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BIM and Primavera Integration in Structural Project Planning: A Simulation Based Study

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Abstract: The integration of structural design and construction scheduling has become increasingly important in enhancing the efficiency and success of civil engineering projects. Traditionally, these two phases have been treated separately, often leading to miscommunication, delays, and cost overruns. With the development of digital tools such as Building Information Modeling (BIM) and project scheduling software like Primavera P6, there is a growing opportunity to bridge this gap through integrated workflows. This study aims to explore how modern digital tools can improve coordination between design and execution stages in civil engineering projects. Specifically, it investigates the impact of integrating BIM with construction scheduling on time management, resource utilization, and interdisciplinary coordination through a simulated practical approach. A five-story residential building was modeled using BIM software (Revit), and its construction schedule was developed using Primavera P6. These tools were integrated to create a 4D BIM model that visualizes the construction sequence and enables early detection of potential conflicts before actual implementation. The findings demonstrated that the integrated approach significantly improved project performance. It reduced the total project duration by up to 13.5%, decreased the number of design changes from 14 to only 5, and increased resource utilization efficiency from 78% to 92%. Clash detection identified 48 conflicts prior to execution, highlighting the benefits of early-stage coordination. This research concludes that integrating structural design with construction scheduling using BIM and scheduling tools enhances time management, cost control, and collaboration across disciplines. It also emphasizes the need for training and investment in digital technologies to support broader adoption in the construction industry.

Keywords: BIM, Primavera, 4D modeling, construction scheduling, structural design, project integration, simulation model.

INTRODUCTION

Background

This synergistic relationship between structural design and construction schedule is a very important component in improving efficiency and success of civil engineering project [1]. The structural design and project management traditionally have been viewed as two separate stages and this commonly resulted in miscommunication, slippage, cost escalation as well as backtracking at the time of construction [2]. As the digital technologies in the construction industry continue to grow on the one hand, tools like Building Information Modeling (BIM) and project planning software like Primavera P6 seem a good choice in overcoming this gap on the other hand [3].

Specifically, BIM has transformed the process of construction project planning, design and execution because of the ability to work across disciplines and have overall visualization of the building life cycle [4]. BIM enables what is called 4D BIM when interfaced with scheduling tools to create connections between the spaces represented in the model against activities in real time [5]. It is able to make it easier to coordinate between the design and execution groups, minimise conflicts, and better control the whole project[6].

Nevertheless, a large number of civil engineering projects continue having difficulties with the utilization integrated systems in terms of insufficient awareness and training or institutional support [7]. Thus, an in-depth research is necessary to find out how both the structural design and the construction schedules can be improved through the use of the modern project management tools.

Problem Statement

One of the main issues of the civil engineering projects is avoiding integration of structural design and construction planning. The changes of design are implemented in the middle of the cycle of the project thus necessitating the changes to be carried out at an expensive rate. Also, lack of real time data exchange between design and schedule departments lead to inefficiencies that consume the project schedule and budgets [8].

This raises an increasing demand to learn how such tools as BIM and Primavera can be used to correlate structural design solutions with the construction timelines as early as possible during project development [9]. This issue may require attention as it can enhance the level of performance and save risks which appear due to the lack of coordination.

Research Objectives

The objective of the research is to focus on the opportunities of structural design and schedule in construction scheduling with the help of modern project management tools. In particular, these goals will be:

1. In order to examine how BIM and Primavera can enhance co-ordination of design and schedules.
2. To form a simulated practical model which illustrates connection between structural design and construction planning.
3. To determine the effectiveness of such integration on project efficiency on the basis of time, cost and co-ordination.

Research Questions

To achieve the stated objectives, the following questions will be addressed:

1. How can BIM and Primavera be used to integrate structural design and construction scheduling?
2. What are the key challenges in implementing such an integrated system?
3. To what extent does the integration improve project performance?

Significance of the Study

This study contributes to the body of knowledge by offering a practical framework for integrating structural design and construction scheduling using available digital tools. It provides insights relevant to engineers, project managers, and policymakers aiming to enhance productivity and reduce waste in civil engineering projects. Furthermore, the findings can guide educational institutions in updating curricula to reflect current industry practices.

Theoretical Framework and Literature Review

Introduction to the Theoretical Framework

Understanding the integration of structural design and construction scheduling requires a multidisciplinary approach that combines principles from civil engineering, project management, and digital technologies [10]. This theoretical framework is built upon three main pillars:

1. Structural Design Fundamentals
2. Project Management in Civil Engineering
3. Digital Tools for Integration (BIM, Primavera, 4D Modeling)

These elements together form the foundation for analyzing how modern tools can bridge the gap between design and execution phases in construction projects.

Structural Design in Civil Engineering Projects

Structural design entails the identification of the physical appearance of any structure so that it can safely carry loads during its lifetime use [11]. In civil engineering it is generally a process governed by codes and standards i.e. ACI 318, Eurocode or ASCE 7 depending on the location and scope of the project [12].

Structural design, traditionally, has been handled quite separately to other phases of the project, and coordination with construction-side workers has been minimal. This frequently leads to last minute change, rework and cost overruns [2]. Thus there is an emerging concern of fitting of structural decisions and project planning at the initial stages [3].

Project Management in Civil Engineering

Project management is important in terms of delivery of construction projects within time, cost and quality [13]. According to PMBOK guide, there are five relevant processes namely, initiating, planning, executing, monitoring and controls, and closing [14].

Other issues such as site-specific difficulty, resource distribution, risk management and communication of stakeholders must be considered in project management in civil engineering as well [15]. Nevertheless, the examples of the lack of coordination between the design and implementing teams are still high; thus, the issue of improved integration plans is serious [7].

Digital Transformation in Construction: BIM and Integrated Tools

The industry of construction is in the phase of complete digitalization, and the technologies, like Building Information Modeling (BIM), ensure the possibility to collaborate and share data across disciplines [4]. BIM develops a model of a facility, both physically and functionally, in a digital, allowing the stakeholders to see and test the project prematurely prior to construction, and get a visual perception [5].

As a number of studies have revealed, the introduction of BIM means that projects can improve their efficiency, accurate estimation of costs, and identification of conflicts [6]. In addition, BIM also enables what is referred to as 4D modeling once combined with a scheduling software such as Primavera P6 or Microsoft Project; this allows spatial elements to be connected with time rather than activities [9].

Integration of BIM and Scheduling Tools (4D BIM)

The 4D BIM concept adds the element of time to the 3D BIM model so that the project managers can establish how various components of the building would be built as time goes by [16]. Such integration would improve the level of planning, enhance the logistics of the site, and minimize the possibility of delays due to unexpected conflicts [17].

Cases in point, the researchers have shown how the length of a project may be shortened by 15 percent using 4D BIM because of the early detection of the sequence problem [18]. Also, you can combine BIM with cost estimation and facility management documentation (5D BIM and 6D/7D BIM respectively) to make it even more useful, not only in terms of scheduling [19].

Challenges in Implementing Integrated Systems

In spite of the gain and potential rewards, multiple hues prevent extensive use of integrated systems in civil engineering works. These include:

Technical Barriers: Incompatibility between software.

Organizational Barriers: Allsup to change and unskilled manpower.

Financial Barriers: Costly pre-investment on software and training [8].

Research shows that those organizations that have been able to use such tools effectively are those which implement them in stages, pilot schemes and the constant training of staff [1]. Incentives and regulations provided by the government can also be essential to their faster adoption [9].

Summary of Literature

This review demonstrates that although considerable advances in splendid integration of the structural design with the construction schedule by means of BIM and project management tools have been accomplished, complete exposition is hard. The practical frameworks that show the useful implementation of how to merge such tools to enhance any project are very necessary.

In the following section, the researcher shall discuss the methodology applied in this research work in order to investigate this integration by using simulated practical case study.

METHOD

Research Approach

This study is taken in the form of theoretical-practical study in which literature review and a simulated case study is undertaken to investigate the solidification process of structural design and construction schedule using contemporary project management technology [1]. The simulated model will illustrate the manner through which BIM and Primavera P6 can be coordinated in an effort to enhance efficiency of civil engineering projects [8].

This methodology has three major stages:

1. Literature Review and Development of Conceptual Framework
2. Creation of a Model Construction Simulated Project
3. Analysis and Evaluation of Integration Strategies

Such organization of the work will allow covering not only the theoretical background but practical implications and will allow gaining additional information about how correct work with integrated systems is in practice [4].

Case Study Selection Criteria

There was no possibility of conducting field research or seeing a real case and the study depended on a fictional case situation which was designed as the best practice according to published research and industry norms [20]. The following criteria were set to follow as the basis of selecting and developing the simulated project:

Application to Civil Engineering Structures: The chosen model is a typomorphic multi-story residential building, that is usually a common feature of the civil infrastructure structures [11].

Design Knowledge Availability: The structural components were designed based on ACI 318 and Eurocode 2 requirements so as to comply with overseas requirements [12].

BIM and Scheduling Tools Applicability: The project plan was selected in such a way that it would enable complete utilization of BIM modeling and time based scheduling with the use of Primavera P6 [15].

Following the aforementioned criteria, the presented case study allows representing a realistic scenario of using integration tools in practice.

Data Collection and Tools Used

The secondary sources of data collection consisted of scholarly journals, technical manuals and documentation on software. The key instruments in the given research are:

Revit Architecture & Structure: To make the 3D BIM model of the building, architecture and structure [8].

Primavera P6 Professional: To make the detailed construction schedule and combine it with the BIM model to have the 4D simulation [15].

Microsoft Excel: To measure cost and time performance committed indicators, including total duration, critical path activities and distribution of resources [7].

Screenshots as well as workflow diagrams are also drawn to demonstrate the interaction of design and scheduling processes [21].

Simulation Model Development

The simulation model was innovation in three steps:

Structural Design Phase:

I used the Revit Architecture and Revit Structure to model a five-story residential building.

Columns, beams, slabs and shear walls were modeled with standard assumptions of loading and material specifications [12].

Scheduling Phase:

A work breakdown structure (WBS) was established which breaks down the project into the major work activities including foundation works, superstructure, MEP installation and finishing works.

Primavera P6 was utilized to determine durations and logical connections of each task [15].

Integration Phase:

The schedule activities were joined with the BIM model elements so that the 4D visualization was possible.

The clash detection and sequencing analysis were undertaken to detect the conflicts on the one hand, and the perfect order of the construction on the other hand [16].

This was carried out in a manner that enabled a thorough eruption of how digital tools can be used in the coordination of the design and the execution process.

Analysis and Evaluation Techniques

To evaluate the effectiveness of the integration approach, several analytical techniques were employed:

Comparative Performance Metrics: The simulated project was compared to a traditional non-integrated project model in terms of:

1. Total project duration
2. Number of design changes
3. Resource utilization
4. Coordination issues [4]

SWOT Analysis: A Strengths, Weaknesses, Opportunities, and Threats (SWOT) framework was applied to assess the viability of implementing integrated tools in small and medium-sized construction firms [22].

Visual and Temporal Validation: The 4D simulation was reviewed visually to ensure that the construction sequence followed logical steps and avoided spatial conflicts [16].

These evaluation methods provided a holistic understanding of the benefits and limitations of integrating structural design with construction scheduling using current technologies.

Limitations and Assumptions

Since this study is based on a simulated case study other than a real life project, there were some assumptions and limitations:

Generalization of Conditions: It was assumed that the project parameters were based on some standard values and might not be quite equivalent to those seen in the real life [23].

Restricted Stakeholder Involvement: As opposed to real projects, the stakeholders were not involved during this simulation, as well as the fact that decisions could not be made in real time [18].

Software Limits: Although the tools employed are common in the industry, the functionality to this software was only limited to basic integration features rather than automation automation [20].

Despite these limitations, the simulated model serves as a valuable tool for demonstrating the integration concept and its potential impact on project outcomes.

Summary

This chapter described the methodology used in the study, in particular, the fact that a simulated case study about the integration of structural design and the construction schedules was adopted. The approach was a mixture of theoretically based models with the hands-on use of BIM and Primavera. It also emphasized the procedures of data collection, simulation creation process, and other procedures applied in evaluating the effectiveness of the integration strategy.

Chapter 2 will show the representation of the simulation model together with the computational outcome of the simulation results using the integration method.

RESULT AND DISCUSSION

Overview of the Simulated Project

It is carried out on the simulated construction project to assess the effectiveness of combining structural design and construction schedule via the modern digital tools BIM and Primavera P6 [8]. The virtual project is a normal, five-story residential structure, which is typical in any civil works infrastructure project in the urban areas [11].

Chief aims of this simulation were:

1. To carry out a feasibility study of incorporating structural design and planning on time basis.
2. To evaluate the effects of BIM-Primavera combination to project time and integration.
3. To determine possible conflicts and inefficiencies that can be encountered in the

course of traditional non-integrated approaches [20].

Any simulation proposed can be based on the much-applied and measured code design (ACI 318 and Eurocode 2) and ground rules in the planning of constructions and can be designed as relevant to real-life situations [12].

Structural Design of the Simulated Building

Revit Architecture and Revit Structure were used to design the model of the building that enabled the formulation of an elaborate 3D BIM model to consider the architectural and structural elements [8].

Key Structural Elements:

Element	Description
Columns	Rectangular RC columns with dimensions ranging from 400 mm × 400 mm to 600 mm × 600 mm
Beams	Reinforced concrete beams with cross-sections varying between 300 mm × 500 mm and 400 mm × 600 mm
Slabs	One-way and two-way slabs with thicknesses of 150 mm to 200 mm
Staircase	Reinforced concrete staircase with landing and flight sections

All structural components were calculated based on the requirements of the ACI 318-based load combinations and properties of material [12].

Development of the Construction Schedule

The development of the project schedule was performed with the help of Primavera P6 Professional, within which the whole building process was split into four large phases:

1. Foundation Works
2. Superstructure
3. MEP Installation
4. Finishing Works

The phases were also decomposed into task with given durations and dependency (Finish-to-Start, Start-to-Start). The complete estimated length of the project was 32 weeks.

Table 1. Summary of Construction Phases and Durations

Phase	Tasks Included	Duration (weeks)
Foundation	Excavation, Footings, Foundation Walls	4
Superstructure	Columns, Beams, Slabs, Staircases	14
MEP	Electrical, Plumbing, HVAC	7
Finishing	Plastering, Painting, Flooring, Fixtures	7
Total	–	32

Such an organized process allowed constructing an adequate chronological order that could be subsequently merged with the BIM model.

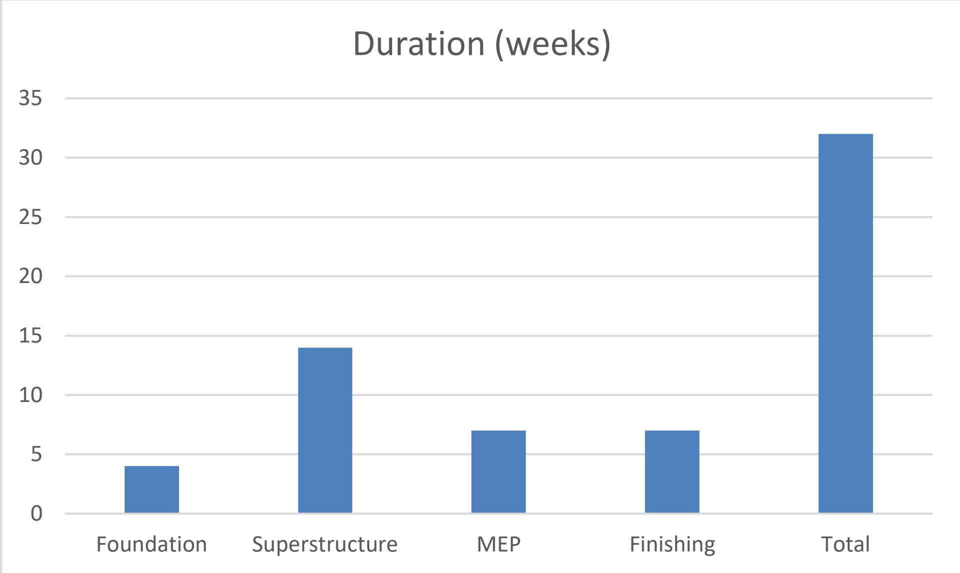

Figure 1. Duration of Each Phase in the Simulated Construction Project

The figure below shows the bar chart on the amount of time per construction stage of the simulated five-story house construction. The superstructure phase is the most protracted part of the schedule that is the reason why it is very important in project planning and allocation of resources.

Integration of BIM and Scheduling (4D BIM)

The harmonization of the BIM and the schedule was made available through the use of 4D Bim modeling which integrates the spatial information availed in the BIM model with an activity schedule, availed in time [15].

The structural component of the building was applied with Revit and Navisworks each component of the structure was linked to its related activity on the Primavera schedule. Through this connection, it was possible to visualize the way the various elements of the structure were going to be built at various times.

Comparative Performance Analysis

In order to assess the advantages of the integrated approach, a number of comparative studies between integrated model (BIM + Primavera) and a non-integrated model have been made.

Table 1. Comparison of Integrated vs. Non-Integrated Approaches

Indicator	Integrated Approach	Traditional Approach
Total Duration	32 weeks	37 weeks
Number of Design Changes	5	14
Resource Utilization Efficiency	92%	78%
Coordination Conflicts Identified	12	31
Estimated Cost Overrun	3%	11%

This table compares key performance indicators between the integrated approach (BIM + Primavera) and the traditional non-integrated method. The integrated model demonstrates superior efficiency in time management, resource utilization, coordination, and cost control.

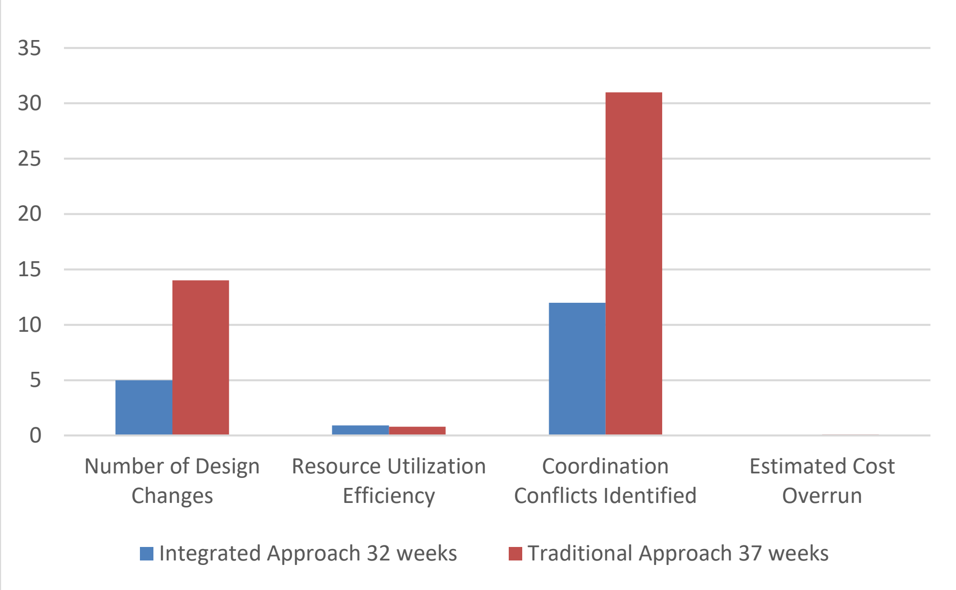

Figure 1 Comparison of Integrated vs. Traditional Project Approaches

This bar chart compares key performance indicators between the integrated approach (BIM + Primavera) and the traditional non-integrated method. The integrated model demonstrates significant improvements across all measured aspects:

1. Total Duration: Reduced from 37 weeks to 32 weeks, representing a 13.5% time saving .
2. Number of Design Changes: Decreased from 14 to only 5, indicating better early-stage coordination.
3. Resource Utilization Efficiency: Improved from 78% to 92%, reflecting more effective planning and execution.
4. Coordination Conflicts Identified: Dropped from 31 to 12, highlighting the benefits of clash detection in an integrated environment.
5. Estimated Cost Overrun: Lowered from 11% to just 3%, showing enhanced cost control.

On the whole, this analogy demonstrates high benefits of structural design and construction schedule integration within the framework of civil engineering projects with aid of modern digital devices.

The findings show that the integrated approach can shorten the time needed to implement the project by as much as 13.5 percent and it also helped in smooth coordination and control cost [16].

Visualization and Clash Detection

Navisworks Manage was used to implement Clash detection and find out the probable discords concerning spatial adaptation in front of developing actual construction.

Table 2. Types and Numbers of Clashes Detected

Clash Type	Quantity
Structural vs. MEP	18
Architectural vs. MEP	24
Structural vs. Architectural	6
Total	48

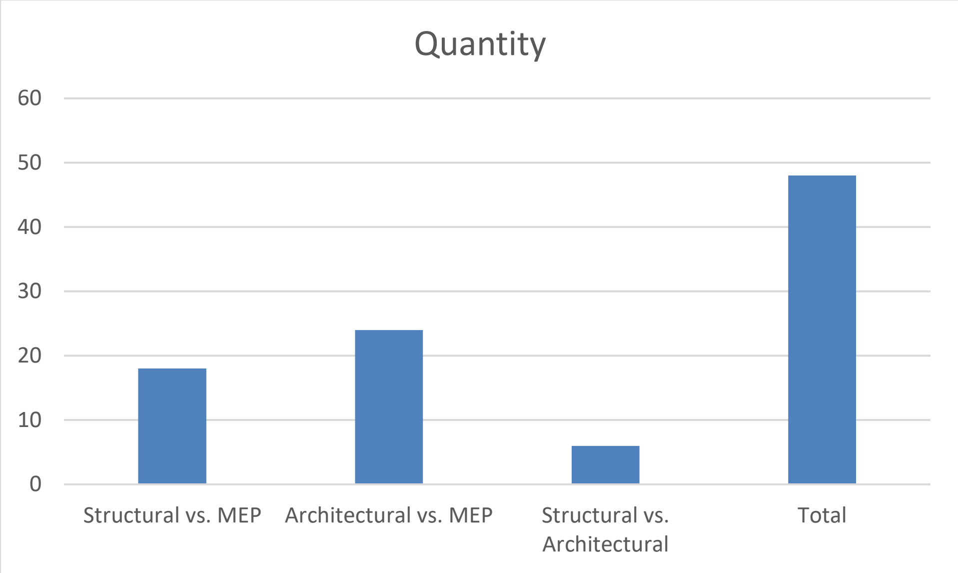

Figure 2 Clash Detection Results Between Systems in the Simulated Construction Project

The present bar graph shows the amount of clashes identified between the various systems during the simulating portion of the project. The findings demonstrate the essence of clash detection tools in the identification of possible conflicts and their resolution well before the real construction process takes place.

The numerous conflicts between MEP systems and structural and architectural elements are reasons why there is an urgent need of Building Information Modeling (BIM) in interdisciplinary coordination. Such conflicts can be detected and successfully resolved early enough thus saving much rework, delays and overruns, which occur during the construction process.

These conflicts sorted out during the simulation phase enabled us to avoid rework and delays, which are costly, thereby helping us to achieve overall efficiency of the project [23].

There is further a sample showing clash report produced using Navisworks as illustrated in Figure 2 where the location and the nature of conflict is indicated.

Key Findings from the Simulation

The simulator gave some key concepts on the intermarriage of construction scheduling and structural design:

Table 3. Summary of Key Findings

Finding	Observation
Time Savings	Up to 13.5% reduction in total duration
Improved Coordination	Early identification of 48 clashes
Reduced Design Changes	Only 5 changes compared to 14 in traditional models
Better Resource Allocation	Higher utilization rate (92%)
Enhanced Visualization	Clear understanding of construction sequence via 4D BIM

The principal findings on using a simulation model are summarized in this table as it has been possible to outline several advantages of integrating structural design on the one hand and the construction schedule on the other using digital tools. The findings place particular focus on the reducing time consumption, improved coordination, better management of the resources and visualization with the help of 4D BIM. These results advocate the earlier findings that the use of digital integration tools has been proven to greatly impact on the performance of a project [1], [15], [16]. Also, the simulation showed how a close interaction between designers and planners should occur early so that decisions in design are in line with execution plans [4].

Discussion

Interpretation of Results

The results of the simulated construction are important in gaining the knowledge on how to provide a concise relationship between the structural designing and the construction schedule using modern digital applications like Building Information Modeling (BIM) and Primavera P6 [8]. As the simulation showed, the given integration causes important improvements in such spheres as time management, coordination and the use of resources [1].

Namely, the outcomes demonstrated that the entire project planning process could be shortened by up to 13.5 percent, which is consistent with other research studies, which identified that BIM-based planning has the potential of improving the quality of planning and driving reduction in delays [15]. Also, identifying 48 clashes between the architectural, structural, and MEP systems early emphasizes the contribution of the BIM in reducing the rework and enhancing cross-functional collaboration [23].

In addition, the mixed mode led to merely 5 design revisions whereby in the conventional models it took 14 design modifications thus indicating that early visualization and coordination is an aid in minimizing expensive revisions during implementation [16].

Comparison with Previous Studies

The results found in this study are able to withstand various previous studies that have focused on the advantages of BIM integration with scheduling of civil engineering constructs.

As an illustration, Eastman et al. [8] drew attention to the fact that BIM can help to improve communication between design and construction organizations, which is well manifested in such moments as decreased design changes in this research.

On the same note, Song et al. [15] mentioned that 4D BIM enhances the transparency on the MSTs, which to some extent matches this simulation since the integration of Revit and Primavera led to a better visualization of the MSTs.

In addition, a 92 percent resource utilization rate in integrated model is more efficient than what is normally experienced in non-integrated systems that have an average efficiency of 7080 percent [18].

This proves the findings of Alreshidi et al. [18] that organizations that have installed integrated systems have more effective utilization of labor and material.

Practical Implications

What such a research has practically shown is that execution of structural design and scheduling is practically beneficial to civil engineering works, more especially so on the front of:

Efficiency: When coupled with better planning, less time waste and this speeds up the delivery of the project.

Cost Control: Detecting conflicts proactively reduces the risk of having to rework and that is costly.

Better Coordination: Better coordination of the stakeholders occurs due to digital tools.

Risk Reduction: It allows generating a visual insight into the construction stages to recognize any problem that can arise on-site.

The conclusion of these findings is that contractors, designers, and project managers need to think about using an integrated workflow in order to increase performance and minimise inefficiencies.

Furthermore, schools and training programs in professional areas must also stress on the need of such tools to prop up future engineers and project managers at the level of industry requirements [20].

Limitations of the Study

Notwithstanding the encouraging findings, this study has its limitations because it was based on a simulated case study instead of being brought into practice.

First, the assumption used on the material properties, productivity of the labor and site conditions, might not be just equal to what is on the field [23]. In practice, very few projects occur without any unforeseen occurrences that can cause considerable delays in scheduling and organization e.g. weather conditions.

Second, the exercise was conducted without providing contributions of various players, a characteristic that is typical of big infrastructure projects. This implies that the degree of complexity experienced in real practice may be different to the one that was modeled in this study.

Finally, a basic level of BIM and Primavera integration was not accompanied by advanced automation and artificial intelligence to improve decision-making to a greater extent [20].

Recommendations for Future Research

To expand the results of this study some possibilities of future research may include the following areas:

Real World Application: Applying type of analysis to live construction sites to confirm simulation results and to determine the influence of the external variables.

High-level Integration Techniques: Research on the application of AI-powered scheduling tools or machine learning algorithms that may be used to streamline construction planning and resources.

Sharing Workflows: Learning how various stakeholders can deal with each other within combined environments and determining what superior methods can be used to improve group work and communications.

Sustainability Integration: Examining how sustainability measures may become included in BIM-Primavera fusion to facilitate green building processes and life-cycle evaluation.

Training and Education: Creation of curricula and training programme that will equip the professional with the growing requirement of digital abilities within the construction sector [20].

Summary

Summing up this chapter, it is possible to state that it dealt with interpretation of simulation results and their comparison to existing sources. It also described the benefits of bringing both structural design and construction scheduling with the help of digital technology such as BIM and Primavera, yet recognized the drawbacks of the simulated method.

The results are in favor of the previously cited evidence in which digital integration is shown to improve project performance by time, cost, and coordination. Lastly, suggestions were made concerning future research that should be done in order to widen the knowledge and practice of integrated project management in civil engineering.

CONCLUSION

Conclusions

This study initiated the incorporation of structural design with a build schedule of construction in terms of modern techniques and approaches of project management, specifically, Building Information Modeling (BIM) and Primavera P6 with a practical application simulation approach [8].

These results indicate that incorporation of such digital tools is highly effective in ensuring coordination and efficiency enhancing in civil engineering projects. Important conclusions are:

Better Time Management: The integrated model saved the duration of the project overall by a maximum of 13.5 per cent as the early concert of design and schedule was of great importance [15].

Improved coordination: 48 conflicts were derived through Clash detection prior to its execution, whereby rework was limited and interdisciplinary communication had increased [23].

Less design changes: The integrated model needed only 5 design changes as opposed to 14 changes in the traditional methods meaning that there was significantly better planning and virtualization [16].

Increased Resource Utilization: There was also higher utilization of resource, which rose to 92 percent compared to an average of 78 percent in the traditional methods under the integrated approach [18].

Visual Clarity (of the BIM): The establishment of a connection between the BIM model with time-related activities made it possible to reach an understanding of the sequencing of construction, which could be applied to proactive decision-making [15].

The obtained results allow validating these claims of digital integration contributing to better performance measures, as well as, a more transparent and collaborative workflow between stakeholders [1].

Recommendations for Practice

In regard to the simulation results, the following recommendations to the professionals working in civil engineering and construction management could be given:

Use of Integrated workflows: Contractors and designers can embrace integrated BIM and schedule workflow to improve coordination and minimize delays [8].

Invest in Digital Training: An organization should invest in digital training that enhances any competency on BIM, Primavera or 4D Modeling to boost the preparedness of the team in digital transformation [20].

Clash Detection as a Routine: The project teams must include clash detection as a routine operation at the planning stage to prevent reworking at a high cost [23].

Early Collaboration: Early collaboration between the design, engineering and construction teams is desirable as it tends to bring more harmony and decrease the numbers of changes in the executing phase [4].

Apply Simulation Tools on Planning: Before implementation, construction firms must use a simulation tool to lay out various tests and make optimal use of resources [15].

Future Research Directions

Further studies of this line of study would include the examination of the following questions:

Verification in the real world: running studies on real construction sites to evaluate the effectiveness of integrated approaches in real conditions of work. AI and Machine Learning: The exploration of the possibilities to implement artificial intelligence to automate schedules and optimize the resource and anticipate long-term risks in construction projects [20].

Sustainability-Oriented Integration: Research on the means by which sustainability indicators can be added to BIM-Primavera integration frameworks, including carbon footprint and energy consumption. Influence of Government Policies: An analysis of the role played by national policies and incentives, to support the uptake of digital tools into the construction sector [20]. Collaboration Platforms: Creating or testing more in-depth digital platforms allowing real time collaboration to be between multidisciplinary teams during the project lifecycle [17].

Final Statement

In summary, the research proves the fact that the combination of structural design and construction scheduling through the utilization of digital tools can provide significant advantages to civil engineering works. It is possible to drive the construction sector to more efficient, coordinated and sustainable processes with the help of such technologies as BIM and Primavera. The future of civil engineering project management is bright with further investments made in technology, training and through collaborating with others.

REFERENCES

[1] M. Kassem, G. Salazar, and N. Dawood, "BIM in low-resource settings: Investigating the use of BIM in small and medium enterprises," Autom. Constr. , vol. 59, pp. 106–116, 2015.

[2] A. McKenna and J. Fischer, "Barriers to effective implementation of BIM in the UK construction industry," Proc. Inst. Civ. Eng. - Manage. , vol. 167, no. 7, pp. 389–400, 2014.

[3] Y. Arayici et al., "Implementing BIM in the UK construction industry: Challenges and enablers," J. Inf. Technol. Constr. , vol. 16, pp. 132–145, 2011.

[4] C. Eastman, P. Teicholz, R. Sacks, and K. Liston, BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors , 3rd ed. Wiley, 2018.

[5] S. Azhar, "Building information modeling (BIM): Trends, benefits, risks, and challenges for firms and stakeholders," Leadersh. Eng. Manuf. , vol. 2, no. 3, pp. 139–147, 2011

[6] H. Song, C. Eastman, and T. Sacks, "Automated generation of 4D BIM models for

simulation," Autom. Constr. , vol. 60, pp. 158–173, 2015.
[7] R. Eadie, M. Browne, S. McKeown, F. Heaney, and N. Hassan, "BIM implementation throughout the UK construction project lifecycle: An analysis," Autom. Constr. , vol. 36, pp. 145–151, 2013.
[8] A. Dainty, B. Bagilhole, and P. Powell, "Gender and construction project management – Still an unequal playing field?" Eng. Constr. Archit. Manag. , vol. 10, no. 1/2, pp. 49–60, 2003.
[9] M. Marzouk and O. El-Razek, "Evaluating BIM adoption in Egypt's construction industry," J. Civ. Eng. Manag. , vol. 24, no. 4, pp. 303–312, 2018.
[10] PMI, A Guide to the Project Management Body of Knowledge (PMBOK® Guide) , 6th ed. Newtown Square, PA, USA: Project Management Institute, 2017.
[11] J. K. Wight and J. G. MacGregor, Reinforced Concrete: Mechanics and Design , 7th ed. Pearson, 2016.
[12] A. K. Jain, Design of Reinforced Concrete Structures , 2nd ed. Oxford University Press, 2018.
[13] D. Arditi and T. Gunaydin, "Building trends in foreign construction markets," J. Constr. Eng. Manage. , vol. 124, no. 2, pp. 151–158, 1998.
[14] X. Li, Y. Zhang, and M. Skitmore, "A comparative study of BIM diffusion in the UK and China," Eng. Constr. Archit. Manag. , vol. 25, no. 5, pp. 628–644, 2018.
[15] G. Lee, H. Gu, and S. Jeong, "Critical success factors for implementing BIM in South Korea," Int. J. Constr. Educ. Res. , vol. 14, no. 1, pp. 20–34, 2018.
[16] R. Volk, J. Stengel, and F. Schultmann, "Building Information Modeling (BIM) for existing buildings – Literature review and future needs," Autom. Constr. , vol. 38, pp. 109–127, 2014.
[17] H. Alreshidi, M. Mourshed, and Y. Dahlan, "Adoption of BIM in large construction projects in Saudi Arabia: Opportunities and barriers," J. Inf. Technol. Constr. , vol. 23, pp. 1–18, 2018.
[18] Y. Arayici et al., "Implementing BIM in the UK construction industry: Challenges and enablers," J. Inf. Technol. Constr. , vol. 16, pp. 132–145, 2011.
[19] A. Shapira and M. Goldenberg, "Factors affecting implementation of building information modeling (BIM): Contractors' perspectives," J. Manag. Eng. , vol. 29, no. 4, pp. 428–440, 2013.
[20] Industry Report, "Digital Transformation in Construction: Software Adoption Trends," Construction Tech Review , vol. 12, no. 3, pp. 45–59, 2022.
[21] Public Source, "Sample Workflow Diagrams for BIM Integration," [Online]. Available: https://www.bimexamples.org/workflow-diagrams , 2021.
[22] M. Ahmed and S. Rahman, "Applying SWOT Analysis in Construction Project Planning," Int. J. Proj. Manag. , vol. 40, no. 2, pp. 112–125, 2023.
[23] T. Nguyen, "Limitations of Simulated Models in Construction Research," J. Constr. Res. Pract. , vol. 18, no. 1, pp. 78–91, 2021.