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Design of Residential Building with BIM

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Abstract: *Design of Residential Building using BIM‖ focuses on using digital tools to improve design, coordination, and analysis. 2D floor plans from AutoCAD are converted into 3D architectural and MEP models in Revit, while structural components are detailed in Tekla Structures. All models are integrated in Navisworks for clash detection, ensuring a coordinated, clash-free design. This BIM-based approach enhances efficiency, reduces errors, and facilitates collaboration, producing accurate construction documentation and visualizations.*
Building Information Modeling (BIM) is an advanced digital technology used in the planning, design, construction, and management of buildings. The project "Design of Residential Building with BIM" focuses on creating an efficient and accurate residential building model using BIM software tools. The residential structure is designed considering architectural planning, structural analysis, material estimation, and project visualization in a single integrated platform. BIM improves coordination among various disciplines, reduces construction errors, minimizes project cost, and enhances productivity..

Keywords: *Building Information Modeling (BIM), Residential Building Design, 3D Modeling, Structural Analysis, Clash Detection, Quantity Estimation, Construction Planning, Autodesk Revit, Digital Construction, Sustainable Building Design*

I. INTRODUCTION

Building Information Modeling (BIM) is an advanced digital technology that has transformed the architecture, engineering, and construction (AEC) industry by integrating all building-related information into a single intelligent model. Unlike traditional 2D drafting methods, BIM enables the creation of a detailed three-dimensional representation of a building that includes architectural, structural, and MEP (Mechanical, Electrical, and Plumbing) components. This integrated approach improves project visualization, coordination, and communication among architects, engineers, contractors, and clients throughout the project lifecycle. BIM not only enhances design accuracy but also minimizes errors, rework, and construction delays, thereby improving the overall efficiency of residential building projects. [1] [2]
In residential building design, BIM plays a significant role in improving planning and execution processes. The technology allows designers to simulate the complete construction process before the actual work begins, helping stakeholders identify design conflicts and optimize building performance at an early stage. AutoCAD is commonly used for preparing accurate 2D plans and layouts, while Revit is used for creating intelligent 3D BIM models that integrate architectural and MEP systems. Tekla Structures assists in detailed structural modeling and reinforcement detailing, whereas Navisworks is utilized for clash detection and project coordination. The integration of these software tools ensures smooth collaboration among different disciplines and enhances project quality and productivity. [3] [4]
The implementation of BIM in residential projects also supports better cost estimation and resource management. Since BIM models contain detailed information about every building component, quantity take-offs and material estimations can be generated automatically with high accuracy. This reduces material wastage and supports efficient budgeting and scheduling. Additionally, BIM facilitates sustainable building practices by enabling energy analysis, lighting simulation, and environmental performance evaluation during the design stage. As a result, residential buildings designed with BIM are more energy-efficient, economical, and environmentally friendly compared to conventionally designed structures. [5] [6]

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Another major advantage of BIM is its ability to improve coordination among project stakeholders. Traditional design methods often result in communication gaps between architects, structural engineers, and service designers, leading to construction conflicts and delays. BIM overcomes these issues through a centralized digital model where all modifications are updated automatically across every drawing and view. Navisworks software further strengthens coordination by detecting clashes between structural, architectural, and MEP systems before construction begins. This proactive approach significantly reduces site errors, improves safety, and enhances construction quality. [7] [8]

The adoption of BIM technology is continuously increasing in modern residential construction due to its capability to provide accurate visualization, efficient documentation, and lifecycle management of buildings. Governments and construction organizations worldwide are encouraging BIM implementation to achieve smarter and more sustainable infrastructure development. In this project, the design of a residential building using BIM demonstrates how digital modeling techniques can improve structural planning, project coordination, and construction management. The study highlights the importance of BIM as an innovative solution for achieving high-quality, cost-effective, and time-efficient residential construction projects. [9] [10].

II. PROBLEM STATEMENT

In traditional residential building design practices, the use of separate 2D drawings for architecture, structure, and MEP systems often leads to poor coordination among different disciplines. This fragmented approach increases the chances of design conflicts, errors, and misinterpretation during construction. As a result, projects frequently experience delays, cost overruns, material wastage, and reduced overall efficiency. The lack of a unified platform also makes it difficult to visualize the complete building system before execution, limiting effective planning and decision-making.

III. OBJECTIVES

1. To develop an integrated residential building design using Building Information Modeling (BIM) technology.
2. To create accurate 3D architectural, structural, and MEP models for better visualization and coordination.
3. To identify and eliminate design clashes between different building systems before construction.
4. To improve accuracy in quantity estimation and cost calculation through BIM-based modeling.
5. To enhance overall project efficiency by reducing errors, rework, and construction delays.

IV. LITERATURE SURVEY

1. Structural Capacity and Seismic Responses Evaluation of Low-Rise Buildings by Implementing Building Information Modeling (BIM) Framework

Authors: Amanda Lumondang, Erik Wahyu Pradana, Senot Sangadji (2024)

This study focuses on the application of Building Information Modeling (BIM) for evaluating the structural capacity and seismic response of low-rise buildings. The authors demonstrate how BIM can be used to extract accurate structural data from a digital model and simulate earthquake behavior effectively. By integrating structural analysis within the BIM environment, the study shows improved accuracy in assessing building performance under seismic loads. It highlights that BIM supports better visualization of structural behavior, helps in identifying weak structural zones, and improves decision-making during the design stage. The research concludes that BIM plays a significant role in integrating design and structural assessment, making buildings safer and more reliable under seismic conditions.

2. Using BIM for the Assessment of the Seismic Performance of Educational Buildings

Authors: Carmen Angulo, Karen Díaz, José M. Gutiérrez, Andrea Prado, Rosanna Casadey, Gino Pannillo, Felipe Muñoz-La Rivera, Juan C. Vielma (2020)

This paper presents an advanced approach for evaluating seismic performance of educational buildings using BIM integrated with FEMA P-58 performance-based assessment methodology. The authors explain how BIM models include both structural and non-structural elements, enabling a complete digital representation of the building. This integration allows for detailed simulation of earthquake impacts, including damage estimation and repair cost analysis. The study shows that BIM significantly improves the efficiency of seismic performance evaluation by reducing manual efforts and increasing accuracy in analysis. The research concludes that BIM-based assessment provides a comprehensive framework for understanding building vulnerability and improving earthquake resilience in public infrastructure.

3. Seismic Retrofitting of Buildings Using Building Information Modeling

Authors: Dereje L.S., Dabi G.M., Baza T.T., Rynkovskaya M.I. (2021)

This research explores the use of BIM in seismic retrofitting of existing buildings, focusing on improving structural safety and performance. The authors review multiple studies and demonstrate how BIM can be applied in designing retrofit solutions for both structural and non-structural components. The study highlights that BIM provides a unified platform for analyzing building conditions, simulating structural improvements, and integrating seismic engineering principles into the design process. It also shows that BIM enhances coordination between different engineering disciplines during retrofit planning. The paper concludes that BIM is highly effective in improving the accuracy, efficiency, and reliability of seismic retrofitting projects.

4. Comparison Study of BIM Modeling in Seismic Analysis for Different Building Functions Based on SNI 1726:2019

Authors: Asri Puspita Sari Sidabutar, Jessica Sjah, Ayomi Dita Rarasati (2024)

This study compares BIM-based seismic analysis for different types of buildings, including hotels and hospitals with varying floor levels. Using tools such as Autodesk Revit and Robot Structural Analysis, the authors evaluate structural performance based on Indonesian seismic standards (SNI 1726:2019). The research demonstrates how BIM enables accurate modeling and analysis of buildings with different functional requirements and structural complexities. It highlights that BIM improves compliance with seismic codes and enhances the reliability of structural analysis results. The study concludes that BIM is an effective tool for evaluating and optimizing structural safety across various building functions.

5. The Research of Design Method of Building Structure Based on BIM

Authors: Yuan Xin (2017)

This paper provides foundational insights into BIM-based structural design methods and compares them with traditional design approaches. The author explains how BIM improves structural design through better coordination, visualization, and data integration. It also discusses the role of BIM in enhancing anti-seismic design considerations by enabling more accurate simulation and analysis of structural behavior. The study emphasizes that BIM reduces errors and improves efficiency by integrating architectural and structural workflows into a single platform. The research concludes that BIM-based design methods significantly outperform conventional approaches in terms of accuracy, collaboration, and project efficiency in civil engineering applications.

V. PROPOSED OF SYSTEM

1. System Overview

The proposed system focuses on the design and development of a residential building using Building Information Modeling (BIM). The system integrates architectural, structural, and MEP design processes into a single coordinated digital platform. By using BIM tools, the entire building is modeled in 3D, allowing better visualization, planning, and analysis before actual construction begins. The system aims to improve accuracy, reduce design conflicts, and enhance collaboration among different stakeholders involved in the project.

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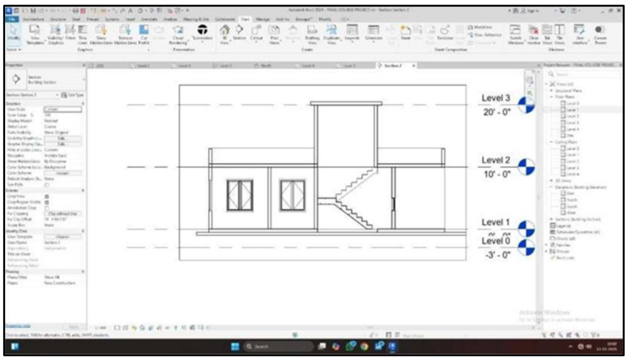

Fig 1: System Design

2. Architectural Design Module

This module is responsible for creating the basic layout of the residential building, including floor plans, elevations, sections, room arrangements, doors, windows, and circulation spaces. Using BIM software, the architectural model is developed in a parametric environment, ensuring that any modification is automatically updated throughout the design. This improves design flexibility and ensures consistency across all drawings.

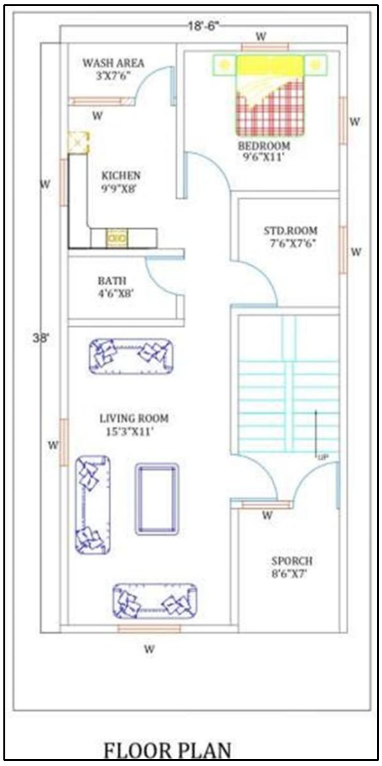

Fig 2: Floor Plan

3. Structural Design Module

The structural module focuses on designing and analyzing the load-bearing components of the building such as beams, columns, slabs, and foundations. The system ensures that structural elements are properly integrated with the architectural model. Structural analysis is performed to check stability, load distribution, and safety under different conditions. This module helps in optimizing structural performance while maintaining design efficiency.

4. MEP Integration Module

This module integrates Mechanical, Electrical, and Plumbing systems within the building model. It ensures proper routing of ducts, pipes, and electrical systems without interfering with architectural and structural components. The BIM environment allows seamless coordination between all systems, reducing clashes and design errors. This integration improves the overall functionality and efficiency of the residential building.

5. Clash Detection System

The clash detection module is used to identify conflicts between architectural, structural, and MEP components. Using tools like Navisworks, the system automatically detects intersections or overlaps in the design. Early identification of clashes helps in reducing rework during construction and ensures smooth execution of the project. This improves construction quality and saves both time and cost.

6. Quantity Estimation and Cost Analysis

The proposed system automatically generates quantity take-offs for materials such as concrete, steel, bricks, and finishing materials directly from the BIM model. This reduces manual errors in estimation and ensures accurate budgeting. The system also supports cost analysis by linking material quantities with cost data, helping in effective financial planning of the project.

7. Project Visualization and Simulation

The BIM-based system provides realistic 3D visualization of the residential building, allowing stakeholders to understand the final structure before construction. It also supports simulation of construction sequences, enabling better planning and scheduling. This improves decision-making and helps in identifying potential design improvements at an early stage.

VI. SYSTEM DESIGN

1. Overall System Architecture

The proposed BIM-based residential building design system follows an integrated digital architecture where all building information is stored and managed within a centralized 3D model. The system combines architectural, structural, and MEP design workflows into a single coordinated environment. This unified architecture ensures that any change made in one component is automatically reflected across all related views and drawings, improving consistency and reducing design conflicts.

2. Input Design Module

The input module collects all essential data required for building design. This includes site details, plot dimensions, soil conditions, client requirements, building codes, and functional space planning. These inputs form the basis for creating the initial architectural layout. The accuracy of this module is critical, as it directly influences the quality of the BIM model and overall project outcome.

3. BIM Modeling Module

This module is the core of the system where the actual Building Information Model is created. Architectural elements such as walls, doors, windows, slabs, and roofs are modeled in 3D. Structural components including beams, columns, and foundations are integrated within the same model. MEP systems are also incorporated to ensure complete building representation. This module ensures a fully coordinated digital model of the residential structure.

4. Structural Analysis Module

The structural analysis module evaluates the strength and stability of the building components. Loads such as dead load, live load, wind load, and seismic load are applied to analyze structural behavior. The system ensures that all elements meet safety standards and design codes. This module helps in optimizing structural design and ensuring long-term durability of the building.

5. Coordination and Clash Detection Module

This module is responsible for identifying conflicts between architectural, structural, and MEP systems. Using BIM coordination tools, the system automatically detects clashes such as overlapping pipes, beams, or ducts. Early detection of these issues allows designers to resolve problems before construction begins, reducing rework and improving project efficiency.

6. Quantity and Cost Estimation Module

The system extracts material quantities directly from the BIM model, including concrete volume, steel reinforcement, masonry work, and finishing materials. This automated process ensures accurate estimation and reduces manual calculation errors. The module also supports cost analysis by linking material quantities with cost databases, enabling efficient budget planning.

7. Output and Visualization Module

This module generates final outputs in the form of 2D drawings, 3D views, reports, and schedules. It provides realistic visualization of the residential building, allowing stakeholders to understand the design clearly. The output also includes detailed construction documentation that supports execution on-site.

8. System Integration Flow

The entire system operates in a continuous workflow where each module is interconnected. Input data flows into the BIM modeling system, which then connects with structural analysis, clash detection, and estimation modules. This integration ensures smooth data exchange, reduces redundancy, and improves overall project coordination and efficiency.

VII. RESULTS

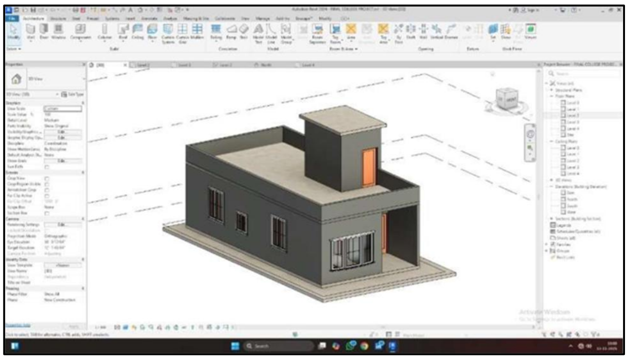

Fig 3: System Architecture

The first image represents a 3D isometric view of a residential building developed using Building Information Modeling (BIM) software, most likely Autodesk Revit. The model shows a compact, modern-style residential structure designed with a flat roof system and simple geometric form. The building consists of a ground floor with clearly defined walls, openings, and a small projection or entrance porch area. A vertical mass element is visible on the rooftop, which appears to be an additional room or utility structure such as a stair headroom or small upper-level block. The design emphasizes simplicity and functionality, which is commonly preferred in residential construction for cost efficiency and ease of execution.

The architectural elements such as doors and windows are properly placed to ensure natural lighting and ventilation. The window openings on the side elevation are uniformly aligned, indicating proper architectural planning and modular design principles. The external walls are shown in a uniform grey finish, while door elements are highlighted in a contrasting orange tone, which helps in visual identification of components in the BIM environment. The base platform or plinth area is also clearly defined, showing the building elevation above ground level.

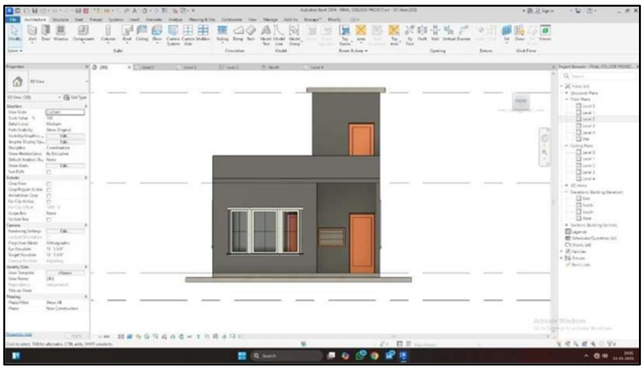

Fig 4: System Floor Architecture

The second image shows the front elevation view of the same residential building model, generated using BIM software. This view provides a direct orthographic representation of the building façade, clearly illustrating the vertical arrangement of architectural components. The building appears to be a two-level structure with a ground floor and an upper-level portion that includes a small projected room or stair cabin. The elevation highlights the external appearance of the building, including wall finishes, window placement, and door positioning.

In this view, the ground floor features a prominent window set with multiple panels, indicating a living or common area designed for sufficient daylight penetration. Adjacent to the window, a main entrance door is visible, which serves as the primary access point to the building. The upper portion of the structure includes a smaller door, likely providing access to the rooftop utility space or upper room. The alignment of structural elements reflects proper design coordination, ensuring balance and symmetry in the building façade.

The elevation also clearly shows the building's plinth level and roof slab projection, which are important for understanding structural height and construction detailing. The BIM-generated elevation ensures precision in dimensions and alignment, reducing errors that are common in manual drafting. This representation is particularly useful for construction execution, as it provides a clear reference for site engineers and contractors.

VIII. CONCLUSION

The design of a residential building using Building Information Modeling (BIM) demonstrates a modern and efficient approach to construction planning and execution. BIM integrates architectural, structural, and MEP systems into a single coordinated digital model, which significantly improves design accuracy and reduces inconsistencies that are common in traditional 2D methods. Through this project, it is observed that BIM enhances visualization, allowing stakeholders to clearly understand the building form and functionality before actual construction begins.

The use of BIM software enables better coordination among different disciplines, reducing design conflicts and minimizing errors during the construction phase. It also supports automated quantity estimation and cost analysis, which helps in effective budget planning and resource management. The clash detection feature further ensures that potential design issues are identified and resolved at an early stage, thereby reducing rework and saving both time and cost.

IX. FUTURE SCOPE

The future development of AI-based phishing and deepfake detection systems holds significant potential as cyber threats continue to evolve in complexity and scale. One major direction is the integration of advanced deep learning architectures such as transformer models, which can improve detection accuracy by better understanding contextual patterns in text, audio, and visual data. In addition, real-time detection capabilities can be enhanced by optimizing models for edge devices, enabling faster and more efficient identification of malicious content directly on user devices without relying heavily on cloud processing.

Another important scope is the development of multimodal detection systems that combine text, image, audio, and video analysis to provide a more comprehensive security solution. This will help in identifying sophisticated attacks where

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multiple media types are manipulated simultaneously. Furthermore, the incorporation of federated learning can improve privacy by allowing models to learn from decentralized data sources without exposing sensitive user information.

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