

Proposed Contract Clauses for Building Information Modelling Integrated Construction Projects

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Abstract

Building Information Modelling (BIM) has been a main approach in modern construction project management due to its abilities in improving efficiency, coordination, and accuracy in all stages of a project lifecycle. Apart from its various benefits, the adoption of BIM technology also presents various contractual problems in construction projects. This study addresses this issue by providing recommended contract clauses that are relevant and contextual for BIM-integrated projects. It employed a context-based mixed-method study approach. First, it identified various contractual issues that occur due to the implementation of BIM technology in construction projects in Indonesia through literature studies and questionnaires. Next, the contract clauses related to these issues were drafted and validated through a two-round Delphi interview with three expert respondents. The results show that contract clauses need to explicitly regulate aspects such as intellectual property rights over BIM, responsibility for data accuracy, etc. This study proposes ten recommended clauses that can be used by practitioners for BIM-integrated projects, namely: definitions, BIM managers, data sharing and exchange, responsibility, project team criteria, intellectual property rights, progress monitoring, security, quality, and costs. These clauses are flexible and applicable for practical use, so that the utilization of BIM technology in construction projects has a clear contractual basis to prevent construction conflicts and disputes. This will encourage a legal ecosystem that supports the optimal and sustainable implementation of BIM in the Indonesian construction sector.

1. Introduction

The fourth industrial revolution, better known as Industry 4.0, is characterized by automation, digital transformation, and accelerated development for many industries, including the construction sector [1-2]. In the construction sector, the development of Industry 4.0 was stimulated by the emergence of various digital and modern technologies such as building information modeling (BIM), digital twin (DT), internet of things (IoT), big data (BD), virtual/augmented reality (VR/AR), and 3D printing [1-3]. Although the emergence of this technology is considered useful, the adoption rate of 4.0 technologies in the construction sector is still relatively low [1-2]. This sector is a renowned latecomer for the adoption of digitalization, mainly due to the reluctance of construction professionals [4]. Apart from this challenge, a 2019 report confirms the huge potential of digital transformation

in the construction sector [5]. This is because the use of these technologies can improve the performance and competitiveness of the construction sector [1, 4, 6].

In the context of Construction 4.0, the main objective is digitizing every stage of construction work, starting from planning, implementation, to completion of the works [2]. There are four key transformations, namely changes in clients' needs and attitude, utilization of technology, shifting the focus of construction production to mass-customization, and an emphasis on sustainable construction [7]. One of the best examples of Construction 4.0 implementation is BIM technology. Many studies reveal the potential for using BIM in the construction sector, such as the use of BIM as a structural health monitoring system [8], real-time schedule monitoring [9], and mass-customization housing design [10]. These studies demonstrate the great benefits of implementing BIM technology to improve construction project performance.

On the other hand, there are also several challenges in BIM implementation, such as poor technology adoption, high initial costs, exposure to data theft, and the need for contractual modification [11]. Ragab and Marzouk [12] convey similar matters regarding the uncertainties concerning the ability of the existing legal paradigm to promote BIM utilization. This is mainly reflected in the fact that many existing construction contracts do not yet facilitate a collaborative approach of BIM, so that they have the potential to become contractual disputes. Whereas the problems that often arise in a BIM-integrated project can be solved if identified and regulated in a construction contract. A study in Indonesia showed that no contract considered various potential problems due to BIM integration in construction projects [13]. Therefore, this study aims to identify various issues from implementing BIM in construction projects and establish contract clauses for integrated BIM projects that can help prevent problems arising from implementing BIM technology.

2. Literature Review

2.1 Building Information Modelling

BIM or Building Information Modeling is the best example of modern applications in the construction sector. It is a technology that provides important information in the form of a 3D (three-dimensional) building modeling process. According to Rafli et al. [14], it can help solve communication problems between stakeholders in construction projects. This integration will facilitate coordination and minimize misunderstandings among stakeholders. The concept was first introduced in the 1970s. In 1987, an ArchiCAD application appeared as the first form of BIM. In 2002, Autodesk released a white paper entitled Building Information Modeling. In 2013, all new buildings in Singapore were required to use BIM. In 2017, BIM began to receive attention in Indonesia through public projects managed by the Ministry of Public Works and Housing [15]. Since then, BIM has rapidly transformed the construction industry by offering many benefits to project outcomes [12].

BIM becomes an important technology because it can integrate various project data [16]. These data are then processed to be used as a communication tool between stakeholders in construction projects. Because of this, BIM is an alternative solution to communication problems that often occur in the Indonesian construction industry. BIM has the benefit of visualizing a clearer picture of a construction project. It can also help control construction project time and cost. A study by Berlian et al. [17] shows that the time and cost needed to carry out construction projects are faster and more efficient by utilizing BIM technology.

On the other hand, implementing BIM in construction projects is not free from challenges. One of the biggest problems that BIM often experiences is the issue of intellectual property rights (IPR) [18-19]. According to Hsu et al. [20], generally, there is still no clarity regarding who owns the BIM model. In addition, issues such as data confidentiality, person in charge, data security, and worker skills are other issues that must be considered [17, 21-22]. Thus, it is necessary to adjust contract conditions for BIM-integrated construction projects.

2.2 Development of BIM Regulations in Indonesia

In 2017, Law No. 2 of 2017 concerning Construction Services was enacted. Article 5 paragraph (5) of this law reads "The Central Government has the authority to develop material standards and construction equipment as well as construction technology innovations". Based on this article, construction service companies are expected to be able to utilize construction technology in their project executions [23]. In 2018, the government, through the Ministry of Public Works and Housing, issued a Ministry Regulation No. 22 of 2018 concerning State Building Construction. Appendix IV.A.13 of this regulation contains provisions for the implementation of BIM for state-owned construction projects. It reads "The use of BIM (Building Information Modeling) must be applied to non-simple state buildings with criteria of an area of over 2,000 m² and above two floors".

Furthermore, Government Regulation No. 16 of 2021 concerning Regulation for Implementing Law No. 28 of 2002 concerning Buildings was issued. This regulation contains provisions that require the application of BIM 5D for technology-intensive projects (medium/high-rise buildings, mid-technology, high risk), and BIM 8D for capital-intensive projects (skyscrapers/special buildings, high technology, and risk, requiring sophisticated equipment). Meanwhile, labor-intensive projects (low-level buildings, simple technology, low risk) do not require

the application of BIM. With these various regulations, the application of BIM in construction projects, especially government projects, is growing in Indonesia. On the other hand, research shows a lack of sensitization regarding BIM implementation regulations in Indonesia [15].

2.3 Construction Contracts

Article 1313 of the Indonesian Civil Code states that "An agreement is an act by which one or more people bind themselves to one or more other people". In the context of construction work, a construction contract is an agreement that is legally binding on the parties involved in carrying out construction work [24]. As an important tool that forms the basis for the work execution, construction contracts aim to create a legally enforceable relationship between the contracting parties; distribute contract risk; state the rights, obligations, and responsibilities of the parties; and state all contracting procedures [24]. If managed properly, it can also be used to prevent construction disputes from occurring [25].

The review of literature found that there is only one contract format for BIM-integrated projects, namely the HKIS BIM Contract Conditions issued by the Hong Kong Institute of Surveyors [26]. These contract conditions are for practitioners in the Hong Kong construction industry. It sets out the obligations, responsibilities, and liabilities of the contracting parties where BIM technology is implemented. There are twelve clauses contained in the HKIS BIM Contract Conditions [26], namely:

1. Definitions: Explains the various definitions related to BIM implementation in construction projects.
2. General Provisions: Explains the general provisions of the BIM contract such as contract value, work duration and others.
3. Priority of Contract Documents: Explains the provision in the event of a conflict related to the contract documents.
4. Obligations of the Project Participant: Describes the obligations that must be fulfilled by participants in the project.
5. Digital Data Exchange: Describes the person in charge of the digital data collection and the software that will be used to carry out the project.
6. Project Participant's BIM Team: Describes the requirements and obligations for BIM team members.
7. BIM Manager: Describes the duties and responsibilities of a BIM manager.
8. BIM Execution Plan: Describes the BIM implementation plan for the project.
9. Use of the Model: Explains the person in charge of each model and the rights to use the model.
10. Intellectual Property Rights of the Model: Regulates intellectual property rights to models that have been made.
11. Indemnity: Describes the requirements for compensation for harmful wrongdoing.
12. Termination, Rescission or Expiry of the Agreement: Explains the conditions for terminating and closing the contract.

2.4 Gap in Research

The results of the literature study show that there are many contractual issues in the implementation of BIM in construction projects, as shown in Table 1. The most common issue that often occurs concerns the intellectual property rights over the BIM model. In addition, there are other issues such as responsibility, data confidentiality, data exchange, data accessibility, security, standards, skilled personnel, and organizational issues. According to Ramonu et al. [25], problems in construction projects can be prevented if the contract is identified and contains provisions related to these problems. Construction contracts have a crucial role in preventing conflicts and disputes [25, 27-28].

Table 1 Review of BIM contractual issues

No	Issues	References
1	Copyright issue	[18, 20, 29-37]
2	Confidentiality	[18, 36]
3	Lack of national standards and guidelines	[22]
4	Organizational problem	[22, 38]
5	Lack of skilled resources	[21-22, 38]
6	Payment issue	[21, 38]
7	Sharing information issue	[21, 32]
8	Security	[33, 37]
9	Duties and responsibilities	[31-32, 34-35]
10	Accessibility	[29, 31, 37, 39]

To avoid problems that often occur in projects that implement BIM, it is necessary to have a contract that regulates it. Currently, there is still no construction contract for BIM-integrated construction projects in Indonesia. This research looks at the important role of construction contracts in providing a clear contractual basis for BIM use in the construction projects. Furthermore, as with the HKIS BIM Contract Conditions, it considers the development of context-based contract conditions that can be used for practical purposes by Indonesian construction practitioners. Considering the growing use of BIM technology in Indonesian construction projects, it is important to research the contracts for BIM-integrated projects.

3. Methodology

This study applies a mixed-method approach. Data collection was carried out using literature review, questionnaire surveys, and a Delphi interview. Data collection begins with conducting a literature study to identify various contractual issues related to the application of BIM in construction projects. Furthermore, to obtain specific respondents' opinions, a context-based questionnaire survey was carried out [40-41]. The distribution of questionnaires aims to identify contractual issues in BIM-integrated projects in Indonesia. Issues that have been identified are used in the development of proposed contract clauses for BIM-integrated projects. The original survey was validated by two experts who have experience in BIM and construction contracts on March 3, 2022. The revised questionnaire was then distributed to the target respondents. The distribution of the questionnaire was carried out online via Google Forms from 27 April to 11 May, 2022. Respondents in filling out this questionnaire must have the following criteria: (1) have a minimum of three years of experience in the construction sector, (2) affiliated with contractors, consultants, or employers, (3) involved and have expertise in BIM and/or construction contracts. From a total of 55 responses, there were nine invalid responses and 46 valid responses. Table 2 presents the profiles of the questionnaire respondents. Survey data were analyzed using descriptive statistics.

Table 2 Survey respondent profiles

Respondent profiles	Number	Percentage
Affiliation		
Contractor	42	91.3%
Consultant	3	6.5%
Employer	1	2.2%
Total	46	100%
Company category		
State-Owned Company	12	26.1%
Private Company	28	60.9%
Multinational Company	5	10.9%
Joint Venture	1	2.2%
Total	46	100%
Dominant roles in		
Construction contract	16	34.8%
BIM implementation	14	30.4%
Contract & BIM	16	34.8%
Total	46	100%

The authors then developed clauses that dictate the contract conditions for BIM-integrated construction projects. To validate the draft clauses, the Delphi interview technique was carried out. The Delphi interview is an approach to answering a problem through a consensus view across experts [42]. It is an anonymous iterative process consisting of a series of rounds where expert participants are allowed to reflect their opinion on the views of others [43-44]. There is no agreement on what constitutes an optimal number of experts in a Delphi study [45]. Similarly, there is no existing criterion for determining the appropriate sample size in a Delphi study [46-48]. A Delphi study does not require a large statistical sample to be representative of a population as it is a mechanism for consensus [49]. A two-round interview was conducted in this study with three experts from 27 May to 18 June 2022. The three interviewees met the criteria of expert respondents, namely having a focus on BIM operations, understanding contractual issues related to BIM, and having at least three years of experience in construction contracts.

4. Results & Discussion

4.1 Proposed Contract Clauses for BIM Integrated Projects

Questionnaire analysis succeeded in identifying seven contractual issues related to the implementation of BIM in construction projects in Indonesia, namely: BIM manager, data exchange, person in charge, project participant criteria, intellectual property rights, BIM progress, and data security (Table 3).

Table 3 Descriptive statistics of survey responses

No	Question	Response	Percentage
1	Based on the experience of the last three projects implementing BIM, does your project already have a contract that regulates the implementation of BIM?	Yes	56.5%
		No	43.5%
		Total	100%
2	Has Copyright become a contractual issue for BIM implementation in construction projects?	Yes	26.1%
		No	73.9%
		Total	100%
3	How can stakeholders use and share information?	Can be used without permission	2.2%
		With permission from the BIM Manager	87.0%
		With permission from the architect	6.5%
		According to the contract	4.3%
		Total	100%
4	What is the procedure for changing the BIM model?	No permission needed	0.0%
		With permission from the BIM Manager	89.1%
		With permission from the architect	4.35%
		With permissions from the BIM Manager and the architect	2.2%
		According to the contract	4.35%
5	How much do you agree that construction contracts need to regulate the progress of BIM modeling?	Total	100%
		Strongly agree	89.1%
		Agree	8.7%
		Disagree	2.2%
		Strongly disagree	0%
6	How should the BIM data protection system be?	Total	100%
		The model can be accessed by anyone	10.9%
		The model can only be accessed by the BIM Manager	10.9%
		The model can only be accessed by the architect	71.7%
		According to the contract	6.5%
7	Who is responsible for the BIM Model?	Total	100%
		Employer	0.0%
		Project Manager	2.2%
		Consultant	0.0%
		Contractor	4.3%
8	How much do you agree that the contract stipulates the criteria for	BIM Manager/task team	93.5%
		Total	100%
		Strongly agree	89.1%
		Agree	6.5%

No	Question	Response	Percentage
	stakeholders to participate in BIM?	Disagree	2.2%
		Strongly disagree	2%
		Total	100%

BIM manager: This clause regulates the duties and obligations of a BIM manager, as well as the competency requirements that must be possessed by a BIM manager. The BIM Manager is a new role evolved within the construction industry. The implementation of BIM technology necessitates certain regulations about project-specific applications [50]. In the BIM environment, coordination activity is rather complex and necessitates engineering and IT skills that cannot be fully covered by existing roles [51]. As the BIM manager plays an important role in BIM-integrated construction projects [32], the contract must contain provisions regarding the BIM manager to avoid the emergence of disputes. In addition, the BIM manager must be able to intercede for stakeholders [52].

Data exchange: This clause regulates how to use data for project purposes as well as data exchange between software applications. The purpose of this clause is to avoid disputes between data users. Problems such as incompatible files in other applications are also often experienced in BIM-integrated projects [38, 53]. Hence, the exchange of information between software applications used in the construction sector is one critical area where BIM standards is required [54].

Person in charge: This clause regulates the party that will be responsible for the BIM works. The survey results agree that the BIM manager is the party most responsible for BIM. BIM managers must know all the activities that occur on the BIM-integrated project. BIM managers have responsibilities like project managers, but within the BIM scope of work [50, 55].

Project participant criteria: This clause regulates the criteria that must be possessed to participate in the BIM integrated construction projects. BIM has altered the duties and responsibilities of construction participants such as the employer, design team, contractor, and quantity surveyor [56]. As BIM is an advanced construction technology, participants should have skills and competencies related to the use of BIM as well [57].

Intellectual property rights: This clause regulates who is entitled to the BIM model created. In addition, it also regulates what may and may not be done with the BIM model. The results of the literature review show high concern regarding intellectual property rights (IPRs) of the BIM model. As an emerging technology, BIM provides a platform involving the generation and management of digital building models. The use of BIM raises concerns about IPRs [36]. Various parties involved in a BIM-integrated construction project may have differing expectations regarding the ownership, use, and licensing of the BIM data, which, if not properly addressed in the contract, may lead to disputes. Hsu et al. [20] highlight the absence of regulations governing this IPR issue in Taiwan. A similar finding in Malaysia by Baharom et al. [36] highlighted the importance of IPRs being spelled out clearly in the contract.

Progress: This clause regulates the progress of the BIM work being carried out. The existence of this clause will help avoid disputes [58].

Security: This clause regulates the data security of the BIM model. According to Mahamadu et al. [59], it is one of the main obstacles to adopting BIM technology. As BIM facilitates a collaborative and integrative working system, the information contained in the BIM model can be easily obtained and copied [59]. Thus, BIM contracts must be able to address data confidentiality and security concerns. Similarly, Abdirad & Pishdad-Bozorgi [60] and Das et al. [61] mentioned that it is necessary to have a provision that regulates data security in BIM-integrated projects.

Next, the authors design clauses that reflect the contract conditions for BIM-integrated projects. The contract language used in this research is Bahasa Indonesia (Indonesian Language), considering that this is a context-specific study that aims to develop contract clauses for BIM-integrated construction projects in Indonesia. Apart from being the national language, the use of Bahasa Indonesia is also useful for minimizing ambiguity in contractual agreements between contracting parties who are Indonesian construction practitioners. In addition, the use of Bahasa Indonesia in contract documents has been regulated in Law No. 24 of 2009 concerning the Flag, Language and State Emblem, and the National Anthem. It is strengthened by Presidential Regulation No. 63 of 2019 concerning the Use of Bahasa Indonesia. Provisions regarding the obligation to use the Bahasa Indonesia in business agreements are contained in Article 31 of Law No. 24 of 2009 and Article 26, paragraph 1 of Presidential Regulation No. 63 of 2019. These two articles contain similar provisions that "Bahasa Indonesia must be used in memorandums of understanding or agreements involving state institutions, government agencies of the Republic of Indonesia, Indonesian private institutions, or individual Indonesian citizens." The translation of the initial draft of the clauses is presented in Table 4.

4.2 Validation of Contract Clauses for BIM Integrated Projects

The drafted clauses were then validated through a two-round Delphi interview. In round 1, there are two additional clauses from the interview results related to quality and cost. Quality issues discuss the quality of the BIM model that must be achieved by the team. Expert 2 stated, "In the implementation of BIM, there must be someone who ensures quality, because quality can become an issue and an added value to compete". This clause refers to ISO 19650-1:2018 regarding BIM. Meanwhile, the issue of costs was raised by the experts regarding the person in charge of the costs that would arise in the BIM model work.

After conducting interviews and getting input, the drafted clauses were then revised. The results were then returned to the expert respondents for reflection on their opinions. In the second round, Experts 1 and 3 have approved the drafted clauses. However, Expert 2 still provided a suggestion to add one clause concerning the definitions. This suggestion is accepted, and thus, there are ten clauses in the final recommended clauses. Table 4 presents the original draft and the final clauses for BIM-integrated projects in Indonesia.

Table 4 Recommended clauses for BIM-integrated projects

No	Issue	Initial Clause	Validated Clause
1	Definitions	-	1.1 Building Information Modeling (BIM): Technologies and processes for creating building information model(s) 1.2 Building Information Model ('model'): a digital form that represents the physical form and function of the entire project 1.3 BIM Manager: A person appointed to manage BIM for the project 1.4 Digital Data: Information includes models, drawings, schedules, specifications, and bills of quantities, which are digitally stored 1.5 Project: The project referred to in the agreement, either in the form of professional services or construction work carried out under the agreement 1.6 Employer: The party that assigns the project to the contractor 1.7 Contractor: The party who is hired by the employer to perform the project
2	BIM Manager	BIM managers are managers who will act as intermediaries for stakeholders. BIM managers are appointed to be in charge of all process activities involving BIM. BIM managers must have a minimum of __ years' experience on projects that have already implemented BIM. BIM managers will have the duty and authority to: - Act as an intermediary between stakeholders to keep the project efficient. - Organize and manage the production of digital images and files. - Cooperate with the BIM engineer who is responsible for producing the model.	BIM managers are those who will act as intermediaries for stakeholders. BIM managers are appointed to oversee all process activities involving BIM. BIM managers must have a minimum of __ years' experience on BIM integrated projects. BIM managers must attach supporting files to prove that they have worked on the project. BIM managers will have the duty and authority to: - Act as an intermediary for stakeholders. - Organize and manage the production of digital images and files. - Cooperate with the BIM engineer who is responsible for producing the model. - Assist in the exchange of information necessary for the sustainability of the project. - Maintain the confidentiality of the model.

No	Issue	Initial Clause	Validated Clause
		<ul style="list-style-type: none"> - Assist in the exchange of information necessary for the sustainability of the project. - Maintain the confidentiality of the created model. - Organize and maintain scheduling so that projects can be completed on time. 	<ul style="list-style-type: none"> - Organize and maintain scheduling so that projects can be completed on time. - Maintain project quality with the ISO 19650 standard.
3	Data sharing and exchange	<p>This contract governs the exchange of modeling data. The use of information in the modeling is carried out with the knowledge and approval of the appointed BIM manager. All data that has been created is confidential. The goal is to avoid disputes and leakage of model data in the project.</p> <p>Before exchanging BIM between different software platforms, the following tasks should be performed:</p> <ul style="list-style-type: none"> - Understand the exchange process between the software used. - Must include a 2D file of the created BIM which can be used by other participants. The file format must conform to CAD standards. - Data exchange between software needs to be re-verified by the designer on another application and must be witnessed by the BIM manager. 	<p>This contract governs the exchange of modeling data. The use of information in the modeling is carried out with the knowledge and approval of the appointed BIM manager. All data that has been created is confidential. The goal is to avoid disputes and leakage of model data in the project.</p> <p>Before exchanging BIM data between different software platforms, the following tasks should be performed:</p> <ul style="list-style-type: none"> - Understand the compatibility and interoperability of the software used. - Must include a 2D file of the BIM model, which can be used by other participants. The file format must conform to CAD standards. - Exchange of data in 3D using IFC & Native file formats - The exchange of data between software needs to be re-verified by the designer on another application and must be known and approved by the BIM manager.
4	BIM Manager responsibility	<p>BIM manager as the party responsible for all activities related to modeling. Everything related to BIM must be reported to the BIM Manager</p>	<p>BIM manager is the party responsible for all activities related to BIM modeling on the project. Everything related to BIM must be reported to the BIM Manager.</p>
5	Project team criteria	<p>Project participants must meet the following criteria:</p> <ul style="list-style-type: none"> - The head of the BIM project team in each field must have experience in running BIM projects for at least X years. - Participants of the project team involved have X years of experience in construction projects. - (add other relevant criteria). 	<p>Project participants must meet the following criteria:</p> <ul style="list-style-type: none"> - Participants of the project team involved have at least ___ experience in construction projects implementing BIM. - (add other relevant criteria).
6	Intellectual property rights	<p>Each model that has been made will be fully owned by the owner. Models that have been accepted by the owner will be registered.</p> <ul style="list-style-type: none"> - Each BIM model maker is fully responsible for claims made by 3rd parties for alleged infringement or 	<ul style="list-style-type: none"> - Every model that has been made will be fully owned by the employer. - If there is a claim made by a third party (a party not involved in the project) for alleged infringement or copyright infringement on their respective models, the BIM engineer must take full responsibility for the claims submitted.

No	Issue	Initial Clause	Validated Clause
		copyright infringement on their respective models. - Each model that has been created is only allowed to be used for project purposes.	- Each model that has been created is only allowed to be used for project and commercial (marketing) purposes. - Every model that will be used for things outside the project must get the employer's approval.
7	Progress monitoring	The progress of the BIM works must follow the agreed schedule. The BIM manager is in charge of keeping the progress of the model created. Any kind of delay that can interfere with the project will be subject to sanctions which are stated in the main contract.	The progress of the BIM works must follow the agreed schedule. Any kind of delay that can interfere the project will be subject to sanctions which are stated in the main contract. Approval for the extension of the time is stated in the addendum to the contract.
8	Security	All BIM data used in the project must be properly protected. All security protocols will use references from PAS1192-5: Specification for security-minded building information management, digital built environments and smart asset management.	All BIM data used in the project must be properly protected. All security protocols will refer to ISO 196550-5. All models that are created need to be backed up on a cloud server that has been provided once every __ days.
9	Quality	-	All activities carried out in this project must comply with ISO 19650.
10	Costs	-	All costs arising from the purchase of software and hardware that are not provided by the employer will be fully borne by the contractor. Any additional costs that are not in the contract will be the responsibility of the contractor. Costs incurred from the employer's instruction that are not regulated in the scope of work will be charged to the employer.

4.3 Research Implications

There have been some challenges associated with BIM implementation in construction projects. Through a context-based study, this research has successfully identified seven key contractual issues in BIM-integrated construction projects, namely BIM manager, data exchange, person in charge, project participant criteria, intellectual property rights, BIM progress, and data security. In BIM, the relationship among the stakeholders involved undergoes a significant change as a result of the transition of the working environment from an individually generated model to an integrated BIM model [62]. This design liability issue associated with BIM adoption has been discussed in prior studies [36, 63]. Therefore, the distribution of risk and liability related to the use of BIM technology and the data it produces should be covered in construction contracts. It may be difficult for the stakeholders to define the responsibilities and liabilities related to the accuracy, completeness, and reliability of the BIM data. To minimize disputes when errors occur, a BIM Manager is needed to manage this system [50]. In addition, the use of BIM data is inevitable for stakeholders who desire to utilize it for post-completion works. This leads to IPR-related concerns [36]. Due to the integration of various sensitive information in the BIM process, concerns regarding the issue of confidentiality and data security became apparent [64-65].

This research attempts to construct contract clauses based on the identified issues and examines them in light of BIM implementation in Indonesia. This study is a novel study that offers solutions to various problems relating to the use of BIM in the Indonesian construction industry. Through validation with experts, this research succeeded in formulating ten contract clauses for BIM-integrated construction projects. As a context-specific study, the results of this study can provide insights for construction practitioners and academics regarding contractual issues of BIM implementation in construction projects and how these issues can be mitigated with proper contract clauses.

The proposed contract clauses can be used as a supplementary document to the main contract. As with contract clauses in general, these clauses can be modified according to the needs and agreements of stakeholders

involved in BIM-integrated construction projects. It is also crucial to note that BIM technology is constantly evolving, and new challenges may arise as construction technology and practices continue to develop [66]. Recognizing this is critical since emerging technologies continue to influence how we work and interact with one another in a digitally driven world.

5. Conclusion

The development and deployment of digital technology is critical to the construction industry transformation. BIM technology is one example of this digital innovation. While BIM technology offers benefits such as increased productivity and performance as well as enhanced collaboration and integration, its implementation is not without challenges. This research succeeded in identifying various contractual issues related to the application of BIM in construction projects in Indonesia. It highlights the important role of construction contracts in preventing disputes and conflicts from arising due to various contractual issues related to BIM. Through a context-based study, this research designs contract conditions that must be complied with by the parties involved in BIM-integrated projects. Along with the growing use of BIM in the Indonesian construction industry, the parties involved can take advantage of the results of this study to assist in negotiating their contract draft. Thus, the results of this study are not only useful for preventing contract disputes due to BIM implementation, but also for streamlining the contract negotiation process for BIM-integrated projects. The recommended clauses are designed flexibly enough so that construction practitioners can use them directly or modify them in accordance with their needs.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Seng Hansen, Andre Feliks Setiawan; **data collection:** Kenrich; **analysis and interpretation of results:** Seng Hansen; **draft manuscript preparation:** Seng Hansen. All authors reviewed the results and approved the final version of the manuscript.

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