Solar™ Decathlon India

Final Design Report - April 2021

OFFICE BUILDING

TEAM SPARIKAM

School of Planning and Architecture, Delhi

Goel International Pvt ltd

Global Institute of Technology & Management, Gurgaon

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Team SPARIKAM from School of Planning and Architecture, Delhi, designs Office Building in Karnal, Haryana. The aim of the project is to create a net-zero-energy-water building with proper day-lighting and also providing thermal comfort catered specifically to the composite climate zone. Developed with a data driven integrated design approach by an ambitious team along with faculty guidance we present project 'RIZAZERO'

The Site is located within the boundary of Rice Mill in Karnal, Haryana. With regular pollution from Rice Mill and seasonal pollution of burning crops from the neighbourhood farmlands, this challenging site lies in the moderate hazardous zone as per NBC. Addressing these issues has been quite challenging but also a worthy learning experience.

With careful consideration to all the building science principles and affordability carrying out pre design comfort & energy simulation we developed an optimized building massing having a huge potential for obtaining thermal comfort through natural ventilation and operating the building on mixed mode.

By addressing Daylighting, which is one of the primary aspect in Office Building, we started with an idea of incorporating Atrium in the office block. In the process of addressing various other issues, we came up with an innovative combination of Atrium and Courtyard. While Atrium helps the office spaces to achieve required Day-lighting of 100-2000 LUX along with the cool atmosphere it provides during the Summer which allows users to open their windows in to the Atrium. The Courtyard with water bodies for Evaporative Cooling also acts as the Solar chimney by throwing out the hot air from the semi-covering above.

Solar PV's integration in southern facade helps to reduce the heat gain and generate energy at same time. Same with the Solar PV's placed over the Roof. By this, huge amount of heat gain can be reduced. Use of low u-value materials in external wall, cavity walls, jalis also helps us to reduce the heat gain.

Existing Biomass plant with 3MW capacity plays a major role in making this a Net-Zero energy building by providing almost half of the energy requirements. As mentioned above, the placement of Solar PV's in all appropriate places makes surplus electricity which will be sent back in to the Grid. Above mentioned measures bring down our EPI. Using low flow fixtures while reusing the grey water and implementing Rainwater harvesting helps us to achieve Net-Zero in water.

Team SPARIKAM
Institutes : SPA-Delhi, GITM-Gurgaon
Division : Office Building

TEAM ORGANISATION

Team SPARIKAM comprises of 11 students from School of Planning and Architecture, Delhi and a Civil Engineering student from Global Institute of Technology and Management, Gurgaon, Haryana. The team was divided into subgroups based on people's expertise in a particular field. By collective decision making and constant efforts from every individual we were able to come up with a Net-Zero design.

TEAM MEMBERS

LEAD INSTITUTION PROFILE

School of Planning and Architecture, Delhi

The School of Planning and Architecture, Delhi comes under the Ministry of Human Resource Department(MHRD). It is deemed to be a university having recognition as an institute of National importance, it had a modest beginning in 1941. The School has taken lead in introducing academic programmes in specialized fields both at Bachelor's and Master's level, some of which are even today not available elsewhere in India. It offers Undergraduate programmes like Bachelor of Architecture, Bachelor of Planning and several Masters and Doctoral Programmes.

FACULTY LEAD & ADVISORS

Ar.Vandana Balakrishnan
Faculty Lead, SPA Delhi

Ar.Sachin Rastogi
Faculty Advisor, SPA Delhi

Ar.Anand Dhote
Faculty Advisor, SPA Delhi

Ar.Debashish Majumdar
Faculty Advisor, SPA Delhi

Ar.Prabhjot Singh
Faculty Advisor, SPA Delhi

INDUSTRY PARTNER

GREENJAMS BUILDTECH

GreenJams is an award-winning cleantech enterprise that exists to create a beautiful carbon-neutral built environment. They create carbon-negative building materials.

Project Name- RizaZero

Project Partner

GOEL International Pvt Ltd

Established in 1993, GOEL International Pvt Ltd has made its name into the list of top exporters of rice in India. The company is located in Karnal district of Haryana and offers high quality of Basmati Rice like Galaxy Jumbo Premium Basmati Rice, Galaxy Gold Premium Basmati Rice etc.

Key Individuals

Name	Name
Mr.Vinod Kumar Goel	Chairman & Managing Director
Mr.Vijay Kumar Goel	Managing Director
Mr.Krishan Kumar Goel	Managing Director
Mr.Vipul Kumar Goel	Managing Director

Brief Description of Project

This Project is a Office Building to accommodate various departments of Rice Mill like Accounts, Sales, HRD, Marketing, etc. This is a Build-Own-Operate project by our Project Partner.

Context

The site is located 4.7kms away from NH 44. Within the vicinity lies village Pakhana which is 1km away and village Taraori which is 2.5 km away. The site is accessible by Sounkra Road from the South and the immediate surroundings include several rice mills and farmlands which leads to a lot of noise and air pollution due to seasonal burning of crops in the fields. Vehicular movements in the South also adds up to the Pollution.

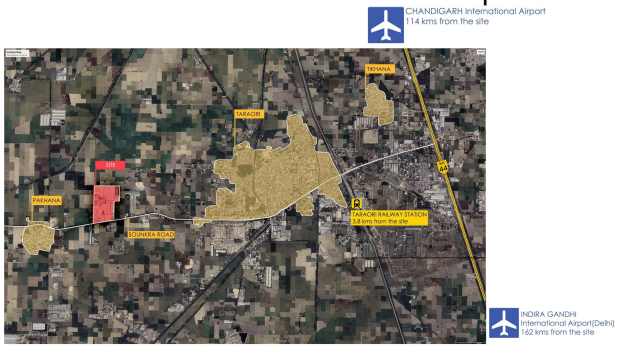


Figure :Context Plan

Figure :Site plan

Market Analysis

Bridging the Demand-Supply Gap

- With the evolution in workstyle owing to economic, demographic, technological and societal influences, work has gradually become more and more flexible and not tethered to a specific place.
- The real opportunity for co-working space providers lies in aggregating this supply and bringing this closer to demand.
- A net-zero energy and water office prototype that can withstand the composite climate range in Haryana region

Special Requirements

Since there will be a lot of foreign clients coming in, the owner wanted four guest rooms to be incorporated within the brief. This Building will be self-occupied by the project partner.

AREA PROGRAM

Total Site Area (sqm)	Total Built up Area(sqm)	Roof Area (sqm)	Non Rentable Area(sqm)	Rentable Area (sqm)
4680	3150	1097	1097	2140

Table 1: Area Program

OFFICE-Open plan : 860sqm

- Administration
- Sales
- Marketing
- Accounts
- Purchase
- HRD

OFFICE-Enclosed : 366.7sqm

- Owners Cabin
- R&D
- Meeting Rooms
- Conference Room
- Board Rooms

Rentable Area Distribution

Functions	Number	Occupancy	Area (sqm)
Administration Department	01	10	710
Sales Department	01	30	
Accounts Department	01	30	
Marketing Department	01	30	
Purchase Department	01	20	
HR Department	01	10	
Entrance lobby+Reception	01	2	90
Waiting Area+Exhibition Area	01	-	90
Cabins	04	04	17.5(4)=70
Owner's utilities	01	03	90
Owners Cabin	07	07	150
Personal Assistant	03	03	30
Board Room	01	10	45
Conference Room	02	15	55
Guest Room	04	-	35(4)=140
Cafetaria	01	-	180
Surveillance Room	01	03	30
R&D Department	01	10	80
Chiller Room + AHU	01	02	45
Office Storage	02	-	17.5(2)=35
Office Utilities	01	08	170
Recreational+Gym	01	-	130
Total Area		199	2140

Table 2: Area Distribution

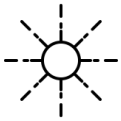
Non-Rentable Area

Non-Rentable Area includes vertical and horizontal circulation, Lift Shafts, Janitors Closet and Ducts etc.,

Cooling Load Classifications:

- **Conditioned areas : 80sq.m** - R&D
- **Hybrid areas : 2060 sq.m** - Workspaces, Entrance Lobby, Reception & rest of the spaces
- **Unconditioned areas** - Janitors Closet, Lift shaft, Staircases & Corridors

Thermal Comfort
To provide adaptive thermal comfort to our users throughout the year to provide healthy and productive environment with temperature range 24-26 degree Celsius.
Strategy
Using proper shading techniques with a combination of passive and mechanical techniques like Radiant Cooling.



Daylighting
Achieving a UDI of more than 80% with illuminance of 100-2000 lux.
Strategy
Taking optimum floor plate depth and introducing Atriums and courts in the office building.

Net zero Water
Reducing the overall building water demand by 30%.
Strategy
Using low flow fixtures while reusing the grey water and implementing Rainwater harvesting.

Energy Efficiency
- To provide a significant reduction of the energy needed for cooling and lighting.
- To reduce the target EPI by 50% and design a net zero energy building.

Strategy
Using energy efficient mechanical cooling systems and orienting the building to reduce heat gain.

Acoustic comfort
Maintaining noise level of 45-50 dBA inside the building.
Strategy
Immediate wall and buffer zone to counter the noise from the factory and traffic.

Air Quality
Providing air with low contamination, low sensory irritation intensity and inoffensive odour with 17 cfm per person of air rate.
Strategy
Using mechanical air purifying systems, with plantations in the building.

Waste management
Reducing and reusing the on site waste generated, while using the factory generated waste to our advantage.
Strategy
Using the excavated earth and rice husk ash as building material, while using the steam from boilers(factory) for running our Vapour absorption chiller system.

Carbon Negative Building Prototype
To create an office building that can be replicated in places of moderate hazard like rice mills and areas with high amount of noise and air pollution.
Strategy
To use materials which have low embodied energy and are carbon negative in nature.

Safety and Security
Physical protection of the assets and occupants of the office building from man made or natural accidents.

Starting from the basics to the extent of detailed study and design, the entire process of design development took place in a very organized and conclusive manner.

Analysis & Study

Due to the covid situations, site visit was not possible. A virtual site analysis was done along with well founded information about the demographics of the site and nearby area. Basic study was performed to understand the problems in the site and traditional solutions to tackle the problem.

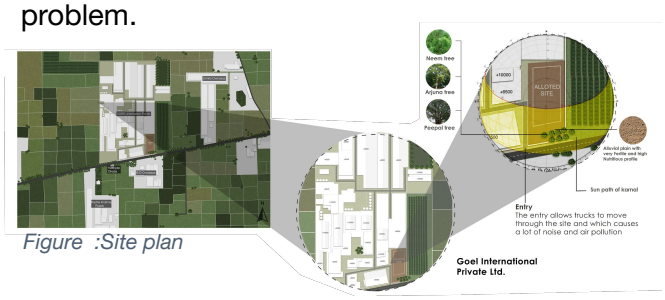


Figure :Site plan

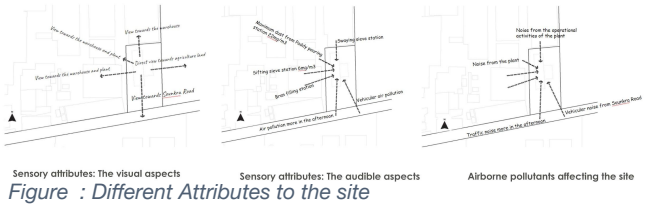


Figure : Different Attributes to the site

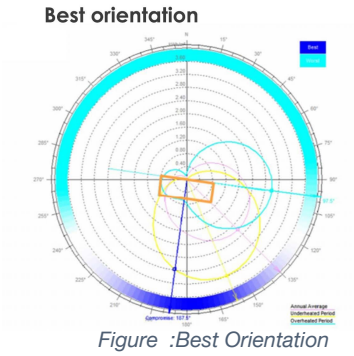


Figure :Best Orientation

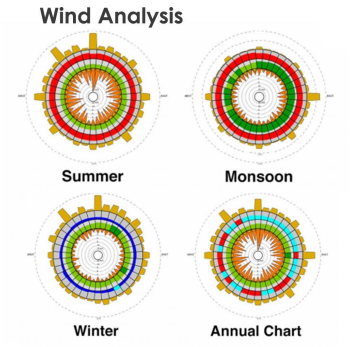


Figure :Wind Flow

Figure : Site Section

Starting from the basics to the extent of detailed study and design, the entire process of design development took place in a very organized and conclusive manner.

Our design process included the creation of ideas, the exploration of problems and their solutions, the improvement of current comfort factors, the enhancement of interactivity and co-relation between the spaces that led us to a final design that is a net zero energy building with interactive open layout workspaces, comfort in various areas with good daylighting as needed in office buildings for working.

In the form development process, we came up with various forms where we unconsciously didn't include the initial idea which can be observed below-

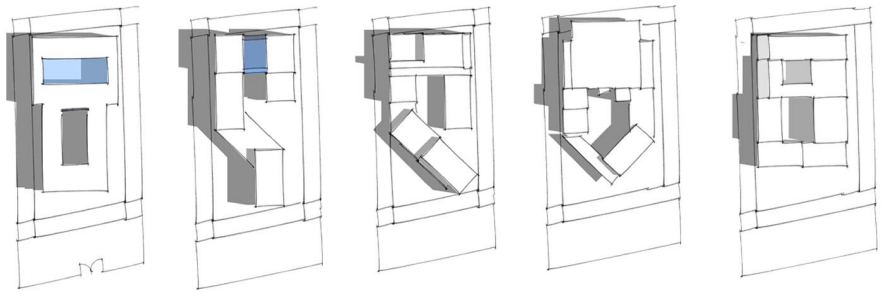


Figure : Initial Sketches

After realising, we went back to the Primary Idea of form with Courtyard and Atrium, which optimises daylight factor and decreases the cooling load at same time. We developed a form with that idea which can be seen below.

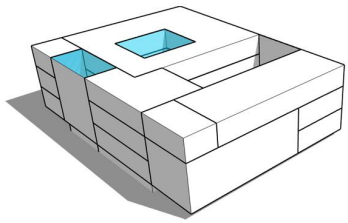


Figure 9: Concept 3d Model

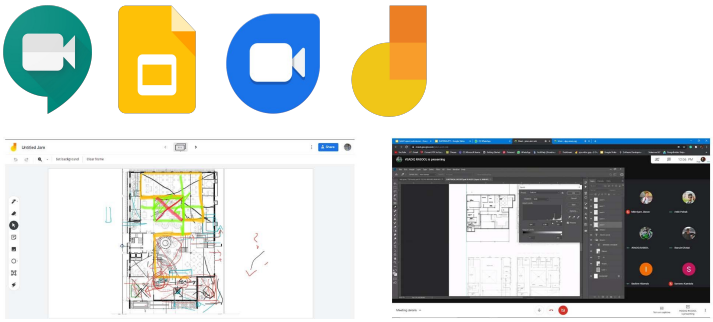
For a deeper understanding and realistic approach to the design, simulations were done using various tools. By interpreting the simulations and realizing the required changes, a back and forth process helped us to reach the appropriate design.

Feedbacks and Crits

Giving special credits to our guides, SDI TRG members, and mentors (our college faculty) helped us at every step of the way guiding us with a selfless mindset. Along with that webinars, self-learning modules and a very interactive resource team provided by the organizers of Solar Decathlon immensely helped us in this journey.

Interactive Platforms

Due to the covid crisis we had to meet on online platforms to make sure everyone has a better understanding about what we were doing.
We had design discussions on google meet and zoom and jamboard depending on the need.



Tools & Simulations used

For a deeper understanding and realistic approach to the design simulations were done using various tools and many other tools were also used to help us with our design and report.

Form Evolution

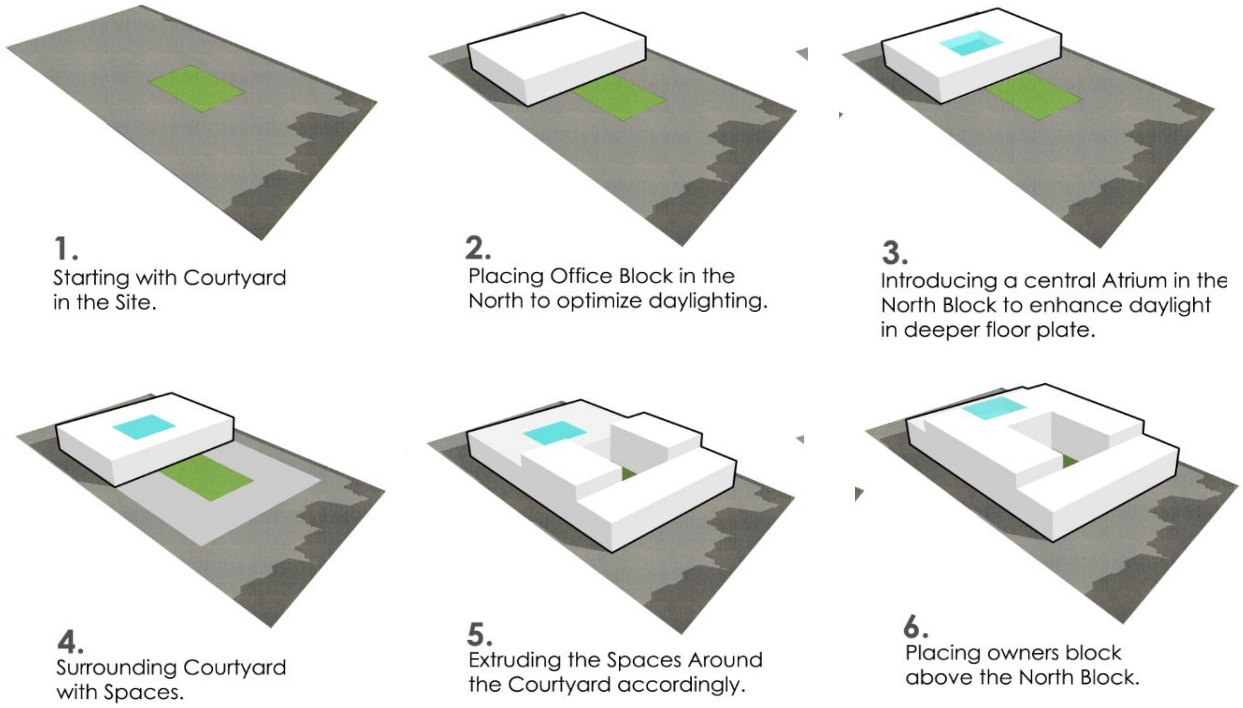


Figure 10: Form Evolution

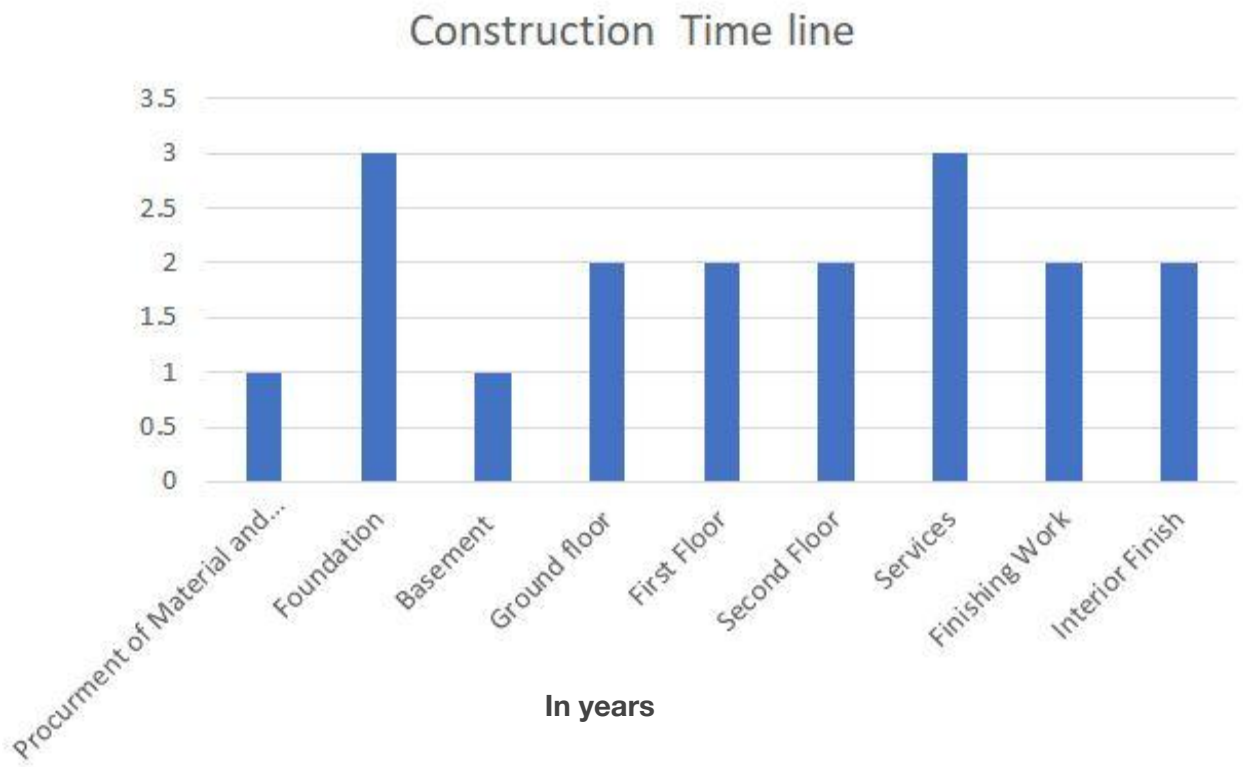
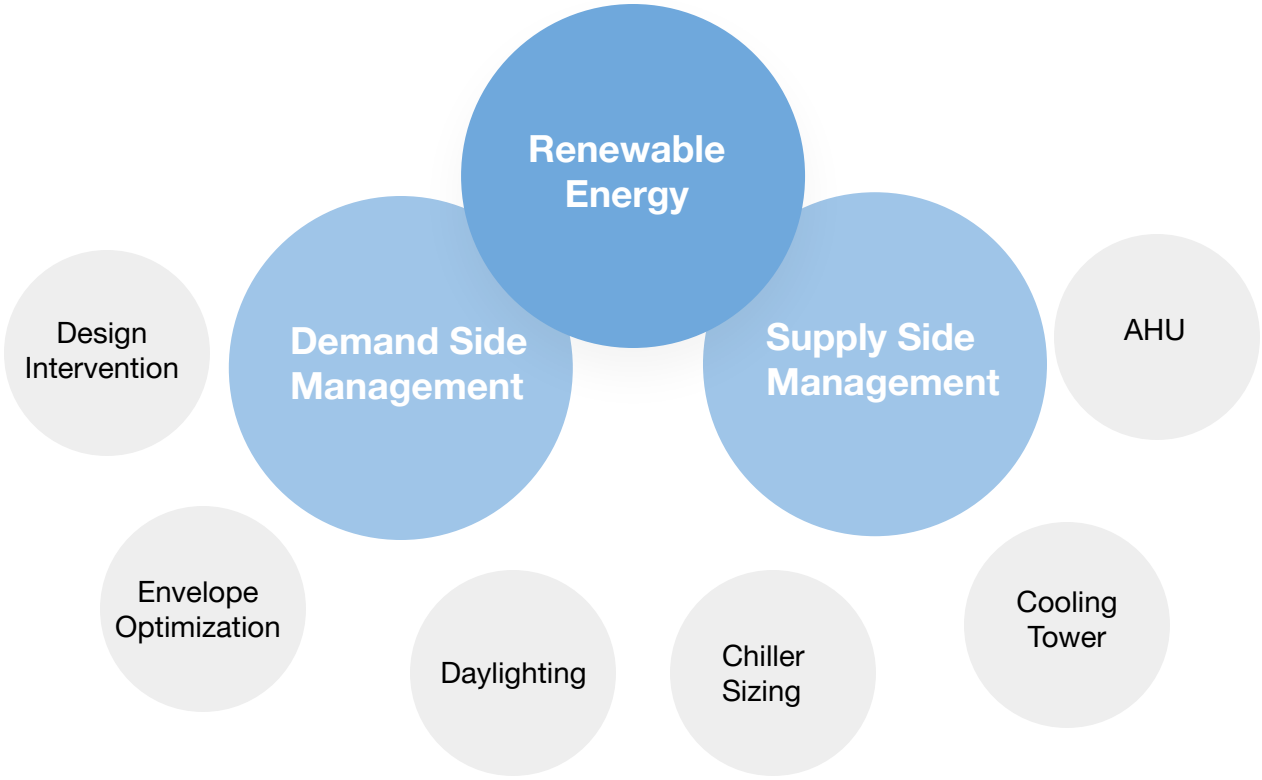


Figure 11: Construction Timeline

10 CONTESTS

1.ENERGY PERFORMANCE

Giving special credits to our guides, SDI TRG members, and mentors (our college faculty) helped us at every step of the way guiding us with a selfless mindset. Along with that webinars, self-learning modules and a very interactive resource team provided by the organizers of Solar Decathlon immensely helped us in this journey.



DEMAND SIDE MANAGEMENT

From the very basic form development level to the envelope optimization. After doing several simulations for mutual shading, insolation and incorporating passive strategies to cool the building.The proposed design was optimized to conserve energy at various levels.

DESIGN INTERVENTION

The building plot had the longer side,facing east and west for which it was completely opposed the ideal building orientation.

Optimum Orientation:187.5 degrees.
Thus shorter sides facing the East and West as it is a bit tougher to shade.

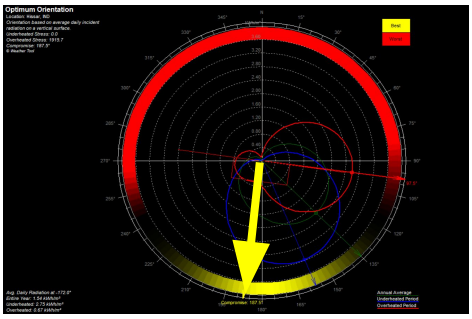
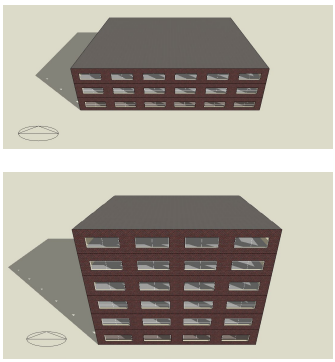


Figure: Best orientation



Based on a shoebox model simulation where we made two building with square foot prints but same built up area.

We found that the building with less number (3 floors) of floors consumed 5.7% less energy when compared to a building double in number of floors(6 floors) with same floor to floor heights of 3.5m.

Figure: Show box model of the building

Design Solution

Since our site already had a major issue of trucks moving from the west which would bring in lot of air pollution and noise pollution.
Providing the west with less occupied spaces that would be operated in the morning hours like gym and making it a complete buffer with very less perforation

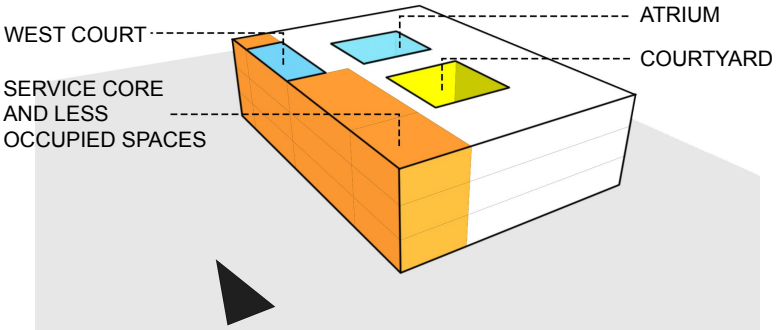


Figure: 3D conceptual model

ENVELOPE OPTIMIZATION

The envelope was selected after comparing U- Values and cost for different materials, but as one of our goals states, that we wanted to make a net carbon zero building. We selected materials keeping in mind their embodied embodied energy.

Our site had a lot of crop or rice waste, which we wanted to utilize for building material and thus we selected Agrocrete for the building blocks.

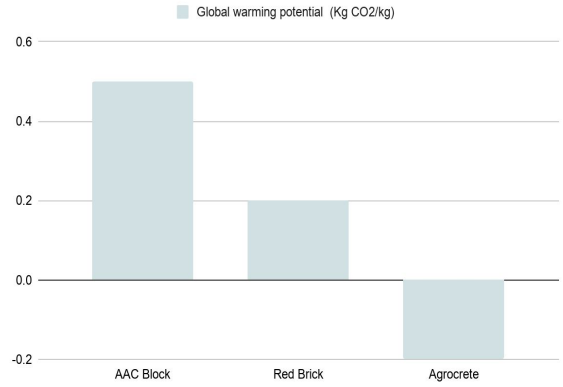


Figure: Embodied carbon emission of building blocks

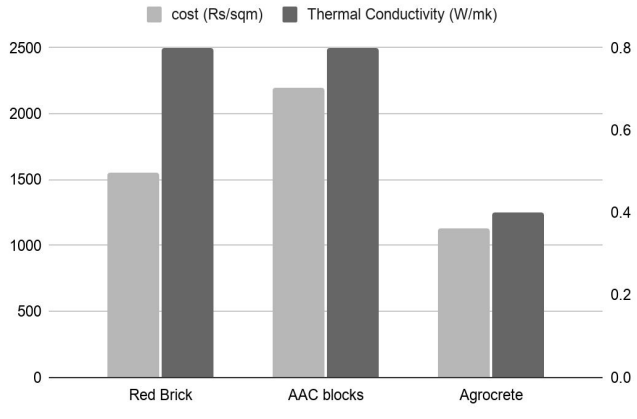


Figure: Cost of thermal conductivity of blocks

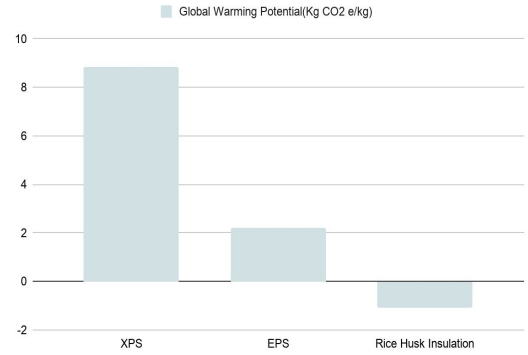


Figure: Embodied carbon emission for insulation

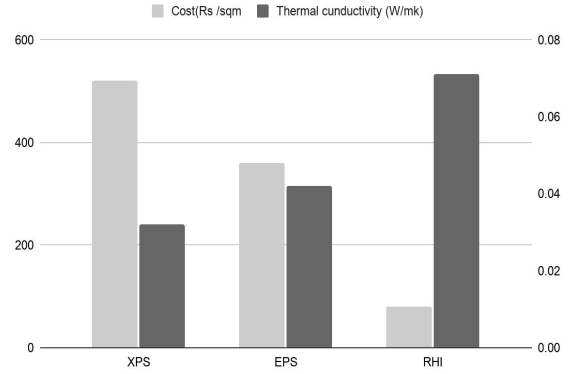


Figure: Cost and thermal conductivity of insulation

Similarly we compared the cost, embodied energy and thermal conductivity of different insulation materials and came up with RHA Insulation for our building material even though it had a relatively low U -Value in comparison with XPS and EPS insulation. As it used 80%RHA which is the ultimate byproduct from the factory.

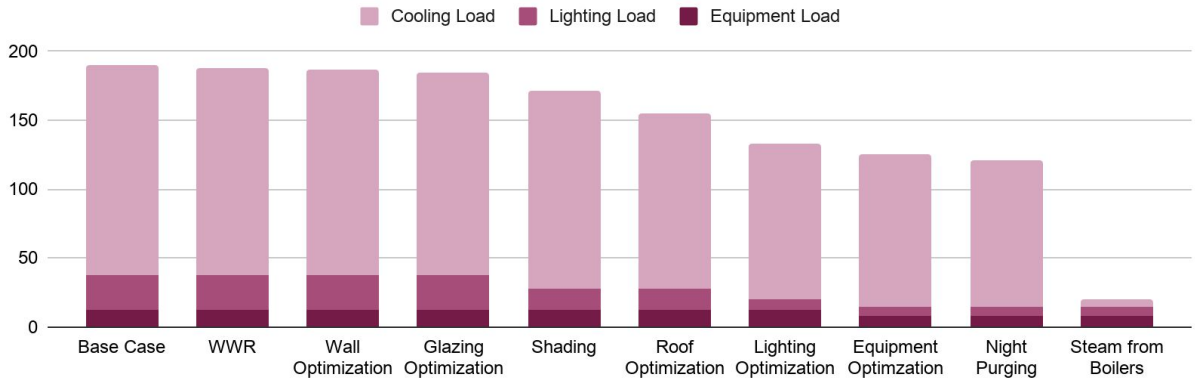
U Value of glass was optimized differently for both north and non north building elevations. It was taken in comparison with ECBC values for SHGC, VLT and U Value.

S No.	Elevation	WWR
1.	East	25%
2.	West	15%
3.	North	25%
4.	South	30%

Table: WWR(Window to wall ratio) on all directions

After doing several daylighting simulations we came up for the window to wall ration keeping it minimum at west.

EPI BREAKDOWN

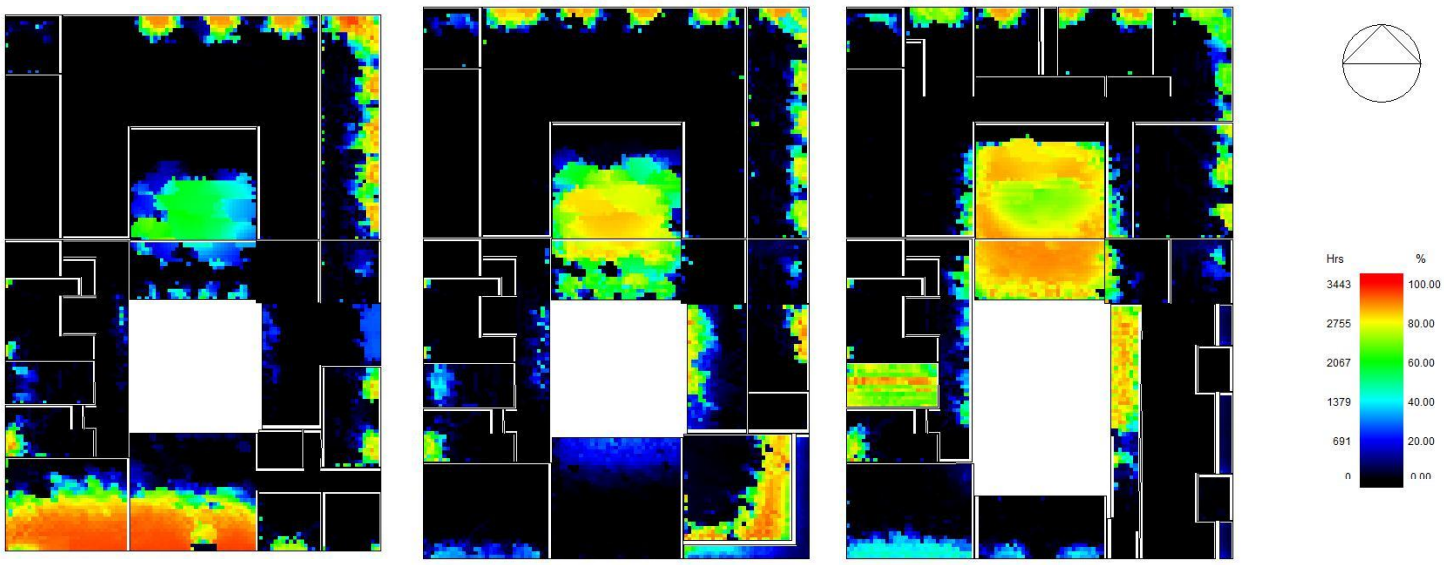


DAYLIGHTING

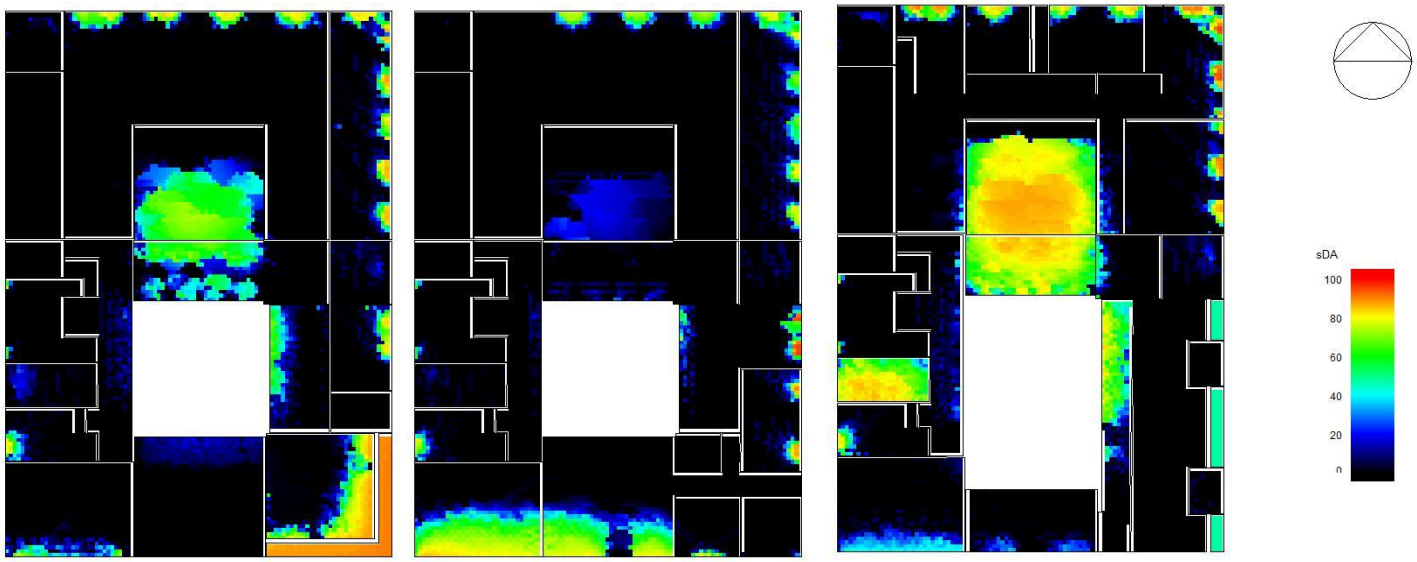
The daylighting simulations were performed for

- Overcast Sky Condition
- 800mm work plane height.
- UDI and sDA analysis.

Surface Reflectance	
Ground (White Tiles)	70%
Walls Paint (Oyster white)	85%
Roof(wood)	55%



UDI Analysis



sDA Analysis

RENEWABLE ENERGY

The EPI of the building achieved is 17 Kwh / sq. m/ yr
And the built up area of the building is 3600 sqm.
So, the total electricity requirement of the building in 1 year is 61200 kwh.

The area on roof top available for solar panels is 1260 sqm. And taking 75% area available for solar panels leaving out the area for circulation,
94.5kwh plant can be set up on the roof and on south facade that will generate 130000 kwh electricity per year.

Adding to that, the building will be net positive with 68800 kwh extra electricity.

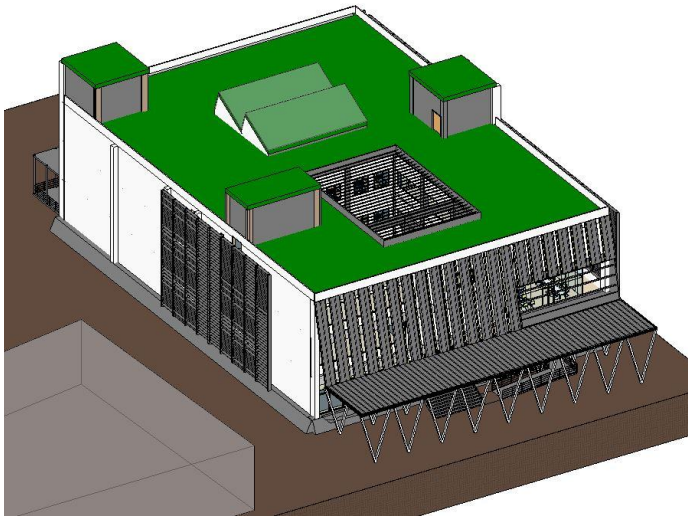


Figure: 3D model of the building

Average solar irradiation in **HARYANA** state is **1156.39** W / sq.m

1kWp solar rooftop plant will generate on an average over the year **4.6** kWh of electricity per day (considering 5.5 sunshine hours)

1. Size of Power Plant	
Feasible Plant size as per your **Roof Top Area** :	**94.5**kW
2. Cost of the Plant :	
MNRE current Benchmark Cost :	Rs. **38000** Rs. / kW
Without subsidy (Based on current MNRE benchmark) :	Rs. **3591000**
With subsidy **0** (Based on current MNRE benchmark) :	Rs. **3591000**
3. Total Electricity Generation from Solar Plant :	
Annual :	**130410**kWh
Life-Time (25 years):	**3260250**kWh
4) Financial Savings :	
a) Tariff @ Rs.8/ kWh (for top slab of traffic) - No increase assumed over 25 years :	
Monthly :	Rs. **86940**
Annually :	Rs. **1043280**
Life-Time (25 years) :	Rs. **26082000**

Carbon dioxide emissions mitigated is	**2673** tonnes.
This installation will be equivalent to planting	**4277** Teak trees over the life time. (Data from IISc)

INNOVATION

Structural / Framing system

A combination of concrete and mass timber construction, with concrete on the perimeter supporting the thick wall assembly with high thermal mass, and mass timber structure and CLT slabs providing the appearance of wood while lowering the dead load and carbon emission of the building manyfolds. Timber is used to replace 50% to 60% of the R.C.C. in the structure, resulting in carbon neutral building.

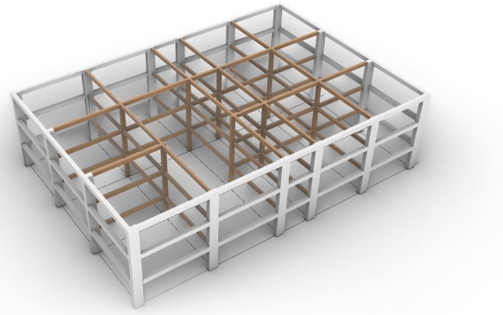


Figure: 3D image of framing system

Imported CLT is provided by Delhi's Eximcorp supplier. Our proposal is to use sustainably managed forests in Delhi, which have enormous potential for providing raw materials for CLT manufacturing in India, thus reducing the carbon footprint caused by material imports.
Carbon storage is an important component of building with CLT. A healthy tree in a forest will release oxygen and store carbon dioxide (CO2). Using mass timber as a building product reduces the carbon footprint by also storing carbon dioxide (CO2) in the same way a healthy tree would. By utilizing that wood before it goes to waste, CLT becomes a building product that not only sequesters tonnes of carbon, but also reduces greenhouse gas emissions during construction through the prefabrication process.

Solar Integrated Facade

Timber framed Solar panel integrated structure on the front(South) facade and drop off canopy at the entry to cut off solar heat gain and generate electricity for the building. The aim is to substitute a material with one that will provide us with a return over time. Simulations were run to determine the angle for the slope in order to increase solar gain for PV cells.

Annual Solar gain at 90 degree- 982 KWh/m2

Annual Solar gain at 76 degree- 1307 KWh/m2

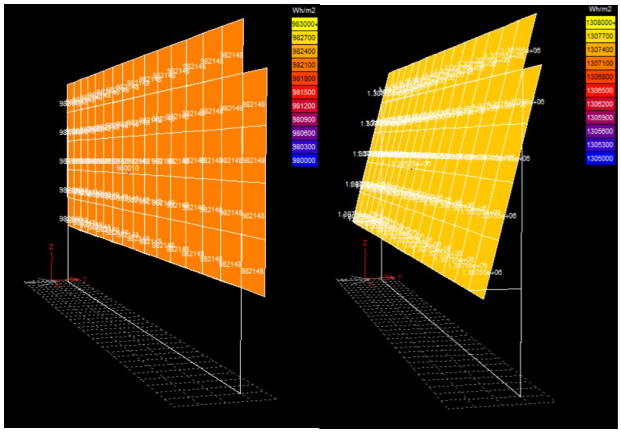


Figure: Solar PV simulations

Solar panels with clt frame with adequate air exchange through the structure

Solar panels with clt frame over drop-off at the entry`

Figure: Front facade with solar PV

Figure: Front entrance

MATERIALS

(INNOVATION, SCALABILITY and AFFORDABILITY

Rice Husk Insulation

We approached **Llyod Insulations India Ltd** as our industry partner to identify solutions for building insulation and the on-site available waste reutilization. Rice husk (RH) and also rice husk ash (RHA) can be used as an insulation material. Rice Husk is the widely available agricultural wastes and is a serious concern for the environment. It is a potential material for use as alternative material in the construction and insulation industry. The proposed board made from rice husk or rice husk ash , bonded by resin under the application of pressure and temperature. Research need to be done to find the best suitable binder or resin for the insulation board.

Figure : Rice husk Bricks

The proposed board can have a density from **50-150 kg/m3** and thermal conductivity ranging from **0.0418–0.0746 W/(m.K).** Since insulation materials with the lowest thermal conductivity are preferred, we chose 0.0746 W/(m/k) as the k value for our proposed insulation board rather than a lower value and still got good results in our simulations. Thermal insulation properties of board can be further improved with decrease in density. The developed boards can exhibited high water uptake, which makes them suitable for use as thermal insulation in wall compositions, where they will be protected against moisture by structural protection.

Scalability and Affordability-

After discussing several research papers and studies on the subject with our industry partner **Llyod Insulations India Ltd**, as well as their experience in the field, we concluded that though new insulation board's density and thermal conductivity fall short of other options on the market, more study into the right binder and best composition will help to increase the insulation board's thermal conductivity and the commodity will be both less expensive and more durable, and it will be able to replace other insulation options in the long run. Since it uses bio waste, the substance would have a very low embodied energy.

Source-
-Fabrication and Analysis of Thermal Insulation Boards from Rice Husk By Deepak Dhand
-Insulation Material from Rice Husk Granule
By Sri Haryati*, Risfidian Mohadi, Khaidir Syah
-Sustainable thermal insulation biocomposites from rice husk, wheat husk, wood fibers and textile waste fibers: Elaboration and performances evaluation
By Rajendran Muthuraj, Clément Lacoste, Patrick Lacroix, Anne Bergeret

Agrocrete®

Agrocrete building block, a Greenjams Pvt Lmt product is around 5 times the size of a Red Brick, thus it cuts building costs by 20% and allows for smoother and simpler masonry. Agrocrete also has a lower thermal conductivity, which means lower operating costs for the building's inhabitants. Because of the crop residues in it, agrocrete has a negative embodied carbon. The proprietary low-carbon binder adds to the carbon-negative nature of the product. BINDR™ is a unique substance manufactured from Industrial byproducts such as fuel ash, lime sludge, and slags.

GreenJams

Parameter	Red Bricks	Agrocrete®
Strength	7 MPa	7.5 MPa
Density	1900 kg/m^3	1400 kg/m^3
Water Absorption	18%	10%
Durability	75+ yrs.	75+ yrs.
Thermal Conductivity*	0.8 W/mK	0.4 W/mK
Embodied Carbon	0.24 kgCO_2/kg	-0.2kgCO_2/kg
Size of Brick (in mm)	215 x 102.5 x 65	400 x 150 x 135
Cost per Unit	₹ 7	₹ 32
Cost of Walling per sq.m. incl. masonry, plastering & mortar joints)	₹ 1550	₹ 1125

Figure : Comparison b/w Bricks & Agrocrete

Source : Greenjjams Buildtech Private Limited

Green Concrete

Concrete with rice husk ash applied to it would be more durable and use less cement. In order to determine the best substitution ratio, a lot of analysis and testing is done. The optimal doses to be added in concrete manufacturing was found to be up to 20% substitution of cement by RHA by mass. This would result in a more cost-effective, long-lasting, and strong concrete construction. As a result of our study on the reports we can conclude that:

- Strength and cost savings of Rice Husk Ash concrete proves it to be a better material than various other supplementary materials which involve higher transport cost.
- By using this Rice husk ash in concrete as replacement the emission of green house gases can be decreased to a greater extent. As a result there is greater possibility to gain more number of carbon credits.
- The technical and economic advantages of incorporating Rice Husk Ash in concrete should be exploited by the construction and rice industries.

Source : Rice husk ash as a partial replacement of cement, Department of Civil Engineering, Khorasgan (Isfahan) Branch, Islamic Azad University, Isfahan, Iran

AIS Ecosense Glass

We have the AIS Group, India's largest integrated glass maker as our industry partner which produces AIS Ecosense, a high-performance product. This glass clearly sets higher levels of green design by providing functional features such as thermal insulation, solar power, protection and protection, and acoustic insulation.

AIS
Asahi India Glass Ltd.

ENVELOPE CONFIGURATION

TYPE	PROPOSED ASSEMBLY	PROPOSED CASE U-VALUE	ECBC CASE MAX. U-VALUE
External wall	Outer Cool Coat Paint +30 mm outer Gypsum Board +75 mm Rice Husk Insulation +150 mm Inner leaf Agrocrete block +12 mm inner plaster	0.61 W/m²K	0.63 W/m²K
Roof	25 mm China mosaic +50 mm Screed L.T.S. +Bitumen Felt +120 mm Wood Fibre Insulation +Geo textile membrane +145 mm CLT slab	0.22 W/m²K	0.33 W/m²K

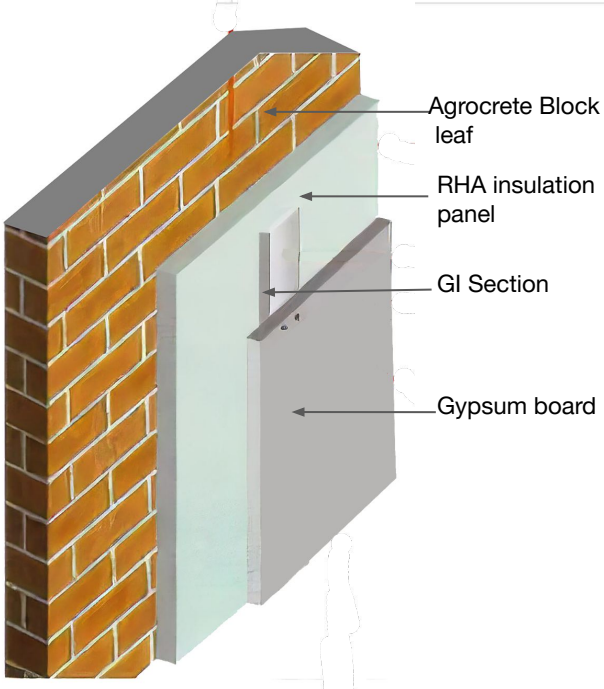


Figure: Wall insulation details

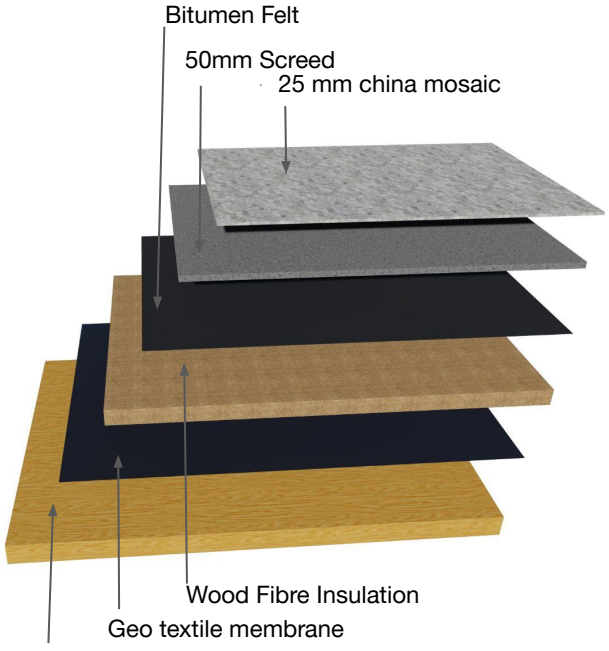


Figure: Roof insulation details

TYPE	PROPOSED ASSEMBLY	LT	PROPOSED CASE SHGC	ECBC+ CASE MAX. SHGC	PROPOSED CASE U-VALUE	ECBC+ CASE MAX. U-VALUE
North Vertical Fenestration	AIS Ecosense Clear Vivid-Wooden frame with 6 mm Double Low-E Glass +12 mm Air Gap +6 mm Clear Glass	66%	0.37	0.50	1.6 W/m²K	2.20 W/m²K
Non-North Vertical Fenestration	AIS Ecosense Clear Pearl-Wooden frame with 6 mm Double Low-E Glass +12 mm Air Gap +6 mm Clear Glass	49%	0.22	0.27	1.6 W/m²K	2.20 W/m²K

AFFORDABILITY

Proposed v/s Baseline

The cost of proposed design is coming out be higher than the baseline estimates, this due to the proposed Design has installation like solar pv panel to generate electricity and using hybrid construction of cltd and RCC fo our goal here was too reduce embodied energy of the building. CLTD has to be imported and its is around 30% costlier than the RCC construction, our aim here was to create a trend of using cltd in india .These add up to initial capital cost of the project .

The right sizing of the various elements in the MEP services by various Design strategies lead to reduction for installation and maintenance

Project Summary					
S.No.	Particulars	Baseline Estimate (Project Partner / SOR basis)		Proposed Design Estimate	
		Amount (Rs Millions)	%	Amount (Rs Millions)	%
1	Land	0.00	0.0%	0.00	0.0%
2	Civil Works	60.76	56.2%	60.99	56.4%
3	Internal Works	10.27	9.5%	10.57	9.8%
4	MEP Services	12.55	11.6%	41.65	38.5%
5	Equipment & Furnishing	18.00	16.6%	18.00	16.6%
6	Landscape & Site Development	6.60	6.1%	4.70	4.3%
7	Contingency	0.00	5.0%	0.00	5.0%
	TOTAL HARD COST	**108.17**	**105.0%**	**135.90**	**130.6%**
8	Pre Operative Expenses	-	0.0%	-	0.0%
9	Consultants	-	0.0%	-	0.0%
10	Interest During Construction	-	0.0%	-	0.0%
	TOTAL SOFT COST	**0.00**	**0.0%**	**0.00**	**0.0%**
	TOTAL PROJECT COST	**108.17**	**100.0%**	**135.90**	**125.6%**

Table: Costing Table

- The use of Radiant cooling with Vapour Absorption Chiller due to availability of steam in the site along ventilation fans has proved to be more efficient than conventional systems in terms of using energy
- RHA insulation used in the wall that was produced with the waste material produce at the site proved to be more efficient

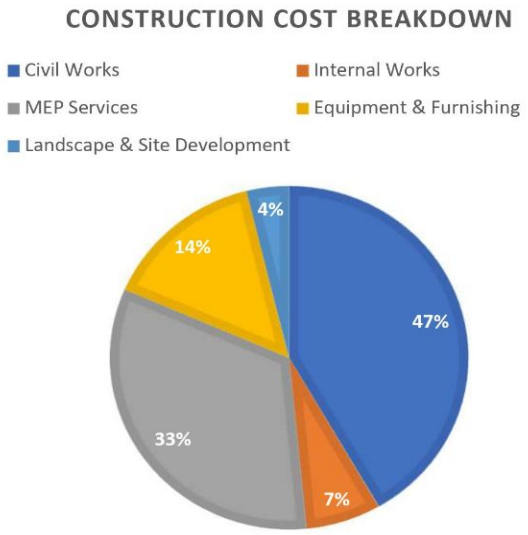


Figure : Construction cost breakdown

Average solar irradiation in **HARYANA** state is **1156.39** W / sq.m

1kWp solar rooftop plant will generate on an average over the year **4.6** kWh of electricity per day (considering 5.5 sunshine hours)

1. Size of Power Plant	
Feasible Plant size as per your **Capacity** :	**150**kW
2. Cost of the Plant :	
MNRE current Benchmark Cost :	Rs. **36000** Rs. / kW
Without subsidy (Based on current MNRE benchmark) :	Rs. **5400000**
With subsidy **0** (Based on current MNRE benchmark) :	Rs. **5400000**
3. Total Electricity Generation from Solar Plant :	
Annual :	**207000**kWh
Life-Time (25 years):	**5175000**kWh
4) Financial Savings :	
a) Tariff @ Rs.8/ kWh (for top slab of traffic) - No increase assumed over 25 years :	
Monthly :	Rs. **138000**
Annually :	Rs. **1656000**
Life-Time (25 years) :	Rs. **41400000**

Solar PV Calculation

Reference

https://solarrooftop.gov.in

Renewable Energy

- The electricity to the whole building is supplied by renewable energy which is one of the criteria that makes our office net zero .
- The ROI every every year generation is divided into three parts Generation per year , operation and maintenance cost which is 1%of the capex and degradation of generation per year which is 1%.
- The cost of the plant is based on MNRE benchmark cost .
- The total revenue after 25 years is Rs 41400000

APPLIANCES

Company : Havells
Product : 1400mm Ceiling Fan
Power : 70 W
Cost : RS 2380

Company : Havells
Product : 250mm ,150mm Exhaust Fan
Power : 70 W , 35W
Cost : RS 1500, RS 1350

Company : Voltas
Product : 400L Deep Freezer
Power : 300 W
Cost : RS 28650

Company : philips
Product : Juice mixer
Power : 500W
Cost : RS 4200

Company : Syska
Product : Tube Lamp
Model : Lumispread Base B22
Power : 10 W
Cost : RS 190

Company : Canon
Product : Scanner
Power : 2.5 W
Cost : RS 4300

Company : HP
Product : Printer
Power : 10W
Cost : RS 5350

Company : Dell
Product : laptop
Power : 135W
Cost : RS 30000

Company : Light concept
Product :Profile Light 48 WFoot Flushmount Wrap Ceiling Light
Power : 50W
Cost : RS 2800

Net- Zero Water Balance Table

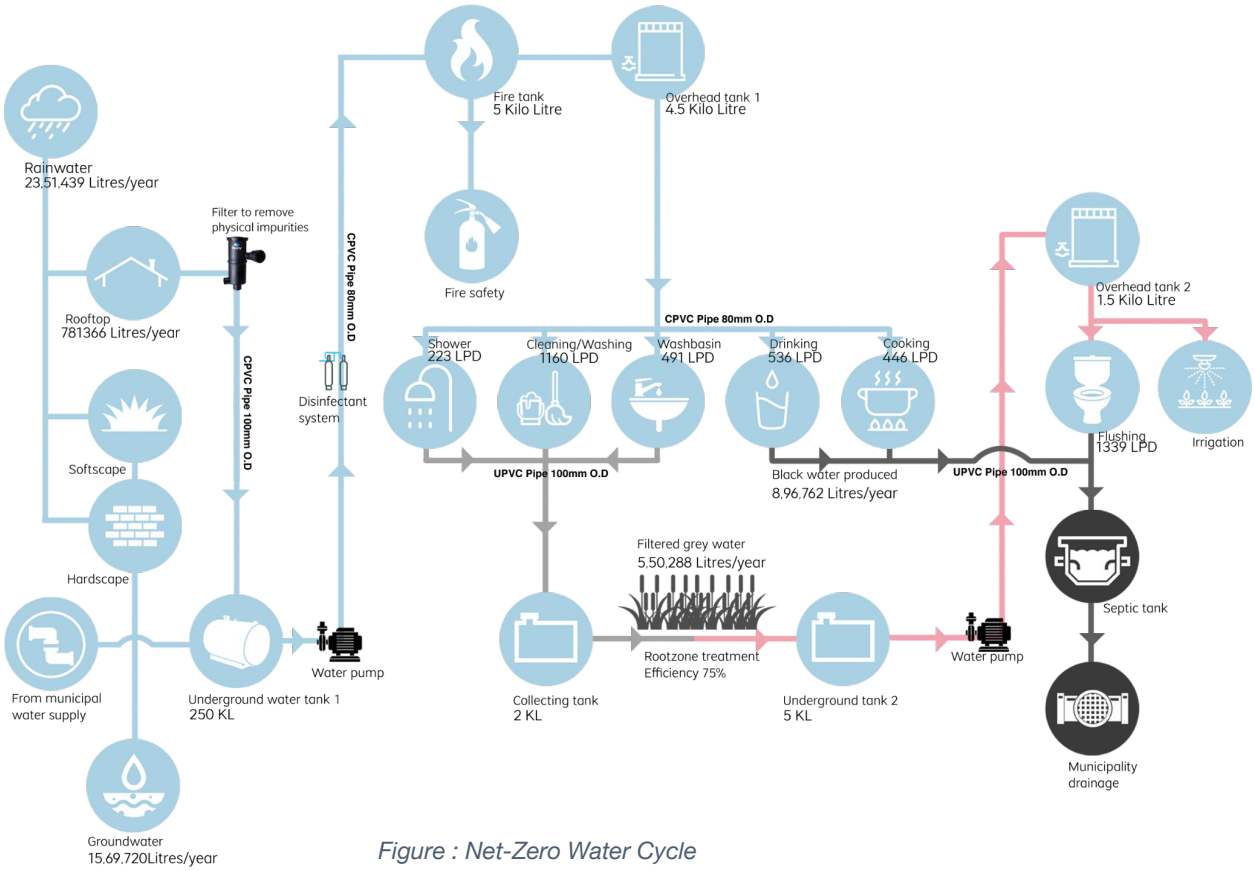


Figure : Net-Zero Water Cycle

During Construction

We will cater to the embodied energy by recycling and reusing the wastewater from the rice mill plant and the waste water from the factory workers working in the plant in the construction of the building.

After Construction

Grey water reuse, harvested rain water and Municipal water supply are the sources of water in our site. We will use root zone system to recycle and reuse the domestic water.
Total Calculated Rainwater is 23,51,439 litres per year, which is higher than Total Consumption (18,23,232 litres per year). We are net zero for water in a year, according to the calculations. We plan to recharge the groundwater source with excess water in net positive months and use municipal water in net negative months to keep the water table intact and reduce the water storage requirement.

We are harvesting 7,81,366 litres of rainwater per year from the roof and recharging the ground water with 15,69,720 litres of rainwater per year falling on the hardscape and softscape areas at ground level with a rain harvesting pit.

Domestic Use		Cooling Use		Irrigation Use	
Use LPD/Head	24	L/Hour	120	L/m^2	1
Number of people	186	Hour per Day (peak)	3	Area m^2	703
Total LPD	**4464**	**Max LPD**	**360**	**Max LPD**	**703**

Table: Total water requirement

		CONSUMPTION						WATER SOURCES						
Month	Days in month	Domestic Use (L)	Cooling Use %	Cooling Use (L)	Irrigation Use %	Irrigation Use (L)	Total Consumption (L)	Municipal Water (L)	Rainwater	Greywater (L)	Filtered grey water(L)	Blackwater (L)	Tolat sourced water(L)	Total Stored
Jul	31	1,38,384	100%	11,160	5%	1,090	1,50,634		211389	62,273	46,705	76,111	2,58,094	107460
Aug	31	1,38,384	50%	5,580	5%	1,090	1,45,054		277794	62,273	46,705	76,111	3,24,499	286906
Sep	30	1,33,920	0%	-	30%	6,327	1,40,247		136130	60,264	45,198	73,656	1,81,328	327987
Oct	31	1,38,384	0%	-	50%	10,897	1,49,281		34309	62,273	46,705	76,111	81,014	259721
Nov	30	1,33,920	0%	-	90%	18,981	1,52,901		1107	60,264	45,198	73,656	46,305	153125
Dec	31	1,38,384	0%	-	90%	19,614	1,57,998		4427	62,273	46,705	76,111	51,132	46259
Jan	31	1,38,384	0%	-	90%	19,614	1,57,998	90,000	33203	62,273	46,705	76,111	1,69,908	58169
Feb	28	1,26,108	0%	-	90%	17,874	1,43,982	90,000	15495	56,749	42,561	69,359	1,48,056	62242
Mar	31	1,38,384	0%	-	100%	21,793	1,60,177	90,000	15495	62,273	46,705	76,111	1,52,200	54265
Apr	30	1,33,920	50%	5,400	100%	21,090	1,60,410	90,000	1107	60,264	45,198	73,656	1,36,305	30160
May	31	1,38,384	100%	11,160	100%	21,793	1,71,337	90,000	5534	62,273	46,705	76,111	1,42,239	1061
Jun	30	1,33,920	100%	10,800	50%	10,545	1,55,265	90,000	45377	60,264	45,198	73,656	1,80,575	26371
Total		**16,30,476**		**44,100**		**1,70,706**	**18,45,282**	**5,40,000**	**7,81,366**	**7,33,714**	**5,50,288**	**8,96,762**	**18,71,653**	

Table: Water Demand and Supply

Total Water Required(L/Year)	Harvested Rain Water(L/Year)	Recycled Grey Water(L/Year)	Municipal Water(L/Year)
18,45,282	7,81,366	5,50,288	5,13,626

Table: Water Sources

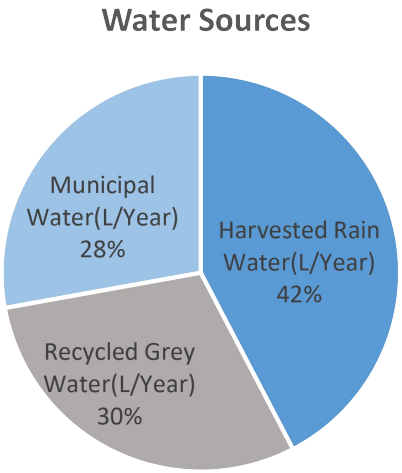


Figure: Water Sources

Water consumption for an office building according to NBC 2016 is 45 LPD/head. The water consumption was brought down to 24 liters per head from 45 liters per head through efficient water-saving hardware.. Domestic water demand reduction will be done using waterless urinals, low flow fixtures and dual flush fixtures.

We had to choose a brand for the fixtures. We went through a list of companies like Jaquar, Kohler and Plumber. We did cost analysis for the brands and came to a decision to use Jaquar for the plumbing fixtures as they are both durable and water efficient at the same time affordable.

Rainy FL-500
Dual Intensity RWH Filter
Capacity:480 LPM
Efficiency of filter: more than 90%

Shakti Openwell Pumps - SHOS Series
Flow, Q : 192 m^3 /hr

Flow Restrictors

This is a revolutionary technology that lets taps and showers save upto 80% of water without compromising on the flow. Flow Restrictors adjust the flow in both low and high pressure conditions and offer the same voluminous flow every time.

Air Showers

Air Showers have a built-in air mixer that mixes air and water in a manner that makes shower drops lighter but voluminous. This technology helps air showers save up to 30% of water.

Sensor Faucets

Faucets with technology that allows water to flow only when you need it and shuts it as soon as you move your hands away, resulting in zero wastage of water.

Dual Flush

Flushes that use more water than needed are the biggest water wastage culprits in every home. Dual flushing systems enable you to use either a combination of 3/6 ltrs of water or 2/4 ltrs of water, depending on your water closet. It is designed to save 50-60% of water every day.

Water consumption chart

	Time consumption in seconds			Water Consumption (A+B+C Stage)	SAVING
	A	B	C		
Single Lever Basin Mixer	5	12	7	4.31 L	BASE*
Sensor Faucet	5	Not in use	7	1.8 L	59%
Pressmatic Faucet	8	Not in use	8	3.01 L	31%

*Base calculation is taken on Florentine basin mixer at 1 bar pressure

Figure: Water consumption chart
Source:
https://jaquar.com/en/save-water-every-drop-counts

Figure: Efficient fixtures from jaquar

Waterless Urinals

Waterless urinals save more than just water: they save time, and money. The upkeep of traditional flush urinals can be expensive, and maintenance in certain instances can take hours. This waterless fixtures eliminate the need for flush valve repairs, waste line clean outs, deodorizers, and blockage removals.

Water Treatment Plant

Greywater is recycled and reused for flushing and irrigation. Greywater passes through three stages of the Root Zone System, which recycles greywater with 75% efficiency.

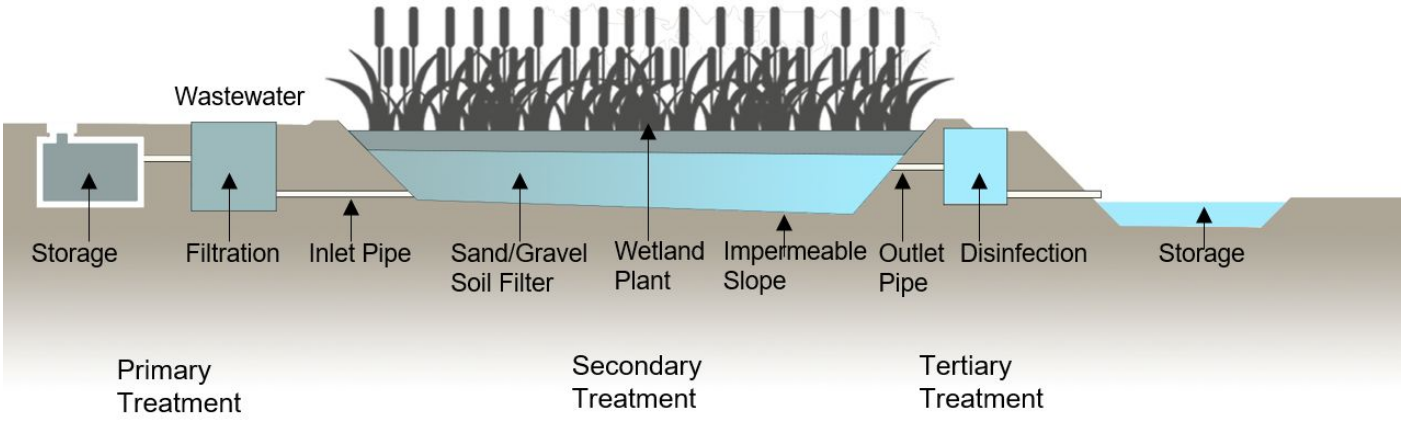


Figure: Water treatment plant

COMFORT AND INDOOR AIR QUALITY

NATURALLY VENTILATED AREA

Unlike a modern day office building where we have air conditioning at all the places and occupants are left with no option but to along with it. The design offers a choice for the occupants whether to go inside and sit in the air conditioned environment or to sit in a naturally ventilated area.

The occupants are mostly from a middle class family with no air conditioning at their homes because of which they have high tolerance for heat and they feel comfortable even at higher set point temperatures. Also, prolonged use of air conditioning causes adverse effects like dry skin, dry eyes, respiratory problems etc. and makes the person more intolerant to heat.

With the design we set a way forward where the occupant can change from place to place if he feels uncomfortable in a certain place and even for the air conditioned area, a point in time a person feels the need for being by the natures side and that's where the change begins and he chooses the naturally ventilated area and even the occupants sitting in

According to the adaptive thermal comfort model for naturally ventilated area as per NBC
Indoor Operative Temperature
=(0.54*Outdoor Temperature) + 12.83
=(0.54*34)+12.83
=31.19 degree Celsius

The 90% acceptability range for India is +-2.38 degree celsius

According to the adaptive thermal comfort model for air conditioned area as per NBC
Indoor Operative Temperature
=(0.078*Outdoor Temperature) + 23.25
=(0.078*34)+23.25
=25.9 degree Celsius

As our building lies in a area with lot of farmlands and green cover. The temperature in Karnal are fairly low in comparison to Hissar to calculate the summer temperatures in 10% monthly design dry bulb and mean coincident wet bulb temperatures..

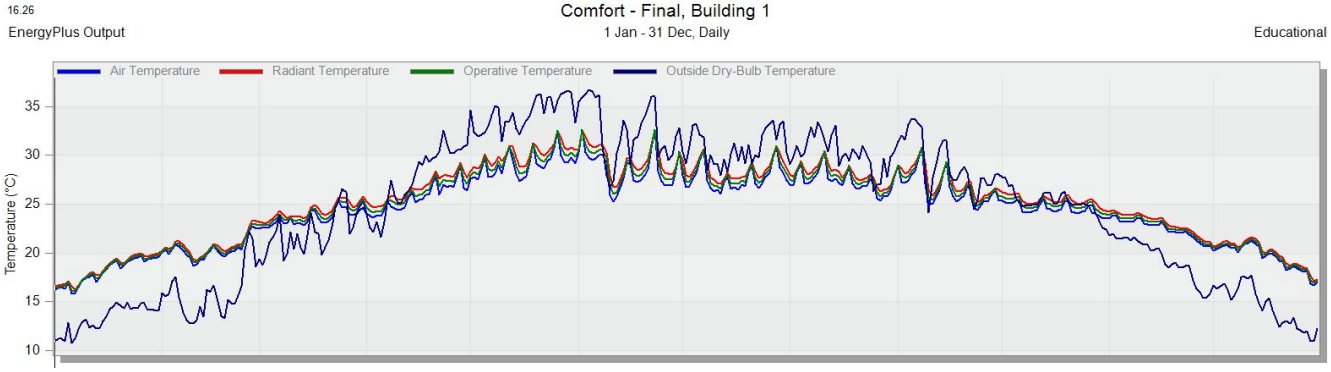


Figure: Annual Operative Temperature for the whole building

The operative temperatures in winters lie in comfortable temperatures. With some uncomfortable hours in summers for naturally ventilated area.

Summer Design Week Simulations

During the summers the temperatures lie in the range of 35 to 40 for the second floor naturally ventilated area and 30-35 for the ground floor naturally ventilated area.

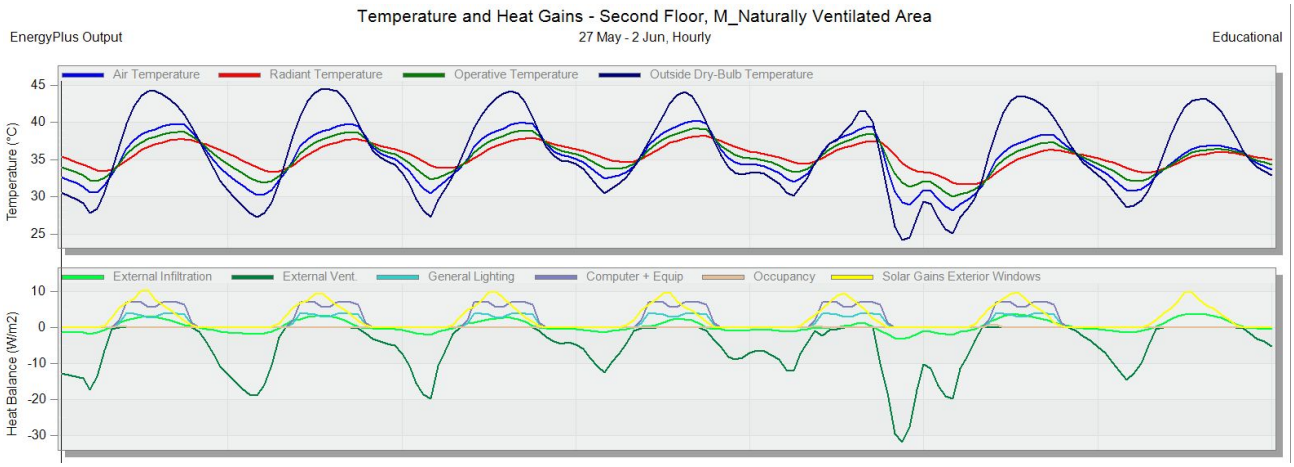
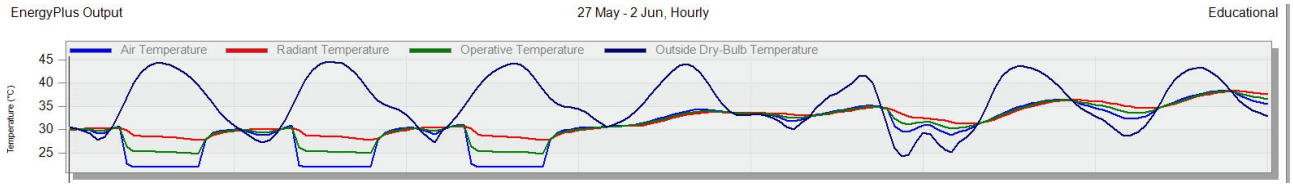


Figure: simulation for Second Floor Naturally ventilated area in summers

To take care of those 400 uncomfortable hours in in summers we will be installing the misting nozzles right over the naturally ventilated area building which will provide instant cooling thus cooling the down the area by 4-5 degrees and bring the temperatures in a comfortable range.

Guest Room



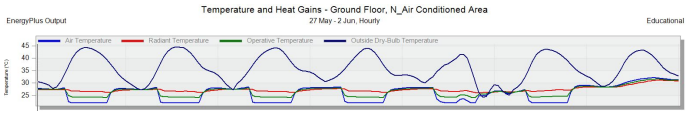
The temperature are well within the comfortable range in the south east of the top most block which is the most heated place when using the air conditioning.

Monthly 90% acceptibility range for **Hisar**

Months	Acceptibility Range	Naturally ventilated	Mix Mode buildings	Air.cond. Based on air temp.	Air.cond. Based on std. effective. Temp
January	90%	23.30	25.52	25.92	25.74
		18.54	18.60	22.92	23.74
February	90%	23.81	25.79	25.99	25.75
		19.05	18.60	22.99	23.75
March	90%	26.58	27.23	26.39	25.82
		21.82	20.31	23.39	23.82
April	90%	29.82	28.90	26.86	25.91
		25.06	21.98	23.86	23.91
May	90%	32.72	30.41	27.28	25.98
		27.96	23.49	24.28	23.98
June	90%	33.82	30.98	27.44	26.01
		29.06	24.06	24.44	24.01
July	90%	33.73	30.93	27.43	26.01
		28.97	24.01	24.43	24.01
August	90%	32.50	30.29	27.25	25.98
		27.74	23.37	24.25	23.98
September	90%	31.75	29.91	27.14	25.96
		26.99	22.99	24.14	23.96
October	90%	30.79	29.41	27.00	25.93
		26.03	22.49	24.00	23.93
November	90%	28.51	28.23	26.67	25.67
		23.75	21.31	23.67	23.67
December	90%	25.71	26.77	26.27	25.80
		20.95	19.85	23.27	23.80

IMAC Standards

Guest Room



Similarly for the air conditioned are the temperatures are in the range of adaptive thermal comfort when using cooling.

Winter Design Week Simulations

Naturally Ventilated Area

The solar gain, internal loads (lighting and equipment loads) and the occupancy loads are high enough to put the winter in a temperature range of 18-24 degrees celsius.

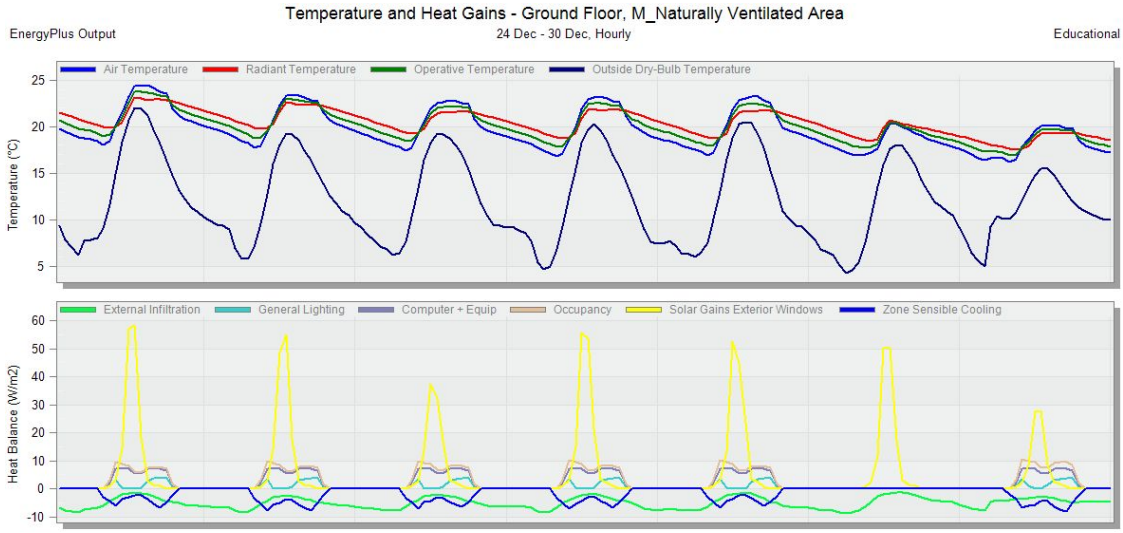


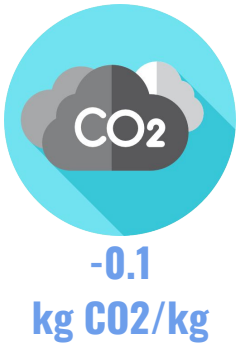
Figure: Ground floor naturally Ventilated area in winter

During the winter the operative temperatures in the naturally ventilated area come in the range of 18 to 25 degrees celsius which can easily be taken care of with clothing factor of 1.

With proper clothing in winter the operative temperature according to PMV tool the temperatures come in the adaptive thermal comfort range.

CARBON EMISSION:
(NET POSITIVE CARBON)

Buildings are responsible for 39 percent of carbon dioxide emissions, both directly and indirectly. The use of environmentally sustainable materials such a cross laminated timber, agrocrete and insulation made up of waste can result in almost zero or positive carbon emissions. We discovered that instead of contributing carbon to the atmosphere, our designed building would store 0.1 kg CO2 per kg of building mass and overall 60 ton of CO2.
The number does not include the carbon emission due to transportation of building materials.



Ventilation Rates

The ventilation rates were calculated by the ASHRAE Standard 6.2(c)(3) (2010): Ventilation for Acceptable Indoor Air Quality in Office buildings.
The ventilation rates for each space inside our office building is calculated as per ASHRAE standards 6.2(c)(3) (2010) ventilation rates.

				ASHRAE ventilation standard		
	Spaces	Ventilation rates (c.f.m.)	No. of occupants	flow rate per person (cfm/person)	flow rate per area (cfm/ sq.feet)	Area (sq.feet)
Ground floor	Office area	466	50	5	0.06	3600
	Meeting Rooms	54.1166	7	5	0.06	318.61
	Entrance Lobby, Reception	166.2512	10	5	0.06	1937.52
	Toilets	73.0666	8	5	0.06	551.11
	Cafeteria	400.6254	25	7.5	0.18	1184.03
First floor	Office area	466	50	5	0.06	3600
	Meeting Rooms	72.6038	10	5	0.06	376.73
	Gym	213.144	-	-	0.3	710.48
	Cabins	42.6038	4	5	0.06	376.73
	Storage	24.5412	-	-	0.12	204.51
	Yoga Point	221.312	10	20	0.06	355.2
	Sleeping Pods	110.3332	20	5	0.06	172.22
	Reading Lounges	164.5116	15	5	0.12	745.93
	Lobby	57.2914	5	5	0.06	538.19
Second floor	Owner's Cabins	178.34396	13	5	0.06	1889.066
	Board Room	72.6038	10	5	0.06	376.73
	Waiting area, Reception	50.5206	3	5	0.06	592.01
	Guest Rooms	105.896	4	5	0.06	1431.6
	Living Room	38.4166	2	5	0.06	473.61
	Recreational	213.123	-	-	0.3	710.41
Lower Ground	Cafeteria	404.4114	30	7.5	0.18	996.73
	R&D Dept.	254.9998	10	10	0.18	861.11
	Surveillance Room	70.6872	3	10	0.12	339.06

The ASHRAE ventilation rates help us in determining flow rates for exhaust fan (c.f.m) in each space. The separate exhaust fans of 60 cfm for each toilet, bathroom is provided inside the building and the ventilation rates for other space is achieved through Bluestar Air Handling Unit system. Some part of office space is naturally ventilated by opening the windows and doors into the Atrium. The duct sizes for each conditioned room was determined according to the ventilation rates.

Reducing the concentration of P.M during ventilation

To reduce the energy consumption of RizaZero, the building is operated in mix mode ventilation. As per occupancy hours, team sparikam implemented natural ventilation and primarily doing night time ventilation to flush out daytime heat ingress and reduce mechanical load. Along with this, unique strategy of atrium along with courtyard is used, which decrease the cooling load.

Source control of pollutants

Use of Low Volatile compounds material (V.O.C) inside RizaZero.

The low VOC paint from Berger paints for walls and ceiling is being used to avoid the contamination of air. Berger breathe easy interior paint has no added Lead, Mercury of Chromium and also has minimal aromatic content, the breathe easy also lies in acceptable levels of VOC.

The wooden products are also coated with low V.O.C varnish to reduce the formaldehyde content in the room. The use of cleaning products and insecticides like mosquitoes and cockroach repellent is also avoided to maintain indoor air quality.

Pest Barrier & control

Corrosion-proof/bird screens installed at all the ducts openings and drainage pipes to control entry of pests etc. All the construction joints are sealed with DOW corning 795 silicone weatherproof sealants.

Fresh air distribution & filtration

In occupied naturally ventilated space, the Philips AC4025 air purifier is provided to clean the air inside the room. Philips AC2882 air purifier has a CADR- clean air delivery rate(m3/hr) of 333, which can be controlled in 3 step fan speed with turbo mode. It is equipped with true High Efficiency Particulate matter (HEPA) filter with an effective filtration efficiency (0.3 micron) of 99.97%. The air purifier is also equipped with auto mode on/off as per the concentration level of pollutants inside the premises. The noise level of air purifier is 20.db which is also under noise control level.

Figure:Philips air purifier

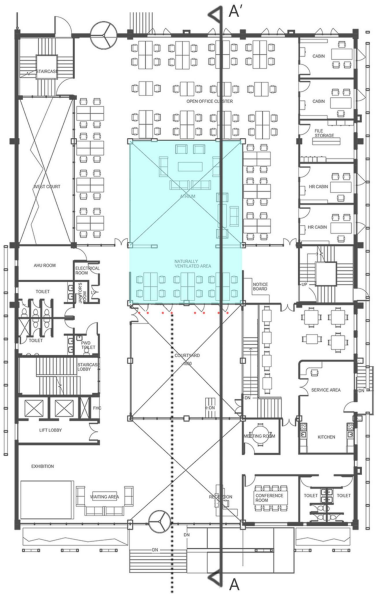
For mechanical ventilation, the heat recovery ventilator is provided with MERV 16 filter in supply duct to reduce the exposure to the ambient concentrations of particulate matter. Also, to increase the life of MERV 16 filter, a separate MERV 10 filter is provided inside the fresh air supply duct. The occupants of the office building are given a detailed instruction report on occupancy schedule to maintain the IAQ inside the rooms i.e. preferable season to open windows, settings to increase the filter life of air purifier, during mechanical ventilation & cooling- switch off the purifier & close down windows and doors.

Indoor air quality sensors

RizaZero is equipped with alarm type CO monitored sensors across each occupied zone to check on CO levels. Philips AC4025 air purifier is also equipped with AERA sense technology which measures real time PM2.5 and displays the concentration with professional – grade air quality sensing technology.

Mist Cooling

Mist cooling is a very effective way of natural cooling by means of evaporation having a potential to reduce the air temperatures by 8-10 degree C just outside the windows so as to meet the comfort range in the not comfort hours in the naturally ventilated work area as well as courtyard



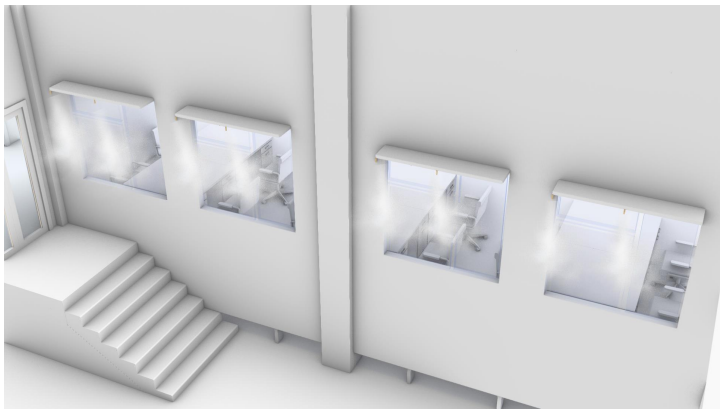


Figure: 3D view showing mist from nozzles

Nozzle placement

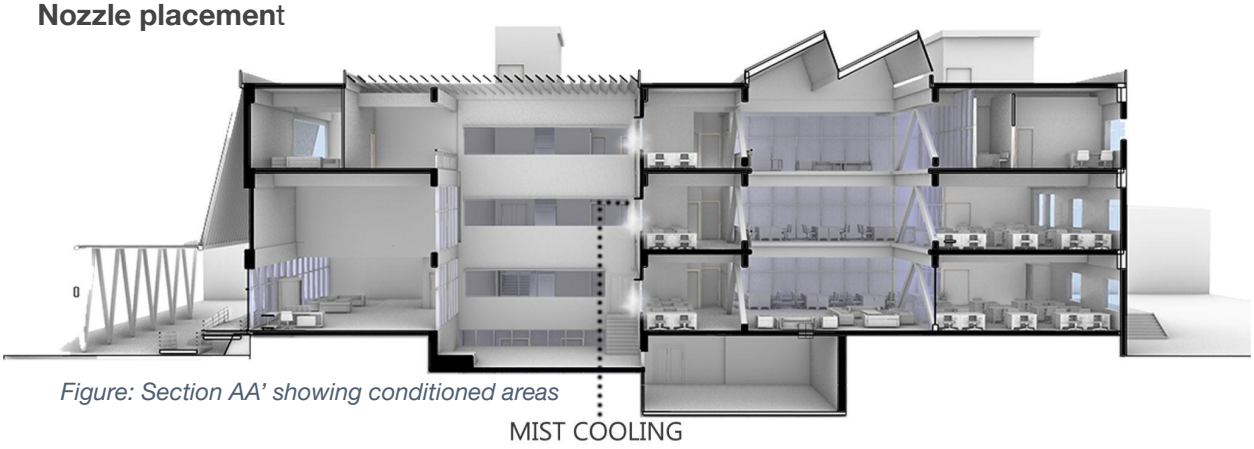


Figure: Section AA' showing conditioned areas

No. of nozzles	Pressure	nozzle flowrate	Pump wattage	Flowrate (L/m)
20	1000 PSI	.1 LPM	750 W	2 LPM

COST OF SYSTEM - Rs 36000

Figure: Brass nozzle 1mm DIA

Figure: 1 hp high pressure pump

SUMMER DESIGN STRATEGY

Mar-May

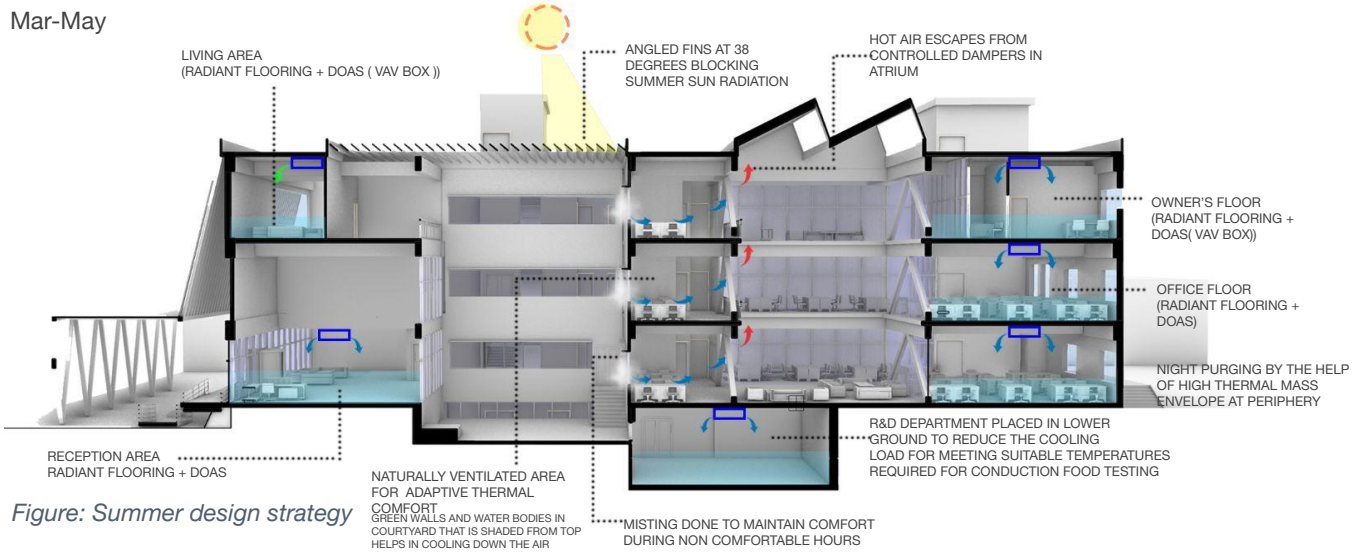


Figure: Summer design strategy

MONSOON/AUTUMN DESIGN STRATEGY

Mar-May

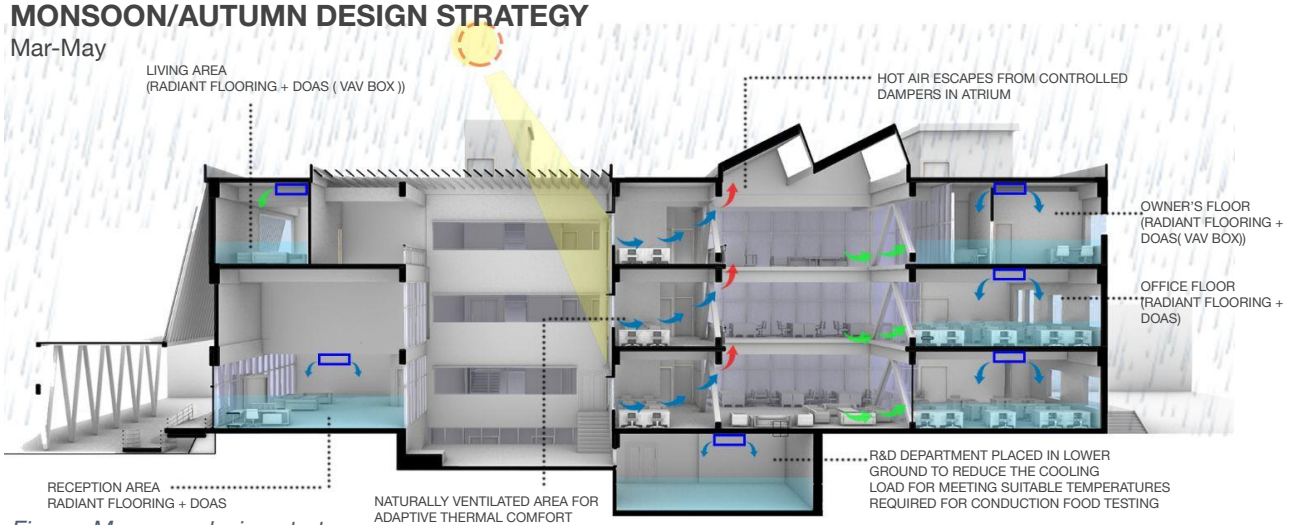


Figure: Monsoon design strategy

WINTER DESIGN STRATEGY

Mar-May

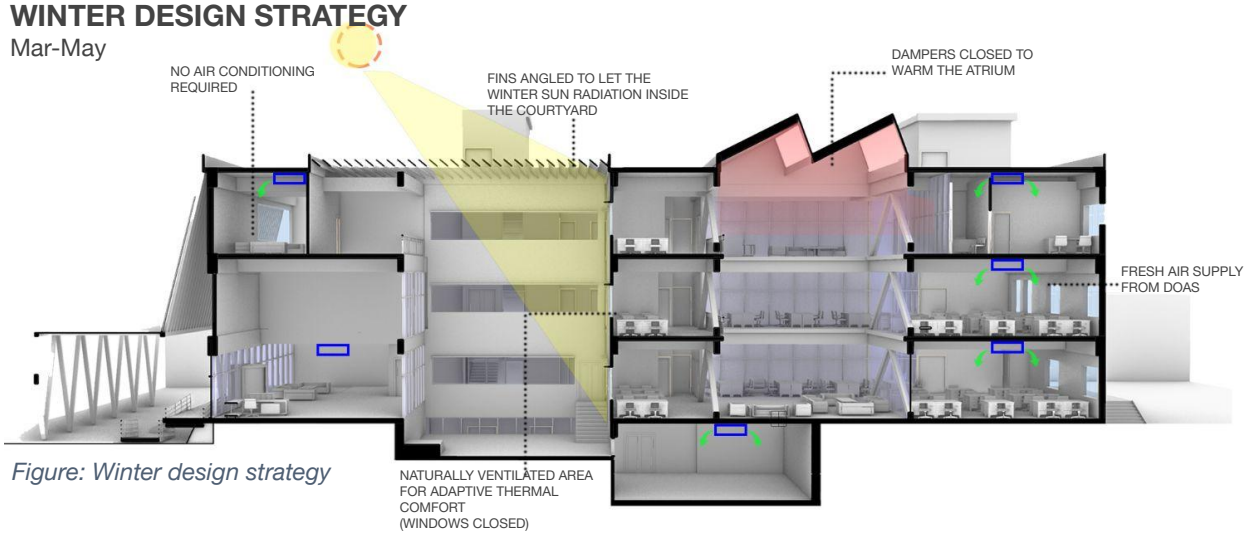


Figure: Winter design strategy

Space Conditioning & Ventilation

Goals for the space cooling and ventilation:

1. Efficient cooling system.
2. Achieve thermal comfort
3. Provide ventilation rates as per the codes & standards.
4. Reduce duct length by planning the space for device efficiently.

System sizing calculation

For sizing the cooling system simulation are done in design builder for summer design week using Hisar, Haryana weather file

Latitude	N 29° 41.1416'
Elevation	240 M
Indoor temperature	25 Degree C
Indoor relative humidity	58%
Outdoor temperature	44 Degree C
Outdoor wet bulb	28 Degree C
Design delta T	19

Table: Climatic parameters of Hisar

Heat load calculation

	Name of space	Sensible load (kw)	Latent Load (kw)
Ground floor	Exhibition space	12.8	9.86
	Meeting Room	1.42	0.95
	Kitchen	3.73	2.57
	Cafeteria	10.41	4.15
	Air Conditioned Area	17.73	15.84
	Cabins	6.41	5.43
	Total	52.5	38.8
First floor	Gym	7.06	2.6
	Reading Lounge	10.1	2.36
	Recreational lobby	5.26	1.93
	Yoga Room	4.28	1.08
	Air Conditioned Area	21.64	8.84
	Cabins	8.95	3.32
	Sleeping Pods	2.69	0.54
	Total	59.98	20.67
Second floor	Guest Rooms	12.06	9.53
	Library	4.12	2.42
	Owners Cabin Left	1.91	1.52
	Owner's Cabin Right	2.78	2.25
	Board Room	3.98	1.58

	Owner Reception Lobby	9.13	7
	Owner's Sons Cabin	5.05	4.14
	Guest Living Area	5.11	3.67
	Owner's Recreational Space	6.53	5.29
	PA's Right	0.69	0.52
	PA's Left	1.75	0.62
	Total	53.11	38.54
	Basement Cafeteria Seating	8.67	8.56
	Surveilance Room	2.85	2.16
	R and D	9.21	3.68
	Total	20.73	14.4
	Total cooing load	187	113
		300	
	T.R.	83	
	System sizing factor	0.15	
	Total cooling load (T.R.)	95.45	

Table: Chiller sizing

As per the ton of refrigeration required for the conditioned space, we compared different system based on efficiency of the system, initial capital cost, low maintenance cost. Finally cost benefit analysis was done for the final selection of the system.

		Vapor absorption chiller	VRF system
Cooling capacity	kw	300	300
E.E.R.			15
Consumed power	kw/hour	4.8	20
Cost/ton	INR	27000	45000
Total cost		2700000 (100 tr)	3600000
Cost of electricity	INR/ unit	6.5	6.5
working hours/day for system	hours	9	9
Cut in/ Cut out condition (actual work by compressor)	%	80	80
Actual working hours by system	hours	7.2	7.2
No. of units consumed per day	kwh	34.56	144
Cost of electricity/ year	INR	36391.68	151632
Operational cost (maintaining + repairing)	INR	300000	250000
Total cost		336391.68	401632
Saving of Chiller	INR/year	65000	

Table: Specifications

Two 50 tr vapor absorption chiller is selected that will run radiant cooling in the building despite of the high

initial capital cost that includes cost of pipework and AHU, Ductwork . Other benefits of using chiller are -

1. Running completely on waste heat generated at site
2. Use of very less refrigerant in comparison to VRF , thus produces very less CFC.

Sizing of AHU for different floor levels

Floor Level	Latent load (kw)	T.R.	System sizing factor	Total cooling load (T.R.)
Ground Floor	39	11		12.65
1st Floor	21	6		6.9
2nd Floor	39	11		12.65
Lower Ground Floor	15	4	0.15	4.6

Table: Sizing of AHU for different floor levels

Sizing of Cooling tower

Because of the rapidly dropping water table in Karnal, Haryana using a dry cooling tower over wet cooling tower is a responsive approach towards the context. Also its a closed loop system therefore reduces the chances of crystallisation in the circuit and saves energy that goes into the treatment of makeup water.

	Cost(INR)	Capacity	Flow rate (gpm)	Loss of water (lpm) (Evaporation + drift loss)	Loss of water/day (L)
Wet cooling tower	20,000	250 tr	440	17	8160
Dry cooling tower	1,50,000	100 tr	440	0	0

Table: Specifications

Heat Load (BTU/Hr) = GPM X 500 X Range (T1 – T2) °F
= 440 x 500 x (95 - 85)
= 22,00,000 BTU/hr
= 5,55,000 kcal/hr

Cooling water inlet temperature - 95°F
Cooling water outlet temperature - 85°F
Flow rate = 2 x 220 = 440 gpm

Flow rate for one 50 tr chiller = 220 gpm
A 100 tr cooling tower is selected for the purpose.

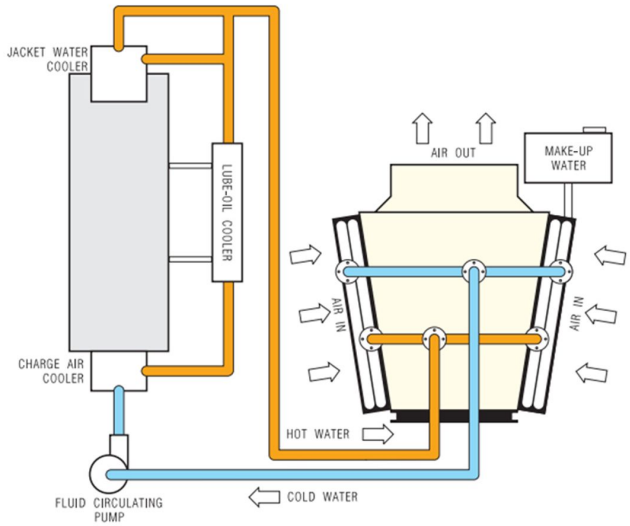


Figure: AHU mechanism

Engine Capacity kVA	Heat Load kcal / h	Model Suggested	Motor	
			Power HP	Quantity
150	81,000	DCT-020	2	2
300	1,50,000	DCT-030	2	2
380	2,70,000	DCT-040	3	2
500	3,30,000	DCT-050	5	2
600	3,30,000	DCT-060	5	2
750	4,20,000	DCT-080	5	2
1000	5,40,000	DCT-100	7.5	2
1250	6,50,000	DCT-120	7.5	2
1500	7,50,000	DCT-140	7.5	2

Figure: Gem equipment limited catalog

Space Conditioning & Ventilation

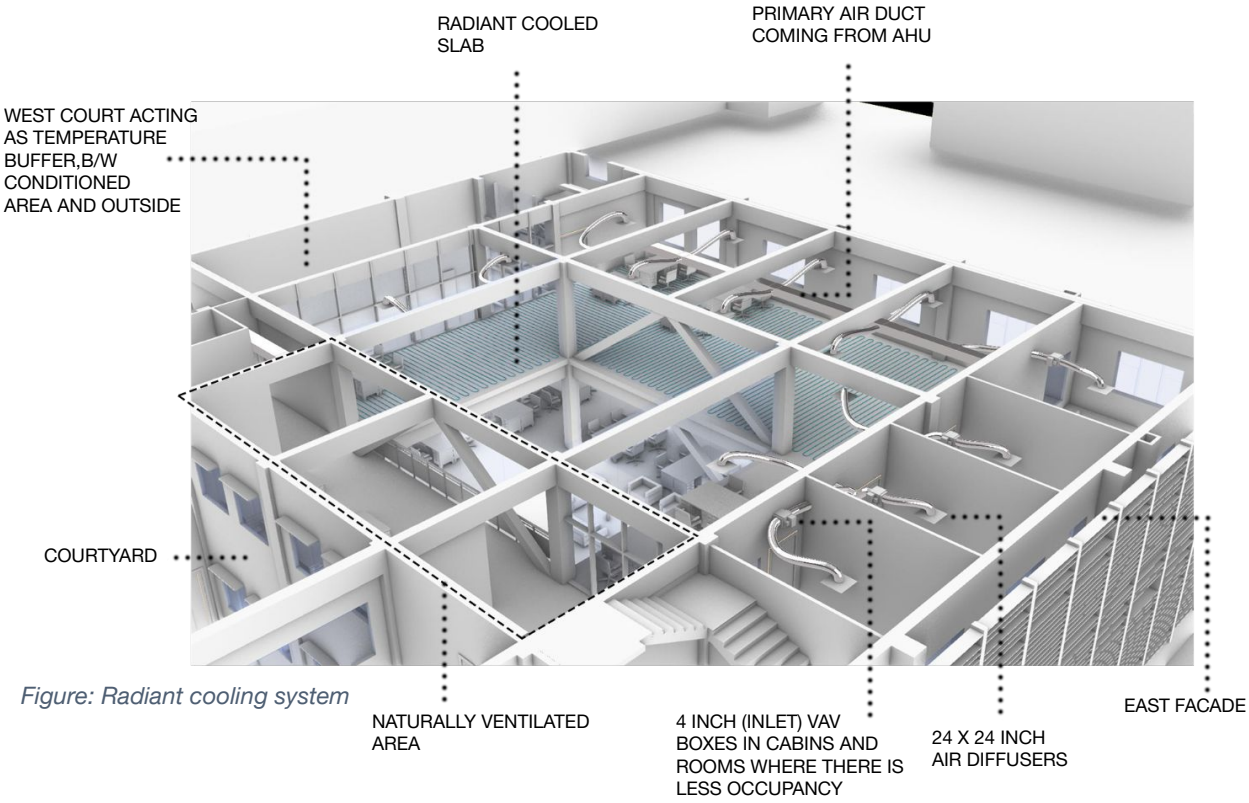


Figure: Radiant cooling system

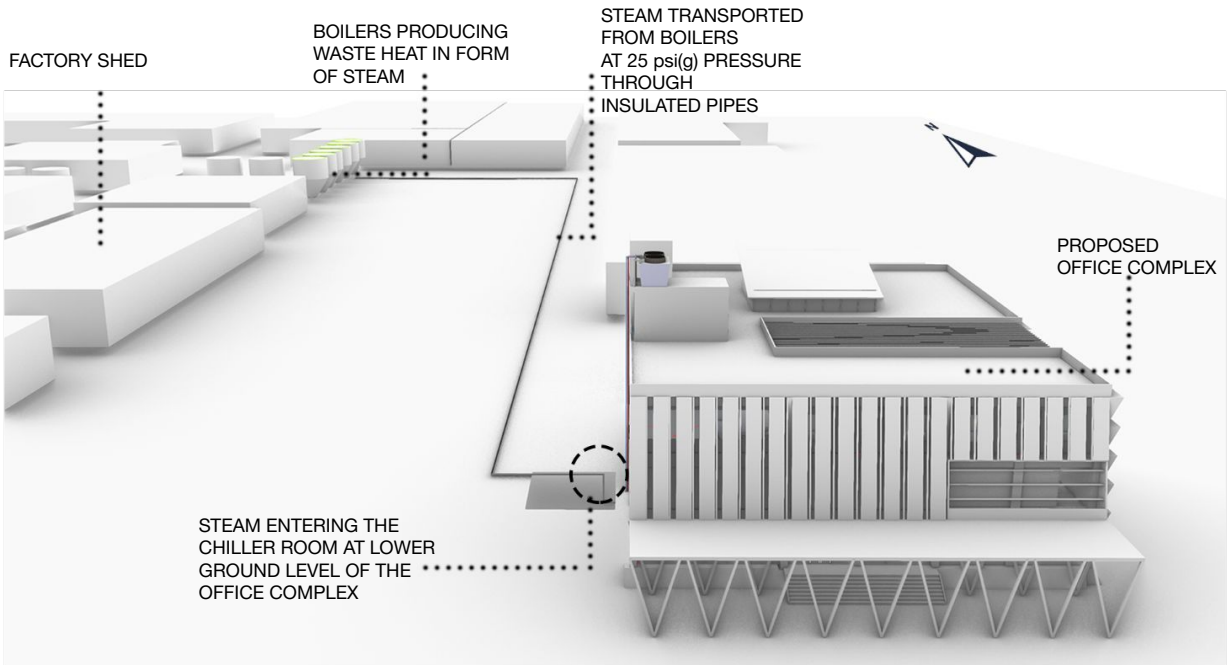


Figure: Site level image showing boilers and chiller room

Space Conditioning & Ventilation

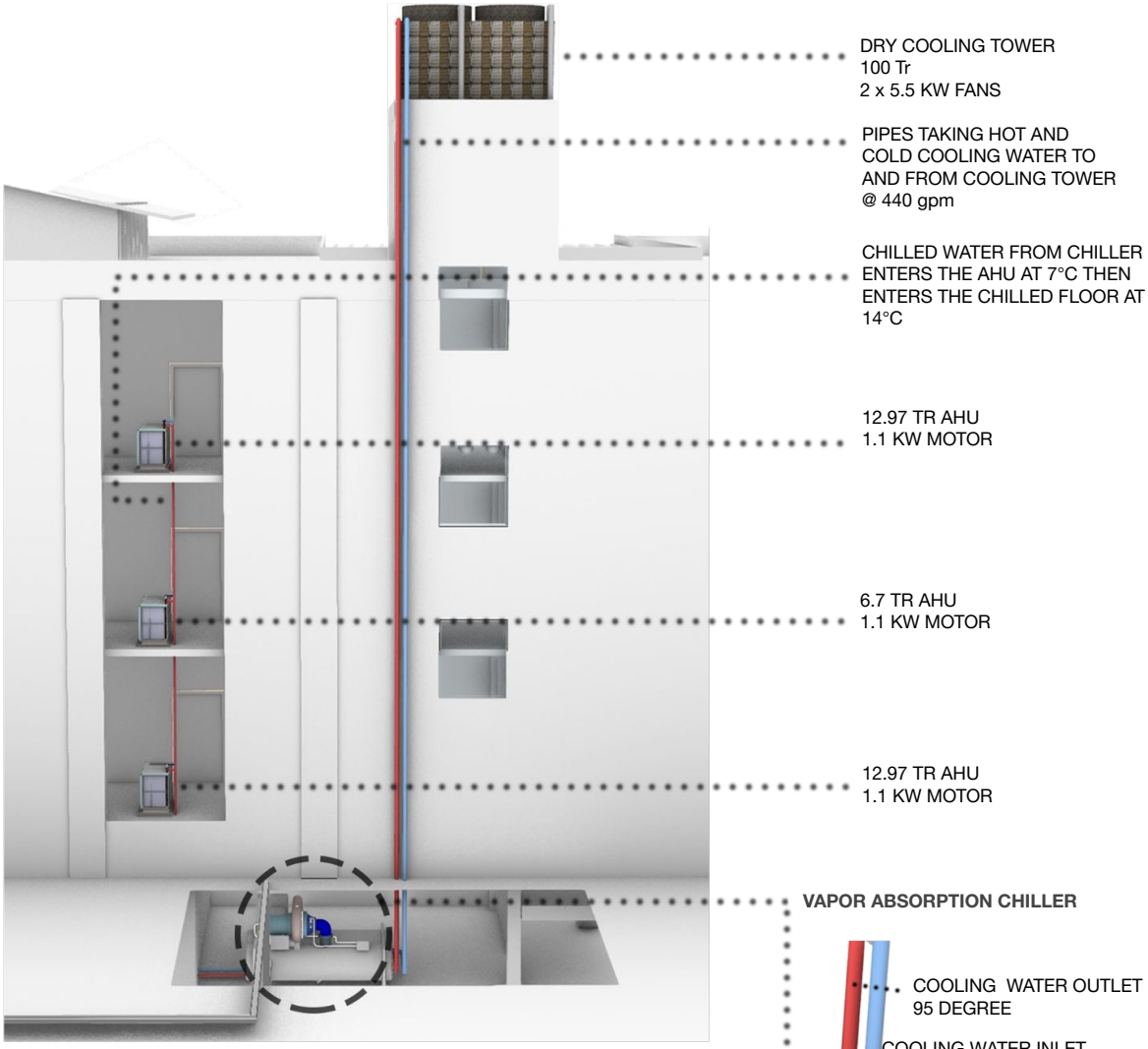


Figure: Cooling tower

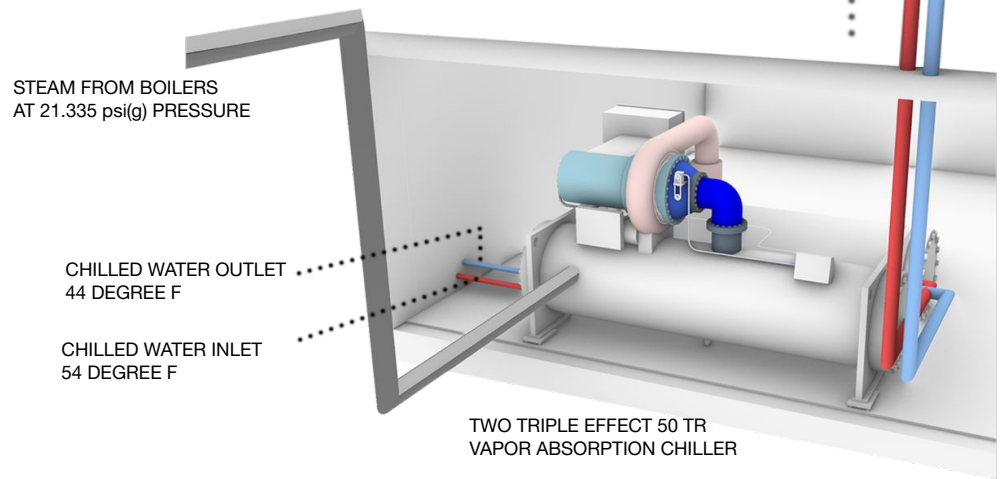


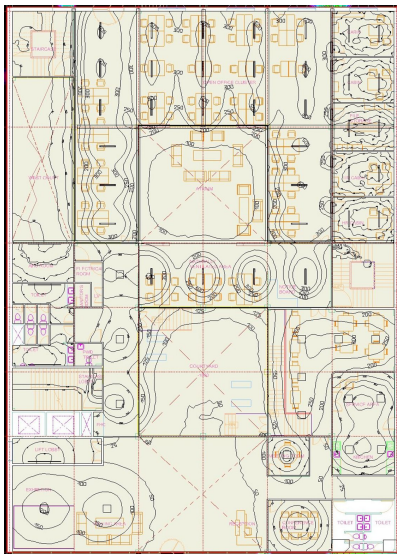
Figure: Vapour absorption chiller

Artificial Lighting Optimisation

Artificial lighting placement was done after identifying the tasks performed in various rooms. LED technology is opted for several advantages like energy savings, environment friendly,etc .The lights have a color temperature range of 5000-6000 K i.e. cool white
color for a natural look.

S no.	Space Function	Target illuminance (Lux)	Type of Lighting	nos.	Avg lumen received	Total power used (kw)	Hours per day	no. of days	Energy consumption anually(kwh)
1	Open Plan office	350 lx	Ceiling Pendant LED	63	5000	0.048	7	306	6477.408
2	Cabins	350 lx	Ceiling Pendant LED	30	5000	0.048	7	306	3084.48
3	Board room	300 lx	Ceiling Pendant LED	9	5000	0.048	7	306	925.344
4	Reception	200 lx	Ceiling Pendant LED	3	5000	0.048	7	306	308.448
5	Reception	200 lx	Chandelier	1	3000	0.06	7	306	128.52
6	Library	350 lx	Ceiling Pendant LED	4	5000	0.048	7	306	411.264
7	Staircase	100lx	Ceiling mounted LED	20	1800	0.02	4	306	489.6
8	Passage	100 lx	Ceiling mounted LED	12	1800	0.02	4	306	293.76
9	Toilet(Common)	100 lx	Wall mounted LED	12	1000	0.01	7	306	257.04
10	Toilet(Private)	100 lx	Wall mounted LED	4	1000	0.01	0.5	306	6.12
			Guest rooms						
1	Guest rooms	100 lx	Syska LED Tubelight	4	2130	0.018	1	306	22.032
2	Living area	100 lx	Ceiling mounted LED	4	1800	0.02	2	306	48.96
3	Dining area	150 lx	Ceiling mounted LED	4	1800	0.02	0.5	306	12.24
4	Toilet	100 lx	Wall mounted LED	4	1000	0.01	0.1	306	1.224
									12466.44
	Total lighting load= 12500/ 3600 sq. m of builtup area = 3.5 kwh/sq. M/year								

Software - Dialux Evo.



Ceiling Reflectance = 55%
FLoor Reflectance = 70%
Wall Reflectance = 80%
Ext. Wall Reflectance = 75%

Ground floor artificial light simulation
(outside condition - dark)

Equipment Optimisation

Appliances selected was 5 star rated based on the BEE energy rating scale.

S No.	Appliance name	Nos.	Wattage(W)	No. of hours per day	No. of days	Energy consumed annually (kwh)
1	Laptop	50	50	7	306	5355
	Total laptop load = 5355/ builtup area of 3600 sq. m = 1.5 kwh/sq. m/year					

The equipment load was derived from studying a survey of 10 offices. The findings of survey are type of equipment and usage patterns.

Equipment Optimisation

S No.	Appliances	Nos.	Wattage(W)	No. of hours per day	No. of days	Energy consumed annually (kwh)
1	Ceiling fan-havells 1400 MM (5 star)	8	50	9	260	936
2	Exhaust fan -havells 250 MM (Office washroom)	4	35	1	306	42.84
3	Exhaust fan -havells 150 MM (Owner's washroom)	5	22	0.5	306	16.83
4	Exhaust fan -havells 150 MM (Guest stay washroom)	4	22	0.5	306	13.464
5	Voltas 400 L Deep Freezer (5 star)	1	50	24	365	438
6	Juicer/Mixer - Philip	1	750	0.2	306	45.9
7	Printer(Home) active + standby	30	30	0.25	306	22.95
8	Printer(Commericial)	3	400	1	306	367.2
9	Printer(Commericial) - standby	3	40	8	306	293.76
10	Refrigerator	1	68	24	306	499.392
11	Microwave	2	700	0.5	306	214.2
12	Paper Shredder	6	146	0.25	306	67.014
	TOTAL					**2957.55**
	Total equipment load = 2958/ builtup area of 3600 sq. m = .8 kwh/sq. m/year					

The equipment load was derived from studying a survey of 10 offices. The findings of survey are type of equipment and usage patterns.

S No	HVAC component name	Nos.	Wattage(kw)	No. of hours per day	No. of days	Energy consumed annually (kwh)
1	Control panel for chiller	1	0.8	9	45	324
2	Electric input for chiller	1	2	9	45	810
3	Control panel for chiller	2	0.8	9	156	2246.4
4	Electric input for chiller	2	2	9	156	5616
5	AHU Fan	4	1.1	9	212	8395.2
6	Mist cooling Pump	1	0.75	4	80	240
7	Cooling tower fan	2	5.5	9	156	15444
						33075.6
	Total equipment load = 33075/builtup area of 3600 sq. m = 9.2 kwh/sq. m/year					

Target Energy Performance Index

Conditions as per GRIHA(nationally accepted benchmark)
We have included Ventilation, space conditioning and lighting loads only.
Climate-Composite
Building type-Office building
Operational for 9 hours and 6 days a week.
GriHA benchmark for EPI as per table 3.3= 90 kWh/m2 per year(for an office facility operational for 8 hrs for 6 days a week in a composite climate)
Total number of working hours in a day = 9 hours
Total number of working days = 6 days
Therefore, the final GRIHA benchmark for EPI=90x(9/8)x(6/5)=121.5 kWh/m2 per year
Energy Performance Index -121.5 kWh/sqm per year
Our goal is to achieve less than or equal to 50% reduction in the EPI.
Target Energy Performance Index(EPI)< 60.75 kWh/sqm per year

EPI = Appliances load + Laptop load + Lighting load + HVAC component electric load + miscellaneous load (Pump load + BMS system)
= .8 + 1.5 +3.5 + 9.2 + 2 = 17 kwh/m^2/year

UNIVERSAL DESIGN:

Accessibility:

- Ramp with a 1:10 slope for non-ambulatory and semi-ambulatory people to gain entry to the building.
- To assist blind people, guiding blocks are placed both outside paths and within the corridors indoors.
- Doorways are provided as per disable accessibility standards.

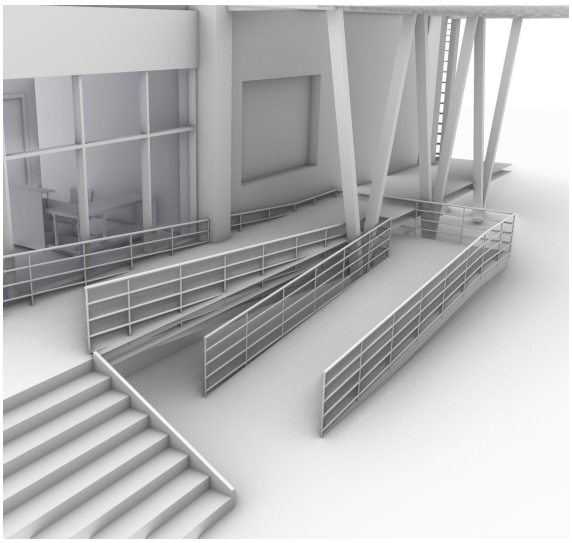


Figure: Ramp for Physically handicapped

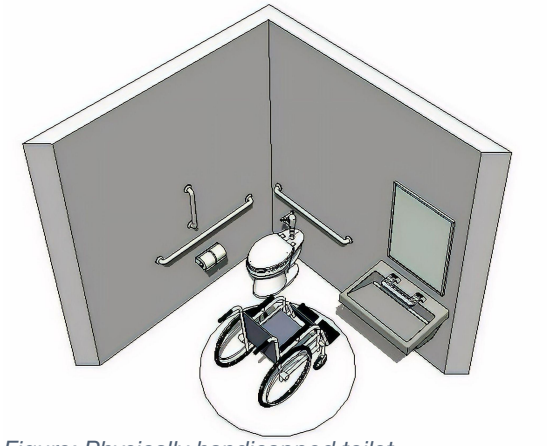


Figure: Physically handicapped toilet

Services:

- PWD toilets for disabled person are provided on each floor with support bars.
- Wheelchair accessible elevators with handrail support for easy vertical circulation for everyone.

FIRE SAFETY:

- As a fire precaution, a fire sprinkler system is located in the floor plates of each floor, along with smoke detectors.
- On each landing, fire hose cabinets are located near the services area.
- To delay the spread of fire in such emergency conditions, passive compartmentation was considered when designing floor plates.
- Narrow floor plates, a courtyard, and an atrium will aid successful active venting, which will enable smoke to exit the building in the event of a fire.
- Fire escape staircase for direct exit to outside of the building.

Your Requirements:

- A Net-Zero Office Building which can accommodate 200 employees.
- Cabins for the 3 Owners.
- Stay Facilities for the International Clients.
-

Our Research Outcomes:

- An office with such role requires departments like accounts, sales, marketing, R&D, Purchase and Administration.
- Air quality and acoustic comfort are to be addressed for creating pleasant working environment.
- Daylighting plays an important role in office buildings.

Our Proposals:

- Our strategy is to include optimum floor plates along with atrium and courts which optimizes the day-lighting.
- Using low flow fixtures and proper rain water harvesting along with purification of grey water helps the building to be a net-zero in water.
- A surplus electricity is produced by the solar panels innovatively included in the southern facade and on the rooftop. The total revenue after 25 years is Rs 4,14,00,000
- Acoustic comfort can be achieved by the inclusion of buffer zones while air quality is developed by indoor plantations and air purifying systems.
- One of the primary concern of the team is to address the wastage. By addressing this, we came up with the building materials by using rice husk, which is a huge wastage from the mill.
- The use of the steam produced by the boilers at the mill will be used to operate vapour absorption chiller system. Chilled water produced here will be used in radiant cooling to decrease the cooling load of the building.

Investments and Growth Plans:

- Use of CLTD is costlier but it sets trends in India.
- Use of excess PVs might increase the capital cost but it will generate revenue of Rs. 4,14,00,000.
- Net- Zero project increases the capital cost but decreases operational cost at huge amount. This will be the first of its kind in this region.

S.No.	Particulars	Amount (Rs Millions)
1	Land	0.00
2	Civil Works	60.99
3	Internal Works	10.57
4	MEP Services	41.65
5	Equipment & Furnishing	18.00
6	Landscape & Site Development	4.70
7	Contingency	0.00
	TOTAL HARD COST	**135.90**

- Net Zero investments shows the environmental responsibility of Project Partner and attracts the clients and gives more advertisement to the Project Partner.
- The capital cost for equipments and machinery is high. But the constant and lifetime reduction in cooling load and lighting load will show huge impact on Opex.
- Proper water management in the proposed design will be handy in summers when there will be water scarcity at the site.