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Validation of Model Content through a Building Information Modelling-based Contract Administration

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Abstract
Purpose: This paper presents a case study exploring the extent to which the BIM contract language supplements the existing contract system employed in the Malaysian construction industry. The following categories of BIM-based contractual issues were assessed: collaboration strategy and facility management-BIM in the construction process.
Design/methodology/approach: The intention of this research was to explore BIM execution within the D-B procurement system. Hence, qualitative research was conducted since this study aimed to attain a thorough comprehension of the examined phenomena, whereby the researcher attempted to explore the respondents' perceptions and opinions regarding the topic discussed in this study and aimed to discover new thoughts and individual views. Semi-structured interviews were conducted with relevant BIM project team members followed by project document reviews using data triangulation
Findings: The analysis results have answered the research question, whereby the findings from the case studies suggest that BIM-based construction projects that it is crucial to include collaboration and communication amongst construction stakeholders as a key concept to ensure an effective BIM execution. It can cause construction stakeholders to possess high efficiency in communication, which surpasses the level in traditional practice.
Research limitations/implications: The initial coding framework was based on data from a literature review and condensed different possible risk factors into categories based on previous respondents' experiences. However, this method only provides one viewpoint and interpretation within the context of the study, which means there may be discrepancies between the authors' understanding and actual experiences of the respondents.
Practical implications: This study was analysed to find the practical implications of implementing BIM, especially those concerning the development of a contract form which represents the integration of BIM and facility management (FM). Moreover, in order to pick up the industry's perspective on the recommended approaches, a document study was performed on a number of key governments and industry publications primarily around Malaysia.

Originality/value: There is a significant impact on the manner project stakeholders collaborate and the possible contractual challenges arising due to any disagreements that occur. Thus, it is imperative to understand BIM's functionality, and how it helps a project, which can possibly enable the vital foundations forming the applicable contractual context. Nonetheless, limited investigations have been conducted and most did not examine industry-wide trends in validating BIM content models by critically aligning BIM functionality with various contractual, consequently contributing originality of the present paper.

Keywords: Construction Industry, Building Information Modelling, Procurement, Contracts

Introduction

The construction and facilities management industries are experiencing an increasing demand for tracking and utilizing data related to building projects and maintenance. The operation and maintenance (O&M) phase of assets is currently incurring high expenses, which is often the most prolonged and costly part of a building's lifecycle (Arayici et al., 2011; Chien et al., 2014). Implementing Building Information Modeling (BIM) in facilities management can enhance cooperation among involved parties, decrease failure costs, and streamline the process, leading to more effective maintenance. However, there are limited real-world examples of its application, as BIM is still not widely adopted in the building operation stage.

Studies on BIM have been conducted in various countries over the past few years, with a growing number of research since 2010. BIM is now used in approximately 65 countries, including Malaysia, and is widely adopted and studied across the industry. The most researched areas of BIM include "process simulation and monitoring," "building information services," and "standardization." As a result, FM is seen as a promising area for future exploration (Abd Jamil and Fathi, 2018). The pursuit of successful project completion in the architecture, engineering, and construction (AEC) industry has resulted in fragmented work practices. The drive for regulation in this field stems from conflicting interests (Becerik-Gerber et al., 2012)

Building Information Modeling (BIM) and design and build (D-B) contract procurement were introduced as innovative project delivery methods for design and construction projects. These concepts aim to enable the active involvement of all project stakeholders within a shared platform. However, BIM innovations have brought both theoretical and practical problems, hence the slow uptake of the method by firms. Previous research on the impact of the D-B procurement system on BIM has found that the prevailing project procurement approach (characterised by improvements in the practical, technical, and industrial aspects) managed to enhance project delivery towards successful BIM execution (Holzer, 2015). These terms are recent additions to the industry and the new work practices have not yet been effectively applied and evaluated in real-world scenarios. As a result, this study aims to develop a BIM-based contractual document that provides information about the AEC industry in Malaysia, covering the conceptual design to facilities management phase, for use in modeling purposes. The aim is to answer the following question: How can information exchange be enhanced by capturing added value for digital FM?

The paper concludes with a discussion regarding the evolution of the roles of the BIM specialists, how the information subprocesses are crystallised around the project team stakeholders, and how the reliability of the proposed contract management approach for BIM-based contract management enhances data interoperability in Malaysia.

Literature Review

Impact of Building Information modelling (BIM) on Design and Build (D-B) Procurement Practice

According to Masterman (1992), procurement refers to "an organizational framework utilized to oversee the design and construction phases of a project." Procurement is also viewed as "a method employed by parties to fulfill building requirements, including allocation of roles, tasks, and risks, as dictated by certain organizational structures." (Podvezko et al., 2010; Uher & Davenport, 2009). Turner (1997) identified two essential procurement decisions, which are managing the entire project and managing the design and construction phases. The procurement structure supports synchronized events by creating a collaborative environment that fosters active communication among parties until the project's completion. In addition, Holzer (2015) analyzed the advantages and disadvantages of BIM in the procurement context in Australia and concluded that the design and build approach was the most suitable for contracts in full BIM adoption. Once integrated, BIM influences the entire project, from the initial conceptual design to engineering, construction, operation, and even the demolition of the facility.

Also, prudent to recognise are the benefits of BIM in improving the procurement approaches for a project. BIM is used as a basis for project bidding documents. It integrates Design BIM by consultants and Construction BIM by contractors and other sub-contractors, early contractor involvement, BIM lifecycle, and distribution of risk among relevant parties. However, prior studies have not analyzed BIM procurement within a contractual context, taking into account the various roles and contractual terms of BIM.

The use of BIM in four project-delivery techniques and how each approach affects various contractual and regulatory aspects of projects in the Netherlands are discussed in Sebastian (2011). He divided contractual issues into two major categories: (1) general contractual considerations pertaining to the legislation and rules governing information and communication, and (2) covered project-specific elements connected to the project delivery strategy and project contractual arrangement. His analysis concentrated on the second category, the BIM project delivery methodology, and noted that many nations' laws and regulations have yet to address the BIM information-exchange process.

Sebastian's (2011) explored the Design-Bid-Build (DBB) approach with early contractor involvement, the Design-Bid-Build and Integrated Project Delivery (IPD) methods, and how the utilization of BIM in a project impacts the division of responsibilities and contract demands among different project stakeholders. The minimisation of data loss between the head designer and contractors' BIM systems and the clarification of IP rights are the two key problems in implementing BIM in the DBB technique. There must be a level of transparency, access rights, and confidentiality for any knowledge offered by and to the various consultants for tenderers to participate in the D-B process.

The Design and Build (D-B) method has garnered significant attention in medium to large-scale projects, as clients seek to minimize risk through the oversight of a general contractor for both design and construction phases. Despite differences in delivery methods, design consultants typically provide BIM at Level of Development (LOD) 300 or higher (Poerier & Forgues, 2015). Transparency of data flow is the advantage of this method as it allows consultants to track the BIM models used by others. Nevertheless, the D-B approach cannot provide a perfect BIM transition from consultants to contractors or even to others.

The D-B (Design-Build) contracting technique is known for its ability to promote dispute avoidance, making it a suitable method for the open environment of Building Information

Modeling (BIM). This is because the D-B method addresses the second contractual challenge towards improving the BIM project delivery methodology and supports the effective use of BIM. One of the main contract-related challenges for legal professionals is the third issue concerning control and utilization of the building information model (BIM). Conventional contracting clearly defines responsibilities between parties, and specific BIM protocols have been created and commonly used as an appendix to the main contract to address contract-related issues related to model management and usage. (Holzer, 2015; Rahmani et al., 2014). Although the use of protocols can address some contractual challenges, none of the standard procurement models provide the necessary frameworks to determine the best integrated teamwork to realize the full benefits of BIM. (Chien et al., 2014). In this regard, Chien et al. (2014) found that the aspects of risk management, dispute prevention, and claim management provide benefits in managing and utilizing the model.

The right to rely on the model and whether it should be a contract document are the two additional contractual concerns that the D-B contracting structure could handle (Patil & Laishram, 2016). According to Love et al. (2014), this sort of procurement offers a framework for shared accountability for any potential errors in the data incorporated into the model. The project participants, in turn, would be more likely to view the model as a contract and consent to rely on its accuracy. As stated by Love et al. (2014) and Alwash et al. (2017), because the main objective of D-B contracting is the distribution of risk and reward, but all participants in a BIM project must still carry out their work effectively to meet the goals.

This model offers one-point accountability to the client, which can result in cost and time savings through the merging of design and construction function and experience. In addition, when one body oversees both the design and construction activities, a conflict of interest may develop (Chien et al., 2014). The client's control over the project and their flexibility to make changes to the design without added costs is diminished when using D-B contracting (Aibinu & Papadonikolaki, 2016; Holzer, 2015). Huber et al. (2011) claimed that the traditional D-B risk distribution causes a reduction in client and single-entity integration, which raises the likelihood of hostile behaviour and uncertainty.

Nevertheless, the D-B model is considered more efficient than traditional methods since the former allows early engagement of contractors who can then provide constructability advice. Rahmani et al. (2014) identified several delivery models that take the principles of early contractor engagement into consideration and discovered that in the D-B approach, the design is frequently created from conceptual design drawings and specified through functional performance. Therefore, the choice of delivery method for a BIM project has an impact on how BIM is developed and used. However, Porwal and Hewage (2013) noted that none of the new project delivery techniques is worthy of combination with BIM. To incorporate BIM, the current project delivery methodology may need to be modified. Thus, there is a need to conduct a study on how BIM might improve the procedure in the current project delivery approach.

The FM phase of a building involves high levels of risk and cost. The goal of FM is to optimize the building's functions while prioritizing the comfort and well-being of its occupants, which requires comprehensive information about the building's features and assets (Lee et al., 2018). ISO 55000: 2014 (Zhang et al., 2014) defines an asset as a item or entity with potential or actual value to an organization, with value varying for different organizations and their stakeholders and can be either tangible or intangible and financial or non-financial. The lifespan of building components, or assets, can vary, and thus, information about this lifespan is necessary for an asset manager during the operation and maintenance (O&M) phase. This information will impact the decision-making process in developing and carrying out maintenance strategies, but

it also depends on the performance of the building components (Lee et al., 2018). Because the prediction of a building component's service life is based on assumptions, it increases the risk and cost during the building's lifecycle. To effectively manage assets, more information can be obtained by utilizing data optimally. However, this also requires monitoring the performance of the building components. To achieve this, the data should be of sufficient quality; hence, validation of information is important. In view of the Malaysian context, such information is still difficult to validate, but can be improved with the use of different software programmes.

BIM provides a representation of the shape, components, and details of an asset, along with non-visual data linked to those assets. Additionally, BIM allows for connections between different objects. The attributes and connections between assets are crucial for facilities management (Patacas et al., 2015). To maximize the benefits of their FM system, facility managers need to clearly define the information they require. This requirement may not always be obvious to the facility manager, so it should be thoroughly researched and defined. The failure to use open standards in FM protocols can contribute to this lack of clarity and be considered a hindrance to improving the transfer of information. (Lee et al., 2018). Improved specification of the needs of the facility manager beforehand might improve the results and willingness to adapt the BIM models before the handover (Ed, 2013; Abd Jamil and Fathi, 2020). As such, the contract language has to be strong, and the required data in the documents have to be spelt out meticulously in the BIM execution plan (BEP), which outlines the overall vision along with implementation details for the project team to follow throughout the project. These requirements are often defined at the beginning of the project and can be supplemented with more details to help new participants who join the project later on. Updates to the BEP must be approved by the owner or his designated BIM Manager, and must not conflict with the terms of the principal contract.

However, no specific contract has been used for BIM projects. Abd Jamil and Fathi (2018) stated that the existing contract in Malaysia can be utilized for BIM projects with the inclusion of a clause that specifies the BIM protocol or international addendum. The significance of the BEP, which serves as a guide for construction professionals to fulfill BIM requirements in BIM-related projects, was recognized from current practices (Holzer, 2015; Hwang et al, 2019). As a result, a BEP must be developed for each BIM project as a tool for the project team to handle the complexities associated with using BIM, primarily due to the different roles, disciplines, amount of data, delivery approach, change management or maturity evaluation, business procedures, information accuracy, lifecycle perspectives, graphical information, timeliness and responsiveness, interoperability, and support for industry foundation class.

Clients must explicitly define their project's BIM goals by outlining the uses of the model and the information that must be provided to fully benefit from and maximise operational and capital efficiency. The first step in a successful BIM journey is to ask the correct questions at the outset of the project to clearly define the purpose of the endeavour and gather the "information" pertaining to themes that the stakeholders believe would be of the most use to them. It has been suggested that inexperienced clients would employ a BIM advisor to support these conversations and provide them with the information they need to make decisions in line with the anticipated BIM objectives. Additionally, the operator must participate in situations where the model will be used for operation and BIM management objectives, as the BIM consultant advised: "Just getting in the operator to define what defines for information and handover and getting this information to be structured in some way". Indeed, they are the only ones who can offer guidance on how to design an asset with an eye toward how it will be used.

The operator or facility manager is actually seen as a critical party to add value during the early design development.

The verification of information is a crucial aspect of the workflow when working with information, as all stakeholders in the AEC industry can use the software of their preference. The exchange of files should be done using an open standard, such as Industry Foundation Classes (IFC). Ensuring the quality of the BIM models in the exchanged files is also important. BIM models can be assessed both quantitatively and qualitatively. A quantitative assessment will ensure that all necessary information is included in the model, while a qualitative assessment will confirm that all information in the model meets the requirements. A distinction can also be made between methods for verifying the accuracy of the information. The information can be considered correct based on the specified data values; for example, if a value is supposed to be a number, it should be a numerical value and not a string. Moreover, a validation of the accuracy of the value should also be conducted. If a number is entered, it should be the correct number for the project. This verification is based on the specifics of the project and cannot be automated easily. Ultimately, the quality and validity of the information in the model also rely on the performance of the IFC export-import converter in the original software (Love et al., 2014).

Research Methodology

The contractual setting for this paper supplies a unique context for the interpretation of the BIM processes, particularly the project stakeholders. Throughout the study, this paper focuses on the problem of interest and selected the most relevant unit of analysis to investigate the problem from the standpoint of the individuals involved, i.e. the owners (project manager), the owner's BIM consultant, the contractor, the BIM architects and the facility management (FM) personnel. To support the case study, interviews were conducted at the company with various stakeholders. The purpose of these interviews was to identify the project needs and requirements from different viewpoints. Additionally, the responsibility for different tasks in the construction project's organizational structure could be clearly determined.

The interviews were necessary to determine how the building information set required by the various stakeholders will be utilized in digital asset management. The interviews were structured in an open-ended manner to facilitate two-way communication, encourage sharing of opinions, and primarily collect reliable and comparable qualitative data. This paper presents a thorough examination of the practices and methods employed by the project management team to analyze and interpret their BIM project setting. The paper also offers extensive understanding of the development areas of the individuals involved in shaping the events for BIM-based collaboration. The primary reason for choosing this approach was the absence of individual-level emphasis in existing literature on BIM-based collaboration.

List of Respondents

The unit of analysis was focused on the individuals involved in the selected construction project throughout its lifecycle, such as the client's project manager, BIM consultant, contractor, engineer, and architects who are often disregarded in stakeholder studies (Holzer, 2015; Hwang et al., 2019). The unit of coding was the various clauses and subclauses within the project contract document. For the case study, years of experience were excluded from discussions because the research topic focuses on the respondents' roles and current positions within the projects.

The main reason for selecting this approach was the limited attention given to the individual level in existing literature (Arayici et al., 2011; Becerik-Gerber et al., 2012). Such scarcity prompted the need for a thorough comprehension of BIM-based contractual settings deriving from rich data gathered as part of a case study. The objective is to involve external roles both as suppliers and users of model information to avoid duplication of data and to establish the authoritative source as the true information provider. It is crucial to define the roles and responsibilities of the design team and specialist subcontractors with design-related tasks in their work packages at the start of the project (Kassem et al., 2015; Koch & Beemsterboer, 2017). Olantuji & Akanmu (2015) emphasized the requirement to specify the roles and responsibilities of individual team members and the timeline for deliverables for the entire team, with ownership, responsibility, and authority being the crucial elements. The construction stakeholders involved in BIM-based construction projects have varying backgrounds and designations, such as clients, architects, engineers, contractors, and those with BIM-related roles.

Case analyses

The case study was the construction of "The Proposed Design, Construction and Completion" of a hospital through the D-B procurement method in Malaysia. An important part of implementing BIM is getting all stakeholders on board. Hospitals are considered to be large and complex construction projects involving various stakeholders. In BIM projects, these stakeholders can be divided into two groups: internal and external stakeholders. The external stakeholders are mostly the owner of the project and the main contractor, who work together during the building project. The facility management (FM) service provider confirms that the personnel and resources identified and approved for the project were assigned and maintained throughout the project on a full-time basis. The main contractor's work will be evaluated by the FM service provider within the project region, who will also help with communication with other solution providers who might affect the design's coherence. For the BIM FM information system (FMIS) and FM protocol, the FM service provider will design the facility information management in line with the design requirements or design criteria indicated in the owner's design brief and information needs (EIR).

In the absence of any statement for any design aspect or any design element, it will be the responsibility of the FM service provider to adopt well-known and internationally accepted design standards, codes of practice, criteria, and methods. The FM service provider, after reviewing the various documents, should ensure that there are no ambiguities, discrepancies, inconsistencies, differences, unrealistic design or construction issues, or missing information within or between these documents. They must also be satisfied that the documents are sufficient in all respects for the purpose of carrying out and completing the design and the construction works.

A difference was identified between employees who prioritize projects and those who prioritize FM. These two groups had different needs, with those working on projects feeling that more attention was given to maintenance, but they believed that more effort should be made to incorporate BIM into project management. People who work on projects were found to have a different perspective from those working in FM, with the former feeling that more attention should be given to project management and the latter feeling that maintenance should be prioritized. To ensure that BIM is fully integrated in the future, both aspects of project management and FM should be considered in the process.

In general, the interviewees expressed that the implementation of BIM should be done in a systematic and defined manner, once the process for FM is established. They expressed a need for a clearer understanding of how and why BIM information will be used during maintenance. With such clarity, the respondents in the interviews felt the need for better communication and collaboration between all parties involved in the construction project, including the contractor and advisor, in order to implement BIM effectively. This can be achieved by providing clear guidance on the Employer Information Requirements (EIR) and BIM execution plan (BEP) and ensuring that all parties understand the reasons behind them. The support of the organization and management is crucial to facilitate the implementation of new processes in a seamless manner.

Nevertheless, the content analysis of the project BEP and the discussion with the FM service provider have led to some apparent and stimulating outcomes through which the proposed BEP did not mention the appointment of FM personnel. Although the appointment of the FM personnel as the Solutions Provider was initiated by the main contractor, it was evident that the owner of this project did not specify in detail the requirements that must be used during operation and maintenance. This will eventually drive the facility manager to fulfil and address any specific in the EIR during the tendering process. Moreover, the BEP was seen as too general and theoretical by the facility manager; nothing was detailed enough.

The Solutions Provider confirmed that he shall take full responsibility for any conditions and requirements by authorities and pursue securing permits and approvals from the respective authorities, notwithstanding any submissions by the owner or any approvals etc. obtained by the Owner Deliverables and Submittals. Furthermore, the Solutions Provider shall provide certain reports and documents at the relevant stages of the Works at no charge. These documents shall be applicable throughout the various design stages as per the Technical Proposal (five sets of documents deliverable as per attachments 5 & 6 of the Contract Document). Softcopy of the Revit model at the level of development (LOD) 500 (attachment 4 & 7 of the Contract Document). To support this new process and capture all new requirements, several documents were set up by the construction organisation. The different documents and the relations between them are indicated in Figure 1.

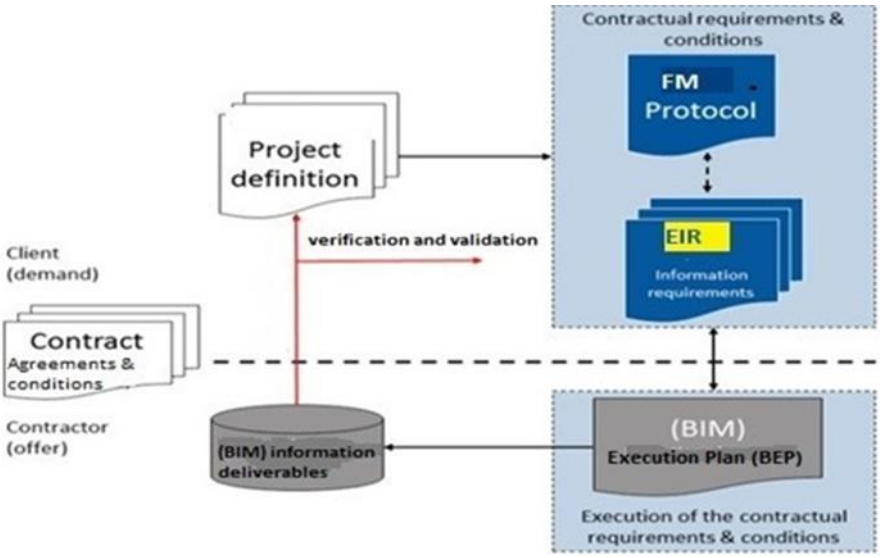

Figure 1. Different documents related to Building Information Modelling (BIM) for the hospital project in Malaysia.

Discussion

The case study demonstrates to owners the need for harnessing knowledge of their own internal business models and work processes related to delivering and operating facilities. The interviews have shaped the general understanding of the current status of using BIM to support FM operations. The goal was to assess the importance of early communication between design and construction teams to thoroughly understand project details. Results from the interviews suggest that the FM data for the project where BIM was used to support FM operations was manually entered into the FM systems software. The Industry Foundation Classes (IFC) and BIM as-built models were explicitly specified in the Employer Information Requirements (EIR). However, the interviewee stated that the FM team chose to manually key in the data into their FM systems as they felt unprepared to handle the IFC spreadsheet. The FM personnel claimed that the IFC spreadsheet did not contain all the data necessary for FM, such as the preventative maintenance data, and that they had to manually add this data into their FM systems. The FM personnel used IFC as a database for their FM systems.

It is vital that interoperability and its effect on the data exchange process between BIM tools, applications, and settings concerning the workflow of projects be spelt out in the contract documents. Nevertheless, certain contractual issues exist, such as determining the compatibility between software applications, allotting responsibilities to sustain an adequate level of interoperability amongst project players, and frequent audits for confirmation of compliance with contracts. The stakeholders interviewed generally understood the inefficiencies inherent in their current work processes and how they impacted the bottom line. For this reason, they were equipped with the knowledge and skills to lead the BIM effort, but the attempt was initiated only by a single project team who happened to lack the expertise to take a leadership position. This problem was related to the facility manager's opinion that the project owner did not significantly contribute to defining the needs for the O&M requirements during the design phase. All the owners had the ability to choose the method of service provider selection and the nature of project deliverables. They had various options for ensuring that the service companies working on their project are familiar with BIM and the construction procedures.

Whether the industry is prepared to supply the handover deliverables and information required by the client is the second concern that emerged from the interviews. A small number of intelligent clients have begun to recognise the importance of data-driven operations and are requesting data so that their facility management system can be connected to their asset lifecycle operating plan. They advertise tenders with very extensive and precise BIM requirements and information outputs by using internal expertise or by hiring external BIM consultants. However, in the case study, it appears that the situation was flipped, with the participants being worried about the industry's lack of knowledge and expertise.

Collaboration Strategy

Despite the significant advantages of the As-Built Model, it is not widely used, especially in Malaysia. One of the main reasons is the "Model not being As-Built" due to its unreliability. As most of the benefit acknowledged is based on a model that can truly reflect reality whilst being instantly interactable, it cannot benefit the owner.

The following sections delve into the reasons for the as-built model being criticised for not being as-built. The project's contract document, however, does not specify the standard accepted procedure detailing the model information obligations and liabilities. Also, the

specific responsibilities of each BIM project team member are not specified except in a general way.

A BIM project's requirements must encompass the modelling, visualisation, analysis, and documentation of the building design and facilitate the validation of the scope and cost of the project. The key aim of integrating BIM is to enhance the quality of design solutions and information exchange amongst stakeholders. Such requires collaboration among the contractor project team, the Public Works Department's (PWD) project team, and the owner. The application of BIM in this project involved the processes of creating the BIM model, building the required models, analyses, and producing design documents from the models. The generated models and analysis results were employed to support the decision-making process.

Therefore, it is important to give serious thought to the important players who will constitute the commercial framework, including the customer, primary designer, and contractor. All the important parties that have a substantial influence on the project's outcome and whose behaviour must be directed have been advised that the compensation model should be expanded to include them. The crucial party may be the one whose job necessitates close cooperation with other parties or the one whose services account for a sizeable chunk of the project's overall cost.

As with the case study, the reviewing process took place after each discipline model had developed the agreed or required model contents to be stipulated in the contract. The coordination of the models took place at the approval stage, whereby the proof of concept or model data validation was involved before the submission of the approved model for the construction process. Evidence has suggested that the requirements for creating added value for a business and project value in the future can be stated. These requirements would support a project's goals from descriptive data analytics to predictive data analytics in the future. With predictive data, insights on asset information or performance can be given, and scenarios can be with this information. In this way, better use of information can be created through model data validation.

The second crucial factor is to provide incentives for those not included in the pool to align with the collaborative contracting culture and share the same project goals and values. In the cases tudy, the project manager for a customer said that such a measure could help set up a performance incentive framework to pay the subcontractors and motivate them to work toward the overall goal.

Facility Management-BIM in Construction Process

Ideally, the building would be constructed as per the original construction drawings distributed by the design team (architect/engineer) to the construction team (builders/contractors). In fact, the built structure would not be the same as the original drawings (sometimes totally different) due to the unforeseen conditions on site and the owner's changes of mind during the construction stage. It is evident that there is no reference to a BIM execution plan within the contract documents. The facility builder, the subcontractors, and the designers typically come to an agreement on the plans. The contract must concentrate on the components that it requires for the FM process or "as-built" documentation. To avoid having to submit the initial design/model again into a BIM authoring software package, it may be necessary for inexperienced designers for the BIM plan to be included in the overall contract paperwork. To guarantee a smooth transition throughout the contract award process, a condition of tendering could be the acknowledgement or submission of a finished BIM execution plan. In this case, a formal process for communication among the stakeholders does not exist in the contract. It was

also suggested that communication should be included as a key performance indicator to monitor the effectiveness of the contract management team, and should comply with the relevant local Information and Communication Technology Act regarding electronic transactions. This also involves communication with subcontractors, suppliers and trades. Due to the lack of provision relating to the BIM communication process and transfer procedures to be executed in the contract, the problems of as-built recording identified in the case study occurred during the construction stage.

According to the study conducted, the facility manager requires a combination of both graphical and non-graphical information, along with attached documents, to effectively manage assets. The non-graphical information is considered to be of the utmost importance in facility management. The information should be stored object-based. All assets must adhere to both the general data requirements and the specific requirements set by the FM. The ideal data should be diverse, uniform, and trustworthy, and it should include the maintenance records of the FM protocol and any necessary legal documents as non-graphic information for the asset. The information requirement is depicted in Figure 1 and should be shared using open standards. If the basic features of each FM requirement are accurately modeled in BIM, this will result in a significantly more efficient FM.

Rethinking Contract Design

The main issues in the case study revolve around the legality of the contract with the use of BIM, the competency of the contracting parties, the rights of third parties, and the liability of the models. Building documentation is vital in the construction industry as it establishes standards, guidelines, and best practices. As a result, there is a need for exceptional productivity, quality, and accuracy in the documentation process. Building documentation professionals work together and share information due to the increasing attention paid to building documentation by property owners/operators, service providers, government agencies, and the general public. It is critical to establish ethical guidelines to support and enhance the community of professionals devoted to building documentation.

For D-B projects, the contractor is responsible for the risk of unexpected events, which results in limited control over the entire project and the cost of any necessary changes. This can make it challenging in some cases to clearly define the desired design standards and quality. A more detailed BIM functions and processes definition as part of contract documents should be critically considered as a result of the risks imposed on the contractor. This paper offers some important insights into the need to extensively identify the specification of each level of development (LOD) regarding the different procurement methods. However, the contract remains silent about the specification of the accuracy of intended information requirements and the vital roles of the information manager in ensuring the data that they receive complies with the agreed LOD. Disputes may arise later if the content and responsibilities of the model information are not clearly defined in the contract documents. If the information used in a project leads to the desired outcome, future projects can benefit from the effective utilization of this information. This enables scenario planning, improved predictability, and the use of real-time data with guaranteed quality and accuracy.

Ideally, a building would be constructed as per the original construction drawings distributed by the design team (architect/engineer) to the construction team (builder/contractors). Nonetheless, the built structure will not be exactly the same as the original drawings (sometimes totally different) due to the unforeseen on-site conditions and the owner having a change of mind during the construction stage. Pertaining to the case study, it was clear that the

contract documents made no mention of a BIM execution plan (BEP). This plan typically constitutes an agreement between the designers, subcontractors, and facility builders. The contract also typically focuses on the components needed for end users or "as-built" documentation as well as owners' information requirements. To avoid having to enter the initial design/model into a BIM authoring software package again in the case of inexperienced designers, a BIM plan may need to be a part of the overall contract agreements. To enable a smooth transition during the contract award process, the acknowledgement or submission of a finished BEP could be a requirement of tendering.

The information contained in the BIM model should be explicitly stated in the contract documents in accordance with the BIM manager's specifications. This information includes graphical model details, non-graphical information attached to graphical model objects, and accompanying documentation. Furthermore, the information exchange framework should be established using open standards, and a validation process for this information should be put in place after transfer. The use of open standards offers a more practical and comprehensive solution that can be widely adopted across the industry and not just by a specific organization. When the information is transferred and validated, the information should be aligned with the information framework of the asset management system. Throughout this process, the added value should be recorded to enhance future asset management procedures.

Conclusion

In conclusion, BIM Employer Information Requirements (EIR) need to be aligned with the facility management's (FM) protocol and the owner's project goals/definition. BIM applications that would enhance a project must be properly evaluated and described in the early stage. They should reflect the owner's ideal project outcome when using BIM. This strategy might also assist the owner in assessing the bidders' BIM skills. Therefore, it is suggested that the procurement team, who will evaluate the bid, be included in the bidding process, along with an information manager who can assess the bidder's capability in meeting the BIM requirements. Typically, the BIM team provides questions for the procurement team to ask during the bidding process, but they rarely participate in the actual questioning of the bidders. It is crucial for the information manager (either in-house or a hired consultant) to play a role in serving the owner by coordinating with stakeholders and ensuring the necessary levels of detail and information are addressed during the procurement process. The responsibilities of the information manager should encompass procurement, design, and construction and be responsible for ensuring that information is extensively aligned with the FM requirements.

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