



# Proposing Criteria to Evaluate the Effectiveness of BIM Application in the Payment of Construction Projects in Vietnam

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**Abstract.** In the construction industry, Building Information modeling (BIM) has been recognized as the advanced technology for changing and improving the construction process. Especially for investors and contractors, the BIM technology has been applied for checking the clash among building elements in the design process and for modeling the construction progress. However, the application of BIM to construction project payment has not emphasised strongly in Vietnam. The implementation process to replace the BIM model for the traditional payment method is facing many obstacles. This study aims to analyze the potentials and benefits of applying the BIM in payment. The quantitative and statistical analysis was performed based on data collected from a questionnaire survey of stakeholders who have experience in the BIM application and construction payment. Then, this study proposes criteria to evaluate the effectiveness of the BIM application in construction project payment. The research supports state agencies and businesses in BIM execution planning (BEP) in general and payment process in particular.

**Keywords:** BIM · Construction project · Payment · Effectiveness · Criteria

## 1 Introduction

In parallel with the implementation of project construction on schedule and quality, it is very important to complete quickly, effectively, accurately and promptly the payment and settlement documents between the contractor and the investor, and this greatly affects the success of construction projects. The contractor needs to ensure finance throughout the construction process. On the other hand, the investor needs to be proactive in preparing the budget to push the contractor to execute the construction according to the committed schedule and quality in order to meet the Investor's plan in putting the project into operation and business.

Accordingly, the payment and settlement by the traditional method is still causing many difficulties and taking up a lot of time for measuring and checking the payment volume between the contractor, the supervision consultant and the investor. This job

requires a quantity surveyor (QS) engineer with years of experience to do it right, quickly and accurately [1]. So in addition to improving the human factor, a tool or model that can optimize the time as well as increase the efficiency of the payment and settlement process between the contractor and the investor is necessary. The application of Building Information Modeling (BIM) as a technology solution helps to solve the above problem. BIM brings efficiency to QS engineers while increasing reliability in the calculation process. Currently, BIM solution in payment and settlement is still new to Vietnam, requiring users to understand the implementation process, experience and knowledge of BIM.

Recognizing the importance and obstacles in applying BIM to the construction industry in Vietnam. State management agencies have issued BIM implementation guidelines aimed at setting applicable standards to suit socio-economic conditions in Vietnam and pave the way for private enterprises to actively participate. On December 22, 2016, the Prime Minister approved the Decision 2500/QĐ-TT to apply Building Information Modeling (BIM) in construction and operation management activities. [2]. The Ministry of Construction issued Decision 1004/QĐ-BXD on July 31, 2020 approving the “Plan for digital transformation of the construction industry in the period of 2020–2025, with a vision to 2030”, issued Decision No. 347/QĐ-BXD dated April 2, 2021 “Publishing detailed instructions on application of Building Information Modeling (BIM) to civil and urban technical infrastructure works” and issued Decision No. 348/QĐ-BXD on the “Publication of general guidelines for the application of Building Information Modeling (BIM)”. Most recently, on March 17, 2023, the Prime Minister issued Decision 258/QĐ-TTg approving the “Roadmap for the application of Building Information Modeling (BIM) in construction activities”.

Currently in Vietnam, BIM is applied in large projects in the design and construction stages. However, the application of BIM is mainly for detecting conflicts, simulating the construction process and deploying shop drawings or analyzing energy consumption and energy costs in buildings [2]. The application of BIM in payment and settlement in the construction process still has many limitations and has not been applied strongly to serve the construction process of works and projects.

This study focuses on synthesizing, assessing the potential and analyzing the benefits of applying BIM model in the payment and settlement of construction projects. Accordingly, the objectives of this study include: (1) to assess the current status of payment and settlement using traditional methods—in Vietnam; (2) identify the potential application of BIM model in settlement work to improve working productivity in civil construction projects; (3) evaluate and analyze the efficiency and benefits that the BIM model brings when applied in payment and settlement work; (4) propose solutions to improve the efficiency of using BIM in payment and settlement work. The research results provide a scientific basis for state agencies, investors, contractors and stakeholders to be more proactive in the process of implementing effective BIM application in payment and settlement of construction projects.

## 2 Methodology

Research and build survey questionnaires based on previous articles combined with opinions of BIM experts working at construction sites. The questionnaire includes the information collection of the survey subjects, the respondents' opinions about the current status of traditional payment and settlement work and the potential of BIM application in this work. In addition, the survey uses 5-level Likert scale questions to collect opinions of subjects to assess the effectiveness of BIM application in settlement of civil construction works.

After studying domestic and foreign documents, conducting empirical surveys and consulting with experts, the contents were adjusted, supplemented and completed the mass survey. The study used the following methods to collect data: online survey through content of official questionnaires built from Google forms, sent through social networking platforms and sent directly to individuals based on relationships during construction activities.

The survey contents revolved around the following issues: Firstly, the study collects general information about the surveyed subjects such as number of years of experience, working expertise, role in construction activities. Then, according to the results of the survey subjects, the research will evaluate the current status of the payment and settlement work according to the traditional method to analyze the shortcomings that this implementation method is facing and evaluate the potential to apply BIM information model. Finally, the study evaluates the effectiveness of the BIM model in payment and settlement, from which the units that want to use have a more specific view to look forward to in the future.

To achieve specific objectives, the study uses descriptive statistical analysis to provide summaries of samples and data parameters. At the same time, for efficient data analysis, the study used SPSS software to calculate the confidence coefficient of Cronbach's Alpha scale, used mean value analysis MVA to rank the important effects, benefits and analyze the results, also analyzed the hypothesis testing to evaluate the difference of opinion between the investor and the contractor, thereby offering suitable solutions for project participants that can improve the effectiveness of BIM application in the payment and settlement work.

To collect data, the survey was transferred to 142 subjects who are individuals operating and working in the field of construction, the survey period is from June 2022 to August 2022. The number of responses is 126, reaching a rate of 88.7%. In order to obtain objective and relevant results, 20 invalid survey results were discarded because they did not meet one of the following requirements:

- Surveyed subjects: individuals working at the positions of the investor, the project management board of the investor, the design unit of the investor and the construction contractor.
- Experience requirements: The surveyed subjects must have the required experience to have participated in projects using BIM and participated in the implementation of payment and settlement records.
- Scope: Civil construction works.

The total number of valid data is 106 subjects. Figure 1 shows the analysis diagram of the effectiveness of BIM application for payment and settlement.

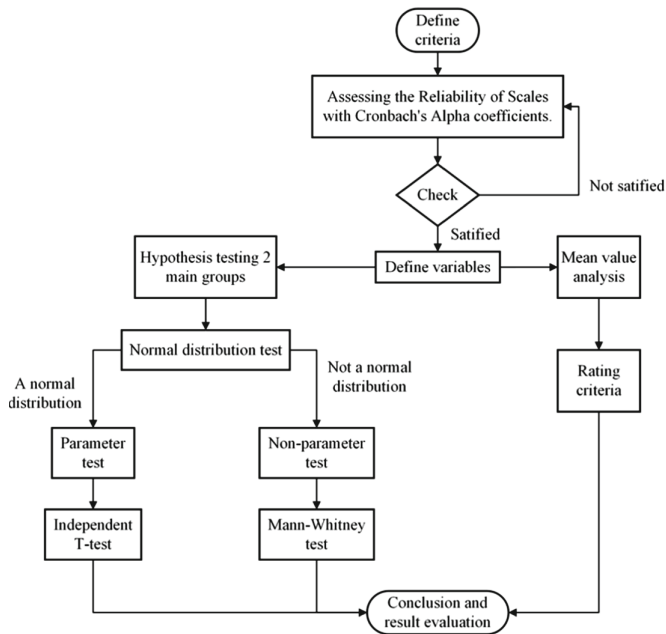


Fig. 1. Diagram of analysis of effectiveness evaluation criteria.

### 3 Results and Discussions

#### 3.1 Proposing Criteria for Evaluating the Effectiveness of BIM Application

Applying BIM technology in construction investment projects brings many advantages and benefits to project participants. They can review and evaluate performance before implementation [3] BIM models create three-dimensional (3D) objects with structured geometric information to classify objects from two-dimensional (2D) drawings design. Therefore, this makes it easy to extract the payment volume during the construction process, it is possible to divide the work items, the implementation areas for subcontractors, construction teams in the same model. From there, retrieve objects automatically and correctly [4].

Besides, the BIM model gives information about the shape and volume of the object. The quantity management in the payment records also depends on the skills of the QS engineer to evaluate the method, construction organization, and materials. Therefore, the combination and exchange of information between the BIM modeler and the QS engineer is very important to unify the input information, identify and classify objects in the model [5].

In fact, BIM has statistical functions to export payment and settlement volumes, grouping objects to divide the construction areas. However, the implementation is also related to many factors. The granularity of the object in the model is a factor for extracting the settlement volume accurately. Moreover, the information needs to be organized and arranged according to a strict and reasonable process in order to effectively coordinate and exploit information for accurate output from beginning.

Table 1 presents the effectiveness and benefits of applying BIM information model in settlement work, based on international and domestic scientific articles, combined with consultation of experts on BIM and payment and settlement in the field of construction. These effects will show the necessity of the BIM model in the process of making payment and settlement of the project, thereby help stakeholders who are project participants have appropriate plans and strategies to apply BIM model in payment and settlement for the implementation of projects.

**Table 1.** Criteria for evaluating the effectiveness of BIM model application.

Code	The effects and benefits in applying BIM in payment and settlement work	Reference source
A1	BIM outputs the correct payment volume	[1, 4]
A2	BIM restricts manual measurement of volume according to traditional methods	[3, 6]
A3	BIM updates itself when information changes	[7, 8]
A4	Visualize the nature of work more specifically and clearly through 3D modeling	[9, 10]
A5	The data is attached with clear information, the system is well controlled	[4, 11]
A6	Division of construction phase, scope of work in the construction process	[4, 5]
A7	Information exchange between stakeholders through BIM	[11, 12]
A8	Accelerate payment and settlement records between parties during the inspection process	[5, 13]

### 3.2 Statistic Analysis for Validating the Proposed Criteria

Cronbach's Alpha test is used to analyze and evaluate the reliability of the scale. The purpose of this test is to find out if the observed variables measure the same concept. The value of more or less contribution is reflected through the correlation coefficient of the total variable Corrected Item—Total Correlation. Thereby, it is possible to eliminate inappropriate variables in the research model. The standard for accepting variables is that the Cronbach's Alpha coefficients of the variables must have a value of 0.8 or higher.

For the first round test, the criteria with Cronbach's Alpha coefficient are all less than 0.869, except for the factor  $A2 = 0.904 > 0.869$ , so the A2 variable should be

eliminated to increase the reliability of the scale. The second Cronbach's Alpha round test was performed with the remaining 7 criteria. The Cronbach's Alpha coefficient in Table 2 show that the criteria with Cronbach's Alpha coefficient are all less than 0.904, removing any criterion does not increase the coefficient for the scale. Therefore, the appropriate criteria for the following sections of this study include the above 7 criteria.

**Table 2.** Cronbach's Alpha coefficient of the criteria.

Criterion		Correlation coefficients	Cronbach's Alpha coefficient
A1	BIM outputs the correct payment volume	0.689	0.893
A3	BIM updates itself when information changes	0.772	0.884
A4	Visualize the nature of work more specifically and clearly through 3D modeling	0.674	0.895
A5	The data is attached with clear information, the system is well controlled	0.832	0.879
A6	Division of construction phase, scope of work in the construction process	0.700	0.892
A7	Information exchange between stakeholders through BIM	0.726	0.889
A8	Accelerate payment and settlement records between parties during the inspection process	0.635	0.899

The criterion hypothesis testing is performed to determine the distribution pattern of the variables. The Kolmogorov-Smirnov test is used when the sample size is greater than 50 or the Shapiro-Wilk test is used when the sample size is less than 50. According to the survey results, the 106 valid samples collected are greater than 50, so the Kolmogorov-Smirnov test is used. The results of the criteria are shown in Table 3. Variables are considered to have a normal distribution when the significance level (Sig.) is greater than 0.05. The results in Table 3 show that Sig is  $<0.05$ , so the survey variables do not have a normal distribution. Therefore, we apply the Mann-Winey non-parametric test.

Mann-Whitney non-parametric test was used to test the difference of opinion on 7 criteria between 2 main groups of subjects: investors and contractors. Group 1 includes the investor, the investor's management board, the investor's design, is coded with the number 1 and has a total of 37 survey subjects. Group 2 is the coded contractor with a data of 2, with a total of 69 survey subjects. Mann-Whitney non-parametric test, shown in Table 4.

**Table 3.** Normal distribution test for 7 criteria.

Criteria	Kolmogorov-Smirnov test			Shapiro-Wilk. Test		
	Statistic	dF	Sig.	Statistic	dF	Sig.
A1	0.328	106	0.000	0.749	106	0.000
A3	0.233	106	0.000	0.818	106	0.000
A4	0.311	106	0.000	0.754	106	0.000
A5	0.241	106	0.000	0.809	106	0.000
A6	0.253	106	0.000	0.862	106	0.000
A7	0.223	106	0.000	0.848	106	0.000
A8	0.242	106	0.000	0.847	106	0.000

**Table 4.** Results of Mann-Whiney non-parametric test for 7 criteria.

Criteria	A1	A3	A4	A5	A6	A7	A8
Mann-Whitney parameter	1177.5	1038	1078	1276	1218	1170	1084
Asymp. Sig. (2-tailed)	0.464	0.09	0.146	0.997	0.681	0.456	0.175

The results of the Mann-Whiney parameter fee test table show the Asymp level. Sig. (2-tailed) are all  $>0.05$ , so we conclude that there is no difference in opinion of the two groups of investors and contractors for the survey criteria. This proves that the criteria for the effectiveness of BIM application in payment and settlement are evaluated to be similar.

Evaluate and rank benefits according to the mean value analysis (MVA). Table 5 describes the order of the criteria according to the mean value. They show the effectiveness of the application of BIM in payment and settlement work. Criteria with a high mean value will be ranked first and descending according to the mean value. The ranking results in Table 5 show that the 4 benefits ranked the highest with values greater than 4. These are the criteria A4, A5, A3 and A1.

Criterion A4—Visualize the nature of work more specifically and clearly through 3D modeling—is ranked highest (MVA = 4.32). This benefit is ranked first because reading 2D drawings by the traditional method to visualize most of the specific details is very difficult during the construction process, especially for personnel with little practical experience. Therefore, the 3D model gives us a more intuitive view in the construction work as well as in the process of making records to avoid errors in the payment and settlement volume and value.

Criterion A5—The data is attached with clear information, the system is well controlled—the second criterion which is briefly understood as attaching construction information to the model for each input object, the output will give accurate results for each

**Table 5.** Outcome ranking of 7 benefits by mean value analysis.

	Criteria	N	Mean value	Standard deviation	Ranking
A4	Visualize the nature of work more specifically and clearly through 3D modeling	106	4.32	0.868	1
A5	The data is attached with clear information, the system is well controlled	106	4.16	0.794	2
A3	BIM updates itself when information changes	106	4.13	0.885	3
A1	BIM outputs the correct payment volume	106	4.05	0.898	4
A7	Information exchange between stakeholders through BIM	106	3.96	0.945	5
A8	Accelerate payment and settlement records between parties during the inspection process	106	3.94	0.903	6
A6	Division of construction phase, scope of work in the construction process	106	3.85	0.934	7

object and information. Attaching information to the early stage of project implementation is very important because it determines the exchange of information between stakeholders and the data that is output during the payment and settlement process correctly.

Criterion A3—BIM updates itself when information changes is ranked third. This benefit is equally important in project implementation. During the process on the construction site, it will inevitably arise due to design changes from objective and subjective requirements. The management of updated information when there is a change in the traditional method is facing many difficulties and disadvantages in terms of time, cost as well as human resource. BIM allows the project to update information on its own during the implementation process. Moreover, it will automatically output the payment and settlement volume when there is a change through the tools applied in the model.

Criterion A1—BIM outputs accurate payment volume—is ranked fourth. The traditional method is used mostly by businesses, investors and contractors. According to scientific researches and practical experience, when implementing 2D payment and settlement records, there will be many disadvantages such as long processing time, high cost, reduced working efficiency, etc. At the same time, during the implementation process, errors are likely to occur. Therefore, the information model is applied in payment and settlement work to solve these limitations and gradually become more popular to businesses, investors and contractors.



## 4 Conclusion

BIM is encouraged to be implemented by state agencies in Vietnam, but this application is only used in the role of construction design, not much applied in the payment and settlement process. The research results show that the traditional payment method is still facing many difficulties in controlling changes in the construction process. Therefore, the time to complete the payment and settlement documents is prolonged, the disbursement flow is slow, causing an increase in costs, significantly affecting the project's finance.

The feedback results from the surveyed respondents confirm that the potential application of BIM in payment and settlement work is being interested by construction industry professionals. It limits the disadvantages of using traditional methods, also increases work efficiency during implementation. With 8 benefits given, through the analysis results, 7 benefits that the BIM model bring in the payment and settlement work, typical benefits are highly appreciated such as visualize the nature of work more specifically and clearly through 3D modeling, the data is attached with clear information, the system is well controlled, BIM updates itself when information changes, BIM outputs the correct payment volume. These benefits show the response of BIM to the urgent needs that businesses and contractors are aiming for in payment and settlement work.

Based on the research results of 7 benefits that BIM brings, the survey opinions of investors and contractors are not different, the author proposes a number of criteria that the parties need to pay attention to to improve BIM application efficiency in payment and settlement. Deploying BIM 3D; Controlling information in the data system; BIM updates itself during design changes; Retrieve exact volumes; The coordination between the project participants; Accelerate the implementation of payment and settlement documents and the implementation of works and scope of works. With the proposed criteria, project participants have a basis to solve problems and promote the role of BIM in payment and settlement.

Previous studies have mainly focused on the technical aspects of BIM implementation, such as time and cost savings, improved collaboration, and reduced errors and rework. Therefore, proposing criteria to evaluate the effectiveness of BIM in payment should also be considered and emphasized. In this study, the proposed criteria not only serve to evaluate the effectiveness of BIM application in the payment and settlement process but also can help identify areas for improvement in BIM implementation in this process in Vietnam, as well as provide a comprehensive assessment of BIM's impact on project performance.

However, the application of BIM in the payment and settlement work requires building an application process and specific guiding documents for businesses and participants to grasp the necessary elements during implementation. Future research needs to be analyzed more clearly on the process of applying BIM in payment and settlement, developing the research scale, expanding the survey subjects, helping to evaluate more accurately the effectiveness of the application BIM model in payment and settlement.

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