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Legal and Contractual Determinants for Further Adoption of Building Information Modelling in the Construction Industry

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ABSTRACT

Intense international competition has led the construction industry to embrace technological digitalisation, including Building Information Modelling (BIM). Despite the well-established benefits of BIM's collaborative nature, it remains constrained by various challenges, notably contractual ambiguity, throughout a project's lifecycle. As a result, industry stakeholders remain cautious in adopting the technology, leading to slow adoption rates. Legal and contractual factors remain interdependent, with legal issues arising from current contractual practice that hinder the accommodation towards BIM's roles, procedures, and outcomes. This paper aims to define the contractual determinants relevant to BIM projects within the construction industry. The paper adopts a comprehensive and systematic literature review to shed light in uncovering prevailing doubts and lack of enthusiasm towards its adoption. A four-stage process of identification, screening, eligibility, and inclusion through Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) of two significant peer-reviewed online databases, Scopus and Web of Science (WOS), has been used to uncover the research topic. The findings indicate unclear contractual documents, misinterpretation of contractual terms and conditions, and inadequate contract management from the review of BIM contractual factors. By clarifying these factors, this paper aims to clarify the contractual aspects of BIM for industry stakeholders, thereby facilitating wider adoption and overcoming the challenges associated with the technology.

Keywords: Building Information Modelling; BIM; construction industry; technological digitalisation; contractual determinants

INTRODUCTION

Building Information Modelling (BIM) can be used throughout the entire lifecycle of a construction project with prominent advantages stemming from its technological capabilities in facilitating information exchange among multidisciplinary stakeholders (Kasim & Razali 2021) from its inception to the end of a building's life (Mughal et al. 2024). BIM's powerful capability for multiple stakeholder's involvement has the potential to improve efficiency and effectiveness through collaboration and coordination enabling stakeholders in the construction industry to create digital models of buildings and infrastructure (Wainwright & Bika 2021; Di Giuda et al. 2020). The adoption mentioned CIDB (2021) brings the advantage of costing within a project lifecycle as it enables a more accurate management of the pre-construction and planning stages, reducing human errors and facilitating better material selection during the construction process.

While the construction industry is rapidly growing to keep pace with digitalisation (Celoza et al. 2023; Kasim & Razali 2021), challenges persist in implementing digital technologies, leading to resistance to change (Khosravi & Afshar 2022; Ahmed et al. 2021). Existing contractual arrangements were not designed to address BIM's processes, and while the technology continues to advance, traditional contractual frameworks remain unchanged. Gaps have been identified in the contractual factors governing the implementation of BIM projects, which is a critical area of concern. Contracts in the construction industry are often complex, and their language can be misunderstood, leading to uncertainties and hindrances in the adoption of digital technologies.

The contractual complexities contribute to setbacks and hinder the industry's potential for growth and its ability to embrace digital transformation. In addition to these complexities, embracing digital technologies in the construction industry necessitates significant changes in culture, processes, and practices. Data management, cybersecurity, and workforce upskilling become crucial considerations (Khosravi & Afshar 2022; Ahmed et al. 2021). Overcoming these challenges is essential to ensure the successful implementation of digital technologies and unlock their full potential in transforming the construction industry.

This paper aims to address the contextual gap by investigating the contractual determinants that may slow the adoption of digital technologies within construction projects. Questions regarding current contractual practices in BIM have been explored to identify the liabilities associated with them. By clarifying these factors, the research seeks to provide valuable insights to the industry's knowledge and decision-making processes. By shedding light on the contractual determinants relevant to BIM projects, this research aims to create a better understanding of the contractual aspects that may hinder the adoption process. Therefore, the objective of this paper is to determine the determinants of BIM contracts within the construction industry. The findings will assist industry stakeholders navigate contractual complexities and creating a conducive environment for the wider adoption of digital technologies, ultimately, overcoming technology-related challenges, and fostering a positive path toward digital transformation.

BUILDING INFORMATION MODELLING (BIM)

Building Information Modelling (BIM) emerged in the 1970s and has since become an innovative advancement in the construction industry. However, BIM garnered significant traction in the early 2000s with the introduction of digitalised model representation, which led to a paradigm shift towards information sharing and collaboration among stakeholders (Hashim et al. 2021; Arayici et al. 2023; Gu et al. 2011; Eastman, 2008; Succar, 2009; Yee & Aouad, 2007). The understanding of BIM can be identified as the collection of data of various stakeholders throughout a holistic construction project through the development of a three-dimensional model following a set of processes of modelling, scheduling, pricing, sustainability and operations and maintenance (Autodesk 2019; Zhange & Gao 2019; Latiffi et al. 2013).

Its versatility across project phases has become essential as the industry embraces digitalisation, yielding numerous well-documented advantages, including enhanced stakeholder collaboration, cost savings, improved visualisation, quality assurance, heightened efficiency, and enhanced sustainability. The collaborative nature of BIM fosters integration among project stakeholders (Arayici et al. 2023; Hashim et al. 2021), enabling smoother teamwork and mitigating conflicts (Mustaffa et al. 2021). This is crucial within the Integrated Project Delivery (IPD) framework, as organisations cultivate their collaborative practices (Paavola & Miettinen (2019). Furthermore, this collaborative approach promotes transparency and open dialogue, facilitating effective interaction and information exchange, which are essential for a project's success (Ahankoob et al. 2023).

Cost savings through BIM arise from its ability to optimise efficiencies and proactive risk management approaches leading to the mitigation of errors. Moreover, its resource management functionalities facilitate reductions in labour expenditures, ultimately decreasing the overall project budget (Ahankoob et al. 2023; Arayici et al. 2023; Hashim et al. 2021; Mustaffa et al. 2021). The advanced modelling and visualisation capabilities of BIM as a technology enable a realistic representation of the project, supporting enhanced decision-making and the mitigation of design errors, which ultimately improves project's outcome (Yousaf et al. 2024; Ahankoob et al. 2023; Arayici et al. 2023; Hashim et al. 2021; Mustaffa et al. 2021; Wu et al. 2019).

BIM's facilitation further promotes quality control through its BIM Execution Plan which is updated and monitored throughout a project. This ensures consistency in the quality of project outputs (Mustaffa et al. 2021), with the shared model enabling improved communication and coordination as part of the overall project quality (Ahankoob et al. 2023). Research by Hashim et al. (2021) highlights that BIM's capabilities allow for higher accuracy through bulk checking and monitoring of quantities, while Arayici et al. (2023) confirm that BIM-enabled assurance

and checking promotes the adoption of standards and specifications.

As a revolutionary technology, the advanced and highly streamlined construction process through the production of documents and Bill of Quantities (BQ) in BIM (Hashim et al. 2021) enables a significant shift from the manual and fragmented approaches of traditional construction to a more integrated and efficient data management system (Ahankoob et al. 2023; Mustaffa et al. 2021; Paavola & Miettinen 2019). Moreover, BIM's improved project efficiency, as discussed by Mustaffa et al. (2021) can reduce resource utilisation and waste, consequently diminishing the carbon impact of a project. Nonetheless, Arayici et al. (2023) while agreeing on the significance of BIM, also highlighted lean construction incorporation as a sustainable outcome.

Generally, the use of BIM has been exponential worldwide with developed countries incorporating it to a large extent. The United Kingdom's adoption rate is found to be at 73% in 2020 while Hong Kong at 75% in 2020. In developing countries like Malaysia meanwhile is at 55% in 2021 due to issues associated with people, processes and technology of BIM which differs significantly from traditional construction. Nonetheless, Malaysia's adoption rate rose by 6% compared to 2019, higher than Singapore (50%), Japan (46%), and China (52%) (CIDB 2021).

BUILDING INFORMATION MODELLING (BIM): CONTRACTUAL DETERMINANTS

While the benefits of BIM in the construction industry are well recognised, challenges persist, particularly during the pre-construction and construction phases of a project's life cycle. Research has exponentially increased over the past decades, exploring potential remedies for BIM implementation addressing these challenges. These studies often colligate legal and contractual issues interchangeably. To discern, legal issues related to BIM's usage are governed by laws and regulations which include intellectual property rights, liability, data privacy, and security (Mahbod et al. 2023). In contrast, contractual issues pertaining to the agreements and obligations among involved parties, addressing matters such as responsibilities of parties using the BIM model, data exchange, collaboration, and dispute resolution. Recent research often highlights contractual factors as a critical contributor to BIM-related challenges as industry players continue to rely on traditional contracting methods (Wang et al. 2023).

Further, the connection between legal and contractual challenges arises from various factors, including vague language in contractual documents, misunderstandings among parties regarding contractual terms and conditions, and poor management of contracts (Wang et al. 2023). Traditional fragmentation in contracts often disconnects the collaboration essential for BIM leading to ambiguities and misunderstandings among project stakeholders. Additionally, the absence of a clear legal and contractual framework amplifies issues regarding the implementation of BIM in projects (Alwee et al. 2024). To mitigate these factors, identifying BIM maturity levels could be beneficial for improving BIM's contractual arrangement (Xu et al. 2022). Efforts to address these issues include the proposal of BIM contractual addendums based on existing addendums and contractual remedies by developed nations (Mahdian et al. 2023). Furthermore, legal and contractual risk management related to BIM could improve the overall BIM practices within the industry (Mohammadi et al. 2024).

METHODOLOGY

This research adopts a systematic review approach to define the contractual determinants relevant to BIM projects within the construction industry. The systematic review incorporates the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) approach through a four-stage process, including identification, screening, eligibility, and inclusion, to ensure a comprehensive and reliable summary of the research topic (Ahn & Kang 2018; Grant & Booth 2009).

In the identification stage, two significant peer-reviewed online databases, Scopus and Web of Science (WOS), were selected for journal inclusion. These databases were chosen for their high-quality journal selection and the inclusion of Journal Impact Factors, which measure the impact of individual articles (Sharma et al. 2014). To narrow down the scope, the focus was placed on BIM publications within the construction industry from the past five years (2019 to 2023). The initial search yielded many publications, with 10,708 from Scopus and 8,484 from WOS.

The screening stage involved the comprehensive selection of terms and keywords related to BIM and relevant issues, challenges, risks, barriers, disputes, and conflicts. These six determinants were identified based on their frequent use in the literature. The screening process was applied to the initial pool of publications, resulting in a reduced number of 3634 from Scopus and 3530 from WOS with a total of 12, 028 records excluded.

The eligibility stage aimed to identify relevant studies primarily focused on BIM contractual aspects. The final step involved a review of 144 journals, 80 from Scopus and 64 from WOS excluding 7020 records. Cross-

referencing further exclude 80 full-text articles of non-accessible articles, non-BIM contractual determinants and non-construction articles. This meticulous process resulted in the final inclusion of 39 journals from various regions around the world excluding 25 duplicates. These results provide a comprehensive overview of the contractual determinants relevant to BIM projects in the construction industry, shedding light on the existing literature and highlighting areas of concern and gaps in knowledge.

The systematic review methodology employed in this research ensures a rigorous and unbiased synthesis of the available evidence. It offers a deep understanding of the contractual challenges faced in BIM implementation within the construction industry. The findings will contribute valuable insights to industry practitioners, policymakers, and researchers, facilitating a better understanding of the contractual aspects associated with BIM adoption and promoting its wider acceptance and successful integration in construction projects. The findings of the systematic review, including key insights and observations, are presented in Table 1 and Figure 1.

TABLE 1. Scopus and WOS search results from 2019 to 2023

BIM Determinant		Issues	Challenges	Risks	Barriers	Disputes	Conflicts
Overall (n=19192) Scopus (n=10708) WOS (n=8484)	Scopus	(n=1136)	(n=1128)	(n=795)	(n=392)	(n=52)	(n=131)
	WOS	(n=894)	(n=1415)	(n=738)	(n=430)	(n=32)	(n=121)
Contractual Scopus (n=80) WOS (n=64)	Scopus	(n=35)	(n=21)	(n=21)	(n=14)	(n=13)	(n=4)
	WOS	(n=31)	(n=24)	(n=14)	(n=13)	(n=10)	(n=5)

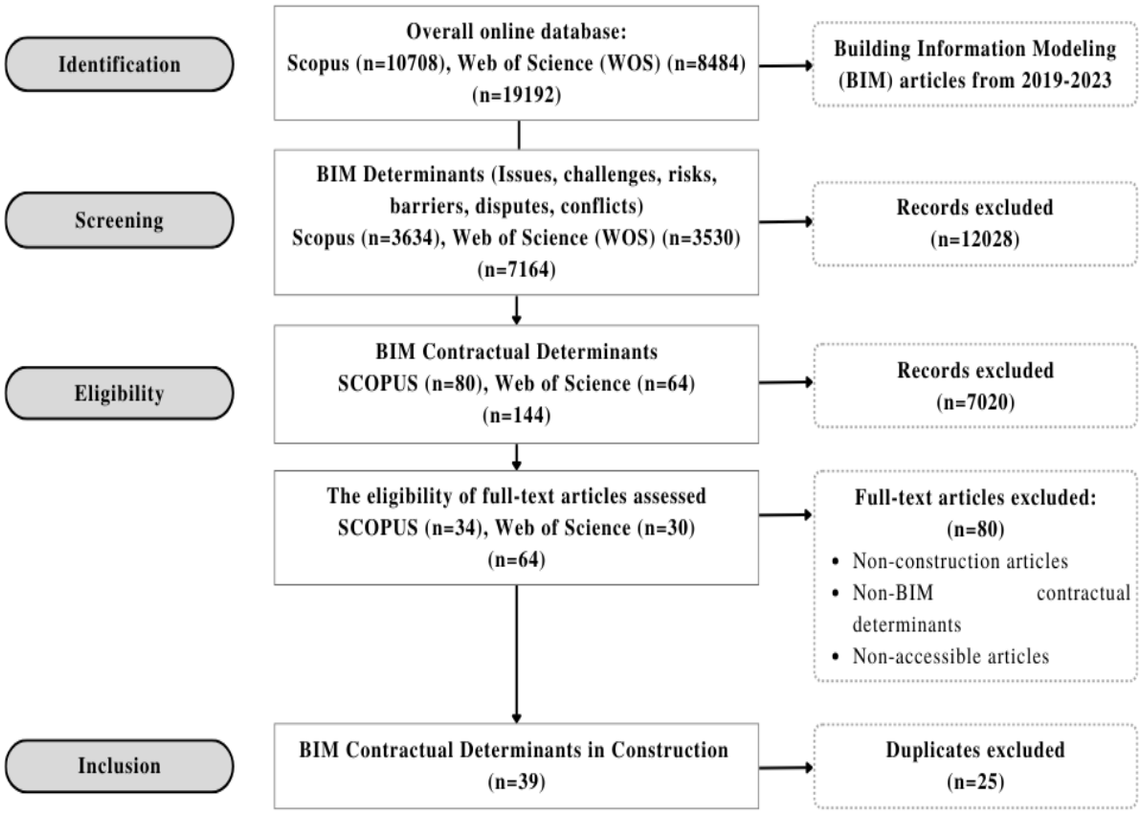

FIGURE 1. Systematic review process following PRISMA

FINDINGS OF THE STUDY

In the systematic review process, a total of 39 journals specifically focused on BIM contractual matters were identified. However, upon further examination, it was discovered that 25 of these journals were duplicates, appearing in both Scopus and WOS databases. The selected sources in these journals were diverse, representing various regions and countries. Malaysia had the highest number of studies with seven, followed by several regions with five studies. The United States (US), Nigeria, and Iran each had three studies. Canada, China, Pakistan, United Arab Emirates (UAE), and the United Kingdom (UK) had two studies each, while Australia, Egypt, Hong Kong, Italy, New Zealand, Spain, Tehran, and Vietnam each had one study. These studies provided insights from different locations and contexts, contributing to the overall understanding of BIM contractual matters. The selected studies spanned a timeframe from 2019 to 2023, with the majority of research conducted in 2021 (35.9% or fourteen studies). This was followed by 2022 with nine studies (23.1%), 2020 with seven studies (17.9%), 2019 with five studies (12.8%), and 2023 with four studies (10.2%). The distribution of studies across these years provides a comprehensive view of the recent developments and trends in BIM contractual research. Detailed data regarding the distribution of studies across regions and years can be found in Table 2. This information contributes to the understanding of the geographical and temporal landscape of BIM contractual research, highlighting the global reach and ongoing interest in this topic.

TABLE 2. BIM contractual studies from 2019 to 2023

Variable	Source	Determinant	Country	Year of research
S1	Mahbod et al.	Contractual documents; Terms and conditions; Contract management	Canada	2023
S2	Mahdian et al.	Contractual documents; Terms and conditions	Iran	2023
S3/ W1	Celoza et al.	Contractual documents; Terms and conditions; Contract management	USA	2023
W2	Wang et al.	Contractual documents; Terms and conditions; Contract management	Various (Worldwide)	2023
S4	Mostafaio et al.	Contractual documents; Terms and conditions; Contract management	UAE	2022
S5/ W3	Okwe et al.	Contractual documents; Terms and conditions	Nigeria	2022
S6/ W4	Oraee et al.	Contractual documents; Terms and conditions; Contract management	Australia	2022
S7/ W5	Faghihi et al.	Contractual documents; Terms and conditions	Iran	2022
S8/ W6	Nilchian et al.	Contractual documents; Contract management	Iran	2022
S9/ W7	Malla et al.	Contractual documents	Various (India, South Africa, UAE, UK, Saudi Arabia)	2022
W8	Baraibar et al.	Contractual documents	Spain	2022
W9	Xu et al.	Contractual documents; Contract management	China	2022
W10	Brooks et al.	Terms and conditions	UK	2022
S10/ W11	Babatunde et al.	Contractual documents; Contract management	Nigeria	2021
S11/ W12	Ragab et al.	Contractual documents	Egypt	2021
S12	Pradeep et al.	Contract management	New Zealand	2021
S13/ W13	Baharom et al.	Contractual documents; Terms and conditions; Contract management	Malaysia	2021
S14/ W14	Raja Berema et al.	Contractual documents	Malaysia	2021
S15/ W15	Assaad et al.	Contractual documents; Terms and conditions	USA	2021
S16/ W16	Taghizadeh et al.	Terms and conditions	Tehran	2021
S17/ W17	Dao et al.	Terms and conditions	Vietnam	2021
S18	Mustaffa et al.	Contractual documents; Terms and conditions; Contract management	Malaysia	2021

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S19/ W18	Ho	Contractual documents; Terms and conditions; Contract management	Hong Kong	2021
S20/ W19	Khawaja et al.	Contractual documents; Terms and conditions	Various (UK, UAE, Australia, Brazil, Malaysia, Saudi Arabia)	2021
S21	Zainon et al.	Contractual documents; Terms and conditions	Malaysia	2021
S22	Alwee et al.	Contract management	Malaysia	2021
W20	Jobidon et al.	Contractual documents; Terms and conditions; Contract management	Canada	2021
S23/ W21	Fan et al.	Contractual documents; Terms and conditions; Contract management	Various (Taiwan, China)	2020
S24/ W22	Liao et al.	Terms and conditions	China	2020
S25/ W23	Aljarman et al.	Contractual documents; Terms and conditions	Various (UK, Europe, USA, Canada, Australia, India, China & Japan)	2020
S26/ W24	Abd Jamil et al.	Contractual documents; Terms and conditions	Malaysia	2020
S27/ W25	Olanrewaju et al.	Contractual documents	Nigeria	2020
S28/ W26	Din et al.	Contractual documents; Contract management	Pakistan	2020
S29	Di Giuda et al.	Contractual documents	Italy	2020
S30	Abd Jamil et al.	Contractual documents; Terms and conditions; Contract management	Malaysia	2019
S31/ W27	Arshad et al.	Contractual documents; Terms and conditions	Pakistan	2019
S32/ W28	Almarri et al.	Contractual documents; Terms and conditions	UAE	2019
S33/ W29	Piroozfar et al.	Contractual documents; Terms and conditions; Contract management	UK	2019
S34/ W30	Dixit et al.	Contractual documents; Terms and conditions; Contract management	USA	2019

In addition to the previously mentioned journals, the distribution of selected journals across different publication years in this systematic review span from 2019 to 2023. Among the selected journals, 2021 had the highest number of publications, accounting for 35.9% of the total studies (fourteen studies). This indicates a significant focus on BIM contractual matters during that year. The year 2022 followed with nine studies, representing 23.1% of the total. In 2020, there were seven studies (17.9%), while in 2019, there were five studies (12.8%). For 2023, four studies were identified, comprising 10.2% of the total.

The detailed distribution of these studies across the years can be found in Table 4. This information provides insight into the temporal landscape of BIM contractual research, highlighting the varying levels of attention and emphasis given to this topic over the years. Furthermore, it is noteworthy that out of the 80 journals identified in Scopus, 34 were selected for inclusion in this review. In comparison, 30 out of the 64 journals identified in WOS were selected. This indicates that a higher percentage of journals from WOS (46.87%) were included in the review compared to Scopus (42.5%). The distribution of selected journals from Scopus and WOS is presented in Table 3 and Figure 2. These findings provide insights into the sources of literature used in the review, facilitating a comprehensive synthesis of research from reputable and influential journals.

TABLE 3. Reviewed Scopus and WOS publications and overall percentage from 2019 to 2023

Source	2019	2020	2021	2022	2023	Total	Percentage
Scopus	5	7	13	6	3	34	42.5
WOS	4	6	10	8	2	30	46.87

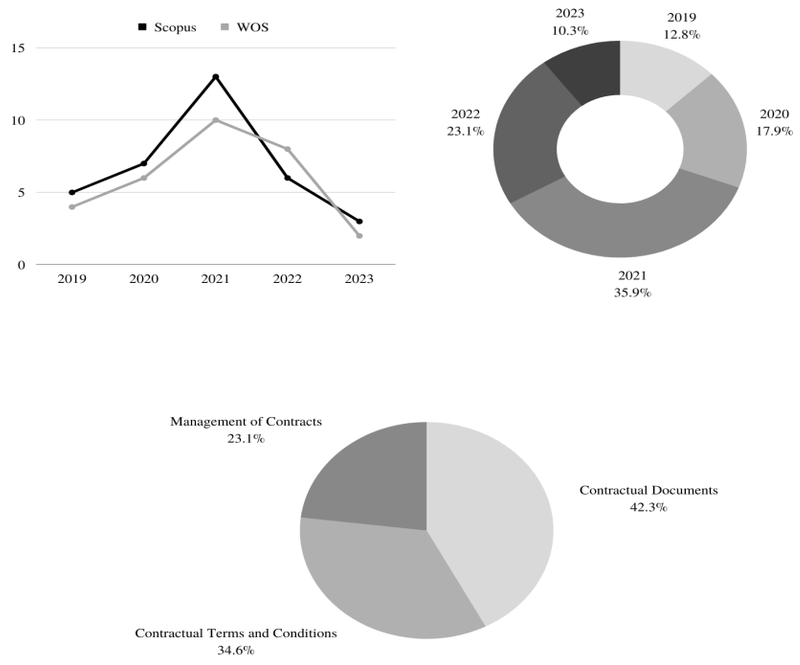

FIGURE 2. Line and doughnut chart of the publications by year

In addition to the previously mentioned findings, the categorisation further delves into the identification and classification of the contractual determinants within the selected studies. Wang et al. (2023) emphasised the division of these factors into three core components: contractual documents, contractual terms and conditions, and contract management. Contractual documents emerged as the most frequently highlighted factor, appearing in 33 of the selected sources, which accounts for 42.3% of the total. This suggests that a significant portion of the research focuses on examining various aspects related to contractual documents within the context of BIM projects. Closely following, contractual terms and conditions were identified as a prominent factor in 27 of the selected sources, constituting 34.6% of the total. This indicates that a considerable body of literature explores the intricacies and challenges associated with the specific terms and conditions outlined in BIM contracts. Contract management was also identified as a significant factor in the adoption and implementation of BIM projects, appearing in 18 of the selected sources, representing 23.1% of the total. This highlights the importance of effective contract management practices in ensuring the successful execution of BIM projects and addressing related challenges. Table 4 provides a comprehensive overview of the distribution of the identified determinants, while Figure 3 offers a graphical representation of the relative proportions of each determinant within the selected sources.

TABLE 4. Findings on the contractual determinants across sources

Determinant	Source	Total	Percentage
Contractual Documents	S1, S2, S3/ W1, W2, S4, S5/ W3, S6/ W4, S7/ W5, S8/ W6, S9/ W7, W8, W9, S10/ W11, S11/ W12, S13/ W13, S14/ W14, S15/ W15, S18, S19/ W18, S20/ W19, S21, W20, S23/ W21, S25/ W23, S26/ W24, S27/ W25, S28/ W26, S29, S30, S31/ W27, S32/ W28, S33/ W29, S34/ W30	33	42.3%
Contractual Terms and Conditions	S1, S2, S3/ W1, W2, S4, S5/ W3, S6/ W4, S7/ W5, W10, S13/ W13, S15/ W15, S16/ W16, S17/ W17, S18, S19/ W18, S20/ W19, S21, W20, S23/ W21, S24/ W22, S25/ W23, S26/ W24, S30, S31/ W27, S32/ W28, S33/ W29, S34/ W30	27	34.6%
Management of Contracts	S1, S3/ W1, W2, S6/ W4, S8/ W6, W9, S10/ W11, S12, S13/ W13, S18, S19/ W18, S22, W20, S23/ W21, S28/ W26, S30, S33/ W29, S34/ W30	18	23.1%

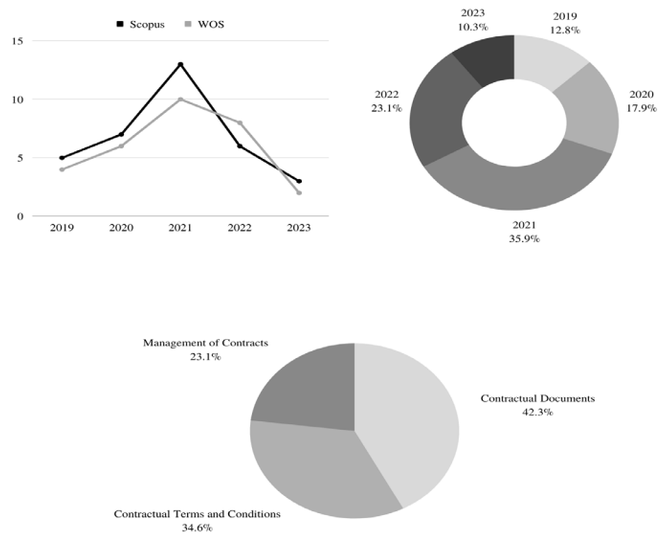

FIGURE 3. Percentage of contractual determinant across sources

DISCUSSIONS

CONTRACTUAL DOCUMENTS

The use of contractual documents in BIM projects is often problematic due to ambiguity and lack of standardisation (Wang et al. 2023; Faghihi et al. 2022; Babatunde et al. 2021; Baharom et al. 2021; Fan et al. 2020; Olanrewaju et al. 2020; Din et al. 2020; Arshad et al. 2019; Piroozfar et al. 2019). Therefore, the need for a clear and detailed contract is essential (Khawaja et al. 2021; Aljarman et al. 2020; Abd Jamil et al. 2020; Din et al. 2020; Abd Jamil et al. 2019; Arshad et al. 2019; Almarri et al. 2019; Dixit et al. 2019). Research from Europe, North America, Oceania, and Africa emphasises contractual documents as key determinants. However, it does not include Asian countries such as Tehran and Vietnam. While the UK and the US have developed comprehensive BIM contracts and addendums, many countries are still using conventional contracts that do not address BIM-specific issues (Ho 2021; Abd Jamil et al. 2020). However, Assaad et al. (2021) highlighted a contractual provision that remains lacking within US construction projects requiring a revisit. The lack of standardisation and guidelines remains a significant challenge BIM integration process (Okwe et al. 2022; Oraee et al. 2022; Baraibar et al. 2022; Raja Berema 2021; Mustaffa et al. 2021; Arshad et al. 2019).

It is essential for a contract to be well-structured to ensure proper understanding of responsibilities and risk allocation among industry players (Mostafaio et al. 2022; Malla et al. 2022). Currently, BIM projects often rely on BIM protocol without amendments of the existing provisions (Ragab et al. 2021). Studies by Mahdian et al. (2023) in Iran and Raja Berema et al. (2021) in Malaysia have identified the gaps in existing contractual documents for BIM's implementation in the construction industry with Zainon et al. (2021) suggesting amendments to Malaysian standard construction contracts. In Canada, Mahbod et al. (2023) advocate for contract modification to incorporate a collaborative contractual language. Additionally, contractual remedies related to BIM vary across jurisdictions particularly regarding the economic loss doctrine (Fan et al. 2018).

In lieu of contract modification, the addition of BIM terms within an agreement is also a possible solution (Winfield 2015). However, this approach can sometimes oversimplify matters as gaps and mismatches are inevitable. Furthermore, the advancement of BIM and its high level of detail compared to traditional construction provide vague language in the documentation for industry players to comprehend (Wang et al. 2023). BIM's collaborative nature involves various professionals with different motivations, which further necessitates flexibility in contractual remedies (Celoza et al. 2023; Nilchian et al. 2022; Xu et al. 2022). In addition, experts' involvement (Mahbod et al. 2023; Abd Jamil et al. 2020) and contract enforcement (Celoza et al. 2023) are crucial in addressing contractual terms to remove misinterpreted opportunistic behaviour. Another innovative solution includes smart contracts, which can streamline and automate payments for BIM contracts (Di Giuda et al. 2020).

The analysis reveals ten (10) key findings regarding the management of contractual documents in BIM projects.

highlighting challenges and the need for improvement and standardisation. The most prevalent issue identified is the ambiguity and lack of standardisation in contractual documents, which is highlighted by the highest number of sources with 9 out of 27 sources (33.3%). The absence of clear and standardised contract formats creates difficulties in effectively managing contracts within BIM projects. This ambiguity can lead to misunderstandings, disputes, and inefficiencies in project execution. Another significant finding is the need for clear and detailed contracts, as emphasised by 8 sources (29.6%).

These sources emphasise the importance of well-structured contracts that define the responsibilities and risk allocation among the various industry stakeholders involved in BIM projects. Clear contracts help to establish a common understanding among stakeholders and provide a solid foundation for successful project execution. The challenges related to the integration of BIM methodology into construction projects are also prominently highlighted, with 6 sources (22.2%) pointing out the difficulties faced in the BIM integration process. These challenges include the lack of standardisation, guidelines, and protocols for BIM implementation, which can hinder the seamless integration of BIM methodology with contract management practices. The existence of gaps in existing contractual documents specifically tailored for BIM implementation is identified by 3 sources (11.1%). This finding underscores the need for amendments and improvements in current contractual frameworks to better address the unique requirements and considerations of BIM projects.

Furthermore, two sources (7.4%) point out that certain countries still lack specific contractual documents for BIM projects, relying instead on conventional contracts that may not fully capture the nuances of BIM methodologies. The importance of flexibility in contractual remedies and addressing misinterpreted behaviour is also highlighted by 2 sources (7.4%). These sources emphasise the need for contractual provisions that can address misinterpretations and opportunistic behaviors that may arise during project execution. Lastly, several factors, including contract modification for a collaborative contractual language, differences in contractual remedies related to BIM, and the addition of BIM terms within an agreement, were mentioned in 1 source each (3.7%).

These findings offer valuable insights into specific aspects of contractual documents that require attention, such as adapting contracts to reflect the collaborative nature of BIM projects, addressing jurisdictional variations in contractual remedies, and incorporating specific BIM terms into contractual agreements. Overall, the data underscore the necessity of improving standardisation, clarity, and adaptability in BIM contractual frameworks to facilitate the successful implementation of BIM in the construction industry. A detailed overview of these findings is presented in Figure 4.

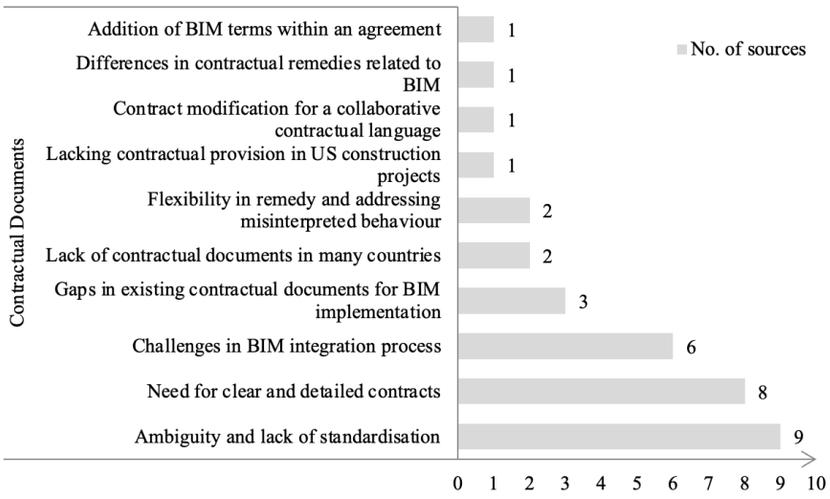

FIGURE 4. Findings on the contractual documents

CONTRACTUAL TERMS AND CONDITIONS

Effective contract terms and conditions are essential in reducing conflicts in the construction industry. However, these terms can often be misunderstood and difficult to interpret by industry players, leading to disputes (Celoza et al. 2023; Abd Jamil et al. 2019). Miscommunications among contractual parties and undefined expectations can cause conflicts (Wang et al. 2023; Celoza et al. 2023; Fan et al. 2020). Additionally, the various parties involved in a construction project and their respective roles and

responsibilities can cause miscommunication and misalignment (Oraee et al. 2022; Faghihi et al. 2022; Khawaja et al. 2021). This includes BIM's lack of contractual clauses (Abd Jamil et al. 2020). Some of the terms and conditions mentioned includes BIM's definition (Ho, 2021; Liao et al. 2020), roles and responsibilities (Assaad et al. 2021; Dao et al. 2021; Khawaja et al. 2021; Jobidon et al. 2021), intellectual property rights (IPRs) (Baharom et al. 2021; Assaad et al. 2021; Dao et al. 2021; Mustaffa et al. 2021; Ho, 2021; Khawaja et al. 2021; Zainon et al. 2021; Liao et al. 2020; Abd Jamil et al. 2020; Arshad et al. 2019; Almarri et al. 2019), level of detail (LOD) (Khawaja et al. 2021; Jobidon et al. 2021), ownership of BIM data (Assaad et al. 2021; Dao et al. 2021; Zainon et al. 2021; Liao et al. 2020), liability for errors and omissions in BIM (Assaad et al. 2021; Taghizadeh et al. 2021; Dao et al. 2021; Ho, 2021; Zainon et al. 2021; Abd Jamil et al. 2020; Abd Jamil et al. 2019; Almarri et al. 2019; Piroozfar et al. 2019; Dixit et al. 2019), dispute resolution (Assaad et al. 2021; Mustaffa et al. 2021; Ho, 2021; Khawaja et al. 2021; Jobidon et al. 2021) security and privacy (Mustaffa et al. 2021; Ho, 2021), interoperability (Aljarman et al. 2020), data management (Ho, 2021; Abd Jamil et al. 2020) and collaboration protocol (Ho, 2021).

While many countries have focused on the importance of contractual terms and conditions in BIM projects, countries such as Egypt, Italy, New Zealand and Spain, as well as a study by Malla et al. (2022) have not specifically highlighted this aspect as a determinant. The analysis revealed fifteen (15) findings related to contractual terms and conditions. The most prominent determinant is intellectual property rights (IPRs), which is emphasised in approximately 42.3% of the sources. This underscores the complexity and significance of managing IPRs within BIM collaborations. Liability for errors and omissions in BIM is another major concern, mentioned in approximately 38.5% of the sources, indicating the need for clear guidelines to address liability issues. The roles and responsibilities of project participants (15.4%) and tailored dispute resolution methods for BIM projects (19.2%) are also highlighted as important considerations. Miscommunications among contractual parties and undefined expectations (11.5%) pose challenges to effective contract management, necessitating improved communication and clarity. Ownership of BIM data (15.4%) and data management (7.7%) emerge as crucial factors for ensuring the integrity and accessibility of project information. Difficult-to-interpret contractual terms and the required level of detail in BIM deliverables (7.7% each) underscore the need for precise language and clear expectations. Security and privacy concerns (7.7%), the involvement of various parties in construction projects (11.5%), and the lack of specific contractual clauses for BIM (3.8%) are additional areas of focus. Furthermore, the definition of BIM (7.7%), interoperability challenges (3.8%), and the development of collaboration protocols (3.8%) also require attention. These findings collectively emphasise the complexity and multifaceted nature of contractual terms and conditions in BIM projects. Addressing these determinants is crucial for establishing effective contracts, fostering collaboration, mitigating disputes, and ensuring the successful implementation of BIM methodologies in the construction industry. A detailed overview of these findings is presented in Figure 5.

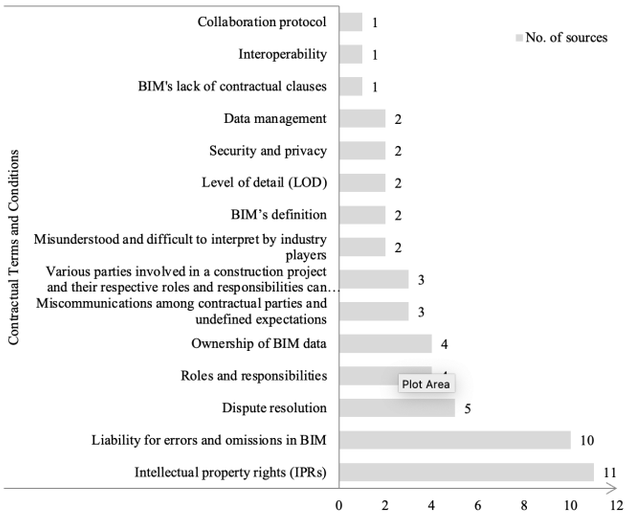

FIGURE 5. Findings on the contractual terms and conditions

MANAGEMENT OF CONTRACTS

Managing contracts is essential for ensuring successful BIM project performance (Xu et al. 2022; Ho, 2021), with a need for a clear contract administration plan (Alwee et al. 2021). Mature countries from North America and Oceania have long focused on the management of contracts as a determinant. While Asian, European, and African countries have addressed this aspect, studies in countries like Vietnam, Tehran, Italy, Spain, and Egypt as well as by Aljarman et al. (2020) and Khawaja et al. (2021), have not specifically focused on contract management for BIM projects. However, challenges remain due to the lack of standardised guidelines and governance mechanisms for contractual adherence, resulting in a mismatch between contract management and BIM methodology (Celoza et al. 2023; Wang et al. 2023; Fan et al. 2020). Managing provisions such as intellectual property rights (IPRs) further complicate contract management, particularly in terms of information exchange and protection within BIM's collaborative environment (Oraee et al. 2022; Baharom et al. 2021).

To address these issues, Wang et al. (2023) suggested a BIM-based claim system for managing legal and factual claim records, while Mustaffa et al. (2021) emphasised the need for effective risk management to address contractual risks. An effective BIM Execution Plan (BEP) can help clarify stakeholder responsibilities and outline contractual relationships in a BIM project (Mahbod et al. 2023; Nilchian et al. 2022). Additionally, Pradeep et al. (2021) proposed using blockchain-based systems to enhance the enforcement of contractual agreements and interactions among stakeholders, providing an immutable and transparent record of these interactions.

Further, industry stakeholders should collaborate and define transparent contractual relationships, adhering to the "privity of contract" concept (Mahbod et al. 2023; Mostafaio et al. 2022; Baharom et al. 2021; Alwee et al. 2021). This includes early contract negotiations to be conducted early in the contract (Assaad et al. 2021) with an Integrated Project Delivery (IPD) contract as a potential approach (Jobidon et al. 2021; Piroozfar et al. 2019).

Explicit coordination provisions, necessary resources, and training should also be provided for successful BIM implementation and collaboration among project players (Mostafaio et al. 2022; Brooks et al. 2022; Babatunde et al. 2021; Khawaja et al. 2021; Din et al. 2020), especially during the facility management phase (Okwe et al. 2022). Taghizadeh et al. (2021) explored the unconventional solution through game theory to mitigate design liability disputes often arise among players. Another solution by Abd Jamil et al. (2019), Dixit et al. (2019), and Piroozfar et al. (2019) highlights the use of legal and insurance tools in managing risks associated with BIM projects.

The findings found ten (10) key aspects of the management of contracts that are critical for the BIM project. The most prominent aspect highlighted by 40% of the sources is the importance of transparent contractual relationships and the "privity of contract" concept. This emphasises the need for clear and open communication among project stakeholders to ensure effective contract management. Close behind, with 33.3% of the sources, is the need for explicit coordination provisions, necessary resources, and training, emphasising the importance of well-defined coordination measures and adequate support to enable successful BIM implementation and collaboration among project participants. The lack of standardised guidelines and governance mechanisms for contractual adherence, discussed in 30% of the sources, is identified as a major challenge, highlighting the need for standardised guidelines to align contract management with BIM methodology effectively.

Additionally, early contract negotiations and the adoption of the Integrated Project Delivery (IPD) approach, highlighted in 30% of the sources, are suggested to enhance collaboration and coordination among stakeholders. The BIM Execution Plan (BEP) is highlighted in 20% of the sources, emphasising its role in outlining contractual relationships and stakeholder responsibilities in BIM projects. Managing Intellectual Property Rights (IPRs) poses challenges in information exchange and protection within BIM's collaborative network, as mentioned in 20% of the sources. Other important findings include the need for a BIM-based claim system, effective risk management and the use of blockchain-based systems, each mentioned in 10% of the sources.

While these findings offer valuable insights into the management of contracts in BIM projects, it is essential to note that the percentages represent the number of sources and may not fully capture the overall prevalence of these findings across the literature. Nonetheless, these findings highlight key areas that both researchers and industry professionals can focus on to improve contract management practices in BIM projects. These findings on the management of contracts have been identified in Figure 6.

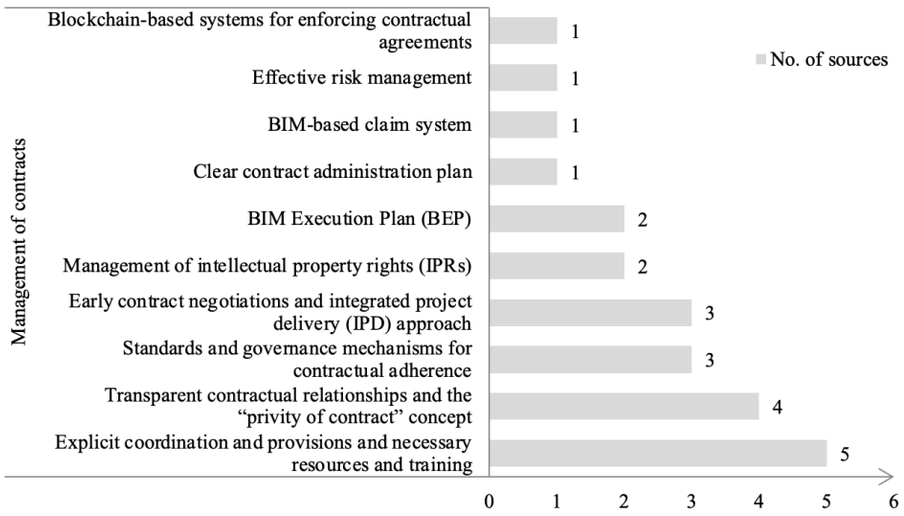

FIGURE 6. Findings on the management of contracts

CONCLUSION

While BIM offers numerous advantages in the construction industry, challenges still exist during the pre-construction and construction phases. Legal and contractual issues are closely interrelated, with legal issues governed by laws and regulations and contractual issues arising from agreements among parties involved in the project. A total of 35 legal and contractual determinants have been identified and classified into three main categories of contractual documents, contractual terms and conditions, and the management of contracts. Detailed findings across sources have been identified as per Table 4.

The results highlight several key issues, clarity, detail, ambiguity and standardisation in the documentation issues. Under contractual terms and conditions, IPRs and liabilities due to errors and omissions in the BIM model emerge as significant concerns. In addition, contractual relationship transparency following the 'privity of contract' and the need for coordination and provisions towards resources and training are identified as critical factors within contract management.

In conclusion, this study's findings offer recommendations for the development of a contractual framework for BIM projects, emphasising the importance of specific contractual documents, BIM contract addendums, and the implementation of effective contract management. By addressing these recommendations, the construction industry can enhance the adoption and implementation of BIM, improve project performance, and establish best practices for contractual management BIM-based in construction projects. Future research should continue to explore these areas and provide novel insights to support the ongoing development and refinement of BIM practices in the construction industry.

LIMITATIONS AND FUTURE RESEARCH

This research provides valuable insights into the development of a contractual framework for BIM projects, contributing to the establishment of best practices for contractual management in the context of BIM implementation. However, it is important to acknowledge the limitations of this study. The research focused specifically on the contractual determinants of BIM projects within the construction industry, and other determinants influencing BIM adoption may not have been fully explored. Determining BIM project level and proposing a specific contractual addendum can significantly contribute to the effective management of contractual documents and terms. These addendums can outline explicit coordination provisions and define contractual relationships for all parties involved in BIM implementation, thereby reducing conflicts and misunderstandings.

Additionally, the study primarily relied on a systematic review of existing literature, and did not involve original empirical data collection. Future research could consider conducting primary research to validate and expand upon the findings of this study. Investigating into the development and implementation of BIM contract addendums in different countries and regions would provide insights into their applicability in diverse contexts.

Further studies could explore the role of technology and digital platforms in facilitating contractual management within BIM projects offering innovative solutions to streamline processes and improve collaboration among

stakeholders. Moreover, evaluating the impact of effective contractual management on project performance and outcomes in BIM projects would provide valuable guidance for industry practitioners and policymakers. Assessing the benefits and challenges of adopting contractual frameworks will contribute to a deeper understanding of their implications for project success.

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DECLARATION OF COMPETING INTEREST

None.

REFERENCES

Abd Jamil, A. H., & Fathi, M. S. 2019, April. Contractual issues for Building Information Modelling (BIM)-based construction projects: An exploratory case study. *In IOP Conf. Ser.: Mater. Sci. Eng* 513: 012035.

Abd Jamil, A. H., & Fathi, M. S. 2020. Enhancing BIM-based information interoperability: Dispute resolution from legal and contractual perspectives. *Journal of Construction Engineering and Management* 146(7): 05020007.

Ahankoob, A., Manley, K., Hon, C., & Drogemuller, R. 2021. The influence of building information modelling on the absorptive capacity of project-based organisations. *Architectural Engineering and Design Management* 19(1): 1–21.

Ahmed, S., Cai, H., Li, H., & Li, H. 2021. Building information modelling (BIM) adoption in construction projects: A critical review of factors, risks, and benefits. *Journal of Civil Engineering and Management* 27(4): 229-246.

Ahn, E., & Kang, H. 2018. Introduction to systematic review and meta-analysis. *Korean Journal of Anesthesiology* 71(2): 103-112.

Akintoye, A., Goulding, J. S., & Zawdie, G. 2020. Construction 4.0: An exploratory review of the implementation of Industry 4.0 in construction. *International Journal of Construction Management* 20(1): 1-23.

Aljarman, M., Boussabaine, H., & Almarri, K. 2020. Emerging technical risks from the application of building information modelling. *Journal of Facilities Management* 18(3): 195-212.

Almarri, K., Aljarman, M., & Boussabaine, H. 2019. Emerging contractual and legal risks from the application of building information modelling. *Engineering, Construction and Architectural Management.*

Almarshad, A., Ibrahim, M., Alabduljabbar, H., & Aslam, M. 2020. BIM adoption in construction projects: Critical success factors and barriers. *Journal of Construction Engineering and Management* 146(10): 04020109.

Alwee, S. N. A. S., Ismail, N. A. A., Zolkafli, U. K., Salleh, H., & Jamil, A. H. A. 2024. Exploring the legal and contractual impediments in BIM-based application: A systematic literature review. *International Journal of Sustainable Construction Engineering and Technology* 15(1): 175-193.

Alwee, S. N. A. S., Salleh, H., & Zulkifli, U. K. 2021. Strategic process protocol for Building Information Modeling (BIM) contract administration in Malaysia – A concept paper. *Malaysian Construction Research Journal (MCRJ):* 37.

Ang, P. S. E., Woo, X. Y., Kasim, N., Osman, M. H., Adnan, S. H., Natasha, N. S., & Ali, R. 2022, May. Building Information Modelling (BIM) in Malaysian Industrialised Building System (IBS) construction projects: Benefits and challenges. *In IOP Conference Series: Earth and Environmental Science* (Vol. 1022, No. 1, p. 012020. IOP Publishing.

Arayici, Y., Tokdemir, O. B., & Kassem, M. 2023. A quantitative, evidence-based analysis of correlations between lean construction and building information modelling. *Smart and Sustainable Built Environment* 12(5): 975-1001.

Arshad, M. F., Thaheem, M. J., Nasir, A. R., & Malik, M. S. A. 2019. Contractual risks of building information modeling: Toward a standardized legal framework for design-bid-build projects. *Journal of Construction Engineering and Management* 145(4): 04019010.

Assaad, R., El-adaway, I. H., El Hakea, A. H., Parker, M. J., Henderson, T. I., Salvo, C. R., & Ahmed, M. O. 2021. Contractual perspective for BIM utilization in US construction projects. *Journal of Construction Engineering and Management* 146(12): 04020128.

Autodesk. 2019. BIM. Retrieved from shorturl.at/uHKY9.

Babatunde, S. O., Udeaja, C., & Adekunle, A. O. 2021. Barriers to BIM implementation and ways forward to improve its adoption in the Nigerian AEC firms. *International Journal of Building Pathology and Adaptation* 39(1): 48-71.

Baharom, M. H., Habib, S. N. H. A., & Ismail, S. 2021. Building information modelling (BIM): Contractual issues of intellectual property rights (IPR) in construction projects. *International Journal of Sustainable Construction Engineering and Technology* 12(1): 170-178.

Baraibar, J. M., De-Paz, J., & Rico, J. 2022. Challenges for the implementation of BIM methodology in the execution of underground works. *Buildings* 12(3): 309.

Bayomy, A. F., & Smith, J. 2019. Reducing construction costs using BIM and VR technologies. *Journal of Construction Engineering and Management* 145(3): 04018105.

Berema, R. K. R., Ismail, Z., & Brahim, J. 2021. Comparative analysis of existing contracts for Building Information Modelling (BIM) projects in Malaysia and selected common law countries. *International Journal of Sustainable Construction Engineering and Technology* 12(5): 9-18.

Brooks, T., Zantinge, R., & Elghaish, F. 2022. Investigating the future of model-based construction in the UK. *Smart and Sustainable Built Environment* (ahead-of-print).

Celoza, A., de Oliveira, D. P., & Leite, F. 2023. Qualitative analysis of the impact of contracts on information management in AEC projects. *Journal of Construction Engineering and Management* 149(3): 04022185.

CIDB. 2021. Malaysia Building Information Modelling (BIM) Report 2021. In *Construction Industry Development Board Malaysia 2022. Malaysia,* 2-7.

Dao, T. N., Chen, P. H., & Nguyen, T. Q. 2021. Critical success factors and a contractual framework for construction projects adopting building information modeling in Vietnam. *International Journal of Civil Engineering* 19: 85-102.

Di Giuda, G. M., Giana, P. E., & Pattini, G. 2020. The shortening and the automation of payments: the potentiality of smart contract in the AECO sector. *In Proceedings of International Structural Engineering and Construction* (Vol. 7, No. 2, pp. 1-6). ISEC Press.

Din, Z. U., Ather, W., & Gibson Jr, G. E. 2020, November. Strategies of BIM application with traditional project delivery method: a case of building construction industry in Pakistan. *In Construction Research Congress 2020: Computer Applications* (pp. 613-621). Reston, VA: American Society of Civil Engineers.

Dixit, M. K., Venkatraj, V., Ostadalimakhmalbaf, M., Pariafsai, F., & Lavy, S. 2019. Integration of facility management and building information modeling (BIM): A review of key issues and challenges. Facilities.

Eastman, C. 2008. *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors*. John Wiley & Sons.

Faghihi, V., Peimankar, P., Nazarpour, M. T., & Shafaat, A. 2022. Effects of contractual challenges in building information modeling on successful implementation. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 14(4): 05022003.

Fan, S. L. 2020. Comparative study for BIM-based contract administration between the cases in Taiwan and China. *Journal of the Chinese Institute of Engineers* 43(7): 648-656.

Grant, M.J. & Booth, A. 2009. A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Information & Libraries Journal* 26: 91-108. https://doi.org/10.1111/j.1471-1842.2009.00848.x

Gu, N., London, K., & Zou, W. 2011. Understanding the implementation of building information modelling in the UK construction industry: An exploratory study. *The Journal of Information Technology in Construction (ITcon):* 16: 115-131.

Hashim, N., Mei, Y. F., Kamarazaly, M. A., Ling, S. C. A., & Md, A. 2021. Building Information Modeling–Utilization in QS Consultant Firms and Competency Requirements of QS Graduates. *Malaysian Construction Research Journal (MCRJ):* 23.

Ho, P. H. 2021. Mapping out BIM contract conditions by way of a comparative study. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction* 13(1): 05020017.

Jobidon, G., Lemieux, P., & Beauregard, R. 2021. Building information modeling in Quebec's procurement for public infrastructure: A case for integrated project delivery. *Laws* 10(2): 43.

Kasim, N., & Razali, S. A. 2021. Reinforce Technology IR 4.0 implementation for improving safety management in construction site. *International Journal of Sustainable Construction Engineering and Technology* 12(3): 289-298.

Khawaja, E. U. R., & Mustapha, A. 2021. Mitigating disputes and managing legal issues in the era of building information modelling. *Journal of Construction in Developing Countries* 26(1): 111-130.

Khosravi, S., & Afshar, A. 2022. A systematic review of the barriers to BIM adoption in construction projects. *Engineering, Construction and Architectural Management,* ahead-of-print, 1-25.

Latiffi, A. A., Mohd, S., Kasim, N., & Fathi, M. S. 2013). Building Information Modeling (BIM) Application in Malaysian Construction Industry. 2: 1–6. https://doi.org/10.5923/s.ijcem.201309.01.

Liao, X., Lee, C. Y., & Chong, H. Y. 2020. Contractual practices between the consultant and employer in Chinese BIM-enabled construction projects. *Engineering, Construction and Architectural Management*.

Mahbod, S., Iordavona, I., & Poirier, E. 2023. A gap analysis of current CCDC standard contract documents and provisions for successful BIM-enabled projects in Canada. *In Proceedings of the Canadian Society of Civil Engineering Annual Conference 2021: CSCE21 Construction Track Volume 1* (pp. 273-285). Singapore: Springer Nature Singapore.

Mahdian, A., Parchami Jalal, M., & Yavari Roushan, T. 2023. Contractual risks of BIM implementation and the proposed contract form for DBB and DB projects. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction* 15(1): 06522003.

Malla, V., Jagannathan, M., & Kumar Delhi, V. S. 2022. Identification of BIM dimension-specific contract clauses in EPC turnkey projects. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction* 14(1): 04521040.

Ministry of Works. 2022. National Construction Policy Dasar Pembinaan Negara 2030. *Kementerian Kerja Raya*.

Mohammadi, S., Aibinu, A. A., & Oraee, M. 2024. Legal and contractual risks and challenges for BIM. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 16(1): 04523043.

Mostafaio, A., & Dulaimi, M. 2022, November). Alignment of Construction Procurement Strategies for the Effective Implementation of BIM in the UAE. *In IOP Conference Series: Earth and Environmental Science* (Vol. 1101, No. 8, p. 082001). IOP Publishing.

Mughal, S., Khoso, A. R., Najeeb, H., Khan, M. S. N., Ali, T. H., & Khahro, S. H. 2024. Green retrofitting of building using BIM-based sustainability optimization. *Jurnal Kejuruteraan* 36(1): 179-189.

Mustaffa, N. E., Xiong, S. K. Z., Mustapa, M., Ariffin, H. L. T., & Ismail, F. 2021, November. Management of contractual risks in a BIM-enabled project. *In AIP Conference Proceedings* (Vol. 2428, No. 1, p. 060004). AIP Publishing LLC.

Nilchian, S., Majrouhi Sardroud, J., Darabpour, M., & Tavousi Tafreshi, S. 2022. Features and conditions of building information modeling contracts. *Buildings* 12(11): 1839.

Okwe, E. I., Olanrewaju, O. I., Heckman, M., & Chileshe, N. 2022. Barriers to building information modelling and facility management practices integration in Nigeria. *Journal of Facilities Management* (ahead-of-print).

Olanrewaju, O. I., Chileshe, N., Babarinde, S. A., & Sandanayake, M. 2020. Investigating the barriers to building information modeling (BIM) implementation within the Nigerian construction industry. *Engineering, Construction and Architectural Management* 27(10): 2931-2958.

Oraee, M., Hosseini, M. R., Edwards, D., & Papadonikolaki, E. 2022. Collaboration in BIM-based construction networks: A qualitative model of influential factors. *Engineering, Construction and Architectural Management* 29(3): 1194-1217.

Paavola, S., & Miettinen, R. (2019). Dynamics of design collaboration: BIM models as intermediary digital objects. *Computer Supported Cooperative Work (CSCW)* 28: 1-23.

Piroozfar, P., Farr, E. R., Zadeh, A. H., Inacio, S. T., Kilgallon, S., & Jin, R. 2019. Facilitating building information modelling (BIM) using integrated project delivery (IPD): A UK perspective. *Journal of Building Engineering* 26: 100907.

Pradeep, A. S. E., Yiu, T. W., Zou, Y., & Amor, R. 2021. Blockchain-aided information exchange records for design liability control and improved security. *Automation in Construction* 126: 103667.

Ragab, M. A., & Marzouk, M. 2021. BIM adoption in construction contracts: Content analysis approach. *Journal of Construction Engineering and Management* 147(8): 04021094.

Raja Berema, R. K., Ismail, Z., & Brahim, J. 2021. Comparative analysis of existing contracts for Building Information Modelling (BIM) projects in Malaysia and selected common law countries. *International Journal of Sustainable Construction Engineering and Technology* 12(5): 9-18.

Sharma, M., Sarin, A., Gupta, P., Sachdeva, S., & Desai, A. 2014. Journal impact factor: Its use, significance and limitations. *World Journal of Nuclear Medicine* 13(02): 146-146.

Succar, B. 2009. Building information modelling framework: A research and delivery foundation for industry stakeholders. *Automation in Construction* 18(3): 357-375.

Taghizadeh, K., Alizadeh, M., & Yavari Roushan, T. 2021. Cooperative game theory solution to design liability assignment issues in BIM projects. *Journal of Construction Engineering and Management* 147(9): 04021103.

Wainwright, T., & Bika, Z. 2021. An investigation of the factors influencing BIM adoption in the construction industry. *Journal of Building Engineering* 43: 102603.

Wang, J., Zhang, S., Fenn, P., Luo, X., Liu, Y., & Zhao, L. 2023. Adopting BIM to facilitate dispute management in the construction industry: A conceptual framework development. *Journal of Construction Engineering and Management* 149(1): 03122010.

Winfield, M. 2015. Building Information Modelling: the legal frontier: Overcoming legal and contractual obstacles. *Society of Construction Law*, D178(April): 18.

Wu, Z., Chen, C., Cai, Y., Lu, C., Wang, H., & Yu, T. 2019. BIM-based visualization research in the construction industry: A network analysis. *International Journal of Environmental Research and Public Health* 16(18): 3473.

Xu, Y., Chong, H. Y., & Chi, M. 2022. Impact of contractual flexibility on BIM-enabled PPP project performance during the construction phase. *Journal of Infrastructure Systems* 28(1): 04021057.

Yang, J., Shen, H., & Wu, Z. 2021. BIM maturity and implementation strategies: A review. *Journal of Cleaner Production* 287: 125146. https://doi.org/10.1016/j.jclepro.2020.125146

Yee, W. M., & Aouad, G. 2007. The uptake of building information modelling in the UK: Results from the 2007 RICS BIM conference survey. *Journal of Information Technology in Construction (ITcon):* 12, 338-345.

Yousaf, M., Sohail, M., Tayyab, M., Javedan, M., & Habib, M. 2024. Structural Design of RCC Building Using Integrated BIM-Based Design Workflow and Analysis Result Comparison between ETABS and RSAP. *Jurnal Kejuruteraan* 36(1): 211-221.

Zainon, N., & Vicky, L. 2021. Proposing BIM-related clauses in standard form of *Malaysian* construction contracts. *Malaysian Construction Research Journal (MCRJ):* 171.

Zhang, X., & Zhang, J. 2020. Optimization of construction cost management based on BIM technology. *Journal of Construction Engineering and Management* 146(8): 04020074.

Zhange, S., & Gao, M. 2019. Construction and Real Estate Education Curriculum Reform Based on BIM: Taking Legal System of Construction Contract Course as an Example. 192–198.