# Evaluating the Impact of Building Information Modeling on Optimizing Quality Management Processes in the Construction Industry

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***Abstract***— *The construction industry is critical to the nation's economic progress. However, due to an insufficient quality management procedure, this industry has been plagued by considerable problems, including the failure to complete projects within the triple constraints. The purpose of this research is to assess the impact of Building Information Modelling (BIM) on the optimization of quality management processes in building projects. Cost overruns, project delays, and ineffective quality control methods are all issues confronting the construction sector. BIM has emerged as a viable solution for addressing these difficulties by offering a digital platform that improves project stakeholders' cooperation, information flow, and decision-making. The aims of this research were attained utilizing qualitative and quantitative data acquired through a comprehensive questionnaire survey and detailed literature survey. The sum of circulated questionnaires was 40 and the number of responses was 75%. Correlation & regression analysis done with the use of SPSS software to analyse the collected data. According to the findings of the study, there is a substantial beneficial association between BIM dimensions (3D, 4D, and 5D) and quality management. According to regression analysis, the adoption of 3D BIM has the greatest influence on quality management, followed by 4D BIM (time) and 5D BIM (cost). According to the study, BIM may greatly improve quality management procedures in building projects. It suggests boosting awareness, encouraging stakeholder collaboration, and developing standardised BIM guidelines for optimal adoption. More empirical research is required to fully realise the benefits of BIM in quality management.*

***Keywords***— Building Information Modeling, Quality Management, Construction Industry

## I. INTRODUCTION

The construction sector is vital to the development and growth of economies across the world. However, it is frequently connected with a variety of difficulties, including inadequate quality management practices that can result in cost overruns, delays, and safety dangers (Smith, 2018; Johnson et al., 2020). Building Information Modelling (BIM) has developed in recent years as a transformational technology with the ability to revolutionise the building sector and address these difficulties. Eastman et al., 2011; Li et al., 2019) define BIM as a collaborative process that uses digital representations of a building's physical and functional attributes to assist efficient planning, design, construction and operation.

Globally, BIM adoption has gained traction, with several nations seeing its potential advantages and establishing efforts to encourage universal usage (Azhar et al., 2018; BuildingSMART, 2020). BIM is gaining popularity due to its capacity to optimise numerous areas of construction projects, including quality management systems. Stakeholders in a project can increase cooperation, expedite information flow, and improve decision-making by using the capabilities of BIM (Succar, 2009; Hartmann and Fischer, 2019). Quality management is an essential component of every construction project because it has a direct impact on the performance, safety, and durability of the built environment (Saatcioglu and Taylor, 2015; Tang et al., 2017). Traditional quality management techniques frequently rely on manual procedures, which may be time-consuming, error-prone, and lacking in efficient communication channels (Lu et al., 2016; Sun et al., 2020). BIM provides a digital platform that combines multiple project data and gives a holistic perspective of the project lifecycle, allowing for more efficient and effective quality management (Huang et al., 2018; Chen et al., 2021). The construction industry is facing numerous challenges, such as cost overruns, project delays, and insufficient quality management processes (Smith, 2018; Johnson et al., 2020). To address these issues, Building Information Modelling (BIM) has emerged as a promising technology that has the potential to revolutionise construction practises (Eastman et al., 2011; Li et al., 2019).

The purpose of this study is to assess the impact of BIM on optimizing quality management processes in the construction industry. The quality management process in the worldwide construction sector can be influenced by many reasons. However, the scope of this study is confined to BIM practices. Moreover, research data is collected based on only the building construction.

## II. LITERATURE REVIEW

### *A. Quality Management in Construction*

Quality management in the construction industry plays a crucial role in ensuring that projects are executed efficiently, meet specified requirements, and achieve the desired outcomes. It encompasses a set of processes and practices aimed at monitoring and controlling the quality of construction activities, materials, and deliverables. According to the Construction Industry Institute (CII), quality management is "the systematic process of defining, establishing, and ensuring adherence to all project quality requirements." (CII, 2017). Building Information Modeling (BIM) has become an integral part of quality management in construction. BIM enables the creation and management of a digital representation of the project, facilitating collaboration, coordination, and clash detection, which helps in identifying and resolving potential quality issues at an early stage (Abanda et al., 2019).

### *B. Building Information Modeling in Construction*

Building Information Modelling (BIM) is a digital representation of a construction project's physical and functional properties. Throughout the project lifecycle, it entails the generation, management, and exchange of information, offering a collaborative platform for architects, engineers, contractors, and other stakeholders. BIM has developed as a significant tool for improving construction quality management. Eastman et al. (2011) argue that BIM improves visualisation, coordination, and collision detection, allowing stakeholders to identify and address possible quality concerns early in the design and construction stages. Construction professionals can use BIM's rich data and visualisation capabilities to ensure compliance with quality standards, improve project performance, and mitigate risks by linking BIM with quality management processes such as quality planning, control, and assurance (Brewer et al., 2014).

### *C. BIM Dimensions and their Impact on Quality Management*

Building Information Modelling (BIM) functions on several levels, each of which contributes to the improvement of quality management procedures in building projects. BIM's three major dimensions are as follows:

3D BIM: A 3D BIM dimension is a graphical depiction of a building's physical parts that allows stakeholders to visualise the construction project in a digital environment (Eastman et al., 2011). 3D BIM improves coordination and avoids confrontations between different building components by offering a full and realistic image of the project (Hartmann and Fischer, 2019).

4D BIM: Time-related data is incorporated into the BIM model, allowing project teams to simulate and visualise building processes over time (Eastman et al., 2011). This dimension allows for more efficient project scheduling, sequencing, and resource management, resulting in more efficient construction practises and improved quality control (Chen et al., 2021).

5D BIM: The 5D BIM dimension adds cost-related data to the BIM model, allowing project stakeholders to estimate project costs at various phases (Eastman et al., 2011). 5D BIM allows better cost management, material optimisation, and value engineering by combining cost and budget information, contributing to enhanced overall project quality (Huang et al., 2018).

The incorporation of these BIM elements offers project stakeholders with a valuable tool for optimising quality management procedures. For example, 5D BIM allows stakeholders to allocate appropriate resources for quality materials and building approaches early in the process (Hartmann and Fischer, 2019). During the building phase, 4D BIM assists in spotting possible conflicts or delays, allowing for prompt remedies and ensuring project quality is not affected (Chen et al., 2021). Furthermore, 3D BIM promotes improved cooperation and communication across project teams, ensuring that quality criteria and specifications are properly understood and followed during the building process (Huang et al., 2018).

### *D. BIM Implementation and Challenges in Quality Management*

While BIM has enormous promise for improving quality management systems, its effective implementation is fraught with difficulties (Chinowsky et al., 2019). One of the most difficult difficulties is incorporating BIM into current processes and project management systems (Kim et al., 2017). Furthermore, certain project stakeholders may be resistant to adopting new technology and changing traditional practises (Guo et al., 2020). To overcome these obstacles and guarantee successful implementation, proper BIM training and instruction are required (Chinowsky et al., 2019).

### *E. BIM-Enabled Quality Management in Construction*

Several real-world case studies have shown how BIM may be successfully implemented in quality management systems. For example, Wang et al. (2022) found that using BIM in a building project led in considerable improvements in construction quality, reduced rework, and increased project efficiency. Similarly, Li et al. (2019) discovered that BIM's 3D visualisation capabilities improved project team collaboration and communication, resulting in improved quality control.

Despite the growing interest in BIM and its potential benefits for quality management, there is a lack of comprehensive studies that focus on the actual impact of BIM on quality management processes in construction projects. In this study identifying the impact of BIM on optimizing the quality management process.

## III. RESEARCH METHODOLOGY

The study's goal is to determine the influence of BIM on optimising the quality management process. A varied group of construction experts will be surveyed in order to analyse the impact of BIM. A questionnaire survey with relevant authorities were used to properly analyse the study. Combining qualitative and quantitative approaches is highly respected since it offers a more complete view of the research field and improves the study.

### *A. Data Collection Methods*

A complete web-based questionnaire (Google forms) was distributed to professional groups in the building sector. Questionnaires were sent among experts in order to collect appropriate replies, and different points of view were graded using the "Likert Scale." and to gather many relevant factors, open-ended questions were also included in the questionnaire survey. A total of 40 questionnaires were issued (chosen by simple random selection), with a response rate of 75% from 16 Quantity Surveyors, 11 Engineers, 01 Architect, and 02 Project Managers.

### *B. Conceptual Framework*

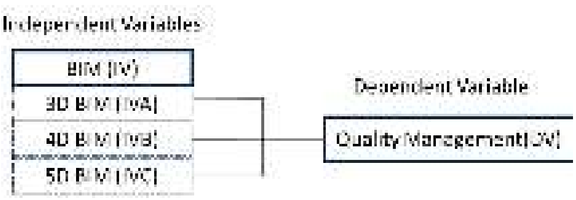


*Figure 1: Conceptual framework*

### *C. Data Analysis Methods*

Primary data was reviewed quantitatively, while secondary data was examined using a content analysis. The statistical investigation enabled the discovery of connections between the examined BIM elements and their effect on quality management. This is a fantastic method for multivariable analysis. The association is hypothesised at the start, and the statistical studies are done correctly. The study was carried out using the SPSS software, which offers a wide choice of formulae and statistical procedures.

The presentation was in the formats, and the tables were generated automatically by the SPSS programme. The majority of the data was converted into information. A cording method used in the SPSS programme is equivalent to variable codes.

## IV. RESEARCH FINDINGS

The general information of respondents, including their occupation and industry experience, was evaluated since the replies to the questions may vary depending on the perspective of various people owing to their thinking ability, knowledge, and industry experience. Figure 2 depicts the different levels of reaction.

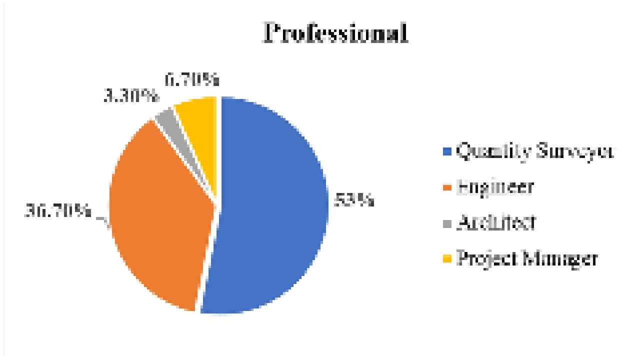


*Figure 2: Respondents' Details*

### *A. Correlation Analysis*

Correlation analysis was carried out to determine the link between the developed independent variables (IV) and the dependent variable (DV). The Pearson correlation coefficient is used to examine the link and is assessed using SPSS software. Each independent variable was examined in conjunction with the dependent variable. When one variable increases, the other variable increases as well, and when one variable decreases, both variables drop.

*Table 1: Correlation Analysis (SPSS Software generated)*

| | | ADV | AIVA | AIVB | AIVC |
|---|---|---|---|---|---|
| ADV | Pearson Correlation | 1 | .831* | .810** | .745 |
| | Sig. (2-tailed) | | <.001 | <.001 | <.001 |
| | N | 30 | 30 | 30 | 30 |
| AIVA | Pearson Correlation | .831* | 1 | .873** | .745* |
| | Sig. (2-tailed) | <.001 | | <.001 | <.001 |
| | N | 30 | 30 | 30 | 30 |
| AIVB | Pearson Correlation | .810** | .804** | 1 | .715* |
| | Sig. (2-tailed) | <.001 | <.001 | | <.001 |
| | N | 30 | 30 | 30 | 30 |
| AIVC | Pearson Correlation | .745 | .745* | .717* | 1 |
| | Sig. (2-tailed) | <.001 | <.001 | <.001 | |
| | N | 30 | 30 | 30 | 30 |

3D BIM (IVA),4D BIM (IVB) and 5D BIM (IVC) has gained less than 0.001 significant value over the quality management (DV) and it is proven that there is a strong relationship between Building Information Modelling (IV) and Quality Management (DV). The correlation values are 0.31, 0.810 & 0.745 respectively. Which suggests there is a substantial and positive relationship between these factors.

### *B. Regression Analysis*

Regression analysis done to identify the impact of developed 4 different variables on the dependent variable. This makes all the independent variables comparable & standardized.

*Table 2: Regression Analysis (SPSS Software generated)*

**Coefficients**

| Model | | Unstandardized Coefficients B | Std. Error | Standardized Coefficients Beta | t | Sig. |
|---|---|---|---|---|---|---|
| 1 | (Constant) | .100 | .325 | | .309 | .759 |
| | AIVA | .483 | .169 | .442 | .600 | .552 |
| | AIVB | .320 | .100 | .330 | 2.868 | .007 |
| | AIVC | .118 | .152 | .124 | 3.206 | .003 |

The regression coefficient indicates the proportion of quality management (DV) expressed by BIM(IV). This study connection is stated in the above table using the results of regression analysis as per the following equation,

$$Y = \alpha + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4$$

$$Y = \{0.100 + [0.483*(AIVA)] + [0.483*(AIVB)] + [0.118*(AIVC)]\} + Std.E$$

*Equation 1: Relationship between dependent & independent variable*

The beta value of 0.483 shows that quality management in the construction sector is impacted by the 3D BIM factor. There is a 48.3% variance in the quality management process affected by when regarding the third dimension in building information modeling. And according to the outcomes, this is the highest impacted factor.

The medium impact is shown by the 4D BIM (Time) factor. The beta value of 0.320 shows that quality management in the construction sector is impacted by the fourth dimension in building information modeling. There is a 32% variance in the quality management process affected by when regarding the use of 4D BIM factors.

The lowest impact is shown by 5D BIM (cost) factor. The beta value of 0.118 shows that quality management in the construction sector is impacted by the fifth dimension related factors in Buiding information modeling. There is a positive relation. This means there is a 11.8% variance of the quality management process affected by when regarding the use of 5D BIM related factors.

## V. CONCLUSION AND RECOMMENDATIONS

### *A. Conclusion*

The major persistence of this study was to examine the impact of building information modeling on optimizing the quality management process in the construction industry. Through the findings of the regression analysis, it was further demonstrated evident that there is an impact of building information modeling on optimizing the quality management process in the construction industry. The second purpose of this exploration was to investigate the relation between BIM dimensions and the quality management process in the construction sector as per the conceptual framework. Clear positive relationships were demonstrated between independent variables and dependent variables which satisfies the H1 (Alternative Factor).

Through a comprehensive literature review highlighted that BIM offers several benefits for quality management in construction projects. By integrating project data into a digital platform, BIM enhances communication, coordination, and decision-making among stakeholders. It provides a holistic view of the project lifecycle, enabling real-time monitoring, streamlined inspections, and improved collaboration. Some studies have shown that BIM may be used successfully in quality management, with gains in construction quality, decreased rework, and increased project efficiency. Traditional manual quality management processes, which are prone to errors and inefficiencies, can be overcome through the implementation of BIM.

### *B. Recommendations*

BIM has enormous promise in terms of improving quality management systems in the building sector. Its integration with other dimensions, such as 3D, 4D, and 5D BIM, improves project visualisation, scheduling, cost control, and communication, leading to overall project quality improvement. Furthermore, to improve the deployment and utilisation of Building Information Modelling (BIM) for quality management in building projects. To begin, raising awareness and offering education about the benefits and possibilities of BIM is critical to its adoption. This can be accomplished through educational and training programmes. Second, encouraging cooperation and stakeholder participation is critical for effective BIM adoption. Developing a collaborative culture and encouraging active engagement will improve communication and coordination. Third, standardised BIM rules should be created to assure project consistency and interoperability. These recommendations should include information needs, data communication formats, and best practises. However, in order to fully realise the benefits of BIM, it is critical to solve implementation issues and fill the knowledge vacuum through detailed empirical investigations.

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