University of Southern Queensland

AN INVESTIGATION OF USING ADVANCED TECHNOLOGY SUCH AS BIM TO REDUCE CONSTRUCTION DISPUTABLE CLAIMS

A Thesis submitted by

Reda Abdelshafy Abouzeid Abougamil

(BEng)

For the award of

Doctor of Philosophy

2024

ABSTRACT

The construction industry in the Kingdom of Saudi Arabia (KSA) is a cornerstone of the Middle East economy, with an annual expenditure exceeding USD 120 billion and a workforce of 2.54 million by 2023. The problem statement is that despite this growth, the sector faces persistent challenges, including skilled labour shortages, escalating costs, material shortages, and disputes, particularly in megaprojects such as NEOM under Vision 2030. These issues, compounded by the reliance on traditional contract forms instead of standardized ones such as NEC4, result in ambiguities and disputable claims. Although a unified contract form was introduced in 2024, its adoption remains limited, particularly in the private sector. This thesis investigates the importance of Building Information Management (BIM) in mitigating construction claims in the KSA. The research objectives were achieved through a comprehensive literature review and three published studies. The first paper analysed 50 contributing factors to claims in 75 projects, identifying recurring issues that drive disputes. The second paper evaluated the role of BIM in mitigating claims, highlighting its potential to address ambiguities and improve collaboration. The third paper proposed a BIM package comprising Revit Architecture, Microsoft Project, and Cost-X integrated with NEC4 contracts. A case study involving a USD 1.87 million claim demonstrated the package's effectiveness by reducing the analysed time claim from 725 days to 450 days, saving 275 days. To validate the proposed package, interviews were conducted with 22 KSA construction professionals. Results showed that 95% of participants endorsed utilizing the BIM package, 86% supported its integration with NEC4, and 82% expressed satisfaction with the claim resolution outcomes. These findings underscore the package’s potential to reduce claims and enhance collaboration among project stakeholders. This thesis contributes to the body of knowledge by presenting a tailored BIM solution addressing claim mitigation in KSA’s unique construction landscape. Its significance lies in integrating advanced BIM tools with standardized contracts, providing a practical and scalable model for the region. Future research is recommended to explore the application of BIM 6D for facility management during the operational phase to reduce and verify potential claims during the defect liability period.

CERTIFICATION OF THESIS

I Reda Abdelshafy Abouzeid Abougamil declare that the PhD Thesis entitled *An Investigation of Using Advanced Technologies Such as BIM to Reduce Construction Disputable Claims* is not more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references, and footnotes.

This Thesis is the work of Reda Abdelshafy Abouzeid Abougamil except where otherwise acknowledged, with the majority of the contribution to the papers presented as a Thesis by Publication undertaken by the student. The work is original and has not previously been submitted for any other award, except where acknowledged.

Date: 11-09-2024

Endorsed by: Reda Abdelshafy Abouzeid Abougamil

Associate Professor: David Thorpe
Principal Supervisor

Dr Amirhossein Heravi
Associate Supervisor

Student and supervisors' signatures of endorsement are held at the University.

STATEMENT OF CONTRIBUTION

Paper 1:
Abougamil, R.A.; Thorpe, D.; Heravi, A. Investigating the Source of Claims with the Importance of BIM Application on Reducing Construction Disputable Claims in KSA. *Buildings* **2023**, *13*, 2219. https://doi.org/10.3390/buildings13092219

Student contributed 70% to this paper. Collectively, David Thorpe, and Amirhossein Heravi contributed the remainder.

Paper 2:
Abougamil, R.A.; Thorpe, D.; Heravi, A. An Investigation of BIM Advantages in Analysing Claims Procedures Related to the Extension of Time and Money in the KSA Construction Industry. *Buildings* **2024**, *14*, 426. https://doi.org/10.3390/buildings14020426.

Student contributed 70% to this paper. Collectively, David Thorpe, and Amirhossein Heravi contributed the remainder.

Paper 3:
Abougamil, R.A.; Thorpe, D.; Heravi, A. A BIM Package with a NEC4 Contract Option to Mitigate Construction Disputes in the Kingdom of Saudi Arabia. *Buildings* **2024**, *14*, 2009. https://doi.org/10.3390/buildings14072009

Student contributed 70% to this paper. Collectively, David Thorpe, and Amirhossein Heravi contributed the remainder.

ACKNOWLEDGEMENTS

I wish to extend my profound gratitude to my principal supervisors, Associate Professor David Thorpe and Dr. Amirhossein Heravi, for their indispensable guidance, encouragement, and unwavering support throughout my doctoral research. Their profound expertise, unwavering patience, and insightful feedback have significantly contributed to the development and refinement of this thesis. I am profoundly indebted to my family for their unwavering love, understanding, and boundless encouragement throughout my academic endeavours. Their steadfast belief in my capabilities has been a constant source of motivation and inspiration.

Special thanks are also to University of Southern Queensland, whose financial support made this research possible.

Finally, I am appreciative of all my friends and colleagues who have provided their support and companionship throughout this journey.

DEDICATION

To my devoted wife Heba,

Throughout my doctoral journey, I am grateful for your steadfast love, patience, and unparalleled support. Your support and comprehension have served as my foundation during these difficult periods. This thesis is equally yours and mine. I am grateful for your unwavering support and for believing in me throughout the entire process.

TABLE OF CONTENTS

ABSTRACT i
CERTIFICATION OF THESIS... ii
STATEMENT OF CONTRIBUTION iii
ACKNOWLEDGEMENTS iv
DEDICATION v
LIST OF TABLES... x
LIST OF FIGURES.. xi
ABBREVIATIONS xii
CHAPTER 1: INTRODUCTION 1
1.1 Background of the Construction Sector in the KSA 1
1.2 Problem Statement 2
1.3 Research Gaps 4
1.4 Research Questions.. 5
1.5 Aims and Objectives of the Research 5
1.6 The Methodology Used in the Thesis... 6
1.7 Expected Outcomes from the Thesis 8
1.8 Contribution to Research 8
1.9 Opportunities in the KSA Construction Industry.. 9
1.10 Thesis Outline.. 9
CHAPTER 2: LITERATURE REVIEW 11
2.1 Introduction 11
2.2 Large-scale Construction Projects in KSA 12
2.3 Challenges in the KSA Construction Industry 14
2.3.1 Challenges from Contractual and Legal Perspectives 14
2.3.2 Challenges in Delivering Construction Projects 15
2.3.3 Challenges in Payment Issues.. 16
2.3.4 Disputes as Major Challenges in the KSA Construction Market 17
2.4 Legal System and Construction Contracts in KSA... 18
2.4.1 Key Features of the KSA Legal System... 18
2.4.2 Islamic Law (Sharia) in KSA.. 19
2.4.3 Civil Law System in KSA.. 19
2.4.4 Laws and Regulations Governing Construction Contracts.. 21

2.5 Type of Contract Used in the KSA Construction Industry 22
2.6 FIDIC Contract Used in the Construction Industry 22
2.7 The Importance of NEC Contract Used in the Construction Industry.................. 24
2.8 Procurement System in the KSA Construction Industry..................................... 25
2.9 Types of Procurement Routes with Involved Parties in Construction Contracts . 26
2.9.1 Risk Involved in Procurement Routes in Construction Contracts.................... 27
2.10 Types and Groups of Claims in Construction Projects 28
2.11 Factors Contributing to Disputable Claims in Construction Projects 31
2.11.1 Time Claims and Cost Overruns in Construction Projects 40
2.11.2 Extension of Time Delay 41
2.11.3 Types of Variation Orders from a Client's Perspective 43
2.11.4 Potential Effects from Variation Orders... 43
2.11.5 Time Schedule Acceleration 44
2.11.6 Cost of Acceleration 45
2.11.7 Design Errors with Associated Risks of Building Components 48
2.12 Key Success Factors to Enhance Construction Project Performance 49
2.13 Importance of Using BIM in the Construction Industry 51
2.13.1 BIM Definition.. 51
2.13.2 BIM as Advanced Technology to Reduce Claims in Construction Projects .. 52
2.13.3 History of BIM.. 53
2.13.4 Maturity Levels of BIM in the Construction Industry..................................... 54
2.13.5 Levels of BIM 55
2.13.6 Level of Development Specification of BIM.. 57
2.14 Review of BIM Implementation in the Construction Industry 59
2.14.1 Using BIM in the UK Construction Industry... 59
2.14.2 Using BIM in the US Construction Industry... 59
2.14.3 Using BIM in the Australian Construction Industry....................................... 60
2.14.4 Using BIM in the KSA Construction Industry.. 62
2.15 Benefits of BIM Application in Construction Industries 63
2.16 Connection Between Claims and BIM in the Construction Industry 64
2.16.1 Role of BIM in Effective Claims Management.. 66
2.17 Conclusion of the Literature Review Chapter 67

CHAPTER 3: PAPER 1 – INVESTIGATING THE SOURCE OF CLAIMS WITH THE IMPORTANCE OF BIM APPLICATION ON REDUCING CONSTRUCTION DISPUTABLE CLAIMS IN KAS 69
Introduction 69
Paper 1 70
Links and Implications 92
CHAPTER 4: PAPER 2 – AN INVESTIGATION OF BIM ADVANTAGES IN ANALYSING CLAIMS PROCEDURES RELATED TO THE EXTENSION OF TIME AND MONEY IN THE KAS CONSTRUCTION INDUSTRY 93
Introduction 93
Paper 2 95
Links and Implications 128
CHAPTER 5: PAPER 3 – A BIM PACKAGE WITH A NEC4 CONTRACT OPTION TO MITIGATE CONSTRUCTION DISPUTES IN THE KINGDOM OF SAUDI ARABIA 129
Introduction 129
Paper 3 130
Connection Between the Three Published Papers 159
Links and Implications 159
CHAPTER 6: DISCUSSION 161
6.1 Discussion Literature Review 161
6.2 Discussion of Published Paper One 168
6.3 Discussion of Published Paper Two 171
6.4 Discussion Published Paper Three 174
6.5 Practical Benefits to Industry Practitioners 177
6.6 The New Development in This Study 179
CHAPTER 7: CONCLUSION 181
REFERENCES 189
APPENDIX A 195
Thesis Plan and Timeline 195
APPENDIX B 196
Questionnaire Survey used for Collecting the Primary Data 196
APPENDIX C 199
The life cycle of BIM 199

APPENDIX D 200
Top 12 benefits from BIM application.. 200
APPENDIX E.. 209
The Benefits of Using CostX Software: A Comprehensive Review 209
APPENDIX F.. 212
Section of NEC 4 Option A that suggested in the Thesis with BIM Package.......... 212

LIST OF TABLES

Table 1: Groups in construction related to construction claims.................... 29

Table 2: Common factors contributing to claims and disputes in construction projects. 32

Table 3: Specific claims factors relating to time and cost overrun. BIM, building information modelling. 47

Table 4: Key success factors to reduce claims and enhance construction projects. 50

Table 5: Twelve principal benefits of BIM application in construction industries (Krzystof, 2019). 64

LIST OF FIGURES

Figure1: The Jeddah Tower: the tallest project in the world (Barber, 2022)…………7

Figure 2: King Salman Energy Park project in Riyad City (Al-Falih, 2018)…..……….8

Figure 3: Neom Project platform (Venema and Thomas, 2022)

Figure 4: Procurement system in both public and private sectors in the construction industry in the Kingdom of Saudi Arabia………………………………………9

Figure 5: Degree of risks for the building, adopted from Peansupap and Ly, 2015. 21

Figure 6: BIM maturity levels (Bew, Richards 2008)……………………………..…44

ABBREVIATIONS

2D	2-dimensional
3D	3-dimensional
AEC	Architecture, Engineering and Construction
BIM	Building Information Modelling
CAD	Computer Added Design
CAM	Computer Added Manufacturing
FIDIC	Fédération Internationale des Ingenieurs-Conseils
GCs	General Conditions
GTPL	Government Tenders and Procurement Law
KSA	The Kingdom of Saudi Arabia
LOD	Level of Development
NATSPEC	National Specification
NBS	National Building Specification
NEC3	New Engineering Contracts
PTC	Parametric Technologies Corporation
PWC	Public Work Contract
SR	Saudi Riyals
UK	United Kingdom
US	United States

CHAPTER 1: INTRODUCTION

1.1 Background of the Construction Sector in the KSA

The construction industry in the Kingdom of Saudi Arabia (KSA) has experienced remarkable growth over the past two decades. It is now one of the largest sectors in the Middle East, with annual expenditures exceeding USD120 billion (Ikediashi et al., 2014). Currently, this industry employs 15% of the workforce and consumes over 14% of the country's energy. However, there are challenges in measuring and improving performance in this sector, such as time delays, cost overruns, and inadequate safety and quality (Sarhan et al., 2018). The organisation of construction projects in KSA is mainly handled by consulting and construction corporations. Although foreign firms from the United States (US), Europe and Japan combine both services, no Saudi companies provide this type of combined expertise for medium to large-sized projects.

The construction industry is a significant sector, both globally and in KSA, the latter nation being where the candidate will conduct research for this thesis. The Saudi government pays great attention to investment in the nation’s construction sector, with over 5,200 construction projects worth USD 819 billion currently underway. KSA’s construction market is projected to grow at a compound annual growth rate of 6% between 2019 and 2023 and is expected to expand significantly and offer lucrative opportunities as a result of initiatives, such as Saudi Vision 2030, the National Transformation Program (NTP) 2020, and ongoing reforms aimed at diversifying the Saudi economy away from oil (The Argaam Report, 2019). These factors, together with increased private sector investment, are anticipated to be the primary drivers of growth in the Saudi construction market from 2020 onwards.

The Argaam report (2019) states that the Saudi Arabian economy is transitioning to a post-oil era, with future growth expected to come from the megacities currently under construction in KSA. The Saudi Vision 2030, together with significant investments in housing and infrastructure development by local governments, is revitalising the construction industry and attracting the attention of international players. With 3,727 active projects worth $386.4 billion anticipated by 2025, the urban construction sector is the fastest growing domain (Alqahtany, 2021). Despite this growth, the adoption of building information modelling (BIM) in KSA still lags behind that in the US, United Kingdom and Australian construction industries, which have paid significant attention to this concept (Al-Yami and Anibire, 2021). The aim of this thesis, therefore, is to provide a comprehensive analysis of BIM implementation in KSA in order to minimise potential disputes.

1.2 Problem Statement

The construction industry in Saudi Arabia (KSA) consistently struggles with delivering projects on time and within budget, as delays and cost overruns are common. According to research, 70% of Saudi public projects encompassing 662 projects with a total estimated cost of 40 billion Saudi Riyals (SR) face significant delays and cost overruns (Alzara, 2016). Accurate cost estimation is crucial for the successful execution of construction projects, especially during the preliminary design stage. At this stage, early cost estimation models can help project managers manage time and resources more effectively (Al-Suliman, 2019). However, achieving precise cost estimates early on remains challenging due to the limited information available (Kim, 2004). In addition, the construction industry in Saudi Arabia has traditionally depended heavily on spreadsheets for project cost control. Although this method is familiar, it often leads to outdated, time consuming, and less valuable cost reports. Preparing these reports for senior management can take days or even weeks, resulting in inefficiencies in decision making (Guset, 2019). Though Building Information Modeling (BIM) is beginning to gain traction in Saudi Arabia, it remains a relatively new technology with limited adoption. Only a handful of projects have acknowledged its many benefits, such as generating multiple design alternatives, identifying errors early through simulations, and reducing costs by preventing costly rework. The gradual adoption of BIM presents an opportunity to explore its potential in addressing existing challenges in project delivery, especially in enhancing cost estimation, efficiency, and reducing delays and cost overruns in the KSA construction sector.

Digital technologies such as BIM are becoming essential in minimizing contentious construction claims, particularly given the complexity of modern construction projects. In the author's experience within the Saudi Arabian construction sector, inaccurate project documents often result in poor visualization and communication. By implementing BIM, stakeholders gain access to detailed visual representations of projects, which enhances understanding of design intentions and reduces misunderstandings. Furthermore, BIM integrates time (4D) and cost (5D) dimensions with the model, facilitating precise scheduling and budgeting. This integration helps reduce delays and cost overruns, which are common sources of claims and are still not fully studied in both research and industry practice. This is one of the main strengths and gaps of this thesis that will be discussed.

Examining and demonstrating the role of BIM in reducing disputable claims is essential for bridging current knowledge deficiencies. This research offers practical insights to enhance conflict management in construction projects, resulting in improved cost control, time management, and efficiency. Moreover, concentrating on the inadequately examined KSA context will facilitate the customization of BIM adoption tactics to the region's distinct requirements, thus aiding in the modernization and expansion of its construction sector.

1.3 Research Gaps

The construction sector in Saudi Arabia (KSA) is experiencing significant transition propelled by large-scale projects associated with Vision 2030. Notwithstanding this expansion, the business persists in encountering enduring challenges, including project delays, budget overruns, and recurrent construction claims. These assertions stem from issues such as contractual ambiguity, ineffective communication, and dependence on conventional project management techniques. Despite Building Information Modeling (BIM) demonstrating its efficacy in tackling analogous difficulties worldwide, its implementation within the KSA construction industry is still restricted and inconsistent.

A significant gap is seen in the integration of BIM with claims management procedures in construction projects in KSA. Although studies in other locations indicate that BIM improves documentation accuracy, boosts communication, and minimizes disagreements, there is a paucity of empirical evidence substantiating these advantages within the distinctive cultural, legal, and operational framework of the KSA construction sector. The dependence on customized contract forms, the restricted application of generic contracts such as NEC4, and the incremental integration of BIM technology exacerbate this disparity.

Contemporary research on BIM in KSA mostly emphasizes on utilization for design coordination, cost estimation, and project scheduling. Research particularly examining BIM's impact on minimizing construction claims and expediting dispute resolution is insufficient. Furthermore, the particular problems related to the implementation of BIM in KSA, including inadequate experience, reluctance to change, and the lack of clear regulatory mandates, have not been sufficiently addressed in the current literature.

This study intends to address this gap by examining the efficacy of BIM in reducing claims and disputes in building projects in KSA. The objective is to create a customized BIM-based framework that corresponds to the specific requirements of the KSA construction sector, offering a systematic method to minimize disagreements, foster collaboration, and boost project results. The study examines the necessity for a comprehensive understanding of the integration of BIM with novel contract forms and digital workflows to enhance claims management processes. This research will enhance the understanding of BIM's application in construction claims management and offer practical insights for optimizing project delivery in the KSA construction sector by solving existing gaps.

1.4 Research Questions

1) How can BIM enhance the accuracy and completeness of construction project documentation?
2) To what extent can BIM improve time efficiency in the processing of construction claims?
3) How effective is BIM in reducing the time required for dispute resolution in construction projects?
4) In what ways can BIM facilitate better communication and collaboration in claims management?

1.5 Aims and Objectives of the Research

The aim of the research is to investigate how advanced technologies, such as BIM, can reduce disputable claims within the Saudi construction industry, as well as in this sector, globally.

The objectives of the research are as follows:

- To identify different factors that cause disputable claims in residential and commercial projects in KSA.
- To investigate to what extent BIM can minimise disputable claims in both residential and commercial construction projects.
- To examine how advanced technologies can be facilitated in order to enable construction projects to be completed with fewer disputable claims.

1.6 The Methodology Used in the Thesis

This section outlines the research plan and technique utilized to fulfill the objectives of this PhD study. The methodology is designed to incorporate secondary data from an extensive literature study with primary data obtained through questionnaire surveys and interviews. The research corresponds with the publishing of three peer-reviewed journal articles, each offering unique insights to the overarching thesis while maintaining a uniform methodological framework.

Research Design

The study used a mixed-methods approach, integrating quantitative and qualitative techniques to thoroughly investigate the research issue. The framework of the study is based on:

Secondary Data Analysis: A comprehensive literature review provided the basis for identifying research gaps, formulating hypotheses, and structuring the project. Primary Data Collection: Data were obtained via structured questionnaires and semi-structured interviews to corroborate research findings and examine practical insights from industry experts.

Literature Review as Secondary Data

The literature study served as the principal secondary data source, integrating existing studies to rticulate fundamental notions and theoretical paradigms. Recognize deficiencies in understanding and develop research inquiries. Establish the groundwork for the three papers included in the thesis. The literature review employed peer-reviewed journal articles, books, and industry reports obtained from sources including Scopus, Web of Science, and Google Scholar. A methodical methodology was employed for the review, guaranteeing the relevance and quality of the material.

Consolidation of Findings from Three Articles

Each essay tackled unique but interrelated research aims:

- Article 1: Concentrated on secondary data derived from the literature review to delineate the problem and hypothesis.
- Article 2: Utilized questionnaire survey data to corroborate and enhance conclusions from the literature.
- Article 3: Integrated survey and interview data to investigate industry-specific viewpoints and suggest pragmatic solutions. The results from all three papers were integrated to provide a thorough comprehension of the research issue in the final thesis.

Ethical Considerations

Ethical approval was secured from the appropriate university the human body. Informed consent was obtained from all participants, guaranteeing anonymity and voluntary involvement. Data were anonymous and securely kept in accordance with ethical requirements.

Methodological Limitations

- Sampling Bias: Purposive sampling may restrict the generalizability of results.

- Self-Reported Data: Surveys and interviews depended on participants' self-reported information, potentially introducing subjectivity.
- Time Constraints: Arranging interviews with occupied professionals presented logistical difficulties.

1.7 Expected Outcomes from the Thesis

Significant causes of construction claims and disputes should be identified and avoided. One proposed solution is to use BIM in order to minimise disputable claims. This system is designed to perform an accurate analysis of the commercial value of any claim or dispute that arises. A benefit of using BIM is that it provides a more precise and convincing evaluation of claims and disputes compared to traditional practices. By implementing BIM in construction projects, the conflicting parties can effectively resolve their claims amicably and reduce the need for legal action.

1.8 Contribution to Research

This study aims to examine the use of advanced technologies, including Building Information Modeling (BIM), in construction projects in the Kingdom of Saudi Arabia (KSA). This study aims to utilize BIM to tackle ongoing issues in the construction sector, such as conflict avoidance, schedule compliance, and effective fulfillment of owners' expectations. The prompt and cost-effective execution of construction projects, with minimal disputes, continues to be a significant issue for project teams.

The application of BIM from the project's commencement can substantially reduce risks, hence decreasing need on contingency funds. Its ability to reduce design conflicts, minimize related expenses, and diminish contentious claims renders it an invaluable asset for project management. Notwithstanding its established benefits, there is a paucity of research about the function of BIM in mitigating contentious claims and enhancing claim analysis procedures. Zaher et al. (2018) identified a study need regarding BIM's capacity to aid in delay claim investigation. Thus, conflict resolution in the construction sector frequently hinges on practitioners' dependence on conventional methods and personal judgment, highlighting the necessity for additional research. By addressing this research gap. This study contributing to the advancement of knowledge in the KSA construction sector by highlighting the necessity of utilizing new technologies to improve project outcomes and mitigate disputes.

1.9 Opportunities in the KSA Construction Industry

Construction and transportation have always been key recipients of investment in the Kingdom. It is predicted that investment in these areas will expand significantly by 2030. The implementation of the NTP is expected to lead to a substantial increase in the number of development initiatives. One notable project is the development of a 30-mile Red Sea bridge between Saudi Arabia and Egypt. This bridge will connect two of the region's largest economies and facilitate the transportation of millions of dollars worth of cargo. Furthermore, it is anticipated that the bridge will greatly enhance trade and commerce. The scale and ambition of the NTP's plans to revamp the Kingdom's infrastructure are evident in this monumental bridge project.

1.10 Thesis Outline

Chapter One: Introduction: This introduction chapter covers the background of the KSA construction industry, the legal system and the contracts used. The opportunities and challenges are also explained, together with the research aims and objectives, thesis outcomes and contribution to the research.

Chapter Two: Literature Review: Chapter Two focuses on secondary data, specifically investigating the sources and causes of disputable claims in the construction industry, with a particular emphasis on the Kingdom of Saudi Arabia

(KSA). It addresses the procurement route in the KSA, explaining the local Public Works of Contracts (PWC) and comparing them with standard forms of contracts. Additionally, Chapter Two explores the role of Building Information Modeling (BIM) technology in reducing construction claims in the KSA industry, highlighting essential key benefits of BIM from previous literature. The findings from this literature review served as the primary basis for the three published papers, respectively.

Chapters Three, Four and Five: Published Papers: In these three chapters, the published papers that address the research aims and objectives are presented, which are supported by three key pillars. The initial paper serves to investigate the origins of claims and the significance of BIM implementation in reducing construction claims within the KSA construction industry. The subsequent paper delves into the profound importance of BIM, proposing a comprehensive BIM package comprising Revit Architecture, Microsoft Project and Cost-X as means to mitigate claims during the construction stage. The final paper elaborates on the BIM package in meticulous detail, presenting a real-world claim case study obtained from the KSA construction industry.

Chapter Six: Results and Discussion: this chapter discuss and explain the literature review, and the published papers.

Chapter Seven: Conclusion and Recommendations: the conclusion chapter conclude the whole thesis including the literature review and the published papers.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Reducing construction claims and disputes is a key objective for many researchers in the construction field, and numerous studies have focused on identifying the underlying causes of these claims. Given the industry's complexity and ambiguity, it is unsurprising that such claims become a primary source of disputes. Cases are often converted into legal arguments and resolved through arbitration or litigation. Lack of communication and ambiguity in project documents can frequently lead to confrontations between owners and contractors during claim negotiations, thus reducing the chances of an amicable resolution. Additionally, construction contracts themselves may contribute to claims and disputes, as it can be challenging to state expectations and requirements clearly in traditional contracts.

The first problem addressed in this thesis is the dominance of spreadsheets in the project cost control toolbox, particularly in the KSA construction industry. However, relying on spreadsheets often leads to delayed production of cost reports for senior management, which diminishes their value (Guset, 2019). The second problem is the limited adoption of BIM technology in KSA, despite the fact that it is already in use in the country. This is in contrast to nations, such as the UK, where there is a clear government trend for encouraging the use of BIM technology in construction projects. BIM implementation in the KSA construction industry has been relatively slow, with only a few projects recognising the multiple advantages it offers, such as the option to create multiple design alternatives. Consequently, the ability to conduct various tests on the BIM model and to detect design errors early in order to avoid costly reworks is not yet widespread. The aim of this study, therefore, is to explore an alternative approach using BIM technology in order to reduce construction disputes. Previous literature has examined the potential of using BIM to minimise claims and disputes, which inspired the proposal to utilise a BIM approach.

2.2 Large-scale Construction Projects in KSA

KSA has a thriving infrastructure and building industry compared to other Gulf countries, boasting an impressive $825 billion worth of planned and un-awarded projects. A steady increase has been observed in awarded contracts from $11.2 billion in 2016 to $14.6 billion in 2018. One notable example is the Jeddah Tower, a colossal project which is over 1000 m in height and spans approximately 439,000 m^2 (Figure 1). The tower will serve as the centrepiece of the expansive Jeddah Economic City, which covers an area of 5.3 million m^2. With the steadfast commitment of both the private and public sectors to Saudi Vision 2030, the demand for infrastructure development is expected to continue to surge (Barber, 2022).

Figure 1: The Jeddah Tower: the tallest project in the world (Barber, 2022)

King Salman Energy Park, located in the Eastern Province of Saudi Arabia, is an integrated industrial ecosystem that aims to become the leading energy gateway in the region (Figure 3). Spanning 50 km^2, this project offers a wide range of economic development solutions to KSA. The first phase of the project alone is expected to attract approximately $1.6 billion in investment (Al-Falih, 2018).

Figure 2: King Salman Energy Park project in Riyad City (Al-Falih, 2018).

The Neom project is one of Saudi Arabia's key initiatives under Saudi Vision 2030, which has the aim of fostering sustainable progress without compromising the planet's well-being. This $500 billion endeavour seeks to diversify the economy in KSA by shifting away from its reliance on oil, which has long driven its prosperity (Venema and Thomas, 2022). The Neom City project's first phase is projected to be completed by 2025. The developers envision Neom as becoming an independent jurisdiction, governed by a legal system crafted by investors. Stretching across approximately 26,500 km^2, the land area of Neom surpasses that of Kuwait and Israel (Venema and Thomas, 2022). Neom will be home to Oxygen, a 7 km-long floating city that will become the world's largest floating structure. Additionally, plans have been announced in relation to Neom for the world's largest coral reef restoration project, which will be located further up the Red Sea coast (Venema and Thomas, 2022).

Figure 3: Neom Project platform (Venema and Thomas, 2022)

2.3 Challenges in the KSA Construction Industry

2.3.1 Challenges from Contractual and Legal Perspectives

Essentially, the extended opportunities mentioned earlier also come with significant challenges. The legal market in KSA is quite distinct from that of the UK, Europe, and even neighbouring Middle Eastern countries, such as the United Arab Emirates and Egypt. Throughout each stage of a project, from initial contract discussions to project delivery and payment, it is crucial to take a systematic approach to identify and reduce potential risks (Buckby and Pendley, 2017). For KSA projects, appointments are almost certain to be governed by Saudi law, which is primarily composed of Shari'ah law, or Islamic law. The following are the fundamental principles of Shari'ah law:

- Contract freedom: parties are free to negotiate their own terms unless expressly prohibited by law;
- Fairness and good faith: in their dealings, contracting parties must adhere to and uphold equitable principles;

- Deception, extreme uncertainty, or speculation on a future outcome: a contract that includes any of these components is generally void; and
- Unjust enrichment: transactions in which one party unfairly benefits at the expense of another are null and void.

Contracts that involve the payment or receipt of interest are generally unenforceable. One reason for not using an International Federation of Consulting Engineers (FIDIC) contract as a standard form in KSA is because of the issue relating to interest. According to sub-clause 14.8 in FIDIC's Red Book, the contractor "is entitled to receive financing charges compounded monthly on the unpaid amount" if they do not receive payment from the owner when it is due (Robinson, 2013, p. 51). Unlike other Middle Eastern jurisdictions, such as Egypt or the United Arab Emirates, KSA does not have a comprehensive civil code or commercial law. Although individual Royal Orders, Ministerial Circulars, and equivalent documents can impose additional legal obligations, there is no system of judicial precedent to follow in similar cases. As a result, it is difficult to determine how Saudi law will apply in a particular situation in practice (National Platform, 2020). Consequently, it is important to negotiate appropriate and specific contract terms when working in KSA. Foreign investors, therefore, must have a good understanding of the principle of conflicting laws when drafting a customised contract in KSA.

2.3.2 Challenges in Delivering Construction Projects

Together with the obligation to fulfil a contract, Shari'ah law also requires parties to uphold principles of fairness and equity in their work. This tenet essentially aligns with the concept of "good faith." In the completion of a construction project, contractors and consultants must also comply with the Saudi Building Code, which establishes minimum construction standards for various disciplines, such as architecture, structural engineering, electrical and mechanical engineering, energy conservation and fire protection (Buckby and Pendley, 2017). It is important to note that in KSA, there is a risk of decennial liability for certain building projects, as is typical in many Middle Eastern jurisdictions. The Government Tenders and Procurement Law (GTPL) governs contracts awarded by government entities and includes a ten-year warranty against partial or complete collapse caused by construction defects. It is not possible to exclude or limit decennial responsibility. Furthermore, most professional indemnity insurance policies do not cover decennial liability, and thus contractors and consultants face significant risks. The GTPL does not apply to private sector contracts, and so contractors should exercise caution when dealing with "hybrid" corporations, public-private partnerships, or similar arrangements (Adama and Kouider, 2019).

2.3.3 Challenges in Payment Issues

Payment delays can pose a significant challenge for companies working on projects in KSA. The standard contract used in the public sector, the Public Work Contract (PWC), does not clearly address the employer's responsibility for non-payment and provides limited protections under Saudi Arabian law (Buckby and Pendley, 2017). Notably, Shari'ah law, which prohibits charging interest on late payments, applies in Saudi Arabia. Furthermore, there is no statutory right to delay activities or to terminate an agreement due to non-payment. Consequently, parties involved in construction projects in KSA often find themselves obligated to continue providing services even when payment is overdue, leading to potentially serious consequences. In case of a payment dispute on a project in KSA, the contract's dispute resolution clauses are typically employed (Loots, 1995).

2.3.4 Disputes as Major Challenges in the KSA Construction Market

Most commercial disputes in the KSA court system are heard by Shari'ah courts, which have broad jurisdiction over civil and criminal cases. However, for disputes involving government entities, the Board of Grievances is a specialist tribunal with jurisdiction. It is often regarded as the more reliable body due to its expertise in resolving commercial issues. Nevertheless, the court system in KSA can be unpredictable since it lacks overarching business law and a framework of judicial precedent.

Ultimately, it is recommended that conflicts be addressed through arbitration, preferably with a globally recognised body, such as the International Chamber of Commerce. Alternatively, the Dubai International Financial Centre with the London Court of International Arbitration can be chosen as a joint venture option, given its location in Dubai and London (Arbitration, 2021). Parties involved in the conflict may also opt for ad hoc arbitration based on their preferences. It is worth noting that enforcing international arbitral judgments can be challenging in practice, even though KSA is a signatory to the New York Convention, as courts often consider the underlying issues on their merits. Irrespective of the chosen path, the enforcement process is likely to be lengthy and burdensome. Unlike in the UK, the KSA construction industry lacks specialised professional bodies to address and to improve the field. This includes the absence of local standard forms of contracts for the private sector and staff training. Additionally, there are no dedicated construction courts or specialised solicitors under the law. The UK, however, has professional bodies such as the Institution of Civil Engineering, the Royal Institute of British Architects (RIBA), and the Royal Institute of Chartered Surveyors, as well as other supporting organisations for the construction industry.

2.4 Legal System and Construction Contracts in KSA

Before the unification of the State of Saudi Arabia, diverse regulations pertaining to trade, commerce, industrial practices, and labour laws were enforced in different regions comprising the State of Saudi Arabia. However, subsequent to the unification, the implementation of new laws and regulations regarding these matters became imperative (Bashayreh, 2022). The fundamental legislative framework of Saudi Arabia, including its Commercial and Labor Codes, is based on Islamic principles derived from the Qur'an and Sunnah, which serve as the primary sources of Islamic law. The commendable task of aligning these codes with Islamic principles and codifying them was accomplished by Mohammad Rushoud, an expert in Islamic commercial, labour, and company laws (Agil, 2021). Consequently, numerous other laws have been enacted in response to the evolving circumstances of the Kingdom and its governance (Aljunied, 2022).

The legal system of Saudi Arabia is distinguished by its unique characteristics, as it is founded on Islamic principles derived from the Qur'an and Sunnah. The laws in Saudi Arabia, both procedural and substantive, are codified and adhere to Islamic law (Alanzi, 2020). The ulama of the Hanbali School of thought have played a significant role in shaping the legal interpretation and reasoning processes in Saudi law. Unlike continental laws, the legal system of Saudi Arabia has evolved from the revealed Islamic Law and Islamic legal principles, making it a distinct non-codified system (Waheedi, 2021).

2.4.1 Key Features of the KSA Legal System

The legislation in Saudi Arabia is based on the principles of Islamic Sharia law. The courts operate in accordance with Islamic Sharia and there is no singular act or codified law. The Sharia comprises the Qur'an and the Sunna and serves as the foundational constitution of the Kingdom. The Qur'an is the primary document, while the teachings of the Prophet Mohammed (Sunna) and the consensus of the community (ijma') are relied upon to supplement the Islamic laws (Alotaibi, 2021). The entire court system in Saudi Arabia, including its judiciary, operates independently from religion, with the development and application of laws running concurrently with Sharia (Balto, 2020).

2.4.2 Islamic Law (Sharia) in KSA

The presence of Islam and Sharia law in Saudi Arabia is crucial in facilitating the growth of economic systems, upholding monarchy leadership, and establishing a robust legal framework. Simultaneously, the construction industry plays a significant role in driving economic growth and implementing changes in Saudi Arabia. This study examines the impact of legal roots on construction disputes and contract forms in Saudi Arabia, considering both religious and commercial considerations present in the country.

Sharia law holds a prominent position in Saudi Arabia as a primary source of legislation and serves as the foundation of the country's legal system. The Quran serves as the primary source of Saudi Arabia's rules and regulations. These concepts are implemented in Saudi Arabia using two methods. The initial approach is the implementation of a codified set of laws that imposes harsh penalties for the infringement of Sharia precepts. The second approach involves utilizing the judicial system, which possesses the authority to uphold Sharia law and render verdicts in accordance with its precepts.

2.4.3 Civil Law System in KSA

The legal system of the Kingdom of Saudi Arabia is primarily controlled by Islamic fundamental rules and codified laws. The Quran and the precedents given by the

Prophet Muhammad establish these essential laws (Alanzi, 2020). Legislation is enacted to encompass a wide range of offenses, civil wrongs, agreements, business dealings, and regulations pertaining to authorization within the Islamic community (Hamzah, 2021). The legislative process and written legislation of the Kingdom are governed by Islamic procedures under the Saudi Arabian legal system. Islamic norms and the Quran allow for the enactment and repeal of legislation. A significant proportion of Saudi Arabia's legal and regulatory system is based on Islamic principles, which are derived from the Quran and the teachings of the Prophet Muhammad. The corpus of teachings and practices of the Prophet Muhammad holds great importance in the legal system of Saudi Arabia. However, in contrast to numerous nations where Islamic courts predominantly interpret legal matters based on the Quran and the teachings of the Prophet Muhammad, the courts in Saudi Arabia additionally have a vital function in the advancement and implementation of all contracts and legal affairs, guaranteeing their adherence within the judicial system.

Islamic contract principles, which are closely aligned with Islamic fundamental laws and enforced by Islamic law courts in certain Muslim countries, can significantly diverge from conventional contract laws. Consequently, the regulations pertaining to contract performance, termination, and other related matters can exhibit notable disparities under Islamic laws. Islamic scholars refer to some religious legal expertise that especially applies in a place as regional principles. The notion of understanding laws based on intention or public policy is a subject on which Islamic courts hold divergent opinions. These comprehensive principles have the potential to yield assessments and legal conclusions that diverge significantly from those derived from the interpretation of regular statutes. Islamic scholars possess a twofold allegiance, both to the Islamic faith as devout followers and to the authority of the court and judiciary, as well as to the laws of the country that are enforceable by a legal system, even if they may clash with their personal religious beliefs. In addition, religious courts in certain Muslim countries serve as legislative drafters, as their laws are both applicable and legally valid. There exists a disparity in the legislation. However, in Saudi Arabia, the responsibility for creating laws is assigned to Parliament, while the courts have a limited role in shaping the legal system. This paper examines the legal framework of Saudi Arabia regarding the execution and resolution of construction contracts.

2.4.4 Laws and Regulations Governing Construction Contracts

Saudi Arabia essentially incorporated the prevailing laws, rules, and regulations of the kingdom that were in force at the time of its establishment, with the exception of any laws that contradicted the principles of Islamic law. In such instances, the state enacted new legislation. Furthermore, in the subsequent phase of state progress, additional specialized legislation was enacted. King Abdul Aziz stated that we inherited the rules and regulations that were in effect during the founding of the Saudi kingdom. This clearly illustrates the supremacy of Islamic law and its ability to effectively address contemporary issues.

It is evident, based on fundamental principles, that the governance under Islamic law in Saudi Arabia is rooted in the Islamic faith, thereby encompassing every facet of life. All actions are subject to Islamic law and its regulations. The legal framework relies on explicit texts, analogical reasoning (qiyas), and consensus (ijmaa), which establish interpretations based on Islamic legal norms. The primary sources comprise the Holy Quran and Sunna, with scholars employing various forms of interpretation as points of reference. The implementation of Islamic state law in Saudi Arabia rests upon the judiciary's handling of contracts between individuals, wherein all parties must adhere to the tenets of Islamic law. Contracts are governed by general principles derived from consensus, analogical reasoning, and explicit texts, which incorporate Sharia's obligations.

2.5 Type of Contract Used in the KSA Construction Industry

The KSA government utilises the PWC, a standardised contract, consisting of two parts, for all public works construction projects. The first section, known as the principal document, includes eight items that cover topics similar to those found in standard construction contract agreements and bid forms. Some of these clauses are identical to those found in specific conditions of conventional contracts, which make up the second part of the contract. The latter, entitled "general conditions," comprises 61 clauses that outline terms and circumstances commonly found in conventional general conditions of such contracts. In the late 1980s, the Saudi Council of Ministers adopted a proposal from the Saudi Ministry of Finance and National Economy to establish this standard contract form. In the KSA private construction sector, parties have the freedom to use either the standard form or tailor-made agreements, as long as they align with the principles of the country's law.

2.6 FIDIC Contract Used in the Construction Industry

The International Federation of Consulting Engineers, the global professional body of consulting engineers, developed and published a standard form of contract, known as FIDIC, in order to meet construction needs arising from agreements. FIDIC is an acronym for the Federation's name in French, i.e. Fédération Internationale des Ingenieurs-Conseils (Turner, 2020). Within the realm of international construction contracts, FIDIC's General Conditions (GCs) of Contracts are commonly employed. These GCs are designed for use in legal systems that encompass four primary forms of FIDIC contracts, which are explained below.

- The Construction Contract 2nd Edition (2017 Red Book) is recommended for construction or engineering projects. The contract is created by the employer or the employer's representative, referred to in the Red Book as the Engineer. In this type of contract, the employer provides the design, and the contractor is responsible for building the project accordingly. Alternatively, the contract may also include works, such as civil, mechanical, electrical and/or construction works, that are designed by the contractor (FIDIC, 2022).
- The Plant and Design-Build Contract 2nd Ed (2017 Yellow Book) recommends including the provision of electrical and/or mechanical equipment in addition to the design and execution of building or engineering work. Contracts of this type typically require the contractor to design and provide a variety of plant and other work, including a combination of civil, mechanical, electrical and construction work as required by the employer (FIDIC, 2022).
- Conditions of Contract for Underground Works (2019 Emerald Book) are prepared by the contractor based on the employer's reference design and a geotechnical baseline assessment. These conditions include tender documents and example forms for the schedule of baselines, the completion schedule, and the schedule of the contractor's key equipment (FIDIC, 2022).
- The Second Edition of the Short Form of Contract (2021 Green Book) includes the agreement, GCs, rules for adjudication, and notes for guidance (FIDIC, 2022). The KSA private construction sector may use FIDIC in some situations with amendments to the contract conditions based on the needs of the involved parties. In most Middle Eastern countries, civil law and Sharia law coexist. Even though it is primarily based on English common law, FIDIC is frequently employed. Historically, both the public and private sectors of Gulf countries have

utilised FIDIC contracts as their standard contract. For example, Abu Dhabi, in the United Arab Emirates, has made FIDIC its standard contract for government contracts, and Dubai is likely to do the same (Shahrour, 2020).

2.7 The Importance of NEC Contract Used in the Construction Industry

The New Engineering Contract (NEC) is a collection of contracts designed to encourage cooperation and teamwork while minimizing legal claims and disagreements in the construction, engineering, and facilities management sectors. The fundamental characteristics of the NEC contracts encompass the advancement of effective project management, the fostering of partnership and collaboration, the utilization of key performance indicators and activity plans, and a well-defined and coherent structure (Mkhize, 2022) (Sampaio, 2022). The NEC contracts were formerly referred to as the 'New Engineering and Construction Contract', but the name has subsequently been abbreviated. The NEC, originally limited to the engineering sector, has since been expanded to encompass a range of other professions by a modification in its nomenclature. Currently, the acronym NEC is widely recognized as referring to the 'New Engineering Contract', regardless of the specific industry in which it is employed. (Ragab & Marzouk, 2021).

From the introduction of the NEC (New Engineering Contract) family of contracts, it is explicitly stated that it is a contract with a completely distinct concept, unlike the traditional approach. The latest iteration of NEC, NEC4, was unveiled in June 2017 with the primary objective of enhancing user-friendliness and adaptability. Currently, there are six distinct 'primary payment alternatives' accessible, encompassing different variations of 'lump sum', 're-measurement', and 'target contract with activity plan'. The 'target contract with activity schedule', also known as Option C, is widely favoured due to its emphasis on transparent project management and the inclusion of a 'open book arrangement'. Importantly, both the Employer and the Contractor have the authority to raise the pricing by considering the 'specified cost' of the work and to distribute any possible advantages if they manage to achieve cost reductions. Nevertheless, EMC (NEC's official journal) acknowledges that the employment of this approach may be perceived as excessively intricate for smaller and less dangerous projects. This is due to the possibility of disputes and compensation events, which can result in added responsibilities and administrative efforts, making it less favourable compared to alternative solutions.

Despite being relatively new, NEC4 has gained significant traction across several projects and industries. According to Smart (2018), the success of NEC contracts in infrastructure and the public sector has led to an increased number of public sector organizations opting for these contracts. This can be seen as more evidence of their progressive nature. In addition, experts in BIM compliance appear to choose NEC4 over other contracts. Lynch (2019) supports this claim by stating that the two are very compatible. In addition, NEC4 incorporates and encourages the use of innovation, enhanced practices, and underlying philosophy. For instance, there is a provision (Option X10: 'Information Modelling and Collaboration') that can be added to ensure that the Contractor has permission to implement a 'BIM Execution Plan'. It is widely thought that this practice promotes the efficient utilization of Building Information Modeling (BIM) and has significant potential to provide substantial assistance.

2.8 Procurement System in the KSA Construction Industry

The procurement system in the public sector involves the purchase of products and services for government bodies. These purchases are made through a competitive system where suppliers can contest for clients by offering the lowest price (Alofi, 2017). In order to ensure transparency, vendors must submit a reasonable offer in line with market prices. The pricing competition mechanism underwent changes between 2006 and 2007. Government procurement can be divided into three types: competitive; direct; and specific. Competitive bidding is the predominant method used for acquiring construction services (Kashiwagi et al., 2016). However, some purchases may be unique and tailored to specific government requirements. The procurement system in the public sector endeavours to uphold values, such as justice, equality, transparency, and the separation of personal and government interests (Alanzi, 2021). In the private construction sector in KSA, the procurement system operates differently. In private projects, such as those involving an owner and a contractor, the parties have the freedom to choose the procurement route that best suits their needs. Figure 5 illustrates the structure of the procurement system in both the public and private sectors of the KSA construction industry.

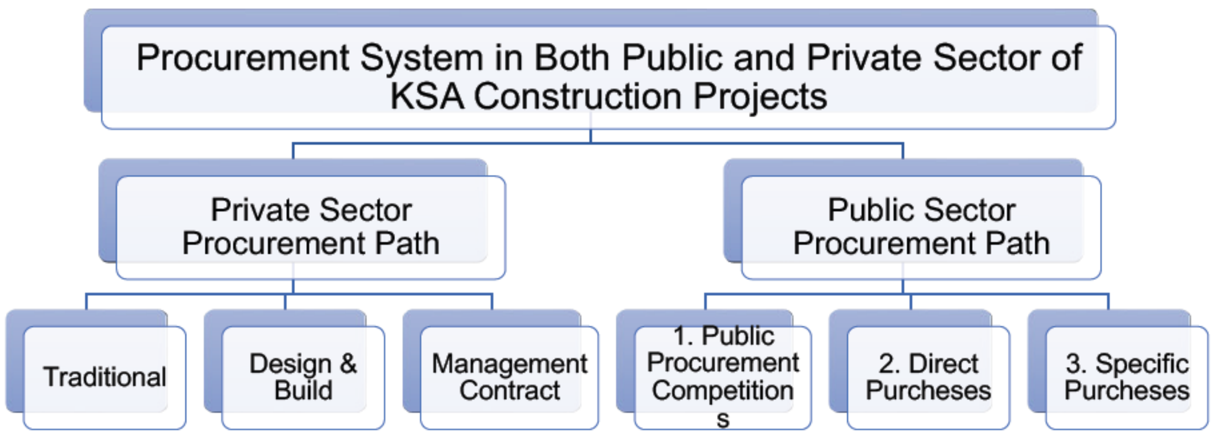


Figure 4: Procurement system in both public and private sectors in the construction industry in the Kingdom of Saudi Arabia

2.9 Types of Procurement Routes with Involved Parties in Construction Contracts

In construction management, there are different approaches to handling contracts and payments relating to a project. Some clients prefer the simplicity of management contracting, where they make a single monthly payment to the managing contractor.

Others seek a single point of responsibility for the meeting of design and construction, which is where design and build contracts come into play. However, not all design and construction firms are equipped to handle complex projects. In such cases, clients may be better off staying with the traditional method and engaging a consulting group. This strategy allows for the completion of complex projects through a two-stage tendering procedure, in which the contractor works on the design, usually with the help of subcontractors (Kashiwagi et al., 2016). This traditional approach can be time-consuming, as a comprehensive design needs to be completed before tender documents can be produced. When time is of the essence, a management contract is generally the best option, as it allows for the overlapping of the design phase with the construction process. The management contractor can also oversee other related subcontractors (Alofi, 2017).

2.9.1 Risk Involved in Procurement Routes in Construction Contracts

Risks can be transferred or shared, and it is important to consider the client's risk tolerance. It is commonly believed that risks should be accepted by those who are best equipped to handle them or those who have insurance coverage. However, this is an oversimplification, as modern risk management requires a more comprehensive assessment. From a contractual standpoint, primary risks can be allocated between the client, designer and contractor (Kashiwagi et al., 2016). In traditional lump-sum contracts, the aim is to balance the risk between all parties involved; the employer procures the design, whereas the contractor carries out the scope of work. In management contracting, the employer assumes most of the risk. Since separate work contracts are awarded, and the employer may continue to make modifications to the design during construction, there may be little certainty regarding time or cost (Francis and Ramy, 2002). In design and build contracts, the contractor is responsible for both design and construction, and major risks are borne by the contractor, particularly in lump sum approaches. The risk can be increased and transferred back to the owner when the preliminary design is finalised before the contract is signed (Alofi, 2017).

2.10 Types and Groups of Claims in Construction Projects

2.10.1 Contractual Claims

Contractual claims arise from agreements between parties involved in construction projects. These claims can include variations in quantity or quality, as well as liquidated damages for defect repair. While FIDIC is the global standard form of contract, British standard forms like Standard Building Contracts (JCT) and New Engineering Contracts (NEC3) may not always be the best option for the parties involved. Project stakeholders have the freedom to choose between a standard form or a bespoke contract form. The choice of contract also depends on the industry's needs and the preferred method of payment, i.e. price-based or cost-reimbursable (FIDIC, 2022).

Parties may choose a standard form, as described above, to meet their needs, but amendments to these forms may alter the contract mechanism and risk balance. For example, it is common practice for parties in the KSA private sector to choose a FIDIC contract and to amend or omit certain conditions from the contract form. While they may believe that these omitted conditions are not relevant to them, there may be hidden risks associated with such practice (Murdoch and Hughes, 2008). One reason for this is that certain clauses may interpret other clauses in the same form, which necessitates them being in chronological order. Construction claims-related groups have been investigated and are explained in Table 1.

Table 1: Groups in construction related to construction claims.

No.	Groups related to construction claims	Key duties of each group to construction claims
1	**Client group** A. Client B. Construction Manager C. Project Manager D. Financier E. Insurer	The client group consists of construction managers, project managers, insurers and financiers who represent clients in construction projects from management and finance perspectives, respectively. For small-to-medium-sized projects, the client establishes a contract with an architect to document their specifications and to design a project within their budget (Abbas, 2007). In larger projects, a contract is signed between the client and the project manager, who holds a supervisory role and is responsible for all professional, technical, administrative and financial aspects of the project (Murdoch and Hughes, 2008). The project manager collaborates with an architect to initiate the design process.
2	**Engineering Group** A. Architect B. Engineer C. Quantity Surveyor	An engineering group consists of specialists who provide essential technical services for planning and constructing a project, either individually or collectively. The client and architect can tailor the contract in various ways. A collaborative team of experts from multiple fields must work together to create the final designs (Abbas, 2007). In the British construction industry, the quantity surveyor plays a crucial role. During construction, their responsibilities include compiling the bills of quantities and taking accurate measurements. Additionally, they are responsible for handling the client's claims. In other construction systems outside of the UK, quantity surveying is performed by different professionals (Murdoch and Hughes, 2008).
3	**Contractor's Group** A. Main Contractor B. Sub-Contractors C. Suppliers D. Shippers	Many different trades work together as a contractor's group so as to complete the project. In order to have a successful relationship and to complete the project, they must collaborate effectively (Abbas, 2007). This can involve organisations of any size, with the necessary financial, technical and administrative resources to ensure that the project is completed on time and within acceptable parameters. For large-scale projects, a single organisation or a joint venture, which is a legal partnership between two or more organisations, may be responsible for the construction (Murdoch and Hughes, 2008).

2.10.2 Common Law Claims

It is common practice in the construction industry to refer to claims arising from the common law as "extra-contractual" or "legal" claims. These types of claims are distinct from contractual claims that may occur under the terms of a contract. Loss and expenditure claims, such as claims for additional time or money, are examples of contractual claims. In contract forms based on common law, procedures for handling claims are usually included (Murdoch and Hughes, 2008). Compliance with claim management standards is crucial, as non-compliance may result in a claim being rejected or influencing its evaluation. Legal claims may go beyond the scope of contractual terms, such as when there is a breach of contract conditions or a failure to comply with health and safety regulations, which could potentially lead to harm or fatalities. Additionally, there may be legal claims for damages if part or the entire building collapses owing to an unstable structure (Thomas, 2001).

2.10.3 Quantum Merit Claims

A quantum meruit claim is a payment method used by a contractor to receive compensation for work performed for the owner at a reasonable monetary value. This type of claim can arise in various situations, i.e. not only when the owner breaches the contract (Abbas, 2007). For instance, if the owner were to instruct the contractor to carry out specific tasks before the original contract is signed, the work may be done under a letter of intent with no predetermined price. In such cases, the contractor can submit a reasonable amount based on a realistic assessment or the prevailing market conditions. Additionally, a quantum meruit claim can be made if there are numerous changes that exceed the contract limit and create an imbalance in the contractual terms (Murdoch and Hughes, 2008).

2.10.4 Ex Gratia Claims

Ex gratia claims, known as "sympathetic" claims, are made when an amount of money is paid against work done without the owner having any obligation or liability to do so (Murdoch and Hughes, 2008). For instance, it is possible that an owner may pay an ex gratia sum in order to save a contractor from becoming insolvent when it would cost far more to hire another contractor to do the work. In addition, the employer has a moral obligation to meet, as the contractor considered (Abbas, 2007). Ex gratia claims can be made, for example, when the price of an item is much lower than it should be or when the price goes up significantly because of a change.

2.11 Factors Contributing to Disputable Claims in Construction Projects

Claims and legal disputes commonly occur in construction projects, including in both public and private sectors. Indeed, construction projects are rarely completed without a time or cost overrun owing to a variety of factors, such as poor planning, design flaws and substandard construction quality (Fuadie et al. 2017). It is therefore essential to consider preventive actions in order to reduce design errors in the early stages of any project. This will ultimately diminish the potential for construction disputes, which is the primary goal of this thesis. The factors and causes of claims in construction projects vary and might arise from different sources. Some of those factors are related to claims presented by contractors against the owners due to compensation for change orders, or for loss and expense. The owner could file a claim against the contractor, asking for money because the contractor broke the contract or failed to meet the objectives set out in the contract.

Claims cases could be raised by the project consultant against the contractor for not complying with safety instructions and gear, for poor performance or for an inexcusable delay. Charehzhi et al. (2017) observed that in large construction projects, the direct cost related to disputes could reach 0.5–5% of the contract value. A study conducted in Malaysia stated that 92% of projects in the construction field were delayed, implying that only 8% of projects had been completed within the planned time (Abdul Rahman and Memon, 2012). Fifty causal claim factors have been identified in this thesis, and are presented in Table 2. These claims were extracted from previous studies and are cited in eight different academic research projects.

Table 2: Common factors contributing to claims and disputes in construction projects.

No.	Factors contributing to claims and disputes	Group related to causes of claims	References
1	Improper design	Client and Engineering groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
2	Extension of time	Client, Engineering and Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
3	Variations and changing orders	Client, Engineering and Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
4	Delay in Contractor's interim payments	Client group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).

No.	Factors contributing to claims and disputes	Group related to causes of claims	References
5	Change in the original scope	Client, Engineering and Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
6	Time schedule acceleration	Client or Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018).
7	Incomplete drawings	Client and Engineering groups, or Contractor in design-built mechanism	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018).
8	Cardinal changes in the quantity, plus or minus	Client or Contractor groups in value engineering	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
9	Changes in type and specifications of materials during construction	Client and Engineering groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018).
10	Drawings and bill of quantities are not fitting the construction site	Client and Engineering groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
11	Ambiguous and incomplete drawings and bill of quantities	Client and Engineering groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).

No.	Factors contributing to claims and disputes	Group related to causes of claims	References
12	Cardinal changes or modifications during construction stage	Client group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
13	Issues of changes in the site location or conditions	Client, Engineering and Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
14	Slow decision making	Client and Engineering groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
15	Poor safety measures	Contractor group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
16	Unexpected increase in material price	Market price factor (External)	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
17	Force majeure	External factors	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).

No.	Factors contributing to claims and disputes	Group related to causes of claims	References
18	Errors and defects in contract	Client, Engineering and Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
19	Different site conditions	Client group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
20	Lack of communication	Client, Engineering and Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
21	Use of unsuitable techniques	Contractor group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
22	Lack of contract awareness	Client, Engineering and Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
23	Concurrent delays	Client and Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).

No.	Factors contributing to claims and disputes	Group related to causes of claims	References
24	Political situation	External factors (Government)	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
25	Economic conditions	External factors (Government and market conditions)	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
26	Financial problems	Client and Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
27	Weather conditions	External factors	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
28	Failure to possess site	Client group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
29	Planning and scheduling problems	Contractor group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).

No.	Factors contributing to claims and disputes	Group related to causes of claims	References
30	Procurement plan deficiency	Contractor group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
31	Delay in supply of drawings	Client and Engineering groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
32	Delay in handing over the site	Contractor group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
33	Ambiguities in contract documents	Client, Engineering and Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
34	Poor management and administration of the construction site	Contractor group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
35	Bond claims	Contractor group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).

No.	Factors contributing to claims and disputes	Group related to causes of claims	References
36	Construction defects	Contractor group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
37	Breach of contract	Client and Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
38	Personal injuries	Contractor group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
39	Unexpected changes in exchange, interest and inflation rate	External factors	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
40	Changes in government regulations and laws	External factors	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
41	Lack of control over sub-contractor	Contractor group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).

No.	Factors contributing to claims and disputes	Group related to causes of claims	References
42	Poor quality of contractor's work	Contractor group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
43	Delay caused by contractor	Contractor group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
44	Variations between original and actual quantities	Client, Engineering and Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
45	Underestimation of cost of projects	Client and Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
46	Delay in obtaining permits from municipality	Client group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
47	Low productivity and efficiency of equipment	Contractor group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).

No.	Factors contributing to claims and disputes	Group related to causes of claims	References
48	Communication and coordination by owner and other parties	Engineering and Consultant groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
49	Unqualified workforce	Contractor groups	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).
50	Change orders by owner during construction	Client group	(Mohamed et al., 2014) & (Mahjoob & Ibraheem, 2022) & (Khan et al., 2020) &(Zaher et al., 2018) & (Kishore & Al-Qershi, 2017) & (Nassar & El Hawary, The Effect Of Building Information Modeling (BIM) On Construction Claims, 2016) & Shah et al., 2014) & (Shahsavand et al., 2018) & (Gritsyenko & Gober, 2021).

2.11.1 Time Claims and Cost Overruns in Construction Projects

Construction projects with cost overruns have the potential to become problematic, with substantial repercussions for all parties involved. For instance, when projects are not yet complete, clients are unable to use the facility, and so consultation and design fees may increase. For contractors, the consequences could include reputational damage and being delayed on a single project for an extended period of time (Moore et al., 2017). The Channel Tunnel project was one of the most well-known examples of a project with cost overruns. Construction costs rose from £4,80 billion to £9,50 billion, the latter amount 80% higher than the original estimated cost (Flyvbjerg et al., 2003). Other international examples of projects with cost overruns include the Great Belt connection in Denmark, which had a 54% cost overrun. Costs for the Humber

Bridge in the United Kingdom and the Paris Nord Train à Grand Vitesse in France overran by 175% and 25%, respectively. A study conducted in Korea's construction industry revealed that the average final cost of seven megaprojects, defined as projects costing more than $1 billion, increased by 122.4% compared to the initial planned cost (Lee et al., 2009). A survey conducted on 130 public projects in Jordan found delays in 106 (82%). Another study in Ghana observed that 33/47 (70%) of construction projects were delayed (Jang et al., 2019). Hence, in addition to the common factors which delay projects listed in Table 2, additional research factors related to cost and time overruns are influential (Table 3).

2.11.2 Extension of Time Delay

In the construction industry, a delay could be defined as a time overrun, which may occur if the project is behind the agreed deadline or beyond the date that the project parties agreed on for delivery (Shahsavand, 2018). However, construction project stakeholders hold different views regarding the concept of delay. For example, delays to the owner may lead to loss of expected income through lack of production facilities or rental space, such as hotels or residential units, shopping malls and hospitals. Delays to the contractor may mean carrying additional direct costs for onsite staff, as well as further overheads and administrative fees owing to the more extended work period. Avoiding delays and completing projects on time is therefore an indicator of efficiency. However, construction project processes are subject to many variables and unpredictable factors which may arise from a variety of sources (Shahsavand, 2018). Consequently, it is essential for project parties to evaluate the project documents prior to the construction stage.

An extension of a time delay from a contractor's point of view might arise primarily due to variations or changes in scope from the owner's aspect. Reasons for such alterations can vary, but a necessary requirement could lead the owner to raise a variation order or change in scope during the construction owing to ambiguities in the original design. An inaccurate engineering estimation prior to project execution is another issue that may force the owner to modify or change the original scope (Goldstrong, 2019). Inaccurate and error-prone estimations for any project prior to the construction stage may affect the initial size of the investment for the owner and may cause the economic benefits of the potential project to fluctuate. Moreover, an extension of time could also be generated by project complexity, e.g. as exists in mega projects, such as skyscrapers, nuclear power stations, dams and motorways. Inadequate planning is one of the major sources of time extensions as project planning means obtaining an outcome at a minimum time and cost. Planning is a comprehensive task that must be achieved early, although it could be carried out at any stage during the construction. A lack of planning in the early stages may therefore result in inaccurate outcomes at the project's close.

Ultimately, late approval of drawings and submittals given to the contractor from the owner's side, or lack of decisions from the project consultant can be considered to be significant sources of time extension claims by the contractor. In some cases, the lack of decisions and late approval from the owner by the consultant could be a result of the unfamiliarity and complexity of the project’s documents (Itzhaki, 2021). In addition, if the project manager follows traditional practices, this might lead to difficulties in organising the coordination of the drawings when a variation is issued. Hence, using modern technology in construction facilitates a timely seamless flow of information between the project parties, and can enable quick and right decisions when necessary.

2.11.3 Types of Variation Orders from a Client's Perspective

Variations are inevitable and can rarely be avoided in construction projects, particularly from an owner's perspective. Variation orders involve alterations, omissions, additions or even substitutions in terms of quantity, quality and work schedule (Enhassi et al., 2010). Arian and Low (2005) categorised two types of variation orders from an owner's perspective, i.e. beneficial and detrimental variation orders. Beneficial variations facilitate a reduction in a project's cost, schedule or level of difficulty. Their purpose is to balance functionality and durability whilst eliminating unnecessary costs from the project for client satisfaction (Ndihokubwayo and Haupt, 2008). A detrimental variation order can be outlined as one that harms project performance and reduces the value of the project owner. Although construction contracts are an agreement subject to variability, they allow the involved parties in the contract , and especially the owner, to initiate variations, although variations may also be raised by the contractor as a result of changes in specifications or value engineering.

2.11.4 Potential Effects from Variation Orders

Numerous researchers have investigated the effects of variation orders due to their negative effects on construction projects. Arian and Low (2005) identified 16 effects of variations and change orders on the construction project. An increase in project cost during the construction phase is a common effect of variation orders due to significant additions or alterations in the original design. A contingency sum may be added to the original budget in construction projects as a precautionary procedure in order to mitigate the financial impact and to cater for potential variations whilst keeping the project's overall cost intact. Hester et al. (1991) mentioned that procurement delay is also a common effect of variations when construction is underway, as newly required materials might not be available in the market when the variation order is issued.

Rework and demolition often occur in construction because of changes that take place during the building process. Alterations that arise during the design process do not require rework or demolition.

As mentioned by Thakur and Gobana (2017), not every variation order affects the situation of a construction project. However, the most predominant source of variations are changes in the original scope from the owner's perspective based on their needs and requirements, either during the design or construction stage. Nonetheless, it was discovered that when issuing a variation order during the construction stage, the budget and project calendar may be equally exaggerated (Thakur and Gobana, 2017). Ultimately, the sources of variation orders are many and various; however, the focus of this thesis is on the source of variation orders from a contractor's point of view. Variation orders and changes in the original scope may affect stakeholders who are directly or indirectly involved in the project (Osman et al., 2009). For example, suppliers of overseas materials, logistics and wages of temporary construction labourers, and, in some cases, lodging expenses, may be influenced.

2.11.5 Time Schedule Acceleration

Time is always referred to as money in any construction project because it is strongly related to cost and quality. The time, cost and quality of a construction project comprise the three pillars described as an "iron triangle”. In some situations, the building owners may desire to complete their projects in a shorter time than planned, a procedure called "acceleration" or "schedule compression" (Mitchell, 2009). Compression or acceleration of a construction process is very time-intensive because the programme mechanism will be changed from a realistic strategy to a fast-track process based on the new extremely tight schedule. However, the general contractor may use a constructive acceleration approach to accelerate the project voluntarily before the planned deadline. Constructive acceleration may also be implemented if the contractor faces an excusable delay and the owner has denied a time extension (Mitchell, 2009). In such a case, the contractor may not be entitled to recover the cost of acceleration from the client, but the contractor can take the action of acceleration in order to reduce direct site costs and office overheads and to avoid a delay penalty.

The complexity of acceleration or compression depends on the scale of the construction project and its activities. In traditional and repetitive projects that include a small number of activities, acceleration and compression may be feasible and accurate with less conflict between the project activities (Bakry et al., 2014). Conversely, acceleration is very complicated in large-scale projects owing to the complex relationship between the project activities. The acceleration procedure in a complicated project will need skills and technological support. Acceleration may also need more than one action at the same time, such as reallocating resources or crashing selected activities on the critical path and reassigning critical activities to be finished in parallel (Tomczak and Jaskowski, 2020).

2.11.6 Cost of Acceleration

The cost of acceleration is usually measured based on a client's request because acceleration from a contractor's perspective will not incur an extra charge for the project, as explained previously. However, a request for acceleration from a client could arise from the potential loss of revenue caused by delays, which may also delay building occupancy by tenants (Ssemwogerere, 2018). The course of action for acceleration cost is not usually straightforward in the construction industry, as there is no precise, approved method to calculate the cost of acceleration in any construction project. Loots (1995) argues that there is no strict and defined formula for calculating acceleration costs; instead, each case should be individually assessed and the granted cost agreed upon. Contractually, the US construction industry has become familiar with the concept of constructive acceleration. The refusal to grant a time extension claim for an excusable delay in the US is generally converted into an implicit order to accelerate (Davison and Mullen, 2019).

Compensation for acceleration under English law is unspecified and left to the circumstances of each project. If there were no express authorisation in the conditions of a contract to accelerate, the contractor may have no right to claim additional acceleration costs (Maritz and Schutte, 2009). Recently, in the New Engineering Contracts (NEC3), a standard form written and used widely in England and South Africa, there has been a clause that gives the contractor a bonus when accelerating the project. Davison and Mullen (2019) described specific methods which can be used individually or in combination to calculate the acceleration cost: (i) a total cost approach; (ii) a modified overall cost approach; (iii) time impact methodology; (iv) a measured mile approach; and (v) a formula approach. Most importantly, claims in construction contracts frequently result from the project's lack of a control system. Hence, if there were no good control systems on site, such as BIM to document or register every change during the construction, conflicts may arise.

Table 3: Specific claims factors relating to time and cost overrun. BIM, building information modelling.

No.	Group for factors related to time claim and cost overrun	References
1	**Financier and Cost Group Factors**	
	1.1 Financial difficulties from owner side	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	1.2 Underestimated budget for the potential project	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	1.3 Slow and delayed payments for completed work	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	1.4 Contractor financial challenges	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	1.5 Low-cost contract related to severe contractor competition	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	1.6 Payment delayed from the project client	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	1.7 Factors due to unplanned bidder	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	1.8 Factors due to inadequate bid information	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	1.9 Factors due to the actual work done but not measured and paid	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
2	**Time Overrun Claims Factors**	
	2.1 Suspension of project work from the client side	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	2.2 Poor coordination and supervision	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	2.3 Delay in procurement or delivery of material	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	2.4 Non-interoperability of BIM tools	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).

No.	Group for factors related to time claim and cost overrun	References
	2.5 Market shortage of materials	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	2.6 Suspension of work from the owner or the contractor	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	2.7 Delay in mobilization time by the contractor	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	2.8 Verbal change of orders by client	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	2.9 Low productivity from the contractor's labourers	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	2.10 Delay in supply of drawings	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	2.11 Poor BIM integration and management	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	2.12 Incomplete BIM model at the time of budgeting	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
	2.13 Design changes to the BIM model	(Jang et al., 2019) & (Moore et al., 2017) & (Shah et al., 2014) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).

2.11.7 Design Errors with Associated Risks of Building Components

The design of any building consists of multiple components, such as architectural structural and electromechanical designs, the latter including electric and mechanical aspects, and plumbing. Peansupap and Ly (2015) categorised the group of design errors in construction projects according to the degree of associated risk. For example, an electromechanical design error is highly expected to occur during construction and is ranked as high risk. A potential reason for this is that the level of detail in the electromechanical elements is frequently complicated, and potential clashes between those elements and a building's structural components are common. The researcher believes that the limited usage of technology in construction makes it problematic for onsite engineers to visualise the coordination and distribution of the mechanical and structural elements of the building without conflicts. As an example, the duct routes of air conditioning may intersect with a concrete drop beam in some critical locations. Additionally, from an architectural perspective, both drainage pipes and air conditioner ducts might not fit into the designated facility shaft. Figure 6 shows the risk degrees of design errors, which are categorised as groups for any building element.

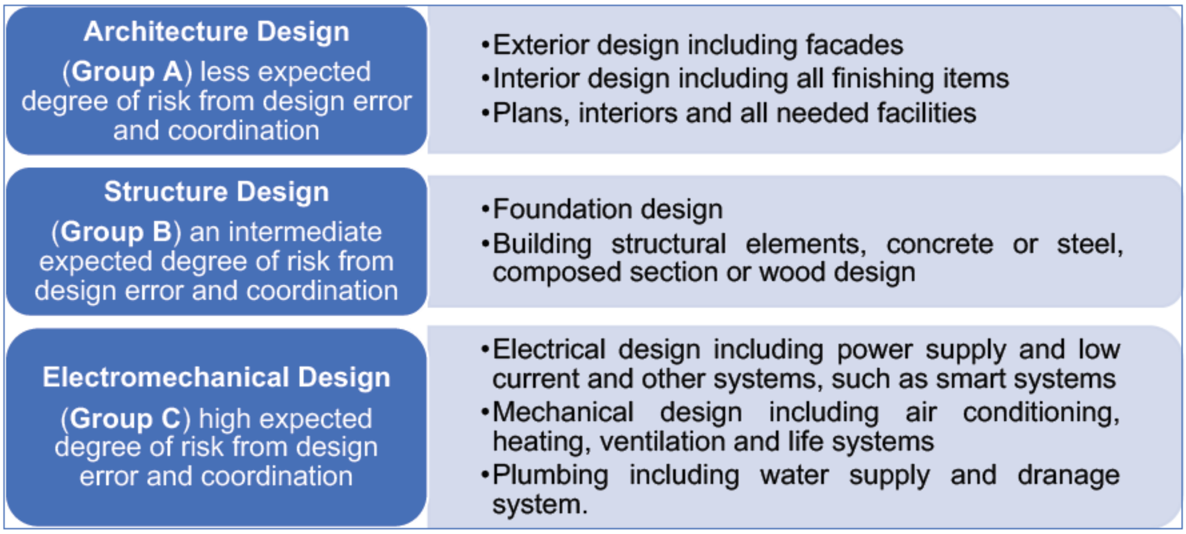


Figure 5: Degree of risks for the building, adopted from Peansupap and Ly, 2015.

2.12 Key Success Factors to Enhance Construction Project Performance

Success factors can be defined as the extent to which the aims and expectations of the project are realised. These are always observed from various angles. Indeed, quantifying the success of a project is a complex process because success is subjective and difficult to agree on (Alzobaee and Al-Ageeli, 2016). In the project management and business literature, the concept of project success is neither adequately nor comprehensively defined. In addition, neither the business nor project management literature has a comprehensive understanding of the concept of success (Jang et al., 2019). These authors reviewed a number of different studies in order to find the most important factors for success. These have been collated in Table 4.

Table 4: Key success factors to reduce claims and enhance construction projects.

No.	Key Success Factors	References
1	Good cordination between project parties	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
2	Using adanced technology in design and construction	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
3	Panel optimisation	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
4	Proper choice of materials	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
5	Avoid underestimated tender price	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
6	Contractor experience	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
7	Realistic time plan to complete the project	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
8	Minimal design changes during the construction process	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
9	Reduced labour costs with proper productivity	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
10	Value engineering to be studied after finishing the desgin	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
11	Adequacy of plans and specifications	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
12	Technical capabiliy of the project manager	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
13	Adaptability of the project manager to changes in project plans	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
14	Early involvement of project manager in project plans	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
15	Commitment of the project manager to meet quality, cost and schedule	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).
16	Communication system and control mechanism	(Jang et al., 2019) & (Moore et al., 2017) & (Alzobaee & Al-Ageeli, 2016) & (Assaf et al., 2019).

2.13 Importance of Using BIM in the Construction Industry

2.13.1 BIM Definition

Hamil (2021) defined BIM as "a process for creating and managing information on a construction project throughout its whole life cycle."

BIM is an acronym for Building Information Modelling or Building Information Management. Hence, BIM is not a tool or just software; instead, it comprises a comprehensive process that enables all the project parties, including architects, engineers, contractors and other construction professionals, to plan, design and build within a single 3-dimensional (3D) model (Lorek, 2021).

BIM is a process of creating and organising information relating to a construction project. Using BIM as a proper technology, a coordinated digital description of every feature of the project is created. This digital description typically includes 3D models containing extensive information and structured data about the product, the execution and the handover (Hamil, 2021).

The National Institute of Building Sciences defined BIM as an automated process to illustrate a facility's physical and functional features. BIM therefore works as a collaborative knowledge resource which provides information about a building, and offers stakeholders a consistent forum in which to make decisions throughout the building's service life (Sodangi et al., 2018).

As stated above, BIM is not just a tool or software, but rather an integrated process for the project which applies from the initial stage, through planning and construction, to operation. When extended and used with facility management, which extends into the operation of building management using data, owners have access to any part of their buildings. The use of BIM during the operation process enables collaboration with the Building Management System, which monitors the functions of all the project's intelligent systems (Lorek, 2021). The life cycle of BIM in the construction industry is explained in detail in

2.13.2 BIM as Advanced Technology to Reduce Claims in Construction Projects

Currently, claims are more common in construction projects than at any other time in history and are regarded as the most disruptive event in any project. The reason for this present day increase may reflect aesthetic complexity with a modern engineering design which mainly relies on composite materials from concrete, steel, and even fibre, and in situations where in such a case, the construction industry still relies on traditional practice. Consequently, there has always been a high demand for new methods and techniques to reduce and prevent construction claims. As previously noted, BIM is a relatively new technology that is rapidly gaining acceptance in the construction industry (Nassar and El Hawary, 2016). It has played a critical role in improving various aspects of construction management, including claims. Experts involved in the construction industry from the architecture, engineering and construction (AEC) sector believe that BIM will improve overall construction industry efficiency and reduce the number of claims and disputes in construction projects (Nassar and El Hawary, 2016). BIM improves construction processes by making it easier to look at more options and analyse them more effectively, leading to fewer claims being filed, and going over budget and scheduled deadlines less often.

This part of the literature review focuses on BIM and its importance for reducing the possibility of disputable claims during the construction stage. The primary goal of proposing the use of BIM in the construction industry in KSA and other adjacent construction neighbourhoods in the Gulf Region is that the implementation of BIM is not yet mandatory. A field survey case study reported that only 20% of construction companies are implementing BIM in the Middle East; 80% are neither applying BIM nor involved in its adoption process regardless of their capacity (Sodangi et al. 2018).

2.13.3 History of BIM

In order to understand the history of BIM in more detail, it is necessary to go back to the early days of computing and to study the conceptual underpinnings in order to trace the history of BIM and BIM systems. Towards the end of the 1960s, Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) emerged as two distinct technologies. No one could have predicted that CAD and CAM would eventually converge and become significant forces in the industrial world (Hanartty, 1999). At the Massachusetts Institute of Technology Lincoln Laboratories in 1963, Ivan Sutherland created the first CAD with a graphical user interface, "Sketchpad." It served as an essential milestone in the advancement of computer graphics and opened the door for human-computer interaction (Cherkaoui, 2017). In 2001, NavisWorks created and commercialised JetStream, a 3D design review software that included tools for 3D CAD navigation, collaboration and coordination. JetStream essentially synchronised data in disparate file formats and enabled construction simulation and problem prediction. When Revit 6 was released in 2004, it gave more well-known architects and engineers the chance to work together using a single integrated model program (Cherkaoui, 2017).

Autodesk Revit Architecture and Structure are examples of the current generation of BIM architectural design tools. Bentley Architecture and its associated products, Graphisoft ArchiCAD, Gehry Technology's Digital ProjectTM, and Nematschek Vectorworks are also included (Quirk, 2012). Furthermore, fabrication-level BIM design applications, such as Tekla Structures grew out of the object-based parametric modelling capabilities first developed and refined for mechanical system design.

Parametric Technologies Corporation (PTC) deserves special mention. In the 1980s, PTC led efforts to define and control 2-dimensional (2D) or 3D shape instances and other properties utilising a hierarchy of parameters at the assembly and individual object levels (Eastman et al., 2011).

2.13.4 Maturity Levels of BIM in the Construction Industry

BIM is not a new concept in AEC. The UK government released an innovative construction strategy in May 2011, intending to lower the cost of public sector assets (UK Construction, 2020). This approach required construction businesses to bid on government contracts in order to achieve BIM Level 2 shown in Figure 6, and called for a phased implementation of BIM Level 3 on all centrally procured projects by 2016. The UK government now requires builders and designers to use BIM in high-rise residential projects (United BIM UK, 2019). Maturity levels of BIM that shown in Figure 6 will be explained with reference to the UK construction industry, as the latter is considered to be at an advanced level of BIM implementation.

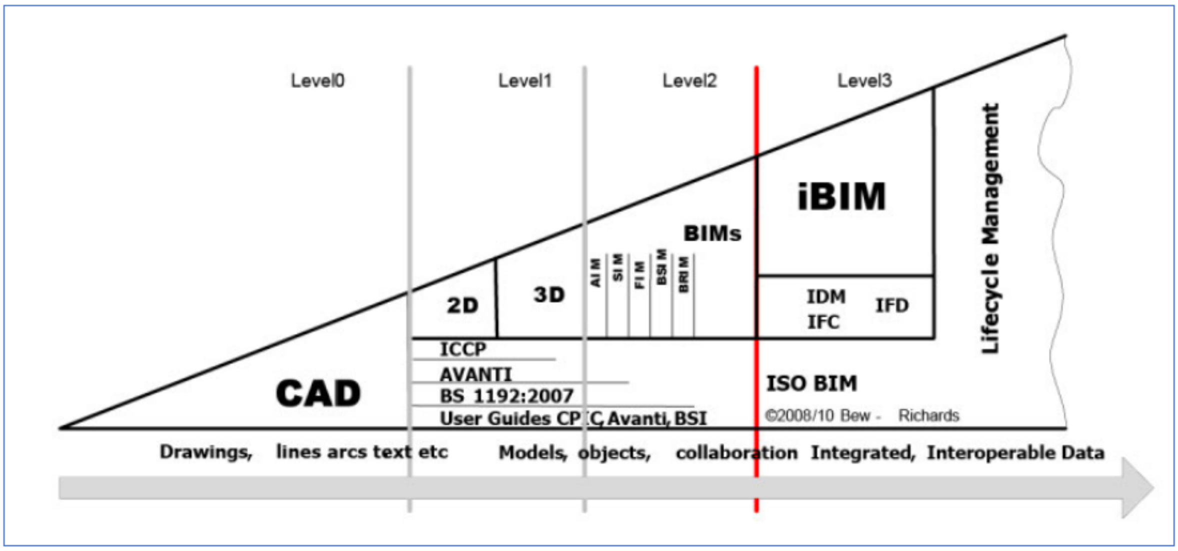


Figure 6: BIM maturity levels (Bew, Richards 2008).

2.13.5 Levels of BIM

BIM Level 0

In its simplest form, BIM level 0 effectively means no collaboration. Partland (2014), in explaining level 0 of BIM, said that only 2D CAD drafting is used, primarily for production information (RIBA, 2013). Paper or electronic prints, or a combination of both, are used for output and distribution. Currently, the majority of the industry is already well ahead of this level.

BIM Level 1

BIM level 1 is a combination of 3D CAD for concept design and 2D drafting for the preparation of statutory approval documentation and production information. CAD standards are managed in accordance with British Standards (BS 1192:2007) (James, 2007). British Standards (2016) include the sharing of electronic data via a common data environment, which is frequently managed by the contractor (Partland, 2014). However, in order to achieve level 1 BIM, there are significant roles that must be considered. These include:

- Defining roles and responsibilities;
- Adoption of naming conventions;
- Creation and maintenance of project-specific codes and spatial coordination;
- Use of a common data environment, such as a project extranet or an electronic document management system to share data across the project team; and
- Consensus regarding a suitable information hierarchy to support the common data environment and document repository.

BIM Level 2

BIM level 2 is defined by collaborative work and requires a project-specific information-sharing mechanism that is coordinated between multiple systems and project participants. Each party using CAD software must be capable of exporting to a standard file format, such as Industry Foundation Class (IFC) or Construction Operations Building Information Exchange (COBIE). This is the work method that the UK government has set as a basic standard for all public sector work.

BIM Level 3

BIM level 3 has not been completely defined, but its purpose is described in the UK Government's Level 3 Strategic Plan (Cable et al. 2015). The following are "critical measures" outlined in this plan for additional funding:

- Development of a new set of international "open data” standards that would pave the way for easy data sharing across the industry;
- Construction of a new contractual structure for BIM-assisted projects so as to maintain uniformity, eliminate confusion and promote open, collaborative working;
- Establishment of a cooperative cultural environment that values learning and sharing;
- Education of the public sector customer on BIM approaches, such as data needs, operational methods and contractual processes; and
- Technology and construction are viewed as driving domestic and worldwide growth and employment (Cable et al. 2015).

2.13.6 Level of Development Specification of BIM

The Level of Development (LOD) specification, which ranges from LOD 100 to LOD 500, is a reference standard tool that has been designed to improve the quality of communication between BIM users on model part attributes. The LOD defines the extent to which an element's geometry and associated information have been considered, i.e. the degree to which team members may rely on the information while utilising the model. The LOD can essentially be viewed as the element's input (Reinhardt et al., 2020).

BIM: LOD 100

In LOD 100, the model element may be represented graphically using a symbol or other generic representation, but it does not meet the criteria for LOD 200 (Eastman et al., 2011). Other model elements can be used to extract information regarding the model element, such as cost per square foot and heating, ventilation and air conditioning tonnage, amongst other factors. LOD 100 items are not geometric representations. Examples include information related to other model parts or symbols indicating a component's existence but not its shape, size or placement (Reinhardt et al., 2020). Any data derived from LOD 100 items must be regarded as approximate. The level of design drawings at LOD 100 is a concept design only, and the drawings are 2D CAD drawings that do not optimise BIM applications.

BIM: LOD 200

In LOD 200, the model element is graphically represented as a generic system, item or assembly, with approximate quantities, size, form, placement and orientation. Model element attachments may also contain non-graphical information. At this level of detail, the items are placeholders. They may be distinguishable as the components they represent, or they may be space reservation volumes (Eastman et al., 2011). Any data obtained from LOD 200 elements must be regarded as approximate. The level of design drawings in LOD 200 is considered to be equivalent to engineering drawings, including (3D) CAD drawings with BIM level 2 (Reinhardt et al., 2020).

BIM: LOD 300

Within LOD 300, the model element is graphically represented as a particular system, object or assembly in terms of quantity, size, shape, location and orientation. Additionally, non-graphical information may be connected to the model element. The amount, size, shape, placement and orientation of the intended piece can be measured directly from the model without having to refer to non-modelled information, such as notes or dimension callouts. The project origin is defined, and the element's location relative to the project origin is accurate. The level of design drawings in LOD 300 is considered to be detailed, and includes 3D CAD drawings with additional information in BIM level 2. A contractor may start to be involved onsite with LOD 300 and develop this level with all the needed information (Reinhardt et al., 2020).

BIM: LOD 400

Within LOD 400, the model element is graphically represented as a particular system, object or assembly in terms of size, shape, position, quantity and orientation, and manufacturing, assembly and installation information is included. Additionally, non-graphical information may be connected to the model element (Reinhardt et al., 2020). The LOD 400 element is modelled with sufficient detail and precision to manufacture the component it represents. The amount, size, shape, placement and orientation of the intended piece can be measured directly from the model without referring to non-modelled information, such as notes or dimension callouts (Eastman et al., 2011).

2.14 Review of BIM Implementation in the Construction Industry

2.14.1 Using BIM in the UK Construction Industry

The use of BIM has accelerated in the UK construction sector. Although it is not yet compulsory for each company to implement BIM, the rate of change is remarkable. According to the National Building Specification (NBS) 2020 BIM Report, awareness of BIM is widespread within the construction sector, with 73% of UK construction companies currently utilising the BIM approach. This is a sharp contrast to the situation in 2011 when 43% of survey respondents were unaware of BIM (British Standard, 2021). According to the 2020 BIM Report, users understand the benefits of BIM, which include enhanced information coordination, increased efficiency, decreased risk and increased profitability. More people are becoming aware that BIM is not just another method of modelling projects. Those working in the construction sector are becoming increasingly familiar with the standard papers and tasks defined in BIM standards, such as the BS EN ISO 19650 series (British Standard, 2021).

2.14.2 Using BIM in the US Construction Industry

In the US construction industry, AEC businesses have increased their use of BIM software to the extent that is now almost the norm in construction projects. According to research conducted by the American Institute of Architects, nearly 100% of large design companies are adopting BIM for billable work, and over a third of small firms also use the technology (Simpson & Richards, 2014). Despite the popularity of BIM within the US AEC industry, barriers to adoption persist. In order to understand more fully how the technology may evolve, it is helpful to review the history of BIM adoption in the US (O'Malley, 2021). According to Kouider and Adama (2019), building operations and facility management in the US AEC industry can gain potential benefits from the use of BIM after construction is completed. These are detailed below:

- Through proper management and coordination, human resources can accomplish tasks based on BIM technology with a 25% improvement in labour productivity.
- A 25% reduction in labour can be achieved; minimising iterative tasks when redoing or correcting work errors will reduce need as the production unit is man-hours per unit. In addition, proper management and coordination give human resources straightforward tasks based on BIM technology.
- A 5% reduction in final construction costs can be attained; clash detection by using BIM reduces rework and may result in saving costs incurred for any defects.
- A 5% increase in completion rate is possible, as the fundamental concept underpinning BIM is to share the needed and correct information at the right time, especially during the construction stage, which decreases the time consumed by redesign (Kouider and Adama, 2019).

2.14.3 Using BIM in the Australian Construction Industry

In Australia, in order to improve asset management productivity in the built environment, the National BIM Working Party was established to report on BIM activities to the Built Environment Industry Innovation Council (National Specification (NATSPEC), 2011). The NATSPEC BIM guide is a body within NATSPEC Construction Information that is maintained by the government and industry. It was formed in 2011 to promote a standardised methodology for the interchange of digital building information in Australia. These include recommendations for BIM implementation on projects, the open BIM object standard, and a tool for standardising object characteristics. National policies and standards were critical in facilitating the Australian building industry's rapid adoption of BIM (Adama and Kouider, 2019).

Following a series of buildingSMART MESH conferences in early 2011 and in response to a recommendation in the Productivity in Buildings Network report, buildingSMART Australia held stakeholder consultation workshops across the nation in early 2012. The workshop recommended that national action be taken immediately in several identified areas in order to expedite BIM adoption in the Australian construction industry (Smart, 2016). Seven critical areas of priority were identified in that workshop:

- Procurement contracts that support collaborative BIM processes;
- BIM guidelines;
- BIM education;
- Product data and BIM libraries;
- Process and data exchange protocols;
- Regulatory frameworks; and
- Pilot projects.

Mustaffa et al. (2017) mentioned that, although stakeholders in the Australian construction industry recommend contracts supporting collaborative BIM processes, there is currently no published contract form that incorporates the BIM process in the Australian market. Conventionally, only a bespoke contract is used, even at level 2, the highest of the most widely used BIM levels. Subsequently, the ACIF-APPC ABIM framework was released in 2014, and the new South Wales Department of Health now requires BIM deliverables on all projects worth over $30 million. This action significantly increased BIM adoption in Australia, despite the absence of a central government mandate. Thus, Australia was designated as a country with a "restricted mandate" under New South Wales' Health BIM mandate. The Australian government has not enforced the use of BIM on public projects (Adama and Kouider, 2019), appearing to have a market-driven approach to BIM adoption. Although there are suggestions by relevant parties in the Australian construction industry to mandate BIM, the plan has received considerable scrutiny.

2.14.4 Using BIM in the KSA Construction Industry

Efforts to establish effective management and to achieve solid organisational performance are not progressing well in the KSA construction industry. The number of projects experiencing delays rose from 700 in 2009 to 3000 in 2013 (Alhumayn et al. 2017). Demonstrating this, numerous projects were put on hold, and owing to design flaws or a lack of competent project management, were left unfinished. This is a result of the project team members' inadequate involvement in project procedures and can be linked to a lack of planning and design. BIM is a virtual simulation and is considered to be an excellent tool for construction planning. It is a virtual approach that encompasses all parts of a facility in one virtual model so all design team members can work together more efficiently than was possible using older techniques (Azhar, 2011).

BIM, together with other digital software, has the potential to impact the Saudi construction sector significantly by addressing difficulties, such as estimating, scheduling and design coordination. The process of BIM group data-based modelling for visualisation, analysis and simulation capabilities is robust. By integrating BIM with building components, including mechanical, electrical and plumbing systems, the project can be coordinated visually, and potential conflicts identified. However, the Saudi construction sector has fallen behind in BIM adoption and implementation as a result of multiple obstacles, such as a dearth of skilled technicians who can manage the technological aspects, and a workforce shortage (Alhumayn et al., 2017). Consequently, a large part of the construction industry in KSA is reluctant to adopt novel ideas, such as BIM, an attitude which is impeding the country’s growth. Adopting

BIM can yield benefits in many areas, including the economy, but these advantages are often not widely understood or accepted in the construction business in KSA. In KSA, this sector remains heavily dependent on local sources, which suffer from the use of advanced technologies.

Although BIM is now being introduced in Saudi Arabia, the country still views the use of BIM as being in its early stages. Deployment of BIM in the KSA industry is therefore relatively gradual. Benefits connected with BIM adoption, such as the ability to produce multiple design options, to run many tests on a BIM model, and the potential to detect design problems early and to reduce costly reworks, is still unknown to most project owners (Alhumayn, et al., 2017). BIM in KSA construction is dominated by a few large organisations, with the subcontracting sector, which comprises the majority of construction firms, still lagging behind (Sodangi et al. 2018). Banawi and Aliobaly (2019) observed that a small number of large construction firms use BIM in their significant projects. Barriers to implementing BIM in KSA can be categorised as legal, business, human and technical. Additionally, the whole sector has limited expertise in BIM implementation. Sodangi et al. (2018) noted that considering only a few top construction firms in KSA have adopted BIM, the subcontracting sector, which is primarily composed of the country's small and medium-sized construction firms, has yet to do so. It has therefore become necessary to devise strategies in order to ensure that BIM is adopted by the firms in this crucial sector of the construction industry.

2.15 Benefits of BIM Application in Construction Industries

BIM has been a hot topic in the construction industry for many years. Despite all the discussion, there is significant uncertainty around BIM in this sector and the ways in which the concept may assist contractors. A widespread misunderstanding is that BIM is only technology or pertains exclusively to 3D design, although 3D models are indeed at the core of BIM. BIM is a procedure for creating and managing all project information, resulting in a model comprising digital descriptions for every part of the physical project (Hall, 2018). Although BIM is most associated with design and preconstruction, it improves every aspect of the project lifecycle, including for a considerable period following structure completion. BIM enables the virtual building of projects before their actual construction, reducing many inefficiencies and complications that arise during the construction process (Krzystof, 2019). The benefits of using BIM in construction are varied, but the principal advantages are listed in Table 5, which the explanation of its benefits are presented in detail in (Appendix D).

Table 5: Twelve principal benefits of BIM application in construction industries (Krzystof, 2019).

No	Benefits of BIM
1	Early detection of a collision
2	Faster design and construction
3	More precise planning
4	Visualisation at an early stage of the project
5	Higher quality of performed work
6	Better communication in the project
7	Reducing delays and errors
8	Increasing efficiency and productivity
9	Competitiveness
10	Easy access to information
11	Project life cycle
12	Improvement of health and safety

2.16 Connection Between Claims and BIM in the Construction Industry

Construction claims have become so widespread because of the dramatic rise in their number that it is expected that when projects grow in complexity, the frequency of causes for filing claims will also rise (Nassar and El Hawary, 2016). Numerous factors and events may lead to the emergence and development of construction claims. Even though there are steps to prevent claims and most projects use them, their total avoidance is challenging (Koc, 2014). Research indicates that project managers spend approximately 25% of their time resolving claims and disputes (Noorzai et al., 2021). According to a report by Arcadis Company, the average time required to resolve a construction dispute is 17 months, and the average value of these disputes is approximately $33 million worldwide (Arcadis, 2020). Indirect costs include a decline in project quality and a deterioration of working relationships between partners who would otherwise benefit from a long-term professional association. These ramifications highlight the significance of reasonable claim management procedures.

BIM has demonstrated its practical application and connection with claims in that its use can improve construction quality, shorten the duration of a project's delivery, and reduce the number of construction claims. Utilising BIM has the potential to improve building processes through enhanced analysis, to offer a more superficial investigation of additional alternatives, leading to fewer claims and reduced budget and time overruns. Rajendran (2014) agreed that BIM capabilities would considerably accelerate the construction process, save costs and minimise legal claims and conflicts. There is evidence that BIM is beneficial to the industry despite several potential challenges, such as concerns with model ownership, copyright protection, confusion about design liability, and a lack of contractual norms, model security and privacy (Noorzai et al., 2021). However, owing to its advantages, governments and building experts offer BIM as a solution to the difficulties in the construction industry. Several BIM technologies, such as BIM-Storm, facilitate the production of a design consistent with the owner's budget and specifications (Noorzai et al., 2021). BIM-Storm enables participants to collaborate via the web and to evaluate design alternatives from cost, time and sustainability perspectives in order to produce more realistic program needs. BIM is beneficial for automatically detecting design mistakes and assessing model modifications. The system can automatically generate a report for 3D object modifications between different model versions (Greenwald, 2013).

2.16.1 Role of BIM in Effective Claims Management

BIM has played a crucial role in developing numerous construction management sectors, including construction claims management. Claims depend heavily on the quality of the claim report. Claim evidence can be delivered through handwritten paperwork or computer-generated digital data (Khan et al., 2020). The use of electronic, visual and demonstrative evidence for construction claims will certainly accelerate the construction industry's use of BIM. All project information would be recorded in a central database linked to a 3D model that could be used to aid in the identification, quantification and visualisation of claims if BIM were utilised on a project from its inception, and suggested record-keeping processes were followed (Nassar and El Hawary, 2016). Visualisation plays a crucial role in achieving desired outcomes. It is typically used to enhance communication in architectural design, but its benefits can be enjoyed across the whole project's lifetime. In order to avoid disagreements, BIM can be utilised as a crucial tool for proactively resolving conflicts and claims (Khan et al., 2020). However, BIM has not yet been effectively employed to control construction claims. This could be attributable to the fact that BIM platforms and tools do not provide capabilities for handling construction claims. Nonetheless, most BIM platforms and tools have an application programming interface to create add-ins or plugins by modelling, accumulating data and visualising current BIM capabilities in order to execute specialised tasks (Noorzai et al., 2021).

2.17 Conclusion of the Literature Review Chapter

The literature review chapter has explained the nature and background of the construction sector in KSA, which increased to reach $120 billion in 2014. The KSA construction sector employs 15% of the workforce and consumes over 14% of the country's energy. The Saudi Vision 2030 initiative includes 3727 active projects worth $386.4 billion, with the first stage of that portfolio expected to be completed by 2025. The problem statement of the research is that the construction industry in KSA suffers from delivering significant numbers of projects on time within the determined budget. Research has indicated that 70% of Saudi public projects, comprising 662 projects estimated at 40 billion SR, faced significant delays with cost overruns.

The aim of the research is to investigate how advanced technologies, such as BIM, can reduce the number of disputable claims in the Saudi construction industry, and also globally. The objectives of the research are: (i) to identify different factors that cause disputable claims in residential and commercial projects in KSA; (ii) to investigate to what extent BIM can minimise disputable claims in both residential and commercial construction projects; and (iii) to examine how advanced technologies can facilitate the completion of construction projects with fewer disputed claims.

KSA has created opportunities for the construction sector, with planned and unawarded mega projects worth $825 billion. Contracts awarded increased from $11.2 billion in 2016 to $14.6 billion in 2018. However, the KSA construction sector faces challenges, which influence construction project delivery, generate issues from contractual and legal perspectives, and affect payment methods. These challenges, in practice, have the potential to lead to disputes between parties and, consequently, result in cost and time impacts. Additionally, in some cases of conflict, the termination of a project contract is expected. One of the significant sources of disputes in the KSA construction industry is that there is no standard form of contract, and yet these are used in the private sector. Instead, the parties usually employ a standard contract form that is written according to their needs. Important legal or technical parts that would help both parties may be omitted. The procurement system in the KSA public sector differs from that used in the private sector, in which a local standard form of contract, the PWC, is used. The procedure of the procurement system in the public sector relies on direct purchases or competitive bidding based on the volume of each project. However, the PWC form is primarily extracted from the FIDIC standard form of contract. From the risk perspective, KSA construction field practitioners expressed the opinion that PWC conditions do not risk-share between the contracting parties and put the owner in a superior position rather than sharing the expected risk with the contractor. The types of claims in construction that were explained in the literature review include contractual, common law, quantum merit and ex gratia claims.

BIM is an advanced technology to reduce claims in construction projects. This was critically explained in the literature review, which included its history and maturity level within the construction industry. Implementation of BIM in different construction industries have been investigated and concluded that 73% and close to 100% of UK and US construction companies, respectively, utilise BIM, whereas in KSA, BIM industry is still new and not yet widely implemented. The significant benefits obtained when implementing BIM in construction projects have been investigated, such as early clash detection, faster design and construction, more precise planning, and reductions in delays and errors. When analysing the root causes of claims in terms of time and cost impact, BIM plays an important role in claims management. BIM may be of advantage in claims analysis as traditional practices generally fail to satisfy the claimant parties and may result in less accurate outcomes.

CHAPTER 3: PAPER 1 – INVESTIGATING THE SOURCE OF CLAIMS WITH THE IMPORTANCE OF BIM APPLICATION ON REDUCING CONSTRUCTION DISPUTABLE CLAIMS IN KAS

Introduction

This section includes the first published paper as an article, which serves as the foundation for the thesis, which investigates the causes of disputable claims in the KSA construction industry. As the first published paper is an article, which included a primary data from the industry. This first research paper uses a narrative review methodology, which provides a broad overview of the construction claims from the existing literature. The characteristics of the selected methodology are subjective and qualitative. This research critically analyzes and summarizes previous literature and construction industry achievements to support the thesis and achieve its objective. Therefore, the methodology of this paper consists of three phases. The first phase involves conducting a review of relevant literature to investigate the factors causing claims in each construction project. The second phase focuses on collecting primary data from the KSA construction industry through interview sessions. These interviews were conducted with 35 experts from civil engineering, construction contracting, and consulting backgrounds. A total of 75 projects, including commercial, residential, and water lines, were selected for the interviews. The findings of the paper indicate that the most common types of claims in KSA construction projects are caused by payment delays from the owner (29%), design errors (27%), variation orders (36%), coordination issues (27%), contract ambiguities (23%), and lack of decisions from the owner and consultant (23%).

Paper 1

buildings

IMPACT FACTOR 3.8

CITESCORE 3.1

Article

Investigating the Source of Claims with the Importance of BIM Application on Reducing Construction Disputable Claims in KSA

Reda Abdelshafy Abougamil, David Thorpe and Amirhossein Heravi

Special Issue
Building Information Modelling (BIM) Applications in Construction Management

Edited by
Dr. Zhili Gao, Dr. Yilei Huang and Dr. Abdulaziz Banawi

MDPI

https://doi.org/10.3390/buildings13092219

buildings

MDPI

Article

Investigating the Source of Claims with the Importance of BIM Application on Reducing Construction Disputable Claims in KSA

Reda Abdelshafy Abougamil *, David Thorpe and Amirhossein Heravi

Department of Civil Engineering, Faculty of Health, Engineering and Sciences, School of Surveying and Built Environment, University of Southern Queensland, Springfield 4300, Australia; david.thorpe@usq.edu.au (D.T.); amirhossein.heravi@usq.edu.au (A.H.)
* Correspondence: u1092138@umail.usq.edu.au

Abstract: The construction industry in the Kingdom of Saudi Arabia (KSA) is a significant sector in the Middle East, with annual expenditures surpassing USD 120 billion. It employs approximately 15% of the workforce and consumes more than 14% of the country's energy resources. However, the Saudi construction sector encounters numerous challenges, including a deficiency in skilled labor, escalating costs, disputes, and material shortages. This study aims to investigate the origins of construction disputes in KSA and emphasize the significance of employing Building Information Modeling (BIM) applications to diminish the factors causing claims in both commercial and residential construction projects. The methodology employed comprises a comprehensive literature review and a field survey consisting of interview sessions. This study analyzes a total of 50 contributing factors to the causes of claims, along with conducting a field survey interview session involving 35 participants. The findings reveal seven substantial sources that give rise to construction claims in the KSA, impacting 75 projects, as discussed in this study. Furthermore, the research critically evaluates the advantages of utilizing BIM technology to mitigate construction disputes in the KSA. The data analysis results indicate that the reliance on traditional project management approaches is one of the catalysts for the emergence of disputes in the construction industry, particularly in the KSA.

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

check for updates

Citation: Abougamil, R.A.; Thorpe, D.; Heravi, A. Investigating the Source of Claims with the Importance of BIM Application on Reducing Construction Disputable Claims in KSA. *Buildings* **2023**, *13*, 2219. https://doi.org/10.3390/buildings13092219

Academic Editors: Abdulaziz Banawi, Zhili Gao and Yilei Huang

Received: 30 July 2023
Revised: 23 August 2023
Accepted: 29 August 2023
Published: 31 August 2023

Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

The construction industry in the Kingdom of Saudi Arabia (KSA) constitutes one of the largest sectors in the Middle East, boasting annual expenditures exceeding USD 120 billion [1,2]. Recently, Saudi Arabia has made significant investments in its construction and infrastructure development, aligning with the government's Vision 2030 plan to diversify the economy through the establishment of new industries such as tourism and entertainment [3]. Consequently, numerous large-scale construction projects are currently in progress, as exemplified by the NEOM project, projected to incur costs of approximately USD 500 billion [4,5]. The NEOM City initiative was officially introduced by Crown Prince Mohammed bin Salman in 2017 in adherence to the Vision 2030 plan, aiming to diversify the Saudi Arabian economy and reduce dependence on energy resources. Encompassing an expansive land area of 26,500 square kilometers, the NEOM City project will surpass Belgium in size [6]. Geographically, it will be strategically situated near the Red Sea and the Gulf of Aqaba, as well as the borders of Egypt, Jordan, and Israel [7]. Nonetheless, despite the thriving construction sector in the KSA and the ongoing NEOM project, various challenges persist, including frequent delays and cost overruns, often leading to contentious claims [8]. A research study conducted on the NEOM project reveals potential challenges in numerous realms, including finance, politics, and design [4]. Furthermore, Assaf and

Al-Hejji [9] ascertain that a staggering 70% of Saudi public projects experience significant delays due to cost overspends, possibly stemming from inaccuracies in project budget estimation [8]. Westland, J [10] proclaims that with enhanced cost estimation techniques at the disposal of project managers, time and financial resources could be better managed. Research confirms that the absence of construction technology, namely advanced software for cost estimation and comprehensive planning, may be a primary factor contributing to the lack of accuracy in early-stage construction project estimates [11,12].

Implementing Building Information Management (BIM) has the potential to be a viable solution for addressing the common challenges of delays and cost overruns in the construction sector of the KSA. While the adoption of BIM in this field may be relatively gradual, it offers significant benefits, such as the reduction in construction claims, clash detection, and minimizing changes in the original scope of work. Another advantage of using BIM is its potential to facilitate amicable resolution of disputes among conflicting parties, thereby mitigating the need for legal action. However, despite the evident advantages, the utilization of BIM in KSA projects remains limited, as indicated by previous studies [13–15]. In practice, the introduction of new approaches, such as BIM, for accurate project cost estimation is crucial for achieving precise budgeting. Moreover, leveraging advanced technology for accurate project calculations during the tender stage may convince contractors to eliminate the contingency amount, typically allocated as 5–7% of the budget to account for hidden risks [16]. The insufficient utilization of BIM in KSA construction projects has resulted in various disputes stemming from ambiguities in contracts, documentation, and unprofessional claim presentations. Additionally, neighboring countries to KSA, Egypt and the United Arab Emirates (UAE) have yet to fully realize mandatory implementation of BIM in their construction industries. Existing literature indicates the absence of specific regulations for BIM in KSA, Egypt, and UAE, highlighting that the adoption of BIM is not currently obligatory in these countries [13,17,18].

To mitigate frequent contentious construction claims, it is highly recommended for participants involved in construction projects to employ Building Information Modeling (BIM) technology. The utilization of BIM can enhance collaboration, facilitate efficient change management, and ensure the use of accurate and updated information in a proactive manner [19]. Moreover, the absence of BIM poses challenges for managing variations during the construction process. While variations are inevitable in any construction projects, effectively tracking and managing them becomes arduous without the support of BIM, potentially leading to disputes among project stakeholders [20]. Despite the benefits of implementing BIM, several obstacles hinder the widespread adoption of this technology in the KSA construction industry, including a lack of awareness and training, standardization issues, high implementation costs (particularly for small organizations), and insufficient government support [10]. Overcoming these barriers necessitates collaborative efforts among construction professionals, government agencies, and educational institutions to promote the integration of BIM technology within the KSA construction sector. Accordingly, this article aims to inquire into the root causes of contentious claims within the KSA construction industry, emphasizing the significance of BIM employment in overcoming such issues. The subsequent section will review pertinent literature, followed by an elucidation of the research methodology, and subsequently present the findings and discussion before concluding this article.

2. Literature Review

2.1. The Importance of the Construction Sector in KSA

During the last 20 years, the Kingdom of Saudi Arabia (KSA) has seen an extraordinary increase in construction projects [21]. It boasts the Middle East's largest construction sector, which is expanding, with current expenditure exceeding USD 120 billion per year [9,22]. In addition, the construction industry employs 15% of the Kingdom's workforce and consumes more than 14% of the country's energy [13]. The awarded construction contracts in the public sector of the KSA increased from USD 78 billion in 2013 to USD 141 billion in 2018 [1,23]. The private and public sectors of construction focus more on Vision 2030, in which the demand for infrastructure development is expected to be increased [24]. Albarrak [25] stated that the economy of the KSA is transitioning into the post-oil era, wherein the construction sector is growing the fastest, with 3727 active projects worth USD 386.4 billion by 2025. Additionally, the construction market of the KSA is expected to grow at a compound annual growth rate of 6% between 2019 and 2024 [24]. The NEOM project is currently considered the largest project in the KSA as part of Saudi Vision 2030, in which the initial cost estimation of the NEOM project is targeted to reach USD 500 billion [5]. The developers believe that NEOM will exist entirely outside the current Saudi judicial system [6]. NEOM is designed to be home to oxygen, a seven km-long floating city, which would be the world's largest floating structure [4]. NEOM announced plans for the world's largest coral reef restoration project, located further on the Red Sea coast from this industrial hub [26]. Even though the construction sector is booming in KSA, it is struggling to measure and improve its performance. Common concerns include but are not limited to time delays, cost overruns, and issues with safety and quality [27]. Inevitably, the delayed construction industry in KSA is an old challenging issue that has harmed the industry's reputation [21]. As a result, this paved the way for researchers to investigate and resolve this issue, in which USD 147 billion is in jeopardy due to delayed public projects [9,21,27]. On the other hand, construction parties are increasingly concerned about delays in large-scale construction projects in the Kingdom of Saudi Arabia, which is regarded as a construction engineering facility [21]. In the following section, the challenges that hinder the KSA construction sector are investigated and explained in depth.

2.2. *Legal Challenges in the KSA Construction Sector*

The construction sector in the KSA faces challenges from different perspectives; for instance, the legal system in the KSA is distinct from other countries such as the USA, UK, and Europe [23]. Appointments controlling projects in the KSA are governed by Saudi law, which primarily comprises Shari'ah and Islamic laws. According to Islamic law, Contracts that include provisions for payment or receipt of interest are generally unenforceable, which might not be preferable for foreign contractors and investors involved in Saudi construction in the event of their delayed payments from the local client's side [28]. The KSA lacks an overarching civil code or commercial law, although individual Royal Orders, Ministerial Circulars can impose additional legal obligations [23]. Therefore, foreign investors must be aware of the principles of conflicting laws when drafting a contract under Saudi law. Shari'ah law requires parties to preserve the principles of fairness and equity during the execution of the work [19]. Contractors and consultants, when completing a construction project, must adhere to the Saudi Building Code and Sustainability Standard that was recently issued in 2020 [29]. Decennial liabilities represent a risk for some construction projects in Saudi Arabia due to the lack of awareness of the need for indemnity insurance for any construction project [13]. A study survey demonstrated that the NEOM project might face legal and contractual challenges due to the involvement of foreign investors, which might not be familiar with Saudi law [4]. Lack of advanced technology and a shortage of skilled manpower is considered other challenges that face the NEOM project [5]. Therefore, the KSA government is drafting special legislation that would safeguard investors while also facilitating the ability to introduce multinational companies to reimburse the lack of technology and skilled labor [19].

Challenges in the KSA construction sector are not limited to the private sector. In the public construction sector, the Public Works Contract (PWC) is the local standard form of contract used, which is silent on employers' liability for non or delayed payment in various remedies [10]. Charging interest for late payments is prohibited by Shari'ah law, which is applicable in Saudi Arabia. Consequently, a party involved in a construction project is often compelled to provide services even if the payment is delayed [30]. However, most commercial disputes in the KSA are heard by Shari'ah courts, which have broad jurisdiction over all civil and criminal cases. The Board of Grievances is a specialist tribunal with jurisdiction over many commercial and contractual disputes involving government entities [31]. It is likely to consider any case that involves a public sector entity. There are no specialized professional bodies in the Saudi Arabian construction industry to tackle or develop that field. In contrast to the UK construction industry, for example, the Institution of Civil Engineers (ICE) in addition to other professional bodies in the UK field created the New Engineering Contract (NEC) more than four decades ago, which is still applicable and periodically updated and used in the UK and other countries such as South Africa [32,33]. One of the reasons why project owners choose the NEC family of contracts in the UK is to avoid the risk of claims and disputes long after the completion of the project [34]. Even under the doctrine of law, there are no specialized courts or construction lawyers to act professionally in the construction cases of the KSA.

Under the UK legal system, the Technology and Construction Court (TCC) is a specialist court with specialist judges who deal with all forms of construction, engineering, and technology disputes that arise both within the UK and internationally [35]. In addition, the Housing Grants, Construction, and Regeneration Act of 1996 is the legal code that governs construction cases in the United Kingdom and English Courts [36]. Regardless of the path taken under the legal system of the KSA, the enforcement process is typically lengthy and challenging, and in some cases, the ultimate speed of the court's decision is dependent on the clarity of the plaintiff's presented documents. Another challenge is the slow payment procedure, which can put contractors and suppliers in bankruptcy. To address this issue in the public sector, the government might create a detailed payment plan and ensure that payments get paid on time [31]. Furthermore, there is a lack of transparency in the government contract bidding process, which can lead to corruption and favoritism. This problem can be solved by putting in place a transparent procurement procedure that provides fairness and equal opportunity for all bids. However, the government recently launched an electronic system called "Manasat Etimad" for interested parties who desire to deal with public tenders [37]. While the government contract in the construction public sector in Saudi Arabia faces several challenges. These issues can be addressed through increased clarity in contract terms, timely payments, transparency in bidding processes, investment in local expertise, and improved communication and coordination between government agencies [38].

2.3. Types of Legal and Contractual Claims in the KSA Construction Projects

Claims and legal disputes are common in both public and private construction projects; therefore, this section explains the distinction between legal classifications and types of construction claims. Contractual claims are based on the provisions of a legally binding contract between two or more parties involved in a construction project, while legal claims may arise based on implied terms that are not necessarily part of that binding contract [39]. Variations in quantity or quality and liquidated damage for defect repair are examples of contractual claims [40]. It is a common practice in the construction business to refer to common law claims as extra-contractual or legal claims [41]. Therefore, it is important to differentiate between contractual and extra-contractual claims that may arise in contract terms. Prolonged time and money claims are examples of loss and expense claims. Common law-based contract forms commonly include procedures for handling claims [41]. Furthermore, legal claims may arise beyond contractual terms, such as a breach of contract conditions or failure to comply with health and safety regulations, leading to significant harm, or death. In addition, there may be legal claims for damages if a part or the entire building collapses because its structure is not stable [39].

A claim under quantum meruit may arise in various circumstances, not all of which will include a breach of contract by the owner [40]. For example, the evaluated claim under a quantum meruit may be subjected to a Letter of Intent (LOI), which is a general word for a document that states a party's intention to engage in a formal contract later and, in the meantime, requires the other party to carry out work before the contract is finalized [42]. This document is typically in the form of a letter from an employer to a contractor containing instructions to carry out work, with the final agreement negotiated or finished later [41]. A quantum meruit claim cannot arise if the parties have a contract to pay an agreed sum. Ex gratia claims are made when money is paid against work done without the owner having any obligation or liability to do so. An owner may pay an ex gratia sum to save a contractor from becoming insolvent when it costs far more to hire another contractor [43].

2.4. Common Claims Factors That Drive up Construction Project Costs

This study investigated from the relevant literature 50 common factors that drive up construction project costs and cause disputable claims, as shown in Table 1. Preventive actions to mitigate the source of potential claims, such as errors during the design stage, must be considered in the initial stages of any project [38]. The purpose of preventive actions to reduce design errors is to reduce potential claims during the construction stage, which may lead to legal disputes. In large construction projects, the direct costs related to disputes can reach 0.5–5% of the contract value [44]. A study conducted in Malaysia stated that 92% of construction projects were delayed, whereas only 8% of projects had been completed within the planned time [45]. Variation orders that lead to time and cost overruns are considered the most common factors related to disputable claims. The number of projects experiencing claims related to variations and delays in the KSA increased from 700 to 3000 in the last five years [43].

Table 1. The 50 common claims factors that drive up construction projects costs.

No	Claim Factors	References	No	Claim Factors	References
1	Improper design	[8,19,20,27,32,35,37]	26	Extension of time	[8,9,15,19,32,35]
2	Variations and change orders	[8,9,13,20,35,37]	27	Delay Contractor's payments	[8,9,13,20,35,37]
3	Change in the original scope	[7,9,14,16,30,35,38]	28	Time schedule acceleration	[7,9,14,16,30,35,38]
4	Incomplete drawings from the client	[8,9,15,19,32,35]	29	Changes in the original quantity	[15,21,24,30,35]
5	Changes in specifications	[19,21,30,39]	30	Drawings not fitting construction sites	[19,21,39]
6	Ambiguous and incomplete drawings	[19,20,27,32]	31	Modifications in the construction stage	[20,27,32]
7	Changes in the site location	[9,14,16,30,35]	32	Slow decision making from the consultant	[9,14,16,30,35]
8	Poor safety measures	[9,11,20,35,37]	33	Prices increase in materials	[8,9,15,19,32,35]
9	Force majeure	[8,9,15,19,32,35]	34	Errors and defects in contract	[19,20,27,32]
10	Different site conditions	[8,9,15,19,32,35]	35	Lack of communication between parties	[20,21,25,32]
11	Use of unsuitable techniques	[14,16,23,35,37]	36	Lack of contract awareness	[14,16,23,35,37]
12	Concurrent delays from both parties	[9,14,16,30,35]	37	Instability of political situation	[9,14,16,30,35]
13	Economic conditions	[15,21,24,30,35]	38	Financial problems	[19,21,30,39]
14	Weather conditions	[19,21,30,39]	39	Failure to possess site work	[19,21,30,39]
15	Planning and scheduling problems	[8,9,15,19,32,35]	40	Procurement plan deficiency	[19,20,27,32]
16	Delay in supply drawings	[15,21,24,30,35]	41	Delay in handing over the site	[15,21,24,30,35]
17	Ambiguities in contract documents	[19,21,30,39]	42	Poor construction management	[19,21,30,39]
18	Failure to provide Bond claims	[12,27,32,36,39]	43	Construction defects	[12,27,32,36,39]
19	Breach of contract by either party	[19–21,27,32]	44	Personal injuries due to lack of safety	[19–21,27,32]
20	Changes in price and inflation	[19–21,27,32]	45	Government regulations and laws	[15,21,24,30,35]
21	Lack of control over subcontractor	[19,21,30,39]	46	Poor quality of contractor's work	[19,21,30,39]
22	Delay caused by the contractor	[19–21,27,32]	47	Variations Vs original designs	[12,19,27,32,35]
23	Underestimation of projects cost	[15,19,21,30,39]	48	Site permits delays from a municipality	[19,21,30,39]
24	Low productivity and efficiency	[19,20,27,32]	49	Lack of communication and coordination	[20,27,32]
25	Unqualified manpower	[19–21,27,32]	50	Change orders during construction	[8,9,15,19,32,35]

Construction projects with time and cost overruns can become overburdened with substantial repercussions for all involved parties. For example, clients may be unable to use facilities at the planned time, wherein the consultation and design fees may increase. From a contracting perspective, the consequences could include reputational damage and being stuck on a single project for an extended period [46]. The Channel Tunnel project was one of the most well-known cost-overrun examples, with construction costs increasing from GBP 4.80 billion to GBP 9.50 billion [47]. The Great Belt Link, which is 18 km long and connects the eastern and western parts of Denmark, incurred 54% of cost overrun [46]. Other international examples of projects with cost overruns include the Humber Bridge and Paris Nord TGV 25% cost overrun [47]. A study conducted in Korea's construction industry showed that the average final cost of seven mega-projects increased by 122.4% compared with the initial planned cost of USD 1 billion [46,47]. A study included a survey conducted on 130 public projects in Jordan and found delays in 106 projects, represented by 82%. Another study in Ghana observed that 33 (70%) out of 47 construction projects were delayed [48].

2.5. Source of Claims in the KSA Construction Sector

Generally, claims are not welcome; however, employers and financial institutions place a high priority on price and time certainty. It is not surprising that construction contracts restrict the contractor from modifying any part of the original scope of work during the construction stage without prior written approval from the owner [44]. A change order from the owner might lead to additional time and cost. In such a case, the contractor must notify the owner immediately in writing and obtain written approval from him of such an additional charge and a new completion date before beginning such work [22]. As found in the existing literature and shown in Table 2, the sources of claims in the KSA construction sector are diverse. Most crucially, the principal causes of claims are associated with the lack to adopt new technology such as BIM in project management. Poor coordination, an incomplete BIM model, and an underestimated budget are just a few examples that might be sources of claims [49]. Further, major causes of claims in KSA are related to contractor payment delays from owners' side. Financial difficulties challenge the contractors because most of them might not be able to inject the required money into a project if the owner delays or holds the contractor's payments unreasonably [6]. Importantly, contractors shall be entitled, under Sub-Clause 14.7 of the FIDIC contract conditions to receive financing charges compounded monthly on the amount unpaid from the owners [50]. Moreover, from a risk-sharing perspective, the contractors may not be charged if they slow down the progress of the work and reduce the project's resources due to payment delays by the owners. Unlike a construction agreement between a contractor and the government in the public sector in KSA using PWC local contract form, where the contractor cannot stop or slow the progress of work even if the government's payment is delayed. In addition, the contractor who signed a contract with the public sector is not eligible to be compensated with additional charge money for the delayed payments. Therefore, contractors must be aware when signing a contract with the public sector and be prepared for funding sources in the event of delayed payments. Hence, this study investigates the source of claims in the KSA using primary data from a field survey, which will be analyzed and discussed in the data analysis and discussion chapters, respectively.

2.6. Key Factors to Mitigate Potential Claims in Construction Projects

Construction projects are challenging and necessitate extensive planning, coordination, and execution. Several key factors must be considered to ensure the success of a construction project [41]. Quantifying a project's success is a complex process because success is subjective and difficult to agree upon. However, success factors can be defined as the extent to which project aims and expectations are realized. An unclear contractual agreement is one of the main sources of disputable claims in construction projects due to a lack of clarity in the contract conditions [40]. A key success factor for avoiding disputable claims is the clarity of the contract, which must be concise and outline the scope of work, such as payment terms, timelines, and quality standards. Further, the language of the contract and the simplicity of the terms and conditions are essential for the engineers and contracts managers to manage. The New Engineering family of Contracts (NEC) is a good example of the simplicity of contract language [51]. It is a formalized system developed by the UK Institution of Civil Engineers that guides the drafting of documentation for civil engineering, construction, and maintenance projects to obtain tenders, award contracts, and administer them [52]. In both the United Kingdom and Hong Kong, the NEC contract is frequently used [41]. Since at least 1994, there have been mainly failed attempts to introduce the NEC contract into both Australia and New Zealand, but the contract remains somewhat obscure in both countries [41]. This study investigated important success factors for any construction project, as listed in Table 3 [39]. From the researcher's experience in the KSA construction industry, most of the winning tenders in both the private and public sectors of construction are based on the lowest price, which is not always the best option. This prevalent technique is due to intense price competition among tenders, which in some cases jeopardizes project quality. Furthermore, regardless of the lowest agreed-upon price, the owners frequently rely on consultants to control the quality of the project. Controlling quality from the consultant's perspective with an underutilized contractor, on the other hand, is challenging and may result in disputes. To minimize future problems, owners must examine the short-listed contractors technically and financially during the bidding stage.

Table 2. Source of claims in the KSA construction industry.

No	Factors Group Related to Time Claim and Cost Overrun	References
1	Financier and Cost Group Causes	
1.1	Financial difficulties from owner side	[8,19,20,27,32,38]
1.2	Underestimated budget for the potential project	[14,15,20,22,27,38]
1.3	Slow and delay payments of completed work	[9,14,16,30,35,37]
1.4	Contractor financial challenges	[15,16,21,24,30,35]
1.5	Low-cost contract related to severe contractor competition	[19,21,30,39]
1.6	Payment delayed from the project client	[19,20,27,32]
1.7	Factors due to unbalanced bidder	[9,14,16,30,35]
1.8	Factors due to inadequate bid information	[20,35,37]
1.9	Factors due to the actual work done but not measured and paid	[19,20,27,32]
2	Claims Factors Related to Time Overrun	
2.1	Suspension of project work from the client side	[20,24,27,35]
2.2	Poor coordination and supervision	[20,35,37]
2.3	Delay in procurement or delivery of material	[9,14,16,30,35]
2.4	Un-interoperability of BIM tools	[15,21,24,30,35]
2.5	Shortage on materials on the market	[19,21,30,39]
2.6	Suspension of work from the owner or the contractor	[19,20,27,32]
2.7	Delay in mobilization time by the contractor	[9,14,16,30,35]
2.8	Oral change orders by client	[20,35,37]
2.9	Low productivity from the contractor's labors	[19,20,27,32]
2.10	Delay in Supply of Drawings	[7,14,35,35]
2.11	Poor BIM integration and management	[8,20,29,37]
2.12	Incomplete BIM model at the time of budgeting	[19,20,27,32]
2.13	Design changes to the BIM model	[9,14,16,30,35]

Table 3. Key factors to mitigate potential claims in construction projects.

No	Key Success Factors	References
1	Good coordination between the project parties	[19,20,27,32,38]
2	Using advanced technology in design and construction	[20,24,35,37]
3	Panel optimization	[9,14,16,30,35]
4	Proper choice of materials selection	[15,21,24,30,35]
5	Avoid underestimated tender price	[19,21,30,39]
6	Contractor experience	[19–21,27,32]
7	A Realistic time plan to complete the project	[9,14,16,30,35]
8	Minimal design changes during the construction process	[9,20,35–37]
9	Reduced labor costs with proper productivity	[19,20,27,32]
10	Value engineering to be studied after finishing the design	[20,21,25,32]
11	Adequacy of plans and specifications	[21,35,37,38]
12	Technical capability of the project manager	[9,14,16,30,35]
13	Adaptability of the project manager to changes in project plans	[15,21,24,30,35]
14	Project Manager early involvement in the project plans	[19,21,26,30,39]
15	Commitment of the project manager to satisfy quality, cost, and schedule	[19,20,27,32]
16	Communication system and control mechanism	[9,14,16,30,35]

2.7. BIM Review in the Construction Industry

Hamil [53] defined BIM as a process for creating and managing information on a construction project throughout its life cycle. BIM is not simply a tool or software; instead, it is a comprehensive process that enables all project parties, including architects, engineers, contractors, and other construction professionals, to plan, design, and build within a comprehensive 3D, 4D and 5D model [54]. BIM is also an acronym for building information modelling or building information management. The National Institute of Building Sciences defines BIM as an automated process that illustrates the physical and functional features of a facility. BIM works as a collaborative knowledge resource for building information, providing people with a consistent place to make decisions throughout a building's service life [54]. When extended and used in facility management as (6D) model, BIM can be used to manage buildings using data. Using BIM during the operational process as (facility management tool) can collaborate with Building Management System (BMS). The lifecycle and process of BIM in the construction industry is explained in the Australia and New Zealand guide as well [49].

It is prudent to acknowledge the significant advancements made in information and communication technologies (ICTs) over the past few decades, and their potential to enhance contemporary management practices [55]. The field of Architecture, Engineering, and Construction (AEC) has undergone significant transformation in its management and information exchange, owing to the swift and pioneering progressions in Information and Communication Technologies (ICTs). The interplay among technology, the construction industry, and legal frameworks is a constantly evolving and dynamic phenomenon, wherein advancements in one domain invariably catalyze transformations in the others [56]. The advent of Building Information Modelling (BIM) has been noted as a significant technological advancement in construction management, with a plethora of reported benefits across various projects [57]. In addition to the technical power of BIM, its capacity for interoperability, early information acquisition, integrated procurement, and enhanced cost control mechanisms, it also offers benefits in the form of diminished conflict and advantages for construction projects [16].

2.7.1. Levels of BIM in the Construction Industry

As indicated in Figure 1, presented below, BIM (Level 0) effectively implies the absence of collaboration in its most basic form. Primarily, two-dimensional CAD drafting is employed for the production of Information [31]. Output and distribution are achieved through the utilization of paper, electronic prints, or a combination of both. BIM (Level 1) amalgamates 3D CAD for conceptual design and 2D drafting for the preparation of statutory approval documentation and production information. The management of CAD standards is conducted in accordance with British Standards (BS 1192:2007) [58]. Data sharing takes place through a commonly shared data environment, often administered by contractors [38]. BIM (Level 2) is characterized by collaborative work and necessitates a project-specific mechanism for sharing information that is coordinated between multiple systems. Each party utilizing the CAD software must possess the capability to export it to a standardized file format, such as the Industry Foundation Class (IFC) or Construction Operations Building Information Exchange (COBIE). Although BIM (Level 3) has not been fully defined, the UK Government's Level 3 Strategic Plan outlines its objectives [19]. The establishment of new international data standards will facilitate seamless data sharing across various industries. Simultaneously, the training of public sector stakeholders on BIM approaches, including data requirements and operational methods, will be prioritized.

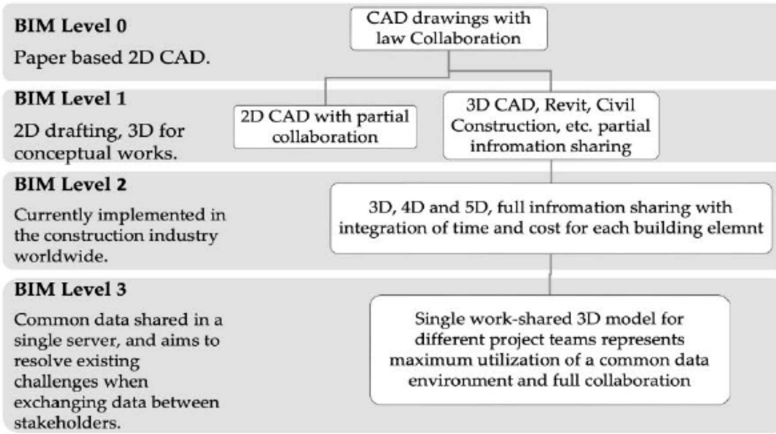


Figure 1. An illustration of BIM level uses in the construction industry [19,38,58].

2.7.2. Benefits of BIM Application for Claims Reduction in the KSA Construction Industry

BIM, which is a computer-based approach to building management that aims to improve efficiency and reduce claims, is a relatively new technology that is rapidly gaining acceptance in the construction industry [10]. BIM makes it easier to look at more options and analyze them better, filing fewer claims, and going over budgets and schedules less often. BIM has been proposed for use in the construction industry in Saudi Arabia and other adjacent construction neighborhoods in the Gulf Region. The primary goal of proposing BIM to be used in the KSA is that the implementation of BIM is not yet mandatory. A field survey case study explained that only 20% of construction companies in the Middle East are implementing BIM, and 80% are not applying or involved in the adoption process [59]. BIM is a virtual approach that encompasses all parts of a facility in a virtual model so that all design team members can work together more efficiently than with old techniques [54]. BIM combined with other digital software can significantly impact the Saudi construction sector.

The construction industry in the KSA is highly dependent on local sources; therefore, it must be technologically advanced. Adopting BIM can yield benefits in many areas, such as the economy and sustainability. BIM allows designers to produce multiple design options and perform numerous tests on a BIM model. A conference paper by Banawi and Aliobaly [60] mentioned that a small number of large construction firms use BIM in their significant projects. Barriers to BIM implementation can be categorized as legal, business, human, and technical; the entire sector has limited expertise in BIM implementation as well [16]. BIM enables the virtual building of projects before their actual construction, reducing the inefficiencies and complications that occur during the construction process [30]. The following sections explain the top benefits of BIM when implemented in the KSA construction projects to reduce construction disputes.

Early Detection of Design Errors: A BIM model might never be completely accurate to reality, but it can be accurately modelled, and the construction conditions will, of course, validate everything. However, even if the BIM model recognizes at least some of the errors before the construction stage, it may simply avoid them on the construction site. Since BIM tools assist users in automating the detection of items such as electrical cables, sewer pipes, and ventilation ducts [47]. Simply, BIM may enable a clash detector, which will automatically verify clashes and generate reports. Instead of manually reviewing drawings from multiple sources, which could prolong the time needed to discover clashes and may give the contractor the right to raise a time claim if he discovers design errors during the construction stage [31]. However, as a rule of thumb in the KSA industry, when following the traditional methods of designing a project, not all clients able to visualize their projects on papers. As a result of their inability to visualize the scope of the project in the planning stages, many of them are likely to require design modifications during construction works. Owners should avoid a lack of design visualization by finalizing the BIM Level of Development (LOD 300) during the detailed design phase as shown in Figure 2 [61]. By visualizing the project in (LOD 300), the owner or his technical representatives can minimize the likelihood of scope changes throughout the construction phase.

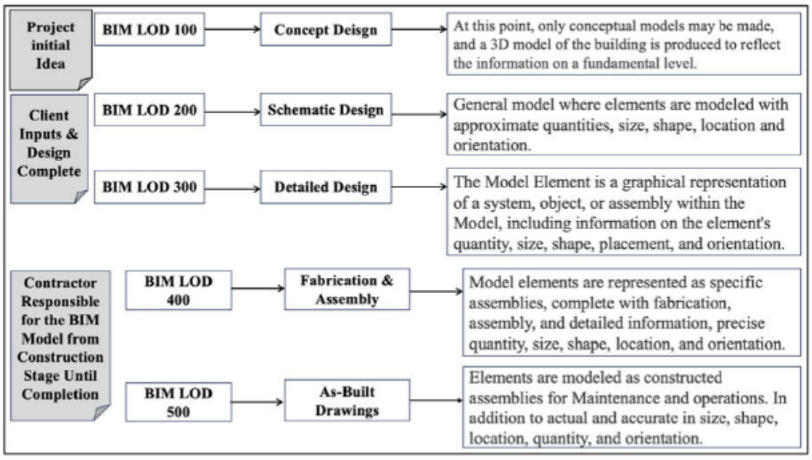


Figure 2. Level of developments of BIM application in construction projects [24].

Mitigate Risk and Reduce Cost: A study by McKinsey found that 75% of organizations that have embraced BIM have experienced positive returns on their investments. Closer coordination, especially from contractors, can result in reduced tender risk assessments, lower insurance costs, fewer overall variations, and fewer claims' opportunities. A better understanding of the project before beginning enables more prefabrication and avoids waste of unneeded materials [54]. Contractors in the (LOD 400) stage can run the BIM model to detect any clashes, if any, and then begin fabricating the necessary objects and materials to finish the project activities precisely, without conflicts and saving time.

Reducing Delays and Errors: Most design offices in KSA develop 3D models of their constructions, but they still transfer them on papers since papers authorizes everything, which increases the likelihood of errors. Therefore, the logical next step is to eliminate the transitional phase and solely use the 3D model as a final product [62]. A contractor with a reinforcement model can make his or her own orders by generating bending lists immediately on the job site, independent of the designer. An example is when the contractor on one of the projects received a reinforcement list with 40 pages and over 200 tons of reinforcement, and nothing was separated into pieces. Because it was easier for the designer, the foundations, walls, and the rest of the building skeleton were all combined in one document [31]. As a result, the contractor had to sift through tons of paper to identify the items needed. In cases involving drafting a money claim compensation from a contractor side due to market fluctuations in steel prices, and when traditional methods are used rather than BIM to examine the compensation claim, the contractor may spend a long time developing the compensation claim, with doubtful accuracy of the claim amount.

2.7.3. Connection between Claims and BIM in the Construction Industry

Construction claims have become widespread, and it is expected that when projects grow in complexity, the number of reasons for filing claims might increase as well. One of the reasons for increasing the degree of claims nowadays is the complexity of modern architectural projects that involve hundreds of activities [59]. According to an industrial report, the average time required to resolve a construction dispute in KSA can reach 17 months, and the average value of these disputes is approximately USD 33 million worldwide [40]. Construction claims management depends on the quality of the construction claims report. Claims evidence can be delivered verbally through handwritten paperwork or computer-generated digital data. With the BIM application, all project information is recorded in a central database linked to a 3D model that can be used to aid in the identification, quantification, and visualization of claims [31]. BIM has not been effectively employed to manage construction claims. This can be attributed to the fact that BIM platforms and tools do not have the capability to handle construction claims [59]. BIM can improve construction quality, shorten the duration of project delivery, and reduce construction claims. It can improve building processes through enhanced analysis, a more superficial investigation of more alternatives, fewer claims, and reduced budget and time overruns [62]. There is evidence that BIM is beneficial to the industry despite several potential challenges. Government and building experts have offered BIM as a solution to difficulties in the construction industry [40]. Several BIM technologies facilitate the production of designs that are consistent with the owner's budget and specifications [59].

2.7.4. Potential Hurdles of Implementing BIM in the KSA Construction Industry

Even though BIM is not yet mandatory in Saudi Arabia, the KSA has been actively promoting the adoption of BIM in the construction and infrastructure sectors since 2021. The local National Transformation Program (NTP) 2020 guidelines and standards aim to increase BIM use in the KSA construction industry [63]. It emphasized the significance of adopting advanced technologies such as BIM to improve construction project efficiency and quality. In addition, the Saudi Buildings family of Codes, which is published by the Saudi Arabian Standards, Metrology, and Quality Organization (SASO) in 2020, provides guidance on construction practices refereed to BIM application [37]. It is probable that BIM requirements and standards are incorporated into specific sections of the code. Currently, most foreign construction companies and consulting firms operating in the construction sector of the KSA employ their own project management systems, which often incorporate BIM technology [20]. The authors argue that most multinational construction firms operating within the construction industry of the KSA have the potential to improve the project management system of local subcontractors upon their participation in construction projects. Hence, it is imperative for the government of the Kingdom of Saudi Arabia (KSA) to actively promote the dissemination of BIM inside the country.

Similarly, this study investigated further the implementation of BIM in Egypt, a neighboring country to the KSA, which found that BIM is still in its nascent stage [18,63]. A comprehensive study was conducted in Egypt through an online survey that reached out to a sample of 42 professionals specializing in architecture, engineering, and contracting [18]. The findings of the survey highlighted that a significant portion of the participants expressed limited familiarity with or comprehension of the concept of BIM [64]. However, it was observed that professionals in the construction industry and governmental bodies were increasingly recognizing the advantages of BIM. Notably, the Egyptian construction sector lacks explicit building legislation pertaining to the application of BIM [65]. Nonetheless, practitioners from the construction field argued that BIM has the potential to enhance collaboration, mitigate errors, optimize project efficiency, and foster streamlined communication among various stakeholders [64,65]. The Egyptian government has exhibited a proclivity for acknowledging the potential benefits of BIM.

Likewise, the study investigated the construction sector in the United Arab Emirates (UAE), in which most construction projects are delivered on a fast-track basis. The main driving force behind this is the incentives that developers, including government organizations, offer [17]. Despite the significant growth of the construction sector in the UAE, research indicates that BIM is currently mandated in Dubai for specific project types, but it is not yet obligatory for all construction projects in the UAE or in all its emirates. Only a small percentage, ranging from 6% to 10% of contractors in the UAE industry possess knowledge or awareness regarding the complete extent of BIM [17,66]. There is a need to establish BIM standards and protocols specifically tailored to the UAE construction industry. It is imperative to standardize the BIM process within the context of the UAE industry to ensure the successful implementation of BIM [17,66,67]. Although the utilization of BIM is emerging in the UAE, there is a lack of BIM contractual documents. Since the Dubai Municipality mandated the use of BIM in 2013, it has increasingly been employed in large-scale projects across the UAE [68]. Unlike jurisdictions such as the UK, few standards have been developed for BIM adoption in the UAE, and the contractual agreements often fail to reflect the BIM approach. This leads to potential ambiguity regarding the obligations and responsibilities related to BIM [17]. Consequently, it is crucial to carefully consider the relevant standards and contractual position for any BIM project in the UAE.

Despite the substantial advantages of BIM, as explained in the preceding sections, the construction sector in countries such as the KSA, Egypt and UAE have yet to implement BIM [10,17,63]. This is due to a variety of barriers, challenges, and hurdles to its adoption and implementation [20]. Several research investigations have focused on this fact [20,69–71]. This study highlighted four areas of potential obstacles, challenges, and impediments to BIM adoption and implementation. (1) Legal Conditions: the implementation of BIM in Saudi Arabia may be hindered by the country's current legal framework [10]. BIM-specific regulations and standards may not be well established or enforced, creating uncertainty, and impeding the widespread adoption of BIM practices [10,72]. In addition, it may be necessary to update the legal framework to resolve issues such as intellectual property rights, data ownership, and liability concerns related to BIM implementation. (2) Cultural practices can influence the adoption of new technologies such as BIM. There may be resistance to change in Saudi Arabia, where traditional construction practices are significantly rooted [72,73]. The construction industry's reliance on hierarchical decision-making processes and conventional project delivery methods may pose obstacles to the adoption of BIM enabled collaborative workflows. It may be necessary to resolve cultural attitudes toward information sharing and collaboration through awareness campaigns and training. (3) Technological limitations might also make it more difficult to implement BIM in Saudi Arabia [10]. The availability of a dependable Internet connection, a compatible hardware infrastructure, and software compatibility are essential for the successful implementation of BIM [10,20]. For effective collaboration among project stakeholders, it is essential to ensure access to current software tools and promote interoperability between different software platforms. (4) Organizational impediments: when using BIM, organizations in the construction industry may encounter internal impediments [73]. Resistance to change, a lack of understanding of the benefits of BIM, and insufficient training can all stymie the adoption process [71,73]. Furthermore, firms must invest in employee training and development programs to ensure that employees have the essential abilities to work effectively with BIM [10,20].

As indicated in Figures 3 and 4, the sources of claims and the strategy of claims avoidance rely on the usage of BIM technology. However, it is essential to establish a universally accepted definition of BIM and develop a systematic approach to evaluate the benefits of BIM [70]. Although the adoption of BIM is increasingly prevalent in the (AEC) worldwide, the lack of skilled professionals poses a significant challenge to the widespread implementation of BIM [72]. Clients are required to provide their consent in the contractual documents and accept it as a binding condition in order to incorporate the data-rich BIM model into their projects. It is vital for owners to embrace a paradigm shift, moving away from relying solely on the Rate of Investment (ROI) as a means of justification and instead employing an evaluation methodology that comprehensively considers the value and benefits of BIM throughout the entire project lifespan [20,69,73].

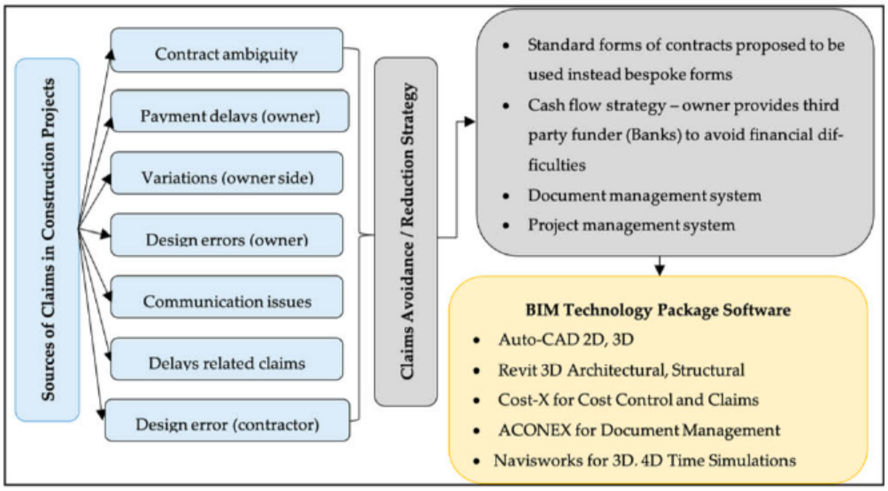


Figure 3. Sources of claims with strategy of claims avoidance based on BIM implementation.

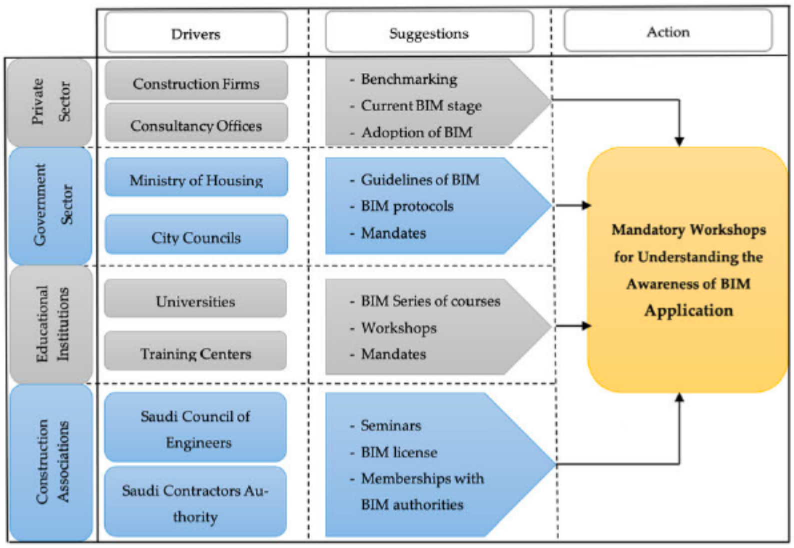


Figure 4. A conceptual flow chart for BIM awareness in the KSA industry [18].

3. Research Methodology

The methodology applied in this research is based on extensive review of the relevant literature with field survey interview sessions as structured in stages in Figure 5.

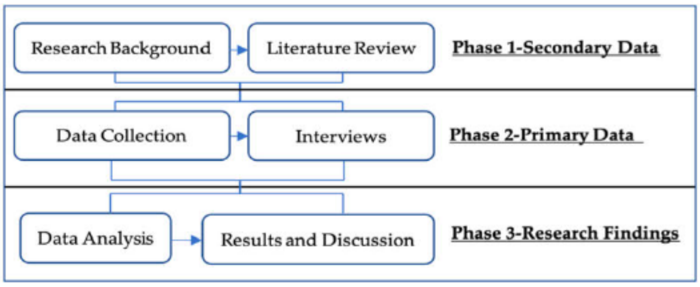


Figure 5. Research methodology flow chart.

3.1. Phase 1: Research Background and Review the Previous Literature

This was accomplished by conducting a comprehensive review to produce a descriptive summary of the relevant literature that suited the background of this study. Additionally, a historical literature analysis was conducted to investigate the factors, causes, and sources of disputed claims in the construction industry generally and in KSA. Finding out what has already been studied in the field of building information modelling (BIM) in Saudi Arabia, Egypt, and the United Arab of Emirates (UAE) were critically investigated.

3.2. Phase 2: Data Collection from the Field Survey as Primary Data

The primary data were collected from the industry based on interview sessions held with professionals in the KSA construction projects. The field survey interview sessions were held with practitioners of different experiences, including owners, project managers, contractors, designers, and consultants. The researcher held 35 sessions and spent approximately 60 min discussing each practitioner, and the number of investigated claims raised by practitioners totaled 175 cases as shown in Table 4. The highest number of claims were related to commercial projects (105 cases), compared to 64 claims for 35 residential projects.

Table 4. Respondents from the KSA construction industry.

Respondents Categories	No of Respondents	No of Projects	No of Claims Faces
Owners	7	12	25
Consultants	8	20	35
Designers	5	18	20
Contractors	9	15	65
Project managers	6	20	30
Total	35	75	175

The data collected in this study employed a qualitative method, which provides insight into the prospective advantages of BIM implementation. Face-to-face interviews with respondents provide a wealth of accurate data from a small sample size, which is an advantage of this method. However, such an approach restricts the ability to generalize, and it uses the lessons learned to formulate theories in a particularistic context. In addition, the purpose of using a qualitative approach lies in its strength and ability to provide complex descriptions of how individuals experience a given research issue. It also provides information about the human side of an issue that is often characterized by paradoxical behaviors, opinions, beliefs, and relationships among individuals. Psychological research aims to address questions regarding experience, meaning, and perspective, typically from the participant's perspective. Typically, these data cannot be counted or measured [74].

Table 5. Distribution of 175 claims cases for different types of construction projects.

Project Category	No of Projects	No of Claims Faces	Percentage of Claims
Commercial	40	105	60%
Residential	35	64	37%
Water lines	5	6	3%
Total	75	175	100%

Table 6. Source of claim frequency.

Source of Claims	Participants	Never	Rare	Average	Frequent	High Frequent
1. Contract ambiguity	35	1	1	2	9	6
2. Delays factors	35	1	2	3	9	12
3. Variation orders	35	1	2	8	7	12
4. Coordination issues	35	1	3	4	5	10
5. Lack of decisions	35	1	2	3	4	9
6. Payment's delay	35	1	2	5	8	9
7. Design error	35	3	4	6	5	8

Respondents were requested to choose one out of the five available alternative claim frequency options to provide a credible estimation of each claim factor's frequency. Two mathematical formulas were utilized to analyze the information collected from the field survey. Moreover, a numerical weight ranging from (0 to 4) was assigned to indicate the category of claim factor frequency. A weight of (0) represented "never", while a weight of (1) represented "rare", a weight of (2) represented "moderate", a weight of (3) represented "frequent", and a weight of (4) represented "high frequent". For instance, respondents rated the claim causes associated with contract ambiguity as (6) for high frequent, (20) for frequent, and only (5) for rare. The weighted average formula marked as (No.1) which was employed to scrutinize the data presented in Table 6 was computed and analyzed. Here, (W) denotes the weight of the claims factor, (X) represents the number of respondents who selected it, and (N) indicates the total number of respondents (35 in this study).

To provide a clear sense of the importance of each source of the claim, a significance index (%) was calculated and shown in Table 7. based on the given weighting scores from the participants as shown in Table 6. The results of the significant index are used in the combination formulas No (1 and 2).

Table 7. The significance index of each claim type with its frequency in KSA.

Types of Claims	Significance Index (%)	Rank
1. Contract ambiguities	23%	6
2. Delay related claims	35%	2
3. Variation orders	36%	1
4. Coordination issues	27%	4
5. Lack of decisions from the owner and consultant	23%	6
6. Payment's delay	29%	3
7. Design error claims	27%	5

Table 7 displays the significance index value for each source of the claim. For example, in Table 6, the weighted average for contract ambiguity is $(0 \times 1 + 1 \times 1 + 2 \times 2 + 3 \times 9 + 4 \times 6)/35 = 1.6$, which has a significant index of $(1.6 \times 100)/7 = 23\%$, while the significant index value of variation order is $(2.48 \times 100)/7 = 36\%$ as the highest importance index score. Furthermore, delays factors claim ranked $(2.46 \times 100)/7 = 35\%$, which is nearly equal with variation orders as a source of claims. Design errors ranked 27%. The weighted average of payments delays is $(0 \times 1 + 1 \times 2 + 2 \times 5 + 3 \times 8 + 4 \times 9)/35 = 2.06$, and its significant index is $(2.06 \times 100)/7 = 29\%$, in which Table 7 shows the rankings for all sources of claims that were investigated in the KSA.

5. Discussion of the Literature Review and Results

The literature review in this paper showed that the total income of the KSA would reach USD 834 billion by 2021. The Saudi construction industry accounts for a significant portion of the country's total income and has a long history dating back to the 1950s. Since then, it has grown significantly, with the government investing heavily in infrastructure projects. The construction industry is currently one of the largest sectors in the Middle East, focusing on residential, commercial, and industrial projects. According to Saudi Vision 2030, large-scale projects are underway, and this paper discusses two significant projects from the total portfolio of the KSA. The project of Neom City is budgeted at USD 500 billion, construction is underway, and the project goal is to build a futuristic city powered solely by renewable energy sources. In addition, the Saudi construction industry offers numerous opportunities for investors and developers to suit the country's ambitions for future expansions. With the government's focus on infrastructure development, the demand for construction projects is growing. In addition, the government has implemented various incentives to attract foreign investment, such as tax breaks and low-interest loans. However, a research conducted in KSA stated that, numerous disputable claims have been raised regarding the Saudi construction industry [76]. This has led to delays and a lack of investment in many projects.

This study investigated 50 claim factors that frequently occur in construction projects, as shown in Table 1. The 50 factors investigated as causes of claims were divided into 7 groups as sources of claims, as illustrated in Figure 6. The indications in Figure 6 shows that 28% of the total 50 factors of claims are related to changes in the original design scope and shifting the project baseline, while 20% of the total factors of claims are related to poor coordination from all involved parties in construction projects. Contract administration-related claims were 18%, while other factors caused minor impacts on the project. It is evident from Figure 6 that the interpretation of the higher percentages causing the claims is due to changes in the project during execution, which may indicate that the owner lacked vision when designing the project prior to execution. This may lead the owner to request modifications to satisfy his requests as he perceives them, which may incur extra costs with additional time. Furthermore, the difficulty of communication between project parties, which scored 20% of the total 50 claim factors, may be related to a lack of coordination, relying on traditional management approaches rather than an advanced methodology. Claims factors related to contract administration are not less important, which may be due to an unclear scope of work for the contract manager because of the project team not using an integrated project management system in many cases, which causes poor communication between project parties.

The primary data have been collected from the field survey conducted by the author, in which the study identified seven significant frequent factors as sources of claims in KSA construction projects, as shown in Table 6. Each participant in the researcher's study, in which a total of 35 professionals involved from the KSA construction industry, as shown in Table 5, voiced their opinions in response to the open-ended questions. The study found that the most frequent factor as a source of claims in KSA construction projects was variation orders ranked (36%), while claims related to delays ranked (35%) as the second rank, as shown in Table 8. As a result, it is clear from the percentages that most delay cases are associated with variations, and variations are typically associated with owner-requested scope changes. One of the reasons for the frequent changes from the owner's side might be due to the lack of virtual conception of the project design before the commencement of the construction stage, and this could be due to the lack of 3D modelling with the related information, which BIM can handle. Contractor payment delays and coordination issues are not less important claims factors in KSA projects, which ranked (29%) and (27%) respectively as sources of claims. Even though payment delays were ranked second in the field survey, it mostly irritates most contractors. For example, in a large-scale commercial building including a hotel in Jeddah, KSA, with a budget of USD 53 million (200 million Saudi Riyals) [77]. The construction process of the commercial project was held up for four years owing to contractor payment delays. Both the contractor and the project's owner went to court, where the contractor raised delay claims and the owner raised a counterclaim due to the contractor's failure to complete contract obligations. This legal case is still pending at the Court of Appeal, as the researcher is appointed in this case by the court as an Expert Witness.

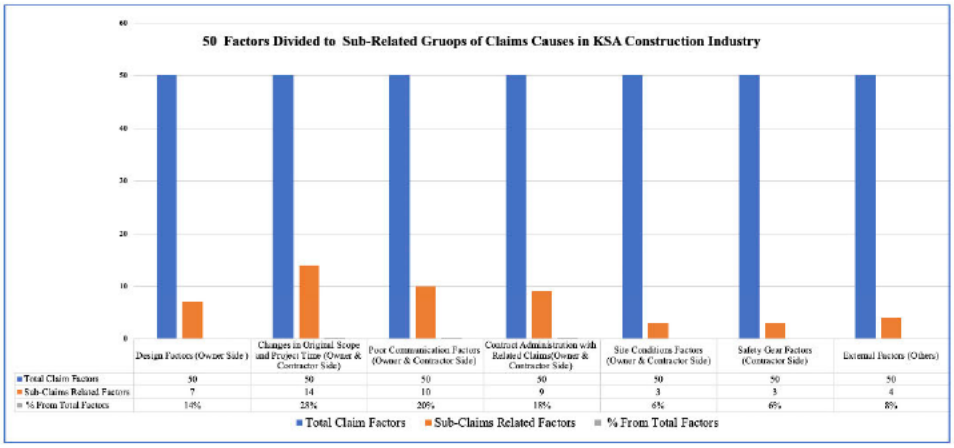


Figure 6. The 50 factors divided to sub-related groups of claims causes in the KSA construction industry [19,20,24,27,35,39].

Table 8. The results of the source of claims from the existing literature and field survey of this study.

Source of Claims from the Field Survey	Rank	Groups of Claims from the Literature Review	Rank
1. Contract ambiguities both sides)	23%	1. External factors	8%
2. Delay related claims (owner side)	35%	2. Safety gear factor (contractor side)	6%
3. Variation orders (owner side)	36%	3. Site coordination factor (both sides)	6%
4. Coordination issues (both sides)	27%	4. Contract administration	18%
5. Lack of decisions from the owner and consultant	23%	5. Poor communication (both sides)	20%
6. Payment's delay (owner side)	29%	6. Changes in original scope (both sides	28%
7. Design error claims (owner side)	27%	7. Design factors (owner side)	14%

Table 7 presents the primary data from the field survey, in which contract ambiguity and errors in design had the least impact on construction projects as a source of claims in KSA, accounting for (23%) and (27%) respectively. Contract ambiguity in the KSA industry is inherent and frequent as a major source of claims, and the reasons for this vary. For example, due to a lack of standard forms of contracts in the KSA industry, parties in the private sector are increasingly resorting to the use of bespoke contract forms, as opposed to the UK industry, which employs standard forms such as Joint Contracts Tribunal (JCT) and the family of New Engineering Contracts (NEC) in both private and public projects [78]. As is widely known, standard forms of engineering contracts such as JCT, NEC or FIDIC conditions of contract are well drafted and examined in terms of risk sharing between the signed parties.

There are various potential reasons why countries outside the UK have not embraced the New Engineering Contracts (NEC) in the construction industry. These reasons can include cultural disparities, legal and regulatory frameworks, a lack of awareness and familiarity, and resistance to change. Cultural disparities arise from different countries having their own established contractual frameworks and deeply ingrained industry practices. The adoption of NEC contracts necessitates a significant mindset shift, which may not align with existing practices. Each country possesses its own unique legal and regulatory framework that governs the construction industry. These frameworks may not be compatible with NEC contracts and adapting or modifying them to fit local requirements may pose challenges. Furthermore, NEC contracts were developed in the UK and may not be well known or understood in other countries. Many nations have their own widely used and accepted standard forms of contracts, resulting in limited knowledge or awareness of NEC contracts among industry professionals in these countries. Moreover, implementing new contract forms often necessitates substantial effort, including training, education, and potentially revising existing processes and procedures. Consequently, resistance to change may emerge, particularly if the benefits of adopting NEC contracts are not clearly understood or if stakeholders perceive a higher level of risk or uncertainty associated with this change.

It is common practice for both owners and contractors in KSA to limit their use of standard forms of contracts because they believe that using bespoke contracts might be simple and easy to manage, which is, by the rule of thumb, not true and may not adequately define the scope of work. Consequently, most claims cases in the KSA that raised disputes in court were due to the ambiguities of bespoke contract use. Although errors in design were evaluated by (26%) of the sources of claims in the field survey data analysis, the researchers believe that it is largely related to changes and variations, which ranked top. There is a reason for this as well; most changes in KSA projects are affected due to poor design and a lack of virtual project conception prior to construction.

Table 8 summarizes the similarities between the secondary and primary data of the sources of claims identified in the relevant literature compared to the findings of this study's field survey. For instance, design errors accounted for 27% of the field survey, representing 14% of the relevant literature. This demonstrates that design factors continue to be a prominent source of claims and constantly increased. Furthermore, the field survey indicated that coordination issues accounted for 27%, corresponding to the 20% reported poor communication in the relevant literature. Additionally, contract ambiguities ranked at 23%, which parallels the 18% prevalence of contract administration issues in the relevant literature. Although there may be variations in claim factors, this study focuses on the most frequent and common factors inherent in the long-term construction industry. From the author's experience, it is rare to see a construction project free from variations, design errors, contractual cases, and lack of communication especially in the KSA industry.

The paper suggested a BIM application to limit the sources of claims investigated via field surveys in KSA projects, as many of those sources of claims are caused by variances, errors in design, and a lack of coordination. As researched and explained in the literature chapter, BIM is a vital tool for the Saudi construction sector. It may help streamline the design process, reduce costs, and improve collaboration between stakeholders. In addition, BIM allows better project visualization, which can reduce errors and improve safety. BIM can aid in the reduction in claims in building projects by enhancing communication, identifying disputes, decreasing alterations orders, enhancing coordination, and offering improved project visualization. The limitations of using BIM include the cost of implementation, software complexity, and difficulty in training personnel. However, BIM might not be suitable for all types of projects and might be difficult to integrate into existing systems. From the author's experience in the KSA construction industry, one of the challenges that courts may confront in analyzing the validity of claims is a lack of dependence on modern technology when examining claims, which many Saudi companies lack. This may result in a long period of litigation and, in some situations, an inaccuracy in the value of the submitted claim, which may jeopardize one of the litigants' parties' rights. Therefore, BIM can be implemented in KSA construction projects to overcome construction disputes through the initial training of personnel using the software. This can be accomplished via online courses or in-person training sessions. Once personnel are trained, the software can be used to streamline the design process and improve collaboration among stakeholders.

6. Conclusions

This study examined the significance and difficulties encountered by the construction sector in the Kingdom of Saudi Arabia (KSA) from contractual and legal perspectives. The KSA has an ambitious vision that encompasses 3727 active projects valued at USD 386.4 billion, with the initial phase of this portfolio projected to be finished by 2025. Despite the thriving construction industry in the KSA, there are numerous challenges impeding its progress. Previous literature indicates that approximately 70% of construction projects in the KSA have encountered substantial delays and cost overruns. Furthermore, the construction sector in the KSA confronts obstacles in project delivery due to delayed payment from project owners, a scarcity of skilled workers, inadequate planning, and the non-utilization of standardized contract forms. Consequently, the absence of standardized contract forms employed in the KSA often leads to conflicts among the involved parties. The research examined 50 factors associated with claims described in the existing literature, with a particular focus on the most frequently occurring ones. Among these factors, changes in the original scope ranked highest, accounting for 28%, followed by poor communication at 20% and contract administration at 18%. Design errors were also deemed significant, constituting 14% of the total factors contributing to claim causes. To gather data, the study conducted primary research through field surveys and interviews with 35 practitioners from diverse backgrounds, including consultants, designers, contractors, project managers, and owners. These professionals were able to identify the root causes of claims in construction projects in KSA. The field study encompassed a total of 75 construction projects, which encountered 175 cases of claims. These cases consisted of 105 claims in commercial projects, 64 claims in residential projects, and 6 claims in water line projects. Extensive data analysis revealed seven major sources of claims, namely variation orders (36%), claims-related delays (35%), and payment delays (29%). Additional significant causes of claims included coordination issues (27%) and design errors (26%). It was further noted that relying on traditional project management approaches and underutilizing advanced technologies such as BIM could also contribute to claims in KSA construction projects.

This study examined the significance of BIM application in the Kingdom of Saudi Arabia (KSA), considering that the sources of claims in this domain are primarily related to inadequate management and coordination, which can be addressed through advanced technology. Many construction companies in KSA, both in the public and private sectors, lack experience in implementing BIM, and only a limited number of international construction firms have incorporated BIM in this field. The reluctance to adopt BIM in KSA is partially attributed to the absence of a requirement from the Saudi government, thereby hindering its widespread implementation. Additionally, smaller, and medium-sized companies, which constitute a significant portion of the Saudi Arabian construction industry, may find the implementation of BIM excessively expensive. Nevertheless, despite the various obstacles encountered in the implementation of BIM in KSA, the government has introduced in 2020 the Saudi Building Codes (SBCs), which facilitate the adoption of BIM and promote green buildings. The Saudi Contractors Authority and professional bodies within the industry have also been encouraged to embrace BIM. Furthermore, the study investigated BIM implementation in Egypt and the UAE, where it identified a shortage of BIM applications. Although BIM usage is not mandatory in Egypt and the UAE, both countries have government initiatives promoting its expansion. In contrast to the construction industry in the UK, where BIM was officially endorsed by the government in 2016, BIM can be implemented in both public and private construction projects. This study elucidated the advantages and level of progression of BIM in construction initiatives, encompassing early clash detection, expedited design and construction processes, precise planning, and decreased occurrence of delays and errors.

Future work: Following the analysis of the sources of claims in the Kingdom of Saudi Arabia (KSA) through primary data obtained from a field survey, subsequent research endeavors involve the formulation of a published paper. This paper aims to develop a claims management system based on an evaluation of the advantages of implementing

Building Information Modeling (BIM) in the construction industry of the KSA from the perspective of industry professionals. A comprehensive case study will be incorporated, utilizing pre-planned 30–50 interview sessions with selected participants from the construction sector. Furthermore, the follow-up paper will also include an examination of the disparities between traditional cost estimation methods in construction projects and the implementation of BIM technology, based on the first author's experiential knowledge.

Limitations of This study: This study is limited in scope to the examination of claims originating from the construction industries in the KSA, Egypt, and the UAE in comparison to the UK industry, specifically focusing on legal and construction disputes. The primary data, collected from 35 practitioners, may have implications on the generalizability of the findings. Additionally, secondary sources from relevant literature were utilized to support the research, as a case study from the industry could not be included due to time constraints.

Author Contributions: Writing—original draft, R.A.A.; Supervision, 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 and be available for interested parties.

Conflicts of Interest: The author declared no conflict of interest.

References

1. Hussain, S.; Hasmori, M.F.; Abas, N.H.; Balasbaneh, A.T.; Khan, M.W. Key Performance Indicators for Project Success in Saudi Arabian Construction Industry. 2022. Available online: https://www.researchsquare.com/article/rs-2329589/v1 (accessed on 3 June 2023).
2. Shaawat, M.E.; Jamil, R.; Al-Enezi, M.M. Analysis of challenges in sustainable construction industry by using analytic hierarchy process: A case study of Jubail Industrial City, Saudi Arabia. *Int. J. Sustain. Real Estate Constr. Econ.* **2018**, *1*, 109–122.
3. Amran, Y.A.; Amran, Y.M.; Alyousef, R.; Alabduljabbar, H. Renewable and sustainable energy production in Saudi Arabia according to Saudi Vision 2030; Current status and future prospects. *J. Clean. Prod.* **2020**, *247*, 119602. [CrossRef]
4. Algumzi, A. Risks and Challenges Associated with NEOM Project in Saudi Arabia: A Marketing Perspective. *J. Risk Financ. Manag.* **2022**, *15*, 381. [CrossRef]
5. Farag, A.A. The story of NEOM city: Opportunities and challenges. In *New cities and Community Extensions in Egypt and the Middle East: Visions and Challenges*; Springer: Cham, Switzerland, 2019; pp. 35–49.
6. Alkhayyat, M.A.I. The Potential for Harvesting Wave Energy Offshore NEOM Region, Northern Red Sea. Ph.D. Thesis, Effat University, Jeddah, Saudi Arabia, 2020.
7. Aly, H. Royal dream: City branding and Saudi Arabia's NEOM. *Middle East-Top. Argum.* **2019**, *12*, 99–109.
8. Alsolami, B.M. Identifying and assessing critical success factors of value management implementation in Saudi Arabia building construction industry. *Ain Shams Eng. J.* **2022**, *13*, 101804. [CrossRef]
9. Assaf, S.A.; Al-Hejji, S. Causes of delay in large construction projects. *Int. J. Proj. Manag.* **2006**, *24*, 349–357. [CrossRef]
10. Alhumayn, S.; Chinyio, E.; Ndekugri, I. The barriers and strategies of implementing BIM in Saudi Arabia. *WIT Trans. Built Environ.* **2017**, *169*, 55–67.
11. Alenazi, E.O. Using BIM for Delay Management in Public Sector Construction Projects in KSA. Ph.D. Thesis, Loughborough University, Reading, UK, 2018.
12. Btoush, M.; Harun, A. Minimizing delays in the Jordanian construction industry by adopting BIM technology. In *IOP Conference Series: Materials Science and Engineering*; IOP Publishing: Bristol, UK, 2017; Volume 271, p. 012041.
13. Alzara, M.; Kashiwagi, J.; Kashiwagi, D.; Al-Tassan, A. Using PIPS to minimize causes of delay in Saudi Arabian construction projects: University case study. *Procedia Eng.* **2016**, *145*, 932–939. [CrossRef]
14. Majzoub, M.; Eweda, A. Probability of Winning the Tender When Proposing Using BIM Strategy: A Case Study in Saudi Arabia. *Buildings* **2021**, *11*, 306. [CrossRef]
15. Naim, A.A.A.A. An investigation of building information modelling implementation in KSA. 2018. Available online: http://hdl.handle.net/2436/621890 (accessed on 14 May 2023).
16. Parchami Jalal, M.; Yavari Roushan, T.; Noorzai, E.; Alizadeh, M. A BIM-based construction claim management model for early identification and visualization of claims. *Smart Sustain. Built Environ.* **2021**, *10*, 227–257. [CrossRef]
17. Mehran, D. Exploring the Adoption of BIM in the UAE Construction Industry for AEC Firms. *Procedia Eng.* **2016**, *145*, 1110–1118. [CrossRef]

50. Fawzy, S.A.; El-Adaway, I.H.; Perreau-Saussine, L.; Abdel Wahab, M.S.; Hamed, T.H. Claims for extension of time and additional payment under common law FIDIC: Civil law analysis. *J. Leg. Aff. Disput. Resolut. Eng. Constr.* **2018**, *10*, 06518002. [CrossRef]
51. Heaphy, I. NEC versus Fidic. *Proc. Inst. Civ. Eng.-Manag. Procure. Law* **2013**, *166*, 21–30. [CrossRef]
52. Patterson, R. Using NEC contracts to manage risk and avoid disputes. *Proc. Inst. Civ. Eng.-Manag. Procure. Law* **2009**, *162*, 157–167. [CrossRef]
53. Charehzehi, A.; Chai, C.; Md Yusof, A.; Chong, H.-Y.; Loo, S.C. Building information modeling in construction conflict management. *Int. J. Eng. Bus. Manag.* **2017**, *9*, 1847979017746257. [CrossRef]
54. Lindblad, H. Black boxing BIM: The public client's strategy in BIM implementation. *Constr. Manag. Econ.* **2019**, *37*, 1–12. [CrossRef]
55. Jalali, Z.; Noorzai, E.; Heidari, S. Design and optimization of form and facade of an office building using the genetic algorithm. *Sci. Technol. Built Environ.* **2020**, *26*, 128–140. [CrossRef]
56. Park, C.-S.; Lee, D.-Y.; Kwon, O.-S.; Wang, X. A framework for proactive construction defect man- agement using BIM, augmented reality, and ontology-based data collection template. *Autom. Constr.* **2013**, *33*, 61–71. [CrossRef]
57. Ghaffarianhoseini, A.; Tookey, J.; Ghaffarianhoseini, A.; Naismith, N.; Azhar, S.; Efimova, O.; Raahemifar, K. Building Information Modelling (BIM) uptake: Clear benefits, understanding its imple- mentation, risks and challenges. *Renew. Sustain. Energy Rev.* **2017**, *75*, 1046–1053. [CrossRef]
58. Chou, H.-Y.; Yang, J.-B. Preliminary evaluation of BIM-based approaches for schedule delay analysis. In *IOP Conference Series: Materials Science and Engineering*; IOP Publishing: Bristol, UK, 2017; Volume 245, p. 062048.
59. Sriyolja, Z.; Harwin, N.; Yahya, K. Barriers to implement building information modeling (BIM) in construction industry: A critical review. In *IOP Conference Series: Earth and Environmental Science*; IOP Publishing: Bristol, UK, 2021; Volume 738, p. 012021.
60. Ali, B.; Zahoor, H.; Nasir, A.R.; Maqsoom, A.; Khan, R.W.A.; Mazher, K.M. BIM-based claims management system: A centralized information repository for extension of time claims. *Autom. Constr.* **2020**, *110*, 102937. [CrossRef]
61. Huang, M.; Zhu, H.; Ninić, J.; Zhang, Q. Multi-LOD BIM for underground metro station: Interoperability and design-to-design enhancement. *Tunn. Undergr. Space Technol.* **2022**, *119*, 104232. [CrossRef]
62. Koc, S.; Skaik, S. *CIB: Proceedings of the 2014 International Conference on Construction in a Changing World*; Heriot Watt: Edinburgh, UK, 2014.
63. Marzouk, M.; Elsaay, H.; Othman, A.A.E. Analysing BIM implementation in the Egyptian construction industry. *Eng. Constr. Archit. Manag.* **2022**, *29*, 4177–4190. [CrossRef]
64. Egypt GDP From Construction. 2018. Available online: https://tradingeconomics.com/egypt/gdp-from-construction (accessed on 17 November 2018).
65. Elyamany, A.H. Current practices of building information modelling in Egypt. *Int. J. Eng. Manag. Econ.* **2016**, *6*, 59–71. [CrossRef]
66. Bhatia, N. Dubai Municipality seeks private sector support on BIM mandate. *Retrieved May* **2014**, *29*, 2017.
67. Faridi, A.S.; El-Sayegh, S.M. Significant factors causing delay in the UAE construction industry. *Constr. Manag. Econ.* **2006**, *24*, 1167–1176. [CrossRef]
68. Croft, A.; Fayyaz, K. BIM Implementation in the UAE on the Rise. Retrieved from Beale & Company Website. 2017. Available online: https://beale-law.com (accessed on 5 July 2023).
69. Tse, T.-C.K.; Wong, K.-D.A.; Wong, K.-W.F. The utilisation of building information models in nD modelling: A study of data interfacing and adoption barriers. *J. Inf. Technol. Constr. (ITcon)* **2005**, *10*, 85–110.
70. Yan, H.; Demian, P. Benefits and Barriers of Building Information Modelling. 2008. Available online: https://hdl.handle.net/2134/23773 (accessed on 15 April 2023).
71. Kerosuo, H.; Miettinen, R.; Paavola, S.; Mäki, T.; Korpela, J. Challenges of the expansive. *Production* **2015**, *25*, 289–297. [CrossRef]
72. Al-Hammadi, M.A.; Tian, W. Challenges and barriers of building information modeling adoption in the Saudi Arabian construction industry. *Open Constr. Build. Technol. J.* **2020**, *14*, 98–110. [CrossRef]
73. Banawi, A. Advances in Human Factors, Sustainable Urban Planning and Infrastructure. In Proceedings of the AHFE 2017 International Conference on Human Factors, Sustainable Urban Planning and Infrastructure, The Westin Bonaventure Hotel. Los Angeles, CA, USA, 17–21 July 2017; 2018; Volume 600, pp. 119–125.
74. Creswell, J.W.; Creswell, J.D. *Mixed Methods Research: Developments, Debates, and Dilemma*; Berrett-Koehler Publishers: San Francisco, CA, USA, 2005.
75. Yang, Y. An evaluation of statistical approaches to text categorization. *Inf. Retr.* **1999**, *1*, 69–90. [CrossRef]
76. Alsharani, S. Overview of disputes in the context of Saudi construction industry. *Int. J. Sci. Basic Appl. Res. (IJSBAR)* **2017**, *33*, 54–67.
77. Writer, S. UAE's DSI refutes legal case from Saudi's Lamar. *Construction Week Magazine*, 2016.
78. Zain-alabdeen, W.R.; Rasheed, S.M. Comparison of time extension provisions between the Joint Contracts Tribunal and Iraqi Standard Bidding Document. *J. Mech. Behav. Mater.* **2022**, *31*, 580–586. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

Links and Implications

The links and implications of the literature review in the first paper of the thesis was significant, as it critically examined the construction industry's background, focusing on its complexity and scalability, particularly within the KSA sector. It also explored the procurement routes and types of contracts commonly used in the industry, including the FIDIC contract. Risk allocation related to disputable claims emerged as one of the main challenges, serving as a key factor and source of claims that influenced the outcomes of the first published paper in this thesis.

The main objective of the first paper was to examine the origins and factors contributing to disputed claims in the KSA construction industry. This objective was directly connected to the overall aim of the thesis, which focused on ways to minimise such disputes. Consequently, the secondary objective of the first paper was to explore the significance of utilising BIM in the KSA industry to mitigate the occurrence of construction claims. The paper proposed a set of software, including Revit Architecture for converting 2D AutoCAD drawings into 3D models, Microsoft Project for developing a project timeline in 4D, and Cost-X for estimating project costs in 5D. This software set, referred to as the BIM package in the study, played a crucial role in reducing construction claims. The first paper thoroughly investigated the origins of claims and emphasised the importance of the BIM package establishing its connection and implications with the second paper.

CHAPTER 4: PAPER 2 – AN INVESTIGATION OF BIM ADVANTAGES IN ANALYSING CLAIMS PROCEDURES RELATED TO THE EXTENSION OF TIME AND MONEY IN THE KAS CONSTRUCTION INDUSTRY

Introduction

The paper in this chapter focuses on the advantages of BIM in analysing claims related to time and money extensions in the KSA construction industry. The main aim of this second paper is to build upon the results of the first published paper, which focused on the source of claims and the importance of using BIM in the KSA construction industry. The published paper explains the types of delays and their effects on construction claims. It also describes the claims management procedure in construction projects without the implementation of BIM. The methodology employed in this paper combines both narrative and systematic approaches. The narrative review provides an in-depth exploration of the significance of BIM by focusing on relevant topics within the study's research area. A systematic analysis of an industry case study complements this approach, facilitating evidence-based decision-making. This dual approach helps identify research gaps and consolidates the findings of a previous paper to be a part of the inputs of the current study. Therefore, the paper presents a delay case study analysed through prospective and retrospective analyses to demonstrate the challenges of analysing a series of delays using traditional practices. The primary data for this paper was collected from a questionnaire survey distributed to 123 practitioners mainly from the construction industry in the KSA, Egypt, and the USA. The respondents had varying experience levels ranging from 1 to 35 years, and out of the 79 completed surveys, 25 respondents were civil engineers, 15 were contract administrators, 13 were claims managers, 9 were project managers, and

17 were BIM managers. The questionnaire survey results showed that 30 participants were familiar with BIM. Additionally, 35 participants expressed the opinion that there is a growing awareness of BIM usage in Saudi Arabia. Furthermore, 25 participants mentioned that their organisation is planning to use BIM. Moreover, 40 participants agreed that using BIM may reduce disputable claims in construction projects, and 37 participants suggested that the implementation of BIM may reduce the overall project cost.

Paper 2

buildings

IMPACT FACTOR 3.8

CITESCORE 3.1

Article

An Investigation of BIM Advantages in Analysing Claims Procedures Related to the Extension of Time and Money in the KSA Construction Industry

Reda Abdelshafy Abougamil, David Thorpe and Amirhossein Heravi

Special Issue
BIM Application in Construction Management

Edited by
Prof. Dr. Irene Lill and Dr. Theophilus Olowa

MDPI

https://doi.org/10.3390/buildings14020426

buildings

MDPI

Article

An Investigation of BIM Advantages in Analysing Claims Procedures Related to the Extension of Time and Money in the KSA Construction Industry

Reda Abdelshafy Abougamil *, David Thorpe and Amirhossein Heravi

Department of Civil Engineering, Faculty of Health, Engineering and Sciences, School of Surveying and Built Environment, University of Southern Queensland, Springfield 4300, Australia; david.thorpe@unisq.edu.au (D.T.); amirhossein.heravi@unisq.edu.au (A.H.)
* Correspondence: u1092138@umail.usq.edu.au

Abstract: The construction industry in the Kingdom of Saudi Arabia (KSA) is a significant sector in the Middle East, with annual expenditures exceeding USD 120 billion. It employs 15% of the workforce and consumes more than 14% of the country's energy resources. Despite the significant growth in the Saudi construction sector, it faces various challenges due to the rapid launch of mega projects, such as the Line project engaged with the NEOM project, as well as other new projects as part of the Saudi Vision 2030. The challenges might be limited to a shortage of skilled labourers, rising costs, construction disputes, and material shortages. This study aims to investigate claims management procedures under traditional practice and compare them with a proposed BIM package as an alternative solution to mitigate construction disputes. The objective of the study focuses on reducing the time consumed when analysing claims against the level of accuracy of claims values. The proposed BIM model improves and streamlines the claims process through automation. This study presents prospective and retrospective methods in delay analysis under an accepted programme. A questionnaire survey was conducted, and out of a total of 123 practitioners, 79 replied. The findings in tables in this article reveal that there are demands and a growing awareness of BIM in the KSA construction industry. The results reveal that BIM can help to reduce potential disputes and can reduce overall project cost overruns.

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

check for updates

Citation: Abougamil, R.A.; Thorpe, D.; Heravi, A. An Investigation of BIM Advantages in Analysing Claims Procedures Related to the Extension of Time and Money in the KSA Construction Industry. *Buildings* **2024**, *14*, 426. https://doi.org/10.3390/buildings14020426

Academic Editors: Irene Lill and Theophilus Olowa

Received: 15 December 2023
Revised: 23 January 2024
Accepted: 1 February 2024
Published: 4 February 2024

Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

The triangle of time, cost, and quality were the key indicators used to measure project success; however, over time, other indicators have been added, such as safety, lean and green building, and dispute-free processes [1,2]. Contracting parties might change their contractual and economic relationships through claims. Research shows that project managers spend 25% of their time resolving conflicts [3]. According to Arcadis (2019) [4], global construction disputes take around 17 months to resolve, with an average cost of USD 33 million for these disputes. Indirect expenses include project quality loss and undesirable working relationships between parties who could benefit from long-term collaboration. It is stated that delays might add from 3–10% to 70% in terms of additional time for construction projects [5]. This emphasises the significance of proper claims management practices and procedures [6]. Managing claims in construction projects remains a time-consuming and difficult undertaking [7]. In addition, inefficiencies might be found in the current traditional methods of claims management. Therefore, there is a high demand for data storage and processing because the construction process is extensive and takes considerably long. However, it has been noted that data collection, analysis, and presentation are significant obstacles to how claims are managed. Under the traditional methods of

buildings

MDPI

Article

An Investigation of BIM Advantages in Analysing Claims Procedures Related to the Extension of Time and Money in the KSA Construction Industry

Reda Abdelshafy Abougamil *, David Thorpe and Amirhossein Heravi

Department of Civil Engineering, Faculty of Health, Engineering and Sciences, School of Surveying and Built Environment, University of Southern Queensland, Springfield 4300, Australia; david.thorpe@unisq.edu.au (D.T.); amirhossein.heravi@unisq.edu.au (A.H.)

* Correspondence: u1092138@umail.usq.edu.au

Abstract: The construction industry in the Kingdom of Saudi Arabia (KSA) is a significant sector in the Middle East, with annual expenditures exceeding USD 120 billion. It employs 15% of the workforce and consumes more than 14% of the country's energy resources. Despite the significant growth in the Saudi construction sector, it faces various challenges due to the rapid launch of mega projects, such as the Line project engaged with the NEOM project, as well as other new projects as part of the Saudi Vision 2030. The challenges might be limited to a shortage of skilled labourers, rising costs, construction disputes, and material shortages. This study aims to investigate claims management procedures under traditional practice and compare them with a proposed BIM package as an alternative solution to mitigate construction disputes. The objective of the study focuses on reducing the time consumed when analysing claims against the level of accuracy of claims values. The proposed BIM model improves and streamlines the claims process through automation. This study presents prospective and retrospective methods in delay analysis under an accepted programme. A questionnaire survey was conducted, and out of a total of 123 practitioners, 79 replied. The findings in tables in this article reveal that there are demands and a growing awareness of BIM in the KSA construction industry. The results reveal that BIM can help to reduce potential disputes and can reduce overall project cost overruns.

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

check for updates

Citation: Abougamil, R.A.; Thorpe, D.; Heravi, A. An Investigation of BIM Advantages in Analysing Claims Procedures Related to the Extension of Time and Money in the KSA Construction Industry. *Buildings* **2024**, *14*, 426. https://doi.org/10.3390/buildings14020426

Academic Editors: Irene Lill and Theophilus Olowa

Received: 15 December 2023
Revised: 23 January 2024
Accepted: 1 February 2024
Published: 4 February 2024

Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

The triangle of time, cost, and quality were the key indicators used to measure project success; however, over time, other indicators have been added, such as safety, lean and green building, and dispute-free processes [1,2]. Contracting parties might change their contractual and economic relationships through claims. Research shows that project managers spend 25% of their time resolving conflicts [3]. According to Arcadis (2019) [4], global construction disputes take around 17 months to resolve, with an average cost of USD 33 million for these disputes. Indirect expenses include project quality loss and undesirable working relationships between parties who could benefit from long-term collaboration. It is stated that delays might add from 3–10% to 70% in terms of additional time for construction projects [5]. This emphasises the significance of proper claims management practices and procedures [6]. Managing claims in construction projects remains a time-consuming and difficult undertaking [7]. In addition, inefficiencies might be found in the current traditional methods of claims management. Therefore, there is a high demand for data storage and processing because the construction process is extensive and takes considerably long. However, it has been noted that data collection, analysis, and presentation are significant obstacles to how claims are managed. Under the traditional methods of claims management, collecting all necessary data and paperwork is an essential process for preparing, presenting, analysing, and handling the claims [8]. Claims must be supported by evidence, including all required information, adhere to procedures, and be submitted within a certain time frame [9]. The complexity of claims management in the Kingdom of Saudi Arabia (KSA) is increased by the absence of an effective document management system and qualified people to oversee the entire procedure of claims, particularly those with the best understanding of claims. Consequently, the current dispute and claim resolution processes in the KSA are still lengthy and complicated [10].

The problem is that traditional practices in construction management necessitate the implementation of new methods for claim procedures [11]. Without an efficient claims management system, claimant parties face the risk of losses. For instance, when a project owner requests a change order to change the air conditioning system from duct split to package units during the construction process, the package units will require duct routes that may intersect concrete beams or increase the false ceiling depth, affecting the clear height of the room. Therefore, to prevent potential money and time claims in later stages, a rapid and accurate revision is required to evaluate the technical design impact, providing a detailed price and time impact for the new item. Hence, it is crucial to employ advanced methods that are interactive, proactive, and capable for handling large volumes of construction information while dynamically engaging with the available data. It is crucial to realise that Information and Communication Technologies (ICTs) have undergone substantial advancements in the past few decades and can be employed to enhance the existing management methods [9].

The rapid and innovative progress in ICTs has had a significant influence on the Architectural, Engineering, and Construction (AEC) sector, as well as its administration and sharing of information [12]. The connection between technology, construction, and legislation is characterised by a dynamic and reciprocal interaction, where modifications in one domain consistently exert an impact on the others. Research has demonstrated that specific computing and ICT tools are approaching their maximum capabilities as researchers and practitioners work towards resolving intricate problems. Quantum computing (QC) is a swiftly progressing technology with the capacity to fundamentally transform computational capabilities across multiple domains, including engineering. It facilitates intricate calculations that are now unreachable or excessively time-consuming [13]. The quantum computing market is forecasted to have a significant 500% expansion over 7 years. Nevertheless, there has been a lack of focus on this technology and its prospective applications in the (AEC) industry, which has faced criticism for its sluggish implementation of ICT tools [13].

Building information modelling (BIM) is a technology that offers significant benefits in construction management for diverse projects. The main components of employing BIM are its technological capabilities, interoperability, early dispute detection, integrated procurement, enhanced cost management methods, reduced team conflict, and project team benefits [14]. Although BIM is not a new concept, it has gained considerable attention in recent years, particularly in UK construction projects [14]. Policy measures, such as the UK Government's Construction 2025 vision, promote the adoption of the BIM method in order to achieve lower construction costs and faster project delivery. Similarly, countries such as Finland, Denmark, and the United States require AEC firms to implement BIM when undertaking public construction projects [15].

The construction sector in the Kingdom of Saudi Arabia (KSA) is planned to be widely expanded with extensive renovation in the existing infrastructure. Precisely, the KSA is dedicated to accomplishing the developmental objectives delineated in "Vision 2030", which is supported by a substantial 2018 budget of USD 260.8 billion, the largest in the history of the KSA [16]. For example, the first phase of the NEOM project is planned to be opened in 2030 with an estimated budget of USD 5 billion. Hence, the present is an opportune time for the KSA to align with the sustainable development trend observed in countries such as the United States, the United Kingdom, and Australia by embracing

BIM [17]. Despite a limited amount of documented work, a comprehensive literature review indicates that the KSA has not yet fully harnessed the potential advantages of BIM. Extensive research on BIM acceptance and implementation in the Saudi construction industry demonstrates many study areas, gaps, benefits, and barriers [18]. Consequently, this paper outlines these aspects, providing a solid foundation for future BIM research within the KSA. The automation of claims management processes in the KSA construction industry has been the subject of limited publications, with scarce availability of claims management based on BIM models, as indicated by survey findings [1]. This study aims to present a claims management model by utilising BIM to promote a systematic approach for efficient and streamlined claims processing and more effective claims management practices. In addition, the purpose of the presented theoretical model is to enhance the accuracy of claims values in a short time to reduce the prolongation of claim.

The proposed model was based on time analysis and cost estimation software. It aimed to analyse time-related claims using either Microsoft Project or Primavera. The cost estimation utilised (Cost-X) as part of the BIM package [9]. Hence, the BIM package aimed to provide a more precise estimation of claimed time or cost, a realistic assessment of risks of potential conflicts, and timely resolution of errors and omissions. To establish a BIM-based claims management model, the researchers selected claims that the model could represent in terms of affected building elements [19,20]. The most prevalent construction claims were identified through a questionnaire focusing on the extensions of time and money claims for inclusion in the BIM-based claim management model [15].

The proposed theoretical model also aims to enhance the practice in the construction field, particularly in the KSA construction industry. The rationale behind the proposed model in this study lies in the performance indicators utilised during claim assessments. These indicators include factors such as time efficiency in claim submission, the accuracy and completeness of documentation, adherence to legal and regulatory requirements, contractual obligations, and the cost and effectiveness of the resolution process. Certainly, when comparing BIM-based claims assessment to traditional practices in construction, we can formulate sets of hypotheses to guide this research. Therefore, four hypotheses are proposed and listed in Table 1 to establish clear objectives for this study and support the proposed framework for testing the effectiveness of BIM in claims management from the field survey perspective as well.

Table 1. Hypotheses that guide the research objectives.

Hypothesis	Null Hypothesis (H0)	Alternative Hypothesis (H1)
H1: BIM improves the accuracy and completeness of documentation.	There is no difference in the accuracy and completeness of documentation between BIM-based claims assessment and traditional practices.	BIM-based claims assessment leads to more accurate and complete documentation compared to traditional practices.
H2: BIM improves time efficiency in claims processing.	The time efficacy of claims processing does not differ significantly between BIM-based assessment and conventional practices.	BIM-based claims assessment yields a processing timeline that is both expedited and more effective in comparison to traditional methodologies.
H3: BIM reduces dispute resolution time.	The time required to resolve disputes is not different between BIM-based and traditional practices.	BIM-based claims assessment expedites the resolution of disputes compared to traditional methods.
H4: The communication in claims management is enhanced by BIM.	The communication effectiveness of BIM-based claims assessment is not significantly different from that of conventional practices.	Compared to conventional practices, BIM-based claims assessment increases the effectiveness of communication among the parties involved in the claims process.

2. Literature Review

2.1. A Review of Claims Management Procedures

The steps of a claim procedure are identification, notification, documentation, presentation, analysis through examination, negotiation, and settlement, and all these processes require different resources to be engaged and co-ordinated [5,19]. Identifying a claim in the construction industry requires the prompt and precise recognition of an alteration. It is the first and most significant step in alerting the engineer to the formation of a potential problem. The time constraint is also significant, and the engineer and the company have their respective responsibilities outlined in the contract at this point [21]. Claims documentation is also crucial to the claims settlement process [20]. Therefore, it is imperative that all the necessary documentation, such as drawings, specifications, written instructions, and timetables, be gathered in one place [22]. The engineer is provided with these records for review and evaluates and decides the amount of compensation after receiving a formal claim [21]. Negotiation is the last step in the claims management process, which is the settlement of the claim. The parties offer an alternate dispute settlement process if they cannot agree and each believes they are in the right [21]. Similar previous studies in the field of construction management proposed solutions to aid the claims procedures and analyses, such as an expert system framework for evaluating claims. In addition, a hypertext-based claims analysis system and a simulation-based approach were proposed for making claims decisions [5,23]. Moreover, decision support systems for delay analysis that encompass an information system for managing delays and an agent-based collaborative system for resolving claims were suggested. An automated system called Claims Manager 2000 is used for administering construction claims as a process model [24,25]. Many of these studies aimed to utilise the visual parameters of building models to connect them to a central database containing information pertaining to claims for each respective model component. Potentially, the database may be used to see the stated parts of a project in context and see how they work together [26]. If this was possible, it may aid in the formulation and evaluation of claims by allowing for a fast access to and retrieval of the relevant information related to each model component [9]. Finally, one of the claims procedures and analyses is the traditional approach, as detailed in the following section.

2.2. Claims Management Analysis under the Traditional Approach

The procedures concerning construction claims under traditional approaches encompass a well-organised sequence of steps and processes that are adhered to by the parties engaged in a construction project in the event of a dispute or claim [25]. These procedures are typically delineated in the construction contract and may be subject to variation depending on the specific terms and conditions stipulated in the signed contract. In this research, Figure 1 outlines the customary steps in construction claims procedures under traditional approaches [16,18]. Initiating a claim requires the entitled party, typically the contractor or subcontractor, to submit a written notice to the other involved party, usually the owner or general contractor. The notice of a claim should be based on the established claim procedure, including the determination of causation and the right to claim, accompanied by the relevant supporting documentation serving as a burden of proof, as indicated in Figure 1. However, the authors believe that the most crucial stage is the formulation of the claim, which necessitates contractual and legal substantiation through the provision of supporting documentation. The duration of the claim formulation and submission is not limited to when a bespoke contract is used under the traditional approach unless agreed otherwise. The preparation of a claim should rely upon appropriate tools and resources to be expedited [9]. Conversely, in the case of using the FIDIC standard contract form, a party entitled to make a claim must submit the claim as soon as practicable and no later than 28 days from the occurrence of the action related to the claim, such as a change in scope or variations, as indicated in Figure 1. Failure to comply with the time frame will result in the forfeit of the entitled party's right to raise a claim later. Therefore, depending solely on the conventional approaches for analysing claims may not grant the claimant the prerogative to scrutinise and submit the claim thoroughly [22]. This is one of the rationales behind this research endeavour, which aims to investigate the utilisation of BIM to evaluate and submit claims, ensuring a more efficient, less timely, and seamless process.

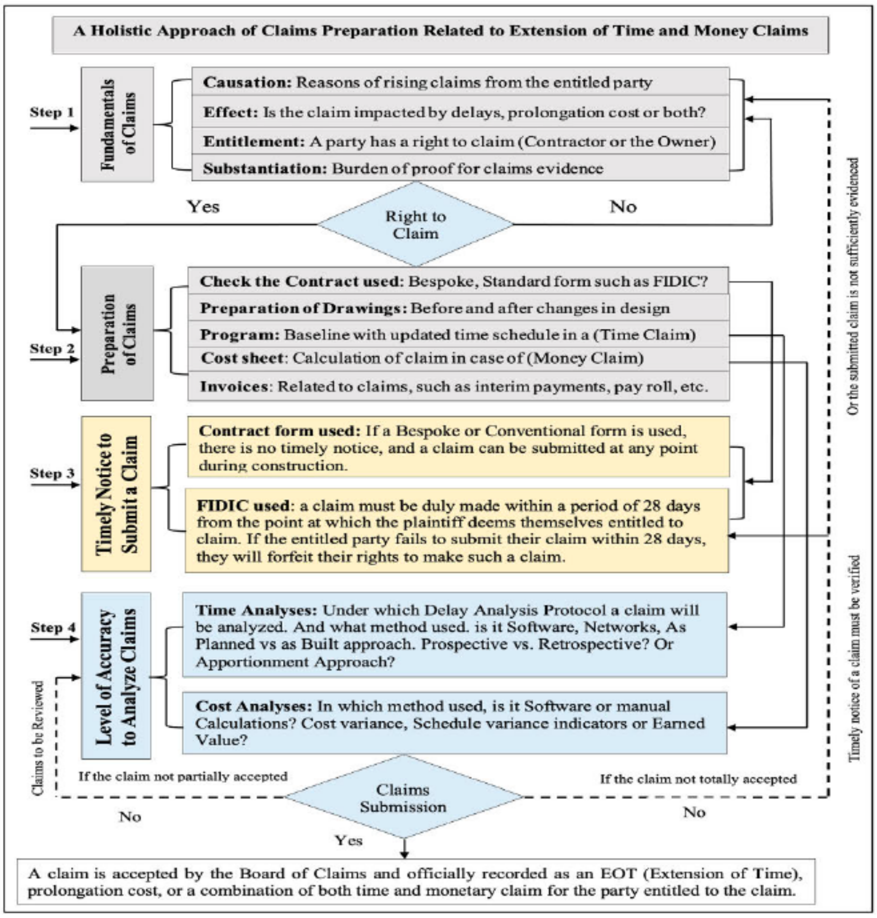


Figure 1. Flow chart created by the authors to show claims procedures and analyses under a traditional approach.

Unlike the FIDIC contract conditions, the doctrine and Sharia law applicable in the KSA allows for certain rights to be exempt from a statute of limitations. This means the claimant can submit a claim at any time during the project, even after completion, within a reasonable time frame [22]. The statutory limitations that result in the forfeiture of rights when raising a claim after a definite time and interest charge due to delayed payments under FIDIC conditions serve as significant obstacles to the full applicability of the FIDIC in the KSA industry due to its conflict with Sharia law. In certain instances, the contracting parties within the KSA industry may customise their contract conditions by selecting specific articles from the FIDIC conditions and referring to the agreement as a mini-FIDIC. Such adaptations may enhance contractual autonomy and align with Sharia law regulations. As indicated in Figure 1, the level of accuracy required to analyse the construction claim under a traditional approach necessitates a comprehensive undertaking, encompassing an analysis of the delays and costs. The claimant must select the appropriate protocol for analysing the delay and the relevant indicators for cost analysis as the burden of proof lies with the party seeking to convince the court or arbitration tribunal.

Most importantly, managing the FIDIC contract can be challenging. For instance, if the contractor spends a long time preparing and analysing a claim, they may lose the right to claim within the 28-day period specified by the FIDIC. Therefore, utilising BIM applications alongside the FIDIC promotes a better collaboration and communication among project stakeholders, aligning with the collaborative principles emphasised in FIDIC contracts. In some instances, the process of handling claims can be complex and time-consuming, as it involves verifying that the constructed elements adhere to the specified requirements outlined in FIDIC contracts. Therefore, BIM provides accurate documentation and effective change tracking, which contribute to claims management by providing a strong foundation for resolving disputes related to delays, variations, or other contractual matters.

2.3. Analysing the Extension of Time with Money Claims under the Traditional Approach

Extension of time (EOT) and delay analysis are inherent in any construction project, especially regarding money claims. Figure 2 presents an overview of the classifications and types of delays and their corresponding impacts on the accountable party for the delays and the nature of compensation [26]. Delays in construction projects can result in additional costs, prompting the parties involved to seek compensation or time extensions to mitigate these effects. Typically, there is a connection between an EOT and delay analysis regarding money claims. An EOT refers to a formal request initiated by a contractor, which might prolong the completion date of a project beyond the initially agreed-upon contract duration [26]. This extension is typically granted in cases where delays occur due to circumstances beyond the contractor's control, such as adverse weather conditions, unforeseen site conditions, or modifications in the project scope. It is worth noting that, when an EOT is granted, considerable financial implications are involved, particularly in avoiding liquidated damages. In many construction contracts, liquidated damages are stipulated as monetary penalties imposed on the contractor for project completion delays. However, by obtaining an EOT, the contractor can potentially mitigate or altogether avoid these penalties [20]. Moreover, an EOT may have financial implications as contractors may incur additional costs during the extended period, including expenses related to labour, equipment, and site overheads. Consequently, these additional costs can be included in the contractor's monetary claims [27].

Concurrent delays in construction projects refer to multiple delays that occur simultaneously, are caused by multiple parties, and might impact the progress of a construction project. Figure 2 refers to the types of delays, including concurrent and nonconcurrent delays, in which nonconcurrent delays are serial independent delays [28]. In addition, Figure 3 illustrates concurrent delays in terms of concurrency and effects, in which true concurrent delays are simultaneous events from both the owner and the contractor, while concurrent effects are non-simultaneous events that occur at different times. In Figure 3a, two concurrent delay events occur on the same day (day 4), one caused by the owner and the other by the contractor. Both events are on parallel critical paths, resulting in simultaneous project delays on day 9. Thus, the delays are concurrent in this case. Figure 3b demonstrates a variation where the contractor event occurs on day 4, while the owner event is scheduled for day 6 [28]. Both events remain highly significant, leading to a project delay that becomes apparent on day 9. As the events causing the delay do not transpire simultaneously, this circumstance can be classified as concurrent effects, with the contractor being solely accountable for the resulting uncertainty. However, from a safety perspective, the increased safety risks in construction activities occur when two or more activities on a construction site take place simultaneously within a shared timeframe, referred to as concurrency [29]. When there is a lack of using BIM, project management tools, such as

Microsoft Project, are often utilised to schedule and organise project activities, enabling the identification of overlaps between activities [29].

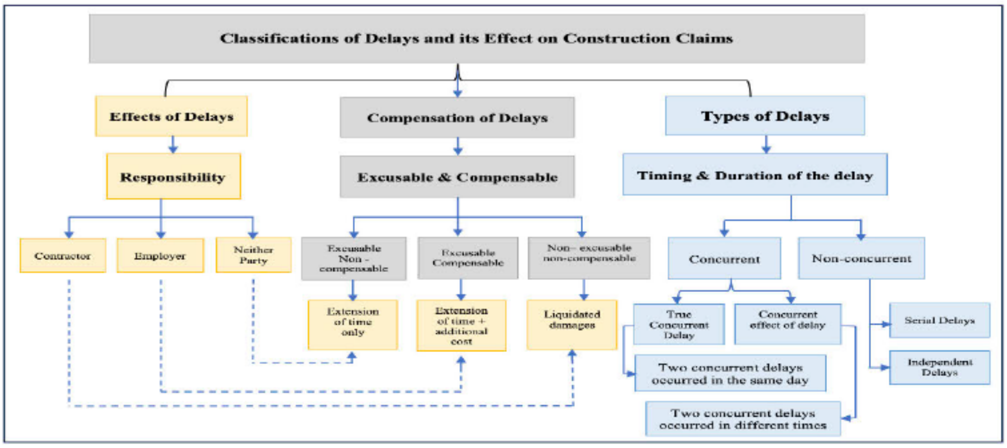


Figure 2. Types and classification of delays with their effects on the involved parties in construction projects.

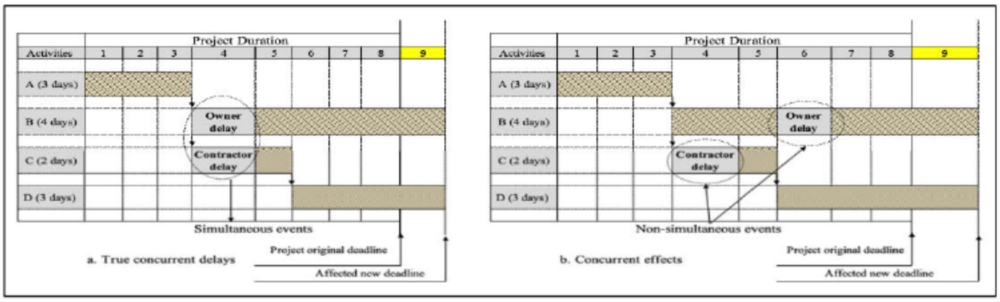


Figure 3. True concurrent delay events vs. concurrent effects, adopted from [28].

Analysing delays under the traditional approach is a difficult task, especially concurrent delays, which can be a significant challenge and may lead to conflicts and claims between the involved parties in the project. Effectively addressing concurrent delays necessitates a wide knowledge of contractual terms, effective communication, and a proactive approach towards mitigation and resolution. It can be challenging to ascertain the occurrence of concurrent delays, as they frequently involve a combination of excusable and non-excusable delays. Most construction contracts do not encompass methods and procedures for delay analysis, which are essential in determining the causes and responsibilities of delays [29]. The absence of a defined protocol or methodology for analysing delays in traditional approaches in countries such as the KSA, Egypt, or the United Arab Emirates, particularly during a claim event, may pose difficulties for the contracting parties. However, in the UK construction industry, the "Delays and Disruption Protocol" established by the Society of Construction Law (SCL) says that, in cases where both the employer and contractor contribute to concurrent delays in the project, this results in additional costs for the contractor [29]. Therefore, the contractor is entitled to receive reimbursement solely on the condition of effectively distinguishing the additional costs resulting from the employer's delay from those arising from the contractor's delay. If the contractor is responsible for the delay that resulted in additional costs, the contractor will not be eligible to claim reimbursement for those additional costs.

2.4. BIM Package as an Alternative Approach to Resolve Disputes in Construction Projects

The widespread adoption of BIM allows for a more integrated design and construction process, resulting in improved quality and reduced costs and time in construction projects [1,27]. Despite the potential hurdles, such as model ownership issues, copyright protection concerns, ambiguity over design liability, a lack of contractual rules, and concerns about model security and privacy, there is evidence that BIM provides advantages to the industry. Government entities and experts in the construction sector are drawn to BIM as a solution to the challenges faced by the construction industry, owing to its numerous benefits [30]. Various BIM systems, such as BIM-Storm, aid in creating a design that aligns with the owner's financial constraints and unique requirements [16]. BIM-Storm facilitates online collaboration among participants to assess design alternatives from the perspectives of cost, time, and sustainability to establish more accurate programme requirements. BIM is a tool for identifying design flaws and evaluating modifications to a model. It can automatically generate a report detailing the changes made to 3D objects between different versions of the model. BIM is mostly associated with enhancing document management and control [31]. When prior experiences are thoroughly documented, they can be utilised to accurately anticipate future conflicts and difficulties [32].

BIM enables comparisons between a project's as-planned vs. as-built data approach, allowing it to provide warnings about cost, time, and quality discrepancies [33]. Therefore, it can analyse and manage time, resources, costs, and conflicts, involving timely decision-making. The use of BIM in quality management is also reasonable [34]. It identifies quality disputes by identifying the quality control criteria and responsibility assignments in the construction process through inspection and testing, as well as providing analysis during the construction phase and feedback on inspection results [35]. As one of the leading causes of project schedule and budget overruns, construction defects can be identified through BIM-assisted automated inspection by utilising augmented reality and image-matching technologies [14,36]. An inadequate safety performance may be improved with the use of BIM, which uses safety rule checking and automatic safety rule simulation to help to make construction sites safer and healthier for workers [9,33]. BIM can help construction managers or owners to analyse and manage process conflicts and safety issues by dynamically supporting the safety analysis of structures and the clash detection of site facilities [37]. Scheduling and space conflicts may be easily analysed with the use of BIM. The mandated collaborative sessions in BIM have been demonstrated to boost trust and communication between the parties involved [38]. By its very nature, BIM will lead to a better communication among all parties involved. Claims can be reduced by using a BIM-based, integrated, and trustworthy approach. One of the most obvious benefits of investing in BIM is enhanced collaboration and communication among the team members [39].

When it comes to common data sharing, the BIM method is a built item that aids in design, construction, and operation and is a future information communication technology (ICT) resource for responsible decision making [5]. It supports interdisciplinary co-operation, knowledge sharing, management changes, and information support throughout the facility lifecycle, as well as drawing and documentation [40]. Information models can incorporate contracts, specifications, properties, employees, programming, numbers, costs, places, and geometry. BIM makes 3D presentations, stores data digitally, and quickly updates and shares data. For example, BIM enables the creation of detailed and accurate 3D models, providing a comprehensive visual representation of the construction project when a claim is related to a change in the original scope. Accurate documentation through BIM helps the parties involved in a dispute to reference the original design intent, construction sequences, and changes over time. BIM allows for the efficient tracking of changes throughout the project lifecycle. Visualisation features in BIM make it easier for stakeholders to identify and understand design changes, construction variations, and as-built conditions, effectively addressing claims related to changes.

BIM can be used for accurate quantity take-offs and measurements, reducing disputes related to discrepancies in quantities. The ability to extract precise data from the BIM model assists in quantifying work performed and evaluating variations from the original scope. From a contractual perspective, BIM helps to ensure compliance with the legal and regulatory requirements by providing a transparent record of design, construction, and changes. This transparency assists in addressing claims related to non-compliance with contractual or regulatory obligations. BIM helps stakeholders to communicate and collaborate on shared project models, as well as access, co-ordinate, and share data [5,41]. Project management, construction, engineering, IT, policy, and regulations use BIM knowledge [42]. BIM has transformed the traditional construction industry from a linear and fragmented industry to one in which project stakeholders share common objectives [5,38,43].

2.5. The Adaptation of BIM in Claims Management

BIM has played a crucial role in the evolution of multiple construction management disciplines, including construction claims management [18]. The outcome of a claim is heavily dependent on the quality of the claim report [44,45]. However, claim evidence in the KSA construction industry is still presented in person, through handwritten documentation, which can be presented via computer-generated digital data, in the case of BIM use [44]. Utilising electronic, visual, and demonstrative evidence for construction claims will likely accelerate the construction industry's adoption of BIM [44]. All project information would be stored in a central database linked to a 3D model that could be used to aid in the identification, quantification, and visualisation of claims if BIM is implemented in a project from its inception and the recommended record-keeping procedures are followed [44]. Visualisation is essential for obtaining the desired outcomes because, in many claim cases, the work related to a claim case might be invisible on site and covered by other activities, requiring it to be better visualised, especially when the raised claim is late in the construction process [46]. It is predominantly used to enhance communication in architectural design, but its benefits can be observed throughout the entire project lifecycle [5]. Consequently, BIM can be adopted as an essential resource for proactively resolving conflicts and claims to avoid disputes [47].

2.6. Associated Risks with BIM Application

The connection between technological advances, the construction industry, and legal aspects is characterised by constant evolution, wherein advancements in one domain invariably influence others; BIM is a significant advancement in this regard [48,49]. The utilisation of BIM technology in the construction industry is subject to various factors and limitations. However, the associated risks with BIM employment have surfaced as a challenge rather than a solution in some projects. This is attributed to inadequate comprehension by the parties responsible for the liability and accountability of the BIM method during the design, construction, and maintenance stages [50]. The contrasting features of BIM's collaborative nature, which facilitates a platform for sharing among those involved in the project, and the contractual nature, which tends to isolate and insulate rather than support and collaborate, have been identified as a complex difference [48].

In order to mitigate the associated risks, the parties involved in a construction project using the BIM process must sign a single legal agreement laying out their respective technical and legal responsibilities throughout the modelling phase [38,48]. Inexperience with BIM technology in a contractually based model leads to issues with the enforceability of specific regulations and agreements for BIM integration within construction projects [51]. Since the construction industry's efforts to reach a level 3 BIM by 2016, wherein all parties work together on a single model, this challenge has arisen [52]. Due to BIM's contractual and legal risks and the immaturity of BIM practices, adopting BIM as a working methodology is fraught with risk and uncertainty from the aforementioned angles. In addition, BIM relies heavily on software and hardware systems that can be prone to failure or malfunction, which might lead to delays in construction schedules and additional costs [51].

Associated risks might be extended to the lifecycle of the project after the construction stage and during the operation phase, when there is a lack of implementation of a building management system based on BIM. Research in the Iranian construction industry focused on the importance of examining risks and their interconnections for the effective implementation of Energy Performance Contracting (EPC) projects in developing countries with significant energy usage [53]. The use of hybrid method techniques has generated a valuable network relation map, providing insights into the interconnections among various risk dimensions and determinants. The project lifecycle risks are closely linked to other risks, either causally or consequentially [53]. This highlights the need for efficient risk management solutions, specifically for hazards and risks throughout the project lifecycle.

3. A Proposed Theoretical Framework Based on the BIM Package for Claims Analyses

The research authors designed the theoretical framework shown in Figure 4 as an alternative approach for analysing claims based on the BIM package instead of the traditional practice. In the realm of traditional practice, the potential resilience of technological advancements may be restricted, or software could be employed in isolation rather than in an integrated manner. In the realm of construction claims analysis using the BIM package shown in the Figure 4, both prospective and retrospective methods can be practically employed. The theoretical framework is divided into three stages, in which stage one identifies both the contractor and owner responsibility under BIM levels that must be identified in the contract conditions. The levels of BIM use 4D for time measurement and 5D for cost measurement as an integrated BIM package to enable its application over the whole lifecycle of a construction project. In order to effectively implement a comprehensive approach using BIM for analysing potential construction claims, it is crucial to acknowledge the existing research gap in exploring the efficacy of BIM in delay claim analysis. Gibbs et al. (2013) [44] and other researchers stated that the assessment of delayed claims poses several challenges, including information retrieval and visualisation during the evaluation process [54,55]. The proposed theoretical framework for analysing claims procedures will be thoroughly validated and examined in a subsequent research paper conducted by the author. This research will be supported by real-life disputable claims cases from the KSA legal industry. Additionally, the next section provides an example from a case study to test the theoretical framework.

To use the theoretical framework in Figure 4, Scenario 1 represents the prospective method as an analysis process that takes place at the time of decision for delays or change orders to predict the likely outcomes of those compensation events related the expected delays with the associated cost, if any. For example, if a variation order is issued to change the location of a precast wall in a project, the supplier estimates that it might take 8 days to deliver the new wall, and the installation is expected to take 1 day. Consequently, when this change is incorporated into the construction schedule, it shows a potential delay impact of 9 days on the completion date. This type of analysis is known as a prospective approach, as it involves forecasting the potential impact of a delay event based on the estimated duration at the time of the event and how it could affect the contractor's programme.

In a practical case study involving the implementation of a medical warehouse project in the KSA, the corresponding author was a member of the contractor's team. The project was being executed following a traditional approach. The owner expressed the need to relocate the indoor air handling units of the air conditioning (AC) system due to storage conditions. These AC units were to be suspended on specific steel elements of the roof structure. The structural elements of the building were under fabrication and the contractor's team referred to the supplying factory for the structural elements of the building with the owner's modification request. The factory accepted the request with an additional cost of change of USD 37,500 and assured that the alteration would be completed within a timeframe of 2 weeks. However, the 2 weeks of the delay impact were accepted by the project team as it would not affect the overall deadline. Contrary to expectations, the steel factory informed the project team that the delivery of the modified steel structure would encounter a significant delay of 2 months. Consequently, the overall project would experience an equivalent delay. The factory justified its lack of awareness regarding the potential ramifications of altering the steel sections that supported the air conditioning units with other interrelated design elements. The project was theoretically subjected to a delay claim longer than expected between the contracting parties due to a lack of proper analysis before taking the action of the change order.

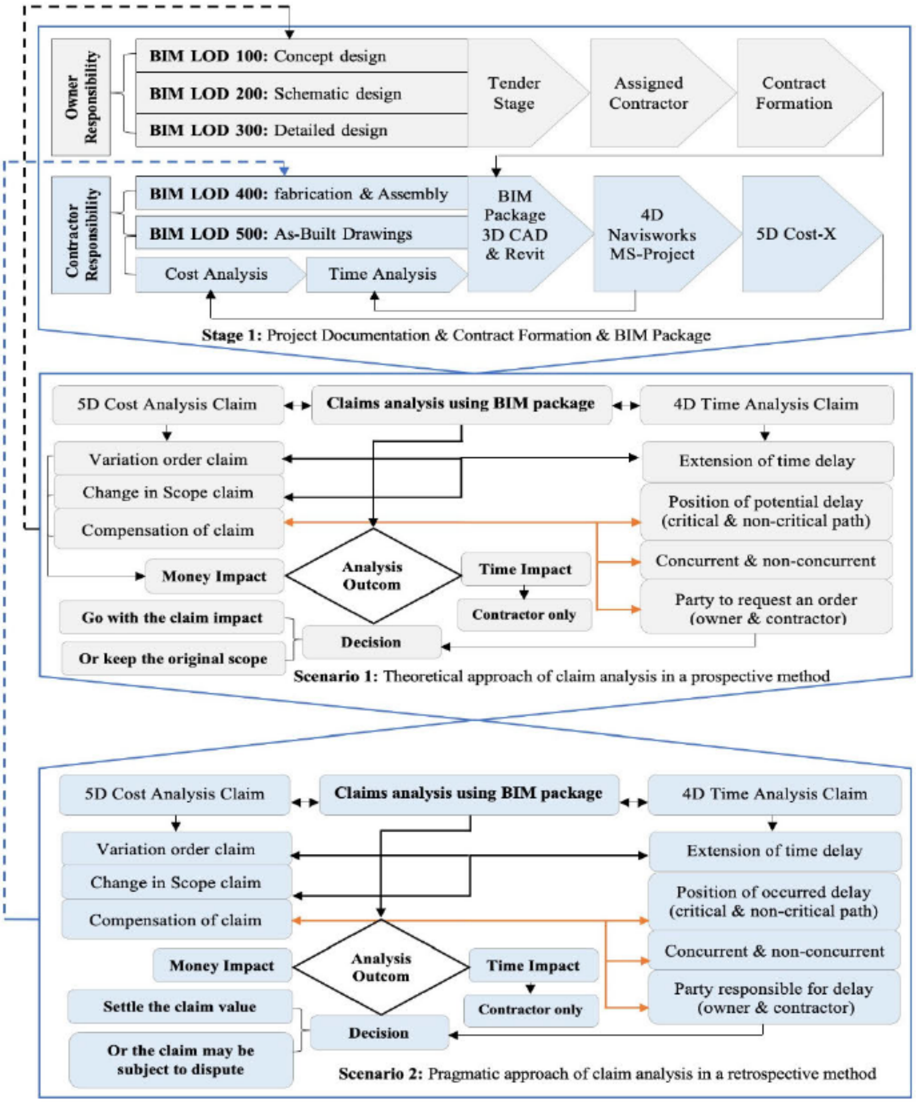


Figure 4. Flow chart created by the authors to show the claims analysis using the BIM package under prospective and retrospective methods.

The above case study was simulated prospectively using the BIM package based on Scenario 1, for which the schedule was re-analysed using Microsoft Project in conjunction with Navisworks. The simulation indicated that a projected delay of 2 weeks would not impact the project's deadline. However, the additional 45 days were not considered when considering the subsequent delay caused by the steel supplier. As a result, the delay in the steel elements also caused a delay in the provision of air conditioning units and the installation of the firefighting network. In total, the project incurred a cumulative delay of 75 days. The owner expressed that, if he had known about this consequence beforehand, he would have reconsidered the decision to modify the handling units' location and would have approached the storage conditions differently. Therefore, it should be noted that the prospective approach relies heavily on theoretical estimates rather than the hard facts of claims. In other words, prospective analyses are conducted in real time before or during the delay event. These analyses involve the analyst's best predictions of future events. They are performed while the project is still in progress and may not be relevant to forensic investigations. The method of delay analysis used for an EOT claim might have significant implications, as it can yield different outcomes. By employing prospective analysis and relying on computer-based BIM modelling and time impact analysis, the contractor may anticipate that the variation will cause a critical delay, thus warranting EOT claim.

To address the aforementioned delay and return to the real-life example from the industry, we retrospectively analysed and simulated the anticipated 75 delays. We expedited and reorganised specific activities in the schedule related to the steel elements so that they could be completed simultaneously (Start to Start and Finish to Finish). Additionally, we planned for the fabrication of the AC unit pipes to take place off site, making them ready for installation once the modified steel elements arrived on site. Furthermore, extensive negotiations and virtual meetings were conducted between the contractor team and the steel supplier in order to minimise the delays to just 50 days. The main contractor and the steel supplier reached an agreement that 50% of the modified steel elements would be delivered to the site within 30 days of the change order. Subsequently, approximately 50% of the steel structural elements would be erected onsite, followed by the sequential installation of 50% of the AC units in their new locations. Based on these analyses, 25 days from the total delayed period were reduced. Therefore, Scenario 2 in the theoretical framework in Figure 4 evaluates the delay retrospectively, after its complete impact has been felt. More precisely, the retrospective approach to delay analysis relies on factual evidence to determine its findings. By comparing the original plans to the actual events that took place during construction, this method offers a more accurate understanding of the impact of the delay. Its conclusions are derived from facts rather than theories, providing a clearer and more precise assessment [53]. The difference between the prospective and retrospective methods can be significant, especially if they determine whether liquidated damages for delay need to be paid. The issue becomes more complex and accurate during adjudication, arbitration, or court proceedings, where the full impact of events is unknown.

After the completion of a project, all project data, such as schedules, correspondence, and project records, is accessible through a retrospective approach. This guarantees a thorough and precise dataset for examining delays, rather than depending on approximations or forecasts during the construction period. The retrospective technique facilitates the comprehensive documenting of events, modifications, and delays during the whole duration of the project. Thorough documentation enhances a more thorough comprehension of the reasons and consequences of delays, establishing a solid basis for presenting claims effectively. From a legal standpoint, following the retrospective approach, the parties involved in a dispute can better support their legal arguments by utilising comprehensive data obtained after the project. This leads to stronger and more defensible claims or defences during legal proceedings, ultimately increasing the likelihood of a favourable outcome for the aggrieved party.

As shown in the Figure 4, the outcomes of analysing claims procedures under the prospective approach often lead to accepting the forecasted delays or maintaining the original decision unchanged. However, the analyses in the prospective approach may retrospectively lead to a corrective action, in which the programme can be modified to reduce the potential delays when the project is totally affected. In contrast, in the retrospective approach, a claims analysis may result in a claim settlement or escalate to disputes. Therefore, the following sections provide a detailed analysis based on a real-life case study, exploring both the prospective and retrospective approaches in greater depth.

3.1. A Real Case Study: Simple Programme for Scenario 1A: An As-Built vs. As-Planned Programmes

We present the real case study of Walter Lilly v Mackay, presented by Ewen Maclean [56]. A simple scenario (Scenario 1) included five milestone activities, substructure, superstructure, finishing, MEP, and handing over, which were expected to be completed by the end of week 15 in the prospective situation. In Scenario 1a in Figure 5, the as-built programme showed a delay of 3 weeks compared to the as-planned programme, resulting in completion at the end of week 18 [56]. The substructure and superstructure activities were completed on time, while the finishing activities were delayed by 3 weeks, and the subsequent activities were completed within their original duration. Therefore, a compensation event lasting 3 weeks was required, as plotted on the programme at the end of week 6. This event accounted for the delay in starting the finishing activities and the overall delay of 3 weeks for completion. In the prospective analysis, the programme started with the same plan and was updated until just before the compensation event occurred [56]. Figure 5 indicates that the as-planned programme is still scheduled to be completed by the end of week 15, with no delay just before the compensation event.

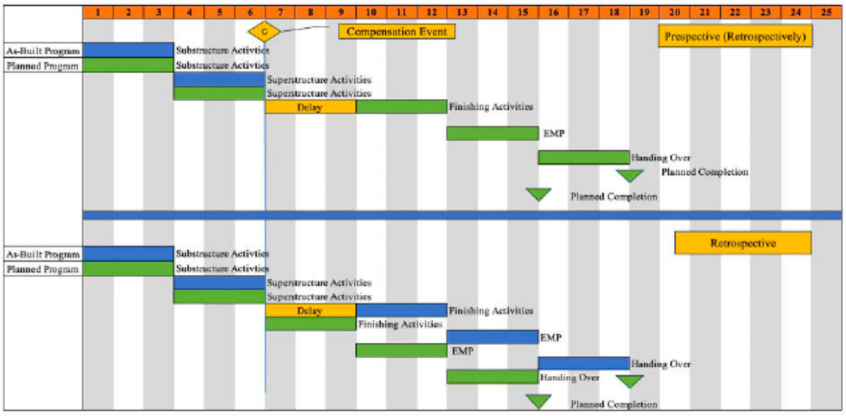


Figure 5. Scenario 1A: prospective vs. retrospective analyses with the benefit of hindsight, adopted from [56–58].

3.2. Developed Programme for Scenario 1B: As-Built vs. as-Planned Programmes

In the retrospective approach, with the benefit of hindsight, the first scenario is developed in Figure 6 by considering the impact of the compensation event on the programme. The compensation event had a 3-week delay, pushing the planned completion date to the end of week 18. This aligns with the completion of the as-built programme and demonstrates the same result as the retrospective analysis. However, a prospective analysis carried out contemporaneously, without the benefit of hindsight, would have forecasted a 6-week delay, as shown in Scenario 1B in Figure 6, as this process would not have been able to forecast that the compensation event would only cause a 3-week delay. This would have pushed the planned completion to the end of week 21, resulting in a different outcome to that of the as-built programme or retrospective analysis. Therefore, prospective and retrospective analyses do not always yield the same result in every situation, unless the forecast delays match the actual delays [53,56].

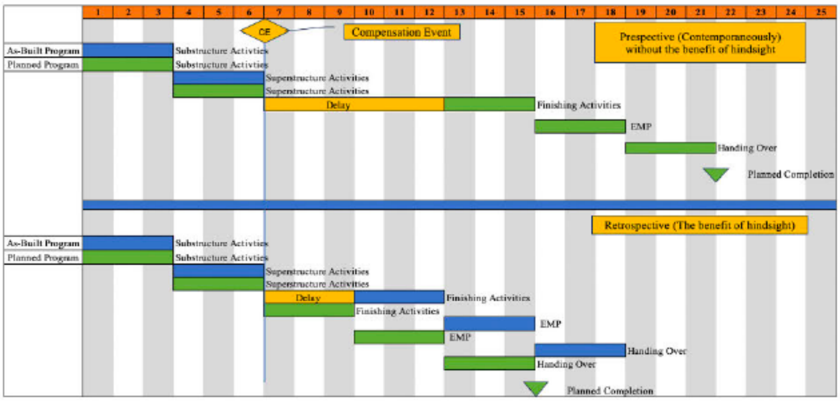


Figure 6. Scenario 1B: prospective vs. retrospective analyses without the benefit of hindsight, adopted from [56–58].

3.3. *Series of Presented Developed Programmes as Accepted Programmes: As-Planned vs. As-Built Programmes*

The prospective and retrospective analyses are explained in more depth in these series scenarios concerning the scenarios mentioned above. The first accepted programme is scheduled to be completed by the end of week 15, with the completion date set for the end of week 19, as shown in Figure 7. A terminal float of 4 weeks is assumed to represent the period between the planned completion and the completion date, for which no delays are attributed to either the contractor or the employer. When programme No.1 is updated, it becomes apparent that the substructure and superstructure activities were completed 1 week later than planned, causing a delay in the overall project schedule from week 15 in programme No.1 to week 16 in the updated programme (No. 2) as shown in Figure 8. In the second accepted programme, a compensation event 1 is presented to have a duration of 6 weeks but only took 3 weeks in the updated programme (No. 3), as shown in Figure 9. In order to analyse its effect, the updated programme is considered relevant to the time when the second accepted programme was created. This delay occurs as there are no compensation events within this period of work. The completion date remains unchanged at the end of week 19, but the terminal float is reduced from 4 weeks to 3 weeks. In other words, the contractor is responsible for the 1-week delay to the project. This holds for both the prospective and retrospective situations, as indicated in the tables in the top right-hand corner of each chart.

In the prospective situation, if the approved programme No.2 undergoes an update for progress and experiences a delay of 6 weeks that impacts the superstructure activities, it results in a 6-week extension to the planned completion from week 16 to week 22. Accordingly, the completion date is also shifted by 6 weeks, from week 19 to week 25. As a result, the terminal float remains unchanged at 3 weeks, and the responsibility for the 6-week delay lies with the employer since the programmes are still based on a prospective situation. At this stage, we cannot assess the situation retrospectively since we do not have the benefit of hindsight regarding what happened. When analysing the accepted programme No. 3, as shown in Figure 9, the assessment of compensation event 1 was incorrect. It only took 3 weeks to address the event, resulting in a shift in the planned completion from week 22 to week 19. Consequently, in the prospective analysis, the terminal float increases from 3 to 6 weeks, as the retrospective analysis does not allow for changing the completion date backwards. We show that the 3-week delay took place in the superstructure activities, which pushes the planned completion from week 16 to week 19. Therefore, the completion date is moved from week 19 to week 22. Hence, in scenario No. 3, the employer is accountable for a 3-week project delay, while the terminal float remains at 3 weeks. In summary, there is a discrepancy in the completion date and the terminal float between the two different analyses.

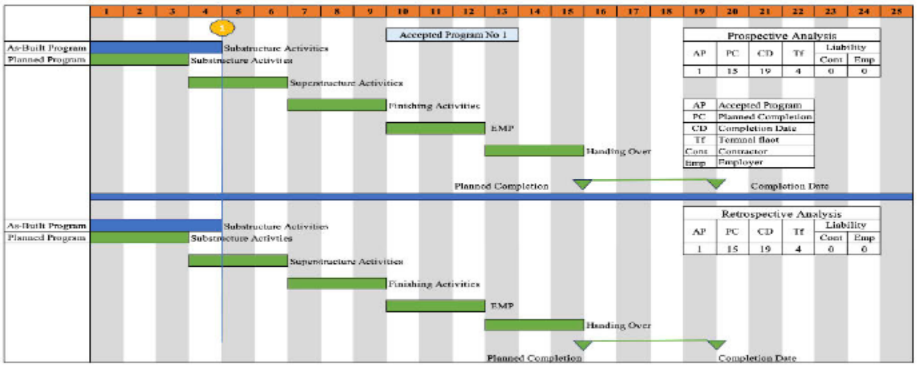


Figure 7. Accepted programme No. 1, adopted from [56–58].

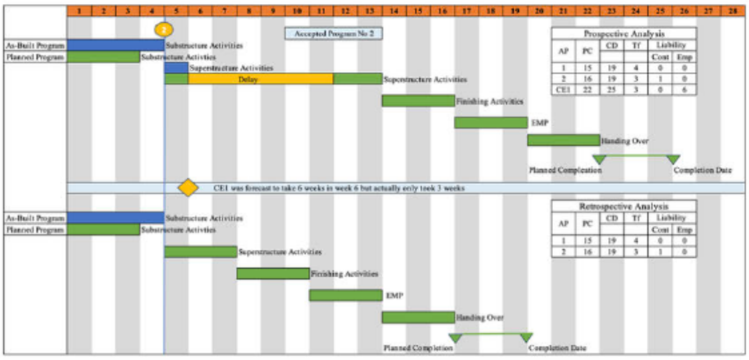


Figure 8. Accepted programme No. 2, adopted from [56–58].

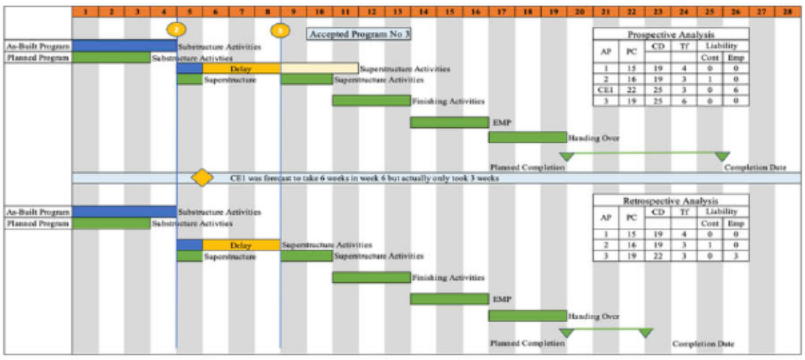
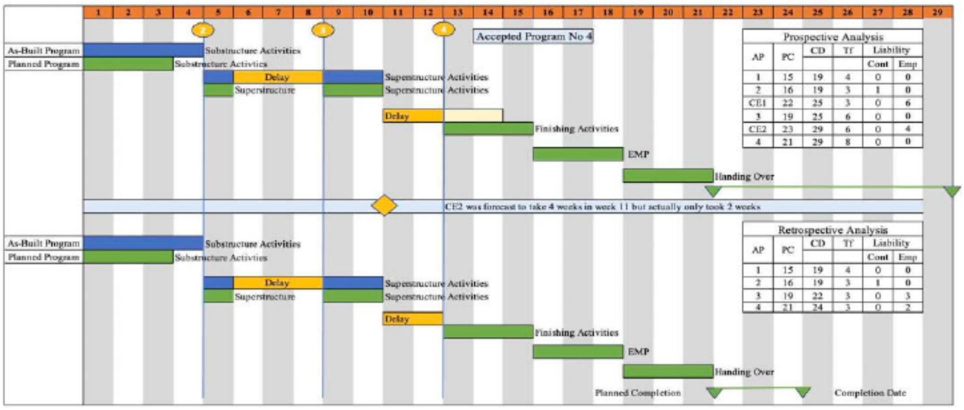


Figure 9. Accepted programme No. 3, adopted from [56–58].

In programme No. 4, the compensation event No. 2 is presented at the beginning of week 11, which was initially expected to take 4 weeks but was completed in just 2 weeks, as shown in Figure 10. In order to assess its impact on the prospective situation, the accepted programme No. 3 is to be updated, resulting in 4 weeks' delay in the superstructure activities. Consequently, the planned completion is pushed back by 4 weeks, moving from week 19 to week 23. The overall completion date also shifts from week 25 to week 29, and it should be noted that the employer bears the responsibility for this four-week delay. Again, since we are still in a prospective situation, we cannot discuss the retrospective situation when considering accepted programme number 4. The assessment shows that the impact of compensation event number 2 was once again miscalculated. This resulted in a two-week delay, shifting the planned completion from week 23 to week 21. In this prospective scenario, the terminal float increases from 6 to 8 weeks, as the completion date cannot be revised backward in the retrospective situation. We simply show the two-week delay in the finishing activities, which ultimately pushes the planned completion back from week 19 to week 21. The completion date is moved from week 22 to week 24. The employer is responsible for the 2 weeks' delay of the project. The terminal float remains at 3 weeks. In summary, there is a further divergence in the completion date and the terminal float under the two different analyses.



Prospective Analysis					
AP	PC	CD	TF	Liability	
				Cont	Emp
1	15	19	4	0	0
2	16	19	3	1	0
CE1	22	25	3	0	6
3	19	25	6	0	0
CE2	23	29	6	0	4
4	21	29	8	0	0

Retrospective Analysis					
AP	PC	CD	TF	Liability	
				Cont	Emp
1	15	19	4	0	0
2	16	19	3	1	0
3	19	22	3	0	3
4	21	24	3	0	2

Figure 10. Accepted programme No. 4, adopted from [56–58].

In the accepted programme No. 5 in Figure 11, a compensation event is examined later and is determined to be under-assessed. Compensation event No. 3 is introduced in week 17, which was initially assessed to take 2 weeks but took 4 weeks. In order to analyse its impact in a prospective scenario, we refer to the accepted programme at that time—accepted programme No. 5. Notably, there is no further delay at this point. It could be contended that it is imperative to demonstrate the impact of the implemented compensation event and the progress achieved on the activities and remaining work. Even in the straightforward scenario presented, the programme starts to lack clarity. The main purpose of presenting a series of simple programmes is to ensure that, when a programme involves a high volume of activities and numerous compensation events, it accurately reflects the effects of these events and the progress made to create a realistic plan. Without using the BIM model, which incorporates cost and time analyses, the programme is disorganised and dysfunctional. This can result in unreliable assessments of compensation events, particularly when dealing with concurrent effects [56].

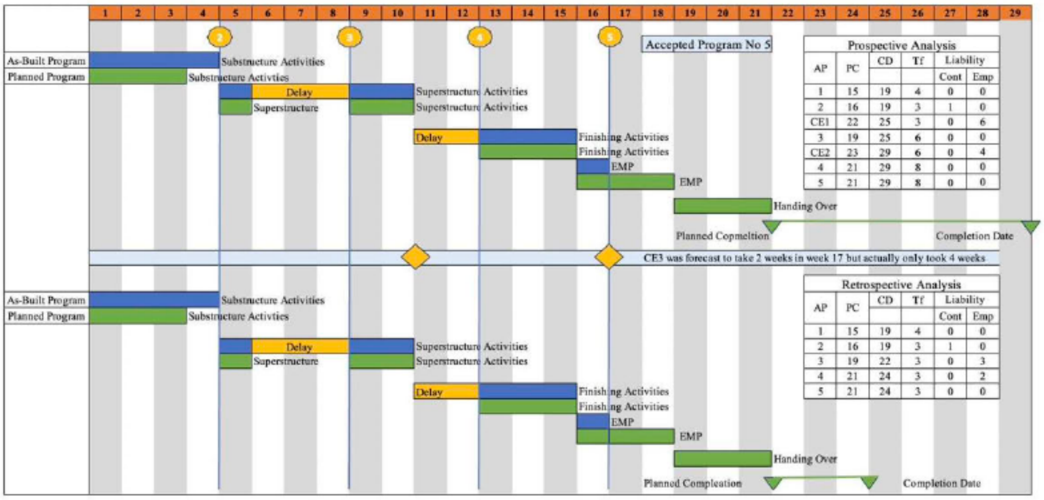


Figure 11. Accepted programme No. 5, adopted from [56–58].

3.4. Summary of the Literature Review with an Explanation of the Research Gap

The literature review examines claims management procedures in the construction industry, highlighting the continued prevalence of traditional practices, particularly in the KSA. These practices rely on manual analysis and documentation, lacking the use of advanced technology to analyse the time and cost and accurately store claim documentation. In this research, the authors proposed a holistic approach consisting of four simplified steps, as illustrated in Figure 1. However, it is important to note that, despite the visualisation provided in the figure, the traditional practice remains impractical in reality.

This research investigated an alternative approach using the BIM package to resolve conflicts related to claims, such as time consumption, accurate valuation, and trust in the claim outcome. A simplified conceptual framework consisting of three steps was proposed to analyse claims based on two scenarios, as illustrated in Figure 4. The proposed approach emphasises the required levels of BIM integration with the appropriate software. Additionally, Figure 4 presents Scenarios 1 and 2, which facilitate the analysis of concurrent delays from various perspectives. These theoretical delay analyses, detailed in Sections 3.1–3.3, highlight the complexity of analysing concurrent delays and assessing the rights of each party involved in the claim process.

Similar studies have investigated the usage of BIM in claims procedures from various perspectives, as summarised in Table 2. These studies proposed different analyses and approaches regarding how to handle claims and presented conceptual frameworks with case studies to facilitate the claims procedure. However, despite the importance of these studies, many of them appear complex and difficult to follow, particularly for claims and contract managers in construction projects. This can be due to the fact that not all claim or delay analysts or even contract managers have an extensive academic background to rely on when engaging with comprehensive research papers with data statistics to derive the benefits of a claim outcome. Consequently, a lack of studies on the KSA construction industry and how to present a claim under traditional practices in a simple manner (Figure 1) were identified as gaps in our research. For example, the first step in Figure 1 introduces the fundamentals of claims, providing a clear identification of the bases and the right to claim for the reader. The subsequent steps (2, 3, and 4) highlight the claim preparation cycle, along with the time notice under the contract used in construction projects. Therefore, the purpose of this study was to introduce a realistic conceptual framework that simplified the procedures for claims under traditional approaches, while also suggesting an alternative approach for easily incorporating the BIM package to resolve claims as a new approach (Figure 4).

Table 2. Similar studies have investigated the integration of BIM in construction claims procedures.

Paper Topic	Objectives of the Study	Reference
A BIM-based construction claims management model for the early identification and visualisation of claims.	Introducing a claim management model based on claims that can be visualised in BIM models.	[1]
BIM-based claims management system: a centralised information repository (T) for the extension of time claims.	The feasibility of using BIM to provide input information for an expert claim management system.	[5]
Claims and dispute resolution using BIM technology and VDC process in construction contract risk analysis.	It focuses on utilising BIM technology to develop a BIM-based claims management system to manage EOT claims.	[48]
A conceptual framework for developing a BIM-enabled claim management system.	Analyses the impacts of changes and delays on the schedule and cost of construction projects using the BIM platform.	[59]
BIM-based framework to quantify delays and cost overruns due to changes in construction projects.	Proposes a BIM approach to control conflict causes before the occurrence of a dispute.	[60]
Building information modelling in construction conflict management.	Reduce claims, disputes, and litigation throughout the construction process.	[61]
Dispute resolution: can BIM help overcome barriers?	Investigate benefits during claims and the resolution of disputes based on a BIM model.	[62]
Improving construction claims management using building information modelling (BIM).	Provide a schedule delay analysis method and tool that uses the correct design, estimating data from the BIM database.	[63]
Integrating BIM in construction dispute resolutions: development of a contractual framework.	To identify, analyse, and classify the legal implications of integrating BIM into construction dispute resolutions and determine the BIM-enabled contract terms.	[64]
Potential applications of BIM in constructions, disputes, and conflicts.	Defining the maturity levels of BIM, which are used to indicate the elements and benefits of BIM.	[65]
A blockchain information management framework for construction safety.	To address the knowledge gap by aiming to create an innovative information management framework for construction safety processes using blockchain technology.	[66]

4. Research Methodology

The methodology applied in this research is explained in three phases in the subsections below, and this is structured in stages, shown in Figure 12. This methodology is primarily based on an extensive review of the relevant literature with a theoretical analysis of delays for claim management cases and a field survey questionnaire. In addition, four hypotheses were assumed in this study to test the given conceptual framework in Figure 12 with additional tests from the field survey. Therefore, the purpose of the field survey was to assess the levels of awareness and knowledge of using BIM in the construction industry, especially in the KSA. Additionally, it aimed to evaluate the capability of construction organisations to implement the BIM application package in resolving claims in construction rather than relying on traditional practices, as shown in Figure 1. The investigation of this study focused on the response replies from the KSA industry, with their responses indicating if it was demanding to implement a BIM package to resolve claims in dispute resolutions. Therefore, the proposed conceptual framework shown in Figure 4 is presented as the appropriate approach to analyse the delays and determine the value of claims in the case of an occurrence.

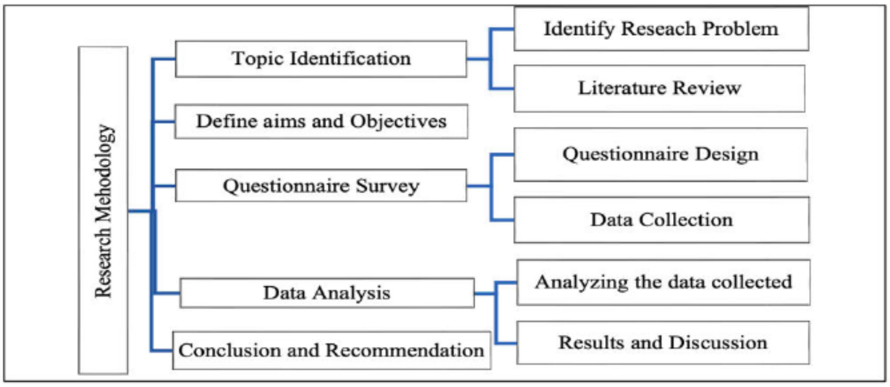


Figure 12. Research methodology.

4.1. Phase 1: Research Background and a Review of the Previous Literature

This was achieved by conducting a thorough literature review to provide a comprehensive summary of any relevant research that aligned with the background of this study. Moreover, a historical analysis of the literature was carried out to explore the factors, causes, and origins of disputed claims in the construction industry, both in general and specifically in Saudi Arabia. The existing studies on BIM technology were critically examined in general and specifically in Saudi Arabia, as shown in Table 2. In order to select the claims management process for this study, it was necessary to identify the source of claims and the most frequently occurring claims in construction projects. Thus, seven significant sources of claims and 50 claims factors that appeared most frequently were investigated in the recent literature, as conducted by the authors of this study [53]. Within those recent studies, a compilation of the most reported sources of claims, originating from both contractors and the owners involved in construction projects, was derived.

4.2. Phase 1: Data Collection from the Field Survey as Primary Data

The primary data were collected from the construction industry through a questionnaire survey distributed among relevant practitioners. The survey was designed using the Survey Monkey platform that was used to send the questionnaire to 120 practitioners. In the population analysis, the number of selected practitioners ranged from 118 to 123, as indicated by Formulas (1) and (2) in Phase 3. The questionnaire was distributed in the construction industry in Saudi Arabia. The scope expanded to include the USA and Egypt to enhance the study's credibility and overcome any potential limitations arising from the limited number of respondents from Saudi Arabia. The number of targeted responses was identified based on the survey population analysis in Phase 3 of this methodology. The questionnaire was sent to those participants who had at least 10 years of experience or more in construction claims management and familiarity with BIM, its tools, and its uses in construction and project management. The targeted audiences ranged from employees from contracting and consulting companies to BIM managers and academics. A total of 56 participants were found to have these requirements in the KSA construction industry, forming the origin of the study; this was possibly due to the limitation of BIM use in this field. In addition, another eight practitioners responded from the USA, and 15 practitioners responded from Egypt, so the total number of respondents reached 79 practitioners.

4.3. Phase 1: Survey Population Selection and Sample Size Calculation

The targeted research sample for this study included professionals with a good knowledge of and experience in BIM technology and a working specialisation related to the AEC industry. This included civil engineers, architects, project managers, BIM managers, and claims managers; it was impossible to calculate the total number of the targeted population precisely in the construction industry. Therefore, the researcher, with the support of experts working in the construction industry, consulted with others to provide an accurate number for the required research population. Based on the available online data, there are approximately 234,738 engineers registered with the Saudi Council of Engineers, making them the primary workforce in the construction industry of the KSA. In order to rationalise the actual population, only a figure of 200,000 (as a statistical calculation) from the total population was used to support this study. We used the Cochran formula to determine the accurate sample size. This formula allows researchers to estimate the number of individuals needed in a study to ensure statistically meaningful and reliable results. It considers the desired level of confidence and margin of error when estimating a proportion within a population. Slovin's formula is another method commonly employed to determine the sample size for research studies, particularly in the context of survey research. It is often used in scenarios where obtaining a complete list of the entire population is not feasible, and researchers need to rely on a representative sample; the formulas are shown as follows:

Formula 1: Cochran formula:

$$n = \frac{z^2 * p * q}{c^2} \quad (1)$$

z = Z value, which is taken as 1.96 for a 95% confidence level; p = percentage for picking a choice, expressed as a decimal, taken as 0.5; q = 1 − p; c = margin of error, taken as 9% = 0.09; N = total population, taken as 200,000; and n = sample size.

By applying the formula, we obtained the following: $n = \frac{1.96^2 * 0.5 * (1-0.5)}{0.09^2} = 118.$

Formula 2: Slovin's formula:

$$n = \frac{\left(\frac{N}{1}\right) + N}{C^2} \quad (2)$$

C = margin of error, taken as 9% = 0.09; N = total population, taken as 200,000; and n = sample size.

By applying the formula, we obtained the following: $n = \frac{\left(\frac{200000}{1}\right) + 200000}{0.09^2} = 123.$

5. Data Collection and Analysis

This section analyses all the data gathered from the responses to the questionnaire survey to achieve the desired outcomes of this research study. The findings are presented in written form, comprising explanations, descriptions, percentages, tables, and charts. Graphical representations were employed due to their ability to enhance the comprehension and clarity of the results. Moreover, to facilitate a better illustration and presentation of the findings, the traditional practice and the assumed automated method of claims management were illustrated in categories based on the identified patterns in each section of this study.

Respondents Profiles

The targeted practitioners were selected based on Formula (2) in the Methodology section; the total selected number was 123 practitioners, and 79 respondents completed the questionnaire. Most were from contracting companies, while the rest were from consulting firms. A few participants were also in positions related to clients. The respondents had diverse academic and field experiences in the construction industry, ranging from 1 to 35 years, as shown in Table 3. The study included the Likert scale in the questionnaire survey, allowing the qualitative data to be quantified, and the open-ended questions were designed to facilitate a statistical analysis of the survey responses. This allowed the practitioners to choose their answers based on whether they agreed, strongly agreed, disagreed, strongly disagreed, or neither agreed nor disagreed, as shown in Table 4.

Table 3. Profile of the respondents; a total of 79 practitioners with a variety of experience in the range of 1–35 years.

Position	Organisation Type	No. of Responses	% of Respondents	Years of Experience
Civil engineers	Contracting	25	32%	1:15
Contract administration	Contracting	15	19%	5:10
Claims managers	Dispute resolution	13	16%	10:15
Project managers	Consultancy	9	11%	11:35
BIM managers	Contracting	17	22%	3:7
Total	Contracting	79	100%	

Table 4. Five-point Likert scale used in this questionnaire survey.

5	4	3	2	1
Agree	Strongly agree	Disagree	Strongly disagree	Neither agree nor disagree

We statistically analysed the respondents' opinions, reflecting the questions of this research paper to test the assumed four hypotheses stated. In addition, the respondents' feedback was used to measure the level of awareness of BIM implementation, especially in the KSA construction sector. Therefore, 10 specific questions were extracted from a total of 20 different questions in the questionnaire survey to analyse them based on the Likert scale; the results are presented in Table 5. The respondents were asked to select one of the five available options to estimate the frequency of each question answer. A numerical weight ranging from 5 to 1 was assigned to indicate each question frequency, with 5 representing "agree", 4 representing "strongly agree", 3 representing "disagree", 2 representing "strongly disagree", and 1 representing "neither agree nor disagree". For example, in the questionnaire, the respondents rated the answer to question No. 1 in Table 5 (How familiar are you with BIM?), for which the answer was 30 for "agree", 20 for "strongly agree", 10 for "disagree", 9 for "strongly disagree", and 10 for "neither agree or not disagree".

Table 5. Open-ended questions as part of the questionnaire survey distributed for BIM awareness.

No	Questions	Rate					
		Participants	Agree	Strongly Agree	Disagree	Strongly Disagree	Neither Agree nor Disagree
1	How familiar are you with BIM?	79	30	20	10	9	10
2	In your opinion, is there a growing awareness of BIM usage in Saudi Arabia?	79	35	25	11	3	5
3	Is your organisation actively using or planning to use BIM?	79	25	18	5	5	5
4	In your opinion, may using BIM in disputable claims reduce the degree of recourse to litigation or arbitration?	79	40	30	3	4	2
5	In your opinion, will BIM implementation reduce the overall project costs?	79	37	20	10	3	9

Table 5. *Cont.*

No	Questions	Rate					
		Participants	Agree	Strongly Agree	Disagree	Strongly Disagree	Neither Agree nor Disagree
6	In your opinion, is the implementation of BIM suitable for small- and medium-sized construction projects?	79	20	15	20	16	8
7	In your opinion, does using BIM reduce the possibility of a cost overrun and keep the original budget on track?	79	50	10	9	10	0
8	From your experience, is it recommended to include BIM technology in the documents of the Standard Form of Contracts so that claims and disputes can be analysed and relied upon for their outcomes?	79	45	20	8	4	2
9	In your opinion, will implementing BIM help improve construction project productivity?	79	35	35	5	4	0
10	Is there a growing demand for BIM usage in Saudi Arabia, Egypt, or the United Arab Emirates?	79	45	22	6	3	3

Two mathematical formulas were used to analyse the data collected from the field survey. The weighted average formula (No. 3) was used to assess the data presented in Table 4. In this formula, W represents the weight of the question factor, X represents the number of respondents who selected it, and N indicates the total number of respondents (79 in this study).

$$\sum = W * \frac{X}{N} \quad (3)$$

(W) is the weight of each question answer;
(X) is the number of respondents who were chosen, and;
(N) is the total number of respondents (79 practitioners in this study).

The formula (Formula (4)) used in the data analysis is the significance index:

$$\sum * \frac{100}{7} \quad (4)$$

For each data point, the index is calculated by dividing the column % of the crossing cell by the percentage of the whole cell and then multiplying the result by 100 and dividing it by 10, which is the total number of questions. The data analysis is explained in detail in the data analysis section and is shown in Table 5. The indexes in this range are not usually noteworthy, although they might be instructive when investigating large audiences and common traits.

In order to provide a clear sense of the importance of the answer to each question, a significance index (%) was calculated and is shown in Table 5 (based on the given weighting scores from the participants, as shown in Table 4). The results of the significance index are used in the combination of Formulas (3) and (4).

Table 6 displays the average response value for each question related to BIM as a proposed package to be used in the KSA industry. For example, in Table 4, the weighted average for Q1

(How familiar are you with BIM?) is (5 × 30 + 4 × 20 + 3 × 10 + 2 × 9 + 1 × 10)/79 = 3.65, which has a significant index of (3.65 × 100)/10 = 36.45%.

Table 6. The weighted average of the responses in the questionnaire survey.

No	Type of Questions Related to BIM Awareness	Average Responses (%)	Ranks
1	How familiar are you with building information modelling (BIM)?	36.45%	7
2	In your opinion, is there a growing awareness of BIM usage in Saudi Arabia?	40.38%	5
3	Is your organisation actively using or planning to use BIM?	28.73%	9
4	In your opinion, may using BIM in disputable claims reduce the degree of recourse to litigation or arbitration?	43%	2
5	In your opinion, will BIM implementation reduce the overall project costs?	39.42%	6
6	In your opinion, is the implementation of BIM suitable for small- and medium-sized construction projects?	32.91%	8
7	In your opinion, does using BIM reduce the possibility of a cost overrun and keep the original budget on track?	43.8%	1
8	From your experience, is it recommended to include BIM technology in the documents of the Standard Form of Contracts so that claims and disputes can be analysed and relied upon for their outcomes?	42.9%	3
9	In your opinion, will implementing BIM help improve construction project productivity?	42.8%	4
10	Is there a growing demand for BIM usage in Saudi Arabia, Egypt, or the United Arab Emirates?	43%	2

The Q2 (in your opinion, is there a growing awareness of BIM usage in Saudi Arabia?) calculation is (5 × 35+ 4 × 25 + 3 × 11 + 2 × 3 + 1 × 5)/79 = 4.04, which has a significant index of (4.04 × 100)/10 = 40.38%.

The Q3 (Is your organisation actively using or planning to use BIM?) calculation is (5 × 25+ 4 × 18 + 3 × 5 + 2 × 5 + 1 × 5)/79 = 2.87, which has a significant index of (2.87 × 100)/10 = 28.73%.

The Q4 (In your opinion, may using BIM in disputable claims reduce the degree of recourse to litigation or arbitration?) calculation is (5 × 40 + 4 × 30 + 3 × 3 + 2 × 4 + 1 × 2)/79 = 2.06, and its significant index is (4.29 × 100)/10 = 43%.

The Q5 (In your opinion, will BIM implementation reduce the overall project costs?) calculation is (5 × 37 + 4 × 20 + 3 × 10 + 2 × 3 + 1 × 9)/79 = 3.92, and its significant index is (3.92 × 100)/10 = 39.24%. However, all of the results of the questionnaire are presented in Table 5 in Section 6.

6. Discussion of the Literature Review and Results

The first section of the literature review examined claim management procedures in construction projects. It emphasised the importance of including a clear claim identification process in the contract conditions between the parties involved. The failure to include a claim identification process in the contract could result in conflicts regarding a claim's measurement and financial assessment. Claims identification and how to solve claims are identified under standard forms of contracts, such as FIDIC, JCT, and NEC3. The issue of professionally settling construction claims in the KSA construction industry is still complex. One of the main reasons for this complexity is the use of different contract forms in the public and private sectors. The local standard form (PWC) used in the public sector is considerably tailored from the FIDIC general conditions, while the private sector relies on traditional contract forms tailored to each project. However, the reliance on traditional contracts has inherent risks and often leads to disputes and conflicts between the parties involved. Claims can be analysed using the traditional approach, which does not rely on comprehensive software, such as BIM packages that includes 4D whether Primavera or Microsoft Project with Navisworks and 5D such as Cost-X. It requires precise sequences, professional claims managers, and clear communication channels among all contracting parties. The absence of a process for claim identification, analysis, and submission could have a subsequent impact on the expected outcome. For instance, under the FIDIC standard form, the entitled party to a claim must notify the engineer within 28 days from when they deem themselves entitled to the claim (as displayed in Figure 1). The failure to submit a claim under the FIDIC within this time frame can result in a significant loss of claim rights. Additionally, if the supporting documents of a claim are unclear, the entitled party can lose the claim due to a lack of evidence or difficulty in demonstrating causation. The mention of the 28-day maximum period under the FIDIC contract is necessary because, in certain cases, analysing a complex claim following the traditional route, particularly when assessing delay-related claims, can be time-consuming from the point of claim awareness.

The BIM package is essential for dispute resolution, delay and time analyses, and cost analysis to improve the claims analysis as an alternative method to the traditional approach. Despite minor obstacles when using BIM in the construction industry, specifically in the KSA, it is evident that BIM can be used by the involved parties to collaborate in construction via the web or common data sharing with each other. For example, when a project owner requests a change in the contractor's scope under the BIM process, prompt action to update the drawings can significantly impact the project timeline and budget. This will allow the owner to decide whether to proceed with the changes and approve the associated cost implications. Risks are inherent in the construction industry, and no project is risk-free. Therefore, the risks associated with BIM can arise from various factors, such as the ownership of project information, responsibility for BIM levels, and the reliability of data sharing. For instance, the owner or engineer is responsible for preparing BIM level 300, while the contractor is accountable for submitting BIM levels 400 and 500 [53]. In addition, a research paper examined the successful construction management process to mitigate the potential risks in construction. These processes utilised blockchain technology to systematically gather, organise, and disseminate a substantial volume of data. These data included stakeholders' safety records, review operations, risk evaluation analyses, daily reports, preventative management, incident reports, and post-incident investigations [66]. However, to integrate data management sharing, the contracting parties can sign a single agreement for using and sharing BIM, allowing for the precise identification of each party's liabilities.

Although this research paper primarily discusses the benefits of BIM packages in claims management, it is important to recognise that the advantages of BIM can also extend to other related factors, such as energy efficiency and sustainable design [58]. A recent study stated that BIM enabled the design and analysis of energy-efficient and sustainable buildings. Integrating green building practices in rural housing projects contributes to climate resilience. BIM facilitates accurate quantity take-offs and material tracking, thereby reducing disputes related to materials [67]. BIM allows for the lifecycle analysis of materials, aiding in the selection of eco-friendly and climate-resilient construction materials. BIM assists in change tracking and visualisation, supporting effective claims management. Additionally, BIM can be utilised to design structures that are resilient to climate-related disasters, such as floods or storms, thereby mitigating the risk of damage and associated claims [67].

When it comes to reducing claims in construction using BIM, there are several factors that must be taken into consideration in addition to the delay and cost analyses, which are the focus of this study. Recent research focuses on the Philippine construction industry has established guidelines to simplify and clarify the instructions for designing and constructing disaster-resistant buildings [68]. This addresses the lack of a standardised approach to residential construction that is accessible to most homeowners in the Philippines. Given the ongoing threat of climate change in at-risk areas, like the Philippines, it is crucial to prioritise the development of local capabilities to enhance the resilience of housing [68]. The study argues that implementing technical advances, such as BIM technologies, is crucial for ensuring efficiency and enhancing safety in construction projects. However, there are still obstacles to fully utilising the capabilities of these technologies, particularly at the organisational level. Offering evidence-based treatments and technical knowledge can help promote the development of resilience. Strengthening the understanding and application of the guidelines in residential construction in earthquake and typhoon-prone regions will enhance the structural integrity of houses and bolster the nation's resilience. To enhance the role of technical knowledge in fostering resilience, it is advisable to focus on building local capacities [68]. This can be accomplished by providing technical support to local builders and homeowners.

Recent research indicates that effective collaboration among key actors, especially governmental bodies, institutions, and local influencers, is crucial for implementing sustainable strategies to enhance housing resilience. The advantages of BIM are not limited to reducing claims resulting in extensions of time or changes in orders; their advantages can be extended to integration with other activities. A recent study stated that the incorporation of low-cost stochastic computing-based fuzzy filtering for image noise reduction in BIM applications for construction projects could have significant implications. It can enhance the image quality in BIM documentations by utilising the noise reduction capabilities of stochastic computing-based fuzzy filtering [69]. Having high-quality images is particularly crucial in BIM for visualisation, project communication, and documentation purposes. In addition, the improved image analysis for site assessments can result in noise reduction, leading to clearer and more precise data for site assessments and analyses. Construction professionals can utilise these clearer images to analyse site conditions, assess progress, and make informed decisions throughout the project lifecycle [70]. A real example is at a private international school in KSA, where the corresponding author of this research was involved in the teamwork of that project. The project was delivered, and the operation team discovered noise and echo in the theatre that disturbed the students during their music classes and training. That problem occurred due to a lack of integration of the relevant specifications and documents for the theatre finishing. The case of that example was one of the reasons that encouraged the author to investigate the importance of the BIM package as an alternative to traditional management practices in construction projects to reduce claims and enhance the construction process.

To ensure the proper implementation of BIM in the KSA industry with minimal obstacles, specific guidelines are crucial. The absence of these guidelines can impede the implementation process. Factors, such as the country's regulations, organisational capability and capacity, standardisation, training, and motivations, should be taken into consideration for successful implementation. Nevertheless, it is crucial to acknowledge that the current regulations fluctuate considerably among different countries, posing challenges for professionals in the AEC sector [70]. Hence, it is crucial to establish uniform and nation-specific norms. Malaysia has demonstrated praiseworthy dedication to the adoption of BIM, as seen by the government's creation of a National Steering Committee on BIM. In addition, Malaysia and Iran have each placed importance on specific factors when it comes to implementing BIM. Malaysia has concentrated on creating a thorough implementation plan, while Iran has emphasised the allocation of adequate resources to satisfy the significant demand for BIM implementation [70].

In order to enhance the understanding of the BIM package and its practical application in the KSA, the authors designed a conceptual framework, which is shown in Figure 4. It provides contract administrators, claims managers, and delay analysts with comprehensive insights. Figure 4 is divided into stages: Stage 1 focuses on contract formation and delineates the responsibilities of each party involved. It is the owner's duty to prepare project documents that adhere to BIM level 300, ensuring that bidders can accurately price the project and minimise hidden risks. Once the winning contractor is selected, he or she will further develop the BIM package, advancing it from level 300 to level 400, which covers the production and shop drawings with all relevant information. This upgraded package demonstrates the cost and time information for each component of the project. Stages 2 and 3 in Figure 4 present the prospective and retrospective methods for handling expected claims related to the extension of time (EOT), additional cost, or both. The main difference between the prospective and retrospective methods lies in the timing of the analysis. Prospective analysis is typically conducted in advance before the occurrence of the compensation event. This aims to identify (theoretically) the expected extension of time and associated costs when the owner needs to issue a variation order or make changes to the project scope under the prospective methods. By doing so, the owner can make informed decisions without potential conflicts with the contractor, as the need for additional time and costs will already be agreed upon in advance, even in the event of a project extension, without the benefit of hindsight. One benefit of prospective analysis is that time-impact-related delays can be accelerated. For instance, when retrospectively examining time impact, a prospective method may only require 3 weeks instead of 6 weeks to reduce the extension of time-related variations. According to what the contracting parties agreed to, accelerating the time may involve fast-tracking or crashing some activities.

The paper presents four accepted programmes to analyse delays in various situations, as indicated in Figures 5–12, addressing the liability of both the owner and contractor in each event, particularly concurrent delays. Claims and delay analysis under a retrospective approach are typically conducted without hindsight, which means they are carried out after the compensation event has already occurred. In this approach, there is no opportunity to minimise the time delay extension since the event has already occurred. Therefore, the primary objective of performing a retrospective delay analysis is to accurately determine the claim outcome, particularly in cases involving concurrent delays, which are more complex. Under a retrospective approach, the claim analysis can result in an amicable settlement or be disputed. Based on Figure 10, a prospective analysis revealed a compensation event for 6 weeks of superstructure activities starting from week 6, with the employer being responsible for 6 weeks of delay, as indicated in the table included in the diagram. However, the delay was shortened to 3 weeks due to acceleration. In Figure 10, a retrospective analysis indicated a delay of 3 weeks, for which the employer was liable since this could not be reduced. Most delays in construction projects in the KSA construction industry are analysed retrospectively because the industry heavily relies on traditional methods instead of embracing the BIM package, as suggested by the authors in Figure 4. As a result, most claims-related delays and cost overruns are not settled amicably and might be resolved through arbitration or in courts due to the lack of advanced analysis with the benefit of hindsight.

In order to ensure that the findings of this study are applicable to the construction industry in the KSA (as the origin of the study, with possible extension to neighbouring countries like Egypt and the United Arab Emirates) and to effectively implement BIM packages, a questionnaire survey was designed and distributed. Out of the 123 individuals approached, 79 responded, representing 71% of the total sample. These respondents had varying levels of experience, ranging from 1 to 35 years, holding positions such as civil engineers, project managers, procurement managers, and contract administrators. The majority work for contracting companies, while others operate in consultancy and business development. The main purpose of the survey questionnaire was to test the four hypotheses assumed in the study that focus on the significant difference between the traditional approach and BIM. In addition, the survey questions tested the level of awareness of BIM implementation in the KSA to validate the proposed framework for resolving claims under BIM use. The selected respondents in the questionnaire survey were asked 10 questions related to BIM integration in the KSA, and the answers are shown in Table 6.

The percentages of the respondents seem similar to those shown in Table 6, and the authors comment that there is a willingness in the Kingdom of Saudi Arabia (KSA) to adopt BIM packages, focusing on adding BIM to the contract conditions. It is also noted that BIM can be implemented in small- and medium-sized companies, according to nearly 33% of the respondents. While there may be concerns about the costs involved for smaller companies, it is important to consider the potential impact of claims in the construction industry, which can reach up to 5–7% of the project budget [52]. In comparison, the cost of implementing BIM is estimated to be an average of 3% of the project budget in medium-sized projects, or it could be less on a large scale that exceeds USD 40 million. The absence of BIM technology in the contract document may not motivate or compel the industry to adopt it, especially considering the inherent complexity of construction and the increasing number of large-scale projects in the KSA that aim to be innovative and sustainable. Therefore, as a general principle, construction projects with intricate designs are not recommended to be managed using traditional practices without the integration of BIM solutions.

7. Conclusions

This study investigated and analysed the claims management procedures used in construction projects under traditional practice, along with a suggestion of an automated methodology to be used in solving claims, especially in the KSA—the origin of this study. It highlights the importance of clear claim identification and the impact of a claim on time and money. Even though standard forms of contracts, such as FIDIC, JCT, and NEC3, offer traditional solutions to settle construction claims, they lack advanced technology such as BIM. In the KSA construction industry, resolving claims seems more complicated compared to countries such as the UK and the USA. This complexity is due to the variety of contracts that are used in the public and private sectors. The public sector uses the local form (PWC) extracted from the FIDIC with the omission of important clauses to support contractors' rights, such as payment delays from the owners' sides. The private sector uses conventional contract forms tailored to each project, posing, in some cases, the inherent risks in contract conditions.

The study investigated the importance of the BIM package, which is crucial for enhancing claims analysis in the construction industry, particularly in the KSA. It facilitates collaboration among the involved parties through web-based or data-sharing platforms. For instance, a client's or the project owner's requests for changes can result in quick updates to drawings, which impacts both the project's schedule and budget. Nonetheless, there are certain risks associated with BIM, including the ownership of project information, allocation of BIM levels, and data reliability. In order to address such risks, contracting parties can establish a comprehensive agreement for the use and sharing of BIM, ensuring clear accountability for each party involved.

The authors have created Figure 4 as a framework to enhance the understanding of the BIM package and its practical application. This visualisation provides contract administrators, claims managers, and delay analysts with comprehensive insights. In addition, the framework in Figure 4 is divided into stages, with Stage 1 focusing on contract formation and the responsibilities of each party involved. The owner is supposed to be responsible for BIM Level 300, while the contractor is responsible for preparing levels 400 and 500 [53]. Stages 2 and 3 in Figure 4 present the prospective and retrospective methods, respectively, for handling expected claims related to time extensions, cost increases, or both. The purpose of analysing such a case study is that any delay-related claims must be analysed using either a prospective or retrospective approach. The main difference between the prospective and retrospective methods lies in the timing of the analysis. Aprospective analysis is conducted in advance to identify the expected extension of time and associated costs, allowing the owner to make informed decisions without potential conflicts with the contractor. The prospective analysis also accounts for accelerated time-impact-related delays. A retrospective analysis is used when a concurrent delay occurs to assess the consumed time and cost, if any, with the benefit of hindsight. Therefore, the study presents a theoretical programme that updates the four steps (based on real-life cases) to analyse the delays in various situations, with a focus on concurrent delays and the liability of both the owner and contractor. A retrospective analysis is conducted without hindsight, aiming to accurately determine the claim outcomes, especially in complex cases involving concurrent delays. In the construction industry of the KSA, delays are predominantly analysed retrospectively due to the reliance on traditional methods instead of embracing

BIM technology. This often leads to disputes and the need for arbitration or legal resolutions for claims-related delays and cost overruns.

In order to validate this study, four hypotheses were assumed to test the proposed framework in Figure 4, and a questionnaire was created and shared with the KSA construction industry. The questionnaire extended to neighbouring countries, like Egypt and the UAE, in which BIM packages were required to be implemented, with limited responses. A total of 79 of the 123 practitioners who answered formed 71% of the total targeted sample; their experience ranged from 1 to 35 years and their answers are summarised in Table 5 in Section 6. It can be believed that the costs of BIM involved ca be a concern, but the impact of claims in the construction industry is usually in the range of 5–7% of the budget and can be more in specific cases when compared to the estimated 3% required to implement BIM [53]. In addition, the absence of BIM technology from contract documents may not motivate or compel the industry to adopt it, as construction is complex, and the KSA strives for innovative, sustainable, large-scale projects.

The paper recommends that practitioners in the construction industry in the KSA utilise BIM as a valuable process to minimise disputes and enhance overall project efficiency. This can be achieved through early adoption and training, standardisation, collaboration, clear contractual agreements, and the inclusion of specific dispute resolution mechanisms related to BIM in construction contracts. By following these recommendations, practitioners can leverage BIM to improve collaboration, reduce disputes, and enhance overall construction project efficiency in the KSA construction industry.

Future work: this study builds on a recently published paper by the authors, which examined the source and contributing factors of claims, as well as the significance of BIM use in mitigating potential claims [53]. The current study delves into claims procedures under traditional methods vs. the BIM package. The authors used a theoretical programme to develop the BIM package, which served as an alternative dispute resolution method. A subsequent future paper is planned and will be based on a real-life dispute case study from the industry, which will be analysed to show how the BIM package shown in Figure 4 is simulated to settle a disputable claim. Hence, the goal of the next paper will be closely related to the goal of this paper because it will use a real-life case study from the KSA construction industry to test and confirm the framework of the BIM package shown in Figure 4.

Limitations of this study: this study focuses on claims processes related to extensions of time and money claims in the construction industry of the Kingdom of Saudi Arabia (KSA), with some additional investigations into Egypt and the UAE and the lack of comparisons in relevant industries, such as those in the UK or the USA. The respondents of this study were from the UAE, which comprised 71% of the targeted practitioners from the KSA industry; this could have impacted the generalisability of the findings. Due to the limitations of the paper and word limits, a planned real construction case study could not be included in the programme due to time constraints, which will be considered in future work, as explained above.

Author Contributions: Writing—original draft, R.A.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 conflict of interest.

References

1. Parchami Jalal, M.; Yavari Roushan, T.; Noorzai, E.; Alizadeh, M. A BIM-based construction claim management model for early identification and visualization of claims. *Smart Sustain. Built Environ.* **2021**, *10*, 227–257. [CrossRef]
2. Noorzai, E. Performance analysis of alternative contracting methods for highway construction projects: Case study for Iran. *J. Infrastruct. Syst.* **2020**, *26*, 04020003. [CrossRef]

3. Hasheminasab, S.; Mortaheb, M.; Ahmadian, F.F.A. Causes of common and frequent claims in oil, gas and petrochemical projects of Iran. *KSCE J. Civ. Eng.* **2014**, *18*, 1270–1278. [CrossRef]
4. *Arcadis Global Construction Dispute Report*; Arcadis: Amsterdam, The Netherlands, 2019.
5. Ali, B.; Zahoor, H.; Nasir, A.R.; Maqsoom, A.; Khan, R.W.A.; Mazher, K.M. BIM-based claims management system: A centralized information repository for extension of time claims. *Autom. Constr.* **2020**, *110*, 102937. [CrossRef]
6. Bektas, S.; Talat Birgonul, M.; Dikmen, I. Integrated probabilistic delay analysis method to estimate expected outcome of construction delay disputes. *J. Leg. Aff. Disput. Resolut. Eng. Constr.* **2021**, *13*, 04520037. [CrossRef]
7. Noorzai, E.; Golabchi, M. Selecting a proper construction system in small and medium mass housing projects, considering success criteria and construction volume and height. *J. Eng. Des. Technol.* **2020**, *18*, 883–903. [CrossRef]
8. Zhang, J.; Hu, Z. BIM-and 4D-based integrated solution of analysis and management for conflicts and structural safety problems during construction: 1. Principles and methodologies. *Autom. Constr.* **2011**, *20*, 155–166. [CrossRef]
9. Jalali, Z.; Noorzai, E.; Heidari, S. Design and optimization of form and facade of an office building using the genetic algorithm. *Sci. Technol. Built Environ.* **2020**, *26*, 128–140. [CrossRef]
10. Abdul-Malak, M.-A.U.; Abdulhai, T.A. Conceptualization of the contractor's project management group dynamics in claims initiation and documentation evolution. *J. Leg. Aff. Disput. Resolut. Eng. Constr.* **2017**, *9*, 04517014. [CrossRef]
11. Tan, H.; Anumba, C. Web-Based Construction Claims Management System: Operation of the Prototype. In Proceedings of the 30th CIB W78 International Conference, Beijing, China, 9–12 October 2013; pp. 594–604.
12. Taghizade, K.; Heidari, A.; Noorzai, E. Environmental impact profiles for glazing systems: Strategies for early design process. *J. Archit. Eng.* **2019**, *25*, 04019005. [CrossRef]
13. Naderi, H.; Shojaei, A.; Rokooei, S. Interface of Quantum Computation and Architecture, Engineering, And Construction (Aec) Industry. *Proc. Int. Struct. Eng. Constr.* **2023**, *10*, 1. [CrossRef]
14. Park, C.-S.; Lee, D.-Y.; Kwon, O.-S.; Wang, X. A framework for proactive construction defect man- agement using BIM, augmented reality and ontology-based data collection template. *Autom. Constr.* **2013**, *33*, 61–71. [CrossRef]
15. Ghaffarianhoseini, A.; Tookey, J.; Ghaffarianhoseini, A.; Naismith, N.; Azhar, S.; Efimova, O.; Raahemifar, K. Building Information Modelling (BIM) uptake: Clear benefits, understanding its imple- mentation, risks and challenges. *Renew. Sustain. Energy Rev.* **2017**, *75*, 1046–1053. [CrossRef]
16. Sodangi, M.; Salman, A.F.; Saleem, M. Building information modeling: Awareness across the subcon- tracting sector of Saudi Arabian construction industry. *Arab. J. Sci. Eng.* **2018**, *43*, 1807–1816. [CrossRef]
17. Almuntaser, T.; Sanni-Anibire, M.O.; Hassanain, M.A. Adoption and implementation of BIM—Case study of a Saudi Arabian AEC firm. *Int. J. Manag. Proj. Bus.* **2018**, *11*, 608–624. [CrossRef]
18. Al-Sulaihi, I.; Al-Gahtani, K.; Alsugair, A.; Tijani, I. Assessing indoor environmental quality of educational buildings using BIM. *J. Environ. Sci. Eng. B* **2015**, *4*, 451–458. [CrossRef]
19. Keane, P.J. A Computer-Aided Systematic Approach to Time Delay Analysis for Extension of Time Claims on Construction Projects. Ph.D. Thesis, Loughborough University, Loughborough, UK, 1994.
20. Palaneeswaran, E.; Kumaraswamy, M.M. An integrated decision support system for dealing with time extension entitlements. *Autom. Constr.* **2008**, *17*, 425–438. [CrossRef]
21. Bakhary, N.A.; Adnan, H.; Ibrahim, A. A study of construction claim management problems in Malaysia. *Procedia Econ. Financ.* **2015**, *23*, 63–70. [CrossRef]
22. Ren, Z.; Anumba, C.; Ugwu, O. Multiagent system for construction claims negotiation. *J. Comput. Civ. Eng.* **2003**, *17*, 180–188. [CrossRef]
23. Diekmann, J.E.; Kim, M.P. SuperChange: Expert system for analysis of changes claims. *J. Constr. Eng. Manag.* **1992**, *118*, 399–411. [CrossRef]
24. AbouRizk, S.M.; Dozzi, S.P. Application of computer simulation in resolving construction disputes. *J. Constr. Eng. Manag.* **1993**, *119*, 355–373. [CrossRef]
25. Abdul-Malak, M.A.U.; El-Saadi, M.M.; Abou-Zeid, M.G. Process model for administrating construction claims. *J. Manag. Eng.* **2002**, *18*, 84–94. [CrossRef]
26. Fan, H.; Li, H. Retrieving similar cases for alternative dispute resolution in construction accidents using text mining techniques. *Autom. Constr.* **2013**, *34*, 85–91. [CrossRef]
27. Eastman, C.M.; Eastman, C.; Teicholz, P.; Sacks, R.; Liston, K. *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*; John Wiley & Sons: Hoboken, NJ, USA, 2011.
28. Bhih, M.; Hegazy, T. Concurrent delays: Comparison among forensic analysis recommended practices. In Proceedings of the CSCE 7th International Construction Conference/Construction Research Congress, Laval, QC, Canada, 12–15 June 2019; pp. 12–15.
29. Rashidi Nasab, A.; Malekitabar, H.; Elzarka, H.; Nekouvaght Tak, A.; Ghorab, K. Managing Safety Risks from Overlapping Construction Activities: A BIM Approach. *Buildings* **2023**, *13*, 2647. [CrossRef]
30. Arshad, M.F.; Thaheem, M.J.; Nasir, A.R.; Malik, M.S.A. Contractual risks of building infor- mation modeling: Toward a standardized legal framework for design-bid-build projects. *J. Constr. Eng. Manag.* **2019**, *145*, 04019010. [CrossRef]
31. Demian, P.; Walters, D. The advantages of information management through building information modelling. *Constr. Manag. Econ.* **2014**, *32*, 1153–1165. [CrossRef]

32. Lee, H.W.; Oh, H.; Kim, Y.; Choi, K. Quantitative analysis of warnings in building information modeling (BIM). *Autom. Constr.* **2015**, *51*, 23–31. [CrossRef]
33. Akram, R.; Thaheem, M.J.; Nasir, A.R.; Ali, T.H.; Khan, S. Exploring the role of building information modeling in construction safety through science mapping. *Saf. Sci.* **2019**, *120*, 456–470. [CrossRef]
34. Ma, Z.; Cai, S.; Mao, N.; Yang, Q.; Feng, J.; Wang, P. Construction quality management based on a collaborative system using BIM and indoor positioning. *Autom. Constr.* **2018**, *92*, 35–45. [CrossRef]
35. Chen, L.; Luo, H. A BIM-based construction quality management model and its applications. *Autom. Constr.* **2014**, *46*, 64–73. [CrossRef]
36. Kwon, O.-S.; Park, C.-S.; Lim, C.-R. A defect management system for reinforced concrete work utilizing BIM, image-matching and augmented reality. *Autom. Constr.* **2014**, *46*, 74–81. [CrossRef]
37. Zhang, S.; Boukamp, F.; Teizer, J. Ontology-based semantic modeling of construction safety knowledge: Towards automated safety planning for job hazard analysis (JHA). *Autom. Constr.* **2015**, *52*, 29–41. [CrossRef]
38. Greenwald, N.W. A creative proposal for dispute systems design for construction projects employing BIM. *J. Leg. Aff. Disput. Resolut. Eng. Constr.* **2013**, *5*, 2–5. [CrossRef]
39. Jin, R.; Hancock, C.M.; Tang, L.; Wanatowski, D. BIM investment, returns, and risks in China's AEC industries. *J. Constr. Eng. Manag.* **2017**, *143*, 04017089. [CrossRef]
40. Azhar, S. Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadersh. Manag. Eng.* **2011**, *11*, 241–252. [CrossRef]
41. Ahmad, Z.; Thaheem, M.J.; Maqsoom, A. Building information modeling as a risk transformer: An evolutionary insight into the project uncertainty. *Autom. Constr.* **2018**, *92*, 103–119. [CrossRef]
42. Singh, V.; Gu, N.; Wang, X. A theoretical framework of a BIM-based multi-disciplinary collaboration platform. *Autom. Constr.* **2011**, *20*, 134–144. [CrossRef]
43. Zhang, J.; El-Gohary, N.M. Integrating semantic NLP and logic reasoning into a unified system for fully-automated code checking. *Autom. Constr.* **2017**, *73*, 45–57. [CrossRef]
44. Gibbs, D.-J.; Emmitt, S.; Ruikar, K.; Lord, W. An investigation into whether building information modelling (BIM) can assist with construction delay claims. *Int. J. 3-D Inf. Model.* **2013**, *2*, 45–52. [CrossRef]
45. Mohamed, A.E. The Implementation of Building Information Modeling (BIM) towards Sustainable Construction Industry in Egypt "The Pre-Construction Phase". 2019. Available online: https://fount.aucegypt.edu/etds/508 (accessed on 9 November 2023).
46. Bouchlaghem, D.; Shang, H.; Whyte, J.; Ganah, A. Visualisation in architecture, engineering and construction (AEC). *Autom. Constr.* **2005**, *14*, 287–295. [CrossRef]
47. Bahu, J.-M.; Koch, A.; Kremers, E.; Murshed, S.M. Towards a 3D spatial urban energy modelling approach. *Int. J. 3-D Inf. Model.* **2014**, *3*, 1–16. [CrossRef]
48. Abd-Ellatif, A.M.A.; Nassar, A.H. Claims and Disputes Resolution Using Bim Technology and Vdc Process in Construction Contract Risk Analysis. *Technol. IJCIET* **2021**, *12*, 82–107.
49. El-adaway, I.; Abotaleb, I.; Eteifa, S. Framework for multiparty relational contracting. *J. Leg. Aff. Disput. Resolut. Eng. Constr.* **2017**, *9*, 04517018. [CrossRef]
50. Klee, L. *International Construction Contract Law*; John Wiley & Sons: Hoboken, NJ, USA, 2018.
51. Abd Jamil, A.H.; Fathi, M.S. Contractual challenges for BIM-based construction projects: A systematic review. *Built Environ. Proj. Asset Manag.* **2018**, *8*, 372–385. [CrossRef]
52. Almarri, K.; Aljarman, M.; Boussabaine, H. Emerging contractual and legal risks from the application of building information modelling. *Eng. Constr. Archit. Manag.* **2019**, *26*, 2307–2325. [CrossRef]
53. Abougamil, R.A.; Thorpe, D.; Heravi, A. Investigating the Source of Claims with the Importance of BIM Application on Reducing Construction Disputable Claims in KSA. *Buildings* **2023**, *13*, 2219. [CrossRef]
54. Marzouk, M.; Othman, A.; Enaba, M.; Zaher, M. Using BIM to identify claims early in the construction industry: Case study. *J. Leg. Aff. Disput. Resolut. Eng. Constr.* **2018**, *10*, 05018001. [CrossRef]
55. Naderi, H.; Heydari, M.H.; Parchami Jalal, M. Risk Analysis in Implementing Building Energy Performance Projects: Hybrid DANP-VIKOR Model Analysis—A Case Study in Iran. *Buildings* **2023**, *13*, 2066. [CrossRef]
56. Maclean, E. Prospective versus Retrospective Programme Analysis and the NEC3 Form of Contract Youtube. Available online: https://www.https://www.youtube.com/watch?v=jewPeRKhlts&t=837s (accessed on 15 July 2023).
57. Ghimire, S.; Mishra, A.K. Comparative study of prospective delay analysis techniques (DATs). *Saudi J. Civ. Eng.* **2019**, *3*, 84–95. [CrossRef]
58. Long, R.J. *Analysis of Concurrent Delay on Construction Claims*; Long International Inc.: Littleton, CO, USA, 2017; Volume 8, p. 2018.
59. Shahhosseini, V.; Hajarolasvadi, H. A conceptual framework for developing a BIM-enabled claim man- agement system. *Int. J. Constr. Manag.* **2021**, *21*, 208–222.
60. Honnappa, D.; Padala, S.S. BIM-based framework to quantify delays and cost overruns due to changes in construction projects. *Asian J. Civ. Eng.* **2022**, *23*, 707–725. [CrossRef]
61. Charehzehi, A.; Chai, C.; Md Yusof, A.; Chong, H.-Y.; Loo, S.C. Building information modeling in construction conflict management. *Int. J. Eng. Bus. Manag.* **2017**, *9*, 1847979017746257. [CrossRef]

62. Koc, S.; Skaik, S. Disputes resolution: Can BIM help overcome barriers. In Proceedings of the CIB Proceedings of the 2014 International Conference on Construction in a Changing World, Heriot Watt, Kandalama, Sri Lanka, 4–7 May 2014.
63. Askari, A.S.; Porgues, D.; Francis, A. Improving construction claim management using building information model (BIM). In Proceedings of the Annual Conference—Canadian Society for Civil Engineering, Montreal, QC, Canada, 29 May–1 June 2013; pp. 1–10.
64. Muhammad, R.; Nasir, A.R. Integrating BIM in Construction Dispute Resolution: Development of a Contractual Framework. *Buildings* **2022**, *12*, 1828. [CrossRef]
65. Khoshnava, S.M.; Ahankoob, A.; Preece, C.; Rostami, R. Potential application of BIM in construction dispute and conflict. In Proceedings of the Management in Construction Research Association Postgraduate Conference, Kuala Lumpur, Malaysia, 5–6 December 2012; pp. 1–8.
66. Morteza, A.; Ilbeigi, M.; Schwed, J. A blockchain information management framework for construction safety. *Comput. Civ. Eng.* **2021**, *2021*, 342–349.
67. Ourang, S. Evaluation of Inter-Organizational Coordination of Housing Services in Rural Alaska through Social Network Analysis. Master's Thesis, Iowa Statement University, Ames, IA, USA, 2022. [CrossRef]
68. Ballesteros, L.; Ourang, S.; Pazdon, J.; Kuffel, K. Increasing safety in residential construction through a simplified earthquake-and typhoon-resistant guidelines. *J. Future Sustain.* **2023**, *3*, 119–124. [CrossRef]
69. Estiri, S.N.; Jalilvand, A.H.; Naderi, S.; Najafi, M.H.; Fazeli, M. A Low-Cost Stochastic Computing-based Fuzzy Filtering for Image Noise Reduction. In Proceedings of the 2022 IEEE 13th International Green and Sustainable Computing Conference (IGSC), Pittsburg, PA, USA, 24–25 October 2022; pp. 1–6.
70. Rajabi, M.S.; Radzi, A.R.; Rezaeiashtiani, M.; Famili, A.; Rashidi, M.E.; Rahman, R.A. Key assessment criteria for organizational BIM capabilities: A cross-regional study. *Buildings* **2022**, *12*, 1013. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

Links and Implications

The links and implications from the literature review in the second paper enabled the researcher to thoroughly investigate the challenges of delivering construction projects, particularly concerning payment and time delays. By critically analyzing existing literature, the researcher developed a comprehensive approach to preparing claims related to extensions of time and monetary compensation. This approach is valuable for both academics and practitioners as it provides guidance on evaluating and preparing claims, especially under the FIDIC contract framework. Additionally, the author created a flowchart for claims analysis within the BIM package, aimed at minimizing disputable claims.

The second paper specifally proposed the BIM package and demonstrated its important for reducing the construction claims in the KSA industry. The second paper deeply explained the characteristics of the BIM package, which is considered the implication with the next published paper that further explained the proposed BIM package and implementing a real claim case study from the KSA construction industry. The connection between the second published paper with the third published paper comprising the third objective of the thesis to validiate the propsed system by a real case study from the KSA industry.

CHAPTER 5: PAPER 3 – A BIM PACKAGE WITH A NEC4 CONTRACT OPTION TO MITIGATE CONSTRUCTION DISPUTES IN THE KINGDOM OF SAUDI ARABIA

Introduction

This chapter introduces the third published paper that focuses on the third objective of the thesis, which is to provide a detailed explanation of the proposed BIM package. The study examined the significance of Building Information Modeling (BIM) and provided a comprehensive analysis of the proposed software solution in relation to previously published research. The methodology in this third paper is primarily centered on a critical review approach. It not only summarizes existing literature but also develops a case study from the Saudi Arabian construction industry. This case study is validated using BIM as an alternative to traditional methods for reducing construction claims. The critical review is further supported by a systematic approach to detail BIM's role in minimizing disputable claims, a key finding from the second paper in this thesis. This critical methodology offers fresh insights and proposes new perspectives and frameworks for BIM applications, addressing gaps found in previous studies. The study elucidated the significance of utilizing the NEC 4 contract within the suggested package. Furthermore, this paper has gathered primary data to strengthen the secondary data that was derived from the existing literature. Interview sessions were conducted with an actual claim case study from the construction industry in the Kingdom of Saudi Arabia (KSA). The suggested package thoroughly investigated the genuine claim case to validate it, as described in detail in the accompanying paper.

Paper 3

buildings

IMPACT FACTOR 3.1

CITESCORE 3.4

Article

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

Reda Abdelshafy Abougamil, David Thorpe and Amirhossein Heravi

Special Issue
BIM Application in Construction Management
Edited by
Prof. Dr. Irene Lill and Dr. Theophilus Olowa

MDPI

https://doi.org/10.3390/buildings14072009

buildings

MDPI

Article

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

Reda Abdelshafy Abougamil *, David Thorpe and Amirhossein Heravi

Department of Civil Engineering, Faculty of Health, Engineering and Sciences, School of Surveying and Built Environment, University of Southern Queensland, Springfield 4300, Australia; david.thorpe@usq.edu.au (D.T.); amirhsein.heravi@usq.edu.au (A.H.)

* Correspondence: u1092138@umail.usq.edu.au

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 modeling; Kingdom of Saudi Arabia; disputes; construction; contracts; NEC4; procurement

check for updates

Citation: Abougamil, R.A.; Thorpe, D.; Heravi, A. A BIM Package with a NEC4 Contract Option to Mitigate Construction Disputes in the Kingdom of Saudi Arabia. *Buildings* **2024**, *14*, 2009. https://doi.org/10.3390/buildings14072009

Academic Editor: Filiberto Chiabrando

Received: 10 May 2024
Revised: 18 June 2024
Accepted: 29 June 2024
Published: 2 July 2024

Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

The construction sector in the Kingdom of Saudi Arabia (KSA) serves as a crucial driver of economic growth, propelled by ambitious infrastructure projects and urban development initiatives. Since 2015, 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 [1,2]. However, amidst the rapid growth, the industry faces persistent obstacles, notably construction disputes that hinder project progress, inflate costs, and erode stakeholder confidence. 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 [3–5].

1.1. Problem Statement

A critical underlying factor contributing to the challenges faced by the KSA construction sector is the persistent reliance on traditional construction practices and methodologies, which are frequently inadequate for managing the complexities inherent in modern construction projects. One of the most pressing issues confronting the Saudi construction industry is the prevalence of disputable claims. These claims typically stem from ambiguities in project documentation, discrepancies between planned and actual work, and ineffective communication among stakeholders.

To tackle this pressing issue, the integration of Building Information Modeling (BIM) technology with customized contract forms for effective project management emerges as a promising strategy. 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 [6,7]. In this regard, option A of this contract form will be integrated with the proposed BIM Package to effectively handle construction claims. However, the choice of contract form is critical in any construction project, influencing aspects such as project governance, risk allocation, and dispute resolution [8].

1.2. Research Objectives

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

To clearly address the research objectives, the authors will examine the root causes and instances of disputable claims in the construction industry using existing literature and new primary data [9]. This investigation will reveal common types of claims and their underlying reasons in similar projects. Subsequently, the BIM Package, comprising software such as Revit 2.1, Microsoft Project Professional 2021, and Cost-X 7.2, will be developed to address these claims [9,10]. From the authors' experience, as detailed in their academic publications, which are connected with the current paper, they indicate that most claims stem from poor communication among project parties, inadequate planning, and an overreliance on traditional concepts and manuals for complex projects. This was the main pillar for the author to investigate how claims can be reduced by an advanced and practical solution. In addition, the choice of contract is crucial, so this study recommends the NEC4 standard form, which mandates BIM processes. A reason for that is because bespoke contracts often fail to meet project requirements, and resolving disputable claims is strongly connected with the contract wording. In addition, the package of the software suite may be simplified for easier use [11]. For example, BIM 360 could be a cloud-based solution that combines Revit and MS with supplementary software such as Cost-X for cost calculation [12]. This option depends on a construction firm's available resources, and this paper thoroughly explores the suggested group of software [12,13].

The essential feature of the NEC4 contract forms is focusing on early warning notices, and collaborative problem-solving mechanisms could complement BIM's capabilities in providing real-time project data and facilitating informed decision-making. Therefore, combining the NEC contract form with BIM could enhance transparency, streamline processes, and improve risk mitigation throughout the project lifecycle. By examining the theoretical foundations and practical applications of the proposed BIM Package with the NEC4 contract option strategy, this research contributes to the academic discourse on enhancing construction dispute mitigation strategies in the KSA [13]. Through theoretical analysis, case studies, empirical analysis, and stakeholder surveys, the study aims to elucidate the potential advantages and best practices associated with adopting this innovative approach within Saudi Arabia's unique socio-economic and legal context. Therefore, the important reason for choosing the NEC contract with BIM is to establish legal liability, which is to bind BIM as part of the contract documents. Unlike other standard forms, the NEC form specifically highlights the ownership liability of BIM in clause (OptionX10) [13,14]. For instance, when dealing with design errors that may result in claims, it is vital to establish contractually which party is responsible.

Concurrently, BIM technology revolutionizes conventional construction practices by offering a comprehensive digital platform for fostering collaborative planning, design, construction, and maintenance activities. With the advent of digital technologies, the construction sector has evolved from traditional, compartmentalized practices, resulting in enhanced efficiency, interoperability, and reliability [4,14]. In markets with high project volumes, such as the KSA, BIM is expected to offer real-time project execution visualization, design continuity, and streamlined structural delivery, benefiting clients and contractors alike through contractual compliance, reliability, and efficient project completion [5]. However, when the authors investigated the source of claims from existing literature and found the number of projects that faced disputes and claims, they noticed that there was no mention of BIM implementation of those affected projects. This gap prompted the authors to delve into the literature and gather industry data based on their experiences and relationships in the industry to support their study. 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 [7,11]. Due to the complexity of construction disputes that could be hard to completely eliminate, implementing BIM may not always be the optimal solution, especially if there is a lack of professional implementation in integrating BIM into the construction process. Therefore, without proper implementation, BIM might not yield its full potential benefits. Furthermore, effective use of BIM requires adequate training to overcome challenges such as communication, coordination, and planning accuracy [14]. The success of BIM also depends on the collaboration of key professionals, including architects, engineers, contractors, and subcontractors within the workflow. Claims related to unforeseen design errors or clashes during construction comprise a high degree of construction risk. Therefore, the latest soft technologies, such as BIM, penetrating the construction field are targeted to reduce construction risks. Despite its advantages in other construction industries such as the USA and the UK, 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].

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].

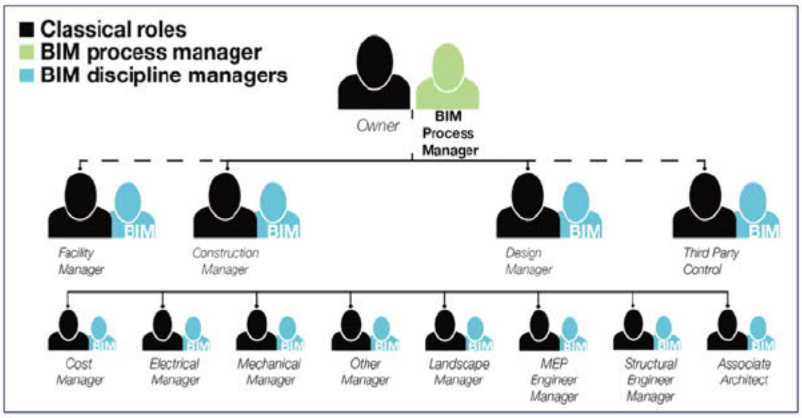


Figure 1. Shows the classic job of project management (black), supported by a BIM role (green and blue) [22].

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, resolve immediate issues, and minimize project delivery disruptions through transparent and reliable technologies. Although the model is not yet capable of addressing complex variables such as changes in material quantities, the future application of real-time BIM models to claim 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 [36]. 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 [37].

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 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 [40]. 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 simultaneous collaboration among interdisciplinary teams on shared digital platforms [40]. 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 [40,41]. 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 [42,43]. 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 [44].

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 2, with further explanation provided in the following points:

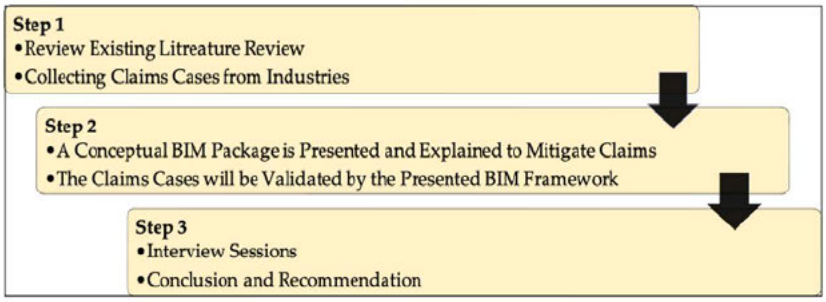


Figure 2. Research Methodology.

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 pinpoint 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 Section 4 in the current research, which will be used in Section 5 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 Section 4, 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.

3. How does the proposed BIM model serve in this study? Section 4 explains the processes of the BIM Package, which the steps of the model illustrated throughout the entire section. The first step in Section 4 highlights that the 2D CAD drawings will be imported into Revit to create a 3D model that displays all project elements. The BIM Package includes Navisworks as an auxiliary software that displays the project's details in Revit and shows any clashes, if any. Once relevant project parties have identified and approved all components in the model, we upload vital information for each item, including technical data and specifications, to avoid future conflicts over changing specifications or item design. Next, we calculate the required duration for each item and use Microsoft Project to determine and visualize the total project time in a Gantt chart. We employ Cost-X to calculate or measure items from the model or 2D drawings. Once drawings are imported into Cost-X, the software automatically measures any selected area and displays the cost based on previously identified specifications in Revit. These sequential steps help minimize human errors that may occur during manual processing. Essential articles from the signed contract in the project case study are highlighted in the provided raw data Section 5 to reflect the bespoke contract conditions with limited provisions. The articles are translated into quantifiable rules and verified against contract BIM outputs.
4. Survey 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.

For the field survey, the authors first obtained ethical approval from the University of Southern Queensland (USQ HREC ID: H22REA273) for the interview sessions, in 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 those related to the real-claims case study presented in this research.

Table 1. Similar studies from existing literature related to BIM applications aim 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 the 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.	Building 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.	A BIM strategy suggests proactively managing conflict causes prior to the onset of a disagreement.	[49]

Table 1. *Cont.*

Paper Topic	Objectives of the Study	References
Building information modeling 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 applications 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 and the importance of BIM applications in 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]

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

Group	Position	Number of Participants	Years of Experiences	Number of Participating Projects
Contracting	Project manager Contract manager	8 7	11–25 10–35	5–12 7–20
Consultancy	Project manager Claims manager	3 4	12–20 16–25	8–12 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 the proposed BIM Package to analyze the selected actual project claims case in this study?
2	Do you agree to use 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 inaccuracies 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?

The questions presented in Table 3 were designed by the authors to align with the participants' experiences regarding BIM usage. This approach was more precise as it was based on interview sessions rather than a broad questionnaire survey. The authors selected practitioners from the construction industry whom they believed were already familiar with the subject matter. They sent the questions to these practitioners in advance to ensure clarity. Additionally, due to the limited use of the NEC4 form of contract in the KSA construction industry, it was important that practitioners were familiar with this contract form. To facilitate this, the authors provided a copy of the contract conditions along with a summary explaining its benefits to ensure a valuable interview discussion.

4. Proposed BIM Package Application for Resolving Construction Claims

To effectively support the project management team in implementing a BIM Package, several steps were taken. First, as depicted in Figure 3, 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 Professional 2021 (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.

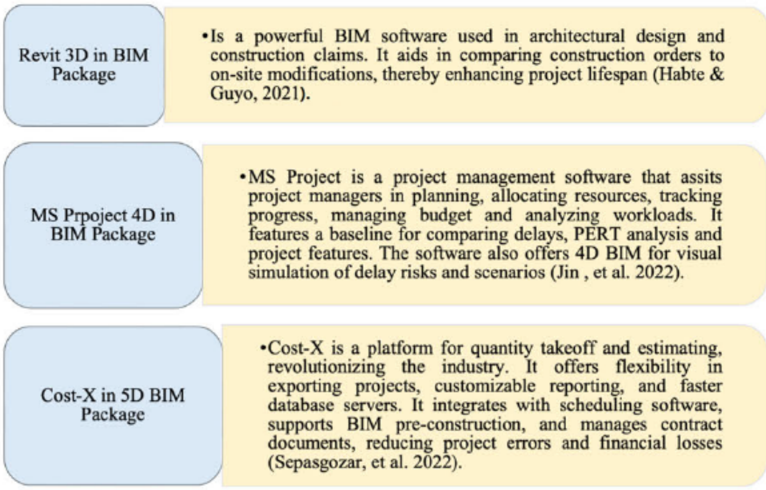


Figure 3. BIM Package software, including Revit, MS Project, and Cost-X [41,50,54].

4.1. Illustration of the Conceptual BIM Package for Reducing Potential Claims

In general, within the scope of BIM software applications, the building lifecycle encompasses a series of stages, ranging from conceptualization to operation and maintenance as shown in Figure 4. 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].

An essential aspect that must be considered, especially by the project owner, is the agreement on the ownership of the BIM package. Specifically, when the involved parties agree to use the BIM package, data will be shared. Therefore, it must be documented who will own the main source of the project data during the project closeout phase. Typically, the owner will be the entity that holds the primary source of project data required during the operational stage. Additionally, potential claims could arise during the rectification period in the operational stage, usually within one year from the initial handover. In such cases, the owner has the right and facility to investigate claims based on the data he or she possesses.

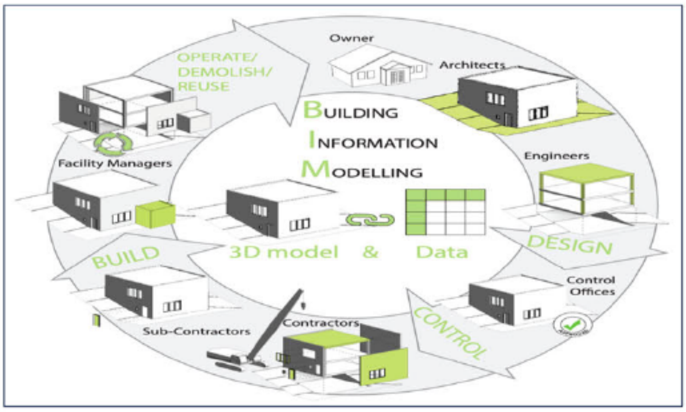


Figure 4. Illustrates the building's lifecycle and its stakeholders under the BIM concept [42,44].

The conceptual BIM framework, as depicted in Figure 5 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 to mitigate 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 6, to provide a more illustrative understanding of how to utilize the BIM Package effectively. The LODs are clearly delineated in Figure 7 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 6), 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 7. 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 7 [43].

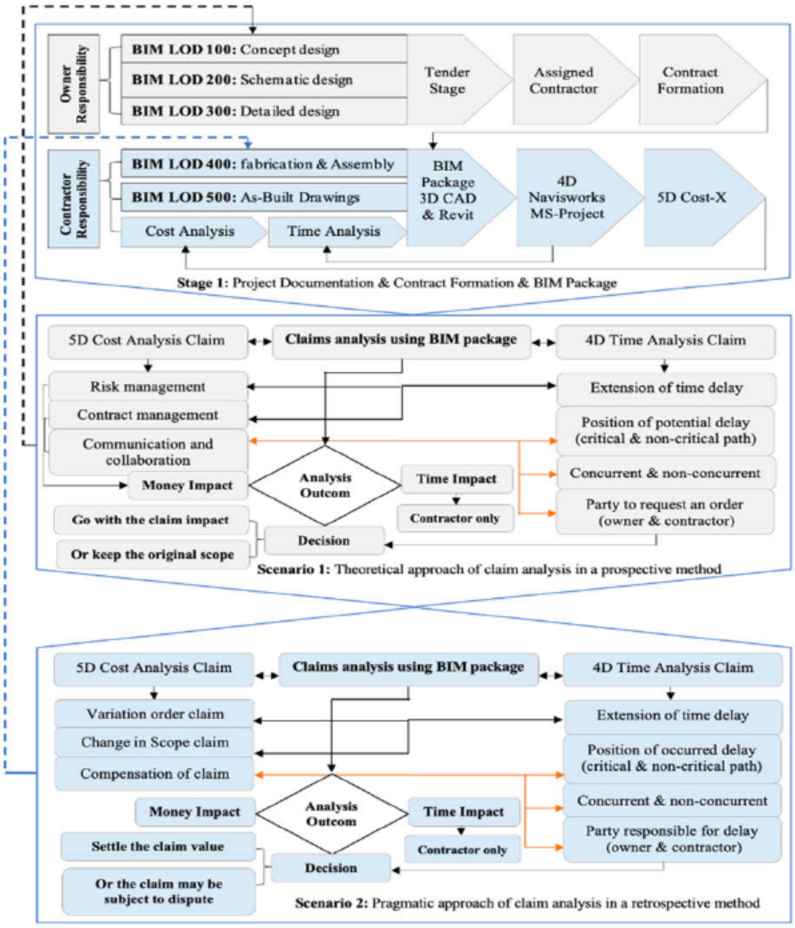


Figure 5. Proposed BIM Package framework for reducing construction claims [32].

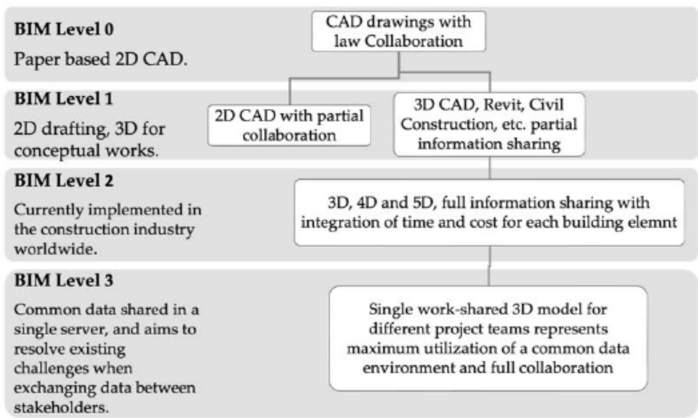


Figure 6. Breakdown of the BIM levels [32].

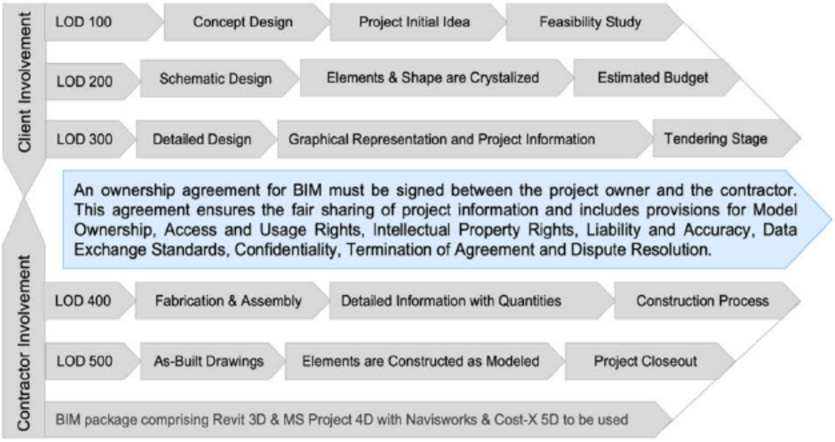


Figure 7. Level of development (LODs) of BIM with contributions from the owner and contractor.

4.2. Proposed Steps for Resolving Construction Claims under the BIM Package

To systematically address claims using the BIM Package, Figure 8 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.

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 ensuring that the project complies with milestone targets in the PEP and fully realizes the benefits of BIM.

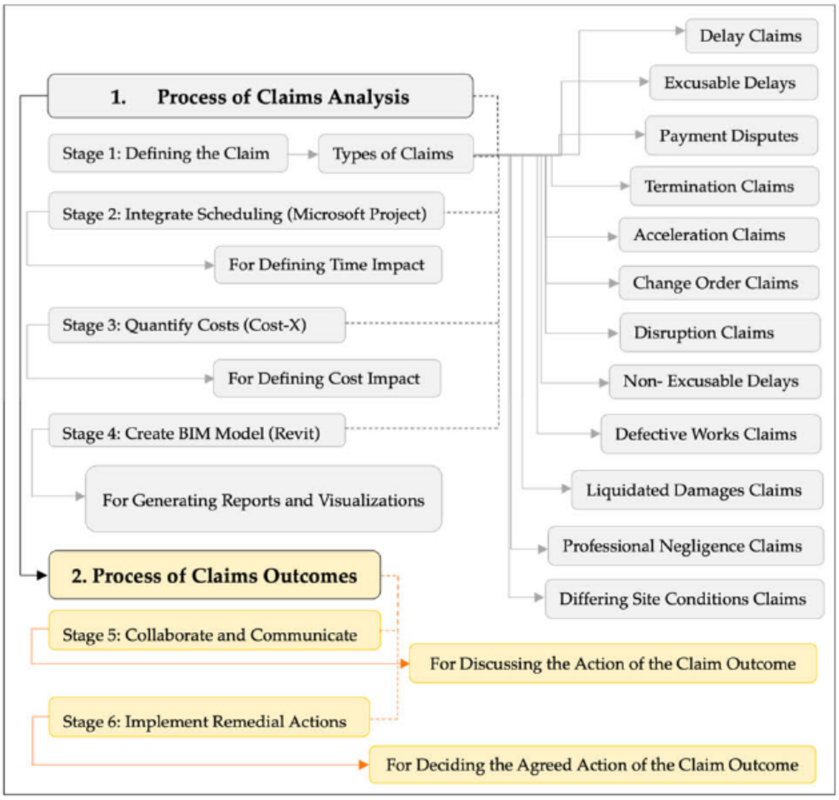


Figure 8. Schematic illustration of the steps of generating and analyzing claims as part of the BIM Package: Source Authors.

5. Claims Case Study from the KSA Construction Industry Using the BIM Package

This claim 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 for 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 on 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 significantly impacted both its cost and timeline. 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 costs 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 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 a 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 claim 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 the design	Contractor	USD 600,000
4	Operation cost claim due to contract termination	Contractor	USD 900,000
5	Total claims value raised by 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.

5.1. Simulating and Solving the Claims Case Study by Implementing the 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).

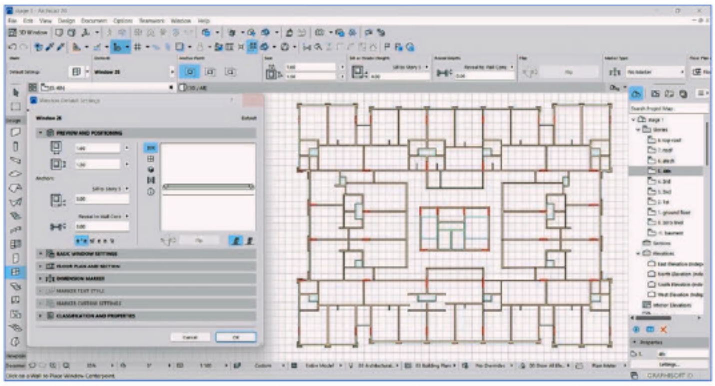


Figure 9. 2D floor layout Revit Architecture.

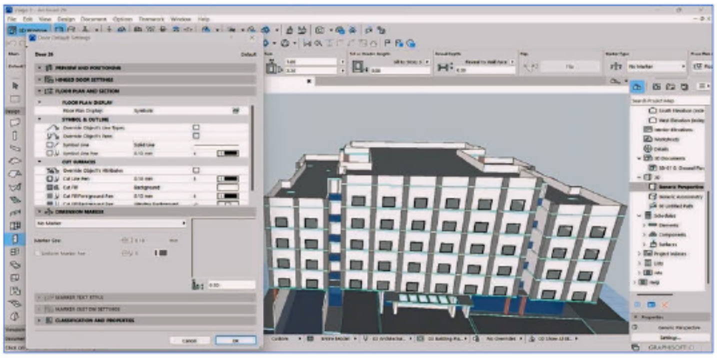


Figure 10. 3D digital model using Revit Architecture.

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.

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.

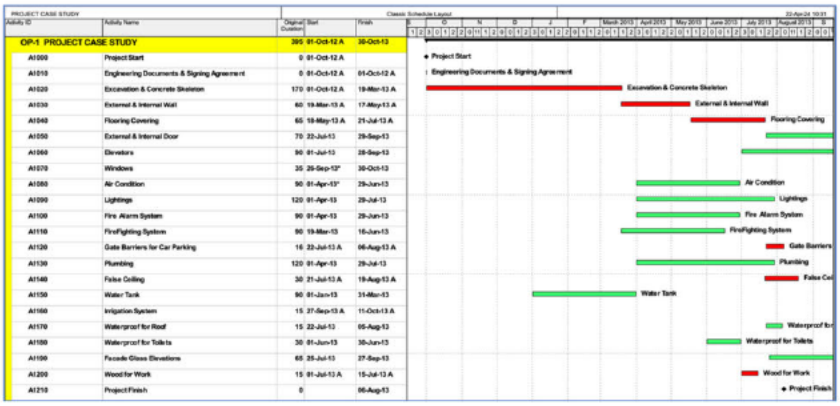


Figure 11. Project timeline generated by the MS Project involved in the BIM Package.

Stage 1: What was missing?

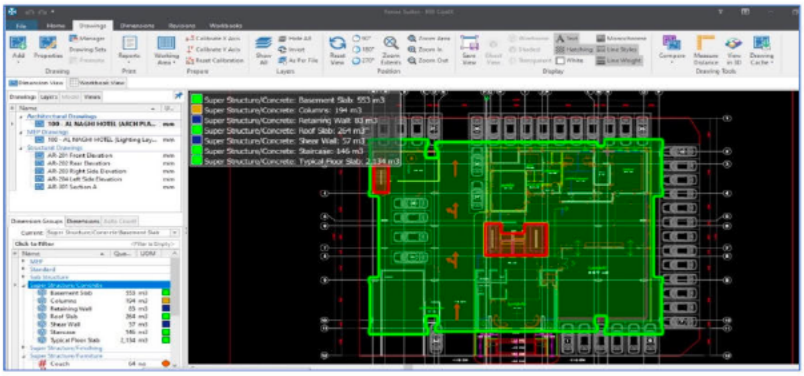
- Stage 1 of this case study involves identifying the missing elements in the original drawings of the selected project. To simulate this, the original 2D CAD drawings, which were converted into a 3D digital model using Revit Architecture, are depicted in Figures 9 and 10. This conversion ensures that 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.

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

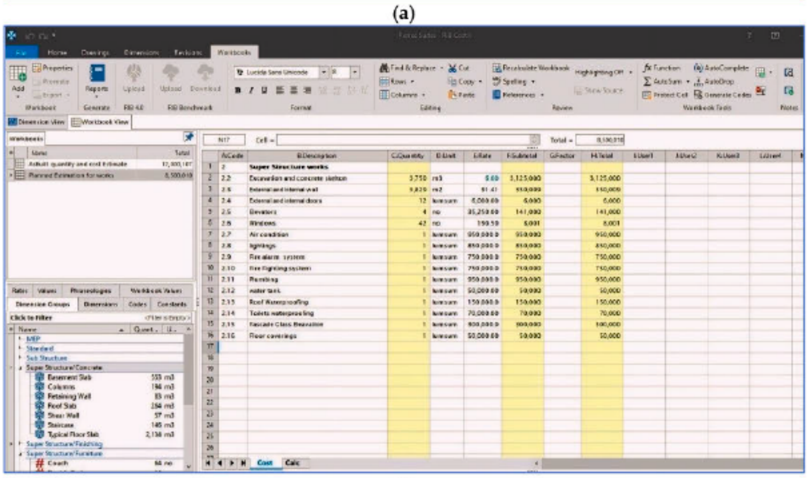
No.	Activity Name	Baseline Duration		Activity Time	Activity Unit	Activity Quantity	Activity Cost
		Start Date	Finish Date				
1	Total Project time	1 October 2012	1 October 2013	365	M^2	12,500	$8.5 Million
2	Planned Schedule and Activities Breakdown that Generated from Cost-X based on Figure 12a,b						
2.1	Engineering and signing agreement	1 October 2012	1 October 2012	0	Lump sum	0	0
2.2	Excavation and Concrete skeleton	1 October 2012	1 April 2013	180	Lump sum	1	$3,125,000
2.3	External and Internal Walls	1 April 2013	1 June 2013	60	Lump sum	1	$350,000
2.4	External and Internal Doors	10 August 2013	1 October 2013	50	No	12	$6000
2.5	Elevators	1 July 2013	1 October 2013	90	No	4	$141,000
2.6	Windows	25 August 2013	1 October 2013	35	No	42	$8000
2.7	Air Condition	1 April 2013	1 October 2013	120	Lump sum	1	$950,000
2.8	Lightings	1 April 2013	1 October 2013	120	Lump sum	1	$850,000
2.9	Fire alarm system	1 April 2013	1 October 2013	120	Lump sum	1	$750,000

Table 7. *Cont.*

No.	Activity Name	Baseline Duration		Activity Time	Activity Unit	Activity Quantity	Activity Cost
		Start Date	Finish Date				
2.10	Firefighting system	1 April 2013	1 October 2013	120	Lump sum	1	$750,000
2.11	Plumbing	1 April 2013	1 October 2013	120	Lump sum	1	$950,000
2.12	Water Tanks	1 January 2013	1 February 2013	60	Lump sum	1	$50,000
2.13	Waterproof for roof	1 September 2013	1 October 2013	30	Lump sum	1	$150,000
2.14	Waterproof for toilets	1 June 2013	1 July 2013	30	Lump sum	1	$70,000
2.15	Façade glass elevations	25 July 2013	1 October 2013	65	Lump sum	1	$300,000
2.16	Flooring Covering	10 August 2023	1 October 2013	50	Lump sum	1	$50,000

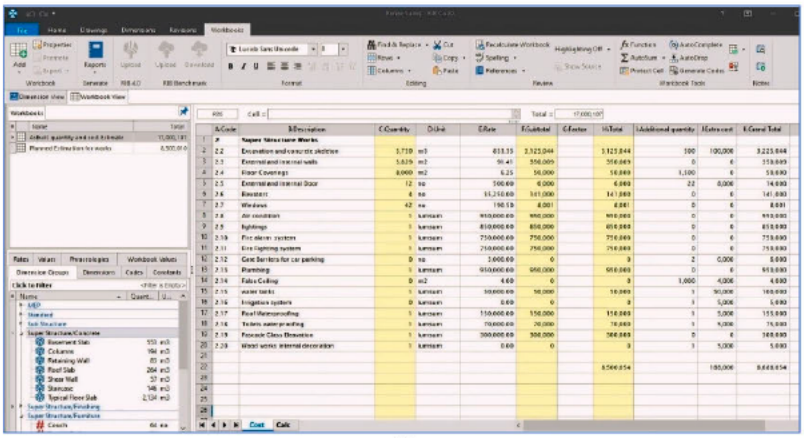


(a)



(b)

Figure 12. *Cont.*



(**c**)

Figure 12. (**a**) Generating the project budget from the original drawings using Cost-X; (**b**) Automated cost report generated from Cost-X based on the original drawings; (**c**) Modified cost report generated using Cost-X based on the detailed drawings.

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

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

No.	Activity Name	Baseline Duration		Original Time	Additional Time	Original Quantity	Additional Quantity	Original Cost	Extra Cost
		Start Date	Finish Date						
1	Total Project time	1 October 2012	1 August 2014	365	360	--		$8.5 Million	188,000
2	As-Built Schedule and Activities Time and Cost Breakdown that Generated from Cost-X based on Figure 12c								
2.1	Engineering and agreement	1 October 2012	1 October 2012	0	0	0	0	0	0
2.2	Excavation and Concrete skeleton	1 October 2012	1 August 2014	180	60	3750 m^3	500 m^3	3,125,000	100,000
2.3	External and Internal Walls	1 April 2013	1 August 2014	60	0	0	0	350,000	0
2.4	Flooring Covering	1 March 2014	1 June 2014	50	40	8000 m^2	1500 m^2		
2.5	External and Internal Doors	10 August 2013	1 October 2013	50	20	12	22 No	6000	8000
2.6	Elevators	1 July 2013	1 October 2013	90	0	4	0	0	0
2.7	Windows	25 August 2013	1 October 2013	35	0	0	0	0	0
2.8	Air Condition	1 April 2013	1 August 2014	120	0	0	0	950,000	0

Table 8. *Cont.*

No.	Activity Name	Baseline Duration		Original Time	Additional Time	Original Quantity	Additional Quantity	Original Cost	Extra Cost
		Start Date	Finish Date						
2.9	Lightings	1 April 2013	1 August 2014	120	0	0	0	850,000	0
2.10	Fire alarm system	1 April 2013	1 August 2014	120	0	0	0	750,000	0
2.11	Firefighting system	1 April 2013	1 August 2014	120	0	0	0	750,000	0
2.12	Gate barriers for cars parking	1 July 2014	1 August 2014	0	30	0	2 No	0	6000
2.13	Plumbing	1 April 2013	1 August 2014	120	0	0	0	950,000	0
2.14	False ceiling	20 April 2014	1 July 2014	0	70	0	1000 m^2	0	4000
2.15	Water Tanks	1 January 2013	1 February 2013	60	30	1	1	50,000	50,000
2.16	Irrigation System	1 May 2014	1 June 2014	0	30	0	LS	0	5000
2.17	Waterproof for roof	15 January 2014	30 January 2014	0	15	0	LS	0	5000
2.18	Waterproof for toilets	30 April 2014	30 May 2014	0	30	0	LS	0	5000
2.19	Façade glass elevations	25 July 2013	1 August 2014	65	0	0	0	350,000	0
2.20	Wood works for internal decoration	25 June 2014	1 August 2014	0	35	0	LS	0	5000

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.

5.2. 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.

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 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 the 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 of 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 might limited data accuracy and documentation issues in the project scope lead to contractual disputes?	A typical answer is given in the following section		A typical answer is given in the following section		68%	--
7	How can delayed information sharing and decision-making affect project timelines, costs, and claims?	A typical answer is given in the following section		A typical answer is 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%
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%

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 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.

Table 10. *Cont.*

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 a 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 a cost perspective includes:

1. Delayed information sharing can result in idle resources, such as labor 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, labor, and time, all of which further inflate project expenditures.

A typical answer from a 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 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.

6. 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 a BIM package to generate electronically shareable project documents among stakeholders. To achieve this, this study initially delved into the significance of BIM in the 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 interviewed 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.

To elaborate on the results of the interview sessions, Table 10 illustrates the questions posed to the selective practitioners and summarizes their typical responses. Some of those questions were designed as closed questions, and others were open-ended. The authors meticulously crafted the questions presented in Table 10 and disseminated them to the willing participants. Subsequently, the authors inquired about the participants' confidence levels regarding the topic, encompassing BIM and the NEC4 contract. Most of the participants expressed enthusiasm about their capacity to discuss the subject matter. However, given the limited use of the NEC4 contract in the KSA, some participants acknowledged their familiarity with NEC due to prior experiences in similar industries. To ensure a comprehensive understanding among all participants, the authors provided everyone with a copy of the relevant contract form, accompanied by a concise description. Hence, the authors presented the following section, which included the raised open-ended questions with answers from practitioners that were involved, as listed below:

Eng. Practitioner, in your opinion, why do limited data accuracy and documentation issues in the project scope lead to contractual disputes?

"Well, there are different reasons why contractual conflicts can happen when there are problems with data accuracy and documentation that are part of the project. One of these reasons is the chance of misinterpreting the project's scope, which can happen when data is missing or wrong and cause confusion about the project's limits. If the scope of work isn't clearly stated or written down, different people involved in the project may have different ideas about what it means, which could lead to arguments about who is responsible for what under the contract. Also, problems with change management can happen when project plan documentation isn't complete. If you don't have accurate data, it's hard to keep track of and record changes that happen during the lifecycle of a project, like when the design is changed or the scope is expanded. This can lead to disagreements about extra costs, delays, or changes in the project's scope".

Another question, Eng. Practitioner, related to the discussed above question! To overcome limited data accuracy and contractual issues, do you agree to use a selected standard form of contract (NEC4) with the BIM Package, and why?

"Yes, I concur with utilizing the NEC4 standard form of contract accompanied by a BIM package to overcome the limitations of data accuracy and contractual issues for numerous reasons. For instance, the NEC4 contract fosters collaboration and communication since it is clearly and simply written, obviating the need for a legal department or specialist to manage the said contract. Instead, the engineer or quantity surveyor can manage that contract in a professional manner, in which you do not need a legal advisor to manage such a contract. In addition, engaging with the BIM package ensures that all parties have access to precise and up-to-date information, thus reducing misunderstandings and discrepancies pertaining to project scope, specifications, and changes and thereby minimizing contractual issues".

Mr. Contractor, what are the main obstacles to adopting BIM technology in the Saudi Arabian construction industry?

I would argue that there exist numerous impediments that may impede the widespread implementation of Building Information Modeling (BIM) in the Kingdom of Saudi Arabia (KSA). Since 2017, the awareness and knowledge regarding BIM have been considerably limited within the construction industry of the country. Nevertheless, with the expansion of opportunities for foreign investors to participate in the local construction sector, international companies introduced their technological advancements, including BIM, due to the absence of standardized principles and guidelines pertaining to BIM and the lack of legal frameworks to support its utilization. Currently, the KSA is actively promoting innovative technologies that improve the construction landscape, exemplified by the enforcement of BIM as a mandatory requirement, albeit its impact is not yet prominently evident. In this regard, it can be considered as an initial step towards the broader integration of BIM.

Mr. Contractor, given more details about the new regulations in the KSA, how do the regulatory frameworks and cultural factors in Saudi Arabia affect the implementation and utilization of BIM in construction projects?

"In my opinion, to address your question comprehensively, several key aspects must be considered. First, in alignment with the Saudi Vision 2023, the Kingdom of Saudi Arabia has increasingly mandated the use of BIM, particularly for public projects, to enhance efficiency and ensure superior project outcomes. Additionally, the implementation of standardized BIM protocols and frameworks is essential to ensure uniformity across projects. This may involve adherence to international BIM standards such as ISO 19650, which is an international standard for managing information over the whole life cycle of a built asset using BIM [55]. Furthermore, there is a cultural emphasis on education and professional development in the fields of construction and technology. Training programs and certifications in BIM can help bridge existing skill gaps. Traditional project management practices may need to be adapted to fully leverage the capabilities of BIM, which includes fostering a collaborative culture among stakeholders. It is important to note that, as in many industries, there may be initial resistance to adopting new technologies. Addressing this resistance through awareness campaigns and demonstrating the benefits of BIM is crucial. Moreover, some argue that the financial investment required for BIM software and training may pose a barrier. However, when considering the volume of claims that still occur, which in some cases reach 5% of the project value comparable to the cost of BIM implementation and training that might not exceed 1.5% of the project value in medium-sized projects or could be less in large-scale projects. This encouraging to implementation of BIM, also encouraging institutional support and government incentives or support programs could further facilitate the adoption of BIM".

Based on the detailed analysis of this paper and insights from industry practitioners, the authors believe that the advantages and benefits outlined in this article will provide readers and professionals in construction projects with the understanding that utilizing Building Information Modeling (BIM) can significantly reduce and amicably resolve most construction claims. The primary reason is that in most cases, claims raised, whether in court or via arbitration, are mostly subjected to a lack of transparency between the conflicting parties. Lack of transparency, mainly between the conflicting parties, is generated by insufficient information from the construction site works, which is the source of generating claims. In addition, until the present, the authorized courts under the KSA legal system for resolving construction claims are mostly the commercial courts, which, in some cases, commercial courts often face challenges when handling construction claims due to the insufficient accuracy of data and information from site work. Additionally, judges or lawyers in the KSA may lack familiarity with construction contracts and documents that contain special terms and conditions, making it difficult for the court to rely on them. Consequently, the time required for the court to issue a final decision may be longer than expected by the conflicting parties. A real example of a claim case in the KSA industry involves a lack of clarity between conflicting parties, with the author serving as an expert appointed by the court. In this case, the claimant, the owner, sued the defendant, the contractor, and submitted a document to support his claim for returning money. This amount was represented by a promissory note for an advanced payment. The owner did not specify that this amount was for an advanced payment made to the contractor. The contractor explained to the court that the advanced payment had already been deducted from interim payments and returned to the owner. The court stated that they understood an advanced payment guarantee as a letter of guarantee issued by a bank and were unfamiliar with using a promissory note as such a guarantee. The case is currently in the court of appeals. Meanwhile, the contractor has paid the disputed amount and is awaiting the court's final decision. Unlike the UK system, there is a specific construction court known as the Technology and Construction Court (TCC) for construction cases. This court usually helps the conflicting parties facilitate and absorb the construction cases quickly, resulting in a quick final decision.

To explain our above-given example in more depth, in the previous customary practice in the KSA industry, advance payment guarantees in contracting agreements were either letters of bank guarantees or bank checks. However, the judicial system in Saudi Arabia prohibited the use of bank checks as a guarantee mechanism; instead, it mandated bank guarantees or a promissory note as a letter of guarantee and specified a particular legal form for the promissory note. If not, the reason for issuing the bond must be stated to the orderer, and it is deemed payable within five working days once it is submitted to the competent court. This was exemplified by the case mentioned in our example, wherein it was not specified that the promissory note was employed as a letter of guarantee against the advance payment. Despite the recovery of advance payments as described above, the court disregarded them and determined that the promissory note was not pertinent to the case. Although similar studies were selected from the existing literature in the methodology described in Table 1, it is still not clear how claims can be minimized, as demonstrated in this article.

The approach outlined in this article could be criticized for not considering the limited use of BIM in the KSA construction industry, which remains largely reliant on traditional project management practices. However, due to the recent boom in construction in the KSA, the regime has mandated the use of BIM in all construction projects commencing in 2024. This top-down imposition of BIM is an attempt to modernize and streamline the industry, and it will be interesting to observe the impact of this decision on the industry's traditional practices (Abougamil et al., 2023, 2024) [14,32].

7. Conclusions

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 1 January 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 6 and 7.

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. 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.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. The raw data supporting the conclusions of this article will be made available by the authors on request.

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

References

1. Hardin, B.; McCool, D. *BIM and Construction Management: Proven Tools, Methods, and Workflows*; John Wiley & Sons: Hoboken, NJ, USA, 2015.
2. Sacks, R.; Eastman, C.; Lee, G.; Teicholz, P. *BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers*; John Wiley & Sons: Hoboken, NJ, USA, 2018.
3. Datta, S.D.; Tayeh, B.A.; Hakeem, I.Y.; Abu Aisheh, Y.I. Benefits and barriers of implementing building information modeling techniques for sustainable practices in the construction industry a comprehensive review. *Sustainability* **2023**, *15*, 12466. [CrossRef]
4. Abdallah, A.; Assaf, S.; Hassanain, M.A. Assessment of the consequences of deficiencies in design documents in Saudi Arabia. *Archit. Eng. Des. Manag.* **2019**, *15*, 282–296. [CrossRef]
5. Alhammadi, Y.; Al-Mohammad, M.S.; Rahman, R.A. Modeling the Causes and Mitigation Measures for Cost Overruns in Building Construction: The Case of Higher Education Projects. *Buildings* **2024**, *14*, 487. [CrossRef]
6. Assaf, S.; Hassanain, M.A.; Abdallah, A.; Sayed, A.M.; Alshahrani, A. Significant causes of claims and disputes in construction projects in Saudi Arabia. *Built Environ. Proj. Asset Manag.* **2019**, *9*, 597–615. [CrossRef]
7. Gopang, R.K.M.; alias Imran, Q.B.; Nagapan, S. Assessment of delay factors in Saudi Arabia railway/metro construction projects. *Int. J. Sustain. Constr. Eng. Technol.* **2020**, *11*, 225–233.
8. Alshihri, S.; Al-Gahtani, K.; Almohsen, A. Risk factors that lead to time and cost overruns of building projects in Saudi Arabia. *Buildings* **2022**, *12*, 902. [CrossRef]
9. Junussova, T.; Nadeem, A.; Kim, J.R.; Azhar, S. Key Drivers for BIM-Enabled Materials Management: Insights for a Sustainable Environment. *Buildings* **2023**, *14*, 84. [CrossRef]
10. Assaf, S.A.; Al-Hejji, S. Causes of delay in large construction projects. *Int. J. Proj. Manag.* **2006**, *24*, 349–357. [CrossRef]
11. Bin Seddeeq, A.; Assaf, S.; Abdallah, A.; Hassanain, M.A. Time and cost overrun in the Saudi Arabian oil and gas construction industry. *Buildings* **2019**, *9*, 41. [CrossRef]
12. Baghdadi, A.; Kishk, M. Saudi Arabian aviation construction projects: Identification of risks and their consequences. *Procedia Eng.* **2015**, *123*, 32–40. [CrossRef]
13. Bajwa, I.A.; Syed, A.M. Identification of major construction sector risks in Saudi Arabia. *World Trans. Eng. Technol. Educ.* **2020**, *18*, 247–256.
14. Abougamil, R.A.; Thorpe, D.; Heravi, A. Investigating the Source of Claims with the Importance of BIM Application on Reducing Construction Disputable Claims in KSA. *Buildings* **2023**, *13*, 2219. [CrossRef]
15. Jong, C.-Y.; Sim, A.K.; Lew, T.Y. The relationship between TQM and project performance: Empirical evidence from Malaysian construction industry. *Cogent Bus. Manag.* **2019**, *6*, 1568655. [CrossRef]

16. Hussain, S.; Hasmori, M.F.; Abas, N.H.; Balasbaneh, A.T.; Khan, M.W. Key Performance Indicators for Project Success in Saudi Arabian Construction Industry. 2022. Available online: https://doi.org/10.21203/rs.3.rs-2329589/v1 (accessed on 4 May 2024). [CrossRef]
17. Keenan, M.; Rostami, A. The impact of quality management systems on construction performance in the Northwest of England. *Int. J. Constr. Manag.* **2021**, *21*, 871–883.
18. Leong, T.K.; Zakuan, N.; Mat Saman, M.Z.; Ariff, M.; Md, S.; Tan, C.S. Using project performance to measure effectiveness of quality management system maintenance and practices in construction industry. *Sci. World J.* **2014**, *2014*, 591361. [CrossRef] [PubMed]
19. Khandar, A.M.A.; Pathak, S.; Sawant, S.K. Performance Management through Quality Measurement at Construction Site, Pune. *Int. J. Eng. Res. Technol. (IJERT)* **2018**, *7*, 143–146.
20. Khosrowshahi, F.; Arayici, Y. Roadmap for implementation of BIM in the UK construction industry. *Eng. Constr. Archit. Manag.* **2012**, *19*, 610–635. [CrossRef]
21. Wang, J.; Zhang, S.; Fenn, P.; Luo, X.; Liu, Y.; Zhao, L. Adopting BIM to facilitate dispute management in the construction industry: A conceptual framework development. *J. Constr. Eng. Manag.* **2023**, *149*, 03122010. [CrossRef]
22. Denis, F. The Guide to Building Information Modeling (BIM)-Belgian Guide for the Construction Industry, ADEB-VBA, Avenue Grandchamp/Grootveldlaan 148–1150 Brussels. 2015. Available online: https://www.iqytechnicalcollege.com/the-guide-to-bim.pdf (accessed on 24 May 2022).
23. Alrashed, I.; Alrashed, A.; Taj, S.A.; Phillips, M.; Kantamaneni, K. Risk assessment for construction projects in Saudi Arabia. *Res. J. Manag. Sci.* **2014**, *3*, 1–6.
24. Sha'ar, K.; Assaf, S.; Bambang, T.; Babsail, M.; Fattah, A.A.E. Design–construction interface problems in large building construction projects. *Int. J. Constr. Manag.* **2017**, *17*, 238–250. [CrossRef]
25. Mahamid, I. Micro and macro level of dispute causes in residential building projects: Studies of Saudi Arabia. *J. King Saud Univ. Eng. Sci.* **2016**, *28*, 12–20. [CrossRef]
26. El-Sayegh, S.; Ahmad, I.; Aljanabi, M.; Herzallah, R.; Metry, S.; El-Ashwal, O. Construction disputes in the UAE: Causes and resolution methods. *Buildings* **2020**, *10*, 171. [CrossRef]
27. AL Mousli, M.H.; El-Sayegh, S.M. Assessment of the design–construction interface problems in the UAE. *Archit. Eng. Des. Manag.* **2016**, *12*, 353–366. [CrossRef]
28. Allahaim, F.S.; Liu, L. Causes of cost overruns on infrastructure projects in Saudi Arabia. *Int. J. Collab. Enterp.* **2015**, *5*, 32–57. [CrossRef]
29. Sarhan, J.; Xia, B.; Fawzia, S.; Karim, A.; Olanipekun, A. Barriers to implementing lean construction practices in the Kingdom of Saudi Arabia (KSA) construction industry. *Constr. Innov.* **2018**, *18*, 246–272. [CrossRef]
30. Elawi, G.S.A.; Algahtany, M.; Kashiwagi, D. Owners' perspective of factors contributing to project delay: Case studies of road and bridge projects in Saudi Arabia. *Procedia Eng.* **2016**, *145*, 1402–1409. [CrossRef]
31. Mahamid, I. Schedule delay in Saudi Arabia Road construction projects: Size, estimate, determinants and effects. *Int. J. Archit. Eng. Constr.* **2017**, *6*, 51–58. [CrossRef]
32. Abougamil, R.A.; Thorpe, D.; Heravi, A. An Investigation of BIM Advantages in Analysing Claims Procedures Related to the Extension of Time and Money in the KSA Construction Industry. *Buildings* **2024**, *14*, 426. [CrossRef]
33. Elbashbishy, T.S.; Hosny, O.A.; Waly, A.F.; Dorra, E.M. Assessing the impact of construction risks on cost overruns: A risk path simulation-driven approach. *J. Manag. Eng.* **2022**, *38*, 04022058. [CrossRef]
34. Marzouk, M.; Elsaay, H.; Othman, A.A.E. Analysing BIM implementation in the Egyptian construction industry. *Eng. Constr. Archit. Manag.* **2022**, *29*, 4177–4190. [CrossRef]
35. Ali, B.; Zahoor, H.; Nasir, A.R.; Maqsoom, A.; Khan, R.W.A.; Mazher, K.M. BIM-based claims management system: A centralized information repository for extension of time claims. *Autom. Constr.* **2020**, *110*, 102937. [CrossRef]
36. Al-Yami, A.; Sanni-Anibire, M.O. BIM in the Saudi Arabian construction industry: State of the art, benefit and barriers. *Int. J. Build. Pathol. Adapt.* **2021**, *39*, 33–47. [CrossRef]
37. Parchami Jalal, M.; Yavari Roushan, T.; Noorzai, E.; Alizadeh, M. A BIM-based construction claims management model for early identification and visualization of claims. *Smart Sustain. Built Environ.* **2021**, *10*, 227–257. [CrossRef]
38. Mohammed, T. *Architect's Legal Handbook*; Routledge: London, UK, 2021; pp. 215–220.
39. Yabar-Ardiles, O.; Sanchez-Carigga, C.; Espinoza Vigil, A.J.; Guillén Málaga, M.S.; Milón Zevallos, A.A. Seeking the Optimisation of Public Infrastructure Procurement with NEC4 ECC: A Peruvian Case Study. *Buildings* **2023**, *13*, 2828. [CrossRef]
40. Shahhosseini, V.; Hajarolasvadi, H. A conceptual framework for developing a BIM-enabled claim management system. *Int. J. Constr. Manag.* **2021**, *21*, 208–222. [CrossRef]
41. Habte, B.; Guyo, E. Application of BIM for structural engineering: A case study using Revit and customary structural analysis and design software. *J. Inf. Technol. Constr.* **2021**, *26*, 1009–1022. [CrossRef]
42. Waas, L. Review of BIM-Based Software in Architectural Design: Graphisoft Archicad VS Autodesk Revit. *J. Artif. Intell. Archit.* **2022**, *1*, 14–22. [CrossRef]
43. Faraji, A.; Homayoon Arya, S.; Ghasemi, E.; Rashidi, M.; Perera, S.; Tam, V.; Rahnamayiezekavat, P. A conceptual framework of decentralized blockchain integrated system based on building information modeling to steering digital administration of disputes in the IPD contracts. *Constr. Innov.* **2024**, *24*, 384–406. [CrossRef]

44. Dinis, F.M.; Sanhudo, L.; Martins, J.P.; Ramos, N.M. Improving project communication in the architecture, engineering and construction industry: Coupling virtual reality and laser scanning. *J. Build. Eng.* **2020**, *30*, 101287. [CrossRef]
45. Creswell, J.W.; Clark, V.L.P. *Designing and Conducting Mixed Methods Research*; Sage Publications: New York, NY, USA, 2017.
46. Tashakkori, A.; Teddlie, C. *Mixed Methodology: Combining Qualitative and Quantitative Approaches*; Sage: New York, NY, USA, 1998; Volume 46.
47. Bayer, S. Business dynamics: Systems thinking and modeling for a complex world. *Interfaces* **2004**, *34*, 324–327.
48. Abd-Ellatif, A.M.A.; Nassar, A.H. Claims and Disputes Resolution Using BIM Technology and Vdc Process in Construction Contract Risk Analysis. *Technol. (IJCIET)* **2021**, *12*, 82–107.
49. Honnappa, D.; Padala, S.S. BIM-based framework to quantify delays and cost overruns due to changes in construction projects. *Asian J. Civ. Eng.* **2022**, *23*, 707–725. [CrossRef]
50. Jin, X.; Ekanayake, E.; Shen, G.Q. Critical policy drivers for Modular integrated Construction projects in Hong Kong. *Build. Res. Inf.* **2022**, *50*, 467–484. [CrossRef]
51. Amaratunga, P.; Haigh, R.P.; Ruddock, L.; Keraminiyage, K.; Kulatunga, U.; Pathirage, C. CIB INTERNATIONAL CONFERENCE 2014: W55/65/89/92/96/102/117 & TG72/74/81/83 Construction in a Changing World; Book of Abstracts. Available online: https://www.researchgate.net/publication/303444308_CIB_INTERNATIONAL_CONFERENCE_2014_W5565899296102117_TG72748183_Construction_in_a_Changing_World_Book_of_Abstracts (accessed on 4 May 2024).
52. Muhammad, R.; Nasir, A.R. Integrating BIM in construction dispute resolution: Development of a contractual framework. *Buildings* **2022**, *12*, 1828. [CrossRef]
53. Charehzehi, A.; Chai, C.; Md Yusof, A.; Chong, H.-Y.; Loo, S.C. Building information modeling in construction conflict management. *Int. J. Eng. Bus. Manag.* **2017**, *9*, 1847979017746257. [CrossRef]
54. Sepasgozar, S.M.E. Construction digital technology assimilation and absorption capability using measurement invariance of composite modeling. *J. Constr. Eng. Manag.* **2023**, *149*, 04023041. [CrossRef]
55. Winfield, M. Construction 4.0 and ISO 19650: A panacea for the digital revolution? *Proc. Inst. Civ. Eng.-Manag. Procure. Law* **2020**, *173*, 175–181. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

Connection Between the Three Published Papers

The connection between the research papers is a progressive exploration of dispute reduction in construction projects, with a specific focus on the KSA industry. The first paper delves into existing literature to identify sources of disputes and evaluates mechanisms for reducing them, concluding that modern technology like BIM is effective. Building on these findings, the second paper extends the research by examining BIM's role in dispute reduction through a detailed case study. This study highlights a scenario involving time delays and the use of the NEC3 contract alongside BIM to mitigate disputes. The doctoral study culminates in a third paper, which introduces conceptual diagrams for the claims process and presents a case study focusing on time delays and additional costs in the Saudi industry, utilizing a proposed BIM package. Interviews with industry experts validate this package, leading to the recommendation that the BIM package is crucial for minimizing disputable claims.

Links and Implications

Links and implications of the literature enabled the findings of thrid research published paper to support current research highlighting the significance of Building Information Modeling (BIM) in mitigating construction claims and disputes. Prior research indicates that BIM improves collaboration and transparency among stakeholders, hence reducing misunderstandings and ambiguities that frequently result in claims. This paper substantiates these assumptions by offering empirical evidence from the construction sector, emphasizing the pragmatic benefits of employing BIM to address prevalent causes of construction claims, including design inaccuracies, scheduling discrepancies, and budget overruns. The paper promotes the incorporation of BIM into comprehensive project risk management frameworks. The case study illustrates a reduction in claims. Therefore, establishing a robust correlation between BIM adoption and enhanced project performance measures, such as cost and time efficiency.

Practical Implications and Future Research

Improved Stakeholder Communication: The findings of the third published paper suggest that BIM serves as an effective communication tool, providing a unified platform for project stakeholders to collaborate and resolve disputes early in the project lifecycle. This highlights the importance for construction firms to invest in training and adopt BIM standards to improve project outcomes. By enabling a proactive approach to claim prevention, BIM allows potential issues to be identified and addressed during the design and planning stages. This has significant implications for project managers and legal consultants in the construction industry, as it reduces the likelihood of disputes escalating into costly legal battles. Future research should investigate the scalability of these findings across other project kinds, sizes, and geographical locations to ascertain the universality of BIM's effect on claim reduction.

CHAPTER 6: DISCUSSION

6.1 Discussion Literature Review

6.1.1 Factors that Cause Disputable Claims

As summarised in Chapter 2, previous studies have proven the existence of different causes of disputes as the first major instance, leading to a need for implementing technologies such as BIM to influence changes while minimising disputable claims in KSA residential and commercial projects. The analysis focused on different challenges and disputable claims. Among the challenges identified in delivering construction projects was the challenge of projects primarily focusing on compliance with the Saudi Building Code based on architectural, structural engineering, electrical and mechanical engineering, fire protection, and energy conservation (Buckby & Pendley, 2017). This challenge is broader when analysing disputable claims clustered with different groups associated with construction claims, including client groups, engineering groups, and contractor groups, each with specified roles in construction claims (Murdoch & Hughes, 2008).

The engineering group, which is a multidisciplinary group of experts, comprising civil, structural, mechanical, and electrical engineers, is committed to the planning, design, analysis, and supervision of construction projects. They focus on ensuring technical integrity, adherence to standards, and successful completion. These professionals often work closely with architects, contractors, and project managers to turn design ideas into practical, safe, and sustainable structures while tackling technical, environmental, and logistical challenges. Those engineering group had a significant impact on the design errors and associated risks, leading to disputable claims. Per the categorisation of the design errors, Peansupap and Ly (2015) state that architectural design is related to exterior and interior designs and plans, inferences, and needed facilities. The structural design was associated with foundational design and building structural elements. Lastly, electrochemical designs were related to different errors, including electrical design, mechanical design, and plumbing considerations (Peansupap & Ly, 2015). Apart from the factors associated with key stakeholders, there are additional causes of disputable claims in the construction industry. The major was associated with design and variation in design and scope, ambiguous and incomplete drawings, inconsistencies in drawings and bill of quantities, change of site locations and conditions, slowed decisions, poor safety concerns, poor communication, lack of contract awareness, planning and scheduling issues, and procurement and plan deficiencies. These factors are associated with contractual challenges.

The last challenge analysed and associated with disputes in the construction industry was the challenge of payment issues. In the analysis of previous literature, payment delays pose a significant challenge to companies working on projects in KSA. In the analysis, it was identified that currently, there is no statutory right to delay activities or terminate agreements, and in instances when there is a dispute in payment in projects in KSA, reliance is on the contract's dispute resolution clause (Buckby & Pendley, 2017; Loots, 1995). Associating this with the groups in construction related to construction claims, the client group, specifically financiers and project managers, and the contractor's group have a role in ensuring effective financial resources within time limits and acceptable parameters (Murdoch & Hughes, 2008). The challenge mainly stems from issues such as legal challenges, with Quantum merit claims focusing on the payment methods for receiving money by contractors and Ex gratia claims focusing on the amount of money paid against work done without the owner's obligation or liability to do so (Murdoch & Hughes, 2008). Critical in influencing the progress of the financial capacity and project completion time are the different causes of the dispute. The major disputes from the instance of this challenge are mainly cost overrun and time constraints, primarily caused by delays in payment (Flyvbjerg et al., 2003; Goldstrong, 2019; Jang et al., 2019; Lee et al., 2009; Shahsavand, 2018).

The major causes of financer and cost of claims included financial challenges from the owner of the project, budget underestimation for the project, delayed and slowed payments, financial challenges of the contractor, contractor competition leading to low-cost contracts, and factors focused on unplanned bidder, inadequate bid information, and work done without measure and payment. The further influence of costs is associated with time factors. From the factors identified from the literature, the major included the client suspending the project, poor supervisor coordination, delayed procurement and product delivery, material shortages, delayed mobilisation time, oral order change by client, low contractor productivity, poor and un-interoperability of BIM tools, incomplete BIM modelling during budgeting, and design changes. These factors have been identified to be significant in implementing technology in the construction industry, considering their influence on addressing different dispute claims.

6.1.2 Extend at Which BIM Can Minimise Disputable Claims

In the analysis of the major success factors that have a significant influence on the performance of construction projects, the quantification of the success of a project is challenging (Alzobaee & Al-Ageeli, 2016). However, different factors have been identified as influential in minimising claims while enhancing the projects. Coordination by project stakeholders, advanced technology for designing and constructing, proper material selection, avoidance of cost underestimation, panel optimisation, realistic time planning for project completion, minimal design changes, studies value engineering after design completion, adaptability of the project manager to changes, early involvement of project manager in project planning, commitment to quality costs and schedules, and effective communication and control mechanisms have been identified as major factors in reducing disputes along a construction project. These factors have been critical in developing BIM technology and its application in the construction industry.

In the development of BIM over the years, there have been different levels from Level 0 to Level 3, with criticality advancing from drawings, modeling, collaboration interrogation, and interoperable data (Bew & Richards, 2008; Cable et al., 2015; James, 2007; Partland, 2014). Despite the development, there has been minimal application and incorporation in KSA commercial and residential building projects. Comparatively, countries such as the UK have considered implementation over the years, currently at 73% use in construction companies. The construction companies implementing the technology identified the relevance in different aspects, especially in reducing challenges expected in major projects. The majority pointed out an increase in efficiency, enhancement of information coordination, risk reduction, and profitability. The application is similar to that of the United States, where nearly 100% of construction companies implement it (Simpson & Richards, 2014). In addressing different disputable claims within the construction industry of the United States, Kouider and Adama (2019) identified improved productivity by 25% through proper coordination and management, labour reduction by 25% due to reduced errors and straightforward tasks, a reduction in construction costs by 5%, and a 5% increased speed in completing projects due to the right information being shared at the right time. In Australia, however, compared to the UK and the US, there has not been a significant implementation despite strategies such as a series of building SMART MESH conferences from 2011 and consultation workshops in 2012 recommending the adoption of BIM in seven key priority areas, including procurement and collaborative practices, guidelines, education, procurement data, process and data exchange, regulatory framework, and pilot projects.

Despite efforts to improve performance in the KSA construction industry, delayed projects have increased from 700 to 3,000 from 2009 to 2013. The strategies have been minimal in considering the impacts of BIM technology in promoting effectiveness and productivity, leading to the country lagging in adoption. Azhar (2011) recommended the consideration of BIM in the industry, with projected impacts on planning assigning, thus improving efficiency. Despite the recommendations, Alhumayn (2017) identified that the major challenges in implementation include a shortage of skilled technicians and shortages in the workforce. The categorisation of the difficulties in implementation leading to the current BIM use by construction companies for major projects in KSA include legal, business, human, and technical aspects (Banawi & Aliobaly, 2019). Fewer firms have adopted the technology, with expectations of increased use, especially based on the improvements noted from other regions in minimising the dominant challenges in the country’s construction industry.

6.1.3 Summary of the Research Gap

The construction sector in Saudi Arabia is crucial to the country's economic advancement, propelled by extensive infrastructure and urbanization initiatives. Still, the sector has ongoing problems with construction claims and disputes, which often cause projects to be late, cost more than planned, and pose challenges for stakeholders. Despite the global trend of integrating advanced technologies such as BIM to tackle these difficulties, the dependence on conventional methods for claim resolution persists in Saudi Arabia. Understanding how BIM could help settle disputes in the Saudi construction industry remains a significant research gap. This is because current methods are mostly reactive, manual, and litigation-focused. These conventional approaches are expensive and susceptible to subjective interpretations, resulting in ineffective resolution processes. Also, there isn't a lot of real-world data from the area that shows the real benefits of BIM in proactively finding, managing, and avoiding construction claims.

Addressing this gap is essential since it corresponds with Saudi Arabia's Vision 2030, which prioritizes modernization, innovation, and efficiency in all sectors, including building. Examining the impact of BIM on minimizing contentious claims can yield practical insights into the technology's potential to revolutionize project delivery methods in the area. This will assist construction professionals in transitioning from antiquated methods to more collaborative, transparent, and data-driven strategies for managing claims. Therefore, important factors are consolidating this research gap as follows:

- Proactive Claim Prevention: Illustrating how BIM may detect and resolve potential disputes early in the project lifecycle to mitigate expensive conflicts.
- Efficiency and Cost Reduction: Investigating how BIM implementation can diminish reliance on conventional claim resolution techniques, resulting in expedited and more economical procedures.
- Localized techniques: Formulating BIM implementation techniques customized to the distinct regulatory, cultural, and operational attributes of the Saudi construction sector.
- Capacity Building: Emphasizing the necessity for training and policy reforms to facilitate BIM integration, hence enabling industry professionals to harness its complete potential.

- Global Competitiveness: Facilitating Saudi construction firms to conform to worldwide best practices, so augmenting their competitiveness in the global marketplace.

6.1.4 Sample Size of the Research

The research sample for this study comprised experts possessing substantial expertise and experience in BIM technology, along with a specialization pertinent to the AEC business. The targeted demographic in the construction business comprises civil engineers, architects, project managers, BIM managers, and claims management; however, accurately quantifying this total is unfeasible. Consequently, the researcher, aided by building industry professionals, conferred with others to ascertain an appropriate figure for the necessary research population. According to the available online data, roughly 234,738 engineers are registered with the Saudi Council of Engineers, constituting the principal workforce in the construction sector in the Kingdom of Saudi Arabia. To rationalize the real population, a statistical figure of 200,000 was extracted from the entire population to support this study. We employed the Cochran formula to ascertain the precise sample size. This technique enables researchers to calculate the requisite number of participants in a study to guarantee statistically significant and dependable outcomes. It takes into account the required confidence level and margin of error when predicting a proportion of a population. Slovin's formula is a widely utilized approach for calculating sample size in research projects, especially in survey research. This method is frequently employed in situations where acquiring a comprehensive list of the entire population is impractical, necessitating researchers to depend on a representative sample.

6.2 Discussion of Published Paper One

The research by Abougamil et al. (2023), as the first focus of study for this analysis, focused their analysis on 50 factors contributing to claims and a further survey of 35 participants through interviews in the Kingdom of Saudi Arabia's (KSA) construction industry. One of the major factors that was identified by the researcher was the variation orders, which entails a change in the scope of the project during the execution and ranking at 36% of the field survey. Similarly, this was a major factor that was identified in previous studies based on the influence on the overall performance of the project. From the analysis of previous studies, variation and change orders were among the major causes of claims and disputes and were related to all the groups identified, including client group, engineering group, and contractor groups. The researcher woud say that claims can be made in instances where numerous changes exceed the contract limit and create an imbalance in contractual terms. Other major order variations that lead to disputable claims as per previous studies supporting the analysis by Abougamil et al. (2023) include change in original scope, major changes or modifications during the construction stage, changing material type and specifications, and changes in orders by the owner during construction. The overall impact is second-order effects, including an increase in project costs, procurement delays, rework and demolitions, exaggerated budget and project calendar, and effects on suppliers, logistics, and temporary construction labourers. These influences exacerbate disputed claims in the construction industry and are among the major causative factors in claims in KSA.

The second-factor ranking at the second position, as identified by Abougamil et al. (2023), is delay-related claims, particularly from the client's side, with 35% of participants ranking it as the second most common cause of disputes in KSA. This cause of disputed claims is further aligned with payment delays, which were a third-ranked issue among 29% of the study participants. Time overrun and focuses on delays for contractors is considered a loss of unexpected income through a lack of production facilities. Delay in construction as a major cause of disputable claims as per previous analyses was found to be a major concern, with countries such as Jordan and Ghana having 106 delays out of 130 public projects (82%) and 33 out of 47 construction projects (70%) respectively (Jang et al., 2019). In the aspect of delay mainly cause by the owner, previous analysis supported the findings by Abougamil et al. (2023) majorly identifying that some causes include delay in contractor's interim payments, delay in supplying drawings, concurrent delays, and slow and delayed payments for completion of the project. The overall effect is increased costs of the project and time factors, affecting the quality of the project and leading to disputable claims (Alzobaee & Al-Ageeli, 2016; Assaf et al., 2019; Jang et al., 2019; Moore et al., 2017; Shah et al., 2014). The payment issue, apart from delays by the project client, has previously been identified as leading to legal challenges. Under the applicable law in the KSA, the issue has not been clearly addressed, especially on the responsibility of the employer for non-payment and protection. Furthermore, under the Shari'ah laws, interests on delayed payments are prohibited, and there are no statutory rights to delay activities or terminate an agreement based on non-payment. However, compensations related to interests and loss of profits arising from delayed payments are addressed in accordance with the new Civil Code, which has been in effect in the courts of the Kingdom of Saudi Arabia since January 2024.

Other dominant issues discussed by Abougamil et al. (2023) focus on the instances associated with coordination, which was ranked fourth by 27% of participants; design errors were ranked fifth by 26% of participants; contract ambiguity was ranked sixth by 23% of participants, and lack of decisions from owners and consultants, ranked seventh accounting for 23% of sources of claims. Previous studies have differently identified these issues as factors associated with the client group, engineering group, and contractors group. They interconnect with other major issues, including time and cost overruns, thus significantly influencing disputable claims in KSA, such as the case of other regions.

In the implementation of technology and the use of BIM, previous analyses found that there is significantly limited use of BIM in KSA (Alhumayn et al. 2017). However, the analysis by Abougamil et al. (2023) identified different major advantegous of BIM usage in reducing construction disputable claims in the KSA. Early detection of errors, particularly before the construction stage through clash detectors, enabled reducing the chances of errors. Furthermore, collaboration and coordination were identified as other significant influences, allowing the visualisation of the project, hence an improvement in safety and reducing misunderstandings and disputes (Abougamil et al., 2023). Dispute resolution in an amicable manner and a further association with enhancing communication and documentation were critical in the construction industry (Abougamil et al., 2023). Last was the issue of minimised change in the scope of projects, with the use of BIM accurately modelling conditions of construction, leading to ease in validation, hence avoidance of unnecessary alterations during the actual projects (Abougamil et al., 2023). The direct influence is supported by the findings by Krzystof (2019) on the benefits of applying BIM in the construction industry; among the major benefits include early collision detection, faster design and construction, visualisation before construction, hence reduced project changes, and high-quality work. The overall influence is an improved project life cycle (Hall, 2018). These benefits are critical in the minimisation of disputable claims in KSA through effectuating the construction stages.

The first published research paper significantly advanced the field by redefining disputes and examining their causes with a fresh, innovative approach. This allowed researchers and industry professionals to address claims more professionally. The paper also compared traditional methods of handling disputes with the use of Building Information Modeling (BIM) technology, highlighting the benefits of adopting BIM. It strongly encouraged practitioners in the Saudi construction industry to embrace BIM as the latest global standard in construction methods.

6.3 Discussion of Published Paper Two

Contrary to previous studies where there were major instances of the causes of disputable claims in KSA's construction industry leading to the utilisation of BIM as a recommendation, Abougamil et al. (2024a) focused on a specific factor. In their analysis, the aim focused on the investigation of claim management procedures under traditional practices compared to the proposal of the BIM package, an alternative dispute management procedure recommended for use. In the analysis, one major determinant of the application is based on the extension of time for money associated with time claims. This is a critically disputable claim that, apart from increasing project costs, thus leading to reputable damage, it has been associated with other claims, such as variation order among other claims (Enhassi et al., 2010; Flyvbjerg et al., 2003; Moore et al., 2017). However, Abougamil et al. (2024a), in the analysis, deviated from the major common disputable claims identified in previous research studies and delved further into different claims that influence the adoption of BIM as an alternative extension of time and money solutions.

A lack of effective document management, for instance, is a major factor that was identified to make it challenging to collect, track, and analyse information for claims, hence leading to disputes over the validity of claims (Abougamil et al., 2024a). However, from a detailed comparison of traditional practices to the implementation of BIM in managing disputes, Abougamil et al. (2024a) appraised the role of clear documentation from a comprehensive and transparent record of projects, from design to construction and implementing changes when the need arises. The major recommendation and comparison to traditional strategies were based on the identification of claims and their resolution, particularly non-compliance with contractual and regulatory obligations. However, despite a sufficient analysis of the implementation, especially focused on clear documentation, there are other challenges that have been identified in KSA based on the utilisation of traditional strategies and the effectiveness of BIM implementation. For instance, traditional claim management is challenging to implement based on non-centralised documentation, making it harder for claim clash detection and data efficiency. For BIM, as a strategy focused on clear documentation, there have been implemented strategies including data-rich details, centralisation of the model to project information, detecting clashes prior to construction, and the improvement of communication and collaboration during each phase of construction, from design to closure of the project (Hall, 2018; Krzystof, 2019). Nevertheless, this is a factor that is associated with transparency, where Abougamil et al. (2024a) identified that the use of BIM in KSA will be effective in allowing visualisation of complex data and processes, hence ease of understanding of the impacts of the claim. The overall influence is on the trust of clients while improving cooperation due to an improved clear role of each stakeholder involved from the client, the engineers, and contractors.

Apart from the lack of effective documentation, other causes of disputable claims identified by Abougamil et al. (2024a) focus on the rapid launch of projects and instances of shortages of materials and rising costs. Contrary to the findings of a previous study by Kashiwagi et al. (2016), the analysis by Abougamil et al. (2024a) in comparing traditional technologies used in the construction industry identified that the use of, for instance, NEOM project for mega projects has, led to increased pressure in the launch of projects, hence an increase in complexities, and potentials of other claims associated with project delay. Project delay has been associated with an increase in time for completion while further being associated with the increase in project costs, reduced quality, and lack of trust among key stakeholders directly and indirectly involved in the project (client, engineers, contractors) (Goldstrong, 2019; Osman et al., 2009; Shahsavand, 2018). The influence is further noted on the lack of standardisation of projects, which Abougamil et al. (2024a) identified to lead to non-collaboration and a further discussion of the material shortages and rising costs, leading to challenges for contractors, hence disputable claims. In the comparison to BIM, Abougamil et al. (2024a) pointed out the relevance of BIM in improving accuracy based on the preciseness of estimations of time and costs, hence a reduced likelihood of errors and omissions before the start of a project. Apart from the reduction of significant changes after the start of the project, this is associated with an increase in the quality of the experience of both parties through collaborative practice and clear communication with all stakeholders. From previous analyses, this was associated with the avoidance of underestimation of tender prices, improved coordination between project parties, and a realistic time plan for the completion of a project (Alzobaee & Al-Ageeli, 2016; Assaf et al., 2019; Jang et al., 2019; Moore et al., 2017). The overall influence is a reduction in disputable claims, especially those associated with time and costs, through automated data processing, visualisation, and data sharing.

However, despite the comparison to traditional strategies and BIM used in claim management, KSA majorly bases its use on balancing the risks between parties, where the employer procures the design, whereas the contractor focuses on carrying out the scope of work. This means that the risks are assumed by employers, especially in design changes along the project, hence little certainty on the aspect of time. It is thus critical to consider the needed knowledge and insights on considering BIM use in the construction industry in KSA. The long-term challenge is the influence of the lack of expertise needed. In KSA, Sodangi et al. (2018) identified that with limited use by small and medium construction firms, there is a lack of skills needed. In instances of large-scale adoption without the needed expertise, the current disputable claims might increase due to inefficiency, especially in input data and lack of knowledge on the use by clients. Furthermore, BIM constantly increases in complexity, and this has been associated with increasing causes of filing claims (Nassar & El Hawary, 2016). The use of a hybrid between traditional means and BIM in KSA by the project parties might make it challenging to ensure coordination, thus exacerbating claims rather than a reduction.

6.4 Discussion Published Paper Three

From the analyses by Abougamil et al. (2023) and Abougamil et al. (2024a), there have been major challenges that have been identified, majorly focusing on disputable claims and the comparison associated with the use of other technologies to BIM. Abougamil et al. (2024b), on the other hand, focused specifically on the use of BIM with NEC4 contracts in the reduction of construction claims. Abougamil et al. (2024b) identified that BIM with NEC4 is a package enabling a comprehensive framework for the management of construction projects, leading to minimal disputes and claims and more efficient project success. In the proposal, the major BIM packages recommended for adoption in KSA INCLUDE Revit Architecture for 3D modelling, Microsoft Project for 4D scheduling, and Cost-X for 5D cost management. These are recommended for integration with the New Engineering Contract (NEC4), which is a price-based contract with activity scheduling.

However, the major focus is on the different disputes and claims. Abougamil et al. (2024b) first identified the first step of the implementation as a means of addressing the current lack of expertise and the minimal use of BIM in the construction industry. The first step in implementation, based on the recommendations of Abougamil et al. (2024b), is a focus on 2D and 3D aspects, considered as the basic BIM implementation stage where the major focus is on Revit Architecture for the creation of 2D and 3D drawings. The major disputable claims targeted in this aspect are an improvement of visualisation associated with the understanding of the project, early detection of conflicts and clashes, and enhancement of collaboration and communication among stakeholders. However, from the historical evaluation of BIM, Revit 6, for instance, came out in 2004, and the focus was establishing collaboration between engineers, with recent Autodesk Revit Architecture and structure being the current generation of Architectural design tools (Cherkaoui, 2017; Quirk, 2012). Other countries such as the US and the UK are far ahead, and with the constant change in the technological landscape, it might be challenging to gain pace in adopting the most recent and further expectation of redundancy and edging out the redundant technology. Nonetheless, with the current limited use, especially by small and medium construction industries in KSA, adoption of the use is recommended, considering the lack of constant upgrades along the development.

The second step mainly focuses on addressing the challenges associated with costs and risk management. The step per the recommendation of Abougamil et al. (2024b) is the implementation of advanced BIM focusing on 4D and 5D capabilities associated with time and costs. The use of software such as Microsoft Project is based on the integration of scheduling and cost data while clashing detection with virtual walkthrough, among other BIM technologies. Apart from advancing communication and coordination, first noted in the first step, the second step is critical in promoting risk management and mitigation of potential claims through proactive identification and resolution of complex conflicts that traditional strategies would not have addressed (Abougamil et al., 2024b). in the analysis of the dominant claims, however, by Abougamil et al. (2023), a major factor that might impede an effective implementation is the constant challenge in the lack of skills from both the clients and contractors, as in KSA, some small and medium construction industries have focused on the use of BIM. Nevertheless, it still remains insufficient to analyse whether the implementation has been successful.

The last stage of the recommendation by Abougamil et al. (2024b) focused on facility management, where the recommendations appraised the role of long-term use of BIM assets, especially 6D, for facility management. This targets the reduction of maintenance costs and improving the performance of the building, streamlining the claim management process, improving transparency, and enhancing data management and analysis for better decisions. However, despite the proposed effectiveness in ensuring an effective implementation to mitigate the current challenges associated with disputes and claims in KSA, Abougamil et al. (2024b) noted the major challenge currently is based on the non-adoption. However, there is a challenge of awareness that might be a major cause of minimal use. In the UK, for instance, 73% of the construction industry utilises the BIM approach, while 43% are unaware. For those who were aware, they mainly identified the benefits, coordination of information, efficiency influence, decreased risk, and increased profitability (British Standard, 2021; NBS, 2020). Despite a small number of small and medium construction companies using it, there is still speculation on the awareness of the use of BIM and the understanding by key stakeholders in construction projects associated with the benefits. Furthermore, compared with the US, where there is almost 100% implementation, the majority of the stakeholders understand the benefits, strategy, and the most effective BIM tools to use based on each need. This thus leads to the concern of whether, despite the recommendation on a stepwise implementation, the potential impacts on disputable claims are going to be minimised and whether adoption will be immediate or knowledge will still be needed to effectuate its use.

6.5 Practical Benefits to Industry Practitioners

This research offers significant insights for construction practitioners on utilizing Building Information Modeling (BIM) to resolve contentious claims and improve project management procedures. Industry professionals may implement the conclusions of this study in the subsequent manners:

Framework for Implementation

The study presents a systematic framework for the implementation of BIM in building projects, emphasizing the reduction of conflicts and contentious claims. This framework prioritizes the early implementation of BIM across the project lifecycle, especially during the planning and design stages, to detect and address any conflicts prior to the commencement of construction. The framework encompasses essential steps such as:

- Thorough instruction for project teams on BIM tools and methodologies.

- Implementing explicit communication procedures for all parties using BIM collaboration platforms.
- Incorporating BIM into project risk management procedures to promptly identify high-risk early.
- Employing BIM for real-time oversight of construction advancement, facilitating prompt identification of discrepancies.

Illustrative Example

To illustrate the practical implementation of the framework, examine a substantial residential housing initiative in KSA. The project team utilized BIM to design and organize intricate MEP (Mechanical, Electrical, and Plumbing) systems. BIM tools identified conflicts between ducting and structural components during the design process, which were cooperatively resolved through BIM-based visualization and analysis. This preemptive strategy mitigated expensive on-site alterations and diminished the probability of claims resulting from delays or rework.

Reduction of Disputable Claims

Utilizing BIM's features for visualization, clash detection, and data centralization enables practitioners to markedly diminish the frequency of disputes. The study emphasizes that BIM can furnish an objective foundation for assessing allegations, such as delays, by supplying comprehensive documentation of project activities, timeframes, and modification orders.

Enhancing Decision Making

The use of BIM into construction processes enhances decision-making by delivering precise and current information. Practitioners can utilize 4D BIM (time-linked models) to assess the effects of schedule alterations on project delivery, hence reducing misunderstandings and conflicts among stakeholders.

Case Study-Based Learning

Practitioners may also employ the data via case study analysis. The study may illustrate a situation comparing two similar projects, one employing traditional methods and the other utilizing BIM, in relation to conflict resolution, claim mitigation, and cost efficiency. This comparative methodology can furnish persuasive data for the use of BIM throughout the industry.

6.6 The New Development in This Study

Focus on the Saudi Construction Sector: The study delved into the unique challenges of the Saudi Arabian construction environment, marked by rapid growth in mega projects and infrastructure. This landscape often leads to a high potential for disputes due to its complexity, time constraints, and budget pressures. The study also highlighted the scarcity of local research exploring modern technologies like Building Information Modeling (BIM) in this context. By incorporating case studies from the Saudi industry, the research offers a deep understanding of dispute issues and presents solutions grounded in local realities.

Publishing Three Academic Articles: Publishing three academic papers within the scope of the research is regarded as evidence of its substantial academic contribution. These studies may have addressed. The conceptual foundation for employing BIM to mitigate disagreements. Practical implementations of BIM in projects within Saudi Arabia. Analysis of data and outcomes on the application of BIM in relation to disputes and expenses.

Analyzing the Impact of BIM on Disputes: This study examines how Building Information Modeling (BIM) can minimize disputes throughout a project's lifecycle. By applying BIM during the design and planning stages, potential design conflicts, such as clash detection, can be identified and resolved before implementation.

Implementation and monitoring BIM provides engineering teams with precise and real-time data, aiding in effective project management. Additionally, it facilitates change management by clearly documenting all modifications, thereby minimizing the risk of delay claims.

Field Case Studies: Incorporating case studies from real projects in Saudi Arabia effectively showcases the practical impact of BIM. These studies illustrate the genuine challenges encountered during BIM implementation and the strategies used to overcome them. By providing replicable examples, they encourage the broader adoption of BIM technology within the local market.

CHAPTER 7: CONCLUSION

The construction industry in KSA has experienced remarkable growth over the years, with an increase in annual expenditure and employment. However, there has been an increase in disputable claims in KSA, with the challenges being based on the role of clients, engineers, and contractors as crucial stakeholders in filing claims. The study thus aimed to investigate advanced technologies, specifically BIM, and their role in reducing claims in the Saudi construction industry. From the analysis of previous literature, it was identified that there are different claims, among the significant being cost overrun, time delays, inadequate safety, and quality. Compared to other developed countries, KSA has been comparably found to lag in the use of BIM, with the current use being on traditional methods, with contractors mainly being involved in handling major tasks, whereas the employer focuses on the risks and handling the management of communication between the key stakeholders. Comparably, the US and the UK have been identified as having implemented close to 100% of the construction industry. The processes, especially communication and collaboration, productivity, the efficiency of operations, identification of errors, and making changes prior to the start of a project, have been the significant benefits of using BIM. These are, however, minimal in KSA, where despite massive investment in more than 3,727 active projects, there has been an increase in delays. The construction industry is thus expected to benefit from the use of BIM tools to address coordination, communication, reduced risks, improved quality, and productivity, leading to profitability. However, from previous literature, there have been limited studies focusing on the use of BIM in KSA's construction industry. This thus led to the analysis of the factors causing disputable claims in KSA residential and commercial projects, the extent of BIM minimising them, and how advanced technologies facilitate completing construction projects with less disputable claims.

Paper 1 focuses on addressing the first aim of the study. The analysis focused on a review of the literature and an interview session with 35 participants, leading to an analysis of 50 contributing factors that caused claims in KSA. From the analysis, seven significant sources of claims in KSA were identified to have an impact on 75 projects, including ambiguity of projects, delay factors, variation order, issues with coordination, lack of decisions, delay in payments, and errors in design. Despite the identification of the factors, the major limitation of the study was the reliance on the analysis of claims originating from KSA, Egypt, and UAE in comparison to the UK, mandating future studies to focus on more claims from a global perspective for the generalisability of findings.

The second paper, on the other hand, was associated with the second aim and investigated the advantages of BIM in claims related to the extension of time and money. The analysis mainly focused on the comparison of traditional means to BIM in reducing claims. For KSA, the significant benefits include dispute resolution, delay and time analysis, and cost analysis, thus improving claim analysis. However, despite the analysis of the benefits and recommendations for implementation of BIM in KSA's construction industry, there are different recommendations that were outlined as critical for effectiveness in implementation and use. Influencing the use mainly by governmental bodies and local influencers is vital to ensuring sustainability, thus enhancing housing reliance. Despite the research limiting the analysis of the use of BIM in the reduction of claims, there are added advantages associated with the use of different elements in the construction industry and other sectors. Future research can thus build on the foundation of this study and other published studies associated with

BIM use in the general construction industry, hence a comprehensive analysis of how to implement the use of BIM in a stepwise manner across KSA. Additional challenges might be identified, therefore building on addressing the critical challenge while ensuring effectiveness in the construction industry.

The last paper, Paper 3, focused on the practical implementation of BIM technology in KSA, explicitly considering the current limited use and the increasing impacts of claims on the successful completion of major projects. With the aim of investigating and demonstrating the effectiveness of BIM in claim reduction and delays in real-world projects, Paper 3 from this analysis proposed the use of Revit Architecture, Microsoft Project, and Cost-X that have been associated with the reduction of claims and delays in construction projects. From the findings, the reduction in claim value ranged from $1,870,000 to $188,000, saving up to 275 days in project time. Through the use of interview sessions, 95% favoured the consideration, whereas 86% of participants supported the use. The findings thus identify the effectiveness and appreciation of the efficacy, mainly after the identification of the benefits of the implementation in influencing the major disputable claims in the construction industry in KSA. However, coopering the development in other countries such as the US, the UK, and Australia, there have been more than 20 years since BIM was first used in addressing different claims, including costs, time, and conflicts based on changes in project scope. Redundancy in BIM tools and the constant changes over the years might be among the significant challenges that might further impede the implementation and practical use. Currently, it has been noted that BIM is only used in small and medium construction industries. A large-scale implementation raises the concern of whether it will be a more practical approach compared to traditional techniques that were identified from the analysis of Paper 2. A further problem associated with the reduction of claims is whether the recommendations will be appropriate and the perspectives of key stakeholders in construction projects regarding the use of BIM in the projects. Future studies might focus on how the implementations might be appreciated in the construction industry in KSA while further assessing the knowledge of the use, benefits, and expertise levels of engineers and contractors in using BIM tools. Furthermore, more case studies and large-scale use of specific advanced BIM tools can be focused on, with the target of identifying the most effective and recommended for use in KSA based on ease of use, reduced challenges in implementation, and reduced resistance to its use.

Listed below are the practical and theoretical implications of this thesis that demonstrate the research purposes and gaps. It provides actionable recommendations for industry professionals and contributes to the academic discourse on building information modelling (BIM) and claim management in the construction sector.

Practical Implications

- Practical Implications Improved Project Efficiency: This study demonstrates that the adoption of Building Information Modelling (BIM) can effectively mitigate claims in construction projects in Saudi Arabia. The capability of BIM to identify design discrepancies, model project timelines, and illustrate construction procedures reduces errors and uncertainties that frequently result in conflicts. These findings advocate for contractors to implement BIM as a routine procedure for project management and risk mitigation.
- Enhanced Stakeholder Collaboration: BIM promotes clear communication and data exchange among stakeholders, minimizing misunderstandings and cultivating trust.

This consequence is especially pertinent in the Saudi construction sector, where collaborative difficulties frequently intensify claims and disputes.

- Cost and Time Efficiency: The research illustrates BIM's effectiveness in mitigating claims and accelerating resolution processes, hence presenting a persuasive argument for its implementation. This may incentivize decision-makers in the Saudi construction sector to invest in BIM tools and training to get improved financial results and timely project completion.

Theortical Implications

- Theoretical Implications Advancing BIM Research: This work enhances the existing literature on BIM by examining its role in mitigating contentious claims, particularly in the setting of Saudi Arabia. This research enhances current theories regarding the advantages of BIM by offering actual evidence from a region characterized by distinct obstacles and opportunities.
- Addressing the Knowledge Deficiency: Although a significant portion of global research on BIM concentrates on industrialized nations, this thesis addresses a crucial void by investigating its significance and effects in the Middle East. It establishes a basis for subsequent research on BIM adoption in analogous cultural and legal contexts.
- Claims Management Frameworks: The results guide the creation of innovative frameworks that incorporate BIM into construction claims management. These frameworks can provide a theoretical foundation for comprehending how technology-driven strategies can supplant conventional, reactive ways in conflict resolution.
- The research elucidates the cultural and operational determinants affecting BIM adoption in Saudi Arabia, providing significant insights into the interplay between

these factors and technology implementation. This enhances the comprehensive theoretical comprehension of BIM's adaptability across various regional contexts. Future Research Directions: The identification of impediments to BIM adoption in Saudi Arabia, including lack of awareness, resistance to change, and inadequate infrastructure, paves the way for additional theoretical investigation. It necessitates further investigation into addressing these problems and assessing the long-term effects of BIM integration on the reduction of disputes.

Key Recommendations

- Strategic Recommendations: The research highlights the necessity for regulatory authorities in Saudi Arabia to integrate BIM into construction standards and guidelines. Policymakers can utilize the findings to advance BIM adoption in both public and private sector projects, in accordance with Vision 2030 goals for digitalization and efficiency.
- The report underscores the necessity of providing industry people with BIM competencies to facilitate efficient adoption. Universities, technical institutes, and professional organizations can utilize these insights to create customized training programs that meet the distinct requirements of the Saudi construction business.
- Implement BIM as a Standard Procedure: Regulatory authorities in Saudi Arabia, including the Ministry of Municipal and Rural Affairs and Housing (MOMRAH), ought to require the implementation of Building Information Modelling (BIM) for all significant construction endeavours. This will standardize its implementation and provide uniformity in mitigating contentious claims.
- Formulate BIM Training Programmes: Educational institutions and industry organizations must collaborate in developing specialized training programs specifically designed for the Saudi construction sector. These workshops ought to

concentrate on practical BIM applications for claims prevention and resolution, aimed at engineers, project managers, and legal experts.

- Encourage BIM Implementation: Government and private sector partners could implement financial incentives, such as tax advantages or subsidies, to motivate construction enterprises to embrace BIM. This can mitigate the initial investment expenses and expedite its execution.
- Incorporate Building Information Modelling with Claims Management Systems: Construction companies want to investigate the integration of BIM technologies with claims management software to enhance the identification and resolution of disputes. This interface facilitates real-time data exchange and improves the transparency of claim-related procedures.
- Enhance Awareness of BIM Advantages: Industry leaders and governments ought to initiate awareness efforts to inform stakeholders about the benefits of BIM in mitigating claims. These campaigns may encompass success narratives, case studies, and workshops that illustrate BIM's contribution to enhancing project outcomes.
- Augment Collaboration via BIM: Organizations ought to implement collaborative BIM processes to enhance communication and collaboration among project stakeholders. This entails the formulation of protocols for the dissemination of BIM models and guaranteeing that all stakeholders have access to precise project information.
- Implement Pilot Projects: To enhance confidence in BIM, stakeholders want to commence pilot projects across various locations and project categories inside Saudi Arabia. These projects can function as proof of concept, illustrating BIM's efficacy in reducing claims and disputes

- Formulate BIM Standards and Protocols: The Saudi Standards, Metrology, and Quality Organization (SASO) ought to engage with worldwide specialists to establish Building Information Modelling (BIM) standards and guidelines adapted to the local situation. These guidelines offer a definitive foundation for the deployment and utilization of BIM.
- Assess and Analyse BIM Implementation: Implement systems for assessing and evaluating the efficacy of BIM in mitigating contentious claims. This entails gathering data on claim frequency, expenses, and resolution duration across BIM-enabled projects to assess its impact and pinpoint areas for enhancement.
- Facilitate Digital Transformation in the Construction Sector: In alignment with Vision 2030, stakeholders must prioritize digital transformation in the construction sector by investing in BIM-compatible technologies, including cloud computing, artificial intelligence, and the Internet of Things (IoT). These technologies can further augment BIM's efficacy in claim mitigation.

These above guidelines outline a strategy for utilizing BIM to resolve contentious claims in the Saudi construction sector, promoting a more efficient and conflict-free project environment.

REFERENCES

Abdul Rahman, I. & Memon, A. H., 2012. Time and cost perfomance in costruction projects in southern and cnrtal regions of penisular Malaysia. *International Journal of Advances in Applied Sciences ,* **1**(1), pp. 45-52.

Abougamil, R.A., Thorpe, D. and Heravi, A., 2023. Investigating the Source of Claims with the Importance of BIM Application on Reducing Construction Disputable Claims in KSA. *Buildings*, **13**(9), p.2219. https://doi.org/10.3390/buildings13092219

Abougamil, R.A., Thorpe, D. and Heravi, A., 2024a. A BIM Package with NEC4 Contract Option to Mitigate Construction Disputes in the Kingdom of Saudi Arabia.. https://doi.org/10.20944/preprints202405.0941.v1

Abougamil, R.A., Thorpe, D. and Heravi, A., 2024b. An Investigation of BIM Advantages in Analysing Claims Procedures Related to the Extension of Time and Money in the KSA Construction Industry. *Buildings*, **14**(2), p.426. https://doi.org/10.3390/buildings14020426.

Adama, M. H. & Kouider, T., 2019. Comparative Analysis of BIM Adoption Efforts by Developed Countries as Precedent for New Adopter Countries. *Current Journal of Applied Science and Technology,* **36** (2), pp. 1-15.

Alhumayn, S., Chinyio, E. & Ndekugri, I., 2017. The barriers and strategies of implementing BIM Saudi Arabia. *Wessex Institute of Technology Press,* **169**(55-67).

Al-Yami, A. and Sanni-Anibire, M.O., 2021. BIM in the Saudi Arabian construction industry: State of the art, benefit and barriers. *International Journal of Building Pathology and Adaptation*, ***39***(1), pp.33-47. https://doi.org/10.1108/IJBPA-08-2018-0065

Alzara, M., Kashiwagi, J., Kashiwagi, D. and Al-Tassan, A., 2016. Using PIPS to minimize causes of delay in Saudi Arabian construction projects: university case study. *Procedia Engineering*, ***145***, pp.932-939.

Autodesk, 2020. *Design and build with BIM.* Available at: https://www.autodesk.com/industry/aec/bim#:~:text=Building%20Information%20Modeling%20(BIM)%20is,business%20and%20the%20built%20world. [Accessed 28 March 2022].

Azhar , S., 2011. Building Information Modelling (BIM): Trends, Benefits, Risks, and Challenges for AEC industry. *Leadership and Management in Engineering,* **11**(3), pp. 241-252.

Banawi, A. & Aliobaly, O., 2019. *Evaluation of the Saudi construction industry for adoption of Building Information Modelling.* Washington, International Conference on Applied Human Factors and Ergonomics.

BSI & Staff, 2021. *Why BIM is going International.* Available at: https://shop.bsigroup.com/articles/why-bim-is-going-international [Accessed 27 September 2021].

Cable, V., Bew, M. & Higgins, D., 2015. *Level 3 Building Information Modelling - Strategic Plan,* London: UCL.

Charehzehi, A. et al., 2017. Building information modeling in construction conflict management. *International Journal of Engineering Business Management,* Volume **9**, pp. 1-18.

Cherkaoui, H., 2017. *LETSBUILD.* Available at: https://www.letsbuild.com/blog/a-history-of-bim [Accessed 24 Setpmeber 2021].

Construction, U., 2020. *BIM progress & adoption in the UK.* Available at: https://www.ukconstructionmedia.co.uk/features/bim-progress-adoption-uk/ [Accessed 09 April 2022].

Eastman, C., Teicholz, P., Sacks, R. & Liston, K., 2011. *BIM Handbook.* 2nd ed. Hoboken, New Jersey: John Wiley & Sons, Inc..

Fathi, M. S., Kasim, N., Mohd, S. & Latiffi, A. A., 2013. Building Information Modeling (BIM) application in Malaysian construction industry. *International Journal of Construction Engineering and Management ,* **4**(2), pp. 1-6.

Hamil, S., 2021. *What is Building Information Modelling (BIM).* Available at: https://www.thenbs.com/knowledge/what-is-building-information-modelling-bim [Accessed 06 April 2022].

Hanartty, P. J., 1999. *American Machinist.* Available at: https://www.letsbuild.com/blog/a-history-of-bim [Accessed 24 September 2021].

https://doi.org/10.3390/buildings13092219.

Ikediashi, D.I., Ogunlana, S.O. and Alotaibi, A., 2014. Analysis of project failure factors for infrastructure projects in Saudi Arabia: A multivariate approach. *Journal of Construction in Developing Countries*, ***19***(1).

James, A., 2007. *NBS and Auto Desk.* Available at: https://www.thenbs.com [Accessed 20 April 2022].

Kouider, T. & Adama, M. H., 2019. Comparative analysis of BIM adoption efforts by developed countries as precedent for new adopter countries. *Journal of Applied Science and Technology,* **36**(2), pp. 1-15.

Latiffi, A. A., Mohd, S., Kasim, N. & Fathi, M. S., 2013. Building Information Modeling (BIM) Application in Malaysian Construction Industry. *International Journal of Construction Engineering and Management,* **Volume 4**, pp. 1-6.

Lavalin, 2018. *The capabilities of CostX: the benefits of new software.* Available at: https://www.fgould.com/worldwide/articles/the-capabilities-of-costx-the-benefits-of-new-s/ [Accessed 08 April 2022].

Lavalin, 2018. *The Capabilities of CostX: the Benefits of New Software.* Available at: https://www.fgould.com/worldwide/articles/the-capabilities-of-costx-the-benefits-of-new-s/#:~:text=CostX%20is%20essentially%20an%20all,together%20with%20ease%20and%20automation. [Accessed 28 March 2022].

Lavalin, G., 2022. *The Capabilities of CostX: the Benefits of New Software.* Available at: https://www.fgould.com/worldwide/articles/the-capabilities-of-costx-the-benefits-of-new-s/ [Accessed 18 Feburary 2022].

Lorek, S., 2021. *Constructible.* Available at: https://constructible.trimble.com/construction-industry/what-is-bim-building-information-modeling [Accessed 23 September 2021].

Mohamed, H. H., Ibrahim, A. H. & Soliman, A. A., 2014. Reducing construction disputes through effective claims management. *American Journal of Civil Engineering and Architecture,* **2**(6), pp. 186-196.

NATSPEC, 2011. *NATSPEC national BIM guide,* Sydney: Construction information systems limited .

O'Malley, A., 2021. *BIM in the US: overview of a game changing technology.* Available at: https://www.planradar.com.us.bim-in-the-us/ [Accessed 27 September 2021].

Partland, R. M., 2014. *BIM Levels explained.* Available at: https://www.thenbs.com/knowledge/bim-levels-explained [Accessed 28 September 2021].

Quirk, V., 2012. *A brief history of BIM.* Available at: https://www.archdaily.com/302490/a-brief-history-of-bim [Accessed 09 April 2022].

RIB Software, R. S., 2022. *RIB trunning together.* Available at: https://www.itwocostx.com/costx/bim/ [Accessed 18 February 2022].

Robinson, M.D., 2013. *An Employer's and Engineer's Guide to the FIDIC Conditions of Contract*. John Wiley & Sons.

Sarhan, J., Xia, B., Fawzia, S., Karim, A. and Olanipekun, A., 2018. Barriers to implementing lean construction practices in the Kingdom of Saudi Arabia (KSA) construction industry. *Construction Innovation*, ***18***(2), pp.246-272. https://doi.org/10.1108/CI-04-2017-0033

Simpson, D. & Richards, D., 2014. *Practice management digest,* s.l.: The American Institute of Architects.

Smart, B., 2016. *Meeting government policy objectives through the adoption of Building Information Modelling (BIM).* Australia , Building Smart.

Sodangi, M., Salman, A. F. & Saleem, M., 2018. Building Information Modeling: awareness across the subcontracting sector of Saudi Arabian construction industry. *Arab Journal science Engineering,* **Volume 43**, pp. 1807-1816.

Standard, B., 2021. *Why BIM standards are going international.* Available at: https://shop.bsigroup.com/articles/why-bim-is-going-international [Accessed 06 April 2022].

Standards, B., 2016. *Collaborative production of architectural, engineering and construction information, code of practice,* London: The British Standards Institution.

UK, Uinted BIM., 2019. *BIM Mandatory in UK High Rise Residential Projects: Implications for Builders & Designers.* Available at: https://www.united-bim.com/bim-mandate-in-uk-high-rise-residential-projects-implications-for-builders-designers/ [Accessed 28 September 2021].

Wendy, W., 2012. *Introduction to CostX,* Australia : exactal.

Zaher, M., Enaba, M., Othman, A. & Marzouk, M., 2018. Using BIM to Identify claims early in the construction industry: case study. *American Society of Civil Engineers,* **3**(10).

.

Al-Falih, K. A. 2018. *King Salman Energy Park sparks new era of growth for Saudi Arabia's energy sector*. Retrieved June 12, 2022, from https://www.aramco.com/en/news-media/news/2018/spark-new-era-of-growth-for-saudi-arabia#

Barber , W. 2022. *Rider Levett Buknall*. Retrieved June 12, 2022, from https://www.rlb.com/middle-east/projects/jeddah-tower/

Buckby, W. H., & Pendley, R. 2017. *The Future Of Saudi Arabia: Opportunities And Challenges In Infrastructure Projects And Beyond*. Retrieved September 30, 2021, from https://www.mondaq.com/saudiarabia/government-contracts-procurement-ppp/614066/the-future-of-saudi-arabia-opportunities-and-challenges-in-infrastructure-projects-and-beyond

Gritsyenko, D., & Gober, M. 2021. *7 Causes of Construction Claims you want to avoid with your construction project*. Retrieved June 10, 2022, from https://cmfusion.com/blog/causes-of-construction-claims#7-causes-of-claims-in-construction-projects

Koc, S. S. 2014. *Dispute resolution: can BIM help overcome barriers.* Dubai: Heriot Watt University.

Loots, P. 1995. *Construction Law and Related Issues.* South Africa: Juta & Cole Ltd.

Nassar, A. H., & El Hawary, A. 2016. The Effect Of Building Information Modeling (BIM) On Construction Claims. *International Journal of scientific & technology research ,* **5**(12), 2016.

Murdoch, J.R. and Hughes, W. 2008. *Construction Contracts: Law and Management*, 4th ed. Taylor and Francis, Oxford

Alzobaee, A.S.J.A. and Al-Ageeli, H.K. 2016. Critical success factors in construction projects (Governmental projects as a case study). *Journal of Engineering*, ***22***(3), pp.129-147.

Assaf, S., Abdallah, A., and Hassanain, M.A., 2019. Assessment of the consequences of deficiencies in design documents in Saudi Arabia. *Architectural engineering and design management*, ***15***(4), pp.282-296.

Bew, M. and Richards, M., 2008. BIM maturity model. In *Construct IT Autumn 2008 Members' Meeting. Brighton, UK*.

Enshassi, A., Arain, F. and Al-Raee, S., 2010. Causes of variation orders in construction projects in the Gaza Strip. *Journal of Civil Engineering and Management*, ***16***(4), pp.540-551.

Fidic, (2022). FIDIC | bookshop | international federation of consulting engineers [online]. *FIDIC | International Federation of Consulting Engineers | The Global Voice of Consulting Engineers*. [Viewed 30 May 2024]. Available from: https://fidic.org/bookshop

Flyvbjerg, B., Bruzelius, N. and Rothengatter, W., 2003. *Megaprojects and risk: An anatomy of ambition*. Cambridge university press.

Goldstrong, V., 2019. Top 8 Reasons for Delays in Construction Projects. *Availabe at: https://www. schedulereader. com/blog/8-reasons-for-construction-project-delays*.

Hall, D., 2018. Cracks in the mirror: Conceptualizing the ongoing AEC industry re-organization. In *Working Paper Proceedings 16th Engineering Project Organization Conference* (pp. 458-477). Engineering Project Organization Society (EPOS).

Jang, H., Kavuma, A., and Ock, J. 2019. Factors influencing time and cost overruns on freeform construction projects. *KSCE Journal of Civil Engineering*, ***23***, pp.1442-1450.

Kashiwagi, D., Alzara, M., Kashiwagi, J., and Al-Tassan, A., 2016. Using PIPS to minimize causes of delay in Saudi Arabian construction projects: university case study. *Procedia Engineering*, ***145***, pp.932-939.

Khan, R.W.A., Ali, B., Zahoor, H., Nasir, A.R., Maqsoom, A., and Mazher, K.M., 2020. BIM-based claims management system: A centralized information repository for extension of time claims. *Automation in Construction*, ***110***, p.102937.

Kishore, R., and Al-Qershi, M.T. 2017. Claim causes and types in Indian construction industry–contractor's perspective. *American Journal of Civil Engineering and Architecture*, ***5***(5), pp.196-203.

Krzysztof, W., (2019). Top 12 benefits of BIM technology - Why should I use BIM? [online]. *Bim Corner*. [Viewed 31 May 2024]. Available from: https://bimcorner.com/benefits-of-using-bim-technology/#:~:text=However,%20using%20BIM%20still%20pays,sewer%20pipes%20or%20ventilation%20ducts.

Lee, S., Golparvar-Fard, M., Peña-Mora, F., and Arboleda, C.A. 2009. Visualization of construction progress monitoring with 4D simulation model overlaid on time-lapsed photographs. *Journal of computing in civil engineering*, ***23***(6), pp.391-404.

Mahjoob, A.M.R. and Ibraheem, R.A.R., 2022. Facilitating claims settlement using building information modeling in the school building projects. *Innovative Infrastructure Solutions*, *7*, pp.1-17.

Manzoor Arain, F. and Low Sui Pheng, L., 2005. The potential effects of variation orders on institutional building projects. *Facilities*, ***23***(11/12), pp.496-510.

Mohamed, H.H., Ibrahim, A.H. and Soliman, A.A., 2014. Reducing construction disputes through effective claims management. *American Journal of Civil Engineering and Architecture*, ***2***(6), pp.186-196.

Moore, D., Aljohani, A. and Ahiaga-Dagbui, D. 2017. Construction projects cost overrun: What does the literature tell us?. *International Journal of Innovation, Management and Technology*, ***8***(2), p.137.

NBS, (2020). NBS' 10th National BIM Report [online]. *NBS*. [Viewed 31 May 2024]. Available from: https://www.thenbs.com/knowledge/national-bim-report-2020#:~:text=The%202020%20BIM%20report%20shows&text=In%202011,%2043%%20of%20respondents,,%20with%2073%%20using%20BIM.

Noorzai, E., Parchami Jalal, M., Yavari Roushan, T., and Alizadeh, M., 2021. A BIM-based construction claim management model for early identification and visualization of claims. *Smart and Sustainable Built Environment*, ***10***(2), pp.227-257.

Osman, Z., Omran, A. and Foo, C.K., 2009. The potential effects of variation orders in construction projects. *Journal of Engineering*, ***2***, pp.141-152.

Peansupap, V. and Ly, R., 2015. Evaluating the impact level of design errors in structural and other building components in building construction projects in Cambodia. *Procedia engineering*, ***123***, pp.370-378.

Shah, A., Bhatt, R. and Bhavsar, J., 2014. Types and causes of construction claims. *International Journal of Engineering Research & Technology (IJERT)*, ***3***(12), pp.732-735.

Shahrour, A., (2020). FIDIC contracts in the Middle East – AfiTaC [online]. *AfiTaC – Commercial & Contract Management Blog*. [Viewed 30 May 2024]. Available from: https://afitac.com/2020/06/16/fidic-contracts-in-the-middle-east/

Shahsavand, P., Marefat, A. and Parchamijalal, M., 2018. Causes of delays in construction industry and comparative delay analysis techniques with SCL protocol. *Engineering, Construction and Architectural Management*, ***25***(4), pp.497-533.

Thakur, A.S., and Gobana, A.B. 2017. Critical review on causes and effects of variation order on construction project. *Critical Review*, ***4***(12), pp.1602-1606.

The Argaam Report, (2019). Jadwa expects Saudi economy to grow 2% in 2019 [online]. *ArgaamPlus*. [Viewed 30 May 2024]. Available from: https://betatesting.argaam.com/en/article/articledetail/id/594235

Turner, (2020). The FIDIC suite of contracts [online]. *FIDIC | International Federation of Consulting Engineers | The Global Voice of Consulting Engineers*. [Viewed 30 May 2024]. Available from: https://fidic.org/sites/default/files/FIDIC_Suite_of_Contracts_0.pdf

Venema, V. and Thomas, M., (2022). Neom: Da gaske Saudiyya za ta gina sabon birni na zamani a tsakiyar Hamada? - BBC News Hausa [online]. *BBC News Hausa*. [Viewed 30 May 2024]. Available from: https://www.bbc.com/hausa/labarai-60475678

Zaher, M., Marzouk, M., Othman, A., and Enaba, M. 2018. Using BIM to identify claims early in the construction industry: Case study. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, ***10***(3), p.05018001.

Ventures , C. (2023). Discover how BIM is implemented in each step of the construction value chain. Retrieved from Cemex ventures : https://www.cemexventures.com/discover-how-bim-is-implemented-in-each-phase-of-the-construction-industry

Wojsław, K. (2019). Top 12 benefits of BIM technology – Why should I use BIM? Retrieved from BIM Corner: https://bimcorner.com/benefits-of-using-bim-technology

Writer, S. (2024). The Benefits of Using CostX Software: A Comprehensive Review. Retrieved from Ask: https://www.ask.com/news/benefits-using-costx-software-comprehensive-review

APPENDIX A

Thesis Plan and Timeline

Steps and Tasks of the Research	Time, Months	Year 1				Year 2				Year 3			
		(1) (Semester 2- 2021) (2) (Semester 1- 2022)				(3) (Semester 2- 2022) (4) (Semester 1- 2023)				(5) (Semester 2- 2023) (6) (Semester 1- 2024)			
		3 months	6 months	9 months	12 months	15 months	18 months	21 months	24 months	27 months	30 months	33 months	36 months
1. Confirmation of Candidature	12M	■	■	■	■								
1.1 Introduction Chapter	3 M	■											
1.2 Literature Review	24 M	■	■	■	■	■	■	■	■				
2. Seminar of Confirmation	1 M				■								
3. Paper 1 Pulicshed	9 M				■	■	■						
4. Paper 2 Pulicshed	9 M							■	■	■			
5. Paper 3 Pulicshed	12 M									■	■	■	
6. Thesis Discussion	6 M									■	■	■	
7. Conclusion	3 M											■	
8. Proof Reading & Submission	1 M												■

APPENDIX B

Questionnaire Survey used for Collecting the Primary Data

University of Southern Queensland

University of Southern Queensland
Consent form
Questionnaire

UniSQ HREC Approval number: H22REA273

Project Title:

An Investigation of Using Advanced Technologies Such as BIM to Reduce Construction Disputable Claims

Research team contact details

Principal Investigator Details

Reda Abdelshafy Abougamil
[redacted]

Supervisor

A Prof David Thorpe
[redacted]

Co-investigator
Dr. Amirhossein Heravi
[redacted]

Statement of consent

By signing below, you are indicating that you:

- Have read and understood the information document regarding this project. ☐ Yes / ☐ No
- Have had any questions answered to your satisfaction. ☐ Yes / ☐ No
- Understand that if you have any additional questions, you can contact the research team. ☐ Yes / ☐ No
- Are over 18 years of age. ☐ Yes / ☐ No
- Understand that any data collected may be used in future research activities ☐ Yes / ☐ No
- Agree to participate in the project. ☐ Yes / ☐ No

Name (first & last)			
Signature		**Date**	

Thank you for taking the time to help with this research project.

Please return this document to a research team member before undertaking the questionnaire.

University of Southern Queensland

University of Southern Queensland
Participant Information Sheet
Interview

UniSQ HREC Approval number: H22REA273

Project Title

An Investigation of Using Advanced Technologies Such as BIM to Reduce Construction Disputable Claims

Research team contact details

Principal Investigator

Reda Abdelshafy Abougamil

[redacted]

Supervisor

A Prof David Thorpe

[redacted]

Co-investigator

Dr. Amirhossein Heravi

[redacted]

Description

This is a PhD construction research project that looks into the importance of using advanced technology in construction, such as Building Information Modelling (BIM), to reduce disputable claims in construction projects. The research is based on three main goals, each of which has three questions. These include a review of the previous literature as secondary data for the research in addition to the primary data gathered from field survey.

This project is being undertaken as part of Doctor of Philosophy through the University of Southern Queensland. The purpose of this project is to:

(1) To identify different factors that cause disputable claims in the KSA residential and commercial projects.
(2) To investigate to what extent BIM can minimize disputable claims in both residential and commercial construction projects.
(3) To examine how advanced technologies be facilitated to help construction projects to be completed with less disputable claims.

Participation

Your participation will involve partaking in an interview session that will take approximately 45 minutes of your time.

Questions will include:

1. How familiar are you with Building Information Modelling (**BIM**)?
2. In your opinion, is there a growing awareness of **BIM** usage in Saudi Arabia?
3. Is your organization actively using or planning to use **BIM**? Explain please to what extent.
4. Have you/your organization had experience with **BIM** strategy that includes Organizational Information Requirements (**OIR**), or Asset Information Requirements (**AIR**), or Exchange Information Requirements (**EIR**), or BIM Execution Plan (**BEP**)? Explain please explain to what extent.
5. If you have not used **BIM**, would you consider using it in the future? Why.
6. Is there a growing demand for **BIM** usage in Saudi Arabia?
7. If you agree, how will implementing BIM reduces the overall project time and minimize the possibility of delay claims?
8. In your opinion, does the use of **BIM** might reduce the possible cost overrun and maintain the original budget on track? Please explain your reasoning.
9. Comment generally about the benefits of using **BIM** in the KSA.
10. What are the barriers to **BIM** adoption in your organization?
11. In your opinion, is the implementation of **BIM** suitable in small and medium-sized construction projects?

12. In your opinion, the use of **BIM** in disputable claims may lead to reducing the degree of resorting to litigation or arbitration? Explain please.
13. In your opinion, how can **BIM** implementation reduce the wasted time in the construction process?
14. In your opinion, will **BIM** implementation reduce the overall project costs? Explain please.
15. In your opinion, will implementing **BIM** help to improve productivity in construction projects? Explain please.
16. In your opinion, how can **BIM** be made more accessible to be used in construction projects?
17. From your experience, is it recommended to include **BIM** technology in the documents of the Standard Form of Contracts so that claims and disputes can be analysed and relied upon its outcomes?

Your participation in this project is entirely voluntary. If you do not wish to take part, you are not obliged to. If you decide to take part and later change your mind, you are free to withdraw from the project at any stage.

You may also request that any data collected about you be withdrawn and confidentially destroyed OR

You will be unable to withdraw data collected about yourself after you have participated in the interview OR

You will be unable to withdraw data collected about yourself after the data has been analysed.

If you do wish to withdraw from this project or withdraw data collected about yourself, please contact the Research Team (contact details at the top of this form).

Your decision whether you take part, do not take part, or take part and then withdraw, will in no way impact your current or future relationship with the University of Southern Queensland.

Expected benefits

It is expected that this project will directly benefit you in participating with the academic research through the field survey questions have been designed from an academic expert team. However, it may benefit you as well by acquiring new and mutual information about BIM technology in the Saudi Industry that I expect will add advanced knowledge to you in that field. Also, you may receive, if you wish, a copy of the published papers of the research once it has been approved and published in a reputable journal.

Risks

In participating in the interview, there are no anticipated risks in this field survey as the is not any human tests is required, or experiment that need special equipment. Instead, the interview session will be held with you in a safe place based on your convenience. The required data from you is technical data from the industry based on your experience and is not related to any confidential work.

Privacy and confidentiality

All comments and responses are confidential unless required by law.

Any data collected as a part of this project will be stored securely, as per University of Southern Queensland's Research Data and Primary Materials Management Procedure.

Consent to participate

We would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate in this project. Please return your signed consent form to a member of the Research team prior to participating in your interview.

Questions

Please refer to the Research team contact details at the top of the form to have any questions answered or to request further information about this project.

Concerns or complaints

If you have any concerns or complaints about the ethical conduct of the project, you may contact the University of Southern Queensland, Manager of Research Integrity and Ethics on +61 7 4631 1839 or email researchintegrity@usq.edu.au. The Manager of Research Integrity and Ethics is not connected with the research project and can address your concern in an unbiased manner.

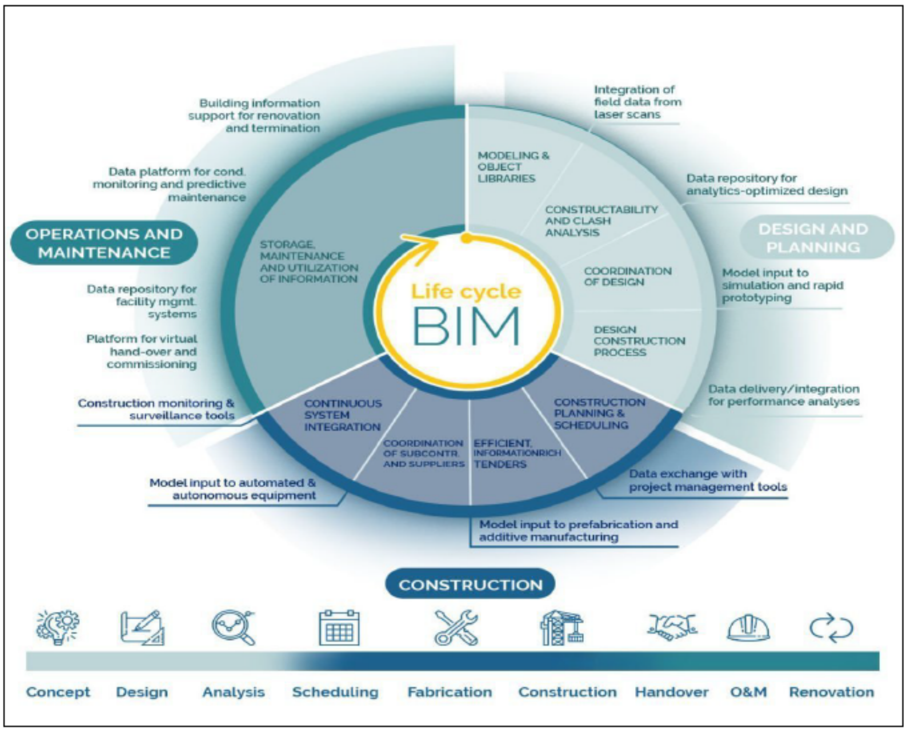
Thank you for taking the time to help with this research project. Please keep this document for your information.

APPENDIX C

The life cycle of BIM

How does BIM work?

Ventures (2023), as one of the biggest construction venture capitals explained the life cycle of BIM and said that**, Building Information Modeling** integrates smart insights to tangible aspects of a building. Not to be confused with Computer Aided Designs (or CAD), whose purpose is focused solely on drafting and design, BIM uses CAD as a medium for bringing broad-scoped information about a building together. Simply put, BIM **makes CAD drawings come alive**; it makes them become smarter, more dynamic and provide much more information of the many systems that can be integrated into a building. When implemented effectively, it can also influence changes in a CAD design. Moreover, it also helps to digitize many aspects of the **building's lifecycle**, going further beyond than only the design phase. In times when smart buildings are also becoming all the rage, it's crucial that facility managers also become smarter in their ways of handling them. Can you guess what can help them? Yes, BIM! This approach may **provide complete context** for buildings and the systems that regulate them, making the I in BIM the epitome of information-driven decision-making.



https://www.cemexventures.com/discover-how-bim-is-implemented-in-each-phase-of-the-construction-industry

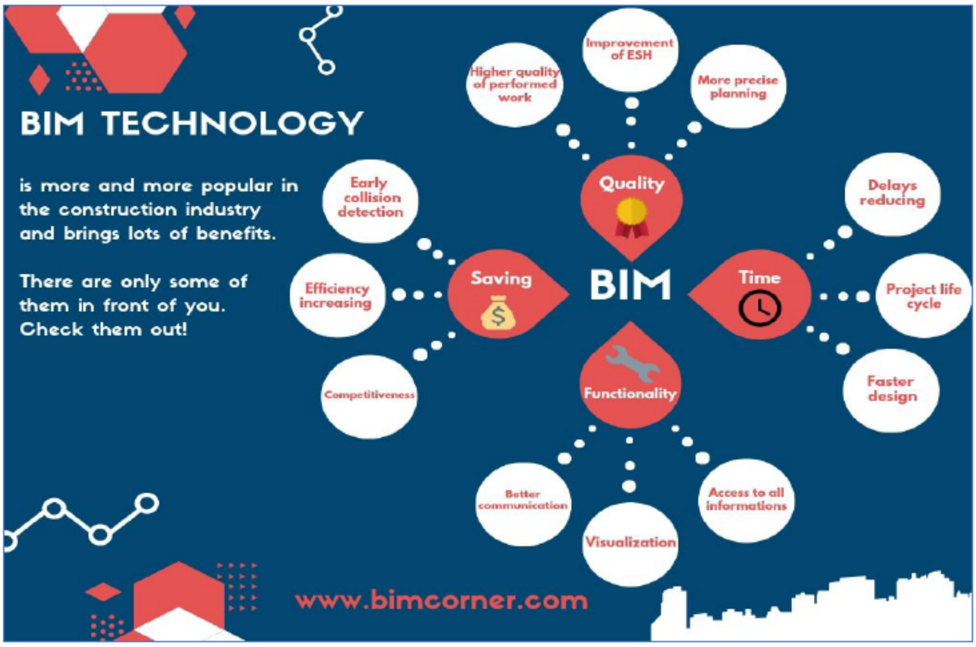
APPENDIX D

Top 12 benefits from BIM application

Benefit 1: Early detection of a collision

“Model is a model, and reality is a reality. Everything looks nice in a model, but it seems to fit merely apparently.“

Wojsław (2019) in the BIM Corner website has demonstated 12 benefits of BIM, which is consedred very useful in this thesis. The model will never be 100% true to reality you can model something perfectly, but the construction conditions will, of course, verify everything. However, using BIM still pays off! Even if you detect at least some of the mistakes in the model at an early stage, you will simply avoid them on the construction site. Because the BIM tools helps you automate the collision detection of elements such as electrical cables, sewer pipes or ventilation ducts (Wojsław, 2019). Simply put, you can turn on a ‘checker’ to automatically verify collisions and make report. This will save time instead of manually checking drawings from different industries, won’t it? Every discipline can link own models to one common where conflicts will be detected at an early stage where the cost of changes is much lower. It’s always better than standing in a two-meter excavation, in the rain, when lunch starts in five minutes, you haven’t checked your Facebook for an hour, and you just detected a sewer pipe going through a concrete wall (Wojsław, 2019).



https://bimcorner.com/benefits-of-using-bim-technology/

Benefit 2: Faster design and construction

“I'll make drawings twice as fast as a 3D model!“

Twice as fast it sounds tempting. But remember the times of blueprints? (or maybe you’re too young and you’ve always used CAD?) Most people at that time also thought that the new huge computers were too slow, too expensive and too complicated to operate. But times are changing and design geometries are getting more and more complicated. Architects and designers are competing in new ideas to make objects unique so that they are distinguished from the crowd (Wojsław, 2019).

At the same time, they want to make them faster and cheaper. Making 2D drawings may be faster than the model, but you won’t be able to make modifications so quickly. With a parametric design which becoming more popular in the industry, we are now able to make rapid changes to the model. Thanks to the accessible change of input data (spacing, width, length), the effects of modification are visible immediately after the relevant values are changed (Wojsław, 2019).

Benefit 3: More precise planning

“Excel is my favorite program - I am an expert in it! Nothing replaces a spreadsheet.“

You can indeed do miracles in Excel. However, the BIM technology is not intended to replace a spreadsheet, but only to streamline and automate the collection of information from the model. Simply put, we replace tedious and often flawed manual work (e.g. “tapping” into tables of values) with automated data generation (Wojsław, 2019).

Here are some examples of how BIM technology supports us in our daily work:

- Materials list - material types, quantities, volumes, surface area or lengths can be 'extracted' directly from the 3D model and exported, for instance, to the above-mentioned Excel. In case of modifications, the amount of reinforcement or concrete will be automatically updated, without tedious calculation with the calculator from the 2D drawing.
- Cost estimation may be more clear and accurate - based on both a list of materials and additional information on the model, such as the assumed number of man-hours per element or the price of the material, with the automatic update of the costs when another material wiil be selected.
- Schedule - based on time and sequence of planned tasks - enables interactive connection with the model. In a graphical way, using appropriate colours, we may demonstrate on the model which construction elements are already planned, ordered, and which are already made.
- Plan of payment/expenses during the construction process - along with the schedule you may prepare a visualization and check the dependencies between the performed works and their costs.

- **Benefit 4: Visualization at an early stage of the project**
- *"Visualizations are just fun for architects, not designers. "*

It often happens that the investor/client does not have an engineering education and made drawings and sections are insufficient for them to imagine the design concept properly. What is more, even qualified employees often have problems with this issue. Creating a three-dimensional and multdiscipline model allows the easier presentation of the final result and placing the structure in the existing reality. Even the simplest 3D model enables a good-looking visualization, which in many cases may be the key to a better understanding of the project, which in turn may even decide who will win the contract.

Benefit 5: Higher quality of performed work

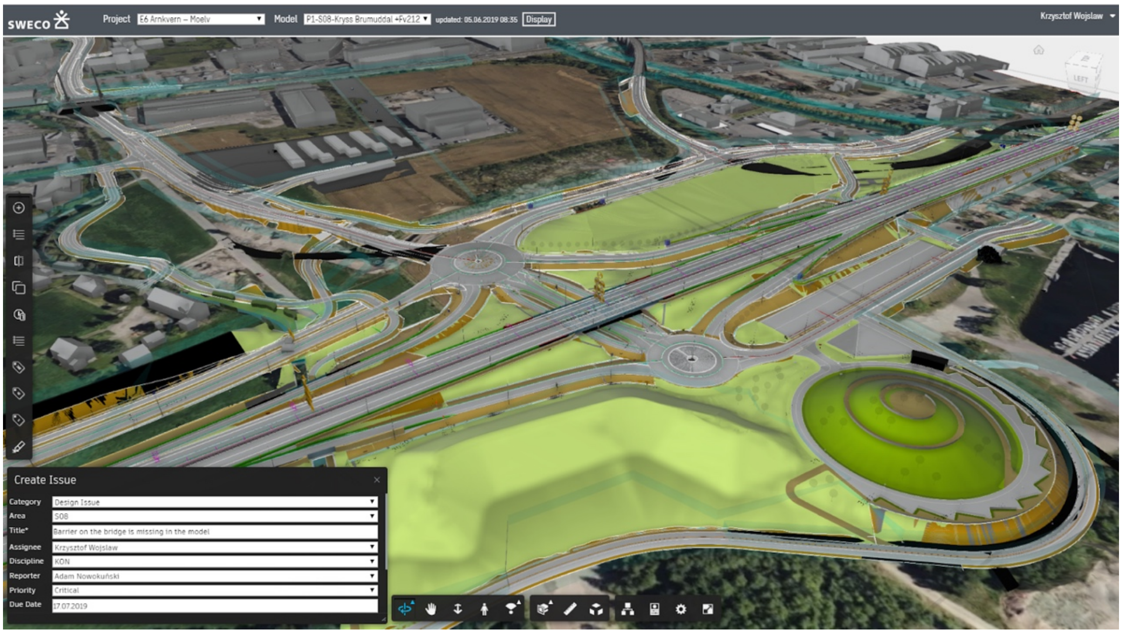
"Oh Lord, I've been making reinforcement without a model for 30 years and I will still do it."

Wojsław (2019) said, you may continue to do it for the next 30 years (unless your retirement comes earlier) and repeat the same mistakes. As the classic used to say: ,,Insanity is doing the same thing over and over again and expect different results." But after all, how much can you get annoyed with designers, that the reinforcement does not fit on the construction site, although you can see everything on a piece of paper? Due to 3D models of reinforcement, we are able to avoid most of the collisions which are not visible on ordinary sections. It saves a lot of time on the construction site, because of the additional contact with the designer, who is usually in no hurry to answer questions. In addition, workers have access to the model and they are able to see the reinforcement scheme of e.g. a complicated connection and do not have to guess "what did the designer mean?"

Benefit 6: Better communication in the project

"E-mail and telephone are the best forms of communication in a team. Drawings are a great basis for discussion."

When asked: What do you think is the key to a successful implementation of the project?, the vast majority answers that the most significant thing is good cooperation among the project participants. The greater the project, the more its success depends on effective communication. It is tough to provide an ideal communication model which will ensure successful cooperation among investors, designers, construction managers and other industries. However, first of all, the reduction of the e-mail number, which we receive too many during the day and the number of tasks we do on the phone, which no one remembers after a few days, is the first step. The next step is to start using project management software, which may be combined with a 3D model such as JIRA. Instead of sending hundreds of messages – concerning different topics (in which it is easy to lose a thread) with copies to a lot of people (we will always skip someone anyway) – we have the ability to track individual tasks on one virtual board. These, in turn, relate to the specific elements in the model and their level of development, which are visible to individual participants. How many times have we had a situation when we waited for status from a person who is on vacation / sick leave and holding a mail only at his/her mailbox to which no one has access? And the project leader needs to be able to view or respond to it?



https://bimcorner.com/benefits-of-using-bim-technology/

Benefit 7: Reducing delays and errors

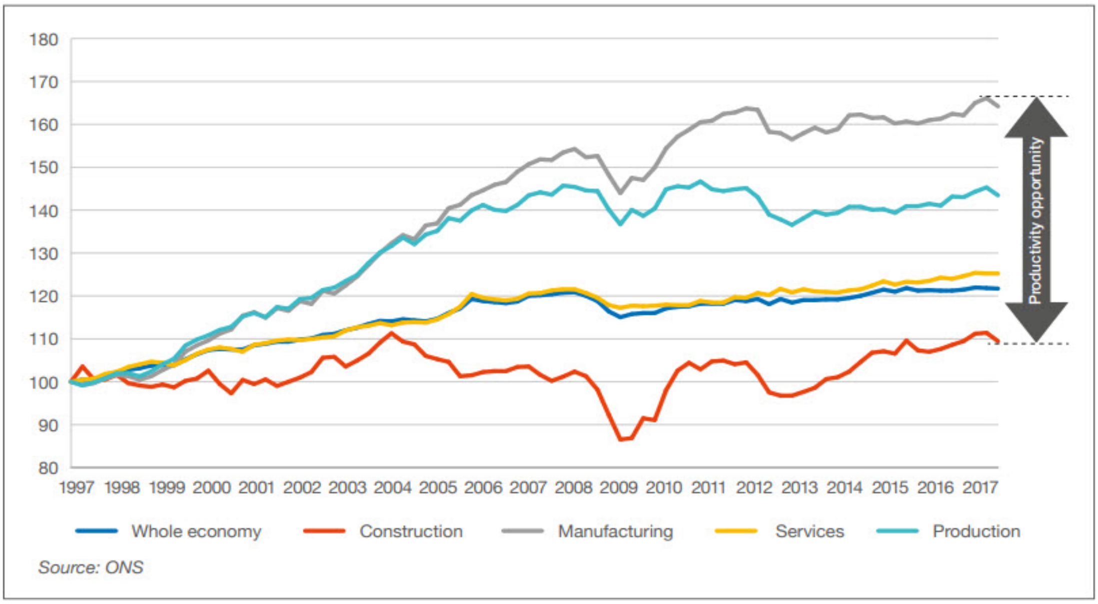
"Drawings are always needed and will always be needed. Without drawings, you do nothing. A tablet on a construction site hasn't got any sense!"

The reality is not such that every worker uses a tablet and helmet with MR (mixed reality) glasses on the construction site (not yet). However, thanks to BIM technology we are able to reduce the number of errors in creating drawings and misunderstandings on the construction site. Nowadays, most design offices in Europe create 3D models of their constructions, but unfortunately, they still transfer them on paper as 'paper approves anything'. As a result, there is a higher probability of errors. The obvious step is, therefore, to eliminate this transitional phase and use only the 3D model as the final product. A contractor with a reinforcement model is able to decide on his/her own orders by generating bending lists directly on the construction site independently from the designer. A good example is when on one of the projects the contractor got a reinforcement list with 40 pages with more than 200 tons of reinforcement and nothing was divided into specific elements. Foundations, walls and the rest of the system were collected in one document because it was easier for the designer to do so. As a result, the contractor had to look through tons of paper in order to find the right items (Wojsław, 2019).

Benefit 8: Increasing efficiency and productivity

“The productivity of the construction industry hasn't changed in the last 20 years and it won't change in the next 20.“

The first part of the sentence is true, but the second one is not necessarily true. The discontinuation of the implementig of new technologies has led to stagnation in the construction industry, whose productivity has only increased by 10% in the last twenty years! By comparison, the manufacturing industry has seen a nearly 70% increase in the same period (source: Transforming Infrastructure Performance by Infrastructure and Projects Authority, December 2017). Productivity increasing by automating tasks, introducing new technologies and expanding competence was the key to this achievement. We now have the opportunity to draw conclusions and learn from our “younger brother” how to keep up with the technological advances which drive the market and offer opportunities we would never have thought about before (Wojsław,



2019).

Benefit 9: Competitiveness

“The price of a project is the most important aspect!“

Fortunately, more and more investors realize that MMM’s approach, monay makes miracles does not always work. It is, therefore, encouraging that investors pay more attention to ‘soft criteria’ in contracts. It enhances the competitiveness of companies which are reliable, comply with labor law, health and safety regulations, quality, but are not necessarily the cheapest (Wojsław, 2019). For instance, in the Best Value Procurement (BVP) method, which is becoming more and more popular in Norway, there are five criteria, including the price criterion, which normally accounts for 25%. Other criteria include how the contractor plans to carry out the project (25%), risk assessment (15%), added value (10%) and the competence and experience of key people in personnel (25%). You may ask, and where is BIM? First of all, BIM at level three is in many cases a requirement in tenders, thus companies unable to guarantee the execution of the project in accordance with this technology will not be taken into account in the tender. Secondly, in the criterion of competence and experience of key personnel, additional points may be awarded for knowledge and experience in new technologies. BIM is therefore not the future. It is a process which already takes place on many projects and is constantly developing (Wojsław, 2019).

Benefit 10: Easy access to information

"I save everything only on disk C, and my desktop is my kingdom where I keep the documentation of the whole project."

Don't be selfish! Remember about your colleagues and other industries. The times when projects are saved on local disk are coming to an end. On the market, there are more and more possibilities and solutions for data storage in a common space, so-called Common Data Environment (CDE link), popularly known as the cloud. Cloud is a virtual portable drive storing all the documentation, to which each authorized person has access. To be honest, the solution of creating such backups several times saved my project from losing important data, and me from the anger of my boss. Furthermore, the cloud is a convenient solution allowing access to the project in almost every place on earth and from every possible device with internet access. Additionally, an increasing number of programs use the shared central mode function (e.g. Quadri), which allows many employees from different industries to work on one model at the same time such a function is incredible in multidiscipline projects (Wojsław, 2019).

Benefit 10: Easy access to information

"I save everything only on disk C, and my desktop is my kingdom where I keep the documentation of the whole project."

Don't be selfish! Remember about your colleagues and other industries. The times when projects are saved on local disk are coming to an end. On the market, there are

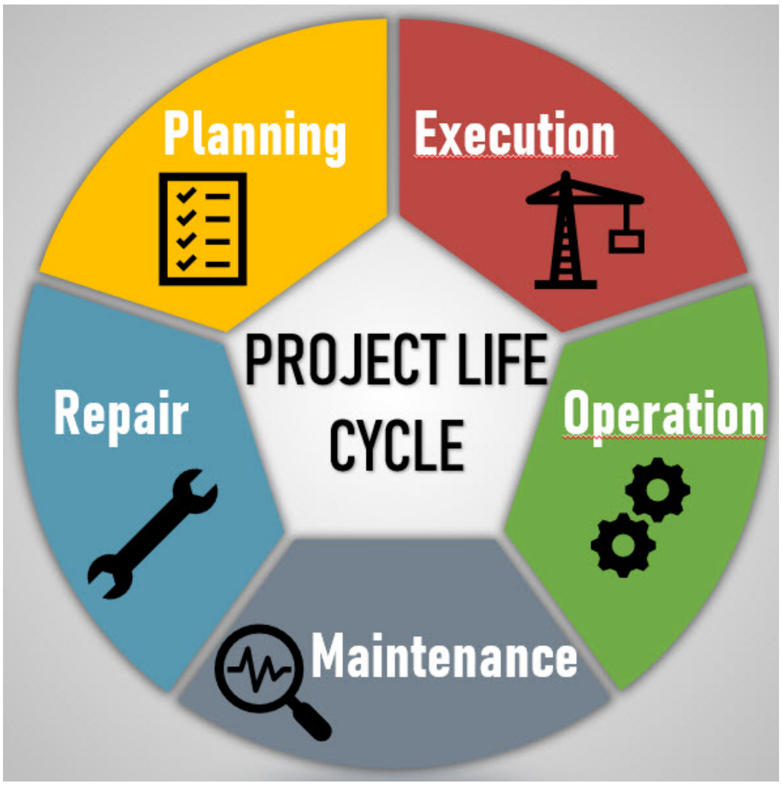
more and more possibilities and solutions for data storage in a common space, so-called Common Data Environment (CDE link), popularly known as the cloud. Cloud is a virtual portable drive storing all the documentation, to which each authorized person has access. To be honest, the solution of creating such backups several times saved my project from losing important data, and me from the anger of my boss. Furthermore, the cloud is a convenient solution allowing access to the project in almost every place on earth and from every possible device with internet access. Additionally, an increasing number of programs use the shared central mode function (e.g. Quadri), which allows many employees from different industries to work on one model at the same time such a function is incredible in multidiscipline projects (Wojsław, 2019).

Benefit 11: Project life cycle

"I keep the as-built documentation in the archive in the basement. It is dry and safe there!"

A typical scheme on the construction site – do your job, forget it and jump into the next project. But what happens with our part of the work after we do it? Usually, there's no time to think about it and we're not really interested in it. The designer is to design, the contractor is to perform, and the investor is to make final acceptance of the project. Here a small problem arises because the investor requires as-built documentation. The designer did his job and the contractor started to transfer the staff to the next object. During the execution, people who worked on it often switch and leave, which also causes a partial loss of knowledge about what and how something was done.

Storing and archiving project data is important, and it would be ideal to do it during the implementation itself. Just like archiving itself, it is also essential to have easy access to it right after the project is completed. Properly recorded information in the 3D model regarding the material, location, date of execution or date of the next inspection, allow you to create a database. The database created in this way can support us both in the case of future expansion or renovation, as well as the maintenance of the object. Thanks to this, we may forget about checking the dates when, for example, carry out the next inspection of the elevator or replace the extinguisher the information can be automatically sent to the appropriate recipient, e.g. in the form of an e-mail directly from the BIM model (Wojsław, 2019).



Benefit 12: Improvement of Healthy and Safety

"BIM - what does it have to do with safety?"

When it comes to OSH, fortunately, the days when you first built and then thought are over – after all, 'it will be fine!' Nowadays, it has become a standard for us to plan our tasks with safety in mind. It is not only essential to build, but also to build safely. How can BIM help in this regard? First of all, by making people think already during the design process, the model shows which works will be done at a height, where the railway line or high voltage cables are located. An experienced designer could say it is also possible to read the same from traditional drawings – however, it requires reviewing different types of documentation separately. In the model, it is possible to combine many disciplines and see what is in the neighbourhood (or underground) of the planned object (Wojsław, 2019).

n the executive phase BIM and OSH also go hand in hand. Before each potentially dangerous task, a risk and job safety analysis (JSA) is required. For example, a tower crane with a height of 100 m is supposed to be installed next to the railway traction. With the model, we are able to take the participants on a virtual journey which allows them to be involved, and above all understand and minimize possible dangers, better than sketches on paper.

APPENDIX E

The Benefits of Using CostX Software: A Comprehensive Review

Writer (2024) of Ask Website explained the benefits of Cost-X and said that, accurate cost estimation is essential for the success of any undertaking in the rapidly evolving construction industry of the present day. Professionals in the field are now utilizing innovative software solutions to optimize their processes as a result of the evolution of technology. CostX is one such software that is acquiring popularity. This article will investigate the advantages of utilizing CostX software and the reasons it has become a preferred instrument for construction estimators .

Accurate and Efficient Cost Estimation

The foundation of any construction project is cost estimation. Manual calculations and time-consuming procedures that are susceptible to errors are frequently employed in conventional methods. Nevertheless, these obstacles are mitigated by the implementation of CostX software (Writer, 2024)

CostX provides users with the ability to rapidly measure quantities from digital drawings by leveraging its sophisticated digitization capabilities. The software has the capability to calculate quantities autonomously using predefined parameters, thereby reducing the time spent on manual calculations and eliminating human error. CostX also allows users to incorporate preexisting data from various sources, including PDFs, CAD files, and images. By directly extracting information from source files, this feature eliminates the necessity for manual data entry and guarantees precise measurements (Writer, 2024).

Enhanced Collaboration and Communication

An effective collaboration among various stakeholders is essential for the successful execution of a project. Making real-time updates and communicating information can be difficult with conventional cost estimation methods. Nevertheless, CostX software resolves these challenges by offering a platform that facilitates improved communication and collaboration.

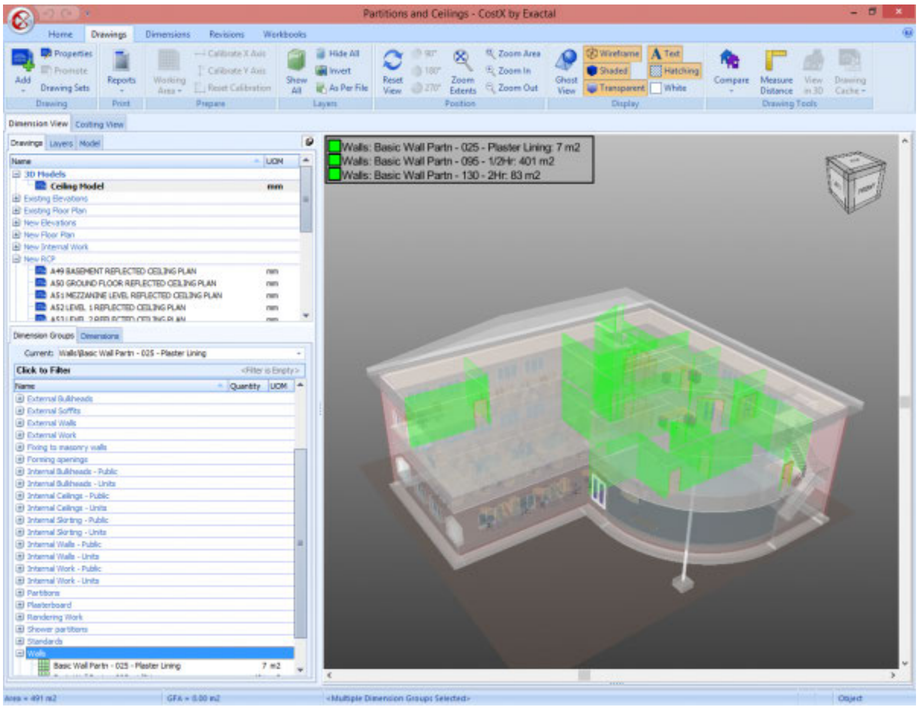
CostX enables the collaboration of numerous users on a project in real time. This feature enables the seamless collaboration of estimators, architects, engineers, and other team members who are involved in a construction project. Users can immediately share their progress and make updates that are immediately visible to all parties involved. Additionally, CostX provides users with incorporated communication tools that allow them to discuss specific details within the software. This eliminates the necessity for extensive email threads or separate communication channels, while simultaneously guaranteeing that all parties are kept informed about any modifications or clarifications that may be implemented during the estimation process (Writer, 2024).

The Advantageous of using Cost-X in Construction Projects

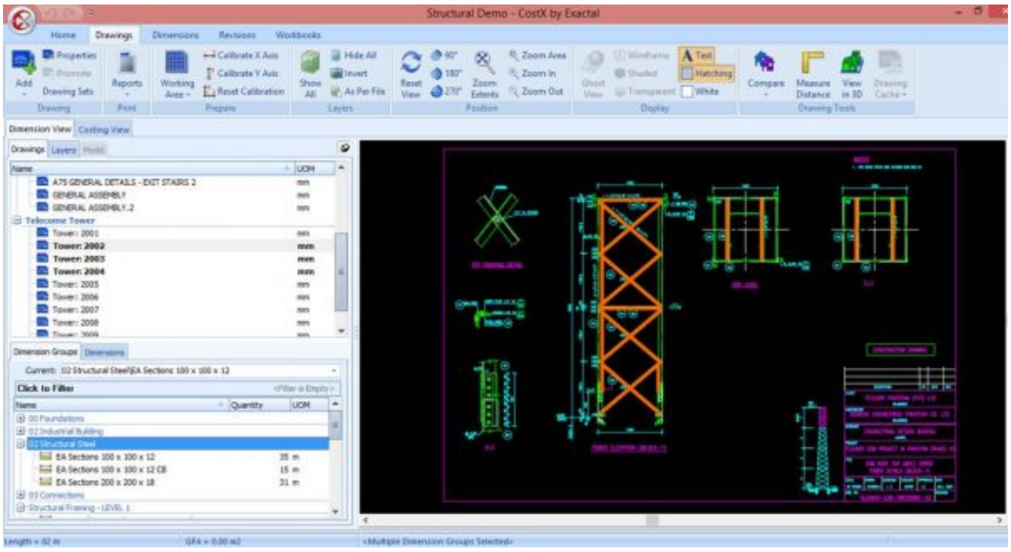
In today's construction environment competitiveness is key, and to keep your business on top, you need to make sure you have the best tools available. This should include a fully integrated estimating solution, such as Cost-X, which supports BIM & 2D takeoff, integrated workbooks and a customisable report writer, among other features. Check out our top four reasons below why you should upgrade now to an all-in-one solution:

Productivity

The principal advantage of using a full-function estimating system is productivity. With a system like Cost-X, you can leverage intuitive technology to reduce human error. Streamline 2D and 3D/BIM takeoff with live-linked quantities, and have multiple users in the same office or different regions working on the same estimate simultaneously. Save time, win more work. Ultimately, speed and productivity will be the differentiating factors for a profitable business (Writer, 2024).



Accuracy
In the construction industry, productivity alone is meaningless without efficiency. You need to have a system like Cost-X which understands the intelligence in 2D drawings. Utilise the freedom of manipulating Excel-like formulas and functions for precise calculations. Using computer-aided estimates where takeoff data is extracted and linked directly into the estimating process is not only more accurate, but also saves you the time and possible errors that come with having to re-enter information (Writer, 2024).

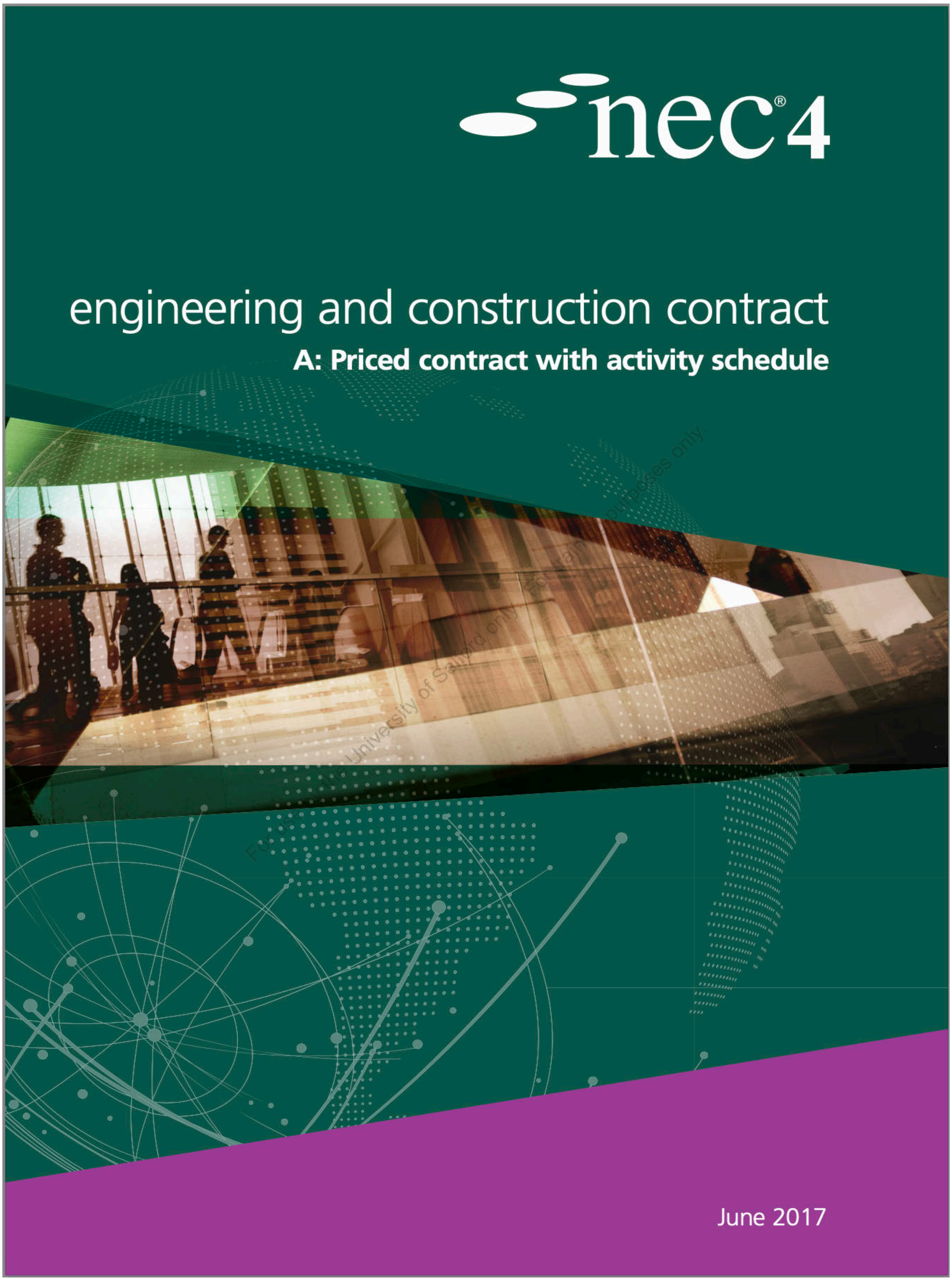


https://designbuildexpo.com.au/designbuild-news/advantages-one-estimating-system/

Consistency
Standardise your estimating process by enhancing cohesiveness. Working within the realm of an estimating software such as Cost-X administers consistency throughout your business. This promotes a more centralised business model enhancing communication while greatly diminishing disputes amongst colleagues. Apply previous projects or prebuilt models as benchmarks for current bids to reduce overlap and increase consistency. Set the standard on how to win projects across the company (Writer, 2024).

APPENDIX F

Section of NEC 4 Option A that suggested in the Thesis with BIM Package



Contents

Foreword	**v**
Preface	**vi**
Acknowledgements	**vii**
Amendments	**viii**
Schedule of Options	**1**
Core Clauses	**3**
1 General	3
2 The *Contractor's* main responsibilities	8
3 Time	10
4 Quality management	13
5 Payment	15
6 Compensation events	18
7 Title	24
8 Liabilities and insurance	25
9 Termination	28
Resolving and Avoiding Disputes	**31**
Option W1	31
Option W2	34
Option W3	37
Secondary Option Clauses	**39**
Option X1: Price adjustment for inflation	39
Option X2: Changes in the law	39
Option X3: Multiple currencies	39
Option X4: Ultimate holding company guarantee	40
Option X5: Sectional Completion	40
Option X6: Bonus for early Completion	40
Option X7: Delay damages	40
Option X8: Undertakings to the *Client* or Others	41
Option X9: Transfer of rights	41
Option X10: Information modelling	41
Option X11: Termination by the *Client*	42
Option X12: Multiparty collaboration (not used with Option X20)	42
Option X13: Performance bond	44
Option X14: Advanced payment to the *Contractor*	44
Option X15: The *Contractor's* design	44
Option X16: Retention	45
Option X17: Low performance damages	45
Option X18: Limitation of liability	46
Option X20: Key Performance Indicators (not used with Option X12)	46

For use by the University of Salford only. For training purposes only.

Option X21: Whole life cost 46
Option X29: Climate change 47

Option Y(UK)1: Project Bank Account 50
Option Y(UK)2: The Housing Grants, Construction and Regeneration Act 1996 54
Option Y(UK)3: The Contracts (Rights of Third Parties) Act 1999 54

Option Z: *Additional conditions of contract* 55

Short Schedule of Cost Components **56**

Contract Data **59**
Part one – Data provided by the *Client* 59
Part two – Data provided by the *Contractor* 72

Index **76**

For use by the University of Salford only. For training purposes only.

Schedule of Options

RESOLVING AND AVOIDING DISPUTES	One of the following procedures for resolving and avoiding disputes must be selected to complete the chosen main Option.
Option W1	Used when adjudication is the method of dispute resolution and the United Kingdom Housing Grants, Construction and Regeneration Act 1996 does not apply
Option W2	Used when adjudication is the method of dispute resolution and the United Kingdom Housing Grants, Construction and Regeneration Act 1996 applies
Option W3	Used when a Dispute Avoidance Board is the method of dispute resolution and the United Kingdom Housing Grants, Construction and Regeneration Act 1996 does not apply
SECONDARY OPTIONS	The following secondary Options should be considered. It is not necessary to use any of them. Any combination other than those stated may be used.
Option X1	Price adjustment for inflation
Option X2	Changes in the law
Option X3	Multiple currencies
Option X4	Ultimate holding company guarantee
Option X5	Sectional Completion
Option X6	Bonus for early Completion
Option X7	Delay damages
Option X8	Undertakings to the *Client* or Others
Option X9	Transfer of rights
Option X10	Information modelling
Option X11	Termination by the *Client*
Option X12	Multiparty collaboration (not used with Option X20)
Option X13	Performance bond
Option X14	Advanced payment to the *Contractor*
Option X15	The *Contractor's* design
Option X16	Retention
Option X17	Low performance damages
Option X18	Limitation of liability
Option X20	Key Performance Indicators (not used with Option X12)
Option X21	Whole life cost
Option X29	Climate change
	The following Options dealing with national legislation should be included if required.
Option Y(UK)1	Project Bank Account
Option Y(UK)2	The Housing Grants, Construction and Regeneration Act 1996
Option Y(UK)3	The Contracts (Rights of Third Parties) Act 1999
Option Z	*Additional conditions of contract*
Note	Options X19 and X22 are not used

For use by the University of Salford only. For training purposes only.

Core Clauses

1. GENERAL

Actions

10

10.1 The Parties, the *Project Manager* and the *Supervisor* shall act as stated in this contract.

10.2 The Parties, the *Project Manager* and the *Supervisor* act in a spirit of mutual trust and co-operation.

Identified and defined terms

11

11.1 In these *conditions of contract*, terms identified in the Contract Data are in italics and defined terms have capital initials.

11.2 (1) The Accepted Programme is the programme identified in the Contract Data or is the latest programme accepted by the *Project Manager*. The latest programme accepted by the *Project Manager* supersedes previous Accepted Programmes.

(2) Completion is when the *Contractor* has

- done all the work which the Scope states is to be done by the Completion Date and
- corrected notified Defects which would have prevented the *Client* from using the *works* or Others from doing their work.

If the work which the *Contractor* is to do by the Completion Date is not stated in the Scope, Completion is when the *Contractor* has done all the work necessary for the *Client* to use the *works* and for Others to do their work.

(3) The Completion Date is the *completion date* unless later changed in accordance with the contract.

(4) The Contract Date is the date when the contract came into existence.

(5) A Corrupt Act is

- the offering, promising, giving, accepting or soliciting of an advantage as an inducement for an action which is illegal, unethical or a breach of trust or
- abusing any entrusted power for private gain

in connection with this contract or any other contract with the *Client*. This includes any commission paid as an inducement which was not declared to the *Client* before the Contract Date.

(6) A Defect is

- a part of the *works* which is not in accordance with the Scope or
- a part of the *works* designed by the *Contractor* which is not in accordance with the applicable law or the *Contractor's* design which the *Project Manager* has accepted.

(7) The Defects Certificate is either a list of Defects that the *Supervisor* has notified before the *defects date* which the *Contractor* has not corrected or, if there are no such Defects, a statement that there are none.

(8) The Early Warning Register is a register of matters which are

- listed in the Contract Data for inclusion and
- notified by the *Project Manager* or the *Contractor* as early warning matters.

For use by the University of Salford only. For training purposes only.

It includes a description of the matter and the way in which the effects of the matter are to be avoided or reduced.

(9) Equipment is items provided and used by the *Contractor* to Provide the Works and which the Scope does not require the *Contractor* to include in the *works*.

(10) The Fee is the amount calculated by applying the *fee percentage* to the amount of Defined Cost.

(11) A Key Date is the date by which work is to meet the Condition stated. The Key Date is the *key date* stated in the Contract Data and the Condition is the *condition* stated in the Contract Data unless later changed in accordance with the contract.

(12) Others are people or organisations who are not the *Client*, the *Project Manager*, the *Supervisor*, the *Adjudicator* or a member of the Dispute Avoidance Board, the *Contractor* or any employee, Subcontractor or supplier of the *Contractor*.

(13) The Parties are the *Client* and the *Contractor*.

(14) Plant and Materials are items intended to be included in the *works*.

(15) To Provide the Works means to do the work necessary to complete the *works* in accordance with the contract and all incidental work, services and actions which the contract requires.

(16) Scope is information which

- specifies and describes the *works* or
- states any constraints on how the *Contractor* Provides the Works

and is either

- in the documents which the Contract Data states it is in or
- in an instruction given in accordance with the contract.

(17) The Site is the area within the *boundaries of the site* and the volumes above and below it which are affected by work included in the contract.

(18) Site Information is information which

- describes the Site and its surroundings and
- is in the documents which the Contract Data states it is in.

(19) A Subcontractor is a person or organisation who has a contract with the *Contractor* to

- construct or install part of the *works*,
- design all or part of the *works*, except the design of Plant and Materials carried out by the supplier or
- provide a service in the Working Areas which is necessary to Provide the Works, except for the
  - hire of Equipment or
  - supply of people paid for by the *Contractor* according to the time they work.

(20) The Working Areas are the Site and those parts of the *working areas* which are

- necessary for Providing the Works and
- used only for work in the contract

unless later changed in accordance with the contract.

For use by the University of Salford only. For training purposes only.

 © nec 2017

OPTION X8: UNDERTAKINGS TO THE *CLIENT* OR OTHERS

Undertakings to the *Client* or Others **X8**

X8.1 The *Contractor* gives *undertakings to Others* as stated in the Contract Data.

X8.2 If the *Contractor* subcontracts the work stated in the Contract Data it arranges for the Subcontractor to provide a *Subcontractor undertaking to Others* if required by the *Client*.

X8.3 If the *Contractor* subcontracts the work stated in the Contract Data it arranges for the Subcontractor to provide a *Subcontractor undertaking to the Client*.

X8.4 The *undertakings to Others*, *Subcontractor undertaking to Others* and *Subcontractor undertaking to the Client* are in the form set out in the Scope.

X8.5 The *Client* prepares the undertakings and sends them to the *Contractor* for signature. The *Contractor* signs the undertakings, or arranges for the Subcontractor to sign them, and returns them to the *Client* within three weeks.

OPTION X9: TRANSFER OF RIGHTS

Transfer of rights **X9**

X9.1 The *Client* owns the *Contractor's* rights over material prepared for the design of the *works* except as stated otherwise in the Scope. The *Contractor* obtains other rights for the *Client* as stated in the Scope and obtains from a Subcontractor equivalent rights for the *Client* over the material prepared by the Subcontractor. The *Contractor* provides to the *Client* the documents which transfer these rights to the *Client*.

For use by the University of Salford only. For training purposes only.

OPTION X10: INFORMATION MODELLING

Defined terms **X10**

X10.1 (1) The Information Execution Plan is the *information execution plan* or is the latest Information Execution Plan accepted by the *Project Manager*. The latest Information Execution Plan accepted by the *Project Manager* supersedes the previous Information Execution Plan.

(2) Project Information is information provided by the *Contractor* which is used to create or change the Information Model Requirements.

(3) The Information Model is the electronic integration of Project Information and similar information provided by the *Client* and other Information Providers and is in the form stated in the Information Model.

(4) The Information Model Requirements are the requirements identified in the Scope for creating or changing the Information Model.

(5) Information Providers are the people or organisations who contribute to the Information Model and are identified in the Information Model Requirements.

Collaboration X10.2 The *Contractor* collaborates with other Information Providers as stated in the Information Model Requirements.

Early warning X10.3 The *Contractor* and the *Project Manager* give an early warning by notifying the other as soon as either becomes aware of any matter which could adversely affect the creation or use of the Information Model.

Information Execution Plan X10.4 (1) If an Information Execution Plan is not identified in the Contract Data, the *Contractor* submits a first Information Execution Plan to the *Project Manager* for acceptance within the period stated in the Contract Data.

(2) Within two weeks of the *Contractor* submitting an Information Execution Plan for acceptance, the *Project Manager* notifies the *Contractor* of the acceptance of the Information Execution Plan or the reasons for not accepting it. A reason for not accepting an Information Execution Plan is that