Solar Decathlon India

INDIAN INSTITUTE OF TECHNOLOGY, ROPAR (LEAD INSTITUTE)

&

MBS SCHOOL OF PLANNING AND ARCHITECTURE

TEAM NAME: TEJASVI IIT ROPAR

DIVISION- EDUCATIONAL BUILDING

FINAL DELIVERABLE REPORT APRIL 2021

भारतीय प्रौद्योगिकी संस्थान रोपड़

INDIAN INSTITUTE OF TECHNOLOGY ROPAR

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2.TABLE OF CONTENTS

3. LIST OF TABLES

4. LIST OF FIGURES

5.EXECUTIVE SUMMARY

About Team: Tejasvi IIT Ropar -MBS School of Architecture Solar Decathlon India 2020 Team is a group of dynamic engineers and architects who aspire to enrich the student life experience in an educational institution through a building which promotes energy efficiency and youthful vibrance . The team believes that the team should itself be energy efficient i.e. must build cooperation among itself, reduce consumption at individual level and generate our own energy via self motivation and most importantly by external supply via our faculty lead. Though there were many hurdles (one of the biggest being the virtual interaction), we kept ourselves high.

Our Processes: We had organised our drive and as we proceeded, it had folders and files , books, weekly meetings, self learning module summaries and much more. From attending SLMs to webinars, from reading books and case studies to getting hands-on experience on design builder, we gained knowledge from scratch.

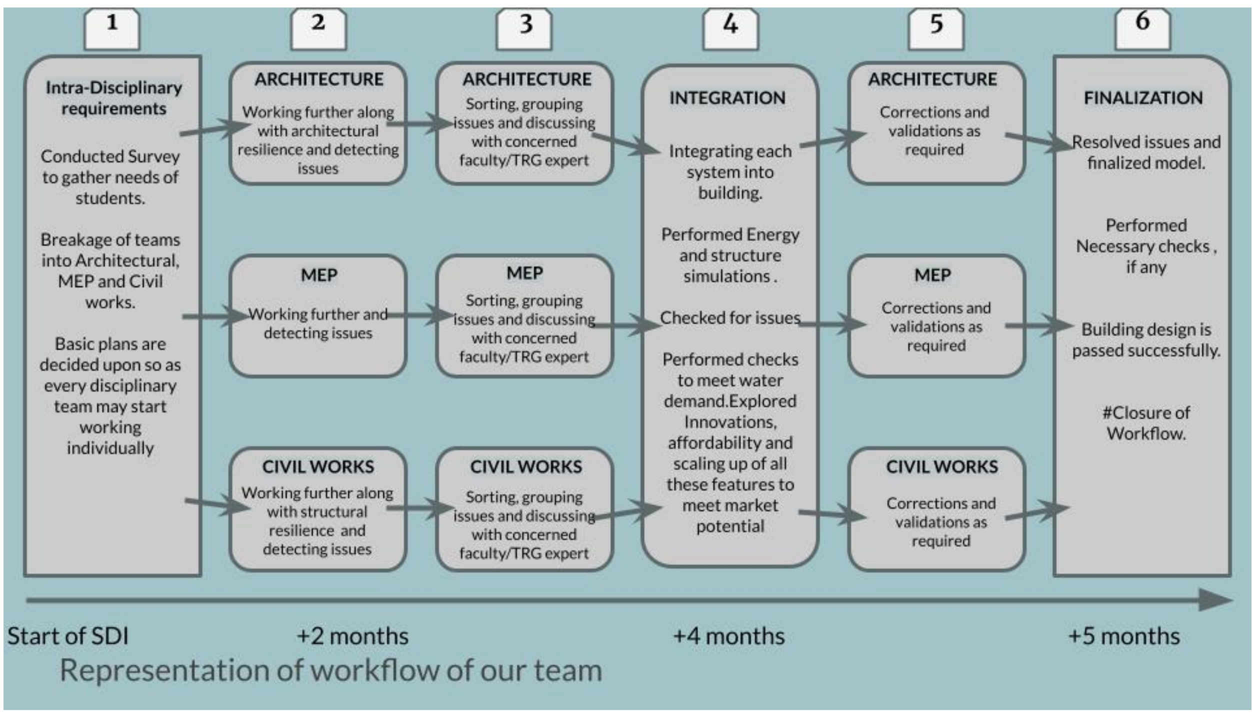


Fig:1 - Workflow Representation of our team

Our Project: Designing Student Life Centre for IIT Ropar.

Design Solution: Use of Variable Refrigerant Flow HVAC, light sensors, various building and lighting strategies, efficient and low flow plumbing fixtures, drought resistant plantations, and sprinkler and drip irrigation will enable reduction of energy and water consumption. A variety of water treatment systems and rainwater harvesting have been designed. Different construction materials are employed to reduce cost ,construction time and U-value of Building Envelope.

Achievements: We were able to reduce our energy consumption from a base case of 260 kWh/sq.m to 72.3 kWh/sq.m, i.e, a drop of around 70%. The annual water consumption was reduced from 24,84,802.5 L to 17,28,536.2 L, i.e., a reduction of 30.4%. Further, in major breakthroughs, we could achieve net positive energy and water performance.

6.TEJASVI IIT ROPAR

[INDIAN INSTITUTE OF TECHNOLOGY ROPAR (IITRPR - LEAD) AND MBS SCHOOL OF PLANNING AND ARCHITECTURE(MBS)]

DIVISION: EDUCATIONAL BUILDING

Team members

Prabhjot Singh (Team Lead) Civil Engineer (UG, 3rd year), IIT ROPAR Energy Performance & Overall team lead

Mehak Gupta (Architect) 2nd Year UG, MBS Architectural design lead	**Aditya Kumar** (Civil Engineer) 3rd Year,UG,IIT ROPAR Affordability lead	**Dikshant Vats** (Civil Engineer) 3rd Year,UG,IIT ROPAR Market potential lead
Hardik Rana (Chemical Engineer) 2nd Year UG, IIT ROPAR Innovation Lead	**Suryansh Pratap Singh** (Chemical Engineer) 2nd Year UG, IIT ROPAR Presentation and misc. lead	**Nalin Bijlani** (Chemical Engineer) 2nd Year UG, IIT ROPAR Presentation and misc. lead
Mohamed Mazhar Laljee (Chemical Engineer) 2nd Year UG, IIT ROPAR Water performance lead	**Vikrant Jaglan** (Mechanical Engineer) 3rd Year UG, IIT ROPAR Comfort &env. Quality lead	**Ritesh M.Chaudhari** (Electrical Engineer) 3rd Year UG, IIT ROPAR Eng.Design & Operations
	Deepali Gaikwad (Civil Engineer) 2nd year, PG, IIT ROPAR Resilience Lead	

FACULTY LEAD: Dr. Asad Sahir

BACKGROUND OF IIT ROPAR: **Indian Institute of Technology, Ropar** is one of the eight new IITs set up by the Ministry of Human Resource Development (MHRD), Government of India in 2008 to expand the reach and enhance the quality of technical education in the country. At present, the institute offers undergraduate and doctoral programs in Engineering disciplines (e.g. Chemical, Civil, Computer Science , Electrical, Metallurgical and Materials Mechanical.), M.Sc programmes in the following disciplines : Physics, Chemistry and Maths and a Masters program in Biomedical Engineering.

PROJECT PARTNER: The Tejasvi IIT Ropar Team has been supported by the Office of Dean (Industrial Consultancy Sponsored Research and Industrial Interaction). Ms. Kirti Dahiya, Institute Architect has helped the team with design assumptions and site information. The team has worked virtually, as the majority of the undergraduate students are currently off-campus, as IIT Ropar is working in online education mode as of April 2021.

7.PROJECT BACKGROUND

A. PROJECT NAME : Student Life Centre

B. PROJECT PARTNER: INDIAN INSTITUTE OF TECHNOLOGY, ROPAR

It is an engineering, science and technology higher education institute located in Rupnagar, Punjab, India. It's a government Educational Institution. Ms. Kirti Dahiya, Institute Architect has helped the team with site information.

C. PROJECT DESCRIPTION: Our Building Student Life Centre brings an innovative concept of "Of the students, for the students and by the students" . Thanks to Solar Decathlon India , which provided students a platform to project their ideas about their requirements for a building which particularly deals with student activities, a must have building for any university/ institution ,so that students can pursue their passions along with studies. The site details and building program are as follows.

1. **LOCATION:** Proposed location (highlighted in yellow) in IIT Ropar Campus

.

Fig. 2 - Aerial view of site

2. **CLIMATE ZONE:** Ropar has a tropical, semi-arid, hot and subtropical monsoon type of climate with cold winter and hot summer, and Ropar also comes under seismic zone IV.

3. **PROJECT STAGE**: FINAL DESIGN STAGE

4. **PROFILE OF OCCUPANTS:** STUDENTS involved in various activities like technical, cultural, sports etc.

5. **HOURS OF OPERATION**:24*7, PEAK HOURS: 4PM-10PM daily

6. **Total occupancy -** 836, **Peak occupancy at a time -** 500

7. **Purpose:** It is a Build-own-operate building dedicated for student activities.

8. **BUILT-UP AREA:** 2600 sq.metre 9. **PROPOSED EPI:** 72.3 kWh/sq.m

F. CONTEXT AND MARKET ANALYSIS: The scalable model of a Student Life Center will provide educational, recreational and socialization experience for students &

faculty. Adopting water and energy efficient measures, this building will address the demands of climate change and future generations.

G. BUDGET: Approximate budget (excluding land area cost)- ₹45-50 Crores

H. Special Requirements by Project Partner - IIT Ropar Campus is currently being constructed and ideas are being explored to enrich the campus. Various departments have been constructed. Solar Decathlon India has given an opportunity for the Project Partner to involve students, faculty members, architects to utilize energy efficient buildings to potentially address an aspect which will be proposed as a part of the New Education Policy (NEP) by the Government of India.

The building will be for self-occupation, however since it is an educational building with the Government of India on a non-profit basis, the possibility of inviting Corporate Social Responsibility funds exists. Operational expenses are expected to be minimized and capital -intensity is a concern as the possibility of revenue generation is less as compared to a commercial building. The proposal of the building will be presented to the new Director of Indian Institute of Technology Ropar who has assumed office from April 1, 2021 for subsequent guidance. On the administrative level, this project is being done under the encouragement of Dean (Industrial Consultancy Sponsored Research and Industrial Interaction).

8. PERFORMANCE SPECIFICATIONS

- **Climate zone:** Ropar has a tropical, semi-arid, hot and subtropical monsoon type of climate with cold winter and hot summer,
- **Site Specifications:**Site has loose alluvial soil. It comes under seismic zone IV.
- **Envelope (U-value, VLT, SHGC)**
    - **Roof Assembly U value -** 0.175W/m²K
    - **Roof Assembly SRI-** 100
    - **Average Wall Assembly U value -** 0.27W/m²K
    - **Window to Wall Area Ratio (WWR) -** 15%
    - **Windows U value -** 2.7 W/m²K
    - **Windows SHGC-** 0.7
    - **Windows VLT -** 78%
    - **Infiltration Rate-** 2.4ac/h
    - **Describe Exterior Shading Devices:** Exterior shading devices include Horizontal devices (fixed overhang) provided above the window on the North side
- **HVAC**
    - **System type -** air cooled VRF
    - **CoP -** 3.5
    - **EER -** 12
    - **Star-rating -** 5
- **Lighting (LPD) :** 2.7 watts per square foot(building)
- **Electrical (EPD) :** 1.38 watts per square foot
- **Renewable energy (system type, generation capacity)**
    - Solar panel system of capacity 165 kW is installed , with 450 pvs and each p.v of 350 W, mix of roof and ground mounted.
    - Annual Generation : 220 MWh
- **Water systems**
    - **Annual Consumption**- 17,28,536.2 L
    - **Annual Greywater Treatment**- 6,09,938.9 L
    - **Annual Blackwater Treatment**- 3,25,300.8 L
    - **Annual Rooftop Rainwater Harvesting**- 5,75,503.0 L
    - **Annual Hardscape Rainwater harvesting**- 15,01,567.2 L
    - **Underground Tank Capacity (with partitions)**- 9,589 L (rooftop rainwater) + 25,019.1 L (hardscape rainwater) + 4275 L (municipal water)
    - **Overhead Tank Capacity (with partitions)**- 9,589 L (rooftop rainwater) + 27,523.9 L (recycled greywater + hardscape rainwater) + 4275 L (municipal water)
    - **Surface Area of Root Zone Bed**- 79.5 m²
- **Innovation** :

  Power generated in the whole year by piezoelectric tiles = 182.625 kWh.

9.GOALS: For the 2020-2021 Solar Decathlon India the Ten Contests are:

1.Energy Performance : Reduced around 73% or 3/4th of Energy Demand by dropping energy from 704 MWh to 193 MWh. Annual Generation of around 210 MWh by Solar PV's which makes the building Net Zero Energy Building. EPI: 72.3 kWh compared to Super Energy Efficient Buildings (Type: College Educational Building; Climate: Composite) EPI: 78 kWh.

2.Water Performance: Minimized water wastage using sensors and IoT and reduced annual occupant water use by 29.6 %. Extensive rainwater harvesting- collected 21 lakh L annually. Annual irrigation demand reduced by 41.2% via xeriscaping and sprinkler and drip irrigation. 6Lakh L of decontaminated greywater obtained annually for irrigation and flushing by extensive treatment. 14.2 Lakh L added to groundwater reserves.

3.Resilience: Building can resist the flood, Extreme climate and earthquake events sustainably. Insulating materials used to reduce the heat exchange of the buildings is eco-friendly and economical. The heat transmittance through walls and roof is reduced by 89.61 % and 92.27% respectively.

4.Affordability: Using modern techniques like precast method (saving nearly 5 month of construction time) , Prestressed Post Tensioned Concrete (reducing height of building by 2.1 m, saving both construction cost and time by nearly 4 month) and use of XPS Cement Sandwich panels helps to achieve the goal to complete the project 8 months before the timeline. Due to completion of the project 9 month before the timeline, it helps to save IDC (interest during construction) cost by 30-35%.

5.Comfort:ASHRAE-55 with 80% acceptability model has been used and the number of hours not met with this model has been minimized in individual zones annually. VRF HVAC system is used. Preliminary required TR was 156, we reduced it to 96TR. Activity specific ventilation and Mixed mode ventilation are used. Proposed VRF system also improved water and energy performance.

6.Scalability and Market : With HEFA model we were able to achieve an IRR of 8.33% from base IRR of .73% . Also we were able to reduce the life cycle cost of the building for 10 years from 52.63 to 45.46.

Income Generated after 6 years of completion of project : Base Case-50.1 million INR
Proposed case -156.0 million INR

7.Architecture: Designed a student life centre with all the norms taken into consideration. Encouraged harmonious and attractive student centres through attention to the exterior architectural quality and appearance of new student centres. Design based on green buildings to improve EPI and orientation taking all the surrounding aspects into consideration. Achieved Cross Ventilation by providing windows on the opposite walls with big corridors to make the building well ventilated without artificial cooling.

8.Engineering : Design the various engineering systems associated with buildings like Electrical systems, HVAC, water systems, etc. Reduced the energy consumed for lighting by around 57% and brought it down to 48.78MWh, by using smart lighting fixtures. Also optimised the load energy consumption, and implemented things like load distribution for greater Electrical stability.

9.Innovation: Successfully achieved a full fledged sustainable building model with employment of visionary, insightful and uncustomary but very effective models which will ensure good performance of building in long term. Achieved an EUI of 72.3 kWh/m2 per year, by employing energy saving measures and added autonomous sources of clean energy generation within the building imparting a beautiful sight (piezoelectric tiles). Ensured the plastic waste generated in initial years, goes in recycling while laying plastic roads in premises.

10.Documentation of design process

- ➔ Design charrettes:

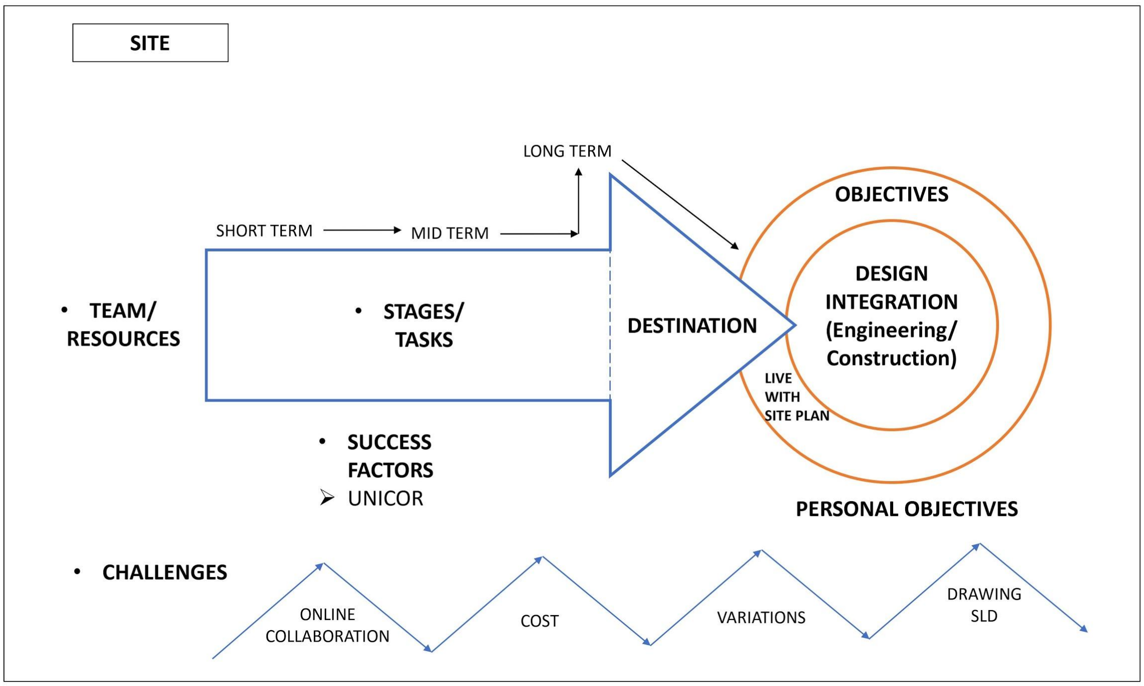


Fig:3- Design charrettes

➔ Team meetings

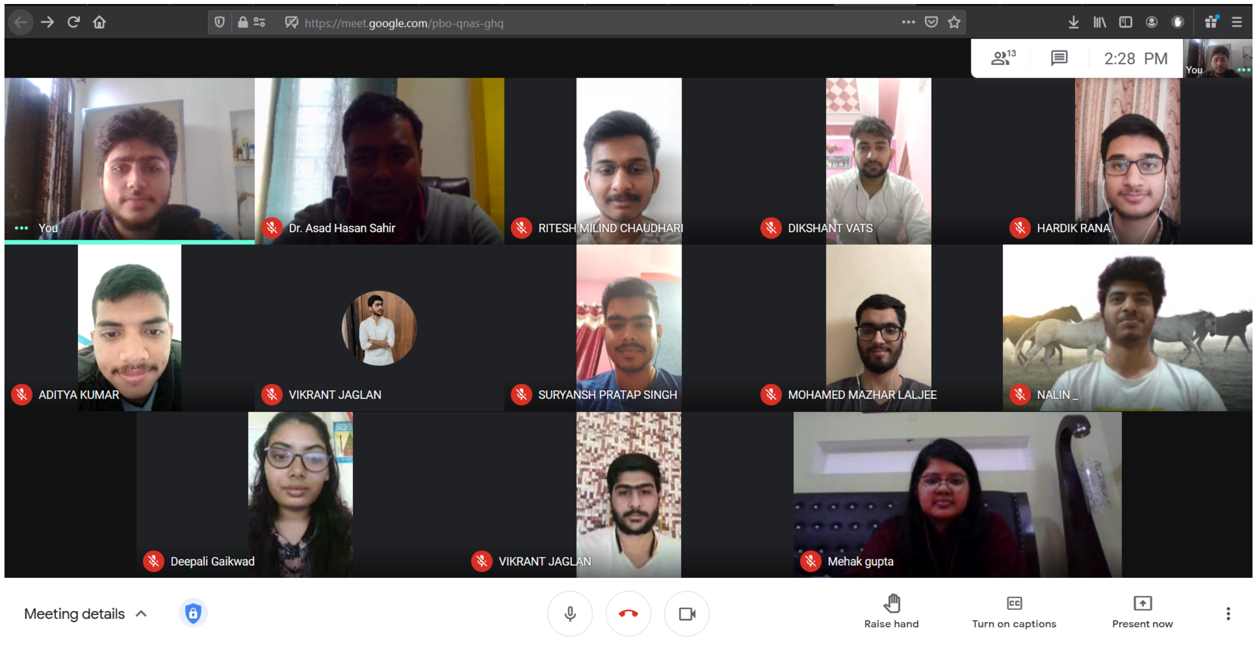


Fig:4- Team meetings

➔ Analysis & Review

- **Architecture-**The architecture team coordinated with the team members to collate ideas for the Student Life Center. The team members according to their interests had different viewpoints which were mapped with the vision of an educational institution. The architect of the project partner also helped us by discussing the site and its merits and demerits. Some of the tools used were AutoCAD, Adobe Photoshop and Sketchup
- **HVAC-**The HVAC team gathered inputs and utilized their domain knowledge in Mechanical and Electrical Engineering, learnt Design Builder and generated various scenarios. The use of Climate Studio was also reviewed by the team.
- **Water Performance-** Strategies to reduce water consumption and the reduction of cost implications of these strategies were formulated. Designing of water harvesting and treatment systems and their optimization was also taken up during these meetings. Literature on water management was reviewed and factored in analysis.
- **Lighting-** An average reduction of about 10% per design review meeting was envisaged as a target. While drawing the electrical Single Line Diagram (SLD), keeping in mind the various output points and Lightings points in mind. Spreadsheet calculations were performed.
- **Energy Performance-**The focus of the team was on reducing the energy consumption, as our site shall only allow us to harness generation from Solar energy. Spreadsheet calculations were performed.
- **Resilience:** Factors contributing to resilience of building against natural disaster and discomfort due to extreme temperature were identified. The

design goal was to withstand any disaster event sustainably with all the comforts, through the use of Economical and eco-friendly materials for insulation.

➔ Project partner discussion: The Institute Architect helped us understand the site and circulation of the site within the campus. Furthermore, information was provided to understand the use and merits and demerits of Budki rivulet adjacent to our site which is located inside the campus of IIT Ropar.
➔ Tools Used:
  - Design Builder (Provided by Solar Decathlon India)
  - Climate Studio (Provided by Solar Decathlon India, and reviewed its use)
  - AutoCAD
  - Photoshop
  - Sketchup
  - MS Excel based programs (e.g. CBE Comfort Tool)
  - MS PowerPoint

CHALLENGES:

★ There was only one architect in the team so the major challenge occurred in design was to manage the areas with each other without generating negative spaces.
★ The challenge that also occurred that each and every member was passionate regarding student life and managing expectations at the architectural level was very challenging and interesting.
★ To collaborate with everyone online in a virtual environment during COVID19 Pandemic.
★ To interact with people with different fields of expertise and hence working as a team on one project.
★ To achieve a reasonable and eye catchy design.
★ The project has given an excellent starting point to develop real case scenarios for energy consumption and generation.
★ In the process of further developing our closed water cycle, the problems that we expect to face are providing easy maintenance access to each component of the treatment systems and deciding the maintenance schedule. The architectural team to determine the exact placement of components and their access points, and further analysis of pollutants in the different water systems to understand the maintenance required (with the possible use of extensive simulations) would help address the issue.
★ The major challenge in developing this solution further is its cost. Which can be addressed by further improving the building design which can reduce the cooling load event further resulting in lower capacity VRF systems to be used and hence reducing the cost. We believe that this can be achieved by further improving the building design and optimizing the HVAC system.
★ Drawing the SLD was very complex and the scope of working with an industry partner towards improving it further exists..

11. DESIGN DOCUMENTATION

ARCHITECTURAL DESIGN:

(High -resolution diagrams added in annexure owing to report page limitations)

Concept:

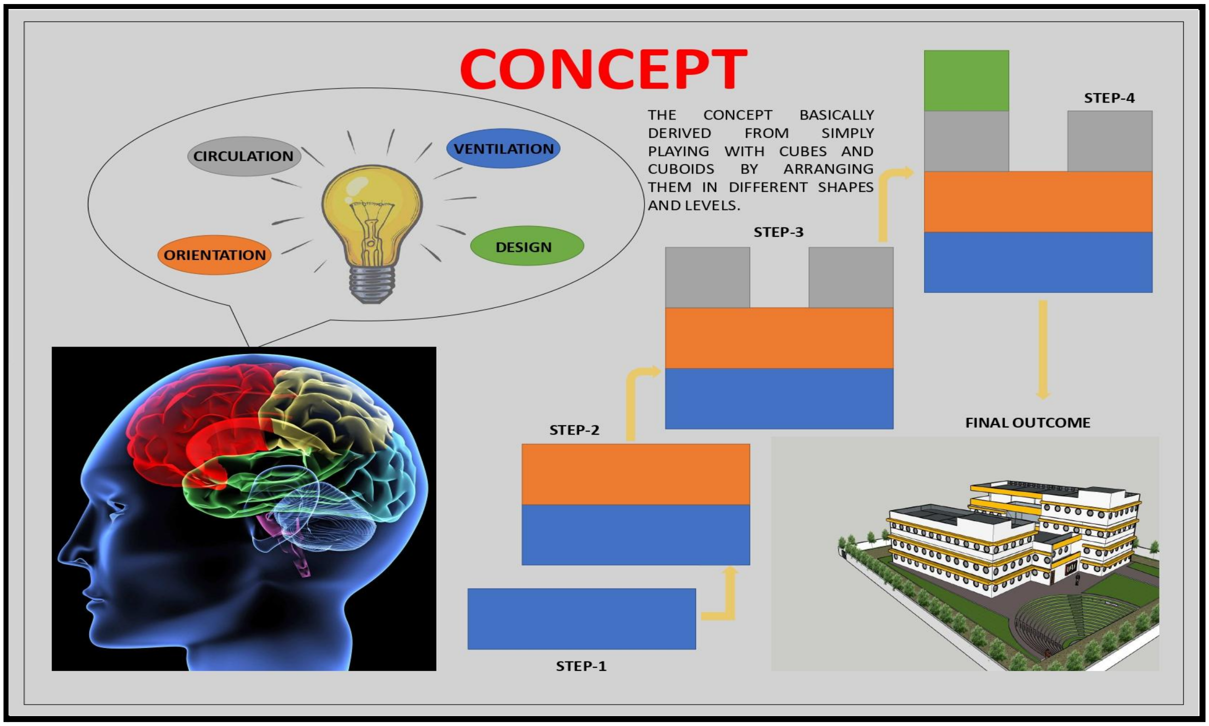


Fig:5-Concept

In our technological age, when so many of our social experiences are virtual, the role architecture can play in the experience of real-time situations is increasingly becoming important. The Student Life Center building is designed in a way to make the students of IIT Ropar comfortable and interactive with themselves while exploring their own hobbies.

To facilitate interaction and involvement among students, a survey was conducted amongst the students about all the things they love to have in their institute which will enrich life on campus. We also visualised the needs of each individual and tried to incorporate it into the building thinking from a utilization view than simply providing spaces for each thing by innovative ideas.

We took care of the sentiments of the students of the institute and provided the spaces at different levels of the building. Care was taken to isolate the spaces from the spaces which are not required to be together so that elements of privacy and individuality can be experienced in a community building. We also took care of the spaces for Science and Technology that are helped by a less noisy environment and provided them on the top of the building so that total privacy can be provided. The sports area and auditorium on the ground floor so that it's easily accessible without much circulation. And we provide cultural areas on the centre of the building which acts as the inner atrium and helps in acoustics. The cultural areas will provide a lot of interaction space and are not at the entrance, which is likely to drive anticipation while attending the event.

Total occupancy in the building is 1727 students including teachers.
Total area of the site is 4500 sq.m in which the build up area is 2440 sq.m in which the total educational area is 1920 sq.m. So it achieves the 50% of criteria of having teaching spaces. There are no more than 65 students in each teaching class and the further details excel sheet is attached in the annexure.

Site Plan:

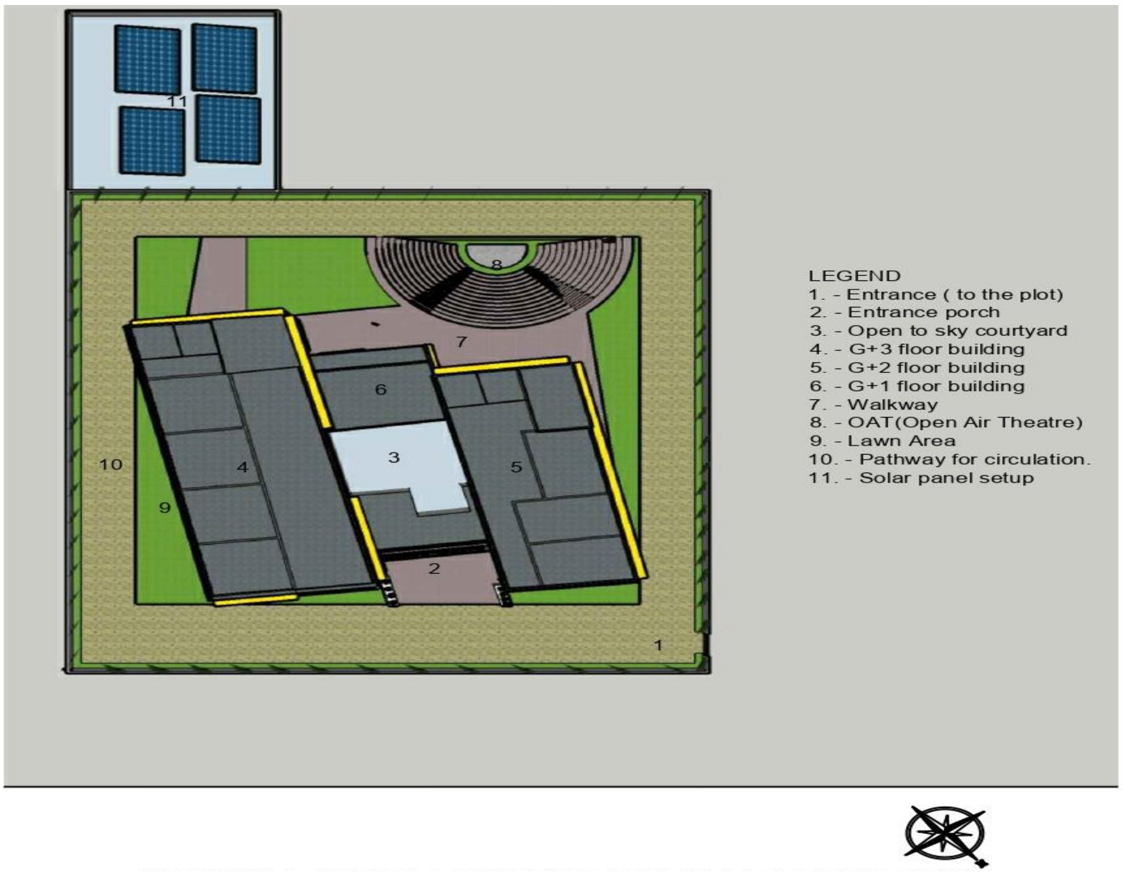
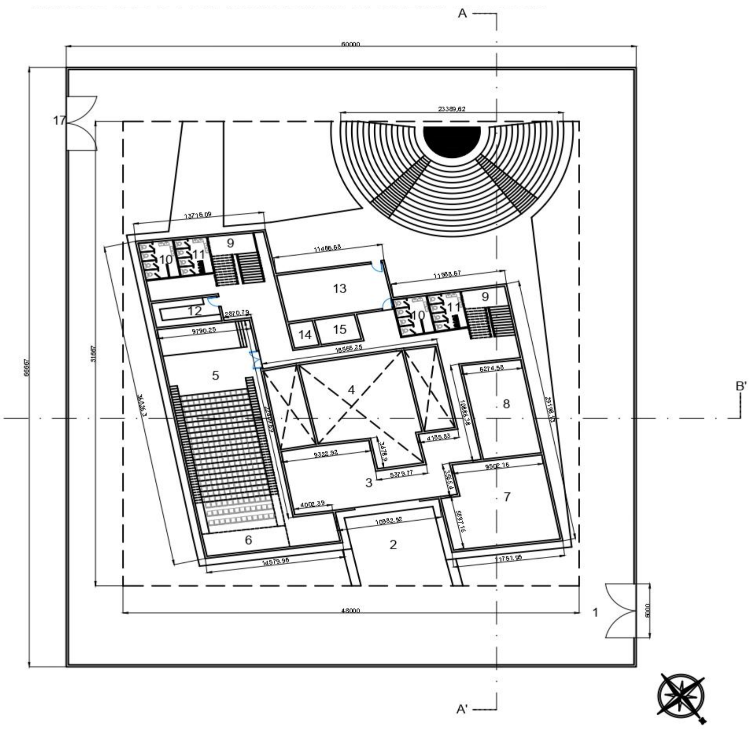


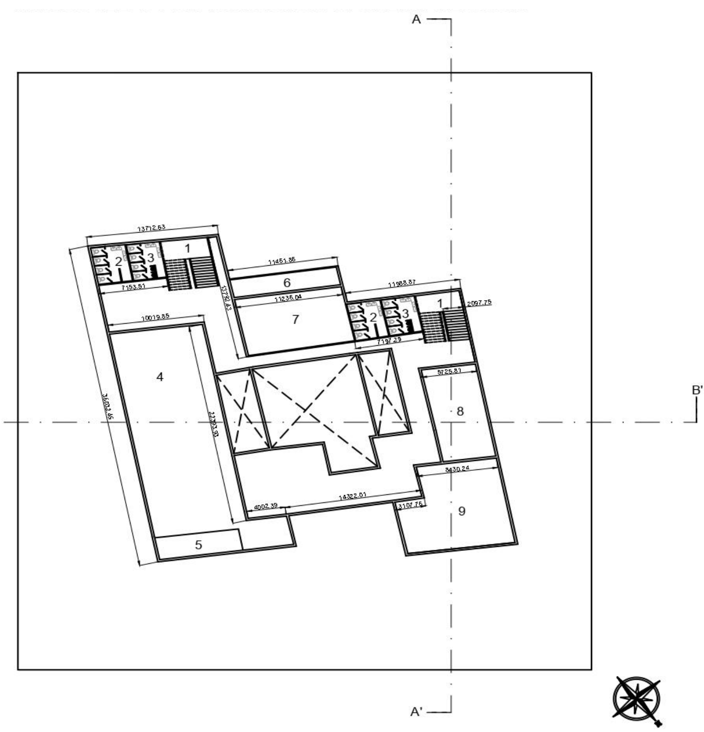
Fig:6- Site Plan

Floor Plans: In sequence of ground floor, first floor, second floor, third floor respectively.

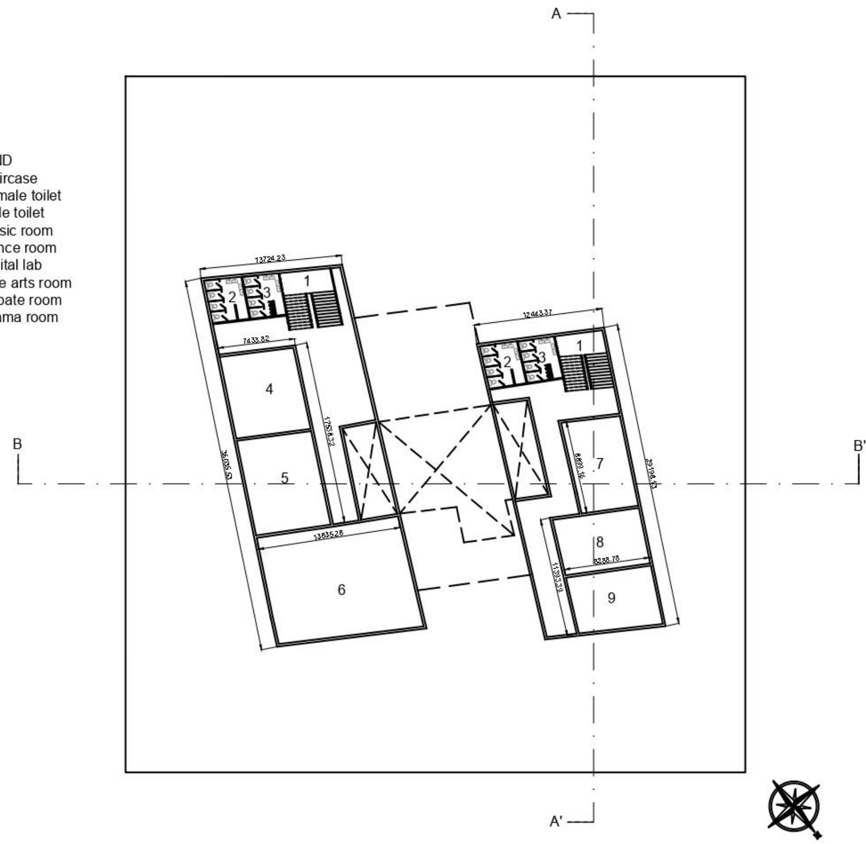
LEGEND
1. - Entrance (to the plot)
2. - Entrance porch
3. - Entrance lobby
4. - Open to sky courtyard
5. - Auditorium
6. - AV room
7. - Conference hall
8. - Badminton court
9. - Staircase
10. - Female washrooms
11. - Male washrooms
12. - Luggage room
13. - Common room
14. - Pantry
15. - Medical room
16. - OAT(Open Air Theatre)
17. - Exit



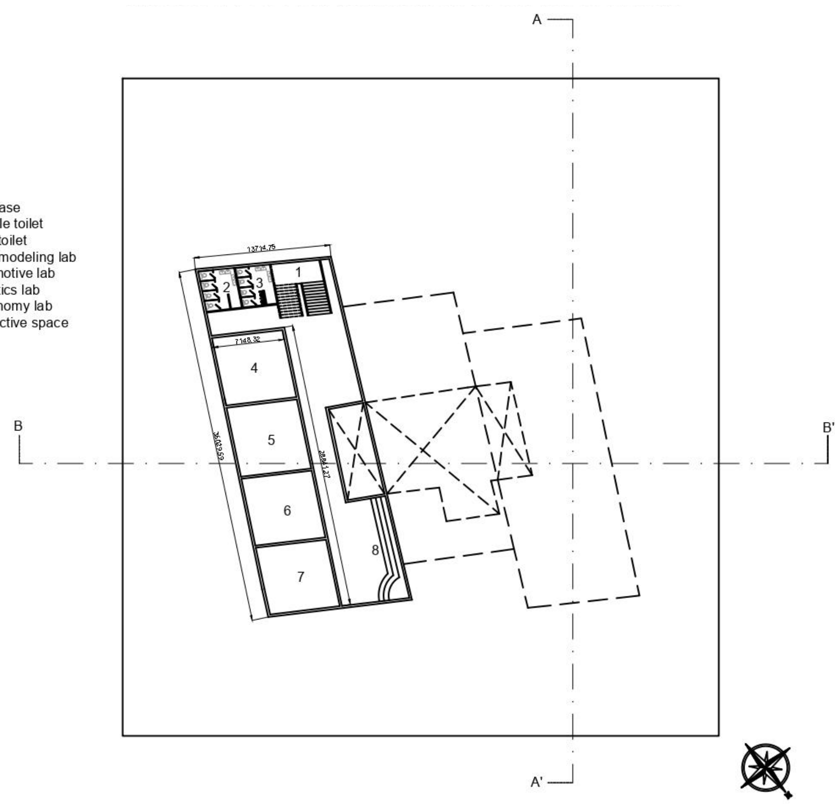
LEGEND
1. - Staircase
2. - Female toilet
3. - Male toilet
4. - Auditorium
5. - AV room
6. - Balcony
7. - Defense art room
8. - Badminton court
9. - Common play room



LEGEND
1. - Staircase
2. - Female toilet
3. - Male toilet
4. - Music room
5. - Dance room
6. - Digital lab
7. - Fine arts room
8. - Debate room
9. - Drama room



LEGEND
1. - Staircase
2. - Female toilet
3. - Male toilet
4. - Aero-modeling lab
5. - Automotive lab
6. - Robotics lab
7. - Astronomy lab
8. - Interactive space



Sections:

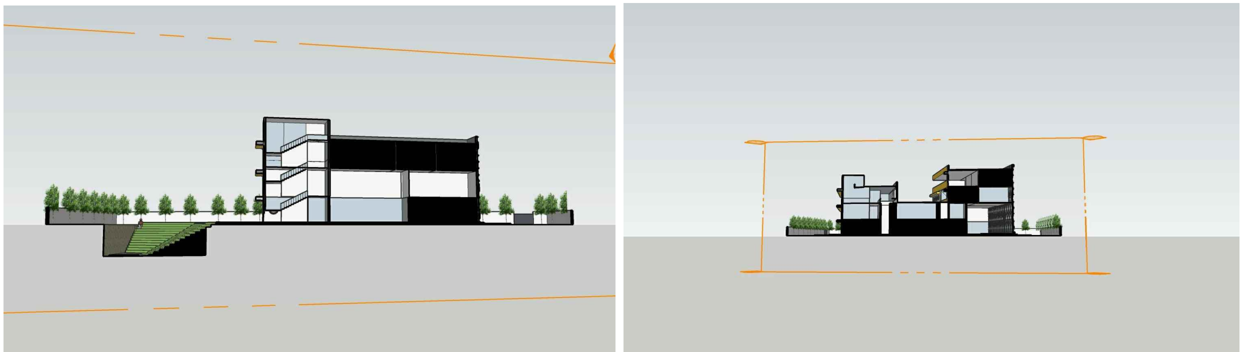


Fig:7- Sections

Elevation:

Fig:8- Elevations

Views:

Fig:9- Views

Structural design:

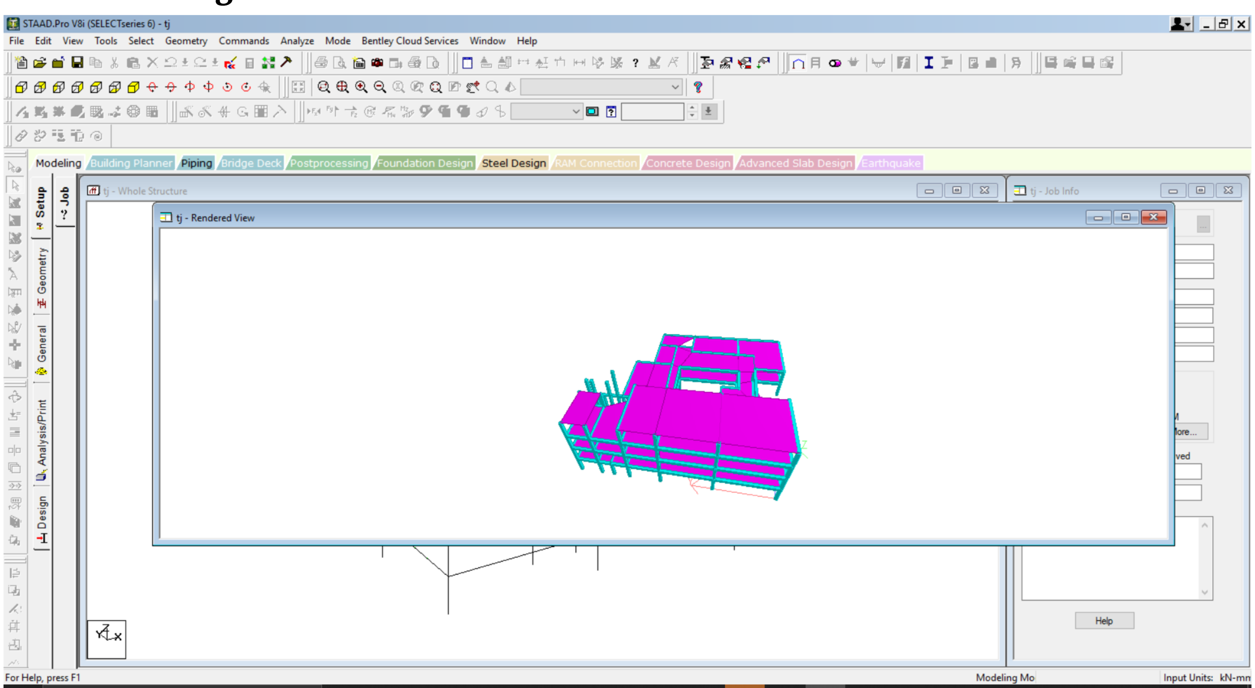


Fig:10- Structural Design

2.ENERGY PERFORMANCE

To maximize energy performance of any building , there are two components:

a. Reducing Energy Consumption

b. Increasing Energy Generation

Reducing Energy Consumption in our model

We set multiple changes from our baseline which are as follows:

➔ **Window Sizing and Glazing along with Local Shading:**

- We did a comparative study by changing WWR(Window wall ratio) and changing the glazing type from Single glazing to Double Glazing, whose results are:

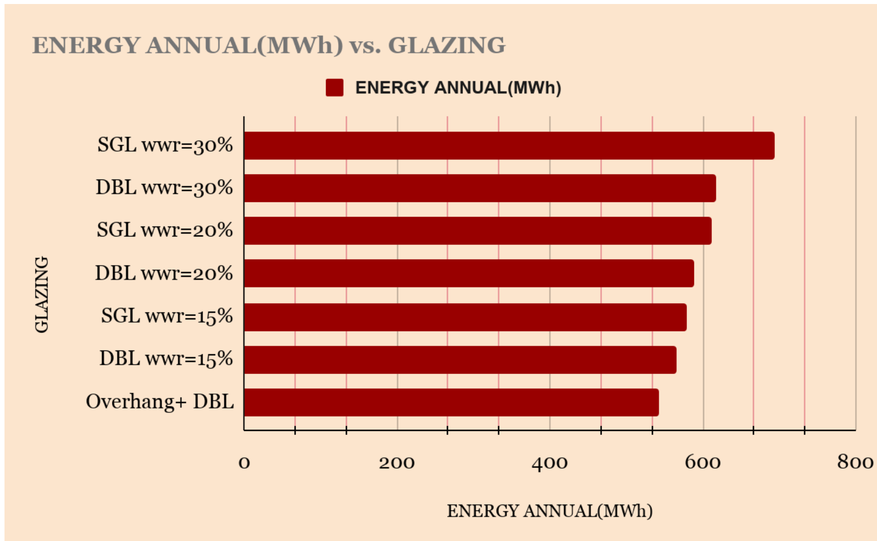


Fig:11- Energy vs glazing and wwr optimization

- Further providing overhang , our overall consumption dropped by 23 MWh as can be seen in the Fig 11 . Energy consumption can be further reduced by 3MWh by changing window frame material from wood to UPVC material.
- Hence our overall energy consumption by changing from **Single glazed, 30% WWR, wooden frame with no local shading** to **Double glazing, 15% WWR with UPVC frame along with overhang** changed from **693MWh** to **541.96 MWh**, i.e, a **drop of 22%** .

➔ **Lighting:**

- Changing Default lighting to Led with controlled scheduling to **464 Mwh** , i.e,**further drop of 14%.**

➔ **Building Envelope**

- Our Roof-top insulation with U-value of 0.175 and External wall insulation with U-value of 0.27 (material details discussed in the resilience section) further reduced the consumption to **324MWh ,i.e, further drop of 30%.**

➔ **HVAC**

- Adopted mixed mode ventilation and further attached radiator surface in ceiling along with VAV water cooled chiller which reduced energy consumption by 13 MWh. However, adopting AIR COOLED VRF systems led to **change from 324MWh to 193 MWh , i.e, a drop of 40.4%.**
- Hence, we adopted an air cooled VRF system as our HVAC Solution. Specifications of our VRF System: 3 Air cooled VRF systems for the 3

buildings with cooling capacities 85kW, 31kW and 154kW, with max terminal side air flow rate of 1.34m3/s, 0.62m3/s and 1.34m3/s respectively.

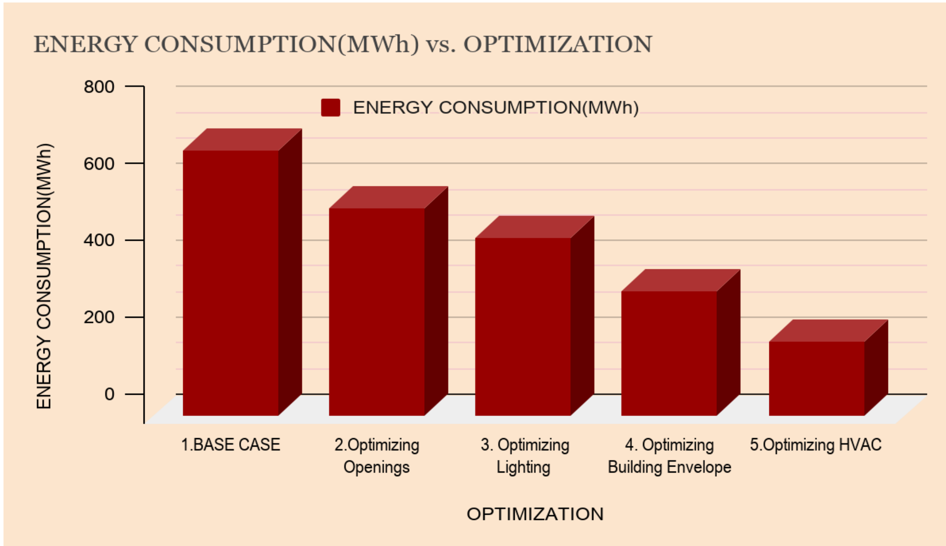


Fig:12-Reduction in Energy Consumption with stepwise optimization

Base Case EPI: 259.5 KWh/sq.m

Proposed Case EPI: 72.3 KWh/sq.m

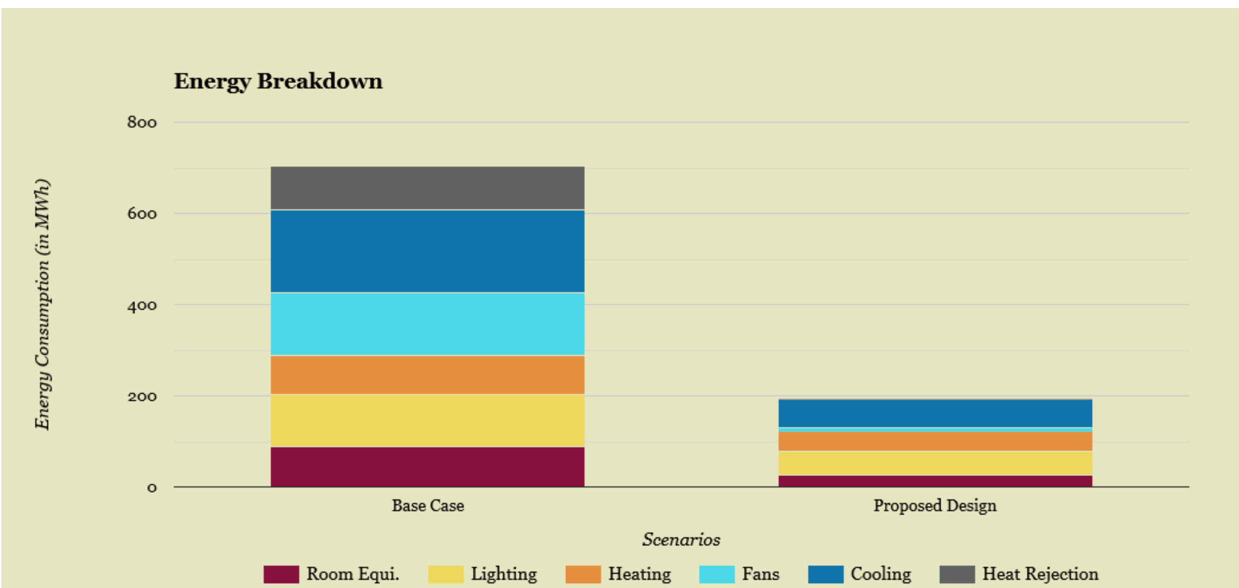


Fig:13- Energy -End Use Breakdown for Base Case and Proposed Case

Demand	**Base Case Scenario (Energy in MWh)**	**Proposed Energy Efficient Case(Energy in MWh)**
Room Equipments	89	27
Lighting	113	51
Heating	86	43

Fans	139	10
Cooling	181	62
Heat Rejection	95	0

Table:1- Energy End Use Breakdown for Base case and proposed case

Monthly Energy Usage Breakdown:

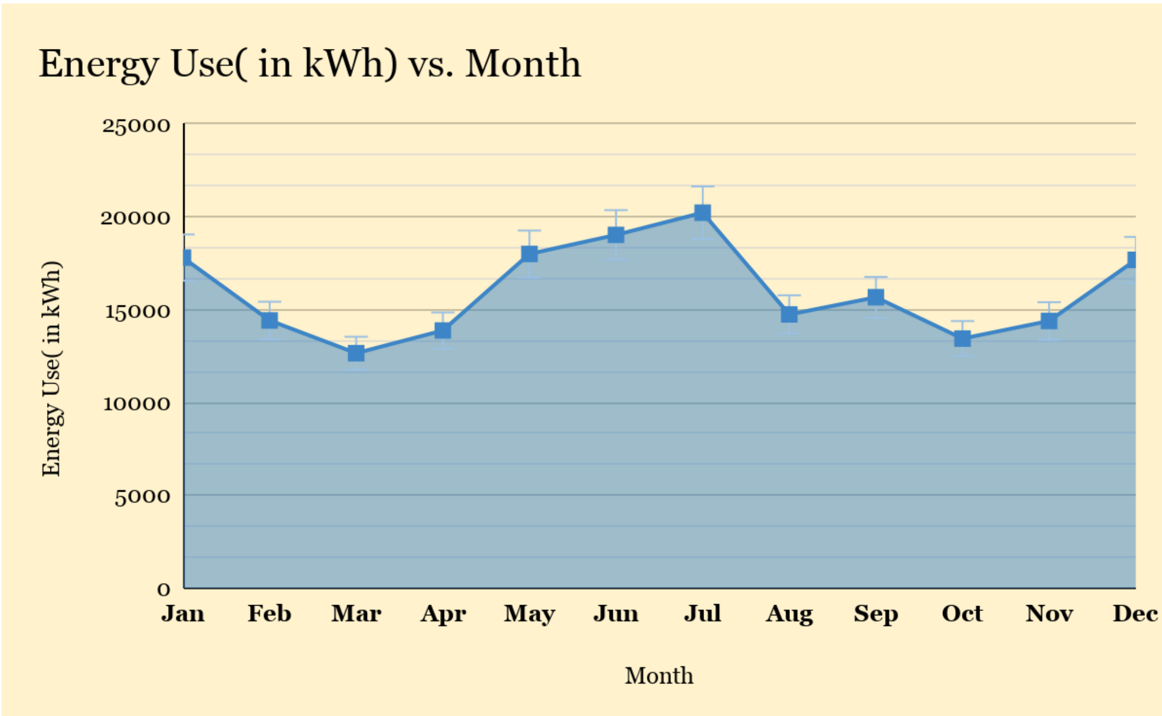


Fig:14-Monthly Energy Consumption

<u>Increasing Energy Generation:</u>

- ➔ Multiplying a design factor of 1.2, our energy generation should be 220 MWh.
- ➔ With 90% rooftop area , roof mounted solar panels in the site generate only 130 MWh annually. Therefore to cover the deficit amount , further site area of 600 sq m will be allotted which will generate around 90 MWh annually.
- ➔ Hence net energy generation will be 220 MWh which will be able to satisfy consumption along with 10% increase , if any.
- ➔ Thus solar panel system of capacity 160 kW is installed , with 450 Photovoltaics and each photovoltaic panel of 350 W

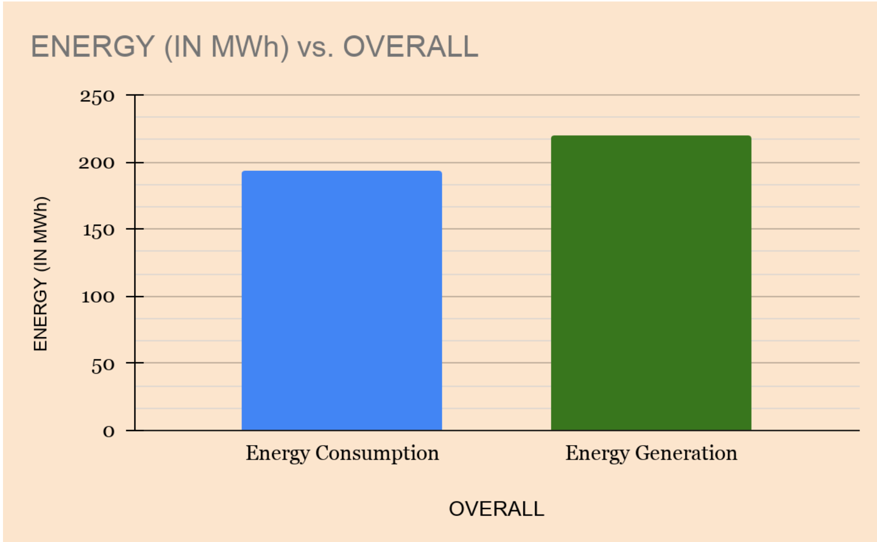


Fig15:- Consumption and Generation of Energy(MWh)

3. WATER PERFORMANCE

To maximize the building's water performance, we have focused on two approaches:

1. Reduction of water consumption and minimization of wastage.
2. Prudent use of onsite water resources and available site area.

Approach 1

To avoid water wastage due to carelessness and leaks, sensors and technologies based on Internet of Things (IoT) will be employed for alerts and predictive maintenance warnings.

To reduce consumption by occupants, aerator fitted low flow fixtures and dual flush cisterns will be installed and this alone reduces total consumption by 27.56%.

Punjab is in a semi arid region and hence to avoid excessive water use for irrigation, in addition to reducing green areas to just 583 m^2, drought tolerant regional plants and flowers like succulents, rain lilies, plumbago, golden thryallis, crepe myrtle, bougainvillea, pink ball flower, palm trees, and grasses (most to least drought tolerant)- buffalo, bermuda, zoysia, St. Augustine will be used (xeriscaping). They will be irrigated using drips (deliver water directly to the roots beneath the soil surface) and sprinklers during the wee hours of the day. These two approaches combined reduce consumption by 30.44%.

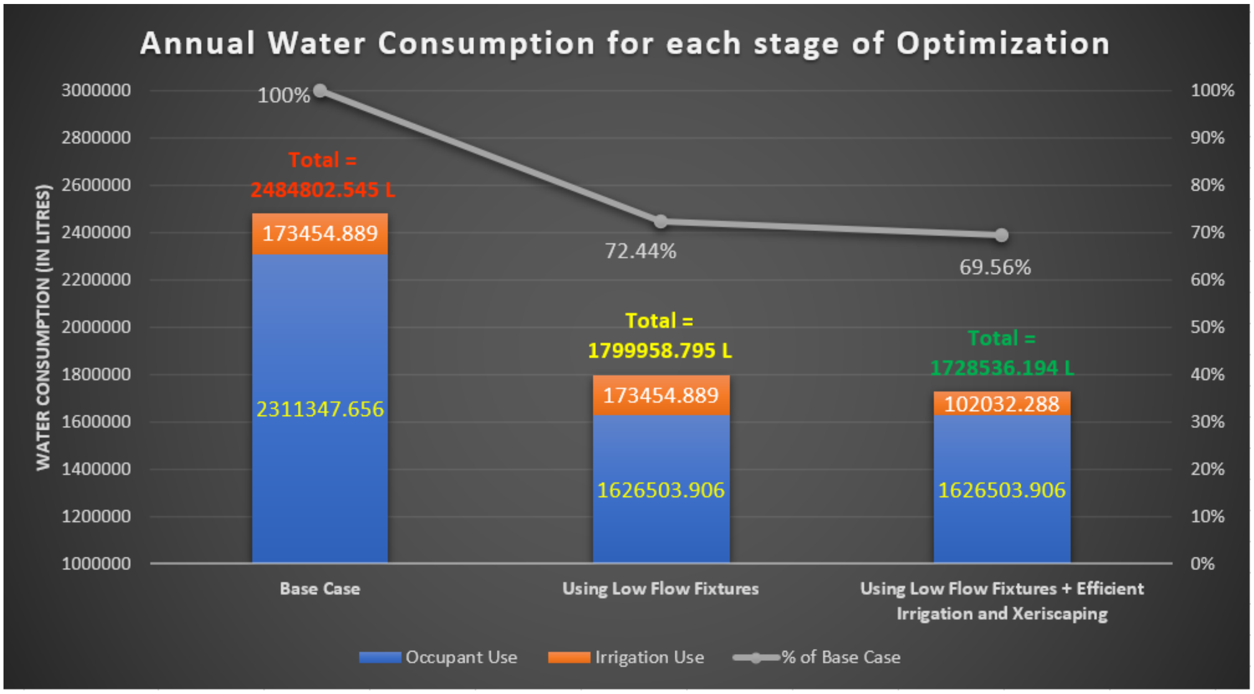


Fig16:- Water Consumption vs Optimization

The monthly occupant and irrigation uses can be seen in this graph:

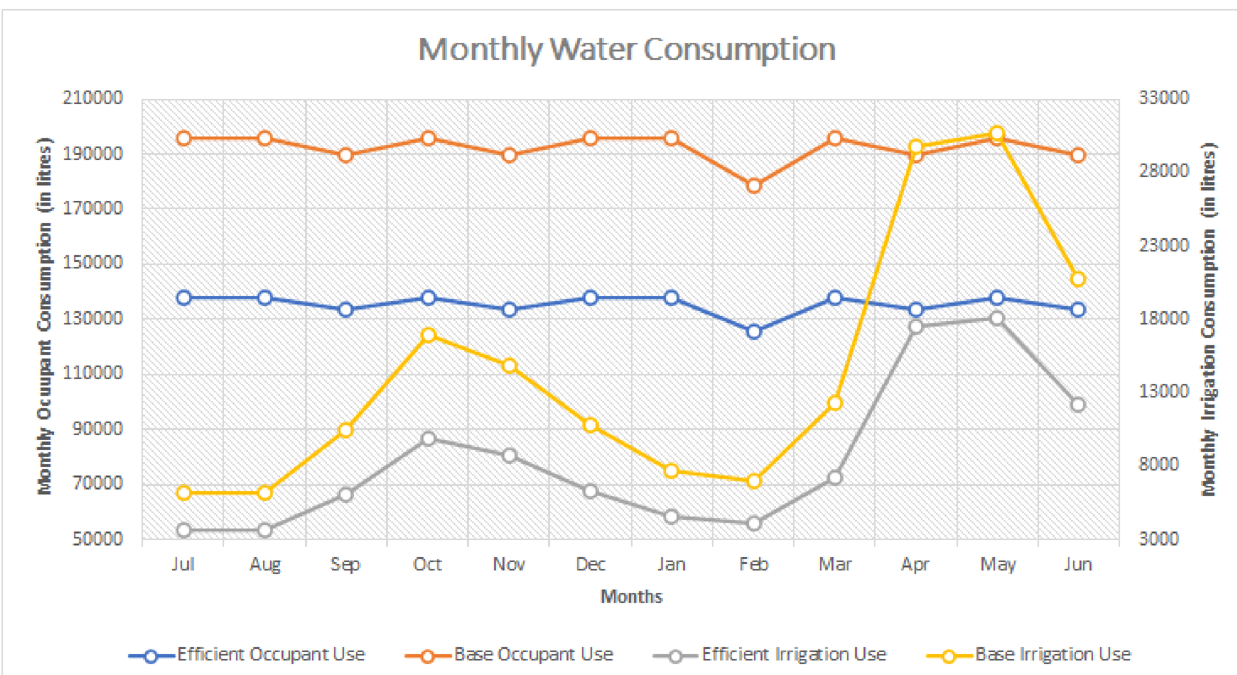


Fig17:- Monthly Water Consumption

The irrigation use is maximum for the summer months of April and May due to very high temperatures, whereas it is considerably less for the monsoon months and the extremely cold winter season which witnesses the shedding of leaves by plants.

Using energy efficient air cooled VRF HVAC systems helped eliminate water use for cooling purposes altogether.

Approach 2

For making a sustainable building, it is imperative to reduce dependence on offsite water resources, and harvesting precipitation is the most obvious and economical way of doing so. Annually, 575503 L of rainwater can be harvested from the building roof and used for potable needs. As discussed earlier, the irrigation area was reduced and this resulted in more space for walkways and other hardscape areas. The water falling on these surfaces will be carried to treatment systems installed to make them fit for non-potable uses, instead of being disposed off. This results in the collection of an additional 1501567.2 L annually. Although the total harvested rainwater (2077070.3 L) is greater than our total consumption of 1728536.2 L, thereby resulting in a net positive water performance, there is a deficit of potable water and hence 465459.5 L of municipal water (an offsite resource) is needed. Thus it is evident that use of efficient systems and rainwater harvesting has heavily reduced our dependence on offsite resources (reduction of 81.27%).

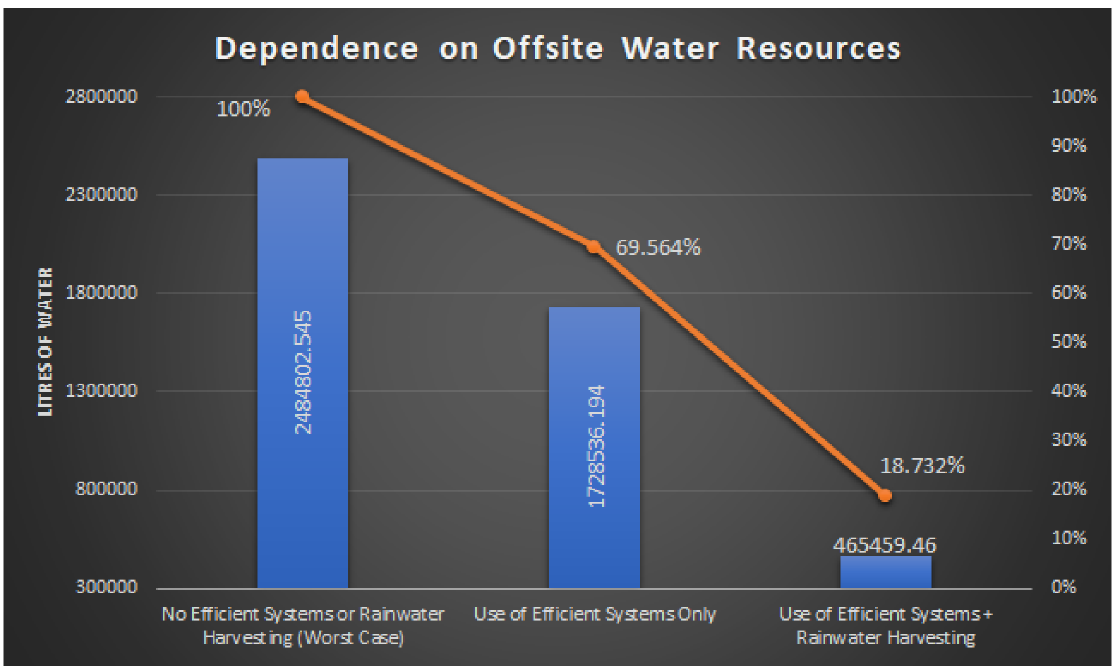


Fig18:- Reduced Dependence on Offsite Water Resources

Although a net positive water cycle had already been achieved, we felt it was necessary to reuse as much water as possible, instead of disposing of it after a single pass. So, the greywater generated on site is to be treated via a root zone system and used for non-potable purposes. Also, the blackwater generated is to be treated to a decent standard and returned to the municipality (offsite source) wastewater treatment facility. All this resulted in an even better water performance (net positive by 1283773.8 L) and left us with 1423932.5 L for recharging groundwater reserves or non-potable use elsewhere.

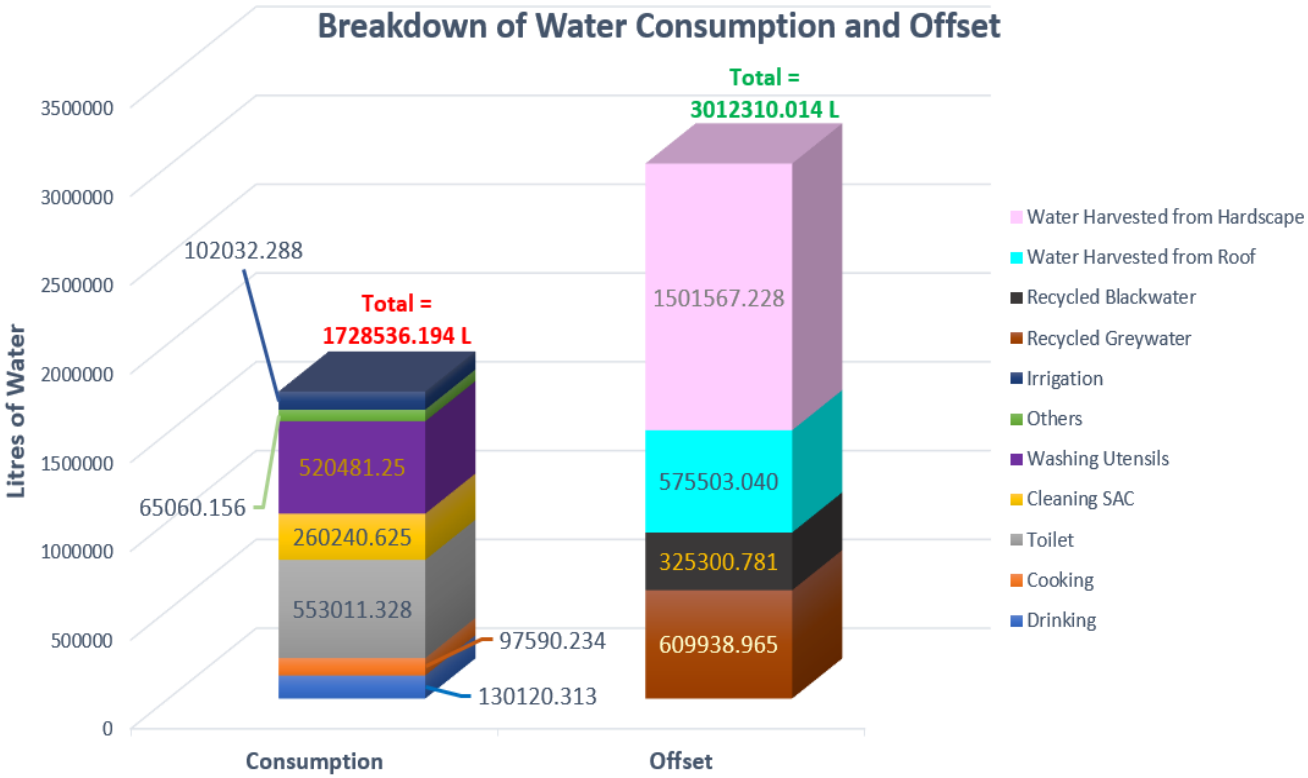


Fig19:- Net Positive Water Performance

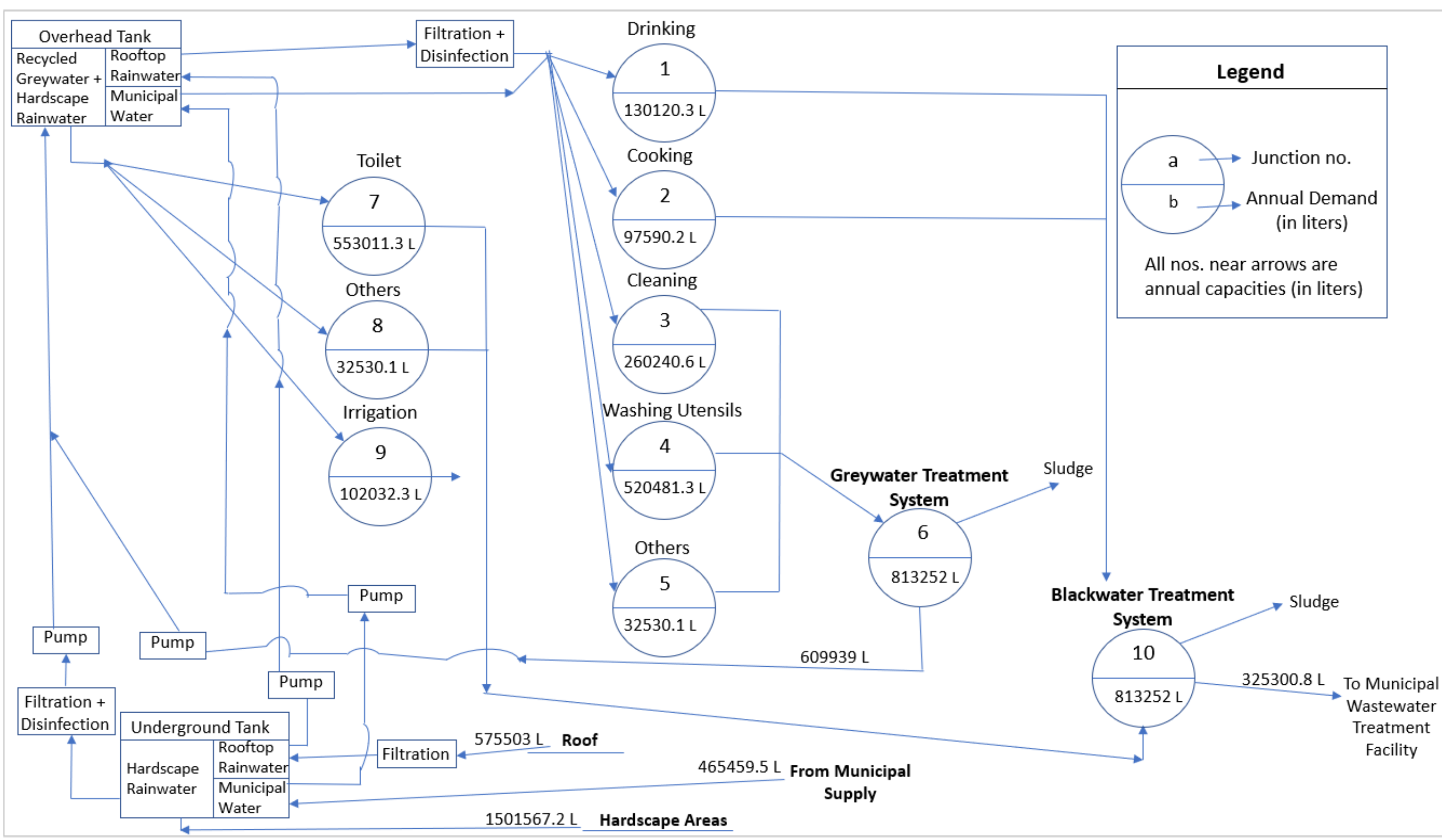


Fig.20:- Water Flow Diagram

The above diagram shows the flow of water to and from tanks and different use locations. The junction number and annual use/capacity has been mentioned for each location and system.
Greater insights and details on results and calculations summarised in this section, consumption breakdown, per head per day requirements and complete description of the water cycle (with SLD schematics) have been provided in the Appendix.

4. RESILIENCE
The performance of the resilient building or infrastructure depends upon its capability to adapt, absorb, and recover quickly from the hazardous and disruptive events. Generally, there are four components of resilience namely robustness, resourcefulness, rapid recovery, and redundancy.The site location is mainly affected by Earthquake , flood and extreme temperature. Heavy wind and drought can also be a probable disaster in the same location. As only two storey buildings and net zero water requirement building have been proposed to mitigate some of the challenges.

1. **Resilient against Flood:** The following measures have been taken to make building sustainable for flood disaster.
    - Increased elevation of building- 218.5 m (Building Base elevation)
    - Water pumps provided on site
    - Drainage channel has designed on both side of the road (2m depth and 1m width)
    - Slope sidewalk with tree pit on the road side and flat main road.
    - Salt tolerant tree and dense tail tree
2. **Resilience against extreme cold and extreme hot climate:** Building is proposed to incorporate insulation to resist from extreme climate conditions. The following materials have been used in different components of building.

2.1 Roof Insulation: The following materials have provided in Roof:

- XPS Extruded Polystyrene has used to insulate in the outermost layer of thickness 80.5mm
- Concrete Cast - aerated (AAC block) have used as layer 2 of thickness 150mm
- Cellulose has used to insulate ceiling as layer 3 of thickness 75mm
- Gypsum Board of 12.7mm thickness provided in the innermost layer.
- The overall U- value achieved from roof is **0.175 W/m²K**

2.2 Floor (Internal) insulation: The following materials have provided in internal floor:

- Gypsum Board of 12.7mm thickness provided in the Outermost Layer.
- Concrete Cast - aerated (AAC block) have used as layer 2 of thickness 150mm
- Wooden derivative-Chipboard of thickness 50mm as layer 3 have used
- Glass Fibre Quilt of 50mm as layer 4 has provided
- Flooring, wood Subfloor of 19.1mm thickness in innermost layer
- The overall U- value achieved from internal floor is **0.306 W/m²K**

2.3 Floor (Ground) Insulation: The following materials have provided in ground floor:

- Urea Formaldehyde Foam of 100mm thickness provided in the Outermost Layer.
- Concrete Cast have used as layer 2 of thickness 100mm

- Floor/Roof Screed of thickness 70mm as layer 3 have used
- Timber Flooring of 30mm thickness in innermost layer
- The overall U- value achieved from ground floor is **0.314 W/m²K**

2.4 Wall Insulation: The following materials have provided in wall:

- Cement/plaster/mortar- plaster of 20mm thickness provided in the outermost Layer.
- Glass fiber batt insulation (compressed) have used as layer 2 of thickness 47mm
- Concrete Cast -aerated of thickness 230mm as layer 3.
- Glass fiber batt insulation (compressed) of thickness 65.9mm as layer 4.
- Cement/plaster/mortar- plaster of 20mm thickness provided in the innermost layer.
- The overall U- value achieved from wall is **0.27 W/m²K**

2.5 Window insulation: For window insulation, a double glazed window is used. Its U- value is 2.7 W/m²K.

3. **Resilient against Earthquake:** The IIT Ropar Location comes under seismic zone IV. The following measures have been adopted to mitigate the effects of an earthquake or seismic event.
    - Framed structure designed
    - Stitches provided at the corners
    - High rise buildings are avoided
    - Ductility is exhibited by the building design so as to ensure that even though damage can occur during the event of an earthquake, the building does not completely lose its load bearing capacity and thereby preventing any major losses in lives or property. This can be achieved by providing adequate connections between the various structural members in the form of anchorage length between the reinforcement bars of the beams and the columns, lap length between any consecutive reinforcement bars within the same section and adequate spacing for the confinement bars in the beams provided.
4. **Resilience against COVID-19 Spread**: In the view of COVID19 pandemic, the building should be resilient enough to reduce the spread of COVID19. For this purpose, a contactless thermometer with hand sanitizer dispenser (e.g. Euronics) would be installed at the entrance, which measures temperature and dispense sanitize together and automatic alarm flashing above 100.4℉. The foot operator hand washing and sanitizer station would be placed at each floor and washrooms of the building.
5. **Resilience in Critical Condition**: In water supply and power supply disruption, water would be used from a reserve storage tank and generators have been considered as an alternative source of power supply. Plantation, clean water facilities and medical services have been provided to promote the healthy ecosystem. Fire Detection alarm systems and fire extinguishers will be placed wherever necessary. Emergency Openings shall be provided.To avoid loss of electricity in the building we have multiple systems in place:If the power from the grid is lost, we can decrease the total connected load by switching off equipment with high power requirement.During the day we can supplement the

power loss with energy generated by solar power.In Case the Solar generation is not enough, we have a central backup(for all campus buildings)And incase of disruption of those we have a backup DG set in place.Which can supply enough power for auxiliary load

5. AFFORDABILITY

Reducing hard Costs:

The type of soil found at the **site is alluvial**. Using **piled-rafts** for the foundation helps in reducing the need for a large number of piles due to the contribution of the intervening soils below the raft. Yields substantial savings as the foundation cost typically comes to about 12% - 15%.

- ❖ Construction of the Student Life Centre building using the precast method in which fabricated building components are built first in the factory then arranged on the site to form a structure. This system's advantages include **quality precast** well preserved, **relatively shorter period of construction**, environmentally friendly, and less residual materials generated.

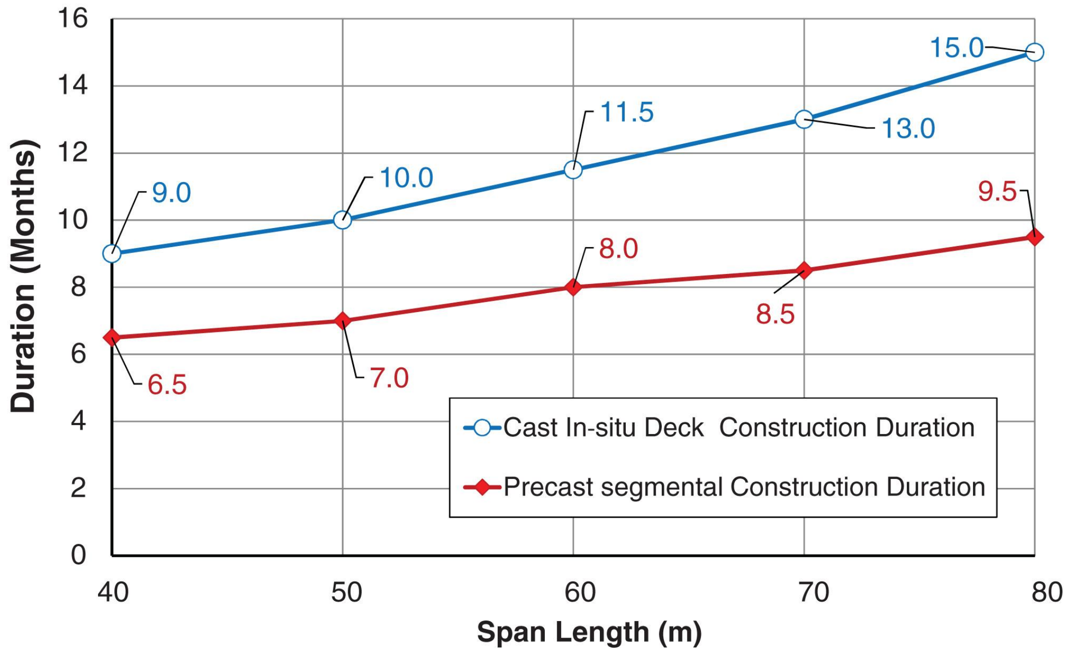


Fig.21:- depicts Construction duration Vs. Span length for In-situ and precast ref.

The typical span length of the Student Life Centre building will be 15m-20m, use of precast segments could help to save nearly 5 months of **beam construction time**.

- ❖ Using XPS Cement Sandwich panels made of reinforced silicate board, filled with cement, XPS polystyrene foam particles are lightweight construction material. The board thickness of 80mm helps in saving construction space compared to the traditional block along with excellent insulation and sound insulation leads to energy saving, thus helping to save costs in the long run.

- Using Prestressed Post Tensioned Concrete instead of conventional RCC will be more economical as they are thin, the materials used in it are also lesser and much more robust than conventional RCC. As they are thinner, it makes valuable savings in the floor to floor height resulting in a lesser height of Student Life Centre building with the same number of floors due to which a significant amount of cost on construction works like **RCC work, Plasterwork, Masonry work, Shuttering work, and painting and cladding** can be saved.

  Calculation :
  Initial height of each floor = 4.2m
  Initial height of the Student Life Centre building (4 floors) = 16.8m
  After using **Post-Tensioned Slab** :
  The **required height of the floor reduces to 3.5m**,
  the **height of the building will reduce to 14m i.e. 16.67% less**, eventually **saving both construction cost and time by at least 4 month**.

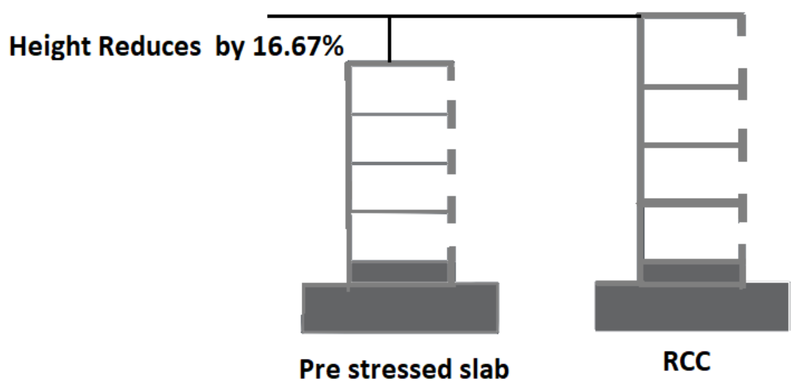


Fig22:-Precast slab vs RCC

Reducing Soft cost

- Implementing modern techniques like prominently using precast materials in most of the construction, pre-ordering materials in such a way that it reaches just before needed will help to complete the construction before the project timeline. Using the precast method and Prestressed Post Tensioned Concrete in construction, will help to complete the Student Life Centre building at least 9 months before the timeline which will eventually save IDC (interest during construction) cost by 30-35%.

By implementing the above techniques, we can reduce a significant amount of cost incurred during construction. Other than this, the project is very much affordable during its operational :

- The annual energy consumption of the proposed Student Life Centre building is 193 MWh whereas the annual energy generation by the renewable methods (majorly, solar energy)is nearly 220 MWh, so this excess energy can be sent to the electricity company by feeding the grid using **Grid-Tie Inverter** (an on-grid rooftop solar solution which runs loads on solar and automatically sends excess power to the main grid).

Calculation : cost of a 350 W solar panel = 11,000 INR
No. of solar panels = 450
Installation cost = 50,000 INR
Total cost = 11,000*450+60,000 = 5,010,000 INR

The following graph shows a comparison of the cost incurred on buying and maintenance of solar panels Vs. the cost saved using solar energy with the time.

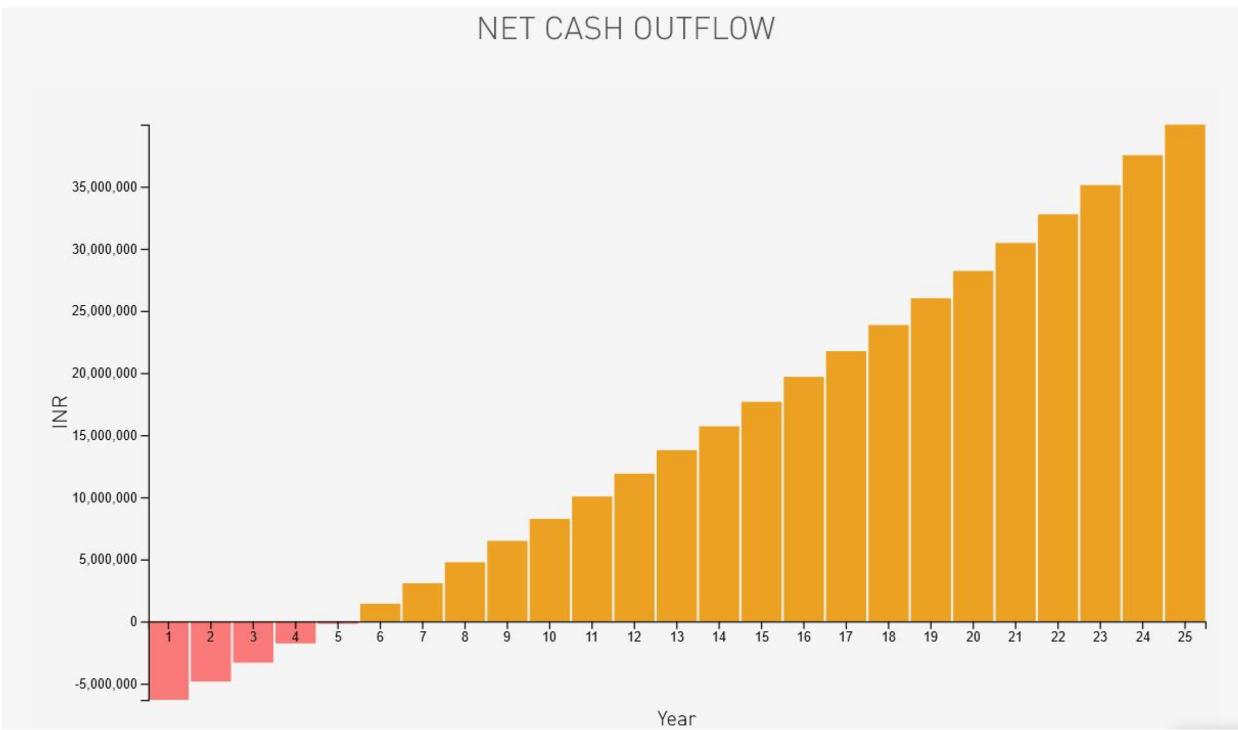


Fig. 23:- shows Net cash outflow with time[link]

6. COMFORT AND ENVIRONMENTAL QUALITY

Comfort and environment quality is a very important aspect of the building as it affects the health of the occupants. And at the heart of it is the HVAC system. The goal is to make the building energy efficient without compromising with the comfort and air quality in the building. So to achieve this goal we used efficient window glass material, shading, and an energy efficient HVAC system.

ASHRAE-55 2017 adaptive comfort model is followed with operative temperature control and 80% acceptability limits to decide on the comfort conditions and the temperatures required to be maintained with proper ventilation and air quality.

We brought down the HVAC peak cooling load in the proposed case to 96TR from the base case of 156TR using shading and more precise modelling and simulation and using air cooled VRF system instead of standard VAV system resulted in a drop of 40.4% in total electrical energy consumption.

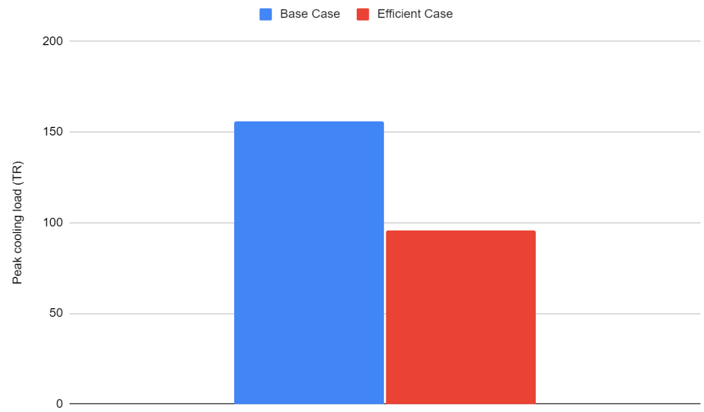


Fig24:- cooling load

Base case - 156 TR (549 kW)
Proposed case -96 TR (340 kW)

As our building is a student life centre there are spaces with people doing a variety of activities ranging from relaxing to sports and dancing which means the different areas require different conditions for providing comfort to the occupants. So to overcome this we used a VRF system which has the capability to maintain different temperatures in different zones while being energy efficient at the same time and this system uses the refrigerant R410A which is an ozone friendly refrigerant. Another advantage of air cooled VRF is that it does use water and hence improves water performance. A trade-off between energy and water efficiency with cost exists as an air cooled VRF is relatively costly and requires maintenance.

The proposed HVAC system consists of 3 units in total, one for each building. The design and Single Line Diagram (SLD) of the 3 units are the same but they will differ in their capacity.

- Minimum capacity of outdoor units of the 3 VRF systems - 85kW, 31kW and 154kW (for west, center and east side buildings respectively).
- Each zone is provided with outdoor air supply.

Only those areas are conditioned which are considered ‘activity areas’ like technology rooms, dance rooms, auditorium etc. And areas like store rooms, corridors, washrooms etc. are unconditioned but naturally ventilated with mechanical ventilations in few as these areas like ‘instant use’ areas and don’t require artificial conditioning. For other area the operative temperature is calculated by using the CBE thermal comfort tool which resulted in very low amount of hours(annual) not meeting the ASHRAE 80% acceptability model during occupied hours, below and near 10 hrs in most of the conditioned zones and below 50 hrs in the rest few.

- 10 l/s-person fresh air.
- Natural ventilation (5ac/h) with mixed mode in all zones (except rooms like music room, auditorium and conference room)
- VRF provides both cooling and heating (in summer and winter respectively).

- Proposed HVAC equipment to be used -
  Indoor unit - Daikin's ceiling mounted cassettes (round flow), model name FXFQ-AVM (VRT smart control), with single unit having capacity upto 6HP. Round flow units have an advantage of more even temperature distribution compared to 4 way type.
  Outdoor unit details provided in annexure.

7.SCALABILITY AND MARKET POTENTIAL

The Student Life Center strives to provide an open, safe environment for recreation, learning, and social interaction while meeting user demands. The primary purpose and focus of the new Student Life Center are for student usage.

Student activities positively impact any Institution's environment, and this scalable model of a student life centre will add a set of valuable learning experiences for students & faculty.

From the various studies, it is observed that the student community is the most vulnerable to mental and physical issues. Following are some important facts and observations:

- Nearly 50% of all mental health conditions originate before the age of 15.
- One-sixth of the population aged between 10-19 suffer from depression.
- Among 15-19 years olds, suicide is the third leading cause of death.
- So, having spaces, especially for students in colleges where they can participate and perform recreational activities apart from their academics, is a must to cope with mental health issues among students.

The facility will be devoted to student recreation, learning and socialization. A student centre or student union is the college's community centre, serving students, faculty, staff, alumni, and guests. Thoughtful planning is given to facility policies and procedures to preserve student recreational programming space.

We care deeply about sustainability for our campus and State. This building will demonstrate how IIT ROPAR can be environmentally conscious in its designs, build and facilities now and into the future. This building will serve as a pilot project from which educational institutions can expand sustainable operation methods to other areas on campus.

The Student Life Centre will take advantage of the Energy-Efficient Building market worldwide, which is projected to grow by USD 103.9 Billion, driven by a compounded growth of 5.5%. The shifting dynamics supporting this growth make it critical for businesses in this space to keep abreast of the changing pulse of the market, poised to reach over USD 246 Billion by the year 2025, which should shape the design philosophy of our Student Life Center.

Target Market: The education sector, especially upcoming Colleges (technical or non-technical), Institutions, and schools, will be our main target as these are places where most students are associated.

Market potential

As of February 2017, there are 789 universities, 37,204 colleges in India. Also, there is a significant number of upcoming colleges. Earlier, colleges were not giving much importance to student co-curricular activities, but time has changed. The Student Life Centre is an integral part of any campus either it's technical college or non-technical as it helps promote the objectives of the New Educational Policy (NEP). India has been adding more than 1000 colleges per year. Most of these campuses either do not have a

Student Life Centre, or they lack basic facilities. In India itself, having such a large number of college campuses, there is tremendous demand for state-of-the-art student life centres that fulfil students' needs and are environmentally friendly. Also, sometimes students face pressure (like academics, peers .), so at this point, a well planned Student Life Centre (having a meditation centre, OAT .) can have an important role, where stu**dents can go for relaxation and re-energization.**

Scalability of energy efficient solutions implemented in our project:

Grid-connected photovoltaic (PV) systems are increasingly attracting the attention of industry and academia as a means of providing an alternative to conventional fossil-fuel generation. In grid-connected PV systems, a key consideration in the design and operation of power converters and how to achieve high efficiency for different power configurations. The requirements for converter connection include: maximum power point, high efficiency, control power injected into the grid, and low total harmonic distortion of the currents injected into the grid.

A photovoltaic power system is carbon negative over its lifespan, as any energy produced over and above that to build the panel initially offsets the need for burning fossil fuels. Even though the sun doesn't always shine, any installation gives a reasonably predictable average reduction in carbon consumption.

Aerators: Taps can flow at 18 litres of water per minute and costs approximately Rs. 3.11 (£0.03) for every minute the taps are running. Hot water is even more expensive as you use energy to heat it. The biggest savings are realised on washroom sink and kitchen taps, as here, water tends to be turned on and off frequently and throughout the day. Using aerators we can reduce our water losses by upto 98% which use only 1.2lpm.

Fig25:-Dual Mode aerators

Piezoelectric Floor Panels:

Renewable and clean energy resources have become a hot research area due to the problems facing energy shortage and environmental concerns using fossil fuel resources. The world electricity demand will increase by almost 80% during the period of 2012-2040.Like a wind generator or solar cells. Piezoelectricity is also a type of technology used for electrical energy harvesting from mechanical pressure such as walking motion. Piezoelectric Energy harvesting floor as a sustainable clean energy is generating usable electricity depending on people's footsteps pressure, this valuable energy is wasted in spite of its available clean source (human movement). Public spaces piezoelectric floors can scavenge a reasonable amount of energy that can power electrical devices like lighting and screens. *(Refer to annexure table Table 3 under Scalability and Market Potential)*

Smart Classrooms

More than 370 million users are on the internet in India helping online education to grow at a fast pace. The E-learning market in India is estimated at more than 3 billion at present.

Online education provides information for every field of education at a wide range. Byjus, Vedantu, Educart and many more startups in India are emerging fast in Indian online education market.

Online learning has helped most of the people in providing education in different languages of their choice. Massive open online courses aim at unlimited participation and open for all via the web to deliver them education through different courses available.

E-Learning Market size surpassed USD 200 billion in 2019 and is anticipated to grow at over 8% CAGR between 2020 and 2026.

Around 1.2 billion children are out of classrooms with schools shut down globally due to COVID-19 pandemic. To combat this situation, large-scale national efforts to leverage technology to the market players in support of distance education, remote, and online learning during the COVID-19 pandemic are emerging and evolving rapidly.

Traditional insulation materials, such as polyurethane foam, mineral wool, rock wool, and stone wool have certain drawbacks. For example, thick layers of these materials are required to achieve the desired R-value, which result in loss of valuable floor space in case of new construction. For old buildings, it is even tougher to introduce high insulation levels, as extra layers lead to changes in the aesthetic appearance of a house. Hence, to fulfill energy standards set by various regulatory bodies and to avoid structural compromises in new constructions, aerogels are projected to be an ideal replacement for traditional insulation materials. Owing to their low thermal conductivity and less thickness, aerogel materials can save a substantial amount of energy, which otherwise would have been used for heating and cooling purposes

The method of synthesizing silica aerogel is economical, and the process is very versatile. Silica aerogels are best known for tremendously combining low thermal conductivity with high optical transparency

According to the Energy Technology Perspectives 2016, the primary energy demand and carbon emissions should be reduced over 30% by 2050,Within this context, the use of urban green infrastructures (green roofs and vertical greenery systems) on building envelopes have become more popular during the last decade as promising passive solutions regarding the energy consumption and CO_2 emissions in built environments. Moreover, they offer multifunctional benefits (ecosystem services) at ecological, economic, and social levels at the same spatial area through natural solutions.

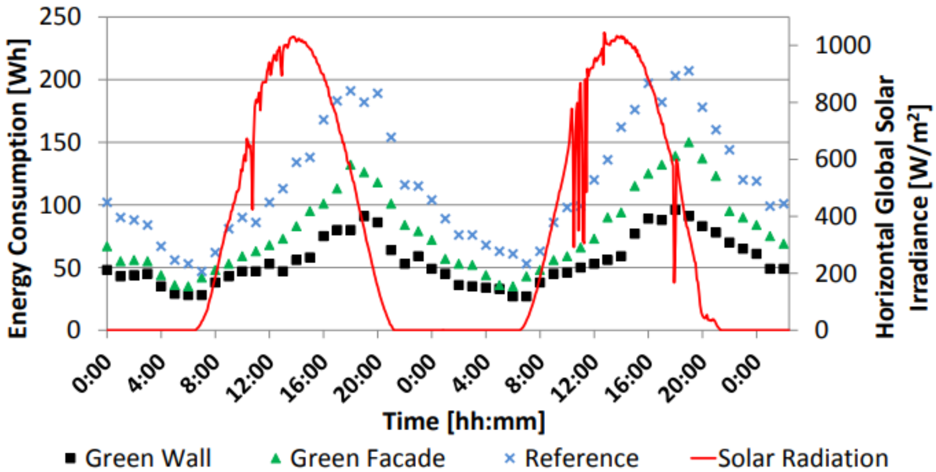


Fig26:-Energy consumption V/s Different wall Insulations

The Green Wall showed an interesting reduction of 4.2 % of energy demand.

The utility-scale industry holds a major solar photovoltaic glass market share among all end-use industries and is expected to grow with the highest CAGR during the forecast period. Utility-scale solar plants provide the benefit of fixed-priced electricity during peak demand periods, when electricity from fossil fuels is the most expensive.

In addition, the market is boosted by laws and regulations, which are promoting photovoltaic panel installation. With growing solar installation, the demand for solar photovoltaic panels is expected to increase significantly, thereby enhancing the chances of it being a economical solution for us.

India generates 9.4 million tonnes of plastic waste annually. Out of this, 40% remains uncollected and 43% is used for packaging, most of which is single use, a study conducted by Un-Plastic Collective, a voluntary initiative to curb plastic pollution, revealed last year.Plastic, when heated at an optimal temperature, acts as a binding agent for traditional road laying materials like bitumen. This mixture does not let water penetrate the roads, hence making them more durable.using 8-10% of plastic waste mixture with traditional road laying material, can reduce the expenditure on road laying material by ₹1 lakh per kilometre of road. Over 86,000 tonnes of plastic can be used in the construction of roads countrywide.

Higher Education Financing Agency (HEFA):

The funding under HEFA will replace the current grant assistance by GOI for infrastructure projects in our project.

It’s an excellent opportunity for corporates to have a stake in this venture and supplement GoI's efforts to promote Research and Innovation in India's premier educational institutions and partner in R & D projects and excellent avenue for corporate donors to channelize the funds to ensure efficient utilization of funds.

HEFA's debt obligation is guaranteed by GoI ensuring prompt repayment of HEFA's obligations to investors. It's a win-win model for all the stakeholders.*(Refer to annexure under Scalability and Market Potential)*

8. ENGINEERING DESIGN AND OPERATION

Engineering and operations being an important part of any building it had to be carefully designed to suit the needs of our Energy-efficient building.

Initial work started with Lighting simulations on Design-Builder software where we did simulations for the base case scenario where we found lighting consumption was on a very high side(112.83 MWh) and with that type of lighting consumption making the building energy-efficient would be very difficult. Hence the various parameters were tweaked in the software to try to achieve a lower lighting power consumption.

With the reduction of power required for lighting the obvious choice was to go with LED lighting fixtures, as LEDs are far more efficient and have a higher luminescence to power ratio than traditional lighting fixtures(A luminous efficacy of 150 lm/W for LED vs. 35 lm/W)

Another part of designing an energy-efficient building is reducing waste. For that, we decided to incorporate various sensors in our building. We found the wastage would be there especially during the late-night time period where there are far fewer people in the building than evening. Hence the power consumption can be reduced by installing motion sensors and heat sensors along with lighting fixtures in places like washrooms, and individual labs. For washrooms 60% of lights will be turned off until motion or heat is detected and in the labs/rooms all lights will be closed when no motion or heat is detected. This alone saves a lot of energy.

Considering the building of this size it is difficult to have an ample amount of natural light in each room throughout the day, various teams worked hard for optimising the natural light available to us. But we found that despite best efforts lighting would be required for some places in our building during the day time. As rooms are larger , through calculations we found that it is more efficient and practical to have lights whose brightness can be controlled and use them than just turning on alternate lights. For the brightness, we incorporate light sensors which will give a reading to the controller and the controller will increase or decrease the brightness of the lights and try to maintain a constant reading of the light sensor. As some of the rooms are bigger they will be having multiple sensors for each section as natural lighting conditions may vary in rooms as well. Considering all these we brought down the lighting energy requirements to 48.78 MWh.

For the energy required estimations for the various appliances and sockets we made a table(link) of sockets (and their average consumption per hour, according to the room they are in), and fixed appliances that will be running continuously throughout the day. If all the various point are running simultaneously throughout the year then those come out to 24.2 MWh but assuming that those will be 70%(as potential demand factor for commercial building is 70-90%) of them will be used (averaging throughout the day and throughout the year), the energy consumption is 16.94MWh.

For the transformer selection, we calculated the total load of the building which came out to 200 kVA which dividing by p.f. 0.8 comes to 250KVA hence we decided to use a

315KVA transformer. For the circuit breaker that is connected on the transformer side the rating is 315*1.4(factor for converting to A from KVA) = 441A. Hence we use a 500A MCCB for the main meter.

Fig27: DG Set

For the individual loads of the rooms we decided to distribute it in such a way that for each load of 10 kWh we had a circuit. The rating for the same would be 10*1.9(standard conversion factor)*2(safety factor) = 38A so we will be using a 63A MCB for operations. For each building we also had a separate 32A circuit breaker for 5kW load in each building. For building-1 common lighting systems and washrooms we are using a 32A circuit breaker on each floor. 16A circuit breaker per floor for building 2 lighting systems and 32A circuit breakers in the 3rd building. Also separate breakers for HVAC(80A,32A,125A for building-1,2,3 respectively) and water systems breaker.

Structural Model has been shown in architectural design and details in appendix.

HVAC Sizing: We will be using an ASHRAE-55 2017 adaptive comfort model with operative temperature control. The Initial load was around 156TR and was brought down to 96TR using modelling, simulation and shading. We will be using an air cooled VRF system instead of the standard VAV system. Sizing details are mentioned in Annexure.

Water Management: For a particular month, we assume the same rainfall, municipal water requirement and quantity of water treated for each day. Thus we see that in a year, maximum rainfall is collected on days of August (23072 L per day), and November days have the highest dependence on municipal water (2850 L per day). 1670 L of greywater is treated per day. Using this data and a safety factor of 1.5, the underground tank and overhead tank volumes come out to be 38883.1 L and 41387.9 L respectively. 2226.6 L of greywater is generated per day. Using thumb rules + scaling for a retention time of 3 days, and a safety factor of 1.5, we find that a root zone bed of 79.5 m^2 is needed. As can be seen from the water flow diagram, we need 4 pumps. Based on daily water requirements, building height and safety factor, we decided to go for COMEX VORTEX 400 pumps of 3kW power, 14m head and 2000L/min capacity.

Renewable energy generation and storage: We will be using SOMERA GRAND (SOMERA VSM.72.AAA.05)Solar PV module for solar panels by Vikram Solar, as it best fits our dimensioning and energy requirements as well as cost. It has a maximum voltage capacity of around 1500V and has a 27 year linear performance guarantee(Performance during 27th year will be around 80%). It has 72 Mono PERC, 5BB solar cells and has composite film back sheet with anodised aluminium frame. The module has superior efficiency at around 19%.
We will be using a 160kW hybrid indoor and outdoor grid modular solar power system with 2 sets of 192V 200Ah lithium batteries along with the solar panels.(All this is by Baykee company). There is 3 phase 220V with a 160kW transformer connected to the front of the solar inverter with the inverter having a bypass module and 8 pieces of 20kW power modules. The TYN-M series in grid hybrid MPPT solar inverter is to be used which has 8 working models,and it can support lithium battery packs, OPZV, GEL as well as Lead-acid batteries. The inverter adopts multi-mode design to adapt to variations in power and can be applied to one-phase or three-phase.

Fig 28: Inverter and storage cell

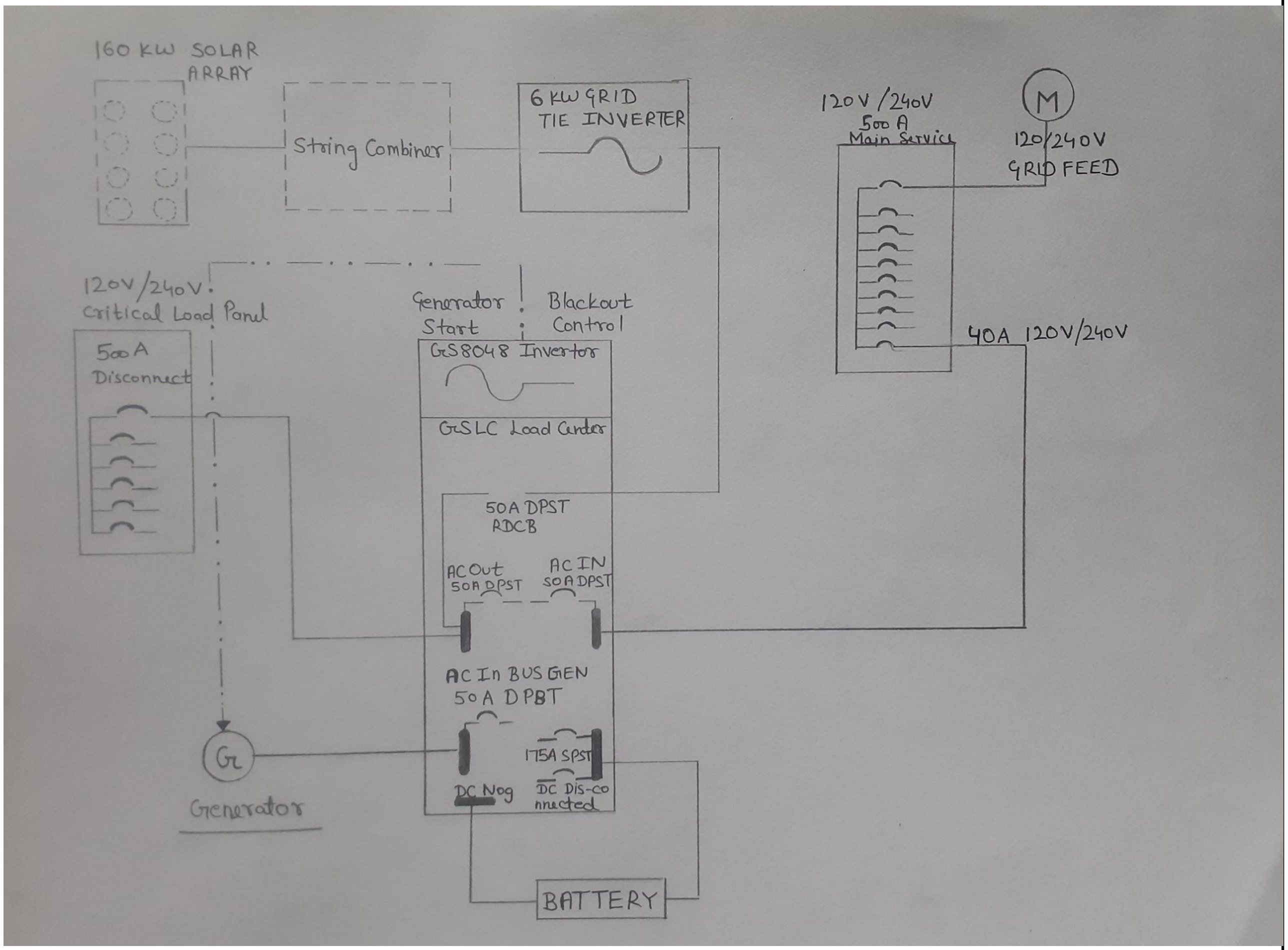


Fig. 29.a:-Electrical SLD(Solar)

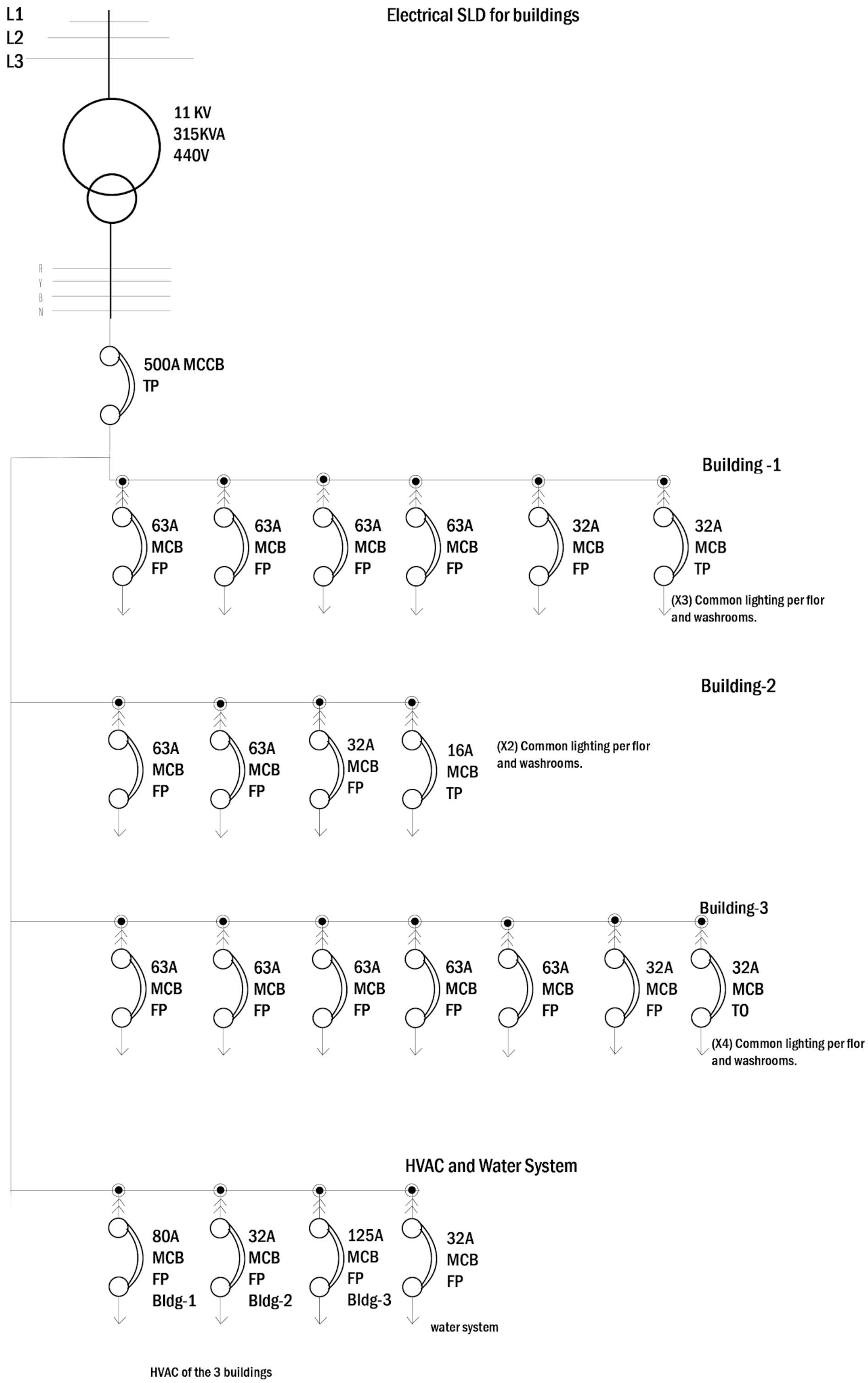


Fig. 29.b:-Electrical SLD(Building load)

9.INNOVATION

- To balance the consumption and generation profile, the Student Life Centre building will be directly connected to the electricity grid present in the campus to export excess power and import when there is less generation. Using the predominant tropical, semi-arid and hot climate of summer to our advantage, we have mounted solar panels on the ground besides the roof to capture maximum solar energy.
- Aerator fitted taps to reduce water usage for same time of flow have significantly helped us to achieve net positive water efficiency building. Further more keeping Covid 19 scenario in mind, Hygiene Aerators can also be installed which have ON-OFF function by finger touch, which means we need not touch knob/lever of tap; which could result in transfer of germs. Anti clogging screen filters sediment/debris and material is scale resistant.
- To meet sustainable and clean energy goals, we are planning to use piezoelectric sensor technology in our life centre. As people walk across this system, the weight from their footsteps compresses electromagnetic generators below, producing upto 5 watt seconds [9] off-grid electrical energy per step. Keeping in mind the 2500+ student strength, this will produce a yearlong clean energy generation method. Further it can be used in sporting areas such as Badminton court, Dance rooms, ensuring fun along with fitness.

Fig30: Piezoelectric Dance Floor

Fig31 : Solar Panel Blinds

Area of Dance room = **200 square meters**
Cost of (50cm X 50cm) **Pavegen** piezoelectric tiles = **200US$- 395 US $ ***
(* As available on internet, however cost might be lower in India)
Number of tiles required = 200/0.25 = 800 tiles
If suppose the dance room is used for 2 hours every day by 50 people then
Power generated in the whole year = 5 X 50 X 365.25 X 2 = 182.625 kWh.

1. These figures are however lower bound considering only one foot of all people is pressing on one tile all the time. These values will be however very high in actual scenarios.
2. Initial costing to lay these tiles may be high but they will start to yield benefits within a year [10]. (Case study 3.1)

- **Social Innovation :-** We intend to open a technology training Centre for people of nearby villages in our student life centre where they would be trained with basic things like operating laptops/ computers and doing all their work online such as paying bills, filling forms, taking appointments etc. to make them 'Atma Nirbhar'/Self Reliant.

- We are planning to explore the replacement of normal glass windows facing the sun with transparent solar glass which will convert a fraction of solar energy into electricity. To do so the cell selectively harnesses a portion of the solar spectrum that is invisible to the naked eye, while allowing the normal visible light to pass through. These glass panels are transparent photovoltaic cells and their advanced version, Solar panel blinds can produce up to 100w of power per 10 sq feet.[11] Hence this way our life centre having a substantial amount of photovoltaic glass will produce its own electricity through the windows and will compensate the cost to plant them. In our life centre, appx. 3230 sq. foot of glass is facing sun hence power generated will be :-
- Power generation = 3230 sq. foot X 10 Watt/sq feet = 32.30 KW
- **Plastic Roads:-**Very frequent rains pose a problem, substationating demand of a well defined drainage system along pathways. However its use can be eliminated by use of Plastic Roads. PlasticRoad offers a comprehensive solution for flooding, harmful emissions, plastic waste and soft soil. During heavy rain, the excess water quickly drains into the storage cavities below the road, from where it gradually infiltrates into the soil below.

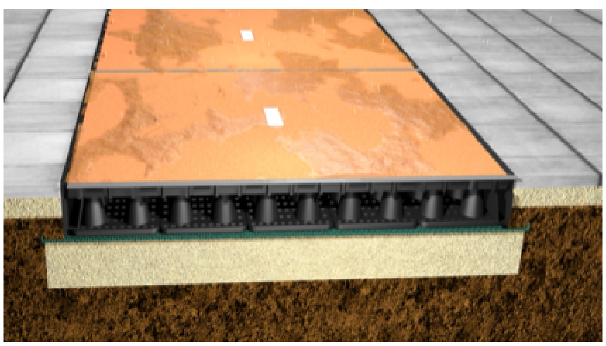


Fig32:- Rain Water pouring on footpath

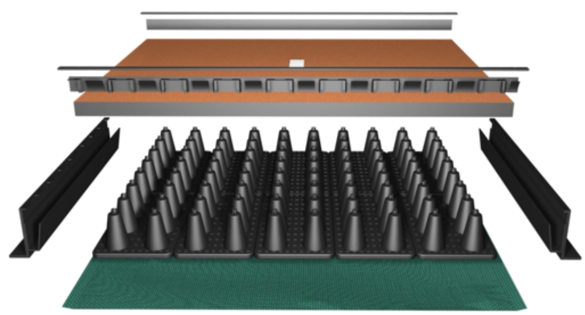


Fig33:- Internal structure of footpath

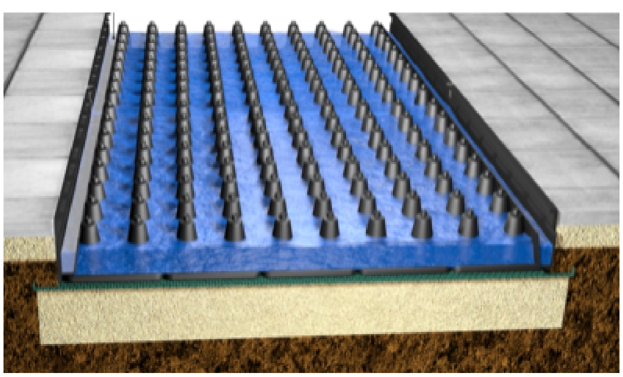


Fig34:- Accumulated Rainwater

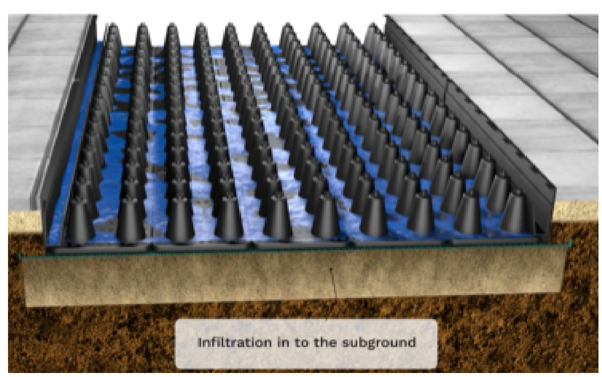


Fig35:- Water sent to the ground

- This technology has been tested successfully in the Netherlands and has proved a promising future. As per officials it is climate adaptive, lightweight, easy to maintain and provides one stop solution to plastic waste as it can accommodate upto 25.7 [12]kg of plastic waste per m^2 . Also it can lead to a reduction in carbon footprint by 52-72% in comparison to conventional paving as per a study by independent enterprise agency of Netherland, RVO. [13]

- A formidable factor contributing to the decrease in efficiency of the root zone water treatment system is evaporation from the soil, thus making less water available for use at the outlet. Hence to prevent evaporation from soil and retain moisture, oil and decayed organic matter will be mixed with the soil.
- To increase the root zone system's nutrient absorption capacity, mushrooms will be cultured in the soil. Not only will they themselves absorb nutrients from the wastewater but will also have a symbiotic relation with the other treatment plants, especially at the root level. The heavy metal adsorption capacity increases, and due to a conducive growth environment for the plants, more nutrients are absorbed thereby increasing the system efficiency, reducing sludge formation and ensuring better quality water is obtained at the outlet.

12. Pitch to your project partner (2pages)

The Inaugural Solar Decathlon India 2020-2021 has been an exhilarating and an intellectually stimulating experience for Team Tejasvi IIT Ropar. In addition to the learning achieved, the concept chosen by the team has many challenges, some of which have been addressed and some provide an avenue for innovation.

The team identified opportunities to develop an energy efficient building, however architectural innovations need to be identified to reduce costs further, as it is a student life center. Rainwater harvesting plan needs to be incorporated by the project partners considering the potential of water stress owing to an agrarian pattern based primarily on rice in Punjab.

If students are able to explore the various facets of life at a campus like IIT Ropar which is in a semi-urban area, then this concept can be adopted nationwide and help in generating revenue. One of the ideas which we will like to work in further development,is that sections of the building be sponsored through Corporate Social Responsibility (CSR) funds. A notable effort is Mpower to promote mental health and well-being in the most holistic manner conceivable which was founded by Ms. Neerja Birla.

As funding for higher education is getting reduced globally, and economic hardships have been severe on millennial and Generation Z students (2008 Crisis, Corona Economic Slowdown), concepts of integrating energy and water efficiency , low operation cost, modern architecture and student life are very important. The Solar Decathlon India contest has provided an opportunity to propose a building designed "by the students", "for the students" and eventually it will be "of the students".

Once it was informed that IIT Ropar has emerged as one of the finalists in the Educational Building competition and technical appreciation was received for the presented work, our Project Partners have been motivated. Dedicated meeting with Civil Engineering faculty members representing structures, hydrology, remote sensing, constructional material experts, environment which has enriched student confidence greatly.

Furthermore, the project has also invited the interest of a Rome (Italy) based architectural firm whose CEO is Ms. Alessia Costarelli (ACK Service & Design) who is helping with the design elements.

The team has also scheduled an appointment with Mr. Sumit Kumar Somani, Founder Director Pickrenew Energy Pvt. Ltd. and Ms. Richa Rathi Somani , Director - Process Implementation at Pickrenew Energy Pvt. Ltd. PickRenew Energy helps Commercial, Industrial and Residential owners to PICK right Renewable (Solar, Wind, Hybrid) systems for their energy requirement and the organization is based out of Indore (Madhya Pradesh).

Tejasvi IIT Ropar is confident that the Solar Decathlon India competition has provided them a very strong platform to shape the future of student life in an educational campus. The thrust of interdisciplinary education envisaged by the Government of India's New Educational Policy, need for energy efficient buildings, architecture promoting student health and wellness is a trio which is essential for the growth of a modern educational institution.

After the completion of the competition, detailed presentations will be given to the IIT Ropar Administration with the hope that this request may be accommodated in future expansion plans of the institute. The provision of plan, 3-D Model, energy and water performance calculation with state of the art software, along with expert feedback will essentially lay the foundation of a new concept in higher education in India. We are grateful to Solar Decathlon India 2020-21 for this great start.

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