iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** V **Month of publication:** May 2024

DOI: https://doi.org/10.22214/ijraset.2024.62247

Building Energy Optimization using BIM: A Study on Institutional Building

M. S. Yuvaraj[1], Shaik Nurulla[2], D. V. Purushotham[3], A. Yaswanth Krishna[4], V. Krishna Sai[5], B. Lokesh Babu[6], P. Azaruddin[7]

[1, 2, 3]*Dept. of Civil Engineering, School of Engineering, Mohan Babu University, Tirupati*

[4, 5, 6, 7]*Dept. of Civil Engineering, Sree Vidyanikethan Engineering College, Tirupati*

Abstract: In many facets of the construction industry, including energy management to encourage the development of green buildings, Building Information Modelling (BIM) is one of the contemporary data information platforms and management technologies that is widely employed. The goal of this study was to optimize an institutional building's energy consumption by analyzing and evaluating its energy performance using BIM-provided capabilities. The Civil Engineering block of Sree Vidyanikethan Engineering College in Tirupati, was taken into consideration for the investigation. The 2D blueprint was obtained from the engineering department and BIM technologies were used to create the necessary building model. The Green Building Studio (GBS) tool and Autodesk Insight 360 were utilized to conduct an energy analysis and derive the energy usage figures. The structural elements that are contributing to the high energy demand, such as the area between windows and walls, the width of the chajja relative to the height of the window, etc., were identified, and the BIM model underwent the required alterations to optimize the energy consumption. Comparing the data obtained in the two aspects, it was found that there was a 30% reduction in energy costs and a roughly 29.76% drop in energy use.

Keywords: Building information modelling (BIM), energy, green buildings, optimization

I. INTRODUCTION

Reducing the amount of energy that buildings use is crucial to curb climate change and improving energy efficiency. In just eight years, there has been a 33% increase in the use of air conditioning and a 7% increase in the energy consumption in buildings [1]. Building energy consumption is caused by a variety of appliances and systems, such as lighting, geysers, air conditioning, ventilation, and electronic devices [2]. The impact of building energy usage on greenhouse gas emissions is just one of the many issues with it. One of the main global sources of carbon emissions is the burning of fossil fuels to power and heat buildings. Buildings are estimated to be responsible for 28% of global carbon emissions by the International Energy Agency [1]. Moreover, excessive energy use can lead to increased energy costs for building owners and tenants, which might put some people in a difficult financial situation.

A sustainable building design solution heavily relies on the use of affordable building envelope components [3]. The solar heat gain and, more frequently, regional characteristics, such as social lifestyle, are the main determinants of energy savings [4]. There are several strategies for reducing the amount of energy used in buildings. Increasing a building's insulation and airtightness is the first strategy. By reducing heat gain in the summer and loss in the winter, a structure with proper insulation and sealing can save a significant amount of energy. Using energy-efficient appliances and lighting is another way to reduce the amount of energy used in buildings. In a similar vein, using high-efficiency heating and cooling technology, such as heat pumps, can reduce energy use and save money. Putting up building automation systems is another way to reduce the amount of energy that a building uses. These systems are able to optimize energy use based on occupancy and other factors. Furthermore, the amount of energy utilized in buildings can be significantly reduced by utilizing renewable energy technology. Solar and geothermal energy systems can be built in order to generate energy locally and reduce dependency on fossil fuels. Sometimes buildings can even produce more energy than they consume, a situation known as net-zero energy.

II. BUILDING INFORMATION MODELING

Building Information Modeling, or BIM for short, is a digital modeling method that generates a virtual three-dimensional model of a building, infrastructure component, or facility for performance analysis in the design stage [5]. It is one of the contemporary technologies that is frequently used in many facets of building projects [6]. The model contains details on the structure's operation, design, and functional aspects in addition to its physical elements.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue V May 2024- Available at www.ijraset.com

It is a cutting-edge platform for managing data that facilitates the growth of green buildings [7]. The ability to superimpose multidisciplinary data within a single model provided by BIM makes it possible to conduct performance studies and sustainability measurements at every stage of the design process [8].

Energy performance efficiency can be greatly increased by using BIM technology in a variety of ways [9]. Better communication between architects, engineers, and construction professionals is made possible by BIM during the project's design, construction, and operating stages. The model can be used to identify incompatibilities between different systems and components. It can also be used to see the structure in three dimensions and predict how it will react to specific circumstances.

A. Energy Analysis with BIM

Generating a comprehensive and precise model of the structure is one of the primary advantages of using BIM for energy analysis and energy optimization. A building's geometry, materials, systems, and occupancy are just a few examples of the types of data that BIM may collect and assess. By simulating the building's energy performance and consumption under multiple design scenarios, BIM may be utilized to conduct an energy analysis on the structure [10].

Designers and engineers can assess how different design choices affect the structure's energy performance by adjusting elements like the building's orientation, insulation, heating and cooling systems, and lighting. By identifying locations where energy use may be decreased and energy efficiency may be increased, BIM can be utilized for energy optimization. BIM may offer a more thorough picture of the energy usage and performance of the structure, which could aid engineers and designers in determining how to lower the building's carbon footprint and increase its overall sustainability.

B. Objectives

The objectives of this study are:

1) To examine the factors affecting the energy usage in buildings.
2) To identify the building components resulting in more energy consumption and study for the alternatives.
3) To optimize the energy consumption of the building.

III. BUILDING MODELING AND ENERGY ANALYSIS

A. Site Selection

The building chosen for this study is the Sree Vidyanikethan Engineering College's institutional building, which is situated in Tirupati, Andhra Pradesh. The campus is an ideal location for optimising building energy consumption due to the large range of buildings with different energy needs.

Fig. 1 Building under consideration

B. Data Collection

The plan, elevation, dimensions and sectional properties of the building were obtained from the Executive Engineer of the Sree Vidyanikethan Educational Trust. The creation of the BIM models for each building was based on the 2D AutoCAD plans of the structures. The project team went over the plans to make sure all the necessary details were included.

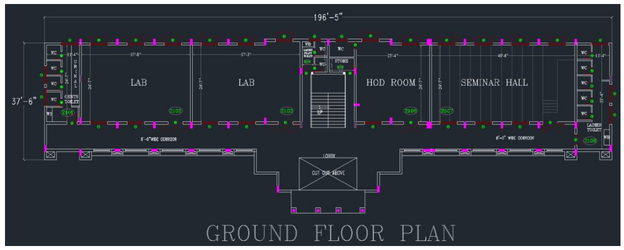


Fig. 2 Ground floor plan of building

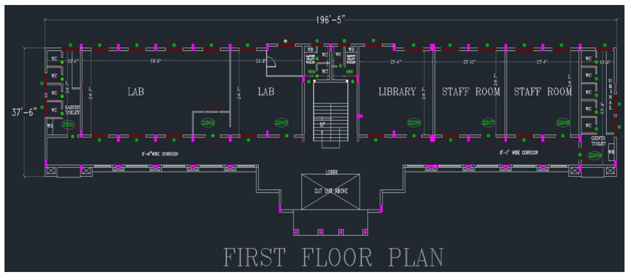


Fig. 3 First floor plan of building

C. Site Visits

Site visits were conducted to get additional building-specific data and to verify the accuracy of the information acquired. During the site inspections, the buildings were inspected to ascertain the instruments, procedures, and materials that were used in their construction. The existing patterns of energy consumption in the buildings were also noted during the site visits.

D. Data Analysis

The floor plans, elevations, sections, and other information gathered from the building are arranged and formatted so that they may be easily entered into the BIM programme.

Fig. 4 3D model of the building

E. Energy Analysis

The energy analysis was done using Autodesk Insight 360, and the energy model of the building was created for detailed information on the building's energy consumption and to visualize the energy use in the building.

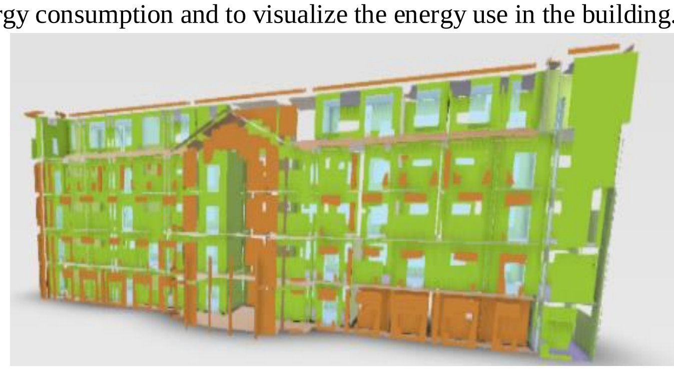


Fig. 5 Energy model of the building

F. Energy Analysis Results

After analysing the energy consumption by the building per year in kWh/m^2/year was obtained and the cost incurred on energy usage was calculated in USD/m^2/year.

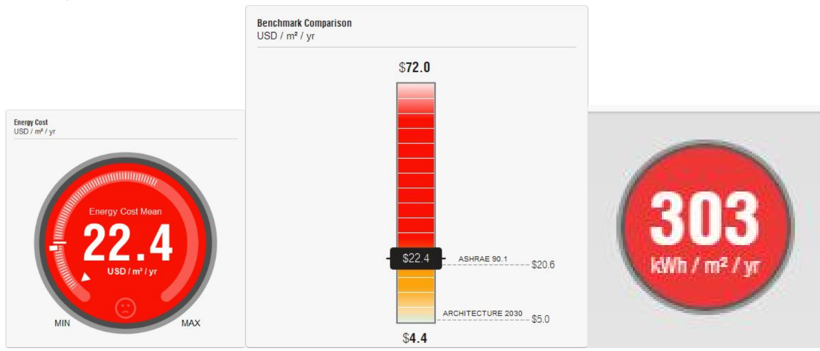


Fig. 6 Energy cost and consumption of the building

IV. ENERGY OPTIMIZATION

A building's energy consumption is mostly determined by the materials used in its construction, its orientation, and the terrain of the area around it. The building components and their role in total energy usage were the primary focus of this investigation. The main energy-consuming components were found, and a number of alternatives were investigated to maximise energy use. Among the many parameters, window glazing, window to wall ratios, window shade to window height ratios, and building orientation are important factors that affect energy usage (Kim et al., 2016). The current building's specifications were changed to reflect more energy-efficient methods, and a BIM model was used to assess the energy usage of the model.

To lessen the amount of radiation that enters the building, double-pane windows are installed in place of the current single-pane windows.

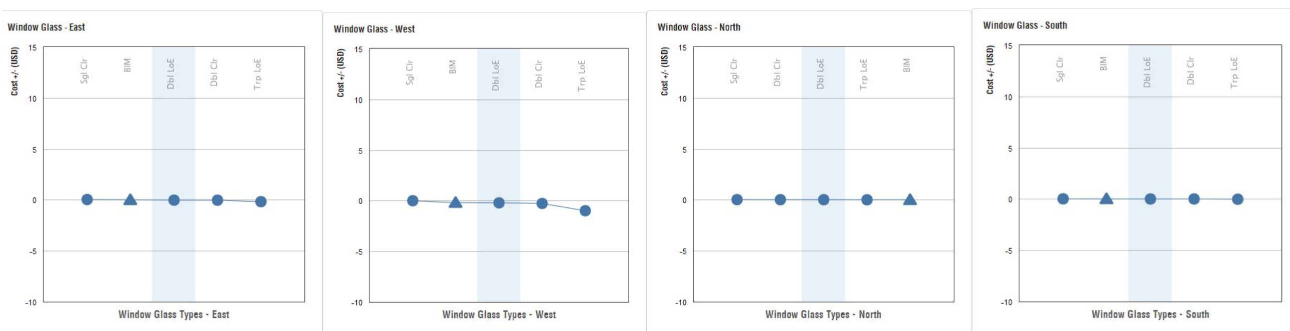


Fig. 7 Window glass type

Since the current WWR is the lowest in terms of energy usage, it is left intact in order to maximise energy efficiency in the building under evaluation.

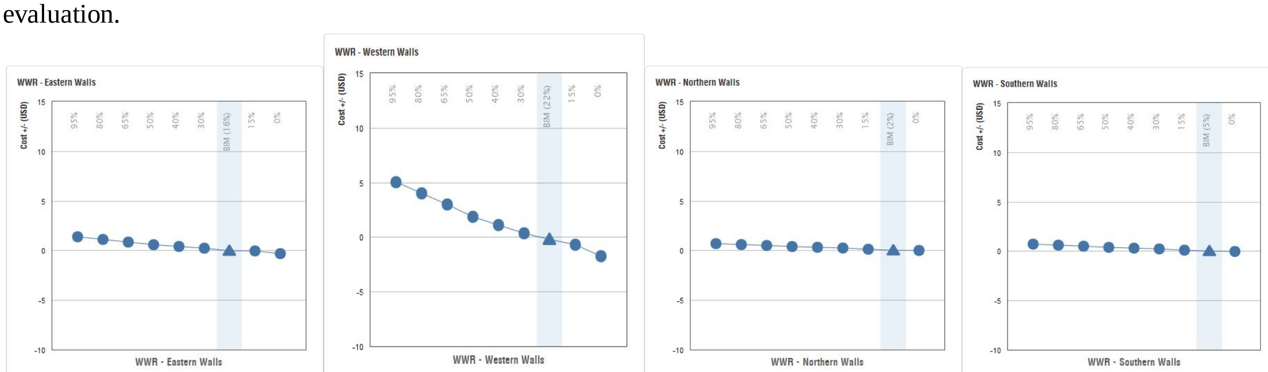


Fig. 8 Window to wall ratio (WWR)

The ASHRAE Package System is used to optimize energy costs with minimal investment on HVAC type.

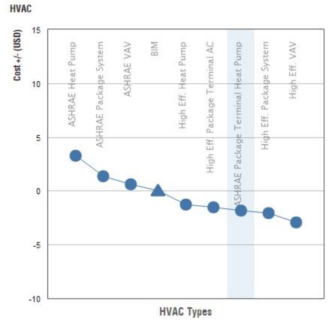


Fig. 9 HVAC type ASHRAE package

In order to harvest the solar radiation, the Photovoltaic (PV) panels were installed on roof top of the building. The panel efficiency, pay back limit and surface coverage of PV panels were considered for study.

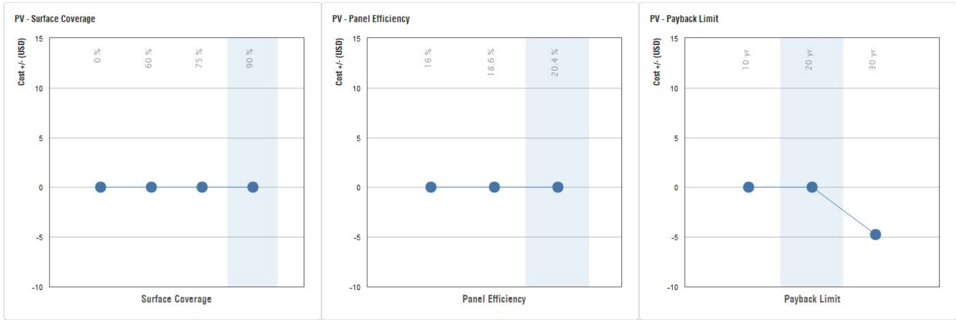


Fig. 10 PV settings

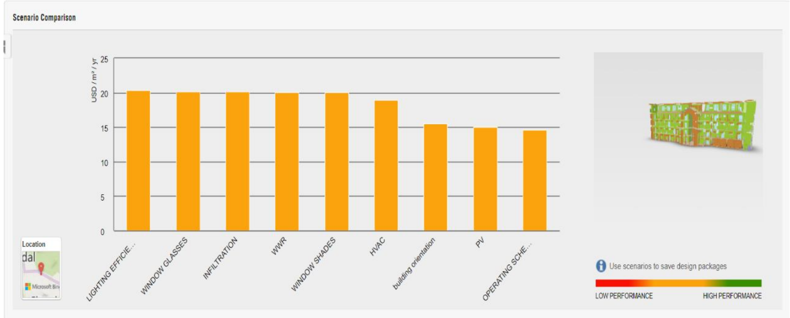


Fig. 11 Reduced energy cost of different factors

Table 1: Comparative study of existing and optimized parameters

Factors	Existing Parameters	Optimized Parameters
HVAC	No existing HVAC	4Pipe-single line
WWR: (EW:WW:NW:SW)	(16%:22%:2%:5%)	(16%:22%:2%:5%)
Window Shades: (E:W:N:S)	1/8 Win height	1/3 Win height
Energy consumption	303 kWh/m^2/yr	213 kWh/m^2/yr
Energy cost	22.45 USD/m^2/yr	15.5 USD/m^2/yr
% saving of annual energy consumption	29.76%	
% saving of annual Energy cost	30.8%	

V. CONCLUSIONS

The following were the conclusions drawn from the above study.

1) Among different parameters HVAC, Window glass, Window shape and PV panel have highest contribution on the energy optimization. Whereas, Orientation, Wall, Roof and Floor have the lowest contribution.
2) Nearly 29.76% and 30.8%, of energy consumption and energy cost respectively are saved by changing the window glass panels, WWR, HVAC PV Panels installation.
3) The study becomes clear that optimising energy use and achieving building sustainability and environmental goals are possible by integration of BIM throughout the design stage.

VI. ACKNOWLEDGEMENT

We would like to acknowledge the Engineering department of Mohan Babu University (erstwhile Sree Vidyanikethan Engineering College) for their support in providing the necessary building plans and inputs required for the study. Further, we would like to acknowledge the Head of Civil Engineering Department for the support in providing required software to carry out the study.

REFERENCES

[1] Alothman, A., Ashour, S., & Krishnaraj, L. (2021). Energy performance analysis of building for sustainable design using BIM: A case study on institute building. Int. J. Renew. Energy Res, 11, 556-565.

[2] Nurulla, S., Purushotham, D. V., Yuvaraj, M. S., & Sai, S. K. (2023, December). Energy Efficient Design for a Conventional Building using BIM Tools. In IOP Conference Series: Earth and Environmental Science (Vol. 1280, No. 1, p. 012030). IOP Publishing.

[3] Pucko, Z., Mau?ec, D., & Šuman, N. (2020). Energy and cost analysis of building envelope components using BIM: A systematic approach. Energies, 13(10), 2643.

[4] Yarramsetty, S., Rohullah, M. S., Sivakumar, M. V. N., & P, A. R. (2020). An investigation on energy consumption in residential building with different orientation: A BIM approach. Asian Journal of Civil Engineering, 21, 253-266.

[5] Shoubi, M. V., Shoubi, M. V., Bagchi, A., & Barough, A. S. (2015). Reducing the operational energy demand in buildings using building information modeling tools and sustainability approaches. Ain Shams Engineering Journal, 6(1), 41-55.

[6] Kareem, F. M., Abd, A. M., & Zahawi, R. N. (2021, September). Building Energy Management in Airport Construction Projects Utilizing BIM Technique. In IOP Conference Series: Earth and Environmental Science (Vol. 856, No. 1, p. 012044). IOP Publishing.

[7] Maglad, A. M., Houda, M., Alrowais, R., Khan, A. M., Jameel, M., Rehman, S. K. U., ... & Rehman, M. F. (2023). Bim-based energy analysis and optimization using insight 360 (case study). Case Studies in Construction Materials, 18, e01755.

[8] Azhar, S., Brown, J. W., & Sattineni, A. (2014). A case study of building performance analyses using building information modelling, 27th International Symposium on Automation and Robotics in Construction (ISARC 2010), pp. 213-222.

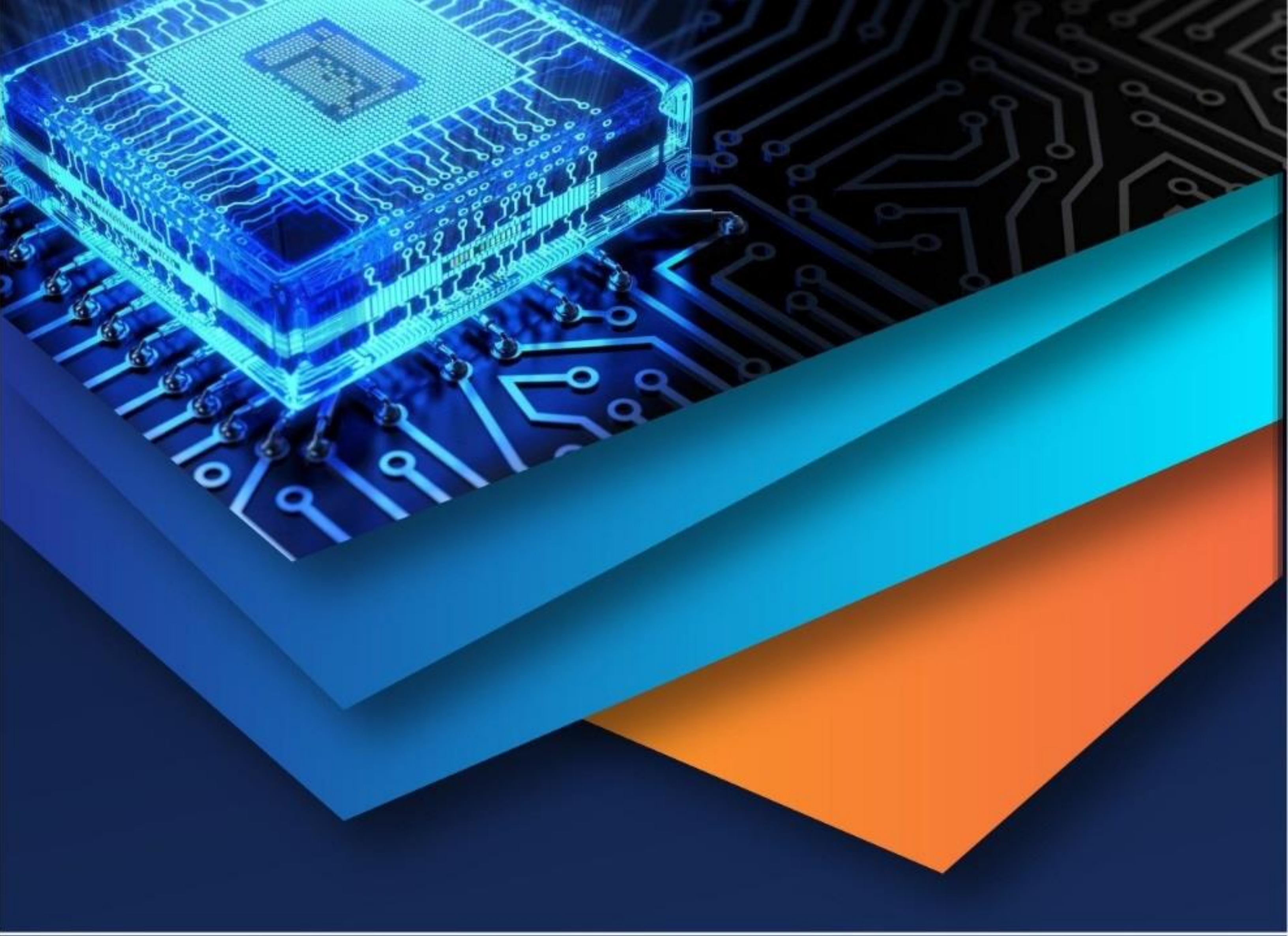
[9] Taha, F. F., Hatem, W. A., & Jasim, N. A. (2020). Effectivity of BIM technology in using green energy strategies for construction projects. Asian Journal of Civil Engineering, 21, 995-1003.

[10] Reeves, T., Olbina, S., & Issa, R. R. (2015). Guidelines for using building information modeling for energy analysis of buildings. Buildings, 5(4), 1361-1388.

[11] Treeck, C. V., Wimmer, R., & Maile, T. (2018). BIM for energy analysis. Building information modeling: Technology foundations and industry practice, 337-347.

[12] Kuo, H. J., Hsieh, S. H., Guo, R. C., & Chan, C. C. (2016). A verification study for energy analysis of BIPV buildings with BIM. Energy and buildings, 130, 676-691.

[13] Kim, S., Zadeh, P. A., Staub-French, S., Froese, T., & Cavka, B. T. (2016). Assessment of the impact of window size, position and orientation on building energy load using BIM. Procedia Engineering, 145, 1424-1431.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY