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FULL LENGTH ARTICLE

A Study of the Impact of Applying Building Information Modeling (BIM) on the Efficiency of Engineering Supervision in Syria

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ABSTRACT

In recent years, the construction sector in Syria has witnessed increasing challenges related to the weak efficiency of engineering supervision, leading to increased costs, delayed completion, and recurring field conflicts between different disciplines. In light of the digital transformation taking place in the global construction sector, Building Information Modeling (BIM) has emerged as a modern technical solution capable of improving the quality and effectiveness of supervision. From this perspective, this study analyzed the impact of implementing Building Information Modeling (BIM) on enhancing the efficiency of engineering supervision in Syrian projects, by assessing its role in improving information quality, controlling schedules, and reducing errors and costs. The study adopted a descriptive analytical approach supported by a field study. A comprehensive questionnaire was developed, including 24 criteria covering all aspects of engineering supervision, and distributed to a sample of 90 supervising engineers in the public and private sectors. The results showed that adopting BIM clearly contributes to improving the accuracy of information and facilitating its exchange between parties, early detection of field conflicts prior to implementation, enhancing progress monitoring, and reducing rework rates. This increases supervision efficiency and achieves cost and time savings. However, the study revealed obstacles that limit the implementation of BIM in Syria, most notably weak digital infrastructure, a shortage of qualified personnel, the absence of regulatory policies supporting digital transformation, and weak training and qualifications in Syrian university curricula. The study concluded the need to adopt clear government policies mandating the use of BIM in major projects, develop specialized training programs for engineering supervisors, and establish a Common Data Environment (CDE) that supports digital integration among all parties. The results also confirmed that the shift to digital supervision using BIM is no longer just a technical option, but rather a strategic step to improve the efficiency of construction projects in Syria and ensure their sustainability.

Keywords: Engineering Supervision Efficiency ▪ Building Information Modeling (BIM)

1. INTRODUCTION

In recent years, the construction and civil engineering sector has undergone a profound transformation driven by rapid technological advances, particularly digital transformation, which has become a decisive factor in improving project quality and efficiency. Among the most salient of these shifts, Building Information Modelling (BIM) has emerged as an advanced tool that fundamentally reshapes how construction projects are planned, designed, executed, and managed [1-5]. BIM is defined as a digital process centered on creating an intelligent three-dimensional information model that serves as a unified, comprehensive reference for all project stakeholders, thereby enhancing coordination and collaboration, reducing errors, and improving decision-making throughout the project lifecycle. BIM is no longer

merely a design technology; it has evolved into an integrated system for managing engineering projects, including site-based construction supervision [6-8]. Construction supervision is a criti cal function for ensuring efficient, high-quality project delivery. It focuses on monitoring field work, verifying conformance with drawings and specifications, and ensuring adherence to established schedules and budgets. As projects grow more complex —with multiple stakeholders and expanding volumes of information the need for smart tools that strengthen supervisors' capacity to perform their duties efficiently has become increasingly pressing [9-10]. Against this backdrop, the present study examines the impact of BIM on enhancing the efficiency of construction supervision by analysing the extent to which BIM contributes to improving supervision quality, reducing waste and errors, and supporting decision-making in field environments. The academic and practical value of this research lies in offering an analytical perspective grounded in field data from the Syrian project context, thereby deepening our understanding of the role of digital transformation in advancing construction supervision.

2. RESEARCH PROBLEM

Construction supervision is one of the fundamental pillars for ensuring high-quality project delivery and achieving targets related to time, cost, and technical standards. However, in Syria this function faces mounting challenges, including the growing complexity of modern projects, weak digital infrastructure, shortages of qualified personnel, and continued reliance on traditional methods for monitoring and documenting work. These factors have diminished supervision efficiency and made it difficult to verify execution quality in a timely manner. In contrast, Building Information Modelling (BIM) has emerged as a promising digital tool to support construction supervision through capabilities such as three-dimensional modelling (3D), 4D scheduling (time linking), 5D cost analysis, and cross-disciplinary clash detection. These capabilities help improve information accuracy, accelerate decision-making, and reduce field errors.

Despite these advantages, a substantial gap persists in the Syrian construction industry rega rding supervisors' awareness of the extent to which BIM adoption can enhance supervision efficiency in construction projects. Local studies have not sufficiently addressed field-based evaluations of BIM's impact on supervision dimensions such as documentation accuracy, quality control, and information exchange.

3. IMPORTANCE OF THE RESEARCH

The importance of this study is grounded in the evolving context of Syria's construction sector, where the shift toward digital solutions and advanced technologies has become imperative to address growing project complexity and demands particularly in the forthcoming reconstruction phase. As the adoption of Building Information Modelling (BIM) expands, there is a pressing need to understand its impact on construction sup ervision, which is the principal safeguard of execution quality. This study highlights recurring challenges in supervision within Syrian construction projects often driven by the unavailability of accurate, timely information and weak coordination among project parties. Drawing on a field study based on data from real projects and the perspectives of engineers working in construction, the research seeks to formulate recommendations for developing mechanisms to enhance supervision efficiency in construction projects, support digital transformation efforts, and strengthen reliance on BIM applications across Syria's construction industry.

4. RESEARCH METHODOLOGY

This study adopts a descriptive–analytical approach as the most suitable framework for examining the relationship between Building Information Modelling (BIM) and the efficiency of construction supervision. It includes a field study involving the design of a questionnaire to collect data relevant to the research, which is distributed to a sample of engineers and BIM specialists working in Syria's construction industry.

5. REFERENCE STUDIES

This research systematically reviewed prior studies addressing Building Information Modelling (BIM) and its impact on various facets of engineering project management — particularly construction supervision. The review encompassed local, regional, and international contributions and focused on construction projects spanning multiple sectors of the industry

First Study

Gang, F., & Shu, W. (2019). A framework for BIM-based quality supervision model in project management (pp. 234–242). In M. Hajdu & G. Lajos (Eds.), Proceedings of the Creative Construction Conference 2019. [11].

"A Framework for a BIM-Based Supervision Model in Project Management" The authors developed a digital supervision framework based on the Industry Foundation Classes (IFC) standard, integrating BIM models into the project quality-management system. They applied the model to a real project in China to assess its impact. The results showed notable improvements in reporting accuracy and the standardization of procedures compared to traditional methods. The study also demonstrated that integrating BIM reduces reliance on paper-based documentation and enhances the accuracy of digital reports. Despite its scientific rigor, the study is limited by its exclusive focus on quality aspects; it does not extend to other supervision performance indicators such as time, cost, or cross-party coordination areas this thesis addresses more comprehensively. Moreover, the single-project application in China constrains the generalizability of the findings to other contexts. By contrast, the present thesis seeks results applicable to the Syrian environment, which has distinct organizational and technological challenges. Accordi ngly, this work views the study as an important foundational reference, especially its key finding that BIM integration reduces paper dependence and improves the accuracy of digital reporting.

Second Study

Shaban, M., Al-Hassan, B., & Mohamad, A. S. (2024). Digital transformation of quality management in the construction industry during the execution phase by integration of building information modelling (BIM) and cloud computing. Building Engineering, 2(1), Article 1132 . [12]. “Digital Transformation in Quality Management through Integrating BIM and Cloud Computing” The researchers developed a digital system that integrates BIM with cloud computing to enhance quality management during execution. Implemented on a project in Syria, the system yielded measura ble improvements in defect-response speed and documentation quality. It enabled supervisors to make rapid, data-driven decisions in real time. This study is particularly relevant because it was conducted in Syria, making its context closely aligned with th e present research. It also examines the integration of BIM and cloud solutions to improve quality during the supervision and execution phase the same stage emphasized in this thesis, especially with respect to empowering supervisors to act on real-time information. Nonetheless, the study concentrates primarily on quality management and does not address broader supervision dimensions such as scheduling, cost management, or reporting efficiency areas that the current research seeks to cover more comprehensiv ely. A key takeaway is that combining BIM with cloud computing improves response times and supports direct, on-site data capture and documentation.

Third Study

Almujibah, H. (2023). Assessment of BIM as a time and cost-saving construction management tool: Evidence from two-story villas in Jeddah. Sustainability, 15, Article 97354. [13]. “Evaluating Building Information Modelling (BIM) as a Time- and Cost-Saving Construction Management Tool: Evidence from Two-Story Residential Villas in Jeddah” This study ev aluates the role of BIM as a tool for managing time and cost in construction through an applied investigation of two-story residential villas in Jeddah, Kingdom of Saudi Arabia. Using a comparative design, the authors contrasted one project that adopted BI M with a counterpart executed through conventional methods. The analysis showed that BIM adoption reduced execution time by 17% and lowered indirect costs by 12%. The study also highlighted challenges associated with limited local expertise and resistance to change, and it recommended broader BIM adoption across public and private residential projects. The study directly addresses time and cost key dimensions incorporated into this thesis’s hypothesis regarding improved supervision performance. However, its scope is confined to small-scale residential projects, and it does not treat supervision as a distinct engineering function. By contrast, the present research aims to examine these issues within the relatively more complex context of Syrian infrastructure projects. A central takeaway is that BIM adoption demonstrably shortens schedules and reduces indirect costs, reinforcing the inclusion of time and cost indicators in evaluating supervision efficiency.

Fourth Study

Matos, J., & Miranda, G. (2018). The use of BIM in public construction supervision in Brazil. Organization, Technology & Management in Construction, 10(1), Article 0007 .[14]. “ Using BIM in the Supervision of Public Construction Projects in Brazil” This study outlines the role of BIM in improvin g supervision processes for public construction projects in Brazil, with emphasis on strengthening stakeholder coordination and reducing execution-phase errors. The researchers

employed an analytical methodology based on surveys and interviews with engineers and supervisors involved in actual projects. Findings indicate that BIM use increased the accuracy of information available to supervisors, reduced delays caused by errors, and improved resource management and scheduling. The study underscores the importance of integrating BIM into supervision to enhance performance and minimize waste. Its focus aligns closely with the present research, particularly in demonstrating how BIM elevates information accuracy and lowers error rates during execution core object ives of this thesis. A key takeaway is that systematic BIM integration within supervision workflows can materially improve schedule reliability and operational efficiency in public-sector projects. Fifth study: Tsai, W., Liu, Y., & Zhang, H. (2023). BIM-based government engineering quality supervision system in China. Journal of Asian Architecture and Building Engineering, 23(6), 1966 –1979. “A Government. [15]. "Supervision System Based on BIM and Cloud Computing in Chinese Construction Projects” This study e xamines the development of a government-led supervision system that leverages BIM and cloud computing to improve the quality of project monitoring and control in China. Using an experimental methodology, the system was deployed on actual construction proje cts and benchmarked against conventional approaches. Results showed substantial gains in decision-making speed, reporting accuracy, and the efficiency of progress tracking, alongside reductions in errors and costs. The findings further indicate that integr ating BIM with cloud technologies enhances the transparency and effectiveness of government supervision. While the study illuminates the governmental dimension of supervision, it does not address the conditions of developing countries such as Syria nor does it provide a detailed analysis of tools for schedule management or cost analytics within the supervisory framework. A key takeaway is that a cloud-enabled BIM supervision system can accelerate decisions, improve report accuracy, and increase the transpar ency and efficiency of government oversight in construction projects.

6. THEORETICAL FRAMEWORK

6.1 Building Information Modeling (BIM)

6.1.1 Introduction

BIM is the process of generating and managing building data throughout its lifecycle. This form of mod elling treats design as objects abstracts or undefined, generic or specific products, and either solid or void forms such as a room shape; these objects carry geometric properties as well as their associated relationships and attributes. Design tools in an information-modelling system allow the extraction of different building views (projections) for production purposes and other uses. These views remain automatically coordinated with one another: each object is defined only once just as in reality and its size, shape, and location are consistent across all views. Such automatic coordination eliminates many of the errors that arise when each view is drafted separately using conventional methods. (1)

BIM is an innovative methodology that improves communicati on and collaboration among stakeholders in a construction project. Implemented as a dynamic system, Building Information Modelling (BIM) helps achieve a high-quality end product and supports information management across the entire project lifecycle not only during design and construction, but also throughout operation and maintenance. (2)

6.1.2 Benefits and Applications of Building Information Modeling (BIM)

1. Faster delivery with higher quality and productivity. (3)
2. Design enhancement, through information-rich 3D models and iterative analyses.
3. Cost control, via automated quantity take off and 5D cost estimation that improve budget accuracy and optimize expenditures.
4. Improved coordination, enabling multidisciplinary integration and streamlined information exchange within a Common Data Environment (CDE).
5. Risk reduction and compliance: BIM can be used to analyse risks and verify compliance with codes, standards, and regulations, thereby lowering project risk and supporting legal and environmental requirements.
6. Schedule precision and progress monitoring: develop accurate project schedules and effectively track progress and milestones (4D scheduling).
7. Accurate project models for both buildings and infrastructure that reduce errors and improve the quality of design and execution.
8. Enhanced collaboration among stakeholders (architects, civil engineers, contractors, and owners), enabling efficient sharing of data and information.
9. Improved sustainability, through performance analyses (e.g., energy and material efficiency) that support green-building objectives.
10. Clash detection: BIM platforms provide tools that facilitate identifying and resolving conflicts among building elements during multidisciplinary model coordination. (4)

6.1.3 BIM Maturity Levels

The term “BIM Maturity Levels” refers to the progressive stages through which organizations or projects advance in their adoption of BIM methods and technologies from basic modelling to full digital integration among all project stakeholders. Developed to assess readiness and progress in effective BIM adoption, and in line with the UK BIM Framework and ISO 19650, maturity is commonly grouped into four primary levels: Level 0: This level is defined as unmanaged CAD. This is likely to be 2D, with information being shared by traditional paper drawings or in some instances, digitally via PDF, essentially separate sources of information covering basic asset information. The majority of the industry is already well ahead of this now Level 1: This is the level at which many companies are currently operating. This typically comprises a mixture of 3D CAD for concept work, and 2D for drafting of statutory approval documentation and Production Information. CAD standards are managed to BS 1192:2007, and electronic sharing of data is carr ied out from a common data environment (CDE), often managed by the contractor. Models are not shared between project team members. Level 2: This is distinguished by collaborative working all parties’ use their own 3D models, but they are not working on a single, shared model. The collaboration comes in the form of how the information is exchanged between different parties—and is the crucial aspect of this level. Design information is shared through a common file format, which enables any organization to combine that data with their own in order to make a federated BIM model, and to carry out interrogative checks on it. Hence any CAD software that each party uses must be capable of exporting to a common file format such as IFC (Industry Foundation Class) or Co bie (Construction Operations Building Information Exchange). This is the method of working that has been set as a minimum target by the UK government for all work on public-sector work, by 2016. Level 3: This level represents full collaboration between all disciplines by means of using a single, shared project model that is held in a centralized repository (normally an object database in cloud stor-age). All parties can access and modify that same model, and the benefit is that it removes the final layer of risk for conflicting information. This is known as “Open BIM.” (5)

6.1.4 BIM Dimensions

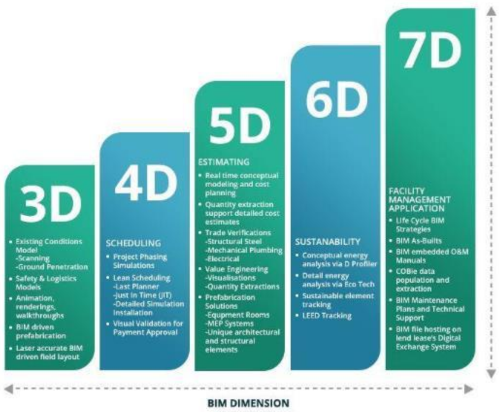

Figure 1. BIM dimensions.

First and Second Dimensions (1D & 2D): This level represents two-dimensional data and information such as engineering drawings and general site plans which can be used for basic review and navigation of the construction project. Third Dimension (3D): This refers to model-linked data such as material specifications, component definitions, and cost attributes that can be used to improve the design, execution, and maintenance of buildings and infrastructure. “The digital representation of a facility’s physical and functional characteristics, together with shared access to information about the facility, constitutes a fundamental basis for decision-making throughout the building’s life cycle.” (6) Fourth Dimension

(4D): A 3D model + time. "Building Information Modelling has enabled the preparation of project schedules for diverse design undertakings in a manner aligned with design and construction processes; previously, thi s was done in a conventional and disjointed way, increasing the time required to complete the task." (7) Fifth Dimension (5D): A 3D model + cost. "Using BIM makes it possible to develop a mechanism that helps compute quantities in accordance with design specifications including material standards and installation methods which in turn enables the direct preparation of pricing schedules during the design and construction phases." (7) Sixth Dimension (6D): This dimension adds environmental and sustainabilit y information to the model such as energy consumption and the project's environmental impact and can be used to assess overall project sustainability. "The sixth dimension provides environmentally sound, energy-efficient solutions for the design and the facility as a whole. The design model is used to meet environmental sustainability standards and to control execution processes in line with their various requirements, while enabling accurate, rapid modifications to the base model." (9)

Seventh Dimension (7D): It has substantially improved the quality aspects of facility operations and maintenance (O&M). Projects that adopt Building Information Modelling (BIM) exhibit significant reductions in cycle time specifically, the interval between issuing a work o rder and completing the repair as well as shorter durations for technician dispatch, on-site execution, and related service turnarounds. (7)

6.2 Engineering Supervision

6.2.1 Definition of Engineering Supervision

Engineering supervision in the Syrian Arab Republic is defined as a system of technical, administrative, and legal processes carried out by licensed engineers or official supervisory entities to ensure that engineering projects are executed in accordance with approved dr awings and technical specifications, and within the prescribed time and budget. Supervision is one of the fundamental pillars of quality control and safety assurance in infrastructure and construction projects, both public and private. According to Legisla tive Decree No. 3 of 1972 governing the Engineers' Syndicate in Syria, the supervising engineer represents the designer or the owner. Their duties include monitoring the execution of works and verifying conformity with the contract documents such as drawings, technical documents/specifications, and the general and special conditions as well as ensuring the contractor's compliance with technical instructions and the regulations governing construction. (11)

6.2.2 Responsibilities of the Supervising Engineer

Engineering supervision is a fundamental pillar for ensuring that projects are executed in conformity with drawings, technical specifications, and regulatory standards. Its functions combine oversight and technical control to enhance field performance and help achieve project objectives within the prescribed time and budget. The supervising engineer's responsibilities vary by project phase and scope (9) and typically include:

1. Verifying conformance with approved drawings, through daily or periodic monitoring of site activities.
2. Controlling the quality of materials and construction processes, by inspecting received materials, approving laboratory/test results, and ensuring compliance with specifications.
3. Preparing periodic technical reports that document work progress, observations, nonconformities, and technical recommendations.
4. Certifying executed quantities and interim payment certificates, following verification of field-executed works.
5. Reviewing shop/execution drawings and coordinating across disciplines to prevent clashes and technical issues during execution.
6. Contributing to the resolution of field problems in coordination with the designer, contractor, and owner.
7. Monitoring the project schedule, reporting delays, and proposing mitigation measures. (12)

7. PRACTICAL FRAMEWORK

7.1 Introduction

The practical framework of this study seeks to assess the current state of Building Information Modelling (BIM) adoption in construction supervision within the Syrian project environment, using a questionnaire as the principal instrument for data collection and analysis. The importance of this component lies in determining the readiness of Syria's construction sector to embrace digital supervision methodologies and in identifying the extent to which BIM standards are activated within current supervisory practices whether in tools, procedures, or work culture.

7.2 Questionnaire and Data Collection

A questionnaire was prepared for a sample of engineers and supervisors working on projects that employ BIM, in order to capture their views on the degree of BIM application and its impact on supervision efficiency in Syria's construction industry, as well as the main challenges and opportunities associated with its use. In constructing the questionnaire, particular attention was paid to clarity and variety of items to ensure precise quantitative data collection. The questionnaire form (see Appendix 1) includes:

An introduction presenting the researcher's information, the study's importance, and the ti me required to

complete the questionnaire.

Respondent demographics and background information.

Criteria for BIM application in the construction supervision environment (24 criteria related to engineering

supervision, identified through interviews with experts working in Syria's construction sector).

7.2.1 Criteria for BIM Application in the Construction Supervision Environment

Drawing on prior studies of engineering supervision and BIM applications, the following twenty-four (24) criteria were identified and incorporated into the questionnaire:

1. Existence of a unified digital system that enables the exchange of technical information among project stakeholders.
2. Use of 3D models to support field supervision activities.
3. Integration of interactive scheduling with execution phases (4D).
4. Use of clash detection tools during the execution phase.
5. Extraction of Quantities and Specifications from Digital Models.
6. Documentation of executed works via a digital platform linked to the model.
7. Analysis of actual progress through interactive interfaces that link the plan to execution.
8. Linking supervision reports to digital drawings and the interactive model.
9. Adoption of a digital platform to track revisions and document field decisions.
10. Implementation of a digital system to verify conformance of executed works with approved designs.
11. Inclusion of time and cost performance reporting through BIM tools.
12. Provision of supervisory permissions to review models and record comments within the system.
13. Integration of cost and schedule analytics with the project model (5D).
14. Visual Analytics for Supervisory Decision Support.
15. Availability of digital tools for execution quality management and automated alerts.
16. Tracking of supervision KPIs via digital dashboards.
17. Real-time linkage between the jobsite and the model for supervision operations.
18. Tracking Schedule Deviations (4D Scheduling).
19. Supervisor participation in updating the model in line with execution changes.
20. Integration of a digital system for documenting nonconformities and observations within the model environment.
21. Use of the Digital Model for Resolving Technical Disputes.
22. Existence of an Institutional Culture Supporting BIM Adoption in the Construction Supervision Environment.
23. Field training for supervisors on BIM tools and their practical application.
24. Integration of the BIM platform with project-management systems used for supervisory work.

7.2.2 Target Survey Sample

The study sample was selected to include male and female engineers working in construction supervision in Syria who possess actual field experience in this sector. The sample comprised 90 participants diversified by gender, engineering discipline, years of experience, employment sector (public or private), and job position. This diversity provided a balanced and realistic representation of supervising engineers within the Syrian context. The questionnaire was distributed electronically and through direct coordination with several e ngineering bodies to ensure access to the target group. Care was taken to include civil, architectural, mechanical, and electrical engineers, reflecting the multidisciplinary nature of project supervision. This diversity aims to ensure comprehensive data collection and to increase the reliability and objectivity of the analysis regarding the extent of BIM application in construction supervision. It also enables assessment of the acceptance and use of digital technologies across a wide range of professional experiences and institutional settings.

7.2.3 Questionnaire Reliability Using Cronbach's Alpha

To verify the reliability and stability of the research instrument, Cronbach's alpha was employed one of the most widely used statistical methods for assessing the internal consistency of questionnaire items. This coefficient is based on the relationship among the number of items, the variance of respondents' answers to each item, and the total variance of the overall questionnaire score. It is computed using the following formula (σi

Table 1. Correlation coefficients and significance values for questionnaire validity.

Axis	Correlation coefficient ρ	p-value
Digital information exchange and documentation	0.82	< 0.001
4D/5D BIM supervision functions	0.79	< 0.001
Quality control and clash detection	0.84	< 0.001
Digital reporting and dashboards	0.77	< 0.001
Training and institutional readiness	0.73	< 0.001

Cronbach's alpha was used to test questionnaire reliability and is expressed as

$$\alpha = \frac{N}{N-1}\left(1 - \frac{\sum_{i=1}^{N}\sigma_i^2}{\sigma_T^2}\right), \tag{1}$$

where N is the number of questionnaire items, σ_i^2 is the variance of item i, and σ_T^2 is the variance of the summed scale score. Interpretive thresholds are: below 0.60 poor, 0.60–0.70 acceptable, 0.70–0.80 good, 0.80–0.90 high reliability, and above 0.90 excellent.

Study results . Data from 90 supervising engineers were en tered for a 24-item questionnaire covering all dimensions of supervision efficiency. Responses were coded on a three-point scale (Not Applied = 1, Partially Applied = 2, Applied = 3) After statistical processing in SPSS, the results indicated that: the overall Cronbach's alpha (α) was 0.947. indicating a high degree of internal consistency and supporting the questionnaire's reliability as a valid measurement instrument for subsequent analyses. Item-deletion diagnostics further showed that removing any item would not increase reliability, confirming the sound internal structure of the scale.

Correlation Analysis (Spearman's Rank Correlation) and Significance Testing

Given the ordinal nature of the 3-point response scale: (Not applied = 1 , Partially app lied = 2 , Applied = 3), Spearman's rank correlation was used to examine associations between BIM implementation and supervision-efficiency practices. Two composite indices were computed from the 24 criteria: (I) a BIM Implementation Index (mean score of the first 12 BIM tools/process-related items) (I I) a Digital Supervision Efficiency Practices Index (mean score of the last 12 supervision-efficiency practice items).

The analysis revealed a strong positive association between BIM implementation and supervision-efficiency practices (Spearman's $\rho = 0.833$, $p = 2.27 \times 10^{-24}$, $n = 90$), indicating that higher BIM implementation levels are associated with higher levels of digitally enabled supervision practices. In addition, prior experience in BIM-based projects showed positive and statistically significant correlations with the overall score ($\rho = 0.460$, $p = 5.20 \times 10^{-6}$), the BIM implementation index ($\rho = 0.455$, $p = 6.76 \times 10^{-6}$), and the supervision-efficiency practices index ($\rho = 0.422$, $p = 3.41 \times 10^{-5}$).

The following table presents the correlation coefficients (ρ) and (p-values):

Overall, these results indicate a strong and statistically si gnificant association between higher BIM implementation levels and improved digitally enabled supervision-efficiency practice

8. RESULTS AND DISCUSSION

8.1 Overall Trend of the Questionnaire

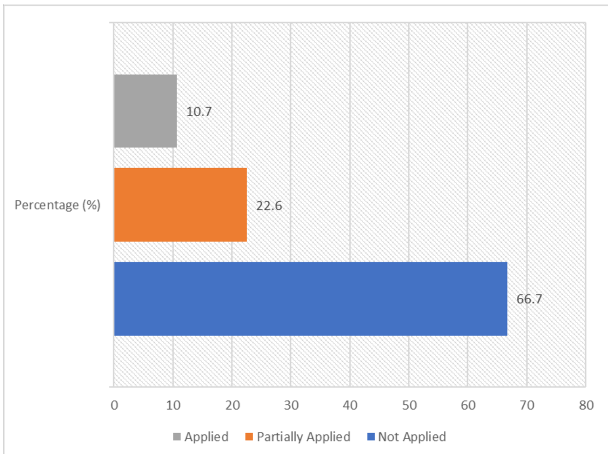

Figure 2. The percentage distribution of BIM application levels in the Syrian construction supervision context.

Analysis of the questionnaire results shows that 66.7% of the criteria are not applied, indicating that most BIM- related supervision criteria have not yet been implemented in practice within Syria's construction industry. This reflects a substantial gap between theory and practice: the construction supervision environm ent in Syria remains largely traditional, with limited digital capacity and weak institutional organization.

Meanwhile, 22.6% of the criteria are partially applied, signalling some nascent attempts to adopt certain BIM tools and techniques; however, these efforts remain incomplete often due to insufficient training or inadequate digital infrastructure. Only 10.7% of the criteria are fully applied, a relatively low proportion that points to the absence of comprehensive, institutionalized adoption of BIM stan dards in the supervision environment. Consequently, reliance on BIM technologies remains limited, even though a subset of advanced, internationally supported private projects has begun to adopt BIM in practice; these cases do not yet reflect the broader in dustry trend.

The following figure illustrates the percentage distribution of BIM application levels in the Syrian construction supervision context based on respondents' answers. Figure 2. The percentage distribution of BIM application levels in the Syrian construction supervision context based on respondents' answers

8.2 Analysis of the Criteria Measuring the Level of BIM Technology Application in the Construction Supervision Environment in Syria

8.2.1 Existence of an Institutional Culture Supporting BIM Adoption in the Construction Supervision Environment

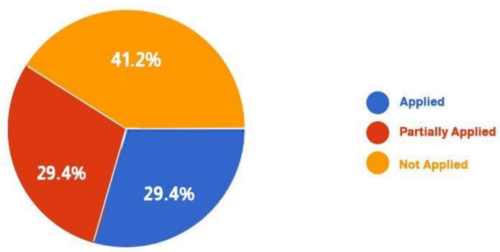

Figure 3. The percentage distribution of respondents' answers for institutional culture supporting BIM adoption.

Table 2. Application-level percentages for institutional culture supporting BIM adoption.

Applied	Partially Applied	Not Applied
29.4%	29.4%	41.2%

The percentages above indicate that only about one-third of organizations maintain a clear culture that supports embedding BIM within the const ruction supervision environment, whereas 41.2% provide no supportive environment or incentivizing policies. This points to weak organizational and structural awareness of digital technologies and underscores the need to adopt institutional policies and enabling regulations—such as mandating BIM on major projects and incorporating BIM requirements into contracts and regulatory frameworks. A strong institutional culture can be viewed as a mediating variable that influences the remaining criteria, since its absence adversely affects training, real-time model–site integration, visual analytics, and other applications.

8.2.2 Field training for supervisors on BIM tools and their practical application

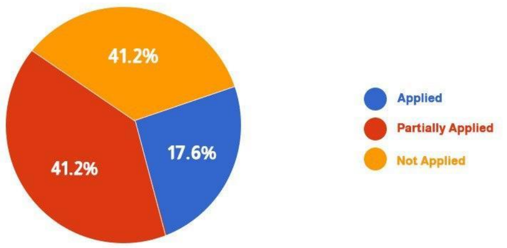

Figure 4. The percentage distribution of respondents' answers for field training on BIM tools.

Table 3. Application-level percentages for field training on BIM tools.

Applied	Partially Applied	Not Applied
17.6%	41.2%	41.2%

Hands-on training is the primary means of converting the theoretical potential of BIM technologies into effective supervisory practice. Despite some partial initiatives (41.2%), the share of full implementation remains low (17.6%), indicating that training is still non-systematic or insufficient.

Field training serves as a key explanatory factor for the weak adoption of other technical criteria such as temporal tracking and visual analytics because the absence of practical skills hinders activation of digital capabilities. Limited training also reflects weak integration among universities, training canters, and engineers' syndicates in

developing continuous pr ofessional development programs for supervisors. A viable solution is to embed specialized BIM curricula within human-capital development plans and tie these programs to real, applied projects.

8.2.3 Supervisor participation in updating the model in response to execution changes

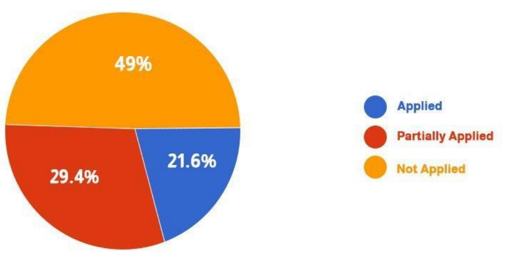

Figure 5. The percentage distribution of respondents' answers for supervisor participation in updating the model.

Table 4. Application-level percentages for supervisor participation in model updating.

Applied	Partially Applied	Not Applied
21.6%	29.4%	49%

This criterion reflects the degree of integration between field supervision and the digital model. Ideally, the supervising engineer should update the model whenever a field change occurs to ensure alignment between site conditions and the modelled information. However, the reported percentages indicate that about half of respondents do not perform this role, resulting in a gap between field information and digital data.

From an information-management perspective, excluding the supervisor from model updates undermines the accuracy of the digital database and leads to project decisions that are not based on correct, real-time data. A practical remedy is to establish standardized data-exchange protocols between the jobsite and the model, and to train supervisors on model-management software such as Revit and Navisworks so that updates are continuously integrated.

8.2.4 Extraction of Quantities and Specifications from Digital Models

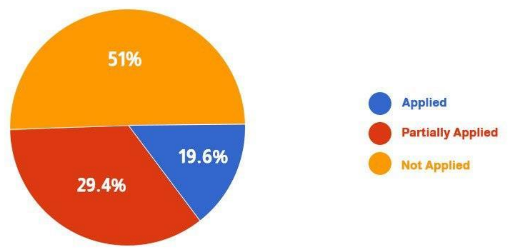

Figure 6. The percentage distribution of respondents' answers for extracting quantities and specifications from digital models.

Table 5. Application-level percentages for extracting quantities and specifications from digital models.

Applied	Partially Applied	Not Applied
19.6%	29.4%	51%

This criterion reflects one of BIM's most immediate advantages: quantities and specifications are expected to be generated automatically from the digital model rather than relying on traditional spreadsheets. However, the data indicate that more than half of supervisors still depend on manual, legacy methods , which leaves room for human error and discrepancies in estimates. This pattern may point to a lack of digital integration between design and execution and to weak supporting infrastructure such as standardized model templates and digital libraries. Potential solutions include restructuring supervision workflows to rely primarily on digital models as the single source of truth for quantities and specifications, coupled with targeted training to build staff capacity for efficient information extraction from the model.

8.2.5 Tracking Schedule Deviations (4D Scheduling)

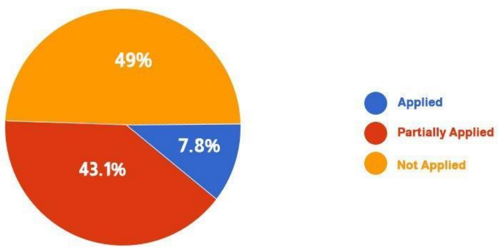

Figure 7. The percentage distribution of respondents' answers for tracking schedule deviations.

Table 6. Application-level percentages for tracking schedule deviations.

Applied	Partially Applied	Not Applied
7.8%	43.1%	49%

Tracking schedule deviations is a core BIM application commonly referred to as the fourth dimension (4D). However, full implementation is nearly absent , with an application rate of only 7.8% This indicates that most projects are not leveraging integrated schedule –model capabilities and continue to rely on standalone, traditional schedules. A plausible explanation is the lack of programmatic linking between scheduling software (e.g., Primavera) and 3D models, compounded by shortages of personnel skilled in managing these technologies. A practical remedy is to expand the use of 4D Simulation tools and connect them directly to field supervision workflows, enabling the early detection of schedule deviations.

8.2.6 Use of the Digital Model for Resolving Technical Disputes

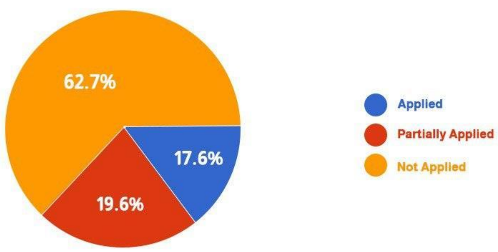

Figure 8. The percentage distribution of respondents' answers for using the digital model to resolve disputes.

Table 7. Application-level percentages for using the digital model to resolve technical disputes.

Applied	Partially Applied	Not Applied
17.6%	19.6%	62.7%

Technical disputes are among the most common challenges in projects, and the digital model is a powerful tool for resolving them through clash detection and clarifying responsibilities. However, the figures indicate that about 62.7% do not use the model for dispute resolution , reflecting continued reliance on paper documentation and traditional meetings practices that raise the likelihood of delays and litigation. This points to a lack of legal or contractual recognition of the digital model as an official document in dispute resolution. The gap can be addressed by promoting the concept of a Legal BIM Model and adopting it as an official reference in engineering contracts.

8.2.7 Real-time linkage between the jobsite and the model for supervision operations.

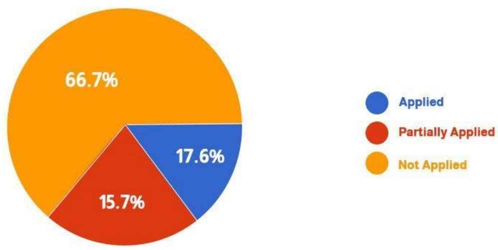

Figure 9. The percentage distribution of respondents' answers for real-time site–model linkage.

Table 8. Application-level percentages for real-time jobsite–model linkage.

Applied	Partially Applied	Not Applied
17.6%	15.7%	66.7%

Real-time linkage between the jobsite and the digital model enables supervisors to track updates instantaneous ly, thereby improving the accuracy of supervisory decisions. However, two-thirds of respondents do not implement this linkage, leaving a gap between field conditions and the digital model. This shortfall is attributable to weak digital infrastructure such as limited cloud connectivity and underdeveloped IoT systems that would otherwise support instantaneous integration.

A practical remedy is to adopt integrated project-management platforms (e.g., BIM 360 or Synchro) and connect them to tablets and smartphon es used on site, thereby closing the data latency gap and strengthening real-time supervision.

8.2.8 Visual Analytics for Supervisory Decision Support

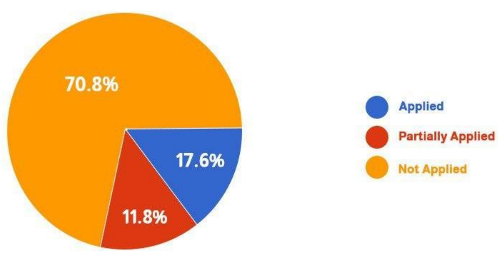

Figure 10. The percentage distribution of respondents' answers for visual analytics for supervisory decision support.

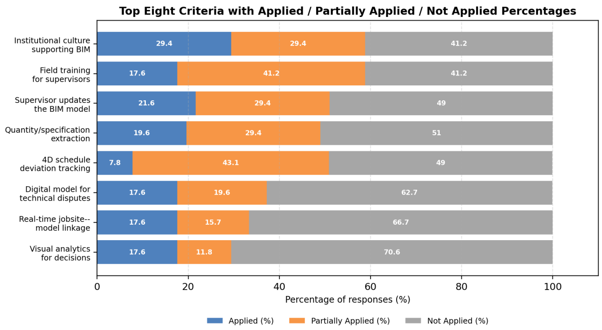

Figure 11. Summary of the foregoing analysis.

Table 9. Application-level percentages for visual analytics for supervisory decision support.

Applied	Partially Applied	Not Applied
17.6%	11.8%	70.6%

Visual analytics is among the most straightforward and accessible capabilities in BIM, enabling supervisors to assess progress and quality through 3D models and simulation renderings. Nevertheless, 70.6% of respondents do not utilize this capability, reflecting limited awareness of the value of visualization in supporting decisions. This also suggests a lack of interactive display tools in supervision offices and a continued reliance on traditional paper- based reports.

To address this gap, visual analytics should be embedded in periodic supervision reports, and offices should be equipped with interactive display screens to facilitate communication with owners and contractors.

As a summary of the foregoing analysis, Figure (11) presents the percentage distribution of respondents' answers for the eight key BIM-related criteria in the construction supervision environment. Table 10 consolidates the same values for direct comparison.

Table 10. Summary of application levels for the eight BIM-related supervision criteria.

Criterion	Applied	Partially Applied	Not Applied
Institutional culture supporting BIM adoption	29.4%	29.4%	41.2%
Field training for supervisors on BIM tools	17.6%	41.2%	41.2%
Supervisor participation in model updating	21.6%	29.4%	49%
Quantity and specification extraction from models	19.6%	29.4%	51%
Tracking schedule deviations (4D)	7.8%	43.1%	49%
Digital model use for technical disputes	17.6%	19.6%	62.7%
Real-time jobsite–model linkage	17.6%	15.7%	66.7%
Visual analytics for decision support	17.6%	11.8%	70.6%

8.3 Mini case study in Syria

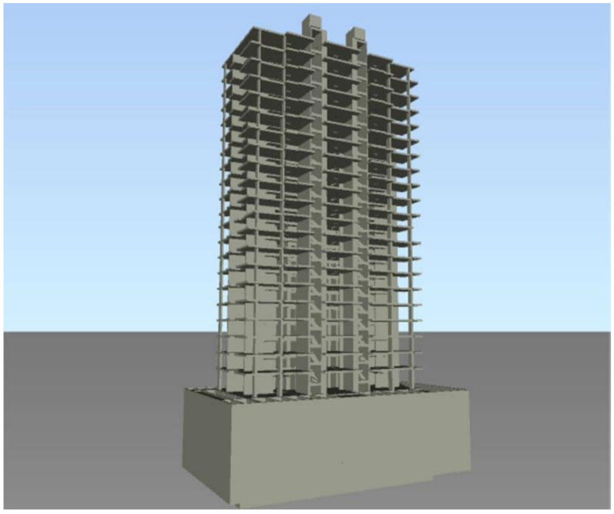

Figure 12. 3D structural model of the case-study tower developed in Autodesk Revit.

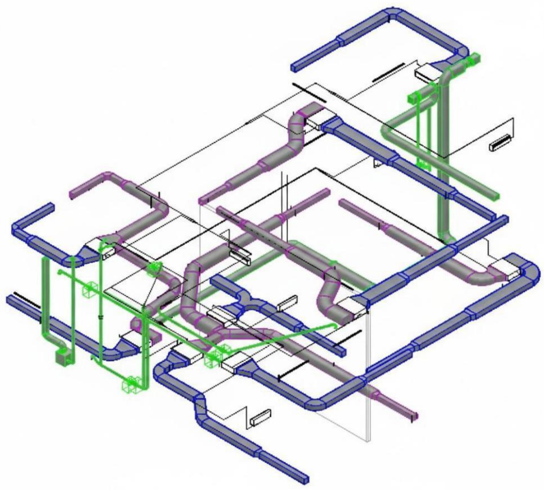

Figure 13. Excerpt of the Revit quantity schedule for reinforced-concrete columns.

Table of columns quantities						
Family and Type	Count	Base Level	Top Level	Length	Volume	Cost
00-Foundation						
M_Concrete-Rectangular-Column: C130X60	6	00-Foundation	1-(-3)	470	20.59 m³	20,592,000 SYP
M_Concrete-Rectangular-Column: C150x50	2	00-Foundation	1-(-3)	470	6.60 m³	6,600,000 SYP
M_Concrete-Rectangular-Column: C160X60	2	00-Foundation	1-(-3)	470	8.45 m³	8,448,000 SYP
M_Concrete-Rectangular-Column: C170X70	2	00-Foundation	1-(-3)	470	10.47 m³	10,472,000 SYP
	12				46.11 m³	46,112,000 SYP
01-Mat Foundation						
M_Concrete-Rectangular-Column: C50X50	20	01-Mat Foundation	1-(-3)	385	17.75 m³	17,750,000 SYP
	20				17.75 m³	17,750,000 SYP
0-(-4)						
M_Concrete-Rectangular-Column: C55X40	1	0-(-4)	1-(-3)	340	0.71 m³	706,993 SYP
	1				0.71 m³	706,993 SYP
1-(-3)						
M_Concrete-Rectangular-Column: C50X50	20	1-(-3)	2-(-2)	340	16.00 m³	16,000,000 SYP
M_Concrete-Rectangular-Column: C55X40	1	1-(-3)	2-(-2)	340	0.70 m³	704,000 SYP
M_Concrete-Rectangular-Column: C130X60	6	1-(-3)	2-(-2)	340	14.98 m³	14,976,000 SYP
M_Concrete-Rectangular-Column: C150x50	2	1-(-3)	2-(-2)	340	4.80 m³	4,800,000 SYP
M_Concrete-Rectangular-Column: C160X60	2	1-(-3)	2-(-2)	340	6.14 m³	6,144,000 SYP
M_Concrete-Rectangular-Column: C170X70	2	1-(-3)	2-(-2)	340	7.62 m³	7,616,000 SYP
	33				50.24 m³	50,240,000 SYP
2-(-2)						
M_Concrete-Rectangular-Column: C50X50	20	2-(-2)	3-(-1)	340	16.00 m³	16,000,000 SYP
M_Concrete-Rectangular-Column: C55X40	1	2-(-2)	3-(-1)	340	0.70 m³	704,000 SYP
M_Concrete-Rectangular-Column: C130X60	6	2-(-2)	3-(-1)	340	14.98 m³	14,976,000 SYP
M_Concrete-Rectangular-Column: C150x50	2	2-(-2)	3-(-1)	340	4.80 m³	4,800,000 SYP
M_Concrete-Rectangular-Column: C160X60	2	2-(-2)	3-(-1)	340	6.14 m³	6,144,000 SYP
M_Concrete-Rectangular-Column: C170X70	2	2-(-2)	3-(-1)	340	7.62 m³	7,616,000 SYP
	33				50.24 m³	50,240,000 SYP

Figure 14. Ventilation layout for a representative floor.

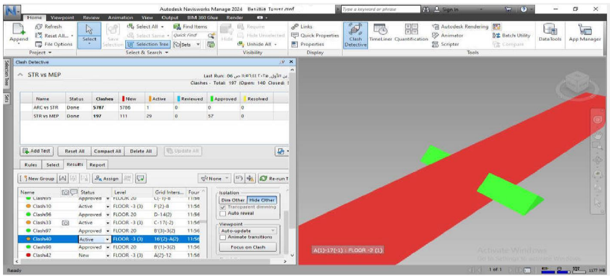

Figure 15. Example of a detected coordination clash in Navisworks.

Figure 16. Navisworks clash report excerpt documenting detected interferences.

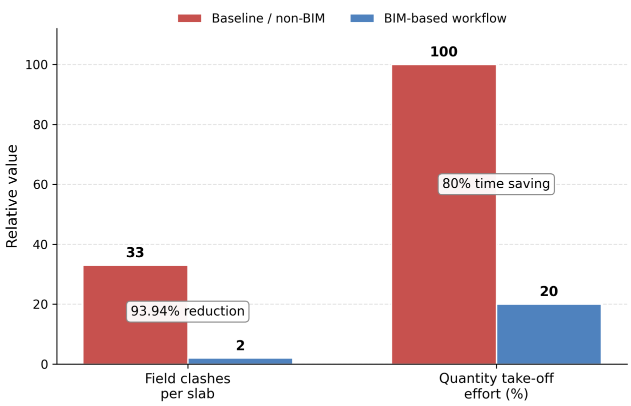

Figure 17. Pilot KPI improvements from the BIM-based workflow.

To complement the questionnaire-based analysis and provide a practical illustration of BIM-enabled supervision, a pilot BIM workflow was carried out on a representative tower model. The building was structurally modelled in Autodesk Revit, where the main structural elements were defined and organized to support quantity take-off. Based on the developed model, quantity schedules were generated (e.g., concrete volumes, reinforcement-related quantities, and key structural components), enabling transparent verification of quantities and supporting supervision tasks related to measurement and progress tracking. Subsequently, the Revit model was integrated into Autodesk Navisworks to support coordination and supervision-oriented checks.

Clash detection was performed to identify potential conflicts and constructability issues prior to execution, and the resulting clash reports and visual snapshots were used as evidence for early issue identific ation and decision- making. The screenshots extracted from Revit and Navisworks, together with the quantity schedules, demonstrate how BIM can enhance supervision efficiency through improved information consistency, faster verification of quantities, and pr oactive identification of coordination issues, thereby reducing the likelihood of rework and strengthening quality control processes.

In the practical demonstration, BIM-based coordination and clash detection reduced the number of field-relevant clashes per slab from 33 (baseline) to 2 after BIM implementation, representing a 93.94% reduction. In addition, quantity take-off became substantially more efficient using Revit schedules, achieving an estimated 80% time saving compared to the non-BIM approach (i.e., the BIM-based take-off required approximately 20% of the baseline effort). These KPI shifts indicate that BIM-enabled workflows can significantly enhance supervision efficiency by preventing coordination-related rework and accelerating quantity verification and control activities.

9. RESULTS AND RECOMMENDATIONS

9.1 Results

The study found that the level of Building Information Modeling (BIM) adoption in construction supervision within Syrian projects remains limited. Field data show that 66.7% of the measured criteria are not applied, 22.6% are partially applied , and only 10.7% are fully applied . This reality reflects a clear gap between theoretical awareness of BIM's potential and its practical implementation in engineering projects.

At the c riterion level, organizational aspects such as the presence of a supportive institutional culture and field training for supervisors on BIM tools were relatively more implemented (30% and 18%, respectively). In contrast, advanced technical criteria such as 4D schedule tracking, real-time site–model integration, and visual analytics were among the weakest, ranging between 8–18%. This points to limited technical capacity and insufficient digital infrastructure for activating these applications. Demographically, more than half of the sample consisted of recent graduates, indicating an educational and training gap: BIM has not been adequately embedded in university curricula, which exacerbates adoption challenges especially in the absence of continuous in-house training.

Additionally, the findings reveal three principal barriers that hinder effective BIM implementation:

1. Lack of institutional policies and regulations that mandate or incentivize BIM use, particularly in the public sector.
2. Insufficient training and practical upskilling for engineers and supervisors including recent graduates and the absence of continuous professional development programs.
3. Weak digital infrastructure and the absence of unified data platforms that directly connect the jobsite with the digital model.

Despite these challenges, the results indicate a readiness for digital transformation among younger engineers. Thus, the primary obstacles are not acceptance or awareness, but rather the organizational, educational, and technical environment, which is not yet mature enough to support adoption at scale. In conclusion, this study affirms that BIM use contributes to improving the quality and efficiency of construction supervision; however, its impact is contingent on preparing a supportive educational, institutional, and technological ecosystem.

9.2 Recommendations

• Integrate BIM into university curricula as a mandatory component. Introduce hands-on courses that cover both the theoretical and applied dimensions of digital construction sup ervision; establish specialized teaching laboratories in engineering schools equipped with BIM software (e.g., Revit, Navisworks, Synchro).

• run joint workshops between universities and engineering offices to bridge academia and practice on real projects; and encourage capstone projects and academic research focused on practical BIM applications in supervision so they become sources of field-ready solutions.

• In parallel, upskill faculty members on the latest BIM tools and technologies to ensure academic staff can keep pace with global developments and transfer that knowledge to students . • Enact national regulations mandating BIM for major projects from design through supervision and execution, with a phased implementation timeline.

• Develop a unified national BIM implementation guide that specifies procedures, standards, and technical specifications to be followed in Syrian projects.

• Enable integration between BIM and project management systems (Microsoft Project and Primavera) to improve planning and the tracking of schedule deviations.

• Promote future applied studies that measure BIM's impact on the actual performance of construction supervision in representative Syrian projects.

• Explore the integration of BIM with advanced technologies such as artificial intelligence and Digital Twins to further enhance supervision efficiency in the future.

REFERENCES

[1] Salim, O., "What is Building Information Modeling (BIM)?," BIM Arabia, no. 12, p. 4.

[2] M. Saudi, H. Al-Shimi, M. Mahdi, and S. Ashur, "Strategies for designing sustainable cities using Building Information Modeling (BIM)," Article, p. 6.

[3] H. Muhammad, "Methodology for integrating sustainable design strategies into Building Information Modeling (BIM): Current capabilities and future prospects," Article, 2012, p. 5.

[4] N. Samaan, "The impact of applying Building Information Modeling (BIM) in engineering projects," Al-Baath University Journal, no. 8, pp. 71–72, 2021.

[5] R. Sacks, C. M. Eastman, G. Lee, and P. Teicholz, BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers, 3rd ed. Hoboken, NJ, USA: John Wiley & Sons, 2018, pp. 15–16.

[6] M. F. Hergunsel, "Benefits of building information modeling for construction managers and BIM scheduling," M.S. thesis, Dept. Civil Eng., Worcester Polytechnic Institute, Worcester, MA, USA, May 2011, p. 5.

[7] M. Youssef, R. Bahy El-Din, S. Surkn, and E. I. Badr, "A holistic vision to achieve sustainability standards using building information modeling technology," Journal of Engineering, Art and Humanities, 2023, p. 623.

[8] VINCI Facilities, BIM for Facility Management Handbook and Technical Specifications for the Digital Model, Les Cahiers Experts Supplement, Groupe Monitor, Apr. 2016, p. 4.

[9] Presidency of the Syrian Arab Republic, Legislative Decree No. 3 of 1972 Regulating the Engineering Profession and the Engineers' Syndicate, 1972, pp. 112–117.

[10] Ministry of Public Works and Housing of the Syrian Arab Republic, Technical Supervision Manual for the Execution of Construction Projects. General Directorate of Planning and International Cooperation, 2014, pp. 35–40.

[11] F. Gang and W. Shu, "A framework for BIM-based quality supervision model in project management," in Proc. Creative Construction Conf. 2019, M. Hajdu and G. Lajos, Eds. Cham, Switzerland: Springer, 2019, pp. 234–242.

[12] M. Shaban, B. Al Hassan, and A. S. Mohamad, "Digital transformation of quality management in the construction industry during the execution phase by integration of building information modeling (BIM) and cloud computing," Building Engineering, vol. 2, no. 1, Art. no. 1132, 2024.

[13] H. Almujibah, "Assessment of BIM as a time and cost-saving construction management tool: Evidence from two-story villas in Jeddah," Sustainability, vol. 15, no. 9, Art. no. 7354, 2023.

[14] J. Matos and G. Miranda, "The use of BIM in public construction supervision in Brazil," Organization, Technology & Management in Construction, vol. 10, no. 1, Art. no. 0007, 2018.

[15] W. Tsai, Y. Liu, and H. Zhang, "BIM-based government engineering quality supervision system in China," Journal of Asian Architecture and Building Engineering, vol. 23, no. 6, pp. 1966–1979, 2023.