ENERGY SIMULATION & DAYLIGHTING SIMULATION OF A BUILDING

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A thesis submitted in partial fulfillment of the requirements for the Degree of
Master of Technology
(Energy Systems)

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CERTIFICATE

This is to certify that the work contained in this thesis titled "**ENERGY SIMULATION OF A BUILDING**" has been carried out by **K. SOBHAN BABU** under my/our supervision.

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ABBREVIATIONS

SL.NO	ABBREVIATIONS	DESCRIPTION
1	ASHRAE	American Society for Heating, Refrigeration and Air-conditioning Engineers
2	ECBC	Energy Conservation Building Code
3	IEQ	Indoor Environmental quality and Occupational Health
4	ISHRAE	Indian Society for Heating, Refrigeration and Air-conditioning Engineers
5	LPD	Lighting Power Density
6	NBC	National Building Code
7	SHGC	Solar Heat Gain Coefficient
8	VLT	Visible Light Transmission

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ABSTRACT

Equest Building Simulation is a widely accepted and used software for understanding how a building consumes energy for the installed system for a normal building design aimed at improving the building' total energy efficiency. The total energy consumed is obtained by giving different real parameters like lighting, heating ventilation air-conditioning system, building envelope, glass, occupancy.

Ecotect is an another software which provides lighting simulation and its intensity or the lux levels for each and every space available in a building through the given input.

These both software programs help us find out the buildings energy consumption by the available parameters and will provide us information regarding the various factors. And the building model can be altered by providing skylights, more wall to window ratio such that the total energy consumed by the building will be reduced. And a better environmental natural air will flow through the building spaces to a better ventilation.

This reduces the total environmental impact created by the building, through energy consumption. In addition, a perfect living environmental ecosystem or the occupants.

In this project work, it is shown how to use and find energy consumption pattern and lighting usage pattern through the above mentioned soft wares

CHAPTER 1

INTRODUCTION

Indian Institute of technology (IIT) is the foremost institution in higher technological education and research. IIT system has seven institution in India among which one is in Chennai. The institution has excellent technical and supporting staff and also the effective administration. Indian Institute of Technology, Chennai has planned to construct the Boys hostel block to accommodate increasing student strength. The proposed Boys hostel block will have two blocks (A&B) of 792 individual rooms in each block, and the construction facility is established in their own IIT Madras Campus in Chennai, Tamilnadu.

Indian Institute of Technology, Chennai is planned to construction their proposed Boys hostel block with a Green strategies of GRIHA four star rating. The building is signed up for the LEED-USGBC under LEED-NC V-3.0 rating. The available points under Energy and atmosphere criteria are 35. The project will explore all possible points that can be modeled under the Energy Simulation tool. The building simulation tool includes all forms of energy consumption in that particular building.

Building simulation is done on the guide lines of ASHRAE standards 90.1-2007 version. The ASHRAE stands for American Standards for Heating Refrigeration and Air conditioning Engineers. The standards have defined values for buildings that fall under different climatic zones.

ASHRAE standard specifies the test procedure for evaluating all the extensive technical capabilities and ranges of the applicability of computer program that can calculate the thermal performance of the buildings and their HVAC systems. The ASHRAE includes weather data, instructions for building envelopes, Service water heating, and HVAC, Power, Lighting, and Equipment details.

The standards have to be referred to design for the baseline design which will include the values of the above said details to build the model. The model thus made will be simulated under four basic orientations for a baseline scenario. The energy consumption will be taken as the average of the four basic orientations. The proposed case building model would have the same model but the HVAC systems lighting density, occupancy would be as per the design documents received from the customer. The energy conservation methods will be modeled by using the energy efficient materials and equipment available in the market and applying each and reduce the energy consumption. The building envelope details, Equipment', Lighting HVAC systems will be modeled and best efficiency practice would be suggested.

The energy reduced is measured in terms of percentage and will help in achieving the maximum available points under the Energy and Atmosphere criteria. Onsite Renewable energy and other innovative approaches for reducing the energy cost will be put forward as suggestions.

The project will also include the daylight simulation for a building displaying the total daylight usage in the building. Daylight simulation is used in evaluation of GRIHA for indicating that the building uses the maximum available daylight. We will explore the tool and demonstrate how it can help for energy efficiency in buildings.

A brief comparison report of various energy conservation methods will be given in terms of energy consumption savings, measures to be taken and the effect on the design of the building will be discussed in detail.

CHAPTER 2

LITERATURE REVIEW

2.1 LEED NC V 3.0- USGBC

U.S. Green Building Council (USGBC) after been formed in 1993, as because it realized that the sustainable building industry is a needed system to define and measure "green buildings." A team of Architects, Real estate agents, Building owners, Environmentalists and Industry representative formulated a set of rules to define and measure green building. The first version LEED V-1.0 was released on august 1998 followed by other editions LEED v-2.0 at March 2000, LEED V-2.1 at 2002, LEED V-2.2 at 2005 and the latest is LEED v-3.0.

LEED has undertaken new initiatives and systems for specific typologies, sectors and different project scopes. Green building is a growing sector daily; it incorporates new technologies and products, innovative design practices introduced in the industry.

LEED evaluates performance of a whole building from environmental perspective over building life cycle and cost providing an exact standard for what constitutes to be a green building design, construction, maintenance, and operation. LEED V-3.0 was designed for new and existing commercial, community, institutional and residential buildings. The rating system is based on accepted energy & certain principles based on environment and strikes a commitment between a known practices and emerging concepts which are well established. The rating systems are broadly organized into five environmental categories namely: Sustainable sites (SS), Water efficiency (WE), Energy & Atmosphere (EA), Materials & Resources (MR) and Indoor Environmental Quality (IEQ).

LEED v-3.0 Green building rating system for New Construction and major renovations is a set of performance standards for the certifying the design and new construction of commercial and institutional buildings and high rise residential buildings for all sizes both private and public.

	Energy and Atmosphere	
Category	Name	Points
EA Prerequisite 2	Minimum Energy Performance	0
EA Credit 1	Optimize Energy Performance	19
EA Credit 2	On-site Renewable Energy	7
EA Credit 6	Green Power	2
	Indoor Environmental Quality	
IE Q Prerequisite 1	Minimum Indoor Air Quality Performance	0
IE Q Credit 1	Outdoor Air Delivery Monitoring	1
IE Q Credit 2	Increased Ventilation	1
IE Q Credit 7.1	Thermal Comfort	1
	Total points available	31

Table 1 Possible points under Energy simulations

2.1.1 EA Prerequisite 2: Minimum Energy Performance

Intent

To set-up, a base for the minimum level of energy required for the total building and its system to reduce the environmental impact with the exceeding energy use.

Requirement

OPTION 1 - Building Energy consumption and Simulation

- Demonstrate a considerable 10 % improvement in the proposed building's total energy performance for a no. of new buildings, or 5 % improvements in the proposed building's energy rating for a major renovation made to all the existing buildings, compared with the baseline building energy performance rating.
- Calculate the baseline energy performance rating of a building according to the building' energy performance rating method given in the standard Appendix-G of ANSI or ASHRAE

or IESNA Standard 90.1-2007 using a computer simulation created model of the whole project's building.

- Appendix-G of Standard 90.1--2007 needs that all the energy analysis is done for the buildings performance method includes all the costs associated with the building' project along with energy. To achieve these credits, the proposed design must comply the following criteria
- For this purpose, analysis of process energy is considered to be included, but not limited, office computers , general miscellaneous equipment and, escalators, kitchen and, elevators, cooking, drying , laundry washing and refrigeration, and, lighting exempt from the lighting power allowance (example- medical equipment to lighting integral)
- Regulated energy means lighting for the parking garage, surface parking, façade, interior or building gr0unds, HVAC-heating, ventilation and air conditioning (kitchen hood exhaust space cooling, fans, parking garage ventilation , for space heating, pumps, ,toilet exhaust, etc.), and water heating for household purposes.
- All the Process loads which are considered should be identical for both the baseline case building performance and the proposed case building performance as for as the rating is concerned. However, all the project teams can follow their own exceptional calculation methods (ANSI or ASHRAE or IESNA Standard 90.1-2007 G 2.5) to document measure' that can reduce the process loads. Documentation of load energy savings process must include a list of all the assumptions made for the base case design and the proposed case design, and theoretical/ empirical information supporting these assumptions.

OR

OPTION 2-- Prescriptive Compliance Path:: ASHRAE's Advanced Design Guide for Energy.
comply with all the prescriptive measure' of the ASHRAE' Advanced Design Guide for Energy required to the project outlined. Projects should comply with all the applicable criteria's as shown in Advanced Energy Design Guide for the provided climatic zone in the place where the building is located.
OR

OPTION 3-- Prescriptive Compliance Paths: Advanced Buildings Core Performance Guide
Comply with all the prescriptive measures provided in the Advanced Buildings Core Performance Guide (ABCPG) developed given by the New Buildings Institute.

2.1.2 EA Credit 1: Optimize Energy Performance

Intent

To reduce the total improper energy performance to the required standard level , the economic impacts and environmental and associated with the excessive energy use will also reduce.

Requirements

Select 1 among the 3 compliance paths option described in the below section. Project persons documenting reaching level using any of the above 3 options has assumed to be in relation with EA Prerequisite 2: Reducing Energy level Performance.

OPTION one Thorough Building Energy level Simulation

Demonstrate a perfect percentage movement in the proposed case building performance compared with the base case building performance. Calculate the base case of the building performance as per Appendix-G of ANSI or ASHRAE or IESNA Standard 90.1-2007 using a computer model simulation for the completely building project.

OR

OPTION 2 ASHRAE's Advanced Guide for Energy Design

Comply with the given prescribed measures of the ASHRAE Advanced Guide for Energy Design appropriate to the level of project scopes, outlined below. Project persons must comply with all the required applicable criteria as established in the Advanced Guide for Energy Design for the climatic zone in which the building is placed.

OR

OPTION 3 Prescriptive Compliance Paths: Advanced Core materials Building Performance Guide

Comply with all the corrective measures identified in the Advanced core material Building Performance Guide developed for the New Buildings Institute.

2.1.3 EA Credit 2: On-site Renewable Energy

Intent

To encourage and resolve the increasing levels of renewable energy in on-site, self-supply to reduce the economic and environmental impacts associated with un-conventional energy use.

Requirements

Use of on-site renewable source of energy systems to reduce the total buildings energy costs. Calculate the project's activity by showing that the energy obtained by the renewable energy systems as a % of the building's annual cost of energy.

Use building's total energy cost calculated in Energy & Atmosphere Credit 1: Optimize Energy Performance to determine the approached data for finding electricity use.

2.1.4 EA Credit 6: Green Power

Intention

To encourage the use of grid-source and its development, renewable energy source technologies for a net zero pollution emission.

Requirement

Engage in a least a long term or 2-year renewable energy purchase contract to get at least a 35% of the building's electricity from renewable sources, as defined by the Resource Solutions'of Green-e Energy solutions product centre certification requirements.

All purchases regarding renewable energy should be on the quantity used by the total energy consumed by the building, not the cost.

CHOICE 1: Determine Base case Electricity Use

Use the provision of annual electricity energy consumption from the results of Energy & Atmosphere Credit : Energy Performance Optimization

OR

CHOICE 2: Estimate Use of Baseline Electricity

Use of the U.S. Department' Energy use of a Commercial Building' Consumption of Energy Survey to determine the electricity use as estimated.

2.1.5 Indoor Environmental Quality Prerequisite 1: Minimum Performance of Indoor Air Quality

Intention

To establish a minimum IAQ performance to enhance the indoor air quality (IAQ) in buildings, thus contributing to a all-new level of comfort and well-being of the residents.

Requirements

Meet the minimum requirements of Sections four through seven of ASHRAE 62.1, Ventilation for Acceptable for Indoor Air Quality.

AND

CASE 1: Mechanically Ventilated Spaces

Mechanical ventilation systems must be designed using the ventilation rate procedure or the applicable local code, whichever is more stringent.

CASE 2: Naturally Ventilated Spaces

Naturally ventilated buildings must comply with ASHRAE Standard 62.1-2007, Paragraph 5.1 (with errata but without addenda1).

2.1.6 IE Q Credit 1: Outdoor Air Delivery quality Monitoring

Intent

To monitor the capacity of the ventilation systems to help promote occupant comfort level and well-being.

Requirement

Install permanent systems for monitoring, to ensure that minimum requirements for design of ventilation quality systems maintenance Configure the monitoring equipment in such a way to generate an emergency alarm when the airflow quantity or carbon dioxide range vary by 10% and provide a visual signal or alarm to alert the occupants

AND

2.1.7 IE Q Credit 2: Increased Ventilation

Intent

To provide additional outdoor air ventilation to improve indoor air quality (IAQ) and promote occupant comfort, well-being and productivity.

Requirements

CASE 1: Mechanically Ventilated Spaces

Increase the breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates required by ASHRAE Standard 62.1 as determined by IEQ Prerequisite 1: Minimum Indoor Air Quality Performance.

CASE 2: Naturally Ventilated Spaces

Design natural ventilation systems for occupied spaces to meet the recommendations as per the given standards, Natural Ventilation in Nondomestic Buildings. Show that natural ventilation is a perfect process and strategy to the project assembly in a many ways.

AND

OPTION 1:

Use diagrams and calculations to show that the design of the natural ventilation systems meets the recommendations set forth in the CIBSE Applications Manual 10: 2005, Natural Ventilation in Non-domestic Buildings, CIBSE AM 13 (Mixed Mode Ventilation), or natural ventilation/mixed mode ventilation related sections of the CIBSE Guide B2 (Ventilation and Air Conditioning).

OR

OPTION 2:

Use a multi zone model to predict the airflow through all the rooms for an effective circulation, defined as providing the minimum ventilation rates required by ASHRAE 62.1-2007 Chapter 6, for at least 90% of occupied spaces.

2.1.8 IE Q Credit 7.1: Thermal Comfort—Design

Intent

To provide a comfortable thermal environment that promotes occupant productivity and well-being.

Requirements

Design heating, ventilating, air conditioning (HVAC) systems, and the building envelope to meet the requirements of ASHRAE Standard 55-2004, Thermal Comfort Conditions for Human Occupancy (with errata but without addenda1). Demonstrate design compliance in accordance with the Section 6.1.1 documentation.

2.2 ASHRAE STANDARDS

This standard provides the minimum requirement standards for a normal building.

The provisions of this norm do not apply to

1. The houses of single family, the structures of multi-family one of three histories or less above the degree, made houses (the movable houses), and the made houses modularize)
2. The buildings that use not more of the fuel of electricity or fossil, or
3. The equipment and the portions of systems of building that use energy principally to provide with industrial, to make, or the advertising processes.

Where in particular renowned in this norm, these certain other buildings or these building elements will be exempt. This norm is not used to bypass security, health, or the ecological conditions.

2.2.1Performance Rating

This performance rating method requires conformance with the following provisions: All requirements of Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 are met. These sections contain the mandatory provisions of the standard and are prerequisites for this rating method. The improved performance of the proposed building design is calculated in accordance with provisions of this appendix using the following formula:

Percentage improvement = 100 × (Baseline building performance – Proposed building performance) / Baseline building performance

Note:

1. Both the proposed building performance and the baseline building performance shall include all end-use load components, such as receptacle and process loads.

2. Neither the execution is proposed building or the execution of basic building are predictions of true consumption of energy or the costs for the proposed conception after the construction. The true experience will differ of these calculations because of the variations as the occupation, constructing the operation and discussion, the time, the energy usage do not cover by this procedure, these changes in the energy rates between the conception of the building and the occupation, and the precision of the tool of calculation

2.2.2 Trade-Off Limits

When the proposed modifications apply to less than the whole building, only parameters related to the systems to be modified shall be allowed to vary. Parameters relating to unmodified existing conditions or to future building components shall be identical for determining both the baseline building performance and the proposed building performance. Future building components shall meet the prescriptive requirements of Sections 5.5, 6.5, 7.5, 9.5, and 9.6.

2.2.3 Simulation General Requirements

Performance Calculations

The proposed building performance and baseline building performance shall be calculated using the following:

a) The same simulation program
b) The same weather data
c) The same energy rates

Simulation Program

The simulation program will be a program computer based for the consumer analysis of energy in the buildings (a program as, but not limited to, DOE-2, the EXPLOSION, or EnergyPlus). The simulation program will include the calculation methodologies for the construction components are modeled. For the components th

at cannot be modeled by the simulation program, the conditions of exceptional methods of calculation could be used.

This program is used to provide a analyze data of

a) 8760 hours per year
b) Hourly variations in, lighting power, thermostat set points, occupancy, miscellaneous equipment power, and HVAC system operation, defined separately for each day of the week and holidays
c) Thermal mass effects
d) Ten or more thermal zones
e) Part-load performance curves for mechanical equipment
f) Capacity and efficiency correction curves for mechanical heating and cooling equipment
g) Air-side economizers with integrated control
h) Baseline building design characteristics specified in further sections.

The program of simulation will have all the ability to directly calculate the proposed case building performance and baseline building performance or to generate an hourly report about the total energy use by an energy source suitable for determining the proposed building performance and baseline building performance using separate detailed calculations software

The simulation program will be one conceived to execute the very conception, thermal calculations and of load to obtain the capacities of equipment of demanded HVAC and airs and waters debits in accordance with generally organizing admitted norms and manuals (for example, the Manual of ASHRAE—les basic Principles) for the proposed conception and basic building conception. The simulation program will be tried according to the Norm of ASHRAE 140, and the software supplier will furnish the results. .

Energy Rates

Either annual energy costs shall be determined by using actual rates for purchased energy or state average energy prices published by DOE's Energy Information Administration (EIA) for commercial building customers, but rates from different sources may not be mixed in the same project.

These details can be obtained from DOE website.

Exception

On-site renewable energy sources or site-recovered energy will not be considered as an energy purchased separately and shall not be included in the proposed building performance. Where on-site renewable or site recovered sources are used, the baseline building performance shall be based on the energy source used as the backup energy source or on the use of electricity if no backup energy source has been specified.

Exceptional Calculation Methods

Where there is no simulation program available that adequately modeling for a design, material, or device, the rating authority may consider approving an exceptional calculations method to demonstrate above-standard energy performance using this method. All the Applications for approval of this type of an exceptional method approval shall include all kind of documentation of the calculations performed and all the theoretical and empirical information's supporting the status of the method.

2.2.4 Calculation of the Baseline Building Performance

Building Performance Calculations

The simulation of building model created for calculating the proposed case and baseline case building performance' can be developed in accordance to the requirements of ASHRAE Appendix-G Table G3.1.

Baseline HVAC System Types and Descriptions:

HVAC systems in the baseline case building design should be based on number of floors , usage, conditioned room area and heating source material will be applied as per standards and shall comply to the system descriptions in Table G3.1.1B. For the other systems in 1, 2, 3, and 4, each thermal model block can be modeled with its own HVAC system. For systems 5, 6, 7, and 8, each room can be modeled with its own separate HVAC system. Rooms with identical thermal model blocks can be grouped under one category for modeling purposes.

Exceptions for the process:

a. Use of additional system' type for a non-predominant conditions (i.e., heating source or residential/non-residential) if those condition applies to more than 20,000 ft^2 of a conditioned floor area.

b. If the baseline system HVAC type is five, six, seven, or eight, then use separate single-zone systems conforming with the requirements of System 3 or System 4 for any spaces that have occupancy or even process loads or schedules that may differ significantly from the rest of the building. A Peak thermal loads that will differ by 10 Btu/h·ft2 or more from average of other room spaces served by the single system or schedules that differs by more than the 40 equivalent full load hours per week from the other spaces served by the system are considered to differ significantly. Examples where this exception may be applicable include, but are not limited to, computer server rooms, natatoriums, and continually occupied security areas.

c. If the baseline HVAC system type is system 5, 6, 7, or 8, use separate single-zone systems conforming with the requirements of System 3 or System 4 (depending on building heat source) for any zones having special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates.

d. For laboratory spaces with a minimum of 5000 cfm of exhaust, use system type 5 or 7 that reduce the exhaust and makeup air volume to 50% of design values during unoccupied periods. For all-electric buildings, the heating shall be electric resistance.

Purchased Heat

For systems using purchased hot water or steam, hot water or steam costs shall be based on actual utility rates, and on-site boilers shall not be modeled in the baseline building design.

CHAPTER 3

DAYLIGHTING PROCESS

3.1 INTRODUCTION

Daylight is a primary source of illuminance over an artificial lighting. It is the practice of placing windows or other openings and reflective surfaces so that during the day natural light provides effective internal lighting. A day-lighting system is comprised of not just of daylight apertures alone, such as skylights and windows, but it is coupled with a day-light-responsive system to control lighting. When there is an adequate ambient lighting required for a room is provided from daylight alone, and there is a capability to reduce electric lighting power. And also Daylight plays an important role in people's daily cycle of circadian rhythm. In spite disruption of circadian rhythm through environmental light changes, may lead to some of the more damaging and psychological effect associate with seasonal depression. So proper design of day-lighting in a building will lead to increase the environmental issues and decreases the lighting power generation.

3.2 OBJECTIVE

The main objective of "Day Lighting Analysis" is to minimize the usage of Artificial Lighting during Day time and there by the reducing the Energy demand. Daylighting ensure the connectivity between the interior and exterior environment. Access of daylight inside the building makes gives healthier and more comfortable air for occupants and is linked with greater productivity. When designed with proper reflectivity and glare control, minimized solar heat gain is made; day lighting provides a good quality light into the building while significantly reducing energy use for providing lighting and for cooling also.

Daylighting significantly reduces energy consumption and operating costs. Energy used for lighting in buildings can account for 40 to 50 percent of total energy consumption. Properly designed and implemented daylighting strategies can save 50 to 80 percent of lighting energy.

3.3 GRIHA

The following are the GRIHA Requirement with respect to the Daylighting simulation

(1) A proper climatic responsive building with the limited Window-to-Wall Ratio (WWR) and ensuring,
That all the fenestration meets the SHGC Requirement as per ECBC.

(2) A minimum 25% of the living area to be daylighted.

(3) An adequate level of daylighting in each functional area.

3.4 SIMULATION TOOLS

Introducing the effective daylight has become an essential goal for any sustainable building. However since it is difficult to evaluate the quality and quantity by through a simple rule of thumb, the use of daylight simulation tool has considerably increased as a necessary step to accurately evaluate daylight in a building.

The Ecotect - Daylight simulation tool is used to simulate the daylight factor and the illuminance level at any part of the building model over the analysis grid, the tool also helps to determine the potential energy saving due to daylighting and also with the linked lighting design.

3.5 SITE DESCRIPTION

Figure 1IIT Hostel Block construction

The proposed boys hostel block is located very closer to the Krishna gate of Indian Institutes of Technology, Madras (IIT).

3.6 SITE PLAN

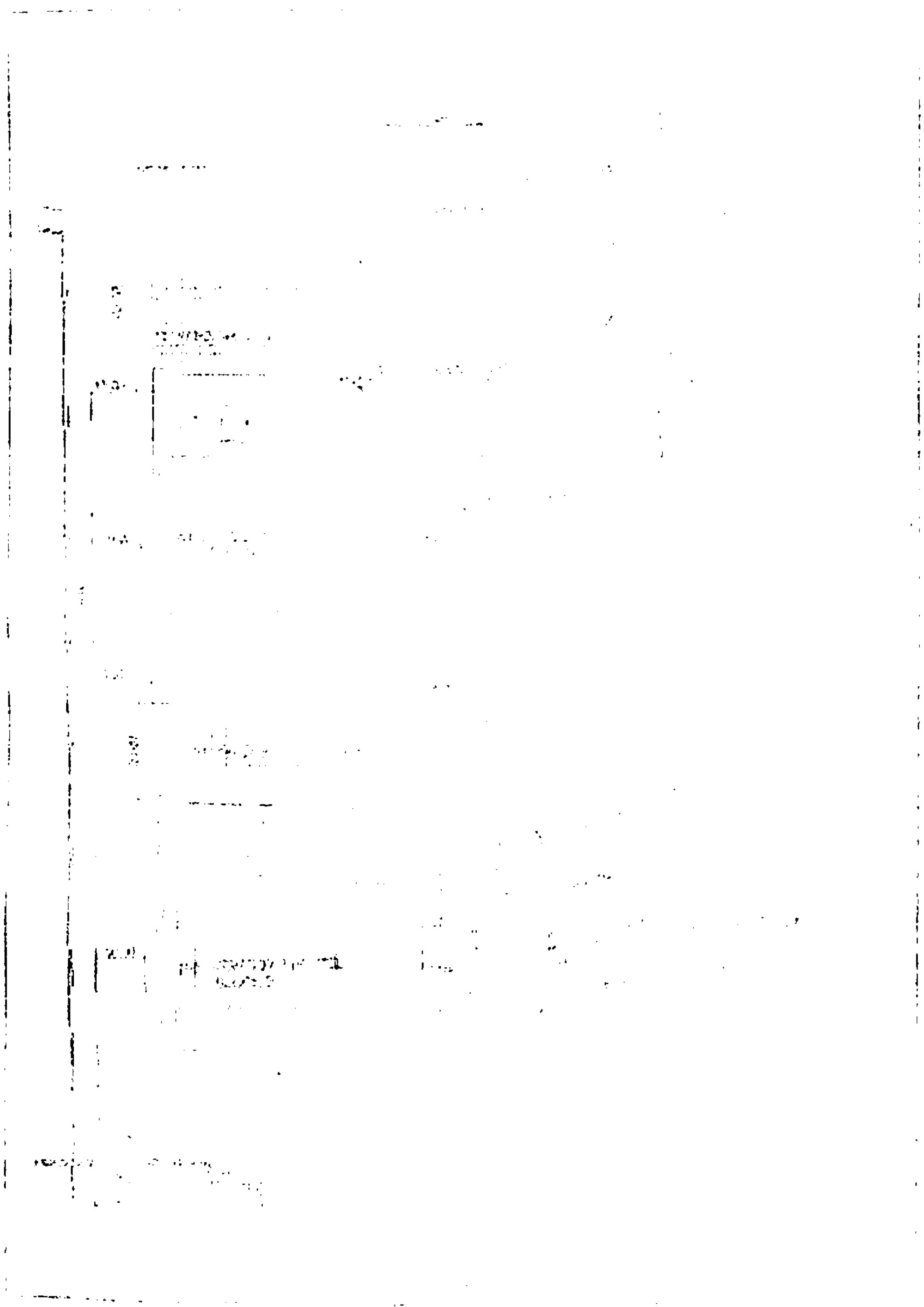


Figure 2 IIT Hostel Block model layout

3.7 ARCHITECTURAL DRAWING

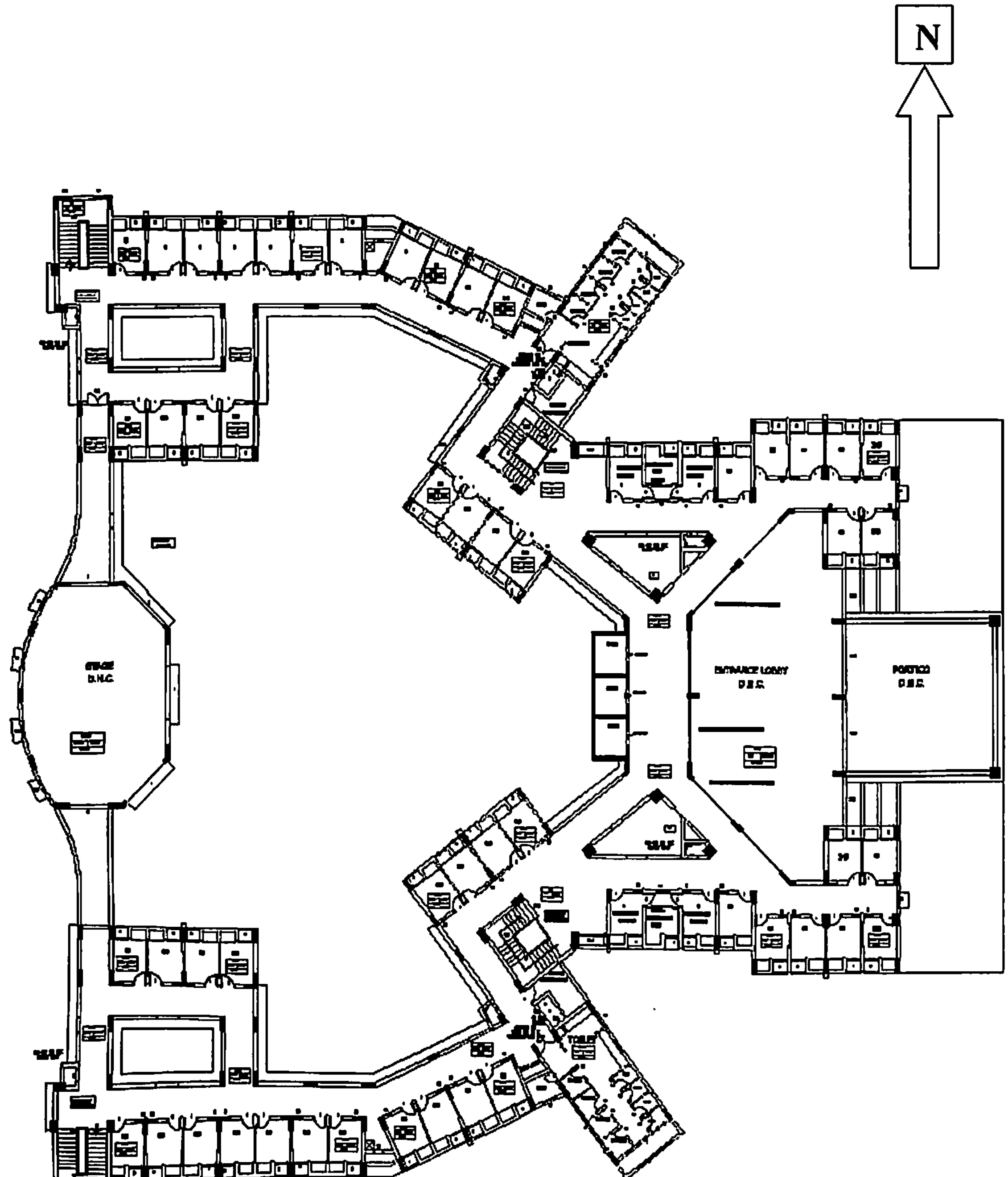


Figure 3 IIT Hostel Block model in CAD diagram

3.8 BUILDING MODEL

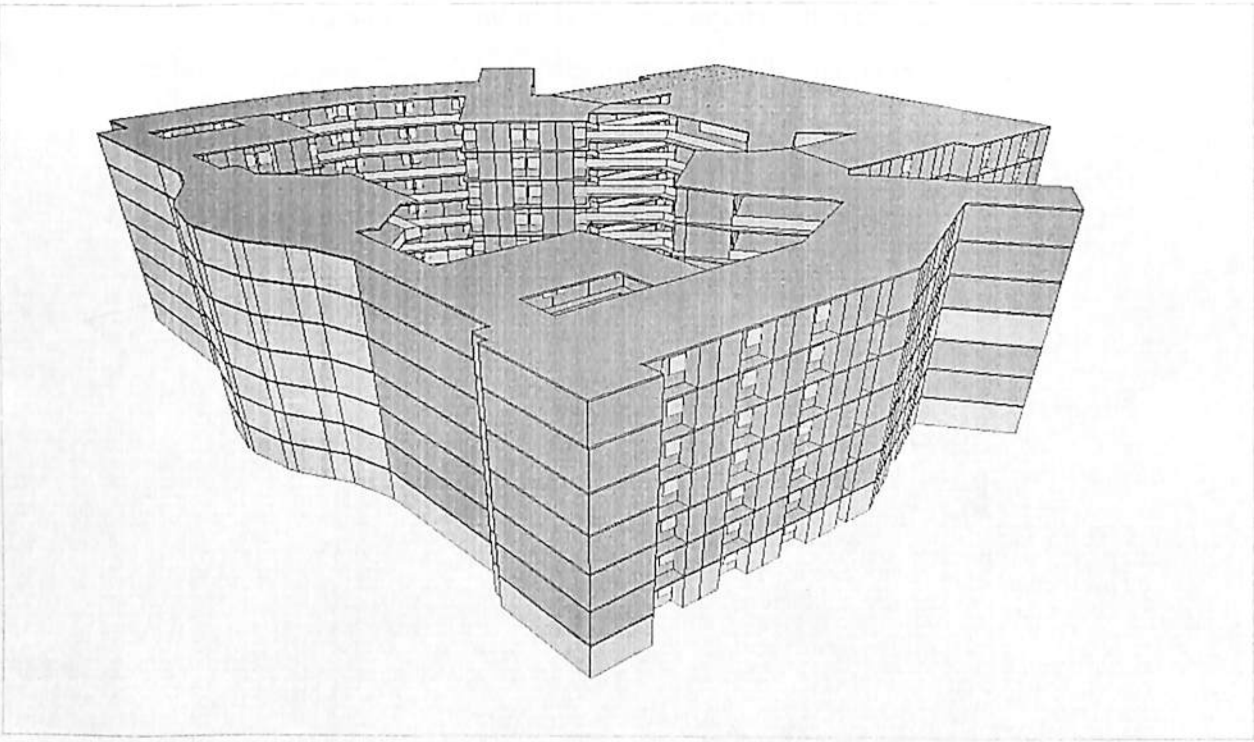


Figure 4 IIT Hostel Block model layout in 3D layout in an orientation

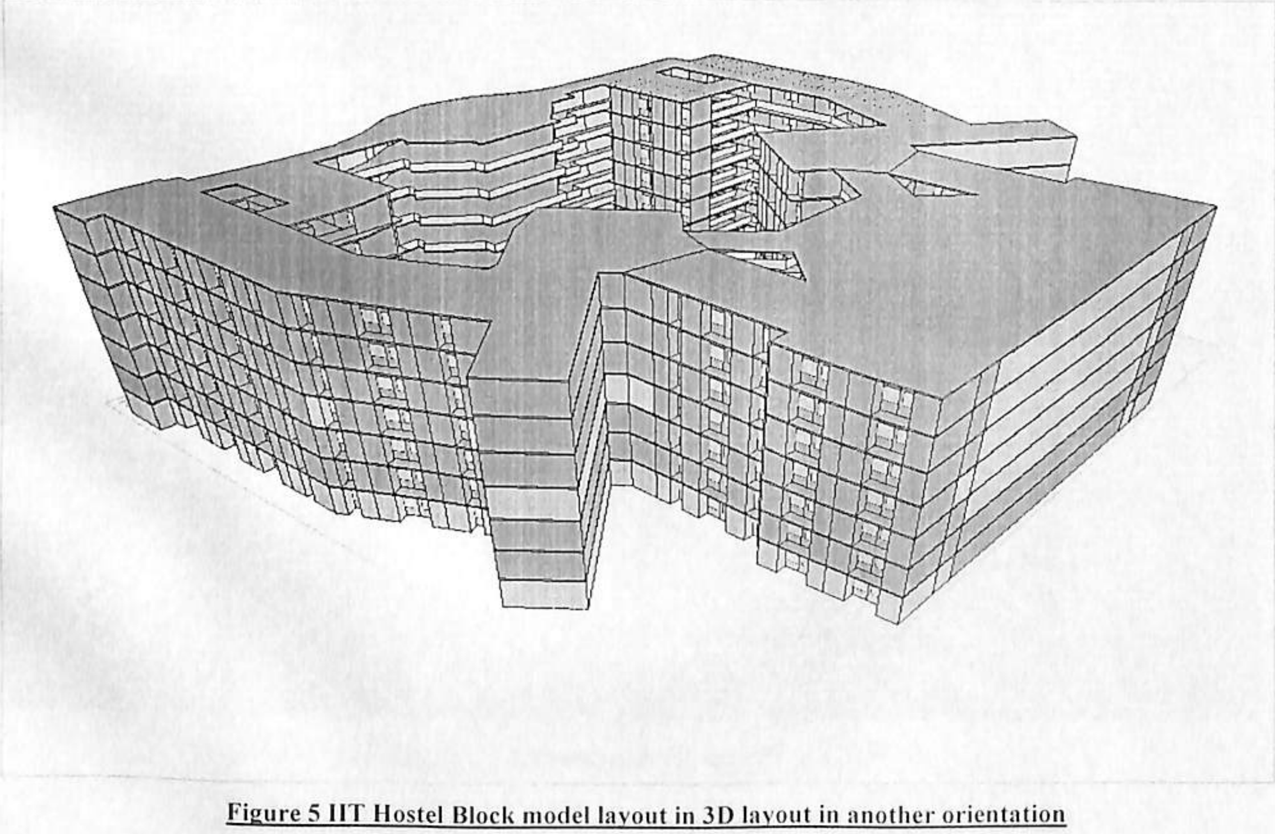


Figure 5 IIT Hostel Block model layout in 3D layout in another orientation

3.9 CLIMATIC CONDITION

Indian Institute of Technology Madras is located in city Chennai which falls under Warm & Humid Climatic condition. The Climatic description for Chennai is shown below.

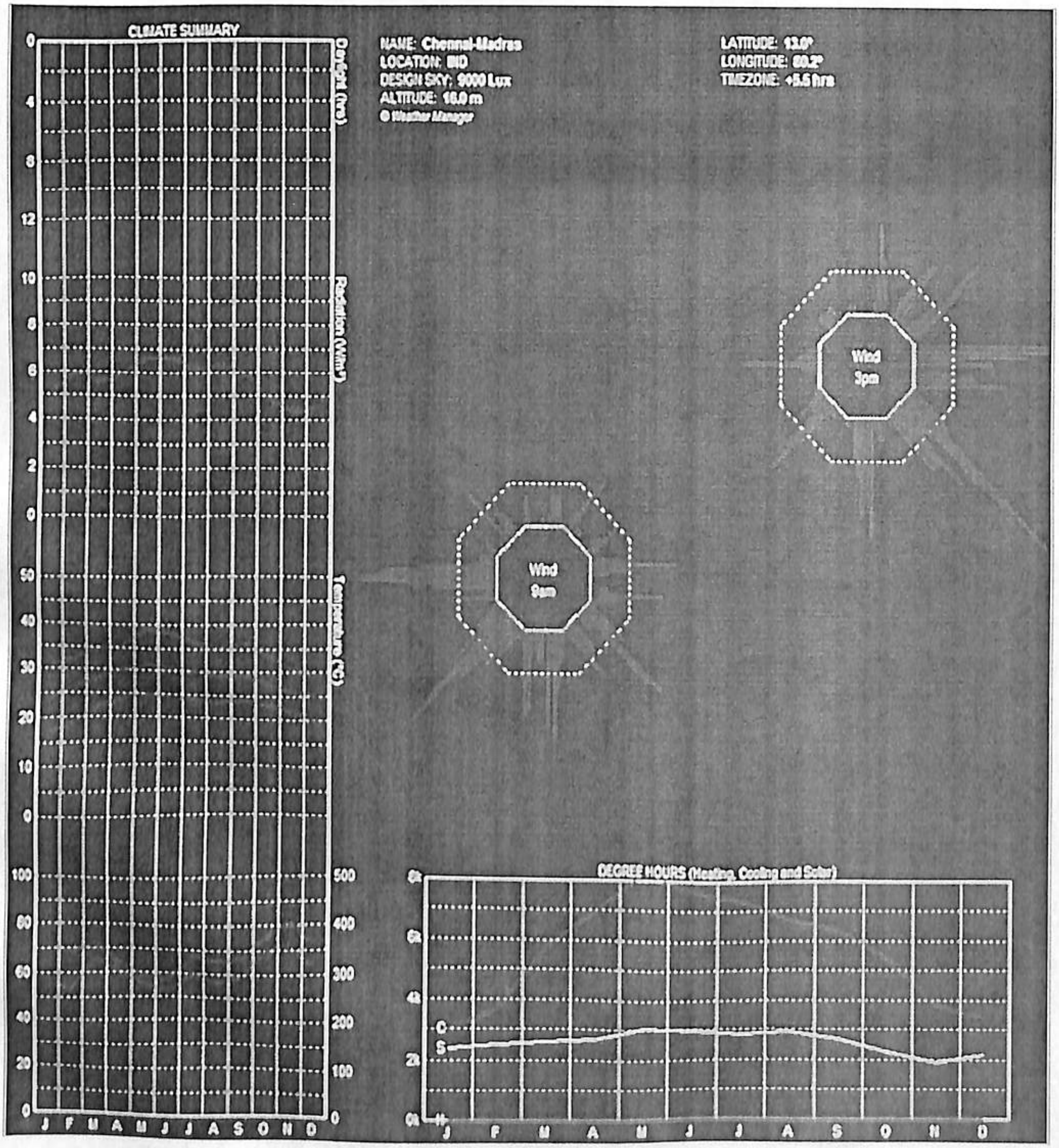


Figure 6 IIT Chennai climatic condition data

3.10 SELECTED GLASS PROPERTIES

Glass Description	"U" Value (W/m²k)	SHGC (%)	VLT (%)
Single glazed	5.67	0.41	0.42

Table 2 Property of used glass

CHAPTER 4

4.1 SIMULATION PARAMETERS

To perform the Daylight simulation certain parameter need to be finalised and set in the simulation tool, such as the dimension and location of the proposed window, depth and pattern of the shading device and glazing specification (Visible Light Transmission), internal reflectance of floor/wall and ceiling, outdoor luminance and sky condition.

The procedure adopted for daylight analysis is as follows

- Develop the model of the building with window sizes and shading devices.
- Load the Weather data as per the location of the building.
- Assign building material properties such as VLT and SHGC of glazing.
- Draw the Analysis grid at a work plane height of 600 mm from floor finish.
- Set the Outdoor design sky condition data as per the climate data to be selected.
- Start the simulation process and check whether the Average DF value and the Daylight level value met recommended values as per ECBC.

4.2 DAYLIGHT ANALYSIS AT ROOM NO 15

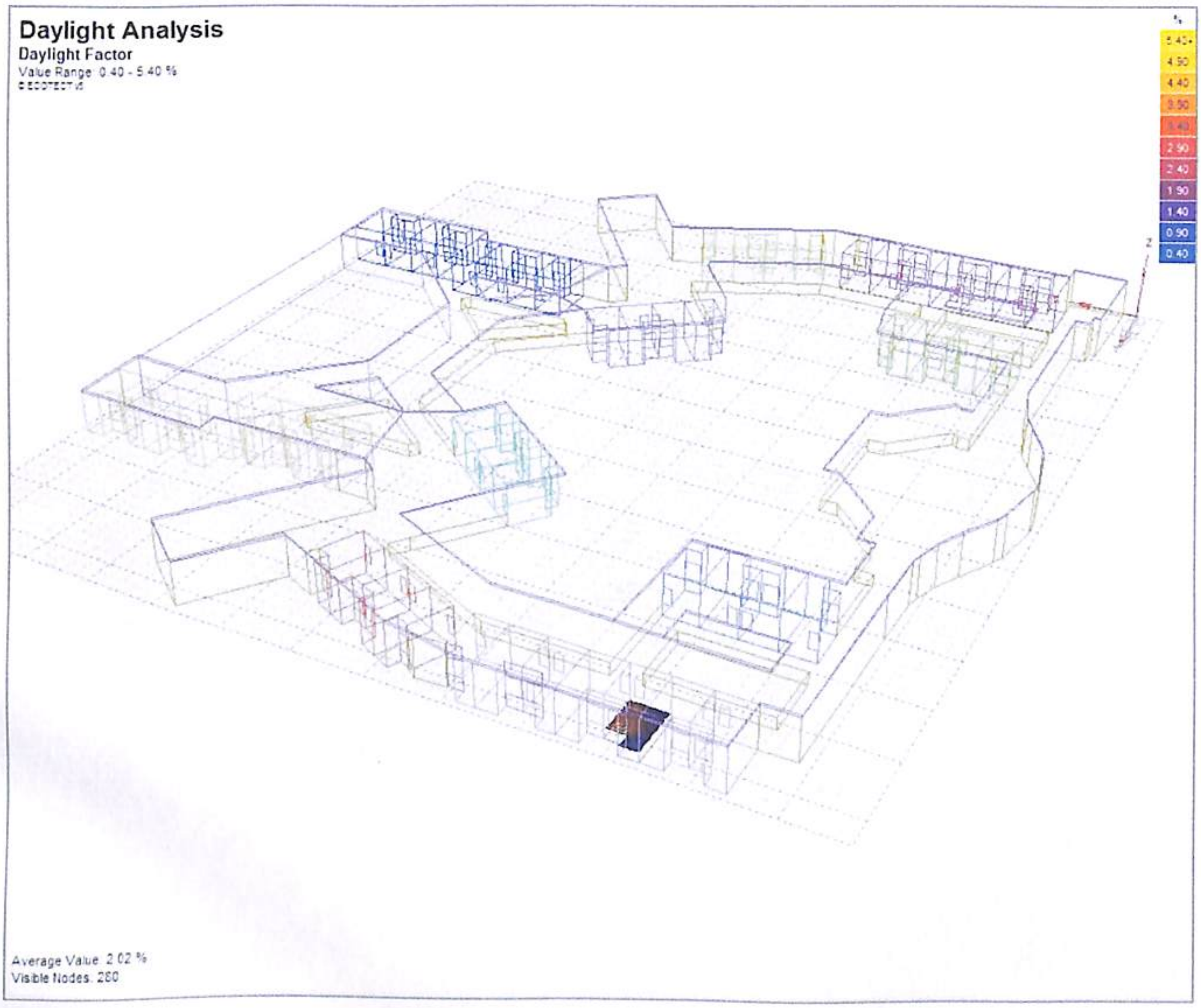


Figure 7 IIT Hostel Block Daylight simulation at room no: 15

AVERAGE DAYLIGHT FACTOR –2.02%

AVERAGE DAYLIGHTING LEVEL – 181.42

4.3 DAYLIGHT ANALYSIS AT ROOM NO 21

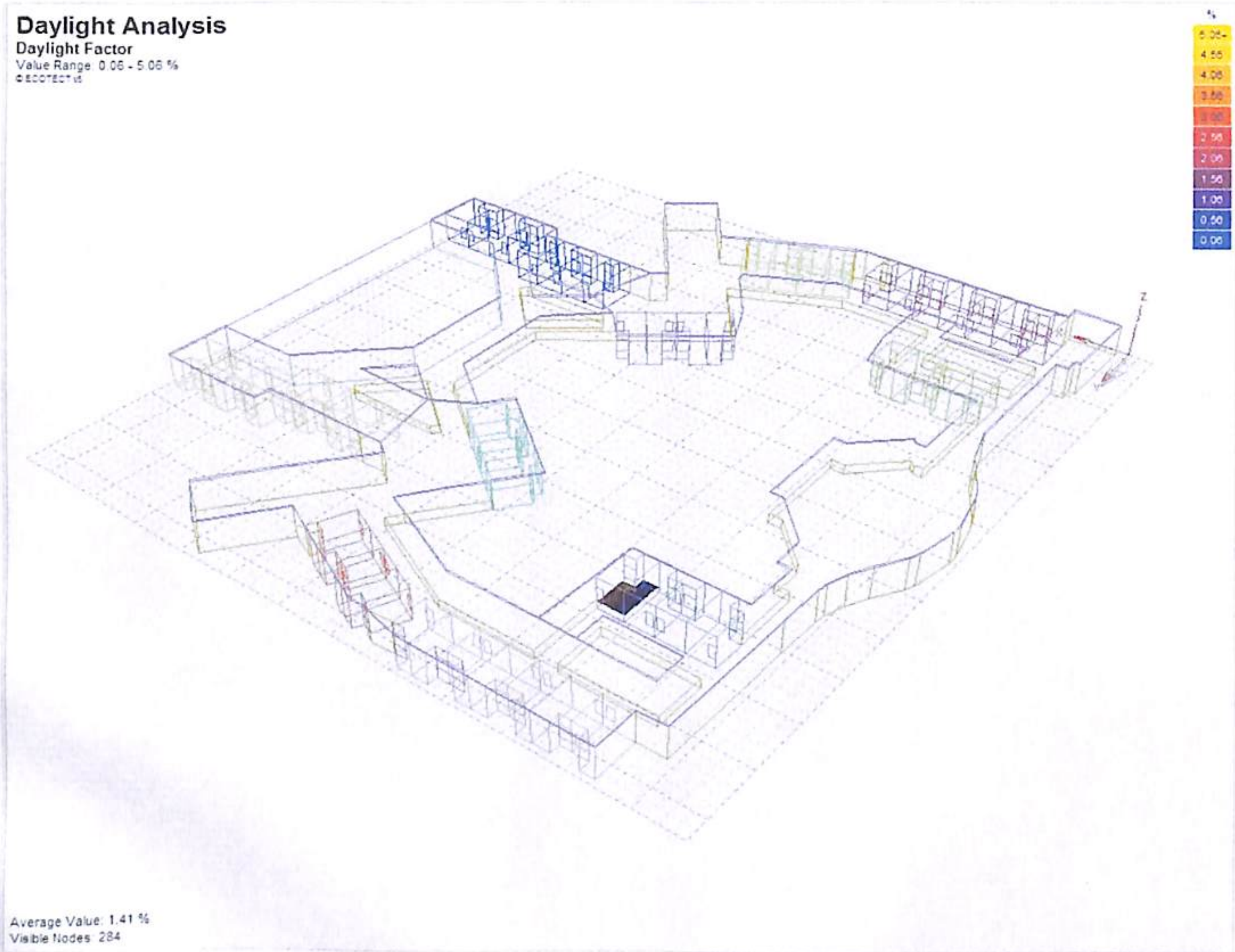


Figure 8 IIT Hostel Block Daylight simulation at room no: 21

AVERAGE DAYLIGHT FACTOR –1.41%

AVERAGE DAYLIGHTING LEVEL – 126.45

4.4 DAYLIGHT ANALYSIS AT ROOM NO 7

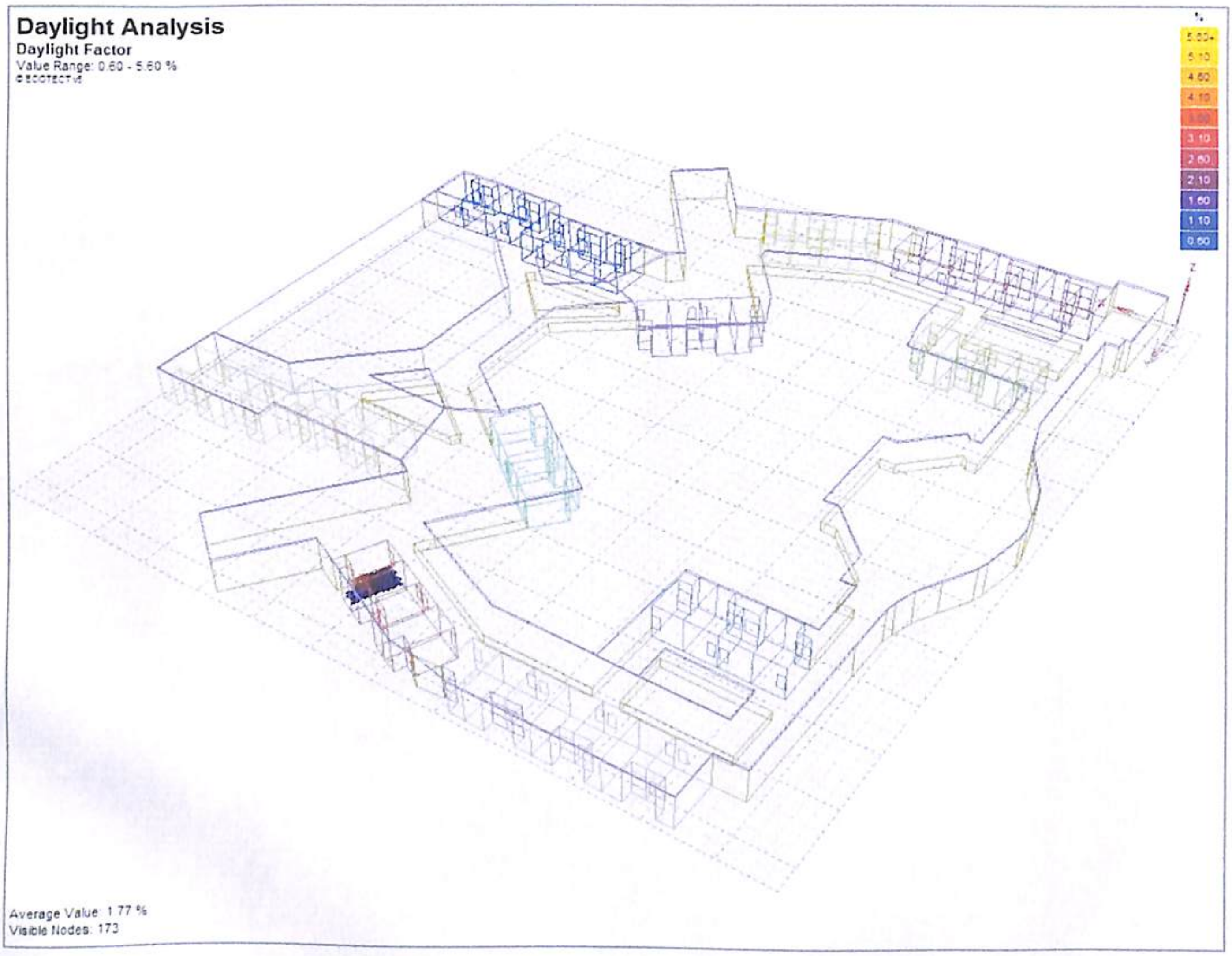


Figure 9 IIT Hostel Block Daylight simulation at room no: 7

AVERAGE DAYLIGHT FACTOR –1.77%

AVERAGE DAYLIGHTING LEVEL – 159.12

4.5 DAYLIGHT ANALYSIS AT ROOM NO 3

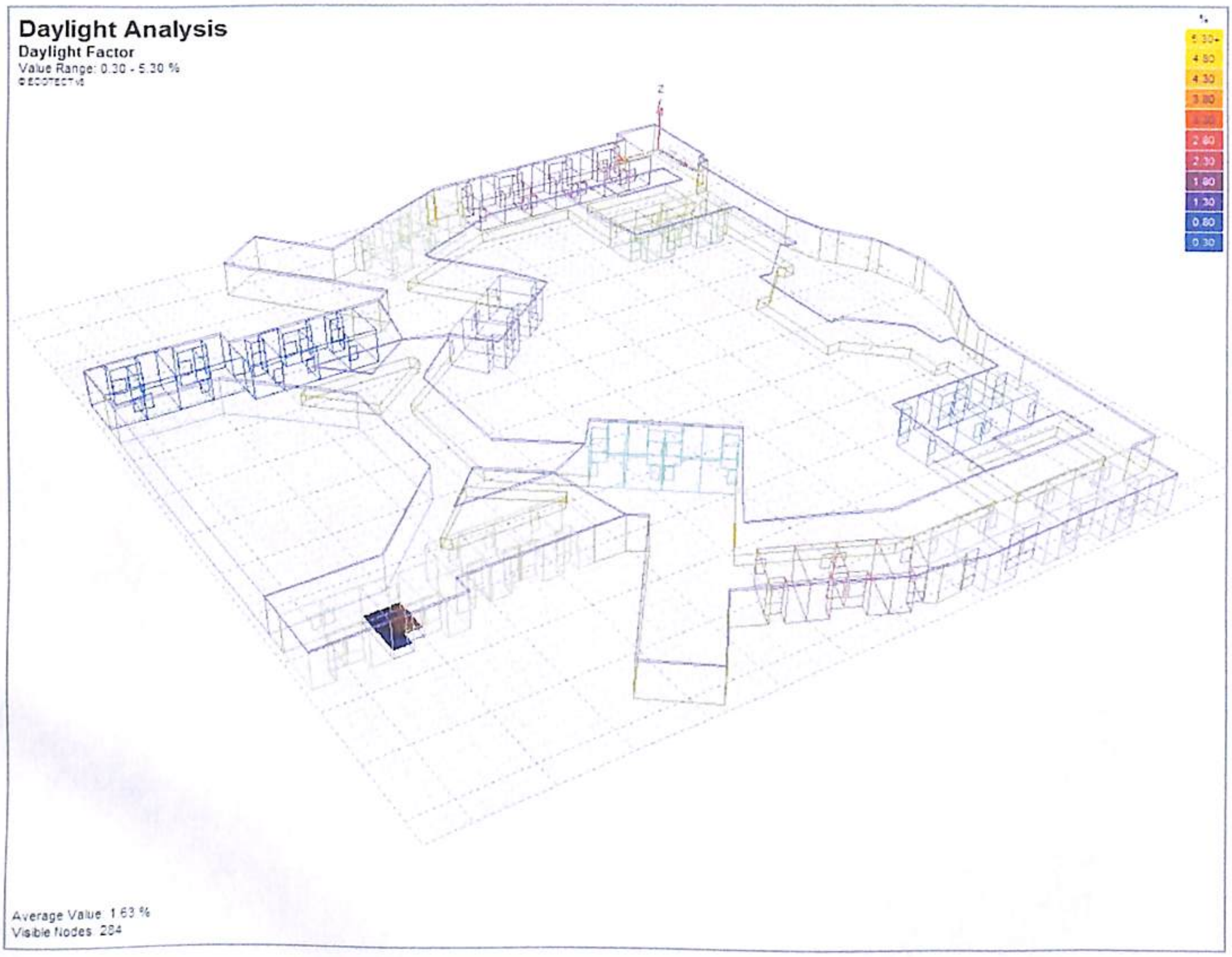


Figure 10 IIT Hostel Block Daylight simulation at room no: 3

AVERAGE DAYLIGHT FACTOR –1.63%

AVERAGE DAYLIGHTING LEVEL – 146.94

4.6 DAYLIGHT ANALYSIS AT ROOM NO 25

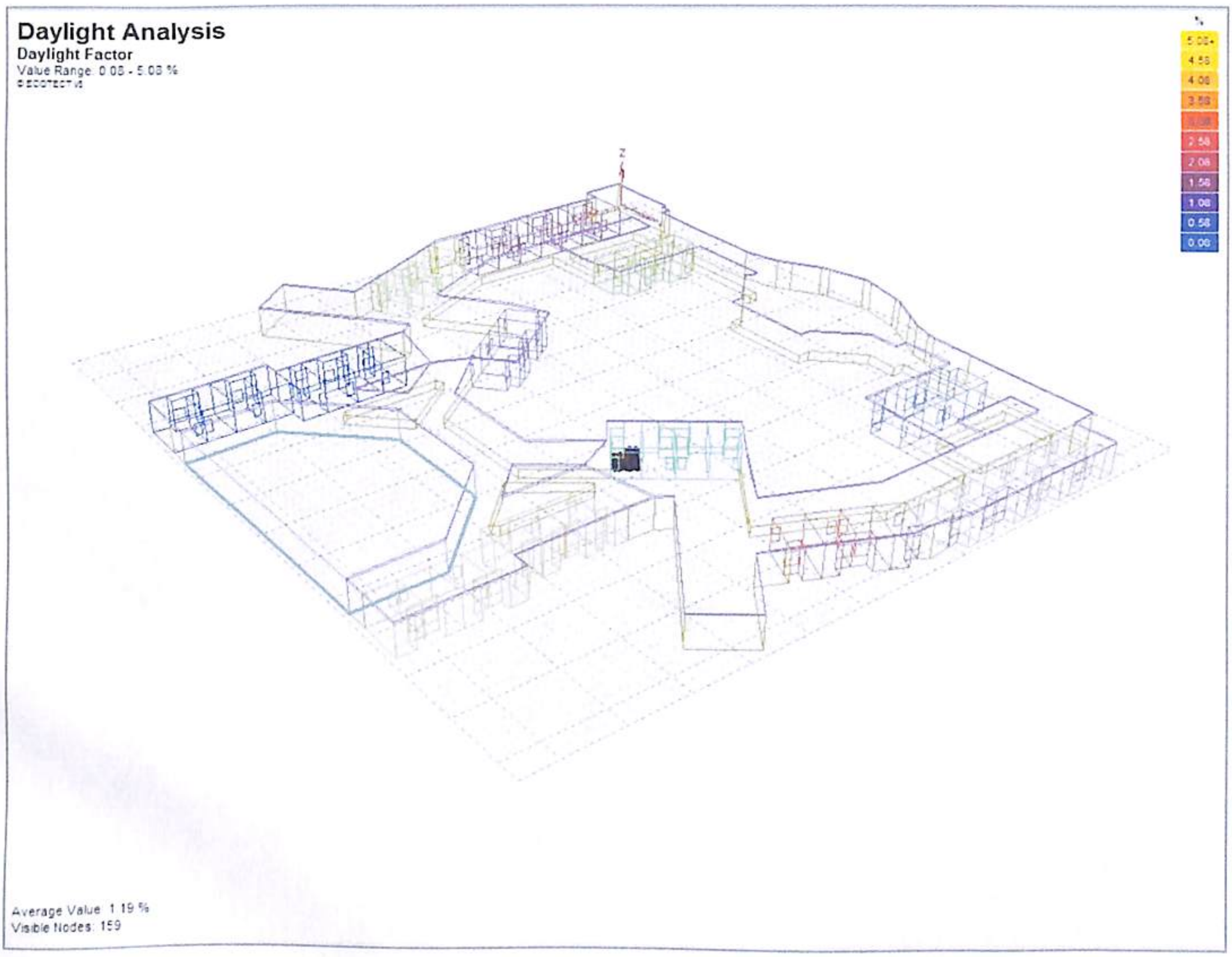


Figure 11 IIT Hostel Block Daylight simulation at room no: 25

AVERAGE DAYLIGHT FACTOR –1.19%

AVERAGE DAYLIGHTING LEVEL – 107.03

4.7 DAYLIGHT ANALYSIS AT ROOM NO 31

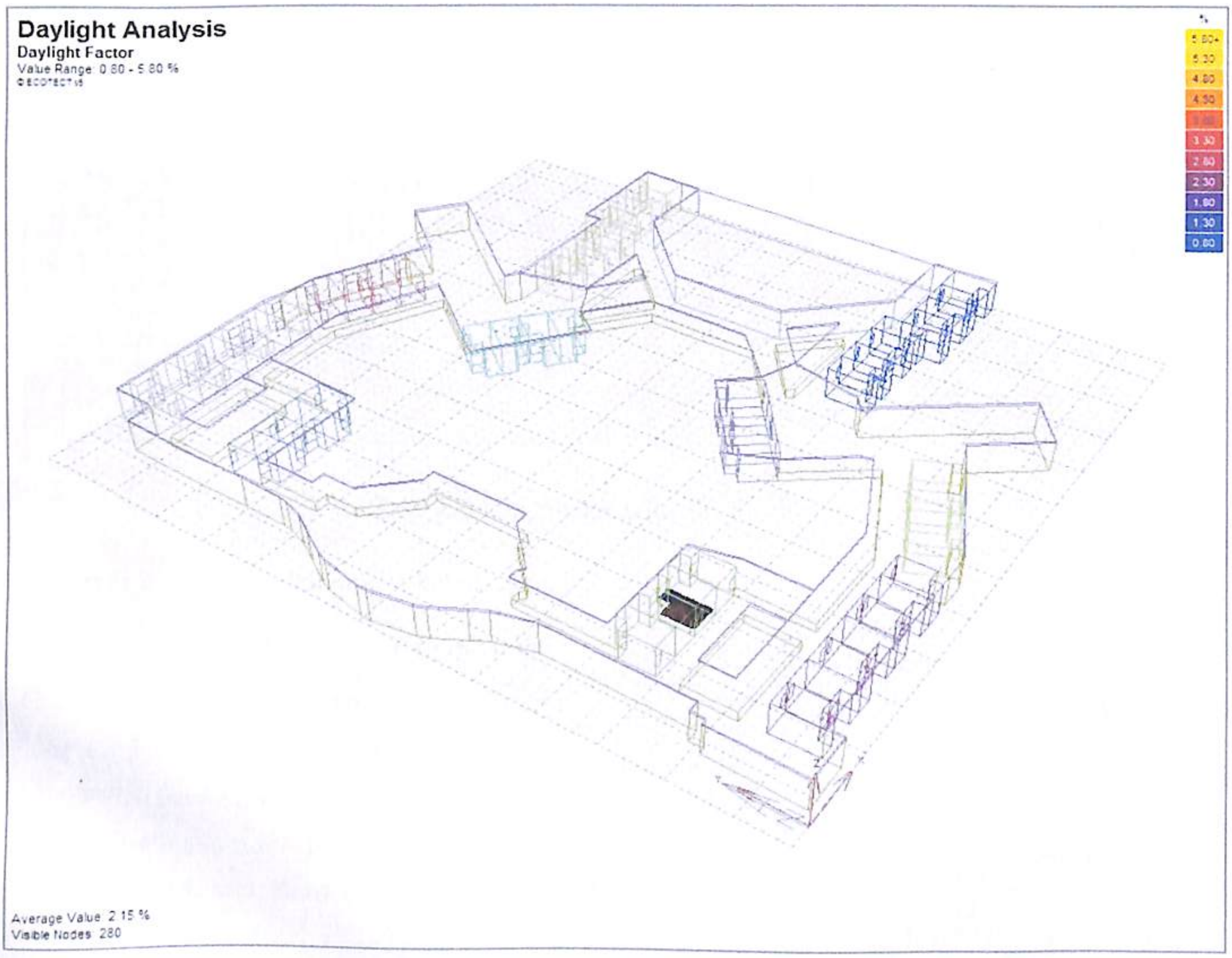


Figure 12 IIT Hostel Block Daylight simulation at room no: 31

AVERAGE DAYLIGHT FACTOR –2.15%

AVERAGE DAYLIGHTING LEVEL – 193.24

CHAPTER 5

5.1 CALCULATION

a. WWR CALCULATION

S.No	Orientation	Net Glazing area	Gross exterior wall area	WWR
1	North	159.60	1310.68	12.17689
2	South	159.60	1310.68	12.17689
3	East	119.07	1483.51	8.026235
4	West	0.00	1483.51	0

Table 3 Wall to Window ratio

Average Window-to-wall ratio is 8.09 %.

b. SHGC CALCULATION

Horizontal Fin (H) = 900 mm

Vertical Fin (V) = 2150 mm

Projection Factor (PF) = H/V = 900/2150 = 0.41

Multiplication Factor (MF) = 0.59

(For PF of 0.41 with North orientation as per ECBC)

Type of Living Space	Window orientation	No. of windows	Window dimension		SHGC of proposed Glass	Shading Dimension		Projection Factor (PF)	Multiplication Factor (MF)	Adjusted SHGC of the fenestration	ECBC Recommended SHGC
			(m)	(m)		Hoz. Fin	Ver. Fin				
Non Air Cond.	N	1	1.2	1	0.41	900	2150	0.41	0.59	0.241	0.25

Table 4 SHGC calculation

c. DAYLIGHTED AREA CALCULATION

Daylight area (%) = (Total Daylighted area / Area of living space) X 100

Type of Living Space	Area of living space (m^2)	Fenestration type	Number of window	Width of Window (m)	Height of Window(m)	Daylighted area (m^2)	Percentage of Daylighted area
Non Air. Cond.	7	Vertical	1	1	1.2	5.4	77.0

Table 5 Daylight area calculation

d. DAYLIGHT FACTOR CALCULATION

Room No.	Daylight Factor Range
01 to 10	1.49 to 2.04
11 to 20	0.94 to 2.06
21 to 30	1.08 to 2.00
31 to 40	1.12 to 2.15
41 to 50	1.11 to 2.27

Table 6 Daylight factor calculation range

Note:

- Area of living space for all rooms in all floors: 7 m^2
- Respective window area for each room: 1.2 m^2
- Selected VLT of glass: 42 %
- Effective daylighted area for the above living space: 5.54m^2
- Recommended Daylight Factor by ECBC: 0.625
- Daylighted area calculation:

  Total daylighted area for window = 2H x (W + 2m)

  Where, H = Height of window from floor level

  W = Width of the window and

  m = metre

The Simulated Daylight Factor for each zone in the building is shown below:

Room No.	Calculated Daylight Factor
01	1.61
02	1.65
03	1.63
04	1.49
05	1.64
06	1.53
07	1.77
08	2.04
09	2.02
10	1.94
11	1.99
12	1.94
13	2.03
14	1.92
15	2.02
16	1.95
17	2.06
18	0.94
19	1.24
20	1.22
21	1.41
22	1.31
23	1.11
24	1.09
25	1.19
26	1.15
27	1.16
28	1.08

29	1.32
30	2.00
31	2.15
32	1.98
33	1.66
34	1.30
35	1.30
36	1.15
37	1.27
38	1.20
39	1.32
40	1.12
41	1.80
42	1.91
43	2.05
44	2.27
45	1.17
46	1.11
47	1.12
48	1.22
49	1.12
50	1.16

Table 7 Individual daylight factor

CHAPTER 6

6.1 LIGHTING INPUT DETAILS

SNO	FLOOR	NAME	AREA in ft^2	OCCUPANTS in Nos	LPD in W/ft
1	Ground	Unconditioned Room - 42 Nos	3948	1	0.60
2	Ground	Physically Challenged Room – 8 Nos	752	1	0.60
3	Ground	Toilets – 2 Nos	1680	-	0.32
4	Ground	Circulation Area	7633	-	0.86 / 1.30
5	First	Unconditioned Room – 52 Nos	5076	1	0.60
6	First	Physically Challenged Room – 4 Nos	376	1	0.60
7	First	Toilets – 2 Nos	1680	-	0.32
8	First	Circulation Area	7633	-	0.86 / 1.30
9	Second	Unconditioned Room – 58 Nos	5452	1	0.60
10	Second	Toilets – 2 Nos	1680	-	0.32
11	Second	Circulation Area	7633	-	0.86 / 1.30
12	Third	Unconditioned Room – 58 Nos	5452	1	0.60
13	Third	Toilets – 2 Nos	1680	-	0.32
14	Third	Circulation Area	7633	-	0.86 / 1.30
15	Fourth	Unconditioned Room – 58 Nos	5452	1	0.60
16	Fourth	Toilets – 2 Nos	1680	-	0.32
17	Fourth	Circulation Area	7633	-	0.86 / 1.30
18	Fifth	Unconditioned Room – 58 Nos	5452	1	0.60
19	Fifth	Toilets – 2 Nos	1680	-	0.32
20	Fifth	Circulation Area	7633	-	0.86 / 1.30
21	Sixth	Unconditioned Room – 58 Nos	5452	1	0.60
22	Sixth	Toilets – 2 Nos	1680	-	0.32
23	Sixth	Circulation Area	7633	-	0.86 / 1.30
24	Ground	Entrance Lobby	2670	4	1.30

	+First				
25	Ground +First	Stage	1435	0	1.30
26	Second + Third	Study Hall	2670	5	1.30
27	Second + Third	Washing/ Drying	2670	0	1
28	Fourth + Fifth	TV Lounge	2670	10	1.20
29	Sixth	Recreation Hall	2670	10	1.20

Table 8 lighting values input

CHAPTER 7

7.1 BUILDING ENVELOPE

#	Envelope Element	Design case	
		Assembly Structure	"U" Factor (Btu/h·ft2·°F)
1	Roof	As per ASHRAE 90.1.2007	0.063
2	Wall above grade	Cement Concrete Blocks	0.375
3	Wall below grade	NA	0.375
4	Floor	As per ASHRAE 90.1.2007	0.350
5	Slab-on-grade Floor	NA	NA
6	Opaque Door	NA	NA
7	Glass	As per manufacturer catalogue	0.998

Table 9 Building envelope input values

Building Performance Calculations

The simulation model for calculating the proposed and baseline building performance shall be developed in accordance with the requirements in ASHRAE Appendix G Table G3.1.

Baseline HVAC System Type and Description

HVAC systems are the assigned for each floor such that they are zoned into different categories under airside hvac system unites. Separate thermal zones will be created and placed under corresponding units and Floors with identical thermal blocks can be grouped for modeling purposes. Other non-ac units will be put under sum, which does not have any hvac system.

a. For laboratory spaces with a minimum of 5000 cfm of exhaust, use system type 5 or 7 that reduce the exhaust and makeup air volume to 50% of design values during unoccupied periods. For all-electric buildings, the heating shall be electric resistance.

Purchased Heat

For systems using purchased hot water or steam, hot water or steam costs shall be based on actual utility rates, and on-site boilers shall not be modeled in the baseline building design.

CHAPTER 8

BUILDING INPUT DETAILS

The input details for the project are collected from the customer and are fed into the software and respective U factors, SHGC are taken as per ASHRAE standards. The HVAC systems are designed as per the design documents and which includes the floor plan, HVAC Duct, HVAC piping plans etc. The lighting loads for the building are given as per the building spaces as defined in the documents. Process loads, lift loads exterior lighting loads also follow the design documents strictly. The energy efficiency measures taken are inducted into the simulation once the building model is done. The input detail for the project is listed in the table below.

S.N.	Model Input Parameter	Baseline Case As per ASHRAE 90.1-2007
1	Exterior Wall Construction	Steel-framed Construction, U-factor=0.124Btu/ hr. ft^2. °F
2	Roof Construction	Insulation entirely above deck, R-20ci, U-factor=0.063 Btu/ hr. ft^2. °F Roof Reflectivity=0.30
3	Fenestration Type(s)	Single glazing
4	Fenestration Assembly U-factor	U-factor=0.55 Btu/ hr. ft^2. °F
5	Glazing Solar Coefficient	SC - 0.41
6	Window to Wall Ratio	40%
7	Air Flow Rate (C.F.M./ Person)	As per Design Documents
8	Equipment Power Density	As per Proposed Case
9	Lighting Power Density	Building Space method as per ASHRAE Room- 1.2 w/sq.ft Restrooms - 0.9 W/sq.ft Store room - 0.8 W/sq.ft Meeting - 1.3 W/sq.ft

10	**Shading Devices**	None
11	**Occupancy Sensors**	None
12	**Daylight Sensors**	None

Table 10 Base case inputs for building envelope

The input sheet above shows the input data for both baseline and proposed case. The baseline follows the ASHRAE standards while the proposed case follows the design documents. The basic concept for the base case is a standardized data, which is the minimum requirement that needs to be followed in order to get certification under Energy and Atmosphere category. Higher the savings; higher is the points that can be achieved. In order to increase the savings best efficient systems should be used.

8.1 MODELING - eQUEST

The model is done in eQUEST by using the SLD's in the Design Development wizard. The simulation software requires weather file, typical usage in a year which would be given as per location and the usage as per original building usage respectively. In most cases the building usage would be taken without any other holidays except the Saturdays and Sundays.

Building envelope is exactly where we use the SLD's exactly to make zones. The site co-ordinates are set to zero and floor to floor height as entered as per the cad drawings. Other aspects of the buildings like windows shades loads in the buildings are also modeled but will follow the guidelines given in ASHRAE appendix table G3.1. For example the windows would be kept as 40% in baseline and as per design in proposed case model; the shades will not be modeled in baseline but in proposed case it is modeled as per design. The baseline and proposed model in eQUEST are shown below with all floors and basement modeled fully. Separate SLD's for each floors and basements were done and modeled

8.2 3D MODELS

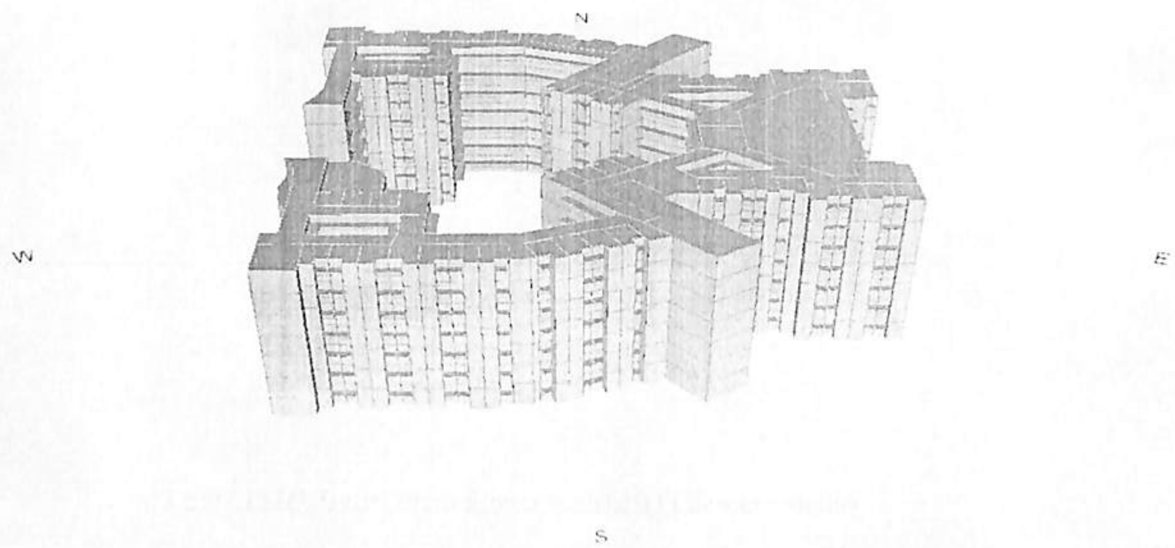
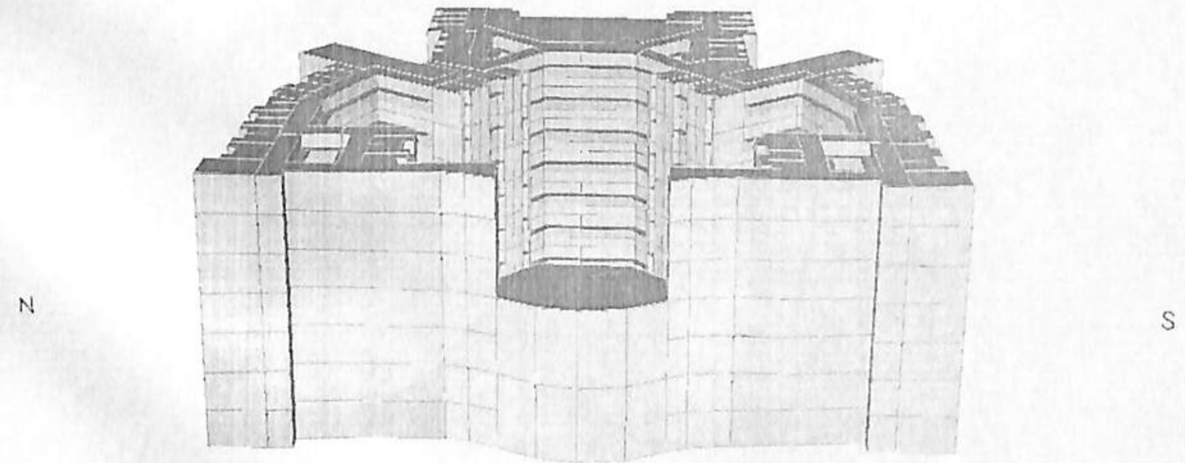


Figure 13 IIT Hostel Block Equest model 3D in South orientation



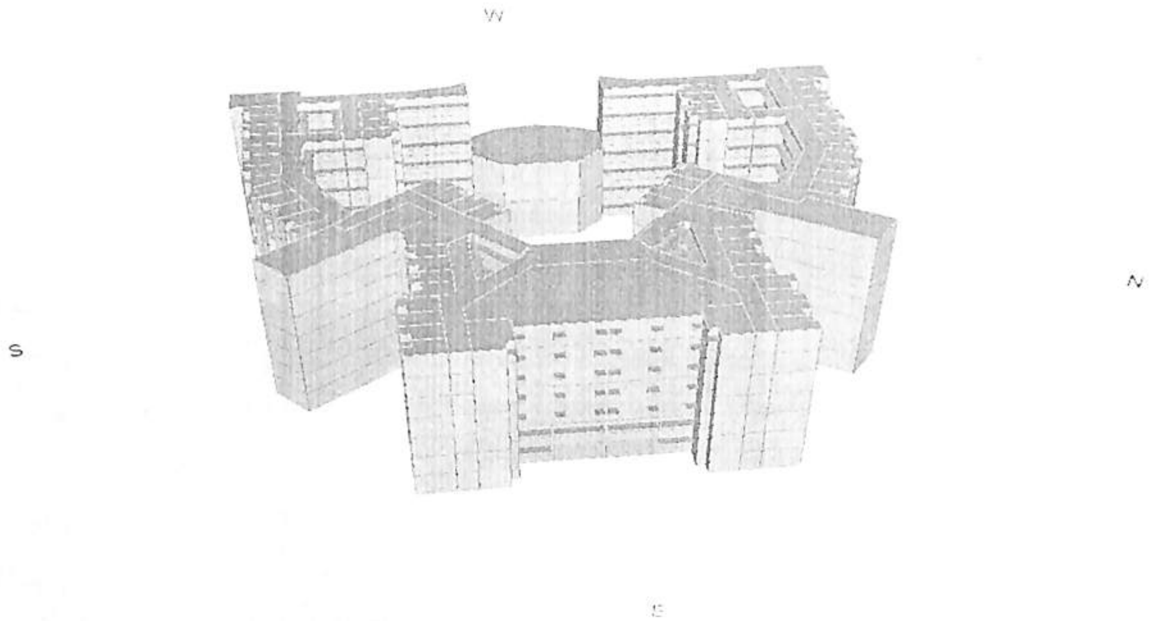


Figure 15 IIT Hostel Block Equest model 3D in East orientation

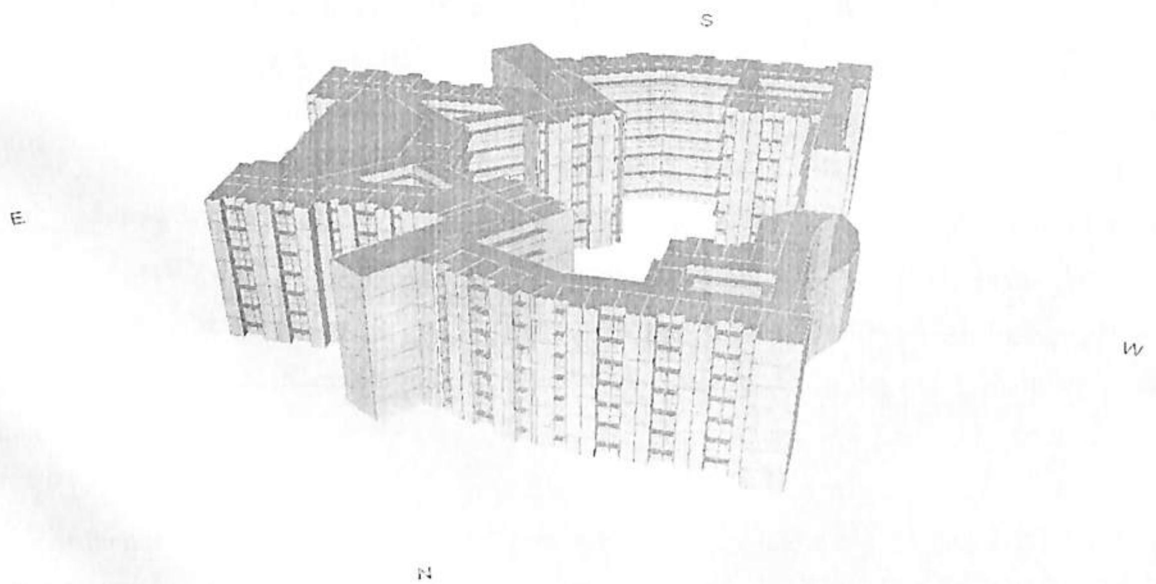


Figure 16 IIT Hostel Block Equest model 3D in North orientation

Models are shown first in 2-dimension and followed by the 3-dimension models of baseline case respectively

8.3 BUILDING PARAMETERS

8.3.1 Schedules: The operation of equipments in the building, HVAC systems, occupancy, lighting has to be defined when it is being operated in the 24 hr period in a day. This schedule is used for calculating the energy cost which defines itself as an important parameter in eQUEST. The schedule is splint into day, week and annual schedules. The week schedules can have different day schedules for a week while the annual schedules can have different week schedules in a year. List of schedules which will be generally used in modeling are:

1. Occupancy Schedule
2. Lighting Schedule
3. Equipment Schedule
4. HVAC system cooling temp Schedule
5. HVAC system Heating temp Schedule
6. Chiller Reset Temperature Schedule
7. Schedules for electricity tariff rates if rate are different for peak hours.
8. Exterior lighting Schedules
9. Miscellaneous load Schedules

8.3.2 Building Shell: once after creating the model the eQUEST will assign a name for each space on itself. We generally change the name according to the floor plans for better identification. The nomenclature we follow is the space name followed by floor name and conditioned or un-conditioned. Similar is done in Air side HVAC for the zones. Sample of space names are given below:

8.3.3 Internal Loads: Internal loads are generally the loads that are used inside the buildings. Lighting power density, Equipment power density, Occupancy Density is defined for the baseline in ASHRAE standards and for the proposed case it is given as per the site details. The screen a shot of LPD is given below; similar would be for occupançy and Equipment.

8.3.4 Water side HVAC Systems: Water side HVAC systems are the supporting systems for the Air side systems. They depend in the type of Air side systems to be used. The equipments in the water side are generally chillers, thermal storage systems, boilers, cooling towers, pumps etc.

The efficiency of all the Equipments used is defined for the Baseline in the ASHRAE standards and for the proposed case the details are fetched from the Equipment details provided from the client.

8.3.5 Air side HVAC Systems: Air side HVAC system includes the HVAC systems used in each zones / Floors as the design documents. The HVAC systems generally differ in baseline and proposed case. The baseline system would always follow the ASHRAE table G.3.1.1A and G.3.1.1B and the proposed case will follow the system that is installed at the site. These HVAC systems will also include equipment's Heat Recovery, DCV, Economizer only in the proposed case if installed at the site. The efficiency of all the systems in the proposed case will be considered in the model. The design CFM is calculated and is shown for the reference in the below table.

8.3.6 Utility Rates: The utility rates for this project have different rates for 4 seasons and each season have peak load, mid peak load and off-peak load rates separately. The table below shows the tariff rate of the Korean electricity board. We take the tariff to be High Voltage A and Option II in the following table.

8.3.7 Simulation

Once after creating all the required models and the equipments the simulation are run with parametric runs for the baseline with changes in orientation i.e. changing the direction of the building north to 0 90 180 270 deg respectively. The building energy consumption is taken as the average of the 4 results of the orientation change. For the proposed case the ECM will be applied in the parametric runs in respective fields.

8.4. SIMULATION OUTPUT

The following are the output sheet generated for each baseline, and proposed case respectively.

8.4.1 CALCULATION OF BENCHMARK EPI FOR NON AIR-CONDITIONED BUILDING

Benchmark energy performance index (EPI) for non air-conditioned building		
Climate Classification	EPI (kWh/m²/year)	EPI (kWh/m²/year)
	Daytime occupancy	24-hour occupancy
	5 days a week	7 days a week
warm and humid	25	100

Table 11- Table 11 EPI calculation

8.4.2 ANNUAL ENERGY PERFORMANCE

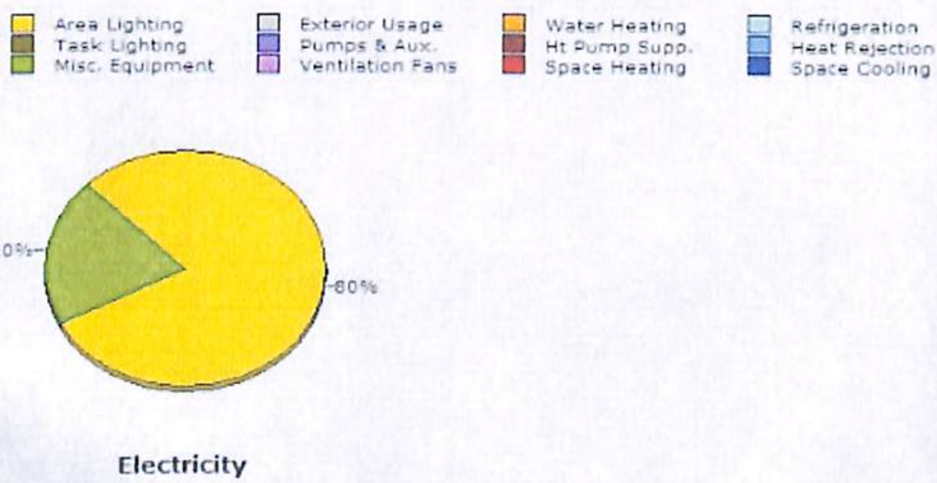
Table 12 Annual energy performance data

Annual Energy Performance	
Total area (m²)	11552
Total annual predicted energy performance (kWh)	302690
Energy performance Index (kWh/m²/year) 24*7	26.20
Percentage reduction in energy performance compared to the benchmarked energy performance	73.8%

Project/Run: IITM Boys Hostel Block - BaseCase - Baseline Design

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas Btu	Steam Btu	Chilled Water Btu
Space Cool	-	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	-	-	-	-
HP Supp.	-	-	-	-
Hot Water	-	-	-	-
Vent. Fans	-	-	-	-
Pumps & Aux.	-	-	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	61.42	-	-	-
Task Lights	-	-	-	-
Area Lights	241.27	-	-	-
Total	302.69	-	-	-



eQUEST 3.64.7130 Annual Energy Consumption by Enduse Page 1

Figure 17 Energy consumption equest result

CHAPTER 9

RESULT

Lighting is a large and rapidly growing source of energy demand and greenhouse gas emissions. Currently, more than 33 billion lamps operate worldwide, consuming more than 2650 TWh of energy annually, which is 19% of global electricity consumption. The total lighting- related carbon dioxide (CO2) emissions were estimated to be 1900 million tons in 2005, which was about 7% of the total global CO2 emissions from the consumption and flaring of fossil fuels.

Based on the analysis done by the simulation tool, the daylight factor for each zone is greater than the recommended daylight factor by Energy Conservation Building Code (ECBC) and Green Rating for Integrated Habitat Assessment (GRIHA).

So, design of lighting system with energy-efficiency and the quality of lighting must go hand in hand. In order to reduce the artificial lighting, the building should be designed in such a way that sufficient amount of day lighting enters into the building. The building comprises of minimum daylight factor of 0.625 as recommended by GRIHA rating system (Criterion 13) for the regularly occupied spaces.

And energy consumption of a normal building type is shown such that green building methods paves way for reducing the overall consumption through skylight & using of double pane glass windows, to reduce overall thermal conductivity & to increase the Visible light transmission. And through this overall energy consumption can be reduced.

REFERENCE

- LEED NC V- 3.0
- ASHRAE STANDARDS 90.1 2007
- ASHRAE STANDARDS 62.1 2007
- ASHRAE STANDARDS 55 2007
- GRIHA MANUAL VOLUME 3