DESIGN FEATURE FOR NET ZERO ENERGY EFFICIENT BUILDING

A CASE OF A OFFICE BUILDING

A DISSERTATION
Submitted in Partial Fulfilment
of the Requirements
for the Degree
of

MASTER OF ARCHITECTURE

By

HEMLATA

Roll No. (1200109005)

Under the Supervision
Of
Prof. SAURABH SAXENA
Babu Banarasi Das University, Lucknow

BBD UNIVERSITY

SCHOOL OF ARCHITECTURE AND PLANNING

BABU BANARASI DAS UNIVERSITY LUCKNOW

(Formerly Uttar Pradesh Technical University, Lucknow)
JUNE, 2023

Topic of Dissertation

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CERTIFICATE

Certified that **HEMLATA (**1200109005) has carried out the research work presented in this thesis entitled **"DESIGN FEATURE FOR NET ZERO ENERGY EFFICIENT BUILDING" A CASE OF A OFFICE BUILDING** for the award of **Master of Architecture** from BABU BANARASI DAS University, Lucknow under our supervision. The thesis embodies results of original work, and studies are carried out by the student himself/herself (print only that is applicable) and the contents of the thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

Hemlata
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Date:

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5. Faculty of the University to which the thesis is submitted:

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ABSTRACT

The purpose of this study is to evaluate various parameters taken to make an energy efficient office building. This analysis explores the energy consumption of an energy efficient building. For this reason an energy-efficient building has been chosen as the case model. The selected energy-efficient building is located in Gurgaon with a composite atmosphere. The analysis examines the steps taken to make every energy efficient building. The case building was analyzed by comparing different active and passive strategies of an already existing Net Zero Energy office building with better energy performance in composite climate. After analyzing various parameters, the amount of energy consumed by different means was evaluated and the parameters were selected which holds the large share of the total energy consumption of the office building. Building simulation on the existing building case model, based on the parameter, is performed to understand the strategies that should be used in enhancingthe case building's energy efficiency and reducing total energy consumption. Moreover, the data were analyzed and recommendations were made to improve the energy performance and the current building's overall EPI.

ACKNOWLEGDEMENT

I would like to express my gratitude to my Dissertation Guides Assistant Professor **Prof. SAURABH SAXENA** I am very thankful fortheir support, motivation, encouragement, and patience. Both professors gave me all the encouragement, knowledge, and support I needed to complete my dissertation. They provided me with the important advice, guidance and directions that was needed for my dissertation to be completed. Secondly, I would like to thank Professor PROF.KESHAV KUMAR and Assistant Professor AR. SATYAM SRIVASTAVA for giving me all the requisite guidance and time to teach and providing me with all required guidance for my dissertation. I would also like to take this opportunity to thank my faculty teachers, who throughout the year have been extremely helpful; their teaching, experience and personal advice have been of greatvalue to me. Last but not least, I would like to extend my gratitude to my family throughout the entire process for their continuous support and encouragement.

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Masters of Architecture
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LIST OF ABBREVIATIONS

HVAC-Heating, Ventilation, air- conditioning

BEE-Bureau of Energy Efficiency

NZEB-Net Zero Energy Buildings

PV-Photovoltaic System

USAID- United States Agency for International Development

DX-Distributed System

LPD-Lighting Power Density

TLF'-Tubular Fluorescent Lamps

WWR-Wall Window Ratio

CNG-Compressed Natural Gas

IBMS-Integrated Building Management System

AAC-Autoclaved Aerated Concrete

RMC-Ready Mix Concrete

BIPV-Building -Integrated Photovoltaics

CFLs-Compact Fluorescent Light

LEDs-Light Emitting Diode

EPI-Energy Performance Index

CHAPTER- 1

INTRODUCTION

1. INTRODUCTION

A significant environmental problem emanates from the construction industry. Buildings account for at least 40% of energy consumption worldwide. Global warming is one of the environmental issues that the construction industry in India is also facing (Ministry of New and Renewable Energy, 2010).
Throughout their lifetime, buildings have a significant impact on the environment: the comfort of their occupants is provided by energy-intensive lighting, air conditioning, and water heating systems.1 To be energy conscious, climate-smart design must be paired with usable building design.
Buildings that use less energy are another approach to combating climate change. (ZHANG & ZHU, 2013) studied the energy consumption of four energy efficient office buildings in four different climates in China. They found that cooling and lighting are the largest contributors to energy consumption in office buildings.

One of the best ways to reduce energy consumption and carbon emissions in the construction industry is to make existing buildings more energy efficient. Numerous studies have shown that heating, ventilation and air conditioning systems account for the majority of energy consumption in buildings.
As a result, much research has been conducted to increase the efficiency of HVAC systems and reduce energy consumption (Sun, Gou, & Siu, 2018).
Retrofitting lighting systems in existing buildings also offers significant potential to reduce energy consumption.
This work not only provides an active and passive approach to upgrading existing buildings in a composite environment, but also evaluates the quality of new energy-efficient buildings.

Need of the study

Energy efficiency retrofit strategies can generally be divided into passive and active solutions. Passive solutions aim to provide more resource-efficient architectural components (such as building envelopes and roofs) to minimise reliance on active solutions (Sadineni, Madala, & Boehm, 2011). Active solutions optimise heating, ventilation, HVAC systems, lighting, and all other building services applications.
It has been shown that lighting is often the second largest energy consumer in office buildings. Daylighting optimization (Campo, 2010) and lighting system replacement are two relevant methods for renovating older buildings.
Therefore, the renewal of glazing and lighting offers great potential to increase the energy efficiency of the current structure.

Aim

The aim of this study is to design and analysis of a building which using passive strategies to achieve thermal comfort. Integration of passive strategies into the building spaces for achieving thermal comfort.

Objective

Analyzing and evaluating the energy performance of building through energy simulation software tool.

Understanding the improved efficiency through each individual design strategy.

Retrofitting of energy efficient building through exterior glazing and artificial lighting.

Research Question

Do energy-efficient lighting systems make a major contribution to reducing an office building's energy consumption and cost-effectiveness?

Research Hypothesis

The strategy of retrofitting of the lighting system will lead individually to a greater reduction in the overall energy consumption of energy-efficient building.

Methodology

In terms of thermal design of buildings, India can be divided into five climatic zones, namely hot and dry, warm and humid, mixed, temperate, and cold, of which the mixed zone covers the largest area of India (BEE, 2011). The mixed zone covers the largest area of India. Based on the rating system, energy consumption patterns and design strategies for energy efficient buildings, the case of an existing building was selected. A literature review was used to collect data on the selected building and evaluate various criteria by which energy efficient buildings perform. The performance of the building is compared with the effectiveness of the different design strategies used in the buildings. A building model simulation was performed to determine the appropriate design measure to reduce the building's energy consumption through an efficient lighting system.

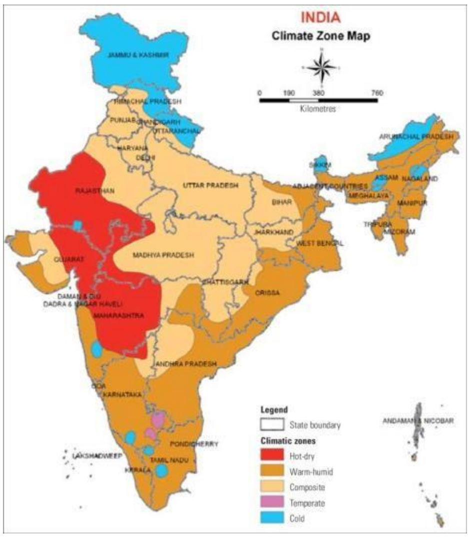


Figure 1.1: Map of India (climate zones)
(source:https://www.researchgate.net/figure/Map-showing-climatic-zones-in-India-Source-National-Building-Code-of-India-2005_fig1_221901881/actions#embed)

A. Selection of case study
   - Assessed using one of the rating systems or high-performance building standards.
   - Availability of energy performance data related to building.
B. Introduction
   - Aim
   - Objective
   - Research question
   - Reasearch Hypothesis
C. Analysis

   Analyzing Parameters of NZEB and Energy Efficient buildings
   - Active Strategies
   - Passive Strategies
   - Renewable Energy Source
D. Literature Review
   - Terms and Definition
   - Analysis of literature Review
E. Case Study
   - Site Study
   - Analysis of case study
   - Comparative analysis of Buildings
F. Data Evaluation
   - Quantifying Parameters
   - Simulation Of Building Model
   - Evaluation Of Simulation data
G. Recommendations and Solutions

Scope

- This work will provide retrofitting options to reduce energy consumption in existing buildings.
- The work will provide approaches to how energy reduction in the existing building stock could be accomplished.
- The study will integrate active and passive strategies.

Limitation

The study was conducted specifically for the composite climate. It is limited to an office building. The study will focus on only two parameters selected:

- Exterior glazing
- Artificial lighting

CHAPTER- 2
LITERATURE REVIEW

2. LITERATURE REVIEW

Definition

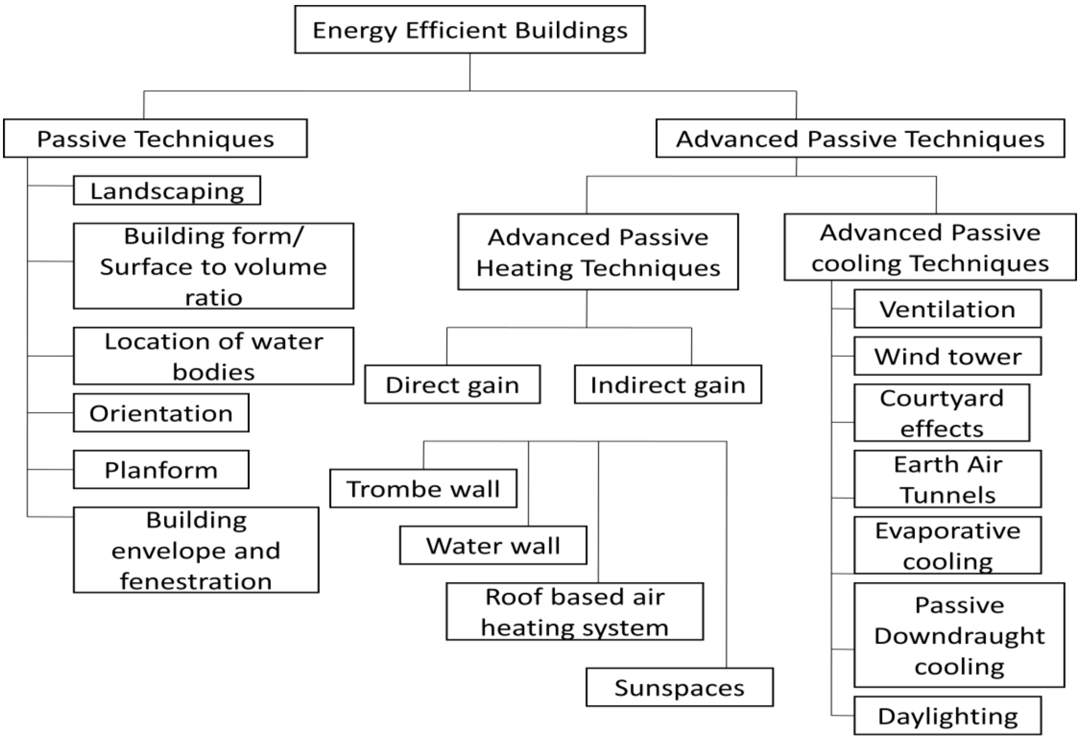
Energy-efficient buildings are buildings that essentially have energy consumption reduction measures compared to conventional buildings of similar size and occupancy. This efficiency is achieved by:

Design elements (Landscaping, building form, orientation, building envelope and fenestration, materials and construction techniques etc.).

Specific strategies for passive, active and renewable energy.

Parameters of Energy Efficient Buildings

- Passive systems provide thermal and visual comfort by using natural energy sources and sinks, such as solar radiation, outdoor air, sky, moist surfaces, vegetation, and internal gains. This reduces the load on conventional systems (heating, cooling, ventilation, and lighting). Passive solar systems change based on climate.
- Create HVAC (heating, ventilation, and air conditioning) and lighting systems that use less energy. When passive solar architecture principles are incorporated into a design, the need for traditional systems (HVAC and lighting) decreases.
- Use renewable energy technologies to meet some of the building load, such as solar water heating or photovoltaic systems.
- Use energy-efficient building materials and construction techniques while reducing energy demand for transportation. - Strive for efficient construction and use less energy-intensive building materials (such as glass, steel, and aluminium) and more low-energy ones.
- An energy efficient building provides an optimal mix of passive solar techniques, energy efficient technology, and renewable energy sources to balance all aspects of energy use in a building, including lighting, air conditioning, and ventilation. An energy efficient building design (TERI) also relies heavily on the use of low energy materials.



Terms and Definitions

Passive Design Strategies

- Considering the building's geographical and meteorological conditions, passive approaches to reduce the building energy demand are implemented during construction layout. Factors that are considered in passive design strategies are (USAID):

➢ **Form and Orientation**

- Form and orientation are two of the most important passive development techniques to reduce energy consumption and improve the thermal comfort of a building's occupants. The design of the building varies depending on its location and environment (USAID).
- The form of the building determines the volume of space that needs to be heated or cooled inside a building (USAID).

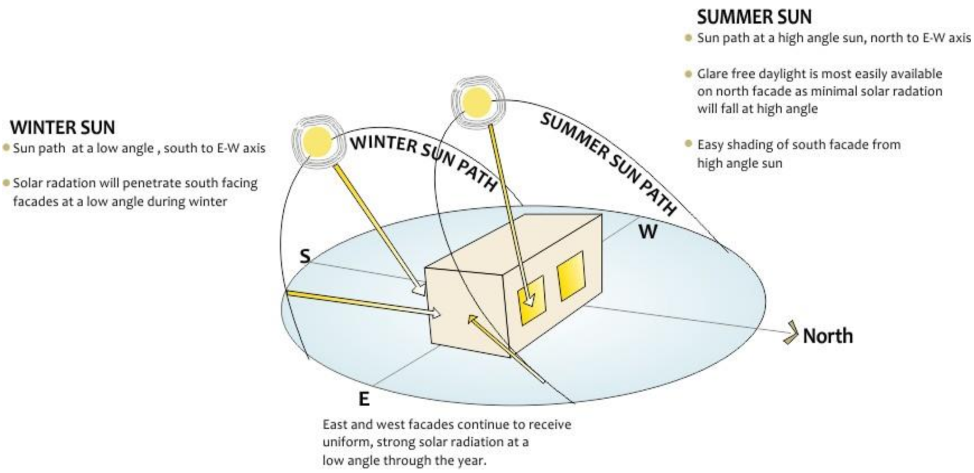


Figure 2.1:Form and orientation

(source: https://nzeb.in/wp-content/uploads/2015/06/form_orientation_1.gif)

- **Shading**
- External shading systems, for example, are important structural measures that either prevent or greatly minimise the need for mechanical heating and cooling to provide thermal comfort in buildings by limiting heat absorption through openings. Consequently, external and internal shading systems can be used as a necessary option to achieve energy efficiency. Opening proposals (USAID, Net-zero buildings)
- Consequently, shading of south-facing openings must allow sunlight to pass through for heat gain in winter, but block it in summer. According to the USAID Net-Zero Energy buildings, shading is only appropriate for north-facing openings to block high solar gain in summer.
- **Cool roofs**

- Just as light-colored clothing can help keep a person cool on a sunny day, cool roofs use solar-reflective surfaces to keep temperatures down on the roof. Highly reflective and light colored roofs are now an integral part of a building's energy efficiency measure(USAID, Net Zero Energy Buildings).
- Traditional dark roofs reach temperatures of 660C (150oF) or higher in the summer sun, while a cool roof could remain more than 280C (50 ° F) cooler under the same conditions (USAID, Net Zero Energy Buildings).

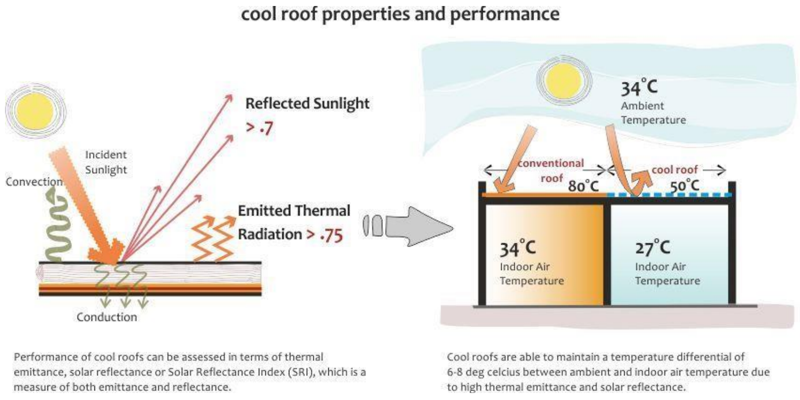


Figure 2.2: Cool roofs

(source: https://nzeb.in/wp-content/uploads/2015/07/Coolroof.jpg)

Fenestrations

- When required, fenestrations (windows, skylights, and other openings in a building, etc.) allow sunshine and the prevailing wind within the building.
- Fenestrations often influence the capacity for daylight harvesting by minimizing lighting charges without compromising the visual and thermal comfort of occupants of buildings.
- Windows position, width and glazing can be used wisely to reduce the cooling load and, as a result, smaller cooling systems for buildings.
- In terms of both quantity and duration, solar radiation intensity is minimal on openings or walls facing north, followed by façades facing south. The openings (or walls) facing east and west receive a large amount of solar radiation all year round (USAID, Net zero energy buildings).

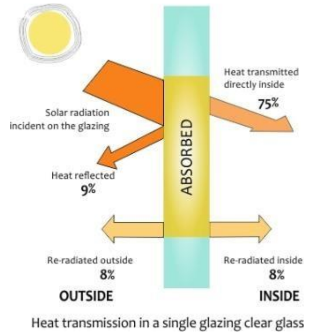


Figure 2.3: Fenestration

(source: https://nzeb.in/wp-content/uploads/2015/07/glazing-properties.jpg)

- **Insulation**
- In walls and roofs, thermal insulation reduces heat transfer from inside to outside and helps to maintain comfortable indoor temperatures. This creates a healthier environment, improves noise safety, and reduces electricity bills most significantly. Insulation helps keep indoor space cooler in summer months and warm during winters.
- Various materials can be selected including fiber glass, mineral wool, rock wool, expanded or extruded polystyrene, cellulose, urethane or phenolic foam boards and cotton.

- Higher R-values mean better insulation and turn into more energy savings, much needed to meet the development goals of the energy efficient buildings (USAID, Net zero energy building).

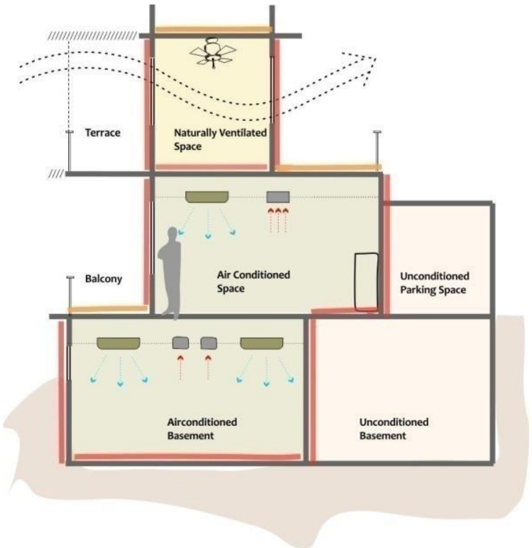


Figure 2.4: Insulation

(source: https://nzeb.in/wp-content/uploads/2015/07/insulation_2.jpg)

- **Daylighting**
- Daylighting is a technique for building design to use daylight. The presence of natural light in an occupied space provides a sense of well-being, raises awareness of one's surroundings and also increases energy saving potential with reduced reliance on artificial light.
- Appropriate use of windows, skylights, clerestories, and other building apertures provides means for daylight harvesting(USAID, Net zero energy buildings).

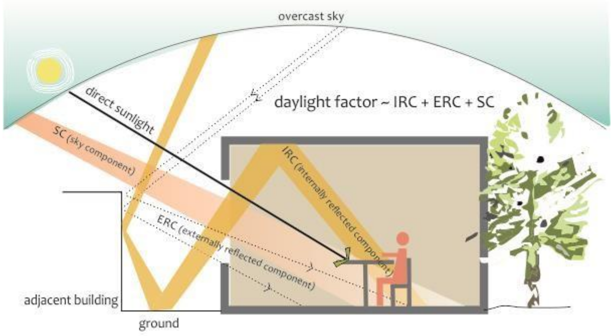


Figure 2.5: Day lighting

(source:https://nzeb.in/wp-content/uploads/2015/07/daylight-factor.jpg)

- **Natural Ventilation**
- Fresh air in a building provides health benefits to its residents and increased levels of comfort. The supply of fresh air is considered an effective and safer solution because it eliminates the need for mechanical ventilation of a house.

- Passive design measures can be used to influence the movement of outside air into a built space by bringing fresh air in order to achieve an Efficient Design goal.
- Different forms such as correct orientation and shape, building envelope openings (windows, doors and ventilators), operating windows, internal space design, etc. are different natural ventilation techniques that can be implemented. Other advanced ventilation techniques are the effect of the courtyard, the effect of the stack, the wind tower or tunnels on the air earth(USAID, net zero energy buildings).

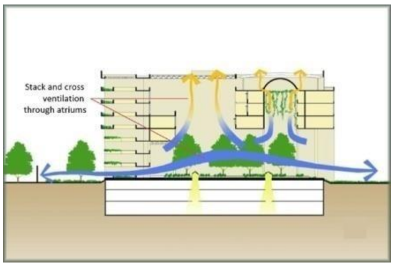


Figure 2.6: Natural Ventilation

(source: https://nzeb.in/wp-content/uploads/2015/10/passive_IPB2.jpg)

- **Thermal Mass**
- Thermal mass helps to retain heat and moderate variations in the indoor temperature within the building structure. The building material heat storage capacity helps by providing time delay in achieving thermal comfort for occupants.
- Building material mass and density influence the ability for heat storage in buildings. High density materials like concrete, bricks and stone have highthermal mass, whereas materials like wood or plastics have low thermal mass.The effectiveness of direct sun irradiation depends on the placements of these components(USAID, net zero energy buildings).

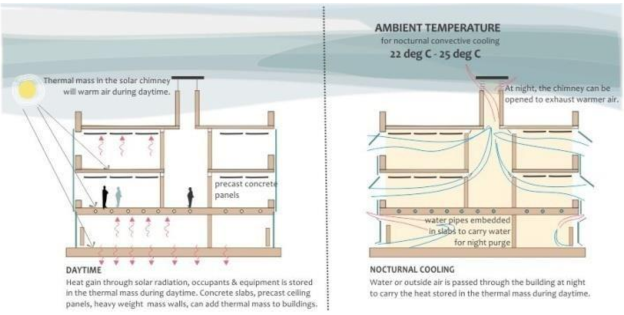


Figure 2.7: Thermal mass

(source: https://nzeb.in/wp-content/uploads/2015/07/thermal-mass-1.jpg)

- **Evaporative cooling**
- Over the years, traditional wisdom has supported the idea of a water body like pond, lake or fountain to give the surrounding environment a cooling effect. This effect reduces the temperature of indoor air-an evaporative cooling phenomenon

that is widely known.This phenomenon is witnessed in most Indian households in systems such as desert coolers.

- Evaporative cooling reduces the temperature of the indoor air, thereby reducing the cost of power in building air conditioning. Reduced energy load leads to achieving the goals of efficient design(USAID, Net zero energy buildings).
- **Thermal Comfort**
- Ultimately, buildings are designed to provide shelter and comfortable habitats. Significant amounts of energy are expended as buildings are cooled or heated by mechanical equipment to maintain the optimal thermal comfort conditionsIt is important to understand what thermal comfort is and how, with the least amount of energy expended, it can be accomplished.
- Thermal comfort is an evaluation of the environment's thermal condition. ISO 7730 states that thermal comfort is described as "a condition of mind expressing satisfaction with the thermal environment"(USAID, Net zero energy buildings).

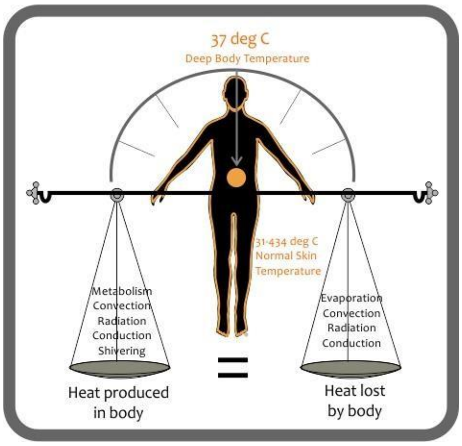


Figure 2.8: Thermal comfort

(source: https://nzeb.in/wp-content/uploads/2015/07/thermal-comfort.jpg)

Human body needs to maintain its core temperature at 37 ºC. In order to do so, it must constantly exchange heat with the surroundings. People feel comfortable when this process is sufficiently supported by the surrounding thermal environment of a building(USAID, Net zero energy buildings).

- **Vegetation**
- Different air circulation patterns are produced by trees and shrubs, providing shade and keeping the surrounding area warmer. Vegetation can be used in buildings to conserve energy in the following ways:

- ❑ Shading of buildings and open spaces through landscaping.
- ❑ Roof gardens (or green roofs).
- ❑ Shading of vertical and horizontal surfaces (green walls).
- ❑ Buffer against cold and hot winds.

- ❑ Changing direction of wind.
- Vegetation is a dynamic control system for the penetration of solar and wind into buildings. This prevents direct sun from hitting and heating building surfaces and decreases the outside air temperature which in turn affects the heat transfer from outside to the exterior and interior of the building.
- Green roofs or roof gardens can also be used to help lower heat loads in a building. Extra thermal insulation is given by the additional thickness of the growing medium(USAID, Net zero energy buildings).

Active Design Strategies

➢ **HVAC**

- Comfort systems contribute almost 40% of the energy used in India by commercial buildings. There are many types of comfort systems on the market that range from low-energy comfort systems to conventional systems.
- Reducing heating / cooling loads through passive design strategies and enhancing HVAC systems efficiency are essential steps for any energy efficiency building policy.
- The system type are broadly categorized into two types:
  - ❑ Centralized system: central cooled water system (air-cooled and water-cooled system
  - ❑ Distributed system (DX system): VRF, duct-capable system, separated air-conditioners, unit systems.

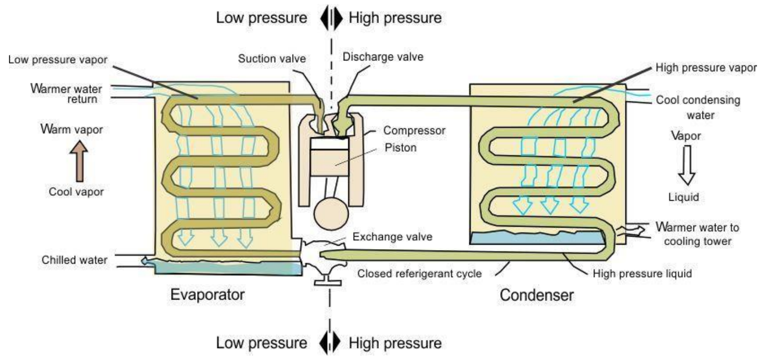


Figure 2.9: HVAC

(Source: https://nzeb.in/wp-content/uploads/2015/08/hvac-intro-image.jpg)

- HVAC design and equipment selection majorly depends on:
  - ❑ Building functional use, type, and operational schedule.
  - ❑ Variation in operational schedule and potential of system controls
  - ❑ System complexity
  - ❑ Commissioning – pre occupancy and post occupancy Design(USAID, Net zero energy buildings).

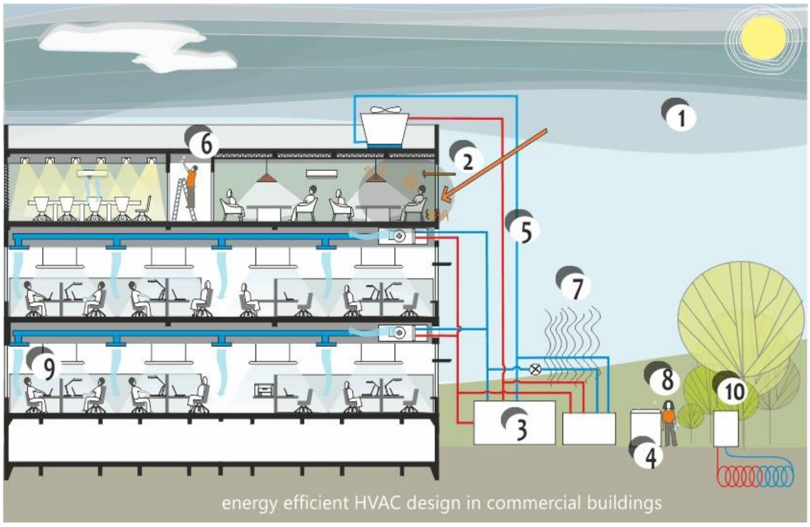


Figure 2.10: Energy efficient HVAC design in commercial building

(source: file:///C:/Users/ANSHU/Desktop/reference/HVAC_landing311.gif)

➢ **Lighting**

- Lighting is designed based on user activity and usable space requirements. To meet the goal, choose possible lamps available on the market.
- Lighting is one of building design's most complex parts. A variety of issues regarding lamp engineering and luminaires, lighting design philosophy, energy efficiency, and aesthetics have to be juggled by the lighting designer.
- Designer should target an LPD reduction of at least 50% of the value stated in ECBC for an energy-efficient design(USAID, Net zero energy buildings).

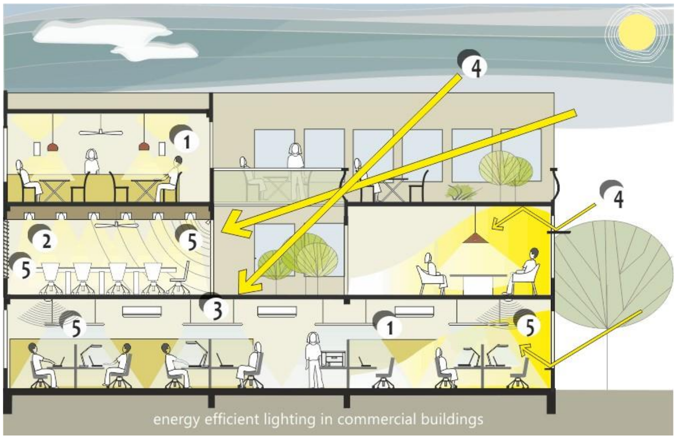


Figure 2.11: Lighting

(source: file:///C:/Users/ANSHU/Desktop/reference/Lighting3.gif)

➢ **Efficient appliances**

Solar and off grid appliances

- Renewable energy-based devices will go a long way towards saving customer money by decreasing energy bills and increasing reliance on the electricity grid.
- For controlling external lighting, small photovoltaic modules can be used.

Solar Water heaters use energy from the rays of the sun for domestic and commercial purposes to heat water. There are two types of closed loop and open loop solar water heaters.

Standards and Labelling

Energy Efficiency Standards & Labelling (S&L) systems in many countries have been active in increasing the supply and performance of energy-efficient goods. In India, the S&L appliance system was launched by the Bureau of Energy Efficiency (BEE) in 2006.

Refrigerator

In particular in residential buildings, refrigerators account for a significant fraction of the annual energy usage. There are two main types of refrigerators in the market, Direct Cool and Frost Free, based on the process of circulating cooling and defrosting.

Room Air Conditioners

Air Conditioners are designed to offer comfort to humans by reducing room temperature and humidity. While air conditioners consume large amounts of electricity, their popularity is increasing among the general public.Two types of air conditioners are present in the market:

- Window Type
- Split Type

Distribution Transformer

This type of transformer is the final step in the electrical distribution system's voltage transformation. This reduces the voltage obtained from the distribution lines to a rate that is expected by the end consumer.The standard ratings covered by the program are 16, 25, 63, 100, 160 and 200kVa and 16 to 200kVa non-standard ratings.

Tubular Fluorescent Lamps (TFLs)

TFLs are typically low-pressure mercury vapor gas discharge lamps that produce light by using fluorescence. The labeling scheme for BEE Star covers 4-foot TFLs with up to 40W wattages.

Ceiling Fans

For 1200 mm sweep and a total air supply of 210 cu. m / min, the BEE star labeling system for ceiling fans is applicable

Electric Geysers

Efficient computer system(USAID, Net zero energy buildings)**.**

Renewable Energy

- **Solar Photovoltaic**

- Solar photovoltaics are a combination of panels that contain a number of solar cells that transform the solar energy incident into usable electricity.
- These panels can be mounted anywhere they receive plenty of sunlight.

Solar cells consist of semiconductor materials such as crystalline silicon, which includes monocrystalline silicon, polycrystalline silicon, ribbon silicon, and mono-like multi-silicon, and thin films like cadmium telluride, copper indium gallium selenide, silicon thin film, and thin film gallium arsenide.

Factors affecting generation of electricity:

- ❑ Location, tilt, and orientation
- ❑ Over shading
- ❑ Temperature
- ❑ Panel efficiency (USAID, Net zero energy buildings)

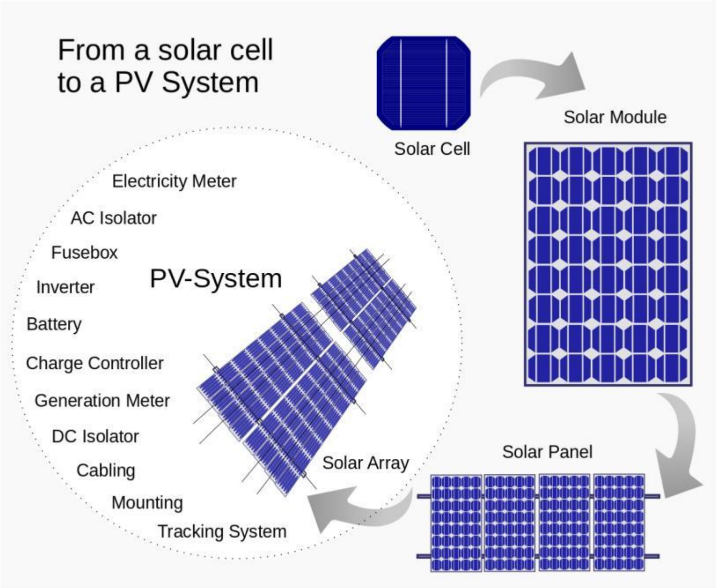


Figure 2.12: Solar Panel Detail

(source: https://nzeb.in/wp-content/uploads/2015/10/From_a_solar_cell_to_a_PV_system.svg_.png)

➢ **Wind Energy**

- By using wind turbines to harness the wind's kinetic energy, wind power is generated. Wind blowing across a wind turbine's rotors causes it to spin.
- Rotator spinning transforms a part of the wind's kinetic energy into mechanical energy. The mechanical power is further transformed into electricity by a generator(USAID, Net zero energy buildings).

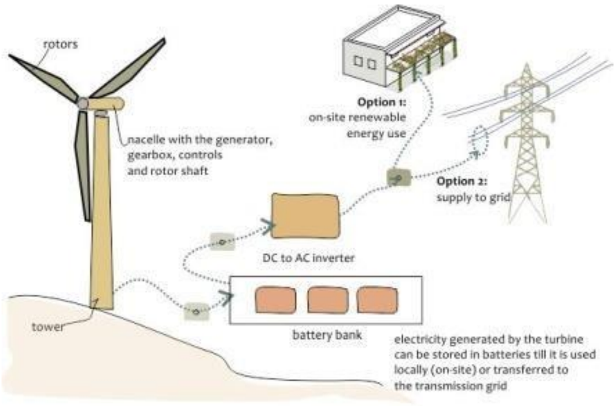


Figure 2.13: Diagram showing wind energy

(source: https://nzeb.in/wp-content/uploads/2015/08/wind-energy_2.jpg)

- **Biomass**
- Biomass fuel is the energy from plants or products derived from plants. Woodis the most widely used source of energy from biomass. Certain biomass sources include: land and aquatic plants, agricultural waste, industrial waste, sewage sludge, animal and municipal waste.

  To transform biomass into useful energy, three main technologies are used:
- Bio Gastification
- Biogas
- Biofuels(USAID, Net zero energy buildings)

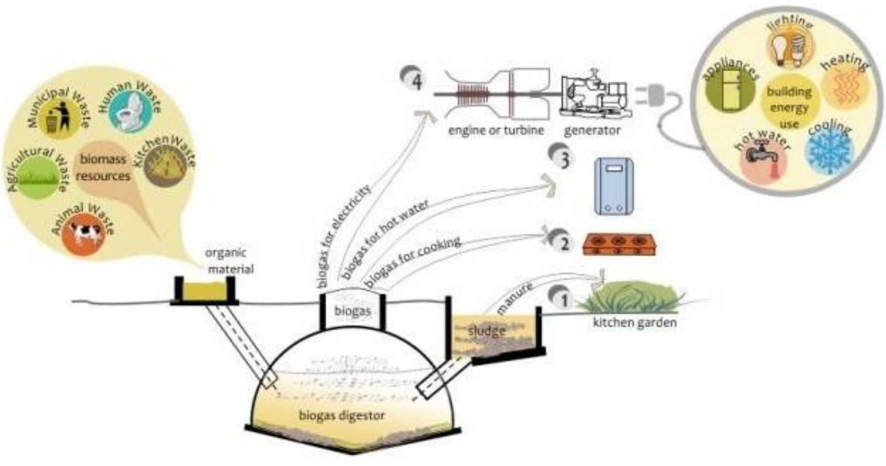


Figure 2.14: Biomass

(source: https://nzeb.in/wp-content/uploads/2015/08/biogas-system.jpg)

- **Hydro**
- Hydro energy is power generated from running or falling water energy on an energy conversion (turbine or wheel) equipment.
- These energy conversion devices transform the kinetic energy into mechanical energy, which is further converted to electrical energy through a generator(USAID, Net zero energy buildings)

Literature Review Analysis

Table 2.1: Literature review

Authors	**Design Variables**	**Analysis Target**	**Simulation tool/method**	**Country**	**Main Finding**
(Su & Zhang, 2009)	WWR,orientation, glass type (e.g.,single, hollow)	Environmental impact	Life cycle environmental analysis	China	WWR is the most important factor in the environmental impact of the life cycle.
(Ma, Wang, & Guo, 2015)	WWR(i.e., 10~100% withinterval 10%), U-value	Recommended WWR	Mathematical model	USA	The optimum WWR is determined not only by the amplitude of the temperature but alsoby the U value of the building envelope.
(G.Zenginis & Kontoleon, 2017)	WWR,building aspect ratio(i.e., length and width dimensions)	Heat gain and loss	Mathematical model	Greek	The orientation of the façade and the design aspect ratio withWWR have a hugeimpact on heat fluxes through the building.
(Wen, Hiyama, & Koganei, 2017)	WWR(i.e., 10~70%, interval:10%), orientation	Total CO2 emission, recommended WWR	EnergyPlus	Japan	This research proposed the optimum WWR of all Japanese regions by taking into account the environment and window properties

(source: author)

CHAPTER- 3

CASE STUDY

3. CASE STUDY

INDIRA PARYAVARN BHAWAN

- Geographic coordinates: 28°N, 77°E;
- Location: New Delhi;
- typology: new construction;
- climate type: composite;
- project area: 9565 m2;
- grid connection: Grid connection; EPI43.75 kWh/m2/year; Type of use: office (MoEF);

Figure 3.1: Indira Paryavaran Bhawan

(source: https://nzeb.in/wp-content/uploads/2015/10/Intro_IPB.jpg)

Background

Indira Paryavaran Bhawan, the new Ministry of Environment and Forests (MoEF) building, is the first major building in the country to receive the Net Zero and Energy Positive marks, and the first government building to do so.The building is located in Aliganj on JorBagh Road in South Delhi and includes the minister's office and various administrative areas of the ministry.This project was undertaken at all levels by the Central Public Works Department (CPWD) and Dependra Prashad, Dependra Prashad, Architects and Planners (DPAP) Sustainable Design Consultants to design a building that is not only energy efficient, but also capable of generating more energy on site than it consumes over the course of a functional year (Prashad & Chetia, 2014).

Developing Indira Paryavaran Bhawan

Figure 3.2: Indira Paryawaran Bhawan Plan
(source:https://mnre.gov.in/file-manager/akshay-urja/november-december-2014/EN/26-31.pdf)

- The design of the building went through various iterations with a twin North-South facing blocks with a large open space court in the middle being the final design.
- To keep the building height in tune with the surroundings, the maximum permitted ground coverage was used.
- Permission to cut 46 trees was granted, the design and measures proposed helped to reduce chopping to just 19 trees.
- The landscaping project was planned not only to serve as a climate change agent, but also to highlight the country's plant diversity (Prashad & Chetia, 2014).

Introduction

- The new office building of the Ministry of Environment and Forests (MoEF), Indira Paryavaran Bhawan, represents a fundamental departure from conventional construction methods.
- The project team paid special attention to strategies to reduce energy demand by providing adequate natural light, shade, landscaping to reduce ambient temperatures, and energy-efficient, effective building systems. - Several energy conservation measures were taken to reduce the building's electricity loads, and the remaining demand was met by generating energy from on-site high-efficiency solar panels to meet net-zero requirements. By reclaiming wastewater from the site, the proposal incorporated sustainable building principles such as water optimization and conservation. The Indira Paryavaran Bhawan is now India's top-rated green building. The project received a GRIHA 5-star rating and LEED Platinum.

- The building has already received recognition for its remarkable demonstration of renewable energy technology integration, including the MNRE's Adarsh/GRIHA award (net zero energy building).

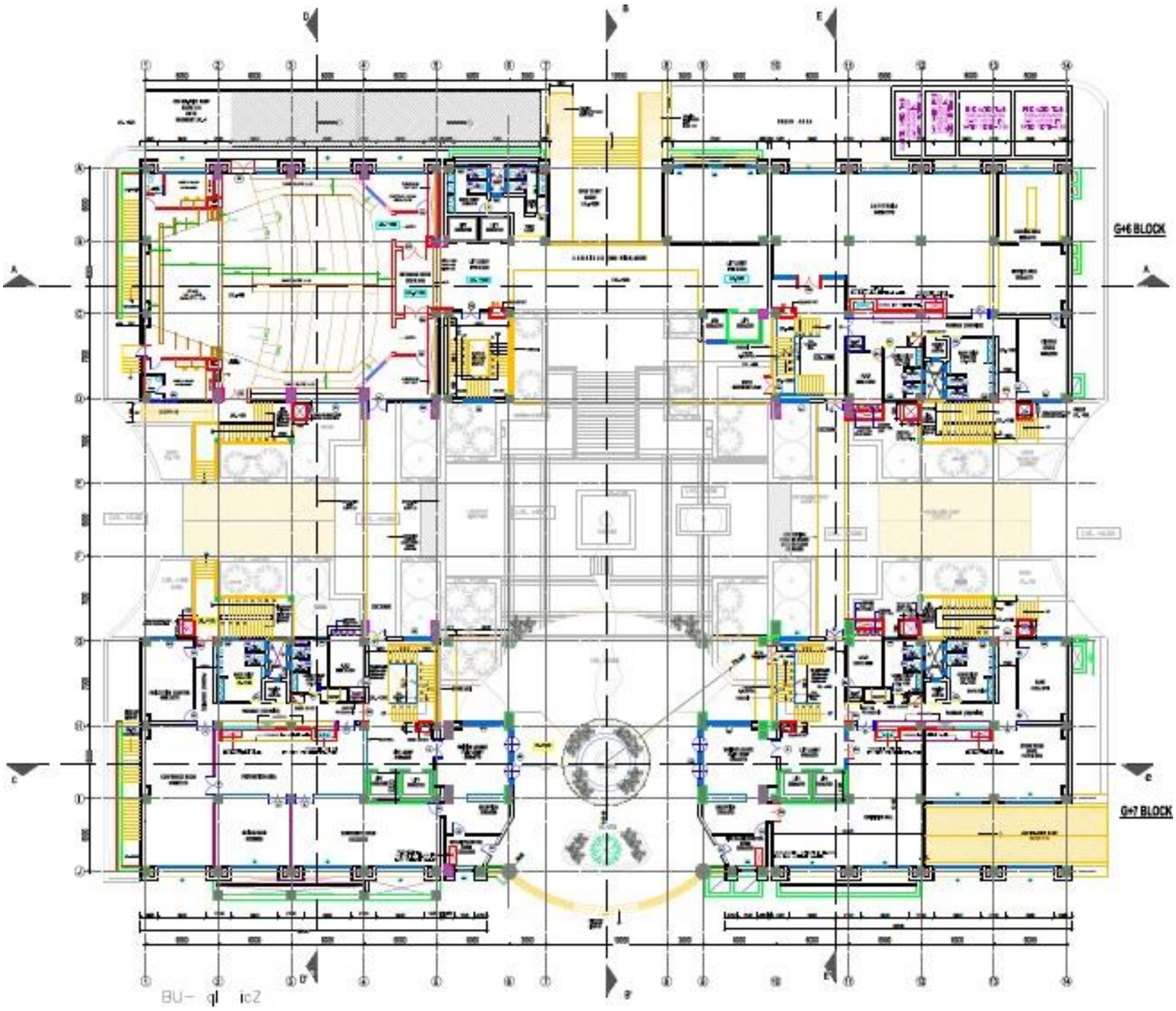


Figure 3.3: Plan
(source: author)

Passive Design Strategies

- **Orientation**

The building is oriented north-south, with separate blocks connected by corridors and a huge central courtyard. Orientation reduces heat intake. Optimal ratio between window and wall.

Figure 3.4: Orientation

(source: https://nzeb.in/wp-content/uploads/2015/10/RE_IPB2.jpg)

- **Landscaping**

  About 50% of the land outside the building is covered by forest. Circulation roads and paths are paved softly to allow drainage of groundwater.

Figure 3.5: Landscaping
(source: author)

- **Daylighting**

  75% of the building floor space is daylight, reducing reliance on artificial lighting sources. The courtyard inside serves as a bright light.

Figure 3.6: Daylighting
(source: author)

- **Ventilation**

  As natural ventilation occurs due to the stack effect, the central courtyard aids in the air movement. Cross ventilation is supported by windows and jaalis.

Figure 3.7: Ventilation
(source: https://nzeb.in/wp-content/uploads/2015/10/passive_IPB1.jpg)

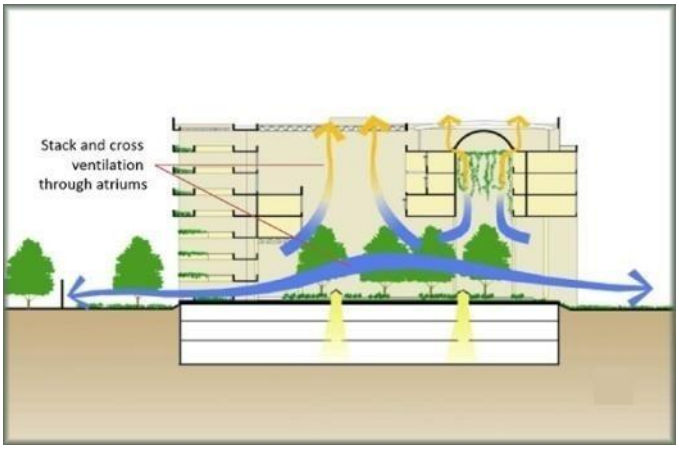


Figure 3.8Stack effect
(Source:https://nzeb.in/wp-content/uploads/2015/10/passive_IPB2.jpg)

Figure 3.9:Cross ventilation through jails
(Source:Author)

➢ **Building Envelope and Fenestration**

- Optimized building envelope -window installation (U-value 0.049 W/m2K), VLT 0.59, SHGC 0.32
- Double-glazed, hermetically sealed windows made of UPVC with low thermal transmittance glass Insulation made of rock wool
- High-efficiency glass
- Cool roofs: use of highly reflective terrace slabs for heat absorption, high resistance, durable

Figure 3.10:Fenestrations with double glazing
(Source:Author)

Figure 3.11:Door with high efficiency glass
(Source:Author)

Figure 3.12:Terrace garden with high reflective tiles
(Source:https://mnre.gov.in/file-manager/akshay-urja/november-december-2014/EN/26-31.pdf)

- **Materials and construction techniques**

- AAC blocks with fly ash
- Plaster and mortar based on fly ash
- Jaalis made of stone and ferrocement
- Floor coverings made of local stone
- Doors, frames and flooring made of bamboo-jute composite material
- High-efficiency glass, high VLT, low SHGC and low U-value, optimized by appropriate shading

- - Light shelves for diffuse sunlight (USAID, net zero energy building)

Figure 3.13:Stone and Ferro cement jails
(Source:Author)

Figure 3.14:Stone Jalis
(Source:Author)

Figure 3.15:Stone jalis providing cross ventilation through staircase
(Source:Author)

Active Design Strategies

- **Lighting Design**

- An energy-efficient lighting system (LPD = 5 W / m2) reduces energy consumption even further because it is over 50% more efficient than the requirements of the Energy Conservation Building Code 2007 (LPD = 11 W / m2).
- Building integrated photovoltaic (BIPV) supplies the remaining lighting load.
- Using T5 bulbs and other energy-efficient lighting fixtures.
- Making use of the lux-level sensor to enhance the performance of artificial lighting.

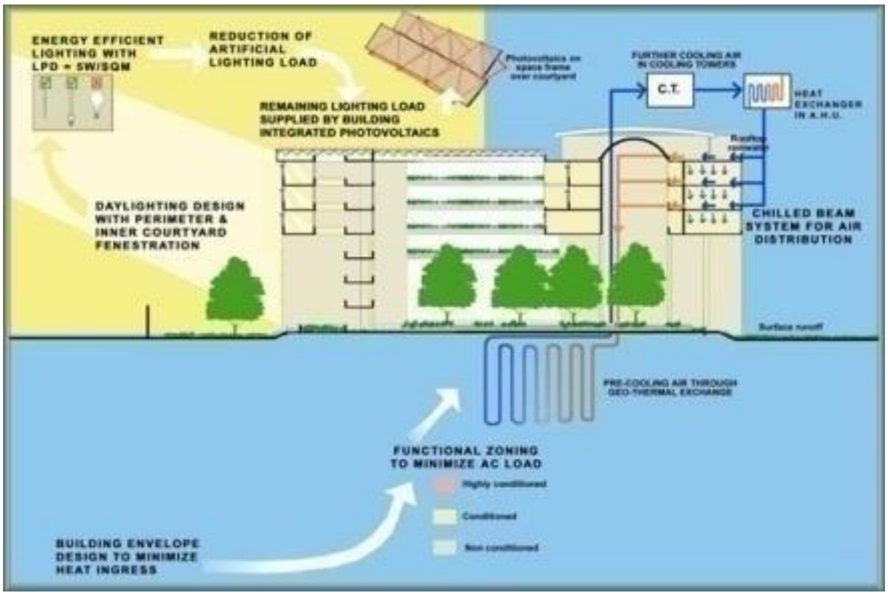


Figure 3.16:Lighting system Of paryavaran bhawan
(Source: https://nzeb.in/wp-content/uploads/2015/10/Active_IPB1.jpg)

- **Optimized Energy Systems / HVAC system**
  Chilled beam system/ VFD/ Screw Chillers

- A chilled beam system handles 160 TR of the building's air conditioning load. From the second to the sixth floor, a chilled beam is used. Compared to a conventional system, this system uses 50% less energy.
- The HVAC load for the building is 40 m2/ TR, which is about 50% more efficient than the ECBC requirements (20 m2/ TR). Chilled water is supplied at 16°C and returned at 20°C.
- The chilled beams are equipped with drain pans to remove water droplets caused by condensation during the monsoon.
- Dual-skin air handling units, chillers, and chilled beams with variable frequency drives (VFDs) that reduce fan power consumption by 50 kW each.
- VFDs on AHUs, cooling tower fans and chilled water pumps.
- Using a sensible and latent heat recovery wheel to pre-cool fresh supply air with toilet exhaust air.
- Control of all systems and HVAC equipment via a comprehensive building management system.

- Use of functional zoning to reduce air conditioning demand. The space is maintained at 26 C plus or minus one.

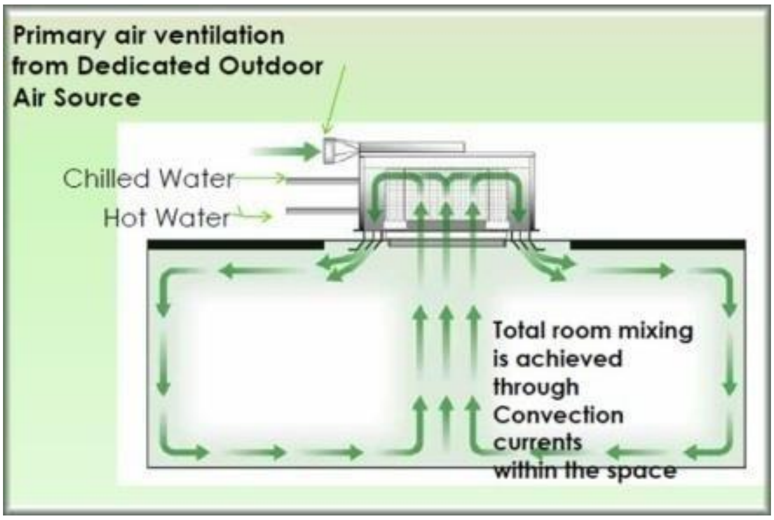


Figure 3.17:HVAC system of Paryavarn Bhawan

(Source:https://nzeb.in/wp-content/uploads/2015/10/Active_IPB2.jpg)

Figure3.18:Chiller Beams

(Source:https://nzeb.in/wp-content/uploads/2015/10/Active_IPB3.jpg)

➢ **Geothermal heat exchange system**

- There are 180 vertical boreholes with a depth of 80 meters on the entire site of the building. A minimum distance of 3 meters must be maintained between two boreholes.
- Each borehole is equipped with a U-loop HDPE pipe (32 mm outer diameter) and a bentonite mud grout. Each U-Loop is connected to the condensate water piping system in the central air conditioning room.
- One U-Loop has a heat rejection capacity of 0.9 TR. Without the use of a cooling tower, a heat release of 160 TR is achieved (USAID, Net zero energy building).

Renewable Energy

- pV solar plant with a power of 930 kW, 6000 m2 total area, 4650 m2 panel area and a total of 2844 panels.
- 14.3 lakh energy units are generated annually
- Actual production on site as of January 25, 2014
- Achieved power generation: 300 kWh per day - power injection to the grid started on November 19, 2013

- Total generation : 2.0 kWh(USAID, Net zero energy building)

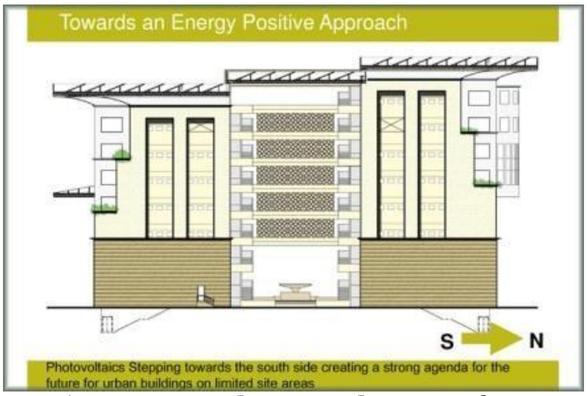


Figure3.19:Solar panels on rooftop

(Source:https://nzeb.in/wp-content/uploads/2015/10/RE_IPB2.jpg)

Figure3.20:Solarpanels

(Source:https://nzeb.in/wp-content/uploads/2015/10/RE_IPB1.jpg)

Figure 3.21:Terrace Covered with solar panels

(Source:author)

Water Efficiency

- A water-efficient site also benefits from landscaping and site management, which can reduce water use for landscaping by up to 50% through the use of native plants and effective irrigation systems.
- The building's water use has been reduced through the use of water-efficient fixtures, recycling, reuse of wastewater from the building, and rainwater harvesting.
- The focus in this case is not only on water efficiency, but also on effective water management on the site and zero runoff, meaning that no water is discharged into the city's stormwater or wastewater systems.
- The excavation had to be extensively dewatered due to the high water table of 9 m; the extracted water is reinjected into the ground 250 m from the site.
- The New Delhi Municipal Corporation (NDMC) receives regular, free supplies of this extracted water to supplement the city's water supply (Prashad & Chetia, 2014).

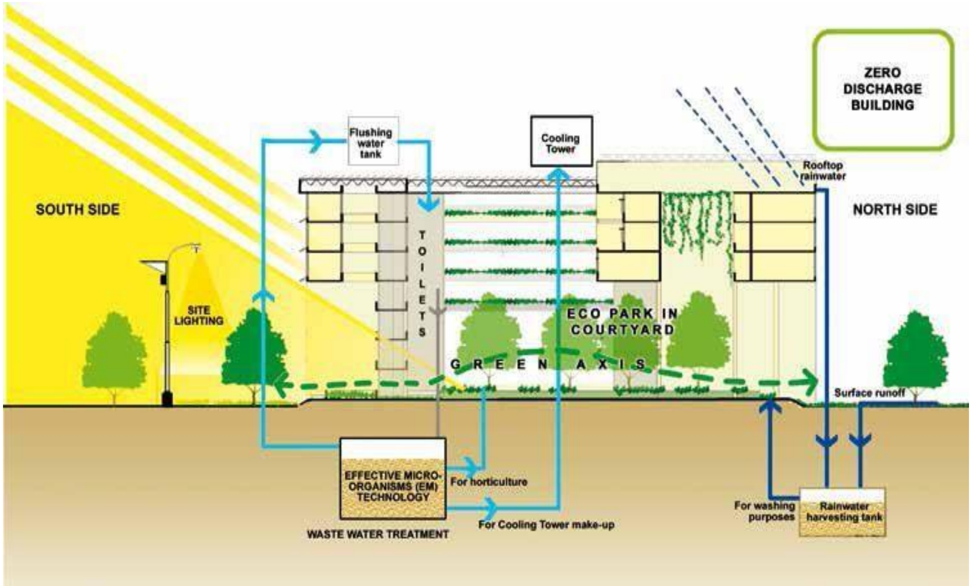


Figure 3.22:Efficient water use and reuse in cycle in Paryavarnbhawan
(Source:https://mnre.gov.in/file-manager/akshay-urja/november-december-2014/EN/26-31.pdf)

Major Design Interventions

- Another important design intervention planned by the planning team was zero tolerance for surface parking.
- A state-of-the-art, three-story parking garage with preferred parking for CNG/electric vehicles and carpools during office hours is planned to handle peak traffic.
- The building is also designed to have a direct, preferred entrance at the front, creating a 'pedestrian priority." vehicles enter the basement from the side and must back up.
- Instead of the usual concrete lawn grids, a large number of polymer plastic grids are installed, making the surface completely soft, resulting in less surface runoff and better infiltration of water.
- A lower contribution of the building to the Urban Heat Island (UHI) effect is another tangible benefit of the lower paved area. The UHI effect leads to an overall increase in temperature in highly urbanized/paved areas due to the absorption and re-radiation of solar heat on hard surfaces (Prashad & Chetia, 2014).

Figure 3.23:Soft paved space made of polymer plastic grids
(Source:https://mnre.gov.in/file-manager/akshay-urja/november-december-2014/EN/26-31.pdf)

Some of the other significant design measures include:

- Window shading design is appropriate for the entire building, and reducing the window-to-wall ratio helps reduce heat gain and necessitates the use of high-efficiency glass.
- Window shading and patio openings are designed to reduce heat gain in the summer while allowing winter sun to pass through. Most of the windows and living areas are located on the outer periphery, allowing good daylighting and views of the scenic surroundings from most office spaces.
- A large number of spaces, including passages and lobbies, have been developed as non-air-conditioned spaces provided by stone jalis for natural cooling and shading (Prashad & Chetia, 2014)

Figure 3.24L:Brown and beige coloredjalis coveringthe vertical movement cores

(Source:https://mnre.gov.in/file-manager/akshay-urja/november-december-2014/EN/26-31.pdf)

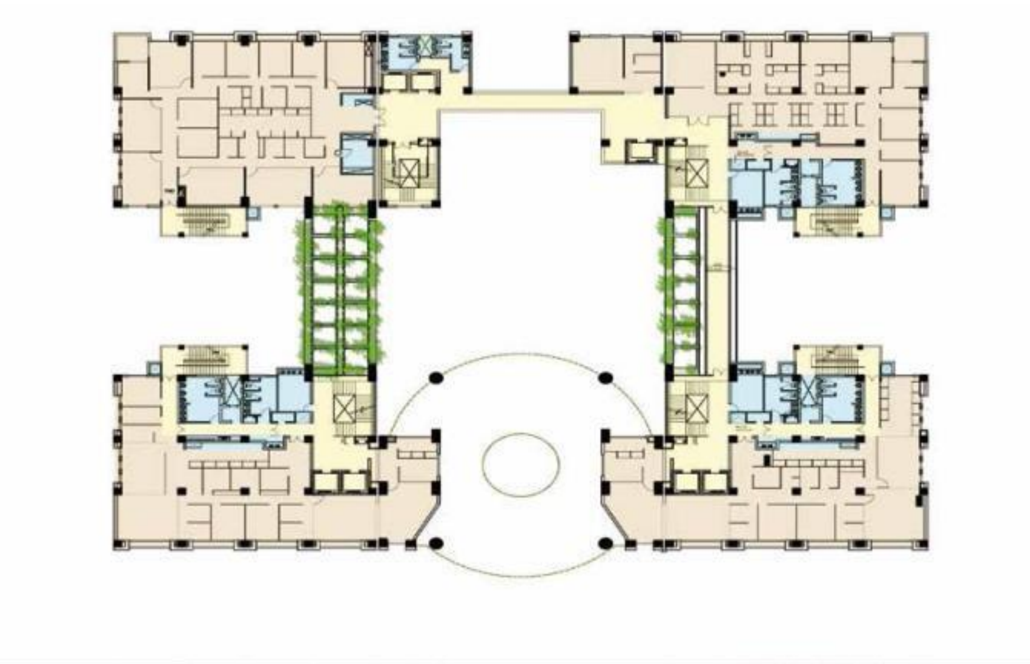


Figure 3.25:The shaded and vegetated passages in one of the upper floor plans

(Source:https://mnre.gov.in/file-manager/akshay-urja/november-december-2014/EN/26-31.pdf)

Other measures promoting energy-efficient systems include:

- To improve the process of artificial lighting, use the Lux level sensor.
- Integrated Building Management System (IBMS) designed to manage energy consumption, monitor performance, etc.

- High-efficiency Cast Resin Dry Electric substation transformers. DG sets for generating captive energy.
- Regenerative lifts that in the course of their service often generate some energy.
- Complete generation of hot water by solar hot water heating system.
- Shared use of facilities for the workplace.
- Promotion of use within the building of BEE-rated appliances.
- Use of ' thin client ' systems that only supply end-user terminals with common servers for terminal groups. This greatly reduces the power consumption of separate computer CPUs.
- Solar-powered external lighting.
- The terrace garden utilizes preserved top soil extracted during the initial excavation.
- Due to existing water bodies and landscaping, temperature differences could be observed below atrium and indoor common area (Prashad & Chetia, 2014).

Figure 3.26:Terrace garden

(Source: https://mnre.gov.in/file-manager/akshay-urja/november-december-2014/EN/26-31.pdf)

Figure 3.27:Water Bodies in the inner courtyard
(Source:Author)

Figure 3.28:Water bodies and fountrains providing thermal comfort
(Source:Author)

ITC Green Centre

- Location: Sector 32, Institutional Area 10, Gurgaon, India
- Footprint: 1 70,000 square feet (15,793 square metres) Rajender Kumar & Associates, an Indian architectural firm Significance: Platinum Award-winning green building

About ITC

- India's most profitable companies with US$ 10 billion in market capitalization.
- ITC's core businesses, including products and brands.
- FMCG - Cigarettes, Branded Packaged Foods, Lifestyle Retailing, Greeting, Gifting and Stationery.

- Hotels
- Paperboards, Specialty Papers and Packaging
- Agri Business (Khatri)

Energy consumption Statistics

- ITC Green Centre - 20,00,000 kWh/year - Conventional building of similar area - 35,00,000 kWh/year - Annual energy savings Rs. 9 million
- An increase of 15% in initial costSocial and environmental commitment of ITC
- ITC is committed to minimising the environmental impact of its direct and indirect operations.
- "Water Positive," "Zero Water Discharge & Solid Wastes Corporation" (Khatri); "Carbon Positive" Corporation, which has succeeded in sequestering the carbon dioxide released by its activities through the use of environmentally friendly fuels, renewable energy and extensive reforestation
- The first difficulty was sourcing environmentally friendly building materials from sustainable forestry, such as low volatility organic compounds and green wood, which were not readily available in the country at the time. in order to sensitise ITC design and architectural consultants and workers to the importance of environmental protection, numerous energy awareness programmes had to be conducted (Khatri)
- During the design of the project, care was taken to drastically reduce energy consumption compared to a standard building. The integration of the design alone reduced the ITC Green Centre's energy consumption by up to 51%.The building's glazing was designed to maximise the effect of natural light and largely eliminate the need for artificial lighting. While the window glass allows light inside, it also prevents heat from entering.
- ITC was able to achieve the dual proposition of letting in plenty of natural light while increasing interior energy gain (Khatri) by using the latest high-performance glazing systems.Design Goals
- A facade with high energy efficiency and ideal light transmission.
- Green building principles emphasise sunshine (natural lighting) and unobstructed views, as both are associated with quality human health. On the north side, the orientation of the building required a glass solution to allow for better light transmission. The only element that can help meet these criteria is glass.

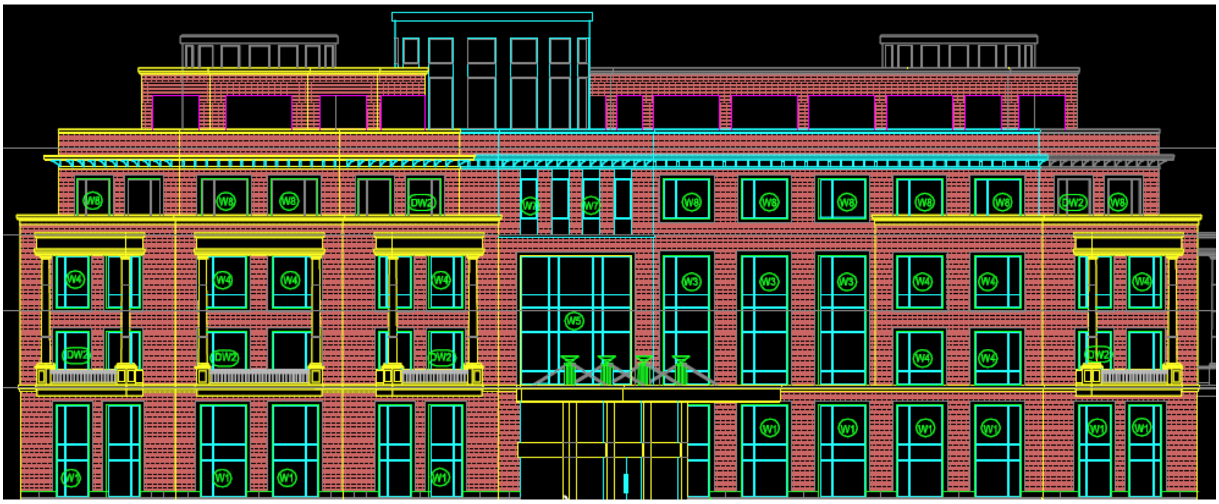


Figure 3.29:Building elevation

(Source:http://www.glazette.com/upload/resources/tb_90520091157467157.PDF)

Building Design

- ‘The design of ' L ' shape reduces floor plate size.
- The building is a composition of three parts:
- A central atrium brings two office wings together, which as an ensemble creates a large L-shaped figure centered on an outdoor landscaped court.
- The blocking of the L-shape ensures that part of the façade is always shaded.
- The wings of the L-shape office end in hexagonal ends that make the approach roads a very strong presence.

Figure 3.30:Site plan of ITC Green centre

(Source:http://www.glazette.com/upload/resources/tb_90520091157467157.PDF)

Figure 3.31:Floor plan of ITC green centre

(Source:http://www.glazette.com/upload/resources/tb_90520091157467157.PDF)

- The atrium unites the various uses of the building and connects them into a cohesive whole that encourages interaction and a sense of community.
- To naturally light the interior without directly heating the roof, the octagonal atrium has sidelights from above.
- Shutters on the inside to reduce heat gain (Khatri).

Analysis of selected Buildings

Table 3.1: Analysis of buildings)

PARAMETERS	INDIRA PARYAVARAN BHAWAN	ITC GREEN CENTRE
PASSIVE STRATEGIES		
ORIENTATION	• NS oriented • Seprate block connected by corridors • Optimal WWR	• NS oriented • Two office wings are held together by a central atrium • Optimal WWR
LANDSCAPING	• More than 50% plantation • Circulation roads and pathways soft paved	• Hardscaping
DAYLIGHTING	• 75% of building floor space is day lit • Inner courtyard serves as a light well	
VENTILATION	• Central courtyard provides natural ventilation due to stack effect. • Windows and jaalis add to cross ventilation	
BUILDING ENVELOPE AND FENESTRATION	• Window assembly (U-Value 0.049 W/m^2K),VLT 0.59, SHGC 0.32 • uPVC windows with hermetically sealed double glazed using low heat transmittance index glass • Rock wool insulation • High efficiency glass • Cool roofs: Use of high reflectance terrace tiles for heat ingress, high strength, hard wearing.	• U value 1.9 w/m2 K • Glass by Saint Gobain • No uPVC windows • No cool roofs.

MATERIAL AND CONSTRUCTION TECHNIQUES	• AAC blocks with fly ash • Fly ash based plaster & mortar • Stone and Ferro cement jaalis • Local stone flooring • Bamboo jute composite doors, frames and flooring • High efficiency glass, highVLT, low SHGC & Low U- value, optimized by appropriate shading • Light shelves for diffused sunlight	• AAC blocks 55% Flyashcontent PortlandPozzolana cement Ready Mix Concrete (RMC) • Fly ash (3.36%) • Medium Density Fibre board (MDF) 85% rapidly renewable materials (eucalyptus which is grown with in ten years life cycle) 15% recycled material
TERRACE GARDEN AND WATER BODIES	• The terrace garden utilizes preserved top soil extracted during the initial excavation • Water bodies in centralcourtyard	

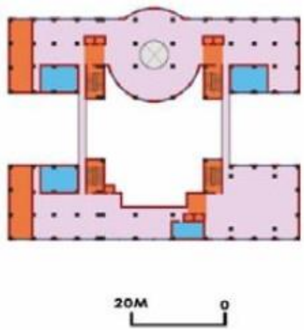
PARAMETERS	INDIRA PARYAVARAN BHAWAN	ITC GREEN CENTRE
ACTIVE STRATEGIES		

EFFICIENT LIGHTING DESIGN	• Energy efficient lighting system • Building integrated photovoltaic (BIPV) • Use of energy efficient lighting fixtures (T5 lamps) • Use of lux level sensor to optimize operation of artificial lighting	• Energy efficient lighting system • No BPV • T5 lamps with electronic ballast, high efficient luminaires) • No lux level sensors
OPTIMIZED ENERGY SYSTEMS/HVAC SYSTEMS	• Chilled beam system/ VFD/ Screw Chillers • Geothermal heat exchange system	• No chilled beam system • CO^2 monitoring systems in AHU
RENEWABLE ENERGY		
SOLAR PV SYSTEM	• Solar PV System of 930 kW capacity • Total Area of panels : 4650 m^2 • No of panels : 2,844	
WATER EFFICIANCY	• Zero water discharge • Extracted water supplied to NDMC	• Zero water discharge

CHAPTER- 4
DATA ANALYSIS

4. DATA ANALYSIS

Table 4.1: Comparative Data Analysis

Parameters		
	ITC Green Centre, Gurgaon	IPB, New Delhi
Year of completion	2004	2014
Significance	Platinum-rated by LEED 52/69	Platinum-rated by LEED Five star-rated by GRIHA
Open plan/Cellular office	60% Cellular office + 40% Open plan	Open + Cellular
<u>Building configuration</u>		
Orientation	Long axis of the building oriented NE–NW	N–S orientation
Placement of core	Central, East, and West	Central and West
Typical floor area (m2)	2047	3150
Total floor area (m2)	15,799	31,400
No. of floors	6 (2B + G + 5)	8 (G + 7)
Floor-to-floor height (m)	3.6	3.9
Plan depth (m) overall	24	15
<u>Window parameters</u>		

Overall WWR (%)	33	20
Shading device	Few windows shaded with horizontal louvers	Box
Sill level (m)	0.3	0.8
Window height (m)	2.1	1.8
Building envelope materials		
Wall assemblyU-value in W/m2K	250-mm AAC block with 70-mm stone cladding and 12.5-mm plaster inside U-value: 0.607	AAC block masonry wall and fly-ash-based plaster and mortar U-value: 0.34 Stone and ferrocement jaalis used in the circulation area
Roof assemblyU-value in W/m2K	120-mm RCC roof with a 76-mm ISO board in the interior U-value: 0.335	150-mm RCC slab with insulation and local stones U-value: 0.5
Glazing type U-value in W/m2K	Double-glazing window (6-12-6), SC = 0.26, and U-value = 1.81 W/m2K	Double-glass windows with a high efficiency, visible light transmission (VLT = 0.59), and U-value (0.049) Light shelves for allowing the entry of diffused sunlight
Occupancy& energy consumption		

Working hours	9am-5pm(per day) 48 hours per week Sunday closed	09am–10:30 pm (5 days per week) 42.5 hours a week Saturday and Sunday closed
HVAC type and capacity ECBC recommends COP: 5.4	Central, 2850 kW capacity, 18 m2/TR COP: 6.1	Chilled beam system of HVAC, geothermal technology for heat rejection, 563 kW capacity, 45 m2/TR COP: 6.7
Lighting fixtures	T5 and CFL lamps (daylight sensors)	Light shelves, T-5, and LED fixtures (daylight sensors)
LPD ECBC recommends 10.8 W/m2	7.2 W/m2	5 W/m2
HVAC performance index (kWh/m2/year)	64	27
Renewable energy (kWp)	Photovoltaic cells for emergency lighting	930 kWp SPV panels

(Source: Author)

CHAPTER- 5
STIMULATION

5. SIMULATION

The sun path diagram

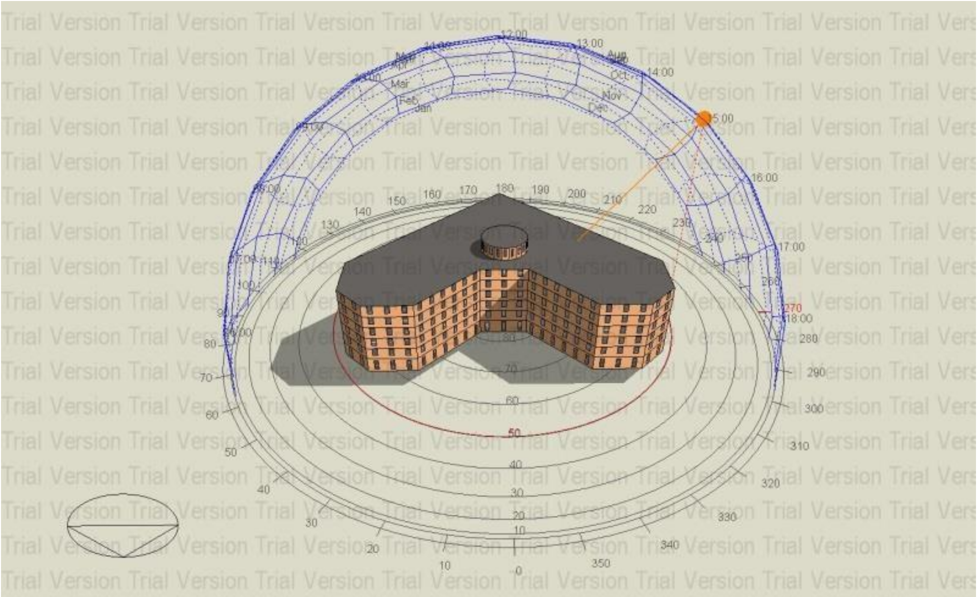


Figure 5.1:Sunpath
(Source:Designbuilder)

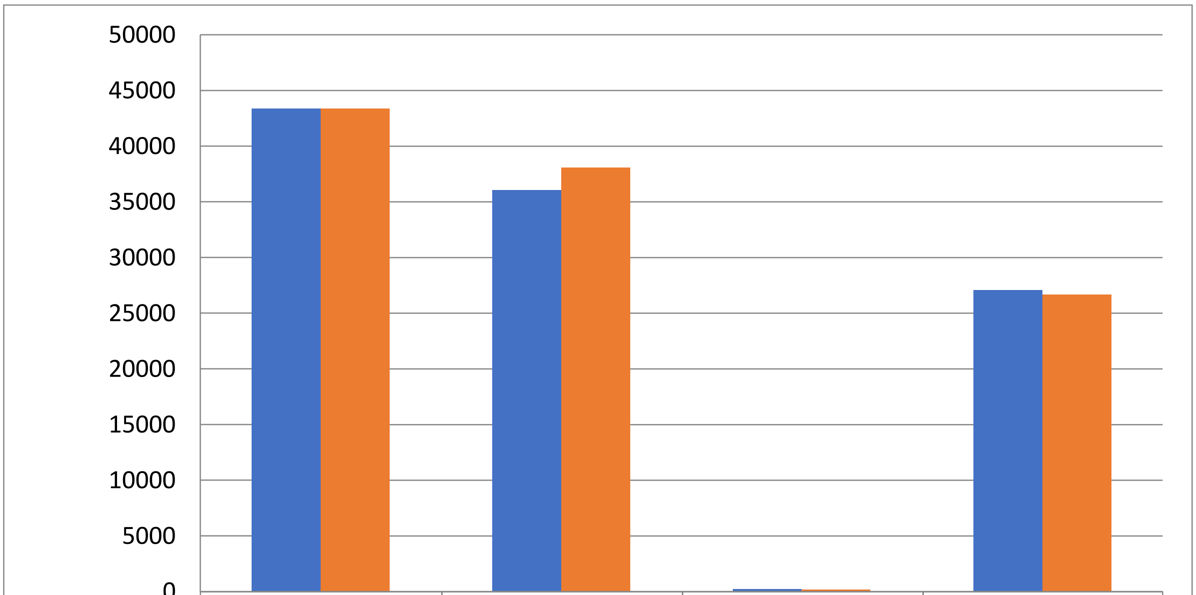
Energy Performance analysis

Window Glazing

Pre-Retrofit of Window Glazing

Glazing type-Double Glazing Window(6-12-6)

U-value -1.81W/m2k

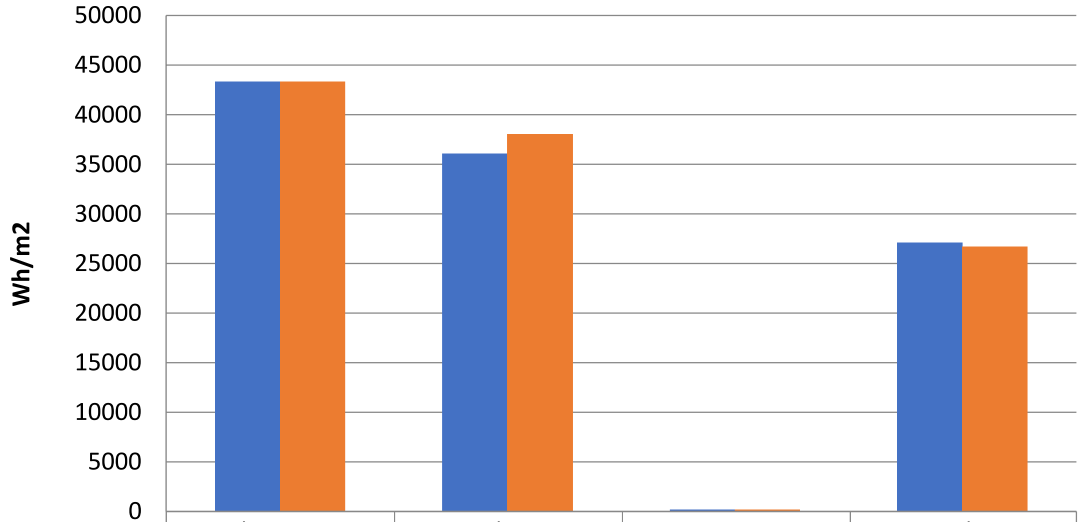


	Electricity	Lighting	Heating	Cooling
WWR 33%	43342.98	36057.33	181.51	27090.23
WWR 20%	43342.98	38028	157.37	26670.75

Post-Retrofit of Window Glazing

Glazing type-Double Glazing Window(6-13-6)

U-value -0.049 W/m2k



	Electricity	Lighting	Heaing	Cooling
WWR 33%	43342.98	36057.33	182.57	27073.6
WWR 20%	43342.98	38028.1	157.37	26670.75

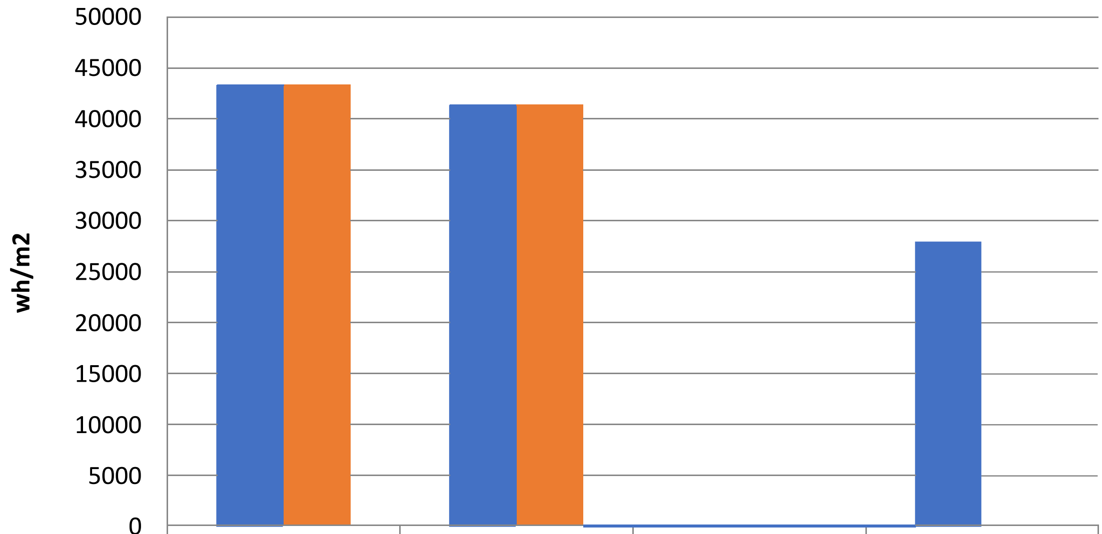
Lighting Fixtures and Window Glazing

Pre-Retrofit of Window Glazing and lighting fixture

Glazing type-Double Glazing Window(6-12-6)

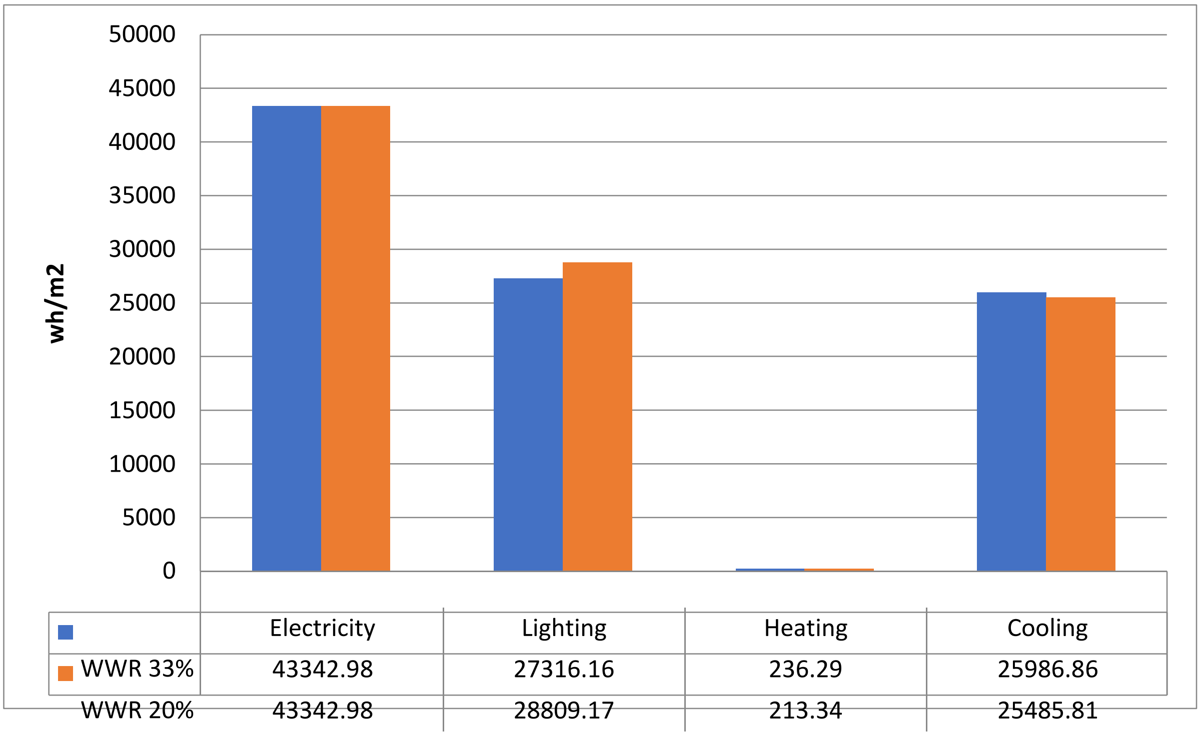
U-value -1.81W/m2k

Lighting Fixture-T5 CFLS



	Electricity	Lighting	Heating	Cooling
WWR 33%	43342.98	41342.4	199.38	27959.6
WWR 20%	43342.98	41342.98	181	2.8

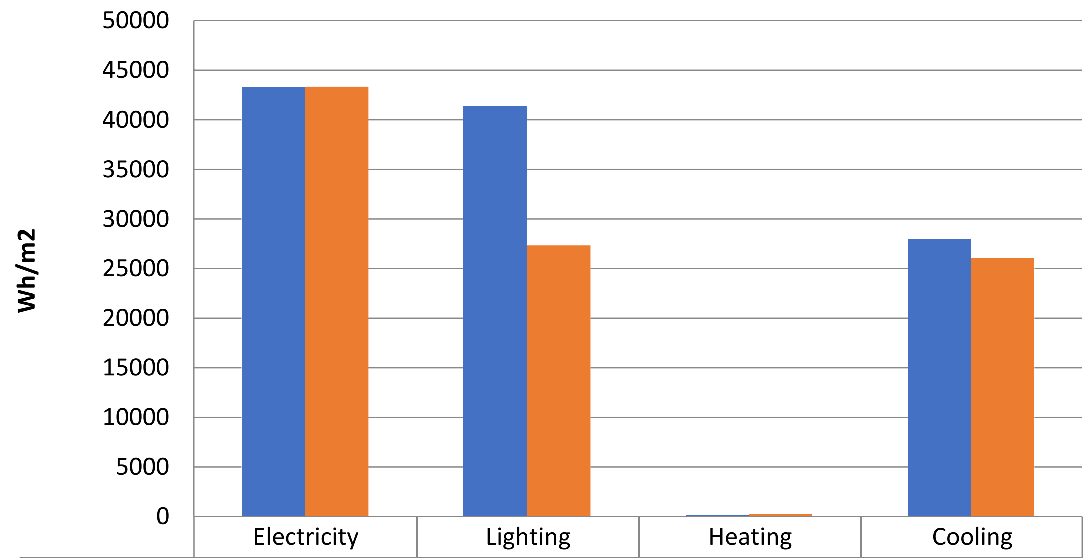
Post-window retrofit glazing and a light source
Window with double glazing (glazing type: 6-13-6) 0,049W/m2k as U-value
Lighting Fixture-LEDS



WWR- It has been observed that a low WWR reduces the cooling load by reducing WWR from 33% to 20% along with the retrofitting in window glazing material and lighting fixtures. It also decreases the amount of natural light within the building, which raises the cost of lighting and heating. The case study indicates that by reducing the WWR to 20%,the increase in lighting load is much higher then the amount of reduction in cooling load. Therefore WWR should be kept 33%.

WWR 33%

- Window glazing and lighting fixtures before renovation
- Double-glazed windows (6-12-6) with a U-value of -1.81/m2k
- T5 CFLS luminaire
- Window glazing and lighting fixtures after retrofitting
- Double-glazed windows (6-13-6) with a U-value of -0.049/m2k glazing
- LED lighting



	Electricity	Lighting	Heating	Cooling
Pre-Retrofit	43342.98	41342.4	199.38	27959.6
Post Retrofit	43342.98	27316.16	236.29	25986.86

The annual energy consumption for lighting of the present building model is 121301 kWh. With glazing (windows) with SC values of 0.26 and 1.81W / m2 K, the WWR of the present building is 33%. Using building simulation, it was found that the reduction in electricity consumption is 7% due to reduction in cooling load and 33.9% due to reduction in lighting load after replacing the glazing (window) glass material with U-value of 0.049 as used in the building (Indira paryavarn Bhawan) used as a benchmark.

It was found that the total electricity consumption for lighting and cooling was reduced by 5.64% after replacing the lighting fixtures (T5 and CFLs) and glazing material of windows (U-value-1.81/m2k) in the existing building model with the lighting fixtures (LED and T8 lamps) used in the comparison building.

CHAPTER- 6

CONCLUSION

6. CONCLUSION

Most of the indoor and outdoor lighting systems used T5 fluorescent tubes. The development of LED (Light Emitting Diode) has continued to push the boundaries of lighting technology, although T5 lighting has historically been considered a relatively energy efficient option.

The building's current lighting consumption was reported at 121301 kwh per year, but dropped to 80179.97 kwh after the installation of LED in November 2019. This represents a 33.9% reduction in energy consumption based on office use.

The lighting retrofitting saved 41121.03kwh of power in a year as compared topre-retrofit settings.

CFL Watts	LED Watts	Lumens(Brightness)
8-12	6-9	400-500
13-18	8-12.5	650-900
18-22	13+	1100-1750
23-30	16-20	1800+
30-55	25-28	2780

Figure 6.1:CFL's used in commercial building's

(Source: https://www.htgsupply.com/products/growbright-4-foot-1-lamp-high-output-t5/#configuration)

Figure 6.2:LED's

(Source:http://www.aialedlighting.com/sale-8252050-panel-modern-indoor-commercial-office-12w-led-pendant-light-showroom-used.html)

CHAPTER- 7
RECOMMENDATION

7. RECOMMENDATION

Parameters	Pre retrofit	Post retrofit	% in reduction
Annual consumption Cooling	596829KWh	555051KWh	7%
Annual Consumption Lighting	121301KWh	80179.97KWh	33.9%
Total Reduction in Electricity consumption	1469307	1386407.97KWh	5.64%
Total reduction in EPI	93	87.75	5.24

The energy efficiency index (EPI), measured in kwh / m2/year, is widely used to understand a building's energy use. The EPI is calculated by dividing the total annual energy consumed by a building in kilowatt hours by the building's floor area in square metres. EPI is expressed as follows:

$$EPI=\frac{Total\ Energy\ Consumed\ in\ a\ ye(kWh)}{Total\ Floor\ Area\ of\ the\ buildi(m2)}$$

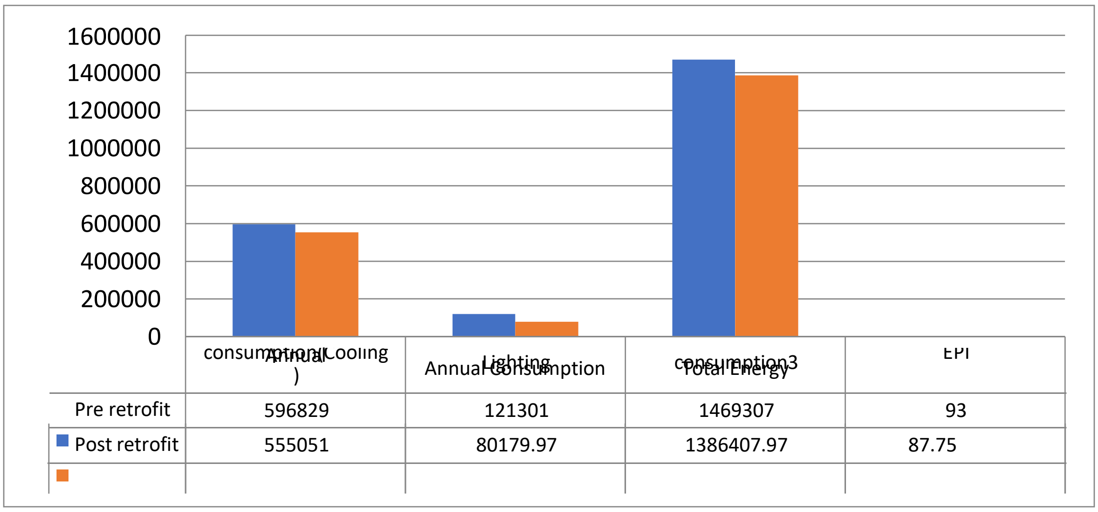
EPI of existing building =93

Reduction in energy consumption through lighting and cooling load=40.9% *i.e*82899.03kWh

Reduction in total energy consumption of building=1469307 – 82899.03 kWh

=1386407.97kWh

Suggested EPI of proposed model will be=87.75



CHAPTER- 8

SITE ANALYSIS

8. SITE ANALYSIS

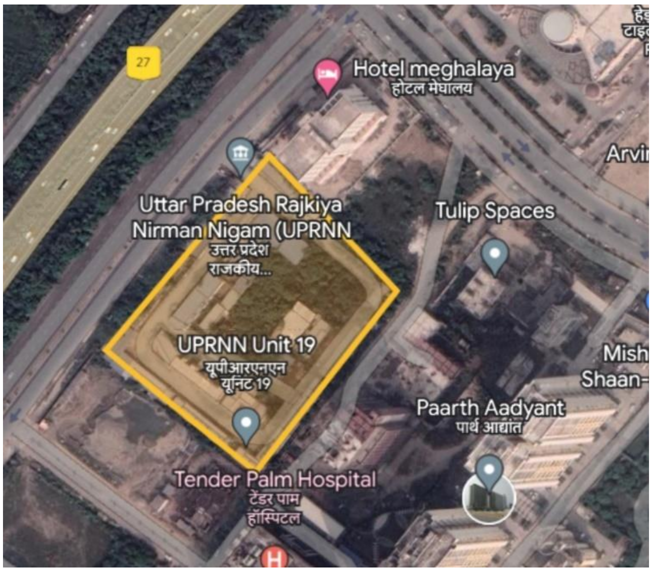
SITE INTORDUCTION

- **:** The site is located in the heart of Uttar Pradesh in the capital Lucknow it is situated right next to Shaheed Path

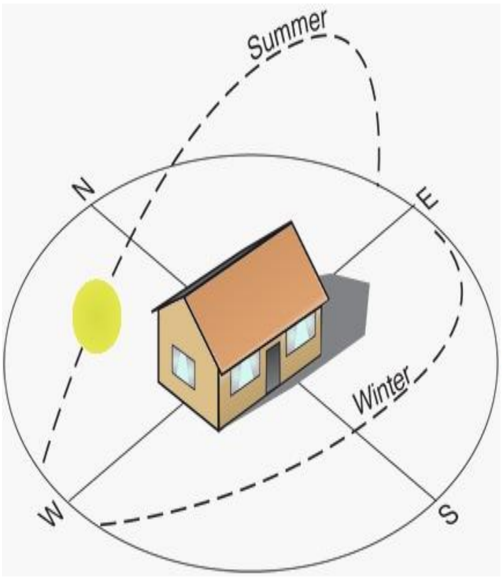
- **Site area : 16187.42 sqmt.**
- **Topography:** The site has plain terrain with no contours. The soil is alluvial

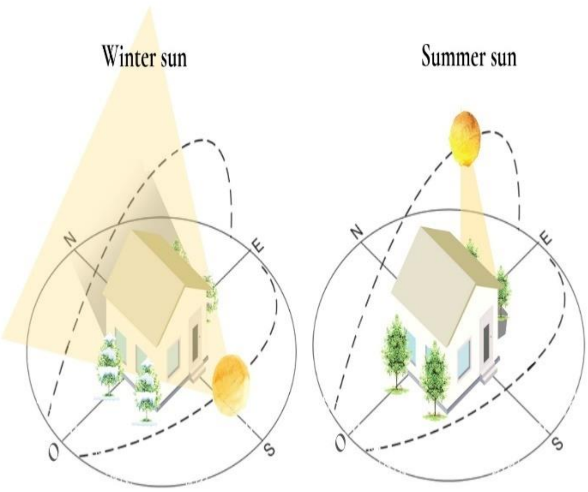
- **Road and accessibility:** The site is well connected through roads. On the front there is service lane accompanying Shaheed Path .On the adjacent there is road connectivity as well .The site is easily accessible from chief points via Shaheed Path the airport is about 20 min (16km) drive from the site. The railway station is about 25 min (15km) drive from the site. The bus station is about 15 min (10 km) drive from the location.

- **Building Type:** The site is surrounded by both government and private projects. On the left there is the proposed office of NHAI. On the right there is Hotel Meghalaya. On the back there is Tender Palm Hospital



- **Direction:** The site is facing the west side with Shaheed Path right in front of it. In the north there is Hotel Meghalaya. In the south there is proposed site of NHAI. In the east there is Pearl view apartment





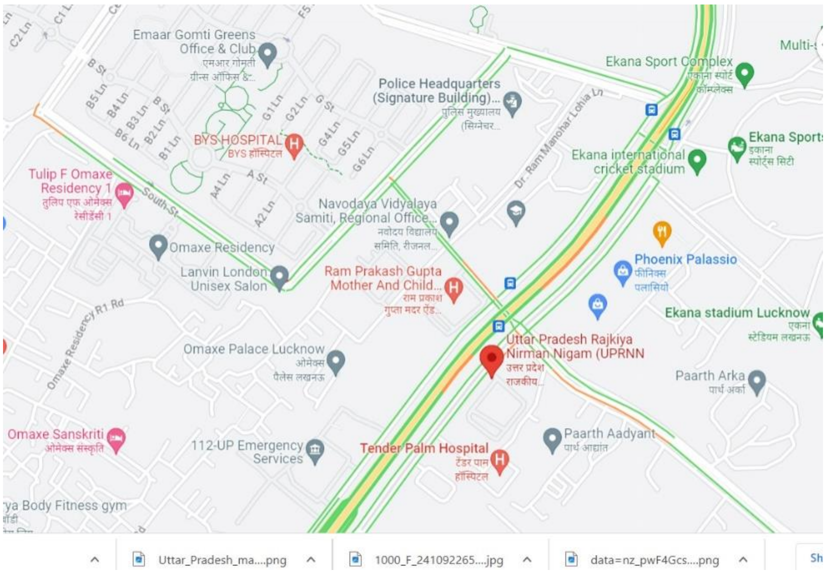
- **Nearby Places :**The site is well surrounded by chief landmarks like

  Police headquarters

  Ekana sports city

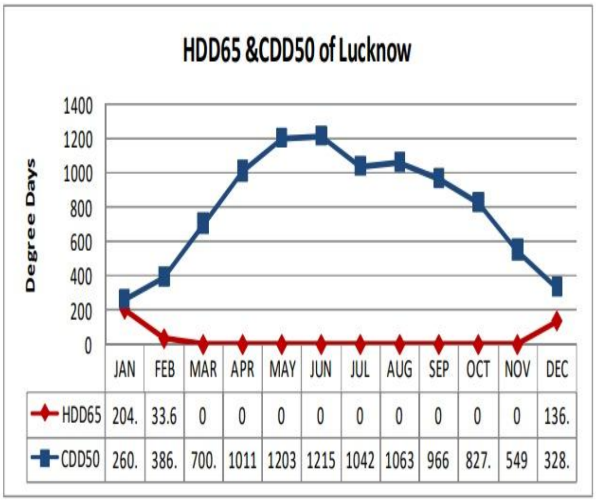
  Phoenix Palassio mall

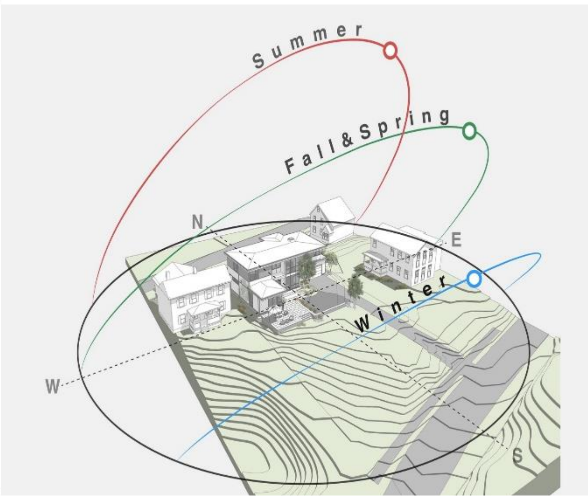
  Child Hospital RML

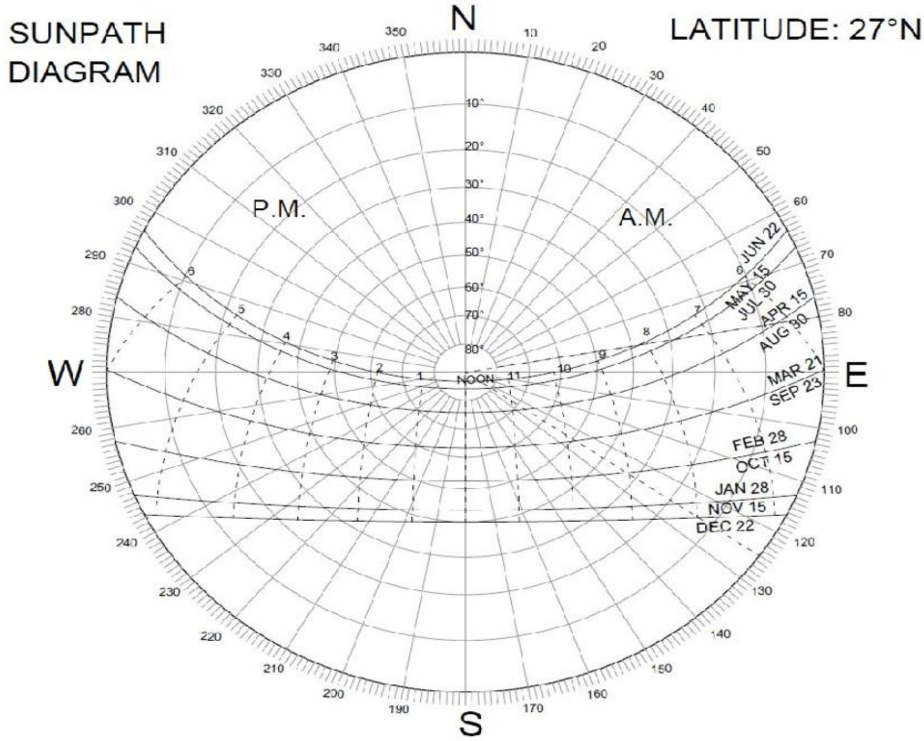


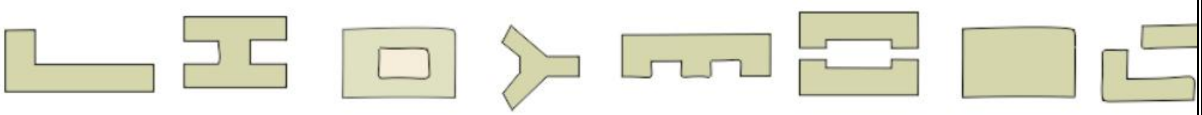
- **Utility Resources:** The site is well connected and supplied with electricity water and sewage. On the front there is huge drain for proper drainage of the site. There are electricity poles at an interval of every 50metres.

- **Climate and Vegetation :**The climate is hot and dry. The site is having light vegetation with some shrub and babool trees

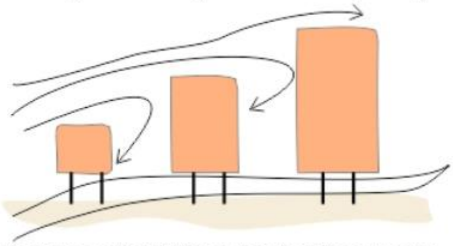




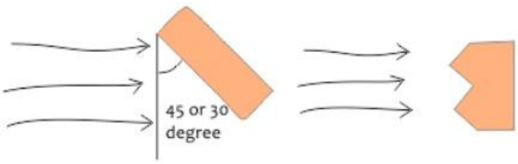




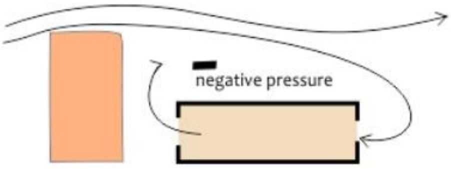
Orient longer facades along the north. This will provide glare free light in summer from north without shading and winter sun penetration from the south



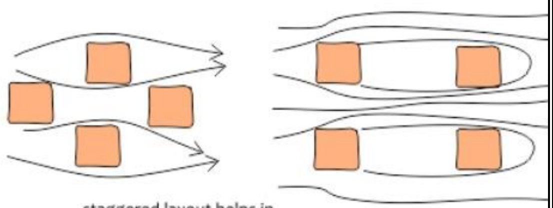
if a site has multiple buildings, they should be arranged in ascending order of their heights and be built on stilts to allow ventilation



Place buildings at a 30 or 45 degree angle to the direction of wind for enhanced ventilation. Form can be staggered in the wind facing direction also to achieve the same result.



Taller forms in the wind direction of prevailing wind can alter the wind movement pattern for low lying buildings behind them



staggered layout helps in accentuating wind movement

Summary: 8 Climate Misses of NZE

Drawbacks of NZE buildings	Climate downside	Solution
They use energy at the wrong time	NZEs draw from the grid when the carbon intensity of energy is at its highest.	Apply energy-efficiency measures and passive design to shift when NZEs rely on the grid.
They lack the flexibility to shift loads in real time	High peak loads on the grid require the operation of dirty "peaker plants."	Equip buildings with thermal storage, battery storage and/or smart appliances that can participate in demand-response programs.
They supply energy to the grid at the wrong time	Exporting renewable energy when the grid is already clean could contribute to curtailment and has a small impact on carbon emissions.	Consider east-west racking for PVs, and use batteries to store clean energy when emissions are low and to discharge when emissions are high.
They make electrification more expensive	Adding demand during peak hours requires infrastructure upgrades, which drives up electricity rates and disincentivizes further electrification.	Make sure electrified end uses—like heat pumps, water heaters, and vehicle chargers—can respond to grid signals.
They are not resilient to power outages	Fossil-fuel-powered generators have high emissions and perpetuate the need for fossil-fuel supply lines.	Design for passive survivability and install battery backup systems.
They don't account for transportation energy	Suburban developments, while optimal for onsite PV, correlate with occupants driving longer distances, causing higher transportation emissions.	Include transportation energy in carbon accounting and install EV charging infrastructure.
They use more embodied carbon	As the grid gets cleaner, some efficiency upgrades (like thicker walls with more insulation) will emit more carbon in embodied energy than they'll save in operational energy.	Prioritize building reuse, choose low-embodied-carbon materials, and study carbon trade-offs.
They don't serve the collective	More carbon emissions might be avoided through electrification and strategic, offsite PV siting.	Consider how best to run the building as a good grid citizen.

CHAPTER- 9

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9. REFERENCES

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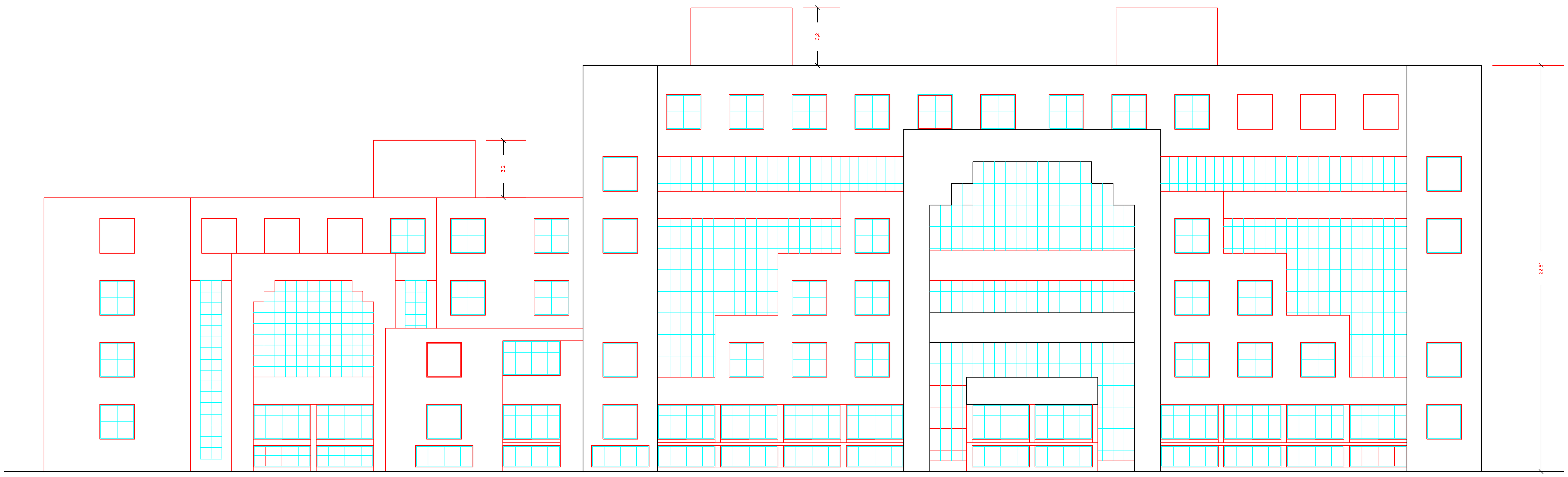
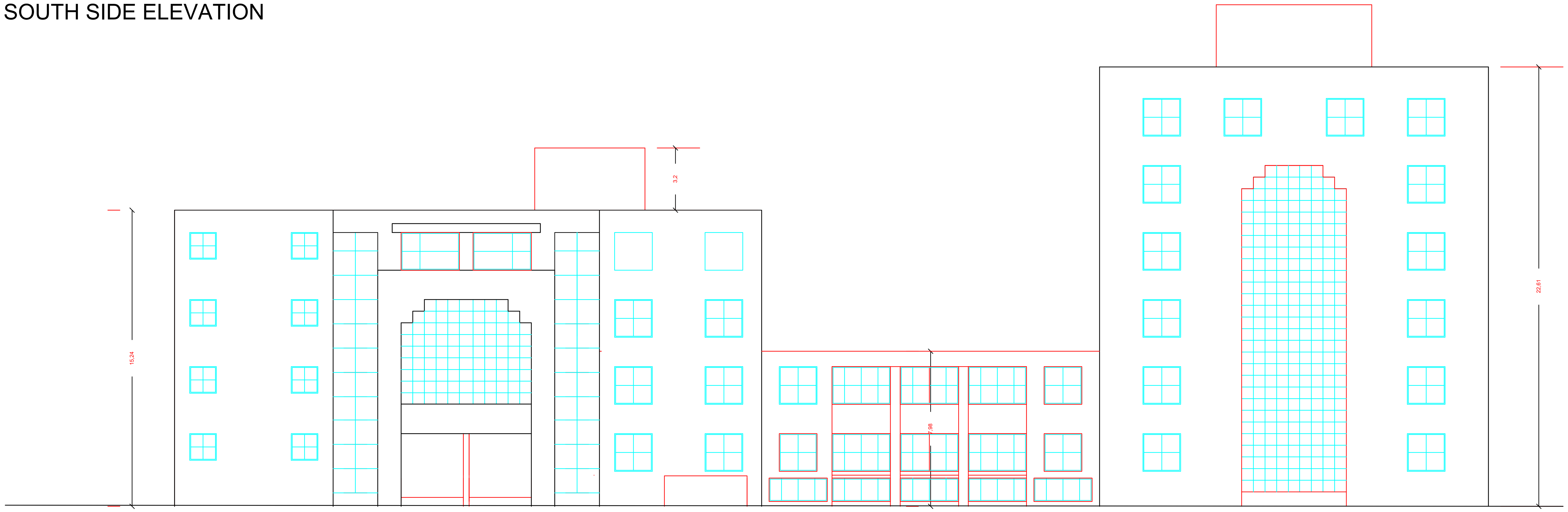
CHAPTER- 10

DRAWINGS

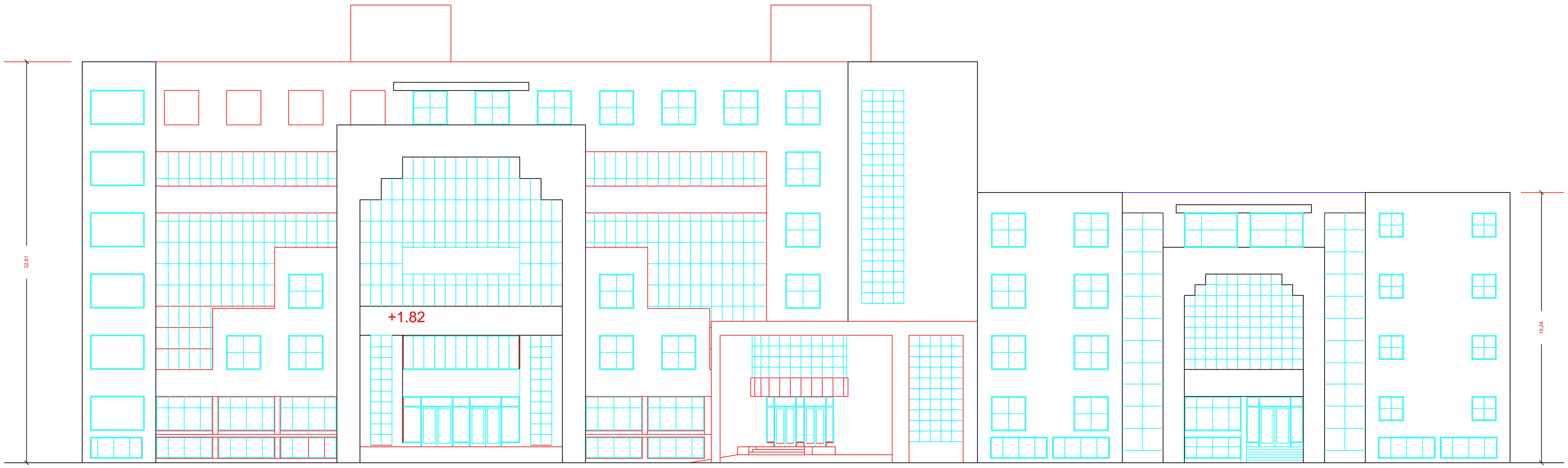


SOUTH SIDE ELEVATION

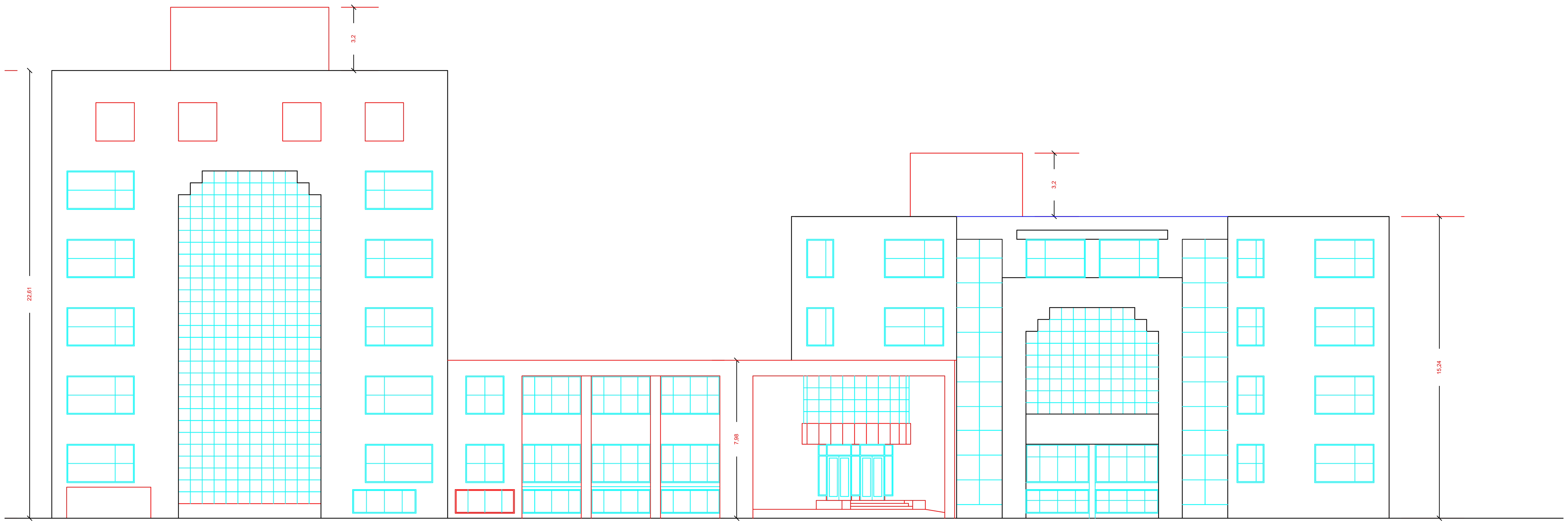


WEST SIDE ELEVATION

SCHOOL OF ARCHITECTURE AND PLANNING, BBDU.	SUBJECT- DISSERTATION II	ELEVATION	NORTH	DATE OF INTRODUCTION - JUNE 2023
ASSIGNMENT DESIGN FEATURE FOR NET ZERO ENERGY EFFICIENT BUILDING, A CASE OF OFFICE BUILDING	SUBJECT CODE-MAR-202P	SCALE-	N	GUIDE NAME - AR. SAURABH SEXENA
	SUBMITTED BY- HEMLATA			DISSERTATION II COORDINATOR- AR. SAURABH SEXENA & AR. KESHAV KUMAR
	ROLL NO.-1200109005	YEAR- 3TH YEAR	MASTER OF ARCHITECTURE (PART TIME)	



NORTH SIDE ELEVATION



EAST SIDE ELEVATION

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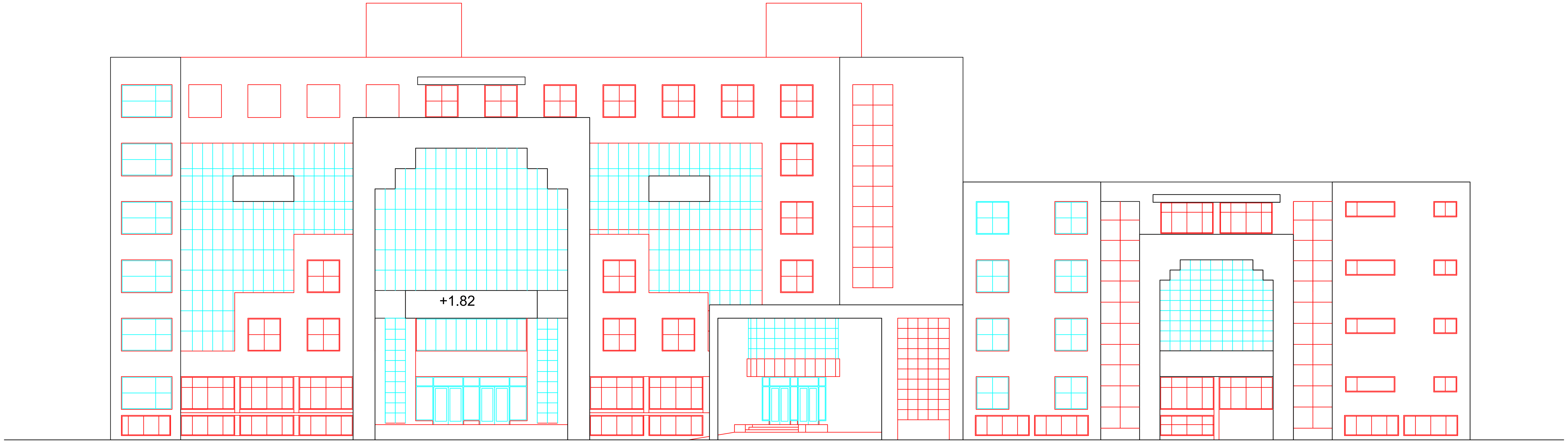
	SUBMITTED BY- HEMLATA				DISSERTATION II COORDINATOR- AR. SAURABH SEXENA & AR. KESHAV KUMAR
	ROLL NO.-1200109005	YEAR- 3TH YEAR	MASTER OF ARCHITECTURE (PART TIME)		



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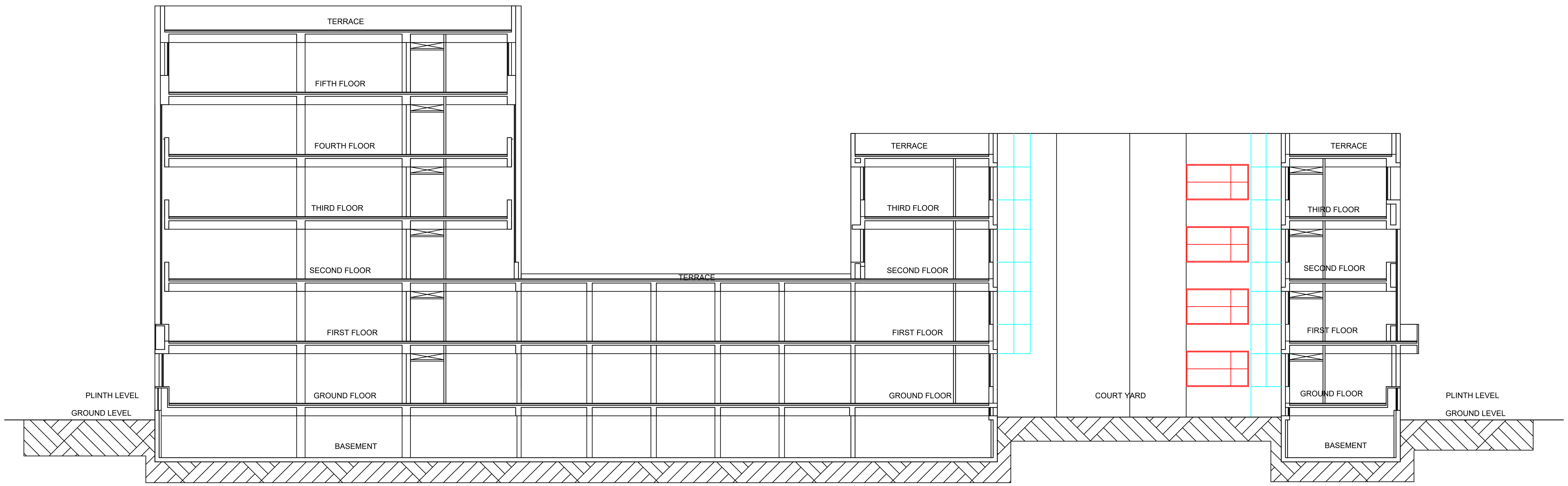

SECTION AT A-A

SCHOOL OF ARCHITECTURE AND PLANNING, BBDU.	SUBJECT- DISSERTATION II	SECTION	NORTH	DATE OF INTRODUCTION - JUNE 2023
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	SUBMITTED BY- HEMLATA			DISSERTATION II COORDINATOR- AR. SAURABH SEXENA & AR. KESHAV KUMAR
	ROLL NO.-1200109005 YEAR- 3TH YEAR	MASTER OF ARCHITECTURE (PART TIME)		

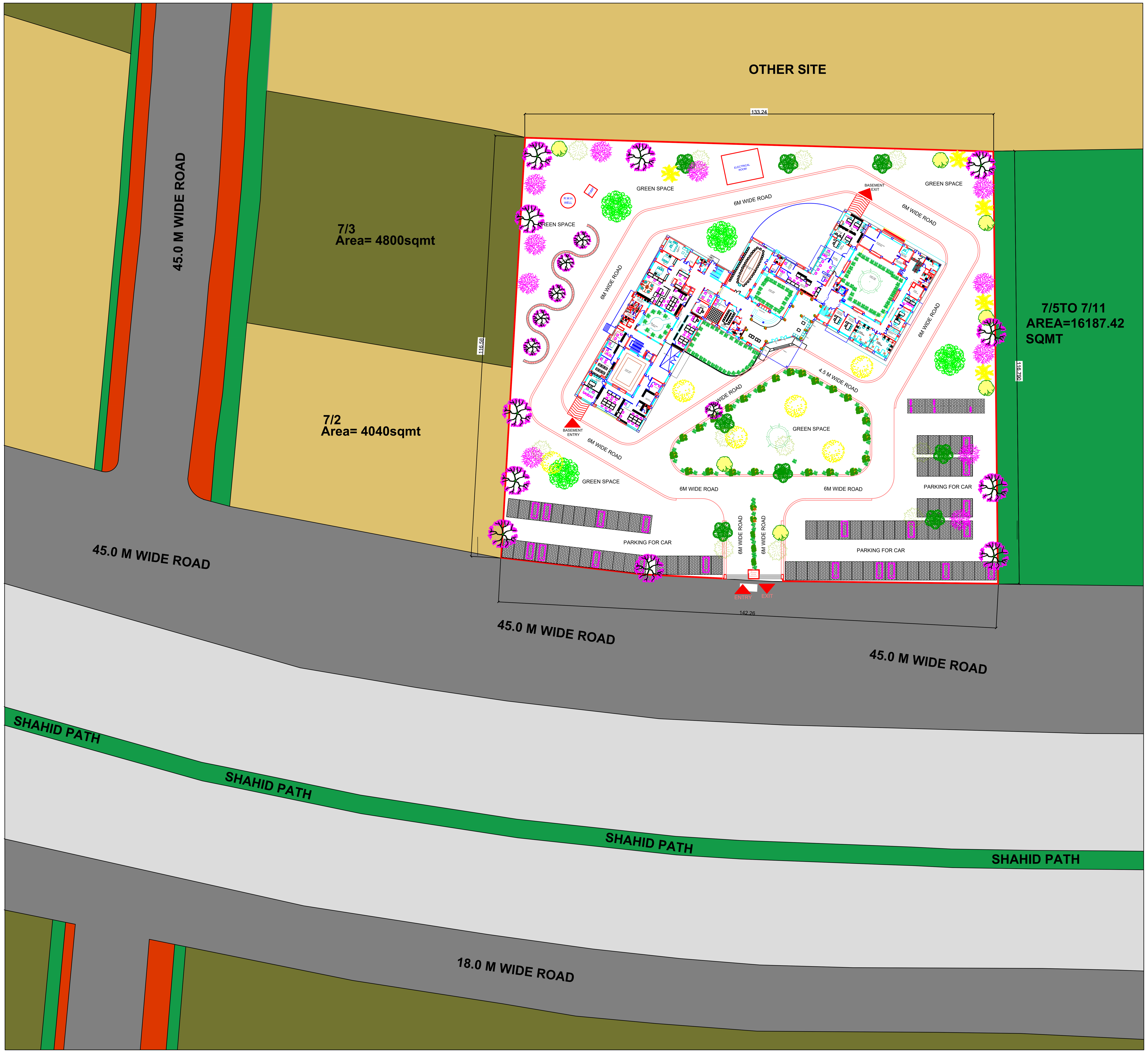
PROPOSED SITE -UPRNN
PLOT AREA=16187.42 SQ.MT.

BUILDING BYE LAWS

SET BACKS
FRONT- 15M WIDE
REAR- 10M WIDE
SIDES- 10M WIDE ON BOTH SIDE
PERMISSIBLE GROUND COVERAGE = 45%
PERMISSIBLE F.A.R. = 2.0
PARKING SANDER E.C.S. = 2(2 CAR ON 100 SQ.MT.)
MAXIMUM HEIGHT - 50 MT.

TOTEL GROUND COVERAGE= 2097.042 SQ.MT.

TOTAL OPEN AREA- 14090.378



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	SUBMITTED BY- HEMLATA		DISSERTATION II COORDINATOR- AR. SAURABH SEXENA & AR. KESHAV KUMAR
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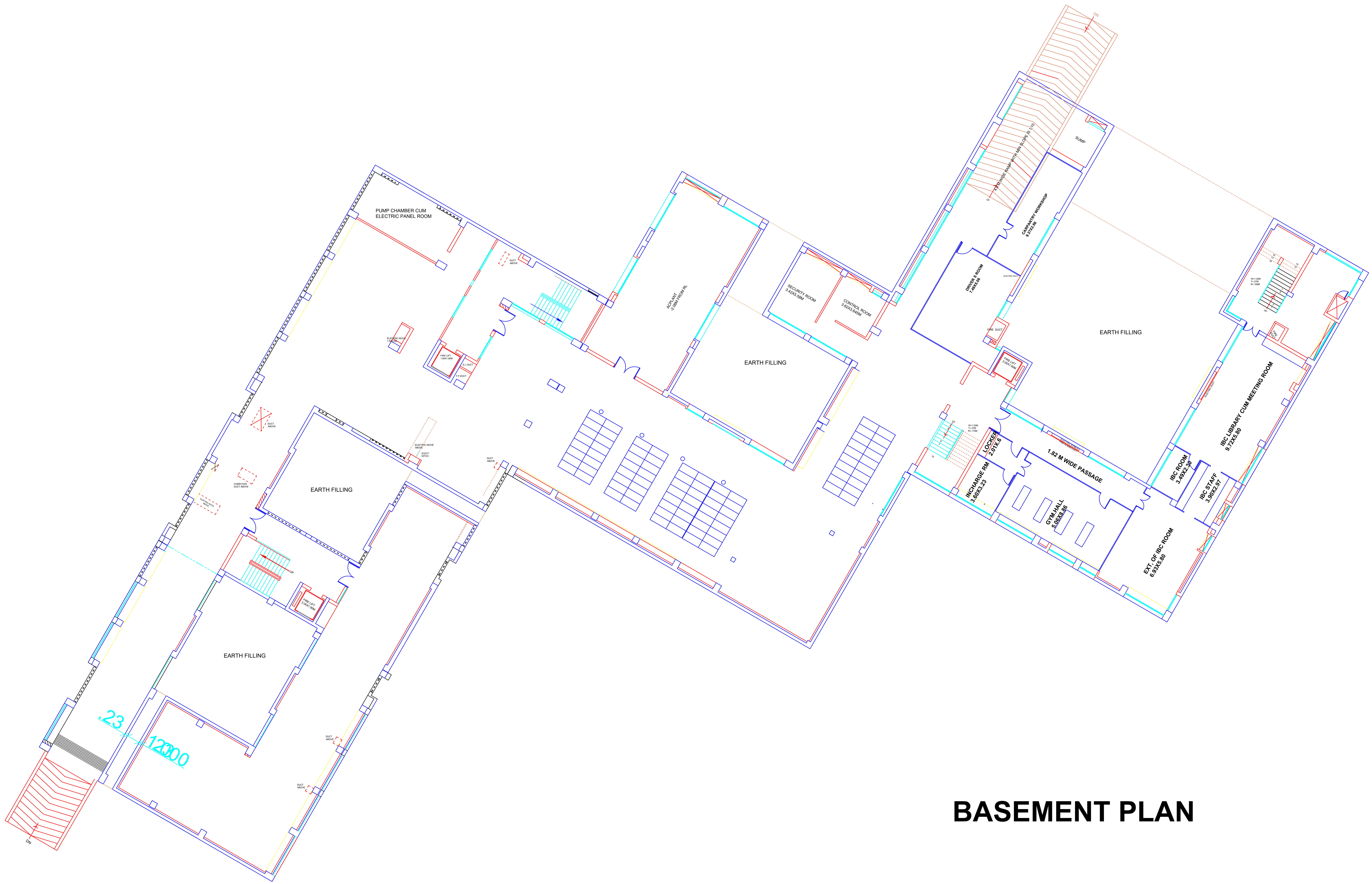
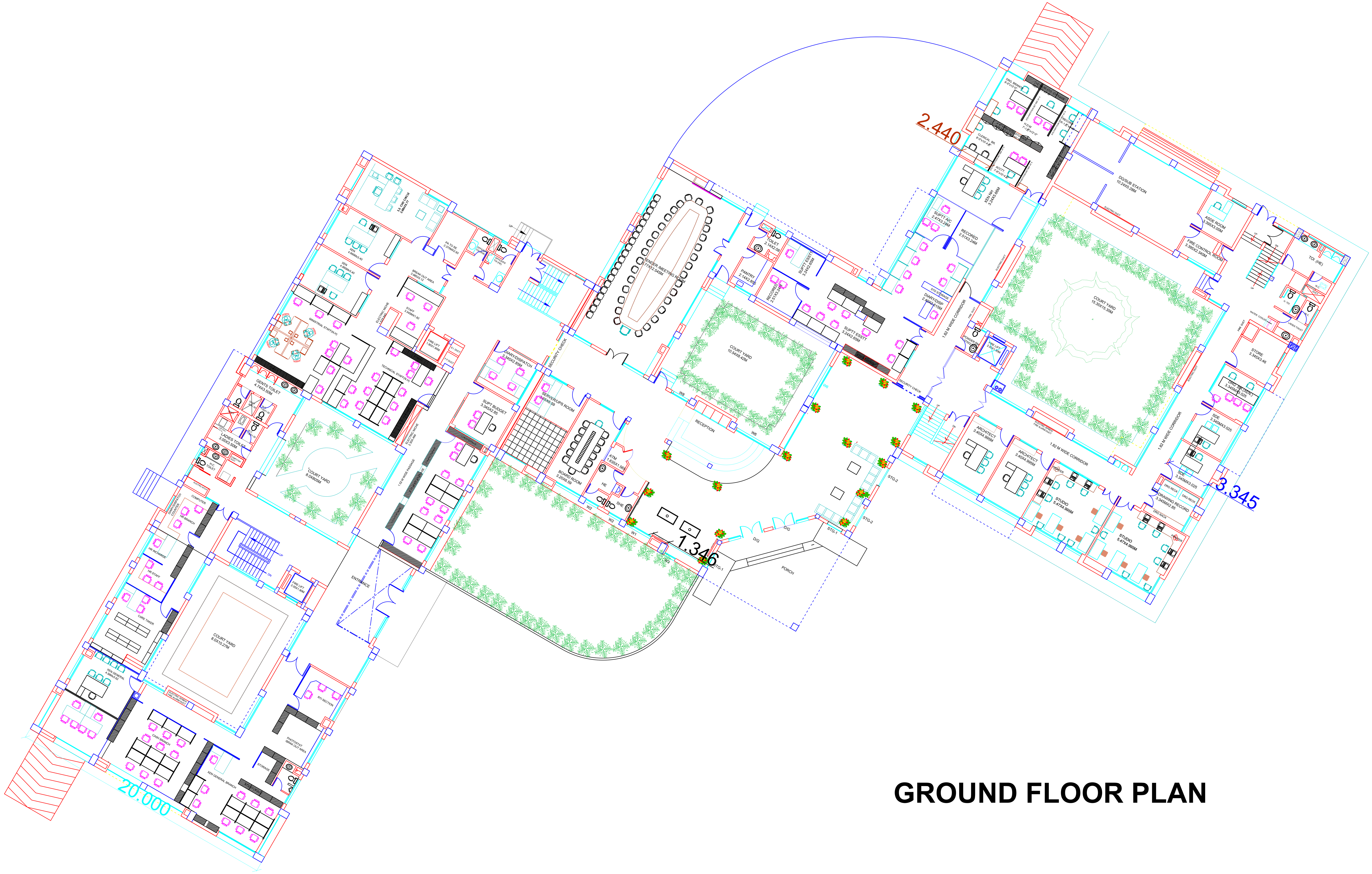


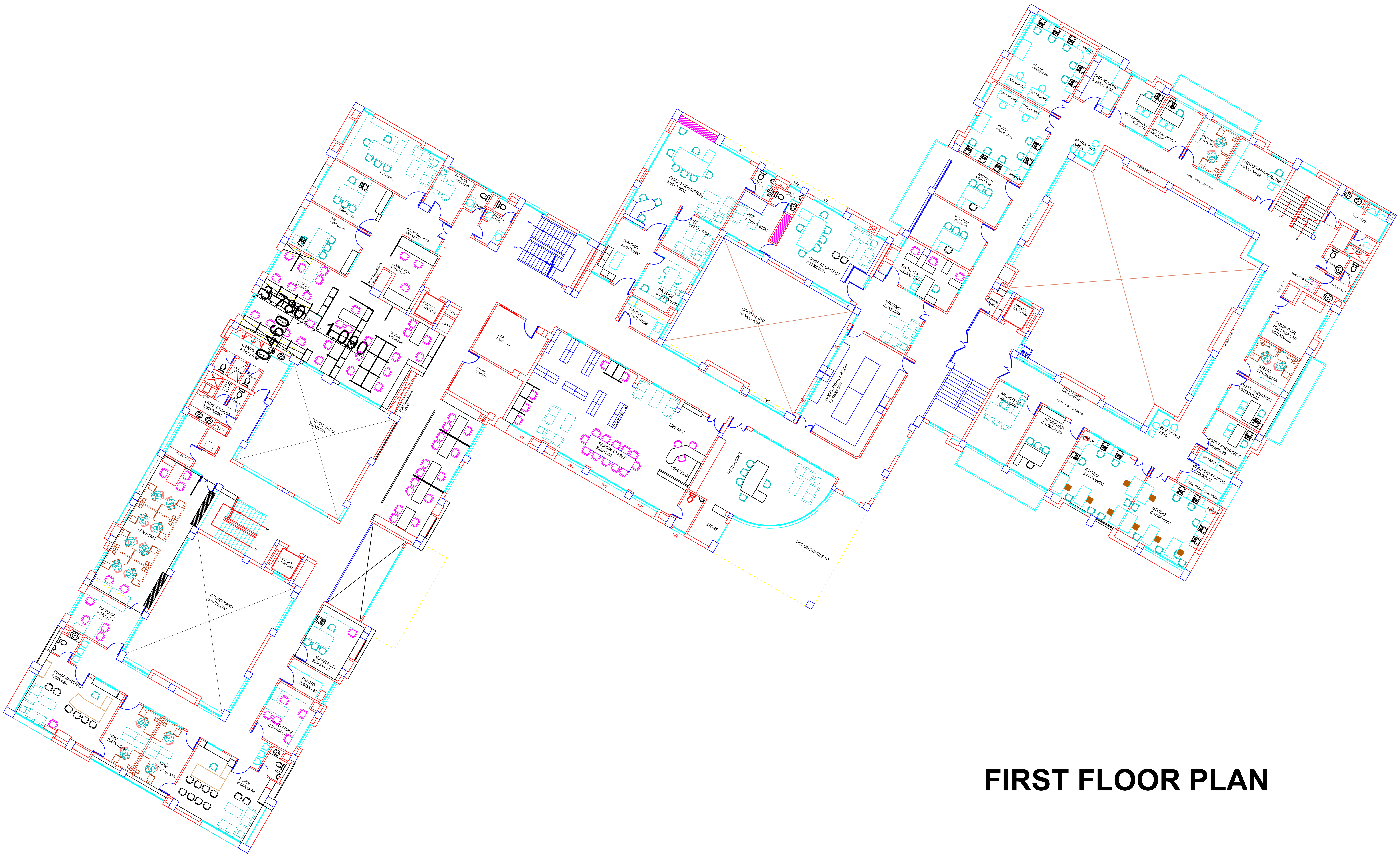
BASEMENT PLAN

SCHOOL OF ARCHITECTURE AND PLANNING, BBDU.	SUBJECT- DISSERTATION II	FLOOR PLAN	NORTH	DATE OF INTRODUCTION - JUNE 2023
ASSIGNMENT DESIGN FEATURE FOR NET ZERO ENERGY EFFICIENT BUILDING, A CASE OF OFFICE BUILDING	SUBJECT CODE-MAR-202P	SCALE-	N	GUIDE NAME - AR. SAURABH SEXENA
	SUBMITTED BY- HEMLATA			DISSERTATION II COORDINATOR- AR. SAURABH SEXENA & AR. KESHAV KUMAR
	ROLL NO.-1200109005	YEAR- 3TH YEAR · MASTER OF ARCHITECTURE (PART TIME)		



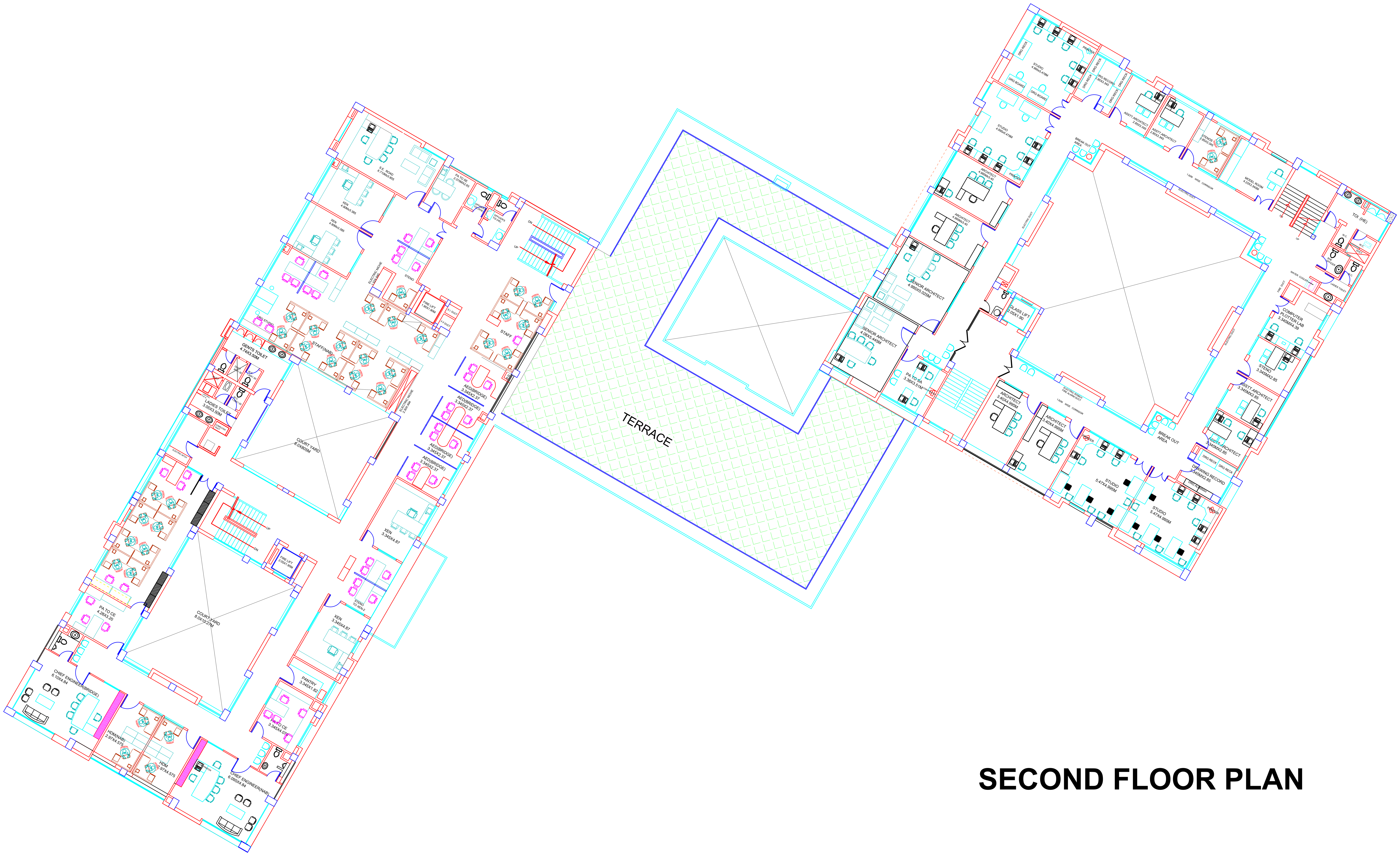
GROUND FLOOR PLAN

SCHOOL OF ARCHITECTURE AND PLANNING, BBDU.	SUBJECT- DISSERTATION II	FLOOR PLAN	NORTH	DATE OF INTRODUCTION - JUNE 2023
ASSIGNMENT DESIGN FEATURE FOR NET ZERO ENERGY EFFICIENT BUILDING, A CASE OF OFFICE BUILDING	SUBJECT CODE-MAR-202P	SCALE-	N	GUIDE NAME - AR. SAURABH SEXENA
	SUBMITTED BY- HEMLATA			DISSERTATION II COORDINATOR- AR. SAURABH SEXENA & AR. KESHAV KUMAR
	ROLL NO.-1200109005 YEAR- 3TH YEAR	MASTER OF ARCHITECTURE (PART TIME)		



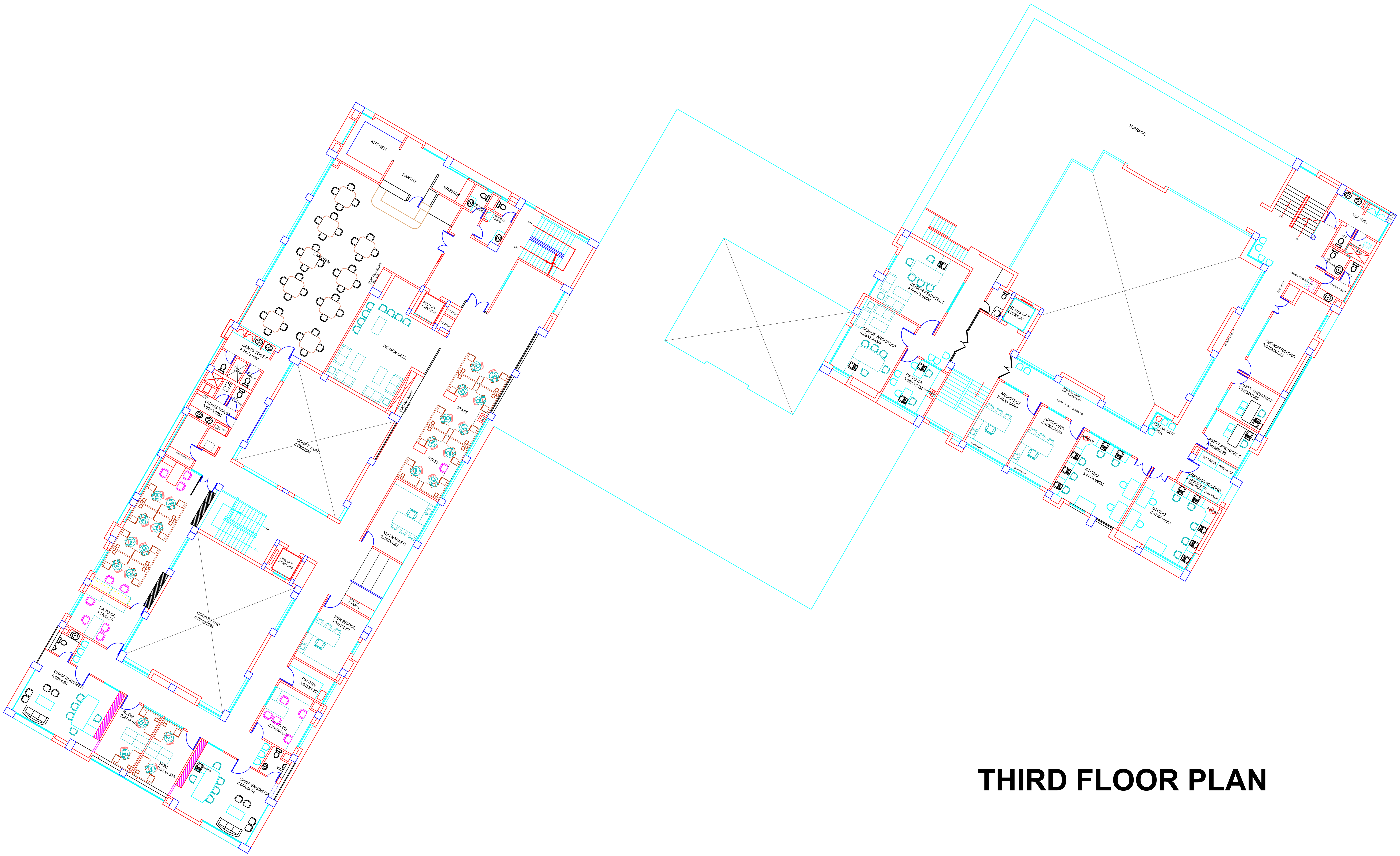
FIRST FLOOR PLAN

SCHOOL OF ARCHITECTURE AND PLANNING, BBDU.	SUBJECT- DISSERTATION II	FLOOR PLAN	NORTH	DATE OF INTRODUCTION - JUNE 2023
ASSIGNMENT DESIGN FEATURE FOR NET ZERO ENERGY EFFICIENT BUILDING, A CASE OF OFFICE BUILDING	SUBJECT CODE-MAR-202P	SCALE-		GUIDE NAME - AR. SAURABH SEXENA
	SUBMITTED BY- HEMLATA			DISSERTATION II COORDINATOR- AR. SAURABH SEXENA & AR. KESHAV KUMAR
	ROLL NO.-1200109005	YEAR- 3TH YEAR	MASTER OF ARCHITECTURE (PART TIME)	



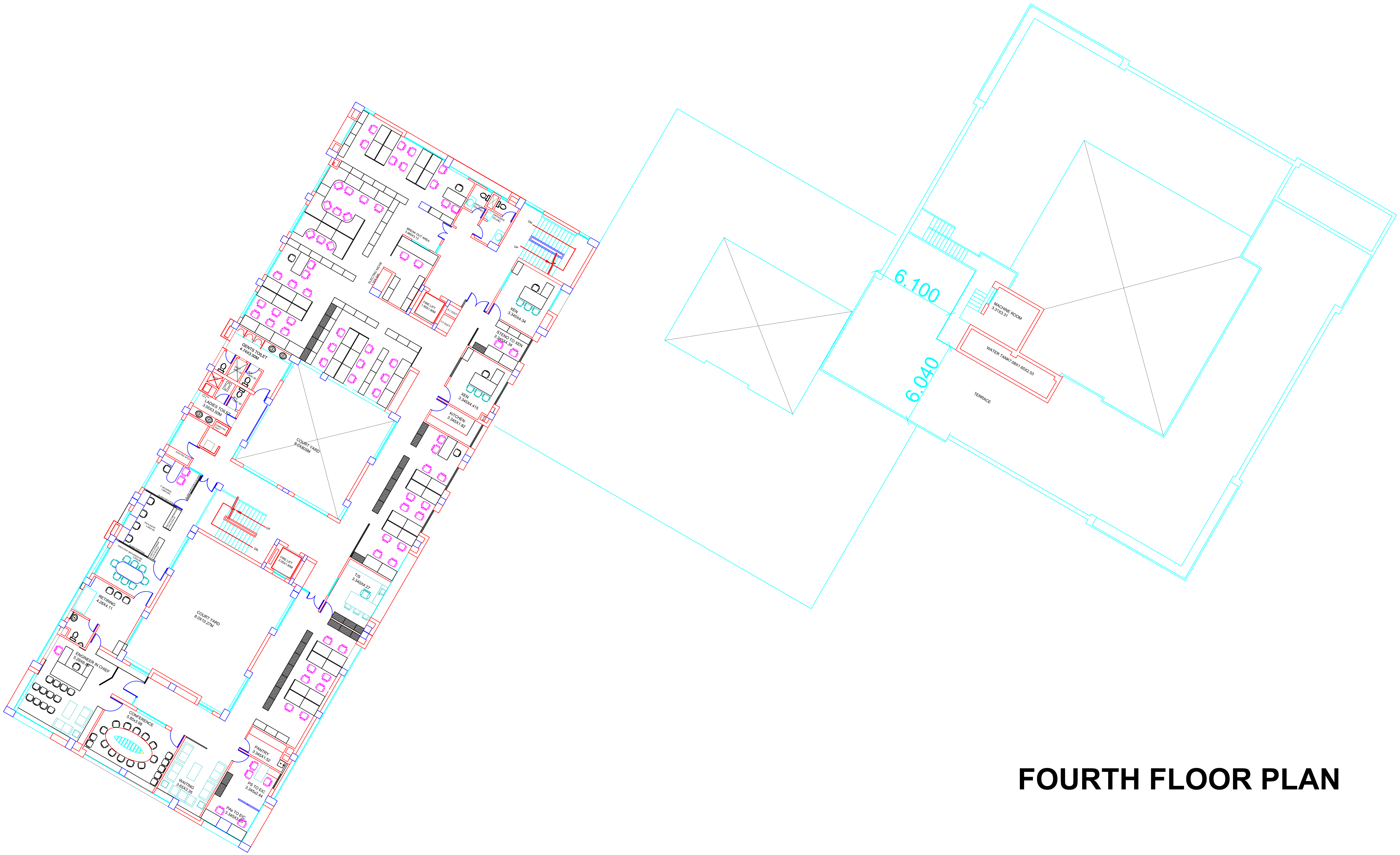
SECOND FLOOR PLAN

SCHOOL OF ARCHITECTURE AND PLANNING, BBDU.	SUBJECT- DISSERTATION II	FLOOR PLAN	NORTH	DATE OF INTRODUCTION - JUNE 2023
ASSIGNMENT DESIGN FEATURE FOR NET ZERO ENERGY EFFICIENT BUILDING, A CASE OF OFFICE BUILDING	SUBJECT CODE-MAR-202P	SCALE-	N	GUIDE NAME - AR. SAURABH SEXENA
	SUBMITTED BY- HEMLATA			DISSERTATION II COORDINATOR- AR. SAURABH SEXENA & AR. KESHAV KUMAR
	ROLL NO.-1200109005 YEAR- 3TH YEAR	MASTER OF ARCHITECTURE (PART TIME)		



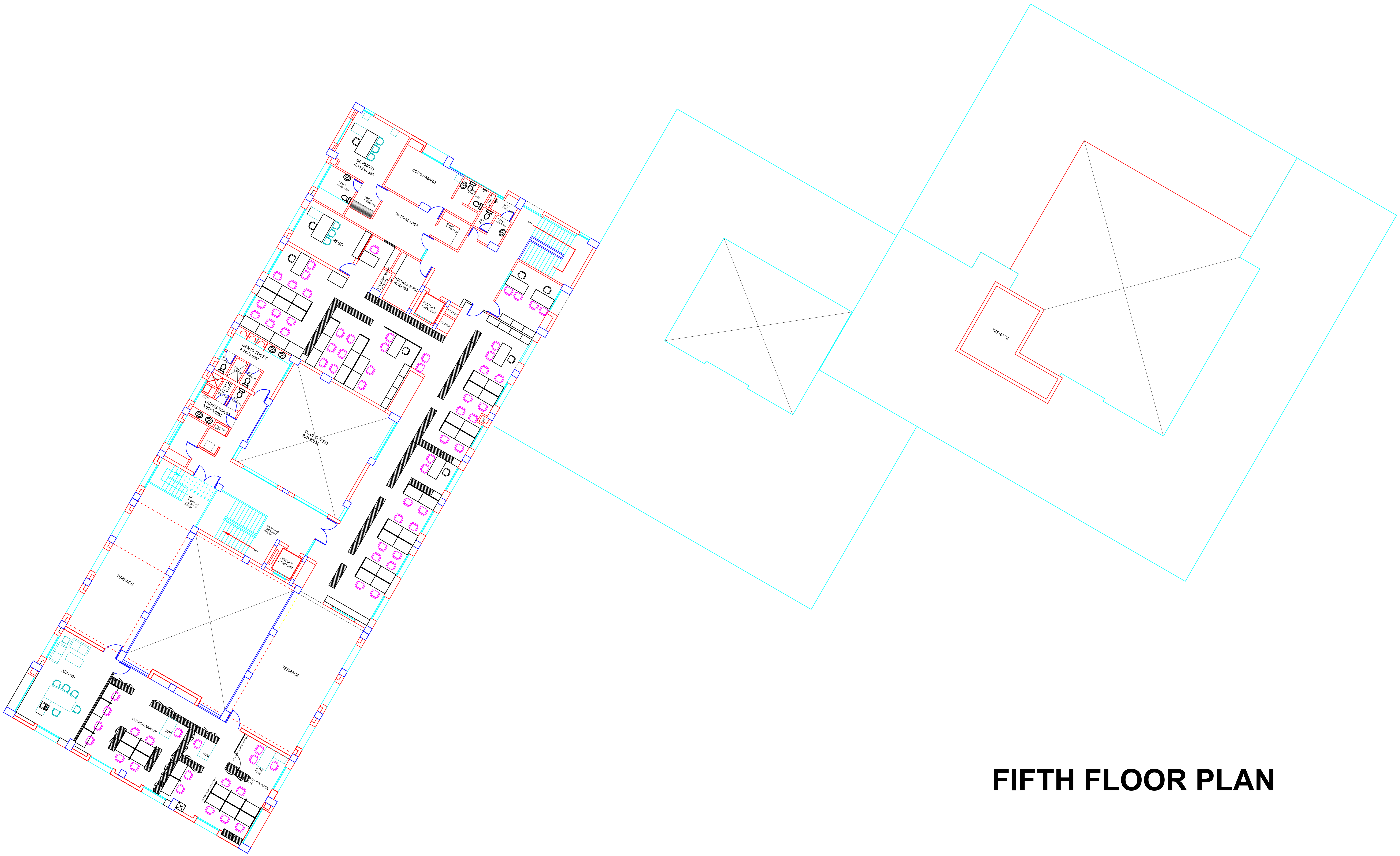
THIRD FLOOR PLAN

SCHOOL OF ARCHITECTURE AND PLANNING, BBDU.	SUBJECT- DISSERTATION II	FLOOR PLAN	NORTH	DATE OF INTRODUCTION - JUNE 2023
ASSIGNMENT DESIGN FEATURE FOR NET ZERO ENERGY EFFICIENT BUILDING, A CASE OF OFFICE BUILDING	SUBJECT CODE-MAR-202P	SCALE-	N	GUIDE NAME - AR. SAURABH SEXENA
	SUBMITTED BY- HEMLATA			DISSERTATION II COORDINATOR- AR. SAURABH SEXENA & AR. KESHAV KUMAR
	ROLL NO.-1200109005 YEAR- 3TH YEAR	MASTER OF ARCHITECTURE (PART TIME)		



FOURTH FLOOR PLAN

SCHOOL OF ARCHITECTURE AND PLANNING, BBDU.	SUBJECT- DISSERTATION II	FLOOR PLAN	NORTH	DATE OF INTRODUCTION - JUNE 2023
ASSIGNMENT DESIGN FEATURE FOR NET ZERO ENERGY EFFICIENT BUILDING, A CASE OF OFFICE BUILDING	SUBJECT CODE-MAR-202P	SCALE-	N	GUIDE NAME - AR. SAURABH SEXENA
	SUBMITTED BY- HEMLATA			DISSERTATION II COORDINATOR- AR. SAURABH SEXENA & AR. KESHAV KUMAR
	ROLL NO.-1200109005 YEAR- 3TH YEAR	MASTER OF ARCHITECTURE (PART TIME)		



FIFTH FLOOR PLAN

SCHOOL OF ARCHITECTURE AND PLANNING, BBDU.	SUBJECT- DISSERTATION II	FLOOR PLAN	NORTH	DATE OF INTRODUCTION - JUNE 2023
ASSIGNMENT DESIGN FEATURE FOR NET ZERO ENERGY EFFICIENT BUILDING, A CASE OF OFFICE BUILDING	SUBJECT CODE-MAR-202P	SCALE-	N	GUIDE NAME - AR. SAURABH SEXENA
	SUBMITTED BY- HEMLATA			DISSERTATION II COORDINATOR- AR. SAURABH SEXENA & AR. KESHAV KUMAR
	ROLL NO.-1200109005	YEAR- 3TH YEAR	MASTER OF ARCHITECTURE (PART TIME)	