# Implementation of Building Information Modeling to Improve Project Management

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**Abstract.** This study aims to analyze the implementation of Building Information Modeling (BIM) in the construction industry using a sample of state-owned enterprises in Indonesia. Building Information Modeling (BIM) is an integrated information system from the design phase, construction phase, and project management. The biggest benefit of using BIM is the ability to develop realistic and detailed 3D models down to the materials used, as well as to estimate project costs. This study uses mixed methods research using a qualitative approach and a quantitative approach. The qualitative approach used is interviews using the Technological, Organizational, Environmental (TOE) Framework and the quantitative approach used was to analyze the project's financial performance. The results indicate that the implementation of BIM provides an improvement for construction project performance. One of the benefits of implementing BIM is being able to detect potential rework thereby minimizing additional costs. In addition, this study suggests a socialization program related to the BIM system for all construction project employees to maximize the benefits of BIM.

**Keywords:** Building Information Modeling, Implementation, Construction Industry, SOE Indonesia

## 1 Introduction

The construction industry is one of the industries that have very significant growth since 2016- 2020, this is evidenced by the increase in the infrastructure budget in the State Budget since 2016- 2020 with a CAGR of 11.9%. Based on the 2020 State Budget data, the infrastructure budget in 2020 has increased by 5.9% from the 2019 outlook or equivalent to Rp423.3 trillion of the allocation for the infrastructure budget. The infrastructure budget is spread through central spending of IDR 191.2 trillion, through transfers to the regions of IDR 200.3 trillion and through the financing of IDR 31.8 trillion [1].

The development of the construction industry encourages contractors to improve the quality of construction projects. The tight competition in the construction industry also requires all contractors to complete construction projects in a shorter time, with better quality and more efficient costs. However, problems that often arise in the implementation of construction projects are various design changes and changes in material planning which will have an impact on increasing project implementation costs and extending construction implementation time.

PT ABC is one of the State-Owned Enterprises in the construction sector. The initial

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interview explained that PT ABC experienced cost overruns and delays in the completion of construction projects. This was analyzed based on the number of construction projects carried out in the 2015-2019 span of 401 projects. Of the total projects carried out, 40% of construction projects got an increase in project costs or run into cost overruns. The cost overrun analysis is carried out by comparing the project cost plan at the beginning of construction with the post-construction project cost realization. In addition to cost overrun analysis, there are also 15% of construction projects that experience an extension of construction execution time so that there are delays in the completion of construction projects.

The existence of cost overruns and delays in the completion of construction projects made PT ABC make changes in business processes. To find out which business processes need to be changed, PT ABC conducts an internal analysis of the entire business process in the implementation of construction projects. Based on the internal analysis that has been carried out, it is concluded that one of the things that cause cost overrun is the non-integration of the construction project information system. Thus PT ABC implements an integrated information system that can be applied in the construction project environment. Changes in business processes carried out by PT ABC include Business Process Reengineering which is defined as a way of making fundamental changes to a certain business process accompanied by the application of information system technology [2].

Changes in business processes that are carried out are by implementing Building Information Modeling (BIM) in order to improve the integrated construction project management process. BIM can be used in all stages of construction starting from project planning, project implementation, to post-construction building management. According to Kementerian PUPR [3], BIM is an information system technology that is integrated with the scope of building design, construction implementation, and management which is applied based on information on all aspects of the building. The scope of BIM includes project design, project activity schedule, project materials, and other information that is well integrated. The use of BIM will provide digital information in a model so as to prevent collisions that will cause additional project construction costs. Even that virtual information provides an easier understanding for stakeholders in understanding construction project activities [3].

The main benefit of BIM is the ability of the BIM system to be able to develop realistic and detailed 3D models to the materials used, as well as to estimate project costs [4]. BIM is able to synthesize the results of the assessment and identify potential project problems that arise for further use as a consideration in decision making [4].

A total of four construction projects at PT ABC have implemented Building Information Modeling (BIM). The four construction projects have implemented BIM starting from the construction project planning process until the construction process is complete. PT ABC has not implemented BIM in all of its construction projects. BIM is only applied in certain projects that serve as pilot projects. According to the Manager of the Business Portfolio and Risk Management Department of PT ABC, this was done to obtain a more detailed analysis of how the impact of implementing the BIM system at PT ABC was before making a decision to apply it to all PT ABC projects. The use of BIM is used by PT ABC as a form of Business Process Reengineering which will then provide a competitive advantage to PT ABC's business processes.

## 2 Method

This research will focus on 4 (four) construction projects that have used BIM since the beginning of the construction process until the construction process is completed in 2020. The research approach used was a qualitative and quantitative approach. A qualitative approach was taken to have a better understanding of the implementation of BIM in improving the performance of construction projects at PT ABC [5]. The quantitative approach that will be used is to analyze the data on cost overrun and data on the addition of construction time. Yin [6] explains that a qualitative approach is used to gain an in-depth understanding of something. To have this understanding, researchers will conduct interviews with PT ABC interviewees. The parties who became interviewees composed of 5 people, with 15-20 years of work experience, which are presented in table 1.

**Table 1.** List of interviewees

| No | Position | Education | Work Experience |
|---|---|---|---|
| 1 | Department Manager | S2/Management | 20 Years |
| 2 | Project Manager - Project 1 | S2/Civil Engineering | 18 Years |
| 3 | Project Manager - Project 2 | S1/Civil Engineering | 18 Years |
| 4 | Project Manager - Project 3 | S1/Civil Engineering | 19 Years |
| 5 | Project Manager - Project 4 | S1/Civil Engineering | 15 Years |

(PT ABC, 2021)

Based on the list of sources in table 1, interviewees are generally dominated by civil engineering backgrounds with more than 15 years of work experience. This is based on the condition that all of the interviewees are top management, either at the project level or at the department level. The selection of interviewees is based on the condition of the number of projects that have completed the construction process in 2020 and have used Building Information Modeling (BIM) since the design process began until construction is complete.

The implementation of Building Information Modeling (BIM) can be analyzed using the Technological, Organization, and Environmental (TOE) Framework which is based on 3 (three) main perspectives, namely the technological context, organizational context, and environmental context [7]. This framework is used to analyze how the adoption or application of new technology in a particular company.

Technological, Organizational, and Environmental (TOE) Framework is the right framework to be used in analyzing the implementation of Building Information Modeling (BIM) based on 3 (three) reasons. First, Building Information Modeling (BIM) is a form of innovation with sophisticated features [8]. These features are considered important by companies in evaluating how to implement Building Information Modeling (BIM). Second, the implementation of Building Information Modeling (BIM) is a form of business process change that must be accompanied by support from the company's organization. Third, Building Information Modeling (BIM) is a collaborative technology that connects various stakeholders [8]. Thus the environmental context becomes an assessment in evaluating the implementation of Building Information Modeling (BIM).

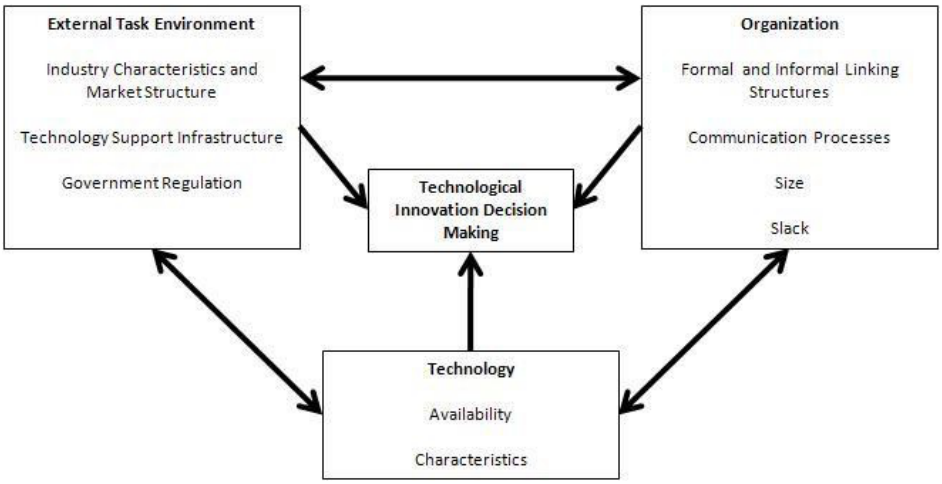


**Fig 1.** Technological, Organization, dan Environmental (TOE) (Tornatzky dan Klein [7])

The Technological, Organization, and Environmental (TOE) Framework was discovered by Tornatzky and Klein [7] in 1982. The Technological, Organization, and Environmental (TOE) Framework describes the factors that influence decision-making related to the implementation of a new system. Based on the Technological, Organizational, and Environmental (TOE) Framework, the factors that need to be analyzed in depth before making a decision are technological, organizational, and environmental **factors**. The combination of these three factors is then analyzed to make a decision on the adoption of a new system.

According to Tornatzky and Klein [7], the first factor that needs to be analyzed is the technology factor. Technology consists of 3 (three) main elements, namely relative advantage, suitability and complexity. In relation to the analysis of the implementation of Building Information Modeling (BIM), the three main elements will be analyzed in terms of how useful the application of Building Information Modeling (BIM) is, how appropriate it is and how complex it is to implement Building Information Modeling (BIM) [9]. The benefits of implementing Building Information Modeling (BIM) is the most important aspect that must be analyzed in depth because it will explain the relative advantages compared to conditions before the existence of Building Information Modeling (BIM).

The second factor that needs to be analyzed is the organization. According to Tornatzky and Klein [7], organizational factors consist of 2 (two) main elements, namely organizational support and organizational readiness. The two main elements are related to the characteristics of the company and the company's commitment to implementing a new system. The two elements of the organization will be analyzed in terms of how the organization supports in implementing Building Information Modeling (BIM), and how the organization is prepared to implement Building Information Modeling (BIM) [9]. High commitment from top management is an important aspect to analyze because it will help in the implementation of the new Building Information Modeling (BIM) system [10].

The last factor according to Tornatzky and Klein [7] is the environmental factor. Environmental factors are related to the climate in which the organization carries out its

operational activities related to other parties. Environmental factors consist of 3 (three) main elements, namely the influence of competitors, consumers, and stakeholders [9]. The three environmental elements will be analyzed in the form of how competitors influence the implementation of Building Information Modeling (BIM), how consumers influence the implementation of Building Information Modeling (BIM), and how stakeholders influence the implementation of Building Information Modeling (BIM). The influence of stakeholders includes the influence of suppliers and also the government as a regulator.

# 3 Result and Discussion

## 3.1 Analysis of Technology Aspects

The implementation of Building Information Modeling (BIM) at PT ABC will then be reviewed in various aspects based on the Technological, Organization, and Environmental (TOE) Framework. The first aspect to be discussed is the technological aspect.

Based on the results of interviews conducted with informants related to the implementation of Building Information Modeling (BIM) at PT ABC on the technological aspect, the results obtained that Building Information Modeling (BIM) provides benefits to PT ABC's business processes, especially in terms of compiling building construction accurately digitally.

**Fig 2.** Display of Building Information Modeling (BIM) Implementation in one of PT ABC's projects (Document of PT ABC, 2021)

A source from PT ABC defines that Building Information Modeling (BIM) is a digital representation or depiction of a building. An example of a digital representation is shown in Figure 2, which is one of PT ABC's projects that have implemented Building Information Modeling (BIM). The shape of the physical characteristics and the functional characteristics of a building will be attached to the results of the Digital Building Information Modeling (BIM) drawing. Thus, Building Information Modeling (BIM) contains all relevant information about the structure of the building accurately [11]. The information generated by Building Information Modeling (BIM) will then be used for decision making during the construction period until the building is demolished.

The main benefit of having a Building Information Modeling (BIM) system is to increase the productivity of a project during the construction period. This is based on the fact that during the construction period, the project will benefit as follows:

### 3.1.1 The creation of continuity between the construction model and the materials to be used.

Implementation of Building Information Modeling (BIM) at PT ABC provides an initial overview of a building or construction project. The initial picture is presented in 3D so as to provide an overview of how the condition of the building after the construction process is complete [11]. The resulting 3D model not only provides a visualization of the building, but also provides information regarding the material requirements to be used. With the material requirements to be used, the project procurement team is able to develop a procurement plan for the construction project more accurately [11].

### 3.1.2 Provide a quick response to changes.

Based on information obtained from resource persons, information was obtained that the project's environmental conditions were very dynamic. It is very possible that there will be many changes in building design due to various conditions in the field. By using BIM, each of these changes can be directly simulated so that image revisions will be available more quickly [12].

### 3.1.3 Able to detect early design errors and omissions prior to construction.

In conditions prior to BIM, building drawings were made with a 2D model. In practice, when the drawing is carried out in a spacious manner, several design errors or omissions will be created which cause inefficiency in construction costs. By using BIM, the resulting model is a 3D dimensional model. By using a 3D dimensional model, it is able to detect early errors in images that have been compiled using 2D dimensions [12].

### 3.1.4 Deliver lean construction impact

Because BIM has an accurate model and material resources needed for each job segment. BIM provides the basis for improved planning and scheduling of subcontractors and helps to ensure the scheduled arrival of people, equipment, and materials [13].

### 3.1.5 Regarding the maturity level of Building Information Modeling (BIM) at PT ABC,

PT ABC's resource person explained that currently PT ABC is still at level 1 of 3 maximum levels [14]. Maturity level 1 explains that the work of building design concepts already uses 3D dimensional models [14]. In addition, documentation related to project information has been prepared digitally. However, the collaboration between stakeholders has not yet been created in the use of BIM. This condition causes the maturity level of Building Information Modeling (BIM) at PT ABC is still at level 1 [14].

### 3.1.6 With regard to the dimensions of the Building Information Modeling (BIM) building model at PT ABC,

currently the majority of PT ABC's projects that implement Building Information Modeling (BIM) have been able to construct a 4D dimensional building model. The 4D dimension describes that the 3D model of the building is combined with project scheduling for construction simulation purposes. The resource person explained that in the future it is hoped that PT ABC will be able to compile Building Information Modeling (BIM) up to level 5D,

which is a model that is combined with implementation budget data which aims to determine costs during the construction phase. The implementation budget data is currently separate from the Building Information Modeling (BIM) system. The current project implementation budget data is in the company's Enterprise Resource Planning (ERP) system. Thus, to realize the 5D dimension Building Information Modeling (BIM) system, it is necessary to synchronize the Building Information Modeling (BIM) system with the Enterprise Resource Planning (ERP) system.

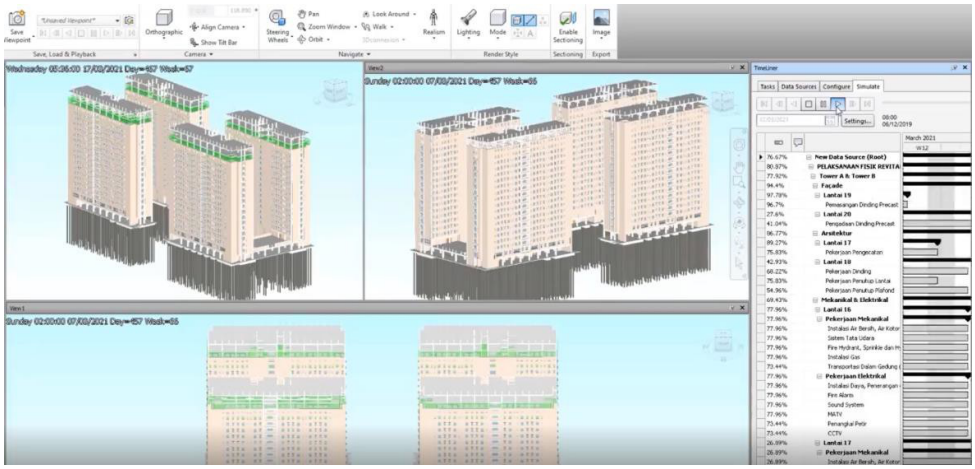

**Fig 3.** Display of Building Information Modeling (BIM) Implementation in one of PT ABC's projects (Document of PT ABC, 2021)

The picture above is one display of the implementation of Building Information Modeling (BIM) in one of PT ABC's building projects. A source from PT ABC explained that Building Information Modeling (BIM) did not change PT ABC's business processes. Activities that occur in the implementation of construction projects in the field are still the same as before the BIM. The only thing that differs is the way in which the construction project implementation activities are operated. Building Information Modeling (BIM) is here to simplify the work in the implementation of construction projects. One of the most basic is the presence of a 3D dimensional building model that provides all project information that will be useful in planning construction projects prior to the construction process.

Although the implementation of Building Information Modeling (BIM) provides various benefits in the construction project development process, there are several obstacles faced by PT ABC. The most dominant obstacle is the need for time to get used to applying Building Information Modeling (BIM) throughout the project environment. Building Information Modeling (BIM) is a new method that still needs to be disseminated to all elements of the PT ABC project. It is hoped that with the socialization to all project elements, a work culture will automatically form to apply Building Information Modeling (BIM) in the implementation of construction projects.

## 3.2 Analysis of Organizational Aspects

The implementation of BIM at PT ABC will also be reviewed based on organizational aspects with reference to the Technological, Organization, and Environmental (TOE) Framework. Based on the results of interviews conducted with informants related to the implementation of Building Information Modeling (BIM) at PT ABC on organizational aspects, the results obtained that Building Information Modeling (BIM) received support from the management of PT ABC. There are several supports provided by the management of PT ABC to implement Building Information Modeling (BIM), including the following:

### 3.2.1 Forming a new department tasked with accelerating the Building Information Modeling (BIM) function at PT ABC.

The management of PT ABC provides support in the implementation process of Building Information Modeling (BIM). This is evidenced by the establishment of a new department whose main task is to accelerate the Building Information Modeling (BIM) function in all projects. Some of the work programs that have been prepared include conducting Building Information Modeling (BIM) training for several employees and certifying the implementation of Building Information Modeling (BIM).

### 3.2.2 Conduct various training or training for related employees.

BIM is currently seen as a new technology at PT ABC. Many employees do not have the capability related to the operation of Building Information Modeling (BIM) and even many employees are not familiar with Building Information Modeling (BIM). Under these conditions, PT ABC made various efforts to improve employee capabilities related to Building Information Modeling (BIM). One way to do this is to disseminate information to all related employees, to form a special studio for Building Information Modeling (BIM). This studio is like a laboratory room that can be used by employees to be creative about the Building Information Modeling (BIM) model.

## 3.3 Analysis of Environmental Aspects

The implementation of Building Information Modeling (BIM) at PT ABC will then be reviewed based on environmental aspects with reference to the Technological, Organization, and Environmental (TOE) Framework. Based on the results of interviews conducted with informants related to the implementation of Building Information Modeling (BIM) at PT ABC on environmental aspects, it is obtained that the development of Building Information Modeling (BIM) at PT ABC is strongly influenced by external factors. Currently, many construction projects, especially those owned by Kementerian PUPR, require the use of Building Information Modeling (BIM) in the construction project tender process. So this forced PT ABC to control BIM if it wanted to participate in the tender for the construction project.

Even if the project owner does not require the use of BIM, competitors or competitors will generally provide a price quote for construction projects using BIM. This is considered a plus for parties who are able to make offers using BIM even though it is not required. This condition makes PT ABC increasingly improve its capability in implementing BIM in the hope that it will be able to win construction project tenders.

However, there are still some obstacles in accelerating BIM at PT ABC. These obstacles arise from the stakeholders of the subcontractors or vendors of PT ABC. In fact, if you want to

increase the BIM maturity level to level 2, the collaboration between all parts of the construction project environment is needed. Not only PT ABC as the main-contractor, but also the owner, planning consultant and sub-contractor.

## 3.4 Analysis of Project Financial Performance Aspects

One of the benefits obtained by implementing BIM is being able to detect various construction design errors early. If the drawing error is not detected until the construction process is running, it is necessary to rework the construction work that has occurred. The rework has additional implications for construction costs, which will reduce the profit of the project. This will create a deviation between the project profit target and the project profit realization. In addition, the rework will certainly increase the time of construction project work, causing project delays.

In this regard, the researchers conducted an analysis of the financial performance of projects that implement BIM. The following are the results of the analysis of the project's financial performance using BIM:

**Table 2.** Financial Performance of PT ABC Project Implementing BIM (PT ABC (2021)

| Project Name | Plan | | | Actual | | |
|---|---|---|---|---|---|---|
| | Revenue | Direct Cost | Gross Profit | Revenue | Direct Cost | Gross Profit |
| Project 1 | 157,84 | 140,47 | 17,36 | 157,84 | 140,47 | 17,36 |
| Project 2 | 273,94 | 241,06 | 32,87 | 273,94 | 241,06 | 32,87 |
| Project 3 | 142,38 | 130,99 | 11,39 | 142,38 | 139,58 | 2,81 |
| Project 4 | 804,09 | 716,10 | 87,99 | 804,09 | 716,10 | 87,99 |

Note: In billion Rupiah

Based on 4 (four) projects that implemented BIM, information was obtained that there were 3 (three) projects that did not experience a decrease in profit targets and 1 (one) project experienced a decrease in profit targets. This proves that implementing BIM will reduce the risk of a decline in profits due to rework. Based on project execution time, resource persons explained that there were no delays related with the project timeliness. However, there are indeed many other factors that affect the realization of project profits. Rework is indeed one of the factors that causes a decrease in profit, but it is not a single variable. Other factors that affect the project's financial performance are fluctuations in material prices, work accidents, and work quality discrepancies. Thus, the implementation of BIM can at least reduce the occurrence of rework.

For the summary, it can be concluded that from a technological aspect, the implementation of Building Information Modeling (BIM) is able to provide benefits to the construction business process of PT ABC. Based on the organizational aspect, the implementation of Building Information Modeling (BIM) has received support from the top management of PT ABC so that management's commitment has been created to develop Building Information Modeling (BIM). Based on environmental aspects, the implementation of Building Information Modeling (BIM) is forced because the owner (project owner) requires the use of Building Information Modeling (BIM) in the construction process, starting with the tender process until the construction project is completed. In addition, from a financial perspective, the implementation of Building Information Modeling (BIM) is proven to provide better benefits. This can be seen in the absence of cost overruns. This proves that implementing Building Information Modeling (BIM) will reduce the risk of a decline in profits due to rework. Based on all these factors, it is concluded that the adoption of Building Information

Modeling (BIM) implementation needs to be continued and applied in all PT ABC projects. This is necessary to increase the capability of PT ABC in working on construction projects.

## 4 Conclusion

After presenting the results of research and data analysis based on the results of interviews and analysis of the financial performance of the PT ABC project that applies Building Information Modeling (BIM), it can be concluded that the answers to the problem formulation are as follows:

a) Implementation of Building Information Modeling (BIM) at PT ABC in terms of technology, concludes that Building Information Modeling (BIM) provides many benefits, especially in terms of modeling the structure of construction projects in the form of 3D models.
b) Implementation of Building Information Modeling (BIM) at PT ABC in terms of organizational aspects, concluded that management fully supports the implementation of Building Information Modeling (BIM). This is evidenced by the existence of a special function (Bureau) whose task is to accelerate Building Information Modeling (BIM) in the PT ABC project environment. However, there are indeed various obstacles faced, especially in terms of the lack of understanding of PT ABC personnel in implementing Building Information Modeling (BIM). Therefore, one of the work programs of the special Bureau of Building Information Modeling (BIM) is to socialize how to operate Building Information Modeling (BIM) in the construction of construction projects.
c) Implementation of Building Information Modeling (BIM) at PT ABC in terms of environmental aspects, concludes that the current construction business conditions require the application of Building Information Modeling (BIM). Building Information Modeling (BIM) is an added value for every contractor during the construction project tender (auction) process. However, the implementation of Building Information Modeling (BIM) is still limited to the main-contractor level. There are still many sub-contractors who do not understand the existence of Building Information Modeling (BIM) in construction projects. This is what hinders the maturity level of Building Information Modeling (BIM) at PT ABC which is still at level 1.

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