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Proposing a Green Model of a Conventional Building by Evaluating Energy-Efficient Design Alternatives using Autodesk Insight

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Abstract: ***This paper is based on contemporary green infrastructure construction technology, which has a substantial influence on the conservation and appropriate usage of resources such as land, energy, water, air, and material, consequently decreasing the total cost of construction as well as the negative effects of climate change by renovating a conventional building into a green building that uses natural resources to the greatest extent possible during construction and operation. The primary focus of the study is to advance knowledge on the implementation of green concepts in the design of buildings. Green building technology is an umbrella word for any innovation that incorporates natural resources and facilitates economic and social growth. These technologies seek to provide a sustainable product while substantially reducing environmental and ecological concerns. This study will focus on the implementation of new and improved concepts in the design and construction of Conventional buildings in India.***

Keywords: Green Buildings, Environment-friendly materials, Sustainable, Saving Energy, Energy-Efficient

I. INTRODUCTION

The principle of **sustainability** attempts to raise living standards and provide a healthy environment without endangering the possibilities of the next generation [1]. Sustainable or green buildings also referred to as environmentally friendly buildings, are considered to achieve a number of objectives, including the health of their occupants. improved use of water, energy, and other resources. Reduce your overall environmental impact. an opportunity to develop healthier buildings that enhance human health, provide a better environment, and cut costs while making optimal use of resources. All development initiatives result in an overuse of natural resources. During all phases of a building's existence, including planning, design, construction, operation, maintenance, renovation, and demolition, the phrase "green building" refers to both the physical structure and the application of resource and environmentally-conscious practices. [2]. Generally speaking, green buildings are regarded as environmental elements. For the purpose of creating a green building, there are various requirements that must be followed, including a Sustainable site, Resources for water, energy, and the environment Resources, materials, and indoor environmental quality [2]. A virtual depiction of a structure's design, construction, and use is known as building information modeling (BIM). BIM is a technology used to mimic the planning, design, execution, and operation of a specific construction project [1]. It creates a 3d visualization of a structure using 3D modeling software that includes all significant information, including architectural plans, structural engineering calculations, and details of building systems and materials. By offering a complete, data-driven approach to building design and construction, BIM aids in the creation of green structures. By providing a more data-driven, collaborative, and sustainable approach to building design and construction, BIM overall offers a potent tool for producing green structures. It is a powerful software program that concentrates on the layout and description of the input data. The features and tools produced by Autodesk add to Building information modeling (BIM) processes and are supported by Revit Architecture, which was created primarily for architects and other building industry professionals [1]. Green BIM refers to the use of Building Information Modeling (BIM) in the design of long-lasting, energy-efficient, and ecologically responsible structures. Utilizing digital technologies and techniques to improve a building's design, construction, and operation in order to reduce its environmental impact, green BIM integrates principles of sustainability into the BIM process. Retrofitting is the process of enhancing an existing structure's usability, performance, or efficiency. This could involve improving the building's insulation, heating and cooling systems, windows, elevators, and other features to improve safety, comfort, and longevity. Retrofitting is done to increase a building's efficiency, minimize its environmental effect, and increase its lifecycle. In general, converting a conventional structure into a green structure is crucial for lowering environmental impact, enhancing health and comfort indoors, and raising property value.

II. METHODOLOGY

Autodesk Revit is a software application that is primarily used for building information modeling (BIM). In order to produce construction documentation, schedules, and other products, it enables architects, engineers, and construction experts to develop 3D models of buildings and structures.

Autodesk Insight is a tool that works in tandem with Revit and other Autodesk software. It gives architects, engineers, and designers a way to conduct energy and environmental analyses on their building concepts. Insight assists architects and designers in optimizing the energy efficiency and sustainability of their building designs by simulating variables like energy usage, daylighting, and thermal performance.

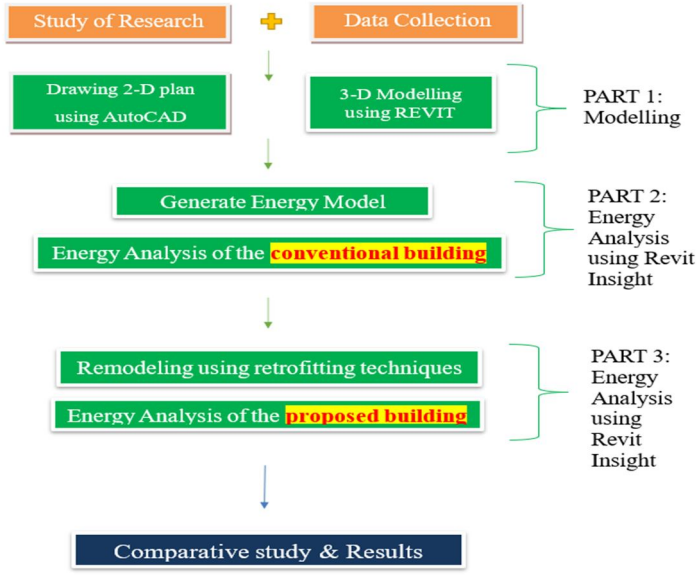

Fig 1: Flowchart of the Methodology

III. BUILDING MODELLING AND ENERGY ANALYSIS

A. Project Details

Building type: Commercial Government Building
Built-up area: 1782+1782 sq. ft.
No of Floors: G+1
Project Location: Kashmere Gate, Delhi, India
Orientation of the building: South-west facing

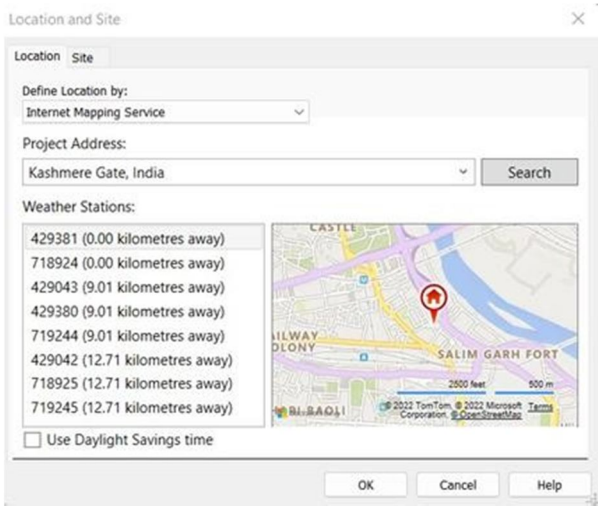

Fig 2: Location settings in Revit

B. Software used

1) *AutoCAD:* AutoCAD is an Autodesk computer-aided design (CAD) software application. Drawings and models in 2D and 3D are the main uses of it. Using a variety of tools and features like lines, shapes, text, dimensions, and layers, AutoCAD enables users to produce accurate and detailed drawings and models. The 2D plan of the conventional building at Kashmere Gate in Delhi was created using AutoCAD.
2) *Autodesk Revit Architecture-2022:* Using Autodesk Revit, a potent building information modeling (BIM) software program, a 3D model of the conventional building was created.
3) *Autodesk Insight Plugin:* Users can run an energy analysis on their Revit models by installing the Autodesk Insight plugin within Revit. Users of Insight can assess the energy efficiency of their building designs and optimize them for it. Autodesk insight was used to conduct a building energy analysis of both the conventional building and the proposed building.

Fig 3: Interface of Autodesk Revit Insight Plugin

C. 2D Plan in AutoCAD and 3D Modelling Using Autodesk Revit

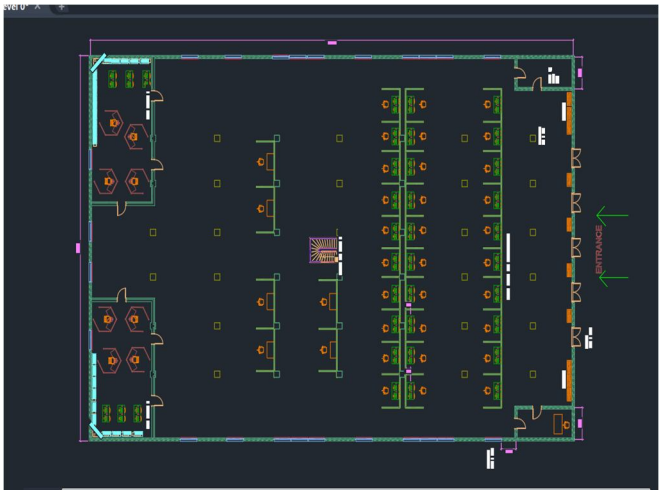

Fig 4: 2D Plan of the conventional building in AutoCAD

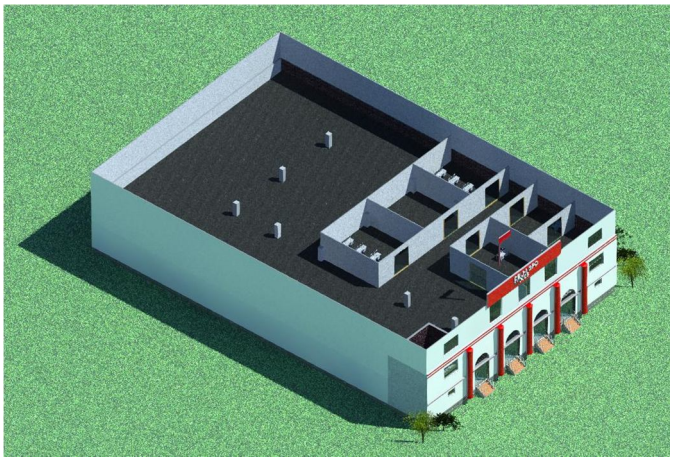

Fig 5: 3D model created in Autodesk Revit Software

D. Energy Analysis by Generating Energy Model in Revit

Autodesk Revit is used to do an energy analysis on the conventional building model. There are mentions of the building's construction materials and project specifics. Prior to starting the energy analysis, the energy settings are configured. The energy analysis is carried out after creating an energy analytical model to run it. In order to transform the conventional building model into a green building, energy-saving elements are included taking the findings of the energy analysis into account.

E. Energy Consumption of the Conventional Building and the Proposed Building

Fig 6: Energy consumption of the baseline model and the proposed model respectively.

Prior to determining the baseline model's energy consumption, an energy model for the baseline model has to be built. The Insight plugin for Revit is used to calculate energy consumption. The baseline model is found to have an annual energy consumption of 372 kWh/m^2/year. The benchmark comparison shows that the baseline model has a somewhat high energy usage. Energy Usage Intensity (EUI), which is measured in kWh/m^2 annually, is used to express energy use. A building's energy use intensity is determined by dividing its entire built-up floor area by the total energy it uses in a given year [1]. A suggested model is created once the baseline model's design parameters have been modified, and the energy of the proposed model is then determined using the Autodesk Revit Insight Plugin. Energy use for the proposed models is 132 kWh/m^2/year. The benchmark comparison shows that the suggested model has a medium level of energy usage.

F. Design Parameters

1) Window Wall Ratio – Western Walls:

The interplay between the window characteristics that affect the building's day illumination, heating, and cooling is represented by the window wall ratio [1]. The window-to-wall ratio (WWR) measures how much of the outside wall surface area is glazed (made up of windows) and has an impact on a number of architectural characteristics, including the size of the window defines the physical and visual link to the outside and establishes the environmental effects of the usage of the materials [3]. The bedroom's increased window-to-wall ratio causes more heat to be gained from solar radiation than it is lost via the windows. But, if the window-wall ratio rises over a certain point, the heat loss via the window would exceed the heat gain from solar radiation [4].

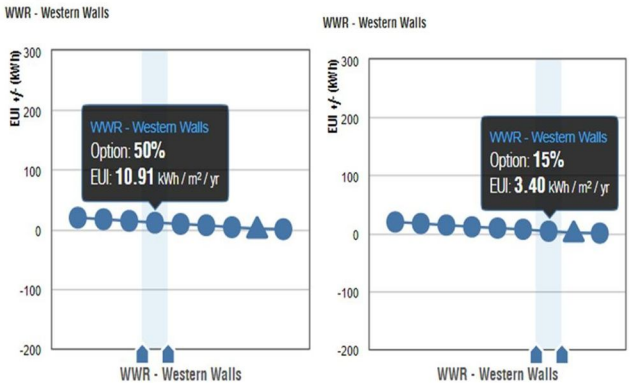

Fig 7: Results are compared of EUI before and after Western Walls WWR alterations

2) Window Glass – West

The following terminology needs to be known to examine and assess window glazing thermal behavior: 1) Solar Heat Gain Coefficient (SHGC): SHGC is a figure between 0 and 1 that represents the percentage of solar radiation that enters a space through the fenestration and is then released as heat into space. Lower SHGC is preferable. 2) U-Value/ Thermal Transmittance: This is a measure of how well heat is transmitted through the fenestration; the lower the U-value, the better. R-value, or a material's capacity to resist heat flow, is the opposite of thermal transmittance. 4) Visible Light Transmission: The proportion of visible light that passes through the glass. There is more daylight the greater the VLT % [5]. As the number of layers of pane glazing increases, the heat gain in structures decreases [6].

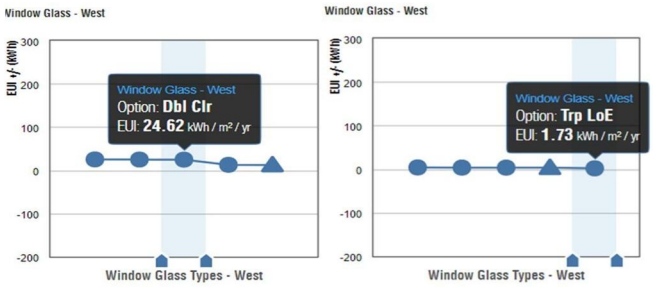

Fig 8: Results are compared of EUI before and after window glazing material alterations

3) Roof Construction

This reflects the roof's total capacity to fend off heat intake and loss [1]. The building envelope has a big impact on the amount of energy that a building uses, which divides the internal and outside environments. There are many different roofing system options accessible when it comes to re-roofing the commercial building. PVC roofing is one choice that offers rooftops the greatest protection while having the least negative environmental effects. [7]. Because PVC systems are constructed of plastic and can experience thermal contraction and expansion depending on the weather, they can operate without maintenance for more than 25 years [7].

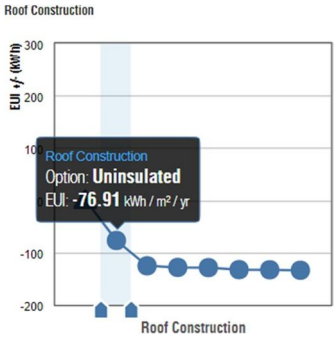

Fig 9: Decreased EUI with insulated roof material is used.

4) Lighting Efficiency

The average internal heat gain and electricity used for electric lighting per square foot are known as lighting efficiency [1].

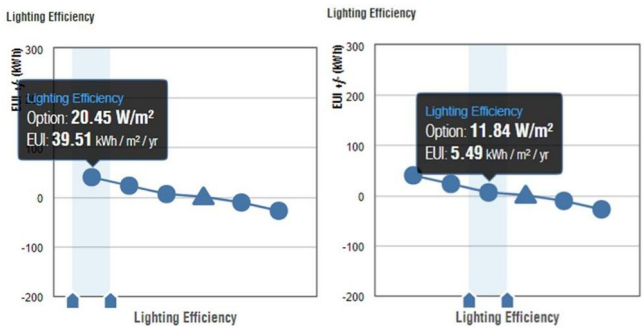

Fig 10: Results are compared of EUI before and after lighting efficiency alterations

5) Plug Load Efficiency

Lighting, heating, and cooling devices are not included in the electricity consumed by equipment like computers and small appliances [1]. Because plug loads are frequently modest, diversified, and dispersed across a facility, they can be challenging to control [8]. Techniques to Use to Reduce Plug Load Efficiency: 1) Employ master-controlled power strips, 2) Program outlets for operating hours using a timer, 3) Invest in automatic-off items, 4) Make use of power strips with remote switches [8].

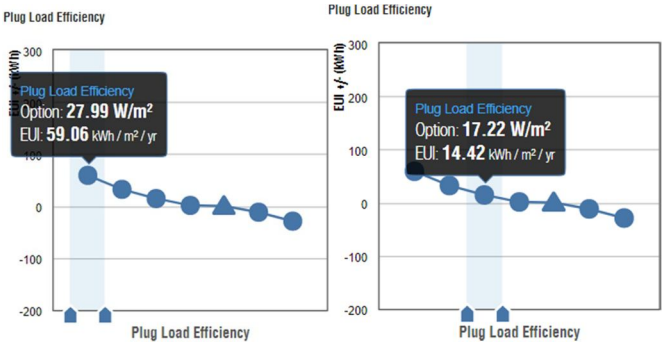

Fig 11: Results are compared of EUI before and after plug load efficiency alterations

6) HVAC

A building is considered "green" if it can save running costs, boost occupant productivity, lower health concerns, and yet be ecologically responsible. As the operation of the HVAC systems has an impact on many aspects of green building, either directly or indirectly, they have a significant role to play in ensuring this. The design and operation of the HVAC system in green buildings must be optimized through an integrated and comprehensive design process that begins at the project's inception [9].

For all climates, heat pumps provide an effective replacement for furnaces and air conditioners. Traditional air conditioners have a cheaper initial cost, which is their major advantage. However, there are several significant disadvantages to this reduced initial cost. Heat pumps are superior in practically every manner, except for their greater initial cost. Usually, they can swap out both an air conditioner and a furnace, saving you the cost of two large pieces of equipment. Furthermore, compared to standard air conditioners and furnaces, heat pumps offer more pleasant heating and cooling.

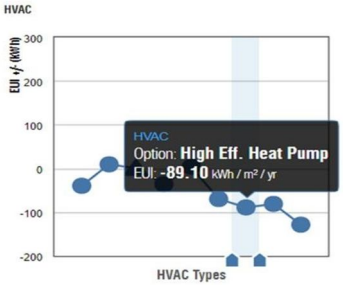

Fig 12: Decreased EUI with Highly efficient heat pump.

IV. RESULTS AND ANALYSIS

Model	Energy Consumption
Baseline	372 kWh/M^2/Year
Proposed	132 kWh/M^2/Year

Fig 13: Energy consumption of the baseline and proposed model

1) Greater solar radiation heat gain through external windows than heat loss through windows is caused by an increase in window-to-wall ratio. However, when the window-wall ratio surpasses a certain value, the heat loss via the window would be more than the heat gain from solar radiation. Hence it was important to decrease the window wall ratio of the western wall.

2) To alleviate the amount of infrared and ultraviolet light that passes through glass without reducing the amount of light that enters the building, low-E, or low-emissivity, glass is recommended.

3) Because PVC systems are made of plastic and can experience thermal contraction and expansion depending on the weather, they can operate without maintenance for more than 25 years. Although insulated roofs would save more energy, they were not appropriate given the climate.

4) The most energy-efficient type of lighting for buildings is DC lighting. A DC lighting system can be powered by a small solar panel, a wind turbine, or any other resource.

5) To decrease the plug load efficiency, it is advised to use master-controlled power strips, Purchase products with auto-off, and use remote switch power strips.

6) Given that they are highly efficient once installed and can generate three to four times as much heat per kWh of electricity used, heat pumps are unquestionably worth the significant investment.

Parameter	Baseline Model	Proposed Model
Window Wall Ratio (Western wall)	50% (10.91 kWh/m²/year)	15% (3.40 kWh/m²/year)
Window Glass	Double Clear (24.62 kWh/m²/year)	Triple Low-E (1.73 kWh/m²/year)
Roof construction	Cement Concrete (0.00 kWh/m²/year)	Uninsulated PVC roofing (-76.91 kWh/m²/year)
Light Efficiency	20.45 W/m² (39/51 kWh/m²/year)	11.84 W/m² (5.49 kWh/m²/year)
Plug Load Efficiency	27.99 W/m² (59.06 kWh/m²/year)	17.33 W/m² (14.42 kWh/m²/year)
HVAC	Air conditioner units (48.00 kWh/m²/year)	High-Efficiency heat pump (-89.10 kWh/m²/year)

Fig 14: Design parameters of baseline and proposed model with their energy consumption.

V. CONCLUSION

Using the Autodesk Revit Insight plugin, energy simulations are run on the model in order to convert the conventional building model into a green building model. The proposed model's design parameters were compared with those of the baseline model. Based on the findings, it is evident that the proposed green building model uses less energy than the baseline conventional building model. We would come to the conclusion that this approach to building energy analysis utilizing Autodesk Revit and Autodesk insight serves as the most effective and cutting-edge way for helping designers, architects, and engineers weigh various design possibilities at the conceptual stage of a structure.

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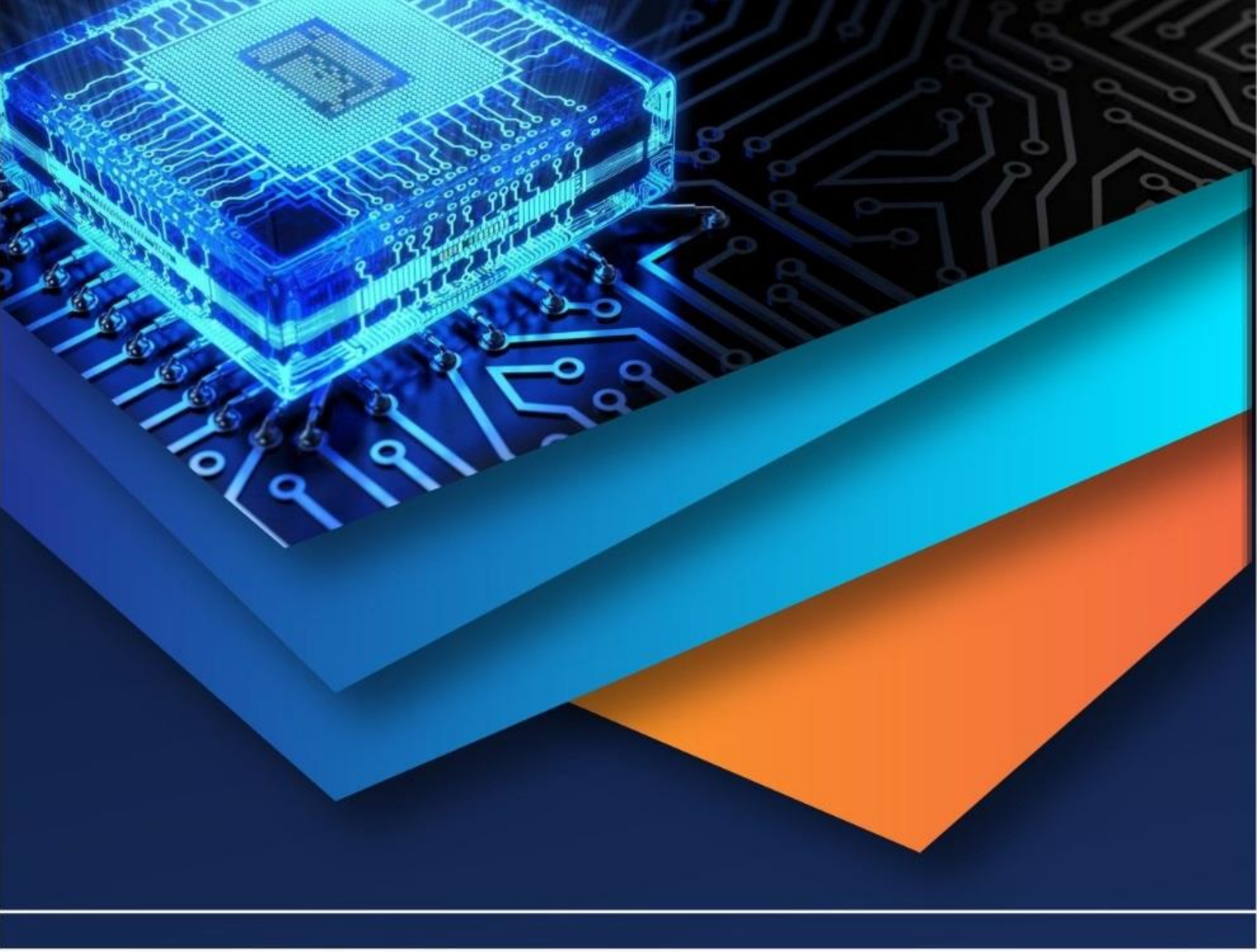

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