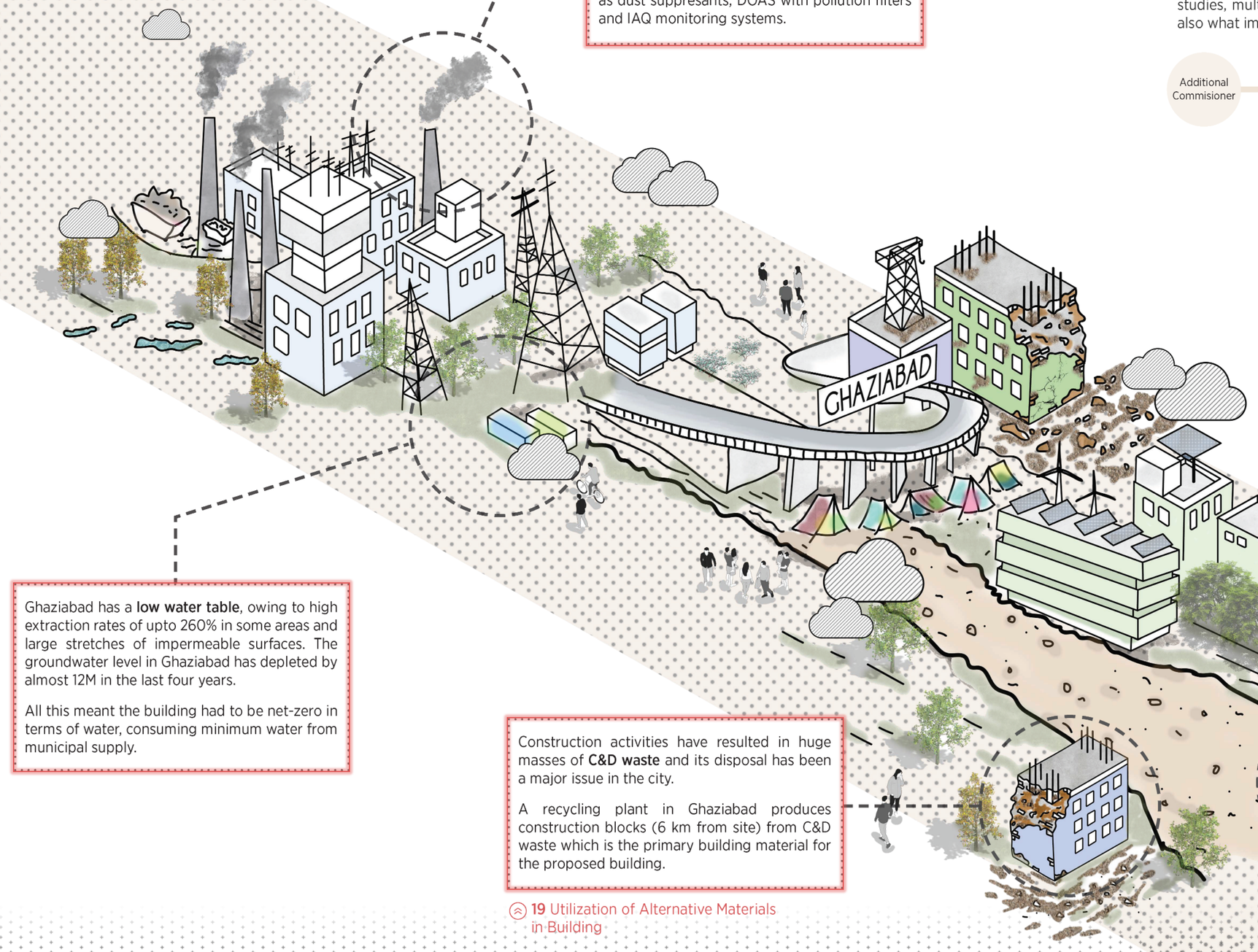
METAMORPHOSIS

Bringing a paradigm shift in conventional government building design with sustainable strategies.

Due to power plants, boom in construction activities and vehicular traffic, the **air quality** in Ghaziabad ranges from severe to dangerous throughout the year.

The challenge in designing building in a city like Ghaziabad was to control the air quality, so a number of strategies had to be adopted such as dust suppresants, DOAS with pollution filters and IAQ monitoring systems.



Ghaziabad has a **low water table**, owing to high extraction rates of upto 260% in some areas and large stretches of impermeable surfaces. The groundwater level in Ghaziabad has depleted by almost 12M in the last four years.

All this meant the building had to be net-zero in terms of water, consuming minimum water from municipal supply.

Construction activities have resulted in huge masses of **C&D waste** and its disposal has been a major issue in the city.

A recycling plant in Ghaziabad produces construction blocks (6 km from site) from C&D waste which is the primary building material for the proposed building.

19 Utilization of Alternative Materials in Building

GST Building, Ghaziabad

When it comes to green buildings in India, the proportion of government buildings is radical. The aim was to design a sustainable and green GST building for the industrial city of Ghaziabad, which could be a paridgm for future designs of government buildings.

Case studies of GST buildings in different cities highlighted various similarities and differences in the requirements of a building for this purpose. Conversations with officers in different positions, helped identify the unarticulated needs. After documentation of studies, multiple conclusions could be drawn, regarding the system, the working and also what improvements were required to make the functioning more efficient.

Additional Commisioner → Assitant Commisioner → Deputy Commisioner → Tax Inspector → Tax Assistant → Shipahi

Understanding Office Hierarchy

Occupancy: Daytime (10AM - 5:30PM)
8 Hours for 6 Days a week with 24 annual holidays

Space	No.	Area (Sqm)
Open Workspace	17	2880
Assistant Commisioner's Cabin	32	480
Deputy Commisioner's Cabin	32	448
Additional Commisioner's Office	1	180
Adj. Additional Commisioner's Office	4	72
Attorney's Cabin	2	30
Meeting Room	3	170
Auditorium	1	195
Cafeteria	1	158
Chiller Room	1	18
Store Room	1	18
Record Room	1	26
Meter Room	1	18

Area Programme

The **water quality** in Hindon river is neither fit for drinking nor for bathing. This is due to the direct disposal 399.693 MLD of sewage and effluent discharged from 10 drains of Ghaziabad district.

Thus, the building needed to responsibily treat sanitary water to levels of safe disposal to municipal lines.

NASA

Climate Analysis

Location: Ghaziabad, UP, India

Climate Type: Local Steppe Climate

Annual Precipitation: 764mm

Air Quality Index: Very Dangerous to Hazardous

Solar Generation Potential: **High** as incident radiation is 4.997 kWh/sqm/day.

Wind Generation Potential: **Low** due to low wind speeds.

IMAC: Monthly Comfort Range

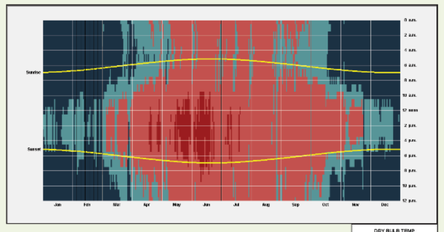
Months	Acceptability Range	Mix Mode Buildings (Temperature Range in deg C)
January	90%	25.27 - 18.35
February		25.67 - 18.35
March		26.92 - 20.00
April		28.73 - 21.81
May		30.24 - 23.32
June		30.54 - 23.62
July		30.13 - 23.21
August		29.87 - 22.95
September		29.75 - 22.83
October		29.26 - 22.34
November		28.06 - 21.14
December		20.30 - 19.52

The acceptability range of IMAC model was used to determine temperature setpoints of water cooling chillers.

Mixed mode of ventilation was chosen in order to **control air quality** of the interiors when the outdoor air quality is poor.

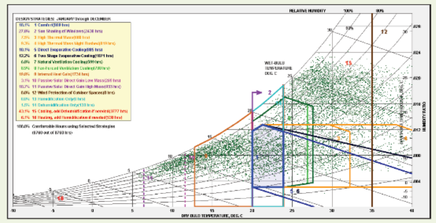
Design using 90% acceptability range takes care of the subjective component of thermal comfort.

Dry Bulb Temperature Plot



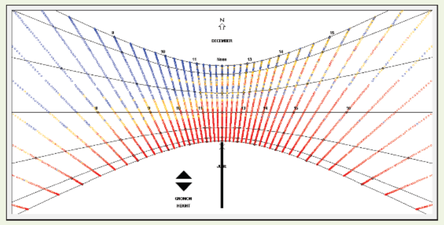
DBT time table plot shows a large part of the occupancy hours are uncomfortable *(according to IMAC)*. February and November have the most comfortable hours.

Psychometric Chart with strategies



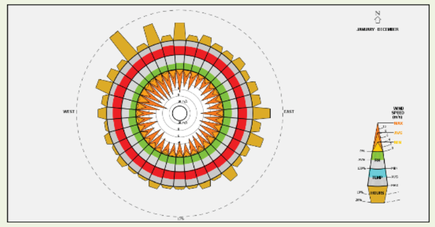
27.8% of the hours can be made comfortable by **sun shading** while **cooling** is required for 47.1% hours.
Monthly design strategies were derived from the psychometric chart.

Sun Shading Hours



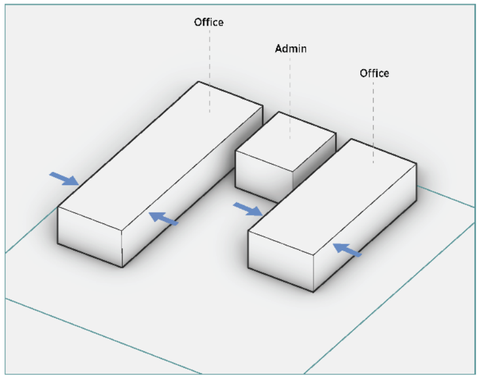
For all months except for December and January, sun shading is required. Windows are shaded from 10:30AM - 5:30PM from March to October.

Wind Rose Diagram

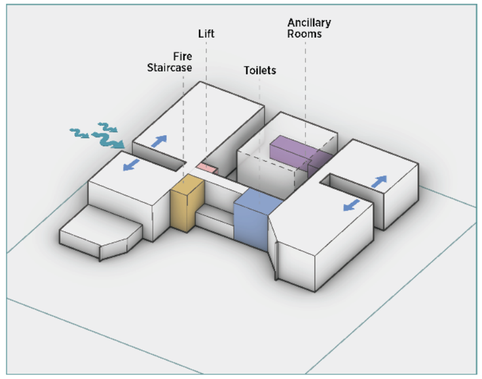


Prevalent wind direction from January to December for 10AM - 6PM is **North West.** Summer winds are also from North West.

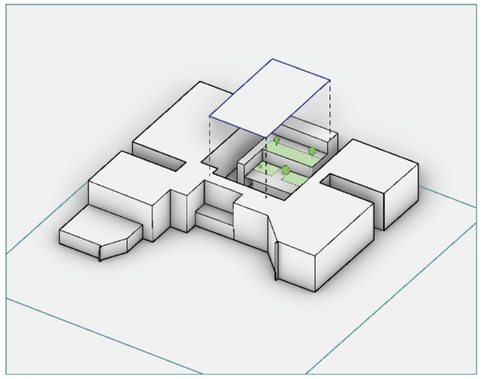
Form Development



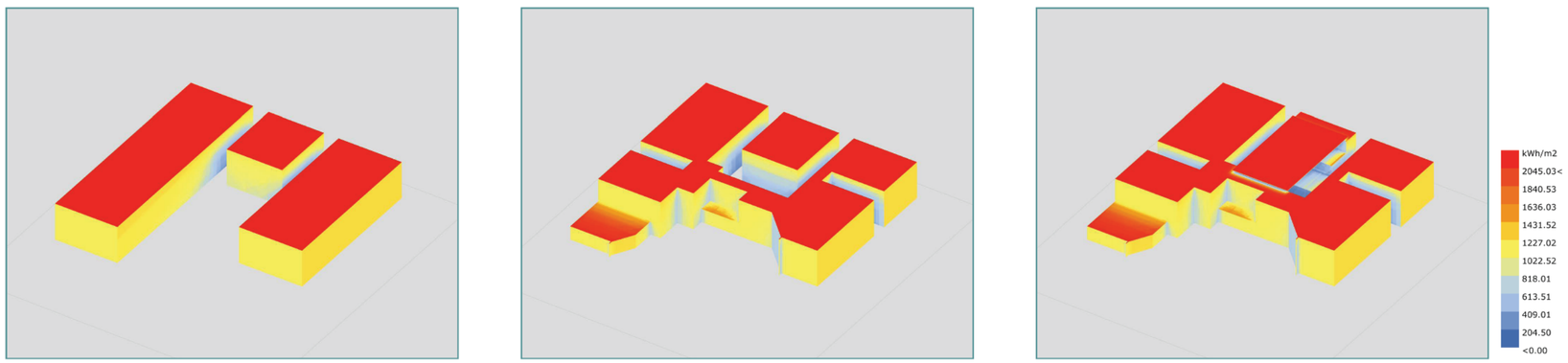
The required building volume is split into two thin and long office blocks and one central admin block, all oriented at 12 degrees to the North to optimize daylighting.



The volume is broken to provide niches which flood daylight into the interiors and create channels for wind. 100% of the service areas are added on the East and West.



The central admin block is terraced with plantation which contributes to a microclimate. A polycarbonate roof is added over the central block for enhancing daylighting. Xeriscaping is done in the niches.



Annual Incident Radiation Analysis: 1 January - 31 December

Massing of the building is done in a manner to reduce heat gain and achieve mutual shading.

ANNUAL CLIMATIC STRATEGIES

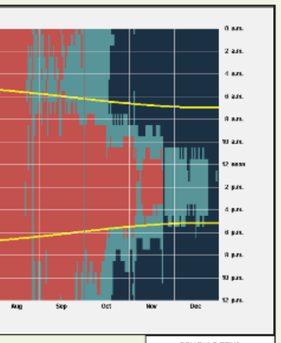
Months	Cold	Comfortable	Hot	Strategies
December, January	10:30AM - 12PM ; 4PM -5:30PM	12PM - 4PM	-	• Plant trees at not less than 45 deg from solar shaded windows. • 10 percent solar windows within 15 deg of true south. • Organize the floor plan so that the sun penetrates into daytime spaces. • No sun shading required.
February	10:30AM - 12PM ; 5PM - 5:30PM	12PM - 5PM	-	• Natural ventilation through openable windows. • Sun shading required 12PM - 1PM.
March	-	10:30AM - 11AM	12PM - 5:30PM	• Shading during 10:30AM - 5:30PM. • Render flat roof surface a light color and choose a roofing material that has a surface Solar Reflectance (SR) of > 0.7; and Thermal Emittance (TE) of > 0.75. • Use natural ventilation, orient windows towards prevalent wind direction, i.e NW.
April, May, June	-	-	10:30AM - 5:30PM	• Cooling required. Use radiant cooling during April, May and June. • Minimize or eliminate west facing glazing to reduce late afternoon gains. Use high performance glazing and insulated frames. • Intercept sunlight before it reaches the walls and glazing of a building to reduce the amount of heat entering that building. • External shading devices can reduce solar heat gain through glazing by up to 80%. • Horizontal overhangs or louvers for south and vertical fins and egg-crate designs for other orientations. • Enclosed well shaded courtyards / atriums.
July, Aug	-	-	10:30AM - 5:30PM	• Shade 10:30AM to 5:30PM. • Exterior horizontal louvers can be used to shade south glazing and the entire facade. • Plant trees on the west to minimize gains. • High humidity, so increase wind flow inside the building. Prevalent wind direction during these months is East, North East.
Sept, Oct	-	-	10:30AM - 5:30PM	• Shade 10:30AM to 5:30PM. • Cooling via DOAS and Radiant Slabs. • Natural ventilation by N-W winds.
Nov	-	10:30AM - 11:30AM ; 3:30PM - 5:30PM	11:30AM - 3:30PM	• Shade 11:30 to 4:30. • No special strategies required.

Concept

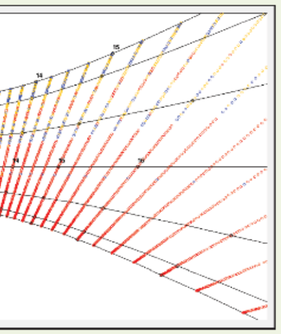
Changing the imageability of government buildings from opaque, rigid and unsustainable to **transparent , flexible and sustainable** through circulation routes, public accessible indoor spaces and office layouts.

Open office areas with work desks which increase **visibilty**, offer flexible use deviating from cell like layout.

Central atrium with circulation passages which increases **transparency** of the entire building.

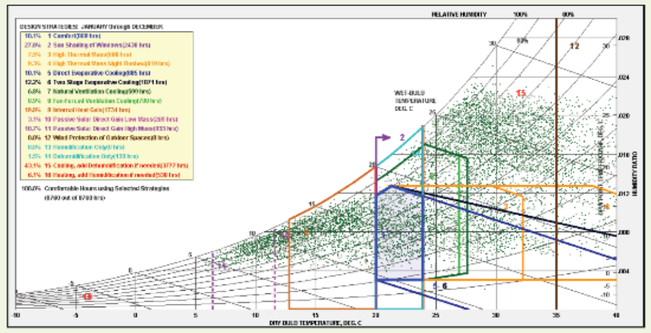


the occupancy
AC). February
hours.



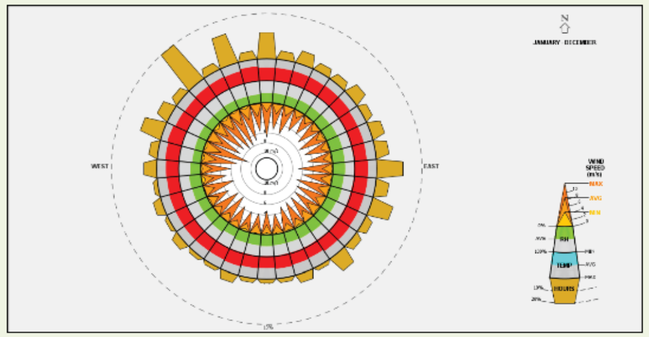
anuary, sun shading is required.
PM from March to October.

Psychometric Chart with strategies



27.8% of the hours can be made comfortable by **sun shading** while **cooling** is required for 47.1% hours.
Monthly design strategies were derived from the psychometric chart.

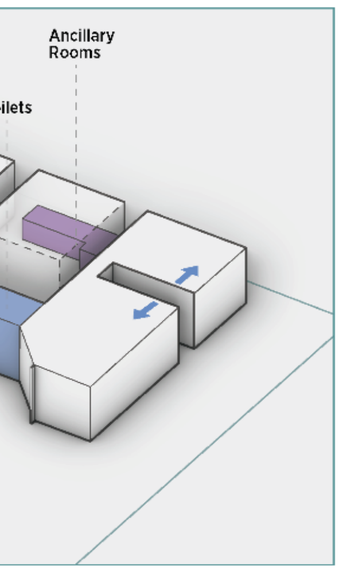
Wind Rose Diagram



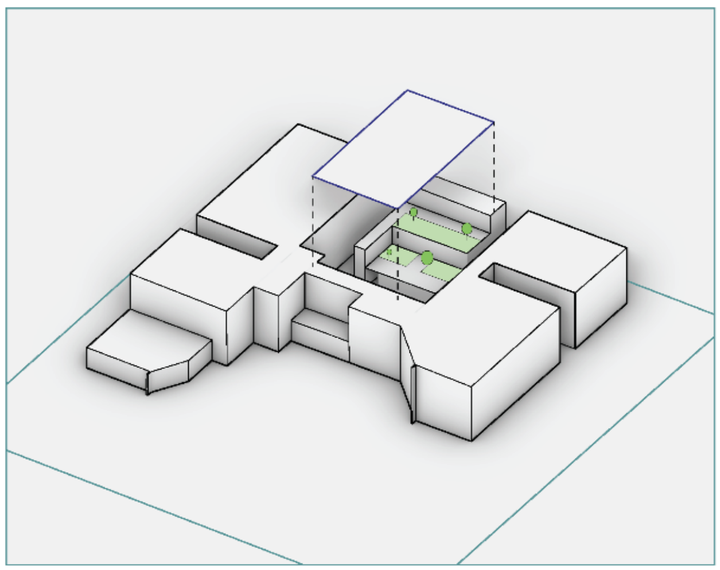
Prevalent wind direction from January to December for 10AM - 6PM is **North West.** Summer winds are also from North West.

ANNUAL CLIMATIC STRATEGIES

Months	Cold	Comfortable	Hot	Strategies
December, January	10:30AM - 12PM ; 4PM -5:30PM	12PM - 4PM	-	• Plant trees at not less than 45 deg from solar shaded windows. • 10 percent solar windows within 15 deg of true south. • Organize the floor plan so that the sun penetrates into daytime spaces. • No sun shading required.
February	10:30AM - 12PM ; 5PM - 5:30PM	12PM - 5PM	-	• Natural ventilation through openable windows. • Sun shading required 12PM - 1PM.
March	-	10:30AM - 11AM	12PM - 5:30PM	• Shading during 10:30AM - 5:30PM. • Render flat roof surface a light color and choose a roofing material that has a surface Solar Reflectance (SR) of > 0.7; and Thermal Emittance (TE) of > 0.75. • Use natural ventilation, orient windows towards prevalent wind direction, i.e NW.
April, May, June	-	-	10:30AM - 5:30PM	• Cooling required. Use radiant cooling during April, May and June. • Minimize or eliminate west facing glazing to reduce late afternoon gains. Use high performance glazing and insulated frames. • Intercept sunlight before it reaches the walls and glazing of a building to reduce the amount of heat entering that building. • External shading devices can reduce solar heat gain through glazing by up to 80%. • Horizontal overhangs or louvers for south and vertical fins and egg-crate designs for other orientations. • Enclosed well shaded courtyards / atriums.
July, Aug	-	-	10:30AM - 5:30PM	• Shade 10:30AM to 5:30PM. • Exterior horizontal louvers can be used to shade south glazing and the entire facade. • Plant trees on the west to minimize gains. • High humidity, so increase wind flow inside the building. Prevalent wind direction during these months is East, North East.
Sept, Oct	-	-	10:30AM - 5:30PM	• Shade 10:30AM to 5:30PM. • Cooling via DOAS and Radiant Slabs. • Natural ventilation by N-W winds.
Nov	-	10:30AM - 11:30AM ; 3:30PM - 5:30PM	11:30AM - 3:30PM	• Shade 11:30 to 4:30. • No special strategies required.



ovide niches which flood
and create channels for
eas are added on the East



The central admin block is terraced with plantation which contributes to a microclimate. A polycarbonate roof is added over the central block for enhancing

Concept

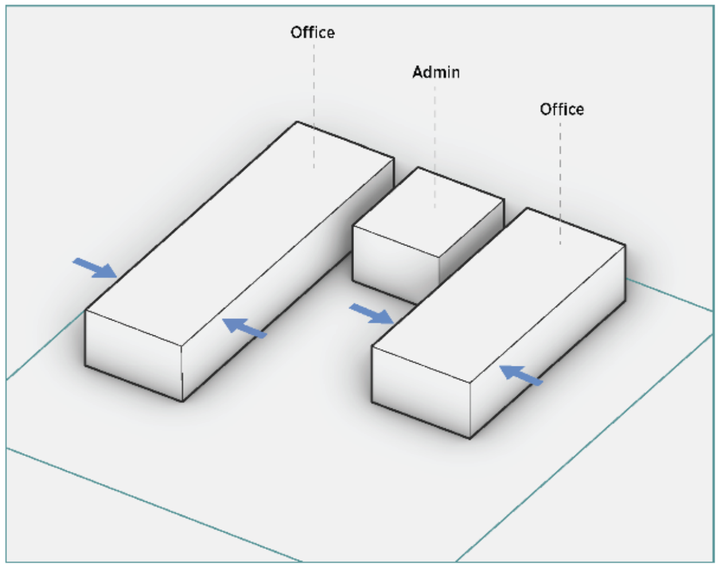
Changing the imageability of government buildings from opaque, rigid and unsustainable to **transparent** , **flexible and sustainable** through circulation routes, public accessible indoor spaces and office layouts.

determine temperature setpoints of water cooling chillers.

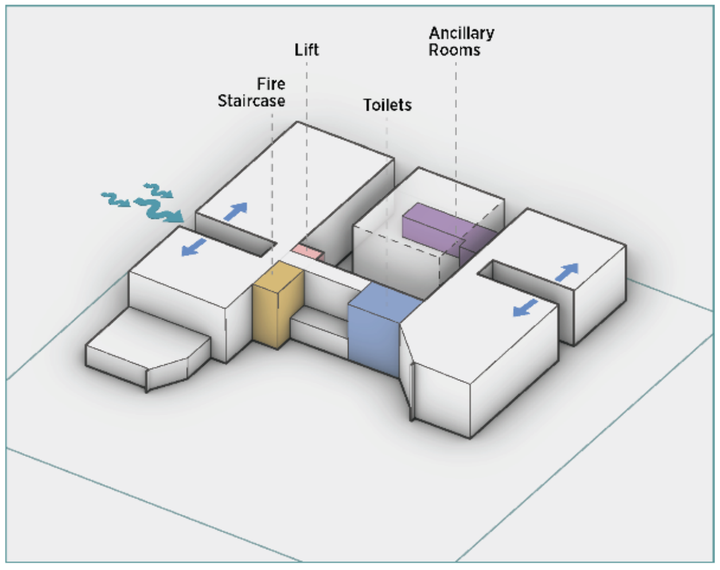
Windows are shaded from 10:30AM - 5:30PM from March to October.

North West. Summer winds are also from North West.

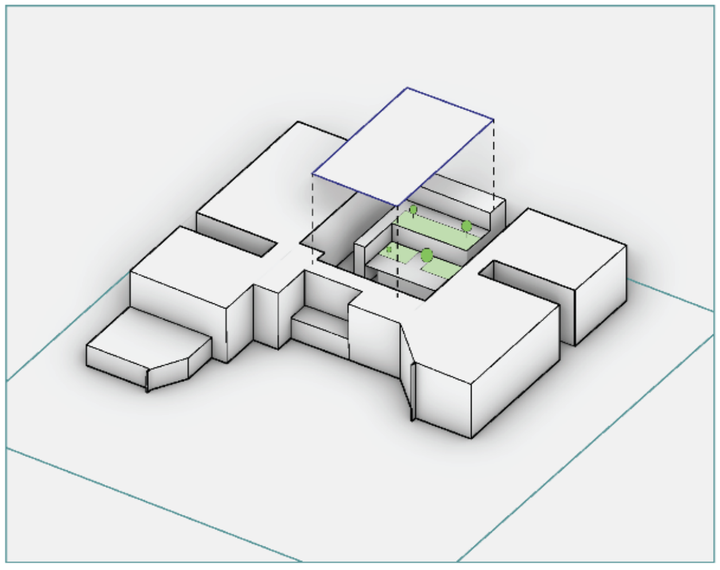
Form Development



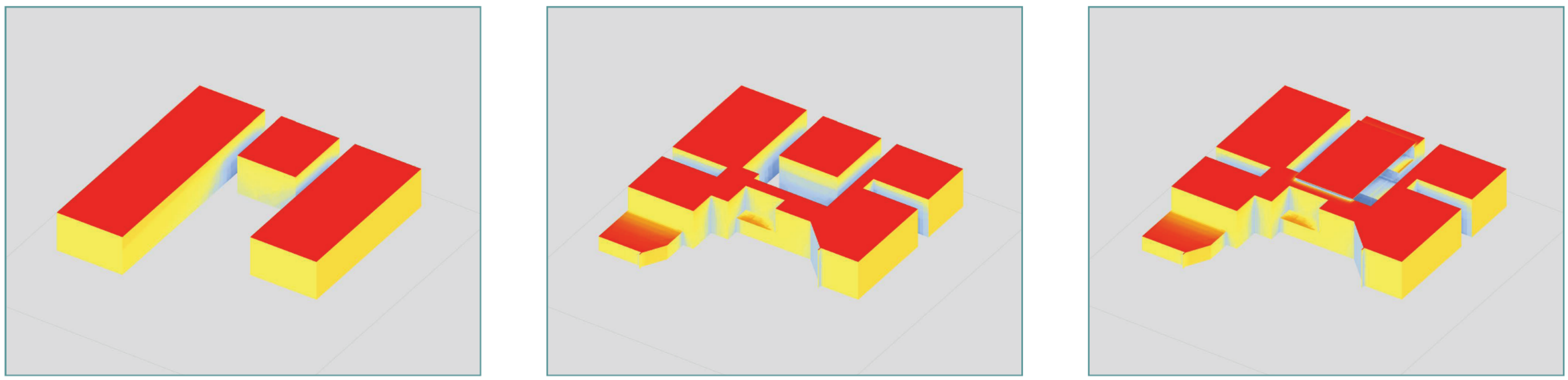
The required building volume is split into two thin and long office blocks and one central admin block, all oriented at 12 degrees to the North to optimize daylighting.



The volume is broken to provide niches which flood daylight into the interiors and create channels for wind. 100% of the service areas are added on the East and West.



The central admin block is terraced with plantation which contributes to a microclimate. A polycarbonate roof is added over the central block for enhancing daylighting. Xeriscaping is done in the niches.



Annual Incident Radiation Analysis: 1 January - 31 December

Massing of the building is done in a manner to reduce heat gain and achieve mutual shading.

Climate Analysis

Location: Ghaziabad, UP, India

Climate Type: Local Steppe Climate

Annual Precipitation: 764mm

Air Quality Index: Very Dangerous to Hazardous

Solar Generation Potential: **High** as incident radiation is 4.997 kWh/sqm/day.

Wind Generation Potential: **Low** due to low wind speeds.

IMAC: Monthly Comfort Range

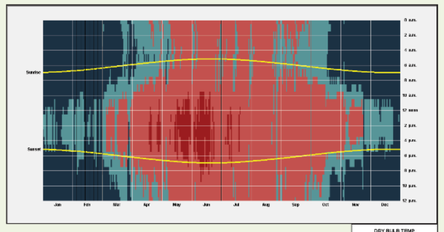
Months	Acceptability Range	Mix Mode Buildings (Temperature Range in deg C)
January	90%	25.27 - 18.35
February		25.67 - 18.35
March		26.92 - 20.00
April		28.73 - 21.81
May		30.24 - 23.32
June		30.54 - 23.62
July		30.13 - 23.21
August		29.87 - 22.95
September		29.75 - 22.83
October		29.26 - 22.34
November		28.06 - 21.14
December		20.30 - 19.52

The acceptability range of IMAC model was used to determine temperature setpoints of water cooling chillers.

Mixed mode of ventilation was chosen in order to **control air quality** of the interiors when the outdoor air quality is poor.

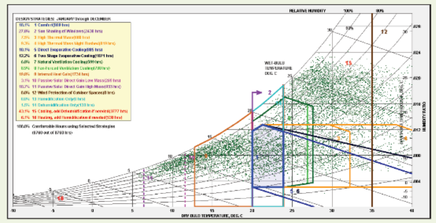
Design using 90% acceptability range takes care of the subjective component of thermal comfort.

Dry Bulb Temperature Plot



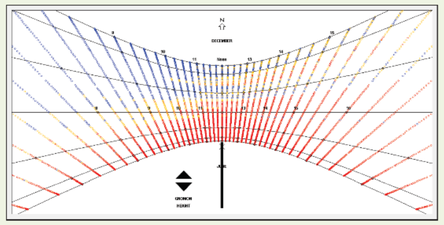
DBT time table plot shows a large part of the occupancy hours are uncomfortable *(according to IMAC)*. February and November have the most comfortable hours.

Psychometric Chart with strategies



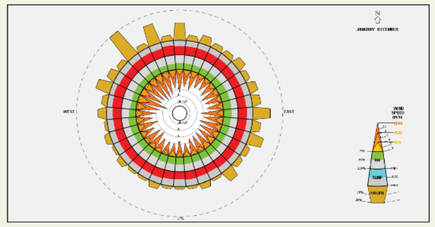
27.8% of the hours can be made comfortable by **sun shading** while **cooling** is required for 47.1% hours.
Monthly design strategies were derived from the psychometric chart.

Sun Shading Hours



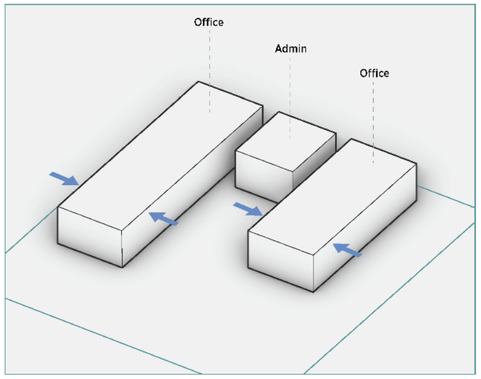
For all months except for December and January, sun shading is required. Windows are shaded from 10:30AM - 5:30PM from March to October.

Wind Rose Diagram

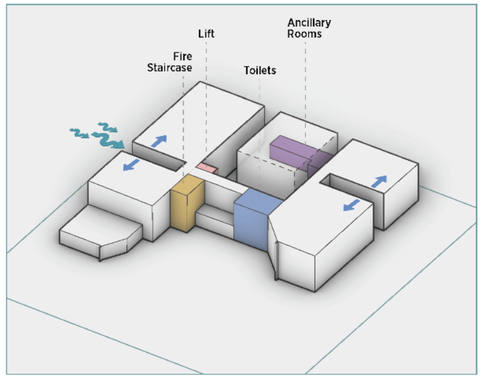


Prevalent wind direction from January to December for 10AM - 6PM is **North West.** Summer winds are also from North West.

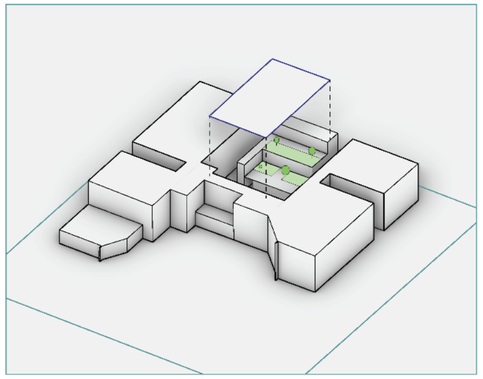
Form Development



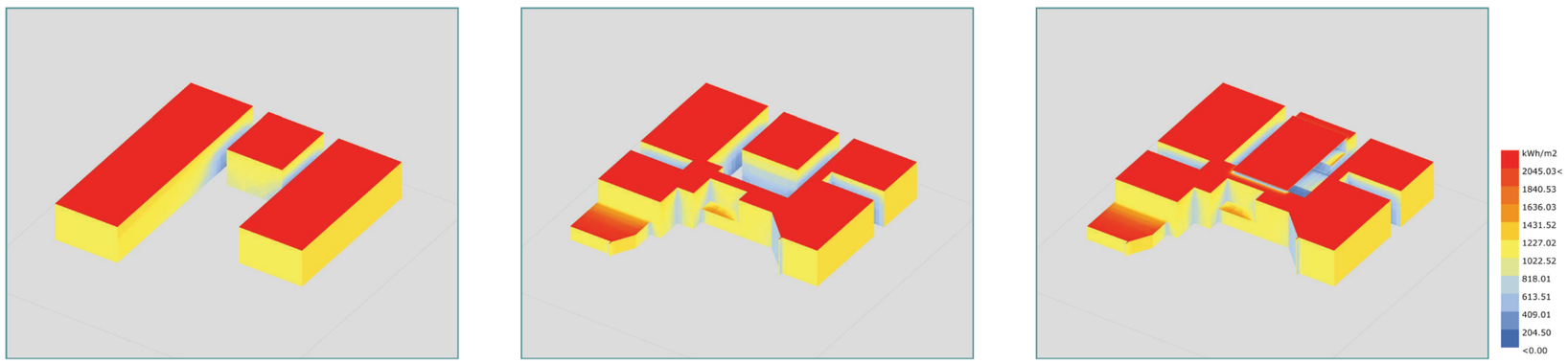
The required building volume is split into two thin and long office blocks and one central admin block, all oriented at 12 degrees to the North to optimize daylighting.



The volume is broken to provide niches which flood daylight into the interiors and create channels for wind. 100% of the service areas are added on the East and West.



The central admin block is terraced with plantation which contributes to a microclimate. A polycarbonate roof is added over the central block for enhancing daylighting. Xeriscaping is done in the niches.



Annual Incident Radiation Analysis: 1 January - 31 December

Massing of the building is done in a manner to reduce heat gain and achieve mutual shading.

ANNUAL CLIMATIC STRATEGIES

Months	Cold	Comfortable	Hot	Strategies
December, January	10:30AM - 12PM ; 4PM -5:30PM	12PM - 4PM	-	• Plant trees at not less than 45 deg from solar shaded windows. • 10 percent solar windows within 15 deg of true south. • Organize the floor plan so that the sun penetrates into daytime spaces. • No sun shading required.
February	10:30AM - 12PM ; 5PM - 5:30PM	12PM - 5PM	-	• Natural ventilation through openable windows. • Sun shading required 12PM - 1PM.
March	-	10:30AM - 11AM	12PM - 5:30PM	• Shading during 10:30AM - 5:30PM. • Render flat roof surface a light color and choose a roofing material that has a surface Solar Reflectance (SR) of > 0.7; and Thermal Emittance (TE) of > 0.75. • Use natural ventilation, orient windows towards prevalent wind direction, i.e NW.
April, May, June	-	-	10:30AM - 5:30PM	• Cooling required. Use radiant cooling during April, May and June. • Minimize or eliminate west facing glazing to reduce late afternoon gains. Use high performance glazing and insulated frames. • Intercept sunlight before it reaches the walls and glazing of a building to reduce the amount of heat entering that building. • External shading devices can reduce solar heat gain through glazing by up to 80%. • Horizontal overhangs or louvers for south and vertical fins and egg-crate designs for other orientations. • Enclosed well shaded courtyards / atriums.
July, Aug	-	-	10:30AM - 5:30PM	• Shade 10:30AM to 5:30PM. • Exterior horizontal louvers can be used to shade south glazing and the entire facade. • Plant trees on the west to minimize gains. • High humidity, so increase wind flow inside the building. Prevalent wind direction during these months is East, North East.
Sept, Oct	-	-	10:30AM - 5:30PM	• Shade 10:30AM to 5:30PM. • Cooling via DOAS and Radiant Slabs. • Natural ventilation by N-W winds.
Nov	-	10:30AM - 11:30AM ; 3:30PM - 5:30PM	11:30AM - 3:30PM	• Shade 11:30 to 4:30. • No special strategies required.

Concept

Changing the imageability of government buildings from opaque, rigid and unsustainable to **transparent , flexible and sustainable** through circulation routes, public accessible indoor spaces and office layouts.

Open office areas with work desks which increase **visibilty**, offer flexible use deviating from cell like layout.

Central atrium with circulation passages which increases **transparency** of the entire building.

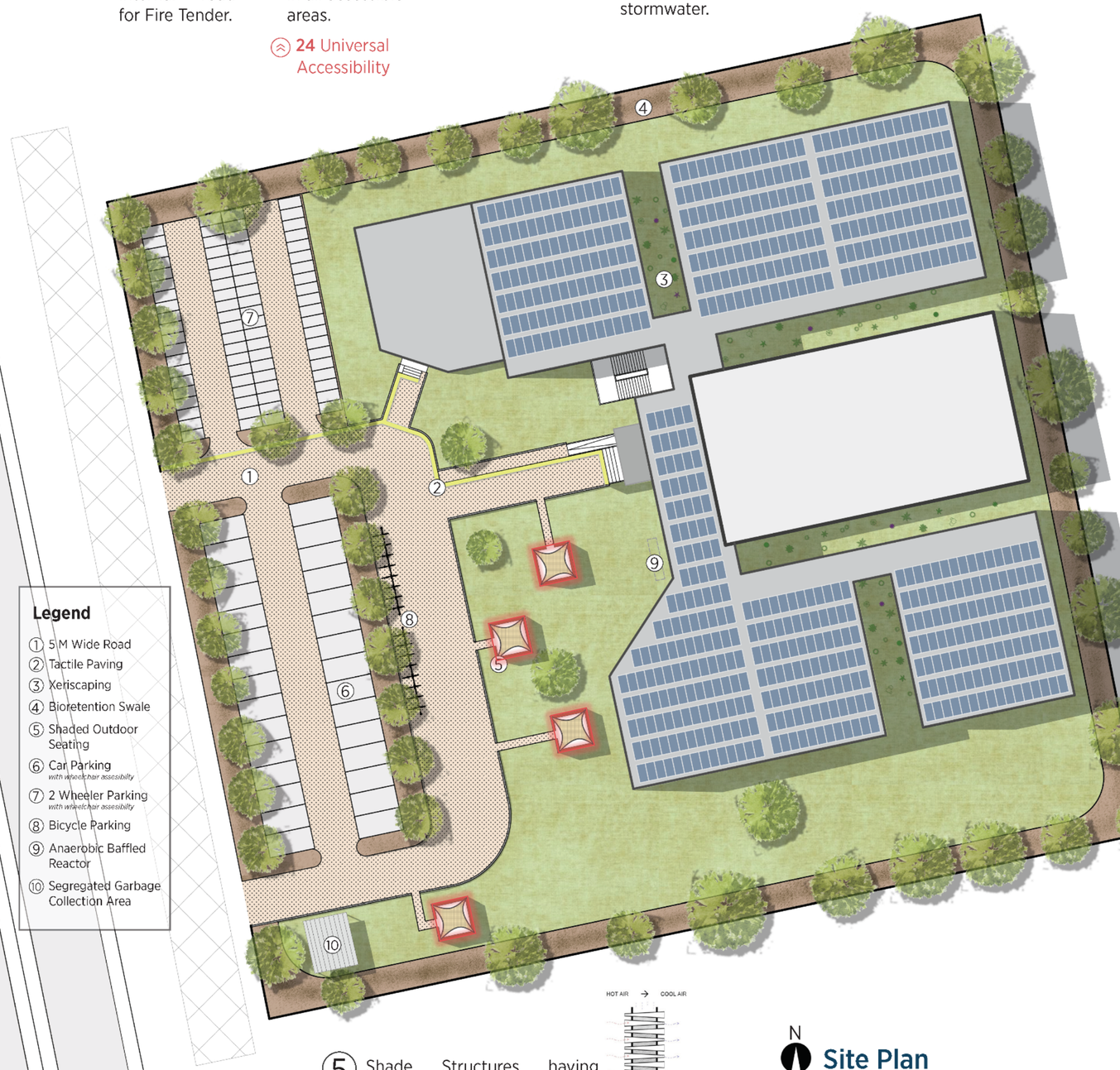
5 Metre wide internal road for Fire Tender.

Tactile Paving in all accessible areas.

24 Universal Accessibility

Xeriscaping

Swales on the perimeter for stormwater.



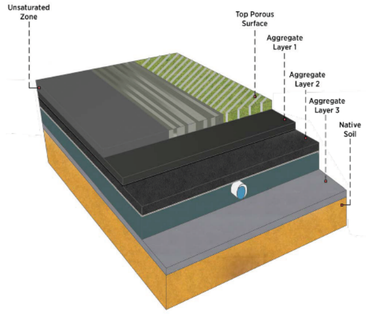
5 Shade Structures having evaporative cooling walls.

3 Design to Mitigate UHIE

N

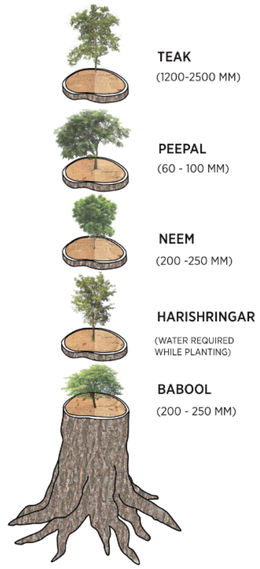
Site Plan

0 5 10 20 30 40



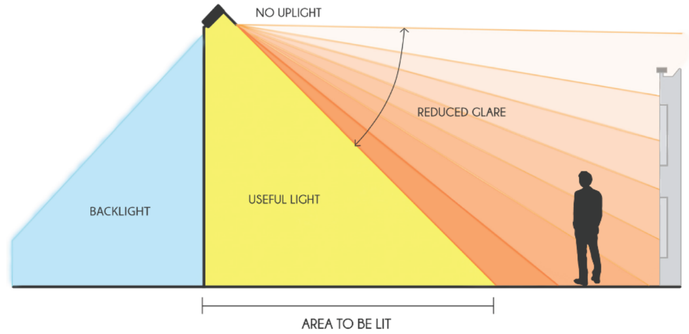
Permeable pavement surface made of 100 % post-consumer recycled high density polyethylene with a stone reservoir underneath. The reservoir temporarily stores surface runoff before infiltrating it into the subsoil. This material with gravel filling has been used for constructing the fire tender path, walkways and car parking.

21 Alternative Materials for External Site Development



The two existing trees on the site were preserved and 51 additional native trees are proposed.

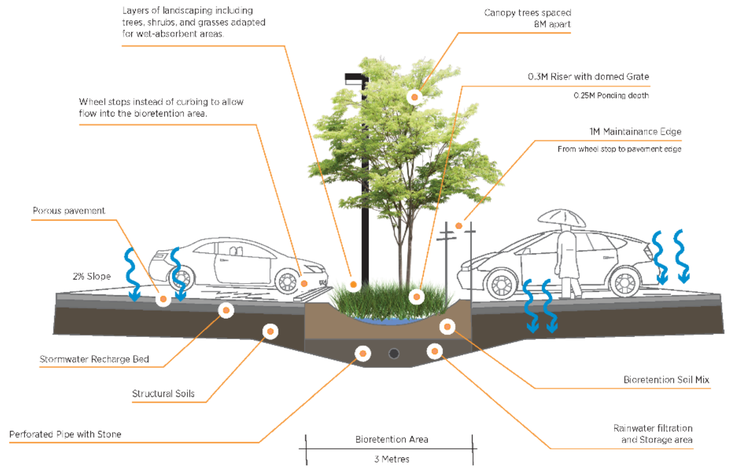
1 Green Infrastructure



Outdoor luminaries with glare control

Downward facing **partial cutoff** fixtures minimize light trespass, reduce glare and costs. *(Luminuous Efficacy = 80 lm/W)*

3 Design to Mitigate UHIE



Green Parking Lots with Bioretention Swales

Green Parking Lots: Incorporates elements for maximizing shading and greening, incorporating naturalized drainage, utilizing paving that infiltrates, using energy efficient lighting, adding safe pedestrian circulation.

Interconnected landscaped bioretention areas capture, slow, clean, and infiltrate stormwater runoff closer to the source, reducing the cost of traditional curbing, gutters, and piping by as much as 15%-50%

Removes a large percentage of total suspended solids; 50-60% of nitrogen and phosphorus and 75% of heavy metals.

3 Design to Mitigate UHIE

NASA

Ground Floor Plan

Legend

① Waiting Area
② Toilets
③ Living Machine
④ Cafeteria
⑤ Auditorium
⑥ Open Office
⑦ Assistant Commisioner's Cabin
⑧ Deputy Commisioner's Cabin
⑨ Meeting Room
⑩ Attorney's Office
⑪ Storage Room
⑫ Chiller Room
⑬ Server Room
⑭ Record Room

First Floor Plan

Legend

① Toilets
② Open Office
③ Assistant Commisioner's Cabin
④ Deputy Commisioner's Cabin
⑤ Meeting Room
⑥ Green Terrace
⑦ Office of the Additional Commisioner of Tax

Second Floor Plan

Legend

① Toilets
② Open Office
③ Assistant Commisioner's Cabin
④ Deputy Commisioner's Cabin
⑤ Meeting Room
⑥ Green Terrace
⑦ Adjunct Additional Commisioner's Cabin

Living Machines

For on-site black water treatment, root based wastewater treatment technology is used, as a cost effective, natural and sustainable treatment system for wastewater. The root based treatment is a combination of the physical, chemical and biological processes and works without electricity, minimum maintenance, less manpower and is self sustainable.

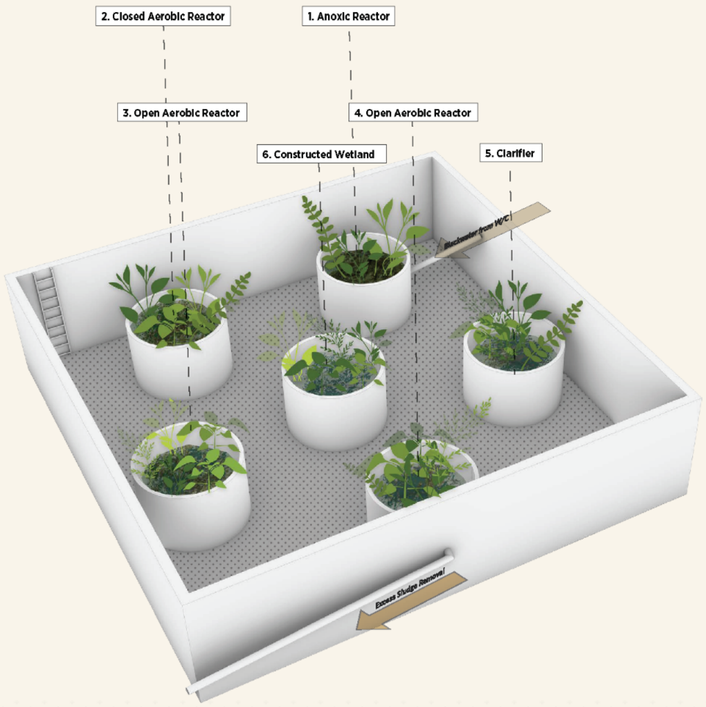
- The system uses natural vegetation and the plant specific associated microbiota, as leads to eco friendly sewage treatment technology.
- The subsurface flow treatment is totally free of mosquitoes and unpleasant odour.
- The treated water is used for irrigation, gardening and toilet flushing.
- The treated water also achieves the permissible limit for sewage discharge in the fresh and marine water bodies.

14 Wastewater Treatment

The living machine is proposed near the entrance lobby and is exposed to increase **public awareness of green building systems** and sustainability.

The plants get diffused light through the polycarbonate roof and since the system is odourless, it can be kept open.

26 Positive Social Impact



Solid Waste Management

Multicoloured waste bins to store e-waste, organic waste, plastic waste, paper waste, and other inorganic solid waste have been provided for building occupants to ensure segregation of waste at the source.

Dedicated, segregated, and hygienic storage space has been provided near the **site exit** for storage before pickup by municipal garbage trucks for treatment/recycling.

17 Waste Management-Post Occupancy

100% organic waste generated is used as manure for landscaping, therefore diverting organic waste from landfill sites.

Composting bins have been provided in the canteen.

18 Organic Waste Treatment On-Site

NASA

Ground Floor Plan

Legend

① Waiting Area
② Toilets
③ Living Machine
④ Cafeteria
⑤ Auditorium
⑥ Open Office
⑦ Assistant Commisioner's Cabin
⑧ Deputy Commisioner's Cabin
⑨ Meeting Room
⑩ Attorney's Office
⑪ Storage Room
⑫ Chiller Room
⑬ Server Room
⑭ Record Room

First Floor Plan

Legend

① Toilets
② Open Office
③ Assistant Commisioner's Cabin
④ Deputy Commisioner's Cabin
⑤ Meeting Room
⑥ Green Terrace
⑦ Office of the Additional Commisioner of Tax

Second Floor Plan

Legend

① Toilets
② Open Office
③ Assistant Commisioner's Cabin
④ Deputy Commisioner's Cabin
⑤ Meeting Room
⑥ Green Terrace
⑦ Adjunct Additional Commisioner's Cabin

Living Machines

For on-site black water treatment, root based wastewater treatment technology is used, as a cost effective, natural and sustainable treatment system for wastewater. The root based treatment is a combination of the physical, chemical and biological processes and works without electricity, minimum maintenance, less manpower and is self sustainable.

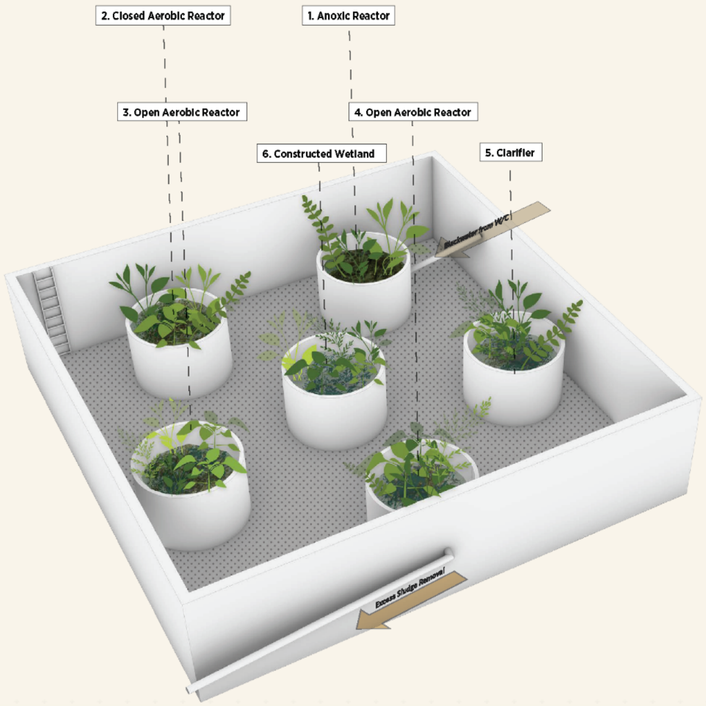
- The system uses natural vegetation and the plant specific associated microbiota, as leads to eco friendly sewage treatment technology.
- The subsurface flow treatment is totally free of mosquitoes and unpleasant odour.
- The treated water is used for irrigation, gardening and toilet flushing.
- The treated water also achieves the permissible limit for sewage discharge in the fresh and marine water bodies.

14 Wastewater Treatment

The living machine is proposed near the entrance lobby and is exposed to increase **public awareness of green building systems** and sustainability.

The plants get diffused light through the polycarbonate roof and since the system is odourless, it can be kept open.

26 Positive Social Impact



Solid Waste Management

Multicoloured waste bins to store e-waste, organic waste, plastic waste, paper waste, and other inorganic solid waste have been provided for building occupants to ensure segregation of waste at the source.

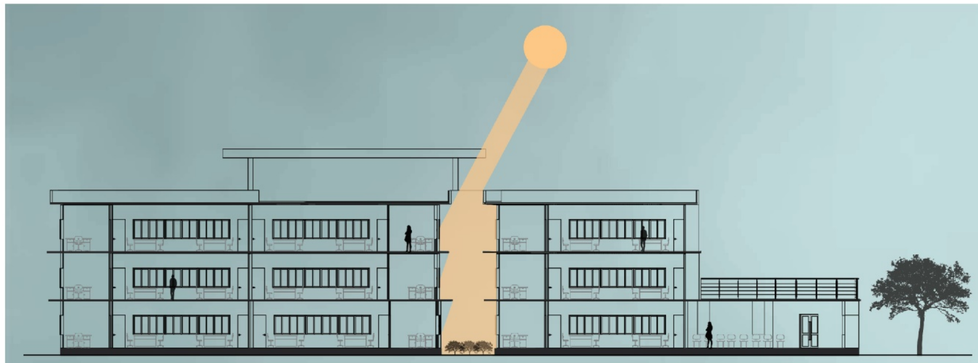
Dedicated, segregated, and hygienic storage space has been provided near the **site exit** for storage before pickup by municipal garbage trucks for treatment/recycling.

17 Waste Management-Post Occupancy

100% organic waste generated is used as manure for landscaping, therefore diverting organic waste from landfill sites.

Composting bins have been provided in the canteen.

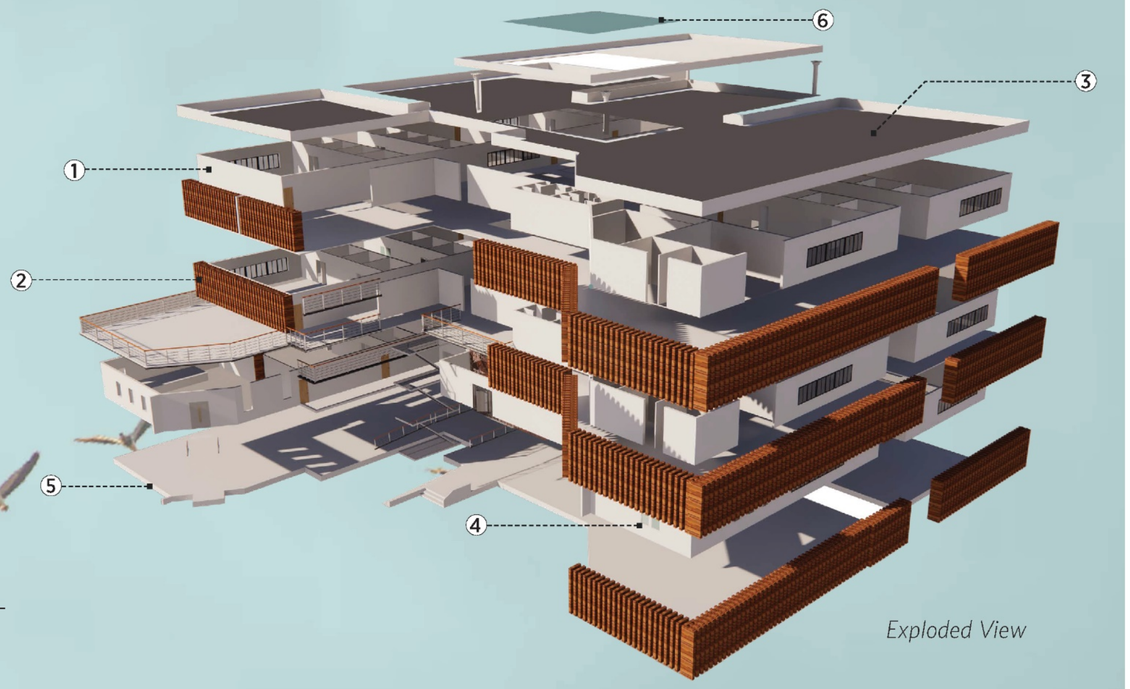
18 Organic Waste Treatment On-Site



Longitudinal Section

Material Pallete:

1. *C&D Blocks*
2. *FRP with rice husk and mineral oil*
3. *Clay Pots*
4. *Lime Plaster*
5. *RCC with 30% PFA*
6. *Polycarbonate*



Exploded View

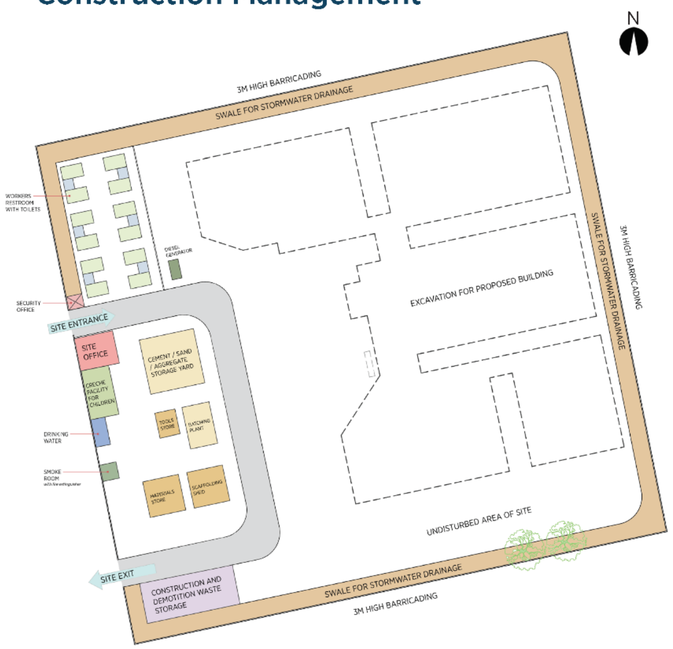
Elevation facing West

Elevation facing South

Front Facade View

NASA

Construction Management



Construction Site Plan *showing areas for material and construction waste storage, restrooms with toilets, smoke room, drinking water facility etc.*

23 Safety and Sanitation for Construction Workers

3 m high continuous barricading along the site boundary.

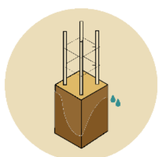
12 Air and Soil Pollution Control

25% site is undisturbed during and post construction.

2 Low Impact Design

Topsoil shall be stripped to a depth of 200 mm from areas proposed for the building, roads, and paved areas. It shall be stockpiled to a height of 400 mm in designated areas and shall be re-applied to site during plantation of the proposed vegetation on the site and in green roofs.

5 Top Soil Preservation



Gunny bags shall be used for curing along with biobased curing agents which reduce water usage during construction. Constructed areas shall be covered with jute or tarpaulin to reduce evaporation rates.

6 Construction Management Practices

Foam based dust supressents shall be used instead of water spray to reduce water consumption during construction.

13 Water Demand Reduction

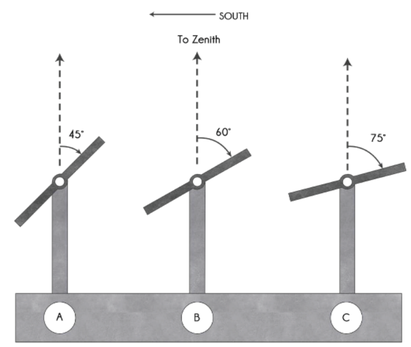
Solar Power Generation

Average daily solar irradiance: 4.997 kWh/sqm/day which promises a positive solar potential.

Solar PV panels 2m x 1m in size have been used to meet the energy demand of the building. Each panel generates **422 Kwh** per year.

Panels have an anti-reflective coating that reduces the glare and improves the light transmittance, thus increasing the efficiency of the PV module.

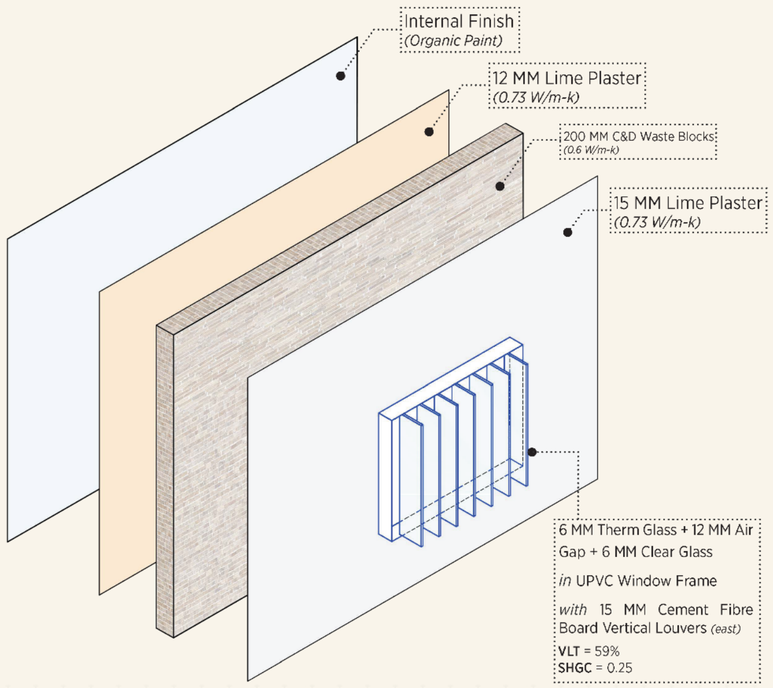
PV panels are installed directly facing south, with operation angles of 45 deg in winter, 75 deg in summer, and 65 deg for the remaining part of the year for optimum irradiance.



Operation angles of PV panels

8 Renewable Energy Utilization

External Wall Assembly **U-Value** = 0.4 kWh/m2-K



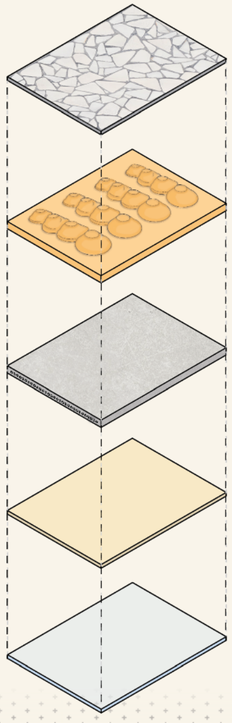
- The lower resistance and conductivity values of C&D blocks are justified by the presence of aggregate with a lower density and lower thermal conductivity than the natural aggregate.
- Fly Ash Mortar is used to reduce cement consumption.
- Recycled aggregates are used in RCC elements.

19 Utilization of Alternative Materials in Building

Organic paint containing soya bean, whey protein, neem oil and casein are used for interior wall and ceiling finishes, as it has low VOC content and is lead free.

12 Maintaining Good IAQ

Roof Assembly **U-Value** = 0.263 kWh/m2-K



16 MM Reflective China Mosaic Tile Finish

80 MM Overdeck Earthen Pot Insulation

19 Utilization of Alternative Materials in Building

150 MM RCC Slab with 30% PFA and Water Cooled PEX Pipes

12 MM Cement Plaster

Internal Finish

Low ODP and GWP Materials

Rice Husk Insulation is used for internal walls which is CFC and HCFC free.

The insulation is in the form of board made from rice husk or rice husk ash , bonded by resin under the application of pressure and temperature.
U Value = 0.0418 – 0.0746 W/(m.K)

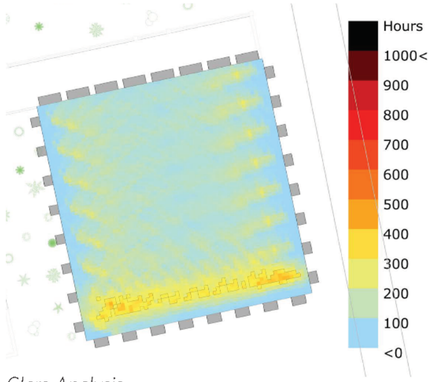
Refrigerants used in recirculating chillers of radiant slabs are free from CFC and HCFC. Use of refrigerants is **restricted to only 1 room** i.e chiller room on ground floor.

Fire extinguishers installed in the project contain condensed aerosol forming solid compound **FPC**, which is non-pyrotechnic and is based on eco-friendly naturally occurring potassium salts and halon free.

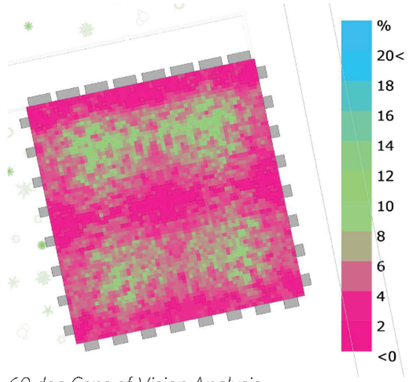
9 Low ODP AND GWP Materials

NASA

Annual Study : Open Office Space on Ground Floor



Glare Analysis



60 deg Cone of Vision Analysis

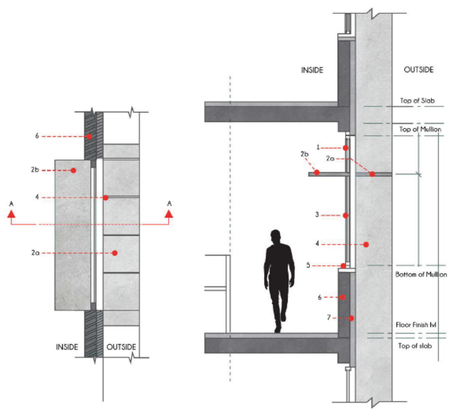
Maximizing Views while Minimizing Glare

View plays an important role in an occupant's appraisal of the interior environment and to establish contact with the exterior environment. The WWR were decided in a way that views are maximized and visual discomfort due to glare is minimized.

Facade	WWR
North	32%
South	20%
East	15%
West	13%

Percentage of area with good view and minimal sun: **84%**
Percentage of area with >3% view: **81%**

10 Visual Comfort



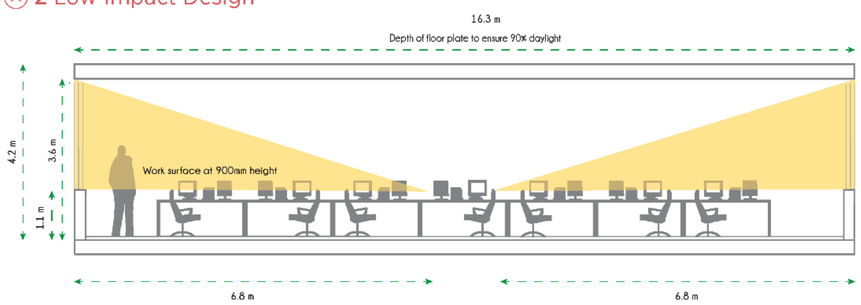
Light Shelves on southern facades and fins on east and west facades help minimize glare.

The sill level is kept at 1.1m given the requirements of the work desks. It also reduces area to be glazed and helps achive a lower WWR.

7 Energy Optimization

1. Daylight Window with U= 1.04 W/m2
2a. Highly Reflective Deep Solar Shade
2b. Reflective Internal Light Shelf
3. Vision Window with U= 1.04 W/m2
4. Vertical Fins
5. Sill
6. C&D Blocks Wall
7. External Finish

2 Low Impact Design



The depth of floor has been restricted to 16.3M which ensures 90% of the space is lit by useful daylight (200-1000 lux) for most of the daylit time of the day.

7 Energy Optimization

Thermal Comfort

Sensible Loads: Radiant Cooled Slabs

The radiant cooling system inherently provides a healthier indoor air quality as there is no recirculation of air in the system. Reduced chiller capacity as compared to conventional forced air conditioning. About **35%** reduction in annual energy consumption.

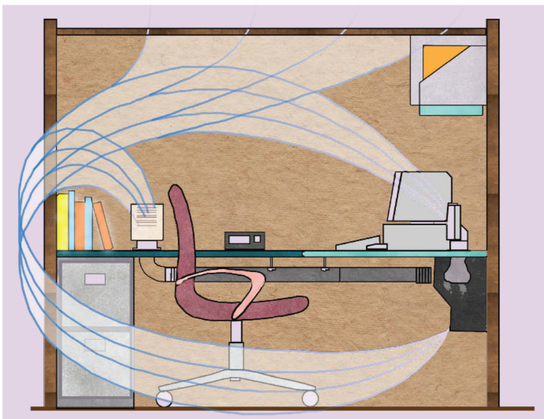
Radiant cooling is coupled with **BLDC Fans** (Reversible Direction) which can increase heat removal capacity of ceiling by upto 2 times.

BLDC Fans

Latent Loads: DOAS

Reduces indoor pollution because contaminants are not transferred readily between rooms, as is the case with centralized HVAC. Avoids condensation in highly humid conditions, while using radiant cooling.

12 Maintaining Good IAQ



Personal Comfort System

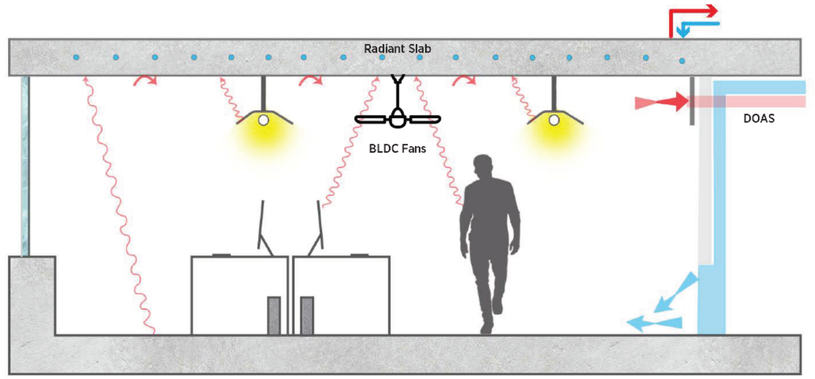
Fans and low-wattage devices are embedded into desks to warm or cool an empolyee on demand. The system focuses on the most thermally sensitive parts of the body, such as the head and feet.

This flexibility on the part of the occupants can translate into **less energy spent** maintaining a fixed temperature set-point.

It also cools down the equipments which increases their efficiency.

11 Thermal and Accoustic Comfort

7 Energy Optimization



Radiant Cooling in Slabs and underfloor DOAS

This has a huge impact on design of the building, because this air-and-water system removes the need for large plenum space required by all-air systems, saving considerable height on each floor.

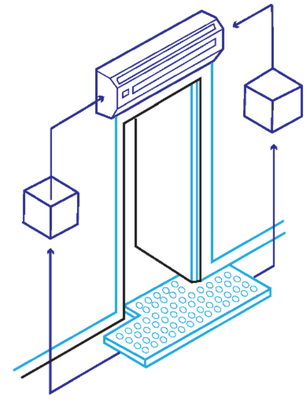
2 Low Impact Design

Indoor Air Quality

Air Curtains: Air curtains are installed at doorways to ensure limited air mixturing when the doors are opened.

Particle kickback from the ground is avoided by adding a **suction duct** at the bottom.

Reduces Cooling Loads | *Keeps Insects and Pollutants Out* | *Increases Quality Control*



Air Curtains

IAQ monitoring systems: One sensor is installed for each space ≥30 m2.

1 digital display showing monitored values for CO, CO2 , temperature, and RH is installed at each floor level.

Screensavers of computers show **real time energy consumption** of the building along with **air quality parameters**. This gives the users control over their own environment and a sense of responsibilty towards energy saving.

Computer Screensaver

12 Maintaining Good IAQ

30 Innovation

NASA

Water Supply and Consumption

A variety of strategies have been employed which leads to a Net-Positive Water design.

- Potable water demand is reduced by **30%** from baseline 45 lpd, by the use of low flow fixtures.
- Landscape water demand is reduced by **50%** by the use of Drip irrigation, Native species plantation with a plant factor of 0.15 and Xeriscaping.
- Water use in radiant cooling system has optimized according to monthly requirement.
- **100%** blackwater is recycled by Living Machines (root based water treatment).

14 Wastewater Treatment

13 Water Demand Reduction

		CONSUMPTION						WATER SOURCES				
Month	Days in month	Domestic Use (L)	Cooling Use %	Cooling Use (L)	Irrigation Use %	Irrigation Use (L)	Total Consumption	Municipal Water (L)	Rainwater	Greywater (L)	Blackwater (L)	Total Stored
Jul	31	627,750	0%	-	5%	1,279	629,029		1062551	288,765	338,985	722287
Aug	31	627,750	50%	12,788	5%	1,279	641,816		957792	288,765	338,985	1327028
Sep	30	607,500	50%	12,375	50%	12,375	632,250		598620	279,450	328,050	1572848
Oct	31	627,750	50%	12,788	30%	7,673	648,210		44897	288,765	338,985	1258299
Nov	30	607,500	0%	-	90%	22,275	629,775		0	279,450	328,050	907974
Dec	31	627,750	0%	-	90%	23,018	650,768		14966	288,765	338,985	560937
Jan	31	627,750	0%	-	90%	23,018	650,768		94782	288,765	338,985	293716
Feb	28	572,063	0%	-	90%	20,976	593,038	20,000	164621	263,149	308,914	148447
Mar	31	627,750	30%	7,673	90%	23,018	658,440	20,000	84805	288,765	338,985	-116423
Apr	30	607,500	90%	22,275	90%	22,275	652,050	20,000	59862	279,450	328,050	-409161
May	31	627,750	100%	25,575	90%	23,018	676,343	20,000	74828	288,765	338,985	-701911
Jun	30	607,500	90%	22,275	90%	22,275	652,050	10,000	354184	279,450	328,050	-710328
Total							3,882,688	90,000	833,080	1,688,344		1,317,560

15 Rainwater Management

End Use	Percent use	Use in LPD	Greywater in LPD	Blackwater in LPD
Washing	30%	6075	6,075	
Cleaning	15%	3038	3,038	
Others	2%	405	203	203
Drinking	20%	4050		4,050
Cooking	3%	608		608
Toilet Flushing	30%	6075		6,075
Total		**20250**	**9,315**	**10,935**

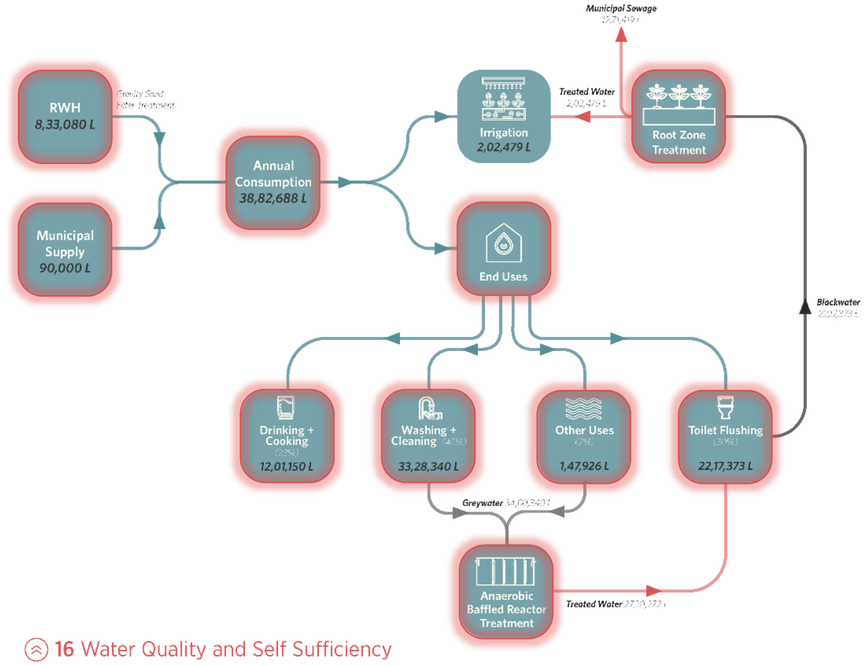
Domestic Use	
Use LPD/Head	45
Number of people	450
Total LPD	20250

Cooling Use	
L/Tr	5.5
Tr per Day (peak)	150
Max LPD	825

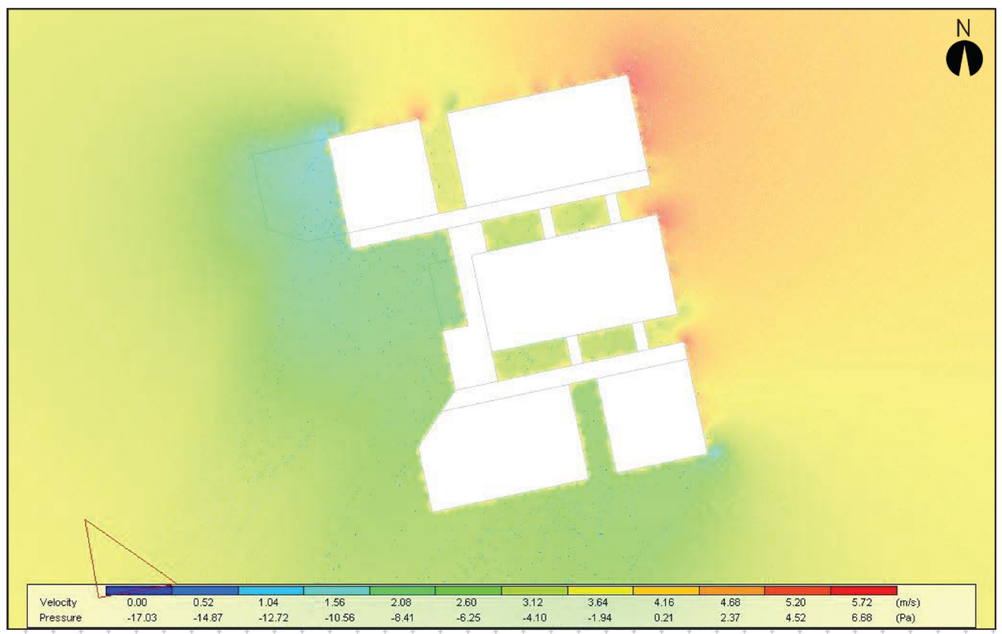
Irrigation Use	
L/m²	1
Area m²	1300
Max LPD	1300

Water Cycle

- An effective water cycle restricts municipal water demand to 5 months of the year.
- Anaerobic baffled reactor treatment recycles greywater which is used for toilet flushing.
- Blackwater from toilets is treated by root zone treatment to BOD 10 level and part of it is used for irrigation. 16 Water Quality and Self Sufficiency
- Sustainable filters (gravity based sand filters) are used in RWH system.



16 Water Quality and Self Sufficiency

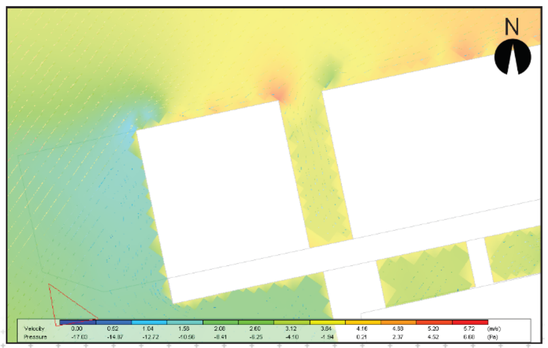


CFD Analysis

CFD Analysis for wind direction of 35 deg North (Prevalent direction in July and August) shows how wind would be useful for removing humidity from the building's central atrium.

The analysis demonstrates how the niches between the office blocks induce air current into the building's central volume.

2 Low Impact Design



Shadow Analysis

Analysis was done for the period of 9 AM to 6 PM on Summer and Winter Solstice and Autumn and Spring Equinox and a composite range of shadows was obtained.

Based on this study, shaded seating structures were proposed on the West side.

The massing of the building was done in a way that the structure **self shades**.

The niches are shaded for most parts of the year.

NASA

Life Cycle Cost Analysis

Building Materials

Walls made of C&D Blocks

Material cost				
Floor	Wall area (Sq m)	Quantity (No.)	Cost per block (Rs.)	Total cost (Rs.)
Ground floor	5600	140,000	35	4900000
First floor	5600	140,000	35	4900000
Second floor	5600	140,000	35	4900000
Total				**14700000**

Transportation cost			
Rate of transport	Truck capacity	Quantity (No.)	Total cost (Rs.)
Rs. 330 per truck	3000 bricks	4200000	**46530**

Labour cost		
Wall volume (cu m)	Labour Rate per cu m	Total Labour Cost (Rs.)
3360	510	**1713600**

Slabs made of RCC with 30% PFA

Cost of Materials + Labour				
Slab	Slab area (sq m)	Slab area sq ft	Cost per sq ft	Total cost (Rs.)
Ground floor slab	2508	27000	108	2916000
First floor slab	2110	22711	108	2452788
Second floor slab	1936	20838	108	2250504
roof slab	1904	20494	108	2213352
Total				**9832644**

RCC Frame Structure

Cost of Materials + Labour+ Shuttering				
No. of Columns	Cost per Column (Rs.)	No. of Beams	Cost per Beam (Rs.)	Total Cost (Rs.)
125	18500	182	7500	**3677500**

Polycarbonate Roof

Area (sq m)	Cost per sq m	Total Cost (Rs.)
545	1200	**654000**

Wall Plastering

Material Cost- Cement				
Floor	Wall area (Sq m)	Quantity (kg)	Cost per Bag (Rs.)	Total cost (Rs.)
Ground floor	5600	42900 kg or 858 bags	300	257400
First floor	5600	42900 kg or 858 bags	300	257400
Second floor	5600	42900 kg or 858 bags	300	257400
Total				**772200**

Transportation cost			
Rate of transport	Truck capacity	Quantity (tonne)	Total cost (Rs.)
Rs.40 for 2 km	9 tonne	128.7	**600**

Labour cost		
Wall area (sq m)	Labour Rate per sq m	Total Labour Cost (Rs.)
16800	Rs.13 /sq m	**218400**

Material Cost - Sand				
Floor	Wall area (Sq m)	Quantity (kg)	Cost per tonne (Rs.)	Total cost (Rs.)
Ground floor	5600	181860 kg or 181.8 ton	1200	218232
First floor	5600	181860 kg or 181.8 ton	1200	218232
Second floor	5600	181860 kg or 181.8 ton	1200	218232
Total				**654696**

Transportation cost				
Rate of transport	Truck capacity	Quantity (tonne)	Total cost in Rs.	
	Rs.45 for 2 km	8 cu m	616.3	**3466.5**

Wall finish

Paint	Area (Sq m)	Quantity (Litres)	Cost (Rs.)	Total Cost (Rs.)
	7350	600	Rs.990 /10 litres	**59400**
Putty	Area (Sq m)	Quantity (kg)	Cost (Rs.)	Total Cost (Rs.)
	7350	7800	Rs.900 /20 kg	**351000**

Water

Rainwater Harvesting							
Total effective catchment area (sq m)	Total litres	Cost of RWH tank (Rs.)	Maintenance Costs for 60 years (Rs.)	Total Capital Cost (Rs.)	Rate in Ghaziabad for municipal water supply	Savings (Rs.)	Payback period
4988.5 sq m	833 kl	1316140	15% of 1316140 = Rs.197421	1381947	Rs 50/kl	833 x 50 = Rs. 41650	**36 years**

Water demand reduction					
Low Flow Fixtures (Griha Certified)	Cost per Unit (Rs.)	Quantity (No.)	Total Cost (Rs.)	Labour Rate (Rs.)	Total Labour Cost (Rs.)
W/C-Somany 2PC EWC Floor mounted Uniex trap	8000	18	144000	Rs. 256 per piece	4608
Faucets- Parryware euclid bib ck	1200	26	31200	Rs. 202 per piece	5252
Urinals- Jaguar (URS-WHT-13261)	4000	9	36000	Rs. 268 per piece	2412
Total					**12272**

Annual Municipal Water Demand = 90kL
Cost = Rs. **4,500**

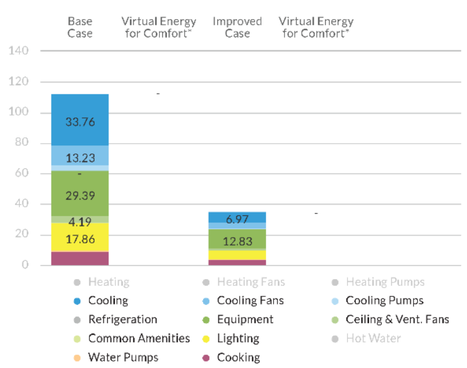
Energy

Radiant Cooling							
Total radiant cooled area (sq m)	Capital cost (Rs.)	Annual operative costs (Rs.)	Capital cost of VRF (Rs.)	Annual operative costs of VRF (Rs.)	Difference in capital costs (Rs.)	Difference in operative costs (Rs.)	Payback period
4328.25	13008750	323176	6492375	2856645	6516375	2533469	**2.57 years**

Solar Panels						
Energy Generated Per Year (kwh)	No of panels	Annual generation (kwh)	Rate in Ghaziabad for commerical HT	Savings (Rs.)	Capital cost (Rs.)	Payback period
422 kwh	656	656 x 422 = 276832 kwh	Rs 8.68 /kwh	276832 x 8.68 = Rs. 2402900	22000 x 656 = 14432000	**6 years**

Annual Unsatisfied Energy Demand = 2,38,308 kwh
Cost = Rs. **20,68,513**

Building Sustainable Performance Summary

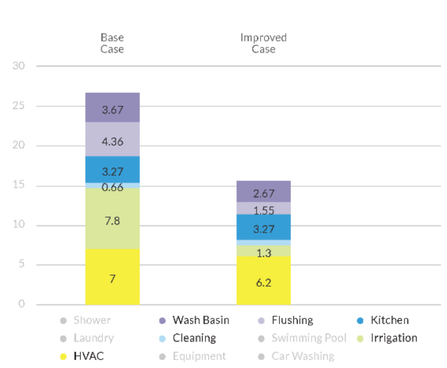


Energy (kwh/m²/year)

GRIHA EPI Benchmark:

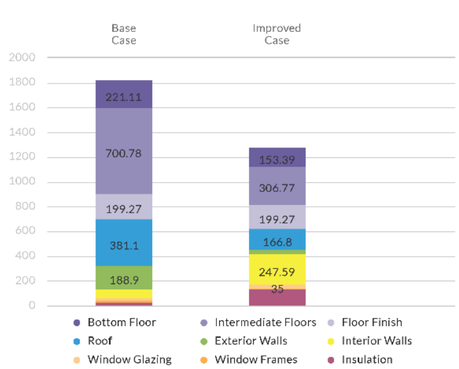
For 8 hours for 6 days a week occupancy,
90 x (6/5) = 108 kWh/m2/yr

Proposed EPI = 2,38,308 kWh / 6565m² = 36.29



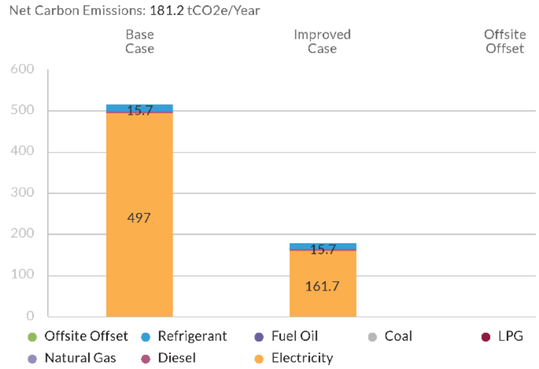
Water (m³/day)

The use of low flow fixtures for faucets, kitchen sinks, wash basins, toilet flush & spray and drip irrigation leads to a reduced water demand.



Embodied Energy (MJ/m²)

Usage of locally available materials and sustainable construction techniques such as C&D block masonry with fly ash mortar, RCC slabs with 30% pulverised fly ash, etc. offsets the embodied energy of the building to **1283 MJ/m²**



Carbon Emissions (tCO_2e/Year)

276,502 kWh (53%) of the annual energy demand is satisfied by rooftop solar PV panels. This clean energy brings down the carbon emmisions to **13.38 tCO_2e/month**.

7 Energy Optimization

NASA

Life Cycle Cost Analysis

Building Materials

Walls made of C&D Blocks	**Material cost**				
	Floor	Wall area (Sq m)	Quantity (No.)	Cost per block (Rs.)	Total cost (Rs.)
	Ground floor	5600	140,000	35	4900000
	First floor	5600	140,000	35	4900000
	Second floor	5600	140,000	35	4900000
	Total				**14700000**
	Transportation cost				
	Rate of transport	Truck capacity	Quantity (No.)	Total cost (Rs.)	
	Rs. 330 per truck	3000 bricks	4200000	**46530**	
	Labour cost				
	Wall volume (cu m)	Labour Rate per cu m	Total Labour Cost (Rs).		
	3360	510	**1713600**		

Slabs made of RCC with 30% PFA	**Cost of Materials + Labour**				
	Slab	Slab area (sq m)	Slab area sq ft	Cost per sq ft	Total cost (Rs.)
	Ground floor slab	2508	27000	108	2916000
	First floor slab	2110	22711	108	2452788
	Second floor slab	1936	20838	108	2250504
	roof slab	1904	20494	108	2213352
	Total				**9832644**

RCC Frame Structure	**Cost of Materials + Labour+ Shuttering**				
	No. of Columns	Cost per Column (Rs.)	No. of Beams	Cost per Beam (Rs.)	Total Cost (Rs.)
	125	18500	182	7500	**3677500**

Polycarbonate Roof	Area (sq m)	Cost per sq m	Total Cost (Rs.)
	545	1200	**654000**

Wall Plastering	**Material Cost- Cement**				
	Floor	Wall area (Sq m)	Quantity (kg)	Cost per Bag (Rs.)	Total cost (Rs.)
	Ground floor	5600	42900 kg or 858 bags	300	257400
	First floor	5600	42900 kg or 858 bags	300	257400
	Second floor	5600	42900 kg or 858 bags	300	257400
	Total				**772200**
	Transportation cost				
	Rate of transport	Truck capacity	Quantity (tonne)	Total cost (Rs.)	
	Rs.40 for 2 km	9 tonne	128.7	**600**	
	Labour cost				
	Wall area (sq m)	Labour Rate per sq m	Total Labour Cost (Rs.)		
	16800	Rs.13 /sq m	**218400**		
	Material Cost - Sand				
	Floor	Wall area (Sq m)	Quantity (kg)	Cost per tonne (Rs.)	Total cost (Rs.)
	Ground floor	5600	181860 kg or 181.8 ton	1200	218232
	First floor	5600	181860 kg or 181.8 ton	1200	218232
	Second floor	5600	181860 kg or 181.8 ton	1200	218232
	Total				**654696**
	Transportation cost				
	Rate of transport	Truck capacity	Quantity (tonne)	Total cost in Rs.	
		Rs.45 for 2 km	8 cu m	616.3	**3466.5**

Wall finish	**Paint**	Area (Sq m)	Quantity (Litres)	Cost (Rs.)	Total Cost (Rs.)
		7350	600	Rs.990 /10 litres	**59400**
	Putty	Area (Sq m)	Quantity (kg)	Cost (Rs.)	Total Cost (Rs.)
		7350	7800	Rs.900 /20 kg	**351000**

Water

Rainwater Harvesting
Total effective catchment area (sq m)
4988.5 sq m

Water demand reduction
Low Flow Fixtures (Griha Co
W/C-Somany 2PC EWC Fla mounted Uniex trap
Faucets- Parryware euclid b
Urinals- Jaguar (URS-WHT
Total

Annual Municipal Wat
Cost = Rs. 4,500

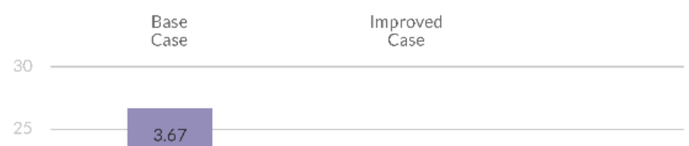
Energy

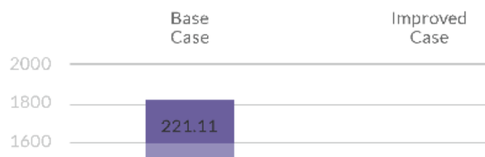
Radiant Cooling
Total radiant cooled area (sq m)
4328.25

Solar Panels
Energy Generated Per Year (kwh)
422 kwh

Annual Unsatisfied En
Cost = Rs. 20,68,513

Building Sustainable Performance Summary





al Cost- Cement				
	Wall area (Sq m)	Quantity (kg)	Cost per Bag (Rs.)	Total cost (Rs.)
floor	5600	42900 kg or 858 bags	300	257400
or	5600	42900 kg or 858 bags	300	257400
floor	5600	42900 kg or 858 bags	300	257400
				772200

ortation cost			
trans-	Truck capacity	Quantity (tonne)	Total cost (Rs.)
or 2 km	9 tonne	128.7	**600**

cost		
ea (sq	Labour Rate per sq m	Total Labour Cost (Rs.)
	Rs.13 /sq m	**218400**

al Cost - Sand				
	Wall area (Sq m)	Quantity (kg)	Cost per tonne (Rs.)	Total cost (Rs.)
floor	5600	181860 kg or 181.8 ton	1200	218232
or	5600	181860 kg or 181.8 ton	1200	218232
floor	5600	181860 kg or 181.8 ton	1200	218232
				654696

ortation cost				
rt	Truck capacity	Quantity (tonne)	Total cost in Rs.	
	Rs.45 for 2 km	8 cu m	616.3	**3466.5**

	Area (Sq m)	Quantity (Litres)	Cost (Rs.)	Total Cost (Rs.)
	7350	600	Rs.990 /10 litres	**59400**
	Area (Sq m)	Quantity (kg)	Cost (Rs.)	Total Cost (Rs.)
	7350	7800	Rs.900 /20 kg	**351000**

Water

Rainwater Harvesting							
Total effective catchment area (sq m)	Total litres	Cost of RWH tank (Rs.)	Maintenance Costs for 60 years (Rs.)	Total Capital Cost (Rs.)	Rate in Ghaziabad for municipal water supply	Savings (Rs.)	Payback period
4988.5 sq m	833 kl	1316140	15% of 1316140 = Rs.197421	1381947	Rs 50/kl	833 x 50 = Rs. 41650	**36 years**

Water demand reduction					
Low Flow Fixtures (Griha Certified)	Cost per Unit (Rs.)	Quantity (No.)	Total Cost (Rs.)	Labour Rate (Rs.)	Total Labour Cost (Rs.)
W/C-Somany 2PC EWC Floor mounted Uniex trap	8000	18	144000	Rs. 256 per piece	4608
Faucets- Parryware euclid bib ck	1200	26	31200	Rs. 202 per piece	5252
Urinals- Jaguar (URS-WHT-13261)	4000	9	36000	Rs. 268 per piece	2412
Total					**12272**

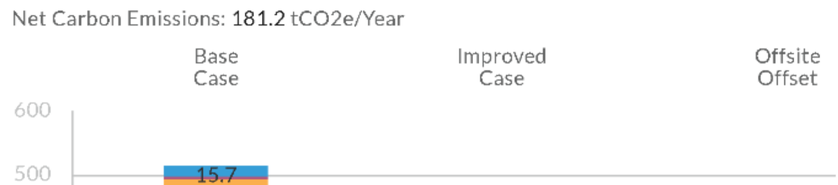
Annual Municipal Water Demand = 90kL
Cost = Rs. **4,500**

Energy

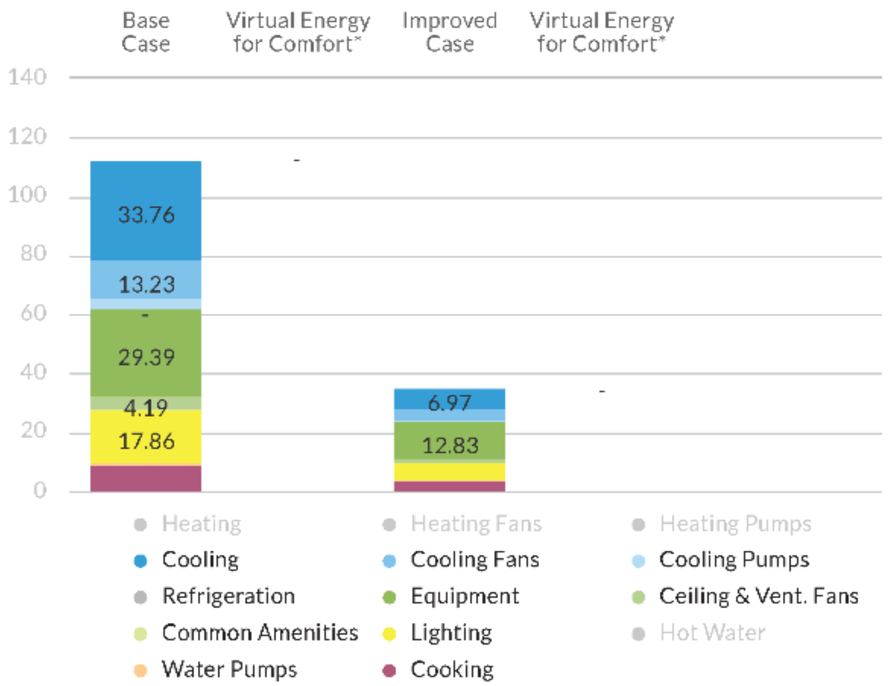
Radiant Cooling							
Total radiant cooled area (sq m)	Capital cost (Rs.)	Annual operative costs (Rs.)	Capital cost of VRF (Rs.)	Annual operative costs of VRF (Rs.)	Difference in capital costs (Rs.)	Difference in operative costs (Rs.)	Payback period
4328.25	13008750	323176	6492375	2856645	6516375	2533469	**2.57 years**

Solar Panels						
Energy Generated Per Year (kwh)	No of panels	Annual generation (kwh)	Rate in Ghaziabad for commerical HT	Savings (Rs.)	Capital cost (Rs.)	Payback period
422 kwh	656	656 x 422 = 276832 kwh	Rs 8.68 /kwh	276832 x 8.68 = Rs. 2402900	22000 x 656 = 14432000	**6 years**

Annual Unsatisfied Energy Demand = 2,38,308 kwh
Cost = Rs. **20,68,513**



Building Sustainable Performance Summary



Energy (kwh/m²/year)

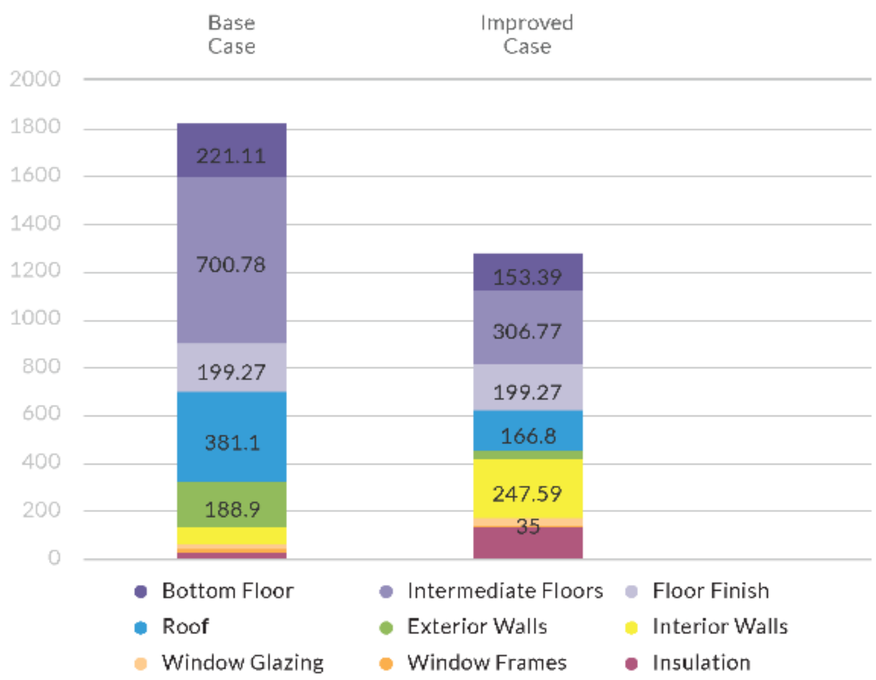
GRIHA EPI Benchmark:

For 8 hours for 6 days a week occupancy,
90 x (6/5) = 108 kWh/m2/yr

Proposed EPI = 2,38,308 kWh / 6565m² = 36.29

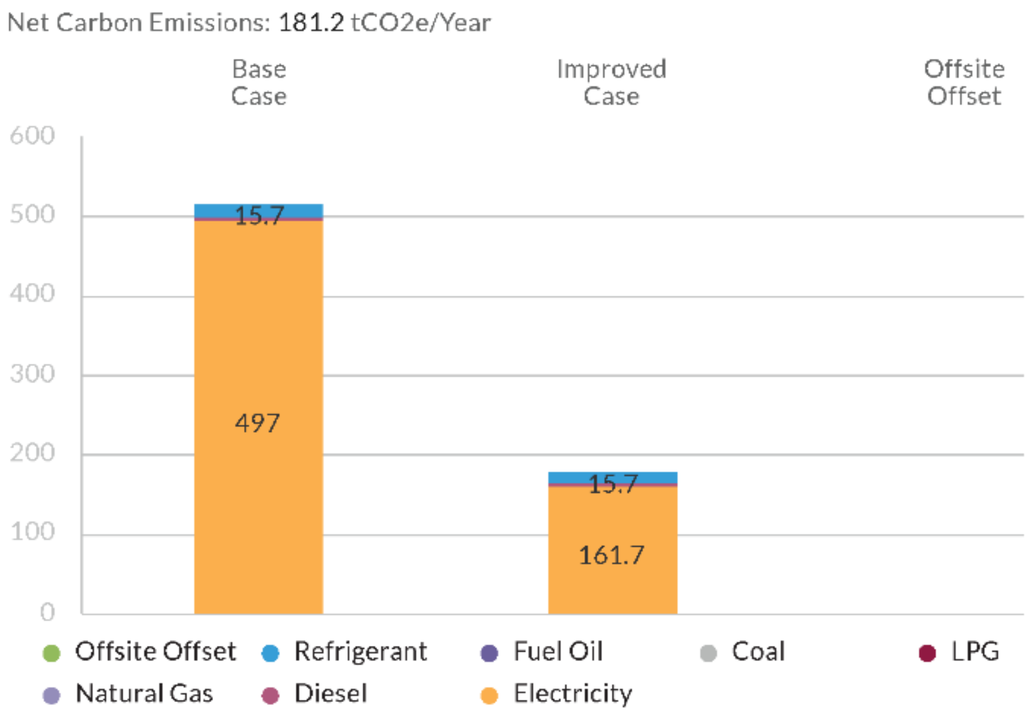
Water (m³/day)

The use of low flow fixtures for faucets, kitchen sinks, wash basins, toilet flush & spray and drip irrigation leads to a reduced water demand.



Embodied Energy (MJ/m²)

Usage of locally available materials and sustainable construction techniques such as C&D block masonry with fly ash mortar, RCC slabs with 30% pulverised fly ash, etc. offsets the embodied energy of the building to **1283 MJ/m²**

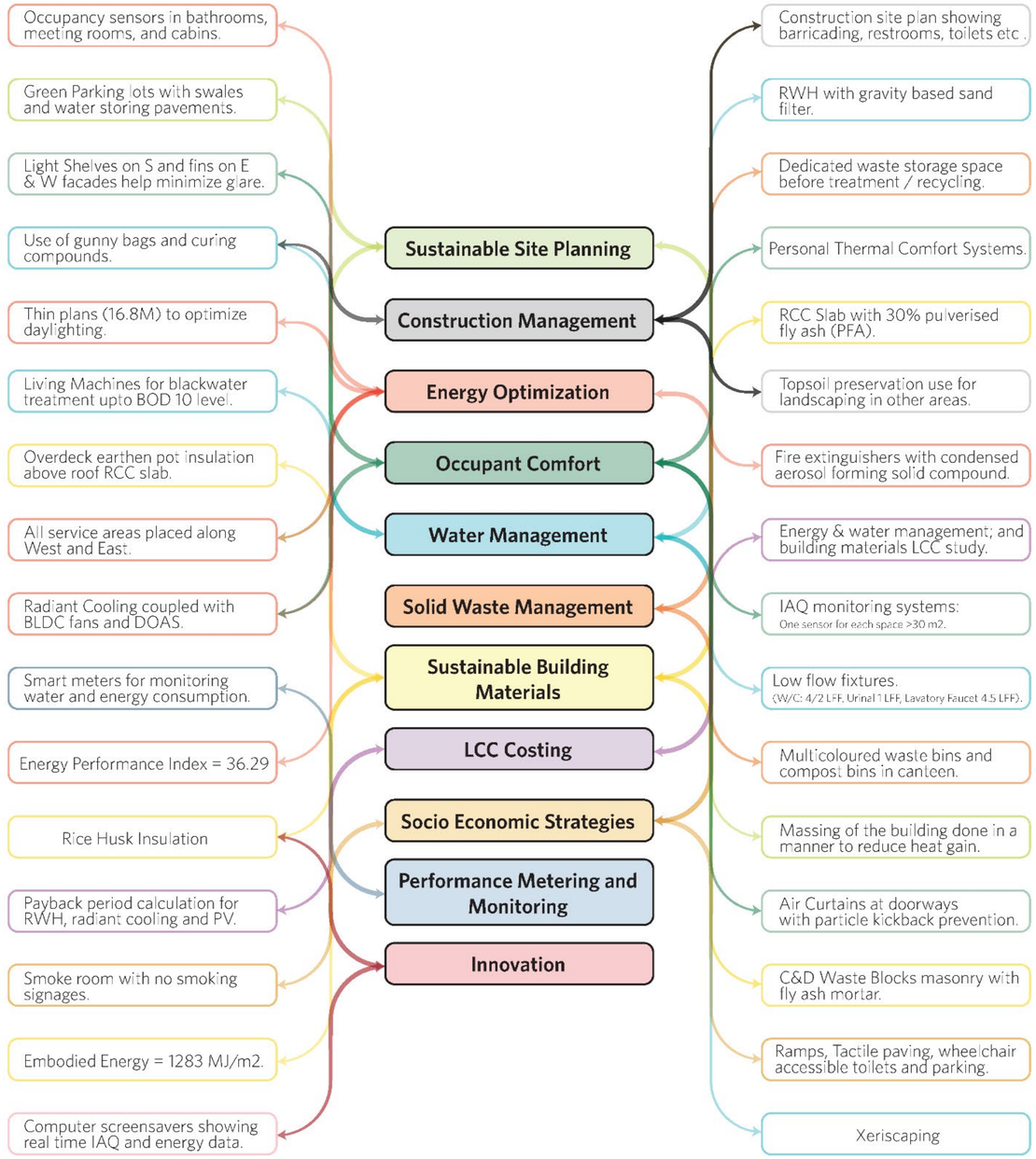


Carbon Emissions (tCO_2e/Year)

276,502 kWh (53%) of the annual energy demand is satisfied by rooftop solar PV panels. This clean energy brings down the carbon emmisions to **13.38 tCO_2e/month**.

NASA®

View of the atrium and lobby with living machine



GRIHA Criterias and Strategies

NASA®