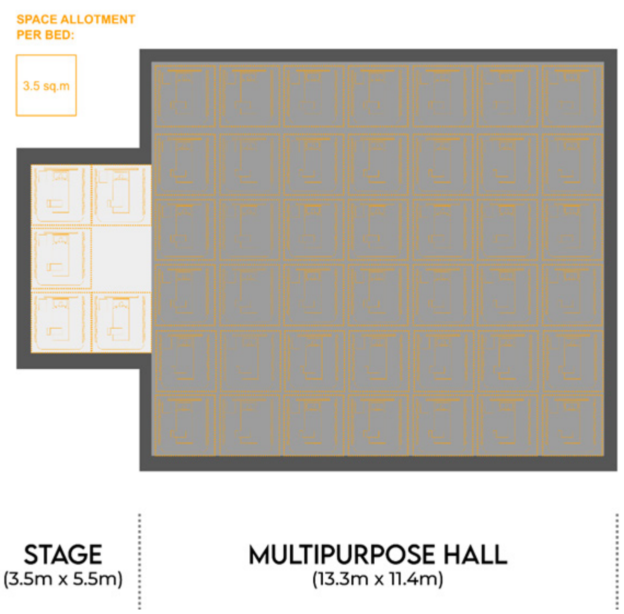


Fig. 3.4 - Following UNHCR guidelines, 3.5 sq.m is allocated per person in disaster shelters

REFERENCES / NOTES

1. USGS General Interest Publication
   https://www.usgs.gov/programs/earthquake-hazards/modified-mercalli-intensity-scale

2. Gupta, Lokesh & Singh, Vivek & Sharma, Manorma. (2014). Disaster Management-Construction and Designing of Earthquake Resistant Buildings in Aligarh City (A Case Study). International Journal of Advanced Earth Science and Engineering. 3. 171-182.
   https://www.researchgate.net/publication/265847645_Disaster_Management-Construction_and_Designing_of_Earthquake_Resistant_Buildings_in_Aligarh_City_A_Case_Study

3. The Guidelines for Improving Earthquake Resistance Housing, 2010 by BMTPC, New Delhi
   https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjgoc6D9Y_2AhXnUGwGHSOvCK4QFnoECAMQAQ&url=https%3A%2F%2Fbmtpc.org%2FDataFiles%2FCMS%2Ffile%2FEarthquake_Hazard_Guidelines_2010.pdf&usg=AOvVaw0U_6ZEuUsQDkmVYVTCLbxV

4. Study by World Wide Fund for Nature (WWF)
   https://www.downtoearth.org.in/news/water/wwf-identifies-100-cities-including-30-in-india-facing-severe-water-risk-by-2050-74058

5. WWF Water Risk Filter - 1
   https://waterriskfilter.org/explore/scenarios

6. WWF Water Risk Filter - 2
   https://waterriskfilter.org/assets/documents/WaterRiskFilter_Methodology.pdf?cid=5dbc3b3a0e159700166b68df

7. Hochrainer-Stigler, Stefan, et al. “Flood Proofing Low-Income Houses in India: An Application of Climate-Sensitive Probabilistic Benefit-Cost Analysis - Economics of Disasters and Climate Change.” SpringerLink, Springer International Publishing, 31 May 2018
   https://link.springer.com/article/10.1007/s41885-018-0032-7

| IV - ENERGY PERFORMANCE |

Step 1 - Building Form, Envelope and Fenestration Design | **Step 2- Lighting Design** | **Step 3 – Plug Loads and appliances** | **Step 4 – Integration of low energy comfort systems** | **Step 5 – Integration of Renewable Energy**

Step 1

1. Longer axis towards North-East and South-West
2. Mutual shading of building blocks
3. Courtyard Planning
4. Thermal mass in Walls
5. Reduced Infiltration through building envelope sealing – window frames design, joinery details
5. Optimized Window to Wall Ratio of 14% with shading to block direct gains
6. Cool roof with Pond and High SRI paint + shading from PV's

Step 2

1. Lighting design in all spaces to meet NBC 2016 requirements for Illuminance
2. Task lighting, ceiling illumination in labs, multipurpose hall, corridors to avoid direct –only overhead lighting
3. Daylighting in all occupied spaces through light shelf and optimized window design
4. Use of LED's
5. Overall reduction of LPD by 27% over ECBC 2017

Step 3

1. Minimum use of equipment's in classrooms
2. Use of BEE 5 Star rated appliances
3. BEE 5 Star rated Ceiling Fans – BLDC Technology

Step 4

1. Thermal comfort and adequate ventilation achieved through use of hybrid system – Free Radiant cooling + Direct Evaporative Cooling in summer months (April to September).
2. Natural Ventilation deployed during free cooling period (October-November) and (February- March)
3. BEE 5 star rated Split AC's in Conference Room and Computer Lab

Step 5

Scenario 1 & 2 – Net Metering available in Aligarh

27 kWp of Solar PV installed on rooftop

Surplus generation is sent back to the grid and on cloudy days electricity is sourced from the Utility.

Scenario 2- Invite Solar Investor to install 27 kWp Solar OV and avail generated energy at cheaper rate.

Scenario 3 – Net Metering not available in Aligarh

10 kWp of Solar PV is installed. The sizing has been calculated as per minimum load required throughout the year. Therefore, no requirement for storage on the site.

Baseline EPI
27.1
kWh/m2/yr

STEP 1 – EPI 23.8 kWh/m2/yr

STEP 2 – EPI 17.7 kWh/m2/yr

STEP 3 – EPI 22.7 kWh/m2/yr

Proposed EPI
13.1
kWh/m2/yr

REDUCTION OF LOADS

A detailed Energy Analysis was done to test various Passive and Active Design Strategies and simulate their impact on the Annual Energy Demand.

Methodology: A Baseline case of the building was modelled and compared with the Proposed case to analyse the Heat gains/losses through the various components of the building envelope.

- Envelope
- Lighting
- Plug loads and appliances
- Low energy comfort systems

Software: The eQUEST 3.65.7175 with DOE-2.2 as the simulation engine was used for the Energy Analysis *(Refer to Annexure (4), Fig. A4.1)*

Simulation Parameters: Refer Annexure C List of Input and Output Parameters

DEFINING THE BASELINE

The competition brief does not have any pre-defined reference for the Baseline case. The design team chose the Conventional construction of the region. (Refer Annexure C List of Input and Output Parameters) The conventional schools do not have any comfort systems, however, to have an apple to apple comparison the same Direct/Indirect Evaporative cooling was considered in the baseline. There was no shading in the baseline.

Building Form - The site has the longer axis towards North East and South-West. Due to site constraints of setback and to achieve the desired area program, the building was aligned with the longer axis. However, the planning was done to mutually shade the building blocks and cut the direct solar gains from the East and West orientations with the Staircase acting as buffer space. The placement of the courtyard and outdoor sitting spaces was also carefully carved out to provide Outdoor thermal comfort to the occupants *(refer to Fig. 4.1)*

Building Envelope - The building is largely naturally ventilated; therefore, high insulation values was not the selection criteria for the building envelope materials. The external walls will be constructed with Rammed Earth . The Roof will be a thick layer of Mud Phuska (to provide thermal mass) finished with high reflective broken china mosaic tiles. The windows are single glazed with metal frames.

Fenestration- The window to wall ratio was carefully worked out to balance heat gains and daylighting in the classrooms. The average Window to Wall ratio is 15% in the North-East and South-West orientations. A shading system is designed to cut down heat gains on the exposed North-East, South-West and South-East facades *(Fig. 4.2).*

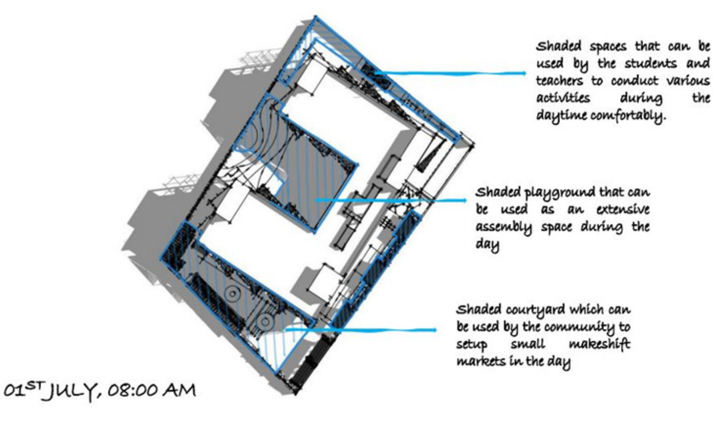


Fig. 4.1 - Image of the Energy Simulation Model - Proposed Case from eQuest v3.65

Fig. 4.2 - 3D view of the proposed building showing the Bamboo shading system on South-west and North-East

Lighting - The lighting in the spaces was designed to comply with NBC 2016 and achieve 27% reductions over ECBC 2017 recommended lighting loads at the building level. The design strategy was to use efficient LED lights with Task lighting to optimize the lighting loads. A simulation of the artificial lighting was performed on ReluxDesktop *(Refer to Annexure (4) , Tab. A4.1)*

Plug Loads and appliances - The overall equipment load is very less in the school, however ceiling fans are considered part of the equipment load. The conventional 75 W Ceiling fans were replaced with 28 W BLDC to reduce energy consumption.

INTEGRATION OF LOW ENERGY COMFORT SYSTEMS (VENTILATION & THERAL COMFORT)

HYBRID MODEL - FREE RADIANT COOLING SYSTEM + DIRECT EVAPORATIVE COOLING

The existing Hamara School, does not have any active comfort system. The students and teachers have an adaptive approach to thermal comfort through changing of clothing, ceiling fans and natural ventilation. A discussion with the occupants revealed that they are largely uncomfortable during the peak summer months, where natural ventilation is not an option because of the hot summer winds.

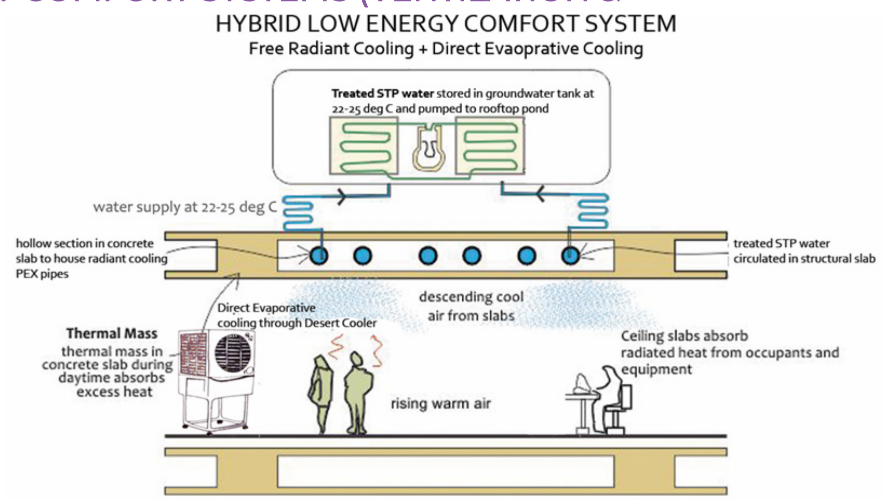


Fig. 4.3- Schematic Diagram of Hybrid low energy comfort system facades

We have proposed a hybrid low-energy comfort system to ensure the thermal comfort is maintained for the majority of the year, especially the summer months (April to September). The system is a combination of Free Radiant cooling and Direct Evaporative cooling. The free radiant cooling system operates on treated STP water stored at the ground level (22-25 deg C) and pumped to the roof pond, from where it is circulated in the structural slab. The system will be operated at night, so that the structure is adequately cooled before the school opening hours i.e. 0800 Hours. This system will be coupled with direct Evaporative cooling i.e. Desert Coolers to ensure adequate comfort during the daytime.

We have performed calculations to measure the impact of the Hybrid system on Indoor Operative temperature and if it meets the thermal comfort. The methodology of calculating the Operative temperature is explained in the Annexure page no. x (Energy Performance section:Modelling the Hybrid Low energy comfort system) . The figure demonstrates that the hybrid system (System 2) will be able to provide adequate thermal comfort to the occupants

PROPOSED CASE – ANNUAL ENERGY PERFORMANCE OVER BASELINE CASE

The proposed case was modelled with a combination of all energy conservation measures (Envelope + Active Design Measures (Refer Annexure-Energy Performance). The proposed case is 51.8% efficient than the Baseline, having an Annual Energy Consumption of 40,520 kWh *(Annexure (4), Fig. A4.2)*

NET ZERO ANNUAL ENERGY USE

To achieve Net Zero Annual Energy use for the project, we did a market survey to understand if the project location has Grid connectivity and Net Metering facility available. It was confirmed from UPNEDA and the Utility Dakshinanchal Vidyut Vitran Nigam Limited that currently Net Metering facility and subsidies on Solar PV is not available in Aligarh. However, we have considered three scenario's to achieve Net Zero/Nearly Zero Energy performance for the project:

SCENARIO 1 - NET METERING FACILITY AVAILABLE (FUTURE SCENARIO)

A total of 27 kWp of Solar PV will be installed on the rooftop to offset 100% of the Annual Energy Demand i.e. 41,222 kWh/year. The analysis for generated electricity can be referred to in Annexure -Energy Performance, Section 6- PV sizing calculations. The surplus generation will be supplied to the grid, and in cloudy/rainy seasons, we will take electricity from the Utility.

SCENARIO 2 - NET METERING FACILITY NOT AVAILABLE – SOLAR INVESTORS

A total of 27 kWp of Solar PV will be installed on the rooftop to offset 100% of the Annual Energy Demand i.e. 41,222 kWh/year. We will approach Solar Investors like SOLON , Hero Future Energy , etc. who install the required Solar PV at their own cost and provide the generated energy at a subsidized rate.

SCENARIO 3 – NET METERING FACILITY NOT AVAILABLE – CURRENT SCENARIO

In the current scenario, we have done the sizing of the PV system to offset 100% connected load of Ceiling Fans (5 kW) and 50% of Lighting load (3 kW). A Solar PV system of 10 kWp will be installed on the rooftop initially to offset the consumption and will eventually move towards Net Zero, once the Net Metering provision is available in Aligarh. *Refer to the sizing calculations in Annexure (4), Tab. 4,4* – Energy Performance, Section 6 – PV Sizing calculations.

EMBODIED CARBON CALCULATIONS

Since we are following a holistic model of net-zero energy design, therefore it was important for us to also account for the embodied energy implications. The project team performed an Embodied Carbon study for the project using Net Zero Carbon tool of One Click LCA software. There are India specific datasets available and for international materials, the tool uses the localization factor. The scope of the analysis was limited to the Structure and Envelope. For the input parameters for Baseline and Proposed case, *refer to Annexure (4), Tab. A4.6*

The use of locally available material and steel with recycled content amounted to a reduction of 47.5% in Embodied Carbon. It was observed that there is minimal contribution in embodied carbon from the envelope. The results are as follows:

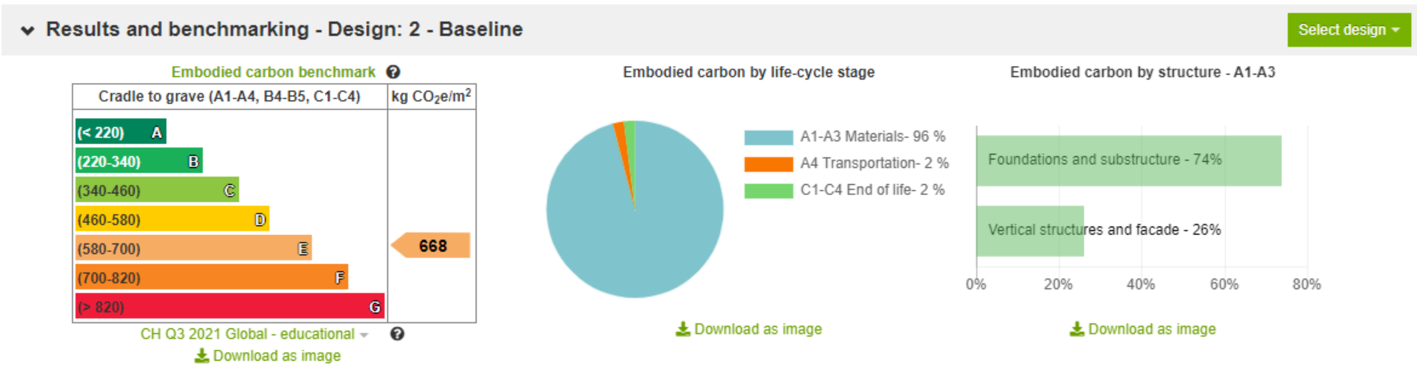


Fig. 4.4 - Embodied Carbon in Baseline Case (Source: Onecllicklca.com)

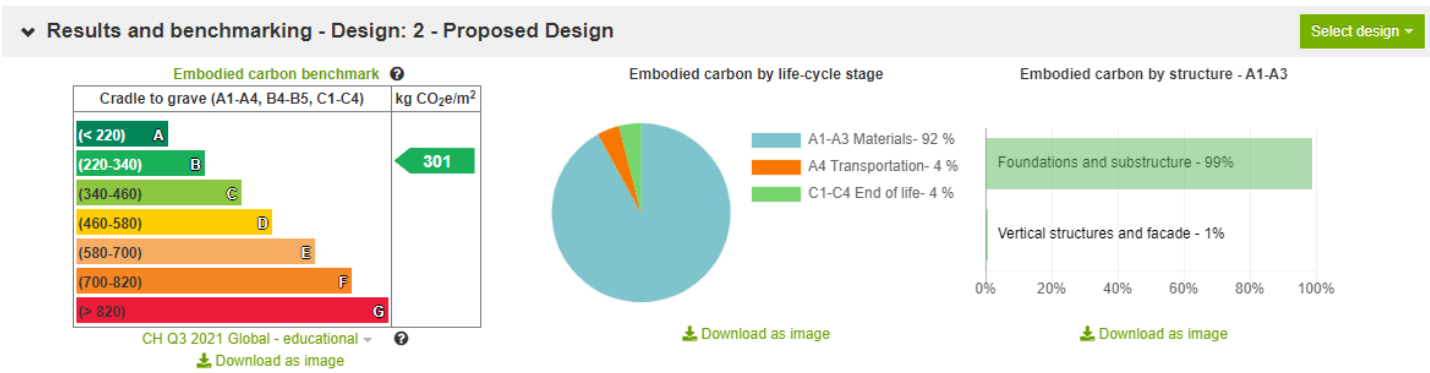


Fig. 4.5 - Embodied Carbon in Proposed Case (Source : Oneclicklca.com)

| V - RESPECTING THE COMMONS (WATER PERFORMANCE |

***"Water is life's matter and matrix, mother and medium.
There is no life without water". – Albert Szent Gyorgyi***

The question which we attempt to address is this : **What are the plausible ways in which we can custom our building, campus and technology- to nurture and nourish the fellow lives and life systems; not only humans but non humans concerning our site and its situatedness**. How must we combine our ways of being and lifestyles with the sciences and technologies available to us in order to develop a holistic, equitable, non-hegemonic relationship with nature and fellow organisms? Put differently, **how must we learn to dwell respecting water resource?**

Our aim is to prioritize both the sustainability of water **that is a net positive water campus but also usage of only sustainable systems that require little energy to operate.**

In order to attain a net-zero water cycle at Hamara School, fundamental 3R's of water conservation – Reduce, Reuse, and Recycle were attentively strategized along with utilizing the rain water. All the water related systems in the building have been designed to eliminate the dependency on fossil water. Efficient and sustainable water treatment system has been incorporated in order to cut down on the repetitive freshwater cycles. Thus, a closed net positive cycle on our site has been developed where the water recharged to the **ground plus the water provided to the surrounded agriculture fields is more than the water extracted from ground source to fulfill the freshwater requirements within the building premise**. But also the building with our notion to co-build, initiate ideas and practices to conserve water within the dwellers by using various forms of representation. *(refer to Fig. 5.1)*

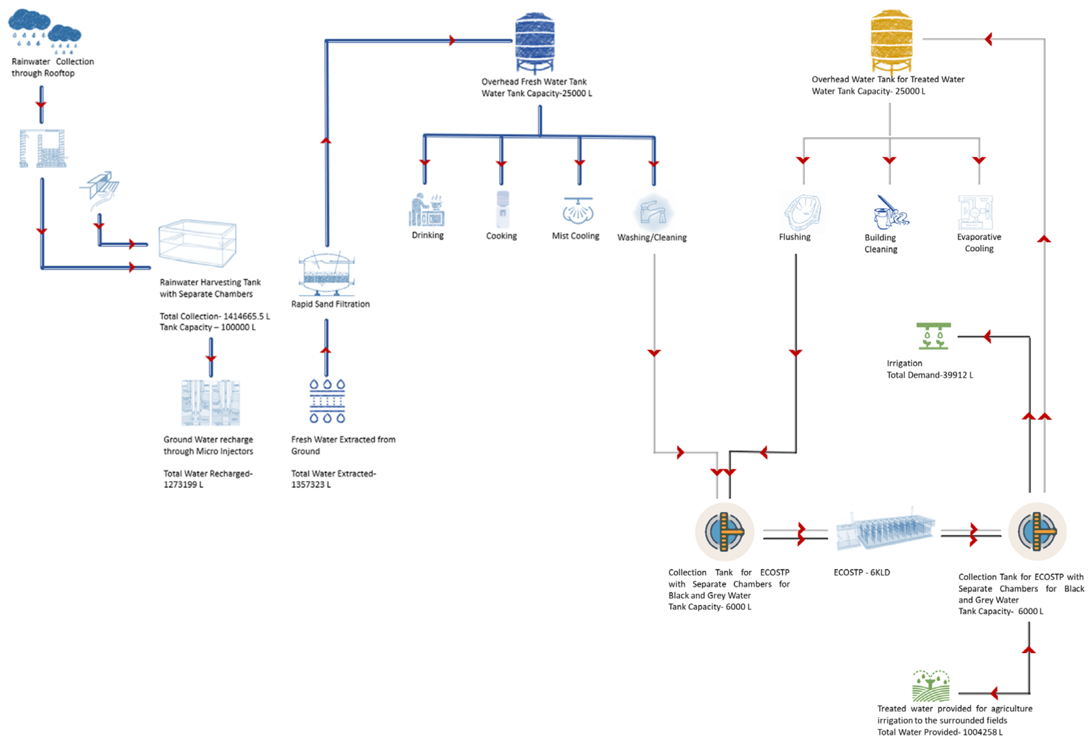
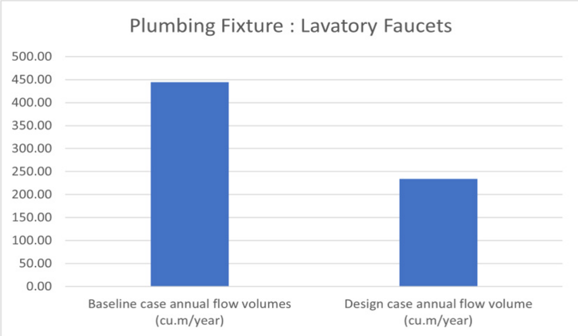


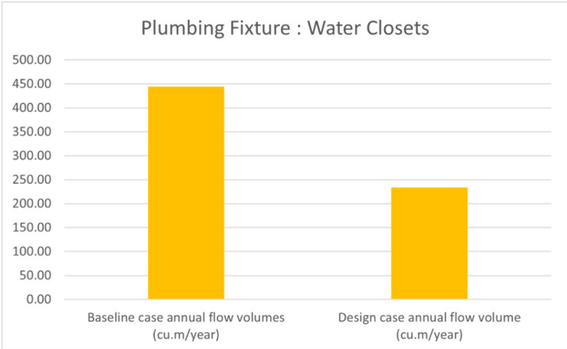
Fig. 5.1- Water Cycle Diagram

MANAGING THE DEMAND SIDE - REDUCING

INDOOR:

The indoor water demand within the building was reduced by using various efficient fixtures including aerators, nozzles and water saving flush bank. Low-cost yet effective aerators and nozzles cut down the water flow to up to 500ml. In addition, few products like water saving flush bank is being implemented, reusing plastic bottles and reducing the flushing demand by 2L per flush. **Thus, the indoor demand of water has been reduced by 66.6%, i.e. 45L per person per day from the base case to 15L per person per day.**





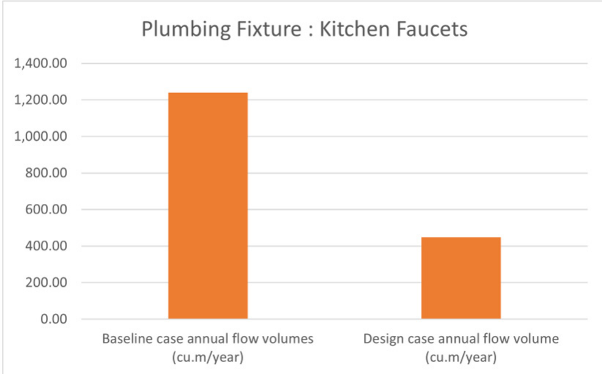


Fig. 5.2 - Comparison between Base and Design Case for Plumbing Fixtures as per LEED's Indoor Standards

OUTDOOR:

The outdoor water demand pertains to landscape plantation and farming. The **combination of effective techniques like Xeriscaping, Mulching, Dryland Agro-forestry and Drip Irrigation** are outlined to reduce and provide an efficient system for outdoor water demandi.e. 45L per person per day from the base case to 15L per person per day.

Xeriscaping - In order to implement the fundamentals of Xeriscaping, native and drought tolerant plants are attentively selected and species with similar water requirements are grouped together.

Dryland Agroforestry - In this, the underground stored rainwater is getting evaporated through weeds and upward movement of water leaving the sub-surface dry. The farming zone is levelled to prevent the rainwater from draining away, for around a week after the first rain, and will be ploughed till one feet depth to remove weeds and capillaries so that the rainwater can seep into the ground. This will be repeated after the rains are over, resulting in the lockage of water in the soil.

Trees and Plants used for Landscaping

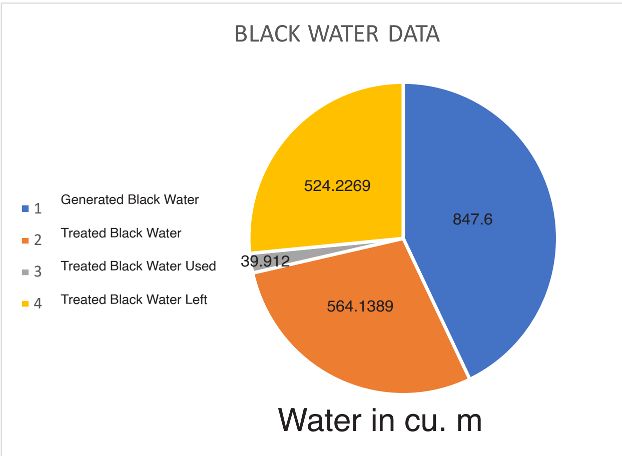
Common Name (Scientific Name)	Image
Red Yucca (Hesperaloe Parviflora)	
Daylilies (Hemerocallis)	
Blanket Flower (Grandiflora)	
Bougainvillea (Bougainvillea)	
Creeping Junipers (Juniperus horizontalis)	
Ber Tree (Ziziphus Mauritiana)	
Butterfly Pea (Clitoria Ternatea)	
Japanese Pagoda Tree (Styphnolobium japonicum)	
Golden Rain Tree (Koelreuteria paniculata)	

Fig. 5.3 - Trees and Plants used in Landscaping
Refer to Landscape Plan in Appendix

MANAGING THE SUPPLY SIDE - REUSING AND RECYCLING ECOSTP

TREATMENT OF BLACK AND GREY WATER:

At Hamara School, **we have incorporated ECOSTP with different chambers to treat grey and black water**. Replica of a cow's stomach , an ECOSTP doesn't use any chemicals or energy to treat the water. Sewage is thus treated by a combination of microorganisms, plants and gravel to clean and return the water. The treated water is used for **flushing, irrigation, building cleaning and evaporated cooling with that about 920 cu m. of water is given to surrounded fields for the usage in agriculture irrigation.**



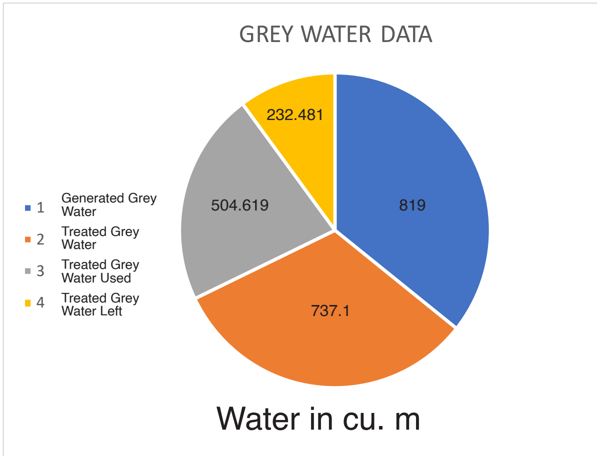


Fig. 5.4 - Black and Grey Water Annual Charts Refer to Water Balance Sheet for Seasonal Data in Appen-

RAINWATER HARVESTING:

All rainwater collected through roof is stored in a 25 cu m. underground water tank and water collected through landscape is used for ground water recharging through micro injection wells. There are in total of 25 micro injections well spread across the site which recharge about 1273 cu m. of water back to the ground. *(refer to Tab. 5.1)*

Rainwater Collected	1414.6655 cu m.
Water Recharged to Ground	1273.199 cu m.
Water Extracted from Ground	1357.323 cu m.
Treated Water Provider for Agriculture	1004.258 cu m.

Tab. 5.1 - Rainwater and Groundwater

MICRO INJECTION WELL SPECIFICATIONS:

Micro Injection wells of 4" diameter, 40 ft deep (designed according to the soil test report and substrata) are 35 ft with aggregate filing and 5 ft 4" (diameter) PVC pipe. Total of 12 wells with 4 wells around the rain water tank , 4 wells for storm water runoff (from the ground), and 4 around the treated water collection tank.

BUILDING TO DWELLING:

In addition to technologies and industrial products, the water performance will rely and simultaneously change dwelling practices, making inhabitants sensitized to water conservation, using multiple form of representation within the school premises. This will initiate ideas and discussions on water conservation in the community.

REFERENCES / NOTES

1. “National Building Code Of India 2016 (Volume 2) : Bureau Of Indian Standards : Free Download, Borrow, And Streaming : Internet Archive”. Internet Archive, 2022 https://archive.org/details/nationalbuilding02.

2. Ecostp.Com, 2022. http://www.ecostp.com/wpcontent/themes/ecostp/assets/whitepapers/ECOSTP_ROI_Whitepaper.pdf.

3. 3. Ecostp.Com, 2022, http://www.ecostp.com/wp-content/themes/ecostp/assets/whitepapers/ECOSTP_Technology_Whitepaper.pdf.

4. 4. Karelia, Gopi. “Can A Tree Grow With Just 1 Litre Of Water? This 68-YO Farmer Has Grown 50,000!”. The Better India, 2022, https://www.thebetterindia.com/189706/tree-planting-how-to-method-advice-water-saving-harvesting-organic-sundaram-verma/.

| VI - ENGINEERING & OPERATIONS |

SYSTEM SIZING & OPTIMISING

LIGHTING

- To achieve proper distribution of lighting as per the spaces requirement in a school facility, proper understanding and designing of spaces as per the conditions set.
- The challenge was to fulfil the visual comfort of the occupant along with taking in consideration the ECBC guidelines.
- During a building's operating time, electrical appliances play a critical part in its overall functioning there for the Use of energy efficient appliances in compliance with BEE Star ratings. With proper designing and wattage use, within the limits of the Super ECBC value the building lighting LPD value is – 4.8. (ECBC- Part 6 – lighting and control-page 61-70)
- The areas were divided into the spaces where most lux was required as compared spaces where least lux was needed. Acc to this distribution, the type of lighting system was implemented and designed. (National Building Code- Part 8: Building Services-Section 1- Lighting and Ventilation, Page-24-25)
- The lighting system is ceiling suspended, ceiling or wall mounted depending upon the need.
- Divided into these considerations-
    1. the class room lighting/utility area -
    2. the corridor lighting / multipurpose room lighting

1. Class room lighting/ utility area -

The space was divided into task lighting, which was over the working plane and ambient lighting which fulfilled the visual comfort for the whole area.

1.1. Luminaire 1-task lighting

Length: 1200 mm, Width: 20 mm, Height: 300 mm

Efficiency: 100%
Luminaire efficacy: 137.93 lm/W (downward- 73.0%, upward- 27.0%)
CIE Flux Codes 83 99 100 73 100
Tot. System power: 29 W

Equipment: 1 x 29W
Total luminous flux: 4000 lm
Luminous flux for emergency lighting: --------

This a suspended acoustic luminaire with low glare optics.
Installation alongside non-luminaire acoustic baffles creates a coherent aesthetic across the ceiling.

Applications: Teaching spaces, Offices, Meeting rooms, Breakout areas, Reception areas

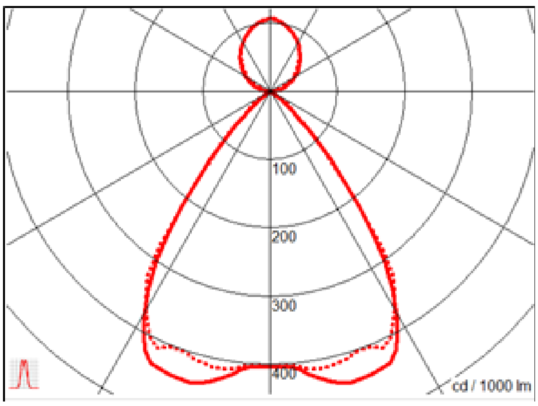


Fig. x-

1.2. Luminaire 2 - ambient lighting

Length: 1200 mm, Width: 20 mm, Height: 20 mm

Efficiency: 100%
Luminaire efficacy: 137.93 lm/W (downward - 99 %, upward- 1%)
CIE Flux Codes: 41 70 89 99 101
Tot. System power: 29 W

Equipment: 1 x LED
Total luminous flux: 4000 lm
Luminous flux for emergency lighting: --------

The luminaire selected provides over 40% energy savings compared to traditional fluorescent, however provides the direct replacements for single or twin fittings in size and output.

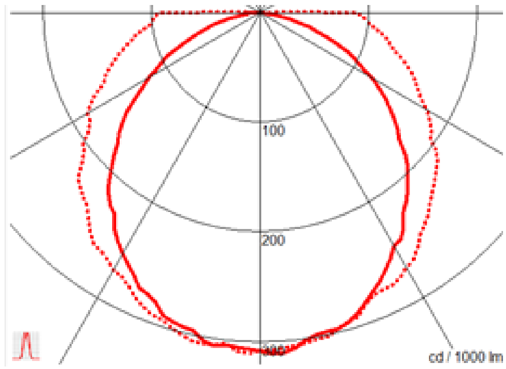


Fig. x-

2. Corridor lighting/ multipurpose room lighting

Luminaire efficacy: 133.33 lm/W (downwards - 100.0%, upwards - 0.0%)
CIE Flux Codes 46 78 95 100 100
Tot. System power: 15 W

Equipment: 1 x LED 830
Total luminous flux: 2000 lm
Luminous flux for emergency lighting: --------

Light source
LED 2000 - 27 000 lumen out
Colour temperature 3000/4000 K, CRI Ra 80

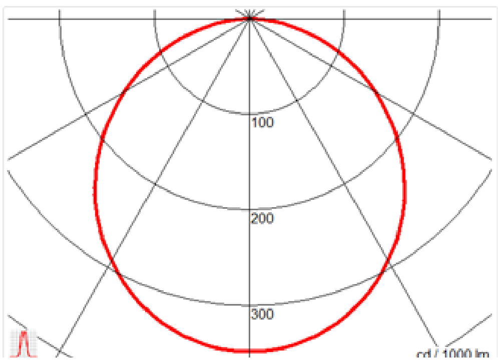


Fig. x-

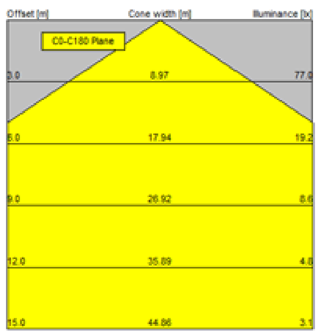


Fig. x-

HVAC SYSTEM

- In order to increase the efficiency of the building, the structure was more accommodating towards passive ventilation system to create a more comfortable built environment.
- This not only reduced the dependence on energy loads but also utilised the importance of mechanical ventilation in areas where it was majorly required.
- Rooms such as conference area and computer labs were installed with 5 star bee rated split ac system with no more than 2 ton per ac requirement.
- The energy load is minimal as well as providing efficient cooling as well as nominal heat load.
- By using the area method for tonnage calculation of the 2 rooms – conference rooms and computer room, we came to the conclusion that 2 ton per ac was enough requirement for both the spaces.
- In consideration to computer lab where system heating may cause the overall thermal load to increase so an extra tonnage is added to compensate, also in case of system failure the main system can still work efficiently.
- Heat rises and so the air conditioning unit inside the room is wall mounted, this unit will only 'push' cool air into the room.

ELECTRICAL SYSTEM

- Power system optimization may help with energy consumption by automatically operating the system and reducing system losses, peak load usage, and control adjustment.
- The power system was considered in such a way to mechanical be while keeping system voltages and equipment loads within the specified range and restrictions.
- Power system optimization can be designed to minimise generating fuel costs, optimise power system functioning, and maximise system security for energy producers or co-generators.
- System optimization offers intelligent load flow solutions that reduce operating costs and improve system efficiency while increasing the return on your energy investment.
- The higher efficiency of the diesel engines compared with gas turbines and small steam turbines in the output range considered. In applications requiring low captive power, without much requirement of process steam, the ideal method of power generation would be by installing diesel generator plants.

Plumbing

- The proximity of the spaces will minimize the amount of large domestic water piping in ceilings. The shorter the runs, the less likely plumbing piping will run into clashes with large mechanical ductwork, electrical conduit or structural elements.
- These conflicts inflate construction costs because they typically require installation of offsets in piping and ductwork, which call for additional costs associated with coordination, material, and labor.
- System efficiency is also jeopardized by the addition of these piping and ductwork offsets.
- Additionally, designing a plumbing system for a building with long piping runs will have a significant impact on the budget of the entire design team.
- It is important to choose quiet type of sanitary fittings and to design the plumbing system so as not to create noise by avoiding sharp bends, restrictions of flow, quick-action valves that might cause water hammer, etc.
- Sewage or other waste will not be discharged into surface or sub-surface water without acceptable form of treatment.
- Plumbing system is installed with due regard to preservation of the structural members and prevention of damage to walls and other surfaces.
- Polyethylene and unplasticized PVC pipes is not installed near hot water pipes or near any other heat sources.
- The bottom of the water service pipe, at all points, is at least 300 mm above the top of the sewer line at its highest point.
- Gravity Distribution System is the most common water distribution system. The system comprises pumping water to one or more overhead water tanks. Water transferred to overhead tank(s) is distributed by gravity to various parts of the building by the system of piping network.
- As per NBC standards a minimum of 15 mm pipe is to be used

Water Supply

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

Vt = 3.0 (Q/d) 2/5

Lt = 0.052 Vt

Drainage

Flow capacity can be expressed in terms of the stack diameter and the water cross-section, as follows:

Q = 27.8 × rs 5/3 × D8/3

Q = capacity, l/s;

rs = ratio of the cross-sectional area of the sheet of water to the cross-sectional area of the stack;

Rain water harvesting

The roof area (RA) for drainage may be worked out by using:

RA = 0.084 × d 5/2/I

RA = roof area, m2;

d = pipe diameter, mm; and

I = intensity of rainfall, mm/h.

| VII - INNOVATION |

"Innovation is the process of creative destruction"
Abhijit Banerjee. Good Economy for Hard Times

The Builders have aimed to find innovative design solutions by focussing our to provide movable and flexible systems to the client, which are feasible and scalable in terms of market potential, as well as allowing us to involve the community in the building process.

TERRACOTA BLOCKS

Our design uses perforated jali wall made from terracotta blocks, developed on site using the excavated earth with the help of potter community, laid parametrically on the south-eastern façade (For the composition of the terracotta block refer to fig 7.1 in annexure) Making terracotta blocks is feasible and easy for us as we found out that our topsoil layer consists of 80% clay through soil test conducted by the team (Refer to annexure 7.2 for soil composition).

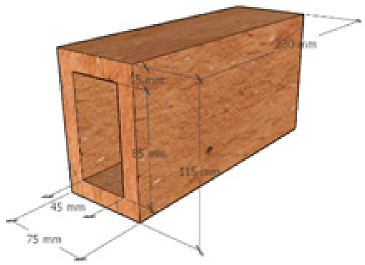


Fig. 7.1 - Terracotta block design and dimensions

Terracotta being a bad conductor of the heat will act as an insulator for the building, protecting the building and its occupant from composite climate by providing natural ventilation. The proposed terracotta blocks have also been used as a design element in the building in boundary walls cutting down the project cost, while allowing visual linkage and porosity (Refer to annexure 7.3 for boundary wall detail)

RAMMED EARTH WALL

From the beginning, our design motto has been to work with and for the community. Rammed earth wall is a unique way to bring the community and stakeholders together. Similar to Terracotta Blocks, site excavated soil will be used for making rammed earth along with lime, coarse sand, and cement. Use of rammed earth wall enables good thermal performance, and is also an innovative answer to the aesthetic question. (Refer to annexure 7.4 for composition of the wall)

Fig 7.2 - Rammed Earth Wall section (material testing done by students)

PARAMETRIC KINETIC BRICK FENESTRATION FAÇADE

The terracotta brick jali in our design is also a parametric façade in which the bricks around the staircase are rotating about z axis and moving in x-y plane to form a wave pattern (Fig. 7.3) providing shade to the staircase from the south-eastern sun. (fig. 7.5)

We took it to another level by making the façade adjustable to light and ventilation. The wall consists of three revolving brick sections (Fig 7.4) adjacent to the sitting areas in the staircase which will allow the occupants to control the light and shade entering inside the building by adjusting/ rotating bricks with help of the lever (For the details of the same please refer to annexure table 7.1 and Fig.7.5)

Fig. 7.3 - Wave pattern used for the fenestration

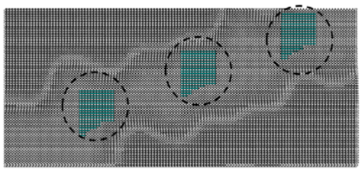


Fig. 7.4 - Revolving bricks location on the wall

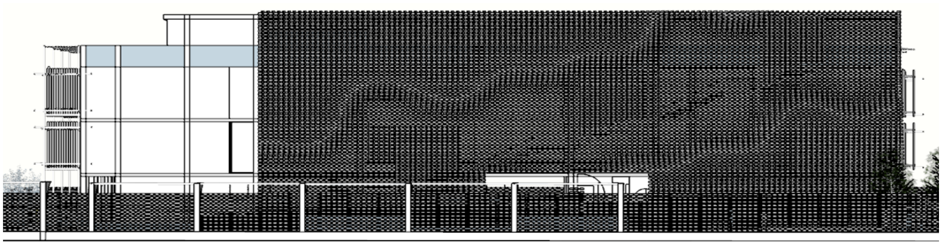


Fig. 7.6 - South-eastern Façade of the proposed design to showcase the parametric brick jali pattern

Fig. 7.5 - Inside View

BAMBOO SCAFFOLDING (AS EXTERNAL SHADING DEVICE)

To provide external shading to the windows, we have proposed the use of bamboo framework and horizontal and vertical mat weaved bamboo shades (Annexure Fig. 7.6) , as shading device for our building. Interesting fact about this bamboo shading is that it is not permanent, and the occupants will be able to remove it in winters, (fig 7.4) allowing the winter sun enter the building.; thus climatic adaptability. Use of bamboo scaffolding allows the locals from the adjacent village to engage in the building process of the school as creation of this device doesn't require technical skill.

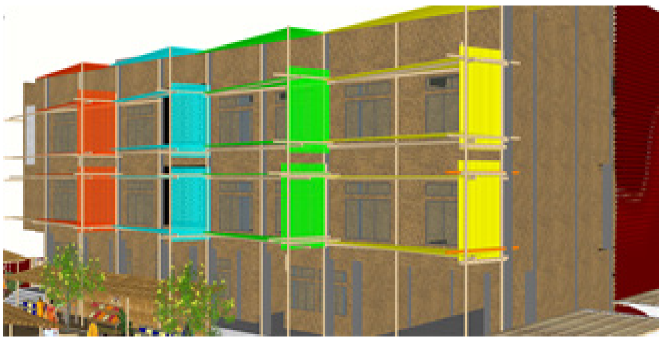


Fig. 7.7 - In summers, with external shading

Fig. 7.8 - In winters, without external shading

LIGHTING FIXTURE

For artificial lighting, we have devised a cost-efficient aesthetic task lighting fixture that will be used by the occupants in evening times for efficient lighting. This light has been innovated with the help of our industry partner Mr Mudassir Ahmed Khan from Metacity. Developing this light fixture helps us in cut down our project cost as this will be made in 490 per fixture whereas the market value for similar fixture starts from 2500rs. In our fixture we have also optimised the light flow with the help of reflective material (For details of the same, kindly refer to annexure 7.11)

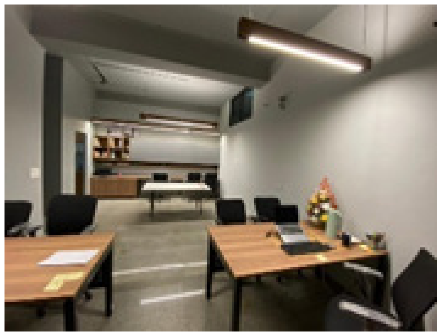


Fig. 7.9 - Lighting Fixture (tried and tested)

COMMUNITY SPACES

Our design enables the client to generate revenue from the building itself therefore for the same, we have utilised our setback area with temporary thatched roof bamboo kiosks. These kiosks will be built using the indigenous skillsets we have but will also help in empowering the people from the adjacent village. The space will also be used for weekly bazaars opening the school boundaries for the people from community. The idea of these structures come from our site visit to the adjacent village named as Nagla Bhaibeg and hence will be built with the help of migrant farmer labour.

Fig 7.10 - Community Spaces

(You can refer to our social media www.instagram.com/thebuilders.2021 or our blog https://thebuilders783003960.wordpress.com/ to know more about our site visits)

SEAMLESS PLAY AREA

Throughout the procedure of designing the school campus, our moto was to utilize the given space with efficiency and thus providing enough space to students. For the same we developed a seamless play area that forms an extension of the built making the built fused with the earth. This extends the play area for the students throughout the building's open spaces. (For details, refer to landscape plan provided in annexure)

Fig. 7.11 - Section of seamless play area allowing the students to flow between the ground and the built

MICRO INJECTION WALL

For fast and effective rainwater harvesting for ground water recharging, we are using micro injection wells. The use of Micro Injection Wells solves three problems – reduces the risk of flooding, recharges the groundwater, and is 50 per cent cost efficient than conventional rain water harvesting pits. (For further details refer to the figure no XYZ in the appendix ABC water section in the report)

MICRO INJECTION WALL

For fast and effective rainwater harvesting for ground water recharging, we are using micro injection wells. The use of Micro Injection Wells solves three problems – reduces the risk of flooding, recharges the groundwater, and is 50 per cent cost efficient than conventional rain water harvesting pits. (For further details refer to the figure no XYZ in the appendix ABC water section in the report)

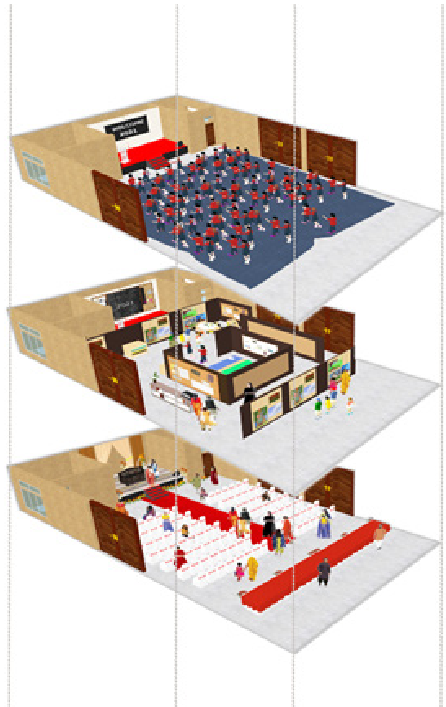


Fig. 7.12 - multipurpose hall being used for marriage, exhibition and school event

| VIII - AFFORDABILITY |

The overall costs of our project are 30.7% less than the proposed costs of the building.

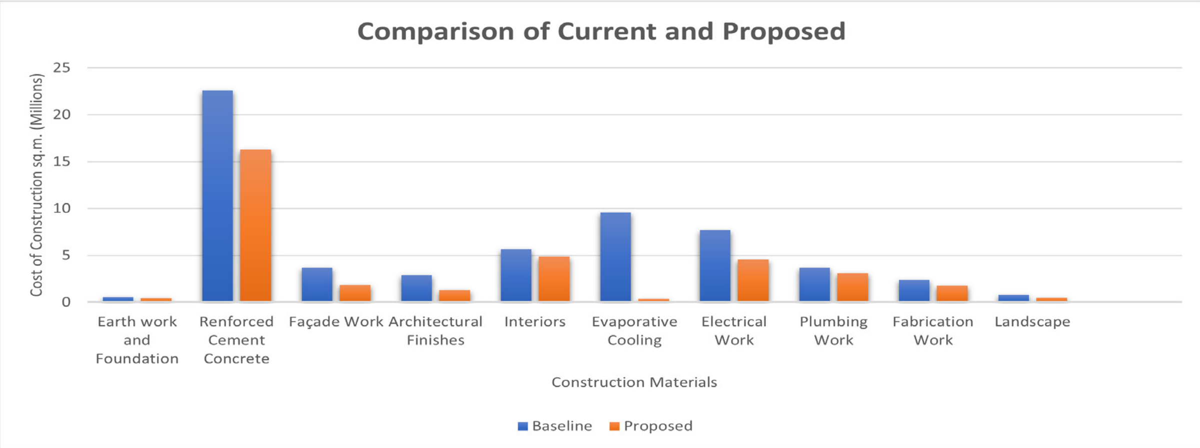


Fig. 8.1 - Comparison of Current & Proposed Costs

APPROACH AND ORIENTATION

Our name is The Builders because we are focussed on making buildings, which means all aspects of building. Our tagline is “From Building to Dwelling”, because we believe (and propose) that affordability is a function of both building and dwelling. Therefore our approach to affordability is a combination of building practices and lifestyle practices.
Following our approach of utilizing the material and human resources available to us, we have been able to build a high performance, net zero campus without pushing the costs through the roof. Our method has been to be very meticulous, paying attention to each and every component of the building.

DESIGN STRATEGIES FOR OPTIMIZING THE COSTS

A. CIVIL WORKS

We were able to reduce the costs by following the approach of three R’s, in which the application of locally available low- cost natural and recycled materials sourced easily from the local suppliers lowered down the transportation energy and associated costs while initiating community participation in construction and maintenance activities for various aspects of roofing, shading, wall, screening and planting. These not only provided cost benefit but also helped in reducing waste generation, mitigating environmental costs, and minimizing maintenance. Overall, the building design utilises no OPEX and minimum CAPEX to save the costs while the friendly nature of materials allows students to play with, thereby catering to the welcoming environment for individuals.

For more detailed calculations on cost performance refer to the sheet Cost of Construction in D4_EDU_TheBuilders_CostEstimate.xlsx excel workbook.

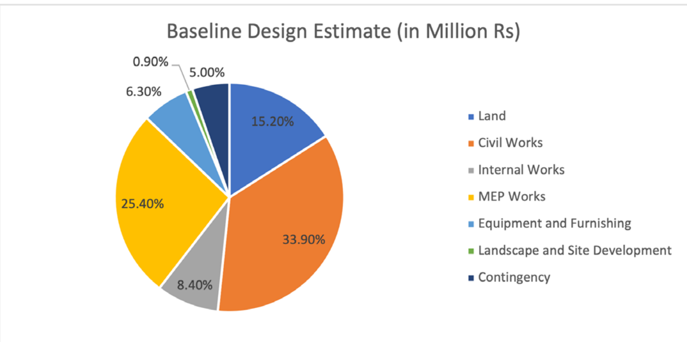


Fig. 8.2 - Baseline Design Estimate (in Millions Rs.)

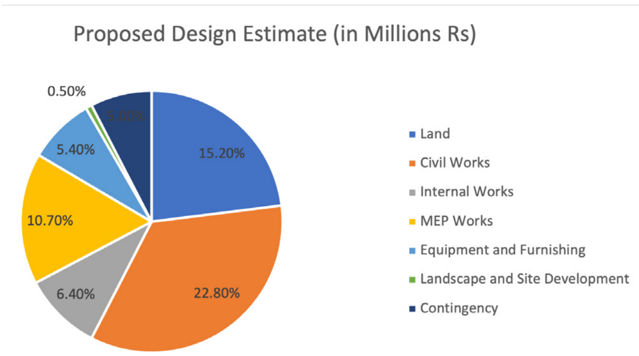


Fig. 8.3 - Proposed Design Estimate (in Millions Rs.)

* Assumptions are based on current market price estimates and availability

B. WALL ASSEMBLY

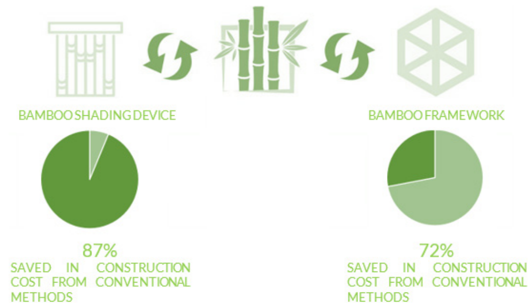
The wall assembly made up of stabilized rammed earth blocks prepared from the soil excavated from the foundation, decreases the cost of the construction by 50% when compared to brick masonry wall system. (Refer to the sheet Cost of Construction in D4_EDU_TheBuilders_CostEstimate.xlsx for more detailed cost estimation) The density, thickness, and thermal conductivity of rammed earth render it an especially suitable material for passive solar heating and being sourced at the site itself, the cost and energy consumption of transportation are minimal as shown in Tab. 8.1. [(1) (2)] , Moreover, the rammed earth construction makes the structure lighter by reducing the steel requirement and allowing for future expansion.

Cost Saving in Materials					
S.no	**Material**	**R Value**	**U Value**	**Costing Reflect[3]**	**Remarks**
1	AAC Blocks (200mm)	0.95	0.67	200%	The costing reflect is calculated with respect to the cost of brick masonry work.
2	Glass	0.96	2.6	50%	
3	Brick Masonry	0.31	2.28	100%	
4	Fly Ash Masonry	0.55	1.79	80% - 100%	
5	Rammed Earth Masonry (300mm)	1.86	1.2	50%	

Tab. 8.1 - R-Value, U- Value and Cost Comparison of Building Materials.

C. INTEGRATION OF PASSIVE DESIGN FEATURES

WIth regards to the passive performance, the open courtyard like spaces with trees planted and appropriate landscaping creates a microclimate inside the building by bringing in good ventilation as shown in contest 6.2. The bamboo framing designed according to the position of the windows allows for complete flexibility with respect to the weather and sun altitude while providing sufficient shading and comfortable daylight throughout the day. The parametric façade on made up of recyclable hollow terracotta bricks dried and made on the site with the help of local community acts as a self- cleaning agent that cools the air.



Tab. 8.1 - Utilizing low-cost material- Bamboo Shading Device

D. BUILDING SERVICES

For Water systems, we are using low flow plumbing fixtures which helps in reducing the water consumption amount. (Refer to 6.5 contest for detailed analysis) While the building's freshwater requirements are fulfilled by harnessing and utilising rainwater which omits down the cost of monthly water bill, the ECOSTP with its different chambers for treating grey and black water recycles the dirty water and makes it an efficient source for irrigation and flushing, making it cost effective. Compared to the conventional STP, the ECOSTP minimal operational expense with lesser maintenance makes it an efficient pay out as shown in Tab. 8.2.[(4)]

	ROI Comparison of ECOSTP in comparison to Conventional STP						
		Conventional STP- CAPEX	**ECOSTP- CAPEX**		**Lifecycle cost**		**Savings- ECOSTP**
		₹ 9,00,000	₹ 13,00,000				
S. No.	**Year**	**Conventional STP- OPEX**	**ECOSTP- OPEX**	**Yearly Savings**	**Conventional STP**	**ECOSTP**	
1	1	₹ 36,000	₹ 9,000	₹ 31,500	₹ 9,36,000	₹ 13,04,500	₹ (3,68,500)
2	2	₹ 39,600		₹ 35,100	₹ 9,75,600	₹ 13,09,000	₹ (3,33,400)
3	3	₹ 47,520	₹ 9,000	₹ 43,020	₹ 10,23,120	₹ 13,13,500	₹ (2,90,380)
4	4	₹ 52,720		₹ 48,220	₹ 10,75,840	₹ 13,18,000	₹ (2,42,160)
5	5	₹ 57,499	₹ 9,900	₹ 52,549	₹ 11,33,339	₹ 13,22,950	₹ (1,89,611)
6	6	₹ 63,249		₹ 58,299	₹ 11,96,588	₹ 13,27,900	₹ (1,31,312)
7	7	₹ 69,579	₹ 9,900	₹ 64,629	₹ 12,66,167	₹ 13,32,850	₹ (66,683)
8	8	₹ 76,531		₹ 71,581	₹ 13,42,698	₹ 13,37,800	₹ 4,898
9	9	₹ 84,184	₹ 10,890	₹ 78,739	₹ 14,26,882	₹ 13,43,245	₹ 83,637
10	10	₹ 92,602		₹ 87,157	₹ 15,19,484	₹ 13,48,690	₹ 1,70,794
	Total	**₹ 6,19,484**	**₹ 48,690**	**₹ 5,70,794**			

Tab. 8.2 - ROI Comparison of ECOSTP in Comparison to Conventional STP

* Assumptions are based on current market price estimates and availability

E. SUB- COMPONENT AND ACCESSORIES

The door and window frame assemblies are chosen from the local markets which use natural and recycled materials and provides benefits pertaining to reduced waste generation, lowering project's material costs, and mitigating the environmental costs necessary to produce new materials.

Fig. 8.5 - Steel Factory in Aligarh

MS Framed windows with rubber gaskets to seal the air gap between the glass thermally insulate the spaces and prevent the heat gain from convection thereby reducing the indirect costs of energy consumption. (Refer to the sheet Cost of Construction in D4_EDU_TheBuilders_CostEstimate.xlsx for more detailed cost estimation)

F. EFFICIENT ELECTRICAL APPLIANCES

Electrical appliances play a major role in entire functioning and costing during the operational phase of a project. Efficient appliances reduce the energy consumption and hence the associated costs of electricity. Table 8.3 and Table 8.4 represents the energy and cost comparison of different appliances used in both conventional and proposed case alongwith the comparison of return of investment. [5]

For the unmet thermal comfort hours, a radiant evaporative cooling system is proposed for conditioning the unconditioned spaces. The evaporative cooling system when compared with the conventional HVAC System shows that it is more efficient. With regards to cost the proposed system saves 85% of the total cost as compared to the conventional one as shown in Table 8.3.

		Annual Energy Consumption			Annual Cost Saving		
S.No.	Appliances	Conventional (kwh)	Proposed (kwh)	Remarks	Conventional (₹)	Proposed (₹)	Remarks
1	Ceiling Fans	31200	10080	Assuming that the school is run for 8 hours a day and 11 months a year wherein in the case of conventional the power consumed is 70W and in proposed is 35W.	₹ 2,80,800	₹ 1,81,440	Taking 9 Rs/unit the cost of electricity in Aligarh.
2	Tubelight	18180	13324		₹ 2,51,547	₹ 1,89,468	
3	Radiant Evaporative Cooling	180180	2574	Assuming that the system is functional for 6 hours a day and 11 months a year wherein in the proposed case only the electrical motor will consume the power.	₹ 16,21,620	₹ 23,166	The CAPEX cost of 70 tonne VRV system is higher than of proposed radiant evaporation cooling system.
	Total	229560	25978		₹ 21,53,967	₹ 3,94,074	

Table 8.3 - Energy Consumption and Annual Cost Saving comparison of appliances used in conventional and proposed case.

	ROI comparison for conventional and efficient electrical appliances								
S.no.	Appliances	Case	Total Expenditure in 1st Year	Total Expenditure from 2nd year to 10th year	Total Expenditure in 10 years	Total Savings in 10 Years	ROI	Payback Period	Remarks
1	Ceiling Fans	Conventional	₹ 4,62,800	₹ 25,36,950	₹ 28,17,750	₹ 9,89,490	54.12%	2 years (Approx.)	For the first year, the cost of expenditure includes the capital, operational and maintenance cost whereas for the progressive years it includes only the operational and maintenance cost.
		Proposed	₹ 4,58,640	₹ 16,46,820	₹ 18,28,260				5- Star Rated BLDC Fan
2	Tubelight	Conventional	₹ 5,53,947	₹ 22,63,923	₹ 25,28,047	₹ 6,23,894	32.76%		For the first year, the cost of expenditure includes the capital, operational and maintenance cost whereas for the progressive years it includes only the operational and maintenance cost.
		Proposed	₹ 3,12,948	₹ 17,05,212	₹ 19,04,153				
3	Radiant Evaporative Cooling	Conventional	₹ 40,50,000	₹ 9,55,000	₹ 11,86,500	₹ 10,02,225			The conventional case has a VRV System of 70 tonne wherein the annual maintenance contract is taken to increase by 10% per year.
		Proposed	₹ 6,00,000	₹ 1,48,500	₹ 1,84,275				The proposed case of radiant evaporative cooling has lesser maintenance cost

Table 8.4 - ROI Comparison for conventional and efficient electrical appliances

F. INTERIORS & FINISHES

The interior spaces are well planned and designed wherein the partition walls are made up of rammed earth in comparison to conventional brick wall. The concrete pigmented floor finishes and paints are decided after a coherent market survey and cost analysis of all the materials that were of a certain quality befitting the school. Moreover, the team has succeeded in saving the costs on plastering and whitewashing the walls by using a rammed earth construction as wall assembly whose natural and organic texture does not require additional finishing works.
For more detailed calculations on cost performance refer to the sheet Cost of Construction in D4_EDU_TheBuilders_CostEstimate.xlsx excel workbook.

REFERENCES / NOTES

1. Indian Green Building Council, Building Insulation, April 2008

2. Green Rating for Integrated Habitat Assessment, Materials and Energy Efficiency.

3. Delhi Schedule of Rates, CPWD, Vol 1, 2021

4. ECOSTP

5. Delhi Schedule of Rates, CPWD, Vol 1, 2021

| IX - SCALABILITY & MARKET POTENTIAL |

"In the long history of humankind those who learned to collaborate and improvise most effectively have prevailed." — Charles Darwin.

From the beginning, our approach towards building Hamara School has been need-based, or gap-based, and our goal has been to probe the nature of this need or gap in sufficient depth. But what is the nature of this need/gap?

Our problem statement therefore is – how to build incessant and deep-rooted mechanisms of exchange and dialogue between the school and the disaffected communities, to the point where they become indistinguishable from one another?

While delving deeper, it became evident that the problem was not merely lack of education, literacy, marginalization, but an overarching disconnect between schools and communities.

The major impediment is the disassociation-cum-alienation of the school stakeholders with that of the disaffected communities. Our method is to find ways of building which multifariously conjoin the school and the community.
vvOur modus operandi is to create multiple cross-linkages between our target markets, which we define qualitatively as well as quantitatively in the analysis and the diversified problems we are resolving through Hamara School. We have identified and analysed key target markets, as well as the ways in which these can be absorbed by the market, and our mantra is repeatability, replicability, desirability.

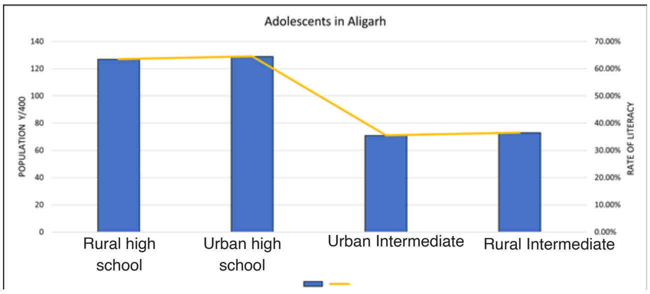


Fig. 9.1 - Adolescents in Aligarh

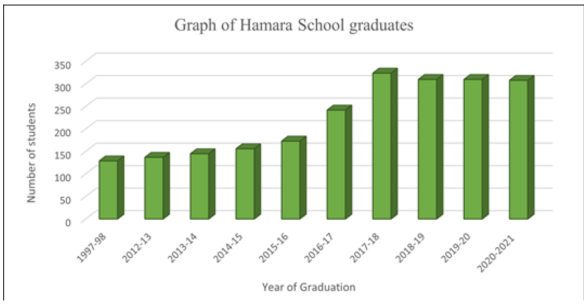


Fig. 9.2 - Graph of Hamara School Graduates

To begin with, we have conducted a thorough quantitative research on the size of our primary targets, the students in Aligarh. The uniqueness of our project comes from the hub and spoke model which caters equally to the rural and urban(and/ intermediate) adolescent student populatio ns of the city *(Fig. 9.1)*. The creation of the new hub of Hamara School would allow for us to build more spokes in the city of Aligarh in a repetitive and replicable pattern.

The past success of Hamara School has proved it that the right training, sensitivity, and education can change the lives of these children. Recent graduates of the school are enrolled in engineering courses, interested in microbiology, or teaching in Hamara School itself. Hence, the future of this model of education and training is certainly going to be fruitful for the children of Aligarh and other places across India.

The chart and graph *(Fig. 9.3 & Fig. 9.4)* depict the past and future projections of the Hub and spoke model which is run by Hamara School.

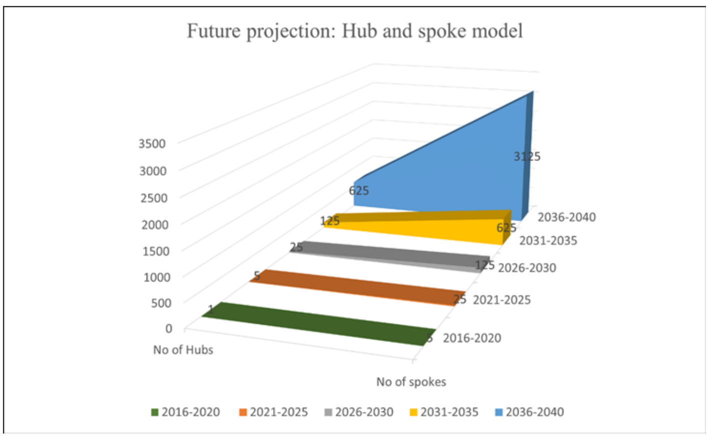


Fig. 9.3 - Future Projection: Hub and Spoke Model

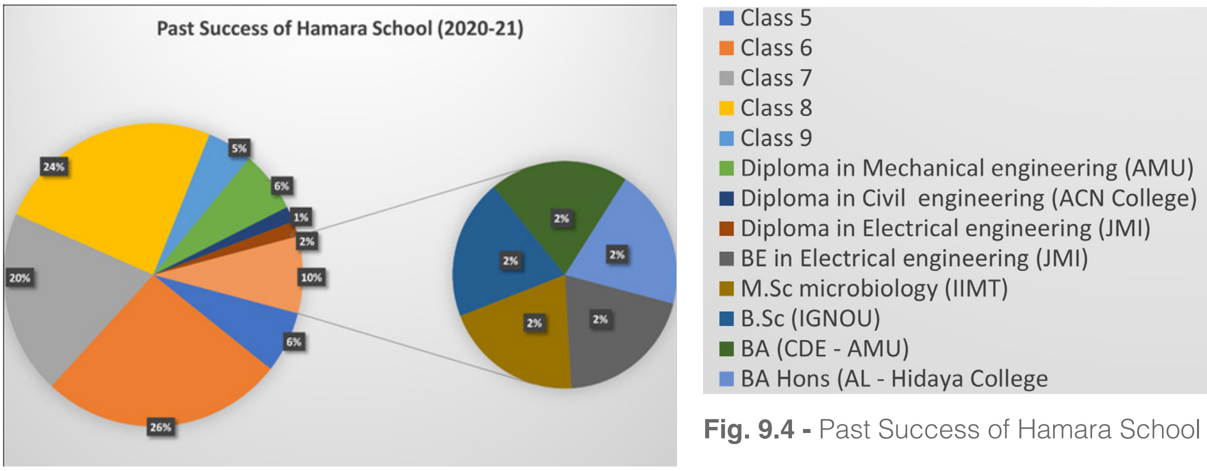


Fig. 9.4 - Past Success of Hamara School

ANALYSIS OF THE TARGET MARKETS, GAPS & PROPOSED SOLUTIONS

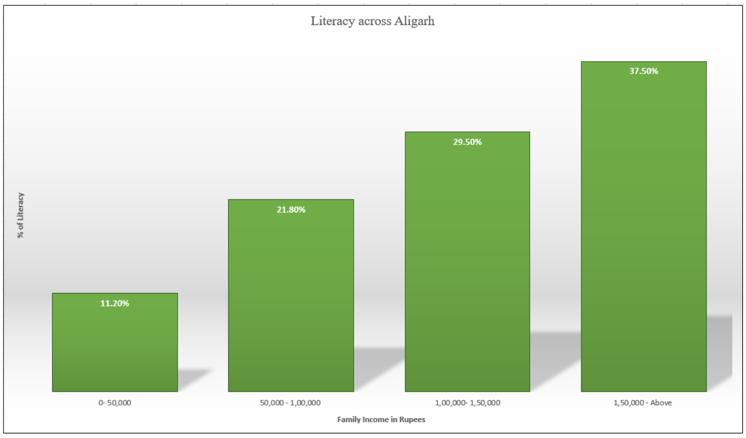
A. STUDENTS, ALUMNI, FAMILIES NEED / MARKET GAP / PROBLEM ANALYSIS

- Narrow, limited meaning of education & empowerment which is limited to classroom and textbook.
- Antipathy towards the monetary and affordability concerns of the students and their families.

<u>Proposed Solutions at Hamara School:</u>

- Our project follows the praxis of ‘environment as education’ to inculcate critical thinking, ecological sensitivity and humanity.

- Hamara School creates a programmatic model which combines a school and a vocational/skill-building institution. Young adults/professionals can choose to acquire vocational training to support.



The exponential graph indicates that there is a dire need for empowerment and adequate education in the lower income households to uplift their living conditions.

Fig. 9.4 - Literacy across Aligarh

B. TEACHERS, EDUCATION EXPERTS & ADMINISTRATORS NEED / MARKET GAP/ PROBLEM ANALYSIS:

- Archaic and outdated models of teaching, learning and sensitization which are disjointed from life and realities of existence.

- Deterioration in the teaching/education quality of hitherto good community-orient-ed schools (for the non-privileged) in Aligarh because of not making it economically self-sustainable and enterprising.

<u>Proposed Solutions at Hamara School</u>

- Hamara School is poised to be a living educational lab where diversified specialists, skilled experts will work with and train the students and teachers, allowing for a wide range of career options and skill building.

- Hamara School is being modelled on a cross-subsidy model where the school space and resources will be let out for events and functions in the evenings, resulting in revenue generation which will help in financial sustainability and independence.

C. LOCAL (DISAFFECTED) COMMUNITIES, VENDORS & HUMAN RESOURCE NEED / MARKET GAP / PROBLEM ANALYSIS:

- Complete disregard and exclusion of local and disaffected communities in the making and running of schools, which creates polarities between the school and the people it is supposed to empower.

Proposed Solutions at Hamara School:

- At Hamara School, the school and community are fused into one. Local populace will have access to the campus for community facilities and functions in the multipurpose hall, grounds, open spaces, etc. for social, cultural, and economic exchanges.
- A dedicated health centre and information centre to support the disenfranchised and the disaffected.
- The pie chart (shown in Appendix 9, Fig. Ax) critically analyses the occupation of residents in Begpur (the new site) and highlights that out of the 8643 people, 6056 are classified as "non-workers". This is a disparity which is extremely concerning and something we shall strive to change in the sub-district.

A. CONSTRUCTION WORKERS NEED / MARKET GAP / PROBLEM ANALYSIS

- The scope lies in interdisciplinarity and inter-exchange of expertise – design, material, construction – all three-expertise working and building together. Exclusion of masons, craftsmen, skilled workforce from the design and building process.
-

Proposed Solutions at Hamara School:

- At Hamara School, we are working with the construction workforce in enabling building solutions as well as facilitating exchange of knowledge and expertise. Our strategies of in-situ utilization of earth into rammed earth construction and terracotta blocks is an intersection of designer, mason, and craftsperson.

- People who earn a living from working as construction labourers, have construction, building, interior finish-related business. For example, people who are involved in painting work, carpentry, trading in GI pipes, jaali craftworks, etc *(refer to Fig. 9.5)*

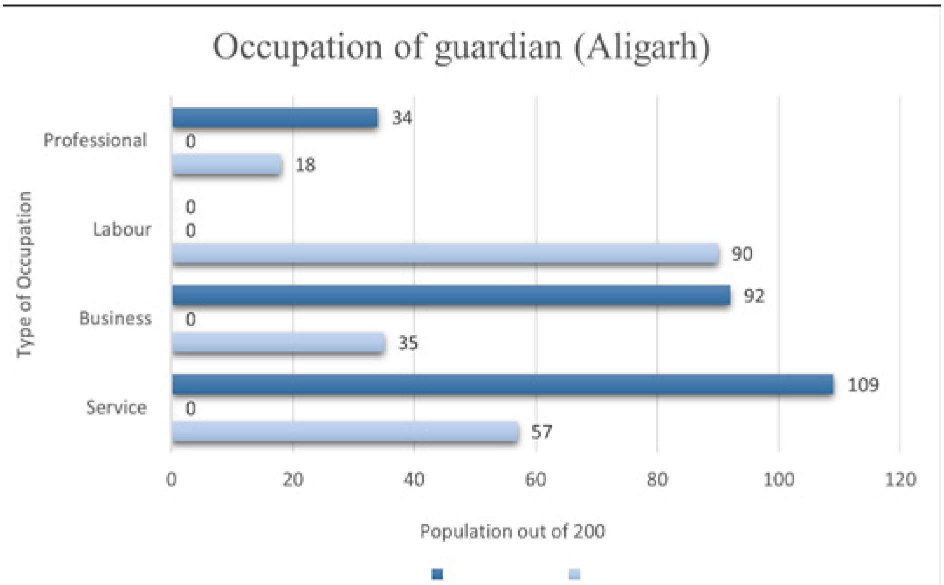


Fig. 9.5 - Occupation of guardian (Aligarh)

REFERENCES

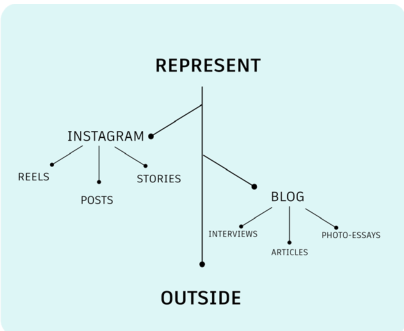
1. Singh , V., & Thakur, S. (n.d.). The Journal of Rural and Agricultural Research Vol. 13 No. 2, 36-38 (2013) . To Study the Distribution of Adolescents According to Education, Age, Occupation of Father and Yearly Family Income in Rural and Urban Areas of District Aligarh (Uttar Pradesh).
2. School , H. (2021). (rep.). Annual Report 2020-2021 (pp. 1–25). Aligarh , UP: Society for Human Welfare & Education.
3. Faruquie, D. S. (Ed.). (2018). ANTHROPOLOGICAL BULLETIN A peer-reviewed International Journal Volume 10, Issue 1, March 2018. (Special Issue). Special Issue: Women and Children's Perspectives, 10(1).
4. Government , I. (2022). Population enumeration data (final population). Census of India Website : Office of the Registrar General & Census Commissioner, India. Retrieved April 9, 2022, from https://censusindia.gov.in/2011census/population_enumeration.html
5. Orgi, I. G. (2011). C-11 population attending educational institution by completed education level, age, and sex - 2011. Census of India Website : Office of the Registrar General & Census Commissioner, India. Retrieved April 9, 2022, from https://censusindia.gov.in /2011census/C-series/c_11.html
6. School, H. (2021). Society for Human Welfare & Education. Retrieved 2021, from www. hamaraschoolaligarh.com.
7. Discussions and help with District, Sub-district and ward data received from – Mariya, ICSSR Post-Doctoral Fellow (Social Geography), Aligarh Muslim University, Aligarh
8. Discussions and help received from stakeholder – Ahmed Faraz Khan, administrator, Hamara School, Aligarh

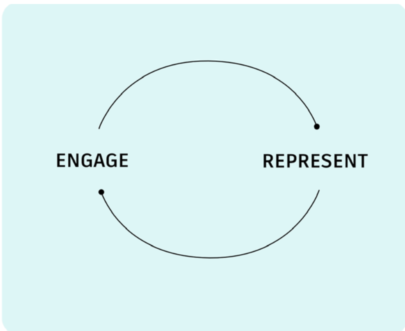
| X - COMMUNICATION |

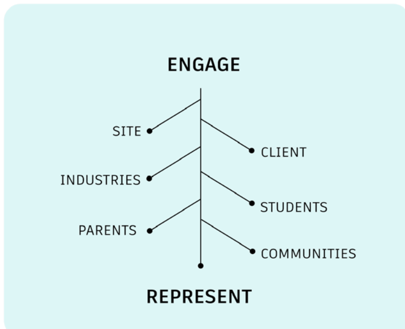
As a team, we were conscious that our role was not only to aid in designing the built aspects of the Hamara School which in turn would be in conversation with their pedagogy but also had the onus to represent their method and condition to the outside world. Our strategy to address the communication contest was hence two-fold. First, to engage and unpack and then to communicate. For us, before we could re-present we had to first occupy the present i.e, the constraints and complexities of the site.

We, therefore, set out for the series of site visits – interacting with communities in and around Aligarh, engaging with the students enrolled at the Hamara as well as their parents, visiting industries to discover the materials locally sourced and methods implemented. And - needless to say, our project partners – folks responsible for running the Hamara school - were kept on speed-dial!

The digital medium – social media sites and blogposts – were then used to communicate our interactions. However, a key learning while covering this contest for our team was, we realised our initial strategy of engaging then representing could not be reduced to a simple linear relation. There was not a definite period where we halted our interaction and transitions into communications. The process was of a constant back-and-forth.







LOCAL INTERACTIONS

For us, the term communication was not just limited to the social media marketing and outreach that we had planned out, but it also included several physical out¬reach programs like visiting another school in Anupshahr named Pardada Pardadi School, which were conducted in an organic fashion while visiting the site, talking to the primary and secondary stakeholders of the project, and explaining to them how building a net-zero educational institution would benefit everyone involved.

Fig. 10.1 - Interacting with the locals near our site

VISITING THE LOCAL INDUSTRIES

We expanded our physical outreach initiatives at the lo¬cal ceramic and steel and locks industry where we ex¬plained our work, and also got many of them to sign up for the construction work of the current project. The local workers, farmers and experts' advice also shaped our design and helped us formulate the frontage of the site.

Fig. 10.2 - Interacting with the local industry workers

INTERACTING WITH STUDENTS & PARENTS: OUR CO-BUILDERS

We organised interactions with the parents of the cur¬rent students of Hamara school. Everyone was excited to bring their expertise and skills in building and shaping the project and really making it "Hamara school" with its sense of belonging.

Fig. 10.3 - Interacting with the students' parents of Hamara School

DIGITAL COMMUNICATION

INSTAGRAM

Our Instagram page, (USERNAME: thebuilders.2021) was designed in a clean and simplistic fashion, in order to broadcast our message clearly. #solardecathlonindia was a hashtag that we made sure was used effectively in every post, reel, and story that we designed. Promotion of this page was done in two phases:

In phase one, we reached out to all our contacts and college students/ faculty who were interested in knowing our work and what we were involved in as a team. We tagged Aligarh, Uttar Pradesh, India and used relevant hashtags of similar names, and terms to create an engaging audience and generate awareness about the stakeholders of the school.

In phase 2 we started off by making reels and expanding the target audience. Our out¬reach was at its highest when we made reels, and that made our social media an engag¬ing platform for other creators, students from several design backgrounds, and the larger target audience which includes all school related stakeholders. With 40 posts, 163 engaged followers, and active 87% user interactions amongst our audience, we are determined towards achieving our goals!

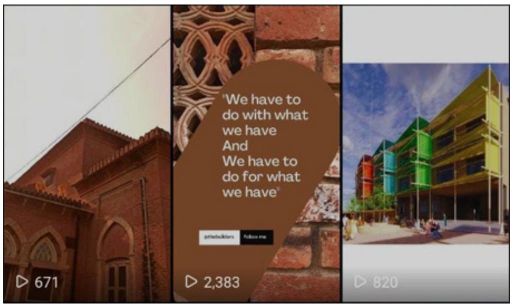
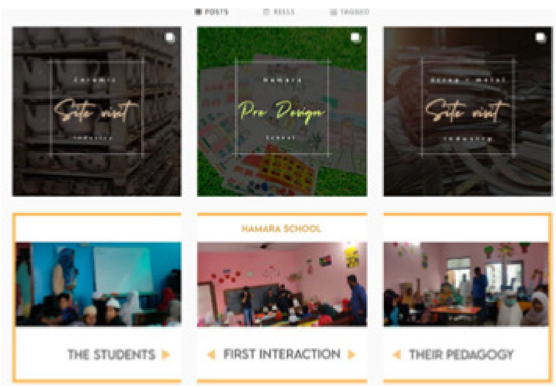


Fig. 10.4 - Reaching around 13,000 views on our reels!



WORDPRESS BLOG SITE

Our second mode of communication was via a blog page and the target audience here in-cluded professionals in academia, university students, and the global network of WordPress readers. Some of our blogs were written by our client, some students included their experi-ence of the site, and its larger relevance to the work they did for the net deliverable. Panned out across a variety of topics, we made sure our readers had something new, engaging, and important to read about!

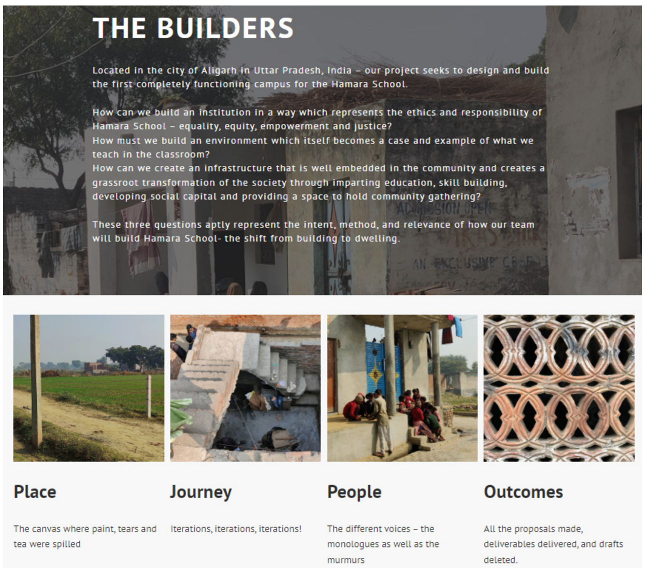
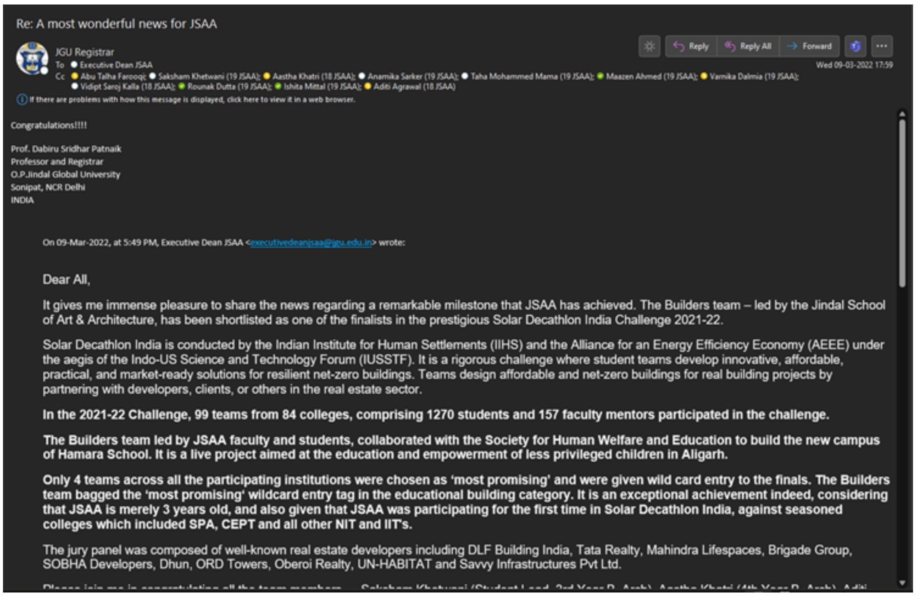


Fig. 10.5 - Our blog posts on WordPress & its subdivisions

JGU OUTREACH

Jindal Global University has been kept apprised of the team's development of the project and its progress every step of the way and the team has sent mails to the 8000+ student body. The official JGU Instagram handle has also reposted several of The Builder's posts, sharing them with an audience base of 16.1 thousand followers. The team has also reached out to the JGU admin informing them of the new heights scaled by The Builders.



Re: A most wonderful news for JSAA

JGU Registrar
To Executive Dean JSAA
Cc Abu Talha Farooqi; Saksham Khetwani (19 JSAA); Aastha Khatri (18 JSAA); Anamika Sarker (19 JSAA); Taha Mohammed Mama (19 JSAA); Maazen Ahmed (19 JSAA); Varnika Dalmia (19 JSAA); Vidipt Saroj Kalla (18 JSAA); Rounak Dutta (19 JSAA); Ishita Mittal (19 JSAA); Aditi Agrawal (18 JSAA)

Wed 09-03-2022 17:59

If there are problems with how this message is displayed, click here to view it in a web browser.

Congratulations!!!!

Prof. Dabiru Sridhar Patnaik
Professor and Registrar
O.P.Jindal Global University
Sonipat, NCR Delhi
INDIA

On 09-Mar-2022, at 5:49 PM, Executive Dean JSAA <executivedeanjsaa@jgu.edu.in> wrote:

Dear All,

It gives me immense pleasure to share the news regarding a remarkable milestone that JSAA has achieved. The Builders team – led by the Jindal School of Art & Architecture, has been shortlisted as one of the finalists in the prestigious Solar Decathlon India Challenge 2021-22.

Solar Decathlon India is conducted by the Indian Institute for Human Settlements (IIHS) and the Alliance for an Energy Efficiency Economy (AEEE) under the aegis of the Indo-US Science and Technology Forum (IUSSTF). It is a rigorous challenge where student teams develop innovative, affordable, practical, and market-ready solutions for resilient net-zero buildings. Teams design affordable and net-zero buildings for real building projects by partnering with developers, clients, or others in the real estate sector.

In the 2021-22 Challenge, 99 teams from 84 colleges, comprising 1270 students and 157 faculty mentors participated in the challenge.

The Builders team led by JSAA faculty and students, collaborated with the Society for Human Welfare and Education to build the new campus of Hamara School. It is a live project aimed at the education and empowerment of less privileged children in Aligarh.

Only 4 teams across all the participating institutions were chosen as 'most promising' and were given wild card entry to the finals. The Builders team bagged the 'most promising' wildcard entry tag in the educational building category. It is an exceptional achievement indeed, considering that JSAA is merely 3 years old, and also given that JSAA was participating for the first time in Solar Decathlon India, against seasoned colleges which included SPA, CEPT and all other NIT and IIT's.

The jury panel was composed of well-known real estate developers including DLF Building India, Tata Realty, Mahindra Lifespaces, Brigade Group, SOBHA Developers, Dhun, ORD Towers, Oberoi Realty, UN-HABITAT and Savvy Infrastructures Pvt Ltd.

Fig. 10.6 - JGU Outreach

JSAA OUTREACH

The Builders conducted a outreach session with the Enactus Society of OP Jindal Global University. This interactive session was hosted in the JSAA Classroom at 7 PM.

The first and second year students were eager to work with the Builders and industry partners in their fabrication lab when they were preparing rammed earth blocks! This turned into an informal workshop for the in house students of Art and Architecture school and positively helped us with our outreach!

Fig. 10.7 - JSAA Outreach