International Journal of Research Publication and Reviews, Vol 5, no 11, pp 2432-2439 November 2024

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Study on Influencing Parameters on Energy Performance and Integration of Augmented Reality to the G+1 Building Bim Model.

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ABSTRACT:

This study explores the integration of augmented reality (AR) and building information modelling (BIM) to enhance construction efficiency and decision-making. By overlaying digital data on the real world, AR aids spatial understanding and teamwork, reducing errors and improving project outcomes. The project focuses on a G+1 building, initially analysed using STAD PRO and later 3D-modeled in Autodesk Revit for both interior and exterior views, which are then linked to Augin software for on-site AR visualization. Additionally, incorporating Green Building Studio enables the assessment of energy performance, sustainability, and environmental impact, positioning the AR-BIM combination as a powerful tool for modern construction.

Keywords Revit, Staad Pro, Green building studio (GBS), AR, Augin

Introduction:

BIM-Building Information Modelling is a highly sophisticated and collaborative process that allows architects, designers, engineers, BIM modelers, contractors, building developers, and other stakeholders to have a single source of truth to rely on throughout the building life cycle. Efficient implementation of BIM in a construction project ensures a well-coordinated plan, design, and construction process. BIM revolves around the concept of centralized information management. Instead of scattered data and drawings, BIM integrates all relevant information about a building project into a single digital model. This model serves as a shared knowledge resource for all parties involved, ensuring that everyone is working with the most up-to-date information. One of the key aspects of BIM is its ability to create detailed 3D models of buildings and infrastructure. These models go beyond traditional 2D drawings, providing a more comprehensive and intuitive representation of the project. This 3D visualization helps stakeholders to better understand the design intent and identify potential conflicts or issues before construction begins. BIM software allows for parametric modelling, which means that elements within the model are defined by their parameters and relationships with other elements. This enables dynamic changes to the model that automatically update all related components, ensuring consistency and accuracy throughout the design process. BIM facilitates the integration of various types of data into the model, including architectural, structural, mechanical, electrical, and plumbing (MEP) information. This interdisciplinary approach enables better coordination and collaboration among different disciplines, reducing errors and conflicts. BIM is not just about design and construction; it also encompasses the entire lifecycle of a building, from initial concept to demolition. By incorporating data about maintenance, operations, and even sustainability factors into the model, BIM helps optimize the building's performance over time and supports informed decision-making at every stage. BIM fosters collaborative workflows among architects, engineers, contractors, and other stakeholders involved in the construction process. Through shared access to the BIM model, teams can communicate more effectively, coordinate tasks, and resolve issues in a timely manner, leading to smoother project delivery and reduced rework. Building information modeling (BIM) and Green Building Studio (GBS) software are used in energy analysis, which is a sophisticated technique to improve the sustainability and efficiency of building designs. Accurate energy models are basedon a thorough digital representation of the building provided by BIM, which includes the structure's geometry, materials, and spatial linkages. The cloud-based GBS tool from Autodesk does thorough whole-building energy evaluations and interfaces.

Methodology:

The project begins with the creation of a detailed 3D BIM model of a G+1 building, which is then imported into Green Building Studio for energy analysis. This crucial step allows the team to assess the building's energy performance, identify optimization opportunities, and generate comprehensive reports. Following the energy analysis, the optimized BIM model and its data are exported to Augin software, which generates a QR code linking to an augmented reality (AR) visualization of the building. On-site, stakeholders can scan the QR code to access the AR model, providing real-time insights into the design and energy performance. This integration of AR significantly enhances project management by improving communication and collaboration while also bolstering safety protocols through visualization of potential hazards. A feedback loop is established to gather stakeholder input, enabling continuous refinement of both the model and the construction process for better alignment with project goals.

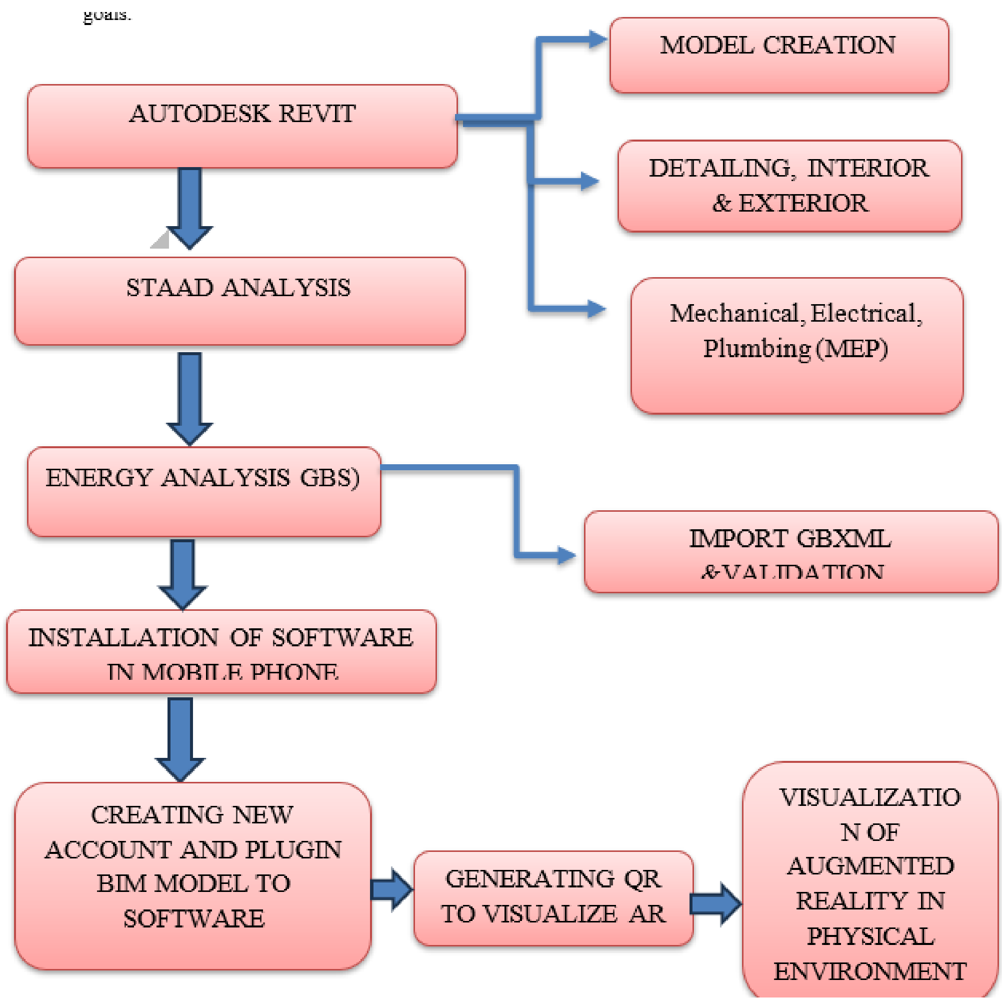

Fig 1: Proposed Methodology

Approach for Revit and GBS Energy Analysis

1.Model Export

To get the model ready for export, use Revit's "Energy Analysis" features. Verify that the energy parameters of the building are set appropriately. Get the building model in a format that is compatible with GBS. Usually, Revit's "Export to gbXML" feature is used for this.

2.Upload to GBS:

Enter the building orientation and WWR scenario's produced gbXML files into Autodesk Green Building Studio after logging in.

3. Setting Up Energy Analysis in GBS Project Setup:

For every model version (orientation and WWR), start a new project in GBS. Enter the relevant project information, such as the building type, location, and operating schedules. Simulation parameters: In GBS, specify the settings for the simulation. These include of occupancy schedules, lighting, HVAC systems, and other pertinent settings. To ensure reliable comparison analysis, make sure these parameters are the same for all models.

4.Executing Energy Simulations:

Carry out energy simulations for every model. Data processing and report generation on a range of energy performance parameters, such as carbon emissions, energy consumption, and cost projections, will be handled by GBS. Study parameters: Pay particular attention to how the building's orientation (15,90, 45, and 120 degrees) and window-wall ratios (differently glazed windows) affect its energy efficiency.

5.Results Analysis and Interpretation:

Analyze the simulation results for various orientations and WWRs using a comparative approach. Keep an eye out for patterns in building efficiency overall, heating and cooling loads, and energy usage. Data Visualization: Make graphs and charts that highlight performance disparities using GBS's visualization capabilities. This aids in determining the best window-to-wall ratio and orientation for energy efficiency.

6.Plugin to Augin:

The Augin app offers users a doorway to a world where the virtual and the real coexist together, marking a dynamic entry into the field of augmented reality. This creative software uses augmented reality (AR) to improve our everyday lives and creates new and interesting connections between the real and virtual worlds. Transforming education, or changing the way we navigate the world. The intriguing field of Augin application will be covered in this introduction, along with its features, importance, and the numerous ways it has the potential to transform how we interact with information and our environment. Install the Augin program on your phone and use the necessary login information to access it. Plugin the document to the software which generates a particular QR.

LITERATURE REVIEW

1.Pereira, V., Santos, J., Leite, F., & Escórcio, P. (2021). Using BIM to improve building energy efficiency–A scientometric and systematic review. *Energy and Buildings*, *250*, 111292.

The systematic literature review in this paper involved searching databases like ScienceDirect, Google Scholar, and specific civil engineering libraries using defined keywords related to BIM and building energy efficiency

- Four main databases were utilized: ScienceDirect, Google Scholar, the American Society of Civil Engineers Library, and the Institution of Civil Engineers Library.
- The review identified 14 main topics related to BIM technologies, their capabilities, compatibility, emergent technologies integration, and external data combination with BIM tools.
- The state of the art for each of the 14 main topics was established, highlighting research gaps, findings, conclusions, and current shortcomings in the field of BIM and building energy efficiency.
- Possible solutions to overcome the identified gaps and shortcomings were proposed based on the findings of the literature review.

2.Changsha, C., Abidi & Hunchuen, G. (2022). Optimising energy performance of an eco-home using building information modelling (BIM). Innovative Infrastructure Solutions, 7(2), 140.

Building Information Modelling (BIM) integration in energy performance analysis is crucial for optimizing building operations and sustainability.

- The study emphasizes the importance of understanding energy performances in buildings, exploring innovative ways to optimize energy consumption, and comparing BIM-based simulations with actual energy consumption data.
- Autodesk Green Building Studio (GBS) and Autodesk Revit were utilized for EP analysis and generating a 3D BIM model of the Eco-Home, showcasing the practical application of BIM in energy optimization.
- Recommendations for energy optimization include the use of occupancy sensors for lighting automation, greywater reclamation systems for water conservation, and photovoltaic panels for renewable energy generation, highlighting practical solutions for improving energy efficiency

3.Rodrigues, F., Isayeva, A., Rodrigues, H., & Pinto, A. (2020). Energy efficiency assessment of a public building resourcing a BIM model. Innovative Infrastructure Solutions, 5, 1-12.

- Building Information Modelling (BIM) is increasingly utilized in the Architecture, Engineering, Construction, and Operation (AECO) sector for energy simulation, aiding in achieving low carbon buildings.
- The study compared the energy consumption results of HVAC systems and lighting using different tools: ECO.AP, Energy Analysis for Autodesk Revit, and Energy Simulator.
- Limitations in HVAC system customization in Revit and the use of HVAC solutions based on data from the USA and Australia hinder accurate representation for Portuguese buildings, making tools like ECO.AP more suitable for detailed assessments.
- The research focused on a 1960 two-story service building in Lisbon, Portugal, with a total gross area of 2088.8 m^2, using Autodesk Revit for BIM modelling and energy analysis.

- The study highlighted the importance of accurate building information, such as architectural drawings, materials, and HVAC system properties, for precise energy efficiency assessments in public buildings.

4.Garbett, J. (2020). A multi-user collaborative BIM-AR system to support design and construction.

- The study aimed to develop a multi-user collaborative BIM-AR system to support remote collaboration and enhance efficiency in the construction industry.
- Designed as a user-friendly system, it facilitates real-time data sharing and collaboration among geographically dispersed teams.
- Marker-based AR technology was integrated to recognize image targets and display 3D models with minimal latency.
- The system was tested with a focus group session, using an interactive demonstration followed by a semi-structured open forum for feedback, providing qualitative insights on functionality and areas for improvement.
- The system was found to integrate effectively with a cloud-based database, enabling real-time collaboration, which was positively received by participants.

5. Amin, K. (2023). Key functions in BIM-based AR platforms.

- This study aims to address fragmentation in BIM-AR research by identifying essential functions of BIM-AR platforms, including positioning, interaction, visualization, collaboration, automation, and integration.
- It offers an evaluation framework to assist practitioners, developers, and researchers in assessing requirements for targeted application areas, emphasizing the need for industrial-academic collaboration in BIM-AR research.
- The authors employed a systematic approach, consisting of thematic analysis, result discussions, and conclusions, to categorize and demonstrate the application of key functions across lifecycle stages.
- Reporting involved structured presentations of results and detailed discussions, contributing to a well-rounded understanding of BIM-AR functionality.

RESULTS AND DISCUSSIONS

Analysing phase: From the phase of analysis the structure is resulted as safe. The required diagrams like displacement, deflection, reactions, shear force are mentioned below in Fig 16, Fig 17 & Fig 18.

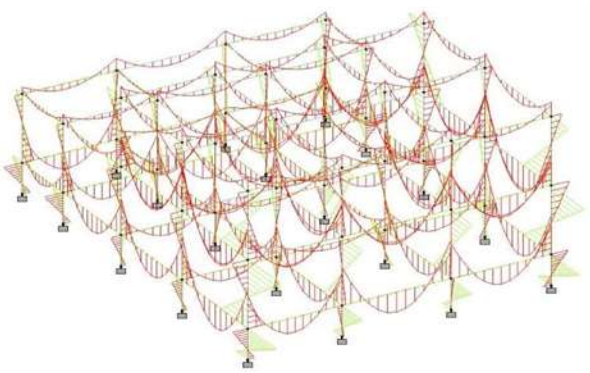

Fig 16: Bending Moment

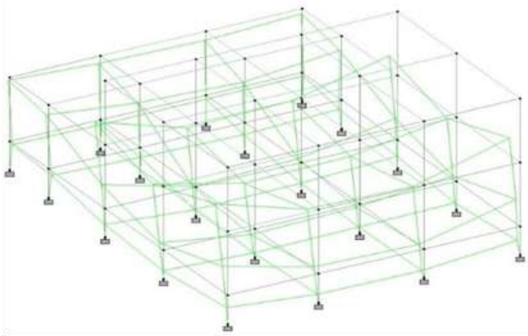

Fig 17: Deflection

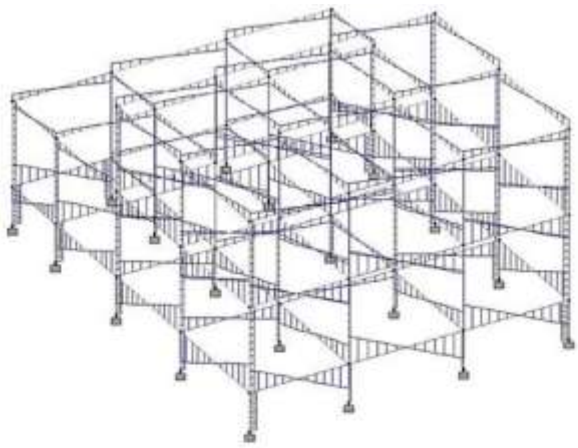

Fig 18: Shear Force

- Maximum bending moment of the structure is 34.216 kN-m which is hogging moment. The max bending moment at beam 55 is shown below.
- Maximum Shear force of the structure is 42.185 kN which is sagging moment. The max shear force at beam 58 is shown below.
- Maximum displacement of the structure is 2.207mm for beam 7.
- Maximum axial force of the structure is 518.76 kN for column 38.
- Maximum bending moment and max shear force diagrams for different beams are shown in Fig 19 and Fig 20

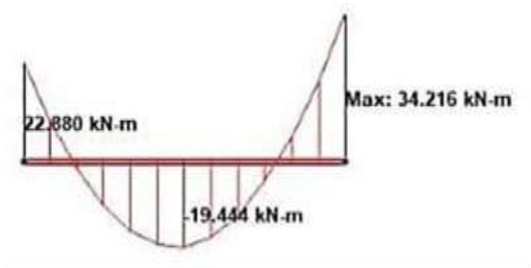

Fig 19: Maximum Bending moment

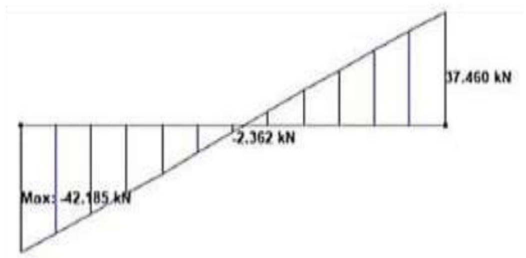

Fig 20: Maximum shear force

Detailing and Modelling:

Using Autodesk Revit, the structure subjected to detailing and modelling. Which includes Interior, Exterior and MEP. When it is plugin to Augin software the Augmented reality of structure is observed in pre-construction stage. The AR of Structure which is taken in physical environment by setting up grid is shown in below diagram.

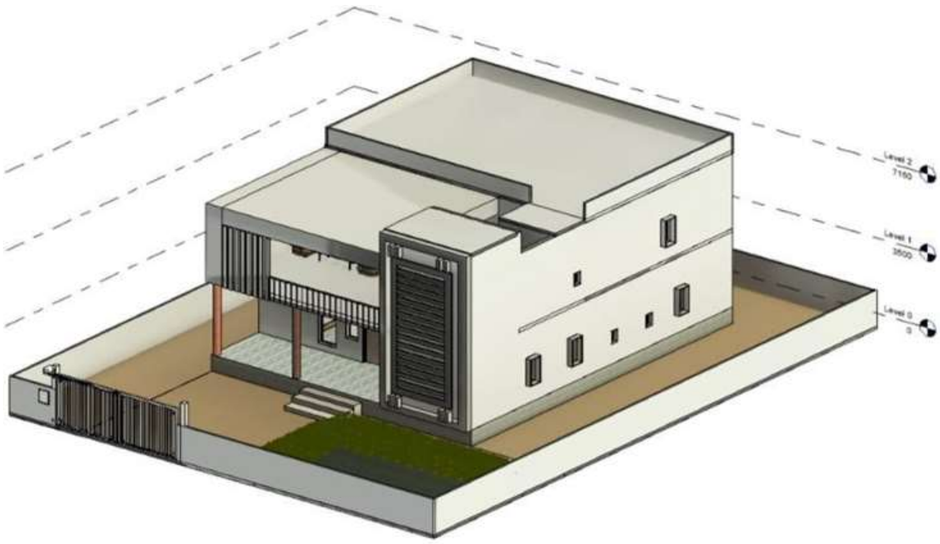

Fig 2: BIM model created using Revit

Plumbing work

building used in this study is shown in Fig 20 that represents the all types of water supply system for G+1 building As shown in the below diagram red color pipe used for hot water supply with diameter 18mm, blue color pipe for cool water supply with diameter 18mm and green colour pipe for drainage passage. The diameter of pipe is 42mm.systemfor G+1 building as shown in fig.

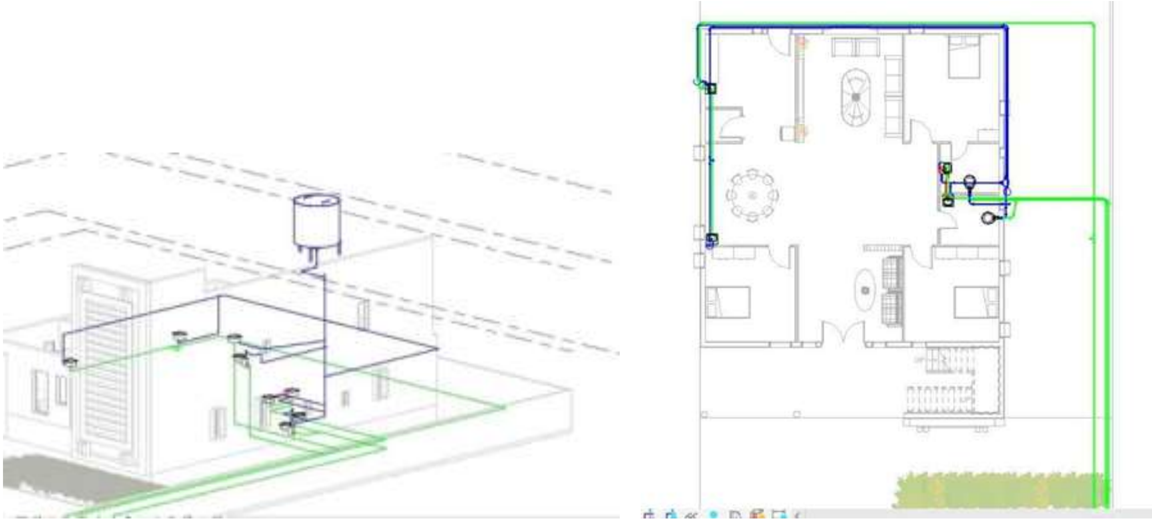

Fig 3: 3D View of building showing plumbing work

GREEN BUILDING STUDIO:

The information provides information on how different glazing types, orientations, and wall-to-window (w-w) ratios in building materials perform in terms of energy efficiency. By influencing how much heat or sunshine the structure absorbs, different angles—designated as "ore" and having values like 15, 90, 120, and 180 degrees—indicate different material orientations, which can have an impact on energy efficiency. There is a list of blue, grey, and reflecting insulated low-e (low emissivity) glazes that are intended to minimize heat transfer while permitting visible light to flow through. By reflecting UV and infrared light, these coatings improve a building's thermal performance and reduce energy loss. Included are the costs related to each material configuration, which may aid in determining each option's economic feasibility. By analyzing these results, one can determine the optimal combination of glazing type, orientation, and wall-window ratio to achieve energy-efficient and cost-effective building designs. Below shown in Fig 27 that represents the all-green building studio

Design alternatives with efficient results.

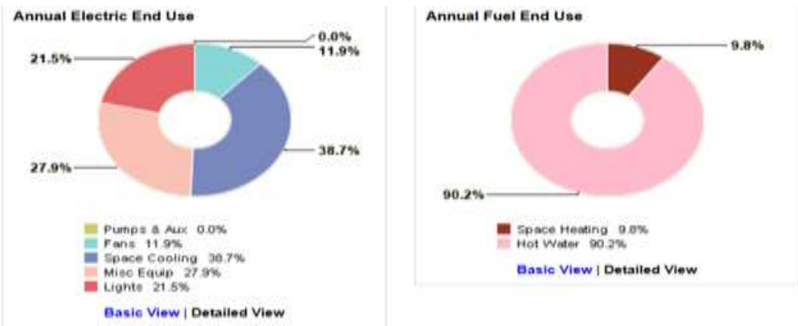

Fig 5: GBS-orientation (15 degree)

Above The charts illustrate the distribution of annual electric and fuel end-use in a building. The left chart shows that space cooling is the largest component of electric use at 38.7%, followed by miscellaneous equipment (27.9%), lighting (21.5%), and fans (11.9%), with pumps and auxiliary equipment using no electricity. The right chart indicates that for fuel consumption, hot water accounts for the majority at 90.2%, while space heating uses 9.8%. This breakdown helps identify key areas for potential energy savings, particularly in space cooling for electricity and hot water for fuel use.

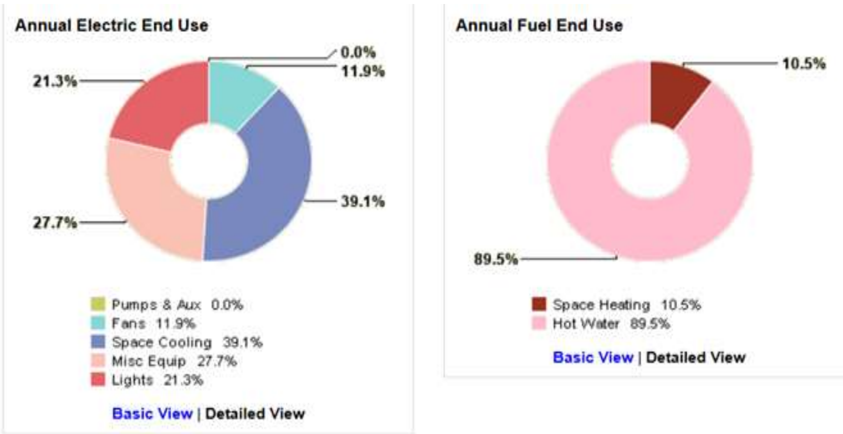

Fig 6: GBS-orientation 15 degree &15%w-w ratio

QR GENERATION

By providing quick access to comprehensive building information via QR codes, Revit's QR-rendering for 3D building models can improve visual comfort. When converted into 3D models, these QR codes offer a simplified method of fusing digital and real-world settings, giving users instant access to pertinent information like room dimensions, material characteristics, and lighting conditions. By assisting engineers and architects in visualizing and interacting with complicated data without overcrowding the model space, this technology promotes improved visual comfort. Stakeholders can quickly access particular data by scanning a QR code included in the model, enhancing accessibility and general design understanding in the Revit environment.

FIG 7: FRONT ELEVATION-QR

FIG 8: INTERIOR VIEW-QR

Conclusions:

- The integration of augmented reality (AR) into Building Information Modelling (BIM) represents a significant advancement in the architecture, engineering, and construction (AEC) field, offering numerous benefits across the entire project lifecycle, from design and construction to facility management.
- Embracing this technology enhances visualization and collaboration while improving decision-making, efficiency, and client satisfaction, ultimately driving innovation within the AEC industry. This project has illuminated the immense potential of AR technology in transforming how construction professionals interact with digital models on real-world sites.
- A key component of this integration is the energy analysis results generated using Green Building Studio, which consider various influencing parameters such as openings, glazings, and different building orientations.
- By assessing these factors, the project provides valuable insights into energy performance, enabling stakeholders to make informed decisions. As we continue exploring new possibilities and refining existing applications, fostering collaboration among stakeholders will be crucial.
- The future of AR in the construction industry holds even greater promise; with ongoing advancements in AR hardware and software, we can anticipate more immersive experiences and enhanced capabilities, further optimizing building design and performance
- The integration of augmented reality into BIM models offers numerous benefits across the entire project lifecycle, from design and construction to facility management.
- Embracing this technology not only enhances visualization and collaboration but also improves decision-making, efficiency, and client satisfaction, ultimately driving innovation and progress within the AEC industry.

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