ENERGY ANALYSIS OF ADICHUNCHANAGIRI POLYTECHNIC USING BIM

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Abstract – *The consciousness of energy usage is crucial for global sustainability efforts, particularly in optimizing the energy consumption of buildings. This research focuses on creating a digital twin of Adichunchangiri Polytechnic's existing building and enhancing its visualization using Twinmotion software. Additionally, a comprehensive three-energy model was developed and analyzed. Among the assessments conducted, Assessment Three emerged with the most favorable operational cost per square meter at 12.4 USD/m2, surpassing Assessment One (20.7 USD/m2) and Assessment Two (17.2 USD/m2). This underscores Assessment Three's superior energy efficiency and effective system optimizations. Key factors contributing to Assessment Three's performance include its high window-to-wall ratio, which enhances natural day lighting and reduces reliance on artificial lighting. Historical analysis of the model reveals ongoing improvements that have consistently enhanced its energy performance. Strategic building orientation further enhances Assessment Three's efficiency, optimizing lighting, airflow, and overall sustainability. This is evident in its superior metrics for daylight utilization, occupancy control, plug load efficiency, and HVAC efficiency, all of which contribute to operational efficiency and sustainability. Financially, the lower operational costs of Assessment Three highlight its long-term cost-effectiveness and potential for substantial savings. This study provides valuable insights for future building designs, emphasizing the importance of optimized ratios, strategic orientation, and integrated efficiencies to achieve superior energy performance and occupant comfort. In conclusion, Assessment Three sets a benchmark for sustainable building practices, showcasing the benefits* of strategic design and efficient systems in achieving exceptional energy performance and operational excellence.

Key Words: Energy efficiency, Sustainability, Building optimization, BIM, Revit, Insight

1. INTRODUCTION

In the ever-evolving landscape of sustainable development and environmental consciousness, the built environment stands as a pivotal arena for innovation and transformation. As societies grapple with the challenges of climate change, resource depletion, and escalating energy costs, the imperative for energy-efficient building design and operation has never been more pressing. In response to this imperative, the integration of advanced technologies and methodologies has emerged as a cornerstone in the pursuit of sustainable building practices. Central to this paradigm shift is the utilization of Building Information Modeling (BIM), a revolutionary approach that transcends traditional architectural design processes by enabling comprehensive digital representations of building projects. At the forefront of this technological revolution is Autodesk Revit 2022, a powerful BIM software suite renowned for its versatility, efficiency, and robust analytical capabilities. Coupled with the cutting-edge insights provided by Insight 2022, Revit 2022 empowers architects, engineers, and building professionals to not only visualize and design intricate building structures but also to analyze, optimize, and streamline their energy performance with unprecedented precision and insight. Against this backdrop, this research endeavor embarks on a comprehensive exploration of the energy analysis capabilities afforded by Revit 2022 and Insight 2022, with a particular focus on their application in the context of sustainable building design and operation. By delving into the intricacies of these software tools, this study seeks to unravel the full spectrum of functionalities, methodologies, and best practices available to practitioners in their quest to create energy-efficient, environmentally sustainable built environments.

1.1 SURVEYING AND DATA COLLECTION

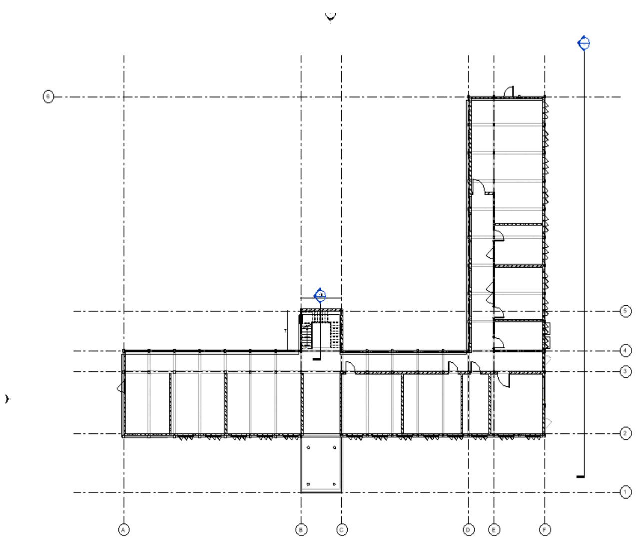

Figure 1: Ground Floor

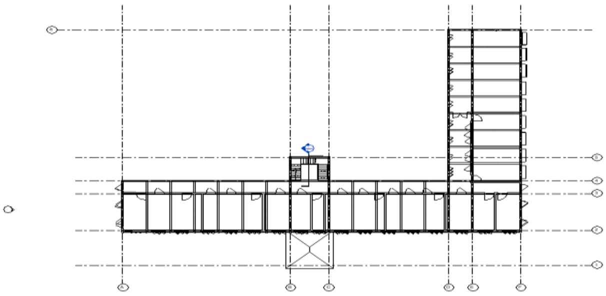

Figure 2: First Floor

Integrating surveyed building data into Revit 2020 for three different floors involves a systematic approach from data collection to final model creation. Initially, detailed surveys using advanced tools like laser scanners and total stations capture precise measurements of the building's structural elements. These measurements are processed to generate accurate plan drawings that serve as the basis for modeling in Revit. Importing these drawings into Revit allows for direct plotting of the surveyed data, ensuring the three-dimensional models accurately represent the physical attributes of each floor. Challenges such as data alignment and accuracy verification were addressed through meticulous quality control measures during both the survey and modeling phases, ensuring the reliability and usability of the final BIM models.

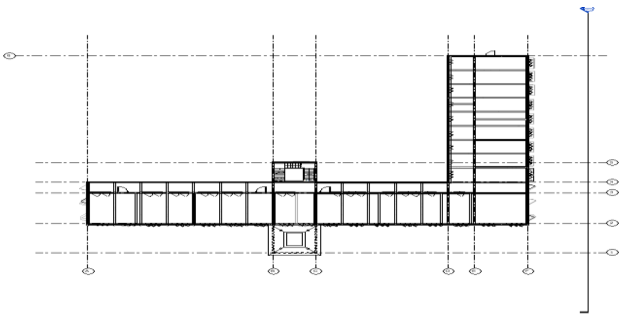

Figure 3: Third Floor

1.2 MODELING

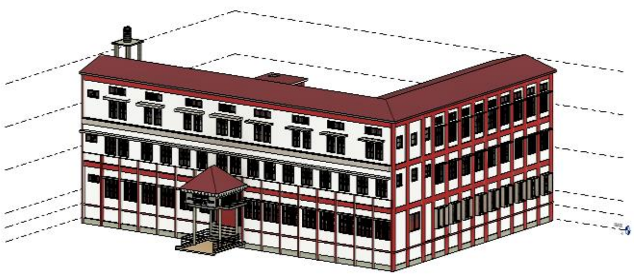

Figure 4: 3D modeling (Front View)

Using the surveyed building data, we proceeded to model the structure in Revit 2022 software while maintaining consistency with the architectural dimensions derived from the plan drawings. This process involved importing the detailed measurements obtained during the survey phase into Revit 2022We ensured that the structural elements, such as walls, columns, and openings, were accurately represented in the digital models to reflect the physical reality observed in the field. By aligning the modelled elements with the architectural dimensions from the plan drawings, we aimed to create cohesive and accurate three-dimensional representations of each floor within the building. This approach not only facilitated the visualization of the building's structure but also enhanced the efficiency and precision of future design and renovation processes.In addition to modeling the structure in Revit 2022, we further enhanced the project by rendering the models using Twinmotion. This step was crucial in providing a more immersive and realistic perspective of the building. Twin motion's capabilities allowed us to apply textures, lighting effects, and environmental elements to the Revit models, thereby creating compelling visualizations that closely simulate real-world conditions

Figure 5: 3D Render (Front View)

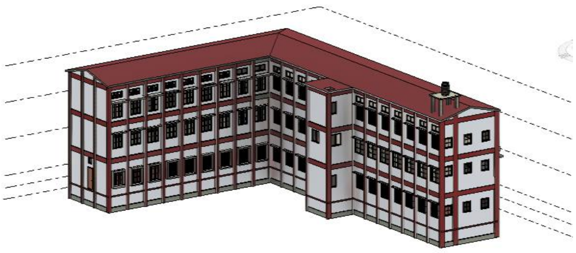

Figure 6: 3D modeling (Rear View)

2. TEST APPROCH:

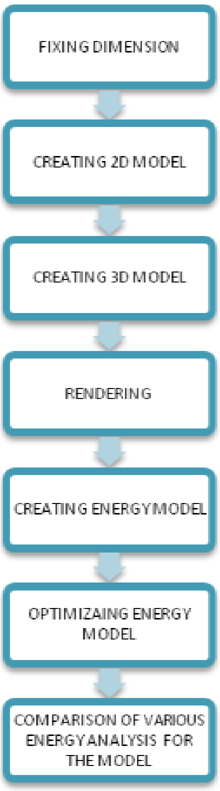

Figure 7: Flowchart of Methodology

The methodology began with fixed dimensions from detailed surveys, followed by creating 2D and 3D models in Revit. Rendering enhanced visualizations using Twin motion. An energy model was then built within Revit, optimizing factors like materials and HVAC systems for efficiency. Various energy analyses were conducted to compare scenarios and inform sustainable design decisions, aiming to minimize environmental impact and operational costs while maximizing building performance.

3. RESULT AND DISCUSSION

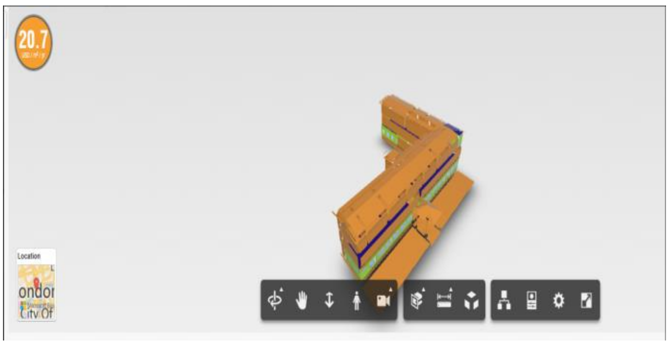

Figure 8: Assessment 1

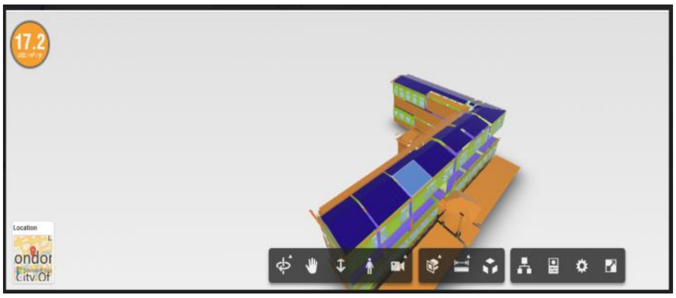

Figure 9: Assessment 2

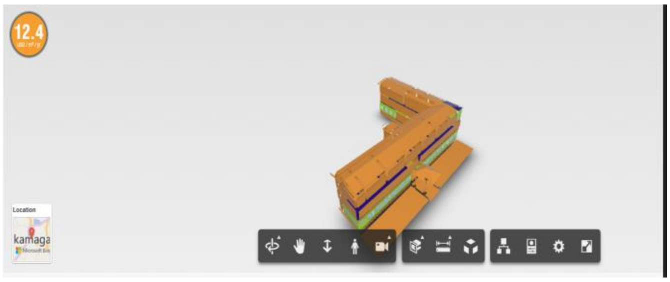

Figure 10: Assessment 3

These results indicate that Assessment Three has the lowest energy cost per square meter compared to Assessments One and Two. This suggests that Assessment Three potentially has superior energy efficiency measures or better utilization of energy systems, leading to lower operational costs.

Assessment Three exhibits a superior window-to-wall ratio compared to Assessments One and Two in all directions. This indicates that Assessment Three has optimized the balance between windows (day lighting and views) and walls (insulation and structural integrity), likely contributing to better day lighting and reduced reliance on artificial lighting.

Figure 11: Window-wall ratio (north)

Figure 12: Window-wall ratio (North, South)

Figure 13: Window-wall ratio (south)

The graphical presentation of model history provides insights into the evolution of the building design. It helps in understanding the iterative improvements made over time, potentially highlighting design decisions that led to enhanced energy performance and overall efficiency.

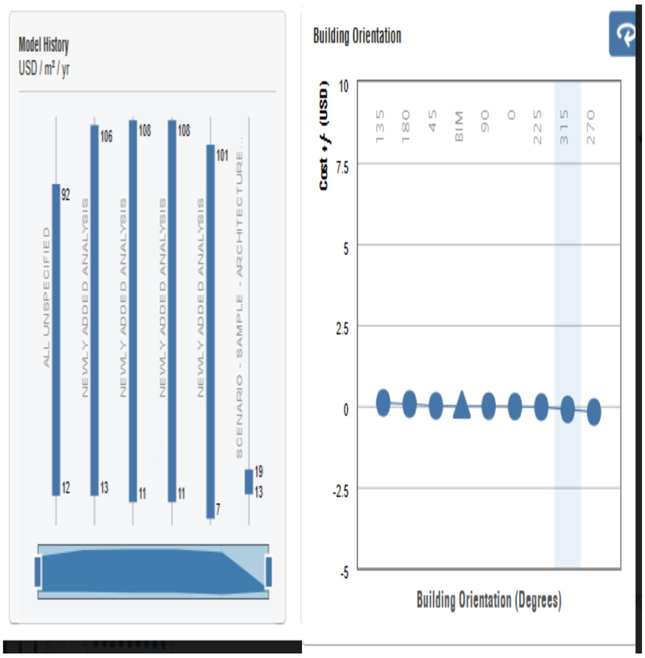

Figure 14: Model history and building orientation

The tabulated data on building orientation shows that improved lighting, airflow, and sustainability were achieved through optimal orientation. This implies that Assessment Three, which likely benefited from better orientation strategies, enjoys natural advantages such as reduced solar heat gain, improved natural ventilation, and enhanced natural lighting conditions.

Figure 15: day light and occupancy controls (case 1 & 2)

Assessment Three outperforms Assessments One and Two in several key aspects Daylight and Occupancy Control Likely due to superior window placement and control systems. Plug Load Efficiency. Efficient use of electrical outlets and devices. Operating Schedule and Panel Efficiency Optimal scheduling of operations and efficient electrical panels. VAC Efficiency Effective heating, ventilation, and air conditioning systems management. These factors collectively contribute to Assessment Three achieving superior overall building performance. Lower energy costs, enhanced comfort through better day lighting and ventilation, and efficient operation of systems highlight Assessment Three as the preferred design option from an energy and sustainability perspective.

Figure 16: Plug load efficiency (case 1)& day light and occupancy controls (case 3)

the results emphasize that Assessment Three not only achieves lower energy costs but also demonstrates superior environmental performance through optimized window-to-wall ratios, strategic building orientation, and efficient system operations. These findings are crucial for making informed decisions in building design and energy efficiency improvements. the comprehensive analysis of energy benchmarks, window-to-wall ratios, model history, building orientation, and overall performance metrics consistently highlight Assessment Three as the optimal choice. Its superior energy efficiency, achieved through strategic design decisions and operational optimizations, not only lowers

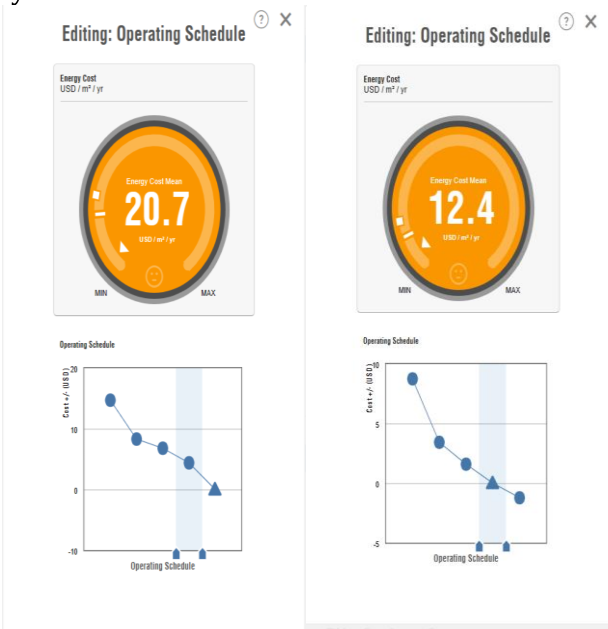

Figure 18: Operation Schedule (case 1 & 3)

Figure 17: Plug load efficiency (case 2 & 3)

Figure 18: Operation Schedule (case 2) & panel efficiency (case 1)

Figure 19: Panel efficiency (case 3)& HVAC (case 1)

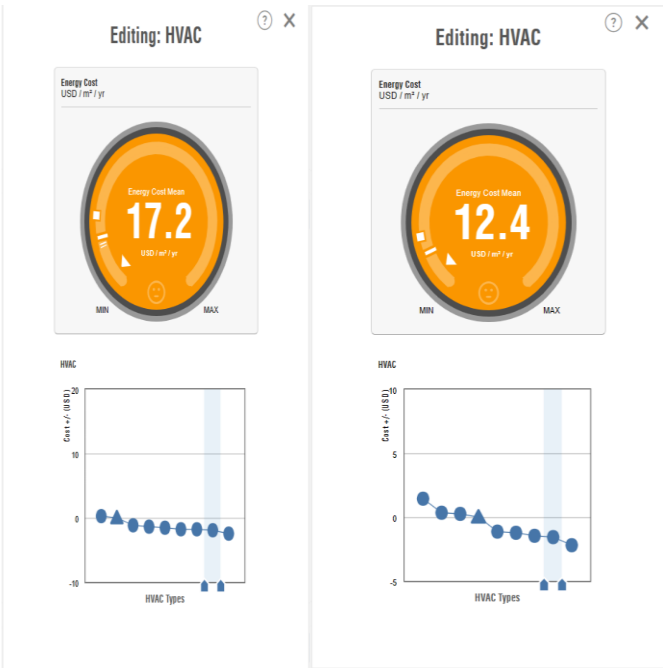

Figure 20: HVAC (case 2 and 3)

Operational costs but also enhances comfort and sustainability. These findings underscore the importance of integrated design approaches and continuous improvement in building performance assessments.

4. CONCLUSIONS

Based on the project analysis, Assessment Three stands out with the lowest operational costs per square meter—12.4 USD/m2 compared to 20.7 USD/m2 for Assessment One and 17.2 USD/m2 for Assessment Two. This highlights Assessment Three's superior energy efficiency and effective system optimizations. Assessment Three also features a superior window-to-wall ratio, enhancing natural day lighting and reducing reliance on artificial lighting. The model history analysis shows continual improvements that have refined its energy performance over time. Strategic building orientation further enhances Assessment Three's performance, improving lighting, airflow, and overall sustainability. This aligns with its superior performance in key operational metrics such as daylight and occupancy control, plug load efficiency, and HVAC efficiency, contributing to overall operational efficiency and sustainability. Financially, Assessment Three's lower operational costs underscore its long-term cost-effectiveness and potential for significant savings. The project provides valuable insights for future building designs, emphasizing optimized ratios, effective orientation, and integrated efficiencies for enhanced energy performance and occupant comfort. In conclusion, Assessment Three sets a benchmark for sustainable building practices, demonstrating the benefits of strategic design and efficient systems in achieving superior energy performance and operational excellence.

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