ENERGY EFFICIENT COLLEGE BUILDING: INTEGRATING PLANNING, ANALYSIS, DESIGN, ENERGY OPTIMIZATION, AND ESTIMATION

PROJECT REPORT

Submitted By

AFRA FATHIMA	**STM20CE008**
DIYA T M	**STM20CE023**
PRADUL P	**STM20CE037**
SARIGA JAYARAJ	**STM20CE043**

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In

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DECLARATION

We hereby declare that the project report titled "ENERGY EFFICIENT COLLEGE BUILDING: INTEGRATING PLANNING, ANALYSIS, DESIGN, ENERGY OPTIMIZATION, AND ESTIMATION" submitted for partial fulfillment of the requirements for the award of the degree of Bachelor of Technology of the APJ Abdul Kalam Technological University, Kerala, is a bonafide work conducted by us under the supervision of Prof Dr. ARUN KUMAR SELVARAJAN.

This submission represents our ideas in our own words and where ideas or words of others have been included, we have adequately and accurately cited and referenced the original sources.

We also declare that we have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in our submission. We understand that any violation of the above will be a cause for disciplinary action by the institute and/or the university and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not previously formed the basis for the award of any degree, diploma or similar title of any other university.

Place: Sivapuram

Date: 12/04/2024

AFRA FATHIMA

DIYA T M

PRADUL P

SARIGA JAYARAJ

DEPARTMENT OF CIVIL ENGINEERING

ST. THOMAS COLLEGE OF ENGINEERING AND TECHNOLOGY

MATTANUR

2023 - 2024

CERTIFICATE

This is to certify that the report entitled, **"ENERGY EFFICIENT COLLEGE BUILDING: INTEGRATING PLANNING, ANALYSIS, DESIGN, ENERGY OPTIMIZATION, AND ESTIMATION"** submitted by **AFRA FATHIMA** (STM20CE008), **DIYA T M** (STM20CE023), **PRADUL P** (STM20CE037) & **SARIGA JAYARAJ** (STM20CE043) to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Civil Engineering is a bonafide record of the Project work carried out by them under our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

Internal Supervisor **Project coordinator** **Head of Department**

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AFRA FATHIMA
DIYA TM
PRADUL P
SARIGA JAYARAJ

ABSTRACT

This project outlines a comprehensive approach to focus on achieving energy efficiency in the design of an educational building, by leveraging BIM software tools such as AutoCAD, Revit, Etabs, Forma and other tools like Green Building Studio and Twinmotion. The project encompasses a series of interconnected stages, like site assessment, planning, analysis, design, energy optimization, estimation and 3D visualization. Our project is a proposal of a G+2 educational institution at the college premises. Preliminary survey, planning and designing work were done using Forma, AutoCAD and Revit in accordance with the guidelines from National Building Code, Kerala Muncipal Building Rule and others. The structural analysis of various elements has been carried out in ETABS as per relevant IS codes. Green Building Studio was used for energy optimization and Twinmotion for 3D visualization. The estimation is done by using Revit referring to current PWD rates. The success of this endeavor contributes not only to a more sustainable educational building but also to a broader shift towards sustainability in the educational sector.

Keywords: Energy efficiency, Building Information Modeling, AutoCAD, Revit, ETABS, Green Building Studio, Twinmotion.

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ABBREVATIONS

AAC	Autoclaved Aerated Concrete
AEC	Architecture, Engineering, and Construction
AICTE	All India Council for Technical Education
BIM	Building Information Modeling
CBOs	Commercial Building Operations
ECBC	Energy Conservation Building Code
ETABS	Extended Three-dimensional Analysis of Building Systems
EUI	Energy Use Intensity
GPS	Global Positioning System
HVAC	Heating, Ventilation, and Air Conditioning
KMBR	Kerala Municipal Building Rules
LED	Light Emitting Diode
NBC	National Building Code
PCM	Phase Change Materials
PWD	Public Works Department
ROI	Return On Investment
VR	Virtual Reality

CHAPTER 1
INTRODUCTION

1.1 GENERAL

In an era defined by environmental consciousness and resource scarcity, the pursuit of energy efficiency has become a concern across various sectors. Among these, educational institutions stand as a crucial battleground in the fight against energy waste and its associated environmental impact. These buildings are more than just physical spaces for education; they represent a commitment to sustainability, innovation, and the well-being of future generations.

1.2 PROJECT OVERVIEW

This project outlines a comprehensive approach to achieve energy efficiency in the design of an educational building, particularly focusing on leveraging BIM software tools. Throughout the project stages, software such as Revit was pivotal for its comprehensive BIM capabilities, facilitating detailed architectural designs and structural systems. Revit allows for the creation of detailed building designs by integrating 3D modeling. The software can manage all phases of a construction project, from conceptual design and analysis to construction documentation, and maintenance. Revit provides a comprehensive platform for linking to and integrating with other software tools for an integrated workflow. AutoCAD played an instrumental role in providing precise drafting and documentation support during the early planning and design stages, ensuring accuracy and efficiency in design development. Autodesk Forma played a crucial role in early-stage planning and design. Forma is a powerful tool that can help planning and design teams make better decisions early in the project lifecycle. ETABS, a pivotal software utilized in the project, offered comprehensive structural analysis and dynamic examination of the proposed building's structural integrity. Green Building Studio was employed for energy modeling and environmental analysis, allowing a comprehensive assessment and optimization of energy performance, aiding in understanding the environmental impact of design choices and facilitating daylighting analysis to enhance the building's energy efficiency. Twinmotion facilitated real-time rendering and high-quality visualization, providing a realistic preview of the building's aesthetic and environmental features. Twinmotion aids in creating compelling presentations, pitch videos, and marketing visuals while streamlining the design process.

Furthermore, the project adheres to a range of Indian Standard Codes to ensure structural integrity and compliance. In addition to the KMBR 2019 and NBC 2016, the project design aligns with codes such as IS 456: 2000 for the design and construction of reinforced concrete structures and IS 875: Part 1 & 3 2015 for the design of loads on buildings and structures. These standards are carefully considered throughout the project, ensuring the building's structural strength and safety measures are in line with the recommended codes. We also integrate other pertinent Indian Standard Codes such as Building Bye-Laws 2016, ECBC 2017 and AICTE Norms and Requirements 2021, reinforcing its compliance with local building regulations and educational institution norms.

By leveraging current PWD rates and proposing a framed structure, with a specific focus on a G+2 building, this project serves as a model for practicality and sustainability within the educational sector.

1.3 OBJECTIVE OF THE PROJECT

The primary objective of this project is to conceive, design, and construct an energy-efficient education building that excels in environmental friendliness, structural integrity, cost-effectiveness, and aesthetic appeal. This undertaking aims to address the prevalent issue of energy inefficiency in educational structures through a multidimensional approach, integrating sustainable design principles, rigorous structural analysis, meticulous cost estimation with a focus on long-term savings, energy modeling and analysis for enhanced efficiency, efficient utilization of BIM software, and advanced 3D visualization techniques. The overarching goal is to create a model engineering college building that not only meets but exceeds local building codes and standards, setting a benchmark for sustainable and efficient educational infrastructure. The project will culminate in comprehensive documentation and reporting, providing a valuable resource for future sustainable building initiatives.

1.4 SCOPE OF PROJECT

This project ambitiously aims to construct an energy-efficient and environmentally friendly educational building. The primary objectives encompass a substantial reduction in energy consumption, leading to lower operational costs and a financially sustainable structure. The focus extends beyond economic considerations to prioritize the health and well-being of occupants, creating a learning environment with improved air quality and comfort. Additionally, the project integrates an educational dimension by instilling eco-consciousness in students, fostering a sustainable mindset for the future. This holistic approach also includes the exploration and utilization of various software tools, such as BIM software, to stay abreast of advancements in sustainable design and construction practices.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

A literature review encompasses an exploration of research, theories and understanding surrounding a specific topic or subject area. Its purpose is to summarize, assess and integrate existing literature providing researchers with a foundation for their studies. The main objectives of conducting a literature review include examining the state of knowledge in a field, identifying gaps or areas of disagreement and situating one's own research within the larger context of scholarly discourse. It plays a role in the research process by enabling researchers to grasp what is already known pinpoint areas, for investigation and elucidate how their work contributes to ongoing academic discussion.

1) L. A. Fontalvo, S. Martínez-Marín, M. Jiménez-Barros, K. Parra-Negrete, L. Cortabarria-Castañeda, and D. Ovallos-Gazabon, "Modeling energy-efficient policies in educational buildings – A literature review," ***Procedia Comput. Sci.*****, vol. 198, pp. 608–613, 2022**

This study shows the key areas in enhancing energy efficiency within educational buildings. The research is focuses on EUI, implementation strategies, and outcomes like reduced energy consumption and carbon dioxide emissions. The findings show that integrating energy efficiency within educational institutions, highlights the potential for fostering environmentally conscious practices with significant social impact.

The research advocates to adopt new simulation methodologies to evaluate national energy efficiency policies. Additionally, the review focuses on implementing energy efficiency measures, such as replacing electronic air conditioning, deploying LED-based lighting, harnessing solar power, and retrofitting buildings to attain energy efficiency in educational buildings.

2) M. U. Deosarkar, D. R. Ballewar, R. R. Chitte, P. B. Swami, and N. S. Shirasath, "Analysis and design of multistoried building by using revit BIM," ***Ijirt.org*****. [Online]. Available:https://ijirt.org/master/publishedpaper/IJIRT151857_PAPER.pdf. 2021**

This case study focuses on the use of BIM software, specifically Revit, in the design, analysis, planning, and clash detection of a residential building in Pune, Maharashtra. The study highlights the creation of an intelligent 3D model, design report, scheduling, estimation, and clash detection capabilities of Revit.

It compares Revit with AutoCAD and emphasizes the advantages of Revit, such as its customization options, time-saving features, and support for parametric engine. The research also explores the concept of families in Revit, which are groups of objects with similar parameters and graphical representation. Overall, the study concludes that Revit is a powerful tool for civil engineers, offering advanced functionalities for architectural design.

3) E. U. Syed and K. M. Manzoor, "Analysis and design of buildings using Revit and ETABS software," ***Mater. Today*****, vol. 65, pp. 1478–1485, 2022.**

The study addresses the crucial aspect of modern construction – the pivotal role of software tools in shaping the future of building design and analysis. In light of a growing population and the increasing shift towards vertical development, the demand for multi-story buildings has surged. This phenomenon highlights the importance of utilizing advanced software applications like Revit and ETABS, which have become central to the design and analysis of such structures, constituting approximately 60-70% of urban infrastructure. The significance of these software tools lies in their ability to streamline the design and analysis process, ultimately impacting the cost-efficiency of construction projects. Through a meticulous comparison, the research uncovers that the choice of software can significantly influence critical parameters, particularly the amount of reinforcement steel. Notably, Revit's Robot Structures often yields higher results, pointing to the potential financial implications of software selection. This highlights a fundamental shift in the construction industry, where software applications have emerged as indispensable allies, saving time and reducing manpower requirements while ensuring precise and cost-effective design solutions. In the ever-evolving landscape of vertical development, the choice of software has become a determining factor in successfully striking the balance between design excellence and affordability.

4) A. S. Shivsharan, D. R. Vaidya, and R. D. Shinde, "3D modeling and energy analysis of a residential building using BIM tools," ***Irjet.net*****. [Online]. Available: https://www.irjet.net/archives/V4/i7/IRJET-V4I7111.pdf. 2017**

This journal discusses the importance of energy analysis in the AEC industry and the use of Autodesk BIM tools, specifically Autodesk Revit and Green Building Studio, for energy analysis of a residential building. The paper emphasizes the need to integrate energy analysis into the design phase of buildings to address global warming and energy crisis concerns. It highlights the functionality of energy balance estimation and the significance of energy modeling in compliance with regulations and project energy use estimation.

The document also provides a step-by-step methodology for conducting energy analysis using Autodesk Revit and Green Building Studio, including creating a 3D model, exporting it to gbXML format, and analyzing the results in the cloud-based Green Building Studio software. Overall, the paper highlights the potential of BIM tools in predicting and tracking energy consumption, optimizing building performance, and supporting sustainable design in the AEC industry.

5) P. Usta and B. Zengin, "Energy assessment of different building materials in the education building," *Energy Rep.*, vol. 7, pp. 603–608, 2021.

This paper investigates the energy efficiency of school buildings using two different building materials, AAC and brick. The authors find that the annual EUI of the two materials is similar, but the AAC material has a lower heating load demand than the brick material. This is because AAC has better thermal properties than brick.

The authors also investigate the effect of reducing interior lighting on energy consumption. They find that reducing interior lighting by 30%, 40%, and 50% can reduce energy consumption by 9.5%, 12.7%, and 15.9%, respectively. Based on their findings, the authors conclude that AAC is a better choice for school buildings than brick in terms of energy efficiency. They also recommend reducing interior lighting to further reduce energy consumption.

6) K. Run, F. Cévaër, and J.-F. Dubé, "Does energy-efficient renovation positively impact thermal comfort and air quality in university buildings?," *J. Build. Eng.*, vol. 78, no. 107507, p. 107507, 2023.

This research paper aims to evaluate the energy-efficient renovation performance of the University Institute of Technology buildings in France, particularly with regard to thermal comfort and indoor air quality. The authors cite a number of studies that have shown a correlation between indoor environmental quality and occupants' performance, health, and attitudes. The authors' primary focus is on evaluating thermal comfort and indoor air quality, but they also acknowledge the importance of visual and acoustic comfort.

The authors will be using a variety of data collection methods, including measurements of temperature, humidity, and air quality. They will also be conducting surveys of occupants to assess their perceptions of thermal comfort and indoor air quality. The study's findings could be used to inform future energy-efficient renovation projects in educational facilities and other types of buildings.

7) S. R. L. da Cunha and J. L. B. de Aguiar, "Phase change materials and energy efficiency of buildings: A review of knowledge," ***J. Energy Storage*****, vol. 27, no. 101083, p. 101083, 2020.**

This research paper discusses the potential of PCMs to improve the energy efficiency of buildings and reduce energy poverty. PCMs are materials that can absorb and release heat at specific temperatures, making them ideal for use in thermal energy storage systems.

The paper describes the operating principle of PCMs and their potential applications in buildings. PCMs can be used to store both heat and cold, and can be integrated into a variety of building components, such as walls, floors, ceilings, and glazed areas.

The paper concludes by discussing the benefits of using PCMs to improve the energy efficiency of buildings and reduce energy poverty. PCMs can help to reduce energy consumption by storing heat and cold during off-peak hours and releasing it during peak hours. This can help to reduce the load on power grids and save money on energy bills. PCMs can also help to improve the thermal comfort of buildings by reducing indoor temperature fluctuations.

8) L. Chen, M. Ma, and X. Xiang, "Decarbonizing or illusion? How carbon emissions of commercial building operations change worldwide," ***Sustain. Cities Soc.*****, vol. 96, no. 104654, p. 104654, 2023.**

Decarbonization efficiency levels across most countries' CBOs are less than 10%, emphasizing the need for concerted efforts. The literature underscores electrification as a pivotal strategy for a low-carbon transition in CBOs. Implementing energy-efficient technologies such as LED lighting, efficient HVAC systems, and adopting renewable sources like photovoltaic, wind, geothermal, and hydrogen energy proves effective in reducing primary energy demand and emissions. However, the review emphasizes that building electrification is just one facet of the decarbonization puzzle.

To deepen the decarbonization of CBOs globally, the literature recommends multifaceted solutions. The promotion of ultralow, near-zero, and zero energy buildings is advocated, along with the endorsement of heat pump technologies, carbon capture, utilization, and storage. Sustainable structure design gains prominence, emphasizing high-performance structures and low-carbon building materials, including innovative walls, energy-saving insulation materials, high-quality cement products, and advanced glass products. Additionally, encouraging sustainable behaviors among building occupants, such as conscientious energy consumption practices, is identified as a crucial component in the overall decarbonization strategy.

9) V. J. L. Gan, M. Deng, Y. Tan, W. Chen, and J. C. P. Cheng, "BIM-based framework to analyze the effect of natural ventilation on thermal comfort and energy performance in buildings," ***Energy Procedia*****, vol. 158, pp. 3319–3324, 2019.**

Buildings globally consume a substantial amount of energy, with mechanical air-conditioning systems representing a significant share. Recognizing the potential of natural ventilation to achieve a comfortable indoor thermal environment while reducing energy consumption, this literature review addresses the existing gap in understanding the correlation between thermal comfort and energy performance facilitated by natural ventilation. Previous studies have predominantly focused on either thermal comfort or energy conservation, without thoroughly exploring their interplay. Furthermore, the impact of natural ventilation on buildings, influenced by factors such as geometry, material properties, outdoor conditions, and occupancy, requires a more comprehensive investigation. This paper introduces a novel framework based on BIM to bridge these gaps and enhance the understanding of the intricate relationship between natural ventilation, thermal comfort, and energy performance.

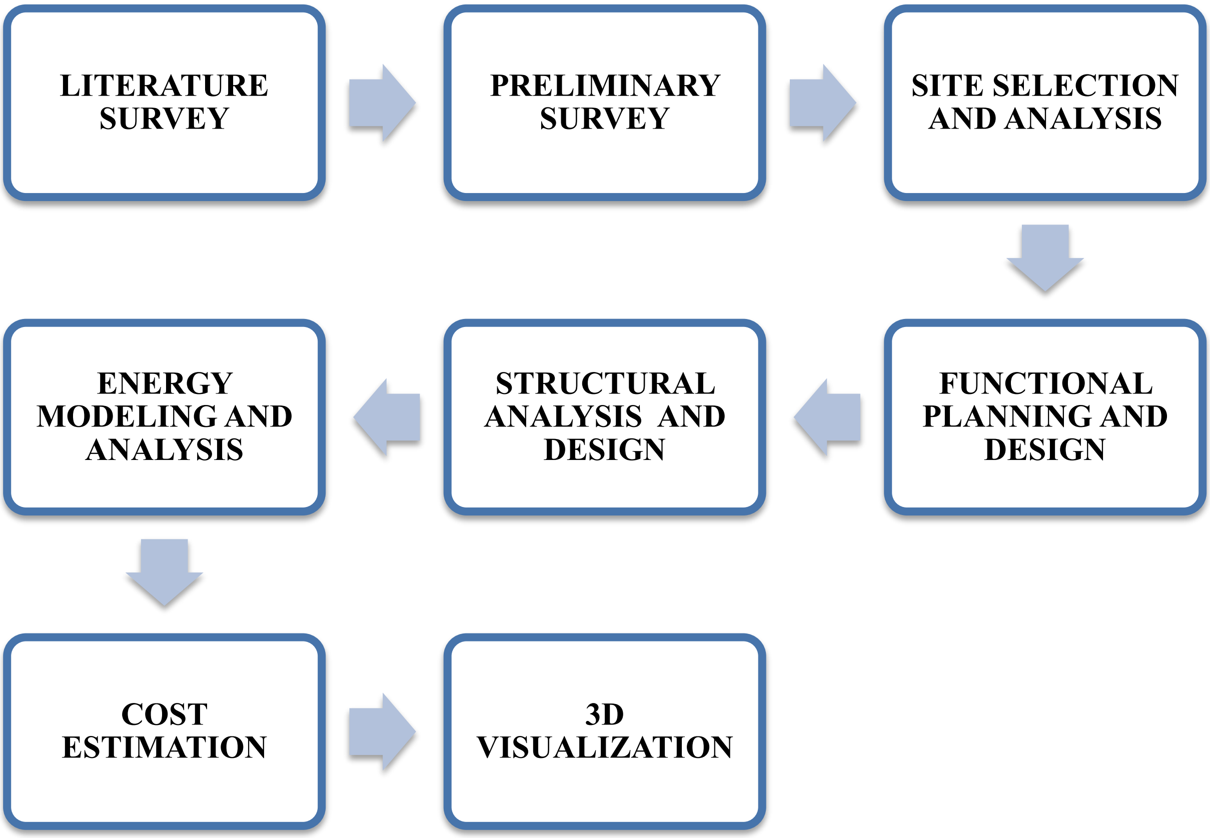
BIM offers a powerful tool for studying the impact of natural ventilation on the correlation between thermal comfort and energy performance in buildings. By providing detailed 3D building models incorporating geometric and material information, as well as data on building location and type, BIM enables a more accurate simulation of outdoor environmental conditions and occupancy factors. This increased accuracy contributes to a more nuanced evaluation of the effectiveness of natural ventilation in achieving thermal comfort while minimizing energy consumption.

10) K. G. Nath and A. M. Thomas, "Analysis of an educational building in ETABS," Ijert.org. [Online]. Available: https://www.ijert.org/research/analysis-of-an-educational-building-in-etabs-IJERTV11IS050103.pdf.

The project focused on the meticulous analysis, design, and detailing of an educational building, adhering rigorously to the Kerala Panchayat Building Rules and Indian standard Codes. Tools like AutoCAD for drafting and ETABS 2016 for structural modeling and analysis were used in the study. The project highlighted the advantages of software in producing efficient, accurate, and economical designs for multi-storied structures.

The research also emphasized the software's capability in accounting for diverse loads such as dead loads, live loads, earthquake loads, and wind loads. The software facilitated 3D visualization, precise calculations, and efficient reinforcement determination, highlighting its convenience for multi-storied buildings despite limited use in India. The advantages of software-based design included error avoidance and enhanced accuracy, especially compared to manual design processes prone to mistakes.

CHAPTER 3
METHODOLOGY



3.1 LITERATURE SURVEY

The integration of advanced software tools such as ETABS and Revit in structural design processes brings about significant advantages, including a reduction in manpower requirements, time savings, and enhanced accuracy. This streamlined approach not only optimizes the structural design workflow but also contributes to overall project efficiency. Moreover, the utilization of AAC as a building material offers notable benefits, particularly in terms of decreased energy consumption when compared to traditional bricks. This makes AAC a superior choice for sustainable construction practices.

In the realm of architectural design, focusing on energy efficiency becomes paramount. Incorporating energy-efficient windows and shadow screens in educational buildings emerges as a strategic measure to enhance indoor air quality. These features not only contribute to a healthier and more comfortable indoor environment but also align with broader sustainability goals.

Another innovative approach to sustainable building design involves the utilization of PCMs. By optimizing heating and cooling processes, PCMs play a crucial role in promoting a more eco-friendly and sustainable approach to both the design and operation of buildings. This integration aligns with the global push towards environmentally conscious practices within the construction industry.

Furthermore, for a comprehensive low-carbon transition, it is imperative to embrace energy-efficient technologies such as LEDs and advanced HVAC systems for building electrification. These technologies not only reduce carbon footprints but also contribute to long-term energy savings. In essence, the combination of these efficient technologies ensures a more sustainable and environmentally responsible approach to building design and operation.

3.2 PRELIMINARY SURVEY

The preliminary survey was a comprehensive process that laid the groundwork for an energy-efficient college building. It began by outlining project goals with a strong emphasis on energy efficiency and sustainability. Simultaneously, our team conducted a thorough review of existing structures, site infrastructure, and environmental factors surrounding the potential site. An integral aspect of this phase was the assessment of code compliance, involving an analysis of various Indian standard codes such as the NBC 2016, KMBR 2019, and IS 456 2000. This ensured that the project's early stages aligned with local regulatory requirements.

Software selection was a critical element of this phase. The team deliberated and selected a suite of BIM software that best suited the project requirements. This involved weighing the capabilities of various software like AutoCAD, Revit, Green Building Studio, ETABS, Twinmotion, and Autodesk Forma. The selection aimed to facilitate an integrated approach to planning, analysis, and design for achieving energy-efficient outcomes. The chosen software suite facilitated the analysis of building performance, material selection, and the creation of detailed design models, aligning seamlessly with the energy efficiency goals.

3.3 SITE SELECTION AND ANALYSIS

The site selection process was fundamental in establishing the foundation for our endeavor to create an energy-efficient college building. Our team engaged in a methodical evaluation process, meticulously assessing potential sites based on a range of criteria. Our goal was to identify a location that not only accommodated the building's infrastructure needs but also aligned with our energy efficiency objectives. This involved an in-depth analysis of topographical features, climate considerations, and environmental factors. The site's characteristics, including sun exposure, wind patterns, and natural surroundings, were thoroughly scrutinized to understand their influence on the building's energy requirements. A detailed evaluation of environmental impact and potential sustainability was carried out to ensure the site was conducive to the implementation of energy-efficient design elements.

3.4 FUNCTIONAL PLANNING AND DESIGN

The architectural planning and design phase was a pivotal stage where the core concept for an energy-efficient building began to take shape. Initial designs were conceptualized, integrating passive design techniques and sustainability principles. These designs were iterated upon, incorporating efficient spatial planning, optimizing natural lighting, and maximizing ventilation. Material selection was a key focus, emphasizing sustainable and eco-friendly materials that aligned with our energy efficiency goals. Every decision, from the orientation of the building to the choice of construction materials, was meticulously planned to harmonize with the overall energy efficiency objectives.

3.5 STRUCTURAL ANALYSIS AND DESIGN

The structural design phase was crucial in ensuring the building's robustness while also adhering to energy-efficient principles. Collaborating closely with the architectural vision, the structural design aimed to optimize energy efficiency without compromising the building's integrity. This phase involved intricate planning of material usage, structural components, and load-bearing elements. The integration of architectural and structural elements was vital to achieving a harmonious balance between aesthetics and energy efficiency. An iterative design process allowed for continuous refinement, enabling us to achieve a design that merged both structural integrity and energy efficiency seamlessly.

3.6 ENERGY MODELING AND ANALYSIS

Sophisticated software and advanced methodologies were employed to conduct detailed energy simulations. These simulations provided critical insights into the building's energy consumption patterns, areas of potential energy loss, and opportunities for optimization. The results of these simulations were analyzed to recommend design modifications that could significantly enhance the building's overall energy efficiency. Strategies for efficient heating, cooling, lighting, and insulation were derived from these simulations, forming the backbone of the energy optimization plan.

3.7 COST ESTIMATION

The cost estimation phase delved into a detailed breakdown of expenses related to energy-efficient features and strategies. It involved a meticulous analysis to ensure that the project aligned with the allocated budget while still achieving optimal energy efficiency. Additionally, a thorough analysis of the long-term ROI was conducted. This assessment aimed to showcase the economic benefits and potential cost savings stemming from investing in an energy-efficient design. It helped in demonstrating the feasibility and long-term sustainability of the proposed design, beyond just energy efficiency.

3.8 3D VISUALIZATION

In this phase, our team developed detailed 3D visual representations and renderings of the proposed design. These visualizations provided a tangible view of how the building design aligned with energy-efficient principles. Through immersive virtual walkthroughs, we can gain a comprehensive understanding of the building's layout, features, and its alignment with energy efficiency goals. This phase significantly aided in communicating the design aspects to the broader team facilitating a clearer vision and understanding of the building's potential upon completion.

3.9 CONCLUSION

A thorough literature survey of each topic provides valuable insights, methodologies, and best practices essential for advancing the field and driving innovation in architecture and engineering. The exploration of energy modeling and analysis, structural design, site selection, functional planning, cost estimation, and 3D visualization underscores the interdisciplinary nature of building design and construction. Efficient energy usage, structural integrity, optimal site selection, functional space planning, accurate cost estimation, and immersive visualization techniques are integral to successful projects. By synthesizing knowledge from these domains, professionals can create sustainable, safe, and cost-effective buildings that meet the needs of occupants.

CHAPTER 4
SOFTWARES

4.1 GENERAL

BIM software has emerged as a transformative tool in the architecture, engineering, and construction industry. This innovative technology goes beyond traditional 3D modeling, offering a holistic approach to the design, construction, and management of buildings and infrastructure. BIM software allows stakeholders to collaboratively create detailed 3D models enriched with essential information such as time, cost, and materials. One of the key strengths lies in its ability to foster improved collaboration among diverse project teams, enhancing communication and coordination. By facilitating real-time interactions, BIM software minimizes errors through clash detection and streamlines project planning, leading to significant cost and time savings. Ultimately, BIM software not only revolutionizes the design process but also supports the entire lifecycle of a building, making it a cornerstone in modern construction methodologies. We use BIM softwares like AutoCAD, Revit, ETABS and Forma. Other softwares like Green Building Studio and Twinmotion are also used.

4.2 AUTOCAD

AutoCAD is an essential tool for building planning, offering architects and designers robust 2D drafting and 3D modeling features. With precision tools for creating floor plans and detailed three-dimensional representations, AutoCAD streamlines the planning process. Its layer management system enhances organization, while detailing and annotation features ensure clear communication with construction teams. The software’s collaborative capabilities support real-time teamwork and coordination among stakeholders. Compatible file formats and support for parametric design make AutoCAD a versatile asset in creating dynamic and easily modifiable designs during building planning. Overall, AutoCAD significantly contributes to the efficiency and accuracy of architectural drawings, providing a solid foundation for successful construction projects.

4.3 REVIT

Revit, developed by Autodesk, is a pivotal tool in the realm of building planning and cost estimation. Functioning as robust BIM software, Revit extends its capabilities beyond traditional design by incorporating data-rich 3D models that include material, quantity, and cost information. A standout feature is its parametric modeling, establishing a dynamic link between design modifications and associated cost elements, thereby streamlining the estimation process. Through quantification and scheduling tools, Revit allows for the extraction of precise material quantities directly from the 3D model, contributing to detailed and accurate cost estimates. The software facilitates ongoing cost tracking and analysis throughout the project, empowering stakeholders with real-time insights for informed decision-making and cost control. Moreover, Revit's collaborative environment supports concurrent work by architects, engineers, and cost estimators, ensuring that cost estimations align seamlessly with the latest design revisions. Its efficiency is further enhanced by industry-standard templates and libraries, promoting standardized practices and adaptable solutions. In essence, Revit serves as an integrated solution that not only advances building planning but also revolutionizes the accuracy and efficiency of cost estimation processes in the construction industry.

4.4 ETABS

ETABS, developed by Computers and Structures, Inc. (CSI), stands as a cornerstone in the field of structural analysis, providing engineers with a powerful tool for designing and evaluating building systems. Renowned for its advanced three-dimensional analysis capabilities, ETABS allows for the comprehensive modeling of intricate structural systems. Structural engineers leverage its user-friendly interface to define elements such as beams, columns, slabs, and walls, applying diverse material properties and loads. ETABS excels in various analyses, encompassing linear and nonlinear static analyses, dynamic analyses crucial for seismic considerations, and evaluations of the structural response to gravity and lateral loads. The software's dynamic analysis capabilities make it particularly valuable for designing structures that can withstand seismic events. Results from these analyses are visualized through detailed reports, graphs, and animations, aiding engineers in comprehending structural behavior and making informed design decisions. Furthermore, ETABS seamlessly integrates with other CSI software, facilitating the transfer of models and analysis results between different programs. The software's adherence to international design codes ensures that structural designs comply with industry standards. In essence, ETABS emerges as a comprehensive and versatile solution for structural analysis, playing a pivotal role in the efficient and accurate design of complex building and bridge projects.

4.5 FORMA

Autodesk Forma, positioned as the pioneering component of Autodesk's industry cloud for AEC, represents a paradigm shift in early-stage AEC processes. Tailored explicitly for preplanning, Forma introduces a suite of advanced features aimed at elevating decision-making efficiency. Its conceptual design capabilities, encompassing massing models, site analysis tools, and generative design options, empower AEC professionals to rapidly explore and refine design ideas. The integration of predictive analytics, driven by artificial intelligence, provides valuable insights through simulations, spanning sun and wind studies to precise energy analyses and cost estimations. Moreover, automation functionalities, notably in code checking and compliance analysis, not only enhance task efficiency but also contribute to heightened accuracy. Beyond these features, the platform's cloud-based environment fosters seamless collaboration within project teams, facilitating swift idea sharing and decision-making. Autodesk Forma, as a user-friendly and comprehensive solution, sets new benchmarks for the initial phases of AEC projects. Its emphasis on improved decision-making, project outcomes, and collaboration efficiency positions it as an indispensable tool for AEC professionals navigating the complexities of preplanning.

4.6 GREEN BUILDING STUDIO

Autodesk Green Building Studio is a versatile cloud-based service designed to facilitate building performance simulations, with the overarching goal of optimizing energy efficiency and contributing to early-stage efforts towards carbon neutrality in the design process. This innovative tool offers architects and engineers the capability to design high-performance buildings more efficiently, with significant time and cost savings compared to traditional methods. By harnessing the power of cloud computing, Autodesk Green Building Studio enables users to run simulations without the need for extensive local computing resources. Notably, this service can function as a standalone web service, providing users with the flexibility to access its features independently. Furthermore, it serves as the backbone for Autodesk Revit's whole building energy analysis tools. The integration with Revit enhances the synergy between design and energy analysis, allowing professionals to seamlessly incorporate insights into the energy performance of their building designs. It is essential to stay updated with the latest information through Autodesk's official channels, as software details and features may undergo updates and enhancements over time.

4.7 TWINMOTION

Twinmotion, developed by Epic Games, is a real-time 3D architectural visualization software that empowers architects and designers to swiftly transform 3D models into captivating visualizations. Its strength lies in its seamless ability to swiftly convert 3D models into stunning visual representations. This software boasts an intuitive interface and a powerful rendering engine that facilitates immediate exploration and modification of designs. With an extensive library offering diverse assets such as foliage, furnishings, and weather effects, users can craft vibrant, lifelike scenes. The software's exceptional feature set allows for the simulation of various weather conditions and lighting scenarios, providing a dynamic canvas for experimentation. Furthermore, its compatibility with VR technology elevates the presentation experience, enabling professionals to immerse clients and stakeholders in interactive, immersive environments. Twinmotion serves as a pivotal tool in effectively conveying design visions and ideas, aiding in the seamless communication of architectural concepts.

4.8 CONCLUSION

Utilizing a suite of software tools including AutoCAD, Revit, ETABS, Forma, Green building studio and Twinmotion, we can design an energy-efficient college building. We used AutoCAD for initial sketches and 2D drawings, Revit for 3D modeling for detailed design, ETABS for ensuring structural integrity through advanced analysis, Forma for initial stage planning and Twinmotion for providing us with real-time visualization, aiding in communication and simulation of lighting and environmental factors. By integrating sustainable design principles and simulation tools, we aim to achieve optimal energy efficiency and comply with green building standards.

CHAPTER 5
SITE SELECTION AND ANALYSIS

5.1 STUDY AREA

The selection of the college ground, covering an expansive 6300 square meters, as the site for the educational building is a strategic decision aimed at optimizing space utilization and promoting sustainability in construction. This choice not only addresses the immediate infrastructure requirements but also aligns seamlessly with the overarching objectives of energy efficiency.

The precise location of the college ground at a latitude of 11° 59' 10.2264" N and a longitude of 75° 22' 50.1996" E provides a specific geographical context for the project. This strategic positioning considers factors such as sunlight exposure, prevailing winds, and overall environmental considerations crucial for sustainable design and construction.

Moreover, the proximity of the chosen site, located approximately 100 meters away from the college's main block, enhances accessibility and connectivity to existing college facilities. This closeness ensures convenience for students, faculty, and staff while fostering a cohesive and integrated campus layout.

In essence, the selection of the college ground as the project site reflects a meticulous approach, considering both functional and sustainable aspects. This decision sets the stage for an educational building that not only meets the immediate needs of the institution but also maximizes energy efficiency and environmental compatibility in its construction and operation.

Fig 5.1 Site Plan Generated using Forma

5.2 SURVEYING

Surveying is a critical process in mapping and measuring the Earth's surface, essential for various fields including construction, engineering, and land development. It involves the collection of accurate spatial data using tools ranging from traditional theodolites to modern technologies like GPS and drones. This data is pivotal in designing and planning projects, setting property boundaries, and ensuring adherence to regulations. Surveying plays a foundational role in the construction industry, aiding tasks such as site analysis and infrastructure planning. Moreover, it is vital for legal purposes, resolving land disputes and maintaining compliance with zoning regulations. Ultimately, surveying provides the crucial spatial information necessary for informed decision-making in diverse fields, contributing to the success and accuracy of projects.

5.2.1 Reconnaissance Survey

The reconnaissance survey at the site has been completed, involving a thorough investigation and the creation of a reference sketch detailing key features such as buildings and roads. Notably, the plot boasts a levelled surface, providing a favorable foundation for construction. The proposed educational building has been strategically positioned, standing at a distance of 30 meters away from the existing laboratory building. This deliberate spacing not only adheres to safety and regulatory considerations but also optimizes the functional layout of the campus. The reconnaissance findings serve as a foundational step in the project, offering valuable insights into the site's topography and existing structures, informing subsequent stages of planning and design for the envisioned energy-efficient educational building.

5.2.2 Detailed Survey

A comprehensive detailed survey utilizing tape was conducted, establishing boundary points, and accurately measuring the site's area. The meticulous measurements obtained through the tape survey reveal that the total area of the site is 6300 square meters. This detailed survey provides a precise understanding of the site's dimensions, facilitating the next phases of design and construction planning for the energy-efficient educational building. The fixation of boundary points ensures clarity in demarcation, contributing to the accuracy and reliability of the collected data. These survey results serve as a crucial foundation for the project, informing decisions regarding optimal space utilization, sustainable design integration, and adherence to regulatory requirements.

Fig 5.2 The site's dimensions are being assessed using a tape measure.

5.3 ANALYSIS USING FORMA

Utilizing Autodesk Forma, a comprehensive scrutiny of site characteristics was undertaken to gain insightful data crucial for the optimal design of the energy-efficient educational building. The analysis included a meticulous examination of sun exposure, wind patterns, and natural surroundings, recognizing their profound impact on the building's energy requirements. Through these sophisticated analyses facilitated by Autodesk Forma, the project gained valuable insights, ensuring that the energy-efficient educational building will be strategically positioned and designed to maximize sustainability while harmonizing with its natural surroundings. (The visualization of daylight potential, in harmony with the surrounding buildings and environment, provided a nuanced understanding of the site's lighting dynamics. The assessment of rooftop solar energy potential, particularly focusing on photovoltaic panel systems, highlighted opportunities for harnessing renewable energy.

Furthermore, a detailed wind analysis was conducted to illustrate how the building and site influence localized air flow patterns, crucial information for optimizing ventilation and energy efficiency. Microclimate analysis was integrated to refine urban site design, enhancing outdoor thermal comfort.)

5.3.1 Sun Hour Analysis

This report analyzes the variation in hours of sunlight recorded for different dates over the course of a year. The dataset encompasses measurements from January to December, categorizing sunlight hours into hourly intervals ranging from 0-1 hour to 9+ hours.

The data reveals distinct seasonal trends in sunlight availability. From January to March, sunlight hours gradually increase, reaching their peak in March. Subsequently, April to June experiences the highest average sunlight hours, with June typically recording the maximum. However, from July to September, there's a slight decrease in sunlight hours compared to the peak months, though levels remain relatively high. Finally, from October to December, there's a decline in sunlight hours as the year progresses towards winter.

The site receives an average of 9 hours of direct sunlight, providing a substantial opportunity for harnessing solar energy (Fig5.3).

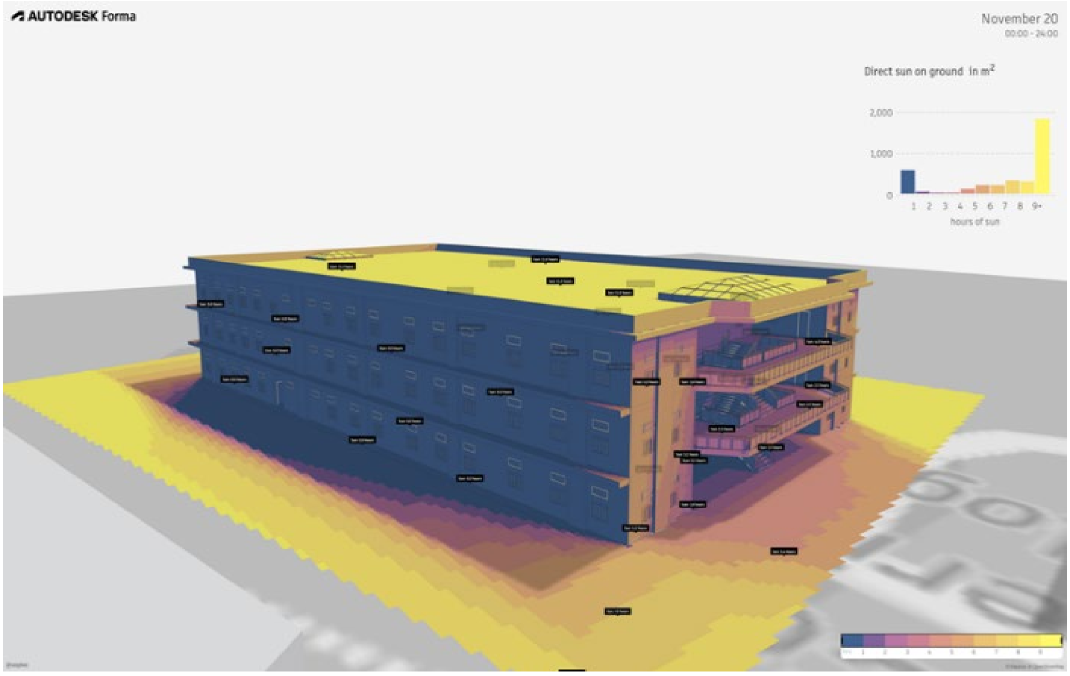


Fig 5.3 Sun Hours Analysis

5.3.2 Daylight Potential Analysis

The data, representing daylight factors measured in lux, illustrates variations in natural light penetration from different directions and floors. The orientations studied include west, north, east, and south, while the floors analyzed range from ground floor to terrace floor. Understanding daylight potential is crucial for architects, engineers, and building designers to optimize building layouts, window placements, and shading strategies for enhanced occupant comfort, energy efficiency, and overall building performance.

Across the various orientations and floors, the data indicates fluctuations in daylight potential. The highest average daylight potential is observed on the terrace floor, with lux values ranging from 96 to 98 across all orientations. Conversely, the ground floor generally exhibits lower daylight potential compared to higher floors, with lux values ranging from 16 to 36. Among orientations, the north orientation consistently shows higher average daylight potential compared to west, east, and south orientations across all floors.

The calculated daylight potential of 40% emphasizes the site's suitability for maximizing natural lighting in and around the proposed educational building (Fig 5.4).

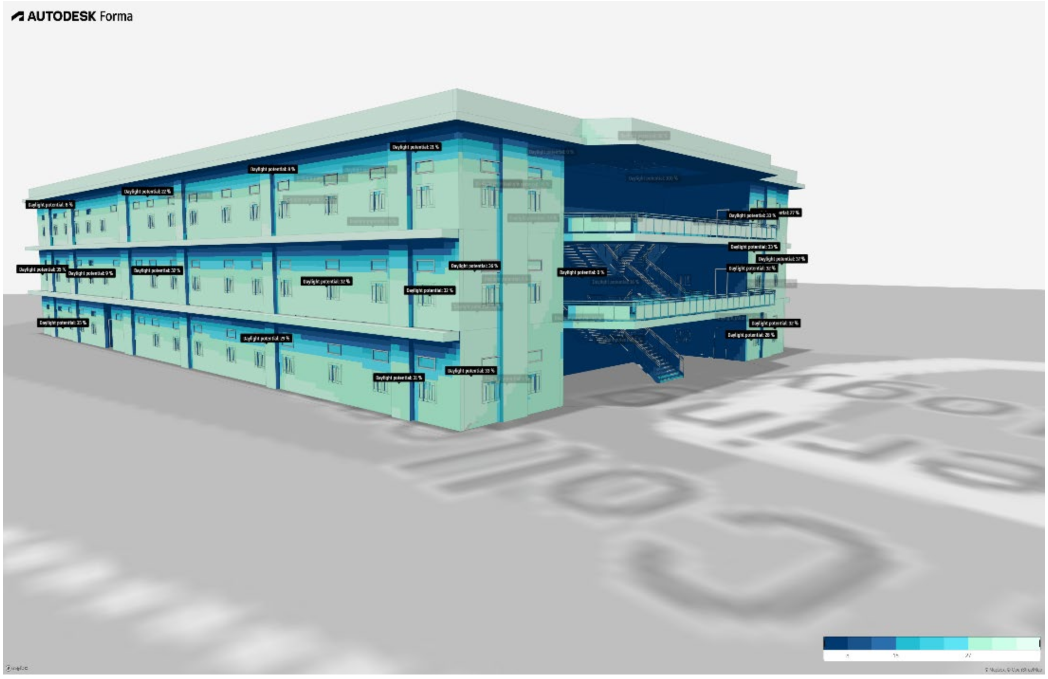


Fig 5.4 Daylight Potential Analysis

5.3.3 Solar Panel Analysis

It presents an analysis of solar panel efficiency across various surface coverage percentages and panel placement areas, focusing on annual electrical output measured in kilowatt-hours (kWh). The data encompasses multiple scenarios with different panel efficiencies ranging from 10% to 100%, along with corresponding surface coverage percentages and placement areas.

Projections indicate an expected average solar energy harvest of 1398 kWh/m^2, translating to an annual electrical output of 422,521 kWh, underscoring the potential for a sustainable and energy-efficient design (Fig 5.5).

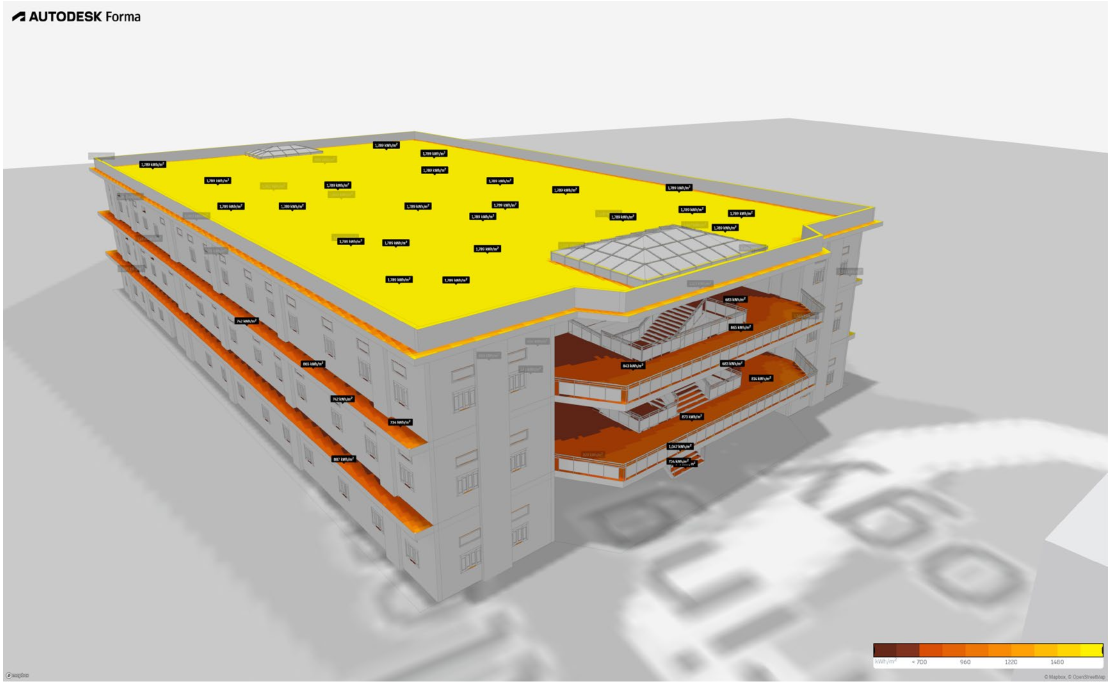


Fig 5.5 Solar Energy Analysis

5.3.4 Wind Analysis

The relationship between wind direction and comfort levels, along with corresponding wind speeds were examined. The data encompasses comfort ratings assigned to different wind directions, ranging from North (N) to Northwest (NW), as well as corresponding wind speeds measured in meters per second (m/s).

The analysis reveals varying comfort levels associated with different wind directions. Winds from the west (W) are rated the most comfortable with a score of 24, followed closely by winds from the east (E) with a rating of 19. Conversely, winds from the north (N) and southeast (SE) are associated with lower comfort ratings, scoring 3 and 5, respectively. Additionally, the corresponding wind speeds align with comfort ratings, with higher wind speeds generally associated with lower comfort levels. Winds from the west (W) and southwest (SW) exhibit the highest wind speeds at 1.8 m/s and 1.6 m/s, respectively. Conversely, winds from the north (N) and northeast (NE) have the lowest wind speeds at 0.7 m/s and 1.1 m/s, respectively.

Wind analysis indicates an average wind speed of 1.8 m/s (Fig 5.6), essential information for optimizing ventilation and energy efficiency.

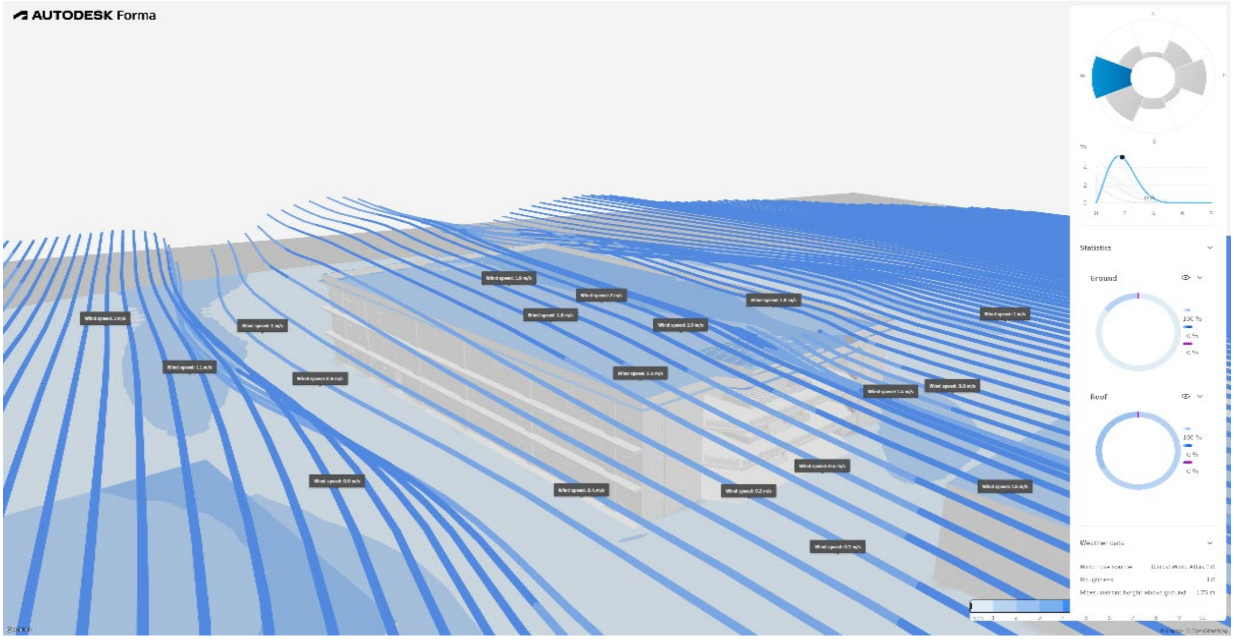


Fig 5.6 Wind Analysis

5.3.5 Microclimate Analysis

The analysis provides a report of climate data including air temperature, humidity, cloud cover, and direct solar radiation across the months of the year. The data, spanning from January to December, offers insights into seasonal variations and climatic trends.

Monthly Trends:

Air temperature remains relatively high in January and February, peaking at 32-33°C, before gradually decreasing towards June and July, where temperatures reach 26°C. Humidity levels show a general trend of increase from January to June, with a peak of 88% in June, before slightly decreasing in the following months. Cloud cover percentage steadily rises from January to May, reaching its peak of 100% in June and July, indicating overcast conditions during these months. Cloud cover then gradually decreases towards December. Direct solar radiation follows an inverse trend to cloud cover, with higher radiation levels recorded during months with lower cloud cover. January and February exhibit the highest direct solar radiation values, while June and July record the lowest.

Annual Average:

The annual average air temperature is 29°C, indicating a warm climate throughout the year. Humidity averages approximately 67.58%, suggesting a moderately humid climate. Cloud cover averages around 65.92%, with variations across different months. The average direct solar radiation is 562.25 W/m², highlighting the solar energy potential in the region.

Additionally, the assessment of outdoor thermal comfort ranging from 25% to 35% further informs the design approach (Fig 5.7).

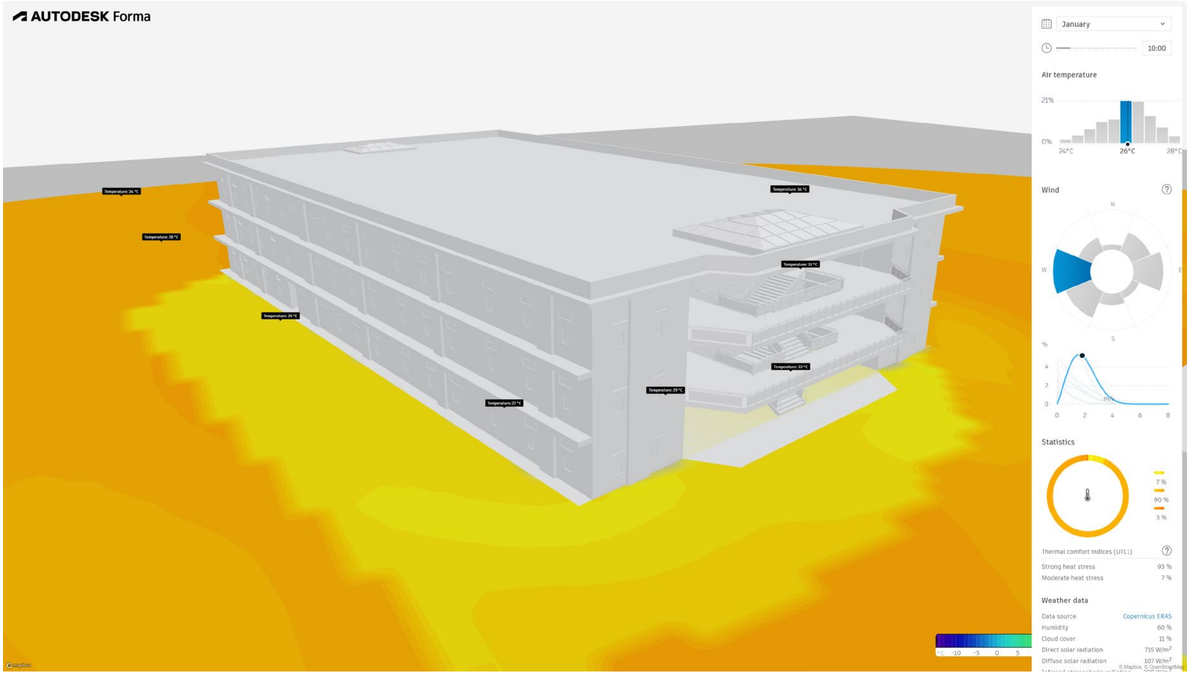


Fig 5.7 Microclimate Analysis

5.4 CONCLUSION

By integrating survey data, including terrain features, property boundaries, and existing infrastructure, Forma analysis enhances the understanding of site context, enabling designers to make informed decisions that respond to the surrounding environment, promote sustainability, and optimize the comfort and functionality of their designs. Autodesk Forma facilitates simulations of sunlight exposure, daylight penetration, wind patterns, energy performance, and site characteristics. This comprehensive approach assists in optimal building orientation, shading strategies, outdoor space design, and energy-efficient solutions. Overall, these findings, derived from the Autodesk Forma analysis, play a pivotal role in guiding the sustainable design decisions for the energy-efficient educational building, ensuring a harmonious integration with the natural elements of the site.

CHAPTER 6
MATERIALS USED

6.1 AUTOCLAVED AERATED CONCRETE(AAC)

AAC is a lightweight precast concrete material that contains numerous small air pockets uniformly distributed throughout its volume. It is also known as autoclaved cellular concrete or autoclaved lightweight concrete. AAC is composed of a precise mixture of sand, cement, lime, water, and a small proportion of aluminum powder. During the manufacturing process, these ingredients undergo a chemical reaction that releases hydrogen gas, creating numerous tiny air pores throughout the material. This cellular structure gives AAC its distinctive lightweight properties while maintaining strength and durability.

It has excellent thermal insulation properties and low thermal conductivity. Its production process generates minimal waste, and it can be recycled or reused at the end of its lifecycle. The porous structure of AAC effectively absorbs sound waves, making it an excellent choice for enhancing acoustic comfort in buildings. When used in walls, AAC can significantly reduce noise transmission between rooms and from external sources, creating quieter and more comfortable indoor environments for occupants.

Fig 6.1 Autoclaved aerated concrete

6.2 UNPLASTICIZED POLYVINYL CHLORIDE (uPVC)

uPVC is a type of rigid, durable plastic widely used in construction for applications such as doors, windows, and piping. Unlike traditional PVC, uPVC is unplasticized, meaning it does not contain added plasticizers, resulting in a stiffer and more durable material suitable for structural applications. uPVC exhibits excellent thermal insulation properties, effectively reducing heat transfer through windows and doors. This helps maintain comfortable indoor temperatures and can contribute to energy savings by reducing the need for heating and cooling.

uPVC windows and doors are designed to fit tightly within their frames, minimizing air leakage. Properly installed uPVC frames contribute to a more airtight building envelope, enhancing overall building performance. uPVC requires minimal maintenance compared to other materials such as wood or aluminum. It is resistant to rot, corrosion, and insect damage, making it suitable for long-term use in various climates. Additionally, uPVC is recyclable at the end of its lifecycle, making it an eco-friendly choice for construction projects and contributing to sustainable building practices.

Fig 6.2 Unplasticized polyvinyl chloride

6.3 KINETIC TILES

Kinetic tiles, also known as energy-harvesting tiles or piezoelectric tiles, are innovative flooring technologies designed to generate electricity through mechanical pressure, typically generated by footsteps. These tiles are integrated with piezoelectric materials that can convert mechanical energy into electrical energy. When individuals walk or move across the surface of kinetic tiles, they apply pressure, causing the piezoelectric materials within the tiles to deform. This deformation generates electric voltage because of the piezoelectric effect, where certain materials produce an electric charge in response to applied mechanical stress.

The electric voltage generated by the kinetic tiles can be harvested using built-in mechanisms such as wires or conductive pathways. This harvested electricity can then be stored in batteries, capacitors, or other energy storage devices for later use. Kinetic tiles provide a renewable energy source that can be utilized to power various applications. The electricity generated by these tiles can be harnessed for lighting systems, signage, sensors, or other electronic devices, offering a sustainable and environmentally friendly energy solution. Kinetic tiles are often installed in areas with high foot traffic, such as staircases or pedestrian walkways, to maximize energy generation potential. By placing them in strategic locations where people frequently walk or move, such as steps or entryways, kinetic tiles can effectively capture mechanical energy and convert it into usable electricity.

Fig 6.3 Kinetic tiles

6.4 LOW-E GLASS

Low emissivity glass, is a type of energy-efficient glass featuring a specialized coating designed to minimize heat transfer through windows. Low-E glass is engineered to reduce the emissivity of the glass surface. Emissivity refers to the ability of a material to emit thermal radiation. By minimizing emissivity, low-E glass inhibits heat transfer, preventing warmth from escaping in cold climates and reducing heat gain in hot climates. Despite its insulating properties, low-E glass still allows visible light to pass through, maintaining natural daylighting within indoor spaces.

By minimizing heat loss or gain through windows, low-E glass contributes to overall energy efficiency in buildings, leading to potential cost savings and reduced environmental impact. Low-E glass is commonly used for window glasses in various building projects. Whether in residential, commercial, or institutional settings, low-E glass contributes to creating comfortable, sustainable, and visually pleasing indoor environments.

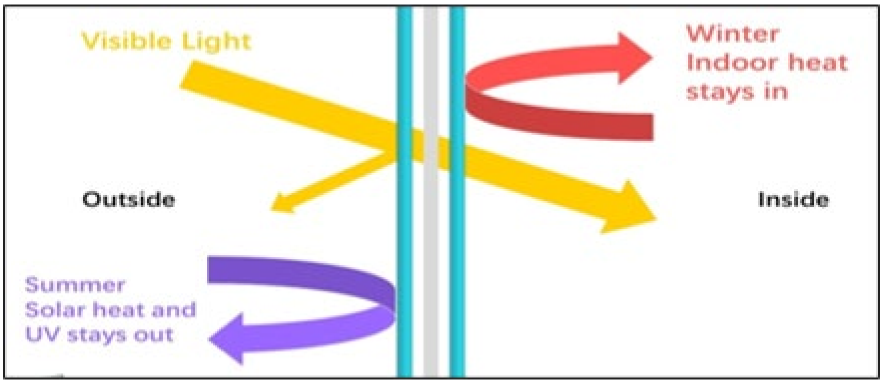


Fig 6.4 Low-E glass

6.5 CONCLUSION

Autoclaved Aerated Concrete (AAC) is a lightweight precast concrete material made of sand, cement, lime, water, and aluminum powder, offering excellent thermal insulation, sound absorption, and recyclability, making it a preferred choice for walls and building blocks. Unplasticized Polyvinyl Chloride (uPVC) is a rigid and durable plastic used in construction for doors, windows, and piping, known for its thermal insulation, airtightness, low maintenance, and recyclability. Kinetic Tiles are innovative flooring technologies integrated with piezoelectric materials, generating electricity from mechanical pressure, such as footsteps, providing a sustainable energy source for lighting, sensors, and other devices in high foot traffic areas. Low-E Glass, featuring a specialized coating to minimize heat transfer, is used for window glasses in various building projects, contributing to energy efficiency, cost savings, and reduced environmental impact while maintaining natural daylighting within indoor spaces.

CHAPTER 7
FUNCTIONAL PLANNING AND DESIGN

7.1 GENERAL

When considering energy-efficient design for a Group B educational building in accordance with NBC, KMBR, and AICTE norms, special attention should be given to major rooms like laboratories and lecture halls. Utilizing advanced design software such as Revit and AutoCAD become instrumental in optimizing spatial layouts and ensuring efficient use of resources.

By leveraging Revit and AutoCAD, architects and engineers can employ BIM to streamline the planning process. This technology allows for a more accurate visualization of major rooms, facilitating effective placement of energy-efficient features such as lighting, ventilation, and equipment. The integration of these software tools enhances collaboration, reduces design errors, and contributes to the overall energy efficiency of the educational facility. Incorporating cutting-edge software into the design process not only aligns with modern technological trends but also ensures the practical implementation of energy-efficient principles in the construction of laboratories and lecture halls.

7.2 BUILDING DETAILS

The college building is a three-story structure, standing at a height of 4 meters from floor to floor. Emphasizing both functionality and accessibility, the building incorporates spacious elements such as corridors, verandas, and passageways, each with a minimum width of 2 meters. This design ensures free movement and promotes a comfortable and well-connected environment within the premises. Furthermore, to enhance accessibility and convenience, a lift has been thoughtfully integrated, adding an additional layer of inclusivity to the overall architectural layout. Together, these features contribute to a well-designed and accommodating educational space, meeting both practical and regulatory requirements.

Ground Floor:

- Floor Area: 2648m²

Ground Floor Room Details:

1. Lecture Hall: 7m x 12m - 6 rooms
2. Laboratory: 15m x 18m - 2 rooms
3. Laboratory: 15.2m x 17.4m - 2 rooms

4. Administrative Room: 8.9m x 7m - 1 room
5. Conference Room: 8.9m x 7m - 1 room
6. Washroom: 7m x 7m - 2 rooms
7. Sick Room: 3.8m x 3.2m - 2 rooms
8. Stair Room: 9m x 6m (3m wide), Emergency Stair: 6.5m x 4m (2m wide)
9. Lift: 4.2m x 3m
10. Store room 2.3m x 3.8m

First Floor:

- Floor Area: 2562 m²

First Floor Room Details:

1. Lecture Hall: 7m x 12m - 6 rooms
2. Laboratory: 15m x 18m - 1 rooms
3. Laboratory: 15.2m x 17.4m - 2 rooms
4. Faculty Room: 9m x 7m - 2 rooms
5. Library: 18m x 15m - 1 room
6. Washroom: 7m x 7m - 2 rooms
7. Sick Room: 3.8m x 3.2m - 2 rooms
8. Stair Room: 9m x 6m (2.5m wide), Emergency Stair: 6.5m x 4m (1.5m wide)
9. Lift: 4.2m x 3m
10. Store room 2.3m x 3.8m

Second Floor:

- Floor Area: 2562 m²

Second Floor Room Details:

1. Lecture Hall: 7m x 12m - 6 rooms
2. Laboratory: 15m x 18m - 1 rooms
3. Laboratory: 15.2m x 17.4m - 2 rooms
4. Faculty Room: 9m x 7m - 1 room
5. Drawing Hall: 18m x 15m - 1 room
6. Seminar Hall: 9m x 15m - 1 room
7. Sports Room: 8.8m x 15m - 1 room
8. Washroom: 7m x 7m - 2 rooms
9. Prayer Room: 3.2m x 3.8m - 2 rooms

10. Stair Room: 9m x 6m (2.5m wide), Emergency Stair: 6.5m x 4m (1.5m wide)

11. Lift: 4.2m x 3m

12. Store room : 2.3m x 3.8m

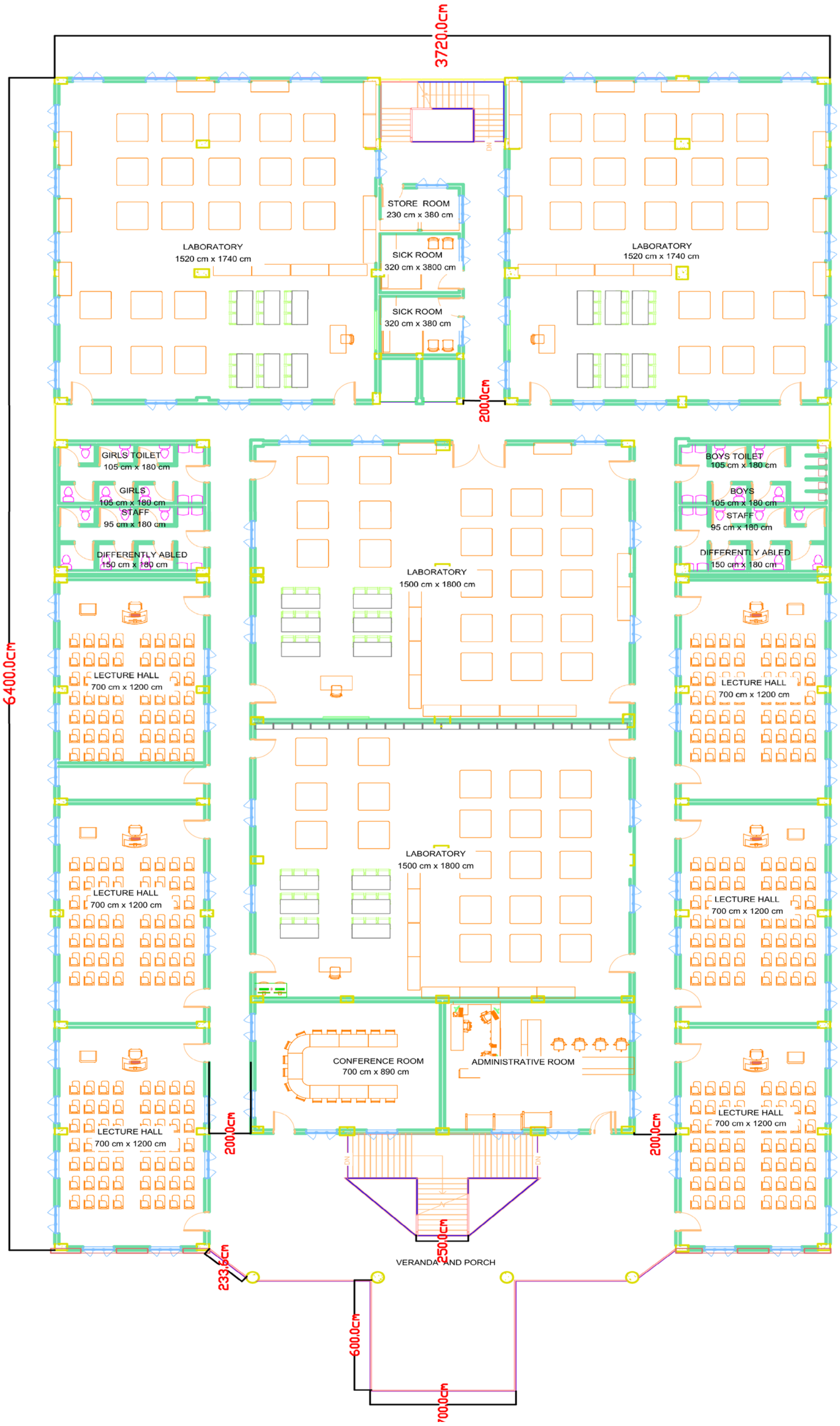


Fig 7.1 Ground Floor Plan

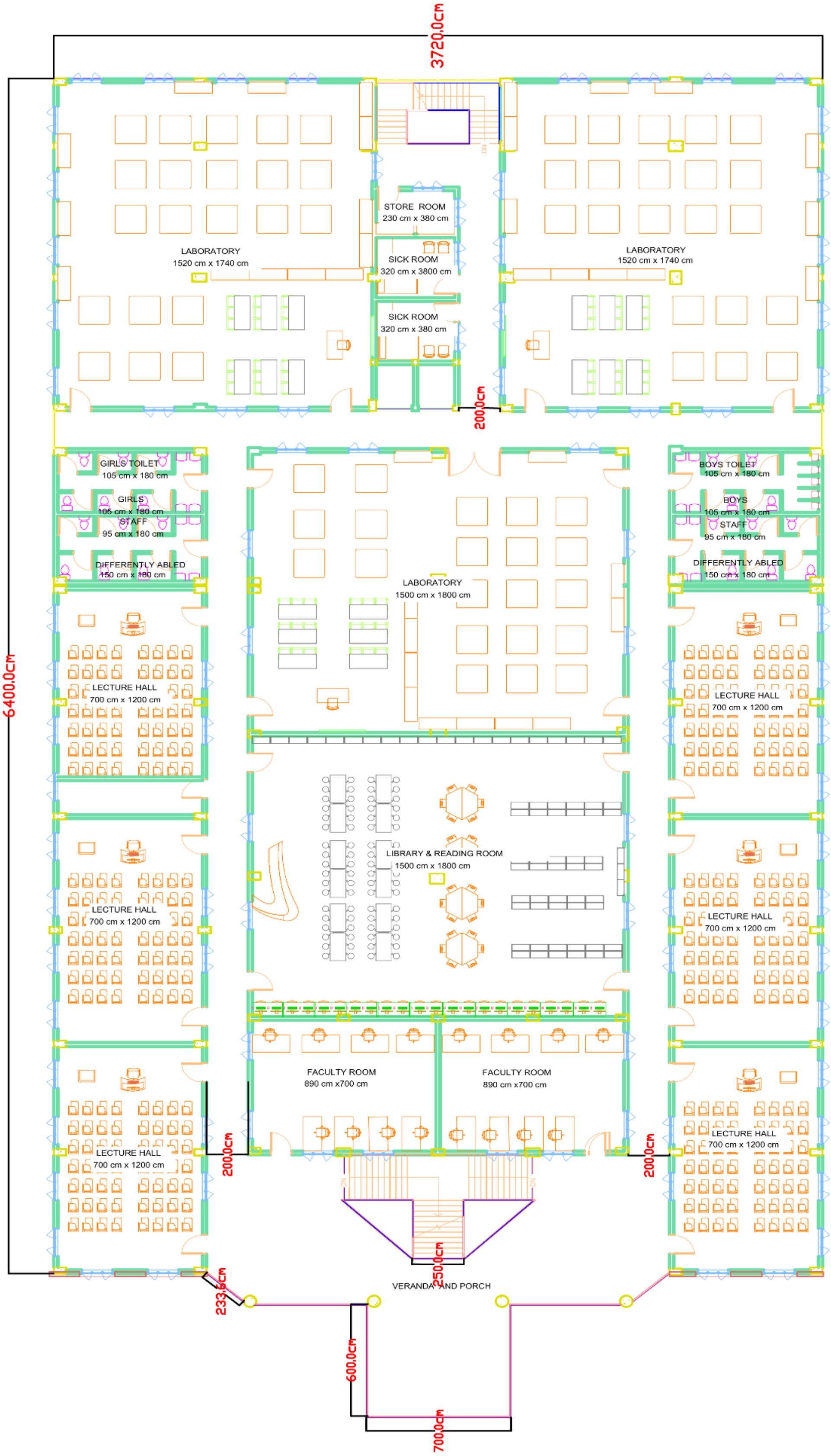


Fig 7.2 First Floor Plan

Fig 7.3 Second Floor Plan

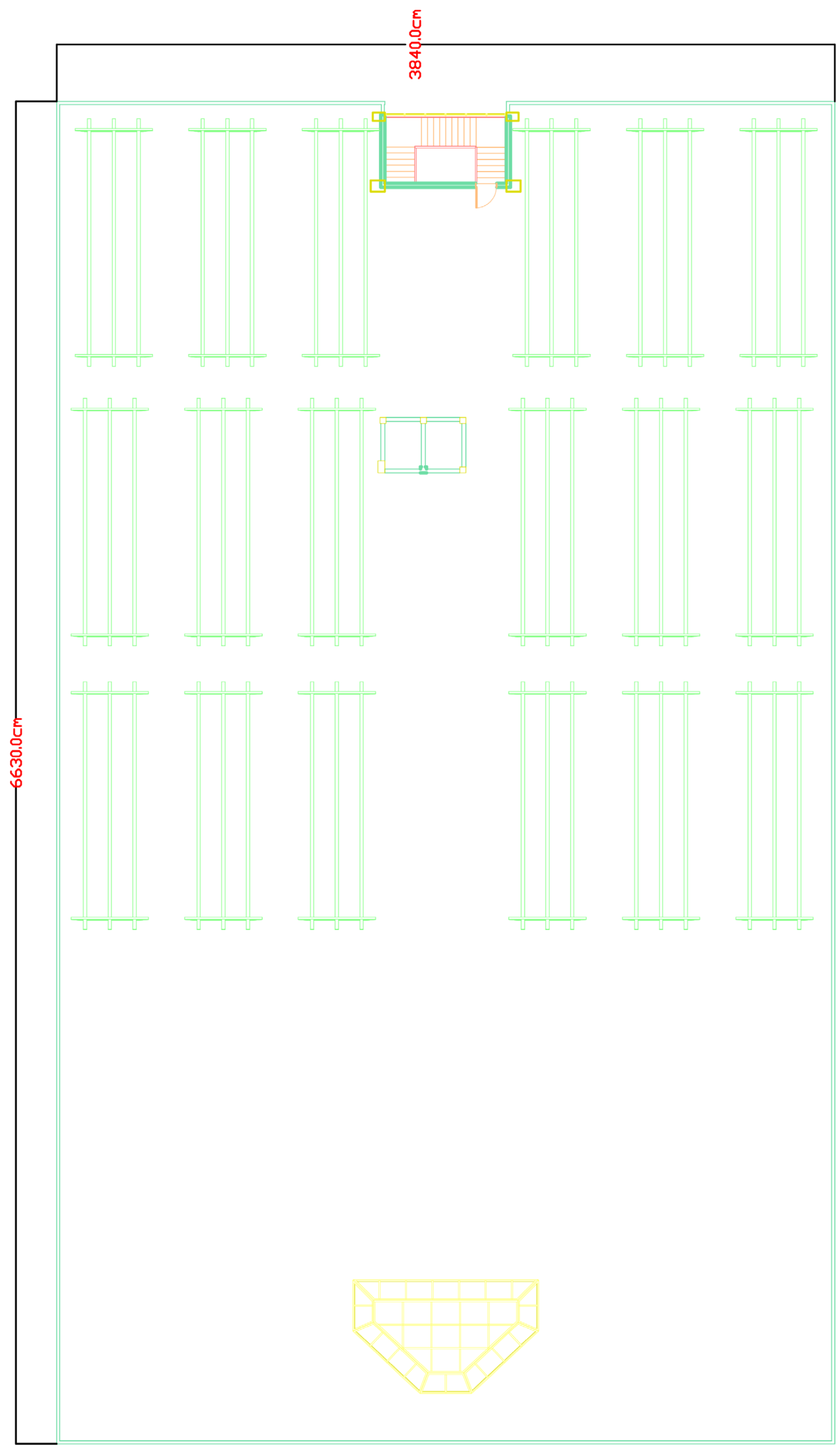


Fig 7.4 Terrace Floor Plan

Fig 7.5 Elevation view west

Fig 7.6 Elevation view east

Fig 7.7 Elevation view south

Fig 7.8 Elevation view north

Fig 7.9 Section view

CHAPTER 8

STRUCTURAL ANALYSIS AND DESIGN

8.1 LOADS AND CODAL PROVISION

8.1.1 Dead Load

Dead loads are permanent or stationary loads which are transferred to the structure throughout their life span. It is primarily due to self-weight of **structural members, permanent partition walls, fixed permanent equipment and weights of different materials. Dead load shall be calculated based on unit weight which shall be established taking into consideration the material specified for construction. Alternatively dead load may be calculated based on unit weight of material given in IS 875(part1):2015. The unit weight of reinforced concrete is taken as 25kN/m^3.**

8.1.2 Live Load

Live load or movable loads without any acceleration or impact included any external loads imposed upon the structure when it is serving its normal purpose. Live load is exposed and uniformly distributed static load. These are assumed to be produced by the intended use or occupancy of the building including weight of material stored, furniture and movable equipment. Alternatively live load may be calculated **based on values given in IS 875(part2):2015.**

TABLE 1 IMPOSED FLOOR LOADS FOR DIFFERENT OCCUPANCIES —*Contd*

Sl. No.	Occupancy Classification	Uniformly Distributed Load (UDL)	Concentrated Load
(1)	(2)	(3) kN/m^2	(4) kN*

vi) MERCANTILE BUILDINGS		
a) Retail shops	4·0	3·6
b) Wholesale shops -- to be calculated but not less than	6·0	4·5
c) Office rooms	2·5	2·7
d) Dining rooms, restaurants and cafeterias	3·0†	2.7
e) Toilets	2·0	--
f) Kitchens and laundries	3·0	4·5
g) Boiler roooms and plant rooms -- to be calculated but not less than	5·0	6.7
h) Corridors, passages, staircases including fire escapes and lobbies	4·0	4·5
j) Corridors, passages, staircases subject to loads greater than from crowds, such as wheeled vehicles, trolleys and the like	5·0	4·5
k) Balconies	Same as rooms to which they give access but with a minimum of 4·0	1·5 per metre run concentrated at the outer edge

8.1.3 Seismic Load

Seismic loads are lateral exceptional loads which induced due to earthquake. Seismic load should be calculated based on IS: 1893(part 1): 2016. The seismic loads are assigned in both the building direction.

Where,

Z = Zone factor

Zone factor for different seismic zones is given below in table.5.2.

Table 5.3: Zone factor

Seismic Zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very Severe
Zone factor	0.10	0.16	0.24	0.36

I = Importance factor (Table 6 of IS 1893 (Part -1) :2002)

R = Response reduction factor (Table 7 of IS 1893 (Part - 1) : 2002)

$\frac{s}{g}$ = Average response acceleration coefficient

8.1 LOAD CALCULATION

8.1.1 Slab Load Calculation

The loads on the slabs are primarily calculated for preliminary design of columns and **beams. The loads coming on the slabs are mainly dead weight the slab, live load on the slab and floor finish on the slab. The dead load of slab is calculated by multiplying the volume of slab per square meter area with the density of concrete. The density of concrete is taken as 25 KN/m. The live load on slab is taken from IS 875: part II. And the weight of floor finish is taken from IS 875: Part 1.**

Self weight of slab= 0.125×25 = 3.125 kN/m2

Floor finish = 0.05×20 = 1kN/m2

Partition load = 1kN/m2

(For office and residential building)

Total Dead load on slab = 5.125 kN/m2

8.1.2 Load Calculation on Beam

• The distribution of gravity loads to various secondary or primary beams and columns may be done by considering the tributary areas.

• The loads coming on beams are self-weights of beams, Load from slab or adjoining structure and also the load from walls.

• Self weight

• Wall load

Size of beam = 230×300mm

Self wt. of the beam = 0.23×0.30×25 = 1.725kN/m2

Self wt. of wall = 0.23×3×20= 13.8 kN/m2

Partition wall load = 0.1×20×3 = 6 kN/m2

Parapet wall load = 0.23×1×20 = 4.6 kN/m2

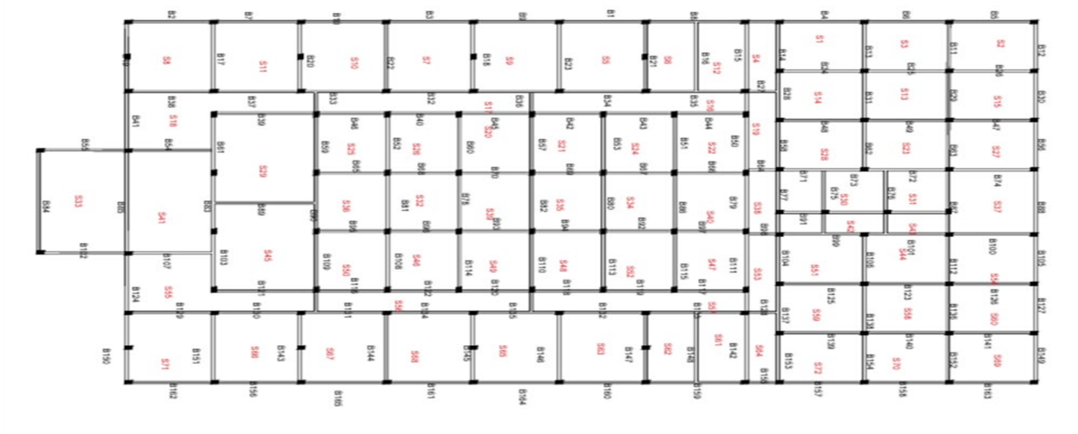
8.1.3 Calculation on column load

Size of the **column= 23×40mm**

Self wt. of column =0.23×0.40×3.3×25 = 7.59kN/m2

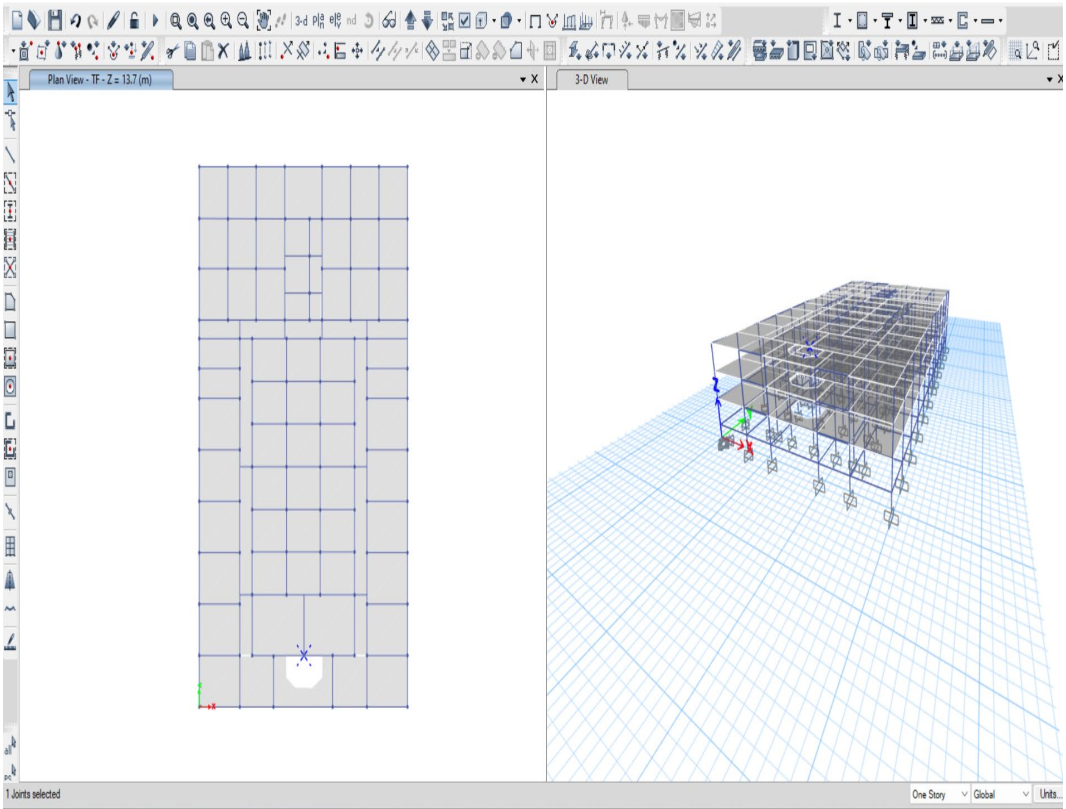
8.2 MODELING IN ETABS

1. The first step is to create the structural model of building. A Centre line diagram of building was created in the AUTOCAD in .dxf format.



File →Import → DXF file Architectural grid →No→ Select → DXF file→ Open → Select layer for grid → Ok

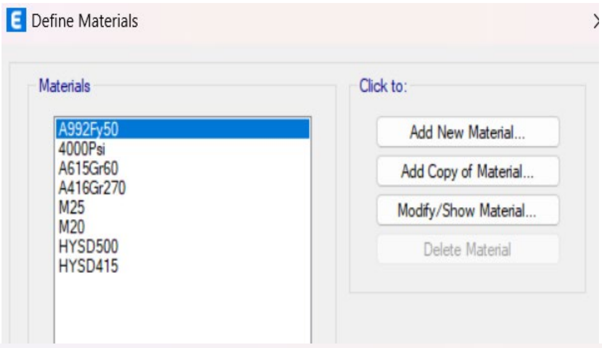
2. The .dxf file is imported into ETABS as floor plans and is replicated to different stories.

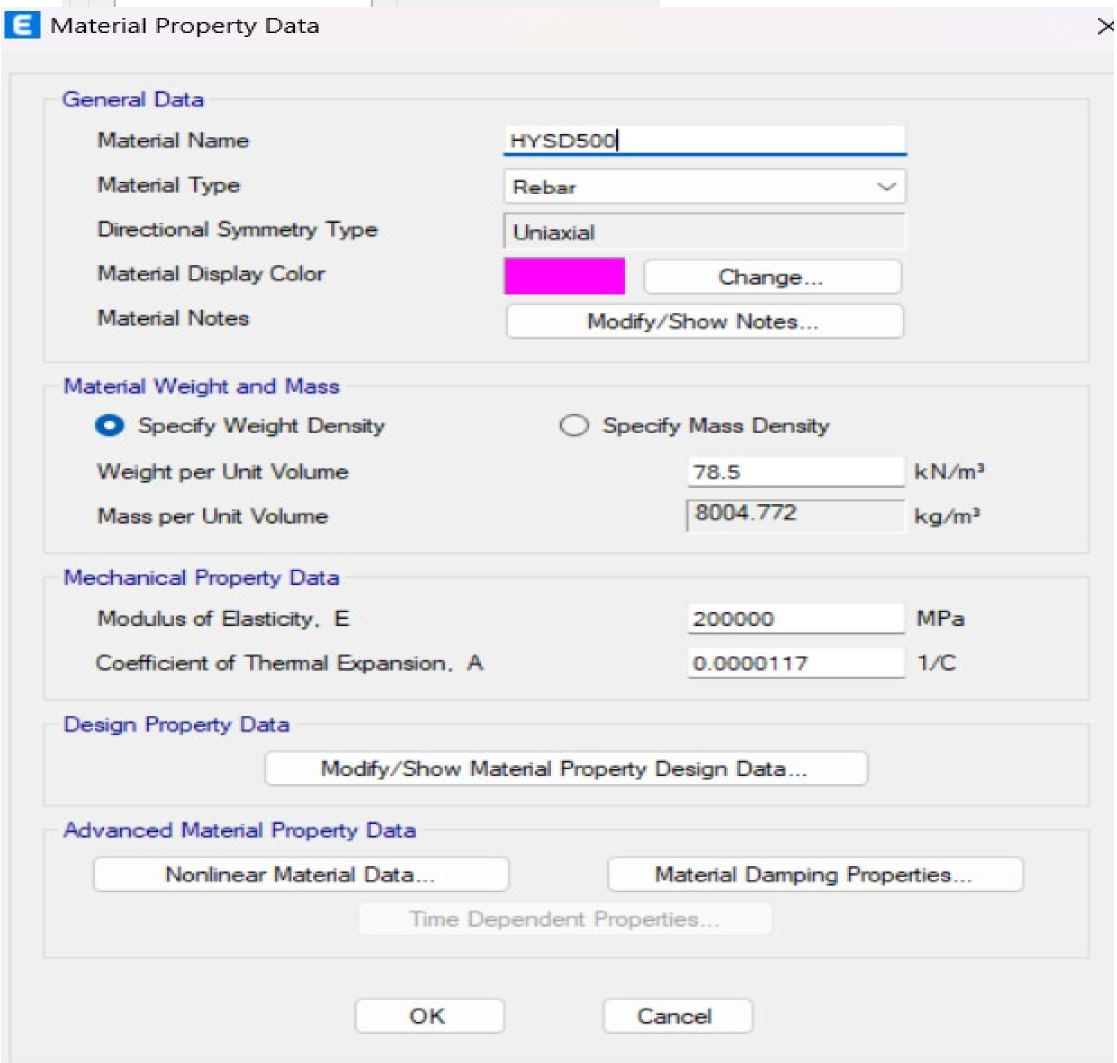


8.2.1 Procedure for Modelling:

New model – change units to KN-M - number of stories = 5- number of bays in X direction = 5- number of bays in Y direction =4- storey height= 3m -Give each bay width in X direction-bay width in Y direction - restraints -OK.

Define materials- add new materials-material type (concrete) material name (concrete)- Tick the switch to advanced property display option- material property -v material properties -material property data-material property - ok.options displays material name (concrete) -material type(concrete) -modify/show.





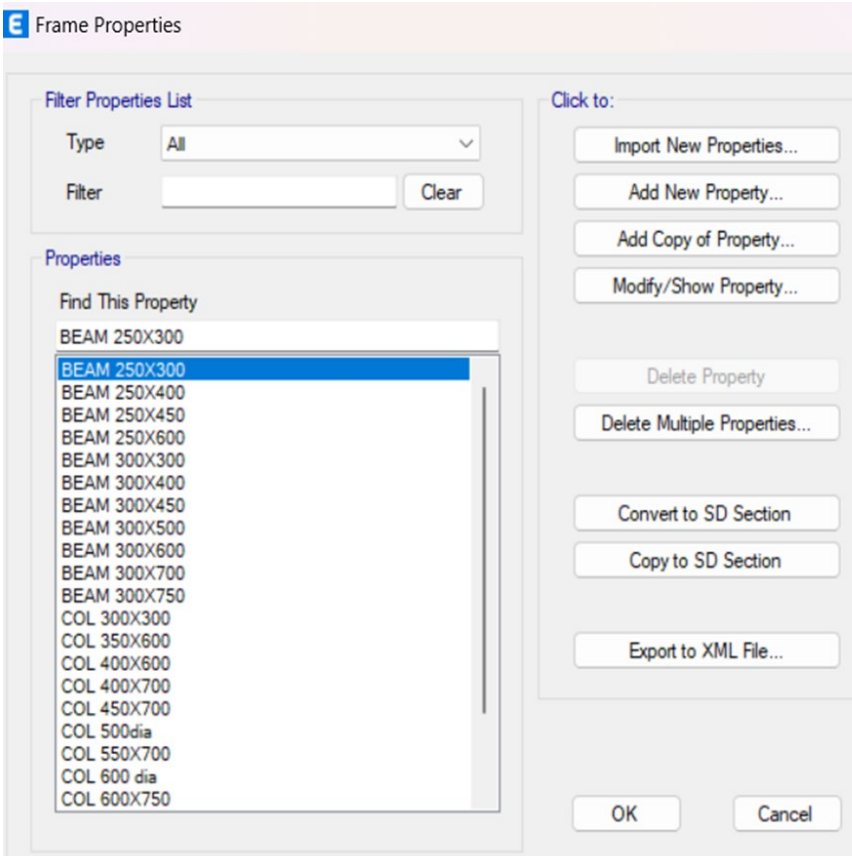
Define-section properties-frame sections-add new properties-frame section - property type (concrete)-select rectangular section name(beam)-depth=0.5- width=0.4-material(concrete)concrete reinforcement-select beam-ok. Add new property-frame section -property type (concrete)-select rectangular- section name (column)-material (square column)

450 x 450 concrete reinforcement-select column-ok-select rectangular-section name (column)-material (rectangular column) 350 x450 concrete reinforcement-select column-ok.

According to IS 456:2000, cl. 23.2.1, pg. no. 37

- L/d ratio =26 or
- Beam depth =L/16
- Breadth = D/1.5

- Defining various section properties such as beams, columns and slabs with required dimensions and properties

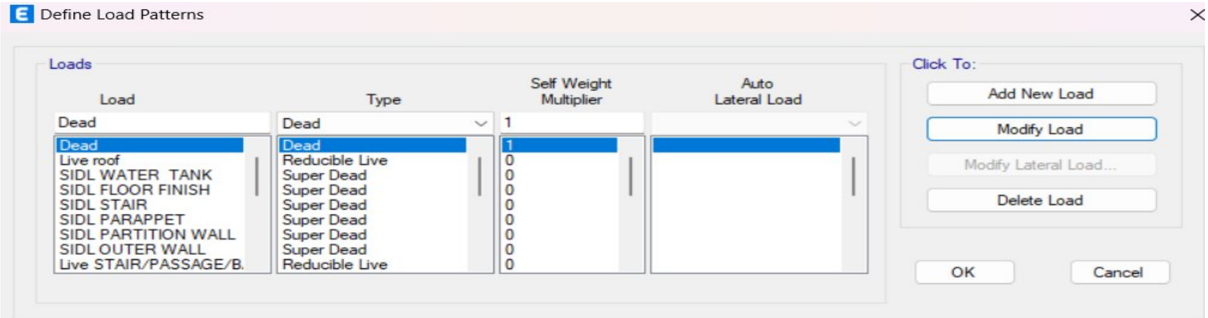


Seismic Analysis Important Terms		
- Seismic Zone	:	III
- Zone Factor (Z)	:	0.16
- Site Type	:	II for Medium Soil as per Table 4 of IS 1893 (Part 1): 2016
- Importance Factor (I)	:	1.2 as per Cl.7.2.3 and Table 8 of IS 1893 (Part 1): 2016
- System	:	SMRF (Special Moment Resisting Frame)
- Response Reduction Factor (R)	:	5 as per Cl.7.2.6 and Table 9 of IS 1893 (Part 1): 2016
- Percentage of Imposed Load to be Considered in Seismic Weight	:	25% for LL is up to 3 kN/m2 as per Cl.7.3.1 and Table 10 of IS 1893 (Part 1): 2016

Thickness of slab = 125 mm

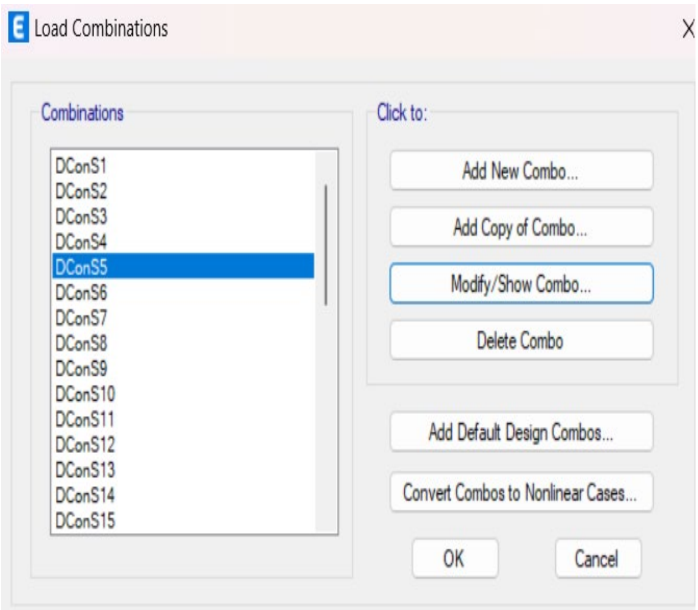
(IS456 page number 39)

- Defining various load pattern

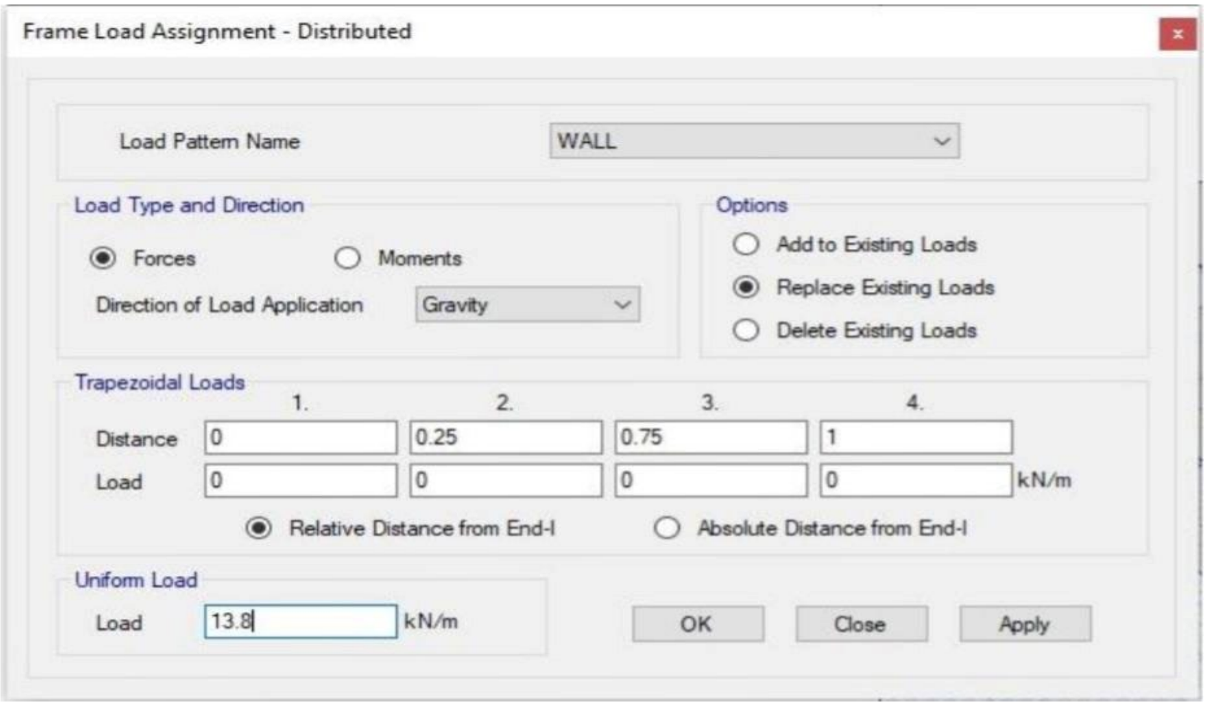


- Defining earthquake loads in both X and Y direction

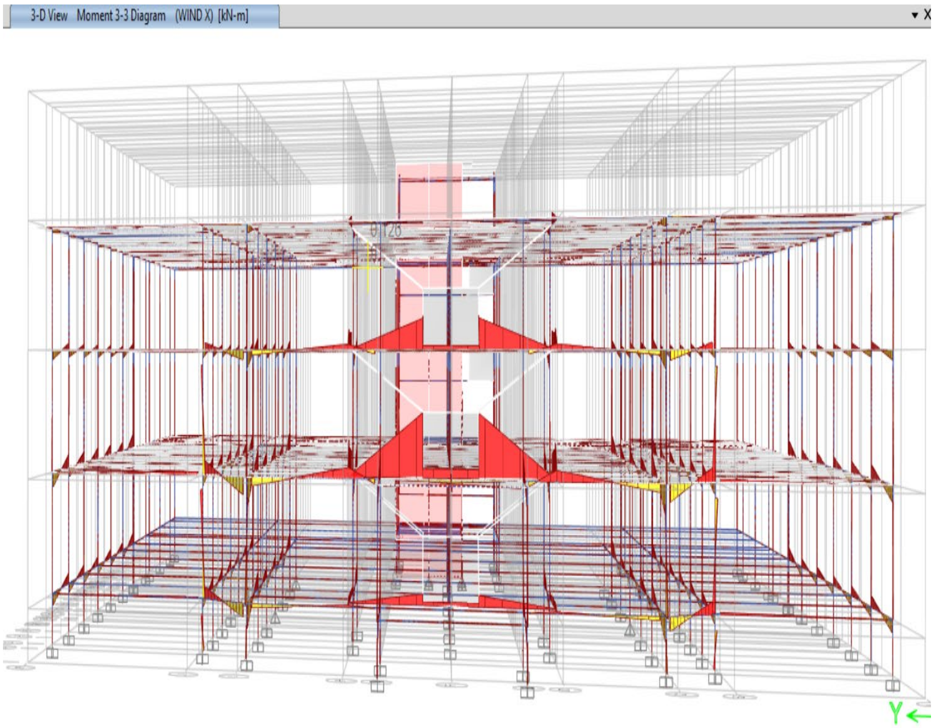
- Defining various load combination

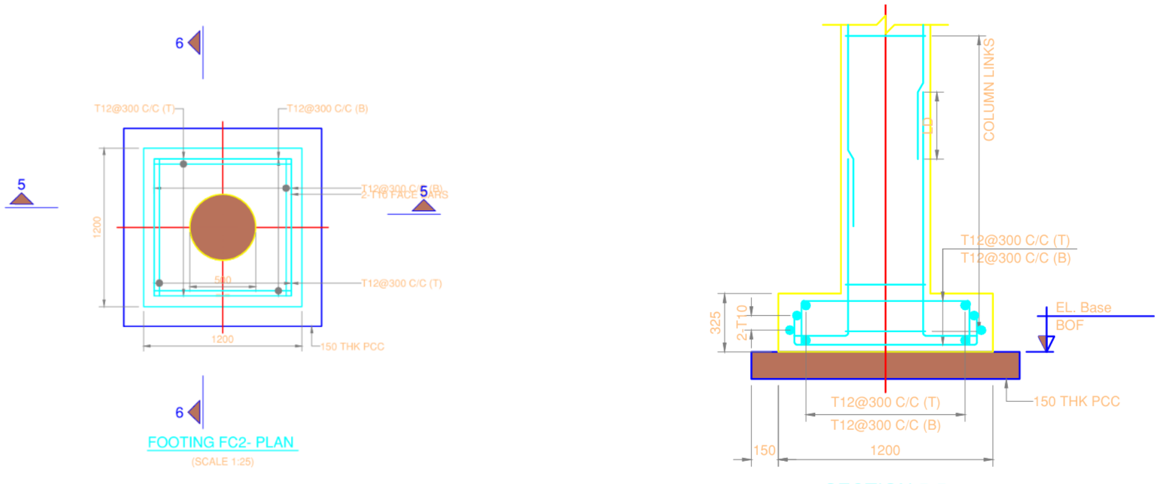


- Assigning loads

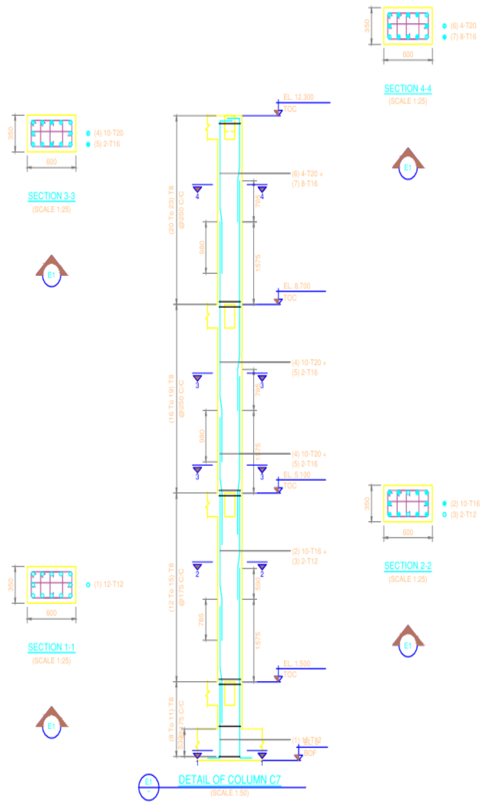


- Bending moment diagram

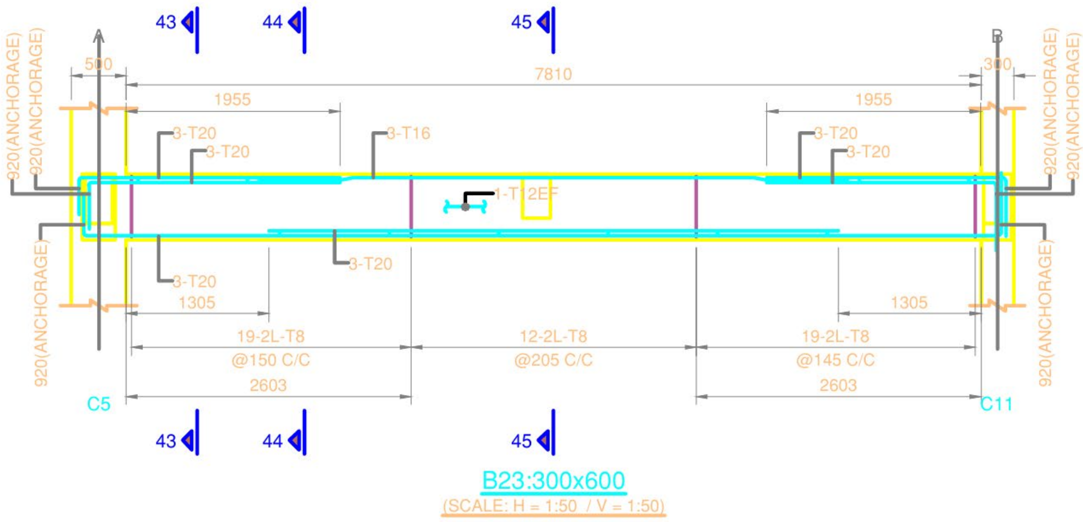




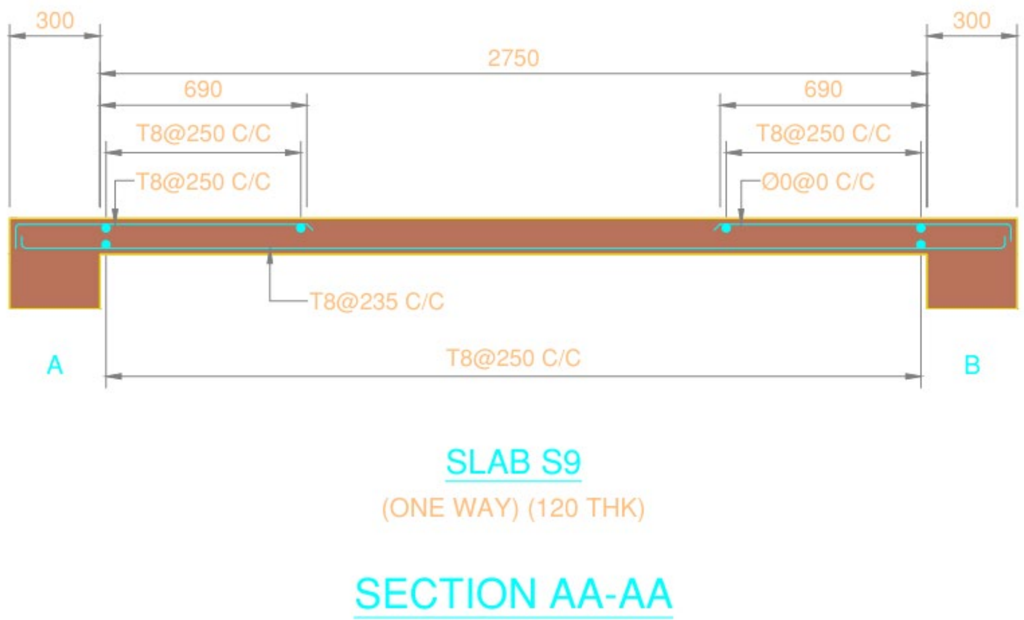
Footing design



Column design



Beam design



Slab design

CHAPTER 9
ENERGY MODELING AND ANALYSIS

9.1 GENERAL

Green Building Studio (GBS) is a cloud-based analysis service by Autodesk, revolutionizing the way architects and engineers evaluate building designs for environmental performance. By leveraging advanced simulation algorithms and cloud computing infrastructure, GBS allows users to seamlessly import building models and define detailed properties such as materials, occupancy schedules, and HVAC systems. Through comprehensive simulation capabilities, users can assess energy consumption, lighting levels, solar radiation, and other key performance metrics, enabling informed design decisions. GBS supports iterative design optimization by facilitating the quick evaluation of design alternatives and the identification of areas for improvement. Its intuitive interface and robust reporting tools streamline the analysis process, empowering users to generate detailed reports and share results with project stakeholders for collaboration and decision-making. With GBS, sustainable design practices are not only achievable but also integrated seamlessly into the design workflow, fostering the creation of environmentally responsible buildings.

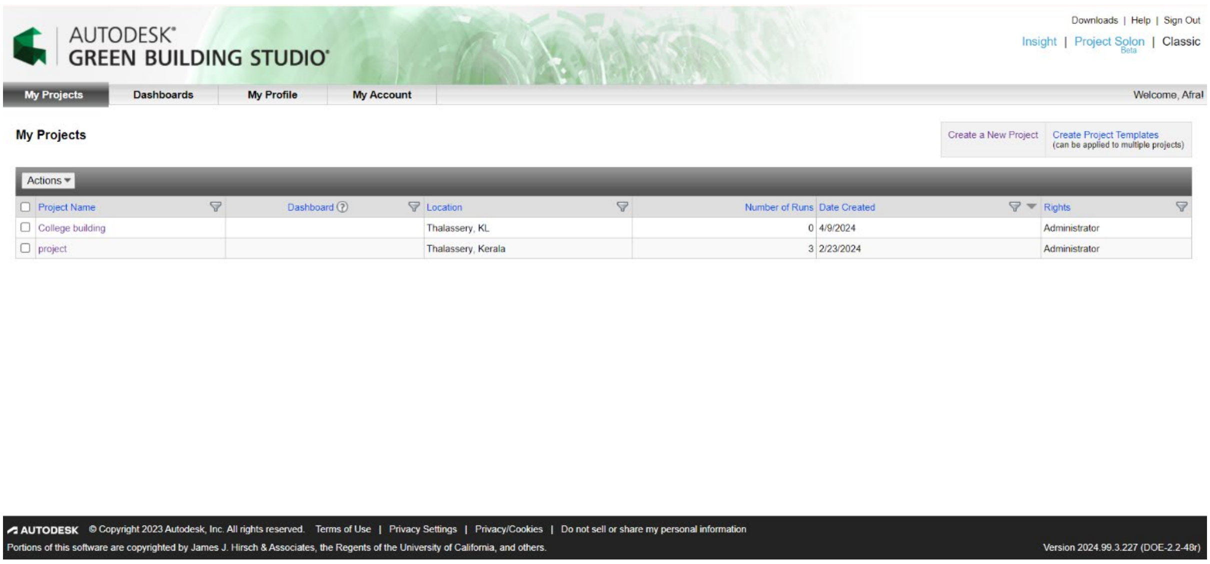


Fig 9.1: Interface of Autodesk Forma

9.2 ENERGY MODELLING

1. The first step is accessing Green Building Studio. Visit the Autodesk website and log in to your account. Navigate to the Green Building Studio web portal.

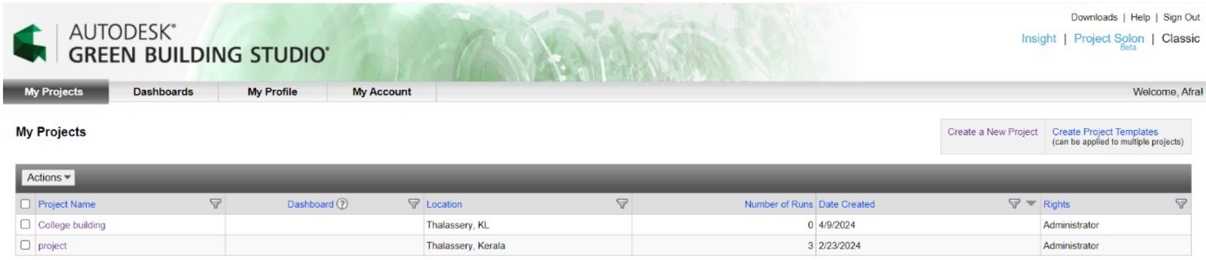


Fig 9.2: Interface of GBS

2.Click on the "Create New Project" button to initiate a new analysis.

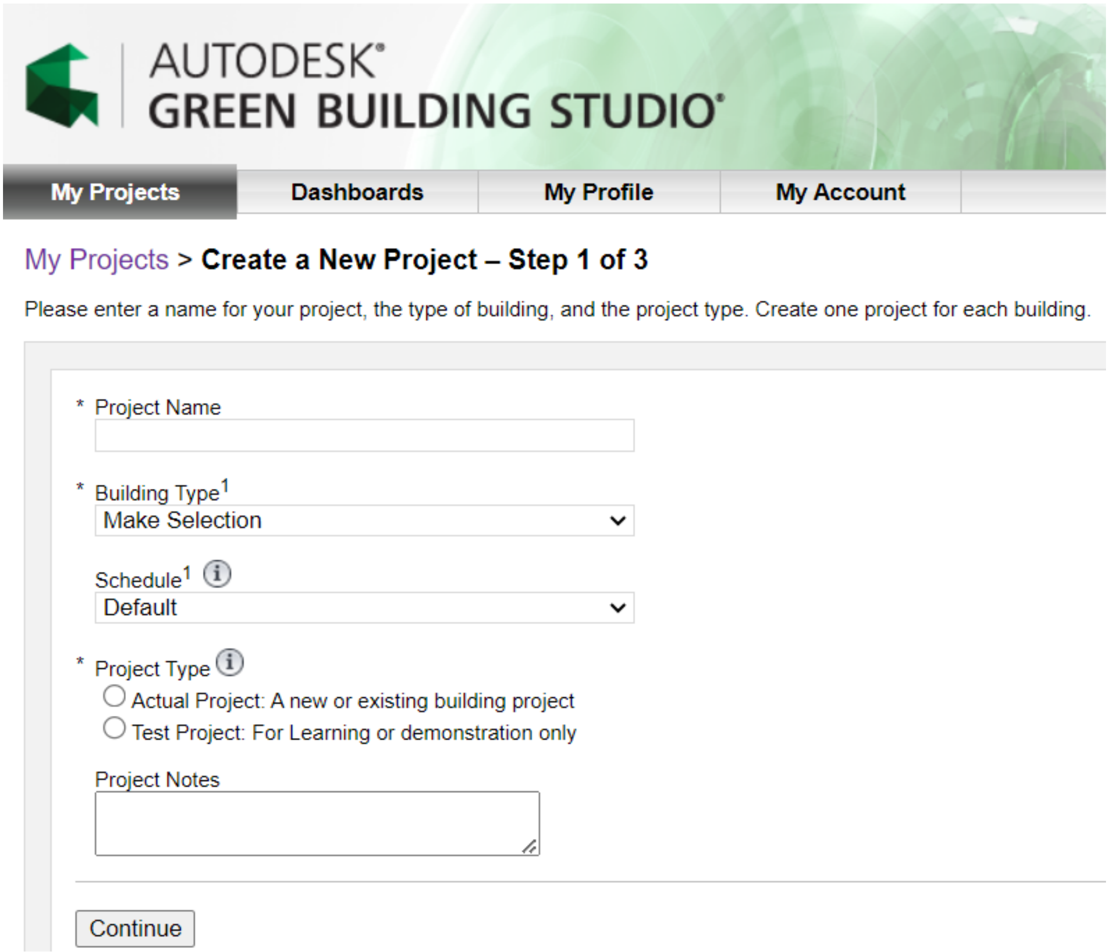


Fig 9.3: Project details

3.Enter the project details such as project name, location, building type (commercial, residential, educational, etc.),schedule of the building and a brief project description outlining its goals and scope**.**

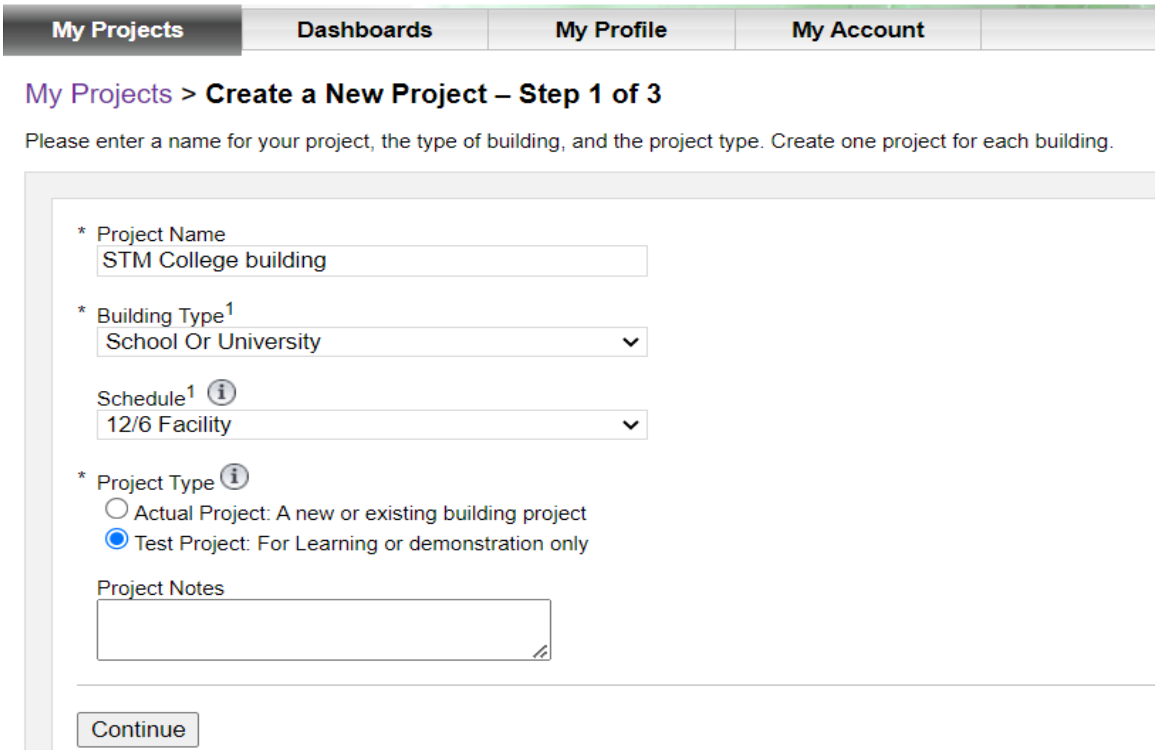


Fig 9.4: Assigning project details

4.Enter the precise location of the building and move the building icon to the site.

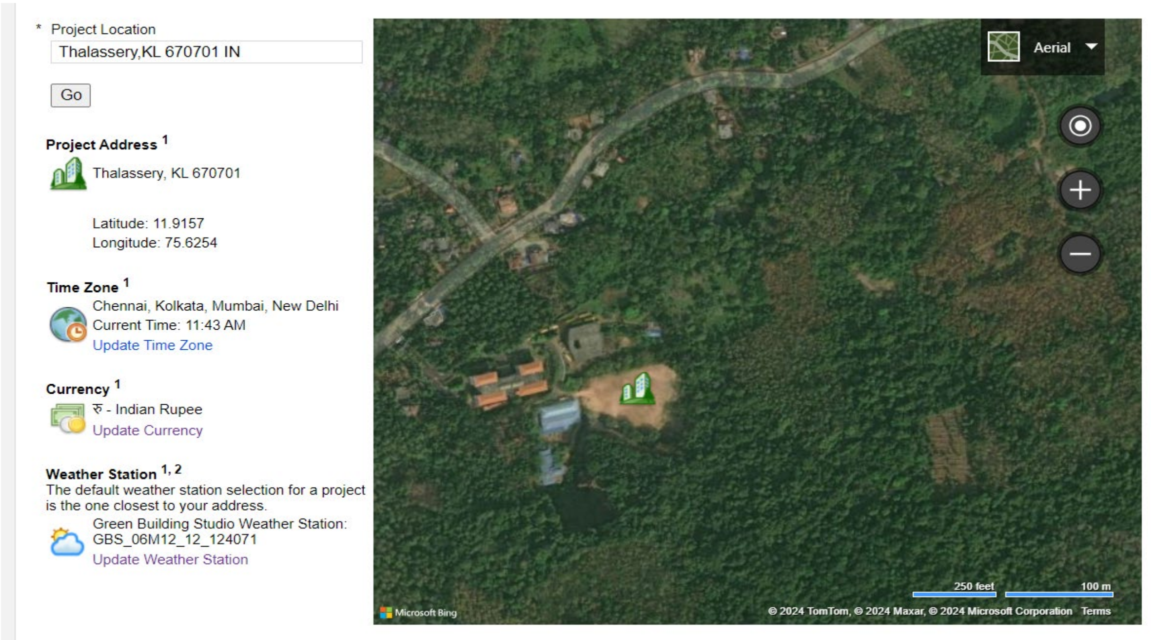


Fig 9.5: Choosing the location

5. The project is now created and ready for energy modelling. Go to project defaults for selecting building properties including construction materials for walls, roofs, floors, and glazing,etc.

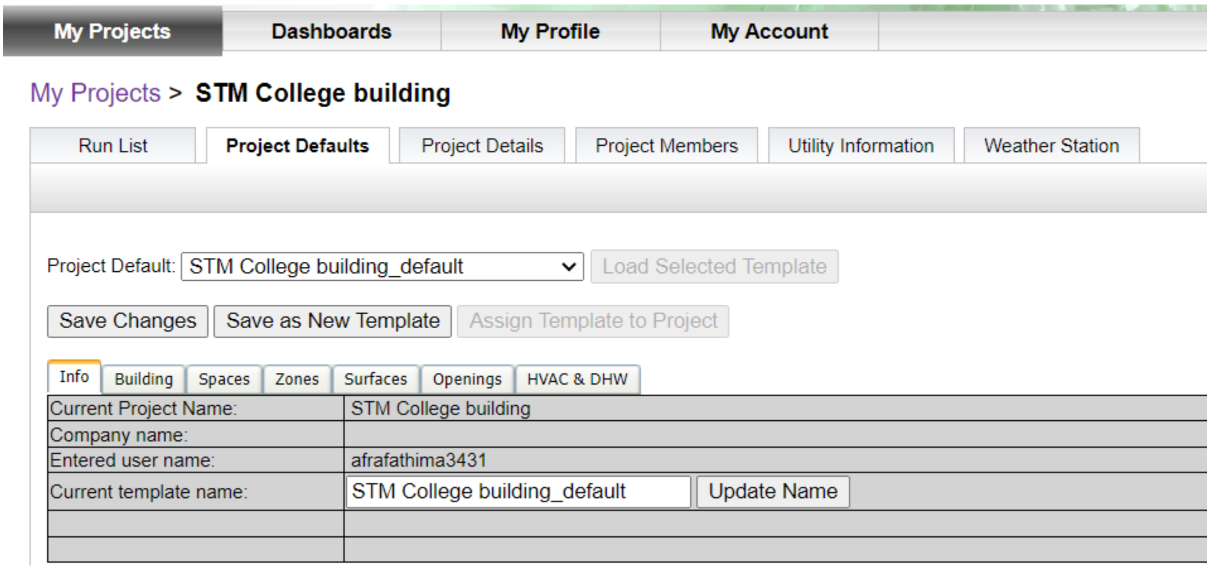


Fig 9.6: Project defaults

6. Selecting condition and space type from spaces.

Condition type: Naturally vented only

Space type: Classroom or lecture or training

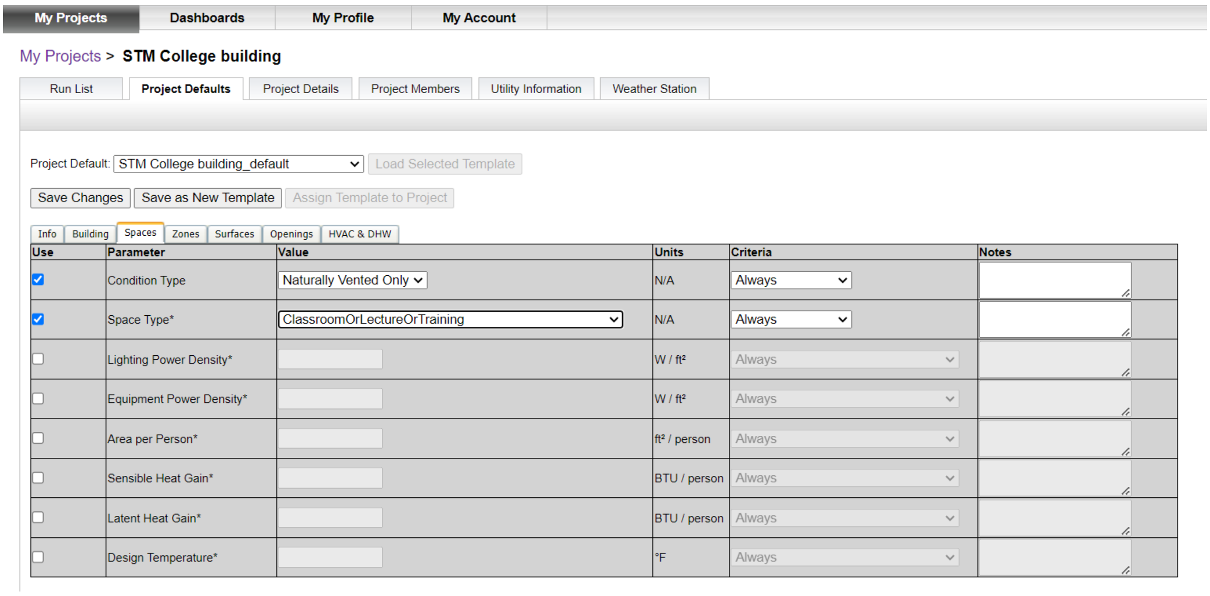


Fig 9.7: Selecting condition and space type

7. Assigning cooling and heating setpoints.

Cooling and heating setpoints refer to the desired temperature ranges at which a building's cooling and heating systems are activated to maintain thermal comfort for occupants. These setpoints are crucial parameters in building energy management, as they directly impact energy consumption and occupant comfort.

Cooling on setpoint: 77

Cooling off setpoint: 77

Heating on setpont: 70

Heating off setpoint: 70

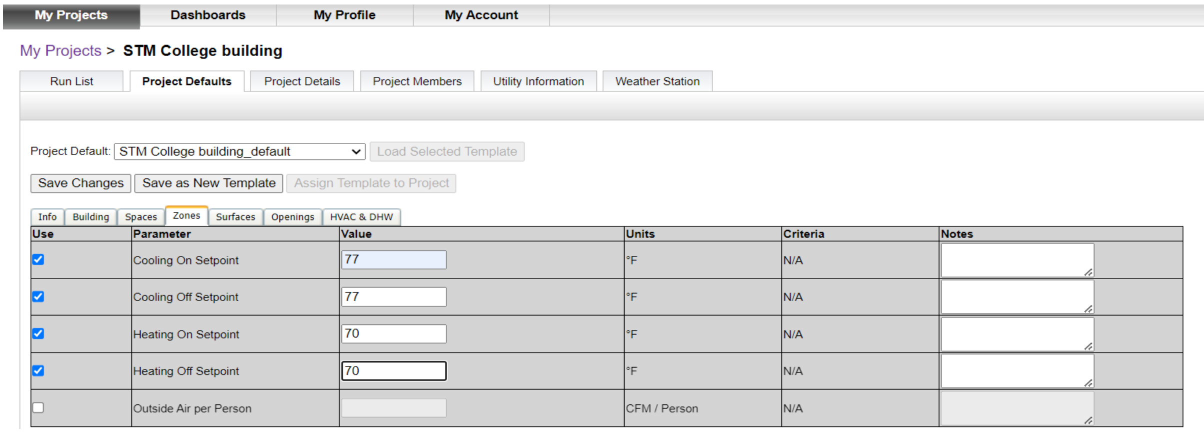


Fig 9.8: Assigning setpoints

8. Assigning construction materials for exterior and interior walls, roof, floors, ceiling and door.

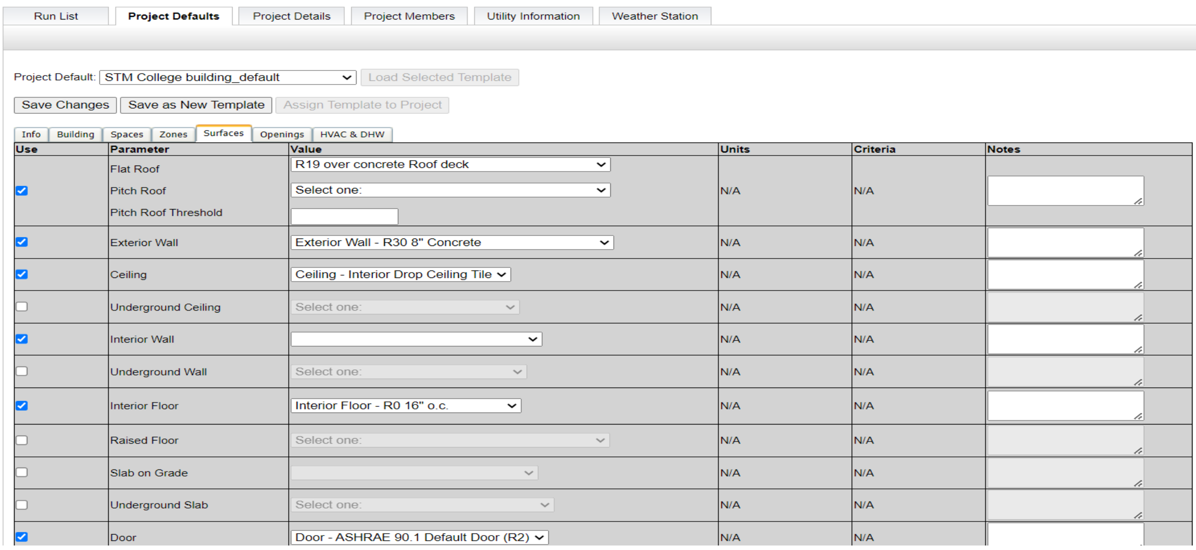


Fig 9.9: Assigning construction materials

9. Assign the opening properties for North glaze, Non-north glaze and skylight glaze.

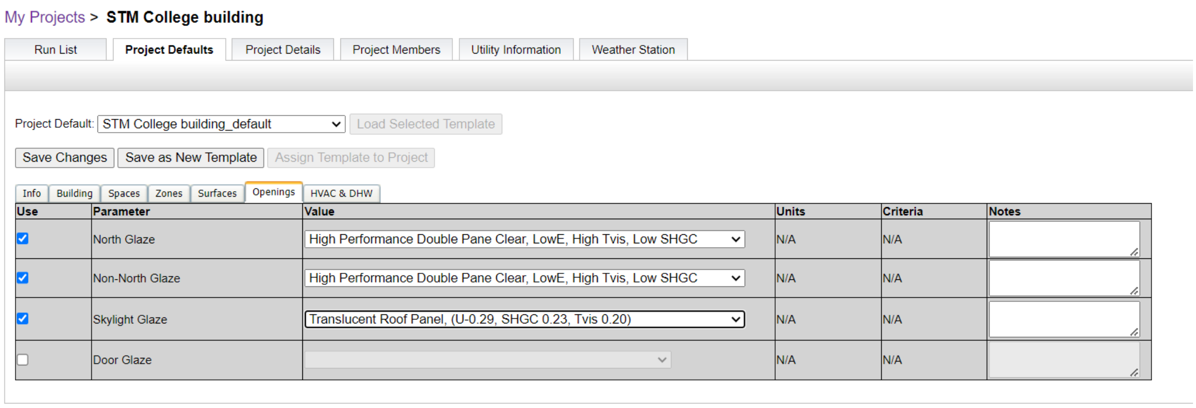


Fig 9.10: Glazing details

10.Save the parameters defined and go to run list. Go to actions and upload the gbXML file of the building from Revit.

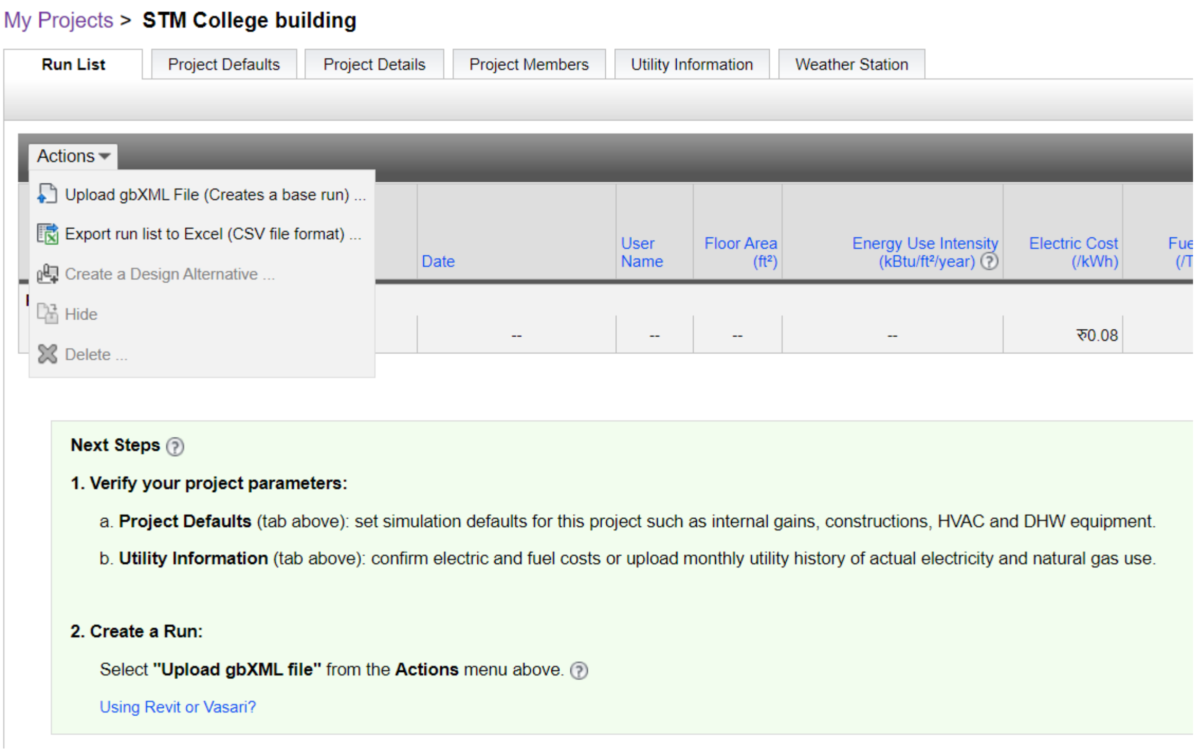


Fig 9.11: Assigning construction materials

11. GBS will automatically run the building after uploading.

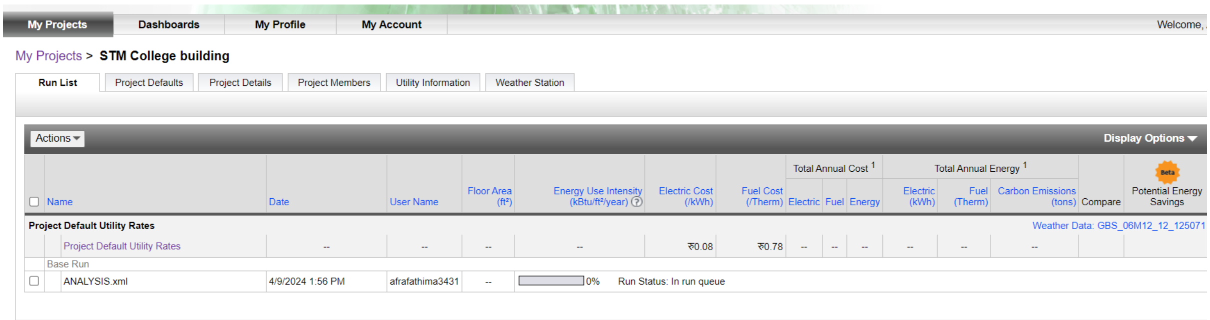


Fig 9.12: Base run

9.3 MODELLING RESULTS

1. Base run details including annual energy cost, annual energy used and lifecycle cost.

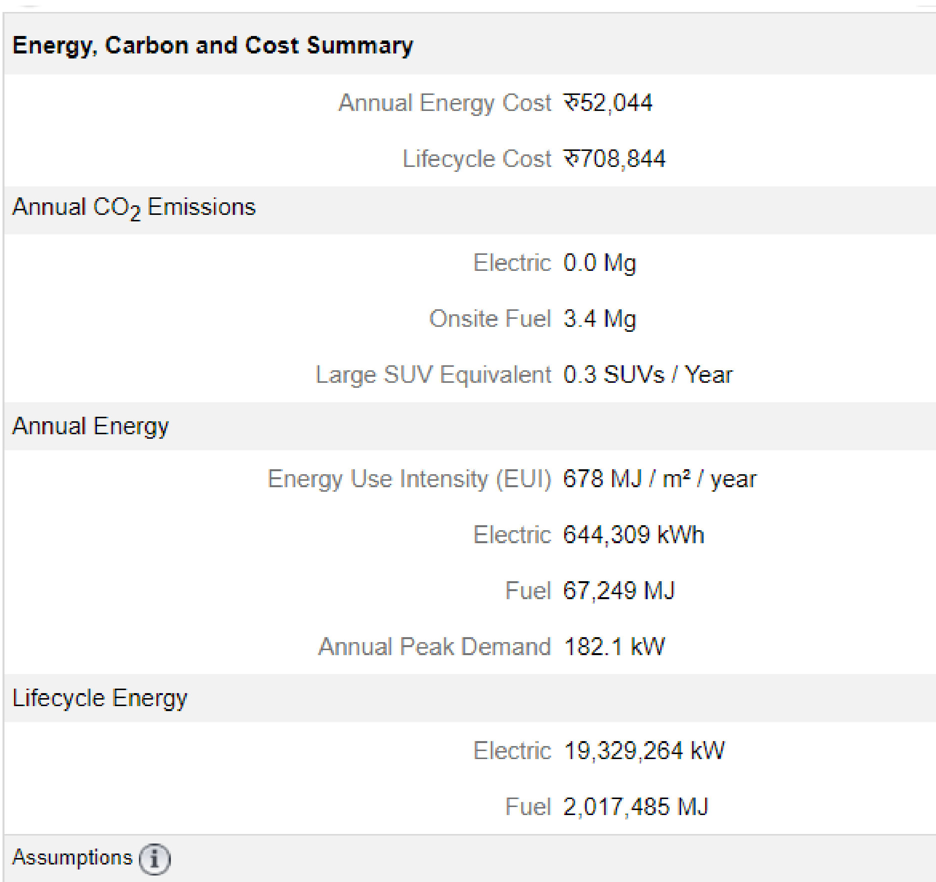


Fig 9.13: Base run results

2. Natural ventilation potential

Natural Ventilation Potential	
Total Hours Mechanical Cooling Required:	4,242 Hours
Possible Natural Ventilation Hours:	19 Hours
Possible Annual Electric Energy Savings:	1,347 kWh
Possible Annual Electric Cost Savings:	रु108
Net Hours Mechanical Cooling Required:	4,223 Hours

Fig 9.14: Ventilation potential

3. Water usage and cost

Water Usage and Costs

Total:	**4,862,806 L / yr**	**रु86,339 / yr**
Indoor:	4,562,181 L / yr	रु78,824 / yr
Outdoor:	300,625 L / yr	रु7,516 / yr
Net Utility:	**3,330,006 L / yr**	रु84,929 / yr

Source: AWWA Research Foundation 2000 Residential / Commercial and Institutional End Uses of Water.

Fig 9.15: Water usage

4. Annual energy end use charts

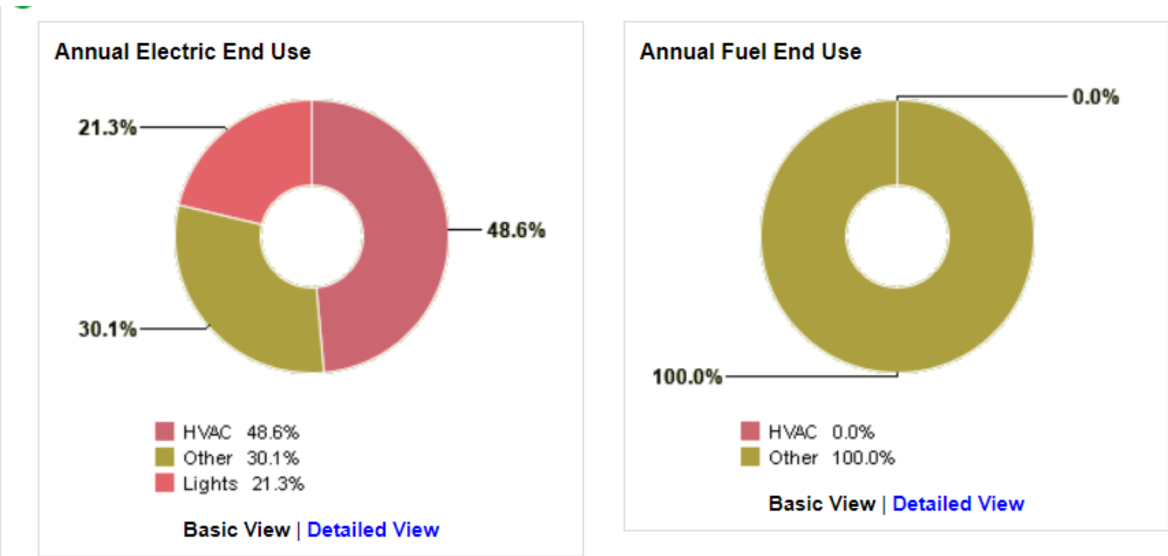


Fig 9.16: Energy end use charts

9.4 RESULTS

1. Base Run Details: The annual energy cost and lifecycle cost are provided, with a significant portion attributed to HVAC operations. The annual CO2 emissions indicate a relatively low environmental impact from electric usage but a noticeable impact from onsite fuel usage.
2. Natural Ventilation Potential: The building has a limited capacity for natural ventilation, with only 19 out of 4,242 total hours suitable for it. This results in minimal annual electric energy savings and cost savings. However, there is still potential to optimize ventilation strategies to reduce mechanical cooling requirements further.

3. Water Usage and Costs: The total water usage is significant, with the majority being consumed indoors. There's a noticeable net utility cost associated with water usage, indicating potential for efficiency improvements or conservation measures, particularly in indoor water usage.

4. Annual Electric End Use and Annual Fuel End Use: HVAC (heating, ventilation, and air conditioning) accounts for a significant portion of both annual electric and fuel end use. This highlights the importance of optimizing HVAC systems for energy efficiency to reduce overall energy consumption and costs.

9.5 CONCLUSION

The building's energy usage and costs are dominated by HVAC operations, emphasizing the importance of improving HVAC efficiency. Water usage, particularly indoor, presents an opportunity for conservation efforts to reduce utility costs. While natural ventilation potential is limited, exploring further optimization strategies could still yield some energy savings. Considering the lifecycle cost and environmental impact, investing in energy-efficient HVAC systems and water conservation measures could lead to long-term savings and sustainability benefits.

CHAPTER 10
COST ESTIMATION

10.1 GENERAL

Cost estimation is the process of predicting the expenses for a project by evaluating factors like materials, labor, and overhead costs. It's crucial for project planning, budgeting, and control, providing stakeholders with accurate forecasts to make informed decisions and optimize resource allocation. Effective cost estimation minimizes financial risks and helps ensure projects stay within budgetary limits.

10.2 QUANTITY ESTIMATION

Description	No	Length	Breadth	Depth	Quantity
Excavation work by mechanical means in foundation trenches or drains (not exceeding 1.5m in width or 10 sqm on plan), including dressing of sides and ramming of bottoms, lift up to 1.5 m, including getting out the excavated soil and disposal of surplus excavated soils as directed, within a lead of 50 m.					
F1	6	1.5	1.5	2	27.00
F2	40	1.6	1.45	2	185.60
F3	7	2	1.85	2	51.80
F4	30	1.9	1.75	2	199.50
F5	1	5.9	4.2	2	49.56
GRAND TOTAL FOR EXCAVATION WORK	513.46				
PCC 1:4:8 (1 Cement: 4 coarse sand (zone-III) derived from natural sources: 8 graded stone aggregate 40 mm nominal size derived from natural sources).					
F1	6	1.5	1.5	0.15	2.03
F2	40	1.6	1.45	0.15	13.92
F3	7	2	1.85	0.15	3.89
F4	30	1.9	1.75	0.15	14.96
F5	1	5.9	4.2	0.15	3.72
GRAND TOTAL FOR PCC	38.51				

RCC 1:1.5:3 using 20mm broken stone for lintel, column footing, beam, column etc. Including formwork, watering, curing, cost of conveyance and all labour charges, etc. complete.					
Column footing					
F1	6	1.2	1.2	0.325	2.81
F2	40	1.3	1.15	0.7	41.86
F3	7	1.7	1.55	0.475	8.76
F4	36	1.6	1.45	0.425	35.50
Total for footing	88.93				
Column					
Column up to plinth					
Circular column					
500 dia.	2	0.5	0.5	1.5	2.35
600 dia.	4	0.6	0.6	1.5	6.78
Rectangular column					
350 X 600	55	0.35	0.6	1.5	17.33
400 X 600	15	0.4	0.6	1.5	5.40
450 X 700	3	0.45	0.7	1.5	1.42
400 X 700	10	0.4	0.7	1.5	4.20
300 X 300	5	0.3	0.3	1.5	0.68
550 X 700	1	0.55	0.7	1.5	0.58
600 X 750	1	0.6	0.75	1.5	0.68
Ground floor column					
Circular column					
500 dia.	2	0.5	0.5	3.6	5.65
600 dia.	4	0.6	0.6	3.6	16.28
Rectangular column					
350 X 600	55	0.35	0.6	3.6	41.58
400 X 600	15	0.4	0.6	3.6	12.96
450 X 700	3	0.45	0.7	3.6	3.40
400 X 700	10	0.4	0.7	3.6	10.08
300 X 300	5	0.3	0.3	3.6	1.62
550 X 700	1	0.55	0.7	3.6	1.39
600 X 750	1	0.6	0.75	3.6	1.62
First floor column					
Circular column					
600 dia.	4	0.6	0.6	3.6	16.28
Rectangular column					
350 X 600	55	0.35	0.6	3.6	41.58
400 X 600	15	0.4	0.6	3.6	12.96
450 X 700	3	0.45	0.7	3.6	3.40
400 X 700	10	0.4	0.7	3.6	10.08

300 X 300	5	0.3	0.3	3.6	1.62
550 X 700	1	0.55	0.7	3.6	1.39
600 X 750	1	0.6	0.75	3.6	1.62
Second floor column					
Circular column					
600 dia.	4	0.6	0.6	3.6	16.28
Rectangular column					
350 X 600	55	0.35	0.6	3.6	41.58
400 X 600	15	0.4	0.6	3.6	12.96
450 X 700	3	0.45	0.7	3.6	3.40
400 X 700	10	0.4	0.7	3.6	10.08
300 X 300	5	0.3	0.3	3.6	1.62
550 X 700	1	0.55	0.7	3.6	1.39
600 X 750	1	0.6	0.75	3.6	1.62
Total for column	311.83				
Slab					
First floor slab					
S1	1	64	37.2	0.12	285.70
S2(Veranda)	1	34.68		0.12	4.16
S3 (Porch)	1	6	7	0.12	5.04
Deduction					
Main stair	1	40.576		0.12	4.87
Emergency stair	1	3.5	6	0.12	2.52
Lift	1	3.8	2.5	0.12	1.14
Total	286.37				
Second floor slab					
S1	1	64	37.2	0.12	285.70
S2(Veranda)	1	34.68		0.12	4.16
Deduction					
Main stair	1	40.576		0.12	4.87
Emergency stair	1	3.5	6	0.12	2.52
Lift	1	3.8	2.5	0.12	1.14
Total	281.33				
Third floor slab					
S1	1.00	66.1	38.4	0.12	304.589
S2(Veranda)	1	34.68		0.12	4.16
Deduction					
Main stair	1	40.576		0.12	4.87
Emergency stair	1	3.5	6	0.12	2.52
Lift	1	3.8	2.5	0.12	1.14
Total	300.22				
Total for slab	867.92				
Beam					

Plinth beam					
250 X 300	1	36.1	0.25	0.3	2.71
250 X 400	1	34	0.25	0.4	3.40
250 X 450	1	440.9	0.25	0.45	49.60
250 X 500	1	53.9	0.25	0.5	6.74
250 X 600	1	356.7	0.25	0.6	53.51
250 X 700	1	6.4	0.25	0.7	1.12
300 X 600	1	113.3	0.3	0.6	20.39
Total plinth beam	137.47				
Ground floor beam					
250X300	1	9.1	0.25	0.18	0.41
250X400	1	38.6	0.25	0.28	2.70
250X450	1	268.9	0.25	0.33	22.18
250X600	1	148.5	0.25	0.48	17.82
300X300	1	20.2	0.3	0.18	1.09
300X400	1	93.4	0.3	0.28	7.85
300X450	1	207.2	0.3	0.33	20.51
300X500	1	13.6	0.3	0.38	1.55
300X600	1	302.6	0.3	0.38	34.50
300X700	1	108.6	0.3	0.58	18.90
300X750	1	29.3	0.3	0.63	5.54
Total ground floor beam	133.05				
First floor beam					
250X300	1	9.1	0.25	0.18	0.41
250X400	1	38.6	0.25	0.28	2.70
250X450	1	268.9	0.25	0.33	22.18
250X600	1	148.5	0.25	0.48	17.82
300X300	1	20.2	0.3	0.18	1.09
300X400	1	93.4	0.3	0.28	7.85
300X450	1	207.2	0.3	0.33	20.51
300X500	1	13.6	0.3	0.38	1.55
300X600	1	302.6	0.3	0.38	34.50
300X700	1	108.6	0.3	0.58	18.90
300X750	1	29.3	0.3	0.63	5.54
Total first floor beam	133.05				
Second floor beam					
250X300	1	9.1	0.25	0.18	0.41
250X400	1	38.6	0.25	0.28	2.70
250X450	1	243.3	0.25	0.33	20.07
250X600	1	148.5	0.25	0.48	17.82
300X300	1	20.2	0.3	0.18	1.09
300X400	1	93.4	0.3	0.28	7.85
300X450	1	207.2	0.3	0.33	20.51

300X500	1	13.6	0.3	0.38	1.55
300X600	1	334.6	0.3	0.38	38.14
300X700	1	108.6	0.3	0.58	18.90
300X750	1	29.3	0.3	0.63	5.54
Total second floor beam	134.58				
Terrace floor beam					
300X600	1	33	0.3	0.6	5.94
Total terrace floor beam	5.94				
Total for beam	409.50				
lintels					
Ground floor	1	340	0.2	0.15	10.20
First floor	1	340	0.2	0.15	10.20
Second floor	1	340	0.2	0.15	10.20
Total for lintel	30.60				
Total for beam and lintel	440.10				
Stair					
Waist slab	3	10.8	2.5	0.15	12.15
Landing	3	3	2.5	0.15	3.38
Steps	36	2.5	0.3	0.15	4.05
Total for steps in 3 floors	19.58				
Emergency Stair					
Waist slab	3.00	7.46	1.5	0.15	5.0355
Landing	6.00	1.5	1.5	0.15	2.025
Steps	36.00	1.5	0.3	0.15	2.43
Total for emergency steps in 3 floors	9.49				
Total stair and slab	896.98				
Earth filling of inside portion of basement including all cost of conveyance, labour charges, ramming, watering etc. Complete					
Lecture Hall	6	7	12	0.45	226.80
Laboratory 1	2	18	15	0.45	243.00
Laboratory 2	2	15.2	17.4	0.45	238.03
Administrative Room	1	8.9	7	0.45	28.04
Conference Room	1	8.9	7	0.45	28.04
Sick Room	2	3.8	3.2	0.45	10.94
Toilet	2	7	6.9	0.45	43.47
Store	1	3.8	2.3	0.45	3.93
GRAND TOTAL FOR EARTH FILLING	822.25				
AAC nearly dressed stone in cement mortar 1:6 including cost of					

conveyance, all labour charges etc. complete.					
Ground floor					
Super structure wall 20 cm	1	603	0.2	3.1	373.86
Super structure wall 10 cm	1	72.7	0.1	2.5	18.18
Front verandah step					
Step 1	1	2	0.3	0.15	0.09
step 2	1	3.2	0.3	0.15	0.14
Total	392.27				
Deduction					
D1	29	1	0.2	2.1	12.18
D2	26	0.9	0.2	2.1	9.83
D3	1	2.5	0.2	2.1	1.05
For window W	92	1.5	0.2	1	27.60
For Ventilator V	128	1.5	0.2	0.5	19.20
Total	69.86				
AAC work for ground floor	322.41				
First Floor					
Super structure wall 20 cm	1	603	0.2	3.1	373.86
Super structure wall 10 cm	1	72.7	0.1	2.5	18.18
Total	392.04				
Deduction					
D1	29	1	0.2	2.1	12.18
D2	26	0.9	0.2	2.1	9.83
D3	1	2.5	0.2	2.1	1.05
For window W	92	1.5	0.2	1	27.60
For Ventilator V	128	1.5	0.2	0.5	19.20
Total	69.86				
AAC work for first floor	322.177				
Second Floor					
Super structure wall 20 cm	1	603	0.2	3.1	373.86
Super structure wall 10 cm	1	72.7	0.1	2.5	18.18
Total	392.04				
Deduction					
D1	29	1	0.2	2.1	12.18
D2	26	0.9	0.2	2.1	9.83
D3	1	2.5	0.2	2.1	1.05
For window W	92	1.5	0.2	1	27.60
For Ventilator V	128	1.5	0.2	0.5	19.20
Total	69.86				
AAC work for second floor	322.177				
GRAND TOTAL FOR AAC WORK	966.77				

Providing and laying vitrified floor tiles laid on 20 mm thick cement mortar 1:4 (1 cement : 4 coarse sand), jointing with grey cement slurry @ 3.3 kg/sqm including grouting the joints with white cement and matching pigments etc. including the sub base of cement concrete 1:4:8 50mm thick, complete.					
Ground floor	1	2400			2400.00
Providing and laying vitrified floor tiles laid on 20 mm thick cement mortar 1:4 (1 cement : 4 coarse sand), jointing with grey cement slurry @ 3.3 kg/sqm including grouting the joints with white cement and matching pigments etc., complete.					
First Floor	1	2500			2400.00
Second floor	1	2400			2400.00
TOTAL FOR FLOORING first and second floor	4800.00				
Plastering with C.M 1:4, 12mm thick one coat loathed hard and trowel led smooth including cost of conveyance and all labour charges etc. complete.					
Ground floor					
Lecture Hall	6	38		3.6	820.80
Laboratory 1	2	66		3.6	475.20
Laboratory 2	2	65.2		3.6	469.44
Administrative Room	1	31.8		3.6	114.48
Conference room	1	31.8		3.6	114.48
Sick Room	2	14		3.6	100.80
Toilet	2	27.8		3.6	200.16
Passage	1	213.6		3.6	768.96
Store	1	12.2		3.6	43.92
Outer wall	1	190		3	570.00
Verandah Column	4	3.14	5*5	3.6	1130.40
Car porch column	2	3.14	6*6	3.6	813.88
Front verandah step					
Step 1	1	2	0.3	0.15	0.09
step 2	1	3.2	0.3	0.15	0.14
Stair					
Waist slab	3	10.8	0.25	0.15	1.22
Landing	3	3	2.5	0.15	3.38
Steps	108	2.5	0.3		81.00

Total	5708.34				
Deduction					
D1	29	1		2.1	60.90
D2	26	0.9		2.1	49.14
D3	1	2.5		2.1	5.25
For window W	92	1.5		1	138.00
For Ventilator V	128	1.5		0.5	96.00
Total	349.29				
Plastering for ground floor	5359.05				
First floor					
Lecture Hall	6	38		3.6	820.80
Laboratory 1	2	66		3.6	475.20
Laboratory 2	2	65.2		3.6	469.44
staff room	1	31.8		3.6	114.48
staff room	1	31.8		3.6	114.48
Sick Room	2	14		3.6	100.80
Toilet	2	27.8		3.6	200.16
Passage	1	213.6		3.6	768.96
Store	1	12.2		3.6	43.92
Outer wall	1	190		3.6	684.00
Verandah Column	4	3.14	5*5	3.6	1130.40
Stair					
Waist slab	3	10.8	0.25	0.15	1.22
Landing	3	3	2.5	0.15	3.38
Steps	108	2.5	0.3		81.00
Total	5008.23				
Deduction					
D1	29	1		2.1	60.90
D2	26	0.9		2.1	49.14
D3	1	2.5		2.1	5.25
For window W	92	1.5		1	138.00
For Ventilator V	128	1.5		0.5	96.00
Total	349.29				
Plastering for first floor	4658.94				
Second floor					
Lecture Hall	6	38		3.6	820.80
Laboratory 1	1	66		3.6	237.60
Laboratory 2	2	65.2		3.6	469.44
staff room	1	31.8		3.6	114.48
sports room	1	31.8		3.6	114.48
Sick Room	2	14		3.6	100.80
Toilet	2	27.8		3.6	200.16
Passage	1	213.6		3.6	768.96

Store	1	12.2		3.6	43.92
Outer wall	1	190		3.6	684.00
Verandah Column	4	3.14	5*5	3.6	45.22
drawing hall	1	47.8		3.6	172.08
seminar hall	1	47.8		3.6	172.08
Stair					
Waist slab	3	10.8	0.25	0.15	1.22
Landing	3	3	2.5	0.15	3.38
Steps	108	2.5	0.3		81.00
Total	4029.61				
Deduction					
D1	29	1		2.1	60.90
D2	26	0.9		2.1	49.14
D3	1	2.5		2.1	5.25
For window W	92	1.5		1	138.00
For Ventilator V	128	1.5		0.5	96.00
Total	349.29				
Plastering for second floor	3680.32				
GRAND TOTAL FOR PLASTERING	13698.31				
Ceiling					
Ground floor	1	2400			2400.00
First floor	1	2400			2400.00
Second floor	1	2600			2400.00
GRAND TOTAL FOR CEILING	7200.00				
Supplying and fixing Steel doors and pvc windows including all hardware fittings.					
D1	29				29.00
D2	26				26.00
D3	1				1.00
For window W	92				92.00
For Ventilator V	128				128.00

10.3 ABSTRACT

DESCRIPTION	QUANTITY	UNIT	RATE	PER	AMOUNT
Excavation work by mechanical means in foundation trenches or drains (not exceeding 1.5m in width or 10 sqm on plan), including dressing of sides and ramming of bottoms, lift up to 1.5 m, including	513.46	cum	632.95	cum	324994.51

getting out the excavated soil and disposal of surplus excavated soils as directed, within a lead of 50 m.					
P.C.C 1:4:8 using 40mm nominal size hard granite stone including cost of conveyance and all labour charge, etc. complete for foundation.	38.51	cum	6812.00	cum	262326.71
R.C.C 1:1.5:3 using 20mm broken stone for column footing, including formwork, watering, curing, cost of conveyance, and all labour charges, etc. complete.	88.93	cum	10065.00	cum	895033.90
R.C.C 1:1.5:3 using 20mm broken stone for column, etc. including formwork, watering, curing, cost of conveyance, and all labour charges, etc. complete.	311.83	cum	19503.95	cum	6081902.69
R.C.C 1:1.5:3 using 20mm broken stone for lintel, beam , etc. including formwork, watering, curing, cost of conveyance, and all labour charges, etc. complete.	440.10	cum	19237.20	cum	8466233.05
R.C.C 1:1.5:3 using 20mm broken stone for slab, stair, etc. including formwork, watering, curing, cost of conveyance, and all labour charges, etc. complete.	896.98	cum	19199.00	cum	17221190.82
Reinforcement for RCC work	145440.00	kg	107.85	kg	15685704.00
Earth filling of inside portion of basement including all cost of conveyance, labour charges, ramming, watering, etc. complete.	822.25	cum	650.00	cum	534461.85
AAC in cement mortar 1:6 including cost of conveyance, all labour charges, etc. complete.	966.77	cum	10195.45	cum	9856604.22

Providing and laying vitrified floor tiles laid on 20 mm thick cement mortar 1:4 (1 cement : 4 coarse sand), jointing with grey cement slurry @ 3.3 kg/ sqm including grouting the joints with white cement and matching pigments etc. including the sub base of cement concrete 1:4:8 50mm thick., complete.	2400.00	sqm	2389.00	sqm	5733600.00
Providing and laying vitrified floor tiles laid on 20 mm thick cement mortar 1:4 (1 cement : 4 coarse sand), jointing with grey cement slurry @ 3.3 kg/ sqm including grouting the joints with white cement and matching pigments etc., complete.	4800.00	sqm	2089.65	sqm	10030320.00
Plastering with C.M 1:4, 12mm thick one coat floated hard and trowel led smooth including all cost and conveyance and all labour charges etc. complete.	13698.31	sqm	347.05	sqm	4753998.486
6 mm cement plaster 1:3 (1 cement : 3 fine sand) finished with a floating coat of neat cement and thick coat of Lime wash on top of walls when dry for bearing of R.C.C. slabs and beams.	7200.00	sqm	396.65	sqm	2855880
Supplying and fixing Steel doors and pvc windows including all hardware fittings					
D1	29	nos	14000	nos	406000
D2	26	nos	6000	nos	156000
D3	1	nos	8000	nos	8000
For window W	92	nos	12000	nos	1104000
For Ventilator V	128	nos	4000	nos	512000
Finishing walls with 100% Premium acrylic emulsion paint having VOC less than 50 gm/litre and UV resistance	20898.31	sqm	146.2	sqm	3055332.922

Steel	60.52	kg	117.35	kg	7102.022
Wood	4.38	sqm	3747.3	sqm	16413.174
Provision for lift and accessories					4000000.00
Provision for solar panel					2000000.00
Total	₹ 93,967,098.35				
Cost of architectural work 1%					₹ 939,670.98
Cost of water supply work 5 %					4698354.92
Cost of sanitary work 5%					4698354.92
Cost of electrification work 6%					5,638,025.90
Unforeseen item					2058494.93
GRAND TOTAL	**₹ 112,000,000.00**				

10.4 CONCLUSION

The construction project encompasses a comprehensive scope, meticulously detailed across various activities and materials. Excavation work, crucial for laying the foundation, is priced at ₹324,994.51 for 513.46 cubic meters, with meticulous attention to dressing sides and ramming bottoms. Concrete works are itemized, from P.C.C to R.C.C mixes for footings, columns, lintels, beams, slabs, and stairs, each meticulously costed, totaling ₹30,433,065.36. Reinforcement for R.C.C work adds further detail, with 145,440 kg priced at ₹10,785 per kg, amounting to ₹15,685,704. Earth filling, AAC, and vitrified floor tiling follow suit, ensuring a comprehensive approach to every aspect of construction. The inclusion of plastering, steel doors, PVC windows, and finishing walls with premium acrylic emulsion paint demonstrates attention to both structural integrity and aesthetic appeal. Moreover, provisions for lift installation and solar panels anticipate future needs. Factoring in costs for architectural, water supply, sanitary, and electrification works, alongside an allowance for unforeseen items, the grand total amounts to a substantial ₹112,000,000.00, reflecting the thoroughness and foresight embedded within this construction endeavor.

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