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SCHEDULE OPTIMISATION IN CONSTRUCTION USING BUILDING INFORMATION MODELLING

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ABSTRACT
The construction industry is improving and looks as promising as never before, as end users persist to demand more and more complex projects to be delivered at a faster pace and in a costeffective manner. Traditional scheduling methods of construction have been used for building of structures previously but they are no longer suitable for producing robust work schedules. Technological innovations have assisted the construction industry to avoid a lot of uncertain hazards through management of resources in an efficient, effective and affordable manner. Building Information Modeling or BIM offers the potential to improve cost, scheduling and co-ordination of infrastructure projects. Building Information Modeling in terms of 4D modeling saves a lot of time and money over traditional scheduling processes. On the other hand, enhancing the reliability of planning is a fundamental factor in achieving stable construction flow and subsequently, high productivity and improved product quality. This paper compares BIM-based scheduling with the traditional method and also focuses on understanding how BIM solves existing problems in the traditional method of scheduling.
Keywords—Building Information, Modeling, Cost effective, Schedule Optimisation, BIM-based.

1.0 INTRODUCTION

The construction industry has been evolving rapidly over the years, with the introduction of innovative technologies that aim to enhance efficiency, reduce costs, and improve project outcomes. One such technology that has gained significant traction in recent times is Building Information Modeling (BIM). BIM is a digital representation of the physical and functional characteristics of a construction project, which offers a collaborative and information-rich platform for project stakeholders. Beyond its role in visualization and coordination, BIM has proven to be an invaluable tool for schedule optimization in construction projects.

Overview of Building Information Modeling (BIM)

To lay the groundwork for understanding schedule optimization using BIM, it is crucial to provide an overview of BIM and its core functionalities. BIM is a digital representation of the physical and functional characteristics of a construction project, encompassing its geometry, spatialrelationships, quantities, and other relevant information. It allows project stakeholders to collaboratively create and manage a project's digital twin, providing a central repository of information that can be accessed and utilized throughout the project lifecycle.

Figure 1.1 Building Information Modeling in Construction Industry

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Benefits of BIM-Enabled Schedule Optimization
The utilization of BIM for schedule optimization in construction projects offers several significant benefits. Firstly, it enhances collaboration and coordination among project stakeholders by providing a common platform for sharing information and making informed decisions. The transparency and accessibility of project data through the BIM model foster improved communication and cooperation, reducing conflicts and delays.
Secondly, BIM's visualization capabilities enable stakeholders to visualize the project in its entirety, promoting better understanding of the construction process and potential challenges.
This improved visualization aids in identifying potential issues early on and making informed decisions to optimize the project schedule.

Figure 1.2 Benefits of BIM process

2.0 LITERATURE REVIEW
[1] Approaches for BIM-based multi-objective optimization in construction scheduling, Noha Essam, Laila Khodeir, atma Fathy, 2023
Construction scheduling is a complex process due to the interdependence and contradiction of project activities. This requires applying population-based optimization algorithms like evolutionary algorithms to reach optimal solutions. However, when optimizing more than three objectives, the efficiency of such algorithms degrades and trade-offs among conflicting objectives must be made to obtain an optimal Pareto Frontier. Recently, there have been attempts to integrate Building Information Modelling (BIM) with Multi-Objective Optimization (MOO) algorithms to solve building design and management problems like construction. This paper aims to assess the potential of developing models that combine information systems and optimization methods for better decision-making process.
[2] Building energy consumption optimization method based on convolutional neural network and BIM, Fang Xu, Qiaoran Liu, 2023
The increasing tension of energy supply and demand makes the optimization of building energy consumption more and more concerned by researchers. Based on the theory of convolutional neural network and BIM (Building Information Modeling), a building energy consumption optimization model is constructed. The optimization parameter solving problem of convolutional neural network is solved. In the simulation process, a calculation model of the same size as Revit's three-dimensional model is established in eQUEST software, and the basic analysis parameters of the model, such as geographical location, meteorological data and other information, component materials, and running time table are set as unified standards.
[3] Design and optimization of construction equipment pipelines in cigarette factories based on BIM technology, Yu Chen, 2023
With the rapid development of the construction industry, the equipment in industrial buildings such as cigarette factories is also increasing. In order to improve the design efficiency and construction quality of industrial buildings such as cigarette factories, and avoid technical problems such as pipeline collisions and missing holes, BIM technology is applied to the overall design and construction of cigarette factories. Guide the actual construction of the project by means of model building, visual analysis of the internal space of the building, conflict detection and optimization in the design of the pipe network, and allround dynamic management of data.

[4] BIM-based architectural analysis and optimization for construction 4.0 concept (a comparison) Jie Zhang , Xuping Zhu , Abdul Mateen Khan , Moustafa Houda , Sardar Kashif Ur Rehman ,Mohammed Jameel , Muhammad Faisal Javed , Raid Alrowais , 2023

The growing need for electricity has put Pakistan's burgeoning economy in peril. The notion of ''Construction 4.000 is considered in this study since it enables the greatest utilization of energy and architectural analysis. A case study and a method for building information modelling are used to analyze the concepts of green building. The case study building is represented as a parametric model using the Autodesk Revit platform with the original blueprints and data. Using Autodesk Insight 360, an energy analysis and comparison of optimization case study of the A-Block and Z- Block COMSATS Abbottabad, Pakistan is chosen. This study analyses an academic building's energy performance as a case study to reduce energy usage.

[5] Multiobjective optimization of building energy consumption and thermal comfort based on integrated BIM framework with machine learning-NSGA II,Haidar Hosamo Hosamo , Merethe Solvang Tingstveit , Henrik Kofoed Nielsen , Paul Ragnar Svennevig ,Kjeld Svidt 2022

Detailed parametric analysis and measurements are required to reduce building energy usage while maintaining acceptable thermal conditions. This research suggested a system that combines Building Information Modeling (BIM), machine learning, and the non-dominated sorting genetic algorithm-II (NSGA II) to investigate the impact of building factors on energy usage and find the optimal design. A plugin is developed to receive sensor data and export all necessary information from BIM to MSSQL and Excel. The BIM model was imported to IDA Indoor Climate and Energy (IDA ICE) to execute an energy consumption simulation and then a pairwise test to produce the sample data set. To study the data set and develop a prediction model between building factors and energy usage, 11 machine learning algorithms are used. The best algorithm was Group Least Square Support Vector Machine (GLSSVM), later employed in NSGA II as the building energy consumption fitness function using Dynamo software. An NSGA II multi-objective optimization model is designed to reduce building energy consumption and optimize interior thermal comfort (measured by the predicted percentage of dissatisfied (PPD)).

[6] BIM adoption in sustainability, energy modelling and implementing using ISO 19650: A review, Xinchen Pan , Abdul Mateen Khan , Sayed M Eldin , Fahid Aslam , Sardar Kashif Ur Rehman ,Mohammed Jameel, 2023

The construction industry is adopting a ground-breaking invention called Building Information Modeling (BIM) to virtually manage and plan projects throughout the building's lifespan. In the architectural, engineering, and construction (AEC) sector, the adoption of BIM is growing throughout the government sector worldwide, including governmental entities and non-profit organizations. This article covers how building information modelling was used to produce suggestions to help customers and operational teams appropriately specify information needs for projects.

[7] Green Building Construction: A Systematic Review of BIM Utilization,Yu Cao , Syahrul Nizam Kamaruzzaman and Nur Mardhiyah Aziz ,2022

As a multi-function method, Building Information Modeling (BIM) can assist construction organizations in improving their project's quality, optimize collaboration efficiency, and reduce construction periods and expenditure. Given the distinguished contributions of BIM utilization, there is a trend that BIM has significant potential to be utilized in the construction phase of green buildings. Compared with traditional buildings, green buildings have more stringent requirements, including environmental protection, saving energy, and residents' comfort. Although BIM is deemed an effective method to achieve the abovementioned requirements in the construction process of green buildings, there are few systematic reviews that explore the capabilities of BIM in the construction phase of green buildings. This has hindered the utilization of BIM in the construction of green buildings. To bridge this research gap and review the latest BIM capabilities, this study was developed to perform a systematic review of the BIM capabilities in the construction phase of green buildings.

3.0 Research Objective:

The primary objective of this research is to develop a comprehensive methodology for schedule optimization in construction projects using BIM. Specifically, the research aims to achieve the following goals:

1. Investigate the current state-of-the-art in BIM-based schedule optimization techniques.
2. Identify the key factors influencing project schedule optimization using BIM.
3. Develop a framework for integrating BIM with project scheduling processes.
4. Evaluate the effectiveness of the proposed methodology through case studies and quantitative analysis.
5. Provide recommendations and guidelines for implementing BIM-based schedule optimization in the construction industry.

3.0 Research Methodology:

To achieve the research objectives, a systematic research methodology will be employed, consisting of the following key steps:

1. Data Collection:

Data collection will involve gathering relevant information on construction projects that have utilized BIM for schedule optimization. This may include project plans, schedules, BIM models, and other relevant project documentation. Additionally, data will be collected on project characteristics, such as project size, complexity, and duration.

2. Identification of Key Factors:

Based on the literature review and data collection, key factors influencing project schedule optimization using BIM will be identified. These factors may include project scope changes, resource allocation, trade coordination, and technological challenges. The identified factors will form the basis for developing the proposed framework.

3. Framework Development:

A conceptual framework will be developed to guide the integration of BIM with project scheduling processes. This framework will consider the identified key factors and propose strategies and techniques for optimizing project schedules using BIM. The framework will also outline the roles and responsibilities of project stakeholders in implementing BIM-based schedule optimization.

4. Case Studies:

Multiple case studies will be conducted to evaluate the effectiveness of the proposed methodology. Real-life construction projects that have utilized BIM for schedule optimization will be selected, and their project data will be analyzed using the developed framework. The case studies will involve quantitative analysis of schedule performance indicators, such as project duration, resource utilization, and cost.

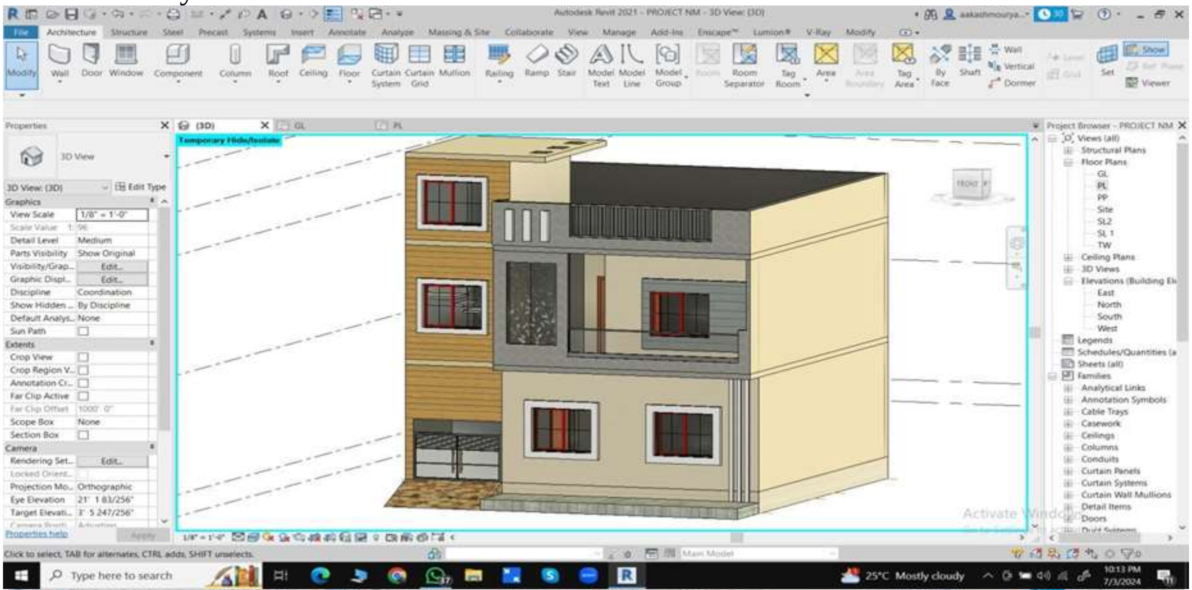
5. Analysis and Results:

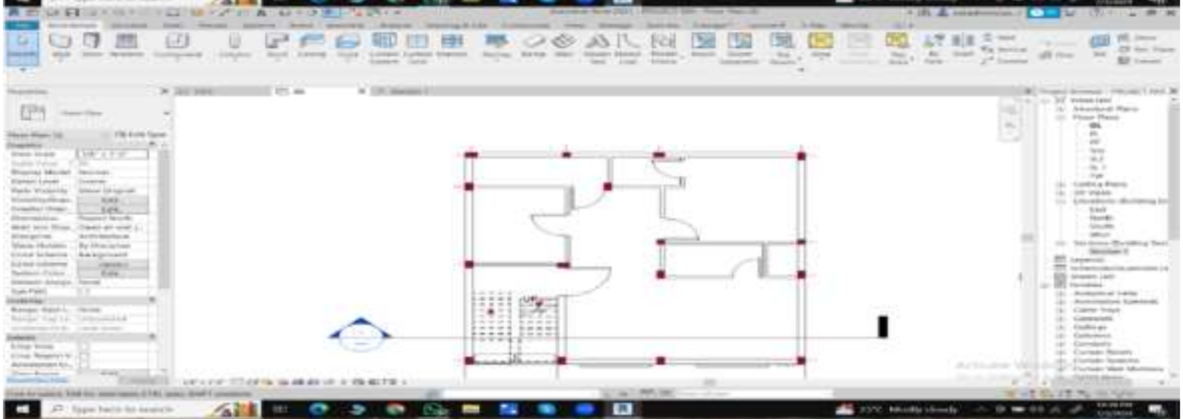
The data collected from the case studies will be analyzed using appropriate statistical methods to assess the effectiveness of the proposed methodology. The results will be presented and discussed, highlighting the benefits and challenges of implementing BIM- based schedule optimization in construction projects.

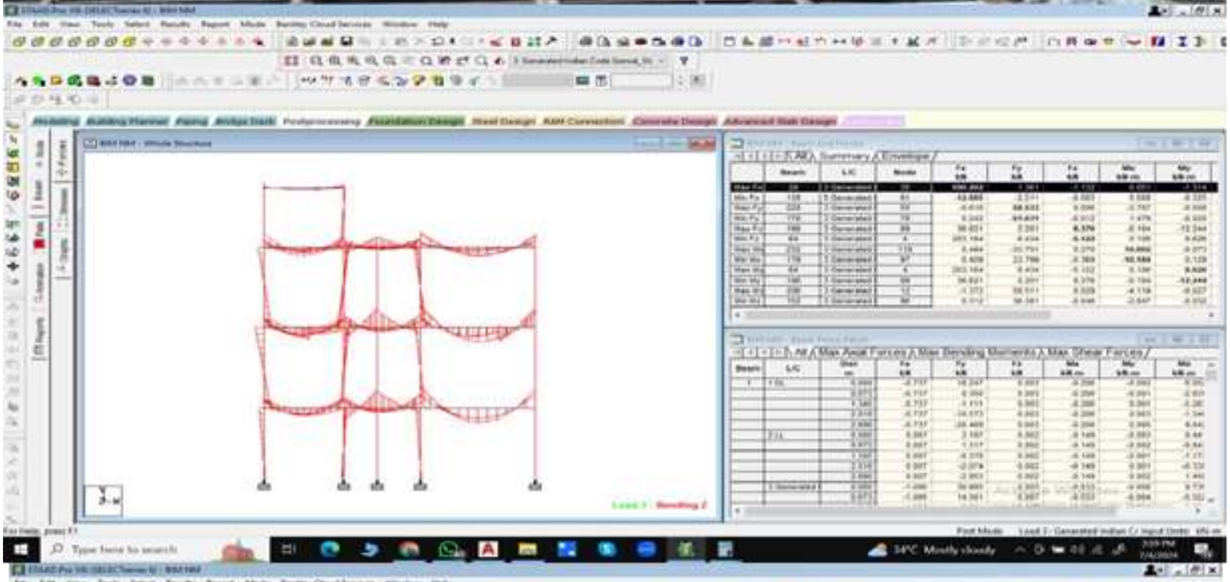
6. Recommendations and Guidelines:

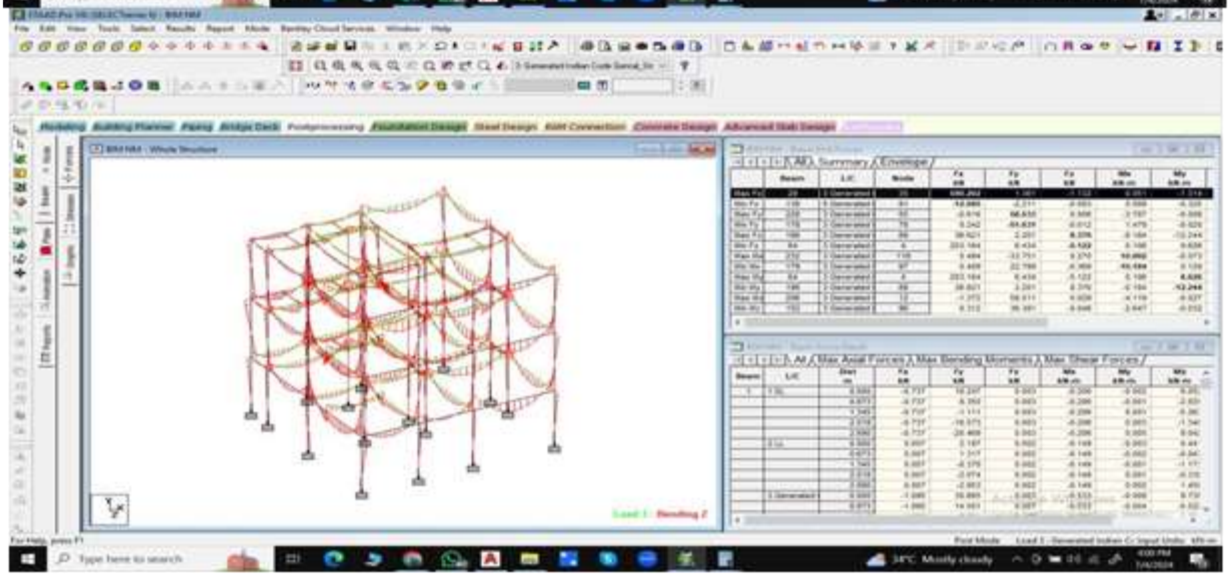
Based on the findings of the research, recommendations and guidelines will be provided for practitioners and stakeholders in the construction industry. These recommendations will focus on best practices for implementing BIM-based schedule optimization, overcoming challenges, and maximizing the benefits of BIM in construction project management.

4.0 Software Analysis:









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5.0 Software Analysis:

Table 1.0: Cost Estimate by traditional method (manual) and Estimate Cost by BIM (with Revit architectural) of each item

S. No Item Cost Estimate by traditional method (manual) Cost Estimate by BIM (with Revit architectural) Percentage Reduced (%)

S. No	Item	Cost Estimate by traditional method (manual)	Cost Estimate by BIM (with Revit architectural)	Percentage Reduced (%)
1	Column	1,75000	1,67002	4.57%
2	Structural Framing	4,25000	3,92785	7.58%
3	Stair	50000	48695	2.61%
4	Wall	1,75000	1,69277	3.27%
5	Floor	8,25000	809572	1.87%
6	Door	2,15000	200530	6.73%
7	Window	1,85000	1,70144	8.03%
8	Furniture	5,45000	5,45000	0%
	Total	Rs. 25,95000	Rs. 24,82636	4.33%

Table 2.0 Software Results

Variables	Maximum
Axial (KN)	590.202
Moment (KN-m)	39.634
Displacement (mm)	6.2
Shear (KN)	58.533

6.0 CONCLUSIONS

COMPARE THE EXISTING AND PROPOSED METHOD

Existing Method (Traditional Scheduling):

1. Manual Data Entry: Traditional scheduling often involves manually inputting data into scheduling software, which can be time-consuming and error-prone.
2. Limited Visualization: Traditional methods may lack comprehensive 3D visualization, making it challenging to understand and communicate the construction schedule effectively.
3. Sequential Scheduling: Many traditional methods rely on sequential scheduling, whichmay not consider interdependencies between activities efficiently.
4. Resource Allocation Challenges: Allocating resources optimally can be difficult intraditional scheduling methods, leading to delays and inefficiencies.
5. Change Management: Adapting to changes in the construction project can be cumbersome, requiring manual adjustments to the schedule.

Proposed Method (BIM-based Schedule Optimization):

1. Automated Data Integration: BIM-based scheduling integrates project data from the BIM model, reducing manual data entry and ensuring data accuracy.
2. 3D Visualization: BIM provides a 3D visual representation of the project, allowing stakeholders to better understand the construction sequence and detect clashes.
3. Improved Interactivity: BIM enables the identification of interdependencies betweenactivities, allowing for more accurate scheduling and resource allocation.

4. Resource Optimization: BIM-based scheduling can optimize resource allocation based onthe 3D model, reducing resource conflicts and enhancing project efficiency.
5. Change Management: BIM allows for real-time updates and automated adjustments to the schedule when changes occur, ensuring that the schedule remains up-to-date.
6. Data-Driven Decision Making: BIM-based scheduling leverages data analytics and simulations to make informed decisions, improving project outcomes.
7. Collaboration: BIM facilitates collaboration and communication among project stakeholders, leading to more effective project management.
8. Cost and Time Savings: BIM-based schedule optimization has the potential to reduce project duration, costs, and rework.

REFERENCES

1. Hendrickson, C. (2000) Project Management for Construction – Fundamental Concepts for Owners, Engineers, Architects and Builders, 2nd edn, available at http://www.ce.cmu.edu/ pmbook/, accessed 14 August 2003.
2. Phair, M. (2000) Software model builders add an extra dimension to 3D CAD. ENR, 6 March.
3. Williams, M. (1996) Graphical simulation for project planning: 4D-planner. 3rd Congress on Computing in Civil Engineering, ASCE, pp. 404–9.
4. Collier, E. and Fischer, M. (1996) Visual based scheduling: 4D modeling on the San Mateo County Health Centre, in Proceedings of the 3rd ASCE Congress on Computing in Civil Engineering, Anaheim, CA.
5. McKinney, K., Kim, J., Fischer, M. and Howard, C. (1996) Interactive 4D CAD, in Proceedings of the Third Congress in Computing in Civil Engineering, ASCE, Anaheim, CA, pp. 383–9.
6. Knutsson, M. (2000) 3D-interface to the process model, available at http://www.ncc.se/english/oprtatio/research/ mats.htm, accessed 1 May 2001.
7. Koo, B. and Fischer, M. (2000) Feasibility study of 4D CAD in commercial construction. Journal of Construction Engineering and Management, ASCE, 126(4), 251–60.
8. David, H. and LAMINE, M. (2003) Trends of 4D CAD applications for construction planning Construction Management and Economics. ISSN 0144-6193 print/ISSN 1466-433X (February 2004) 22, 171–182
9. Salazar, G., H. Mokbel, et al. (2006). The Building Information Model in the Civil and Environmental Engineering Education at WPI. The ASEE New England Section 2006 Annual Conference, New England
10. Thompson, D.B., and Miner, R.G. (November 23, 2007). “Building Information Modeling - BIM: Contractual Risks are Changing with Technology” [WWW document] URL http://www.aepronet.org/ge/no35.html
11. Associated General Contractors of America. (2005). The Contractor’s Guide to BIM, 1st ed. AGC Research Foundation, Las Vegas, NV.R. S. Mishra, V. Kushwaha, and S. Kumar. 2015. A Comparative Study of Different Configuration of Shear Wall Location in Soft Story Building Subjected to Seismic Load. IRJET, 2(7): 513–519.
12. Dasovic´ B, Galic´ M, Klanšek U. A survey on integration of optimization and project management tools for sustainable construction scheduling. Sustainability 2020;12:3405.
13. Nguyen D-T, Chou J-S, Tran D-H. Integrating a novel multiple-objective FBI with BIM to determine tradeoff among resources in project scheduling. Knowledge-Based Syst 2022;235:107640.
14. Jeunet J, Bou Orm M. Optimizing temporary work and overtime in the Time Cost Quality Trade-off Problem. Eur J Oper Res 2020;284:743–61.