iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: VII Month of publication: July 2025
DOI: https://doi.org/10.22214/ijraset.2025.71370

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VII July 2025- Available at www.ijraset.com

Use of BIM for Construction Projects in KP and Its Comparison with Traditional Designs

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Abstract: Building Information Modeling (BIM) facilitates better collaboration between project stakeholders, such as architects, engineers, contractors, and clients. BIM allows for real-time 3D visualizations and simulations, enabling stakeholders to better visualize the outcome of projects. BIM, however, demands a heavy upfront investment in software, hardware, and training. On the other hand, Traditional design methods take a linear and sequential path, which has been extensively applied by professionals for decades. Although Traditional approaches are cheaper in the short term, they tend to create inefficient communication and fragmented processes. This paper provides a comparison of BIM and traditional design methods on their impact on cost estimation, project planning, visualization, and stakeholder coordination. It is found that BIM has a significant impact on efficiency, accuracy, and coordination, particularly on large and complex projects with multiple stakeholders. On small projects with limited resources, traditional design is still beneficial. The study highlights the importance of professional and industry-level consciousness to enable the implementation of BIM within KP's construction industry.
Keywords: Efficiency in Construction, Traditional Design Comparison, BIM Implementation, Revit in KP, Navisworks Manage

I. INTRODUCTION

Pakistan's construction industry has experienced significant growth, recording a 9.05% increase between 2016 and 2017, outperforming other sectors [1].

However, it is noteworthy that the construction sector is the culprit of many dishonest practices that are the reason for Pakistan's failure in infrastructure development. Like many other countries, Pakistan's construction sector has a poor track record of completing projects on time and within budget, often exceeding both [3][4][5][6]. BIM is a widely promoted technology that is believed to have the potential to solve all the problems that the architectural, engineering, and construction (AEC) industry has been facing [7].

It helps engineers, builders, and architects by bringing out the project in a simulated modeling setting and identifying any problems with design, building, or operation [8][9]. It involves the development and implementation of digital templates for a building that consist of the functional and physical aspects of the building during its entire lifecycle from the planning stage through to disposal [10].

In the BIM designing process, Revit is used for 3D models and cost estimation, and the Navisworks Manage tool is used for clash detection, planning, and scheduling. On the contrary, the traditional design pattern involves separate application packages like AutoCAD for drawing, Excel for costing, and Primavera P6 for planning and scheduling.

Design methods used by engineers are still the traditional ones [3]. The construction industry has been using Building Information Modeling (BIM) more in recent years due to information traceability and visualization capabilities. [11]. The main topic of the article is a comparison of contemporary BIM technology and traditional techniques in the KP building sector. It also identifies the difficulties in switching from the traditional BIM design process to the new one. To facilitate this analysis, the study examines four distinct types of buildings:

1) A single-story primary school in Peshawar
2) A two-story residential house in Phase 6, Hayatabad, Peshawar
3) A twelve-story commercial building in Bahria Phase 8, Rawalpindi
4) A three-story hostel building in Sheikh Maltoon Town, Mardan

This paper will focus on the design process currently in practice in Khyber Pakhtunkhwa, research up to BIM5D, which is a core requirement for transition, and the traditional design process along with its limitations. This paper provides valuable insights into what policies, practices, and investments can make construction projects in the KP region more efficient and effective.

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II. RESEARCH METHODOLOGY

The construction that happens in KP has processes that entail getting 2-D drawings of the projects that were developed using the traditional method of construction from the consulting firms. As such, these drawings are used in the PlanSwift and Excel spreadsheets for cost estimation, ETABS for structure analysis, and Primavera P6 for project scheduling.

It consists of the production of 3D representations based on the original 2D drawings. On that account, cost estimation, detailing, annotations, and documentation are made in the Revit environment that utilizes its functionality. Furthermore, project scheduling, clash detection of building elements integrating architecture and structure models, and 4D simulation are done with Navisworks. Structural analysis using Robot Structural Analysis, Autodesk Insight for energy analysis, and Dynamo, a visual programming tool, for automation work. This process is replicated for all four case studies: the primary school building, the residential building, the hostel building, and the multi-story commercial building. Such an assessment will measure the ability of each methodology to complete the project cost-effectively, construct the project schedule, identify clashes, and generally manage the project. The analysis thus makes a foundation for drawing inferences and providing future construction project suggestions for KP.

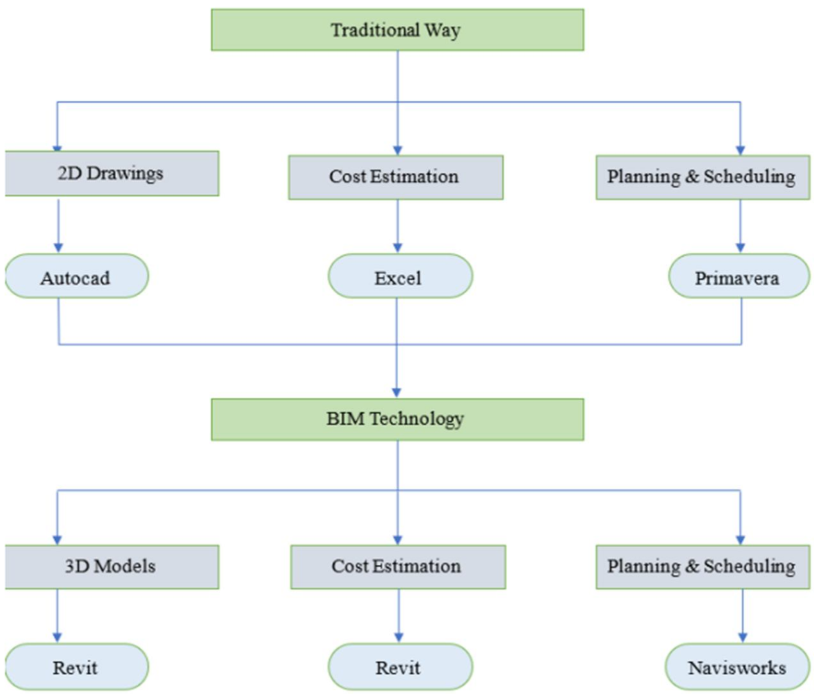
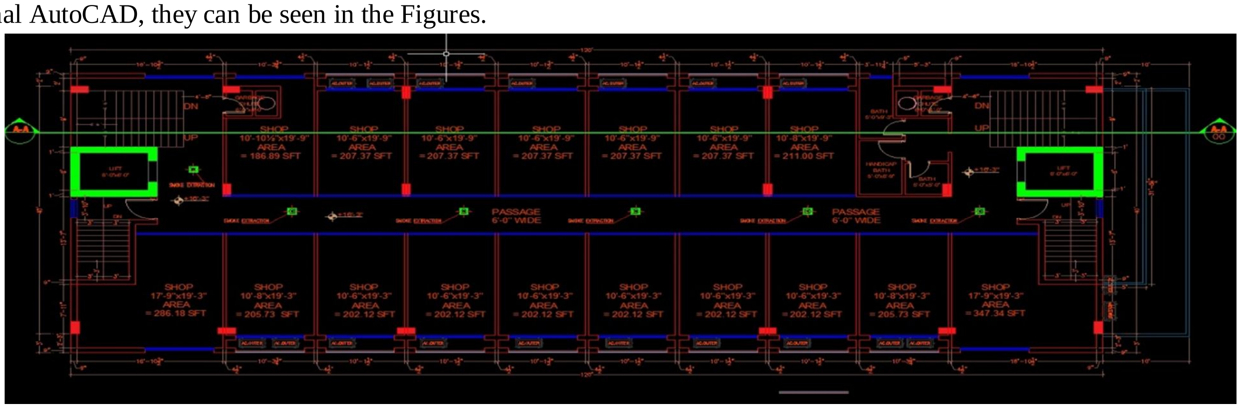


Fig 1: Methodology Flow Chart

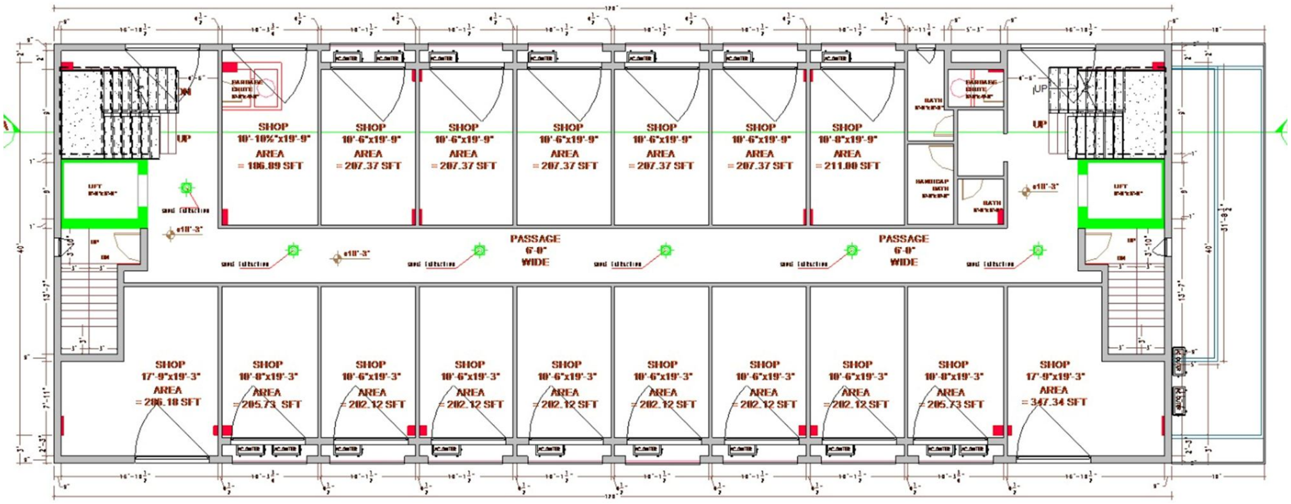
III.RESULTS

A. Visualization

The below figures illustrate the 2D & 3D Model view of a commercial building, which are made by Revit and 2D Elevation view in traditional AutoCAD, they can be seen in the Figures.

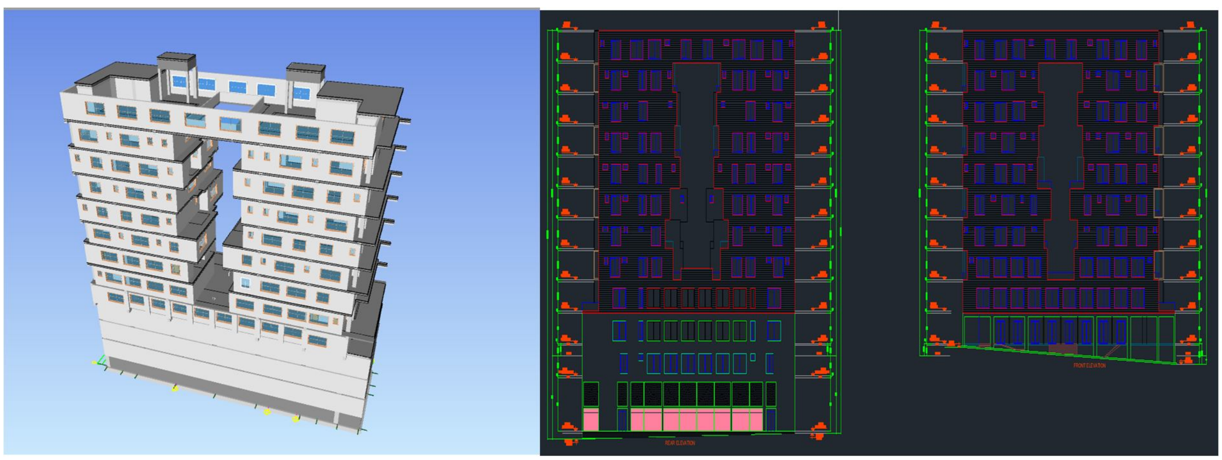


(a)



(b)

Fig. 1: 2D Plan, (a) AutoCAD 2D plan, (b) Revit 2D plan



(a) (b)

Fig. 3: Visualization – (a) Revit 3D Model, (b) AutoCAD 2D Elevation

As we can see, Revit is used for BIM technology, while AutoCAD can't be used for BIM technology, which is a huge disadvantage that can play a crucial role in making sure that the project follows the deadline and also meets the budget. With Revit, we are not only able to make 2D drawings but can also convert them into 3D models. With Revit, we can extract various 2D drawings like the plan, sections, and elevation, etc., readily, which otherwise, with AutoCAD, would have been manual work. Moreover, Revit can handle some additional yet important information about the building, like material, quantities, and rendering, which can prove vital in a rapidly advancing construction industry.

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B. Cost Estimation

The comparison of the quantities for the Traditional design process and BIM process indicates obvious differences. Modern BIM technologies estimate quantities more accurately than Traditional methods, leading to precise cost estimation and reducing cost variations caused by manual errors in Excel-based calculations. It's not the Excel that poses that problem but the human intervention that is needed to operate the Traditional tools, which not only increases the time for the estimation but also makes it more prone to inaccurate estimation. That is how Traditional technologies might not be as efficient as one might think, and it eventually leads to increased costs of projects. Table I below presents a comparison of quantities for three different structural elements of a commercial building.

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TABLE I. COMPARISON OF QUANTITIES IN BIM & EXCEL

S. No	Structure	BIM Quantities (ft^3)	Excel Quantities (ft^3)
1	Column	36.875	35
2	Beam	588.27	558.4
3	Slab	3656.43	3470.51

This graph illustrates the quantity take-off for various column types using (BIM) and traditional methods. The x-axis represents the column numbers (which are essentially different types of columns being labeled), while the y-axis shows the quantity take-off values.

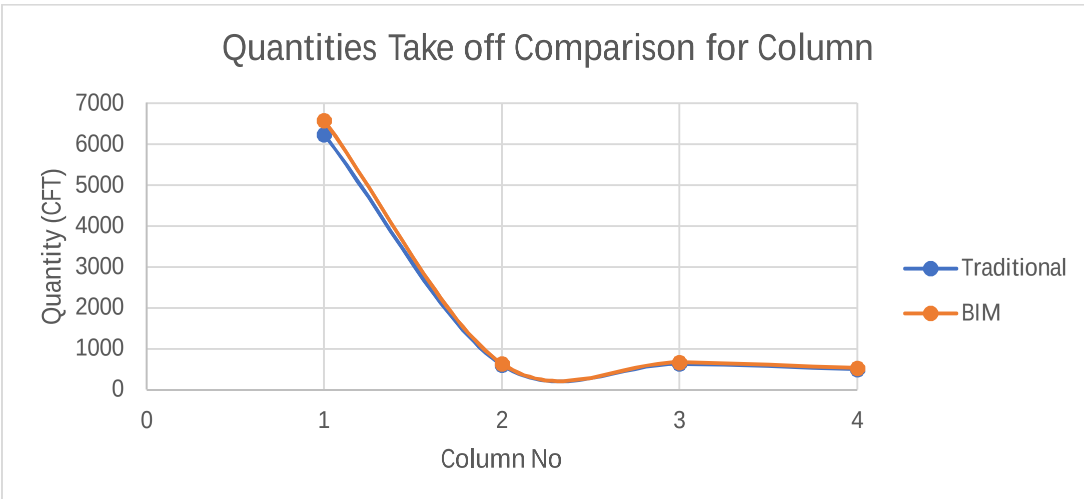

Fig. 4: Comparison of Column Quantities: BIM vs. Traditional Methods

This graph indicates that the quantity variation given because of the estimation done by the two methods increases as the quantities increases, which means more accurate cost estimation (excluding the fact that the quantities are lost on site). For commercial buildings, the quantity estimation error was calculated to be 5.36%. The same pattern occurred in all other case studies.

C. Project Scheduling

Figure 5 shows the planning and scheduling of commercial building performed in Primavera P6 & Navisworks Manage, respectively. In Navisworks, a 4D simulation was performed, giving an overview to the stakeholders regarding different construction phases as per their initial baseline timeframe, which was more difficult to understand and to manage than a traditional Gantt chart for the site facilities.

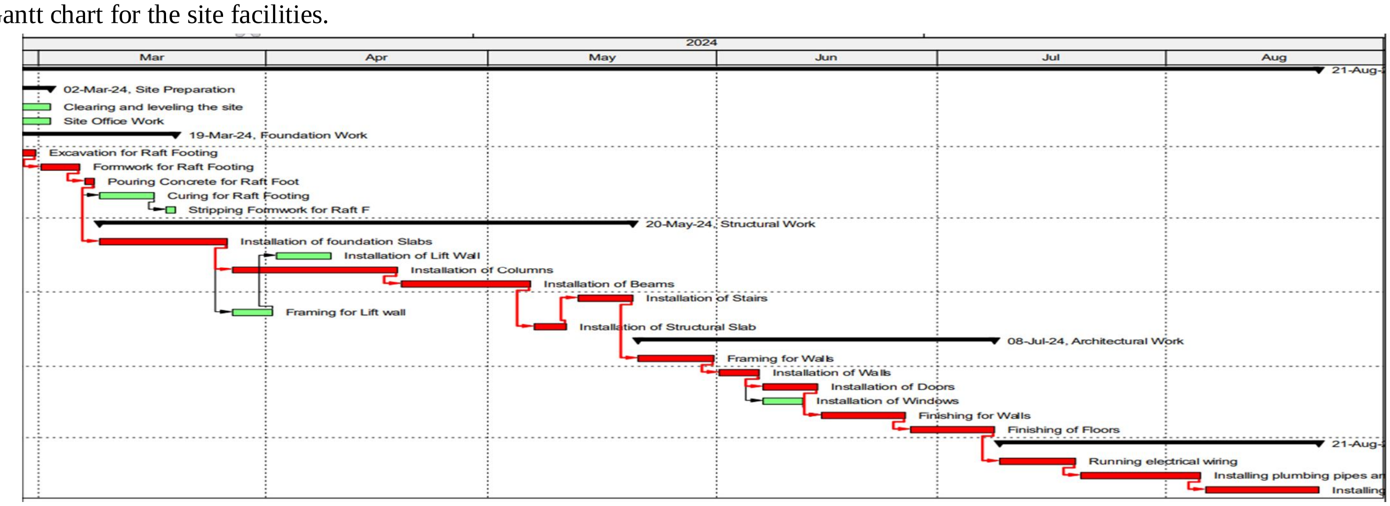

Fig. 5: Gantt Chart in Primavera P6

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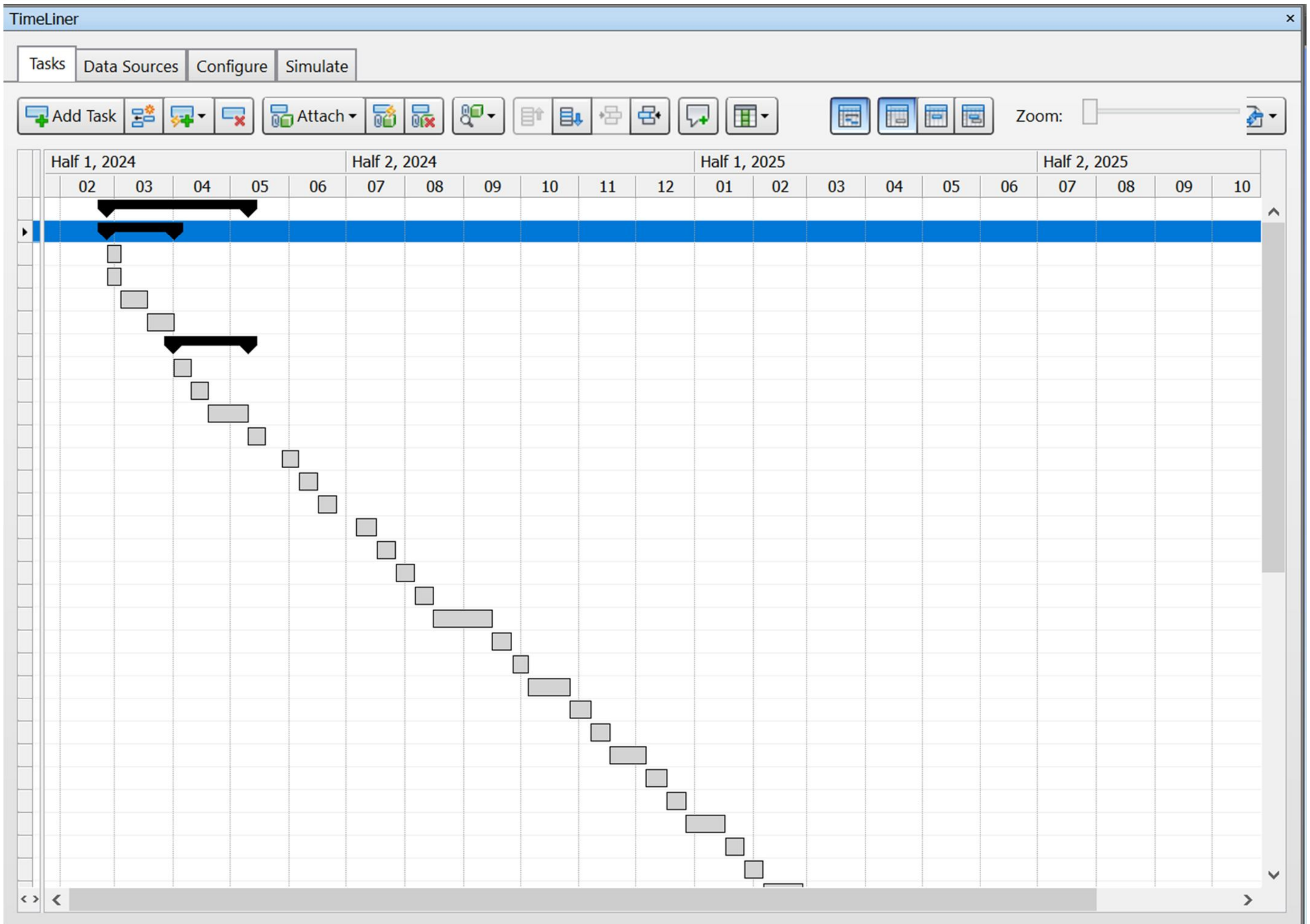


Fig. 6: Gantt Chart in Autodesk Navisworks

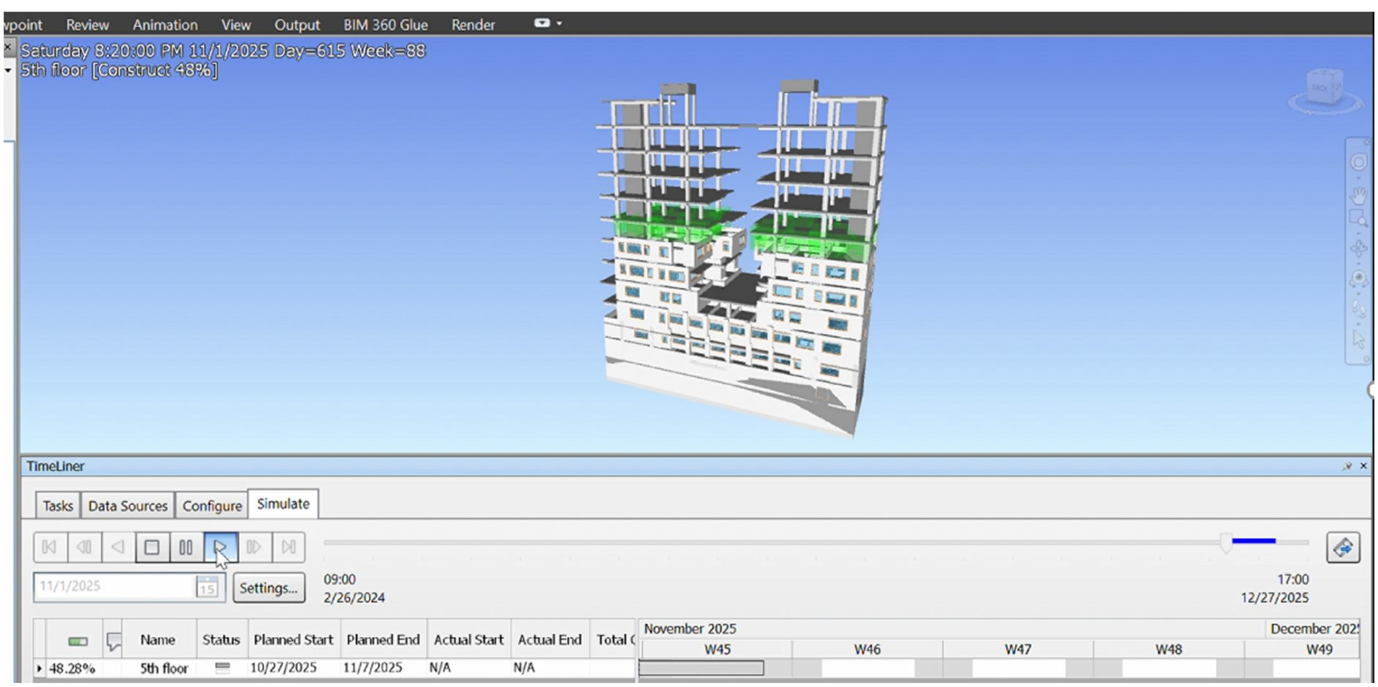
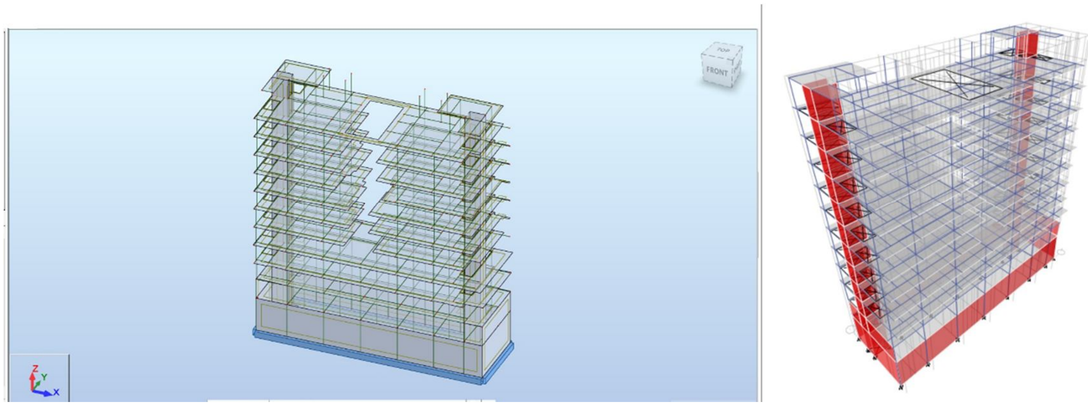


Fig. 7: Autodesk Navisworks 4D simulation

As we can see from the figures above, Navisworks helps us visualize the schedules. In Navisworks we have a 4D model parallel to the schedule, which facilitates understanding which deliverables or activities, which helps not only the designers but also the clients in deciding various aspects of the project like baseline approvals and governmental approvals. Since Navisworks is a relatively new technology, it currently lacks the advanced features of Primavera P6, such as resource leveling, risk management, and critical path analysis.

D. Structure Analysis

Figure 8 shows the structural models of a commercial building, created using Robot Structural Analysis and ETABS software.



(a) (b)

Fig. 8: Structural Model – (a) Robot Structure Analysis, (b) ETABS

The following Table II Shows the output generated by both Software which indicates the results are almost same, with minimal differences.

TABLE II. COMPARISON OF STRUCTURE ANALYSIS RESULTS IN ROBOT & ETABS

S. No	Description	Value
1	ETABS Support-9 Reaction, Fz (output)	143.029 Kips
2	Robot Structure, Support-9 Reaction, Fz (output)	143.049 kips

In Robot Structure Analysis, we are able to skip the tedious process of creating a model from scratch like we do in ETABS. With Robot Structure Analysis, we simply have to fetch the already prepared model in Revit and feed it into it. It automatically translates the reinforcements drawn in Revit into its model, which makes the process a lot easier. On the contrary side, with ETABS, we will have to prepare the whole model from scratch, which makes the process time-consuming. The table is given to prove that the accuracy doesn't fall down if we use robot structure analysis compared to popular ETABS software. So the point we are making is that to move towards a more productive environment while ensuring comparable accuracy.

E. Clash Detection Report

Figure 9 show the wall and column clash report of the commercial building with a tolerance of 0.061 m with 29 clashes yielded. These clashes were then removed by revising the architectural and structural models.

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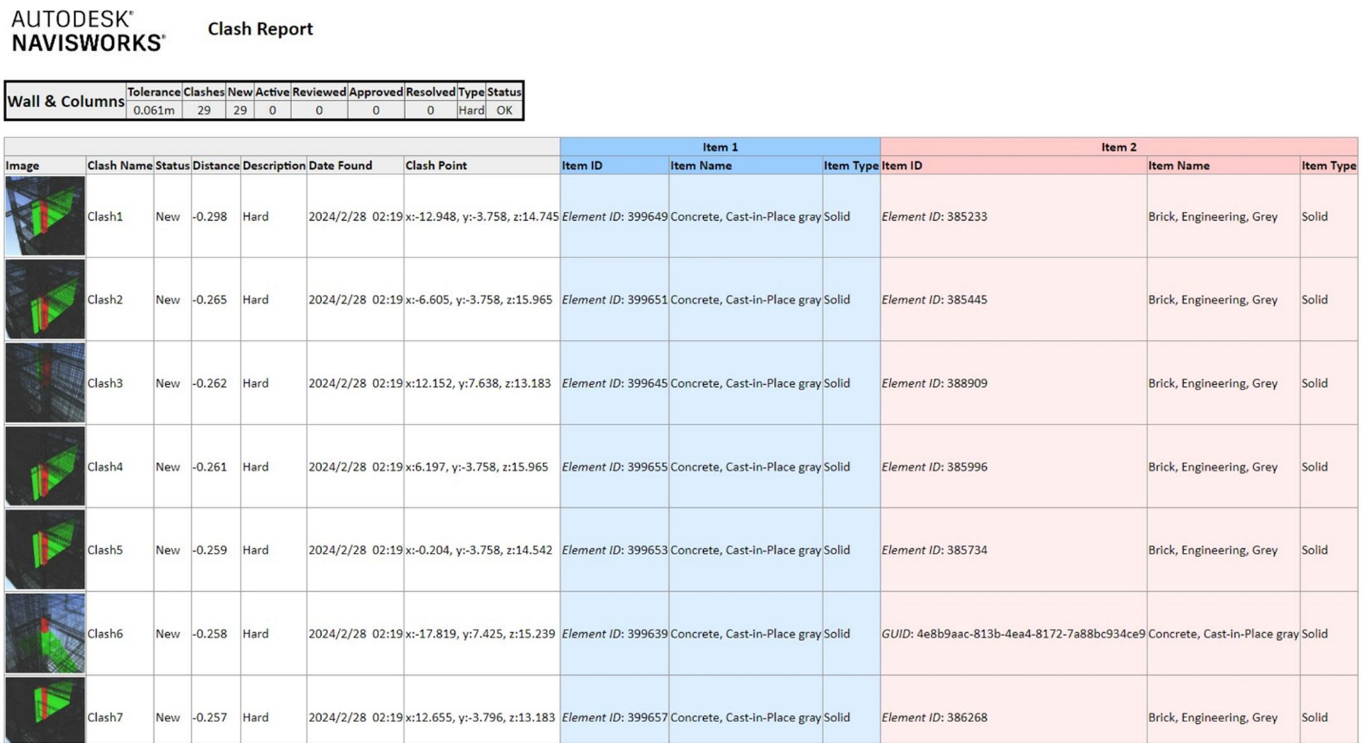


AUTODESK NAVISWORKS Clash Report

Wall & Columns	Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
	0.061m	29	29	0	0	0	0	Hard	OK

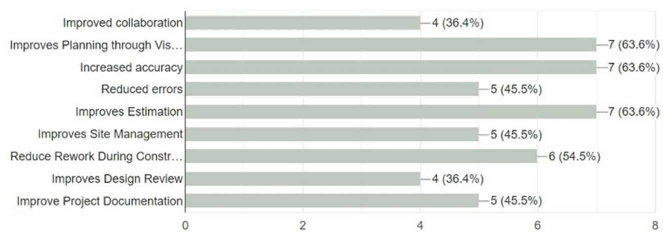
							Item 1			Item 2		
Image	Clash Name	Status	Distance	Description	Date Found	Clash Point	Item ID	Item Name	Item Type	Item ID	Item Name	Item Type
	Clash1	New	-0.298	Hard	2024/2/28 02:19	x:-12.948, y:-3.758, z:14.745	*Element ID*: 399649	Concrete, Cast-in-Place gray	Solid	*Element ID*: 385233	Brick, Engineering, Grey	Solid
	Clash2	New	-0.265	Hard	2024/2/28 02:19	x:-6.605, y:-3.758, z:15.965	*Element ID*: 399651	Concrete, Cast-in-Place gray	Solid	*Element ID*: 385445	Brick, Engineering, Grey	Solid
	Clash3	New	-0.262	Hard	2024/2/28 02:19	x:12.152, y:7.638, z:13.183	*Element ID*: 399645	Concrete, Cast-in-Place gray	Solid	*Element ID*: 388909	Brick, Engineering, Grey	Solid
	Clash4	New	-0.261	Hard	2024/2/28 02:19	x:6.197, y:-3.758, z:15.965	*Element ID*: 399655	Concrete, Cast-in-Place gray	Solid	*Element ID*: 385996	Brick, Engineering, Grey	Solid
	Clash5	New	-0.259	Hard	2024/2/28 02:19	x:-0.204, y:-3.758, z:14.542	*Element ID*: 399653	Concrete, Cast-in-Place gray	Solid	*Element ID*: 385734	Brick, Engineering, Grey	Solid
	Clash6	New	-0.258	Hard	2024/2/28 02:19	x:-17.819, y:7.425, z:15.239	*Element ID*: 399639	Concrete, Cast-in-Place gray	Solid	*GUID*: 4e8b9aac-813b-4ea4-8172-7a88bc934ce9	Concrete, Cast-in-Place gray	Solid
	Clash7	New	-0.257	Hard	2024/2/28 02:19	x:12.655, y:-3.796, z:13.183	*Element ID*: 399657	Concrete, Cast-in-Place gray	Solid	*Element ID*: 386268	Brick, Engineering, Grey	Solid

Fig. 9: Clash Detection Report

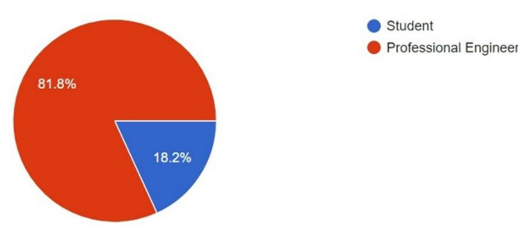
However, the Traditional method does not provide a clash detection report, which is a disadvantage that can show not only in the design but ultimately leads to a cost increase.

F. Survey Results

The below shows the survey, which was conducted as a part of the research, from the industry professionals & students. A total of 50 respondents participated in the questionnaire; they can be seen in the figures.



(a)



b)

Fig. 10: Survey – (a) Benefits of BIM, (b) Occupation

IV. DISCUSSION

The results indicate that BIM implementation enhances cost estimation accuracy, project scheduling efficiency, 3D visualization, and stakeholder engagement. Dynamo scripts are developed to automate the BIM models to lower the time & repetitive works, thus improving the planning phase in the building's lifecycle. Conversely, traditional design processes may face challenges with cost estimation accuracy and 2D design limitations. A lack of integration with design and analysis software for change requests and efficient workflows can increase the risk of delays in design plans of infrastructure. However, some of the technologies mentioned are still under development, like the Autodesk Navisworks, which, although it can give us a 4D model, still has to be able to integrate some advanced features to race with Primavera P6, which has some advanced features that can still win the favor of many contractors due to the level of detail it can take and provide. Plus, these advanced technologies require some technical expertise before operating them, which can prove to be a challenge in KP, where the construction market is still very conservative.

V. CONCLUSION

The following inferences can be made from the comparative study:

1) Traditional processes are flexible and familiar but can be ineffective in collaboration and lead to more errors.
2) BIM offers a simplified workflow, easy importation and exportation of data, and capitalizing on the advantages of BIM for improved design, analysis, and collaboration.
3) Implement BIM in most construction projects, particularly with intricate designs and multiple stakeholders.
4) Evaluate project requirements, size, and complexity to conclude if BIM implementation would benefit significantly.
5) In cases of less complex situations and limited resources and for smaller projects, consider legacy design methods.
6) BIM implementation involves investment upfront, introduces data management as well as interoperability challenges, and is largely dependent on technology.
7) The change will need collaboration among academics and the industry to respond to problems and greater skill and experience in BIM techniques.
8) One of the significant challenges that face BIM adoption in KP's construction industry is the inadequacy in terms of skill and awareness because there are inadequate professionals who know about applications such as Robot Structural Analysis.
9) Robot Structure Analysis Software user interface differs a lot from the traditional CSI software, and therefore there exists resistance to the change.

Overall, BIM exhibits great benefits in terms of efficiency, precision, and project results, especially for intricate projects and can be extremely important for KP's construction industry which is still very much entrenched in the Traditional inefficient but tested approaches.

VI. ACKNOWLEDGMENT

We would like to express my deep appreciation to Engr. Faisal ur Rehman from UET Peshawar Civil Engineering Department for his steadfast leadership throughout the process of writing our paper. His vigilant supervision ensured that our work was completed in all aspects. We appreciate the support and collaboration provided by NESPAK and other consultancies, whose contributions have enriched our research with practical industry insights and expertise.

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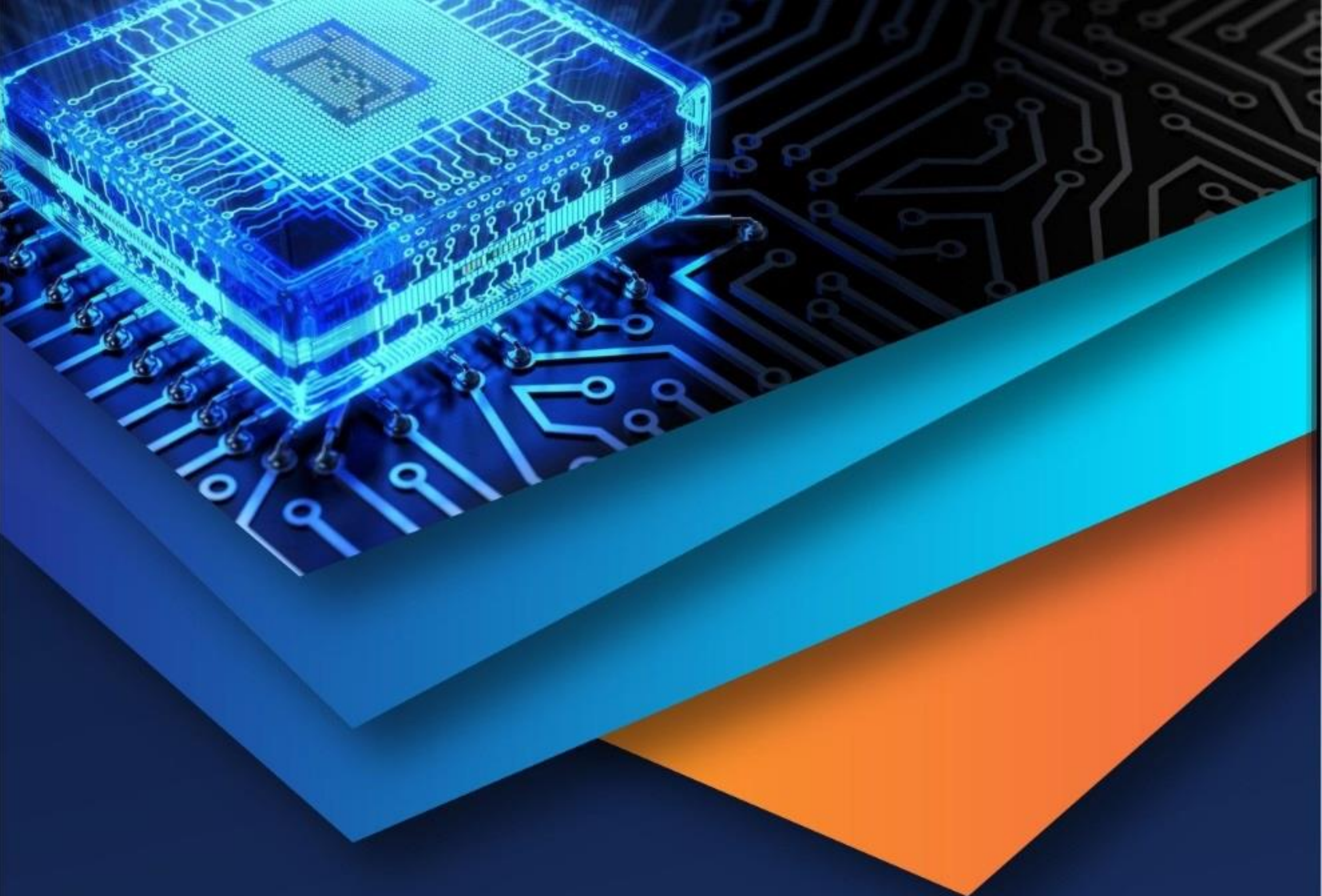

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