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Development of Cost Overrun Risk Control Using 3D-8D Building Information Modeling (BIM) Technology in Integrated Design-and-Build Construction Projects to Improve Project Performance

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building projects; building information management (BIM) 3d-8d; control process; project performance.

Abstract
This study aims to develop cost overrun risk control using 3D-8D Building Information Modeling (BIM) technology in building construction projects with integrated Design and Build contracts to improve project performance. The research method employed a quantitative approach with descriptive and inferential designs. Data were collected through questionnaires from 30 respondents involved in building projects with integrated Design and Build contracts in Indonesia. The research instruments were tested for validity using Pearson correlation and for reliability using Cronbach's Alpha. Data analysis was performed using descriptive statistics and multiple regression using SPSS version 25.0 software. The results showed that all variables achieved high average scores, with 3D-5D BIM implementation being the most dominant dimension (average 145.90). Validity and reliability tests indicated that all instruments were valid and reliable (Cronbach's Alpha > 0.60). The dominant factors causing cost overrun were design changes, design delays, unclear scope of work, and weak change control. The implementation of 3D-8D BIM has been proven to improve coordination, project information accuracy, cost and time control, asset management, and occupational safety. Project control processes play a crucial role in achieving cost, quality, time, and safety targets. In conclusion, the integrated implementation of 3D-8D BIM is recommended as a primary strategy for controlling the risk of cost overrun and improving design and build project performance. The synergy between BIM implementation and effective project control processes has been proven to detect design and construction risks early, enabling immediate preventive action to maintain overall project performance.

INTRODUCTION

The Design and Build method is an approach to the implementation of construction projects where the project owner gives a single contract to one party to handle the entire design process as well as construction (Adamtey, 2022; Amoah & Nkosazana, 2023; Assaf & Assaad, 2025; Smith et al., 2023). In contrast to the conventional Design-Bid-Build method which separates the planning and execution stages, this method allows the two processes to run in parallel (fast track), thereby cutting bureaucratic lines, shortening implementation time, and reducing costs. In Indonesia, this method is regulated through the Minister of PUPR Regulation No. 1/PRT/M/2020 concerning Standards and Guidelines for the Procurement of Integrated Construction Work Design and Build, which is a refinement of the previous regulation to encourage efficiency and innovation in national infrastructure development.

The main advantage of the Design and Build method lies in the integration of a single communication line between the planning and implementation teams, which minimizes the potential for miscommunication, design errors, and delays due to repetitive revisions (Adamtey, 2021; Alkilani & Loosemore, 2022; Alameri & Esmaeili, 2023). For project owners, this method provides convenience because it only deals with one party who is fully responsible for the final project results, from the conceptualization of the design to the handover of construction (Adamtey, 2021; Alameri & Esmaeili, 2023). The trend of using this method continues to increase, both in the public and private sectors, as the demand for time delivery, cost control, and high quality assurance in large-scale projects increases (Ahmed & El-Sayegh, 2021; Alkilani & Loosemore, 2022).

The research urgency is underscored by the increasing adoption of Design-Build methods in Indonesian infrastructure projects and the persistent challenge of cost overruns that threaten project viability and national development objectives. The novelty of this study lies in its comprehensive integration of all BIM dimensions (3D through 8D) into a unified risk control framework specifically tailored for Design-Build projects, with empirical validation from Indonesian construction projects.

Behind its various advantages, the application of the Design and Build method carries a significant risk of cost overrun, which is a condition where the actual cost of project implementation exceeds the planned budget (Alnaser et al., 2024; Alshihri et al., 2022; Chadee et al., 2023; Chamikara et al., 2023, 2026; Khalef & El-adaway, 2023; Mumtaz et al., 2025; Shoar et al., 2023). This risk stems from a number of factors typical of this method: design changes that take place in the middle of construction, unclear scope of work, incorrect initial cost estimates, and weak change order control. In many projects in Indonesia, the basic design process that runs in parallel with the field work causes the design review time to be very narrow, so that it often results in over-design conditions which ultimately trigger over-budget and have a domino impact on the overall performance of the project (Andi et al., 2005).

The experience of a number of large projects in Indonesia reinforces the urgency of handling cost overrun risks in Design and Build contracts. The Bogor Ring Road Toll Road project faces the unclear definition of work variations and design changes made simultaneously by both parties; Soekarno-Hatta Airport T3 Ultimate Terminal experienced significant differences between the volume of the initial contract and the realization of the installed due to repeated design revisions; while the MRT Project faces administrative disputes related to variation orders that have an impact on the project's cash flow (Ministry of Public Works and Housing, 2020; FIDIC, 1999). A similar phenomenon was also found in the JLNT Project and the XVIII Asian Games 2018 Project, where weakness in cost planning in the early stages was the root of cost overruns during implementation.

To answer the challenges of cost and risk control in Design and Build projects, the use of Building Information Modeling (BIM) technology from 3D to 8D dimensions present as a scalable and comprehensive solution. BIM 3D provides an accurate three-dimensional visual representation, BIM 4D adds a time dimension to construction schedule planning, and BIM 5D integrates cost estimation data. Meanwhile, BIM 6D contains sustainability information, BIM 7D supports asset management, and BIM 8D serves as construction safety management. The application of 3D–8D BIM from the planning stage to the construction period allows for early detection of design and construction risks (early warning) so that preventive actions can be taken immediately to maintain project performance in terms of cost, quality, time, and K3L in an integrated manner (Azhar, 2011).

Previous research

Relevant previous research covers the topics of Design and Build, Work Breakdown Structure (WBS), construction project accountability, audit process, and the SMM (Standard Method of Measurement) method. A recapitulation of the study is presented in the State of The Art Table in the Appendix.

Problem Identification

The experience of several major projects in Indonesia with *the Design and Build* contract system including the Bogor Ring Road Toll Road, Soekarno-Hatta Airport Terminal T3 Ultimate, MRT, JLNT Project, and the XVIII 2018 Asian Games reveals a series of recurring problems: unclear scope of work, ambiguous definition of variation, repetitive design changes, and weak contract administration and cost control (Ministry of Public Works and Housing, 2020; BPK RI, 2019; FIDIC, 1999).

Systematically, the root of the problem in *the Design and Build* project can be identified as follows:

1. The design process on the D&B contract runs parallel to the construction on the ground.
2. Design is often late for field progress needs.
3. Narrow design timelines often result in over-design.
4. Design review time is very limited compared to the needs in the field.
5. Over-design execution results in over-budget (cost overrun).
6. Cost overruns have a domino impact on the overall poor performance of the project.

Problem Formulation

1. What are the risk factors that cause cost overruns in the Integrated Design and Build Project?
2. Which factor is the most dominant factor affecting the cost overrun in the Design and Build project?
3. How to develop cost overrun risk control in the Building Design Integrated Project by utilizing BIM technology from 3D–8D to improve project performance?

Research Objectives

1. Identify the risk factors that cause cost overrun in the design and build Integrated Project building.
2. Analyze the dominant factors that affect cost overrun in Integrated Design and Build Projects.
3. Develop cost overrun risk control in Building Design Integrated Projects by utilizing BIM technology from 3D–8D.

Cost Overrun in Design-and-Build Projects

Cost overrun is one of the main indicators of construction project failure. According to Soeharto (1997), cost overrun occurs when the actual cost of project implementation exceeds the approved budget. Flyvbjerg et al. (2003) stated that the main factors causing cost overrun include cost-estimation errors, changes in the scope of work, uncertainty in project conditions, and weak control during implementation.

In design-and-build projects, the risk of cost overrun tends to be generally higher because construction activities may commence before the design phase is fully completed. This condition increases the possibility of design changes during project implementation, potentially leading to rework and cost overrun (Love et al., 2016).

Building Information Modeling (BIM)

BIM is a process that involves digital creation and management of building information in the project lifecycle (Eastman et al., 2018).

The 3D BIM

The 3D BIM is used for design visualization and coordination between work disciplines. This technology helps reduce design errors and improves stakeholder understanding of the project (Azhar, 2011).

The 4D BIM

The 4D BIM integrates three-dimensional models with the project implementation schedule, enabling simulation of work sequences and identification of potential project delays (Kymmell, 2008).

The 5D BIM

The 5D BIM connects building models with cost data, enabling more accurate cost estimates and real-time cost change control (Eastman et al., 2018).

The 6D BIM

The 6D BIM supports sustainability and life cycle cost analyses of buildings, thereby facilitating decision-making that considers long-term costs (Succar, 2009).

The 7D BIM

The 7D BIM focuses on facility management and the management of building assets after construction is complete (Becerik-Gerber et al., 2012).

The 8D BIM

The 8D BIM is used to improve occupational safety through more effective risk identification and safety planning during construction (Zhou et al., 2013).

Project Performance

Project performance refers to the extent to which a project successfully achieves its predefined objectives. According to Chan and Chan (2004), key project performance indicators include cost, time, quality, occupational safety, productivity, and project owner satisfaction.

METHOD

A data processing method was a statistical approach that involves data collection and summarization, scoring based on respondents' responses, data presentation, and the drawing of conclusions (generalization). The data processing method will influence the conclusions.

Descriptive statistics is a data analysis method that provides an overview of a dataset and is used to summarize and describe its main characteristics. Inferential statistics, on the other hand, is used for further analysis, such as hypothesis testing and concluding the processed data (Nursyafitri, 2021). The following are the types of tests that will be used in this study:

Validity Test

According to Azwar (1986), validity refers to the extent to which a measuring instrument accurately and precisely performs its function. Furthermore, Cooper and Schindler in Zulganef (2006) define validity as a measure indicating whether a variable accurately represents the construct intended by the researcher (Wahyuni, 2014).

The validity test for this study will be conducted using Spearman's correlation. The Spearman correlation test is used to identify relationships or test the significance of associative hypotheses when the variables are ordinal and the data sources do not need to be the same. The following is the formula for the Spearman correlation test for sample sizes ≤30 (Suharto, 2015).

$$rs = 1 - \frac{6\sum d^2}{n(n^2-1)} \quad (3.1)$$

Description:

: Spearman's rank correlation coefficient

d^2: Squared rank difference

n: Number of samples

Formula 3.1 can be used for samples with a size of 30 or fewer, while for samples with a size greater than 30, the z-value should be calculated first. The formula for finding the z-value is as follows:

$$z = rs\sqrt{n-1} \quad \ldots\ldots\ldots\ldots\ldots \ (3.2)$$

Description:

Z: Calculated z-value

rs: Spearman correlation coefficient

n: Number of samples

The Spearman significance test uses the Z-test because its distribution approximates a normal distribution. To interpret the level of relationship based on the obtained correlation coefficient, the following table shows the correlation values:

Table 1. Interpretation of the Correlation Coefficient

Coefficient Interval	Relationship Level
0.00 – 1.99	Very Low
0.20 – 0.399	Low
0.40 – 0.599	Moderate
0.60 – 0.799	Strong
0.80 – 1.000	Very Strong

The rs value in the formula above is found using Formula 1 and then compared with the calculated z value from the table in the statistics textbook.

RESULTS AND DISCUSSION

Project Performance with Design-and-Build Contracts

The use of 3D–8D BIM technology in the construction process under design–build contracts, from the planning phase through to construction, enables the early detection of design and construction errors and risks (early warning) during project implementation. This facilitates the implementation of preventive actions to maintain overall project performance across cost, quality, time, as well as Security, Safety, Health, and Environment (K3L).

Building Information Modeling (BIM), 3D-5D BIM (X.1)

The 3D BIM involves the creation of geometric and graphical data to represent a building in three dimensions for visualization purposes. In contrast, the 4D BIM provides additional project information in the form of scheduling data. Scheduling data is created in detail as the project progresses and can be used to show how the project develops sequentially. 5D BIM enables the provision of information for project cost estimates.

Building Information Modeling (BIM), 6D BIM (X.2)

The 6D BIM provides accurate energy estimates from design through construction for high-performance facilities.

Building Information Modeling (BIM), 7D BIM (X.3)

BIM dimension provides additional relevant information to support facility management and operations, aiming to deliver better projects.

Building Information Modeling (BIM), 8D BIM (X.4)

Health and safety are the focus of this dimension. The 8D BIM is an advanced risk analysis tool used to predict and assess potential problems or accidents.

Control Process (X.5)

The output of the 3D-5D BIM enables visualization of the building form, determination of the building sequence and schedule, and volume calculations, which support systematic project cost control. In addition, the 6D BIM enables proper evaluation of materials used to support efficient building maintenance and green building practices. The 7D BIM ensures that all stakeholders access consistent and up-to-date project information, while the 8D BIM enhances occupational health, safety, and environmental (HSE/K3L) performance management. Plan-Do-Check-Act process is carried out continuously to ensure project performance.

Project Performance (Y)

Project performance aims to reduce errors and omissions, minimize repetitive work, shorten project duration, and increase profitability in the construction industry. The scope of BIM includes well-coordinated project design, schedules, and other information. BIM serves as a tool for planning, designing, implementing, and maintaining buildings and their infrastructure for all relevant stakeholders. This ensures project performance is carried out with appropriate quality, on time, and on budget.

Factor Explanation

Table 2. Factor Explanation

Factor	Indicator	Definition
Building Information Modeling (BIM) — 3D–5D BIM (X.1)	3D visual modeling (X1.1) Clash detection (X1.2) 5D cost estimate (X1.3)	The application level of 3D–5D BIM for visualization of building models, detection of conflicts between elements, and integrated project cost estimation from the design stage.

Factor	Indicator	Definition
Building Information Modeling (BIM) — 6D BIM (X.2)	Energy efficiency analysis (X2.1) Building life cycle analysis (X2.2)	The utilization level of 6D BIM in analyzing aspects of sustainability, energy efficiency, and environmental impact in the life of a building.
Building Information Modeling (BIM) — 7D BIM (X.3)	Asset data documentation (X3.1) Maintenance schedule (X3.2)	The utilization level of 7D BIM to support post-construction building operations and maintenance management.
Building Information Modeling (BIM) — 8D BIM (X.4)	Identification of K3 risks (X4.1) Work safety simulation (X4.2)	The application level of 8D BIM to identify occupational safety risks and create simulations of K3 procedures at the construction implementation stage.
Project Control Process (X.5)	Monitoring progress (X5.1) Cost & time control (X5.2) Quality control (X5.3)	The application level of project control processes to ensure the achievement of cost, time, and quality targets.
Design & Build Project Performance (Y)	Cost (Y1) Quality (Y2) Time (Y3) K3L (Y4)	The level of project success is seen from the achievement of cost, time, quality, and work safety targets.

Results

Study Data Characteristics

This study involved 30 respondents engaged in building projects under an integrated design-and-build contract system. Data were obtained through a questionnaire consisting of the following variables: 3D–5D BIM (X1), 6D BIM (X2), 7D BIM (X3), 8D BIM (X4), Project Control Process (X5), and Project Performance (Y).

The descriptive analysis results show that all variables obtained high mean scores. The 3D–5D BIM variable had the highest mean value of 145.90, while the 6D BIM variable obtained a mean value of 23.73. The 7D BIM, 8D BIM, and Project Control Process variables each had mean values of 140.17, 76.90, and 86.83, respectively. Meanwhile, the Project Performance variable obtained a mean value of 105.27. These results indicate that the implementation of BIM and the project control process at the study object has been running smoothly.

Descriptive Statistics Summary Table

Table 3. Descriptive Statistics Summary

Variable	Mean	Std. Deviation
3D–5D BIM (X1)	145.90	3.556
6D BIM (X2)	23.73	1.258

Variable	Mean	Std. Deviation
7D BIM (X3)	140.17	2.793
8D BIM (X4)	76.90	1.807
Control Process (X5)	86.83	1.663
Project Performance (Y)	105.27	2.149

Source: SPSS 25.0 Processing Results

Validity and Reliability Tests

Validity test was conducted using Pearson's correlation, yielding an r-table value of 0.349. All indicators in the study variables had R-count values greater than the R-table values. Therefore, all questionnaire items were declared valid and suitable for use in the study.

Reliability test was conducted using Cronbach's Alpha, and the test results showed that all variables had Cronbach's Alpha values greater than 0.60, indicating that all instruments were reliable.

Table 4. Reliability Test Results

Variable	Cronbach's Alpha	Description
3D–5D BIM (X1)	0.772	Reliable
6D BIM (X2)	0.709	Reliable
7D BIM (X3)	0.787	Reliable
8D BIM (X4)	0.726	Reliable
Control Process (X5)	0.717	Reliable
Project Performance (Y)	0.769	Reliable

Source: SPSS 25.0 Processing Results

The results indicate that the implementation of BIM in a design-and-build project has been successful. The implementation of 3D–5D BIM is the most dominant dimension, as it supports design visualization, coordination among work disciplines, project schedule integration, and construction cost control. By using an integrated digital model, the potential for design errors and rework can be minimized, thereby reducing the risk of cost overrun.

In the 6D BIM dimension, incorporating sustainability aspects benefits the assessment of energy efficiency and the life-cycle costs of buildings. Meanwhile, the 7D BIM supports asset information management and post-construction building maintenance. The 8D BIM contributes to improved construction safety by identifying risks from the planning stage, thereby reducing the potential for work accidents and project cost losses.

In addition to BIM implementation, this study shows that the project control process plays an important role in achieving cost, quality, time, and safety targets. Effective project control facilitates the early identification of deviations, enabling corrective actions to be implemented before such deviations adversely affect overall project performance.

In general, the results indicate that integrating BIM into the project control process is crucial for improving design-and-build project performance and reducing the risk of cost overrun.

CONCLUSION

Based on the findings presented above, the following conclusions are drawn. Cost overrun in design-and-build projects is influenced by factors such as owner management, planning, implementation, scope of work, and project control. The dominant factors causing cost overrun are design changes, design delays, unclear scope of work, and weak change control. The implementation of 3D-8D BIM can improve coordination, project information accuracy, cost control, time control, asset management, and work safety. The integrated use of BIM is recommended as the primary strategy to control the risk of cost overrun in design-and-build projects.

REFERENCES

Adamtey, S. A. (2021). A case study performance analysis of design-build and integrated project delivery methods. *International Journal of Construction Education and Research, 17*(1), 68–84. https://doi.org/10.1080/15578771.2019.1696903

Adamtey, S. A. (2022). An empirical study to assist owners in selecting the right procurement method for design-build projects. *International Journal of Construction Education and Research, 18*(1), 67–84.

Ahmed, S., & El-Sayegh, S. (2021). Critical review of the evolution of project delivery methods in the construction industry. *Buildings, 11*(1), Article 11. https://doi.org/10.3390/buildings11010011

Alameri, R., & Esmaeili, B. (2023). Progressive design-build delivery method: Assessment of project performance. *International Journal of Construction Education and Research, 19*(1), 22–41. https://doi.org/10.1080/15578771.2021.1950242

Alkilani, S., & Loosemore, M. (2022). Project performance measurement for small-and-medium sized construction contractors in the Jordanian construction industry. *Construction Management and Economics, 40*(10), 743–769. https://doi.org/10.1080/01446193.2022.2108863

Alnaser, A. A., Al-Gahtani, K. S., & Alsanabani, N. M. (2024). Building information modeling impact on cost overrun risk factors and interrelationships. *Applied Sciences, 14*(22), 10711.

Alshihri, S., Al-Gahtani, K., & Almohsen, A. (2022). Risk factors that lead to time and cost overruns of building projects in Saudi Arabia. *Buildings, 12*(7), 902.

Amoah, C., & Nkosazana, H. (2023). Effective management strategies for construction contract disputes. *International Journal of Building Pathology and Adaptation, 41*(6), 70–84.

Assaf, G., & Assaad, R. H. (2025). A decision-support system for choosing between traditional and alternative project delivery methods for bundled projects. *Engineering, Construction and Architectural Management, 32*(11), 7181–7216.

Azhar, S. (2017). Sustainability assessment of buildings using BIM-based 6D approach.

International Journal of Sustainable Built Environment.
Becerik-Gerber, B., et al. (2012). BIM for facilities management: Challenges and opportunities. *Journal of Performance of Constructed Facilities*.
Chadee, A. A., Martin, H. H., Gallage, S., Banerjee, K. S., Roopan, R., Rathnayake, U., & Ray, I. (2023). Risk evaluation of cost overruns (COS) in public sector construction projects: A fuzzy synthetic evaluation. *Buildings, 13*(5), 1116.
Chamikara, K. L., Perera, B., & Kurukulasooriya, I. N. (2023). Use of building information modelling to mitigate cost overruns in design and build projects. *World Construction Symposium, 1*, 1104–1115.
Chamikara, K. L., Perera, B., Raigama Acharige, D. P., & Ekanayake, B. (2026). Adaptability of BIM technology to mitigate the cost overruns in design and build projects. *Construction Innovation, 26*(2), 464–490.
Chan, A. P. C., et al. (2004). Measuring project performance using key performance indicators (KPIs). *Benchmarking: An International Journal*.
Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011). *Building information modeling: Planning and managing construction projects with 4D CAD and simulations*. Wiley.
Khalef, R., & El-Adaway, I. H. (2023). Advancing airport project delivery: A comparison of design-build and traditional methods in terms of schedule and cost performance. *Journal of Management in Engineering, 39*(6), Article 04023041.
Mumtaz, F., Muhammad, T., & Abid, H. M. S. (2025). Budget overruns in large-scale projects: Root causes and preventive project management practice. *Advance Journal of Econometrics and Finance, 3*(3), 21–33.
Shoar, S., Yiu, T. W., Payan, S., & Parchamijalal, M. (2023). Modeling cost overrun in building construction projects using the interpretive structural modeling approach: A developing country perspective. *Engineering, Construction and Architectural Management, 30*(2), 365–392.
Smith, J., Edwards, D. J., Martek, I., Chileshe, N., Hayhow, S., & Roberts, C. J. (2023). The antecedents of construction project change: An analysis of design and build procurement application. *Journal of Engineering, Design and Technology, 21*(3), 655–689.