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Posted Date: 14 May 2024

doi: 10.20944/preprints202405.0941.v1

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A BIM Package with NEC4 Contract Option to Mitigate Construction Disputes in the Kingdom of Saudi Arabia

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Abstract: The construction sector of the Kingdom of Saudi Arabia (KSA), valued at USD 152 billion and employing 2.54 million people by 2023, is crucial to its economy. However, it faces challenges such as delays, disputes, and cost overruns. This study aims to address these issues by implementing Building Information Modeling (BIM) in the KSA, based on an extensive literature review highlighting the role and significance of BIM in mitigating construction claims. BIM improves collaboration, communication, and data integration among stakeholders. Hence, this study proposes a comprehensive BIM package framework comprising Revit Architecture, Microsoft Project, and Cost-X to reduce claims effectively. Validated through a KSA claims case study with a USD 1,870,000 claims value and 360-day delay, the BIM package significantly reduced the claims value to USD 188,000 and saved 275 days. Interview sessions were conducted to validate the effectiveness of the BIM package; 95% favored the use of BIM, 86% supported NEC4 contract adoption alongside BIM, 100% acknowledged BIM's potential in reducing design errors, 95% were confident in the case study's accuracy, and 82% were satisfied with data accuracy. This study confirms that BIM is an effective approach for minimizing construction claims in the KSA.

Keywords: building information modelling; Kingdom of Saudi Arabia; disputes; construction; contracts; NEC4; procurement

1. Introduction

With the advent of digital technologies, the construction sector has evolved from traditional, compartmentalized practices, resulting in enhanced efficiency, interoperability, and reliability [1]. Building Information Modeling (BIM) serves as a digital representation of the design and construction phases for complex structural projects [2]. In markets with high project volumes such as the Kingdom of Saudi Arabia (KSA), BIM offers real-time project execution visualization, design continuity, and streamlined structural delivery, benefiting clients and contractors alike through contractual compliance, reliability, and efficient project completion [3].

Despite its advantages, BIM has been underutilized in the KSA until recently, when it became mandatory in the construction sector starting in 2024. This technology holds significant promise for industries grappling with techno-structural disparities [4,5]. However, despite its availability, a noticeable increase in contractual claims and project disputes has been observed in recent years, adversely impacting the construction sector's performance and value allocation due to inter-industry conflicts [6–8].

Since 2019, the construction sector in the KSA has seen substantial growth, surpassing $137 billion in 2023, with forecasts projecting an average annual growth rate exceeding 4% over the next five years [9]. Despite industry-wide commitments to project reliability and contractual execution, more than 70% of completed projects have encountered time and cost overruns stemming from systemic shortcomings in budget forecasting, quantity surveying, cost estimation, and lifecycle planning [8,10,11]. Consequently, construction firms in the KSA are grappling with a rising number of claims and legal disputes due to contractual conflicts and client grievances [12–14]. The lack of mandatory BIM integration in the industry poses a threat to project efficiency, service continuity, and the long-term value and structural integrity of the KSA construction sector [3,8].

This research addresses the absence of BIM implementation in the construction industry of the KSA, which has led to challenges in claims management, communication, coordination, design accuracy, cost control, documentation, and risk management. It aims to bridge this technological and institutional gap by evaluating the potential advantages of BIM in contract enforcement and claim mitigation within the KSA construction sector. As the form of the contract plays a crucial role in every construction project, the NEC4 form of contract, developed by the Institution of Civil Engineers (ICE), serves to facilitate effective project management practices and foster collaboration among project stakeholders. In this regard, option A of this contract form will be integrated with the proposed BIM package to effectively handle construction claims.

1.1. Research Objectives

- Investigate the incidence of disputable claims within the KSA construction industry.
- Analyze the impact of claim mitigation in KSA construction using BIM technology.
- Validate the proposed framework for BIM-based claim mitigation in upcoming construction contracts.

2. Literature Review

2.1. Role of BIM in the Construction Industry

The intricacy, lack of reproducibility, and diverse stakeholders in construction projects result in varying standards of quality and control, leading to conflicting success predictors [15,16]. Addressing this, formal quality management systems measuring key performance indicators (KPIs) are proposed as practical solutions for real-time performance monitoring [17]. However, these systems lack integrated analytics to assess relationships between causal factors, determine fault or culpability in construction claims, or identify project delivery deviations [18,19]. Several western nations, including the UK and the USA, have embraced BIM, a digital blueprint modeling project delivery across its lifecycle, identifying performance measures, potential gaps, and faults or failures [20].

While BIM initially revolutionized construction projects through virtualization and visualization, the evolution of digital information and workflow resources has significantly impacted project efficiency and optimization [1]. BIM has evolved into a comprehensive lifecycle methodology, encompassing crucial aspects of design, data, digital representation, and documentation, effectively managing project information resources [3]. In the realm of design–bid–build (DBB) contracts, where numerous buildings are constructed, BIM offers interoperability, connecting diverse stakeholder groups to a unified digital tool ensuring continuity and real-time project delivery [2]. However, successful implementation of such systems hinges on coordinated digital connections linking contractors, clients, and key stakeholders across localized and distributed networks, facilitating real-time site, resource, and personnel management [21,22].

The incorporation of the BIM process involves creating a digital building prototype and seamlessly exchanging and integrating information. Consequently, establishing new roles and responsibilities directly tied to this process becomes imperative. As depicted in Figure 1, these additional roles should not replace traditional duties and obligations. For example, despite utilizing the BIM model for cost calculations, the presence of a cost estimation manager remains essential [22].

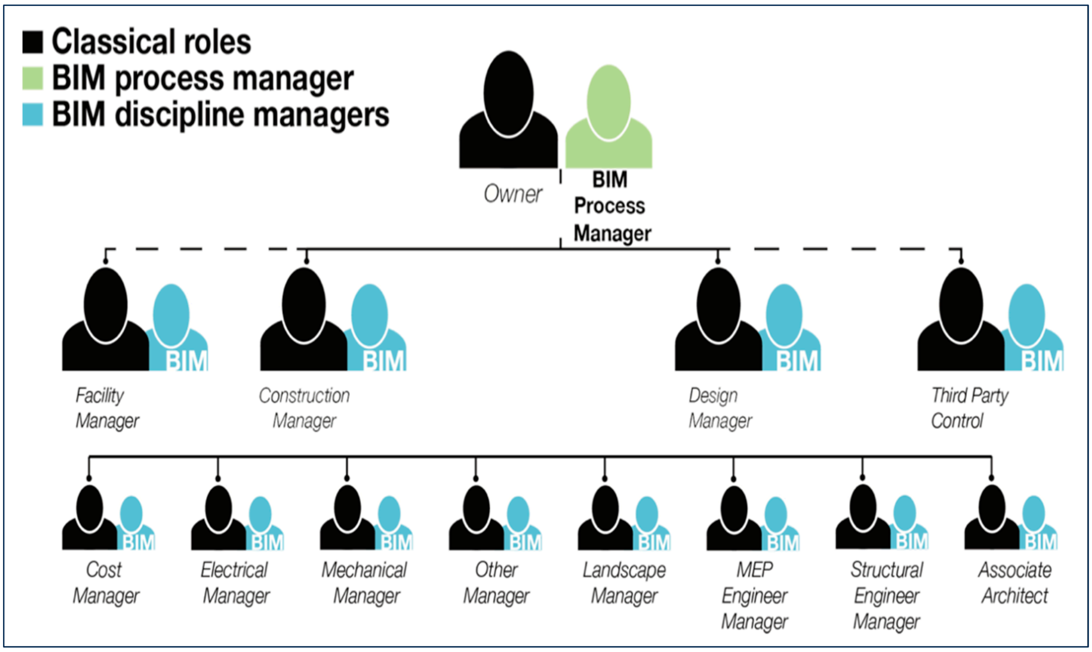

Figure 1. Shows the classic job of project management (black) supported by a BIM role (green and blue) [22].

2.2. BIM and Construction Claims Reduction in the KSA Industry

In their critical assessment of risks in Saudi Arabia's construction sector, Bajwa and Syed (2020) [13] identified factors affecting contractors and clients, such as delayed payments, design changes, and contractor incompetence. Although these issues directly affect project delivery, underlying deficiencies such as inaccurate material forecasts, time overruns in project stages, and a shortage of skilled staff also play a role. These factors can progressively disrupt project milestones, leading to delays, increased costs, and compromised quality upon completion [23,24]. Mahamid's research (2016, p.14) [25] categorizes variation disputes as "macro- and micro-level events" and outlines various causal pathways linking predicted project outcomes to actual results. Understanding the interplay between direct and indirect causal relationships is crucial for comprehending the impact of these discrepancies on claim filings and project disputes at various stages [25,26].

As described by Al Mousli and El-Sayegh (2016) [27] in the "design-construction interface," conflicts stemming from claims often arise due to inconsistencies in the early phases. Assaf et al. (2019) [6], state that most contract disputes in the KSA are attributed to discrepancies between design-build commitments and their execution effects, such as delays, material shortages, and cost overruns. In large-scale construction projects, the impact of both macro and micro-level factors tends to magnify over time, adversely affecting scheduling, resource allocation, and site management outcomes. To mitigate the cumulative effects of potential threats throughout the project lifecycle, the proposal of robust and reliable project administration through BIM not only correlates with favorable design-build outcomes but also acts as a strategic resource to alleviate disputes and claims arising from diverse expectations and conflicting priorities [14,20,21].

2.3. Impact of Construction Claims on Project Success in the KSA Industry

Despite the extensive construction activities in the KSA, a culture of competitive restraint and protectionism persists, rooted in tradition, limited technological infrastructure, and resistance to change. This culture hinders the transparency necessary to mitigate claims and contractual disputes [28,29]. Several factors, such as limited experience among clients and contractors, frequent changes to contract terms during the project lifecycle, and flaws in project design and execution, pose significant risks that undermine long-term performance [8,11]. Schedule delays resulting from inadequate planning, insufficient resources, or material deficiencies during construction have led to notable legal disputes, impacting project performance and industry collaboration [30,31].

Gopang et al. (2020) [7] examined over 36 factors contributing to project delays in large-scale infrastructure construction. They identified five main causes: design errors, labor performance, design changes, stakeholder conflicts, and control and decision-making conflicts. Considering the potential of BIM (refer to Abougamil et al. 2023, 2024), [14,32] a clear opportunity exists to address intra-project deficiencies and conflicts and reduce disputes through the tracing and documentation of digital events.

Claims in the KSA significantly contribute to procedural delays, reducing value for money and extending the delivery of crucial infrastructure projects such as schools, roads, and oil and gas facilities [33]. These claims often stem from uncertainties and ambiguities in project objectives, particularly concerning design factors. Alhammadi et al. (2024) [5] argue that proving such claims can be challenging and often results in inflated financial claims that impact downstream project stages. To address these challenges, the future of claims management hinges on organizational and project integration, particularly regarding multi-stakeholder participation in BIM-related systems that require interoperability and cross-network immutability, including change approval [34].

Despite BIM's decades-long use in the construction industry, its practical integration in KSA construction is still evolving and requires analysis and refinement. Ali et al. (2020) [35] proposed a BIM-based claims management system aiming to streamline the identification and processing of construction claims, resolving immediate issues and minimizing project delivery disruptions through transparent and reliable technologies. Although the model is not yet capable of addressing complex variables such as changes in materials quantities, the future application of real-time BIM models to claims reconciliation shows promise for efficient and transparent digitalization throughout the design–build–deliver process [35]. Despite foreign contractors in KSA employing their BIM-supported project management technologies, the lack of institutionalization and mandatory adoption at the regulatory level has led to conflicts regarding effectiveness and reliability [36].

2.4. Importance of BIM Package Application in Resolving Construction Claims

The importance of a BIM package in effectively implementing digital construction to resolve claims is widely acknowledged. BIM is based on generating and managing digital representations of the physical and functional characteristics of a construction project [14]. BIM software offers a digital portrayal of the system under construction, enhancing the accuracy of work analysis. This capability enables the visualization of the consequences of altering a component within an interconnected environment. In contrast to 2D drawings, where identifying task dependencies is challenging and clashes between designs surface only during physical installation, using 4D or 5D BIM introduces a third dimension or intelligent information attribute, enabling a comprehensive understanding of the intricate site layout. This approach maximizes the potential to preempt claims stemming from such issues [14].

Moreover, the operation of maintenance manuals can be simplified by utilizing the BIM model; it furnishes building owners with information regarding each asset's life expectancy, thereby reducing the risk of future claims related to defects [3]. Additionally, 5D BIM, incorporating cost data, empowers designers and quantity surveyors with a more comprehensive understanding of total construction costs and future running expenses. This helps prevent any unjustified claims inserted by contractors to maximize profits [14]. The advanced features of the BIM package enable early-stage project teams to readily identify conflicts and proactively resolve them in a virtual environment, thereby mitigating the necessity for costly changes and claims once the project is underway on-site.

2.5. Importance of NEC4 Contract Form Option C with BIM Package

The New Engineering Contracts family (NEC4) Option C incorporates explicit regulations for risk allocation aimed at assigning risks to the party that is most capable of handling them. This effectively reduces the uncertainty and conflicts related to accountability for unforeseen events or changes in project specifications [38]. BIM implementation supports risk assessment and

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management by promptly identifying potential conflicts, design discrepancies, and construction feasibility concerns during the early stages of a project. By proactively addressing these challenges, the likelihood of claims resulting from design flaws or coordination issues is significantly reduced [39]. Additionally, BIM enhances cost estimation and management by providing comprehensive quantity takeoffs, material schedules, and connected cost data, thereby improving the accuracy of cost predictions and mitigating conflicts related to cost overruns and unexpected expenses. In line with NEC contract option C, collaborative project management and frequent communication are emphasized through designated roles such as project managers and contractors. This approach promotes efficient collaboration and facilitates timely resolutions. BIM enhances project coordination by enabling the simultaneous collaboration among interdisciplinary teams on shared digital platforms. The integration of clash detection, 4D scheduling, and virtual walkthroughs enables the identification and resolution of conflicts, thus minimizing rework and potential claims. Furthermore, NEC contracts require comprehensive documentation, encompassing records of communications, decisions, and modifications [40]. This meticulous paperwork is an invaluable resource for resolving disputes and addressing claims. However, BIM provides a digital record of the project's progression, including design modifications, construction technology, and final construction details. The digital twin of BIM with the NEC contracts serves as a reliable repository of information for settling conflicts and demonstrating adherence to contractual obligations.

2.6. Proposed BIM Package Application in Resolving Construction Claims

To effectively support the project management team in implementing a BIM package, several steps were taken. First, as depicted in Figure 2, we meticulously chose the BIM software 'Revit Architecture' based on the project's nature, scale, and objectives, notably reducing construction claims [41]. Revit Architecture facilitates the enhancement of design from 2D to 3D and encompasses BIM LODs (levels of development) ranging from 100 to 300, primarily focusing on the concept and schematic design phases. Microsoft Project software (MS) was utilized to formulate the project program, detailing activities and required resources. Navisworks, in conjunction with MS, served as an additional tool for simulating project timelines and updating the schedule, specifically addressing LOD 400 requirements. Cost-X was also integrated into the package to manage project costs, covering LOD 500 aspects within BIM [14]. The selection committee comprised industry experts well-versed in BIM and its potential advantages.

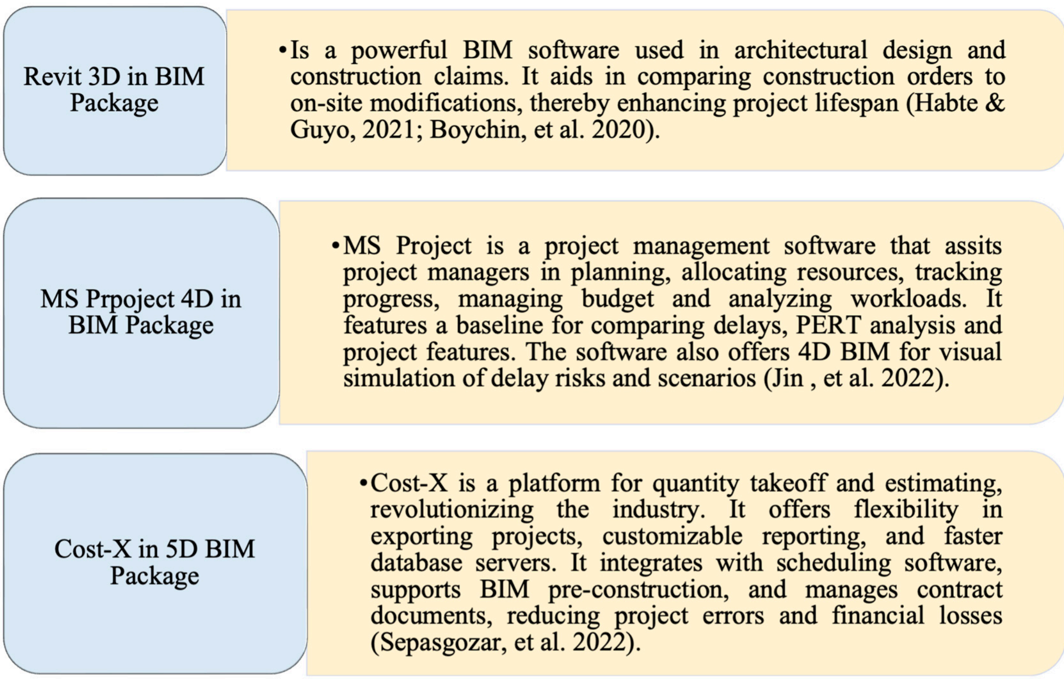

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Figure 2. BIM package software, including Revit, MS Project, and Cost-X.

2.7. Illustration of the Conceptual BIM Package in Reducing Potential Claims

In general, within the scope of BIM software application, the building lifecycle encompasses a series of stages, ranging from conceptualization to operation and maintenance. These stages entail active participation from multiple stakeholders throughout the entire process. Figure 3 illustrates the integration of BIM, which plays a pivotal role in enhancing collaboration, communication, and efficiency among stakeholders at each stage of the lifecycle [42]. In BIM collaboration, the architect could serve as the primary liaison in the traditional relationship between a client, designer, and contractor in a construction project. Alternatively, this role could be assumed by an impartial party working on behalf of the owner to ensure impartiality among stakeholders [42].

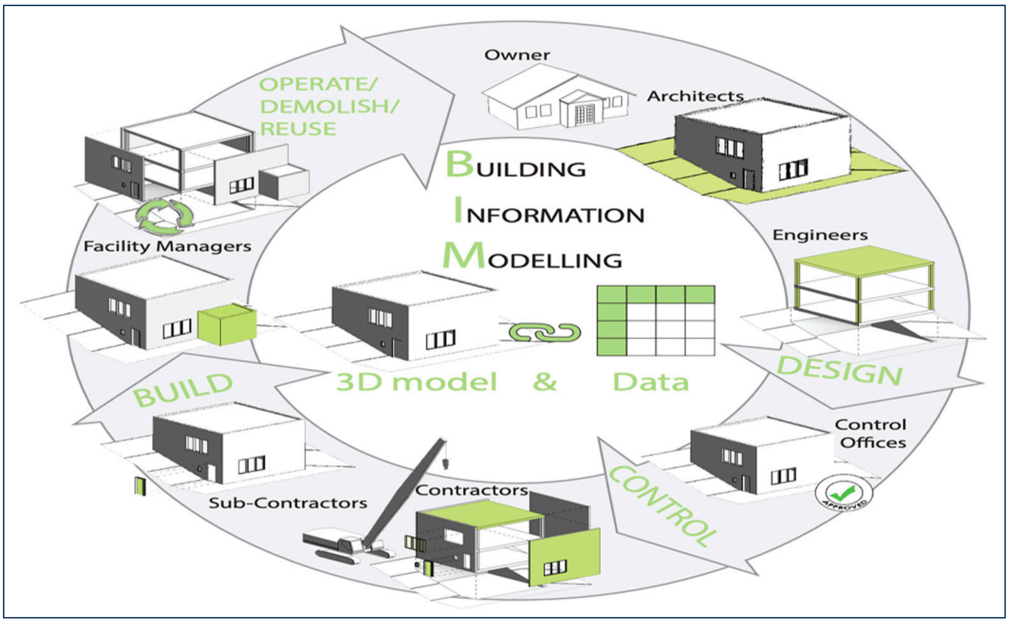

Figure 3. Illustrates the building's lifecycle and its stakeholders under BIM concept [42,44].

The conceptual BIM framework, as depicted in Figure 4 and comprising Revit, Microsoft Project, and Cost-X, was initially designed in a previously published article [32]. This framework will be elaborated upon in this section; the main aim of the framework is mitigating potential claims in construction projects, both during and after the construction phase. Upon acquiring the BIM package, the subsequent step involves creating a detailed project execution plan (PEP) specifically tailored for BIM [42]. The PEP includes criteria and a breakdown of BIM levels, as shown in Figure 5, to provide a more illustrative understanding of how to utilize the BIM package effectively. The LODs are clearly delineated in Figure 6 for various project stages, outlining roles and responsibilities for the project team from both the client and contractor's perspectives throughout the project lifecycle.

To elaborate on stage 1 in detail (refer to Figure 4), both BIM levels 1 and 2 must be implemented, as illustrated in Figure 5. The design and contract documents for the construction project should be prepared according to the proposed BIM package framework. Following the engineering, procurement, and construction (EPC) approach, the project owner has the authority to develop the design from the concept to a detailed level, including drawings, starting with LOD 100 representing the concept design and progressing to a detailed design (LOD 300), as shown in Figure 6. At this stage, the design drawings will be tendered to competitive contractors. The selected contractor will then take responsibility for further developing the design package received from the owner, progressing from LOD 400 to LOD 500, as also depicted in Figure 6. Importantly, both the owner and contractor must sign an ownership agreement governing the utilization of the BIM package from start to project completion, as also shown in Figure 6 [43].

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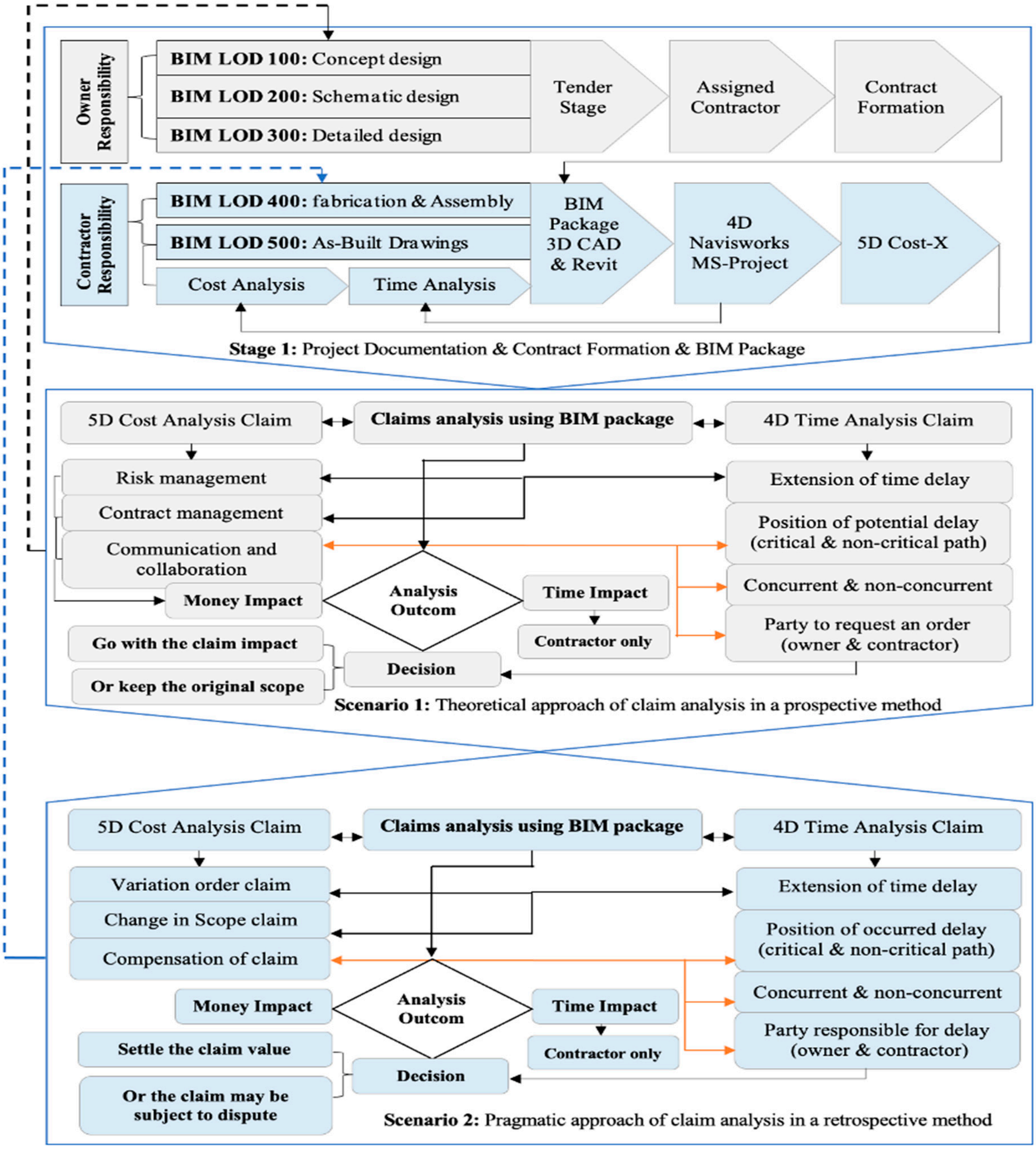

Figure 4. Proposed BIM package framework for reducing construction claims [32].

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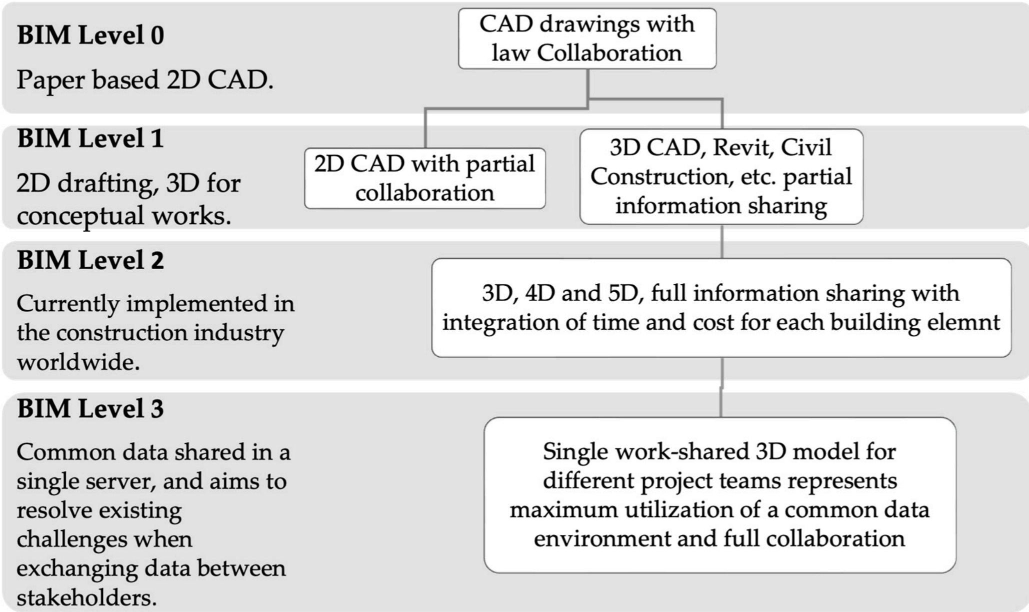

Figure 5. Breakdown of the BIM levels [32].

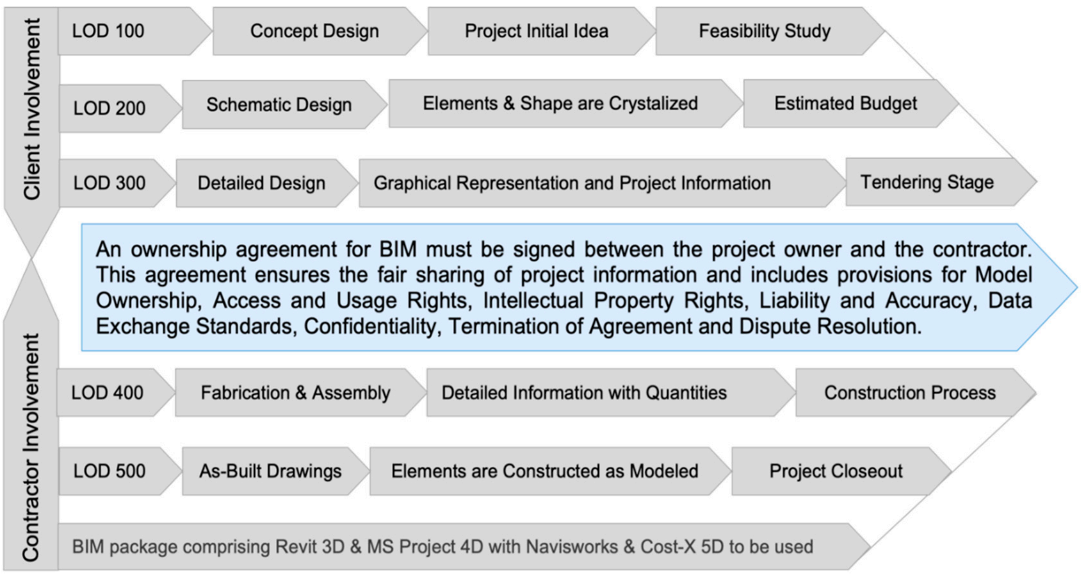

Figure 6. Level of development (LODs) of BIM with contribution from the Owner and Contractor.

2.8. Proposed Steps of Resolving Construction Claims Under the BIM Package

To systematically address claims using the BIM package, Figure 7 provides a visual representation of six sequential stages that can streamline the claims process and lead to the desired corrective measures. Detecting and resolving construction claims requires a methodical approach to identifying, analyzing, and resolving issues or disputes that arise during the project lifecycle. Effectively detecting and resolving construction claims involves several steps. Initially, potential claims can be identified through a thorough review of project documentation, contracts, and communication logs. This process aids in identifying areas where claims may emerge, such as delays, changes, disruptions, or quality issues. Furthermore, documenting all relevant events, activities, and communications related to potential claims, including change orders, delay notices, site condition reports, and meeting minutes is crucial. Maintaining a comprehensive record of project data, timelines, and milestones is vital for supporting claim analysis and resolution.

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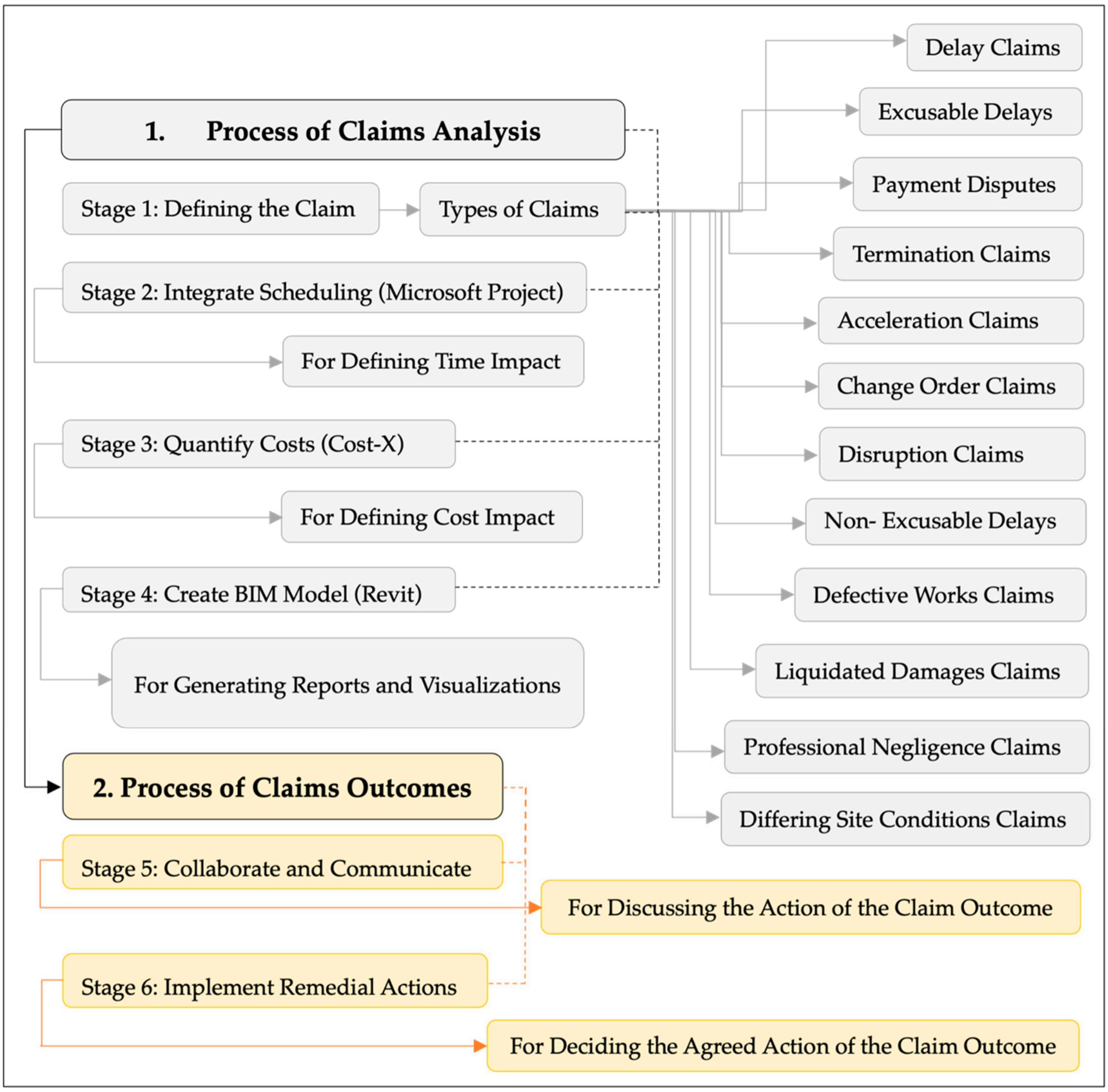

Figure 7. Schematic illustration of the steps of generating and analyzing claims as part of BIM Package: Source Authors.

To commence the practical implementation of BIM, a kickoff meeting must be conducted to ensure that all project members understand the objectives and goals of BIM implementation and the PEP. Attendance is mandatory for all team members utilizing BIM, including consultants and subcontractors. To equip the project team with the necessary knowledge and skills to effectively use BIM, training and support for the BIM package must be organized [32]. Training methods include workshops, online tutorials, and on-site training provided by software vendors. Additionally, learning sessions will be conducted to educate project members on the benefits of BIM, covering topics such as transitioning from 2D CAD platforms to 3D models, the interoperability of BIM software, and potential reductions in construction claims through BIM-generated outputs [44]. At biweekly intervals, internal project BIM meetings are to be held to assess important matters, including the establishment of BIM according to the PEP, collaborative work with shared models, and the quality of the BIM model for upcoming project stages. These checks are essential to ensure that the project complied with milestone targets in the PEP and fully realized the benefits of BIM.

3. Methodology

This study adopts a phenomenological approach and utilizes qualitative research methods. Phenomenological research delves into the original experiences of those involved in the study [45].

Tashakkori and Teddlie (1998) [46] along with Creswell and Clark (2017) [45] argue that using qualitative data and analyzing it aids in clarifying and explaining participants' opinions more precisely. Therefore, this study aims to gain a precise understanding of participants' perspectives on the use of BIM in the claims process. Consequently, qualitative methods are deemed more suitable for achieving the research objectives. The methodology for this study involves three steps, as depicted in Figure 8, with further explanation provided in the following points:

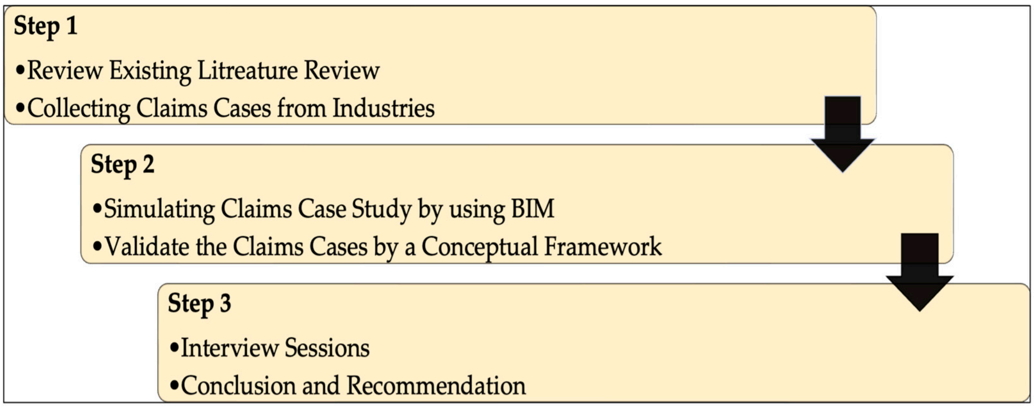

Figure 8. Research Methodology.

1. The literature review critically analyzes previous studies on BIM applications in construction. Additional similar studies are identified from the existing literature as shown in Table 1. The primary objective of the study is to identify gaps and areas where existing research lacks and pinpointing key factors contributing to construction claims.
2. Abougamil et al. (2024) [32], as the authors of this research, have proposed a BIM conceptual framework in a linked published study with the current research for reducing construction claims. The proposed framework is further developed, explained, and broken down in the current research as shown in Figures 4–7, which will be used in Section 4 as a case study to reduce construction claims. The question confronting researchers and modelers is not whether a model is realistic, but whether it is beneficial [47]. Therefore, to implement the developed BIM framework in Figures 4, 6 and 7, a real claims case has been selected and analyzed from an actual project chosen from the author's experience and modeled with the involvement of BIM in the project contract. Essential articles from the signed contract in the project case study are highlighted in Table 6 to reflect the bespoke contract conditions with limited provisions. The articles are translated into quantifiable rules and verified against contract BIM outputs.
3. Surveying interviews will be considered to validate the case study simulation. Subsequently, the last stage of the applied methodology is to conclude the research outcomes with future recommendations.

Table 1. Similar studies from existing literature related to BIM application aimed to reduce construction claims.

Paper Topic	Objectives of the study	References
A BIM-based construction claims management model for the early identification and visualization of claims.	Present a claim management framework that uses BIM models to visualize claims.	[37]
BIM-based claims management system: A centralized information repository (T) for extension of time claims.	Determine feasibility of using BIM to feed an expert claim management system.	[35]

Claims and dispute resolution using BIM technology and VDC process in construction contract risk analysis.	Build a BIM-based EOT claims management system is the primary objective.	[48]
BIM-based framework to quantify delays and cost overruns due to changes in construction projects.	Suggest a BIM strategy is to proactively manage conflict causes prior to the onset of a disagreement.	[49]
Building information modelling in construction conflict management.	Minimize claims, conflicts, and legal actions throughout the construction phase.	[50]
Dispute resolution: can BIM help overcome barriers?	Examine the advantages of utilizing a BIM model for claims and dispute settlement.	[51]
Integrating BIM in construction dispute resolution: development of a contractual framework.	Evaluate, categorize, and determine the legal effects of BIM in construction dispute resolution and its contractual implications.	[52]
Potential application of BIM in construction, disputes, and conflict.	Define the maturity stages of BIM to denote the components and advantages of BIM.	[40]
A conceptual framework for developing a BIM- enabled claim management system	Investigate the viability of utilizing BIM to supply expert systems for claim management with input data.	[53]
Investigating the source of claims with the importance of BIM application on reducing construction disputable claims in KSA	Examine the construction disputes in the KSA with BIM software to reduce claims.	[14]
An investigation of BIM advantages in analyzing claims procedures related to the extension of time and money in the KSA construction industry	Compare standard claims management methods to a BIM suite for building disputes in the KSA industry.	[32]

For the field survey, the authors first obtained ethical approval from the University of Southern Queensland (USQ HREC ID: H22REA273) for the interview sessions, which 22 experts participated in semi-structured interviews to assess identified issues and propose additional significant factors. This phenomenological study involved experts with practical experience to explore the challenges they encounter. The sample size adhered to qualitative research method requirements for phenomenological interviews, typically ranging between 5 and 25 [45]. The expert interviews concluded upon reaching saturation, signifying that new information or data could no longer add value [46]. A diverse group of experts was intentionally selected from contracting and engineering backgrounds, with substantial experience in handling construction delays in both local and international projects. The profiles of the interviewees are presented in Table 2. Table 3 outlines the designed questions for participants regarding factors influencing traditional practices in the absence of BIM when using conventional contracts in construction projects. Some questions in Table 3 aim to validate the proposed BIM Package's effectiveness in reducing construction claims, particularly related to the real-claims case study presented in this research.

Table 2. Profile of participants that participated in the field survey interviews.

Group	Position	No of Participants	Years of Experiences	No of Participated Projects
Contracting	Project manager	8	11-25	5-12
	Contract manager	7	10-35	7-20
Consultancy	Project manager	3	12-20	8-12
	Claims manager	4	16-25	10-13

Table 3. Questions asked to the participants during the interviews.

NO	Hypothetical questions for participants from the relevant construction projects
1	Do you agree to use such a proposed BIM Package to analyze the selected actual project claims case in this study?
2	Do you agree to use such a selected standard form of contract (NEC4) with BIM Package instead of a bespoke contract?
3	Do you struggle to manage and mitigate risks without BIM's real-time simulation, analysis, and scenario planning?
4	How difficult is it to estimate change order and variation costs without the use of BIM technology?
5	How does the lack of clash detection and coordination technologies affect construction claims from clashes, conflicts, and interferences?
6	Why do data inaccuracy and documentation issues in the project scope lead to contractual disputes?
7	How can delayed information sharing and decision-making affect project timelines, costs, and claims?
8	How does BIM reduce design-related claims and conflicts compared to traditional project visualization and planning?
9	Do you agree with the accuracy of the results of the presented case study, which were based on the proposed BIM Package?
10	In light of the extracted outcomes from the case study, at which level are you confident about the data accuracy?

4. Claims Case Study from the KSA Construction Industry

This claims case study originates from a construction project in Jeddah City, Saudi Arabia, with key details listed in Table 4. The corresponding author of this research served as a consultant site manager in the selected project during its construction phase. The project owner chose a medium-sized company as the principal contractor. The principal contractor's responsibility was to construct and deliver the project as a turnkey mechanism, ensuring its readiness for operation. Specialized subcontractors were engaged under the principal contractor's scope of work for the electromechanical systems, aluminum cladding and glass for the facade, elevators, and finishing materials.

Table 4. Information of a real project case study from the KSA construction industry.

No	Item Description	Project Details
1	Project Type	Commercial Building 6 Multi-Storey
2	Building's Area	12,500 m^2
3	Original Agreed Budget	$8,5 Million USD
4	Actual Spent Cost	$12 Million USD
5	Planned Time	365 Days
6	Actual Spent Time	725 Days
7	Contract Type Used	Traditional Bespoke Form

The project encountered several claims cases that impacted both its cost and timeline significantly. The first claim arose due to contractor error during the excavation of the basement, specifically improper digging of sheet piles used for shoring. This faulty methodology led to the wall diaphragm's failure, extending the project deadline by 60 days beyond the agreed timeline.

The second claim stemmed from a variation order raised by the contractor due to discrepancies in the original drawings provided by the owner. The contractor submitted a claim to the project consultant, seeking additional cost and 70 extra days. The basis for this claim was that certain items were not included in the initial drawings, resulting in increased square meter costs. However, the submitted variation order claim was rejected due to the absence of grounds as stipulated in the

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contract. The owner maintained that the project's cost was based on a fixed price per square meter (USD 680), agreed upon regardless of the level of detailed design later submitted to the contractor.

Project progress slowed during negotiations between the conflicting parties and eventually halted due to the rejected variation order claim by the contractor. Subsequently, the owner unilaterally terminated the contract and completed the project independently, finishing within 360 days after the original deadline. The owner then raised a claim for liquidated damages due to significant delays and loss of expected income. In response, the contractor raised counterclaims for variations, operational costs, and losses incurred from the contract termination. Table 5 outlines the claims descriptions and values from both the owner and contractor, ultimately resolved through mediation with an outcome unfavorable to both parties.

Table 5. An overview of the project claims.

No.	Claim item	Claimant	Value
1	Liquidated damages claim due to delays	Owner	USD 120,000
2	Losses of expected income due to delays	Owner	USD 250,000
3	Variation order claim due to missing items in design	Contractor	USD 600,000
4	Operation cost claim due to contract termination	Contractor	USD 900,000
5	Total claims value raised from both the owner and contractor against each other	Owner and Contractor	USD 1,870,000

The bespoke agreement signed between the owner and the contractor includes crucial provisions governing the project's time and cost, as outlined in Table 6. Quoting three essential articles from the bespoke contract used in the actual project aims to highlight the disparities between the real events that caused disputes between the contracting parties and the contractual stipulations.

Table 6. The essential articles written in the bespoke contract used in the project case study.

Clauses	Clause Description from the contract agreement
Clause 10	The project must be completed within the agreed-upon timeframe stated in the contract. In the event of a delay, the owner will receive compensation of USD 500 per day, with a maximum of 10% of the contract value, if the delays exceed 60 days.
Clause 12	The project is priced as a lump sum based on the square meter rate and must be completed within the agreed-upon budget. The contractor will not receive compensation for extra costs unless the owner requests additional work.
Clause 13	The contractor is required to construct all project activities in full compliance with the agreed-upon specifications in the contract. In addition, both parties have verbally agreed that the doors supplied by the contractor must be the same as those used by "Krispy Kreme Doughnuts" Company.

4.1. Simulating and Solving the Claims Cases Study by Implementing BIM Package

In this study, the conceptual BIM framework is employed to address the real claims case study and reduce construction claims. The input of the framework involves project documents such as drawings and specifications, which are transferred from CAD 2D to 3D using Revit Architecture (Figures 9 and 10).

The project timeline is managed using MS Project, incorporating key activities outlined in Figure 11. In simulating the real claims cases, the authors recommend the use of the New Engineering Contracts (NEC 4) option A, which is price-based with an activity schedule, alongside the BIM package. The choice of NEC 4 option A is justified by the fact that the project case study was fixed-price based, aligning with the approach of this research. However, it is important to note that the bespoke contract utilized in the actual project case lacked significant provisions found in the NEC standard form of contract, including risk-sharing, defined roles and responsibilities, transparency, and mechanisms for dispute resolution.

Moreover, Mohammed, T (2021) [38] highlights the compatibility of NEC4 with BIM, with BIM compliance specialists showing a preference for it over other contracts. Notably, NEC 4 incorporates Option X10: "Information Modelling and Collaboration," enabling the Contractor to implement a BIM Execution Plan [34]. This provision promotes efficient BIM utilization and holds potential for providing substantial support in project management and execution.

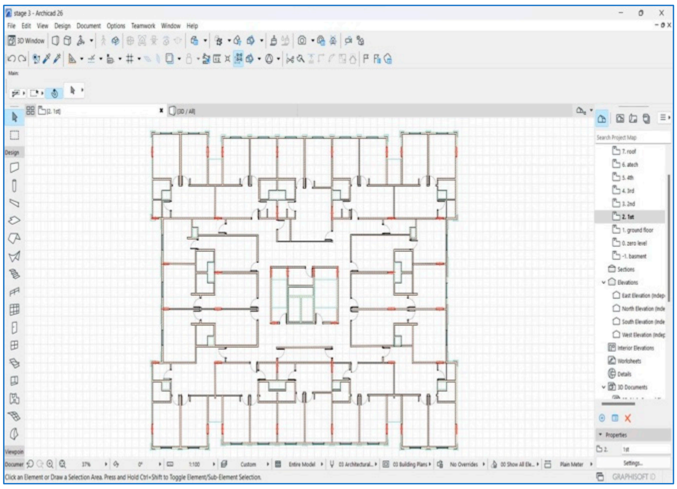

Figure 9. 2D floor layout Revit Architecture.

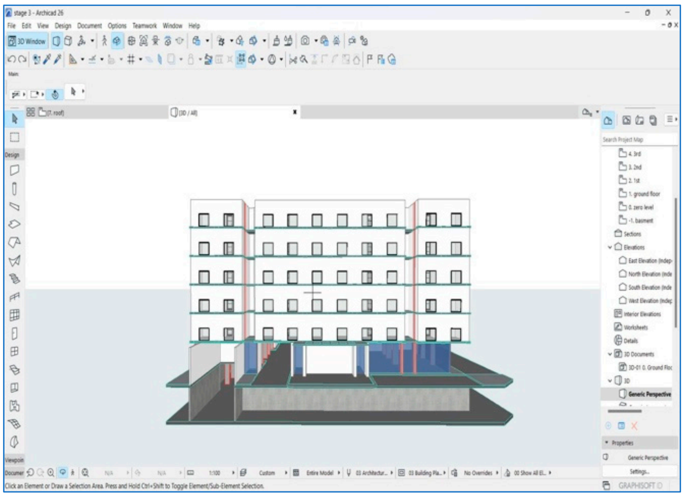

Figure 10. 3D digital model using Revit Architecture.

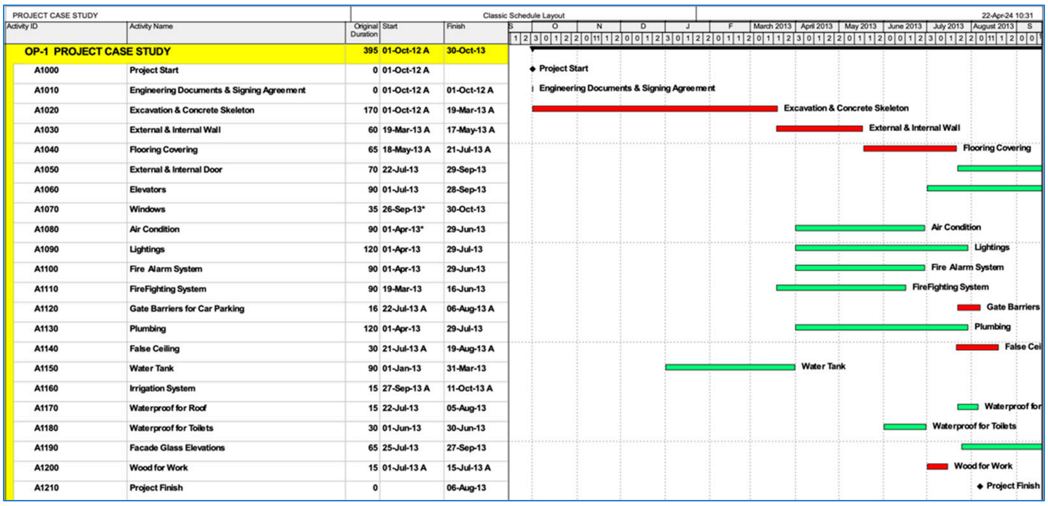

Figure 11. Project timeline generated by MS Project involved in the BIM Package.

The aim is to accurately identify the missing items in the project scope, which should have been properly accounted for during the contract stage, and to determine the suitable contract format to minimize potential claims. The subsequent steps outline the appropriate procedure, including the use of the BIM Package, detailing how the project is prepared, how claims are identified along with their respective values, and the potential for reducing each claim through both prospective and retrospective analyses.

Stage 1: What was Missing?

- Stage 1 of this case study involves identifying the missing elements in the original drawings of the selected project. To simulate this, the original 2D CAD drawings, w hichconverted into a 3D digital model using Revit Architecture, depicted in Figures 9 and 10. This conversion ensures that all included items are visually represented in the model. Subsequently, the project activities outlined in the original drawings are detailed using MS Project, establishing the project baseline as illustrated in Figure 11. Furthermore, Table 7 provides a breakdown of the project budget, delineating the cost and time allocated for each item. The data in Table 7 is derived from MS Project (Figure 11) and Cost-X (Figure 12a,b), tailored to suit NEC 4 Option A with an activity schedule.

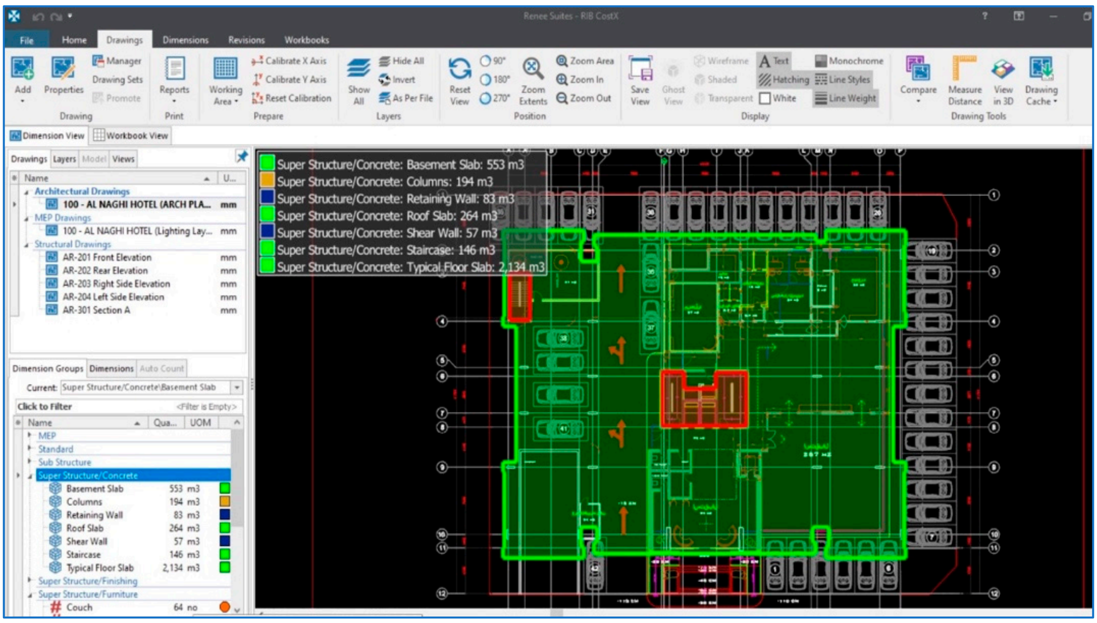

Figure 12. (a) Generating the project budget from the original drawings using Cost-X.

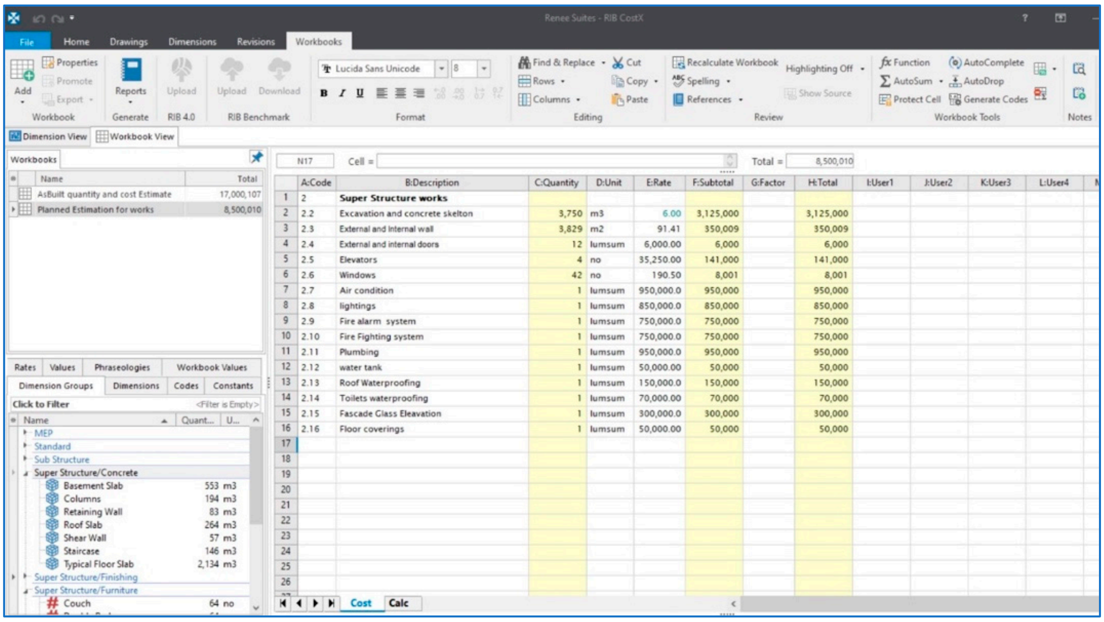

Figure 12. (b) Automated cost report generated from Cost-X based on the original drawings.

Table 7. Planned schdeule with cost sheet developed from Cost-X report for the project budget.

No	Activity Name	Baseline Duration		Activity	Activity	Activity	Activity
		Start Date	Finish Date	Time	Unit	Quantity	Cost
1	Total Project time	01-10-2012	01-10-2013	365	M^2	12500	$ 8.5 Million
2	Planned Schedule & Activities Breakdown that Generated from Cost-X based on Figures 13 and 13.1						
2.1	Engineering & signing agreement	01-10-2012	01-10-2012	0	Lump sum	0	0
2.2	Excavation & Concrete skeleton	01-10-2012	01-04-2013	180	Lump sum	1	$ 3,125,000
2.3	External & Internal Walls	01-04-2013	01-06-2013	60	Lump sum	1	$ 350,000
2.4	External & Internal Doors	10-08-2013	01-10-2013	50	No	12	$ 6,000
2.5	Elevators	01-07-2013	01-10-2013	90	No	4	$ 141,000
2.6	Windows	25-08-2013	01-10-2013	35	No	42	$ 8000
2.7	Air Condition	01-04-2013	01-10-2013	120	Lump sum	1	$ 950,000
2.8	Lightings	01-04-2013	01-10-2013	120	Lump sum	1	$ 850,000
2.9	Fire alarm system	01-04-2013	01-10-2013	120	Lump sum	1	$ 750,000
2.10	Firefighting system	01-04-2013	01-10-2013	120	Lump sum	1	$ 750,000
2.11	Plumbing	01-04-2013	01-10-2013	120	Lump sum	1	$ 950,000
2.12	Water Tanks	01-01-2013	01-02-2013	60	Lump sum	1	$ 50,000
2.13	Waterproof for roof	01-09-2013	01-10-2013	30	Lump sum	1	$ 150,000
2.14	Waterproof for toilets	01-06-2013	01-07-2013	30	Lump sum	1	$ 70,000
2.15	Façade glass elevations	25-07-2013	01-10-2013	65	Lump sum	1	$ 300,000
2.16	Flooring Covering	10-08-2023	01-10-2013	50	Lump sum	1	$ 50,000

Stage 2: What has Been Improved?

- In Stage 2, following the contract agreement, the original 3D model undergoes enhancements derived from the Issued for Construction (IFC) drawings provided by the contractor and subcontractors. This process reveals discrepancies between the original and the shop drawings, highlighting any missing items. The revised outcomes obtained from the updated 3D model,

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facilitated by the BIM Package utilizing Revit, MS Project, and Cost-X, are illustrated in Figure 12b and detailed in Table 8.

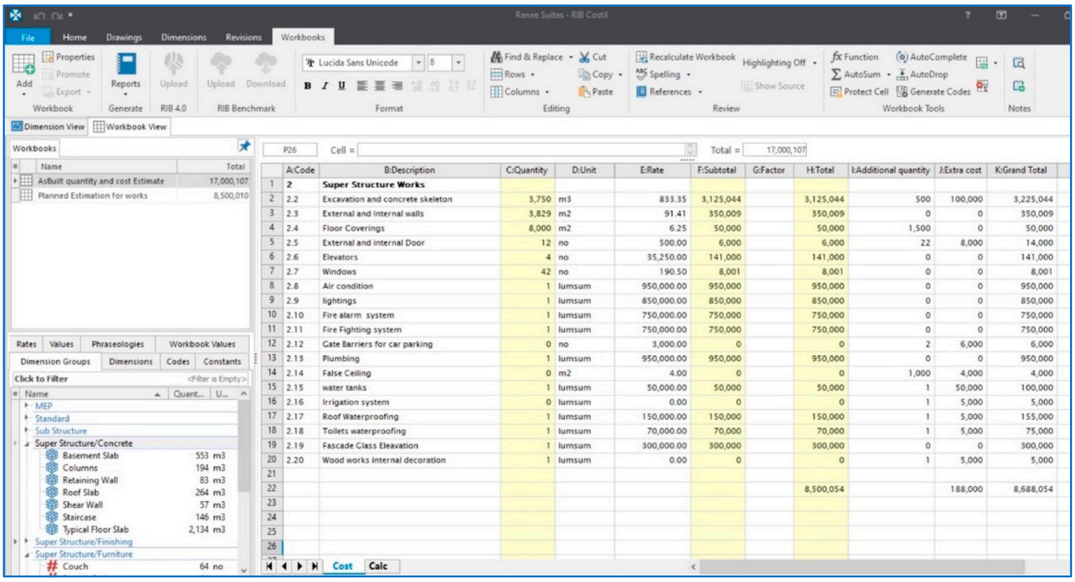

Figure 12. (c) Modified cost report generated using Cost-X based on the detailed drawings.

Table 8. As-built schedule including missing items in the affected project, along with time and cost claims.

No	Activity Name	Baseline Duration		Original	Additional	Original	Additional	Original	Extra
		Start Date	Finish Date	time	Time	Quantity	Quantity	Cost	Cost
1	Total Project time	01-10-2012	01-08-2014	365	360	--		$ 8.5 Million	188,000
2	As-Built Schedule & Activities Time and Cost Breakdown that Generated from Cost-X based on Figure 13.2								
2.1	Engineering & agreement	01-10-2012	01-10-2012	0	0	0	0	0	0
2.2	Excavation & Concrete skeleton	01-10-2012	01-08-2014	180	60	3750 m^3	500 m^3	3,125,000	100,000
2.3	External & Internal Walls	01-04-2013	01-08-2014	60	0	0	0	350,000	0
2.4	Flooring Covering	01-03-2014	01-06-2014	50	40	8000 m^2	1500 m^2		
2.5	External & Internal Doors	10-08-2013	01-10-2013	50	20	12	22 No	6,000	8,000
2.6	Elevators	01-07-2013	01-10-2013	90	0	4	0	0	0
2.7	Windows	25-08-2013	01-10-2013	35	0	0	0	0	0
2.8	Air Condition	01-04-2013	01-08-2014	120	0	0	0	950,000	0
2.9	Lightings	01-04-2013	01-08-2014	120	0	0	0	850,000	0
2.10	Fire alarm system	01-04-2013	01-08-2014	120	0	0	0	750,000	0
2.11	Firefighting system	01-04-2013	01-08-2014	120	0	0	0	750,000	0
2.12	Gate barriers for cars parking	01-07-2014	01-08-2014	0	30	0	2 No	0	6,000
2.13	Plumbing	01-04-2013	01-08-2014	120	0	0	0	950,000	0
2.14	False ceiling	20-04-2014	01-07-2014	0	70	0	1000 m^2	0	4,000
2.15	Water Tanks	01-01-2013	01-02-2013	60	30	1	1	50,000	50,000
2.16	Irrigation System	01-05-2014	01-06-2014	0	30	0	LS	0	5,000
2.17	Waterproof for roof	15-01-2014	30-01-2014	0	15	0	LS	0	5,000
2.18	Waterproof for toilets	30-04-2014	30-05-2014	0	30	0	LS	0	5,000
2.19	Façade glass elevations	25-07-2013	01-08-2014	65	0	0	0	350,000	0
2.20	Wood works for internal decoration	25-06-2014	01-08-2014	0	35	0	LS	0	5,000

Stage 3: Mitigating the Factual Claims Value by Prospective Analysis Retrospectively

After defining and analyzing the claims cases in the case study, we determined that the value of the claims was $188,000 with an additional time of 360 days. However, notably these claims are necessary for the project, as they involve missing elements from the original design, irrespective of the detailed design. Therefore, the main focus should be on reassessing the time required to reduce the additional time to the extent possible. To achieve this, activities missing from the original drawings were incorporated into the project baseline schedule, which was analyzed and updated both prospectively and retrospectively. The reanalyzed time schedule reduced the total project time from 725 days, as shown in Table 8, to 450 days, saving 275 days.

4.2. Conducting Interview Sessions to Validate the BIM Package Used in the Case Study

After conducting a real claims case study, the results and discussion section present and explain the examination outcomes. Additionally, the authors first obtained ethical approval from the University of Southern Queensland (USQ HREC ID: H22REA273) and held interview sessions with 22 experts from the KSA industry, including those directly involved in the project. The experts were asked to express their opinions based on the questions presented in Table 3, which were designed in the methodology section. The participants' responses are presented in Table 9.

Table 9. the participants' responses from the interview sessions conducted by the researchers.

No	**Questions brief from Table 3 that slightly modified to fit explanations with yes or no answers as well.**	**Contracting**		**Consultancy**		**Percentage of the Responses**	
		15		**7**		**%**	**%**
		Agree	**Disagree**	**Agree**	**Disagree**	**Agree**	**Disagree**
1	Do you agree to use such a proposed BIM Package in this case study?	14	1	7	0	95%	5%
2	Do you agree to use such a selected standard form of contract (NEC4) with BIM Package?	13	2	6	1	86%	14%
3	Do you struggle to manage and mitigate risks without BIM's real-time simulation, analysis, and scenario planning?	12	3	7	0	86%	14%
4	Is it difficult to estimate change order and variation costs without the use BIM technology?	10	5	6	1	73%	27%
5	Is the lack of clash detection and coordination technologies affect construction claims?	10	5	5	2	68%	32%
6	Why do limited data accuracy and documentation issues in the project scope might lead to contractual disputes?	A typical answer given in the following section		A typical answer given in the following section		68%	--
7	How can delayed information sharing and decision-making affect project timelines, costs, and claims?	A typical answer given in the following section		A typical answer given in the following section		75%	--
8	Does BIM reduce errors in design-related claims and conflicts?	15	0	7	0	100%	0%
9	Do you agree with the accuracy of the results of the presented case study, which were based on the proposed BIM Package?	14	1	7	0	95%	5%

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10	In light of the extracted outcomes from the case study, at which level are you confident about the data accuracy?	13	2	5	2	82%	18%

To present a segment of the interview responses and initiate discussion, Table 10 offers explanations derived from the respondents' answers during the interview sessions. These answers encompass various reasons for the observed outcomes.

Table 10. shows typical Answers from the participants opinions in the interview's sessions.

No of Respondents	Q6: Why do limited data accuracy and documentation issues in the project scope might lead to contractual disputes?
15	

- Similar answers to question 6 were provided by 15 participants, are summarized in this table as follows:
  1. Ambiguity in defining the scope of a project can arise due to inaccurate or incomplete data. When the scope is poorly defined or not adequately documented, disputes may occur concerning the inclusion or exclusion of certain activities within the contract. This lack of clarity can lead to disagreements between the involved parties regarding their respective responsibilities and obligations.
  2. Scope creep: Limited data accuracy in scope definition can result in scope creep, where changes or additions to the project scope occur during the execution phase, leading to disputes over whether these changes are within the original scope of work stated in the contract. Parties may argue about the necessity for extra costs or extensions of time due to scope changes that were not adequately documented in the contract.
  3. Non-conformance issues arise when documentation is inaccurate or insufficient, leading to the delivered work not meeting the specified requirements or quality standards outlined in the contract. Consequently, disputes may occur regarding work acceptance, necessitating remedial actions and potentially giving rise to claims for damages or rework costs.

No of Respondents	Q7: How can delayed information sharing and decision-making affect project timelines, costs, and claims?
16	

- Similar answers to question 7 were provided by 16 participants, are summarized in this table as follows:

  A typical answer from time perspective includes:
  1. Delays in Project Progress: When there are delays in obtaining essential information for project advancement, such as design approvals, material selections, or permit acquisition, it can directly impact the project schedule. This scenario can lead to contractors and subcontractors being unable to proceed with their work, resulting in overall project delays.
  2. Sequential Dependencies: A significant number of tasks in construction projects rely on preceding activities. If decisions or information pertinent to a specific task are delayed, it can trigger a chain reaction, leading to delays in subsequent tasks and ultimately prolonging the project timeline.

  A typical answer from cost perspective includes:
  1. Delayed information sharing can result in idle resources, such as labour and equipment, awaiting directives. Idle resources accrue costs without advancing the project, thereby increasing overall project expenses.
  2. Furthermore, delays in decision-making regarding design alterations may necessitate rework or corrections to previously completed tasks to meet updated specifications. This rework contributes additional costs in the form of materials, labour, and time, all of which further inflate project expenditures.

  A typical answer from claims perspective includes:
  1. Contractors and subcontractors have the right to submit claims for additional compensation as a result of delays arising from delayed information sharing and decision-making. These

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	claims may involve expenses incurred due to prolonged overhead, increased labor costs, and additional project management expenses.
2.	Delays can result in disruptions to work sequences and productivity, leading to claims for the loss of productivity and efficiency. Contractors may assert that the delays hindered their ability to work effectively, thereby causing increased costs and diminished profitability.

5. Results and Discussion

The present study, along with two related studies by Abougamil et al. (2023, 2024), [14,32] delves into understanding the origins of claims both generally and specifically within Saudi Arabia. The aim is to mitigate contentious claims in construction projects. It has been revealed that common sources of recurring claims include design errors, inadequate contract documentation, and poor communication among involved parties. Notably, the prevalence of traditional contracts, particularly in the private sector, rather than standardized forms such as NEC and FIDIC, contributes to conflicts and disputes during projects. Therefore, to enhance the construction process, particularly during the construction stage, this study suggests implementing the BIM package to generate electronically shareable project documents among stakeholders. To achieve this, this study initially delved into the significance of BIM in existing literature and proposed a comprehensive framework for its utilization. Furthermore, an in-depth analysis of a project case study, representing primary data, was conducted to provide detailed insights, as outlined in the following section.

The primary data collected from the industry regarding the claims case study reveals that both the owner and contractor raised total claims against each other, totaling USD 1,870,000. Notably, the contract agreement lacked specific provisions for handling claims, except for clause 10 ("Delays Penalty") as mentioned in Table 6.

To address the claims case study effectively, the authors customized the project case by selecting the NEC4 form of contract Option A with an activity schedule. This selection closely aligns with the project case and the specific contract signed, considering the available drawings and specifications. The authors allocated a project budget value of USD 8,500,000 and a timeline of 365 days to the corresponding activities mentioned in the original drawings, as outlined in Table 7.

The subsequent step involved modifying the customized data in Table 7. The authors developed the 3D model using the BIM Package, encompassing all the missing items depicted in the IFC drawings. At this stage, the project had already experienced a delay of 360 days. Therefore, significant attention was given to scrutinizing the fair value of claims, leading to the determination that the appropriate direct claims value amounted to USD 188,000, as shown in Table 8.

To address the 360-day delay identified by the parties involved, the baseline time of the project needs adjustment. Originally set at 365 days based on the initial drawings, the discovery of missing items necessitated a reevaluation and reduction of the anticipated delay. This retrospective analysis empowers the contractor or project manager to revise the deadline with the benefit of hindsight. The authors were theoretically able to reduce the total expected time from 725 days to 450 days, achieving a significant saving of 275 days. This strategy aligns with our research goal of mitigating potential delays that could lead to time and cost claims.

In validating the proposed BIM package, the authors conducted interview sessions with 22 experts from the contracting and consulting industries, including professionals from the project case study. These experts were queried based on their experiences in the KSA construction industry. The interview results indicated that 95% of the experts favored selecting the BIM package, while 86% preferred pairing it with the NEC4 Option A contract form to reduce construction claims. Moreover, among the interviewed experts, 86% expressed challenges in managing and mitigating risks without resilient construction technologies, such as BIM. A majority (73%) believed that estimating change orders could be difficult without BIM technology. However, all participants, including those involved in the project case study, agreed that BIM can reduce design errors related to claims and conflicts. Significantly, 95% of the experts were satisfied with the accuracy of the case study outcomes, and 82% were confident about the accuracy of the claims analysis. Only 18% expressed doubts about the data's confidence level.

The participants further articulated their viewpoints in Table 10, emphasizing the limited data's role from the outset. Inadequate data can potentially lead to scope creep, a phenomenon witnessed in the project case study. Furthermore, delayed information sharing emerged as a significant factor contributing to claims and overall project cost escalation.

6. Conclusion

This study initially explored the impact of BIM on the construction industry as a whole and specifically in the Kingdom of Saudi Arabia (KSA) with the aim of reducing construction claims and disputes. Despite being a crucial contributor to the country's development and revenue, the construction sector in KSA faces challenges due to the absence of advanced technologies, such as BIM, CDM regulations, a skilled workforce, and unified quality standards. Although the Saudi Code of Buildings has been recently introduced, its adoption among practitioners remains limited. Although KSA is continuously enhancing its local laws governing the construction sector, it lacks specific construction regulations comparable to the Housing Grants, Construction, and Regeneration Acts 1996 in the UK system.

As per the Engineering Council in KSA, Building Information Modeling (BIM) is mandatory in the construction sector from January 1, 2024. However, the mandatory adoption of BIM initially focuses on the design phase and the issuance of site permits. It is anticipated that the phased implementation of BIM in KSA will eventually encourage construction organizations to integrate BIM into the construction stage as well. In contrast, the mandatory implementation of BIM has been in effect in the United Kingdom since 2016, contributing to conflict mitigation, claim reduction, and dispute resolution within the construction sector. Therefore, the objectives of this research align with and support the recent announcement of mandatory BIM implementation in KSA, a demand echoed in the industry since its inception in the UK.

The study also introduces the BIM Package as a potential strategy for reducing construction claims within the KSA industry. This package includes the utilization of Revit Architectural in 3D dimensions to create comprehensive 3D models. Additionally, it involves integrating MS Project in 4D dimensions for efficient project scheduling and using Cost-X in 5D dimensions to produce precise cost estimates. Moreover, the research delves into the significance of BIM levels of development (LODs), highlighting the client's involvement with LODs 100 to 300 and the contractor's involvement with LODs 400 and 500, as depicted in Figures 5 and 6.

Establishing a well-defined project scope from the beginning, following the EPC route, is crucial. This process starts with the client meticulously preparing the project from the conceptual stage to the detailed design stage, aligning with LODs 100 to 300. Subsequently, the client hands over this groundwork to the contractor. The contractor then uses this foundation to refine the design and create accurate production drawings (IFC), seeking approval from either the client or the engineer representing them. Finally, the contractor develops the as-built drawings during the project's final stages, adhering to LODs 400 and 500.

To put the BIM package developed by this research into practical use, the authors have chosen a claims case study from an actual commercial project within the KSA industry. The project faced total claims amounting to USD 1,870,000, raised by both the owner and contractor against each other. Using the BIM package, the authors simulated the project case study and theoretically realigned the project scope, as demonstrated in Table 7, which ideally should have been well-prepared from the project's inception. Subsequently, the authors enhanced the original project data to analyze these claims, reducing the value from USD 1,870,000 to USD 188,000, as shown in Table 8. This revised amount reflects the value of claims considering the contractor's entitlement due to missing items in the original drawings.

Further exploration into the project timeline revealed a 360-day delay beyond the original 365-day timeline. The authors discovered that without robust construction management technology, identifying the root causes of each delay was challenging due to varied and ambiguous factors. The monetary claims, valued at USD 188,000, were assessed at market prices for fair estimation in the analysis. To illustrate the potential benefits of the proposed BIM Package in alleviating prolonged timelines, the authors conducted a retrospective prospective analysis with the benefit of hindsight. This theoretical reevaluation reduced the total project time from 725 days to 450 days, resulting in a substantial time savings of 275 days, as depicted in Figure 14. This practice should have been initiated from the moment the parties were aware of the anticipated time delay due to change orders or alterations in the original scope.

The authors conducted interviews with 22 participants from the construction industry to validate the proposed BIM package, particularly within the KSA construction context, where BIM implementation is still developing. The participants' responses are detailed in Table 9. It was observed that 95% of the participants agreed to utilize the BIM package for analyzing the project case study. Similarly, 86% of the participants favored using NEC4 as a standard contract form alongside the BIM package rather than opting for a customized contract. Notably, all participants acknowledged that BIM has the potential to reduce design errors and detect clashes at early stages. Furthermore, 95% of the participants were satisfied with the accuracy of outcomes generated from the BIM framework, while 82% expressed confidence in the data accuracy.

Recommendations and future research: It is strongly recommended that construction firms integrate BIM packages into their projects to mitigate disputable claims. This is primarily due to the intricate nature of the construction sector, characterized by complex designs and innovations, which often pose challenges for practitioners to visualize accurately from the start. For further exploration in the field, academics and industry professionals are encouraged to investigate the benefits of BIM in facility management as the sixth dimension (6D). This could enhance operational efficiency and minimize potential claims during the defect rectification period following the construction stage, typically spanning one year in customary practice.

Limitations of this study: This study focuses on a proposed BIM package to reduce construction claims during the construction stage in the Kingdom of Saudi Arabia (KSA). The goal of this study is to specifically focus on the construction field in KSA, so there is limited exploration outside of KSA, with some additional investigation into Egypt and the UAE, but without comparisons to relevant industries such as those in the UK or the USA.

Author Contributions: Writing – original draft, R.A.; Supervision and editing, D.T. and A.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: This research is designed to be published as open-source material and be available for interested parties.

Conflicts of Interest: The author declares no conflicts of interest.

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