Enhancing Information Flow in Construction: Integrating BIM and Lean Tools into the RFI Process

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Dedication

I dedicate this thesis to my beloved family, whose constant encouragement, sacrifices, and belief in my aspirations have been my greatest source of strength. To my parents, your unconditional love, guidance, and support have shaped my journey, giving me the confidence to pursue my academic dreams. I could not have done this without you.

To my brother, Sasan, your steadfast support and motivation have been invaluable. Your faith in me and your encouragement along the way have meant more than words can express.

To my esteemed supervisors, Dr. Kenneth Park and Dr. Maxwell Antwi Afari, I am deeply grateful for your insightful mentorship, guidance, and constructive feedback. Your expertise has played a pivotal role in shaping this research and my growth as a scholar.

I also extend my appreciation to the School of Engineering and Applied Science at Aston University for providing an exceptional academic environment and the resources necessary to complete this work.

Finally, to all the participants who generously contributed their time and insights—this research would not have been possible without your valuable input. To everyone who has stood by me throughout this journey, I share this achievement with you.

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Lastly, I extend my heartfelt appreciation to all the participants who contributed their time and expertise to this research. Your input was instrumental in shaping the outcomes of this study. To everyone who has supported me in any way, I am truly grateful. This accomplishment is not mine alone—it belongs to all who have been part of this journey.

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Abstract:

This doctoral research addresses inefficiencies in the Request for Information (RFI) process within the construction industry by proposing a novel, BIM-Lean integrated RFI system. While BIM and Lean methodologies have been widely adopted, their integration into RFI workflows remains limited, leading to persistent inefficiencies in information flow and waste reduction. This research develops a streamlined RFI process designed to enhance communication, reduce delays, and improve project outcomes.

Through a comprehensive literature review, the study identifies key challenges in the existing RFI process, including delays, cost overruns, and fragmented communication. Using a mixed-methods approach, combining grounded theory for qualitative insights and quantitative survey analysis, the study evaluates how BIM and Lean tools—such as the Last Planner System and Value Stream Mapping—can optimise RFI workflows. The core outcome is an enhanced RFI process, validated through industry workshops and focus groups, accompanied by a structured guideline for implementation.

A prototype website was developed to demonstrate the integration of BIM and Lean principles into the RFI process, providing a centralised platform for RFI management, improved information flow, and structured issue resolution. While real-world implementation is yet to be conducted, the research establishes a strong theoretical and practical foundation for future adoption. These findings contribute to the knowledge base on BIM, Lean Construction, and RFI optimisation, offering a scalable, industry-driven framework to enhance construction project management.

Keywords:
Building Information Modelling (BIM), Lean Construction, Request for Information (RFI), Construction project management, Waste reduction in construction, Value Stream Mapping (VSM), Last Planner System (LPS), Kanban in construction, BIM integration, Construction process optimisation, Design science methodology, Communication efficiency in construction, Pull planning, Digital workflows in construction

Abbreviation

AEC – Architecture, Engineering, and Construction
BIM – Building Information Modelling
CPC – Construction Progress Collision
CUQ – Complexities, Uncertainties, and Quickness
DLO – Direct Labour Organisation
DM – Design Management
DL – Design for Lean
EIR – Employer Information Requirement
FGD – Focus Group Discussion
IGLC – International Group for Lean Construction
IM – Information Management
IPD – Integrated Project Delivery
JIT – Just-in-Time
KPI – Key Performance Indicator
LCI – Lean Construction Institute
LPDS – Lean Project Delivery System
LPS – Last Planner System
NC – Navigate Construction
NCF – Navigate Construction Forum
PP – Pull Planning
RFI – Request for Information
SME – Small and Medium Enterprises
TFV – Theory of Production; Transformation, Flow, and Value
TPS – Toyota Production System
VSM – Value Stream Mapping

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Chapter: 1 Introduction

1.1 Research Background

The construction industry plays a pivotal role in the global economy, contributing significantly to GDP and employment across numerous countries. In the United Kingdom, for example, the construction sector accounted for approximately £117 billion in output, representing around 6% of the nation's GDP (Rhodes, 2019). By 2019, it employed about 2.4 million people, constituting 6.6% of the UK's total workforce, marking the highest employment rate in the sector since 2007 (Rhodes, 2019). Despite these contributions, the industry continues to face persistent challenges, particularly regarding inefficiencies, underperformance, and a sluggish pace of innovation (Latham, 1994; Egan, 1998).

For decades, construction has been criticised for its inability to deliver projects on time and within budget, as well as for its failure to minimise waste. Key reports, such as Latham's *Constructing the Team* (1994) and Egan's *Rethinking Construction* (1998), have urged the industry to adopt more collaborative, performance-oriented approaches. These reports highlighted the importance of modernising construction processes and technologies to drive improvements in efficiency and client value (Tezel et al., 2017). However, despite early calls for reform, progress has remained inconsistent, with many firms showing reluctance to depart from traditional practices due to uncertainty about new methodologies and their potential risks (McPartland, 2017; Cidik et al., 2017).

A critical factor underlying these challenges is poor information flow management, which has a significant impact on project performance. Poor information flow has been directly linked to delays, rework, and cost overruns, with studies showing that errors in design documentation alone can account for up to 52% of the cost of rework on projects (Love et al., 2004). Inefficient information management, particularly during key project phases, exacerbates these issues, as stakeholders fail to share or act on critical project data in a timely manner. Thus, optimising information flow is fundamental to improving project outcomes and operational efficiency in the construction industry.

In response to these challenges, two complementary methodologies have emerged in recent decades: Building Information Modelling (BIM) and Lean Construction (LC). BIM is a digital representation of a project's physical and functional characteristics, designed to enhance collaboration, coordination, and visualisation across the project lifecycle (Eastman et al., 2008). Meanwhile, Lean Construction focuses on maximising value and minimising waste through the continuous improvement of processes and workflows (Sacks et al., 2010). When implemented together, BIM and Lean Construction are believed to have the potential to revolutionise construction project delivery, improving information flow and reducing inefficiencies (Mollasalehi et al., 2017; Bolpagni et al., 2017).

Despite their theoretical benefits, the practical integration of BIM and Lean Construction into everyday construction workflows has encountered difficulties. One area where this integration is particularly critical is in the Request for Information (RFI) process—a formal communication tool used to clarify information or resolve issues during construction projects (Hanna et al., 2012). Inefficiencies in the current RFI process, such as delayed responses and poor documentation, frequently result in project delays and cost overruns (Shim et al., 2016; Hughes et al., 2013). The absence of a streamlined, standardised RFI process limits the potential of BIM and Lean to achieve their full impact in enhancing information flow and project performance.

This thesis addresses these gaps by developing a new RFI process that integrates BIM and Lean Construction tools. The proposed process aims to streamline information flow, reduce waste, and enhance overall project efficiency. It will provide a detailed analysis of existing RFI practices and offer practical guidelines for industry professionals, validated through feedback from workshops with construction stakeholders.

1.2 Research Justification

The construction industry continues to struggle with inefficiencies in managing information flow, particularly concerning the Request for Information (RFI) process. Studies indicate that fragmented communication, reliance on outdated manual processes, and lack of standardisation contribute to project delays, cost overruns, and rework (Egan, 1998; Latham, 1994; Hanna et al., 2012). Despite technological advancements, the integration of Building Information Modelling (BIM) and Lean Construction within the RFI process remains significantly underexplored, leaving room for improvement in industry practices (Azhar et al., 2012; Sacks et al., 2010).

1.2.1 The Industry-Wide Challenge of RFIs

The RFI process plays a crucial role in clarifying design intent, resolving ambiguities, and ensuring project stakeholders are aligned (Hanna et al., 2012; Shim et al., 2016). However, its mismanagement leads to inefficiencies:

- RFIs account for significant project delays and cost increases. Large-scale projects generate an average of 9.9 RFIs per $1 million of project value, with delayed responses directly impacting construction timelines (Papajohn & El Asmar, 2021).
- Miscommunication and lack of standardisation result in redundant RFIs, creating additional administrative burden (Gootee, 2015; Hughes et al., 2013).
- Studies show that design and documentation errors contribute to 52% of rework costs on projects (Love et al., 2004), highlighting the need for better information flow mechanisms.

Despite these challenges, many industry professionals still rely on traditional, paper-based or semi-digital RFI processes, leading to lost information, slow decision-making, and project bottlenecks (Eastman et al., 2011; Cho & Ballard, 2011). A structured, BIM-Lean-integrated RFI framework has not yet been fully developed or widely adopted, despite its potential to enhance efficiency, improve collaboration, and reduce information waste.

1.2.2 The Untapped Potential of BIM and Lean Construction in RFIs

BIM and Lean Construction have independently demonstrated their ability to enhance efficiency, reduce waste, and improve collaboration (Azhar, 2011; Dave et al., 2013). BIM enables real-time clash detection, centralised information management, and automation, significantly reducing the number of RFIs by improving design coordination and minimising inconsistencies (Sacks et al., 2010; Eastman et al., 2011). Lean Construction, on the other hand, focuses on continuous improvement, waste reduction, and process efficiency (Ballard & Howell, 2003; Koskela, 2000).

Despite their demonstrated benefits, the integration of BIM and Lean principles in RFI workflows remains limited:

- BIM is typically used for design coordination and clash detection, but its potential in structuring and automating RFIs is underutilised (Tauriainen et al., 2016).
- Lean Construction methods such as the Last Planner System and Value Stream Mapping are used to improve workflow reliability, but their direct application in RFI management has not been fully explored (Sacks et al., 2010; Howell & Ballard, 1998).
- The combination of BIM and Lean Construction offers an opportunity to optimise RFIs, yet research has not yet provided a structured and validated framework for integrating these methodologies into RFI workflows (Dave et al., 2013; Sacks et al., 2010).

1.2.3 Addressing the Research Gap with a BIM-Lean Integrated RFI Process

This research fills a critical gap in the literature by developing a structured, BIM-Lean-integrated RFI framework to enhance information flow and efficiency. The study contributes by:

1. Developing an industry-informed RFI process: Unlike previous studies that focus on quantifying RFI impacts, this research proposes a structured workflow that integrates BIM and Lean Construction principles.
2. Bridging theoretical knowledge and industry practice: The research applies BIM-Lean synergies to the practical challenge of RFI inefficiencies, offering a validated solution through industry engagement.
3. Introducing a novel digital guideline and process validation: A dedicated online resource demonstrates the proposed BIM-Lean RFI workflow, providing industry practitioners with an interactive and user-friendly guideline for implementation.

1.2.4 Practical Implications for the Industry

The significance of this study extends beyond academic contributions; it has direct implications for construction professionals by:

- Improving communication efficiency between designers, contractors, and project managers.

- Reducing project delays and cost overruns by automating and structuring RFI workflows.
- Enhancing collaboration and decision-making through real-time BIM-based information exchange.
- Aligning with the UK Government's BIM mandate, which promotes digital transformation and efficiency in public-sector projects (Cabinet Office, 2011).

1.2.5 Key Contributions of This Study

- First-of-its-kind structured BIM-Lean RFI process: While previous research has examined RFIs as indicators of project coordination, this study proposes an integrated framework that actively optimises RFI workflows.
- Validation through industry engagement: Unlike theoretical models, this research incorporates practical insights from construction professionals, ensuring real-world feasibility.
- Development of a digital tool: A dedicated website serves as a practical guide for industry stakeholders, fostering the adoption of the new RFI workflow across various construction projects.

1.2.6 Conclusion

This research fills a crucial knowledge gap by providing an innovative, validated solution to RFI inefficiencies. By leveraging BIM and Lean Construction synergies, it offers a structured, practical approach to improving information flow, reducing delays, and enhancing project efficiency. The findings have significant implications for both academic research and industry practice, paving the way for a more standardised, digital, and Lean-oriented approach to RFI management.

1.3 Problem Statement

The construction industry continues to struggle with inefficiencies in managing information flow, particularly concerning the Request for Information (RFI) process. RFIs are a fundamental communication tool used to clarify design intent, resolve ambiguities, and ensure all project stakeholders have the necessary information to proceed with construction activities. However, despite their importance, the traditional RFI process remains fragmented, slow, and inconsistently managed, leading to significant project delays, cost overruns, and operational inefficiencies (Eastman et al., 2011). Studies have shown that large-scale construction projects generate an average of 9.9 RFIs per $1 million of project value (Navigant Construction Forum, 2013), with unresolved RFIs accounting for over 13% of total project costs (Hanna et al., 2012). On average, each RFI takes 8.4 days to resolve, delaying decision-making and disrupting workflow (Hanna et al., 2012). In complex projects, such as Boston's Big Dig, over 40,000 RFIs were raised, many of which remained unresolved for extended periods, contributing to cost overruns exceeding $12 billion (Shapiro, 2007).

Furthermore, traditional RFI management contributes to inefficiencies due to a lack of standardisation and integration with modern digital tools (Gledson & Greenwood, 2017). The slow adoption of Building Information Modelling (BIM) and Lean Construction methodologies further exacerbates these issues, preventing streamlined communication and efficient decision-making in construction projects (Eastman et al., 2011). Addressing these challenges requires a structured, technology-driven approach to RFI management to mitigate delays and enhance overall project performance.

The persistence of RFI inefficiencies stems from the construction industry's continued reliance on outdated manual processes, with many organisations still using paper-based or semi-digital workflows that lack automation, real-time tracking, and structured categorisation. Without a standardised framework, RFIs are frequently delayed due to inconsistent formatting, unclear queries, and poor coordination between project stakeholders. The absence of an integrated system to streamline RFIs results in unnecessary rework, miscommunication, and lost productivity (Navigant Construction Forum, 2013). Additionally, many RFI requests are preventable, as they often arise from design discrepancies, missing documentation, or coordination errors, which could be mitigated through more effective collaboration and information management (Hanna et al., 2012).

Building Information Modelling (BIM) and Lean Construction have emerged as two of the most transformative methodologies in the construction industry, each offering significant improvements in project efficiency, communication, and waste reduction. BIM enables real-time clash detection, centralised data management, and enhanced visualisation, reducing the need for RFIs by improving design accuracy and coordination (Eastman et al., 2011). Lean Construction, through tools such as the Last Planner System and Value Stream Mapping, enhances workflow efficiency by reducing variability, improving predictability, and fostering collaborative decision-making (Gledson & Greenwood, 2017). Despite their individual successes, BIM and Lean have not been systematically integrated into the RFI process. Current BIM applications focus primarily on design coordination rather than streamlining RFI workflows, while Lean principles have been applied to production planning but rarely to RFI management. As a result, there is a significant research gap in understanding how these methodologies can be combined to optimise information flow and decision-making in RFI workflows.

The construction industry's slow adoption of digital and process-driven solutions for RFIs is in stark contrast to the increasing pressure for modernisation, particularly following government mandates advocating for the digital transformation of construction workflows. The UK Government's BIM Mandate, introduced in 2016, required the adoption of fully collaborative 3D BIM for all public-sector projects, aiming to improve efficiency, reduce waste, and enhance project delivery (Cabinet Office, 2011). However, while BIM adoption has improved design coordination, the integration of BIM into specific project communication processes, such as RFIs, remains inconsistent. Reports from the Construction Industry Institute indicate that standardising the RFI process across projects could improve efficiency by at least 25%, yet no widely accepted framework currently exists to support this transition.

The absence of a structured, validated BIM-Lean RFI framework represents a critical barrier to improving project communication and decision-making. Industry professionals currently lack a systematic approach for leveraging BIM's data management capabilities and Lean's workflow efficiency to enhance the RFI process. Without an integrated approach, RFI responses remain inconsistent, leading to delays, misinterpretations, and lost opportunities for proactive issue resolution (Gledson & Greenwood, 2017). While previous studies have quantified the impact of RFI inefficiencies, there has been little research on developing a structured solution that integrates BIM and Lean principles into a cohesive framework.

This research directly addresses this gap by developing an industry-informed RFI process that integrates BIM and Lean Construction methodologies to improve efficiency, reduce delays, and enhance communication. The study contributes by proposing a structured workflow that standardises the RFI lifecycle, enhances information flow, and introduces automation to eliminate inefficiencies. It bridges theoretical knowledge with industry practice by applying BIM-Lean synergies to the practical challenge of RFI inefficiencies, offering a validated solution through engagement with construction professionals. Additionally, this research introduces a novel digital guideline and process validation mechanism, supported by an interactive online resource that demonstrates the proposed BIM-Lean RFI workflow.

By integrating BIM and Lean principles, the proposed framework aims to standardise and automate RFI workflows, reducing delays, improving communication, and enhancing decision-making. The findings have significant implications for both academic research and industry practice, providing a structured, practical approach to improving information flow and project efficiency. This research not only contributes to knowledge on BIM, Lean Construction, and RFI optimisation but also aligns with industry-wide digital transformation initiatives, offering a scalable and adaptable solution for improving communication and efficiency in construction projects.

1.4 Research Aim and Objectives

The purpose of this thesis is to develop a comprehensive guideline and propose a new Request for Information (RFI) process for the construction industry. This process leverages Building Information Modelling (BIM) and Lean tools to enhance information flow, reduce waste, and improve overall project efficiency. By addressing current gaps in the RFI process, this research seeks to foster better decision-making, improve communication, and contribute to improved project delivery outcomes.

1.4.1 Objectives

1. Understand BIM and Lean Principles
   Conduct a comprehensive literature review to understand the concepts, benefits, and applications of BIM and Lean Construction in the construction industry.

2. Assess the Current RFI Process
   Evaluate the existing RFI process, identifying its challenges and inefficiencies, and examining their impact on project delivery.

3. Investigate BIM and Lean Applications for RFI
   Explore how BIM and Lean principles can be applied to the RFI process to reduce waste and improve information flow.

4. Develop a New RFI Process
   Design an RFI process map integrating BIM and Lean tools to address existing challenges.

5. Create a Practical Guideline and Visualisation Tool
   Develop a guideline and dummy website to visually demonstrate the proposed RFI process and facilitate its adoption.

6. Validate the Proposed Process
   Test and refine the RFI process through focus groups with industry professionals.

Having established the alignment between the research objectives and their respective chapters, this thesis provides a clear roadmap for exploring the integration of BIM and Lean principles to enhance the RFI process. This structured approach ensures a thorough investigation and analysis, contributing to the overall goal of improving information flow and project efficiency in the construction industry. The following section outlines the structure of the thesis, detailing how each chapter collectively addresses the research objectives.

1.5 Thesis Structure

This thesis is organised into eight chapters, each carefully designed to serve a specific purpose in addressing the research objectives and building a cohesive narrative around the proposed enhancements to the Request for Information (RFI) process within the construction industry. The structure reflects a logical flow, guiding the reader through the identification of the problem, the exploration of existing knowledge, and the development and validation of a new approach to improve information flow using Building Information Modelling (BIM) and Lean Construction principles.

To provide a visual representation of the thesis structure and how the various chapters are interconnected, Figure 1-1 presents a mindmap that outlines the key elements of each chapter. This diagram helps to summarise the overall flow and organisation of the thesis, illustrating how each chapter contributes to the development of the research narrative.

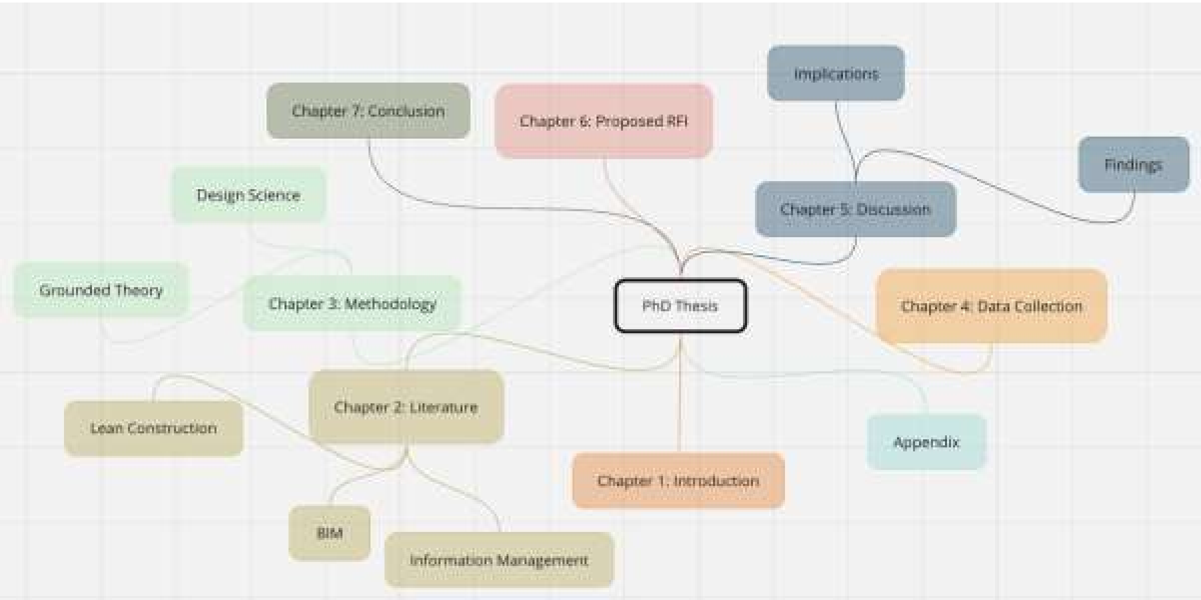

Figure 1-1 PhD Thesis Structure Mindmap

Chapter 1: Introduction

The introductory chapter sets the stage for the research by presenting the context in which the study is situated. It begins by outlining the critical challenges that the construction industry faces in relation to the management of information flow, particularly through the RFI process. The chapter highlights the significance of efficient communication in construction projects and frames the need for integrating innovative methodologies like BIM and Lean Construction to overcome these inefficiencies. It provides a clear rationale for the research, drawing attention to the gaps in current practices and the potential benefits of adopting a new RFI process. Furthermore, the research aim and objectives are presented in detail, establishing a solid foundation for the subsequent chapters. This chapter not only introduces the reader to the problem but also lays out the roadmap that the thesis will follow in seeking solutions.

Chapter 2: Literature Review

Chapter 2 offers an in-depth review of the existing literature on the key themes relevant to the research: BIM, Lean Construction, information management, and the Request for Information process. This chapter critically examines a wide range of academic and industry sources, exploring the concepts, theories, and frameworks that underpin current practices in the construction sector. The literature review serves multiple purposes. It identifies the strengths and limitations of existing approaches to information management and highlights the potential for BIM and Lean methodologies to address inefficiencies in the RFI process. Through this critical analysis, the chapter not only provides context for the research but also identifies the gaps in knowledge that this thesis aims to fill. The insights gleaned from the literature inform the development of the new RFI process, ensuring that the proposed solution is grounded in both theoretical and practical considerations.

Chapter 3: Methodology

The third chapter focuses on the research methodology that underpins the study. It explains the use of the design science methodology in combination with grounded theory as the guiding framework for the research. Design science is particularly suited to this study, as it emphasises the creation and iterative development of artefacts designed to solve real-world problems—in this case, an enhanced RFI process. The methodology chapter elaborates on how the iterative process of designing, testing, and refining the RFI process was conducted, with a strong emphasis on industry feedback through surveys and focus groups. The chapter outlines the research design, detailing the methods of data collection, such as the online survey distributed to industry professionals and the focus groups that provided in-depth qualitative insights. Additionally, the chapter explains the rationale behind selecting these methods, demonstrating how they align with the research objectives and how the iterative nature of design science enables continuous refinement of the proposed process.

Chapter 4: Data Collection and Analysis

Chapter 4 presents the findings from the data collection phase, offering a detailed analysis of the results obtained from both quantitative and qualitative sources. The online survey, administered to a diverse group of construction industry professionals, provided valuable insights into current practices and challenges related to the management of RFIs and the use of BIM and Lean tools. The focus group discussions added depth to these findings by revealing the practical experiences and opinions of those directly involved in construction projects. This chapter analyses the survey responses and the feedback from focus groups, identifying key themes and recurring issues that impact the effectiveness of current RFI processes. By comparing these findings with the theoretical insights from the literature review, the chapter builds a comprehensive understanding of the industry's current approach to RFIs and the areas where improvements are most needed.

Chapter 5: Discussion

The discussion chapter synthesises the findings from the data analysis with the insights gained from the literature review. It critically examines the implications of the research for the construction industry, focusing on how the proposed RFI process addresses the inefficiencies identified in the current practices. The chapter explores the potential benefits of integrating BIM and Lean Construction principles into the RFI process, particularly in terms of enhancing information flow, reducing waste, and improving communication among stakeholders. By comparing the survey and focus group data with the theoretical frameworks explored in Chapter 2, the discussion highlights how the proposed process aligns with industry needs and expectations. The chapter also considers the broader implications of the research for project management and information systems in construction, suggesting that the integration of BIM and Lean tools offers a promising solution to the longstanding challenges in managing RFIs.

Chapter 6: Proposed RFI Process

This chapter introduces the newly developed RFI process, which has been refined through an iterative process of design, testing, and feedback. The proposed process is presented in detail, with a focus on how it integrates BIM and Lean Construction tools to streamline the flow of information. The chapter provides a comprehensive explanation of the RFI process map, illustrating how each step has been designed to address the challenges identified in previous chapters. The process is accompanied by a practical guideline that outlines the roles and responsibilities of key stakeholders in managing RFIs, ensuring that the new system is both effective and user-friendly. In addition to the guideline, the chapter also introduces the dummy website developed to visually demonstrate the RFI process. This website serves as an interactive tool, allowing stakeholders to better understand how the proposed process can be implemented in real-world construction projects. By providing both theoretical and practical insights, this chapter bridges the gap between research and practice.

Chapter 7: Conclusion

The final chapter draws together the key findings of the research, offering a concise summary of the contributions made to the body of knowledge in the areas of BIM, Lean Construction, and RFI processes. It reflects on the extent to which the research objectives have been achieved and evaluates the practical implications of the proposed RFI process for the construction industry. The chapter also discusses the limitations of the study, acknowledging areas where further research is needed to fully validate the proposed solution. In addition to summarising the research, the chapter offers recommendations for future studies, particularly in terms of refining the RFI process and exploring the integration of new technologies in information management. The conclusion emphasises the potential of the proposed process to improve project outcomes, reduce inefficiencies, and enhance communication across the construction sector.

To provide a visual representation of the thesis structure and how the various chapters are interconnected, Figure 1-1 presents a mindmap that outlines the key elements of each chapter. This diagram helps to summarise the overall flow and organisation of the thesis, illustrating how each chapter contributes to the development of the research narrative.

Appendix

The appendices provide supplementary materials that support the research findings presented in this thesis. Each appendix offers additional insights and documentation that reinforce the study's validity, transparency, and applicability in real-world construction projects.

Appendix A contains examples of RFIs used during the first two focus groups (October–November 2022). These examples offer practical insights into the challenges and inefficiencies observed in traditional RFI management, providing a foundation for refining the structured RFI submission process proposed in this study. The appendix serves as a critical reference for understanding how RFIs were analysed, categorised, and addressed within the research framework.

Appendix B presents the structured RFI categorisation and reasoning framework developed in this study. This appendix outlines the classification of RFIs under different categories—Technical, Programme, Cost, and Other—along with associated reasoning codes. It provides a systematic approach to improving RFI management by enhancing clarity, efficiency, and consistency in RFI processing. Additionally, the framework includes guiding questions that help project teams classify and resolve RFIs effectively, supporting more informed decision-making and minimising delays in construction workflows.

Appendix C provides the complete set of survey questions used in the study. These questions were designed to gather industry insights on current practices, challenges, and perspectives regarding the RFI process, BIM adoption, and Lean Construction methodologies. The survey results helped to inform the development of the structured RFI framework and provided data to support the research conclusions.

Appendix D outlines the reasoning behind the workshop survey questions. This appendix explains the rationale for each question and how responses were used to analyse participants' experiences with RFIs. The structured approach ensured that only participants with relevant experience were included and helped frame discussions around the categorisation and impact of RFIs on project outcomes. Additionally, it highlights how the survey responses influenced the refinements made to the proposed BIM-Lean RFI framework.

By offering detailed documentation of the research process, these appendices bridge theoretical discussions with practical applications. They provide valuable insights that contribute to the refinement of industry practices, ensuring that the proposed framework is both theoretically grounded and practically implementable in real-world construction projects.

By following this structured approach, the thesis ensures a coherent progression of ideas and findings. Figure 1-2 visually represents the breakdown of the thesis chapters, guiding the reader through the research journey.

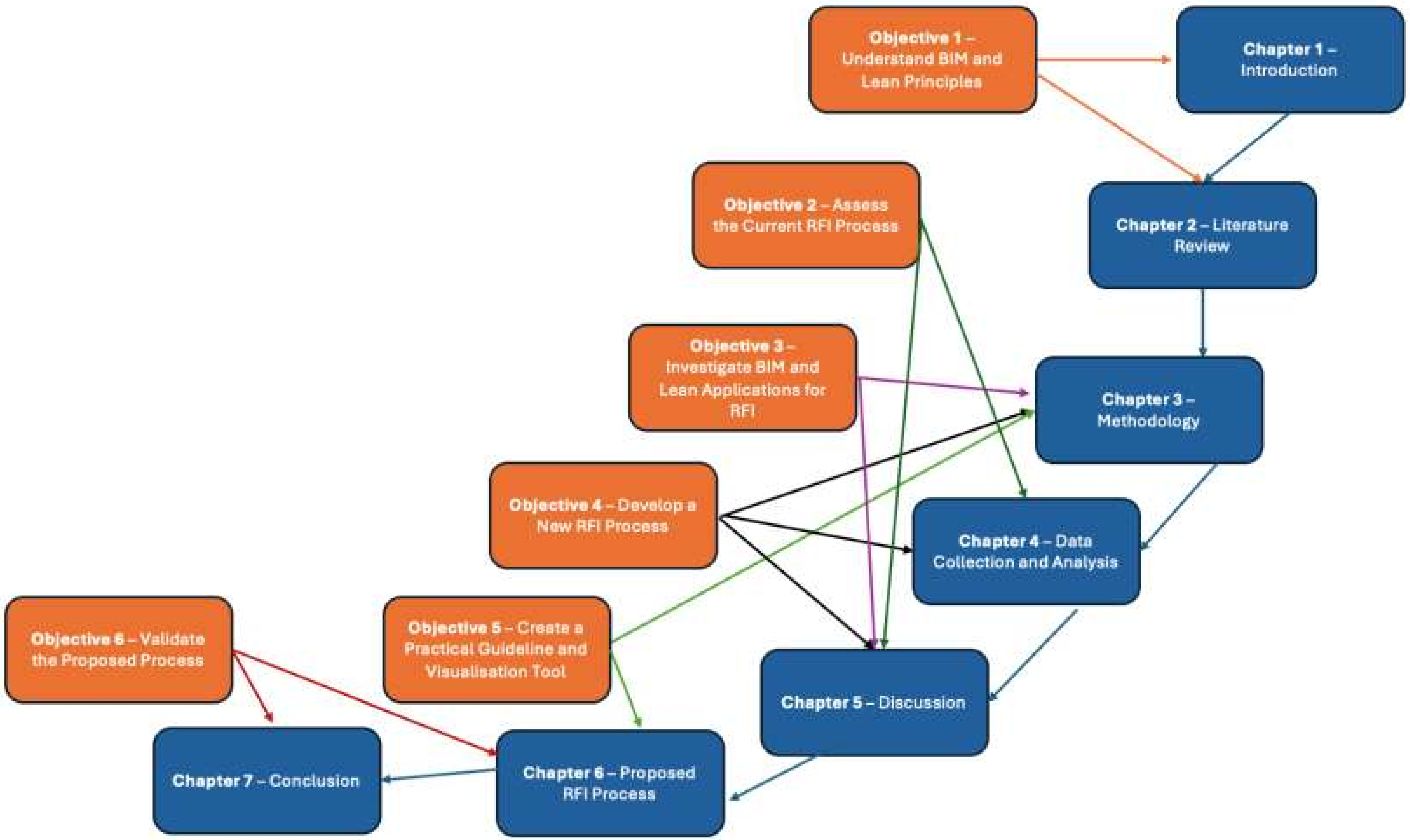

Figure 1-2 Research Process Map

Chapter: 2 Literature Review

2.1 Introduction

The construction industry is characterised by its high complexity and the necessity for seamless coordination among diverse stakeholders to ensure the successful delivery of projects. The involvement of multiple entities, including clients, designers, contractors, subcontractors, and suppliers, creates an intricate web of dependencies that must be effectively managed. Within this dynamic environment, the flow of information plays a pivotal role in ensuring that project activities progress efficiently from conception to completion. The ability to communicate and exchange information in a structured and timely manner is critical for avoiding misinterpretations, errors, and disruptions in the construction workflow. However, the industry has long struggled with inefficiencies in information management, leading to delays, cost overruns, and rework (Love et al., 2004; Dossick & Neff, 2010). These inefficiencies, often exacerbated by fragmented communication channels and siloed decision-making, continue to pose challenges in project delivery.

Recognising the detrimental impact of poor information flow, the construction sector has increasingly turned to technological advancements and process-driven management frameworks to enhance communication and efficiency. Among the most notable innovations are Building Information Modelling (BIM) and Lean Construction, both of which offer transformative potential in addressing long-standing inefficiencies. BIM, as a digital representation of a project's physical and functional characteristics, provides a centralised platform for storing and managing construction-related information. This digital repository fosters greater collaboration by enabling real-time access to up-to-date project data. Meanwhile, Lean Construction, adapted from Lean manufacturing principles, emphasises minimising waste and optimising workflows to enhance project performance (Sacks et al., 2010). By reducing redundancies, eliminating inefficiencies, and improving coordination, Lean Construction complements BIM in offering a holistic approach to project management.

The integration of BIM and Lean Construction has gained significant attention from both academic researchers and industry practitioners, as their combined application holds the potential to revolutionise project delivery. Synergies between these methodologies create opportunities for enhanced communication, reduced delays, and improved decision-making by streamlining the flow of critical information (Bolpagni et al., 2017). Despite these advantages, the construction industry still struggles with fully leveraging BIM and Lean principles to optimise information management processes. One area where this gap is particularly evident is in the Request for Information (RFI) process, which remains a fundamental yet inefficient communication tool in project execution.

The RFI process serves as a mechanism for clarifying design intent, resolving ambiguities, and ensuring that all project stakeholders have the information necessary to proceed with construction activities.

However, RFIs are often poorly managed, inconsistently documented, and slow to resolve, leading to project disruptions and financial implications. Integrating BIM's structured data environment with Lean's efficiency-driven workflows presents an opportunity to transform how RFIs are processed, eliminating redundancies, expediting response times, and improving overall project coordination.

This chapter critically reviews the literature on information flow management in construction, with a particular emphasis on the roles of BIM and Lean Construction in enhancing communication and reducing inefficiencies. It also examines the challenges associated with current RFI processes, highlighting the opportunities for integrating BIM and Lean principles to streamline information exchange and decision-making. The review will trace the historical development of these methodologies, assess their current applications in the industry, and identify existing research gaps. In doing so, this chapter sets the foundation for the research by exploring how BIM and Lean Construction can be systematically integrated to optimise RFI management, addressing a critical need for improved efficiency and communication in construction projects.

2.2 Project Success Criteria

Defining project success has long been a challenge in the construction industry, given the diverse range of stakeholder perspectives and the complexity of projects. Historically, success has been measured using the iron triangle of time, cost, and quality (Atkinson, 1999). While these parameters remain fundamental, they have been increasingly critiqued for their narrow scope, as they fail to capture broader project impacts, such as stakeholder satisfaction, long-term project benefits, and sustainability (Shenhar et al., 2001). Modern approaches to project success now emphasise a multidimensional evaluation, acknowledging that a project deemed successful by one metric may not meet the expectations of another, depending on the priorities of different stakeholders (Kerzner, 2017).

To provide a more comprehensive framework for measuring project outcomes, Critical Success Factors (CSFs) and Key Performance Indicators (KPIs) have been widely adopted. CSFs refer to the essential elements that drive a project's desired outcome, while KPIs provide measurable indicators of performance (Ika, 2009). In construction, effective collaboration, communication, and trust have emerged as key CSFs, particularly in complex environments where multiple teams and disciplines are involved (Fortune & White, 2006). Given the fragmented nature of the industry, the ability to efficiently manage the flow of information across stakeholders has become a determining factor in achieving project objectives.

From the perspective of Lean Construction, success is intricately linked to the elimination of waste and the creation of value for stakeholders. Lean Construction places emphasis on understanding stakeholder needs, improving workflow efficiency, and reducing non-value-adding activities through structured methodologies such as the Last Planner System and Value Stream Mapping (Koskela, 1992). By streamlining processes and minimising inefficiencies, Lean Construction promotes continuous improvement and predictable project outcomes, ensuring that stakeholder expectations are met with greater reliability.

Recent research by Moradi and Kähkönen (2022) highlights six core success factors in collaborative construction projects (Table 2.1), including:

- Contract commitment
- Open communication
- Mutual trust
- Effective decision-making
- Competent team selection
- Early stakeholder involvement

These factors strongly align with Lean Construction principles, reinforcing the importance of collaboration, transparency, and proactive engagement in achieving successful project outcomes. As the construction industry continues to embrace digital transformation, particularly through BIM and Lean integration, project success criteria are evolving to include efficiency-driven metrics that reflect enhanced coordination, reduced waste, and stakeholder-centric value delivery.

Table 2-1 Core Success Factors for Collaborative Construction Projects (Moradi & Kähkönen, 2022)

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Success factor	Alliance	IPD	Partnering	Reference
Appropriate and relevant contract	√	√	√	Hietajärvi *et al.* (2017), Kent and Becerik-Gerber (2010), Zhang and Kumaraswamy (2001)
Commitment to win–win philosophy	√	√	√	Chan *et al.* (2004a, b), Cheng and Li (2004), Cho *et al.* (2010), Kent and Becerik-Gerber (2010), MohammadHasanzadeh *et al.* (2014), Ng *et al.* (2002), Raslim and Mustaffa (2017), Wang *et al.* (2016), Young *et al.* (2016)
Collaboration and Cooperation	√	√	√	Bellini *et al.* (2016), Ling *et al.* (2020), Nevstad *et al.* (2018), Young *et al.* (2016)
Equality	√	√	√	Kent and Becerik-Gerber (2010), Lichtig (2005), Wang *et al.* (2016), Young *et al.* (2016)
Incentive system	√	√	√	Bellini *et al.* (2016), Kent and Becerik-Gerber (2010), Young *et al.* (2016)
Open communication	√	√	√	Bellini *et al.* (2016), Cheng and Li (2004), Cho *et al.* (2010), Doloi (2013), Lloyd and Varey (2003), Kent and Becerik-Gerber (2010), Nevstad *et al.* (2018), Raslim and Mustaffa (2017), Wang *et al.* (2016), Young *et al.* (2016)
Mutual trust	√	√	√	Bellini *et al.* (2016), Cheng and Li (2004), Doloi (2013), Ghassemi and Becerik-Gerber (2011), Kent and Becerik-Gerber (2010), Nevstad *et al.* (2018), Raslim and Mustaffa (2017), Whang *et al.* (2019), Wang *et al.* (2016), Young *et al.* (2016)
Selecting competent people for the project	√	√	√	Ghassemi and Becerik-Gerber (2011), Ling *et al.* (2020), MohammadHasanzadeh *et al.* (2014), Young *et al.* (2016)

Table 2. Core success factors for collaborative construction projects

An essential component of project success is effective communication, particularly within the Request for Information (RFI) process. RFIs serve as formal requests for clarification or additional information and are a critical tool for ensuring alignment among project stakeholders. An efficiently managed RFI process facilitates prompt issue resolution, mitigating the risk of delays, cost overruns, and rework (Dainty et al., 2007). By streamlining the exchange of information between teams, RFIs play a crucial role in maintaining project momentum and reducing inefficiencies that arise from miscommunication or ambiguity. The ability to effectively manage RFIs is therefore integral to achieving overall project success.

In conclusion, project success in the modern construction industry must be viewed through a holistic lens that extends beyond the traditional time-cost-quality paradigm. The integration of Lean Construction and BIM methodologies offers powerful tools and strategies for enhancing communication, collaboration, and efficiency, all of which are essential for meeting the expanding criteria of project success. Understanding and addressing information flow challenges, particularly through structured

RFI management, is critical to ensuring that project teams can effectively coordinate their efforts and achieve optimal project outcomes.

2.3 Information Flow in the Construction Industry

Technological advancements in recent years have led to an unprecedented expansion in the volume of data generated during construction projects (Al Hattab & Hamzeh, 2013). However, the key challenge lies in effectively managing and utilising this data to enhance decision-making and streamline project processes (Leite et al., 2016). Mismanagement of information, whether through redundancy, inaccuracy, or delayed sharing, can result in significant inefficiencies, such as rework, project delays, and increased costs (Phelps, 2012). Given the complexity of construction projects and the number of stakeholders involved, ensuring the smooth flow of accurate and timely information is critical for project success and risk mitigation.

Poor information flow management often results from fragmented processes where data is not adequately disseminated to all relevant stakeholders, leading to miscommunication and delays in decision-making (Hicks, 2007; Tribelsky & Sacks, 2010). When information is not effectively shared or structured, project teams face numerous challenges that affect productivity and performance. The consequences of ineffective information flow include extended project timelines, cost overruns, and missed opportunities for optimisation. Table 2.2 summarises the most common challenges in information flow management and their associated impacts on construction projects.

Table 2-2 Common Challenges in Information Flow Management

Challenge	Impact on Project
Redundant Information	Increased rework and inefficiencies
Inaccurate Data	Poor decision-making
Delayed Sharing	Project delays and misalignment
Fragmented Processes	Miscommunication between stakeholders

Both Lean Construction and BIM offer promising solutions to overcome these inefficiencies. Lean Construction focuses on eliminating waste, improving workflow, and enhancing efficiency, while BIM provides digital tools for better data visualisation, coordination, and real-time information sharing (Sacks & Pikas, 2013). Together, these approaches improve the flow of critical project data, reduce inefficiencies, and support better decision-making.

BIM, in particular, enables transparent and dynamic information sharing among stakeholders by providing a centralised digital repository for project-related data. This helps reduce delays, improve coordination, and facilitate real-time decision-making (Al Hattab & Hamzeh, 2013; Sacks & Pikas, 2013). Through features such as visualisation, clash detection, and comprehensive asset information, BIM promotes a more collaborative and efficient work environment, ensuring that all project participants have access to accurate and up-to-date information (Azhar, 2011).

2.3.1 Definition of Information

In construction project management, it is essential to understand how raw data transforms into meaningful information and knowledge. According to Davis & Olson (1984), information is data that has been processed into a form that is useful for decision-making. This transformation occurs through a structured hierarchy, typically categorised into three levels:

- Data: Raw, unprocessed facts collected for reference or analysis. In construction, data may include measurements, material specifications, cost estimates, or project schedules (Ackoff, 1989).
- Information: Processed data that provides context and relevance, helping guide decisions. For instance, summarising project timelines or financial reports converts raw data into actionable information (Ackoff, 1989).
- Knowledge: The interpretation and synthesis of information that enables deeper insights and strategic decision-making. Knowledge is often gained through experience, industry best practices, and predictive analysis, helping project teams anticipate challenges and optimise workflows (Nonaka & Takeuchi, 1995).

The transformation from data to knowledge is crucial in construction management, as it allows project teams to predict outcomes, mitigate risks, and improve overall efficiency. Without structured information flow, decision-making can become fragmented, leading to inconsistencies and operational delays.

2.3.2 Pillars of Information Management

Effective information flow in the construction industry relies on three interdependent pillars: people, processes, and technology (Davenport & Prusak, 1998). Each of these components plays a crucial role in ensuring the smooth transmission, accessibility, and usability of project-related information.

- People: The originators and users of information who are responsible for collecting, processing, and applying it in project decision-making. Well-trained personnel, leadership support, and collaboration among stakeholders are essential for effective information flow (Dalkir, 2017). Without skilled individuals, even the most advanced technologies and processes fail to function optimally.
- Processes: Formalised methods for collecting, storing, disseminating, and using information. Standardised workflows ensure that relevant data reaches the right individuals at the right time

(Al Hattab & Hamzeh, 2013). Well-defined processes help maintain data accuracy, eliminate inefficiencies, and streamline communication across teams.

- Technology: Digital tools such as databases, BIM platforms, and automation software provide a structured means of storing, analysing, and sharing information (Leite et al., 2016). Technology enables real-time collaboration, ensuring that project teams have instant access to critical information and can make informed decisions accordingly.

These pillars are interdependent, meaning that advanced technology alone will not compensate for a lack of skilled personnel, and efficient processes require adequate technological support and human expertise. When integrated effectively, these three pillars facilitate seamless information flow, enhancing decision-making, collaboration, and overall project success.

Building Information Modelling (BIM) has emerged as a transformative enabler of information management in construction projects (Azhar, 2011). By aligning people, processes, and technology, BIM fosters a collaborative digital environment where project stakeholders can access, update, and share critical information in real time. Figure 2.1 illustrates how BIM enhances the three pillars of information management, ultimately leading to improved project coordination, reduced waste, and increased efficiency.

Figure 2-1 BIM - People, Process and Technology

By integrating BIM with Lean Construction methodologies, the industry can move toward a more streamlined, error-free, and highly efficient information flow framework. As the construction sector continues its digital transformation, ensuring that information flows seamlessly across project teams will be key to enhancing productivity, reducing costs, and delivering projects on time.

2.3.3 Information Flow and the RFI Process

The Request for Information (RFI) process is one of the most essential communication tools in construction, enabling the exchange of critical information between stakeholders during project execution. RFIs are typically used to clarify design details, resolve ambiguities, and address unforeseen issues that arise during construction. However, inefficiencies in the traditional RFI process—such as delays in responses, lack of standardisation, and unclear questions—can lead to significant time and cost overruns, negatively impacting project performance (Hughes et al., 2013). Given that RFIs play a pivotal role in project coordination and risk mitigation, improving the efficiency of this process is crucial for ensuring smooth project execution and reducing unnecessary disruptions.

BIM and Lean Construction present viable solutions to enhance the RFI process by streamlining information flow and reducing inefficiencies. BIM provides a centralised platform where RFIs can be logged, tracked, and resolved in a more structured manner. By integrating RFI management into a BIM environment, project teams gain access to real-time information, enabling faster collaboration, better transparency, and more efficient issue resolution (Azhar, 2011). Additionally, BIM facilitates visualisation and digital documentation, allowing stakeholders to access and interpret project details more accurately and promptly, thus reducing the number of unnecessary RFIs.

Similarly, Lean Construction principles focus on optimising workflows and eliminating non-value-adding activities, which can greatly improve the efficiency of the RFI process. Lean methodologies, such as the Last Planner System and Value Stream Mapping, help identify process bottlenecks and inefficiencies in RFI management (Sacks et al., 2010). By applying Lean principles, project teams can enhance communication, improve response times, and reduce the waste associated with excessive RFIs, ensuring that information reaches the right people at the right time.

Despite these advancements, there remains a notable gap in the literature regarding the full integration of BIM and Lean Construction into the RFI process. While existing research has extensively examined the individual benefits of these tools, limited studies have explored their combined application in optimising RFI workflows. The lack of a structured framework that integrates BIM and Lean methodologies into a unified RFI management approach represents an opportunity for further research. Understanding how these tools can be synergistically applied to refine the RFI process is critical to addressing persistent inefficiencies in construction project communication.

The following section will explore Building Information Modelling (BIM) in greater detail, tracing its historical development, examining its role in enhancing information flow, and evaluating its impact on project coordination and communication efficiency.

2.4 Building Information Modelling (BIM)

2.4.1 Definition of BIM

The evolution of Building Information Modelling (BIM) is closely tied to advancements in computer-aided design (CAD) and drafting technologies, which have shaped the digital transformation of the construction industry since the 1960s. Early CAD systems enhanced design accuracy and drafting efficiency, but they were limited to static graphical outputs, lacking the ability to incorporate non-visual project data. As construction projects became increasingly complex, there was a growing demand for a more integrated approach that could merge graphical representation with essential project information, such as scheduling, costs, and material specifications (Lee & Borrmann, 2020). The emergence of object-oriented modelling in the 1980s, which allowed designers to embed metadata within digital objects, marked a significant turning point that laid the foundation for the evolution of BIM (Eastman et al., 2011).

Among the earliest conceptualisations of BIM was Eastman's (1975) Building Description System, which introduced the idea of a digital model capturing both the physical and functional attributes of a building. This pioneering vision set the groundwork for a centralised information repository, anticipating a future where digital models could streamline design, construction, and facility management. However, it was not until Jerry Laiserin formally introduced the term "Building Information Modelling" in 2002 that BIM gained widespread industry recognition (Miettinen & Paavola, 2014). The practical adoption of BIM in large-scale projects did not gain momentum until the early 2000s, when advancements in data storage, processing power, and interoperability enabled the effective implementation of BIM across diverse construction disciplines (Eastman et al., 2011).

The development of BIM also coincided with the rise of Lean Construction, a management philosophy aimed at reducing waste, improving efficiency, and enhancing value generation within the construction sector (Koskela, 1992). The synergies between Lean and BIM became increasingly apparent as both methodologies focused on eliminating inefficiencies, enhancing collaboration, and optimising project workflows. This intersection is central to this thesis, which explores how the integration of BIM and Lean methodologies can enhance information flow and streamline project management processes, particularly in relation to the Request for Information (RFI) process. By leveraging the combined capabilities of BIM's structured data environment and Lean's process-driven efficiency, the construction industry can address longstanding communication bottlenecks and move toward a more proactive and streamlined information management approach.

2.4.2 The UK BIM Mandate and its Impact

The UK Government's BIM Mandate of 2011 marked a transformational shift in the global construction industry. By 2016, the mandate required all public projects in the UK to adopt BIM Level 2, setting a new standard for digital collaboration, data management, and process integration (Cabinet Office, 2011). This initiative was part of a broader effort to modernise the UK construction sector, which had long suffered from inefficiencies, cost overruns, and fragmented communication (HM Government, 2017). The mandate's primary objective was to standardise data management, enhance transparency, and improve cross-disciplinary collaboration across public construction projects.

While the BIM mandate has significantly accelerated BIM adoption in the UK, leading to notable cost savings, improved project coordination, and increased efficiency (HM Government, 2017), several challenges and gaps remain. Although public-sector projects have benefited from greater digital integration, private-sector adoption has been inconsistent. Smaller firms, in particular, have struggled to implement BIM due to financial constraints, lack of technical expertise, and resource limitations (NBS, 2017). This disparity in adoption rates creates an uneven landscape, undermining the mandate's broader ambition to standardise and optimise construction efficiency across the entire industry.

Additionally, while the BIM mandate promotes structured collaboration, some critics argue that it risks imposing a rigid, one-size-fits-all model, potentially stifling innovation and adaptability. Smaller firms, often lacking the resources to meet stringent compliance requirements, may find themselves excluded from government contracts, thereby widening the gap between large and small firms in the industry (NBS, 2017). This imbalance presents an ongoing challenge in achieving uniform BIM maturity across organisations.

Addressing this challenge is a key focus of this thesis, particularly in exploring how BIM can be tailored to meet diverse project requirements and varying levels of organisational readiness. By examining adaptive implementation strategies, this research seeks to contribute to the ongoing discourse on BIM's role in fostering industry-wide digital transformation.

Figure 2.2 demonstrates the evolving role of BIM, illustrating how its usage varies depending on the perspectives of different stakeholders and highlighting the differential impact of BIM adoption across the construction sector (HM Government, 2017).

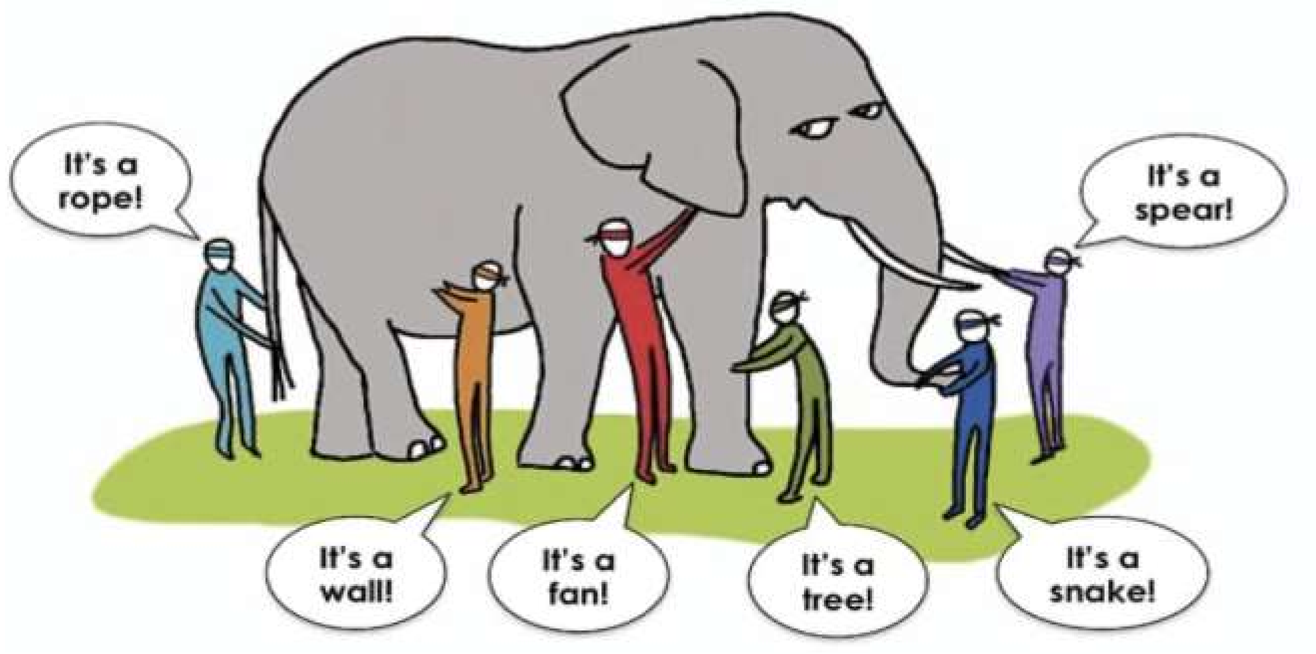


Figure 2-2 BIM's meaning depending on perspective (Eastman et al., 2011)

2.4.3 BIM Adoption Worldwide

BIM adoption has expanded significantly over the past decade, yet its implementation remains highly variable across regions and industries. Countries such as the UK, the US, and parts of Europe have led the way, largely driven by governmental mandates, industry initiatives, and market pressure to enhance efficiency and collaboration in construction projects (UK BIM Alliance, 2020; Khosrowshahi & Arayici, 2012). For example, the UK Government's BIM Mandate of 2011 required the use of BIM Level 2 for all public projects by 2016, accelerating its adoption within the public sector (Cabinet Office, 2011). However, private sector uptake has been slower, particularly among small and medium-sized enterprises (SMEs) that often lack the resources and expertise to implement BIM effectively (NBS, 2017).

Globally, BIM adoption is shaped by a combination of factors, including governmental policies, industry regulations, market demand, and workforce capabilities. In regions with strong governmental support, such as the UK and Singapore, BIM adoption has progressed more rapidly, benefiting from national strategies, regulatory enforcement, and structured training programs. Conversely, in countries without legislative mandates, BIM adoption has been gradual, often concentrated within large-scale construction firms, leaving smaller companies and private sector developments lagging behind (Sun et al., 2015). The disparity in adoption across developed and developing markets highlights the need for customised implementation strategies that cater to the unique challenges faced by different regions and industry sectors.

2.4.3.1 Critical Analysis of BIM Adoption Barriers

Despite significant advancements, multiple barriers continue to impede widespread BIM adoption, particularly in regions with less robust industry regulations or in smaller firms that lack the financial and technical capacity to invest in BIM. One of the most significant barriers to adoption is the high cost of BIM implementation, including software licensing, hardware upgrades, and specialised training required to integrate BIM into existing workflows (Sun et al., 2015). While large firms are more likely to absorb these costs, SMEs often struggle to justify the upfront investment, leading to disparities in adoption rates (Barlish, 2011). This financial burden highlights the need for more accessible training programs, government subsidies, and phased implementation approaches to support smaller firms in transitioning to BIM-based processes.

Another major challenge is interoperability between different BIM platforms, as the lack of standardisation in file formats, data protocols, and software integration hampers seamless collaboration (Khosrowshahi & Arayici, 2012). The absence of uniform interoperability standards results in data silos, inefficient workflows, and difficulties in cross-disciplinary collaboration, particularly in projects involving multiple stakeholders using different BIM software.

Additionally, legal and contractual issues present complex obstacles to BIM adoption, particularly concerning model ownership, intellectual property rights, and liability (Azhar, 2011). These issues become particularly problematic in collaborative projects, where multiple organisations contribute to and rely on shared BIM models. Disputes over data accuracy, model modifications, and responsibility for errors can hinder trust and discourage firms from fully embracing BIM workflows (Eadie et al., 2013). Developing clear contractual frameworks, defining roles and responsibilities, and establishing transparent data-sharing agreements are crucial steps toward resolving these challenges and enhancing industry-wide adoption of BIM.

Addressing these barriers requires a multi-faceted approach, including regulatory support, standardisation initiatives, cost-reduction strategies, and industry-wide education programs. By tackling these challenges, BIM adoption can progress more uniformly, ensuring that both public and private sector projects benefit from the efficiencies, cost savings, and enhanced collaboration that BIM offers.

2.4.3.2 Overview of Global BIM Adoption

Tables 2.3 and 2.4, based on the work of Eischet & Kaduma (2022), provide a comprehensive overview of BIM adoption trends worldwide. These tables illustrate the varying levels of BIM implementation across different regions and industry sectors, highlighting the key factors influencing the uptake of BIM technology. While governmental mandates, industry standards, and digital transformation initiatives have accelerated adoption in certain countries, persistent barriers such as financial constraints, lack of expertise, interoperability challenges, and legal uncertainties continue to slow progress in others.

Table 2-3 Overview of BIM adoption worldwide part1 (Eischet & Kaduma, 2022)

United States of America	2003	National 3D-4D-BIM Program
Finland	2007	Open-BIM mandate for new buildings
Norway	2008	Open-BIM mandate
Denmark	2011	BIM mandate for all government buildings
Netherlands	2012	Open-BIM mandate for infrastructure
Austria	2015	Introduction of Open-BIM standards
Sweden	2015	BIM mandatory for transportation
United Kingdom	2016	BIM compulsory for government contracts
France	2017	Announcement of BIM roadmap
Germany	2017	Phased BIM implementation for infrastructure
Czech Republic	2017	Launch of BIM program
European Union	2017	Handbook for the introduction of BIM
Spain	2018	BIM mandatory for all the public construction tenders.
Italy	2019	BIM mandate for large public projects
Russia	2021	BIM mandatory for federal contracts

This table summarises the current state of BIM adoption in leading construction markets, categorising regions based on their level of maturity, regulatory framework, and integration across public and private sectors. The data underscores how policy-driven implementation—as seen in the UK, Singapore, and Scandinavian countries—has facilitated widespread BIM adoption, while market-driven uptake in regions such as the US and parts of Europe reflects industry-led progress rather than government mandates.

Table 2-4 Overview of BIM adoption worldwide part1 (Eischet & Kaduma, 2022)

	Dubai	2013	BIM mandate for 40+ stories or 300,000+ square feet
	Hong Kong	2014	BIM mandate Roadmap
	New Zealand	2014	Launch of BIM program
	Singapore	2015	Mandate for BIM electronic submissions
	Chile	2015	BIM mandate for government projects by 2020
	South Korea	2016	BIM mandate for public projects >S$50 million
	Australia	2018	Start of BIM implementation strategy at state level
	Malaysia	2019	BIM obligatory for public projects >RM100 million
	Abu Dhabi	2019	BIM mandate
	Peru	2019	Launch of BIM program
	Argentina	2019	Plan for adaption of BIM by 2025
	Japan	2020	Guideline for BIM standard workflows
	China	2020	Proposed BIM mandate
	Brazil	2021	BIM mandatory for federal projects

Expanding on regional insights, this table delves into sector-specific variations in BIM adoption, comparing its prevalence in public infrastructure projects, commercial developments, and smaller-scale residential construction. The findings indicate that while large-scale public infrastructure projects tend to embrace BIM due to regulatory requirements, private-sector engagement—particularly among SMEs and independent contractors—remains inconsistent.

These tables provide valuable insights into the global trajectory of BIM adoption, reinforcing the need for tailored implementation strategies that consider regional regulations, industry needs, and technological readiness. Understanding these dynamics is critical to developing sustainable BIM adoption frameworks that support both large enterprises and smaller industry players in achieving digital transformation.

2.4.4 BIM Concept

Building Information Modelling (BIM) represents a paradigm shift in the construction industry, moving beyond a mere software tool to a comprehensive process that integrates various data streams and facilitates real-time collaboration across the entire project lifecycle (Hardin & McCool, 2015). The multifaceted nature of BIM extends beyond traditional 3D modelling to include scheduling (4D), cost estimation (5D), sustainability analysis (6D), and facilities management (7D), demonstrating its transformative potential in project management (Succar, 2009). However, while these capabilities offer unprecedented efficiency gains, they also present challenges related to digital literacy, interoperability, and implementation readiness.

Despite its numerous benefits, misconceptions about BIM persist within the construction industry. A significant number of industry professionals still perceive BIM solely as a 3D visualisation tool, overlooking its potential to enhance data-driven decision-making, automate workflows, and improve information management (Eastman et al., 2011). This narrow perception limits adoption, preventing firms from fully leveraging BIM's capabilities to drive efficiency and collaboration across the project lifecycle. Additionally, smaller firms often struggle with resource constraints, lacking the necessary investment in training, software, and technology upgrades required for complete BIM implementation (Sun et al., 2015). This uneven adoption results in fragmented workflows, limiting the overall impact of BIM-driven efficiency improvements.

Moreover, while BIM is widely promoted as a tool for enhancing collaboration, cultural resistance remains a significant barrier to its successful integration. Many construction firms continue to rely on traditional, siloed methods of information sharing, making it difficult to transition to a collaborative, data-driven work environment (Fenwick et al., 2009). This silo mentality, deeply ingrained in industry practices, contradicts the core principles of BIM, which emphasise transparency, information accessibility, and seamless coordination among project stakeholders. Overcoming this resistance requires not only technological solutions but also robust change management strategies, ensuring that organisational structures and workflows align with BIM's collaborative framework.

At its core, Building Information Modelling (BIM) is about fostering collaboration across all phases of a construction project, from design and planning to execution and facility management. Figure 2.3 visually represents the collaborative nature of BIM, demonstrating how multiple data streams are integrated to facilitate real-time decision-making among project stakeholders. This diagram underscores the importance of teamwork and digital coordination in harnessing the full potential of BIM (Eastman et al., 2011; Hui, 2018). As BIM adoption continues to evolve, industry-wide education, standardisation, and organisational adaptation will be key to overcoming barriers and ensuring seamless integration of BIM-enabled workflows.

Figure 2-3 BIM Collaborative Diagram (Eastman et al., 2011; Hui, 2018)

2.4.5 BIM Maturity Stages

The BIM Maturity Model, developed by Mark Bew and Mervyn Richards, provides a structured framework for the progressive adoption of BIM, categorised into four levels of increasing complexity and collaboration (BSI BIM Task Group, 2011). As illustrated in Figure 2.4, the model outlines the evolution of BIM implementation, ranging from basic 2D drafting (Level 0) to fully integrated, cloud-based collaboration systems (Level 3).

- Level 0 represents the use of 2D CAD drawings, where information is largely paper-based, fragmented, and lacks standardisation.
- Level 1 involves basic digital collaboration, using 3D models, but with separate data sources and semi-structured electronic documents.
- Level 2 requires a Common Data Environment (CDE), where models and information are federated, allowing improved collaboration and structured data exchange.
- Level 3, also referred to as iBIM (integrated BIM), envisions fully automated, real-time collaboration, where interoperable data is web-stored and accessible across project stakeholders throughout the asset lifecycle.

While the BIM Maturity Model has been instrumental in guiding BIM adoption, several challenges have emerged in its practical application. The transition from Level 1 to Level 2, which involves file-based collaboration to a fully integrated CDE, is often a significant hurdle for many firms (Mordue, 2016). This shift requires not only technological investment but also a fundamental transformation in organisational workflows and collaborative practices. Firms lacking experience in digital systems often struggle with process alignment, data standardisation, and interoperability, making this transition particularly complex and resource-intensive.

Additionally, firms that successfully implement BIM Level 2 frequently face further obstacles in advancing to BIM Level 3. Level 3 adoption demands real-time collaboration and concurrent engineering workflows, necessitating significant investments in cloud-based technologies, interoperability frameworks, and staff training. These barriers are especially daunting for small and medium-sized enterprises (SMEs), where financial constraints and the complexities of full integration can hinder progress (Sun et al., 2015). Moreover, the lack of globally standardised guidelines contributes to inconsistencies in BIM implementation, making it difficult to achieve uniformity in workflows and data-sharing practices across different regions and project types.

Understanding the BIM Maturity Model and its associated challenges is crucial for organisations seeking to optimise their digital transformation strategies. As industry-wide adoption continues, overcoming these technological, organisational, and regulatory barriers will be key to ensuring the seamless integration of BIM processes across all levels of project execution.

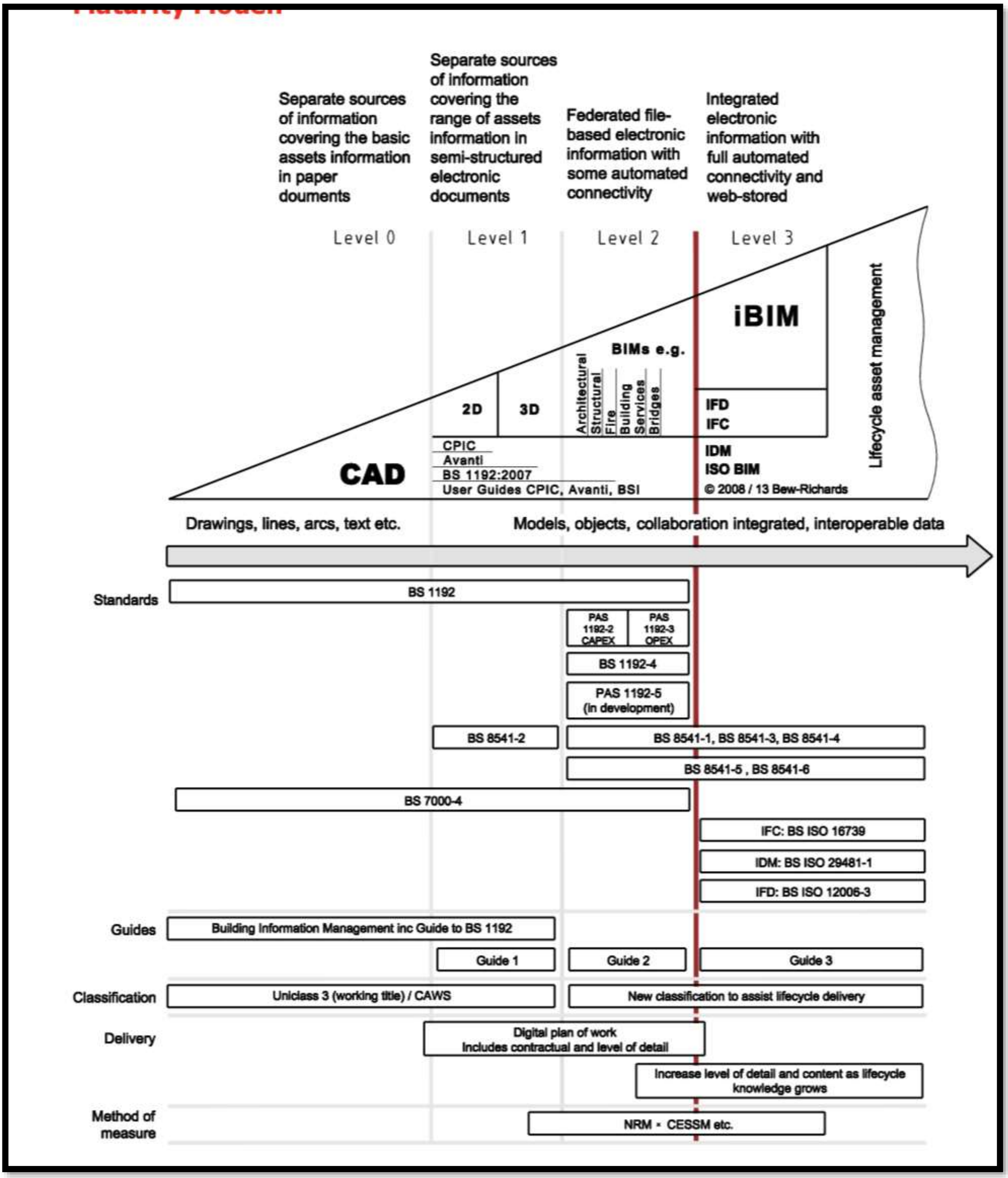


Figure 2-4 BIM maturity level Model (BSI BIM Task Group, 2011)

2.4.6 Components of the UK BIM Framework

The UK BIM Framework provides a comprehensive set of standards and guidelines for implementing BIM across construction projects, with a strong emphasis on collaboration, information management, and interoperability (UK BIM Alliance, 2020). At its core, the framework promotes the use of a Common Data Environment (CDE), ensuring real-time access to up-to-date project data for all stakeholders. By fostering transparency, accuracy, and collaboration, the CDE serves as a foundation for digital construction workflows.

However, the implementation of the UK BIM Framework has revealed several challenges. While larger firms often have the resources and expertise to establish robust CDEs, smaller firms frequently struggle due to limited infrastructure, financial constraints, and a lack of skilled personnel (Sun et al., 2015). This disparity results in varying levels of BIM maturity across the construction supply chain, creating gaps in efficiency and digital integration.

Additionally, the framework's rigid focus on compliance can sometimes lead to an overemphasis on meeting regulatory requirements at the expense of fostering innovation. Some firms perceive compliance as an additional bureaucratic hurdle, rather than as an opportunity for process enhancement. Striking a balance between standardisation and adaptability remains a key challenge for the industry.

Another crucial aspect of the framework is its strong emphasis on digital competency, underscoring the importance of training and skill development. As the construction industry continues to digitise, a significant skills gap has emerged, particularly among firms that have traditionally relied on manual processes (Khosrowshahi & Arayici, 2012). Ensuring that all project stakeholders possess the necessary BIM expertise is critical for achieving consistent implementation and maximising the benefits of digital construction methodologies.

2.4.7 Benefits of BIM

BIM offers numerous advantages throughout the project lifecycle, including enhanced visualisation, increased productivity, improved collaboration, and streamlined project coordination (Azhar, 2011). As a centralised knowledge resource, BIM enables stakeholders to make more informed decisions at every stage of the project, reducing the need for rework and accelerating project delivery. One of BIM's most valuable capabilities is clash detection, which allows teams to identify and resolve conflicts between building systems before construction begins, saving time, costs, and resources (Eastman et al., 2011). However, the effectiveness of clash detection depends on how early BIM is integrated into the project. If introduced too late, design conflicts may have already materialised, reducing BIM's ability to proactively prevent issues (Azhar et al., 2008).

The extent to which these benefits are realised is heavily dependent on data quality and digital literacy among BIM users (Kjartansdóttir et al., 2017). Poor data management practices can undermine BIM's potential benefits, as inaccurate or incomplete data can lead to flawed visualisations, misinformation, and erroneous decision-making (Eastman et al., 2011). This highlights the need for robust data governance protocols, standardised workflows, and consistent stakeholder training to ensure accurate and effective use of BIM.

Beyond efficiency gains, sustainability is another key area where BIM can have a significant impact. By enabling energy modelling, carbon footprint analysis, and environmental impact assessments, BIM assists project teams in making sustainable design and construction choices (Volk et al., 2014). However, in practice, the real-world impact of BIM on sustainability is often limited by a lack of expertise in fully leveraging these capabilities (Valero et al., 2011). Expanding education and training in BIM-based sustainability analysis could bridge this gap and improve environmental outcomes in the construction industry.

Additionally, BIM's centralised data management enhances project coordination and reduces miscommunication. By ensuring that all project participants—including designers, engineers, contractors, and facility managers—are working with the most up-to-date information, BIM minimises errors, enhances collaboration, and improves data accuracy (Sacks et al., 2018).

Figure 2.5 visually summarises these key BIM benefits, illustrating how features such as clash detection, project coordination, sustainability, and safety management integrate into the BIM framework to enhance project efficiency and outcomes.

Figure 2-5 BIM benefits

2.4.8 Challenges of BIM Adoption

Despite the recognised benefits of BIM, its adoption within the Architecture, Engineering, and Construction (AEC) industry continues to face significant challenges. A primary barrier is the lack of interoperability between various BIM software platforms, which complicates data sharing and disrupts the seamless information flow that BIM is designed to facilitate (Sun et al., 2015), as shown in Table 2.5. The reliance on proprietary systems and the slow adoption of open standards, such as Industry Foundation Classes (IFCs), further exacerbates this issue, leading to fragmented workflows and data silos.

Another major challenge is the high costs associated with BIM implementation. While larger firms often have the financial resources to invest in software, hardware, and workforce training, small to medium-sized enterprises (SMEs) frequently struggle with the financial outlay, making it difficult to justify investment (Barlish, 2011). This disparity in BIM adoption leads to inconsistent implementation across projects, affecting collaboration efficiency in multi-stakeholder environments.

Legal and contractual issues also pose significant obstacles, particularly regarding intellectual property rights (IPR). Disputes over model ownership, data-sharing responsibilities, and liability concerns often lead to hesitancy in collaborative working practices (Azhar, 2011). The lack of clear legal frameworks governing BIM usage further complicates the integration of shared digital models into construction workflows.

Table 2-5 Categories of factors limiting BIM adoption (Sun et al., 2015)

Category	Key Challenges
Technology	Lack of interoperability, software limitations, and integration with existing systems
Cost	High initial investment in software, hardware, and training
Management	Resistance to change, lack of top-down support for BIM implementation
Personnel	Insufficient training and expertise in BIM tools and processes
Legal	Ambiguity in model ownership, liability issues, and intellectual property rights

2.4.9 Management and Cultural Resistance

Organisational resistance to change is another significant challenge in BIM adoption. The construction industry, historically slow in embracing new technologies, often clings to traditional workflows and practices. This resistance is particularly pronounced in organisations where leadership does not actively promote digital transformation. Without top-down support, BIM adoption tends to be fragmented and inconsistent, limiting its full potential (Sun et al., 2015).

Additionally, the skills gap within the industry plays a crucial role in hindering BIM adoption. Effective use of BIM requires both technical proficiency and a deep understanding of collaborative workflows. Many firms, particularly SMEs, struggle to bridge this skills gap, resulting in suboptimal BIM implementation and an inability to fully leverage BIM's capabilities (Liu et al., 2022). Addressing these training and competency gaps through structured education programs and industry-wide upskilling initiatives is essential for ensuring the long-term success of BIM integration.

2.4.10 Interoperability and Legal Issues

While technological advancements such as open standards exist to address interoperability challenges, adoption has been slow. Many software vendors continue to rely on proprietary systems, hindering the development of universally compatible standards and limiting BIM's potential as a fully collaborative tool (Sun et al., 2015). This fragmentation in software ecosystems restricts seamless data exchange and cross-platform integration, making interdisciplinary collaboration more complex.

Legal concerns surrounding data ownership and intellectual property rights introduce further complexities in collaborative BIM projects. While frameworks such as the UK BIM Protocol have been developed to address these concerns, many legal uncertainties remain unresolved, particularly in international projects where jurisdictional differences complicate data-sharing agreements (Khosrowshahi & Arayici, 2012). The lack of standardised legal governance across regions creates inconsistencies in contract structures, making it challenging for firms to confidently engage in BIM-based collaborations.

In summary, the steep learning curve associated with BIM adoption, combined with high implementation costs, resistance to change, and limited legal clarity, presents ongoing challenges, particularly for SMEs. Overcoming these barriers requires industry-wide efforts, including investment in training, regulatory standardisation, and strategic leadership support to facilitate widespread BIM adoption (Eadie et al., 2013).

2.4.11 Summary of Critical BIM Literature Review

Building Information Modelling (BIM) offers transformative potential for the Architecture, Engineering, and Construction (AEC) industry, serving as a powerful enabler of digital collaboration, improved visualisation, and enhanced project coordination. By providing a centralised repository of structured information, BIM facilitates better decision-making, minimises rework, and accelerates project delivery timelines. Its capabilities extend far beyond 3D modelling, encompassing cost estimation (5D), scheduling (4D), sustainability analysis (6D), and facilities management (7D), making it an indispensable tool for modern construction workflows. Additionally, the integration of BIM with Lean Construction methodologies positions it as a key driver in reducing inefficiencies, streamlining communication, and optimising processes such as the Request for Information (RFI) system.

However, despite these significant advantages, BIM adoption continues to face considerable challenges. Interoperability issues between different BIM software platforms hinder seamless collaboration, creating data exchange limitations and workflow inefficiencies. Furthermore, the high costs of implementation, particularly for small and medium enterprises (SMEs), pose financial barriers that limit widespread adoption. This financial constraint extends to training investments, preventing many firms from developing the necessary expertise to maximise BIM's full potential.

Additionally, legal complexities surrounding intellectual property rights and data ownership further complicate industry-wide adoption. Uncertainties regarding model ownership, shared responsibilities, and liability risks create hesitation in collaborative environments, particularly in multi-stakeholder projects where data security and contractual frameworks remain inconsistent. Moreover, cultural resistance to change—particularly within firms reliant on traditional design and construction methodologies—continues to pose a significant barrier to digital transformation. Many industry professionals are still reluctant to transition to digital workflows, preferring familiar manual processes over automated, data-driven approaches.

Furthermore, a critical skills gap persists across the AEC industry, both in terms of technical BIM proficiency and collaborative information management. Many professionals lack the expertise to effectively leverage BIM's advanced functionalities, resulting in suboptimal implementation and limited return on investment. Addressing this skills gap requires industry-wide training initiatives, competency development programs, and educational frameworks to ensure consistent knowledge dissemination across all levels of the workforce.

To fully leverage BIM's potential, the construction industry must take proactive steps to overcome these barriers. Standardisation of BIM protocols, including the adoption of open data standards and interoperability frameworks, will be essential in facilitating seamless data exchange and cross-platform collaboration. Moreover, enhanced training programs and knowledge-sharing initiatives will help bridge the digital skills gap, ensuring that industry professionals can effectively navigate BIM's complexities. Finally, a strong commitment to fostering a collaborative culture that embraces digital innovation will be essential in driving widespread BIM adoption, ultimately transforming project efficiency, sustainability, and industry best practices.

2.5 Lean Construction a Literature Review

2.5.1 Introduction

Lean Construction (LC) represents a transformative shift in the Architecture, Engineering, and Construction (AEC) industry, offering a structured framework to reduce waste, enhance productivity, and streamline project delivery. Inspired by Lean Manufacturing principles, specifically the Toyota Production System (TPS) pioneered by Taiichi Ohno, LC applies similar process-driven methodologies to the construction sector, focusing on continuous improvement, waste minimisation, and value maximisation (Ohno, 1988). The fundamental philosophy of Lean emphasises collaboration, efficiency, and predictability, aligning these objectives with the construction industry’s need for more reliable project outcomes (Koskela, 1992).

Beyond process efficiency, LC fosters a cultural transformation in project management, introducing methodologies to enhance workflow, mitigate bottlenecks, and optimise value generation at every stage of the construction process. Given the inherent complexity and unpredictability of construction environments, LC principles aim to enhance process reliability, ensuring that project execution aligns more closely with client expectations and industry best practices (Ballard, 2000). By focusing on collaborative project delivery, LC shifts traditional construction paradigms from reactive problem-solving to proactive planning and continuous improvement.

The significance of Lean Construction within this research lies in its potential to address inefficiencies in the Request for Information (RFI) process. The RFI system, a critical mechanism for clarifying project details and resolving uncertainties, is frequently hampered by delays, miscommunication, and inefficiencies. This research aims to explore how integrating LC with BIM can optimise the RFI process, fostering faster, more effective communication and decision-making among project stakeholders. By examining the core principles of LC, this chapter establishes the foundation for understanding how Lean strategies can streamline information flow and enhance project coordination within complex construction environments.

2.5.2 History and Development of Lean Construction

The development of Lean Construction (LC) originates from Lean Manufacturing principles, particularly the Toyota Production System (TPS), conceptualised by Taiichi Ohno in the mid-20th century. TPS introduced foundational concepts such as Just-in-Time (JIT), Kaizen (continuous improvement), and waste elimination, with the goal of enhancing productivity, minimising waste (muda), and increasing value through process optimisation and efficiency improvements (Ohno, 1988). These principles were later adapted for the construction industry to address persistent inefficiencies in construction workflows (Womack et al., 1990).

A pivotal moment in the transition of Lean principles to construction was the work of Koskela (1992), who challenged traditional construction paradigms by framing construction as a production system rather than a series of isolated tasks. His Transformation-Flow-Value (TFV) theory laid the foundation for Lean Construction, advocating for an integrated approach where production flows, material transformations, and client value generation are aligned into a cohesive process (Koskela, 2000). This model remains highly influential, guiding Lean Construction practices toward reducing waste, improving project timelines, and enhancing overall efficiency.

The formation of the Lean Construction Institute (LCI) in 1997 marked a significant milestone in the formalisation of Lean principles within the AEC industry. Founded by Glenn Ballard and Greg Howell, the LCI introduced pivotal tools such as the Last Planner System (LPS), which focuses on improving workflow reliability and reducing variability in project schedules (Ballard & Howell, 2003). Unlike traditional scheduling approaches, LPS ensures that tasks are not only planned but also executed as scheduled, mitigating the unpredictability that often disrupts project performance.

Over the years, Lean Construction has expanded through the development of tools designed to enhance communication and collaboration among project stakeholders. Techniques such as Pull Planning and Value Stream Mapping (VSM) have been instrumental in aligning production schedules with actual project requirements and identifying process inefficiencies (Tezel et al., 2017). These tools help reduce waste, streamline workflows, and foster proactive problem-solving, making them essential for enhancing construction project performance.

Figure 2.6, "The House of TPS" (Liker, 2004), encapsulates how Lean Manufacturing principles apply to construction by emphasising teamwork, continuous improvement, and respect for individuals. These core principles promote a culture of collaboration, where open communication, shared responsibilities, and client-centred project management are prioritised. The integration of these principles within construction management has resulted in more predictable project outcomes, increased stakeholder alignment, and greater adaptability to evolving project demands (Liker, 2004).

Figure 2-6 The House of TPS (Liker, 2004)

As Lean Construction methodologies continue to evolve, their emphasis on improving information flow, reducing delays, and fostering collaboration makes them particularly relevant for enhancing processes such as RFIs. By understanding the historical development and theoretical foundations of Lean principles, this research seeks to integrate Lean with BIM, ultimately enhancing RFI efficiency and addressing communication bottlenecks that often contribute to construction project delays.

2.5.3 Lean Construction Principles

Lean Construction (LC) is founded on several core principles, adapted from Lean Manufacturing, to address inefficiencies, enhance collaboration, and maximise project value. One of the fundamental frameworks informing Lean thinking is Liker's (2004) 4P model—Philosophy, Process, People/Partners, and Problem-Solving, as illustrated in Figure 2.7. Each of these pillars contributes to a holistic approach that fosters continuous improvement and waste minimisation throughout the construction lifecycle.

Figure 2-7 The 4P Model of the Toyota Way (Liker, 2004)

The Philosophy element focuses on long-term improvement, where decisions are made with an eye towards sustained growth and value creation rather than short-term gains. Lean Construction, like Lean Manufacturing, advocates for a project philosophy that prioritises value generation and long-term client satisfaction (Liker, 2004). This approach is particularly significant in complex construction projects, where aligning team goals with broader project objectives can lead to enhanced outcomes.

In terms of Process, Lean Construction seeks to streamline workflows by reducing variability and increasing predictability in task completion. Processes are evaluated through a lens of waste reduction, ensuring that non-value-adding activities are minimised or eliminated. This concept is closely tied to Koskela's TFV theory, which frames construction as a system of interrelated processes aimed at maximising value creation while minimising waste (Koskela, 1992).

The People/Partners pillar highlights the importance of collaboration and teamwork in Lean Construction. Effective collaboration between all stakeholders, including contractors, clients, and suppliers, ensures that communication barriers are minimised and that the project runs smoothly. This is particularly relevant in construction, where traditional siloed approaches often result in delays and miscommunications. By fostering a culture of shared responsibility and transparency, Lean Construction promotes better decision-making and a more efficient workflow.

Finally, Problem-Solving in Lean Construction involves a systematic approach to identifying and resolving issues as they arise. This approach encourages continuous improvement (Kaizen) and relies on data-driven methods to tackle challenges that may impede progress. By focusing on root cause analysis and preventive measures, Lean Construction teams can prevent recurring issues and improve overall project performance.

Figure 2.8, illustrating Koskela's (2000) TFV theory, outlines how these principles are applied to construction workflows. The Transformation component refers to the efficient conversion of inputs into outputs, while Flow aims to maintain a smooth progression of materials, information, and tasks across the project lifecycle. Value focuses on delivering the optimal product to meet the client's needs. Each of these components is vital to ensuring that projects are completed on time, within budget, and to the required quality standards.

	Transformation view	**Flow view**	**Value generation view**
Conceptualization of production	As a transformation of inputs into outputs	As a flow of material, composed of transformation, inspection, moving and waiting	As a process where value for the customer is created through fulfilment of his/her requirements
Main principle	Getting production realized efficiently	Elimination of waste (non-value-adding activities)	Elimination of value loss (achieved value in relation to best possible value)
Methods and practices	Work breakdown structure, MRP, organizational responsibility chart	Continuous flow, pull production control, continuous improvement	Methods for requirement capture, quality function deployment
Practical contribution	Taking care of what has to be done	Making sure that unnecessary things are done as little as possible	Taking care that customer requirements are met in the best possible manner
Suggested name of practical application of the view	Task management	Flow management	Value management

Figure 2-8 Theory of Production (TFV) (Koskela, 2000)

The TFV model is particularly applicable in information-heavy processes like RFIs, where inefficiencies can lead to delays and rework. By applying Lean principles to streamline the exchange of information and reduce bottlenecks, construction teams can ensure a smoother workflow and improve project outcomes (Koskela, 2000).

In summary, the core principles of Lean Construction—Philosophy, Process, People/Partners, and Problem-Solving—serve as a foundation for driving continuous improvement in construction projects.

These principles not only reduce waste but also foster collaboration, enhance communication, and optimise project delivery. As this research explores the integration of Lean with BIM, these principles will be central to developing an improved RFI process that addresses the inefficiencies commonly experienced in construction projects.

2.5.4 Concept of Waste and Value in Construction Projects

In Lean Construction, the concepts of waste and value are central to improving project outcomes. Waste is defined as any activity that consumes resources without adding value, while value refers to activities that directly contribute to the project's objectives, primarily by meeting client needs. Koskela (1992, 2000) identified seven types of waste prevalent in the construction industry: overproduction, waiting times, unnecessary processing, excessive inventory, defects, transportation inefficiencies, and rework. These forms of waste frequently result from poor communication, inadequate planning, and ineffective information flow, often leading to delays, cost overruns, and reduced quality in construction projects.

The seven categories of waste identified by Koskela (2000) offer a structured framework for analysing inefficiencies in construction projects. Overproduction refers to producing more than what is required or completing tasks earlier than necessary, leading to idle work or unnecessary expenses. Waiting times, a common issue in construction, occur when workers or processes are delayed due to missing information or materials, creating bottlenecks that stall progress. Unnecessary processing involves completing tasks that do not add value to the project, often due to poor design or inefficient workflow (Mollasalehi et al., 2016).

Excessive inventory can manifest as the overstocking of materials or accumulation of unused information, both of which tie up resources and hinder productivity. Defects are errors that occur during construction, requiring rework or repairs, which not only increase costs but also extend project timelines. Transportation inefficiencies involve the unnecessary movement of materials or people, leading to wasted time and effort. Finally, rework is one of the most costly forms of waste, occurring when tasks need to be repeated due to incomplete or incorrect information, often as a result of communication breakdowns.

In addition to the seven types of waste identified by Koskela (2000), Rashid & Heravi (2012) introduced an eighth category: movement. This includes unnecessary physical movement of workers, excessive handling of materials, and inefficient workflows that do not add value but instead contribute to project delays and resource wastage.

Table 2-6 The Seven Waste (Rashid & Heravi, 2012)

Wastes	Description
Over Production	Product that is more than required. Production much earlier than the time required (do something before it is actually needed). Manufacturing items for which there are no orders. Changes in the needs of the next delivery recipients (design changes).
Defect, Correction & Rework	Errors in the execution of required process that cause wastes in time, materials, etc., more than usual. Failure in machine tools and equipment due to incorrect use of them. Correcting incorrect and unnecessary processes. Reworks due to work interferences.
Inventory	A large number of under way processes in the construction or incomplete endeavor (or completed deliverables but not yet delivered). Possession of large and unnecessary quantities of raw materials that the capital still holds.
Transportat ion	Any mobility of materials that do not add to production values. Multiple transfers of data and information for final approval.
Waiting	Time wasted in the activities of employees and machines work due to bottlenecks and interferences, and capacity bottlenecks. Waiting for the information needs and customer requests or final approvals. Delays associated with stock-outs, lot processing delays, equipment.
Movement	Any physical movement or walking workers that keeps them from the work or causing delays in their work.
Over Processing	Additional steps in the production that is not required. Product with a number of features and quality over what the customer expected of the product. Unnecessary inspection.

These wastes are particularly problematic during the design and information exchange phases of construction, where inefficiencies in communication can lead to rework, delays, and increased costs (Aka et al., 2017). Managing these wastes effectively requires a commitment to continuous improvement and the application of Lean tools such as VSM to identify and eliminate non-value-adding activities.

Value, in contrast, is defined as anything that directly contributes to meeting the client’s objectives. In Lean Construction, delivering value involves not only completing tasks efficiently but also ensuring that the final product aligns with the client’s needs and expectations. This client-centred approach to value creation emphasises the importance of clear communication and alignment between project stakeholders. Lean Construction seeks to maximise value by streamlining processes, improving collaboration, and reducing unnecessary steps that do not contribute to the project’s goals.

The relationship between waste and value is crucial in Lean Construction, as eliminating waste is key to maximising value. For example, by reducing waiting times and unnecessary processing, construction teams can ensure that resources are focused on activities that deliver tangible benefits to the client. Similarly, minimising rework and defects enhances project quality and reduces delays, leading to greater client satisfaction.

Figure 2.9 illustrates the process of waste elimination in Lean Construction, as proposed by O'Connor & Swain (2013). This figure highlights the role of Lean tools in identifying and addressing inefficiencies across the project lifecycle, particularly in areas such as design, construction, and information management.

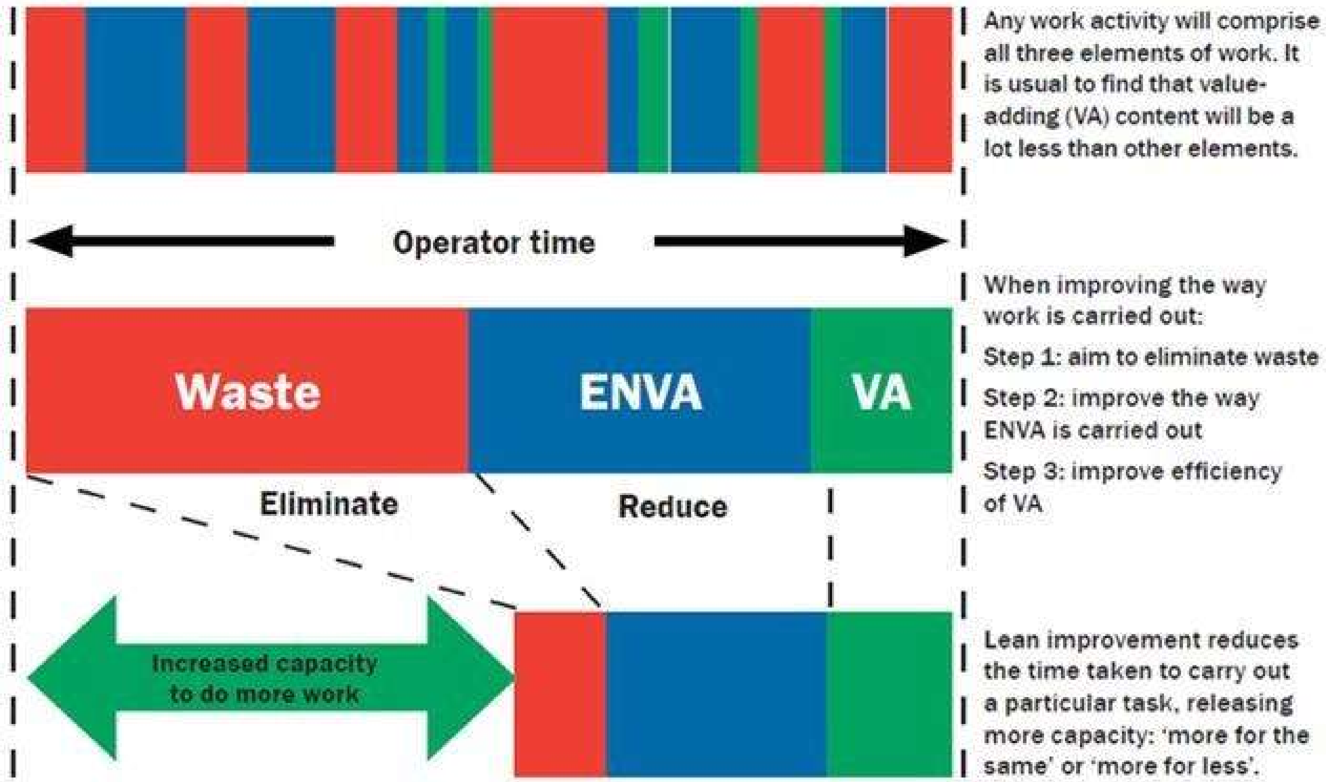


Figure 2-9 Waste Elimination (O'Connor & Swain, 2013)

In the context of this research, the integration of Lean principles with BIM is proposed as a strategy for reducing waste in the RFI process. By improving the flow of information and ensuring that RFIs are resolved promptly, this approach aims to minimise the inefficiencies commonly associated with RFIs, such as delays and miscommunications. The synergy between Lean's focus on waste reduction and BIM's capacity for data management and visualisation holds significant potential for improving overall project performance.

2.5.5 Lean Tools and Techniques in Construction

Lean Construction is underpinned by a suite of tools and techniques specifically designed to minimise waste, optimise workflows, and enhance collaboration. These tools, drawn from Lean manufacturing practices, have been adapted to meet the unique challenges of the AEC industry. Among the most widely recognised tools are the Last Planner System (LPS), Pull Planning, Kanban, and Value Stream Mapping (VSM), each playing a pivotal role in improving project management and information flow.

The Last Planner System (LPS), introduced by Ballard (2000), is one of the cornerstone tools of Lean Construction. It is designed to reduce variability in workflows and ensure that tasks are completed as scheduled. LPS focuses on aligning project activities with the capacity of downstream teams, thus preventing bottlenecks and ensuring that all tasks are achievable within a set timeframe. By creating a more predictable workflow, LPS helps to stabilise construction processes and reduce delays, contributing to more consistent project delivery.

Pull Planning is another critical technique that complements the LPS. This approach reverses traditional planning methods by focusing on the needs of the final project stages and working backward to ensure that all preceding tasks are aligned with those requirements. This method ensures that each step in the construction process is necessary and supports the overall project goal, eliminating non-essential activities and improving the flow of work (Tezel et al., 2017). Pull Planning plays a particularly important role in reducing inefficiencies caused by mismatched scheduling and task prioritisation.

Kanban, a visual management tool, is instrumental in tracking project progress and improving communication among stakeholders. Originating from Lean manufacturing, Kanban uses visual boards to map out tasks and workflows, making it easier to identify bottlenecks and delays in real time. By providing a clear overview of project status, Kanban facilitates better decision-making and task allocation, ensuring that resources are effectively deployed (Tezel et al., 2017). In the context of Lean Construction, Kanban supports the effective management of information flow, particularly in processes such as the Request for Information (RFI) system, where delays and miscommunication can disrupt project timelines.

Value Stream Mapping (VSM) is a diagnostic tool used to identify non-value-adding activities within construction processes. VSM visually represents the flow of materials, information, and tasks throughout a project, allowing teams to pinpoint inefficiencies and streamline workflows. By mapping out the entire value stream, from design to completion, construction teams can identify areas where waste occurs, such as waiting times, excessive movement of materials, or redundant tasks (Koskela et al., 2002). Once these inefficiencies are identified, VSM enables teams to develop strategies to eliminate waste and optimise the flow of value to the client.

Table 2.7 provides an overview of the key Lean tools and their applications in the construction industry (Tezel et al., 2017):

Table 2-7 Lean Construction Tools and Techniques (Tezel et al., 2017)

Tool	Application
Last Planner System (LPS)	Reduces variability and improves workflow predictability
Pull Planning	Aligns work with downstream needs to optimise task flow
Kanban	Visualises workflow, making it easier to track progress and identify bottlenecks
Value Stream Mapping (VSM)	Identifies non-value-adding activities and streamlines processes to improve efficiency

These tools, when integrated into construction management practices, offer significant improvements in terms of reducing waste, enhancing collaboration, and improving project outcomes. For example, LPS has been shown to improve task completion rates and minimise the uncertainty that often arises in construction schedules. Similarly, Kanban provides a dynamic visual platform that keeps project teams informed about the progress of tasks, allowing for real-time adjustments and improving overall coordination.

In the context of this research, the integration of Lean tools such as LPS, Kanban, and VSM with BIM provides an opportunity to further optimise the RFI process. By leveraging these tools to improve information flow and reduce delays, this integrated approach aims to streamline the RFI process and minimise the disruptions that typically arise from poor communication and planning.

Through the application of these tools, Lean Construction aims to create a more predictable and efficient construction environment. By focusing on waste reduction and process improvement, Lean tools and techniques offer significant potential to enhance the performance of construction projects, particularly when integrated with BIM. This integration allows for real-time data sharing, better decision-making, and more collaborative project management, addressing many of the inefficiencies currently faced in the construction industry.

2.5.6 Lean Construction and Information Flow Management

Efficient information flow is a critical component of Lean Construction, as it directly influences project timelines, collaboration, and overall performance. In the construction industry, where projects are often complex and involve multiple stakeholders, delays and miscommunication can lead to significant disruptions. Lean principles offer a framework for managing and optimising the flow of information to ensure that it reaches the right people at the right time, minimising waste and preventing bottlenecks in the construction process.

Lean Construction emphasises the elimination of non-value-adding activities, many of which stem from poor information management. Delays in information flow, unclear communication, and redundant processes can all lead to waste in the form of rework, idle time, and missed deadlines. By adopting Lean tools and techniques, such as Pull Planning and Value Stream Mapping (VSM), construction teams can enhance the efficiency of information sharing and communication (Azhar, 2011). These tools are designed to align project tasks with the available information, ensuring that work progresses smoothly without unnecessary interruptions.

Pull Planning is particularly relevant in managing information flow. This method works by identifying the information needs of the project's downstream activities and ensuring that the necessary data is available when required. By focusing on the end goal and working backwards to align all tasks with that goal, Pull Planning helps eliminate the misalignment of schedules and information delays. This approach ensures that information flows in a timely manner, supporting the continuous progress of construction activities without disruptions caused by waiting for approvals, clarifications, or additional data (Tezel et al., 2017).

Additionally, Kanban, with its visual management capabilities, enhances transparency in the information flow by providing real-time updates on task status and information availability. When integrated into project workflows, Kanban boards allow teams to track information requests, such as Requests for Information (RFIs), and monitor their resolution. By doing so, project teams can prevent delays in decision-making and avoid the accumulation of unresolved information queries that often impede progress.

Moreover, Value Stream Mapping (VSM) plays an essential role in diagnosing inefficiencies in information management. VSM visually represents the flow of information, materials, and tasks throughout the project lifecycle. By mapping out these flows, project teams can identify points where information bottlenecks occur and develop strategies to streamline communication. This approach is particularly effective in processes like RFIs, where delays in receiving and responding to information requests can disrupt the entire construction timeline (Koskela et al., 2002).

The integration of Lean principles into information flow management is further enhanced when combined with Building Information Modelling (BIM). By using BIM's capabilities for real-time data sharing and visualisation, Lean Construction techniques can be more effectively applied to optimise information management. The synergy between Lean and BIM ensures that information is readily accessible to all project stakeholders, reducing the likelihood of miscommunication and improving the overall coordination of tasks. This integration is particularly important in improving the RFI process, which often suffers from delays due to fragmented communication channels.

In this research, the focus on improving the RFI process through Lean Construction principles highlights the importance of effective information flow. By aligning Lean tools such as Pull Planning, Kanban, and VSM with BIM's data management capabilities, the proposed BIM-Lean RFI process aims to reduce delays and enhance communication across project teams. The result is a more streamlined flow of information that supports efficient project management and timely decision-making.

Table 2.8 illustrates the relationship between Lean Construction tools and information flow management, highlighting how these tools contribute to improving communication, reducing delays, and enhancing project outcomes. This visual representation demonstrates the interconnectedness of Lean principles in managing the flow of information, which is essential for reducing waste and ensuring the smooth execution of construction projects.

Table 2-8 Lean Construction Tools and Techniques (Tezel et al., 2017)

No.	Lean Construction Tool/Technique	Definition	Manufacturing References	Construction References
1	The Last Planner System (LPS)	A collaborative task planning and control framework for the construction industry that emphasizes removing production blockages and self-planning of work by construction workers.	Ballard and Howell (1998), Kim and Ballard (2010)	Seppänen et al. (2010), Ballard et al. (2017)
2	Visual Management	A management strategy that uses easy-to-understand sensory systems, such as visual performance boards, to increase process transparency and facilitate work control and information flow.	Parry and Turner (2006), Murata and Katayama (2010)	Formoso et al. (2002), Tzortzopoulos et al. (2015)
3	5S	A systematic housekeeping methodology represented by five distinct steps: Sort, Set-in-order, Shine, Standardize, and Sustain.	Abdulahelk and Rajgopal (2007), Bayo-Moriones et al. (2010)	Johansen and Walter (2007), Stehn and Hook (2008)
4	Value Stream Mapping (VSM)	A material and information flow mapping technique used to analyze current processes and design future production or service delivery processes, from beginning through to the customer.	Seth and Gupta (2005), Serrano Lasa et al. (2009), Ben Fredj (2016)	Yu et al. (2009), Rosenbaum et al. (2013), Toledo and González (2013)

5	Problem Solving Process (PDCA Cycle)	A work improvement cycle for identifying and solving process problems, developing potential solutions, implementing and standardizing the solution, and monitoring its effectiveness.	Herron and Braiden (2006), Sokovic et al. (2010)	Salem et al. (2006), Yu et al. (2011)
6	Continuous Improvement Cells	A small-group work improvement activity based on Quality Circles (QC).	Ahlström (1998), Kitazawa and Sarkis (2000)	Nahmens and Ikuma (2009), Miron et al. (2016)
7	Line of Balance Method (Location-Based Planning)	A graphical work scheduling, control, and balancing method used in planning/coordination of construction projects, especially for highway or high-rise buildings.	Mendes and Heineck (1998), Soini et al. (2004)	Yu et al. (2009), Ballard et al. (2013)
8	Takt Time Planning	Work planning based on the time set for the supply of certain process tasks derived from customer demand. Forms the basis for single-piece flow in lean thinking.	Seth and Gupta (2005), Millstein and Martinich (2014)	Yu et al. (2009), Ballard et al. (2013)
9	First Run Studies	An alternative approach to work improvement, based on process observation and photos/video recording of critical construction tasks.	Shingo and Dillon (1989), Mileham et al. (1989)	Tsao et al. (2004), Frandson et al. (2015)
10	Work Structuring	A term used to describe the effort of integrating product and process development to optimize production and flow efficiency.	Fawcett and Magnan (2002), Flynn et al. (2010)	Filho et al. (2005), Paez et al. (2008)
11	Set-up Preparation and Improvement	A systematic study of a work setup to optimize and save time in changeovers, reducing non-value-added tasks.	Shingo (1986), Saurin et al. (2010)	Dainty et al. (2001), Briscoe

				and Dainty (2005)
12	Supply Chain Integration	A close alignment and coordination with supply chain partners to improve service and transparency in information flows.	Fawcett and Magnan (2002), Huq and Zhao (2010)	Dos Santos and Powell (1999), Tommelein (2008)
13	Mistake-Proofing (Poka-Yoke) Systems	Tools and systems designed to prevent errors from occurring in the production process.	Shingo (1986), Saurin et al. (2010)	Bruun and Mefford (2008), Petersen (2008)
14	In-Station Quality – Jidoka	A system that enables operators to detect when a problem has occurred and immediately stop work to address the issue.	Shingo (1986), Saurin et al. (2010)	Kemmer et al. (2006), Heineck et al. (2009)
15	Standard Operating Sheets (SOPs)	A visual documentation of a work process that helps ensure standardization and adherence to process steps.	Schuring (1996), Shaw and Edwards (2006)	Tommelein et al. (1998), Pheng and Chuan (2001)
16	Just-in-Time (JIT) Material/Component Flow	Maintaining a smooth and continuous flow of materials to optimize stock and minimize inventory, by aligning production pace to customer demand.	Sugimori et al. (1977), Golhar and Stamm (1991)	Ballard et al. (1998), Pheng and Chuan (2001)
17	Pull Production System using Kanbans	Controlling and harmonizing production between units based on specific cards or signals (Kanbans).	Sugimori et al. (1977), Mukhopadhyay and Shanker (2005)	Ballard et al. (2003), Ko and Kuo (2015)

18	Pre-fabrication and Modularisation	Extensively using pre-fabricated and modularised construction components to overcome on-site production problems (e.g., low productivity, quality, variability).	Gosling and Naim (2009)	Gosling et al. (2016)
19	Cell Production Units (Multi-functional Construction Work Units)	Forming teams of different construction trades (e.g., plasterer, electrician, carpenter) to work together as a unit to minimize work-in-progress and maintain flow.	Deif (2012), Saurin et al. (2011)	Moser and Dos Santos (2003), Mariz et al. (2013)
20	Information Technologies to Support Lean Construction Deployments	Extensive use of digital technologies, such as BIM (Building Information Modelling), mobile systems, cloud computing, and sensor networks to optimize information flow.	Sacks et al. (2010)	Sacks et al. (2011), Becerik-Gerber et al. (2011)

2.5.7 Lean Project Delivery System (LPDS)

The Lean Project Delivery System (LPDS), initially developed by Ballard (2000) shown in Figure 2.10, offers a comprehensive approach to managing construction projects. Central to this system is an emphasis on waste reduction, collaboration, and value creation throughout the project lifecycle. LPDS divides the project into several distinct phases, including project definition, lean design, lean supply, lean assembly, and lean use. Each phase incorporates continuous feedback loops that promote iterative learning and improvement (Ballard, 2000).

The framework's underlying principles address many of the issues traditionally encountered in the construction sector, particularly fragmentation and inefficiency. By fostering collaboration and concurrent engineering, LPDS aims to create a more cohesive approach to project management. The integration of these principles has proven particularly valuable in enhancing processes such as the Request for Information (RFI) mechanism, where timely and clear communication is essential (Ballard, 2008). This structured framework facilitates the alignment of the entire construction team toward a shared goal, reducing delays caused by bottlenecks in information flow.

Moreover, key tools associated with LPDS, such as the Last Planner System (LPS) and Pull Planning, play pivotal roles in synchronising the flow of tasks with available resources. LPS helps to improve workflow predictability and efficiency by stabilising task sequencing, while Pull Planning ensures that tasks align with downstream activities, thereby enhancing the flow of information (Tezel et al., 2017). The use of these tools has shown considerable promise in reducing waste, minimising delays, and improving communication, all of which are critical for optimising the RFI process in construction projects.

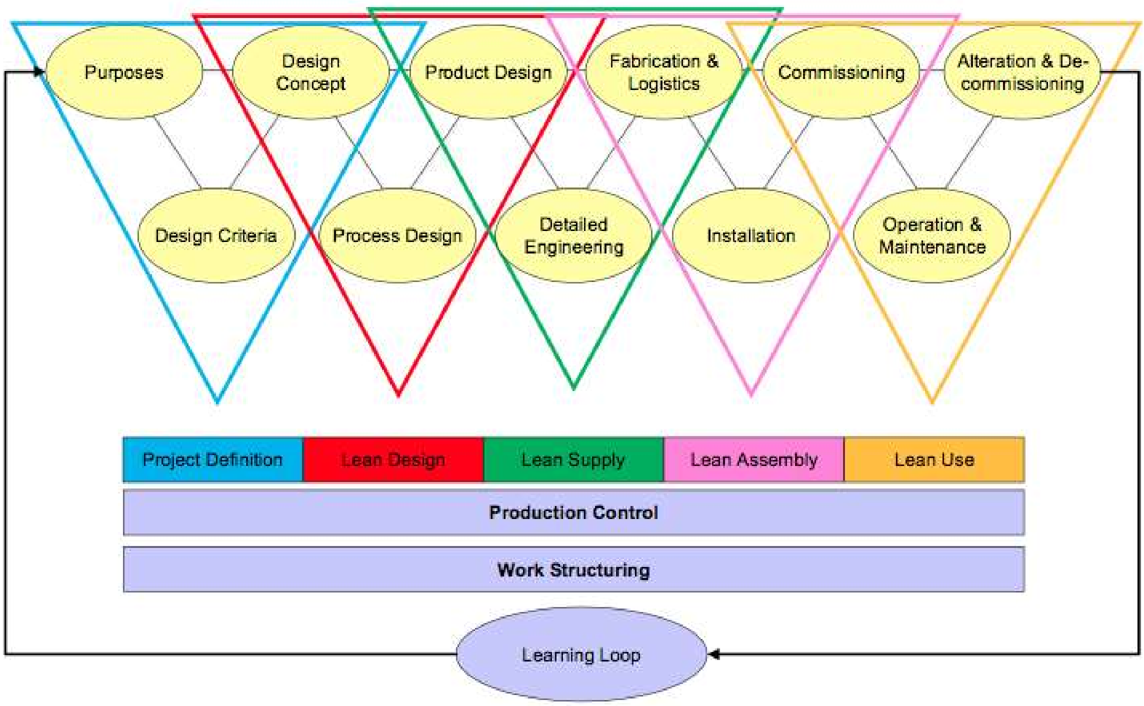


Figure 2-10 Lean Project Design System (Ballard, 2000)

The LPDS model also encourages a focus on value generation throughout the construction process. By concentrating on delivering client-defined value, LPDS shifts the traditional focus of construction from completing tasks to creating systems that work effectively for all stakeholders involved. This collaborative mindset is particularly important in complex, multi-stakeholder projects, where communication barriers often hinder project efficiency (Koskela et al., 2002). The LPDS model, through its structured feedback loops and focus on process optimisation, helps to address these barriers, ensuring that essential information reaches the right stakeholders at the right time.

2.5.8 Lean Construction Barriers

Despite its transformative potential, LC faces a range of barriers that have hindered its widespread adoption in the construction industry (Table 2.9). Cultural resistance is one of the most significant obstacles, as many organisations, particularly those entrenched in traditional project management practices, are reluctant to adopt the collaborative and iterative nature of Lean principles (Sarhan & Fox, 2013). In many cases, the established culture within firms is deeply rooted in hierarchical structures and compartmentalised work practices, making the transition to a Lean approach—requiring greater transparency, teamwork, and flexibility—challenging to implement.

Table 2-9 Barriers to Lean Construction (Sarhan & Fox, 2013)

Barrier	Description
Cultural Resistance	Resistance to changing established practices
Lack of Awareness	Insufficient understanding of Lean principles
Financial Constraints	Limited financial resources to invest in Lean training and tools
Contractual Issues	Traditional contracts that discourage collaboration
Time Pressures	Pressure to meet deadlines, leading to reluctance to adopt new methods
Lack of Management Support	Lack of top-down support for Lean initiatives
Educational Gaps	Insufficient Lean training and understanding in the workforce

Another critical barrier is the lack of awareness and understanding of Lean principles. Many stakeholders within the AEC sectors are either unfamiliar with Lean methodologies or perceive them as abstract concepts without clear, tangible applications (Sarhan & Fox, 2013). This gap in knowledge limits Lean's potential to be incorporated into project planning, as stakeholders fail to see the value in adopting Lean practices when faced with other pressing concerns such as project deadlines and budgets.

Financial constraints also present a significant challenge, particularly for small and medium-sized enterprises (SMEs). The initial investment required for Lean training, tools, and implementation can be prohibitive, especially for firms operating with limited financial resources (Barlish & Sullivan, 2011). Moreover, Lean implementation often requires a longer-term perspective on return on investment (ROI), which can be difficult to justify in an industry that frequently prioritises short-term gains and immediate project outcomes.

Additionally, time pressures in the construction industry often lead to reluctance in adopting new methods. Project deadlines are typically tight, leaving little room for experimentation or the implementation of new management approaches (Sarhan & Fox, 2013). Many project managers and contractors remain focused on meeting immediate milestones, and they may view Lean Construction as an additional burden rather than an opportunity to improve long-term outcomes.

Contractual issues also contribute to the slow uptake of Lean principles in construction projects. Traditional contracts, which tend to focus on fixed-price agreements and risk-shifting between stakeholders, do not align well with the collaborative and flexible nature of Lean Construction (Bølviken & Koskela, 2016). The lack of contractual frameworks that support Lean practices creates uncertainty and may discourage firms from adopting Lean methodologies, particularly in multi-stakeholder environments where roles and responsibilities are rigidly defined.

Finally, Lean Construction faces educational barriers. There is often insufficient Lean training available within the industry, particularly in regions where Lean has not yet gained significant traction. Many construction professionals are not exposed to Lean practices during their formal education or training, which leads to a lack of proficiency in applying these principles on-site (Bølviken & Koskela, 2016). This educational gap perpetuates the cycle of resistance to Lean, as firms that lack in-house expertise struggle to implement Lean practices effectively.

2.5.9 Summary of Lean Construction

Lean Construction has emerged as a transformative methodology in the AEC industry, significantly improving project outcomes through the systematic reduction of waste and fostering enhanced collaboration. Drawing inspiration from Lean manufacturing, particularly the TPS, Lean Construction adapts principles such as JIT continuous improvement (Kaizen), and the elimination of inefficiencies (Ohno, 1988). This framework fundamentally redefines how construction projects are approached by prioritising value creation for the client, continuous process optimisation, and a culture of collaboration (Koskela, 1992).

Central to Lean Construction are tools such as the LPS, VSM, and Pull Planning, which facilitate better control over construction workflows and minimise non-value-adding activities (Tezel et al., 2017). These tools have proven effective in improving predictability, reducing variability, and enhancing communication across project stakeholders. Notably, these principles align closely with the objectives of this thesis, as the integration of Lean Construction tools with BIM provides an opportunity to optimise the RFI process, addressing common bottlenecks and inefficiencies.

Despite the numerous advantages, Lean Construction faces several barriers to widespread adoption, including cultural resistance, financial constraints, and management reluctance (Sarhan & Fox, 2013). These challenges must be addressed through targeted training, top-down support, and the alignment of contracts with Lean principles to unlock the full potential of Lean Construction within the AEC industry.

The synergy between Lean Construction and BIM represents a powerful strategy for improving information flow, streamlining project delivery, and achieving better project outcomes. As the next section explores, the integration of BIM and Lean principles provides a robust framework for addressing the complex information management challenges faced by the construction industry today, particularly in enhancing the efficiency and effectiveness of the RFI process.

2.6 BIM-Lean Interaction: Synergies and Implementation

Building Information Modelling (BIM) and Lean Construction represent two of the most influential methodologies within the AEC industry, both aiming to enhance project efficiency, reduce waste, and improve collaboration. Though traditionally applied in isolation, recent studies have demonstrated the potential benefits of integrating these approaches, particularly in addressing communication inefficiencies and optimising project delivery (Sacks et al., 2009). This section explores how BIM and Lean Construction can be combined to support the aim of this thesis, which seeks to improve the Request for Information (RFI) process in construction projects. By analysing the synergies between these methodologies, a framework can be established that enhances project communication, streamlines workflow, and reduces delays.

Historically, BIM and Lean methodologies were developed independently, each serving a distinct purpose within construction projects. BIM, initially introduced as a tool for improving visualisation, planning, and coordination, evolved into a comprehensive digital platform for managing the design, construction, and maintenance of buildings. In contrast, Lean Construction, adapted from Lean manufacturing, focuses on process optimisation, eliminating waste, and enhancing productivity through collaborative efforts (Sacks et al., 2010). The convergence of these two methodologies has recently gained momentum, driven by the recognition that their combined strengths can significantly enhance project outcomes.

In particular, BIM's capabilities in visualising real-time data, detecting clashes, and managing schedules align well with Lean's objectives of continuous improvement and reducing inefficiencies. Lean Construction's focus on minimising waste and enhancing value through collaborative processes naturally complements BIM's ability to integrate data and improve decision-making. The integration of these methodologies is particularly relevant to the thesis' aim of optimising the RFI process, as both BIM and Lean provide tools and strategies for improving information flow and communication (Azhar et al., 2012).

The following subsections explore the evolution of this interaction, the synergies between BIM and Lean, and the challenges in their implementation.

2.6.1 Evolution of the Interaction

The initial development of BIM and LC occurred in relative isolation, with minimal focus on the potential synergies between the two methodologies. BIM was primarily introduced as a digital toolset designed to enhance visualisation, coordination, and project planning through the creation of comprehensive, real-time data models. LC, on the other hand, was adapted from Lean manufacturing principles, targeting the optimisation of processes to eliminate waste and improve productivity within construction workflows. For many years, these methodologies were applied independently, with little thought given to their possible integration. However, over the past decade, the convergence of BIM and Lean principles has become a prominent area of study in the AEC industry (Sacks et al., 2010).

The pivotal research by Sacks et al. (2009) was one of the first to present a comprehensive framework that examined how BIM and Lean methodologies could complement and enhance each other. Their work established a BIM-Lean Interaction Matrix, which outlined the potential synergies between BIM functionalities and Lean principles. This matrix, still widely referenced in contemporary research, provided a structured approach to understanding the interaction between these two methodologies, identifying 56 distinct positive interactions (Sacks et al., 2010a). It remains a foundational contribution to both academic and practical applications of BIM and Lean integration.

Table 2-10 BIM-Lean Interaction Matrix (Sacks et al., 2010)

		Lean principles																							
		Reduce variability		Reduce cycle times		Reduce batch sizes	Increase flexibility		Select an appropriate production control approach		Standardize	Institute continuous improvement	Use visual management		Design the production system for flow and value				Ensure comprehensive requirements capture	Focus on concept selection	Ensure requirements flow down	Verify and validate	Go and see for yourself	Decide by consensus consider all options	Cultivate an extended network of partners
BIM functionality		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
Visualization of form	1	1,2													3				4		11	5	6	4	
Rapid generation of design alternatives	2	1		22									7	7		8									
Reuse of model data for predictive analyses	3	9	9	22			51												1	16		5			
	4		10	12												8				16		5			
	5	1,2	1	12															1	1	1	5			
Maintenance of information and design model integrity	6	11	11																		11				
	7	12	12	22																		12			
Automated generation of drawings and documents	8	11		22	(52)	53											54	54							
Collaboration in design and construction	9			23						36						36									
	10	2,13		24				33											43		56	46		49	
Rapid generation and evaluation of multiple construction plan alternatives	11	14		25	(29)		31								(41)										
	12		15	25	(29)					37					(41)					44		47			
	13	2	40	25	(29)						17		40	40		40						47		49	
Online/ electronic object-based communication	14		29	26	30	30			34					34			(42)					47	48		
	15	18		26	30	30			34		38		38	34			(42)				45			49	
	16	19		27			32																		
	17		20	28					35								(42)								50
	18		21		30	30			34			39					(42)					47	48		

The matrix outlined in Table 2.10 reveals how the functionality of BIM supports Lean principles, particularly in areas such as reducing waste and improving communication. For example, BIM's ability to provide real-time visualisation and automated clash detection during the design phase helps to prevent errors and construction delays, thus aligning with Lean's objective of minimising waste. Similarly, the real-time data-sharing capabilities offered by BIM ensure that all stakeholders are kept informed throughout the construction process, enhancing the Lean principle of continuous improvement by fostering collaborative decision-making and adaptive planning (Sacks et al., 2009).

The evolution of this interaction has not been static. Researchers like Oskouie et al. (2012) have extended Sacks et al.'s initial work by introducing new dimensions to the BIM-Lean matrix. For instance, they explored BIM's role in supporting emerging technologies such as augmented reality (AR), real-time construction tracking, and digital twins. These innovations align with Lean principles by providing enhanced capabilities for monitoring project progress and responding to **'make-ready needs'**, a key component of Lean's pull-planning approach. The incorporation of AR, for example, allows for real-time visualisation of project stages, ensuring that potential issues are identified and addressed before they can escalate into larger problems, further reducing waste and inefficiencies on the construction site.

As the BIM-Lean interaction has continued to evolve, its significance within construction project management has grown. The framework established by these synergies is crucial for addressing core inefficiencies, particularly in relation to the RFI process. The thesis aims to build upon this existing body of knowledge, proposing an enhanced RFI management process that leverages the strengths of both BIM and Lean methodologies. The real-time communication facilitated by BIM, combined with Lean's focus on process optimisation, provides an ideal foundation for streamlining the flow of information and reducing the delays that currently hinder RFI processes in construction projects.

The evolution of this interaction underscores the broader importance of integrating these methodologies to achieve more efficient project delivery. Through the lens of the BIM-Lean Interaction Matrix, it becomes clear how the two approaches can complement each other in improving communication, minimising waste, and fostering a culture of continuous improvement. As this thesis explores the optimisation of the RFI process, understanding how BIM and Lean interact is essential for developing solutions that can address current inefficiencies in information flow and project communication. These interactions form a critical framework for proposing an RFI process that is both responsive and adaptable, leveraging BIM's technological strengths and Lean's process-driven focus to improve project outcomes

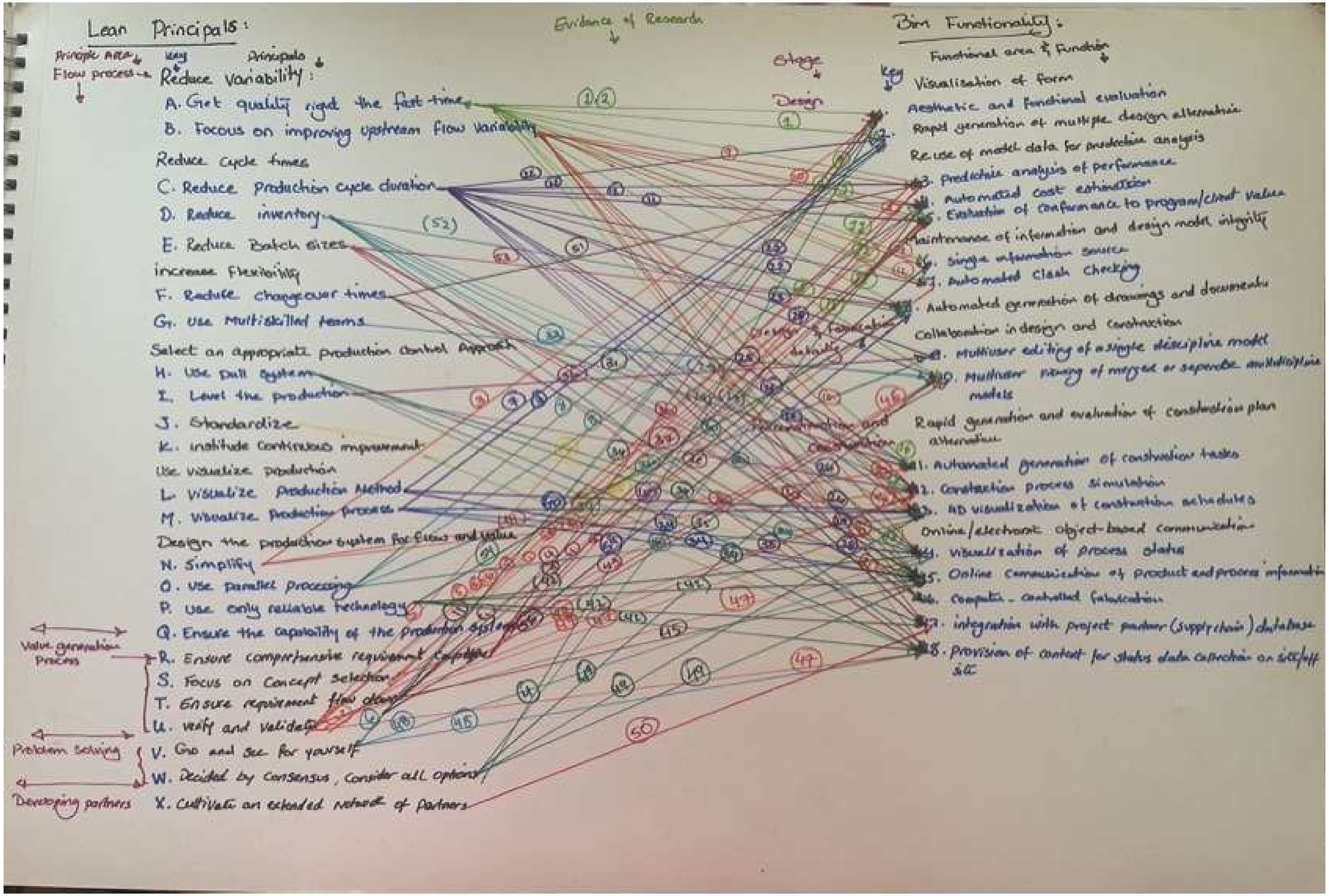


Figure 2-11 BIM-Lean Interaction matrix visualised

In conclusion, the evolution of BIM and Lean interaction represents a key development in modern construction practices, offering significant potential for improving project efficiency. The research by Sacks et al. (2009) and its subsequent extensions by other scholars have laid the groundwork for understanding how these methodologies can be integrated to enhance communication and reduce waste. By continuing to refine this framework, particularly through its application to the RFI process, this thesis seeks to contribute to the development of more effective and efficient construction management practices.

2.6.2 Synergies between BIM and Lean Construction

The synergy between Building Information Modelling (BIM) and Lean Construction is founded on their shared objectives of reducing waste, enhancing project quality, and fostering improved collaboration across all phases of construction. Both methodologies focus on addressing inefficiencies, with Lean targeting process optimisation and the elimination of non-value-adding activities, while BIM provides tools that facilitate better visualisation, planning, and data management (Azhar et al., 2012). When integrated, BIM and Lean Construction create a comprehensive framework capable of tackling both strategic and operational challenges common to construction projects.

One of the most significant synergies between BIM and Lean Construction is BIM's role in supporting visual management, a critical aspect of Lean. BIM's advanced 3D modelling and real-time visualisation capabilities enable project teams to clearly understand the dependencies, sequences, and critical paths in a project. These tools enhance the ability to foresee potential issues, allowing for more accurate planning and preventing disruptions before they occur (Clemente & Cachadinha, 2013). This supports Lean's objective of creating a continuous and smooth workflow, where potential sources of waste—such as delays or unnecessary activities—are minimised. Through visual management, the project team can effectively coordinate the various stages of construction, ensuring that work progresses in alignment with client expectations and project timelines.

In addition to enhancing workflow, BIM's capacity to facilitate real-time collaboration between stakeholders aligns seamlessly with Lean's emphasis on teamwork and communication. A core principle of Lean Construction is that the success of a project is heavily dependent on the continuous flow of information between all team members. BIM provides a shared digital platform where all project data is integrated and accessible in real-time. This ensures that stakeholders—whether they are involved in design, construction, or project management—are consistently working with the same set of information (Sarhan & Fox, 2013). Such access reduces the likelihood of errors or miscommunication, streamlining decision-making processes and enhancing overall project efficiency. With fewer information gaps, project teams are better positioned to address challenges as they arise, ensuring that resources are used efficiently, thus minimising waste.

Another key synergy between BIM and Lean is how BIM's data-rich environment supports Lean's focus on continuous improvement and value stream mapping. In Lean Construction, value stream mapping is used to analyse and design workflows, ensuring that every step in the process adds value from the client's perspective. BIM's ability to capture and store vast amounts of data on construction processes, materials, and performance metrics offers an invaluable resource for this kind of analysis. By providing accurate, real-time data, BIM enables project managers to identify inefficiencies and make informed decisions about process improvements (Oskouie et al., 2012). This capability is essential in construction environments, where conditions are often complex and dynamic, and the ability to adapt quickly is critical to maintaining project momentum.

The synergy between BIM and Lean extends beyond individual project phases and touches on the entire project lifecycle, from initial design to post-construction maintenance. BIM's comprehensive digital model captures the entire scope of a project, making it easier to track progress and make adjustments as necessary. Lean Construction's focus on Just-in-Time (JIT) delivery further enhances this by ensuring that resources are only allocated when they are needed, reducing material waste and storage costs. JIT principles, when applied in conjunction with BIM's scheduling tools, enable project managers to plan more precisely, ensuring that tasks are performed at the right time, by the right people, with the right resources.

As this thesis seeks to improve the Request for Information (RFI) process, the synergies between BIM and Lean are particularly relevant. The RFI process is often delayed by inefficient information exchanges, which lead to miscommunication, rework, and project delays. By integrating BIM and Lean methodologies into the RFI process, it becomes possible to streamline the flow of information, reducing the time spent waiting for clarifications and approvals. BIM's real-time data sharing ensures that RFIs can be addressed promptly, while Lean's process optimisation ensures that each step in the RFI process is value-adding, rather than a source of delay or waste.

In conclusion, the synergies between BIM and Lean Construction are significant, offering numerous opportunities to enhance project delivery by reducing waste, improving workflow, and fostering collaboration. As this thesis explores ways to optimise the RFI process, these synergies will be leveraged to propose an integrated framework that not only improves communication but also enhances overall project efficiency. By combining the strengths of BIM and Lean, the construction industry can better address the persistent challenges of information flow and process inefficiency that continue to undermine project success.

2.6.3 The Relationship between Integrated BIM and Lean Approaches with Waste and Value Concepts

The synergy between Building Information Modelling (BIM) and Lean Construction is fundamentally aligned with the concepts of waste reduction and value enhancement, which are central to Lean philosophy. Several studies have extensively documented this relationship (Eastman et al., 2011; Dave et al., 2013), with Sacks et al. (2010) providing an influential framework that identifies four primary mechanisms by which BIM and Lean interact to achieve these objectives. These mechanisms underscore how the integration of BIM and Lean methodologies enhances both waste reduction and value creation within construction projects.

The first mechanism highlights BIM's direct contribution to Lean goals. BIM's ability to detect clashes early in the design process significantly minimises the need for rework, which is a major source of waste in construction. By allowing early-stage visualisation and coordination across multiple disciplines, BIM ensures that client input is incorporated efficiently, thus avoiding costly alterations at later stages of the project. This proactive approach aligns perfectly with Lean's goal of eliminating unnecessary processes and waste while enhancing value by ensuring that all efforts are aligned with the client's requirements (Sacks et al., 2010).

Secondly, BIM makes an indirect contribution to Lean goals through the enablement of Lean processes. For instance, BIM supports collaborative planning through 4D scheduling, which integrates time management into the 3D model. This capability allows construction teams to visualise activities over time, reducing bottlenecks and delays by ensuring that tasks are appropriately sequenced. This real-time visualisation aligns with Lean's emphasis on streamlining workflows, reducing waiting times, and eliminating defects (Sacks et al., 2010).

Another significant mechanism is the role of BIM-enabled auxiliary information systems. Through BIM, detailed cost estimation, and environmental performance data can be generated, which provide essential insights for decision-making. Such data enable construction teams to optimise resource use and align project activities with sustainability goals. This directly supports Lean's value-maximisation principles, as resources can be allocated more effectively, reducing waste and enhancing the overall efficiency of the project (Dave et al., 2013).

Finally, the relationship between BIM and Lean is further reinforced by the fact that Lean processes facilitate the introduction of BIM. Organisations that have already embraced Lean principles are typically more collaborative and process-oriented, which creates a conducive environment for the successful adoption of BIM. Lean's focus on process optimisation and continuous improvement naturally complements BIM's functionalities, leading to a smoother integration of the two methodologies (Sacks et al., 2018).

In summary, the relationship between BIM and Lean is deeply rooted in their mutual goals of reducing waste and maximising value. The integration of these methodologies not only improves the efficiency of construction projects but also aligns with broader sustainability goals. This thesis leverages these synergies to propose improvements to the RFI process, ensuring that information flow is optimised and waste in the form of delays and rework is minimised.

2.6.4 BIM-Lean Implementation Challenges

Despite the substantial benefits associated with the integration of BIM and Lean Construction, their implementation in the Architecture, Engineering, and Construction (AEC) industry faces several significant challenges. These challenges are multi-faceted, encompassing both cultural and technical aspects, which have created barriers to the widespread adoption of BIM-Lean approaches.

One of the primary challenges is the cultural shift required within organisations to embrace a combined BIM-Lean methodology (Evans & Farrell, 2021). The construction industry has long been entrenched in traditional methods, which are often resistant to change. Lean Construction demands a cultural environment built on collaboration, trust, and a commitment to continuous improvement. However, the hierarchical and often siloed nature of traditional construction project structures can hinder the development of such a culture. Achieving successful BIM-Lean integration requires organisations to adopt a more collaborative, process-driven approach, which is not always easily achieved in an industry accustomed to compartmentalised working practices (Sacks, Bhargav, et al., 2010).

The technical challenges associated with integrating BIM into existing systems also present substantial obstacles. BIM’s advanced functionalities, including 3D modelling and visualisation tools, often require significant investments in software, hardware, and training (Evans & Farrell, 2021). These investments, coupled with concerns over data security and privacy, particularly when sharing sensitive project information across multiple stakeholders, can act as a deterrent for organisations considering BIM-Lean integration. Additionally, many firms within the construction industry lack the necessary IT infrastructure to support BIM implementation at a large scale, further exacerbating these technical challenges (Arayici et al., 2011).

In conclusion, while the integration of BIM and Lean methodologies offers significant potential to improve project efficiency and reduce waste, it is not without its challenges. Organisations must be prepared to invest in both cultural and technical transformation if they are to realise the full benefits of BIM-Lean integration.

2.6.5 Functionality of BIM and Lean Tools

The integration of Building Information Modelling (BIM) and Lean Construction presents a structured approach to improving efficiency in construction by reducing waste and enhancing collaboration. BIM serves as a digital platform that enhances project planning and execution through functionalities such as 3D modelling, clash detection, 4D scheduling, and 6D facility management (Eastman et al., 2011). Conversely, Lean Construction employs methodologies such as the Last Planner System (LPS), Value Stream Mapping (VSM), and Pull Planning to streamline workflows and eliminate non-value-adding activities (Womack et al., 2007). These methodologies allow for better control of project workflows, ensuring that inefficiencies such as waiting times, overproduction, and redundant processes are minimised.

The principles of Lean Construction, as outlined in Table 2.12 (Sacks et al., 2009), highlight the necessity of reducing process variability, cycle times, and inefficiencies while reinforcing standardisation, visual management, and continuous improvement. These principles align closely with BIM's ability to digitise workflows, ensuring that project teams operate based on accurate, real-time data, thereby mitigating errors and inefficiencies.

Table 2-11 Lean Construction Principles (Sacks et al., 2009)

Principal area	*Principle*	Column Key
Flow process	**Reduce variability**	
	Get quality right the first time (reduce product variability)	A
	Focus on improving upstream flow variability (reduce production variability)	B
	Reduce cycle times	
	Reduce production cycle durations	C
	Reduce inventory	D
	Reduce batch sizes (strive for single piece flow)	E
	Increase flexibility	
	Reduce changeover times	F
	Use multi-skilled teams	G
	Select an appropriate production control approach	
	Use pull systems	H
	Level the production	I
	Standardize	J
	Institute continuous improvement	K
	Use visual management	
	Visualize production methods	L
	Visualize production process	M
	Design the production system for flow and value	
	Simplify	N
	Use parallel processing	O
	Use only reliable technology	P
	Ensure the capability of the production system	Q
Value generation process	**Ensure comprehensive requirements capture**	R
	Focus on concept selection	S
	Ensure requirement flowdown	T
	Verify and validate	U
Problem-solving	**Go and see for yourself**	V
	Decide by consensus, consider all options	W
Developing partners	**Cultivate an extended network of partners**	X

One of the fundamental connections between BIM and Lean Construction is their shared focus on optimising process flows and minimising waste. As Table 2.11 illustrates, Lean principles such as reducing variability, improving cycle times, and increasing flexibility correspond directly with BIM functionalities, particularly clash detection, real-time updates, and integrated project scheduling. By aligning Lean's production control approaches with BIM's visualisation and data-driven planning, project teams can establish cohesive workflows that reduce uncertainty and enhance efficiency.

A structured understanding of the relationship between BIM and Lean methodologies is provided in Figure 2.12 (Dave et al., 2013), which illustrates the reciprocal impact of BIM in facilitating Lean processes and Lean's role in driving efficient BIM adoption. BIM supports Lean objectives by improving process visibility and reducing uncertainty, while Lean ensures that BIM is applied efficiently to eliminate process waste and enhance coordination. The interaction between these two methodologies enables project teams to better manage project complexities, track progress in real-time, and proactively address potential inefficiencies before they impact overall project timelines.

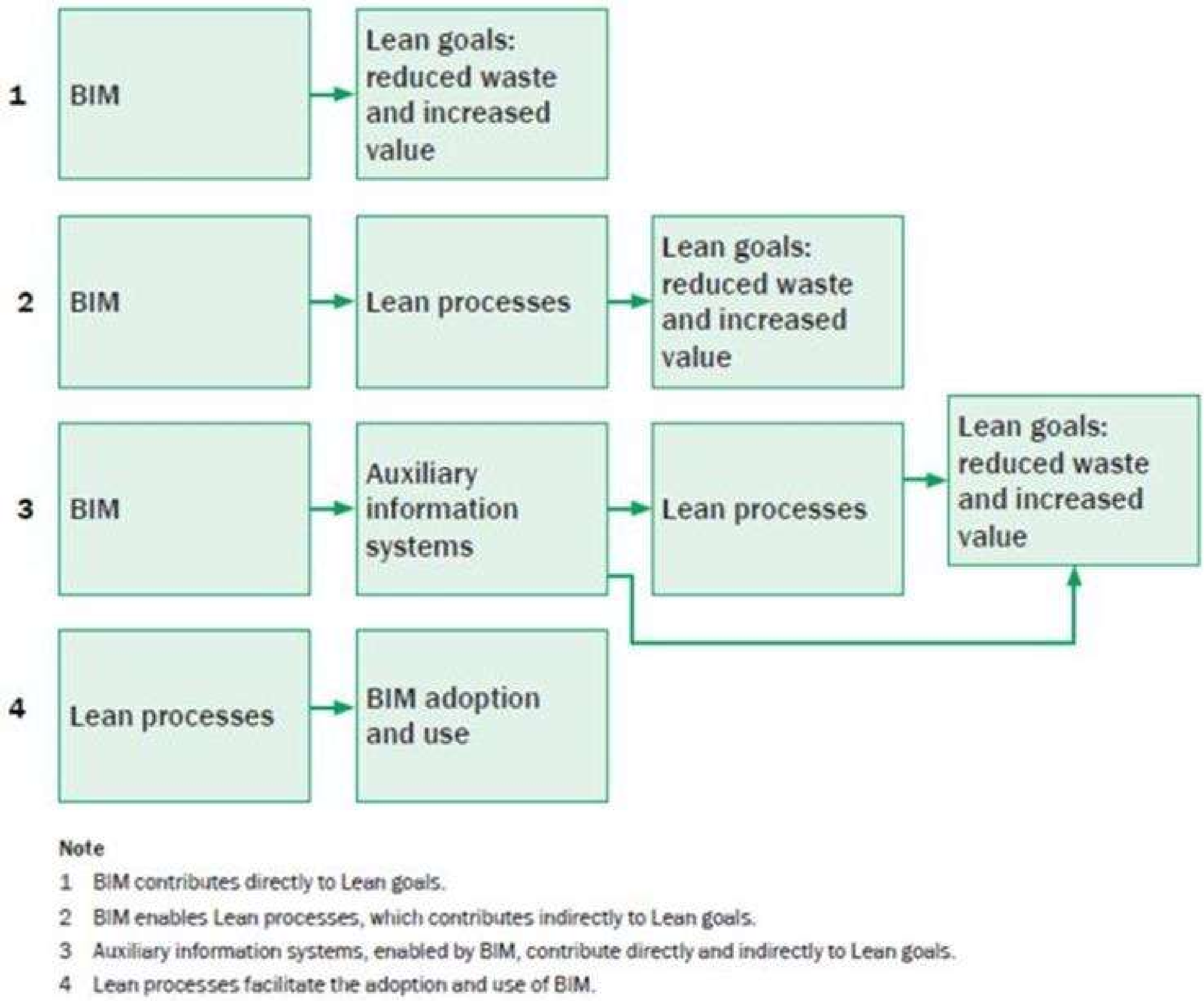


Figure 2-12 Conceptual Connection Between BIM and Lean (Dave et al., 2013)

By leveraging these synergies, BIM and Lean collectively enhance project delivery through improved decision-making, workflow integration, and reduced project delays. The structured approach depicted in Figure 2.12 highlights how BIM not only contributes directly to Lean goals but also enables auxiliary information systems that indirectly support Lean process implementation. This recurring relationship between BIM-driven digital tools and Lean process optimisation ensures that project efficiency is continuously improved through iterative learning and refinement. However, effective implementation requires addressing challenges related to technological adoption, industry resistance, and the need for cultural change. The integration of these tools remains essential for achieving optimal project performance and ensuring structured RFI management, aligning with the broader objectives of this research.

2.6.6 Summary of BIM-Lean Interaction

The interaction between Building Information Modelling (BIM) and Lean Construction presents a powerful synergy within the Architecture, Engineering, and Construction (AEC) industry. BIM, through functionalities such as 3D modelling, clash detection, 4D scheduling, and 6D facility management, enhances project delivery by providing detailed visualisation and improving the accuracy of project planning. These tools allow for real-time data sharing and visual management, ensuring that project teams can anticipate and mitigate potential disruptions, thus aligning with Lean Construction’s goal of optimising workflows and eliminating waste.

Lean Construction, with tools like the Last Planner System (LPS), Value Stream Mapping (VSM), and Pull Planning, focuses on improving process efficiency by eliminating non-value-adding activities and ensuring that workflows are continuous and streamlined. Lean principles encourage collaboration, continuous improvement, and process optimisation, all of which naturally complement BIM’s real-time data management capabilities. Together, BIM and Lean reduce inefficiencies in construction projects by improving communication, enhancing decision-making, and preventing rework or delays caused by poorly coordinated activities.

Through these synergies, BIM supports Lean's focus on waste reduction by enabling accurate, data-driven decision-making, and Lean enhances BIM’s implementation by fostering a collaborative and process-driven project environment. However, the full potential of BIM-Lean integration can only be realised through addressing both technical and cultural challenges. These include the need for substantial investment in IT infrastructure and software, as well as the cultural shift required within organisations to embrace collaborative, non-siloed working practices. Despite these challenges, the integration of BIM and Lean offers substantial opportunities to enhance the efficiency and sustainability of construction projects.

2.7 Integration of BIM and Lean Construction in Construction Management

Building Information Modelling (BIM) and Lean Construction have been widely studied as separate methodologies, each demonstrating significant advantages in improving construction efficiency, reducing waste, and enhancing collaboration. However, their combined application in streamlining the RFI process remains underexplored, highlighting a critical research gap.Existing studies (Sacks et al., 2010; Eastman et al., 2011) have shown that BIM improves design coordination, reducing RFIs by up to 30%. Azhar (2011) further highlights BIM's role in streamlining project communication, leading to reduced delays and improved decision-making. While these findings illustrate BIM's effectiveness, most research has focused on clash detection and early design phases rather than its potential to automate and manage RFIs efficiently.

Lean Construction principles aim to eliminate waste and improve process efficiency (Ballard & Howell, 2003; Dave et al., 2013). Studies show that Lean tools such as the Last Planner System enhance workflow reliability, but their application in RFI workflows is rarely examined. While Lean Construction effectively reduces project delays by minimising rework (Shim et al., 2016), its role in structuring and automating RFIs remains a significant gap. While the literature provides strong support for BIM and Lean Construction as tools for improving construction workflows, their application to RFIs lacks systematic research. To address this gap, Table 2-12 summarises key literature findings, illustrating their contributions, limitations, and relevance to this study.

princiTable 2-12 Comparative Summary of Key Literature on BIM, Lean Construction, and RFIs

Author(s)	Key Findings	Relevance to This Study
Sacks et al. (2010)	BIM improves design coordination, reducing RFIs by up to 30%.	Supports BIM's role in reducing RFIs, justifying its integration into RFI management.
Azhar (2011)	BIM adoption streamlines project communication, reducing delays.	Highlights BIM's efficiency in information flow, reinforcing its relevance to RFIs.
Dave et al. (2013)	Lean Construction tools optimise workflow, reducing information waste.	Demonstrates Lean's role in reducing inefficiencies, applicable to RFI processes.
Papajohn & El Asmar (2021)	Large projects generate 9.9 RFIs per $1 million, causing significant delays.	Quantifies the impact of RFIs, providing evidence for the need to optimise the process.
Shim et al. (2016)	Each RFI takes an average of 8.4 days to resolve, delaying project progress.	Reinforces the need for faster RFI resolution, supporting automation.
Hanna et al. (2012)	Unresolved RFIs contribute to cost overruns and disputes.	Justifies the focus on minimising unresolved RFIs through structured processes.
Eastman et al. (2011)	BIM offers automated clash detection, reducing coordination errors.	Aligns with study objectives by demonstrating BIM's potential for process automation.
Ballard & Howell (2003)	Lean Construction principles improve decision-making and project flow.	Supports Lean principles as a means of improving RFI handling and decision-making.

This comparative analysis highlights that while BIM enhances coordination and Lean Construction improves workflow efficiency, their integration into RFI management is not well-documented in existing research. Therefore, this study aims to bridge this gap by exploring a structured framework that combines these methodologies to optimise the RFI process. Given these limitations in the literature, it is crucial to examine the existing RFI challenges in construction projects. The following section explores the inefficiencies associated with RFIs, providing further justification for a structured BIM-Lean integration to improve the process.

2.8 Introduction to RFI process in Construction

The Request for Information (RFI) process is a critical communication tool in the Architecture, Engineering, and Construction (AEC) industry, ensuring that uncertainties and ambiguities in project documentation are clarified in a formal and structured manner. RFIs are typically raised when contractors, subcontractors, or project managers encounter unclear specifications, conflicting drawings, or unforeseen site conditions. These documents may lack sufficient detail, contain inconsistencies, or present contradictions that require formal clarification to prevent project delays and costly errors (Hanna, 2016). As noted by Tilley et al. (1997), the primary function of RFIs is to maintain project momentum by addressing ambiguities before they escalate into disputes, rework, or contract variations. Over time, the increasing complexity of construction projects and regulatory requirements has necessitated more structured RFI management approaches, incorporating digital collaboration platforms and Lean methodologies to streamline information exchange and response efficiency.

Despite their essential role in construction management, RFIs are frequently associated with inefficiencies such as delayed responses, poorly formulated queries, and inconsistent tracking mechanisms, all of which contribute to project slowdowns and cost overruns. Research conducted by the Navigant Construction Forum (NCF) on over 1,300 projects indicates that large-scale projects generate an average of 9.9 RFIs per £1 million in construction value, with response delays averaging eight days (Gootee, 2015). In highly complex projects, these delays often extend beyond initial estimates, leading to schedule disruptions, misallocated resources, and increased project costs (Hanna et al., 2012). While the RFI process is intended to facilitate structured communication between stakeholders, in practice, fragmented workflows, inadequate categorisation, and lack of accountability often hinder timely resolutions, exacerbating inefficiencies across project phases.

Empirical evidence further supports the claim that ineffective RFI management has substantial financial implications. Case studies, such as the Boston Big Dig, reveal that excessive RFIs—over 40,000 issued—were a major contributing factor to the project's £9 billion cost overrun (Shapiro, 2007). The case analysis conducted by Papajohn et al. (2018) similarly confirms that unresolved RFIs disrupt project schedules, necessitate rework, and escalate labour costs. Notably, RFIs raised late in the construction phase tend to have a disproportionately negative impact, as they often require immediate resolution, force redesign decisions, and introduce unplanned expenses. This phenomenon is further supported by the MacLeamy Curve, which illustrates that the later an issue is identified and addressed, the greater the cost and schedule impact it imposes (CPC, 2017). Projects that prioritise RFIs during early design stages experience fewer disruptions, whereas those that accumulate a backlog of unresolved RFIs during construction face compounded delays, contractual disputes, and financial losses.

In response to these challenges, modern construction management increasingly advocates for technology-driven solutions and process optimisation strategies to enhance RFI handling. The integration of BIM (Building Information Modelling) and Lean Construction methodologies has been identified as a transformative approach to improving RFI tracking, response times, and overall project coordination. These advancements facilitate real-time collaboration, standardise documentation, and ensure that RFIs are efficiently categorised based on urgency and project impact (Eastman et al., 2011). However, despite these innovations, the industry still lacks a unified framework for integrating BIM and Lean principles into a standardised RFI workflow, leaving gaps in research and practical implementation. This underscores the need for a structured, validated RFI process that minimises inefficiencies and enhances construction productivity.

2.8.1 The RFI Process

The efficiency of the Request for Information (RFI) process is heavily influenced by the clarity of project documentation, stakeholder communication, and the effectiveness of response mechanisms. A well-structured RFI workflow is essential to preventing misinterpretations that can lead to costly project delays and disputes. However, industry research has highlighted recurring inefficiencies, including inconsistencies in submission formats, ambiguous queries, and a lack of accountability in response tracking (Papajohn et al., 2018). These issues underscore the necessity for structured RFI management frameworks that ensure timely and precise information exchange.

A key challenge in RFI workflows is the variability in response times. While some RFIs are addressed promptly, others remain unresolved for extended periods, creating bottlenecks in project schedules. Studies by Mao et al. (2007) and Shim et al. (2016) suggest that RFIs should be categorised by urgency to optimise prioritisation. For example, RFIs related to design discrepancies may require immediate resolution, whereas those concerning non-critical material specifications can follow a longer response cycle. Establishing tiered response mechanisms, with predefined turnaround times, is vital to mitigating disruptions and ensuring smoother project execution.

The integration of digital tools has been widely recognised as a transformative approach to enhancing RFI efficiency. Building Information Modelling (BIM) provides a centralised platform for managing RFIs by linking them directly to specific project components, reducing ambiguity and improving traceability

(Dantas Filho et al., 2016). The ability to visualise and contextualise RFIs within the digital model facilitates faster decision-making and minimises miscommunication between stakeholders. In addition, Lean Construction methodologies, such as the Last Planner System (LPS), have demonstrated their effectiveness in improving coordination and reducing workflow inefficiencies by aligning project participants on issue resolution priorities (Ballard & Howell, 2003). The combination of BIM and Lean Construction offers a robust framework for enhancing RFI processes by integrating real-time tracking, standardised documentation, and proactive workflow management.

Despite the availability of these advanced methodologies, industry adoption remains inconsistent. Many construction projects still rely on manual RFI tracking systems, which contribute to disjointed communication and inefficiencies in response workflows (Tezel et al., 2017). Standardising digital RFI submission processes and integrating structured review protocols can significantly improve overall project efficiency. As construction projects continue to grow in complexity, the necessity for an optimised, technology-driven RFI framework becomes increasingly evident, reinforcing the importance of continued research into best practices for implementation.

2.8.2 The Impact of RFI Delays

Delays in responding to Requests for Information (RFIs) have far-reaching consequences for construction projects, affecting financial stability, resource allocation, and overall project performance. Unresolved RFIs can cause work stoppages, leading to scheduling disruptions and unplanned costs. According to Papajohn et al. (2018), prolonged RFI response times contribute to inefficiencies that escalate labour and material expenses while reducing productivity. Since unresolved RFIs delay decision-making, affected stakeholders—such as contractors, subcontractors, and project owners—experience increased expenditure on wages, equipment rental, and administrative overheads, even when construction activities remain stalled (Shim et al., 2016).

Project timelines are particularly vulnerable to RFI delays. Research conducted by Kelly & Ilozor (2013) demonstrates that unaddressed RFIs disrupt critical path activities, setting off a cascading effect that delays subsequent tasks. The necessity to pause operations while awaiting clarifications often results in workforce demobilisation, further compounding inefficiencies and creating difficulties in resource reallocation. When RFIs remain unresolved for extended periods, project teams may resort to makeshift solutions or assumptions, increasing the risk of design inconsistencies and non-compliance with contract specifications.

A notable case study presented by Hanna et al. (2012) highlights the significance of specific RFI types in influencing project outcomes. Using the RFI Reasoning Code framework, the study identified that RFIs concerning design clarifications and differing site conditions often lead to substantial delays and cost overruns. As shown in Table 2.13, these RFIs typically require comprehensive analysis and multiparty coordination before resolutions can be implemented. Failure to address such RFIs promptly may result in excessive rework, material wastage, and contract variations, exacerbating budgetary constraints and causing friction between project stakeholders.

Table 2-13 RFI Reasoning Code (Hanna et al., 2012)

Reason code	Description
Added scope (AD)	Addition of items to the original project scope
Construction coordination (CC)	Organizing and coordinating construction-related procedures, schedules, and safety items
Constructability issues (CI)	Difficulty in constructing an item as detailed or designed
Change of staging/phasing (CS)	Sequence of construction previously determined inadequate or in need of reorganizing due to resource limitations and manpower organization
Design change (DC)	Request to modify a design to simplify efforts by construction team or to correct an error in construction
Design clarification (DL)	Additional information requested to further understand and clarify components of the design and its related constituents
Different method (DM)	Change in installation technique or construction process
Design coordination (DR)	Organizing and coordinating the design and related documents between entities
Deleted scope (DS)	Scope or line items to be removed from the project
Incomplete plans/specs (IP)	Error or omission in the plans/specifications
Material change (MC)	Different material requested other than what is specified due to having an excess material readily available, or experience demonstrates another material has an improved performance
Differing site conditions (SC)	Impediments discovered at the site that were previously unknown or were not in the condition as described in the contract
Utility conflict (UC)	Utility pipes, lines, or boxes prevent the construction strategy from proceeding as planned
Value engineering (VE)	Cost-reduction and construction improvement techniques
Other (OR)	Any justified RFI submitted that does not fit into one of the other 14 categories including but not limited to payment methods, certification requirements, penalties, warranties, and non-design-related documents

The Navigant Construction Forum (2014) further reinforces these findings, reporting that delayed RFIs are a leading cause of budget overruns. Their study of over 1,300 construction projects revealed that for each additional day an RFI remains unresolved, project costs increase—sometimes by as much as 0.5% of the total contract value per day. This cumulative financial burden is especially pronounced in large-scale infrastructure developments, where extended RFI response times contribute to millions of pounds in additional expenses. Beyond financial impacts, prolonged RFI delays also affect contractual relationships, often leading to disputes between project participants over liability for project slowdowns and increased expenditure.

In some instances, contractors and subcontractors may exploit RFI-related inefficiencies to justify claims for compensation due to extended idle times. Zack Jr. (1998) notes that delayed RFIs can serve as a strategic tool in claim disputes, where prolonged response times are leveraged to negotiate additional payments for work stoppages. This practice underscores the necessity of establishing clear contractual guidelines that define RFI response timelines, escalation procedures, and associated penalties for delays. Without such measures, RFI inefficiencies may be intentionally prolonged, creating financial and legal complexities that further hinder project delivery.

In addition to economic ramifications, RFI delays pose serious quality and safety risks. Ballard & Howell (2003) explain that when project teams fail to receive timely responses to RFIs, they may proceed with incomplete or ambiguous information, compromising the integrity of the construction process. This can lead to errors that necessitate extensive rework, increasing costs and affecting overall project quality. Poorly managed RFIs have been linked to structural deficiencies, unsafe working conditions, and regulatory non-compliance, particularly in projects with complex engineering requirements (Papajohn et al., 2018). Addressing these risks requires a proactive approach to RFI management, ensuring that information is disseminated efficiently and that quality assurance measures are upheld throughout the project lifecycle.

To mitigate the adverse effects of RFI delays, researchers have proposed several strategies aimed at improving response efficiency and minimising project disruptions. Papajohn et al. (2018) advocate for the implementation of a tiered response system, where RFIs are categorised based on urgency and assigned predefined resolution timeframes. Under this system, high-priority RFIs—such as those impacting structural integrity must be addressed within a strict seven-day window, while less critical queries are allocated longer response times. Additionally, Shim et al. (2016) recommend maintaining a centralised RFI tracking system that logs submission and response times, ensuring greater accountability in the resolution process.

Technological advancements also offer promising solutions for improving RFI workflows. The integration of Building Information Modelling (BIM) with Lean Construction methodologies enables stakeholders to centralise RFI data, streamline collaboration, and enhance transparency in issue resolution (Dantas Filho et al., 2016). By embedding RFIs directly into digital project models, teams can visually identify problem areas, access relevant documentation in real time, and expedite decision-making. Furthermore, Lean tools such as the Last Planner System (LPS) facilitate proactive planning by ensuring that RFIs are resolved before they cause workflow disruptions, reducing reliance on reactive issue management (Ballard & Howell, 2003).

In conclusion, delayed RFIs introduce significant risks to construction projects, including financial losses, scheduling conflicts, quality compromises, and contractual disputes. The extent of these risks is highly dependent on the nature of the RFI, the response efficiency of project teams, and the presence of structured management frameworks. By adopting tiered prioritisation models, digital collaboration platforms, and Lean Construction strategies, the construction industry can enhance RFI resolution processes, minimising disruptions and improving project outcomes.

2.8.3 Advancements in AEC Technology in the Construction Industry

The construction industry has experienced significant technological advancements, with Building Information Modelling (BIM) and Lean Construction emerging as transformative methodologies. These tools are fundamentally reshaping how information is managed, shared, and utilised in construction projects. The integration of BIM and Lean tools enhances collaboration, optimises workflows, and supports informed decision-making, thereby addressing many of the long-standing challenges in construction project delivery (Azhar, 2011; Eastman et al., 2011).

BIM is primarily known for its capabilities in 3D visualisation, but its functionality extends far beyond this. By creating comprehensive, data-rich models of construction projects, BIM allows stakeholders to access detailed information about every aspect of a project in real-time. This includes data on materials, costs, timelines, and even environmental impacts, enabling more informed decision-making across all phases of the project (Azhar et al., 2012). Azhar (2011) has noted that BIM is particularly effective at improving the efficiency of communication among stakeholders, reducing misunderstandings and errors that often lead to delays and cost overruns.

The integration of BIM with Lean Construction principles further amplifies the potential of both technologies. Lean Construction focuses on eliminating waste and improving efficiency by optimising processes and enhancing collaboration. When combined with BIM, Lean tools like the Last Planner System (LPS) allow for more accurate scheduling and project management, as well as better anticipation of potential bottlenecks (Ballard & Howell, 2003). The synergy between BIM and Lean enhances the flow of information, ensuring that project tasks are aligned with stakeholder expectations and that work is completed on schedule (Tauriainen et al., 2016).

A practical example of BIM and Lean integration can be found in the case study by Luth et al. (2014), where BIM was used to increase design-construction integration. In this study, the use of BIM for clash detection and visualisation directly supported Lean's aim of reducing waste, as issues were identified and resolved early in the project lifecycle. This reduced the need for costly rework and ensured that the project remained on track.

Furthermore, the adoption of advanced technologies like 4D and 5D BIM—which incorporate time and cost elements into the model—has revolutionised project planning and management. By providing real-time insights into project progress and budgetary considerations, 4D and 5D BIM help construction teams avoid delays and keep project costs under control (McPartland, 2017). These advancements are particularly relevant in the context of Request for Information (RFI) management, where delays can significantly impact project timelines and costs. By integrating RFIs into the BIM model, project teams can quickly address issues and reduce the time spent waiting for clarifications (Dantas Filho et al., 2016).

Another noteworthy application of BIM and Lean technologies is in constructability analysis, as highlighted by Dantas Filho et al. (2016). This approach ensures that design decisions are reviewed early in the project to identify potential conflicts or inefficiencies. By integrating constructability reviews into the BIM model, teams can reduce the volume of RFIs and ensure that issues are addressed before they cause significant delays or cost overruns. This proactive approach aligns with Lean's goal of continuous improvement and waste reduction, further enhancing the efficiency of the construction process.

However, despite the substantial benefits of BIM and Lean technologies, there are challenges associated with their implementation. Michalski et al. (2022) conducted a systematic review of Lean construction management techniques and BIM, identifying several barriers to their successful adoption, including the need for significant upfront investment in software and training, as well as the resistance to change within the traditionally conservative construction industry. Moreover, integrating BIM with existing workflows requires careful planning and coordination to avoid disruptions to project delivery (Tezel et al., 2017).

In conclusion, the advancements in AEC technology, particularly the integration of BIM and Lean Construction, offer a promising solution for improving the efficiency of construction projects. By enhancing collaboration, optimising workflows, and providing real-time insights into project progress, these technologies address many of the inefficiencies that have traditionally plagued the industry. However, their successful implementation requires careful planning, investment, and a willingness to embrace new ways of working.

2.8.4 RFI Management During Project Handover

Requests for Information (RFIs) play a critical role not only during the design and construction phases but also during the project handover phase. At this stage, RFIs ensure that any unresolved issues, clarifications, or information gaps regarding operations, warranties, or maintenance responsibilities are adequately addressed before the project is transferred to the owner or facility manager (Kelly & Ilozor, 2013). Effective RFI management during this phase can mitigate delays in the handover process and ensure that the project is fully operational, with all necessary information available for smooth facility management post-handover.

During the handover, the nature of RFIs tends to shift. Earlier in the project, RFIs typically deal with design issues, material specifications, and site conditions. However, in the handover phase, RFIs often pertain to operational details, such as equipment verification, final adjustments in documentation, and clarifications regarding warranties or future maintenance plans (Kelly & Ilozor, 2013). If these RFIs are not managed promptly and effectively, they can result in costly operational inefficiencies, delays in building occupancy, and an increase in long-term maintenance costs.

The Navigant Construction Forum (NCF) study shows that RFIs raised during the final stages of a project, particularly those related to operational issues, often result in substantial delays. The average response time to such RFIs is frequently longer, as they require input from multiple stakeholders, including the project owner, contractors, and equipment suppliers (Gootee, 2015). Delayed responses to these RFIs can disrupt the transition from construction to operation, causing a bottleneck in project completion.

A case study by Kelly & Ilozor (2013) illustrates how poor RFI management during handover led to extended delays in the operational start-up of a major healthcare facility. Several RFIs related to equipment warranties and operation procedures remained unresolved during the project handover, leading to significant downtime, additional costs, and a six-month delay in facility opening. This case highlights the necessity of ensuring that all critical RFIs, especially those impacting operations and maintenance, are addressed well before the official handover.

To avoid such complications, the literature recommends several best practices for RFI management during the handover phase:

- Comprehensive Pre-Handover Review: RFIs related to operational and maintenance aspects should be reviewed comprehensively at least 3–6 months before the scheduled handover. This ensures that any unresolved issues can be clarified in advance, reducing the likelihood of last-minute disruptions (Shim et al., 2016).

- Proactive Communication with Facility Managers: Facility managers or owners should be included in discussions related to RFIs during the handover phase to ensure they fully understand any changes or operational considerations that have arisen throughout the construction process (Kelly & Ilozor, 2013).

- Use of BIM for Handover RFIs: Building Information Modelling (BIM) provides an ideal platform for tracking handover-related RFIs. By tagging operational RFIs directly within the model, facility managers can gain a clear visual representation of issues that need to be resolved, facilitating smoother communication and resolution before the facility becomes operational (Dantas Filho et al., 2016).

Moreover, RFIs raised during handover often involve questions that can affect the long-term operational efficiency of the building. Issues like equipment performance, clarification of technical specifications, and final adjustments in mechanical and electrical systems can all be subject to RFIs. When these questions are delayed, they can impede the proper functioning of critical systems and increase long-term maintenance costs (Papajohn et al., 2018).

A streamlined RFI process during the handover phase, supported by technological tools like BIM and Lean Construction principles, is essential for minimising delays and ensuring that all stakeholders have access to the information they need to make informed decisions. The integration of Lean tools, such as the Last Planner System (LPS), can also enhance the efficiency of the handover process by coordinating tasks and ensuring that final-stage RFIs are prioritised appropriately (Ballard & Howell, 2003).

In conclusion, RFI management during project handover is critical to ensuring a smooth transition from construction to operation. By implementing best practices such as early review of operational RFIs, proactive communication with stakeholders, and leveraging BIM, project teams can reduce delays, prevent operational inefficiencies, and facilitate a seamless handover process. This ensures that the project is delivered on time and within budget, with all systems functioning as intended, and provides the facility managers with the information needed for effective long-term management.

2.8.5 Good vs Bad RFIs: Insights from the CPC Report

The Construction Progress Collision (CPC) 2017 report provides valuable insights into the distinction between "good" and "bad" Requests for Information (RFIs), clarifying their impact on project efficiency, cost, and scheduling (Figure 2.13). The classification of RFIs as either good or bad primarily depends on the timing of their submission within the project lifecycle and their ability to support efficient project execution. Poorly timed RFIs can introduce significant disruptions, rework, and budget overruns, whereas well-structured RFIs facilitate clarity, collaboration, and seamless project progression.

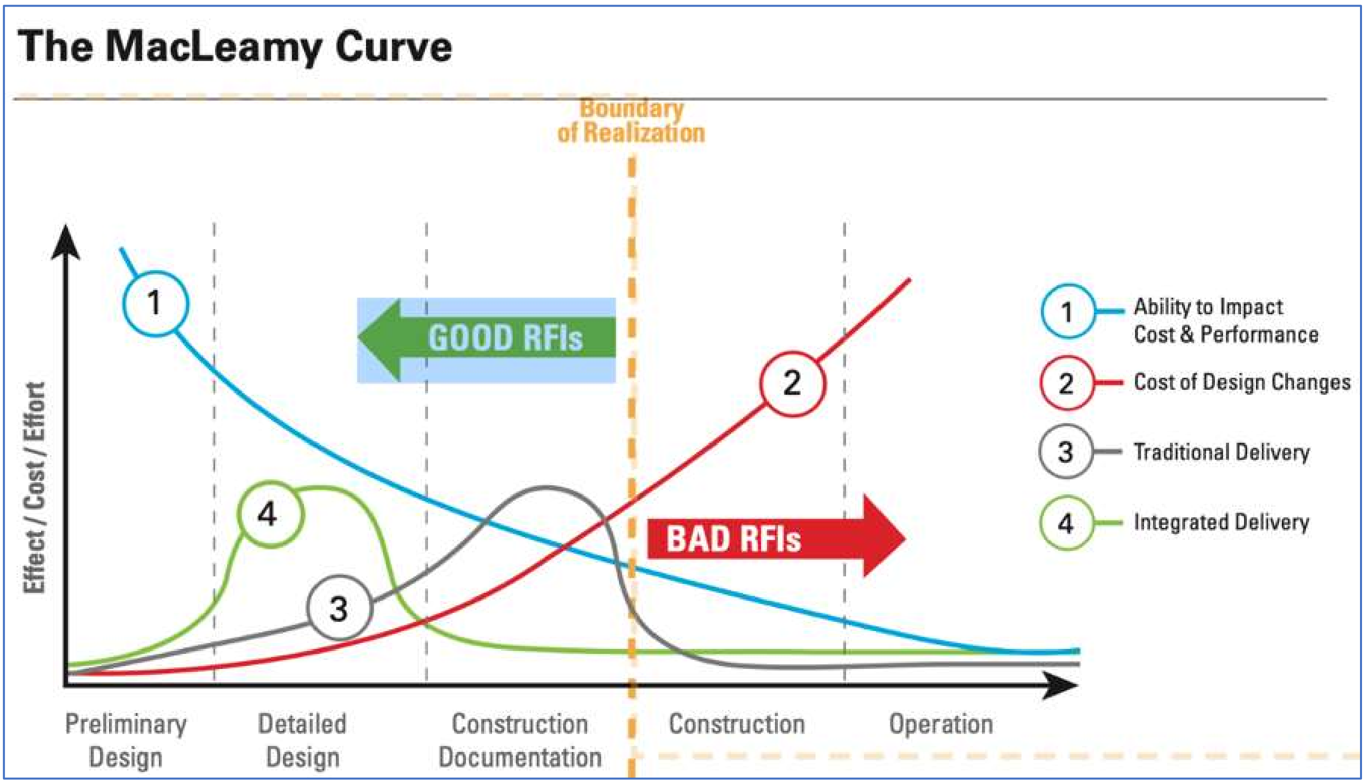


Figure 2-13 Good RFIs vs Bad RFIs McLeamy Curve (CPC, 2017)

2.8.5.1 Good RFIs

Good RFIs are those submitted during the early stages of the project lifecycle, typically in the design or pre-construction phases. Their primary function is to clarify ambiguities, prevent conflicts, and support well-informed decision-making before construction activities commence. When issued in a timely manner, these RFIs contribute to the alignment of all project stakeholders, ensuring that potential risks are identified and mitigated at the lowest possible cost.

For instance, RFIs that seek clarification on design specifications, materials, or construction methodologies allow teams to resolve uncertainties before execution begins, thereby preventing costly delays or rework in the later stages (CPC, 2017). According to the CPC report, projects that address RFIs proactively experience fewer workflow disruptions, as they allow for better allocation of resources and reduced last-minute design modifications.

A clear example of a good RFI can be seen in pre-construction coordination efforts, where contractors submit requests to confirm compliance with structural and regulatory requirements. Such RFIs ensure that all elements are aligned before procurement and execution, reducing miscommunication and unforeseen obstacles during actual construction.

2.8.5.2 Bad RFIs

Conversely, bad RFIs are those submitted too late in the construction phase or at a point where design modifications are no longer feasible without causing major disruptions. These RFIs tend to introduce inefficiencies, leading to project delays, cost overruns, and unnecessary rework. The CPC 2017 report highlights that late-stage RFIs—particularly those related to design changes or site conflicts that could have been anticipated earlier—are highly problematic.

The MacLeamy Curve further illustrates this concept, showing that as RFIs are raised later in the project lifecycle, the cost and effort required to resolve them increase exponentially (Figure 2.13). When RFIs arise at the construction phase due to previously overlooked issues, they often result in rework, schedule disruptions, and increased expenses.

A practical example of a bad RFI is one that raises a design change request after materials have already been procured and construction is underway. Such RFIs create waste in terms of time, labour, and material costs, while also impacting dependent activities along the critical path. To avoid bad RFIs, it is crucial for project teams to conduct thorough pre-construction reviews, ensure proactive coordination, and implement structured issue-tracking mechanisms.

2.8.5.3 RFI Management and Lean Construction

The integration of Building Information Modelling (BIM) and Lean Construction techniques provides a structured approach to minimising the occurrence of bad RFIs, while enhancing project efficiency and planning. BIM facilitates early clash detection and digital coordination, allowing project teams to identify and resolve issues virtually before they materialise on-site (Dantas Filho et al., 2016).

Additionally, Lean Construction methodologies, such as the Last Planner System (LPS), encourage a collaborative planning environment where RFIs are identified and resolved before they impact the project schedule (Ballard & Howell, 2003). Through structured coordination meetings, real-time issue tracking, and proactive communication, these tools help to reduce waste and improve decision-making processes. By leveraging these strategies, construction teams can ensure that RFIs support rather than hinder project delivery, ultimately improving overall project efficiency, reducing unnecessary costs, and enhancing collaboration.

2.8.6 Current RFI Process Guidelines in Construction

Requests for Information (RFIs) are integral to managing construction projects, serving as a formal communication tool used by contractors, subcontractors, and other stakeholders to seek clarification on aspects of the project not adequately covered in the original contract documents. The RFI process ensures that information gaps are resolved before they lead to costly rework, delays, or misunderstandings. Here’s a breakdown of the current RFI process, including best practices for its management as outlined by recent literature.

2.8.6.1 Industry Standard and guideline for the RFI Process

The RFI process generally follows a structured approach, with key steps to ensure clear communication:

1. Submission: A contractor or subcontractor identifies an ambiguity or requires additional details regarding the design, specifications, or scope of the project. The RFI is then drafted and submitted to the appropriate party, typically the general contractor or architect. The request should include clear questions and relevant context, such as drawings, photos, or site conditions.

2. Review: The recipient, whether an architect, engineer, or project manager, reviews the request and seeks to provide a comprehensive response. In some cases, the response might involve further consultations with other stakeholders.

3. Response: Once the required information is gathered, a formal response is issued, typically within a set time frame. This response might resolve the issue or, in more complex cases, prompt further inquiries.

4. Resolution: Once the RFI is answered satisfactorily, work can proceed. If not, the RFI may be resubmitted for additional clarification.

This process is essential for maintaining project flow, as RFIs document and clarify crucial aspects that, if unresolved, could lead to delays, legal disputes, or cost increases (Smartsheet, 2022; Autodesk Construction, 2022).

2.8.6.2 Key Elements of an Effective RFI identified by current guidelines

To streamline the RFI process and prevent bottlenecks, several best practices are recommended:

- Clarity and specificity: RFIs should focus on a single issue at a time, clearly outlining the question and providing all necessary context to expedite a response. Including visuals such as drawings or photographs often helps clarify the issue (Buildertrend, 2022).

- Standardised templates: Using a standardised RFI template ensures consistency and helps all parties quickly identify and respond to the issue at hand. This template should include fields for RFI numbers, project information, detailed questions, and references to specific drawings or sections of the contract (TrustRadius, 2022).

- Timely submission and response: Establishing deadlines for both submission and response is crucial. Delayed responses can lead to extended downtime and cost overruns. According to the Navigant Construction Forum, delayed RFIs cost projects an average of $1,080 per response and can increase project duration by 9.7 days on average (InEight, 2022).

2.8.6.3 Technological Integration in RFI Management – (current guidelines)

The advent of cloud-based platforms and tools such as Building Information Modelling (BIM) has significantly improved the RFI management process. BIM allows RFIs to be tagged to specific project elements, giving all stakeholders real-time access to relevant information, drawings, and updates. This eliminates much of the back-and-forth traditionally associated with RFI responses and helps reduce delays (Autodesk Construction, 2022).

Moreover, integrating digital document control systems allows for better tracking of RFI submissions and responses. These systems ensure that all project documents and RFIs are centralised, accessible to the right parties, and managed efficiently to reduce the risk of errors or missed deadlines (InEight, 2022).

In conclusion, the current RFI process has evolved to become more efficient with technological advancements, particularly through the use of BIM and cloud-based document management systems. By adhering to best practices, including clarity in submissions, standardised forms, and timely responses, the construction industry can mitigate the potential risks associated with delays and improve project outcomes.

2.8.7 Critical Review of the Current RFI Guideline Process

The current RFI guideline process in construction provides a basic framework for managing Requests for Information (RFIs), but it is not without significant limitations that affect its efficiency and effectiveness. This section outlines the primary gaps in the current process and explains how the proposed RFI process in this thesis addresses these shortcomings.

1. Technological Adoption and Industry Support: While the current RFI guideline process recommends the use of advanced technologies such as Building Information Modelling (BIM) and Lean Construction tools, their adoption across the construction industry is inconsistent. Smaller firms or those in less technologically advanced regions may lack the resources or expertise to fully engage with these tools (Autodesk, 2022). As a result, the effectiveness of the RFI process varies widely, with many stakeholders unable to benefit from the full potential of BIM and Lean.

Response in Thesis: The proposed RFI process in this thesis recognises this disparity in technological adoption and provides a scalable framework that works for firms at various levels of technological maturity. While leveraging BIM and Lean tools for enhanced collaboration and workflow efficiency, it also outlines alternative approaches for stakeholders who may not have full access to these technologies, ensuring broader applicability.

2. Complexity in Role Assignments and Accountability: The current RFI guideline process assigns distinct roles—such as RFI Creator, RFI Manager, and RFI Responder—to ensure clarity in responsibility. However, in practice, role assignments can lead to confusion, particularly when responsibilities overlap or when accountability for delays is not clearly defined (InEight, 2022). This ambiguity can lead to bottlenecks and project delays, as it becomes unclear who is responsible for resolving the issue.

Response in Thesis: The thesis addresses this by implementing a clear accountability structure within the RFI process. It introduces specific escalation procedures for addressing delays and non-responses, ensuring that every stakeholder knows their role and that unresolved RFIs are escalated quickly to higher management for prompt resolution.

3. Timeliness and Flexibility in Responses: The current process defines rigid timelines for responding to RFIs based on their urgency—high, medium, or low—without accounting for the complexity or scale of the project (Buildertrend, 2022). This inflexibility can lead to either rushed responses that don't fully address the issue or project delays when more time is needed to gather the necessary information.

Response in Thesis: The proposed RFI process in this thesis introduces a more flexible timeline model. It adjusts response times based on the complexity of the RFI and its impact on the overall project schedule, ensuring that responses are thorough and not rushed to meet arbitrary deadlines. This flexibility is particularly important in large-scale or highly technical projects.

4. Escalation of Insufficient or Non-Responses: One major gap in the current RFI guideline process is the lack of a clear mechanism for escalating RFIs that are either unanswered or inadequately answered. This gap can lead to unresolved issues persisting through the project, eventually causing rework and increased costs (Smartsheet, 2022).

Response in Thesis: To address this, the thesis proposes a structured escalation mechanism within the RFI process. If an RFI is not adequately addressed within the specified timeframe, it is automatically escalated to higher project management levels, ensuring that critical project issues do not remain unresolved.

5. Repetitive RFIs and Information Continuity: The current process does not adequately address the issue of repetitive RFIs. As project teams change over the course of long-term projects, previously resolved issues may resurface, leading to unnecessary repetition of RFIs (Autodesk Construction, 2022).

Response in Thesis: The thesis mitigates this by integrating BIM with a detailed RFI documentation system. This ensures that each RFI is tagged within the project model and that its history, along with the resolution, is easily accessible to all team members. This reduces redundancy and ensures information continuity, even when there are personnel changes.

6. Tracking of RFI Types and Categories (KPI) for Continuous Improvement: The current RFI guideline process lacks any system for tracking and categorising RFIs, which prevents project managers from analysing trends or identifying areas for improvement in future projects. Without

categorisation, management cannot effectively evaluate the root causes of RFIs, making it difficult to implement long-term performance improvements (InEight, 2022).

Response in Thesis: The thesis addresses this by introducing a comprehensive RFI categorisation system that groups RFIs by type and cause (e.g., Design Clarification, Scope Change, Differing Site Conditions). This system serves as a valuable Key Performance Indicator (KPI), allowing management to review and understand the types of RFIs that occur most frequently and where improvements can be made. For example, if a project experiences a high volume of Design Clarification RFIs, this may indicate a need for better design documentation or communication during the planning phase.

Additionally, these RFI categories are designed to be flexible and adaptable, allowing them to be tailored to the specific needs of different sectors within the construction industry. Infrastructure projects, for instance, may encounter different types of RFIs compared to high-rise building construction. The categorisation system allows for industry-specific modifications, ensuring it remains relevant and effective across a range of project types.

7. Training and Implementation: The current RFI guideline process does not provide adequate support for training and onboarding project teams, particularly those unfamiliar with advanced tools like BIM and Lean (InEight, 2022). This gap can lead to inconsistent application of the RFI process and reduced effectiveness, particularly in smaller firms or projects with limited technological infrastructure.

Response in Thesis: The proposed RFI process includes a comprehensive training module to ensure that all stakeholders, regardless of their familiarity with advanced tools, can efficiently engage with the process. This training covers both the use of digital tools and the principles of Lean Construction, ensuring scalability across diverse project environments.

In conclusion, the current RFI guideline process, while offering a basic structure for managing information in construction projects, presents several critical gaps that can lead to inefficiencies, delays, and increased costs. These gaps include inconsistent technology adoption, a lack of role accountability, inflexible timelines, inadequate escalation procedures, and an absence of RFI tracking and categorisation. The proposed RFI process in this thesis addresses these shortcomings by offering a scalable, flexible, and structured approach that incorporates advanced technologies, detailed RFI categorisation, and robust training and escalation mechanisms. In doing so, the thesis contributes to the broader Lean Construction strategy of continuous improvement, ensuring that RFIs are managed more effectively, both in real-time and for future project planning.

2.8.8 Summary of the RFI Process in Construction

In conclusion, this section thoroughly explores the significance of RFIs in the construction process, highlighting the limitations of the current guidelines and offering innovative solutions through the integration of BIM and Lean methodologies. The proposed RFI process in this thesis not only addresses the existing gaps but also introduces a comprehensive system for categorising and managing RFIs. By leveraging BIM for better visualisation and Lean principles for continuous improvement, the thesis aims to enhance the efficiency of RFI management, ensuring better project outcomes, reduced delays, and improved cost control. The subsequent chapter will outline the research methodology, detailing how these solutions will be empirically tested through case studies and focus groups to validate the proposed framework.

Chapter: 3 Research Methodology

3.1 Introduction to Methodology

This chapter delineates the methodological approach undertaken to explore the integration of Building Information Modelling (BIM) and Lean Construction (LC) and their potential influence on enhancing the Request for Information (RFI) process within the AEC sector. At the time of the study, both BIM and Lean Construction were still in the early stages of adoption within the industry, necessitating the use of an exploratory research approach. Such an approach is particularly effective when the research problem is not yet fully defined, offering the flexibility needed to accommodate emerging findings and enabling the development of hypotheses and new research questions (Saunders et al., 2016).

The adopted methodology employs mixed methods, blending both qualitative and quantitative techniques. This approach aligns well with exploratory research as it facilitates a comprehensive investigation of the research questions from multiple perspectives. Grounded theory, the core qualitative method used, allows for the generation of theoretical insights directly from data collected through various means, including surveys, literature reviews, and focus groups (Glaser & Strauss, 1967). In addition, the methodology integrates Design Science Research (DSR) to steer the development and iterative refinement of a practical software tool aimed at improving the RFI process. This blend of grounded theory and DSR ensures a balance between theoretical contributions and real-world applicability (Hevner et al., 2004).

Given the limited prior research on the convergence of BIM, Lean principles, and RFIs, the mixed-methods exploratory approach proves to be most suitable. The combination of quantitative surveys and qualitative focus groups captures both broad industry trends and specific, in-depth insights from seasoned professionals within the AEC industry.

3.2 Research Onion Framework

The Research Onion, as proposed by Saunders et al. (2016), provides a structured approach to research design, guiding researchers through the multiple layers of methodology. These layers encompass philosophical assumptions, research approaches, strategies, and specific data collection techniques. The flexibility and adaptability embedded within this framework render it especially appropriate for exploratory research, as it allows for modifications in research direction as new insights are discovered throughout the study (refer to Figure 3.1).

This framework is fundamental to the design of this research, which seeks to investigate the integration of BIM and Lean Construction principles within the RFI process. As the research unfolded, the layers of the Research Onion enabled the systematic development of research methods, ensuring consistency while allowing room for exploration. The framework's structured nature facilitated the management of both qualitative and quantitative data collection and analysis, ensuring that each phase of the study built upon a coherent philosophical and methodological foundation.

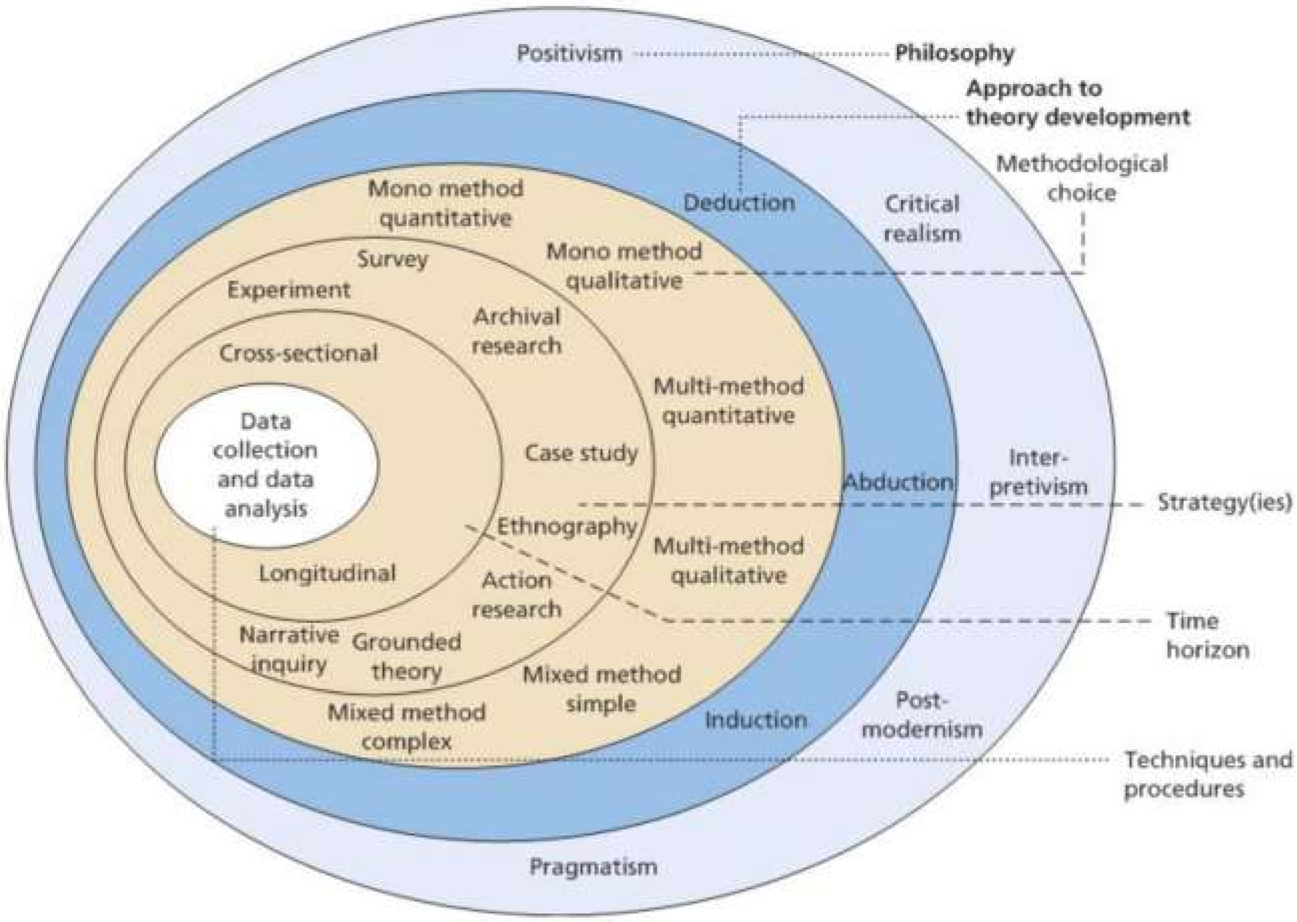


Figure 3-1 Research Onion (Saunders et al., 2016)

3.2.1 Research Philosophy

The outermost layer of the Research Onion framework addresses research philosophy, which shapes the assumptions about reality (ontology) and knowledge (epistemology) underlying the study. This research adopts an interpretivist philosophical stance, which is particularly fitting given the focus on BIM, Lean Construction, and RFIs. These concepts are not merely technical systems; they are embedded within intricate social and organisational processes that influence how information flows and decisions are made within construction projects. An interpretivist approach allows for a deeper examination of the subjective experiences and perceptions of professionals in the AEC industry (Bryman, 2016).

The alignment of interpretivism with an exploratory research strategy underscores the expectation that new themes and concepts will emerge through qualitative inquiry. As Saunders et al. (2016) note, interpretivism acknowledges the socially constructed nature of knowledge, which is formed and evolved through human interactions. This perspective is particularly appropriate for studies examining the management of information flow in dynamic, multifaceted project environments. Through the interpretivist lens, the complexities of BIM and Lean Construction in relation to RFIs are explored in a manner that considers the human and social elements inherent in construction industry practices.

3.2.2 Research Approach

The second layer of the Research Onion pertains to the research approach adopted for this study, which follows a mixed-methods exploratory strategy. This dual approach effectively combines both inductive and deductive reasoning. Grounded theory, which is inherently inductive, allows theories and insights to emerge directly from the data gathered throughout the study, fostering the identification of patterns and themes relevant to the research. Simultaneously, Design Science Research (DSR) incorporates deductive elements by developing, testing, and refining a practical tool aimed at improving the RFI process (Hevner et al., 2004).

The reliance on inductive reasoning through grounded theory is crucial given the limited body of existing research exploring the intersection of BIM, Lean Construction principles, and the RFI process (Glaser & Strauss, 1967). Grounded theory's inherent flexibility facilitates the emergence of new patterns and theoretical insights, thus supporting the exploratory nature of the study. Conversely, the deductive reasoning embedded within the DSR methodology enables the iterative development and evaluation of the proposed RFI software tool, incorporating feedback from industry professionals. This iterative cycle ensures the tool's practical applicability and enhances the real-world relevance of the theoretical concepts being explored.

3.2.3 Research Strategy

The third layer of the Research Onion addresses the research strategy, which was selected based on the exploratory nature of this study and the dual need to explore real-world challenges while developing practical, actionable solutions. A mixed-methods strategy was adopted, integrating both qualitative and quantitative data collection techniques to ensure a comprehensive analysis of the research problem.

Grounded Theory: Grounded theory served as the primary qualitative strategy in this research. This approach facilitated the analysis of qualitative data collected from literature reviews, surveys, and focus group discussions, allowing the emergence of new themes and concepts related to the management of RFIs and the application of BIM and Lean Construction principles (Charmaz, 2014). The use of grounded theory was particularly critical in identifying patterns from the survey responses and focus group discussions, offering insights into the industry's understanding and utilisation of BIM, Lean, and RFIs.

Design Science Research (DSR): As a complementary strategy, Design Science Research (DSR) guided the iterative development and evaluation of a software tool designed to improve the RFI process. DSR’s focus on creating artefacts to solve practical problems ensured the research maintained real-world relevance. The exploratory nature of DSR provided the flexibility to continuously refine and adapt the tool, which was improved based on direct feedback from industry professionals involved in focus groups (Hevner et al., 2004, Peffers et al., 2007).

Surveys and Focus Groups: The mixed-methods strategy incorporated both quantitative surveys and qualitative focus groups, allowing for a broad yet detailed exploration of the research questions. The online survey gathered comprehensive insights into the industry's knowledge of BIM, Lean Construction, and the RFI process, while the focus groups provided an opportunity for in-depth discussions on the challenges faced and the potential for innovative solutions (Creswell & Clark, 2017). The combination of these methods allowed the research to capture both wide-reaching trends and nuanced, detailed insights, providing a robust foundation for addressing the research objectives.

3.2.4 Research Choices and Time Horizons

This study adopted a mixed-methods research choice, which allowed for the collection of both qualitative and quantitative data through separate yet complementary phases. The quantitative data was gathered via an online survey, focusing on the industry's familiarity and adoption of BIM and Lean Construction practices. Meanwhile, qualitative data was collected through focus groups, which provided deeper insights into the challenges associated with the RFI process and how it might be enhanced using BIM and Lean methodologies.

In terms of time horizons, a cross-sectional approach was employed. The decision to use a cross-sectional time horizon was driven by the need to assess the state of BIM and Lean Construction within the construction industry at a specific point in time. Data collection occurred between 2016 and 2022, a period marked by substantial technological advancements and the increasing adoption of BIM and Lean principles. This time frame provided the opportunity to capture insights into the early stages of adoption and the progressive evolution of these methodologies in real-world construction projects.

The choice of a cross-sectional design reflects the research's goal of assessing current industry practices and providing a snapshot of how BIM and Lean Construction are applied to improve the RFI process during a time of significant industry change.

3.2.5 Data Collection Techniques

The innermost layer of the Research Onion addresses the specific techniques employed for data collection in this research. These methods were selected to provide a comprehensive examination of the relationship between Building Information Modelling (BIM), Lean Construction, and the Request for Information (RFI) process. The following techniques were utilised:

- Literature Review: An extensive literature review was conducted, covering relevant studies from 1960 to 2022. This review served to explore the intersections of BIM, Lean Construction, and RFIs, with the primary aim of identifying gaps in current knowledge. The literature review not only provided a theoretical foundation for the study but also highlighted key challenges in the construction industry's adoption of these methodologies. This stage was crucial in framing the subsequent empirical research.

- Online Surveys: Quantitative data was gathered through an online survey distributed to professionals within the Architecture, Engineering, and Construction (AEC) sector. The survey focused on gathering information regarding the industry's awareness and application of BIM and Lean principles, as well as insights into current RFI management practices. The responses were instrumental in capturing industry-wide trends, assessing the extent of adoption of these tools, and understanding the perceived challenges in managing RFIs.

- Focus Groups: To supplement the quantitative survey data, qualitative insights were obtained through two focus groups comprised of experienced industry professionals. These focus group sessions offered a platform for discussing the practical challenges associated with the RFI process and exploring the potential for integrating BIM and Lean Construction principles to improve information flow. Moreover, the focus groups enabled a critical evaluation of the proposed RFI software tool, allowing participants to provide feedback on its functionality and relevance. The feedback from these discussions was invaluable for refining both the theoretical framework and the practical artefact proposed by the research.

Each of these data collection techniques contributed to building a holistic understanding of the research problem, with the literature review providing the theoretical backdrop, the survey capturing quantitative trends, and the focus groups offering qualitative depth and practical feedback.

3.3 Grounded Theory

Grounded theory represents a qualitative research methodology that facilitates the generation of theory directly from empirical data, rather than beginning with predefined hypotheses. This methodology is especially well-suited for exploratory research, where the aim is to uncover emergent patterns and develop a theoretical framework grounded in real-world data. The iterative nature of grounded theory—where data collection and analysis occur in cycles—supports this inductive approach, allowing new insights to surface progressively (Glaser & Strauss, 1967; Charmaz, 2006).

Within this study, grounded theory was employed to investigate how professionals within the Architecture, Engineering, and Construction (AEC) industry perceive and manage RFIs, and to explore their experiences with the integration of BIM and Lean Construction methodologies. The process involved iterative cycles of data collection, including surveys, focus groups, and workshops, followed by thematic analysis. Key themes emerged regarding the flow of information, communication challenges, and the potential for improving the RFI process through the application of BIM and Lean principles. These emergent themes were subsequently used to construct a theoretical framework that could enhance the efficiency of RFI management.

The inductive nature of grounded theory made it an ideal choice for this research, as it enabled the study to remain open to unexpected findings and build a robust theoretical foundation directly from the data. Given the limited prior research exploring the intersection of BIM, Lean Construction, and RFIs, grounded theory's flexibility was essential in allowing the research to respond to the complexities encountered within the AEC industry.

3.4 Design Science Research (DSR)

Design Science Research (DSR) is a methodological framework that focuses on the creation, implementation, and iterative evaluation of artefacts—such as models, software tools, or processes—to address practical, real-world problems (Hevner et al., 2004; Peffers et al., 2007). The artefacts created through DSR aim to improve or innovate solutions to specific challenges, and this methodology is particularly effective when the research objective centres on practical problem-solving (March & Smith, 1995).

In the context of this study, DSR was utilised to guide the development of a software tool designed to improve the Request for Information (RFI) process within construction projects. This tool was intended to integrate BIM and Lean Construction principles to address inefficiencies identified in the current RFI process, providing a practical solution to enhance information flow and project management in the industry.

The DSR methodology involved iterative cycles of design, testing, and refinement. Initially, the software tool was conceptualised based on insights drawn from a comprehensive literature review and survey data, which highlighted key challenges in the RFI process. These preliminary findings provided the foundation for the tool's development, addressing the industry's need for a more streamlined and effective RFI management process (Gregor & Hevner, 2013).

Subsequent iterations of the tool were refined based on feedback from industry professionals during focus group sessions. These professionals, with extensive experience in construction and project management, contributed valuable insights regarding the tool's usability, functionality, and real-world applicability. Their input ensured that the tool evolved in line with practical industry needs and addressed the specific inefficiencies identified through earlier phases of the research. This iterative process of design, testing, and evaluation aligns with the core principles of DSR, where the artefact is continuously improved to better meet the needs of its users (Peffers et al., 2007).

By combining DSR with grounded theory, this research effectively bridges the gap between theoretical exploration and practical application. Grounded theory provided the theoretical framework necessary for understanding the complexities of RFI management in the construction industry, while DSR facilitated the development of a functional solution. The iterative process ensured that the theoretical insights emerging from the data directly informed the creation of an artefact that could effectively address the operational challenges within the construction industry's RFI process, thereby offering both academic and practical contributions (Gregor & Jones, 2007).

3.5 Survey

An online survey was conducted to collect quantitative data regarding the current application of Building Information Modelling (BIM), Lean methodologies, and Request for Information (RFI) processes within the Architecture, Engineering, and Construction (AEC) industry. This survey was distributed to a broad group of industry professionals, with the aim of capturing diverse perspectives on RFI management, the technologies in use, and the common challenges encountered in construction projects.

The survey was essential in establishing a foundational understanding of baseline industry practices. It yielded key insights into the degree of adoption of BIM and Lean methodologies and provided an assessment of their perceived effectiveness in mitigating issues related to the RFI process. By evaluating the industry's current practices, the survey helped identify gaps in the implementation of these methodologies, particularly in terms of their role in streamlining RFI management.

The data gathered through the survey informed the subsequent phases of the research, including the development of focus group discussions. The survey results served as a springboard for more in-depth qualitative inquiry, helping to shape the themes and issues to be explored further during the focus group sessions. As such, it played a critical role in connecting the initial exploratory phase with the more detailed qualitative analysis that followed.

By capturing a wide range of industry experiences and opinions, the survey contributed to a comprehensive understanding of how BIM and Lean principles are currently utilised in the management of RFIs, as well as highlighting areas for potential improvement. The findings from this phase were instrumental in guiding the design of the proposed RFI software tool and identifying the specific needs and challenges faced by professionals in the AEC sector.

3.6 Focus Group

Focus groups were conducted to gather qualitative insights from industry professionals on their experiences with the Request for Information (RFI) process, Building Information Modelling (BIM), and Lean Construction methodologies. These sessions allowed for in-depth discussions about the challenges of managing RFIs and provided a platform for participants to give feedback on the proposed software tool developed through the Design Science Research (DSR) process.

The focus groups served as a critical mechanism for refining both the theoretical framework and the practical artefact of the research. Through these sessions, professionals shared insights about the practical challenges they faced in RFI management, and their feedback directly contributed to refining the proposed tool's design and functionality. This iterative feedback loop allowed for the continuous development of the tool, ensuring its relevance to the real-world needs of the Architecture, Engineering, and Construction (AEC) sector.

The focus group data were analysed using descriptive statistics and cross-tabulation. These methods were utilised to summarise the participants' feedback and to identify patterns related to the functionality of the tool and the common challenges in managing RFIs. The use of cross-tabulation provided insights into the relationships between different variables, such as how different professional roles affected their perceptions of the tool's usefulness or how the size of projects impacted RFI management.

The insights gained from the focus groups were pivotal in making the final adjustments to the RFI management tool, ensuring that it was user-friendly and addressed the specific inefficiencies identified in the initial phases of the research.

3.7 Data Collection

The data collection in this research was structured to integrate both **quantitative and qualitative methods**, providing a comprehensive understanding of how Building Information Modelling (BIM) and Lean methodologies can improve the Request for Information (RFI) process in the AEC industry. The multi-phase approach combined a literature review, survey, focus groups, and the development of a website to test the proposed improvements.

3.7.1 Literature Review

The initial phase of data collection involved an extensive literature review, which explored studies from 1960 to 2022 focusing on the integration of BIM and Lean methodologies in construction processes, specifically in relation to RFIs. The use of VosViewer software enabled the visualisation of key terms and identified significant gaps in existing research, particularly regarding the practical integration of these methodologies to improve the RFI process. This phase provided the theoretical foundation for the research and informed subsequent data collection.

3.7.2 Online Survey

The online survey was conducted at the beginning of the research, prior to the PhD qualification stage, and was distributed via LinkedIn, email, and official professional bodies to maximise industry participation. Due to time constraints and the necessity to meet the project deadline, the survey was closed after receiving 87 responses. Following data validation, 60 responses were deemed complete and used for analysis. Although the response rate was constrained by the survey timeline, the dataset provided valuable insights into industry practices and informed subsequent research phases.

Conducted between 2017 and 2018, the survey captured quantitative data from AEC professionals to assess the industry's adoption of BIM and Lean tools and the challenges within RFI management. The key findings focused on:

- Industry familiarity with BIM and Lean methodologies.
- Challenges and inefficiencies in RFI management.
- The correlation between project size and RFI frequency.

These insights established a foundation for deeper exploration in focus groups, facilitating a more detailed examination of industry perspectives on RFIs and workflow optimisation.

3.7.3 Literature Review Refinement and RFI Process Proposal

Insights from the survey led to a refinement of the initial literature review, this time focusing specifically on the RFI process and its common challenges. Based on these findings, a new RFI framework was developed, integrating BIM and Lean methodologies to improve information flow and minimise inefficiencies.

3.7.4 Focus Groups and Website Development

Two focus groups were conducted to test and refine the proposed framework. The first group provided feedback on a set of RFI examples and the initial framework, identifying areas for improvement. Based on their feedback, a website was developed to visualise the process. In the second focus group, conducted online, participants used the website to explore the framework in detail, offering additional feedback that led to the final refinement of the RFI process and the supporting tool.

3.8 Data Analysis

Data analysis was performed using both quantitative and qualitative methods, focusing on descriptive statistics and cross-tabulation for the quantitative data, and direct observations for the qualitative data from focus groups.

3.8.1 Quantitative Data Analysis

The survey data were analysed using descriptive statistics, which helped identify patterns in RFI management practices and the use of BIM and Lean methodologies. Cross-tabulation revealed relationships between project characteristics and RFI volumes, offering insights into how BIM and Lean could mitigate inefficiencies.

3.8.2 Qualitative Data Analysis

Qualitative feedback from the focus groups was summarised through direct observations, identifying key insights from participants' experiences with RFI management and the proposed framework. This feedback informed the iterative refinement of the RFI tool and provided a deeper understanding of the industry's challenges.

3.8.3 Ethical Considerations

Ethical considerations were integral to this research to ensure the protection and dignity of participants, as well as responsible handling of data. The study adhered to institutional and legal ethical standards, as outlined by Saunders et al. (2016), ensuring the research was conducted in a manner that respected participants' rights and maintained data integrity.

3.8.3.1 Informed Consent

Informed consent was obtained from all participants prior to their involvement in the study. Participants were provided with a clear explanation of the study's objectives, their role, and their rights, including the voluntary nature of participation and the option to withdraw at any time without penalty. This process ensured that participants were fully aware of the implications of their participation before proceeding.

3.8.3.2 Privacy and Confidentiality

To protect participants' privacy, all personal data were anonymised, and identifying information was removed before analysis. Data were securely stored on password-protected devices, and access was restricted to the research team. The research adhered to the General Data Protection Regulation (GDPR) and institutional data protection policies, ensuring that participant information was treated with the highest level of confidentiality.

3.8.3.3 Voluntary Participation and Right to Withdraw

Participants were reminded throughout the study of their right to voluntarily participate or withdraw at any point. This principle was especially important during focus groups, where sensitive industry insights were discussed. No incentives were offered to encourage participation, preserving the voluntary nature of the research. The integrity of the research was maintained by ensuring participants felt free from any pressure to contribute.

3.8.3.4 Data Use and Integrity

All data collected were used exclusively for academic purposes, with careful attention to participant anonymity and privacy. The feedback gathered, particularly from industry professionals, was handled with care to avoid exposing sensitive industry practices. This ethical approach ensured that all data were responsibly used, contributing to the development of the RFI process framework while safeguarding participants' confidentiality.

3.8.3.5 Ethical Approval

Ethical approval was obtained from the institutional review board before data collection commenced. This approval confirmed that the study adhered to all legal and institutional guidelines for research involving human subjects. By securing ethical approval, the research ensured that participants' dignity, rights, and welfare were prioritised throughout the study.

3.8.4 Variables Affecting the Research

Several variables influenced the data collection and analysis processes in this study, affecting both the scope and the applicability of the findings. These factors shaped the research outcomes and are crucial in understanding the limitations of the study.

3.8.4.1 Timing of the Initial Survey

The initial survey was conducted between 2016 and 2017, during a period when the adoption of BIM and Lean methodologies within the AEC industry was still emerging. Since then, the industry's understanding and use of these technologies have advanced. As a result, if the same survey were conducted today, the responses may reflect a more mature and widespread application of these practices. The changing landscape of BIM and Lean adoption may impact the general applicability of the findings, as the challenges professionals face today could differ from those reported at the time of the survey.

3.8.4.2 Impact of the COVID-19 Pandemic

The COVID-19 pandemic significantly affected the research, particularly with regard to data collection. The initial research design included action research, with plans for direct observation of BIM applications and information flow on active construction sites. However, the pandemic necessitated a shift to virtual data collection methods, preventing in-person observations. The inability to conduct site visits limited the study’s scope, as real-time insights into how BIM and Lean tools were used to manage RFIs could not be gathered.

3.8.4.3 Access to Historical RFI Data

Efforts to access historical RFI data from completed projects were met with challenges. Despite outreach to multiple companies, concerns over confidentiality and data protection resulted in refusals to share historical RFI documentation. This limitation affected the study's ability to analyse real-world RFI trends and recurring challenges in information flow, as planned. The absence of historical data restricted the depth of the analysis of industry-specific RFI management issues.

3.8.4.4 Workshop Participant Numbers

Two in-person workshops were conducted with a total of eight participants. Although the sample size was limited, the participants had significant expertise in RFI management, contributing valuable insights. However, the small number of participants restricted the diversity of perspectives in the study. While the workshops provided in-depth discussions, involving a larger participant pool could have broadened the scope of insights gained from the industry.

3.8.4.5 Overall Implications

The variables affecting the research, including the timing of the survey, the impact of the COVID-19 pandemic, and the limited access to RFI data, posed challenges to data collection and analysis. Despite these limitations, the insights gathered from experienced professionals contributed meaningfully to the study, identifying critical challenges in the RFI process and opportunities for improvement through the integration of BIM and Lean methodologies. These variables highlight areas for future research and contextualise the findings within the constraints of the research environment.

3.9 Conclusion of the Methodology

The research methodology adopted in this study followed a structured framework based on Saunders et al.'s Research Onion (2016), ensuring a systematic approach to investigating the integration of Building Information Modelling (BIM) and Lean Construction methodologies into the Request for Information (RFI) process in the construction industry. Given the limited existing research on the interactions between these specific methodologies and the RFI process, an exploratory research approach was deemed most appropriate. This approach offered the necessary flexibility to accommodate emerging insights and adjust the research direction as new information surfaced throughout the study.

At the core of this methodology was a mixed-methods strategy, combining qualitative and quantitative techniques to provide both depth and breadth in data collection. The study began with an extensive literature review, covering publications from 1960 to 2022. This review established the theoretical foundation for understanding how BIM and Lean methodologies could enhance RFI management processes. Through the literature review, critical gaps in existing knowledge were identified, particularly regarding the lack of comprehensive frameworks that integrate BIM and Lean tools into the RFI process to improve information flow and reduce inefficiencies. These findings informed the subsequent stages of the research and highlighted the need for an innovative solution.

Building on the theoretical foundation laid by the literature review, an online survey was conducted to gather quantitative data from industry professionals. The survey, distributed to a broad cross-section of Architecture, Engineering, and Construction (AEC) professionals, sought to capture insights into current industry practices related to BIM and Lean adoption, as well as the challenges encountered in managing RFIs. The data collected through this survey provided valuable quantitative insights that informed the design and focus of the focus groups that followed. In these focus groups, participants engaged in detailed discussions about their experiences with RFI management and offered feedback on potential improvements, specifically related to the integration of BIM and Lean methodologies into their workflows.

A distinctive feature of this methodology was the application of Design Science Research (DSR), which played a pivotal role in the development and refinement of the proposed RFI framework and its associated website. The iterative nature of DSR allowed for the continuous evolution of the artefact based on direct feedback from industry professionals, ensuring that the tool was both theoretically robust and practically relevant. The two in-person focus groups, which formed a crucial part of the DSR process, provided essential feedback on the proposed RFI process. These focus group sessions were invaluable in refining the framework, addressing real-world challenges faced by professionals, and ensuring that the final artefact was user-friendly and applicable to diverse construction scenarios. By involving practitioners in the iterative development process, the methodology bridged the gap between theoretical exploration and practical application, ensuring that the research outcomes were grounded in the realities of the AEC industry.

The exploratory research approach, combined with the flexibility of Grounded Theory and the iterative principles of DSR, enabled the study to develop a comprehensive understanding of how BIM and Lean tools could be effectively integrated to streamline the RFI process. The use of the Research Onion framework provided a clear and structured progression, guiding the research from philosophical assumptions to practical data collection and analysis. Each stage of the methodology was designed to build upon the insights gained from the previous phase, ensuring a logical and cohesive approach throughout the study.

In conclusion, the methodology employed was well-suited to the exploratory nature of the research and facilitated the discovery of new insights into the integration of BIM and Lean methodologies in RFI management. By combining both qualitative and quantitative methods, and employing an iterative DSR approach, the research was able to produce a theoretically grounded and practically applicable framework for improving RFI processes in the construction industry. The next chapter will present the results of the Data Collection and Analysis, detailing the findings from the survey, focus groups, and the iterative refinement of the RFI framework and its accompanying website.

Chapter: 4 Data Collection

4.1 Overview of Methods

The data for this study were collected using a combination of quantitative and qualitative approaches to ensure a comprehensive understanding of the current practices and challenges associated with the adoption of Building Information Modelling (BIM) and Lean Construction methodologies in the Request for Information (RFI) process. The primary data collection methods included an online survey distributed to professionals in the Architecture, Engineering, and Construction (AEC) industry and a series of focus groups conducted with experienced professionals to gather more detailed insights.

4.1.1 Literature Review

The literature review in this study aimed to provide a thorough exploration of existing knowledge on Building Information Modelling (BIM), Lean Construction, and the Request for Information (RFI) process in the Architecture, Engineering, and Construction (AEC) industry. The review process was comprehensive, covering literature published between 1960 and 2022, allowing for both historical and contemporary perspectives on how these methodologies have evolved and can be applied in current construction practices. The review was guided by systematic search procedures that ensured all relevant literature was identified, categorised, and critically analyse demonstrated in Figure 4-1 and Figure 4-2.

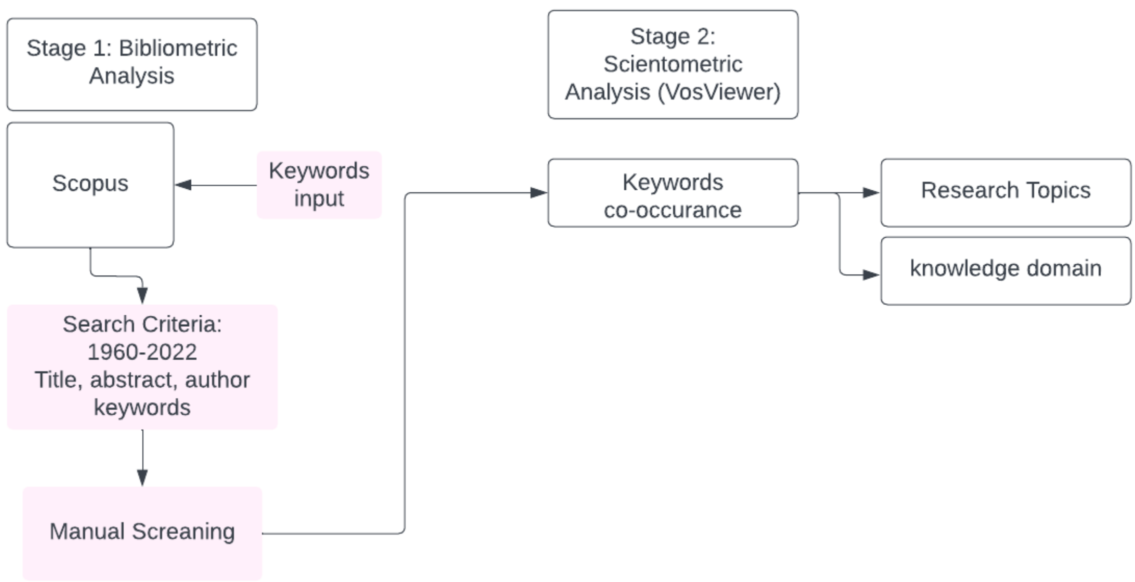


Figure 4-1 Scientometric approach

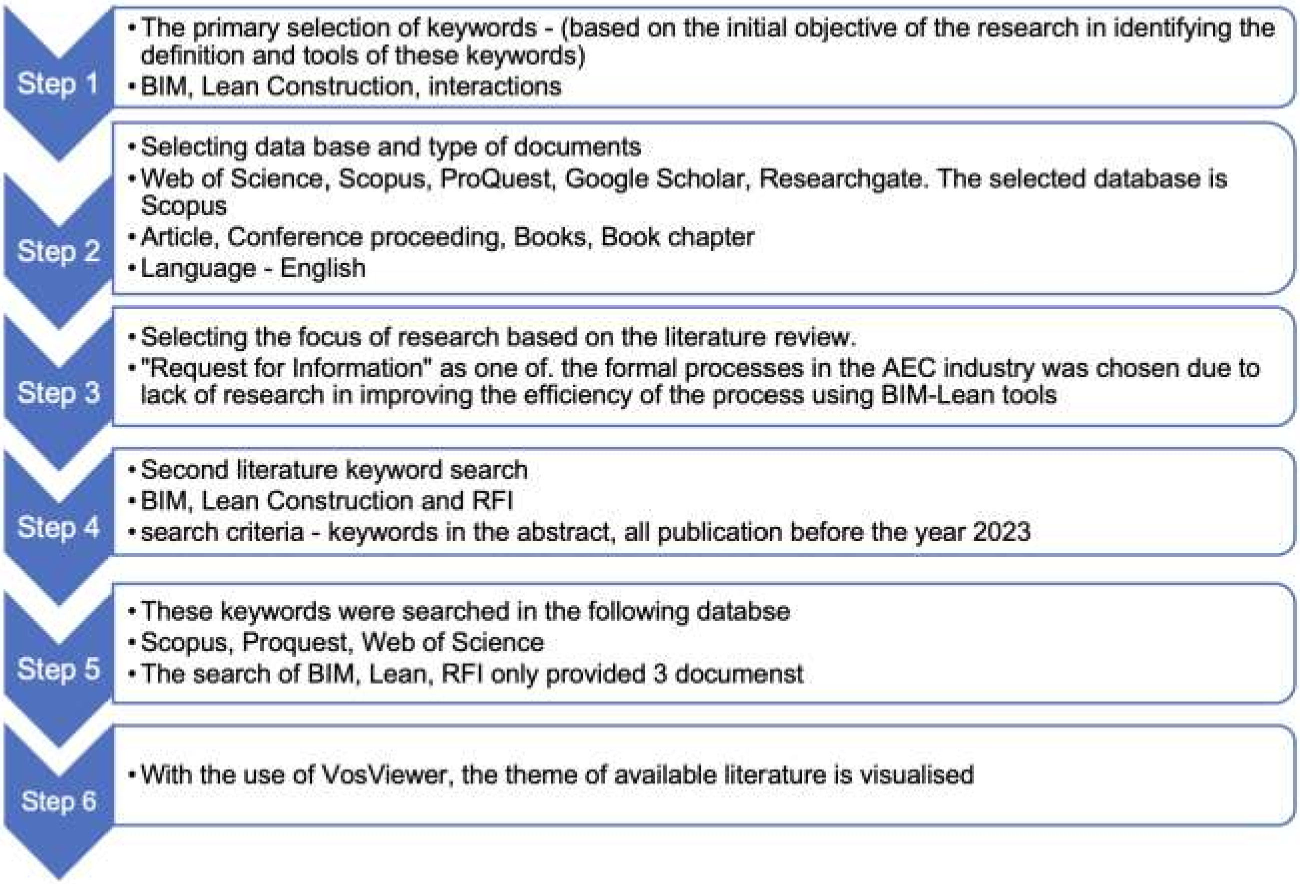


Figure 4-2 Literature review methodology steps

4.1.1.1 Step 1: Identifying Key Terminology

The first step in the literature review involved defining a set of key terms and concepts that were central to this research. Terms such as *Building Information Modelling (BIM)*, *Lean Construction*, *Request for Information (RFI)*, *process efficiency*, and *information flow* were identified as foundational to the study's objectives. Defining these key terms ensured that the search could focus on publications that directly addressed the integration of BIM and Lean methodologies into the RFI process. A list of synonyms and alternative keywords was also developed to capture a broad spectrum of relevant studies. For example, in addition to *BIM*, alternative terms like *digital construction tools* and *building simulation* were included to widen the scope of the review.

Table 4-1 First keyword search 2018

Source	Terms used		
	BIM	Lean Construction	BIM-Lean construction
ProQuest	1,132	42	9
Scopus	8,529	692	70
Web of Science	6,201	157	0

4.1.1.2 Step 2: Database Search

The next step was the database search, which involved systematically searching databases such as Scopus, ProQuest, Web of Science, and Google Scholar. Each database was searched using the defined key terms, focusing on peer-reviewed journal articles, conference papers, and relevant industry reports. Special attention was paid to identifying seminal works on BIM and Lean methodologies, such as those by Eastman et al. (2011) and Koskela et al. (2002). The search criteria also included studies that focused on the practical application of these methodologies in managing RFIs and improving information flow in construction projects (Table 4.2).

Table 4-2 Keyword search up to end of 2022

Search Engine	BIM	Lean Construction	BIM-Lean Construction-	Request for Information, Construction	BIM, Lean and RFI
ProQuest	296	167	75	54	1
Scopus	17,896	1,183	291	110	3
Web of Science	12,501	402	66	62	1

Over 150 studies were initially identified during the database search, but through an intensive screening process, this number was reduced to 85 studies that met the inclusion criteria. These criteria focused on publications that were peer-reviewed, written in English, and relevant to BIM, Lean, and RFI processes in the construction industry. Studies that focused purely on theoretical frameworks, without practical applications, were excluded from further analysis.

4.1.1.3 Step 3: Screening and Filtering

Once the relevant studies were gathered, a multi-stage screening process was applied. The first stage involved abstract screening, where each study's abstract was reviewed to assess its relevance to the research objectives. Studies that only tangentially mentioned BIM or Lean in construction contexts without specific reference to RFIs or process efficiency were filtered out. The second stage involved full-text screening, where the full content of the remaining studies was carefully reviewed. Only studies that provided either empirical evidence or strong theoretical insights into the integration of BIM and Lean tools into RFI management were included in the final review Figure 4.3.

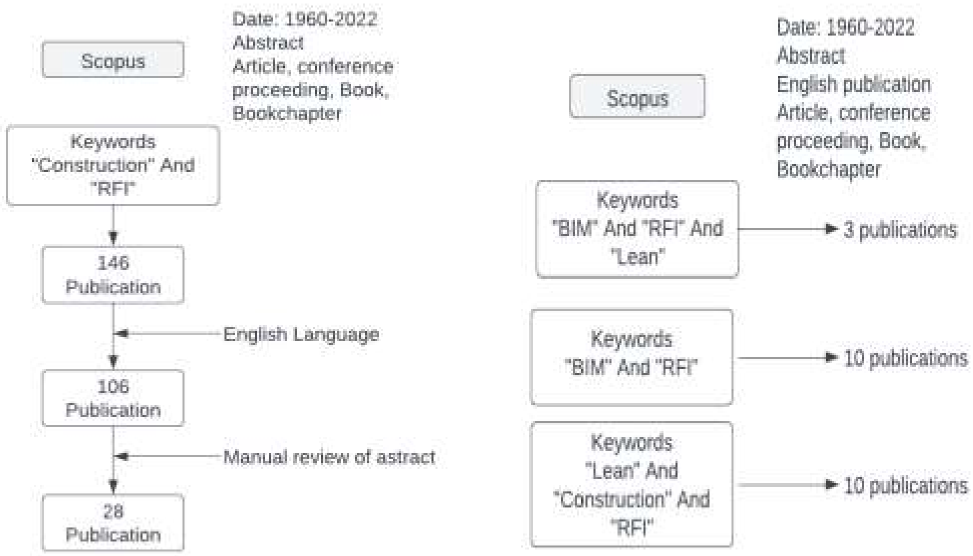


Figure 4-3 RFI, BIM, Lean Scopus search

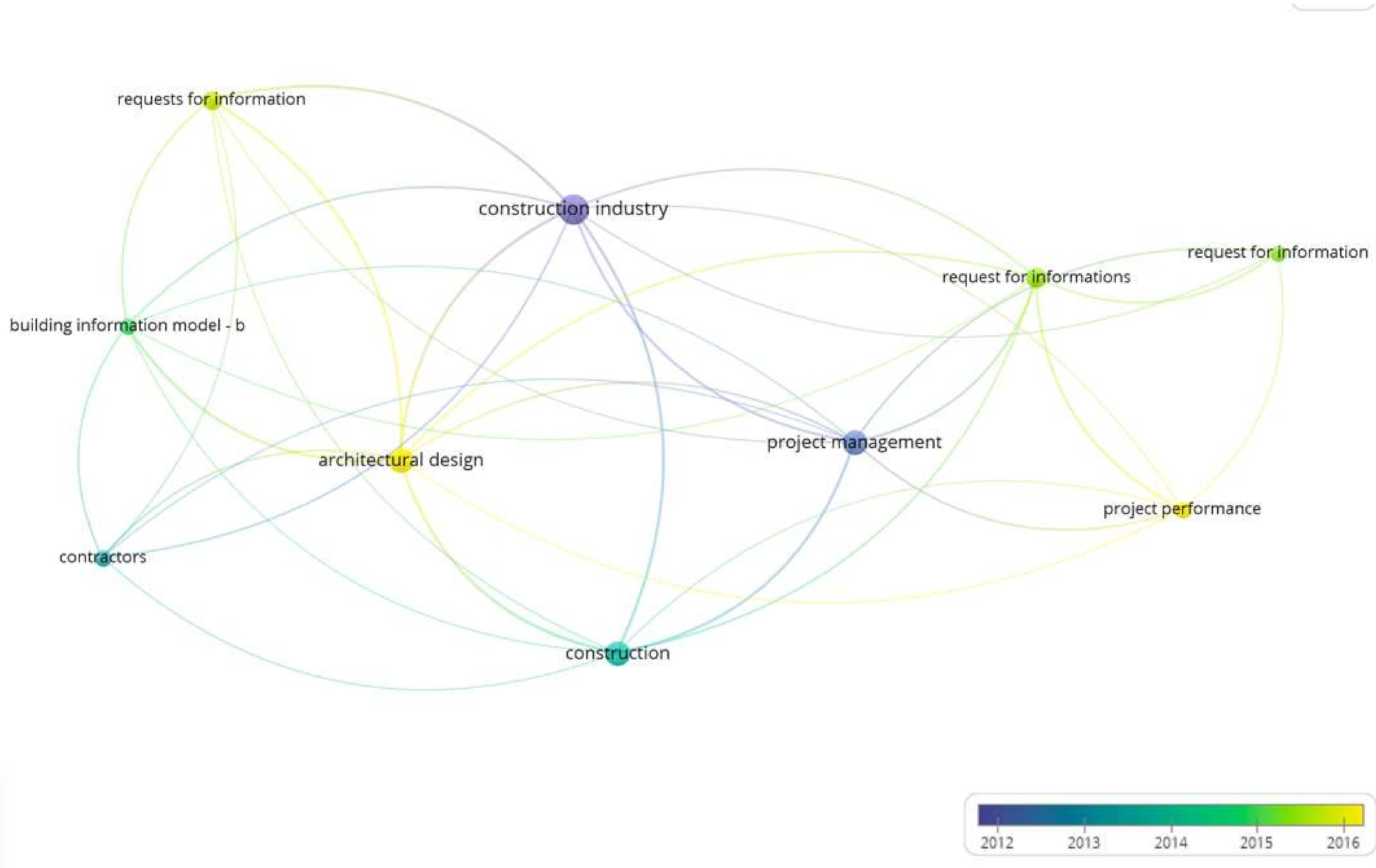


Figure 4-4 keyword search - Construction And RFI

4.1.2 Challenges and Findings from the Initial Search

While the initial search using BIM and Lean Construction keywords yielded a substantial amount of literature, the specific search for studies on BIM and RFI integration resulted in very few relevant papers. For instance, only three documents shown in Table 4.3, were identified in Scopus that directly focused on the integration of BIM, Lean Construction, and RFIs. This outcome highlighted the significant research gap on how these methodologies can be used in tandem to improve the RFI process.

Table 4-3 Keyword search Scopus BIM-Lean-RFI

	Authors	Title	Year	Source title	Language of Document
1	Eldeep A.M., Farag M.A.M., Abd El-hafez L.M.	Using BIM as a lean management tool in construction processes – A case study: Using BIM as a lean management tool	2022	Ain Shams Engineering Journal	English
2	Filho J.B.P.D., Angelim B.M., Guedes J.P., Silveira S.S., De Paula Barros Neto J.	Constructability analysis of architecture-structure interface based on BIM	2016	IGLC 2016 - 24th Annual Conference of the International Group for Lean Construction	English
3	Toledo M., Olivares K., González V.	Exploration of a lean-BIM planning framework: A last planner system and BIM-based case study	2016	IGLC 2016 - 24th Annual Conference of the International Group for Lean Construction	English

Despite the limited academic literature on the specific topic, the three documents found provided valuable insights into the broader potential of BIM and Lean methodologies for reducing RFIs. However, these studies mainly discussed the potential for BIM and Lean to enhance overall project coordination and reduce the number of RFIs indirectly, rather than offering explicit frameworks or tools for improving the RFI process.

4.1.2.1 Supplementary Searches for Grey Literature

Given the limited results from academic databases, supplementary searches were conducted using Google and industry websites. These searches aimed to uncover grey literature, such as industry reports, guidelines, and documents published by professional bodies and government agencies.

The supplementary searches did not yield significant findings in terms of specific strategies for integrating BIM and Lean Construction into the RFI process. Most documents found focused on improving RFI questioning techniques or general process improvements in the construction industry.

There were few practical guidelines or frameworks addressing how to leverage BIM and Lean tools to directly enhance the RFI process.

4.1.2.2 Data Organisation and Management

All retrieved literature, including journal articles and grey literature, was organised using EndNote, a reference management software. This tool allowed for efficient categorisation of the references into thematic groups such as BIM, Lean Construction, RFIs, and BIM-Lean integration. This categorisation allowed for easier access and analysis of the material as the research progressed.
Key categories included:

- BIM and Lean Construction General Studies – Sources discussing the individual or combined application of BIM and Lean methodologies in construction, without specific mention of RFIs.
- RFI-Specific Literature – The few articles and documents focusing on RFIs and how they can be improved, particularly in relation to BIM and Lean Construction.
- Industry Reports and Grey Literature – Documents from industry bodies or government agencies discussing BIM, Lean, and RFIs from a practical perspective.

4.1.2.3 Step 4: Thematic Categorisation

To organise the literature, the selected studies were categorised into thematic areas that aligned with the study's research objectives. These themes included BIM for improving information flow, Lean methodologies for waste reduction, RFI management challenges, and digital tool integration in construction projects. VosViewer software was utilised to map the co-occurrence of key terms within the literature, providing a visual representation of how research topics were interrelated Figure 4-5. This visualisation revealed that while there was substantial research on BIM and Lean individually, very few studies explored their combined application to RFIs. This gap in the literature underscored the need for the current research, particularly in developing a framework that integrates BIM and Lean tools to optimise the RFI process.

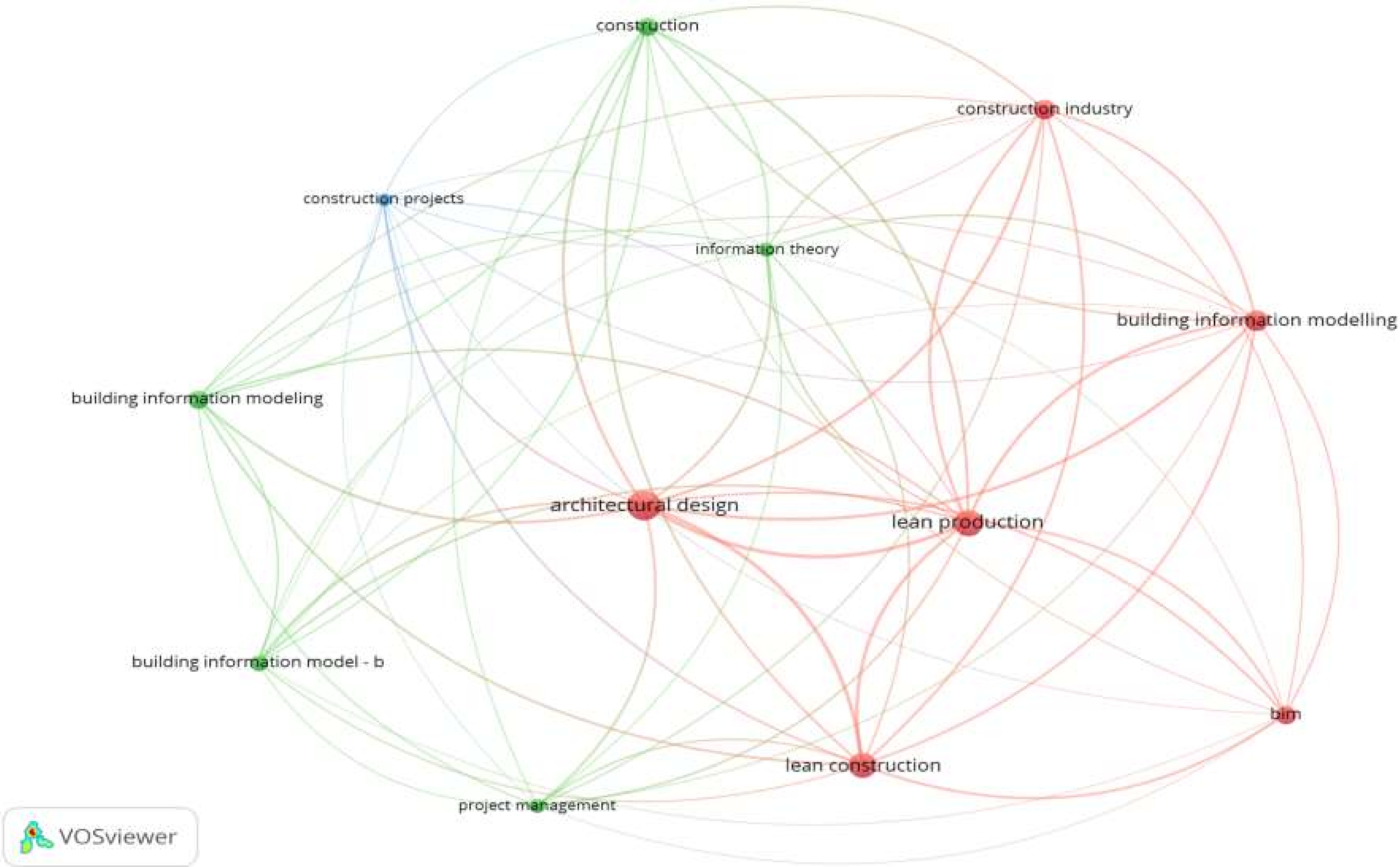


Figure 4-5 VosViewer, co-occurrence keywords BIM, lean, construction, and interaction

4.1.2.4 Key Insights and Research Gaps

The comprehensive search strategy highlighted a number of key insights:

- Growing research on BIM and Lean Construction: The literature review demonstrated a clear increase in the number of publications on BIM and Lean methodologies since 2017. This likely reflects the industry's increasing adoption of these tools in construction project management.

- Limited focus on RFIs: While BIM and Lean have been studied extensively, the RFI process has received comparatively little attention. The literature often mentioned RFIs as an indicator of improved project coordination, but few studies focused on how these tools could directly improve RFI workflows.

- Gap in Practical Guidelines: There remains a notable gap in the literature regarding practical frameworks for integrating BIM and Lean Construction tools into the RFI process. The few studies that did explore this integration only hinted at the benefits but failed to offer actionable guidelines for implementation.

These insights provided the foundation for the subsequent stages of the research, where the focus shifted to developing a BIM-Lean RFI process. The literature review phase was thus essential in identifying the research gap and formulating the theoretical foundation upon which this thesis builds.

4.1.3 Conclusion of Literature Review

The literature review provided a solid theoretical foundation for understanding how BIM and Lean methodologies could be applied to streamline the RFI process and improve information flow in construction projects. The review also identified significant gaps in the literature, particularly regarding the practical integration of these tools. This insight informed the subsequent phases of the research, particularly the design of the survey and focus group methodologies. By mapping the key themes and gaps in the existing literature, the review reinforced the importance of this study in contributing to both academic knowledge and industry practice.

4.2 Survey Methodology

This section outlines the methodology employed to collect and analyse data regarding the integration of BIM and Lean Construction methodologies within the RFI process. A mixed-methods approach was adopted, combining quantitative data from an online survey with qualitative insights from focus group discussions. This approach ensured a comprehensive understanding of industry practices, challenges, and opportunities for improvement in managing RFIs through digital and process-driven innovations.

The primary objective of this research phase was to capture empirical evidence on how professionals within the Architecture, Engineering, and Construction (AEC) sector engage with BIM and Lean methodologies in the context of RFIs. The methodology was designed to:

- Assess industry awareness and adoption levels of BIM and Lean principles in RFI workflows.
- Identify common challenges faced in traditional RFI management processes.
- Evaluate the feasibility of integrating BIM and Lean tools to enhance RFI efficiency.

The survey and focus group discussions were structured to provide both breadth and depth in data collection. The survey offered a broad industry perspective through numerical data, while the focus groups enabled in-depth exploration of practical applications, challenges, and recommendations for improving the BIM-Lean RFI framework. This combination allowed the research to move beyond theoretical assumptions, grounding its findings in real-world industry experiences.

Subsequent sections provide a detailed breakdown of the survey design, participant recruitment, data collection procedures, and analytical approaches used to interpret the findings.

This section outlines the research methodology used to collect and analyse survey data regarding the integration of BIM and Lean Construction methodologies into the RFI process. The survey was designed to assess industry awareness, identify challenges, and gather insights into current practices related to RFIs, BIM, and Lean principles.

4.2.1 Online Survey Data Collection & Analysis

4.2.1.1 Survey Design and Objectives

Following the completion of the literature review, an online survey was developed to gather insights from professionals within the Architecture, Engineering, and Construction (AEC) industry regarding their understanding and application of Building Information Modelling (BIM), Lean Construction, and the Request for Information (RFI) process. Initially, the study focused on examining how BIM and Lean tools were being utilised within UK rail construction projects. However, as the research progressed, it became evident that the challenges associated with RFIs extended beyond a single sector. Consequently, the scope was expanded to explore the feasibility of a BIM-Lean integrated RFI process across the broader AEC industry, ensuring that the findings could be applicable in a variety of construction environments.

The primary objectives of the survey were to quantify industry knowledge and adoption levels of BIM and Lean Construction principles in RFI workflows, to identify common challenges and inefficiencies in RFI management, and to evaluate professionals' familiarity with the UK Government's BIM mandate for public sector projects, which was officially implemented in April 2016. By addressing these objectives, the research aimed to provide a comprehensive assessment of industry-wide RFI practices while establishing a foundation for integrating digital and process-driven innovations into existing workflows.

To ensure that the survey captured a well-rounded understanding of industry practices, it was structured into five core categories. The first category focused on general information, collecting demographic data on respondents, including their job roles, years of experience, and project sectors. The second category assessed participants' knowledge and understanding of BIM, allowing for the identification of varying levels of awareness and adoption. The third category explored the extent to which Lean Construction tools and techniques were being applied across projects. The fourth category examined how BIM-Lean tools were currently being used, or could be used, to enhance the efficiency of the RFI process. Finally, an optional section was included to allow participants to provide contact details for follow-up discussions or further clarification, ensuring that deeper insights could be obtained where necessary.

The survey was designed based on insights gathered from the literature review, as well as contemporary reports such as the National Building Specification (NBS) and the SmartMarket Report, which provided additional industry perspectives. A pilot survey was conducted with five professionals, in accordance with the recommendations of Fellows and Liu (2015), to ensure that the questionnaire was clear, concise, and free from ambiguity. Their feedback was instrumental in refining the survey, leading to the revision of five questions to improve clarity and the addition of an extra question to enhance the depth of responses regarding participants' experiences with RFIs. This iterative approach to survey design ensured that the instrument was both academically rigorous and practically relevant to industry professionals.

Following the completion of the literature review, an online survey was developed to gather insights from Architecture, Engineering, and Construction (AEC) professionals regarding their understanding and application of Building Information Modelling (BIM), Lean Construction, and the Request for Information (RFI) process. While the research initially targeted BIM and Lean applications in UK rail construction projects, the scope was broadened to the wider AEC industry due to the universal nature of RFI challenges and the need for a standardised, cross-sector approach.

The primary objectives of the survey were:

- To quantify industry knowledge and adoption of BIM and Lean Construction principles in RFI workflows.
- To identify challenges and inefficiencies in current RFI management processes.
- To assess the industry's level of compliance with the UK Government's BIM mandate for public sector projects (April 2016).

The survey structure was informed by insights from the literature review and supplemented by contemporary industry reports, including the National Building Specification (NBS) and the SmartMarket Report, ensuring alignment with prevailing industry standards. The survey was structured into five key categories to capture a broad understanding of industry practices:

- General Information (job role, years of experience, project sector).
- Knowledge and understanding of BIM.
- Awareness and application of Lean Construction tools and techniques.
- Use of BIM-Lean tools in the RFI process.
- Optional contact information for follow-up or further clarification.

To ensure clarity and relevance, a pilot study was conducted with five AEC professionals, following the guidance of Fellows and Liu (2015). Their feedback led to the rewording of five questions to eliminate ambiguity and the addition of an extra question to capture detailed insights into RFI management practices. This refinement process ensured that the survey effectively addressed the research objectives while maintaining clarity for respondents. The survey was developed to capture industry perspectives on the application of Building Information Modelling (BIM) and Lean Construction tools in RFI management. Initially, the research targeted UK rail projects; however, the scope was expanded to encompass the wider AEC industry to ensure broader applicability.

The primary objectives of the survey were:

- To collect quantitative data on industry awareness and use of BIM and Lean Construction principles.
- To identify existing challenges and inefficiencies in RFI management.
- To evaluate professionals' familiarity with the UK Government's BIM mandate.

The survey was structured into five categories:

1. General Information – Respondents' job role, years of experience, and sector.
2. BIM Knowledge – Understanding and application of BIM methodologies.
3. Lean Construction Awareness – Experience with Lean tools and techniques.
4. RFI Management – Existing tools, workflows, and challenges in RFI handling.
5. BIM-Lean Integration – Perceptions of how these methodologies can improve RFI workflows.

To ensure clarity and relevance, a pilot test was conducted with five AEC professionals, resulting in the refinement of five questions and the addition of a question on RFI experience.

4.2.1.2 Survey Distribution and Sample Size

To maximise outreach and obtain a diverse range of responses, the survey was distributed through multiple professional channels, including direct email invitations, LinkedIn groups, and various industry bodies. However, data privacy regulations posed significant challenges, as several organisations declined to share the survey link with their members. Despite these limitations, the Association for Project Managers (APM) and the Lean Construction Institute UK (LCI) actively supported the research by promoting the survey on their social media platforms, helping to expand its visibility within the industry.

To further enhance participation, the survey was disseminated across 20 targeted LinkedIn groups, specifically engaging professionals with experience in BIM and Lean Construction. These groups encompassed a broad spectrum of AEC industry specialists, ensuring a representative mix of participants across different professional roles. Table 4.4 provides a detailed list of the LinkedIn groups where the survey link was shared, illustrating the strategic approach used to maximise industry engagement.

Table 4-4 LinkedIn Groups for Survey Distribution

No	LinkedIn Group
1	Lean Construction Network
2	CIOB (Chartered Institute Of Building)
3	BIM (Building Information Modeling) and Architecture, Engineering & Construction Projects and Jobs
4	BIM & the AEC Profession
5	BIM Experts
6	Women in Architecture UK
7	CITA BIM Group
8	Women in BIM
9	H2020 SMART CITIES & Communities" ICT in Building and Construction, ASCE, BIM & VDC
10	BIM 4 Infrastructure (UK)
11	BIM (Building Information Modeling) and Architecture, Engineering & Construction Projects and Jobs
12	The BIM Roundtable
13	Lean Design Forum
14	American Society of Civil Engineers (ASCE)
15	National BIM Library
16	RICS Digital Construction (incorporating BIM)
17	Construction News
18	Project Managers in UK Construction
19	International BIM Consultants

Despite the challenges encountered in survey distribution, a total of 87 responses were collected. However, following a rigorous data validation process, 60 responses were deemed valid and retained for analysis. The responses were obtained from professionals representing various sectors and roles within the construction industry, ensuring a well-rounded dataset that reflected the diversity of industry stakeholders. Given the open-ended nature of survey distribution through multiple online platforms and networks, it was not possible to determine the exact number of individuals who accessed the survey. Nevertheless, the survey remained actively available for eight months, thereby facilitating broad industry exposure and maximising the likelihood of capturing meaningful insights.

To maintain the integrity of the dataset, strict inclusion criteria were applied. Participants were required to have relevant industry experience within the AEC sector, particularly in BIM and Lean Construction. Responses that were incomplete, duplicated, or lacked sufficient evidence of relevant expertise were excluded from the final dataset. Consequently, 27 responses were removed to ensure that the final dataset of 60 responses accurately represented professionals with direct experience in the research subject matter. This filtering process was essential to uphold the credibility and reliability of the findings, allowing for more robust conclusions to be drawn from the survey results. The survey was distributed via multiple platforms, including LinkedIn groups, professional associations, and direct emails. However, data privacy concerns prevented certain organisations from sharing the survey widely. Despite this, the Association for Project Managers (APM) and the Lean Construction Institute UK (LCI) promoted the survey through their networks, significantly enhancing its reach.

The survey was shared across 20 LinkedIn groups targeting AEC professionals, as shown in Table 4.4. Despite distribution challenges, 87 responses were received, with 60 valid responses retained after filtering for completeness and relevance. The dataset was diverse, encompassing professionals from various sectors and roles.

Exclusion criteria included:

- Incomplete or duplicate responses.
- Lack of industry experience in BIM, Lean Construction, or RFIs.

The survey remained open for eight months, ensuring wide exposure within the industry.

4.2.2 Survey Content and Structure

The survey was designed to capture a comprehensive understanding of industry practices, challenges, and perceptions regarding BIM, Lean Construction, and RFI management. It consisted of 35 structured questions, which were carefully grouped into four key thematic categories to ensure a systematic approach to data collection and analysis.

The categories were as follows:

- Demographics: This section captured essential background information about the respondents, including their job roles, years of experience, and the sectors in which they were engaged. These demographic insights were critical in assessing how professional background influences perspectives on BIM, Lean Construction, and RFIs.
- BIM and Lean Awareness and Usage: This category focused on measuring respondents' familiarity with BIM and Lean methodologies. Additionally, it explored their experience with the

UK Government's BIM mandate, introduced in April 2016, to determine the extent to which national policies influenced industry adoption and integration.

- RFI Management Practices: This section evaluated how respondents handled RFIs, including the tools they utilised, the frequency of RFI submissions, and the key challenges they encountered in the traditional RFI workflow. The responses provided valuable insights into current inefficiencies and the potential for process improvement.
- BIM-Lean Integration: This final category assessed participants' experiences with integrating BIM and Lean tools into the RFI process. The questions explored how these methodologies were applied to improve efficiency, reduce project delays, and enhance communication across project teams.

To facilitate a deeper analysis of responses, the questionnaire also incorporated rating scales, allowing participants to quantify their perceptions of BIM and Lean's impact on project efficiency, design coordination, and information management. Furthermore, a cross-tabulation analysis was conducted to examine relationships between variables such as industry roles, years of experience, and project types. This analytical approach enabled the identification of trends and correlations, providing a data-driven foundation for subsequent phases of the research.

By structuring the survey in this manner, the study ensured that it captured both quantitative and qualitative insights, offering a holistic perspective on the current state of BIM and Lean integration in RFI management. The survey consisted of 35 questions, divided into key themes:

- Demographics – Professional background, experience, and sector.
- BIM and Lean Awareness – Knowledge of methodologies and government mandates.
- RFI Practices – Management processes, tools used, and encountered challenges.
- BIM-Lean Integration – Adoption trends and perceived benefits.

Rating scales were incorporated to assess perceptions of BIM and Lean's impact on efficiency, design coordination, and RFI workflows. Cross-tabulation analysis was performed to explore trends across job roles, experience levels, and project types.

4.2.2.1 Pre-Testing and Refinement

Before the survey was fully distributed, it underwent a pre-test phase to validate its clarity, relevance, and effectiveness in addressing the research objectives. Five experienced professionals from the Architecture, Engineering, and Construction (AEC) industry were invited to participate in this pilot study. Their expertise in BIM, Lean Construction, and RFI management provided critical insights into potential ambiguities, terminology inconsistencies, and question relevance.

This pre-testing step was crucial in ensuring that the survey questions were well understood by the target audience and that all wording and concepts aligned with industry practices. Participants were asked to review the structure, phrasing, and logical flow of the questionnaire, as well as to identify any questions that were unclear, redundant, or misaligned with the study's aims.

Based on the feedback received, five questions were rewritten to enhance their accuracy and to ensure they directly corresponded with the research objectives. Additionally, minor refinements were made to clarify certain technical terms and improve response format consistency. The revised survey was then finalised and re-submitted for distribution through industry platforms, ensuring that it effectively captured meaningful and high-quality responses from industry professionals. Prior to full deployment, the survey underwent pre-testing with five industry professionals to refine ambiguous questions. This process led to:

- The revision of five questions for improved clarity.
- The addition of a new question to better capture participants' RFI experiences.

4.2.3 Challenges and Limitations

The survey distribution encountered several notable challenges, particularly concerning data privacy regulations, which prevented some organisations from disseminating the survey link to their members. These restrictions limited the ability to reach a broader audience through official industry channels. Despite these obstacles, the survey was effectively distributed via professional networks, industry associations, and LinkedIn groups, ensuring meaningful engagement with AEC professionals. The collaboration with the Lean Construction Institute (LCI) and proactive participation within LinkedIn groups played a critical role in overcoming these barriers and expanding the survey's reach within the industry.

Another significant limitation was the sample size. While 60 valid responses provided a solid foundation for analysis, the research acknowledges that a larger dataset would have strengthened the generalisability of the findings. Greater participation from professional bodies and industry organisations could have further enriched the dataset by incorporating a wider range of perspectives and experiences. However, despite these limitations, the responses gathered were sufficiently diverse, representing a broad cross-section of industry professionals with varying levels of expertise and involvement in BIM, Lean Construction, and RFI management.

Additionally, the self-selection nature of the survey presents a potential response bias. Professionals with a stronger familiarity with BIM and Lean methodologies may have been more inclined to participate, potentially skewing the results towards those already engaged in digital and process-driven construction practices. While this limitation is inherent to voluntary surveys, efforts were made to mitigate its impact by targeting a diverse range of professionals across different roles and experience levels. The insights gained from the responses remain valuable in identifying trends, challenges, and opportunities within the industry, forming a strong basis for the subsequent phases of this research.** Survey distribution encountered constraints due to data protection policies limiting organisational participation. However, leveraging professional networks and LinkedIn groups helped expand its outreach.

Despite securing 60 valid responses, a larger sample size would have strengthened the findings. The study acknowledges that:

- Self-selection bias may have influenced responses, as professionals familiar with BIM and Lean were more likely to participate.
- Limited representation from smaller firms and contractors may skew results towards larger organisations with established digital workflows.

4.2.4 Data Analysis Approach

The data collected from the survey was analysed using descriptive statistics and cross-tabulation methods in Microsoft Excel. Descriptive statistics were utilised to summarise key trends, providing insights into industry-wide practices, levels of BIM and Lean awareness, and the frequency and management of RFIs. By examining these overarching trends, the study was able to establish a quantitative baseline for understanding the extent of BIM and Lean Construction adoption in RFI workflows.

4.2.4.1 Key Findings from Descriptive Statistics

- Frequency of RFIs: The survey revealed significant variability in RFI submission rates, with some projects reporting high volumes that had a direct impact on project timelines. This variability underscored the need for improved coordination and more efficient RFI management strategies.
- Digital Tools for RFI Management: A range of commonly used digital platforms was identified, highlighting the prevalent systems in place for managing and transferring design information. This finding provided insight into the industry's reliance on specific tools and the potential for further digital integration.

4.2.4.2 Cross-Tabulation Analysis

To further explore industry trends, cross-tabulation analysis was conducted to examine the relationships between key variables. This approach provided a deeper understanding of how different factors influenced RFI management and the effectiveness of BIM and Lean methodologies.

- Project Size and RFI Frequency: Larger projects tended to experience higher RFI volumes, suggesting that project complexity plays a significant role in information requests and potential bottlenecks.
- BIM Usage and Design Coordination Efficiency: Projects with greater BIM implementation reported fewer RFIs, indicating that BIM enhances design coordination by reducing inconsistencies and information gaps.
- Experience Level and Lean Construction Familiarity: Professionals with greater exposure to Lean Construction tools demonstrated better RFI workflow management, reinforcing the value of Lean principles in streamlining processes and minimising inefficiencies.

The analysis identified patterns that support the argument for integrating BIM and Lean methodologies into the RFI process. The findings suggest that BIM adoption contributes to reducing information conflicts and enhancing communication, while Lean practices improve workflow efficiency. These insights form a critical foundation for the subsequent research phases, including qualitative analysis through focus groups, to further explore industry perspectives on refining the RFI process. Survey data was analysed using descriptive statistics and cross-tabulation to identify trends and relationships among key variables. Key findings included:

- RFI Frequency – Some projects experienced high RFI volumes, impacting timelines.
- RFI Management Tools – Identification of commonly used digital platforms.
- BIM Adoption vs. RFI Reduction – Projects with higher BIM implementation reported fewer RFIs, suggesting improved coordination.
- Experience and Lean Knowledge – Senior professionals exhibited greater familiarity with Lean tools.

Table 4.5 presents respondents’ familiarity with BIM and Lean across job roles and experience levels, highlighting trends in industry adoption.

4.2.5 Limitations of Survey Data

While the survey provided valuable insights into the integration of BIM and Lean methodologies within the RFI process, certain limitations must be acknowledged. One of the primary constraints was the sample size of 60 respondents. Although this dataset offers a meaningful snapshot of industry practices, it may not comprehensively represent the diversity of experiences across the entire AEC sector. A larger sample could have strengthened the reliability of the findings and provided a broader range of perspectives on BIM and Lean adoption in RFI management.

Another key limitation was the potential for response bias. Given the voluntary nature of the survey, it is possible that professionals who were already familiar with BIM and Lean tools were more inclined to participate. This could have resulted in a skewed dataset, where the responses disproportionately reflected the experiences of those who actively engage with these methodologies. Consequently, the survey results may present a more favourable view of BIM and Lean adoption than is truly representative of the wider industry. Additionally, professionals from smaller firms or those with limited access to BIM and Lean technologies may have been underrepresented, further impacting the generalisability of the findings.

Despite these limitations, the survey findings serve as a critical starting point for understanding the current state of BIM and Lean practices in RFI workflows. The insights gained provide a strong foundation for further exploration through qualitative research methods, including focus group discussions, to validate and expand upon the identified trends.

4.2.6 Conclusion

The data collected from the online survey established a quantitative foundation that captured the state of BIM, Lean Construction, and RFI processes within the AEC industry. The findings highlighted key industry challenges, inefficiencies, and areas where improvements could be made to enhance RFI workflows through BIM and Lean integration.

Furthermore, the survey revealed existing knowledge gaps and varying levels of familiarity with these methodologies, reinforcing the need for structured guidance on their implementation in RFI management. The results also underscored the potential benefits of digital tools and Lean principles in reducing RFIs, improving coordination, and streamlining communication among project stakeholders.

These insights form the groundwork for the subsequent phases of this research, particularly the focus group discussions and the development of a BIM-Lean RFI process map. These next stages will further investigate industry perspectives, refine the proposed integration framework, and validate the practicality of the findings through qualitative engagement with industry experts. The combination of survey data and focus group insights will ensure a well-rounded and empirically grounded approach to enhancing RFI management in construction projects. While the survey provided valuable insights, limitations must be acknowledged:

- The sample size (60 respondents), though diverse, does not fully represent the entire AEC industry.
- Response bias – Participants more familiar with BIM and Lean may have been more inclined to respond, potentially skewing results towards higher awareness levels.

4.2.7 Focus Group Methodology

The qualitative component of this research involved a series of focus groups conducted to gather in-depth insights from experienced professionals within the Architecture, Engineering, and Construction (AEC) industry. The primary aim of these focus groups was to explore the application of Building Information Modelling (BIM) and Lean methodologies within the Request for Information (RFI) process, to identify practical challenges, and to assess the feasibility of proposed improvements. By engaging directly with industry practitioners, this study sought to understand the complexities of real-world project environments and capture perspectives that could inform the development of a more efficient and structured RFI process. The insights derived from these discussions played a critical role in shaping the final framework, ensuring that it was both relevant and practical for industry adoption.

4.2.7.1 Participant Recruitment

Recruitment for the focus groups targeted professionals with extensive experience in managing RFIs and implementing BIM and Lean methodologies. Invitations were extended through professional networks, LinkedIn, and personal industry contacts. In total, eight participants were selected to participate in two focus group sessions, ensuring diversity in roles and sector representation. Participants included project managers, site supervisors, and BIM coordinators, each contributing unique perspectives on RFI management in construction projects. Their experience ranged from 10 to 30 years, offering a broad understanding of both historical RFI practices and contemporary, technology-driven approaches. The diversity of participants ensured a balanced discussion, highlighting challenges from different angles and providing a holistic view of current industry practices.

The limited number of participants reflects the challenge of coordinating busy professionals for in-depth discussions but also allowed for more focused and detailed feedback. The small sample size facilitated a rich dialogue where each participant’s views were thoroughly explored, though it should be noted that the results may not fully represent the broader industry’s perspective. However, the qualitative depth of these discussions provided valuable insights that might have been diluted in larger sessions. Furthermore, the ability to engage directly with each participant ensured that no critical viewpoints were overlooked, making the findings more nuanced and actionable.

4.2.7.2 Focus Group Structure

The first focus group was designed to be semi-structured, allowing participants the freedom to share their experiences while also ensuring that key research questions were addressed. The session was divided into three phases, each serving a specific purpose to extract meaningful insights from the participants. This structured yet flexible format facilitated a balance between guided discussion and organic dialogue, encouraging participants to share both challenges and opportunities they encountered in their professional experience

4.2.7.2.1 Phase 1 – Introduction and Overview

Participants were briefed on the research objectives and provided with background information on BIM, Lean methodologies, and the RFI process. This phase ensured that all participants had a shared understanding of the technical aspects of the discussion. The session started with an overview of current RFI challenges, encouraging participants to reflect on their experiences and how these methodologies could potentially offer solutions. This introductory phase served to align expectations and create a foundation for meaningful discussions in the subsequent phases.

4.2.7.2.2 Phase 2 – Testing the Initial RFI Process Map

Participants were presented with the initial RFI process map, designed to integrate BIM and Lean methodologies. They were then asked to categorise 50 real-world RFIs according to the framework provided (Appendix A). During this exercise, participants shared immediate reactions, focusing on areas of difficulty, clarity, and any barriers they encountered in applying the framework. The categorisation activity allowed for real-time engagement with the proposed model, offering direct feedback on its usability and applicability in different project contexts.

Figure 4.6 represents the initial proposed RFI process map, which was presented and discussed in the first focus group. The visual representation provided a tangible reference for participants, helping them critically assess the strengths and weaknesses of the proposed structure. The discussions following this exercise were particularly insightful, as participants highlighted areas where the categorisation system could be improved to better align with industry practices.

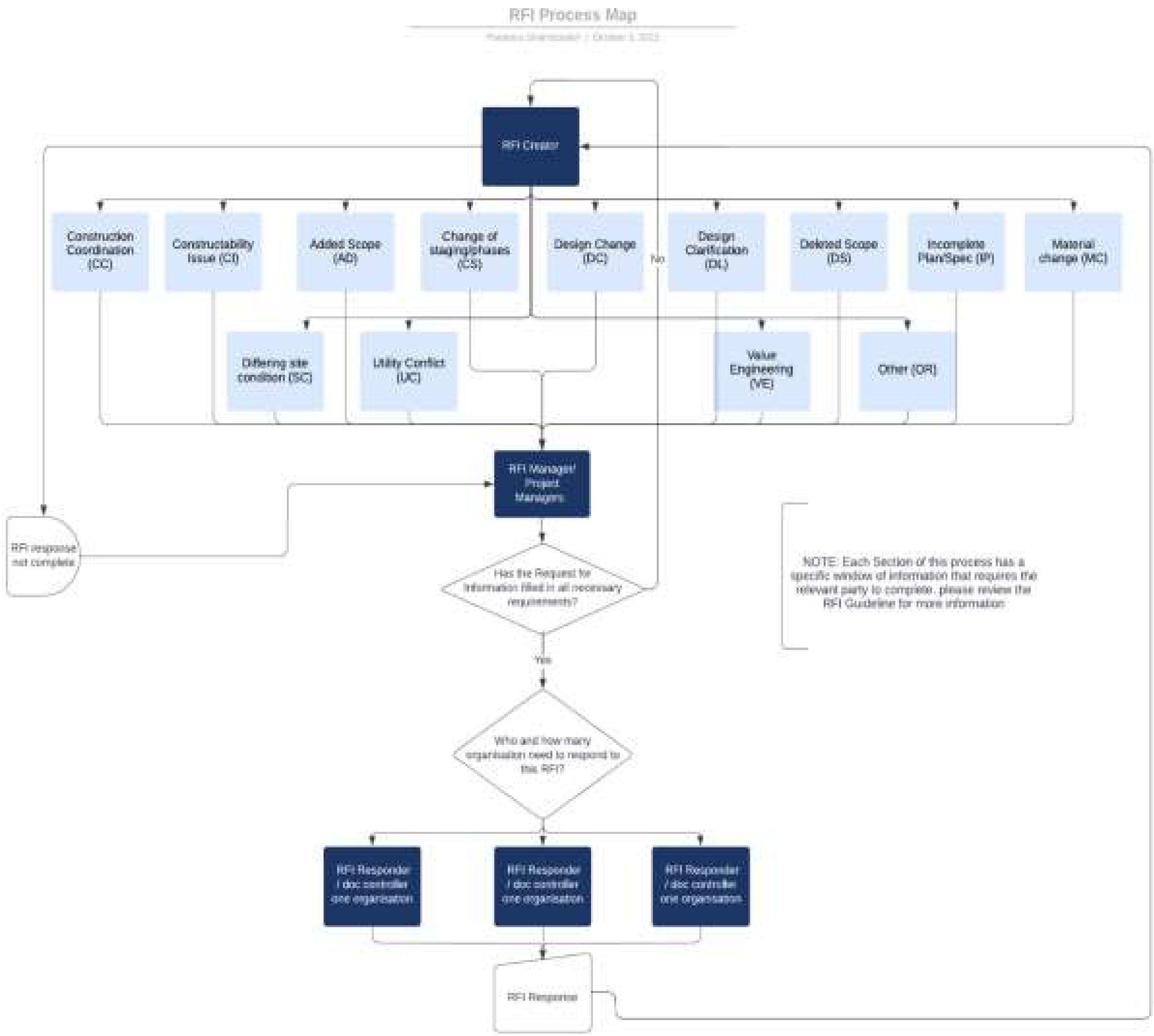


Figure 4-6 Proposed RFI Process

4.2.7.2.3 Phase 3 – Group Discussion and Feedback:

The final phase of the session involved an open discussion where participants were encouraged to critique the RFI process map and suggest improvements. This discussion highlighted the practical challenges of applying Lean principles to RFI management, particularly concerning categorisation consistency and the clarity of RFI classification codes. Several participants noted that while the framework provided a structured approach, it needed more flexibility to accommodate project-specific variations. Additionally, discussions emphasized the need for a transition plan to bridge the gap between traditional RFI processes and the proposed BIM-Lean integration.

4.2.7.3 Key Findings from the First Focus Group

The feedback from the first focus group revealed several critical insights. Participants noted that while the proposed RFI process map showed promise, it required further refinement to improve usability. Specifically, the focus group highlighted issues related to the classification of RFIs, with many participants indicating that the process was too rigid and did not account for the diversity of RFIs encountered in day-to-day project management. This feedback led to the creation of a more flexible categorisation system that would allow for the classification of RFIs based on their complexity, urgency, and the stage of the project.

Participants also emphasised the need for better integration of BIM tools within the process. While the proposed map suggested linking RFIs directly to BIM models, many participants found this integration difficult due to the varying levels of BIM adoption within their organisations. Some professionals were still using traditional methods, such as email-based RFI submissions, highlighting the gap between technological innovation and industry practices. To bridge this gap, it was recommended that any new system should offer parallel workflows that allow both traditional and digital processes to coexist until full BIM adoption becomes feasible.

The iterative nature of these discussions allowed for real-time validation of research findings and recommendations. The feedback obtained from industry experts was instrumental in refining the proposed RFI framework, enhancing its practicality, and ensuring it addressed the specific needs of construction professionals. By integrating the experiences and expertise of focus group participants, this study was able to bridge the gap between theoretical research and practical application, reinforcing the value of stakeholder-driven process improvements in the AEC industry.

4.2.7.4 Refinement of the RFI Process Map

Based on the feedback from the first focus group, the RFI process map was revised to address the concerns raised by participants. The refined process map allowed for a more dynamic categorisation system, enabling users to classify RFIs according to project-specific factors. This revision provided greater flexibility, allowing project teams to tailor the categorisation approach based on the complexity, urgency, and stage of the project. Additionally, clearer guidelines were added to help users understand how to integrate BIM tools within the RFI process, ensuring that even those with limited BIM experience could engage with the system effectively. These guidelines included step-by-step instructions on linking RFIs to digital models, ensuring traceability and reducing miscommunication between project stakeholders.

Furthermore, to enhance usability, the revised process map introduced visual indicators that signified the urgency level of RFIs, enabling project teams to prioritise responses more efficiently. This improvement addressed concerns from the first focus group regarding the previous system's rigidity, making the new process map more adaptable to real-world project demands. These refinements were validated through participant feedback, which confirmed that the updated approach improved both clarity and efficiency in RFI management

4.2.8 Development of the Website

To facilitate the testing and refinement of the RFI process, a dummy website was developed following the first focus group. The purpose of the website was to provide participants with a visual and interactive tool to better understand the proposed improvements and engage with the RFI process map. By allowing users to interact with the framework digitally, the website aimed to bridge the gap between theoretical discussions and practical implementation. Participants could explore the categorisation system, submit trial RFIs, and evaluate the efficiency of the revised workflow in a controlled digital environment.

The website was structured to offer an intuitive user experience, accommodating professionals with varying levels of digital literacy. It incorporated feedback-driven refinements, ensuring that navigation was seamless and that key functionalities were easily accessible. By using an interactive platform, the research facilitated a more hands-on engagement with the proposed framework, ultimately supporting a more effective evaluation of its usability and relevance in practice.

4.2.9 Design and Functionality of the Website

The website was designed with user experience as a primary focus, ensuring that industry professionals with varying levels of digital literacy could easily navigate the tool. It featured a step-by-step walkthrough of the proposed RFI process, showing how BIM and Lean methodologies could be applied to streamline information flow and reduce delays. The interactive nature of the site allowed users to engage with the system in a way that mirrored real-world project scenarios, making it easier to assess its practicality and effectiveness.

Users could:

- Explore the RFI categorisation system and understand how RFIs are classified based on project-specific needs.
- Submit and track dummy RFIs, simulating real-world scenarios to evaluate the efficiency of the process.
- Visualise how RFIs were linked to BIM models, providing a direct connection between the RFI and the corresponding area of the construction project.
- Receive automated notifications and feedback on the status of their RFIs, simulating real-time project communication.

The integration of these features provided an immersive learning experience, reinforcing the benefits of the refined RFI process. The user-friendly interface ensured that even professionals unfamiliar with digital workflows could engage with the tool effectively. Moreover, the inclusion of real-time tracking mechanisms demonstrated how Lean principles could be applied to reduce delays, further validating the effectiveness of the proposed improvements in RFI management.

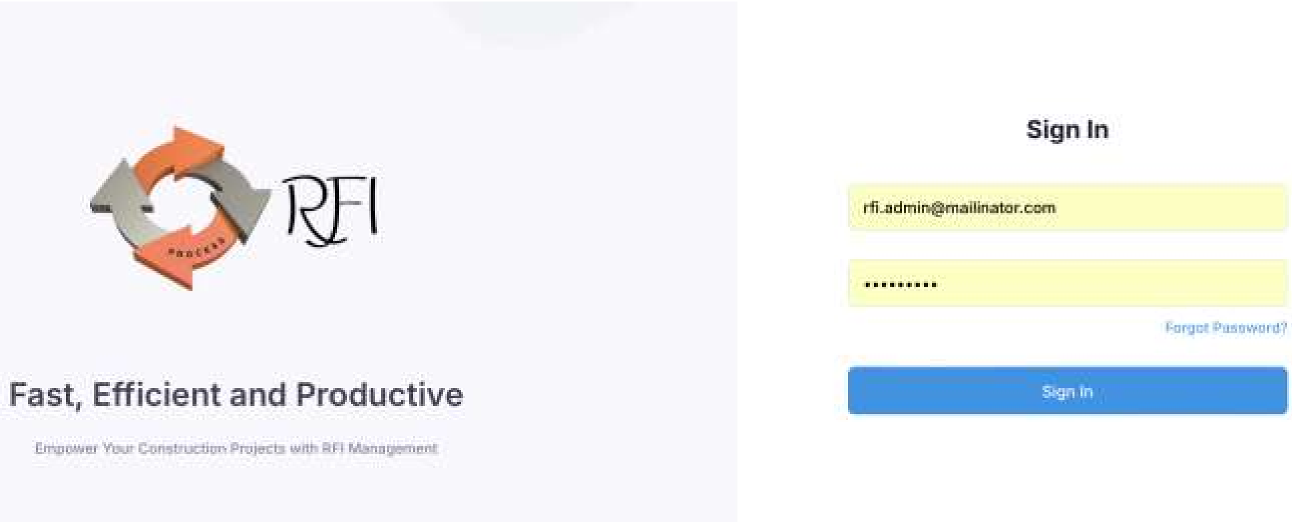


Figure 4-7 Creation of the Website

4.2.10 Importance of Visualisation

The decision to develop a website stemmed from the need to provide participants with a more tangible representation of the proposed RFI process. The feedback from the first focus group indicated that many participants struggled to visualise how the integration of BIM and Lean principles would work in practice. Traditional documentation methods were insufficient in conveying the interactive nature of the proposed improvements, leading to a gap between conceptual understanding and practical application.

By providing an interactive, web-based tool, the research aimed to bridge this gap between theory and practice, allowing participants to engage more effectively with the proposed framework. This approach ensured that even those less familiar with digital processes could develop a clear understanding of how the new system functioned within real-world construction environments.

The website also served as a validation tool, allowing users to interact with the RFI process in a simulated environment. By experiencing the system firsthand, participants were able to assess its feasibility, functionality, and potential impact on their workflows. This level of engagement was crucial in determining how well the framework could be adopted across different project settings. Additionally, it provided an opportunity for iterative improvements, incorporating real-time feedback to refine the process before potential industry implementation.

4.2.10.1 Testing the Website

The website was shared with the participants of the second focus group, enabling them to test the tool and provide feedback on its usability. The interactive nature of the website helped clarify some of the ambiguities encountered in the first focus group, such as how RFIs would be linked to specific areas of the BIM model. This feature allowed participants to navigate through different RFI classifications and visually map them to relevant construction components, reinforcing the value of integrating digital tools into RFI management.

Participants were able to see, in real-time, how changes in the RFI categorisation system affected the flow of information within the project. The ability to manipulate and test different scenarios provided greater confidence in the proposed methodology, as users could directly observe the efficiency gains offered by BIM and Lean principles. Furthermore, the website included built-in tracking features that demonstrated how RFIs progressed through the approval and resolution stages, offering a transparent and structured approach to information flow management.

The feedback obtained from this testing phase was instrumental in refining the usability and practicality of the website. Many participants suggested minor adjustments to improve navigation and enhance clarity, leading to the development of additional tutorial features and tooltips to guide users through the process. This iterative approach ensured that the final version of the website was as intuitive and user-friendly as possible, making it a valuable resource for industry professionals aiming to streamline their RFI processes.

4.2.11 Second Focus Group (Expanded)

The second focus group was held online due to COVID-19 restrictions. This session focused on testing the refined RFI process map and the dummy website developed after the first focus group. The shift to an online format introduced new dynamics, as participants engaged with the system remotely rather than in a controlled, in-person environment. Despite this limitation, the feedback collected was crucial in validating the proposed improvements and assessing the usability of the website.

Participants provided constructive insights into the functionality of the digital tool, with a particular focus on the ease of integration with existing RFI workflows. Several professionals noted that while the website effectively demonstrated the structured approach to RFI categorisation and tracking, further refinements were necessary to ensure seamless compatibility with commonly used project management software. This feedback highlighted the importance of interoperability, leading to recommendations for API integrations that could enable the tool to function alongside established digital platforms.

Additionally, discussions during this session underscored the varying levels of digital literacy among industry professionals, reinforcing the need for comprehensive onboarding materials. Participants emphasized that a well-structured training module would be essential for widespread adoption, ensuring that all users, regardless of their technical proficiency, could effectively engage with the system. These findings informed the development of supplementary user guides and interactive tutorials, further enhancing the accessibility and practical value of the proposed framework.

4.2.11.1 Structure of the Second Focus Group

The second focus group followed a similar structure to the first but placed greater emphasis on interactivity. Participants were given a guided tour of the website and were then asked to complete several tasks, ensuring hands-on engagement with the proposed RFI process. These tasks included:

- Submitting a dummy RFI using the categorisation system to evaluate its clarity and applicability.
- Linking an RFI to a BIM model, demonstrating how digital tools could streamline the resolution process.
- Tracking the RFI response time and assessing how Lean principles could be applied to reduce delays and inefficiencies.

This structured approach allowed participants to experience the functionality of the tool in a controlled setting, providing real-time feedback on its usability and integration potential. By actively engaging with the system, they could identify any inconsistencies or areas requiring further refinement, making this phase a crucial step in validating the effectiveness of the BIM-Lean RFI integration.

4.2.11.2 Key Findings from the Second Focus Group

Participants in the second focus group provided generally positive feedback on the website and the revised RFI process map. The visual interface was particularly well-received, with several participants commenting that it made the RFI process much easier to understand and apply in real-world scenarios. The intuitive design allowed users to navigate the system efficiently, reducing the learning curve often associated with new digital tools. Additionally, the categorisation framework was praised for its structured yet flexible approach, accommodating various project complexities.

However, there were still concerns about the feasibility of full BIM integration across all project types, with smaller firms in particular expressing doubts about the cost and complexity of adopting such technologies. Participants from smaller organisations highlighted challenges such as the need for additional training, financial constraints, and compatibility with existing workflows. These concerns underscored the importance of ensuring that the tool remains scalable and adaptable for firms of different sizes and levels of technological readiness.

Participants also suggested additional features to enhance the tool's functionality. Key recommendations included:

- Implementing automated notifications when RFIs were delayed, improving response efficiency and accountability.
- Developing a more detailed tracking system to monitor RFI status at different stages of the project lifecycle.
- Enhancing interoperability with other project management platforms to ensure seamless integration with existing workflows.

These suggestions highlighted the potential for further development of the RFI process tool, ensuring it remains adaptable to different project needs. By incorporating these enhancements, the tool could provide even greater efficiency gains and a more seamless user experience for professionals across the AEC industry.

4.2.11.3 Validation and Next Steps

The second focus group served as a critical validation phase for the research, confirming that the proposed improvements to the RFI process were both practical and beneficial. The feedback from participants indicated that while there was still room for refinement, the BIM-Lean integrated RFI process had the potential to significantly improve information flow and reduce waste in construction projects. The ability to track RFIs in real-time, link them directly to project components, and apply Lean principles to minimise delays was recognised as a major advancement in RFI management.

While the initial findings were promising, the research concluded that further testing and development of the tool would be necessary to ensure its widespread applicability across the AEC industry. Next steps include conducting additional pilot studies with a larger sample of industry professionals, refining the categorisation framework based on real-world implementation, and exploring further integrations with project management software. These actions will help validate the tool's effectiveness on a broader scale and ensure that it aligns with the needs of various industry stakeholders.

4.2.12 Quantitative Data Analysis

4.2.12.1 Survey Analysis

The survey data, collected from professionals within the AEC industry, provides a snapshot of current familiarity and adoption rates for BIM and Lean Construction methodologies. The findings indicate that 42.4% of respondents reported limited familiarity with BIM, while a significant 60% expressed uncertainty regarding Lean Construction practices. This relatively low adoption aligns with findings by Azhar et al. (2012), who argue that insufficient training and lack of awareness are key barriers to the effective implementation of BIM in construction projects. Similar trends have been observed in studies by Gledson and Greenwood (2017), who highlighted that while larger firms are driving BIM adoption, smaller companies are lagging behind due to resource constraints and limited access to training opportunities.

Table 4-5 Breakdown of Participants' Familiarity with BIM and Lean Construction

Job Role	Years of Experience	Familiar with BIM (%)	Familiar with Lean (%)
Project Manager	10+	55%	40%
Engineer	5-10	30%	20%
Architect	1-5	45%	15%
Site Supervisor	10+	60%	35%
Contractor	5-10	50%	25%

The data shown in Table 4.5 reveals a general trend where those with more years of experience, such as site supervisors and contractors, exhibit higher familiarity with BIM. This suggests that familiarity may be closely linked to long-term exposure, as more experienced professionals often have greater access to BIM tools through projects in larger firms, which are more likely to adopt these technologies. However, the lower familiarity with Lean principles across all job roles indicates that Lean practices are still not well integrated into the industry's mainstream workflows. These findings reinforce the need for targeted training initiatives to increase awareness and practical understanding of Lean methodologies across all experience levels.

A key limitation of the survey is the relatively small sample size, with data collected from only 60 participants. While the responses provide valuable insights into current industry practices, the limited number of respondents means that the results may not fully represent the diversity of experience and adoption across the wider AEC industry. Studies such as those by Eastman et al. (2011) and Smith (2014) have drawn on much larger samples, allowing for a more nuanced analysis of BIM adoption trends across different regions and project types. Additionally, the survey did not account for regional variations, which may also affect familiarity and usage rates of BIM and Lean tools.

Furthermore, respondent bias should be considered. Professionals who were more familiar with BIM and Lean were perhaps more likely to respond to the survey, leading to a possible overestimation of their general adoption within the industry. Despite this, the survey data offers an important starting point for understanding the current barriers to adoption, especially when paired with the focus group findings, which delve into more qualitative insights on the practical challenges faced by industry professionals. By triangulating these findings with additional industry data, future research can provide a more comprehensive analysis of the factors influencing BIM and Lean adoption within the construction sector.

Chapter: 5 Data Analysis and Discussion

5.1 Introduction to Data Analysis

This chapter presents a detailed discussion of the findings derived from the mixed-methods approach employed in this research, integrating both quantitative and qualitative analyses to provide a robust understanding of the research problem. The study sought to explore how the integration of Building Information Modelling (BIM) and Lean Construction (LC) can enhance the Request for Information (RFI) process within the Architecture, Engineering, and Construction (AEC) industry. The discussion synthesises key insights drawn from the online survey, focus groups, and existing academic literature, ensuring that the findings are contextualised within both theoretical and practical frameworks. By examining the role of BIM and Lean tools in addressing inefficiencies in RFI management, this chapter establishes the foundation for the development of an integrated framework aimed at improving industry practices.

To illustrate the methodological flow that underpinned this research, Figure 5.1 presents a methodology flow map, offering a visual representation of how each research phase contributed to achieving the study's objectives. This structured approach ensured that data collection and analysis were aligned with the overarching aim of developing an effective, industry-informed RFI process.

Figure 5.1 illustrates a methodology flow map to this thesis to accomplish the research aim.

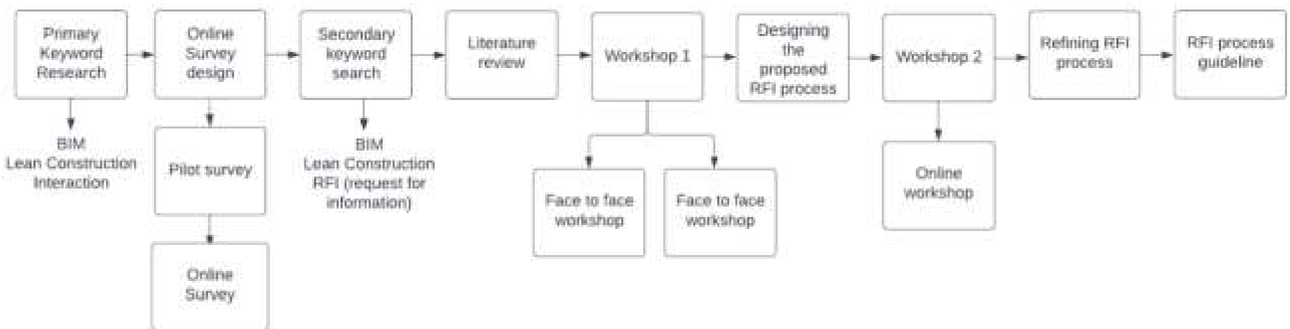


Figure 5-1 Methodology flow Map

The structure of this chapter is framed by the research objectives, which sought to (1) Understand the key principles of BIM and Lean Construction, (2) Evaluate the current RFI process, (3) Investigate the potential for BIM and Lean tools to improve this process, (4) Develop a new, integrated RFI process framework, and (5) Provide practical tools and guidelines to facilitate the implementation of this framework. The discussion aims to not only highlight the key findings of the research but also situate them within the broader context of the construction industry, referencing existing academic studies and real-world examples to underscore the relevance and applicability of the findings.

The findings from the online survey reveal general trends in the current adoption and understanding of BIM and Lean principles across various sectors of the AEC industry. This quantitative data is vital for establishing a baseline of current industry practices, identifying the key challenges professionals face when managing RFIs, and providing insights into the extent to which BIM and Lean methodologies are currently employed. Likert scale analysis and cross-tabulation methods were used to explore these trends, offering a detailed look at the relationship between BIM/Lean adoption and project performance, particularly in managing RFIs. This analysis serves as a foundation for the subsequent qualitative discussion.

The focus group discussions provide a deeper, more contextualised exploration of the specific issues identified in the survey, particularly in relation to the RFI process. The feedback from industry professionals who participated in the focus groups highlighted recurring challenges, such as miscommunication between project stakeholders and the difficulties in categorising RFIs effectively. These discussions also helped refine the proposed BIM-Lean integrated RFI framework, offering real-world insights into how such a system could improve project outcomes. Focus groups, as qualitative methods, added a layer of depth to the survey data, enabling the development of practical tools tailored to industry needs.

Furthermore, this chapter compares the research findings with existing literature, demonstrating how the proposed framework fills a critical gap in current RFI management practices. Scholars such as Hanna et al. (2012) have previously highlighted the inefficiencies associated with RFIs, including their propensity to delay projects and increase costs. However, while much of the literature points to the benefits of BIM and Lean tools in isolation, there remains limited research on how these methodologies can be effectively combined to enhance the RFI process specifically. This research contributes to the literature by proposing a clear and actionable process for integrating these tools, a framework that has been refined through both quantitative data analysis and qualitative insights from industry experts.

By addressing these themes, the discussion in this chapter will evaluate the extent to which the research objectives have been achieved. Each section will focus on specific aspects of the findings, from the initial understanding of BIM and Lean principles through to the practical application of these tools in the RFI process. In doing so, the chapter will also consider the broader theoretical implications of the research, including the potential for further study and development in this area.

This chapter is structured as follows:

1. Analysis of Survey Findings – presents the key insights from the survey, focusing on the adoption of BIM and Lean methodologies across various sectors and the main challenges identified in the current RFI process.

2. Insights from Focus Groups – delves deeper into the qualitative feedback gathered during the focus groups, highlighting the industry's perspective on the proposed BIM-Lean RFI process and its potential impact on project outcomes.
3. Comparative Analysis with Existing Literature – evaluates how the findings align with or challenge existing studies in the field, particularly regarding the integration of BIM and Lean tools to improve RFI workflows.
4. Practical Implications for the Industry – outlines the practical contributions of the research, discussing the potential for the proposed RFI framework to enhance efficiency and communication in construction projects.
5. Conclusion – summarises the key points of the discussion, linking them back to the original research objectives and suggesting directions for future research.

5.2 Understand BIM and Lean Principles

The analysis of the survey responses highlights key gaps in the understanding and application of Building Information Modelling (BIM) and Lean Construction tools across the Architecture, Engineering, and Construction (AEC) industry. These gaps have significant implications for the Request for Information (RFI) process and the potential improvements that could be achieved through the integration of BIM and Lean methodologies.

The literature highlights that BIM has been widely adopted as a digital innovation capable of improving collaboration, reducing errors, and enhancing efficiency in construction projects (Succar, 2009). However, despite its benefits, the survey results indicate that many professionals still struggle with full implementation due to issues such as lack of training, high initial costs, and resistance to change. This aligns with prior research suggesting that organisations often face challenges in shifting from traditional construction practices to digital workflows (Ghaffarianhoseini et al., 2017). The UK's BIM Level 2 mandate, introduced in 2016, aimed to standardise adoption, yet discrepancies remain across different sectors and project scales.

Similarly, Lean Construction, which focuses on minimising waste and maximising value, has not seen the same level of industry-wide adoption as BIM. The literature indicates that Lean principles, when properly implemented, can lead to substantial efficiency gains (Ballard & Howell, 1998). However, survey findings suggest that Lean is often perceived as complex or impractical, particularly in organisations that lack structured implementation frameworks. Research by Dave et al. (2016) suggests that the integration of BIM and Lean methodologies can address these challenges by leveraging BIM's real-time data capabilities to support Lean workflows.

Therefore, the integration of BIM and Lean principles presents a significant opportunity to enhance the efficiency of the RFI process. By structuring information flows and improving collaboration, the combined approach can mitigate many of the inefficiencies traditionally associated with RFIs. The following sections delve deeper into the survey findings, analysing the current state of BIM and Lean adoption and exploring strategies to overcome identified barriers.

5.3 Survey and Focus Group Findings:

5.3.1 Objective 1 Adoption of BIM, Lean adoption in the AEC industry

The survey results (Figure 5.2) indicate that BIM adoption is widely recognised within the industry, with the majority of respondents indicating some level of engagement with BIM tools and processes. This finding aligns with the increasing prominence of BIM since the UK government's BIM Level 2 mandate, introduced in 2016 for public sector projects. Despite this mandate, the survey shows that while 61.2% of respondents reported active BIM usage in their projects, a significant proportion (37.6%) are aware of BIM but have not yet implemented it, and 1.2% have never heard of BIM (Figure 5.3). These findings suggest that while BIM adoption is relatively high, barriers such as lack of training, high implementation costs, and resistance to change persist within the industry, as highlighted by Succar (2009) and Ghaffarianhoseini et al. (2017).

From the data, it is evident that transportation and infrastructure projects (as indicated by 32% of respondents from these sectors) lead the way in BIM adoption, particularly in public sector work where compliance with the mandate is obligatory (Figure 5.2). These findings align with research by Eadie et al. (2013), which notes that regulatory requirements often drive higher BIM adoption rates. In contrast, commercial and residential projects report lower levels of adoption, with many professionals citing cost concerns and a perceived lack of immediate return on investment as key barriers. Studies by Gledson and Greenwood (2017) support this claim, noting that while BIM offers long-term efficiency, upfront costs and unclear benefits deter many firms from fully committing to its implementation.

The findings shown in Figure 5.3 indicate that 61.2% of respondents are currently using BIM tools in their projects, which reflects a strong adoption rate compared to the global average. This widespread use of BIM is likely driven by the UK Government's BIM Mandate, which has made BIM implementation mandatory for all public-sector projects since 2016. However, 37.6% of respondents, despite being aware of BIM, are not yet using it in their projects, while 1.2% have no knowledge of BIM. These findings underline a significant knowledge gap and potential barriers to wider adoption, such as the initial costs and training requirements associated with BIM implementation, a challenge also discussed by Azhar (2011), who highlights that lack of industry-wide training programmes slows down BIM diffusion in practice.

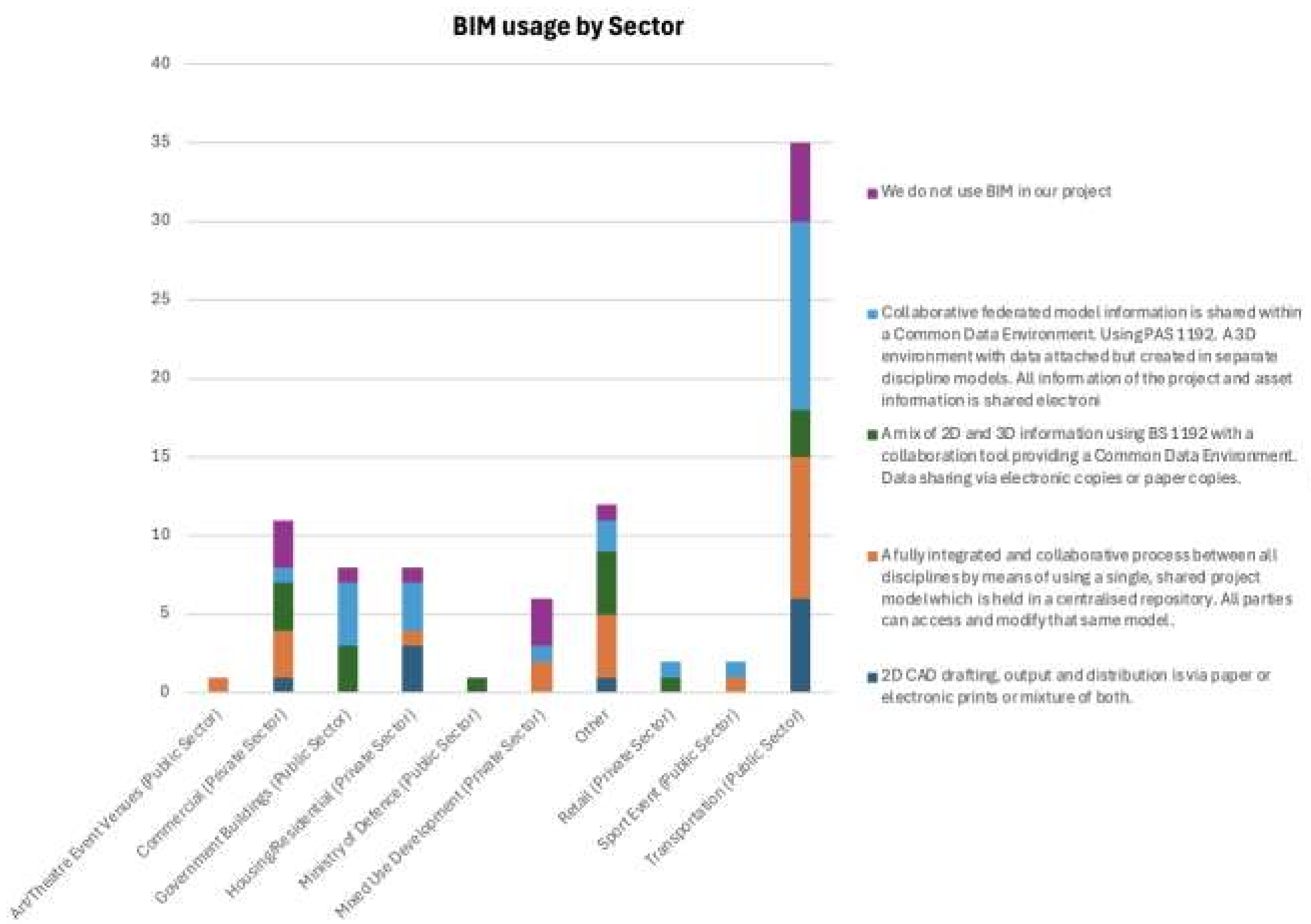


Figure 5-2 BIM Usage by Sector

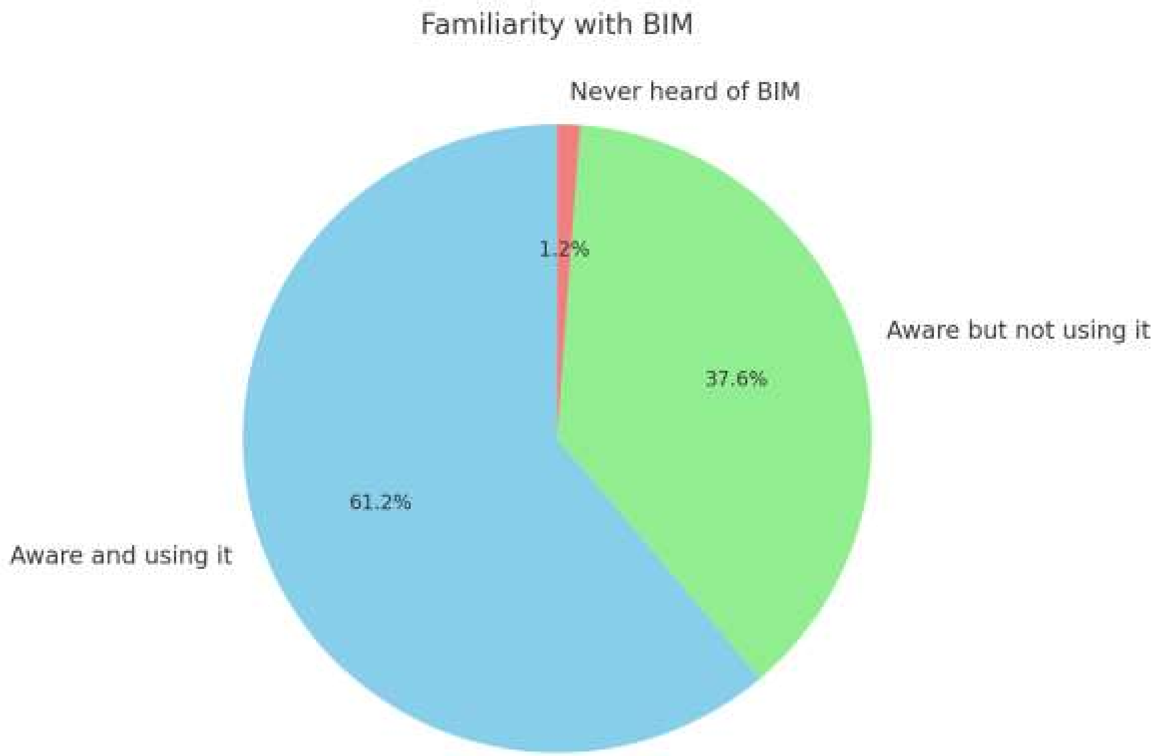


Figure 5-3 Familiarity of BIM

In contrast, the adoption of Lean Construction tools remains relatively limited, with many professionals still viewing Lean methodologies as either too complex or inapplicable to their projects. The survey data suggests that there is a lack of standardised protocols for Lean implementation, which could explain the slower uptake compared to BIM. These findings are consistent with the literature, which points to the organisational challenges and cultural resistance that often impede the adoption of Lean principles in construction (Ballard & Howell, 1998). Research by Dave et al. (2016) further suggests that integrating Lean with BIM can enhance its adoption by providing digital tools to streamline Lean workflows. This underscores the potential for a combined BIM-Lean approach to improve RFI processes by minimising inefficiencies and promoting collaborative workflows in the AEC industry.

Overall, these findings reinforce the need for industry-wide initiatives to bridge the knowledge gap and promote both BIM and Lean methodologies. Establishing structured training programmes, providing financial incentives, and demonstrating tangible project benefits could drive higher adoption rates. Additionally, integrating Lean principles within digital workflows, such as using BIM to support Lean Construction practices, could facilitate a more seamless transition toward efficiency-driven project delivery.

5.3.2 Survey Results on Lean Construction Adoption

Lean Construction principles, on the other hand, show a lower rate of adoption compared to BIM, with only 38% of respondents reporting regular use of Lean tools and methodologies in their projects. This disparity is reflective of the broader industry trend, where Lean principles, while highly beneficial in theory, have been slower to gain traction due to the industry's traditional and often fragmented nature. Research by Koskela (1992) and Ballard & Howell (1998) emphasises that while Lean principles can improve efficiency and reduce waste, the construction industry has historically struggled with implementing systematic process improvements due to its project-based and often siloed operations.

Cross-tabulation analysis shows that Lean principles are more commonly applied in larger-scale infrastructure projects, where waste reduction and process efficiency are seen as critical to managing complex, multi-phase projects. This aligns with the findings of Sarhan et al. (2017), who argue that large infrastructure projects are more likely to integrate Lean due to their scale, complexity, and the need for optimised workflows. Conversely, smaller firms, particularly those involved in residential and commercial projects, reported a much lower engagement with Lean methodologies (Figure 5.4). This may be attributed to the perception that Lean construction is more applicable to manufacturing processes rather than bespoke, design-driven projects typically found in these sectors. Scholars such as Green (1999) have also pointed out that Lean is often misinterpreted as a rigid manufacturing approach rather than a flexible, process-oriented philosophy adaptable to construction workflows.

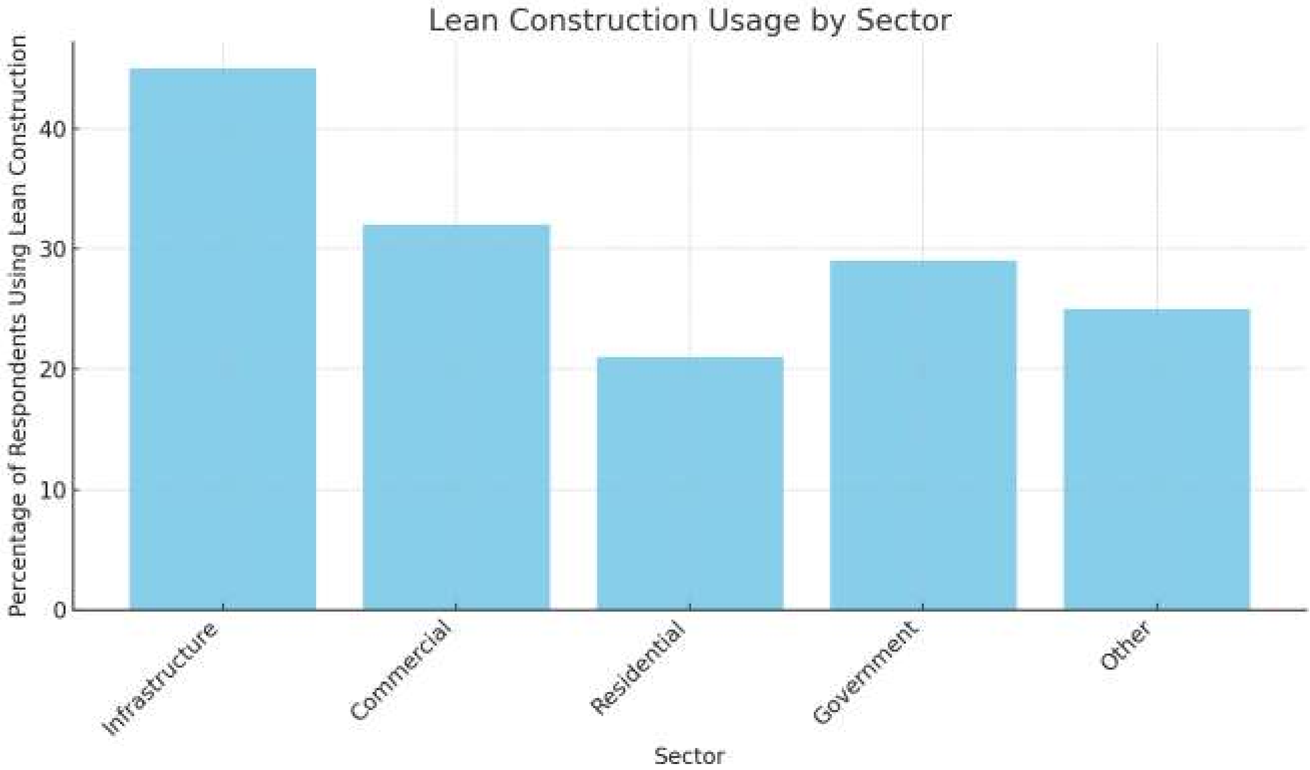


Figure 5-4 Lean Construction Usage by Sector

As one respondent noted in the survey, "Lean is still seen as more of a factory-floor concept in our firm, and we struggle to see its relevance to bespoke, client-driven design processes." This statement reflects the broader challenges identified in the literature, where the cultural and operational shift required for Lean implementation remains a significant barrier (Jørgensen & Emmitt, 2009). These findings highlight the need for better education and case studies demonstrating the adaptability of Lean principles beyond large-scale infrastructure projects to smaller, design-intensive sectors.

5.3.3 Comparative Analysis with Existing Literature

The survey findings regarding BIM and Lean adoption are consistent with the trends identified in the literature. Scholars such as Eadie et al. (2013) and Smith et al. (2014) have documented the rapid growth of BIM adoption, particularly in the UK, where government policy has played a significant role in driving uptake. However, these studies also highlight the uneven adoption across sectors, a finding that this research corroborates. The challenges noted in the survey, particularly around training and organisational resistance, echo the concerns raised by Gledson and Greenwood (2017), who argue that the lack of consistent BIM education and the fragmented nature of the AEC industry have hindered the widespread adoption of BIM.

The data in Figure 5.5 shows that 38.4% of respondents are using both BIM and Lean tools in their current projects, while 47.7% do not use these tools together. This highlights a significant opportunity to increase the combined application of these methodologies. Research by Sacks et al. (2010) supports this notion, indicating that the integration of BIM and Lean Construction enhances project coordination, reduces waste, and improves efficiency. Respondents who use both tools report increased collaboration and streamlined workflows, yet many professionals remain unaware of the synergies between BIM and Lean. This lack of awareness is consistent with findings by Dave et al. (2016), who argue that the siloed implementation of these methodologies limits their full potential.

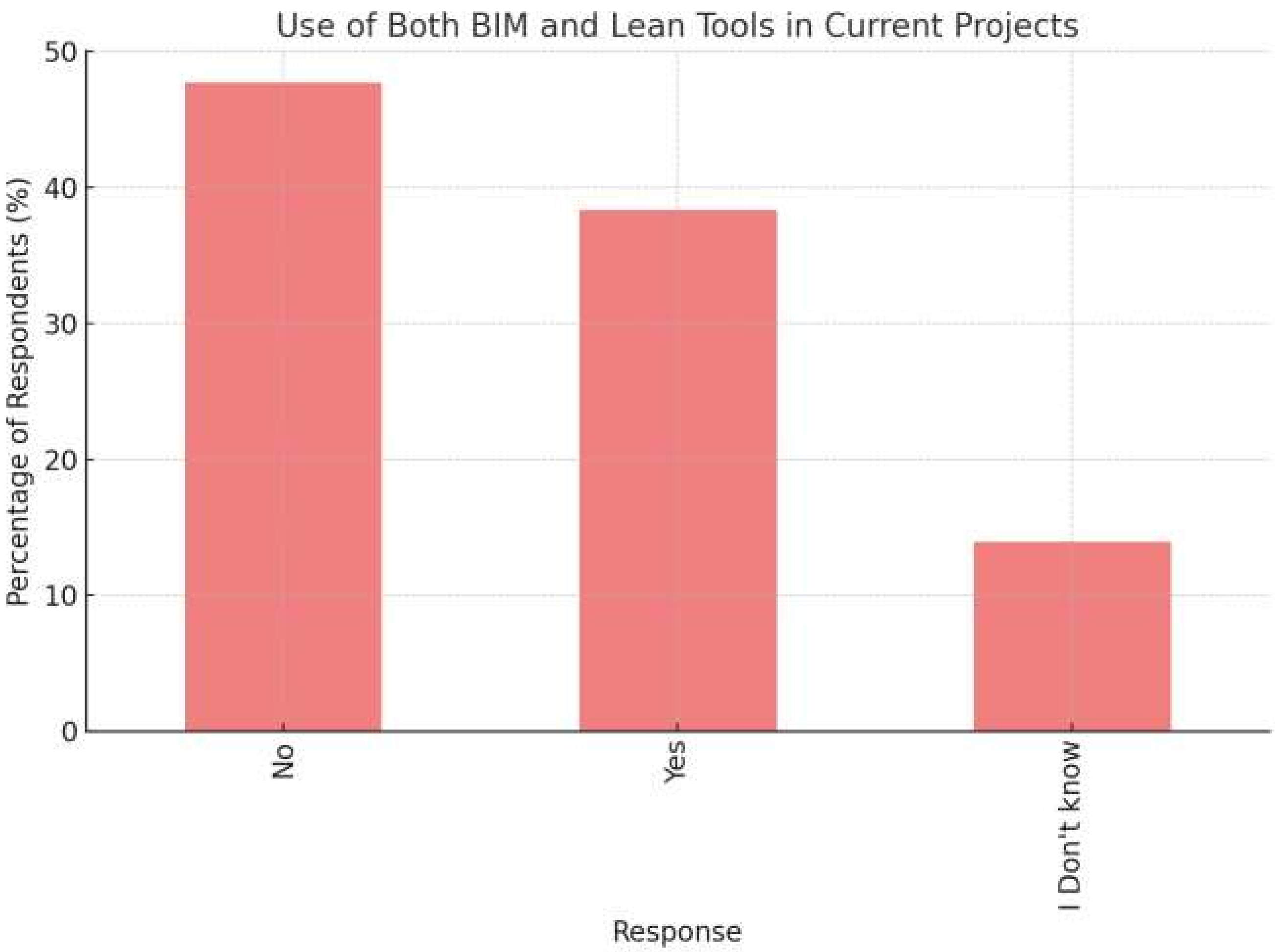


Figure 5-5 Use of Both BIM and Lean Tools in Current projects

Similarly, the literature on Lean Construction, such as the works by Koskela (1992) and Alarcón (1997), suggests that while Lean principles offer significant potential to improve project efficiency and reduce waste, their adoption remains limited. This is particularly true in the AEC industry, where traditional project management methods still dominate. The survey results in this research further substantiate these findings, highlighting the disconnect between the theoretical benefits of Lean and its practical application in day-to-day construction activities. Research by Sarhan et al. (2017) points out that cultural resistance and the perception of Lean as a rigid manufacturing approach contribute to its slow adoption in construction. These barriers align with the survey responses, which indicate that many firms lack structured guidance on implementing Lean in a way that complements their existing workflows.

Overall, the comparative analysis confirms that while the adoption of BIM has seen significant growth, Lean Construction remains underutilised despite its proven benefits. By addressing the knowledge gap and promoting an integrated approach, the industry can leverage both methodologies more effectively to drive project efficiency and reduce waste.

5.3.4 Challenges and Opportunities in Adoption

Both BIM and Lean offer substantial opportunities for improving project outcomes, particularly in terms of reducing RFIs, enhancing communication, and improving information flow across stakeholders. However, the survey highlights several key barriers to their full adoption, including:

- Training and Education: A recurring theme in the survey responses is the need for more robust training on both BIM and Lean principles. Many respondents indicated that while their organisations have invested in BIM software, the lack of adequate training has resulted in underutilisation of its full potential. This aligns with research by Gledson and Greenwood (2017), who highlight that the gap in digital literacy and structured training programmes has hindered effective BIM implementation in the construction sector.
- Cost and Resource Concerns: Especially for smaller firms, the upfront cost of implementing BIM and Lean tools, coupled with the perception of a slow return on investment, remains a significant hurdle. This finding is supported by Barlish and Sullivan (2012), who argue that while the long-term benefits of BIM are clear, the short-term cost implications can be a deterrent for smaller companies. Similarly, Koskela (1992) notes that Lean Construction, despite its efficiency-driven advantages, often requires upfront restructuring and investment, which can be challenging for firms with limited resources.
- Cultural Resistance: Organisational culture plays a significant role in the adoption of new tools and methodologies. The survey results reveal that in many firms, particularly those in the commercial and residential sectors, there is resistance to change, with many professionals expressing a preference for traditional project management methods over BIM and Lean. This aligns with findings by Sarhan et al. (2017), who emphasise that deep-rooted conventional practices and a lack of leadership commitment often hinder the adoption of Lean principles in construction.

Despite these challenges, the survey findings also point to significant opportunities for growth in the adoption of BIM and Lean tools. The growing recognition of the UK Government's BIM Level 2 mandate, coupled with increasing client demand for more efficient, data-driven project management, suggests that BIM adoption will continue to rise in the coming years. This is further supported by McAuley et al. (2017), who predict that regulatory pressures will drive higher digitalisation rates in construction. Similarly, as the industry becomes more aware of the potential for Lean principles to reduce waste and improve efficiency, particularly in larger, more complex projects, there is potential for broader Lean adoption across sectors. Studies such as those by Dave et al. (2016) have shown that when integrated effectively, BIM and Lean can drive project efficiencies, reduce waste, and improve collaboration.

Overall, addressing these challenges through structured training, incentivised cost structures, and cultural change initiatives will be key to unlocking the full potential of BIM and Lean methodologies in the construction industry.

5.3.5 Insights from Focus Groups

The focus group discussions provided a deeper exploration of the themes identified in the survey, with participants offering first-hand insights into the real-world challenges of managing RFIs and how BIM and Lean principles could improve this process. Feedback from industry professionals highlighted several recurring issues, including the difficulty in categorising RFIs and the lack of a structured, standardised process for RFI management. These findings are consistent with the literature, where Hanna et al. (2012) and Dave et al. (2016) emphasise that unstructured RFI processes contribute to delays and inefficiencies in project workflows.

One of the key themes emerging from the focus groups was the inconsistent use of BIM for RFI tracking. Several participants noted that while BIM has the potential to improve information flow, many firms still rely on traditional documentation methods, leading to delays and miscommunication. This aligns with Eastman et al. (2011), who argue that the fragmented nature of construction workflows limits the full integration of BIM in RFI management. The discussions also revealed that while some companies have attempted to implement Lean principles to streamline RFIs, the lack of proper training and awareness has hindered successful adoption.

Participants further highlighted the challenge of accountability in RFI resolution. Many expressed frustration with the absence of clear roles and responsibilities in the RFI workflow, which often results in delayed responses and project disruptions. Research by Gledson and Greenwood (2017) supports this observation, indicating that without a defined framework, RFIs can become bottlenecks that impede project progress. Several participants suggested that integrating BIM with Lean principles, such as the Last Planner System (Ballard & Howell, 1998), could enhance coordination by providing real-time visibility into RFI statuses and ensuring accountability among project stakeholders.

Moreover, the focus groups underscored the potential benefits of categorising RFIs based on their root causes, as suggested in studies by Koskela (1992) and Sarhan et al. (2017). Participants agreed that a structured categorisation system could facilitate more efficient resolution processes by allowing teams to prioritise RFIs based on their impact on project timelines and costs. This would align with the principles of Lean Construction, which advocate for waste reduction and continuous improvement in construction workflows.

Overall, the insights from the focus groups reinforce the need for a more structured, technology-driven approach to RFI management. By leveraging BIM's data integration capabilities and Lean's efficiency-driven methodologies, the construction industry can improve RFI handling, minimise delays, and enhance collaboration across project teams.

5.3.6 Proposed BIM-Lean Integrated RFI Framework

The focus group participants expressed strong support for the proposed BIM-Lean integrated RFI framework, which combines the visualisation capabilities of BIM with the process efficiency of Lean. By applying BIM's 3D modelling capabilities to detect clashes and information gaps early in the design phase, and using Lean principles to streamline communication and reduce waste, the proposed framework offers a comprehensive solution to the inefficiencies currently plaguing the RFI process. These findings align with research by Sacks et al. (2010), which highlights the potential of BIM-Lean integration in enhancing collaboration and reducing project uncertainties.

Participants also stressed the importance of developing a standardised RFI categorisation system, which would ensure that all project stakeholders are aligned and can respond to RFIs more efficiently. This feedback was instrumental in refining the proposed framework, which now incorporates a detailed RFI categorisation protocol as part of the process. The importance of structured categorisation is supported by Hanna et al. (2012), who argue that RFI classification improves response times and facilitates better project tracking.

Additionally, focus group discussions emphasised the need for enhanced accountability within the RFI framework. Several participants noted that assigning clear responsibilities for RFI resolution could mitigate delays and prevent RFIs from becoming bottlenecks. Research by Ballard and Howell (1998) supports this notion, suggesting that Lean-based workflows, such as the Last Planner System, can improve accountability and workflow reliability in project environments. Incorporating these Lean methodologies into the proposed framework ensures that RFIs are not only categorised efficiently but also processed in a manner that minimises delays and optimises resource allocation.

Overall, the proposed BIM-Lean integrated RFI framework represents a significant advancement in addressing RFI inefficiencies. By leveraging BIM's digital capabilities alongside Lean's structured workflows, this approach fosters greater collaboration, reduces waste, and enhances information flow across project teams. The integration of stakeholder feedback into the refinement of the framework ensures that it remains practical, adaptable, and capable of addressing real-world challenges in construction project management.

5.4 Objective 2: Assess the Current RFI Process

5.4.1 Fragmented Tools for Managing RFIs

The survey responses indicate a lack of standardisation in how RFIs are handled across projects. While ProjectWise and Conject are recognised industry tools, the presence of many other systems, including custom or niche solutions, suggests that firms do not rely on a universal system for managing RFIs. This fragmentation poses a significant challenge in terms of consistency and efficiency, as different systems may offer varying levels of collaboration, data integration, and information flow. These findings align with research by Wilmot-Smith (2017), who argues that the absence of a common platform for RFI management increases administrative burden and reduces transparency across project stakeholders.

The literature highlights the importance of having a streamlined, consistent system for handling RFIs to reduce miscommunication and delays. Eastman et al. (2018) stress that when RFIs are poorly managed, they can result in costly delays and information bottlenecks. Similarly, research by Hanna et al. (2012) highlights that inefficient RFI processes contribute to increased project costs and prolonged timelines. The current survey data corroborates these findings, suggesting that the AEC industry still struggles with the effective management of RFIs due to the diverse range of tools in use.

Moreover, participants in the focus groups emphasised that the inconsistency in RFI management tools often leads to misaligned workflows and difficulty in tracking responses. Several respondents noted that RFIs raised in one system may not always be accurately transferred to another, causing miscommunication and a lack of accountability. This supports the findings of Sacks et al. (2010), who state that the interoperability of digital tools in construction is crucial for improving communication efficiency and data integration.

A potential solution emerging from both the literature and industry feedback is the integration of BIM-based platforms for managing RFIs. Succar (2009) suggests that embedding RFIs within a BIM workflow enhances accessibility, ensures real-time tracking, and reduces duplication of requests. By transitioning toward a centralised digital system that aligns with BIM and Lean Construction principles, the industry could mitigate the inefficiencies caused by fragmented tools and improve overall project performance.

5.4.2 Frequency of RFI Submissions

From the data in Figure 5.6, 38.4% of projects submit 1-10 RFIs per week, while another 37.2% report between 10-50 RFIs per week. This frequency suggests a high reliance on RFIs for clarification, communication, and coordination between different project stakeholders. Frequent RFIs can often be an indicator of incomplete or unclear designs, as identified by Hanna et al. (2012), who noted that excessive RFIs can contribute to project inefficiencies by increasing administrative workload and delaying project timelines.

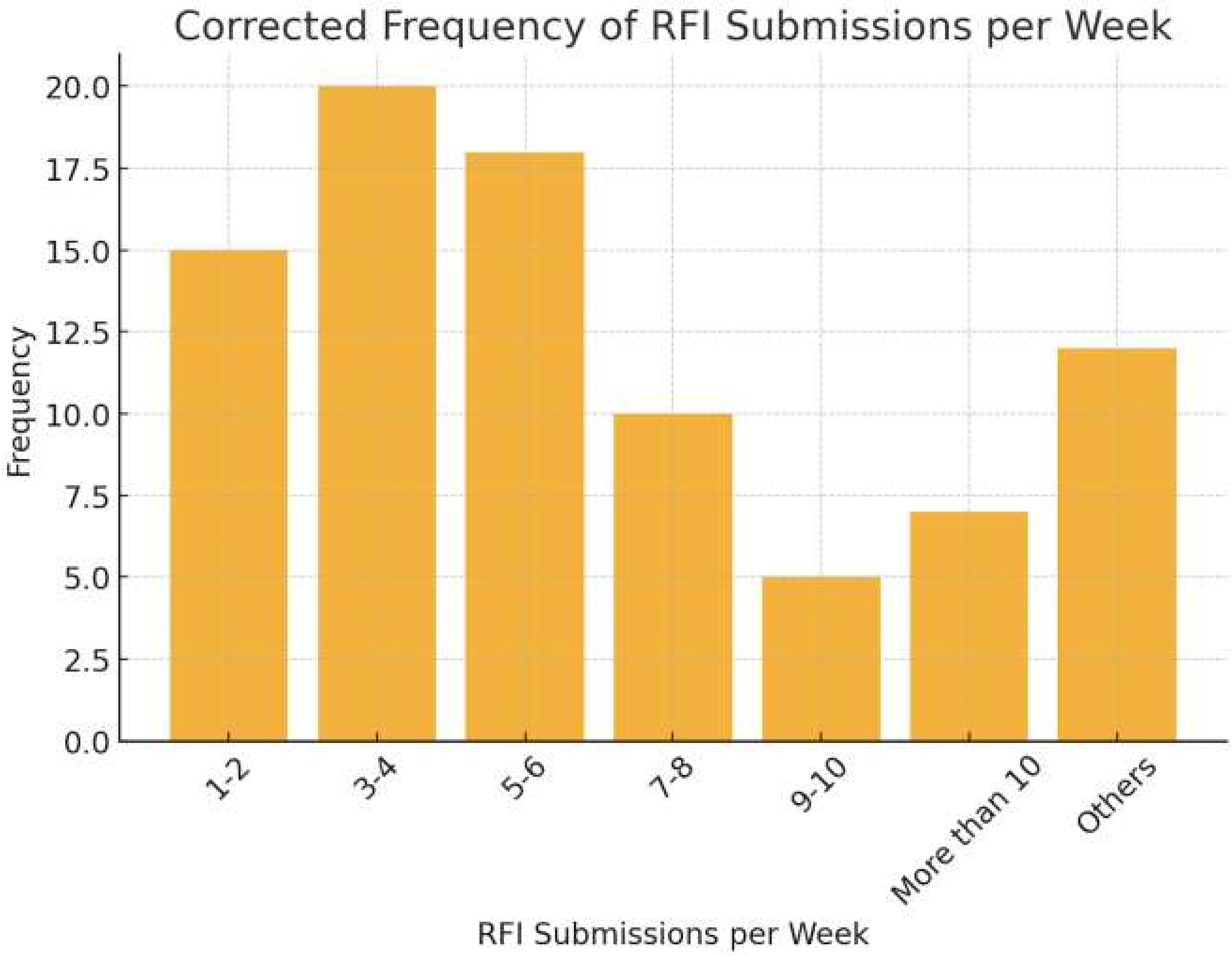


Figure 5-6 Frequency of RFI Submissions per week

The literature underscores that the RFI process should be streamlined and closely integrated into the project workflow to reduce inefficiencies. However, the large number of RFIs submitted weekly indicates that projects may not have adequate processes in place for resolving design conflicts or providing clear instructions early in the design stage. This observation is consistent with Azhar et al. (2011), who highlight that many RFIs stem from ambiguities in the initial design documents. Similarly, Love et al. (2014) argue that excessive RFIs often result from a lack of coordination in design documentation and poor communication among project stakeholders, leading to costly rework and project delays.

Furthermore, participants in the focus groups echoed these concerns, noting that the high frequency of RFIs often signals inefficiencies in the design development phase. Several respondents highlighted that early-stage design coordination and collaborative review processes, particularly through BIM-integrated workflows, could significantly reduce the volume of RFIs. This aligns with the findings of Eastman et al.

(2018), who advocate for the use of BIM to enhance design clarity and mitigate the need for excessive RFIs by facilitating early clash detection and improving multidisciplinary coordination.

Overall, the findings suggest that while RFIs play a critical role in project communication, their high frequency indicates a need for improved design coordination and better integration of BIM and Lean methodologies to streamline project workflows and reduce unnecessary RFIs.

5.4.3 Communication and Delays in RFI Management

The diversity of tools used to manage RFIs, alongside the significant volume of submissions, leads to further concerns about communication breakdowns and delayed responses. With systems such as ProjectWise, Conject, and various other tools being used across different projects, there is a risk of miscommunication between stakeholders, especially when data cannot be easily shared or integrated across platforms. This fragmentation in communication channels often results in inefficiencies that hinder decision-making and cause delays in project execution.

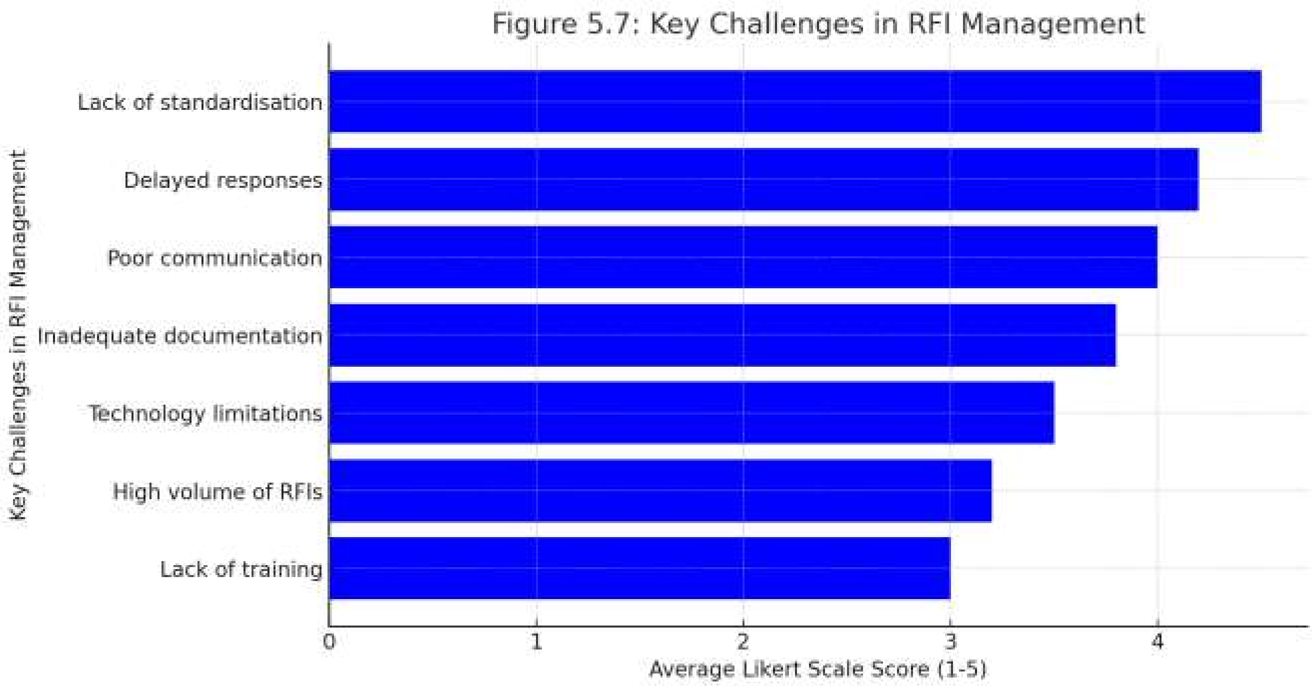


Figure 5-7 Key Challenges un RFI Management

Studies by Eastman et al. (2018) and Hanna et al. (2012) highlight that poor communication in RFI management is a major contributor to project delays. The survey findings reflect similar issues, where respondents reported inefficient RFI processes that result in delays and misalignment between project teams. These inefficiencies may result in prolonged project timelines, additional costs, and compromised project quality, as RFIs accumulate without timely resolution. Research by Love et al. (2014) further supports this, indicating that fragmented communication workflows often lead to information loss, redundant RFIs, and inefficient dispute resolution processes.

Moreover, focus group discussions reinforced these findings, with participants citing frequent delays in RFI response times due to a lack of clear accountability and coordination across teams. Many professionals noted that project stakeholders often rely on informal communication channels to expedite responses, but these methods lack traceability and accountability, exacerbating project risks. This is consistent with the findings of Sacks et al. (2010), who advocate for the implementation of digital platforms that centralise RFI management and provide real-time tracking to improve response efficiency.

To address these challenges, the integration of BIM-enabled RFI tracking systems has been proposed as a viable solution. Succar (2009) suggests that embedding RFIs into a BIM workflow enhances real-time accessibility, reduces miscommunication, and ensures that issues are resolved more efficiently. Implementing a unified, transparent communication framework within BIM and Lean workflows could significantly improve RFI response times and mitigate the risks associated with fragmented data management.

5.4.4 Comparison with the Proposed BIM-Lean Integrated RFI Process

The survey data indicates that the current RFI process is inefficient due to both the fragmentation of tools and the high volume of RFIs. These findings align with the rationale for developing a BIM-Lean integrated RFI process, as explored in this research. The proposed framework seeks to address these inefficiencies by:

- Leveraging BIM for better visualisation and clash detection, which could significantly reduce the number of RFIs required by addressing issues early in the design phase. Studies by Eastman et al. (2018) highlight that incorporating BIM into the design and coordination process minimises errors and improves interdisciplinary collaboration, thereby decreasing the need for RFIs.
- Using Lean Construction principles to streamline the flow of information and minimise waste in communication, ensuring RFIs are processed efficiently and effectively. Research by Koskela (1992) and Ballard & Howell (1998) supports this, indicating that Lean methodologies help standardise workflows, reduce redundancies, and improve communication flow among project stakeholders.

As highlighted by Sacks et al. (2010), the combination of BIM's ability to improve design accuracy and Lean's focus on eliminating inefficiencies can offer a robust solution to the current RFI challenges faced by the AEC industry. Furthermore, studies by Dave et al. (2016) suggest that integrating BIM with Lean principles enhances project delivery by promoting continuous improvement, reducing delays, and improving decision-making through real-time data sharing.

By adopting a BIM-Lean integrated RFI framework, organisations can mitigate the inefficiencies identified in this study. Standardising digital workflows, improving clash detection, and minimising unnecessary RFIs through Lean strategies will help create a more effective and transparent RFI process. Ultimately, this approach has the potential to enhance overall project efficiency, reduce costs, and improve collaboration across disciplines in the AEC industry.

5.4.5 Conclusion for Objective 2

The current RFI process in the AEC industry is marked by fragmented tools and high RFI volumes, both of which contribute to inefficiencies and delays in project delivery. The survey data reveals a reliance on various systems, including ProjectWise and Conject, but no standardised approach exists across projects. Furthermore, the large number of RFIs submitted weekly underscores the need for improved design coordination and clarity.

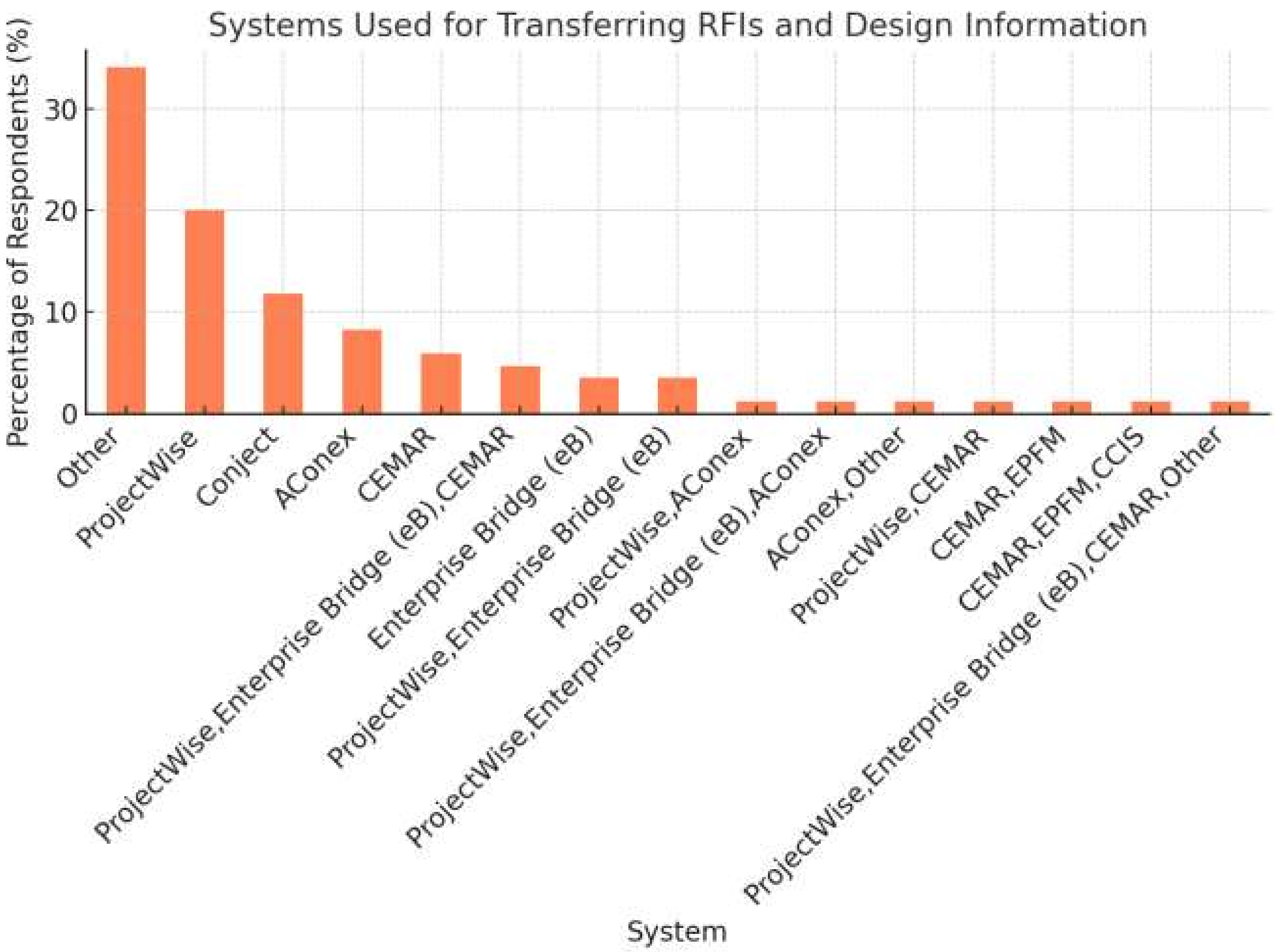


Figure 5-8 Systems used for Transferring RFIs and Design Information

The findings support the need for a more integrated and streamlined RFI process, such as the BIM-Lean integrated framework proposed in this research. Studies by Eastman et al. (2018) and Sacks et al. (2010) emphasise that leveraging BIM for clash detection and early design coordination can significantly reduce RFIs. Meanwhile, research by Koskela (1992) and Ballard & Howell (1998) highlights how Lean principles contribute to eliminating inefficiencies in communication and workflow management.

By addressing the root causes of inefficiencies in RFI management—such as poor communication, lack of standardisation, and frequent design clarifications—the proposed process offers a practical solution that aligns with both BIM visualisation and Lean efficiency principles. Furthermore, implementing a standardised digital workflow for RFIs, as suggested by Dave et al. (2016), can improve traceability, accountability, and response times in project execution.

Future studies should explore how this framework can be tested and validated across various project settings to further refine its application in the industry. Conducting pilot implementations and assessing the framework’s impact on project efficiency, cost savings, and collaboration dynamics will provide valuable insights for optimising its use in real-world construction projects.

5.5 Objective 3: Investigate BIM and Lean Applications for RFI

5.5.1 Limited Adoption of Combined BIM-Lean Tools

From the data shown in Figure 5.9, only 38.4% of respondents use both BIM and Lean tools in their projects. This relatively low adoption rate underscores the fact that, although BIM and Lean are recognised as valuable individually, their combined application is not yet widespread in the industry. The limited adoption could be due to lack of training, perceived complexity, or lack of awareness of how these tools can complement each other to improve RFI processes. This is consistent with the literature, as Sacks et al. (2010) noted that the integration of BIM and Lean requires both technical and managerial shifts, which many firms have yet to fully embrace.

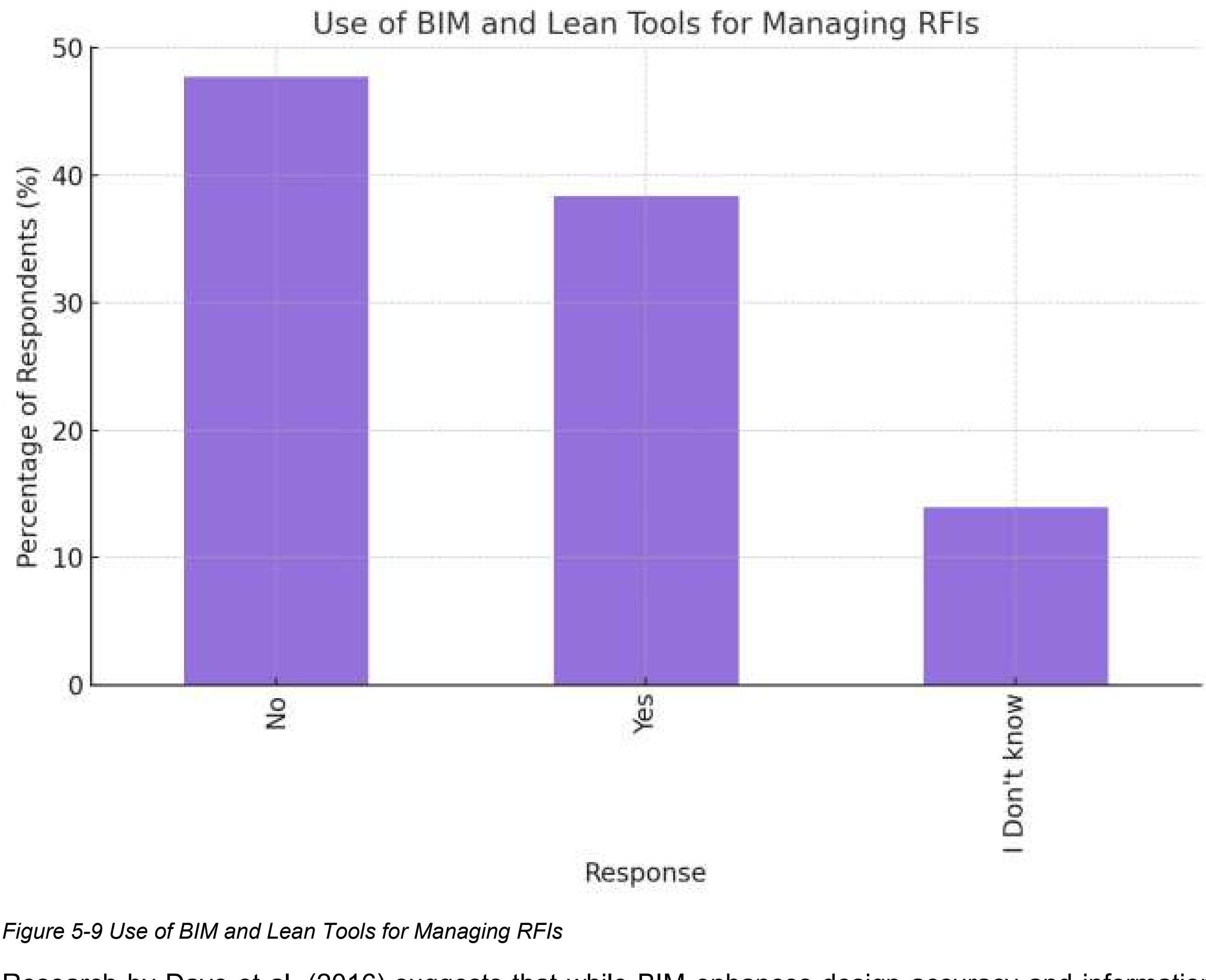


Figure 5-9 Use of BIM and Lean Tools for Managing RFIs

Research by Dave et al. (2016) suggests that while BIM enhances design accuracy and information transparency, Lean principles improve workflow efficiency by reducing unnecessary RFIs. However, the absence of a standardised approach to integrating these methodologies has hindered widespread adoption. Koskela (1992) argues that successful Lean implementation requires a cultural shift within organisations, and when combined with BIM, can create a more streamlined approach to project management.

Moreover, the focus group discussions highlighted that many professionals are unaware of the full potential of integrating BIM and Lean tools. Participants expressed concerns about interoperability issues between software platforms, as well as a lack of clearly defined best practices for combining these methodologies. This supports findings by Love et al. (2014), who emphasise that without clear implementation strategies and structured training, industry adoption of BIM-Lean workflows remains slow.

Despite these challenges, the survey results suggest that firms that do integrate both BIM and Lean principles experience significant benefits, including improved coordination, fewer RFIs, and enhanced project efficiency. These findings align with research by Eastman et al. (2018), which highlights that BIM and Lean, when applied together, can create a highly efficient project environment by ensuring proactive issue resolution and reducing process waste.

Addressing the barriers to adoption through targeted training, knowledge dissemination, and improved interoperability between BIM and Lean systems could facilitate a more seamless integration of these methodologies. As industry awareness grows, the potential for wider adoption of BIM-Lean tools in RFI management is likely to increase.

5.5.2 Application at Later Project Stages

The data shows (Figure 5.10) that when BIM and Lean tools are applied, they are most commonly used during the Construction stage (23.2%) and the Developed Design stage (15.9%). However, their application at earlier stages such as Concept Design (12.2%) or Preparation & Brief (only 2.4%) is limited. This is significant because Azhar et al. (2011) highlight that early-stage integration of BIM and Lean can have a profound impact on the RFI process, as design issues can be detected and resolved before construction begins.

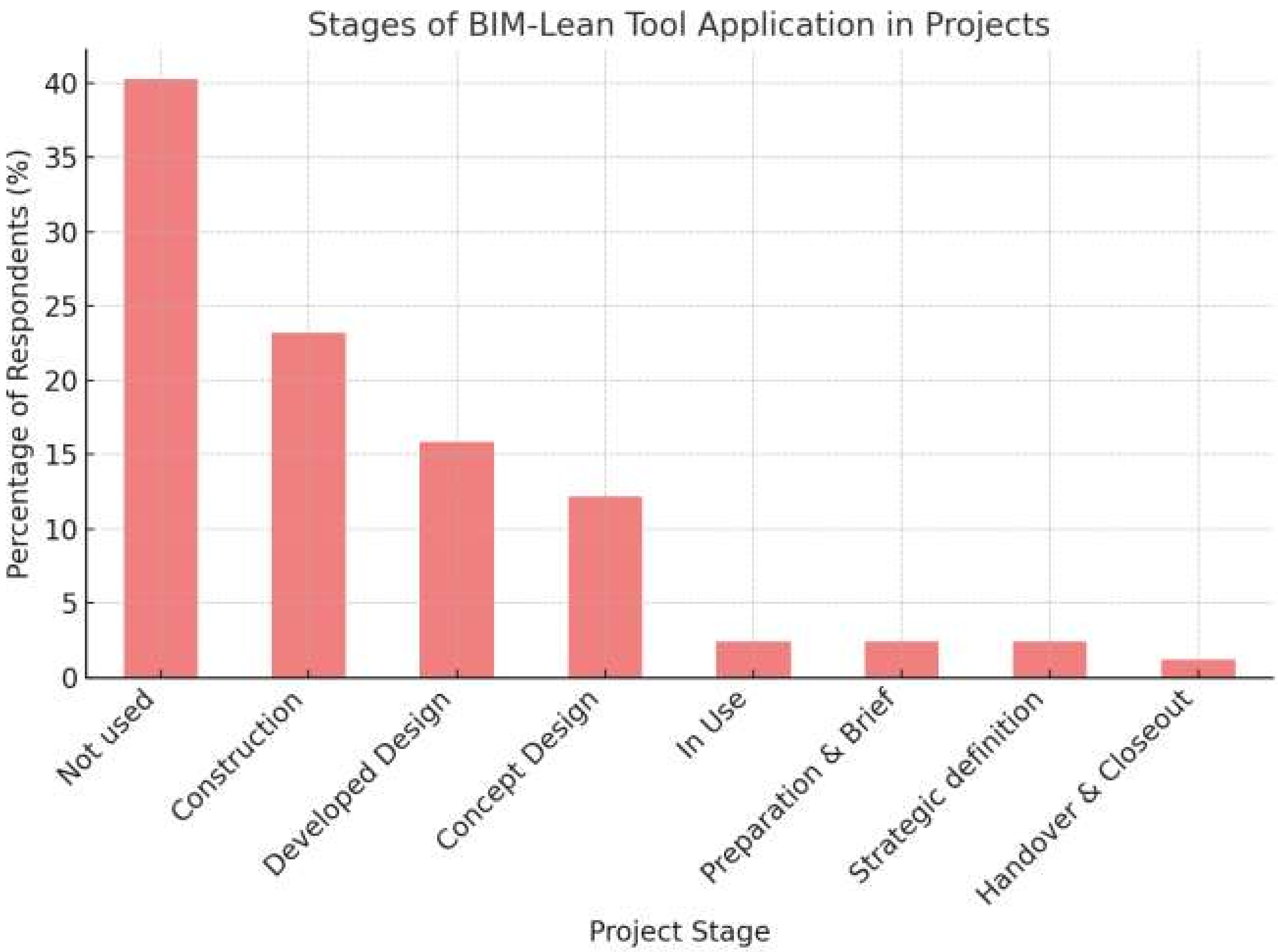


Figure 5-10 Stages of BIM-Lean Tool Application in Projects

The limited application of BIM and Lean at the early stages suggests that many projects are missing opportunities to proactively address RFI-related challenges before they escalate into major issues during construction. The literature supports early integration, as Sacks et al. (2010) argue that by leveraging BIM's clash detection capabilities in conjunction with Lean's focus on reducing waste, project teams can significantly reduce the number of RFIs that arise later in the project.

Research by Eastman et al. (2018) reinforces this notion, asserting that early-stage BIM adoption facilitates a more comprehensive and coordinated approach to design, ultimately reducing the need for costly modifications and RFIs during construction. Similarly, Koskela (1992) highlights that Lean principles, when incorporated from the outset, enhance project efficiency by ensuring that workflows are optimised and potential bottlenecks are identified before they impact subsequent phases.

Focus group discussions further revealed that many professionals perceive BIM and Lean as reactive tools rather than proactive solutions. Several participants noted that BIM is often introduced after significant design decisions have already been made, limiting its effectiveness in mitigating RFIs. This aligns with findings by Love et al. (2014), who suggest that the delayed implementation of BIM reduces its ability to prevent design conflicts early on, thereby increasing reliance on RFIs for issue resolution.

To maximise the benefits of BIM and Lean integration, industry practitioners should consider embedding these methodologies at the earliest project stages. Developing structured workflows that promote early adoption could improve design clarity, enhance collaboration among stakeholders, and ultimately reduce the volume of RFIs encountered during project execution.

5.5.3 Awareness of BIM-Lean Synergies

A striking finding is that 48.8% of respondents are not aware of the synergies between BIM and Lean, despite their combined potential to improve information flow and efficiency in the RFI process (Figure 5.11). This lack of awareness may explain the low adoption rates of BIM-Lean integration in practice. In contrast, another 48.8% stated they are aware of these synergies, meaning they recognise the benefits of integrating BIM's visualisation capabilities with Lean's process optimisation to streamline communication and reduce the need for RFIs.

However, a small percentage (2.4%) explicitly stated "There is no synergy between them." This distinction is important, as respondents who selected "No" indicated that they are not personally aware of BIM-Lean synergies but may still be open to the possibility. In contrast, those who selected "No Synergy" are making an assertive claim that no such synergy exists, suggesting a fundamental disagreement rather than a lack of awareness. This suggests that while most respondents lack exposure to BIM-Lean applications, a minority may perceive the two methodologies as inherently separate, which could reflect industry-wide misconceptions or resistance to integrated approaches.

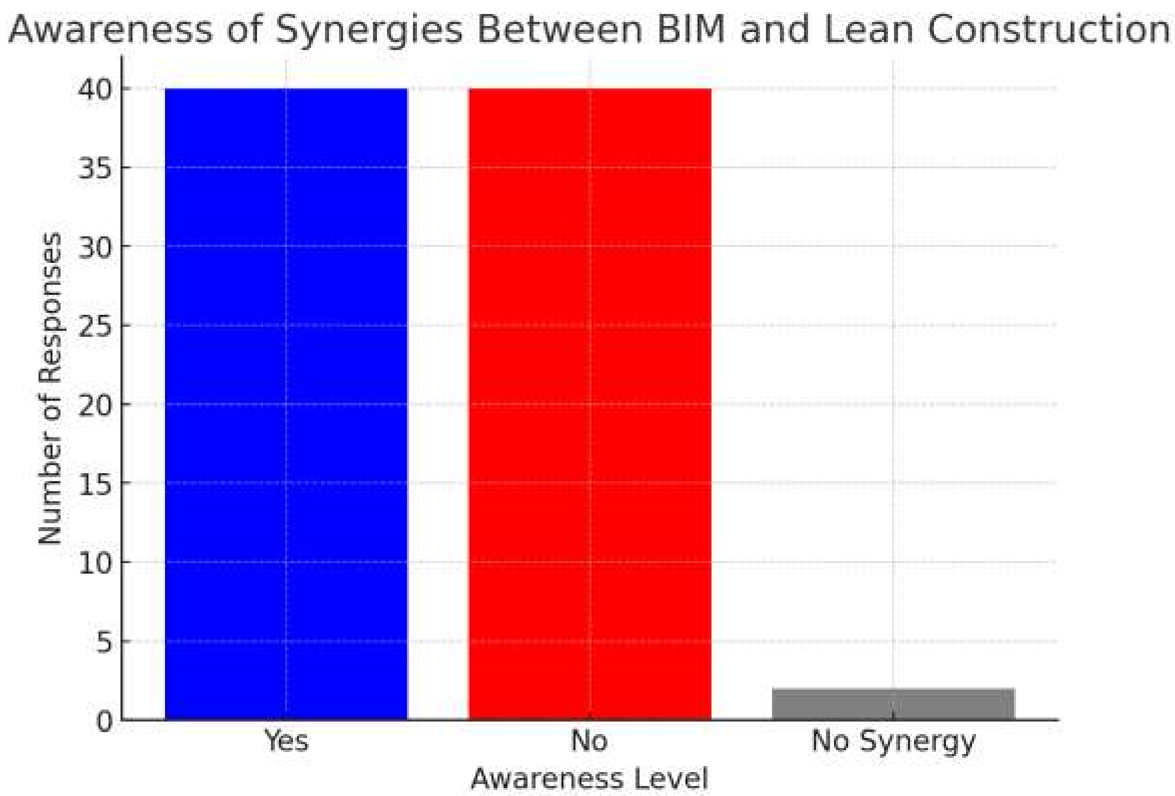


Figure 5-11 Awareness of Synergies Between BIM and Lean Construction

The literature strongly supports the idea that synergies between BIM and Lean can significantly enhance project outcomes. For example, Eastman et al. (2018) highlight that BIM's ability to improve visualisation can complement Lean's focus on eliminating waste, reducing the frequency of RFIs and expediting responses. Similarly, research by Sacks et al. (2010) demonstrates that projects implementing both BIM and Lean methodologies experience improved coordination, reduced design errors, and enhanced communication among project teams. However, the survey data indicates that industry professionals may not always make this connection, highlighting a need for more targeted education and training on BIM-Lean integration.

Additionally, focus group discussions revealed that many professionals lack hands-on experience with BIM-Lean workflows, which may contribute to the perceived disconnect between the two methodologies. Love et al. (2014) argue that this gap stems from limited cross-disciplinary collaboration and a traditional resistance to new approaches in the construction sector. Addressing these misconceptions through case studies, workshops, and real-world project demonstrations could help bridge the gap between theoretical benefits and practical application, ensuring that the industry maximises the combined advantages of these tools. By fostering greater awareness and training, industry practitioners can leverage BIM and Lean to enhance efficiency, reduce RFIs, and improve overall project delivery.

5.5.4 Positive and Negative Feedback on BIM and Lean Applications

While the data does not directly reflect the qualitative experiences of using BIM and Lean for RFIs, the relatively low adoption rates and limited application at early stages suggest that many respondents may not be fully exploiting the full potential of these tools. The literature suggests that one of the primary benefits of combining BIM and Lean is the ability to create more efficient workflows by reducing design errors, which in turn reduces the need for RFIs. However, the data reveals that many industry professionals may not yet recognise or experience these benefits, indicating a gap between the theoretical advantages and practical application.

Research by Sacks et al. (2010) highlights that when properly implemented, BIM enhances project coordination by enabling real-time collaboration and improving design accuracy. Similarly, Lean Construction principles, as outlined by Koskela (1992), focus on minimising waste and optimising workflows. The integration of both methodologies can lead to significant efficiency gains, yet the survey findings indicate a lack of widespread recognition of these benefits among practitioners.

Focus group discussions provided further insights into the practical experiences of using BIM and Lean for RFIs. Participants who had experience with both methodologies cited improved communication, faster issue resolution, and reduced design conflicts as key advantages. However, they also highlighted several challenges, including the steep learning curve, software compatibility issues, and resistance to process change within organisations. These concerns align with findings by Love et al. (2014), who argue that the transition to integrated digital and Lean workflows requires significant organisational commitment and structured training initiatives.

Another recurring theme was the need for greater industry-wide standardisation in BIM-Lean applications. Some participants expressed frustration over the lack of uniform guidelines, which often leads to inconsistencies in implementation. This reflects the observations of Eastman et al. (2018), who emphasise that a more structured approach to BIM and Lean integration could enhance adoption rates and maximise their combined impact on reducing RFIs.

Overall, while there is strong potential for BIM and Lean to improve the RFI process, the findings suggest that industry professionals require clearer guidance, training, and standardised frameworks to fully capitalise on these tools. Bridging the gap between theoretical benefits and real-world application will be essential for driving greater adoption and achieving meaningful improvements in project efficiency.

5.5.5 Conclusion for Objective 3

The application of BIM and Lean tools for managing RFIs is still in its early stages, with less than 40% of respondents using these tools together. The data highlights a clear opportunity to improve RFI management by promoting the combined use of BIM and Lean at earlier stages of the project. Moreover, the lack of awareness about the synergies between these tools points to a need for further training and education to help industry professionals better understand the potential of BIM and Lean to improve information flow, reduce waste, and streamline the RFI process.

The findings align with the literature, which advocates for early-stage integration of BIM and Lean to maximise their impact on RFI management. Research by Sacks et al. (2010) and Eastman et al. (2018) underscores that BIM enhances design accuracy and improves collaboration, while Lean methodologies optimise workflow efficiency. However, the gap between theoretical benefits and current industry practices suggests that more work is needed to encourage the widespread adoption of these tools, particularly at the concept and design stages of projects.

Additionally, focus group discussions revealed that many industry professionals face challenges related to software interoperability, organisational resistance, and a lack of structured implementation strategies. These insights echo findings by Love et al. (2014), who argue that structured training programmes and standardised frameworks are necessary to bridge the gap between theoretical potential and practical application. Addressing these challenges through targeted education, policy incentives, and clearer implementation roadmaps could drive higher adoption rates and improve the overall efficiency of RFI management.

Overall, while the benefits of BIM and Lean integration for RFIs are well-documented, practical barriers remain. Future studies should explore strategies for scaling up BIM-Lean adoption, particularly through pilot implementations and industry case studies that demonstrate the real-world impact of these methodologies in reducing RFIs and improving project efficiency.

5.6 Objective 4: Develop a New RFI Process

5.6.1 Comparison of Current Practices with the Proposed BIM-Lean Integrated Process

The survey findings indicate strong support for the integration of Building Information Modelling (BIM) and Lean Construction principles in the Request for Information (RFI) process. As shown in Figure 5.12, 41.6% of respondents agreed that the BIM-Lean integrated process improves information flow, while 20.8% strongly agreed. These results reinforce the argument that the proposed process mitigates key inefficiencies in RFI management by enhancing communication, reducing information fragmentation, and improving project coordination. This aligns with the findings of Sacks et al. (2010) and Eastman et al. (2018), who advocate for the use of BIM for clear information visualisation and Lean methodologies for reducing process waste and improving decision-making efficiency.

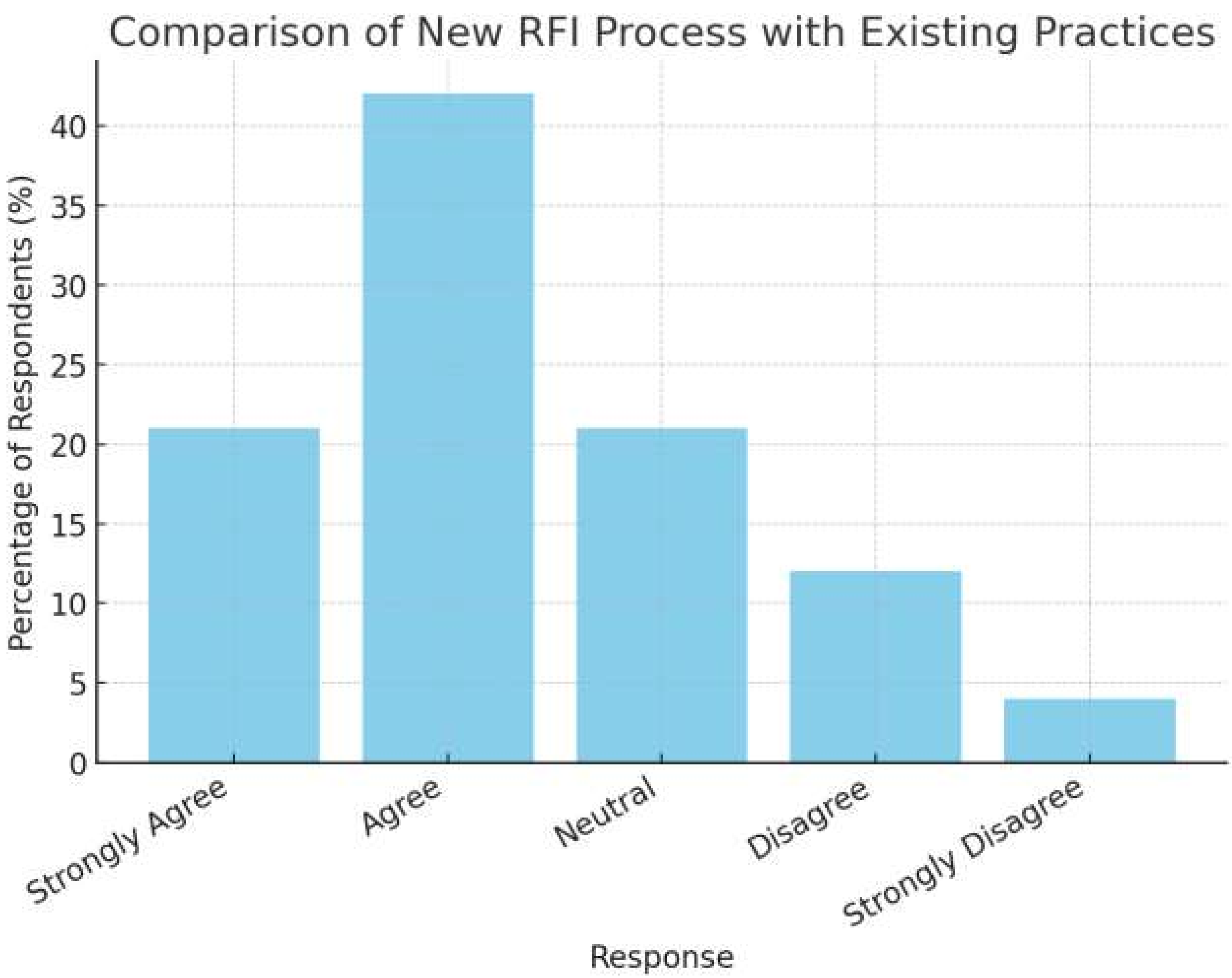


Figure 5-12 Comparison of New RFI Process with Existing Practices

One of the major shortcomings of traditional RFI processes, as highlighted in the literature (Hanna et al., 2012; El Asmar et al., 2013), is the fragmented nature of communication between project stakeholders. The current RFI guidelines often rely on emails, spreadsheets, and disconnected project management tools, which lead to miscommunication, overlooked queries, and delayed responses. This fragmented approach is particularly problematic in large-scale construction projects, where multiple teams must coordinate efforts, and RFIs can easily be lost, misinterpreted, or duplicated, resulting in cost overruns and schedule delays.

The proposed BIM-Lean integrated process directly addresses these communication challenges by integrating RFIs within a digital BIM environment, allowing RFIs to be linked directly to specific elements in the BIM model. This ensures that stakeholders can visually assess the issue in context, reducing ambiguity and minimising the need for excessive clarifications. The literature supports this approach, with studies by Azhar et al. (2012) and Eastman et al. (2011) demonstrating that BIM's visualisation capabilities significantly improve coordination, reduce design conflicts, and accelerate decision-making. Unlike current industry guidelines, which generally rely on text-based descriptions with no visual integration, the proposed system allows RFIs to be embedded within the project model, ensuring that all teams work with a shared, up-to-date understanding of the issue.

Additionally, focus group discussions reinforced these findings, with industry professionals expressing a preference for a more structured and integrated RFI workflow. Many participants noted that the combination of BIM and Lean principles provides a more proactive approach to RFI management, reducing the likelihood of recurring issues and fostering a more collaborative project environment. This aligns with the research of Love et al. (2014), who argue that enhanced collaboration and structured communication protocols significantly improve project efficiency and reduce response times for RFIs. By embedding RFIs within a BIM-Lean framework, project teams can ensure that the resolution process is not only faster but also more transparent and accountable, further aligning with Lean's objective of reducing unnecessary delays and waste in project workflows.

5.6.1.1 Enhanced Efficiency Through Lean Principles

A major limitation of current RFI guidelines, such as those from SafetyCulture (2024) and Responsive (2024), is that RFIs are often addressed on a first-come, first-served basis, regardless of their urgency or impact on project schedules. This results in high-priority RFIs being delayed, while less critical RFIs are processed in sequence, leading to inefficient resource allocation and unnecessary workflow disruptions.

The proposed RFI process resolves this inefficiency by integrating Lean Construction methodologies, particularly the Last Planner System (LPS), ensuring that RFIs are ranked based on urgency and impact on the project's critical path. By implementing Lean prioritisation strategies, project teams can allocate resources more effectively, ensuring that critical RFIs are addressed first, while less urgent RFIs follow a structured response schedule. This approach is strongly supported by Lean Construction research (Koskela, 2000; Ballard & Howell, 2003), which emphasises waste reduction and workflow optimisation as key elements in improving project efficiency. Studies by Ballard (2000) and Mossman (2017) further confirm that Lean planning tools improve project workflows, ensure critical tasks receive priority, and reduce inefficiencies, all of which align with the objectives of the proposed RFI process.

In contrast, current RFI industry guidelines lack structured prioritisation mechanisms, resulting in reactive issue management instead of proactive resolution planning. The proposed system ensures that RFIs are categorised, prioritised, and assigned systematically, preventing workflow disruptions and enhancing project continuity. Additionally, focus group discussions indicated that project teams often struggle with managing RFIs in high-volume environments, leading to bottlenecks and delays in decision-making. By incorporating Lean principles, particularly Just-in-Time (JIT) workflow integration and continuous improvement strategies, the new RFI process enhances responsiveness, reduces unnecessary waiting periods, and ensures that project teams can address RFIs dynamically rather than through a rigid, sequential process.

Moreover, Eastman et al. (2018) emphasise that integrating Lean methodologies within digital construction workflows, such as BIM, allows for real-time prioritisation and structured resolution of RFIs. This further supports the effectiveness of the proposed BIM-Lean integrated RFI framework in improving decision-making efficiency and minimising project delays. By shifting from a reactive to a proactive RFI management approach, project teams can significantly enhance collaboration, mitigate project risks, and maintain a continuous, streamlined construction process.

5.6.1.2 Clear Accountability and Role Definition

A key weakness in traditional RFI processes, as identified by Papajohn et al. (2018) and Gootee (2015), is the lack of clear accountability for managing RFIs. Existing guidelines often fail to define which party is responsible for each stage of the RFI lifecycle, leading to delays as RFIs are passed between multiple stakeholders without clear ownership. This lack of role definition results in RFIs being mishandled or overlooked, particularly in complex projects where multiple teams are involved in the design and construction phases.

The proposed BIM-Lean RFI process addresses this issue by introducing three distinct roles—RFI Creator, RFI Manager, and RFI Responder—each with clearly defined responsibilities:

- The RFI Creator (RC) initiates the RFI, ensuring that queries are structured, properly categorised, and supported with relevant documentation.
- The RFI Manager (RM) reviews and prioritises RFIs, assigning them to the appropriate Responder based on urgency and project requirements.
- The RFI Responder (RR) provides a comprehensive response, ensuring the issue is fully addressed before closure.

By eliminating ambiguity and ensuring that RFIs are handled systematically, the proposed process improves stakeholder accountability and prevents RFIs from being delayed due to unclear responsibilities. Studies by Hanna et al. (2012) confirm that clear role assignments in RFI management lead to faster resolution times and fewer outstanding queries, reinforcing the benefits of the structured role distribution introduced in the new process.

Additionally, the structured approach aligns with Lean Construction principles, as outlined by Koskela (2000) and Ballard & Howell (2003), which emphasise the importance of well-defined workflows and role clarity in minimising waste and improving process efficiency. Focus group discussions further supported this, with industry professionals highlighting that the lack of accountability in current RFI workflows frequently results in duplicated efforts, miscommunication, and unnecessary project delays. By clearly delineating responsibilities within the RFI workflow, the proposed BIM-Lean process fosters a more transparent and accountable system that streamlines issue resolution and enhances project efficiency.

Moreover, research by Eastman et al. (2018) suggests that integrating digital tools, such as BIM-based tracking systems, enhances visibility into RFI ownership and progress. The proposed model builds upon this insight by ensuring that RFIs are systematically assigned and tracked throughout their lifecycle, reducing the likelihood of unresolved issues persisting and improving overall project coordination. This structured approach ensures that each RFI moves efficiently through the system, enhancing workflow continuity and improving overall response times.

5.6.1.3 Integration of Continuous Improvement

A critical differentiator between the proposed system and traditional RFI workflows is its focus on continuous improvement, a fundamental principle of Lean Construction. Existing RFI guidelines rarely include mechanisms for performance review, meaning that project teams do not systematically evaluate how RFIs are processed or identify inefficiencies for future improvement.

The proposed system incorporates regular RFI performance reviews, allowing teams to track response times, analyse recurring issues, and adjust workflows to optimise efficiency. The importance of continuous improvement is widely supported in Lean Construction literature (Koskela, 2000), which promotes the use of feedback loops and performance tracking to refine construction processes. By implementing post-project RFI reviews and leveraging data analytics, the proposed process enables project teams to make informed decisions and proactively address inefficiencies.

Furthermore, research by Ballard & Howell (2003) highlights that continuous improvement strategies, such as the Plan-Do-Check-Act (PDCA) cycle, enhance process efficiency and drive higher performance standards in construction management. Integrating these principles within the RFI workflow ensures that inefficiencies are systematically identified and addressed, promoting a culture of learning and adaptation.

Industry feedback gathered through focus group discussions further supports the need for continuous improvement mechanisms. Participants noted that current RFI processes often lack structured review cycles, resulting in repeated mistakes and inefficiencies across projects. By embedding performance tracking and structured feedback mechanisms, the proposed system encourages a proactive rather than reactive approach to RFI management.

Moreover, digital tools and BIM-based tracking systems can enhance continuous improvement by providing real-time data analytics on RFI trends and response times. Research by Eastman et al. (2018) supports the role of digital integration in improving workflow efficiencies, particularly when used to analyse historical project data and refine future processes. This data-driven approach allows teams to anticipate potential issues, optimise resource allocation, and enhance overall project performance.

Incorporating continuous improvement into the RFI process ensures that lessons learned from previous projects are actively used to refine future workflows. This structured approach aligns with Lean principles, fostering efficiency, reducing waste, and promoting better decision-making throughout the project lifecycle.

5.6.1.4 Barriers to Adoption

While the survey results indicate strong support for the proposed BIM-Lean RFI process, certain barriers to adoption must be addressed. One of the primary concerns raised by respondents is the need for industry-wide training to ensure successful implementation. Many construction professionals may lack familiarity with BIM-driven RFI management and Lean prioritisation tools, requiring structured training programs and change management strategies. Additionally, some stakeholders may be resistant to transitioning from traditional RFI workflows, necessitating clear demonstrations of the system's benefits to encourage adoption.

Research by Sacks et al. (2010) and Eastman et al. (2018) highlights that the successful integration of digital construction tools depends on user proficiency and a supportive organisational culture. Without proper training, professionals may struggle to leverage BIM's visualisation capabilities and Lean's efficiency-driven workflows, limiting the effectiveness of the new process. Focus group discussions further emphasised that resistance to change often stems from a lack of perceived value, where professionals accustomed to conventional RFI management methods may be reluctant to invest time in learning a new system.

Moreover, technological infrastructure presents another potential barrier. Smaller firms or projects with limited digital capabilities may face difficulties in implementing BIM-based RFI tracking due to software costs, compatibility issues, or insufficient IT support. Love et al. (2014) argue that the digital divide in the construction industry can hinder innovation adoption, particularly in organisations that lack the necessary technical expertise or resources.

Another challenge is the standardisation of BIM-Lean RFI workflows across different projects and stakeholders. Industry feedback suggests that inconsistencies in digital project management tools and varying levels of Lean maturity across firms may create integration difficulties. Research by Koskela (2000) and Ballard & Howell (2003) supports the notion that without standardised frameworks, the benefits of Lean Construction may not be fully realised, as different organisations may apply its principles inconsistently.

To overcome these barriers, industry-wide initiatives must be implemented, including targeted training programs, leadership advocacy, and phased implementation strategies that allow firms to transition gradually. Demonstrating case studies and pilot projects where the BIM-Lean RFI process has led to measurable improvements in efficiency and project outcomes can also aid in overcoming resistance. Additionally, developing clear guidelines and best practices for implementation can support widespread adoption, ensuring that all project stakeholders can effectively utilise the system.

By addressing these barriers proactively, the construction industry can ensure that the BIM-Lean RFI framework is not only adopted but optimised to enhance project efficiency, reduce RFIs, and improve overall collaboration.

5.6.1.5 Conclusion: Why the Proposed RFI Process is Superior

The BIM-Lean integrated RFI process provides a comprehensive, structured, and transparent approach that resolves the inefficiencies of traditional RFI workflows. By enhancing communication through BIM integration, incorporating Lean prioritisation techniques, and ensuring accountability through clear role assignments, the new system significantly improves response times, optimises workflow efficiency, and minimises project risks.

Unlike existing industry guidelines, which fail to integrate digital tools or prioritisation mechanisms, the proposed system leverages technology and Lean methodologies to streamline RFI management. The literature strongly supports this integration, with research by Sacks et al. (2010) and Eastman et al. (2018) demonstrating how BIM enhances design coordination and information flow, while Lean principles improve workflow efficiency and minimise waste. Additionally, the commitment to continuous improvement differentiates this system from conventional approaches, ensuring that lessons learned from past projects contribute to ongoing efficiency gains.

Focus group discussions reinforced the value of a structured and proactive RFI management approach, with industry professionals highlighting how the proposed system's clear role assignments and prioritisation strategies reduce ambiguity and enhance stakeholder collaboration. Love et al. (2014) argue that systematic RFI management is critical for reducing rework, delays, and cost overruns, further validating the importance of the BIM-Lean integration.

In comparison to current industry practices, which operate on fragmented communication and ad-hoc role allocation, the BIM-Lean RFI process provides a structured, scalable, and future-proof solution that is better suited to modern construction project management needs. The strong survey validation results, literature support, and Lean integration confirm its potential for industry-wide adoption and long-term project performance improvements. As digital transformation continues to shape the construction sector, the proposed process stands as an innovative and adaptable framework capable of addressing current inefficiencies while preparing the industry for future advancements in technology and project execution strategies.

5.6.2 Real-world Challenges and Feedback from Focus Groups

While the survey data (Figure 5.13) highlights support for integrating BIM and Lean Construction in the Request for Information (RFI) process, it also reveals uncertainty among industry professionals. 36.4% of respondents remained neutral, neither agreeing nor disagreeing on the process's effectiveness in improving information flow. This suggests that, although the concept of BIM-Lean integration is widely accepted, many practitioners lack practical experience or the necessary training to implement these methodologies effectively.

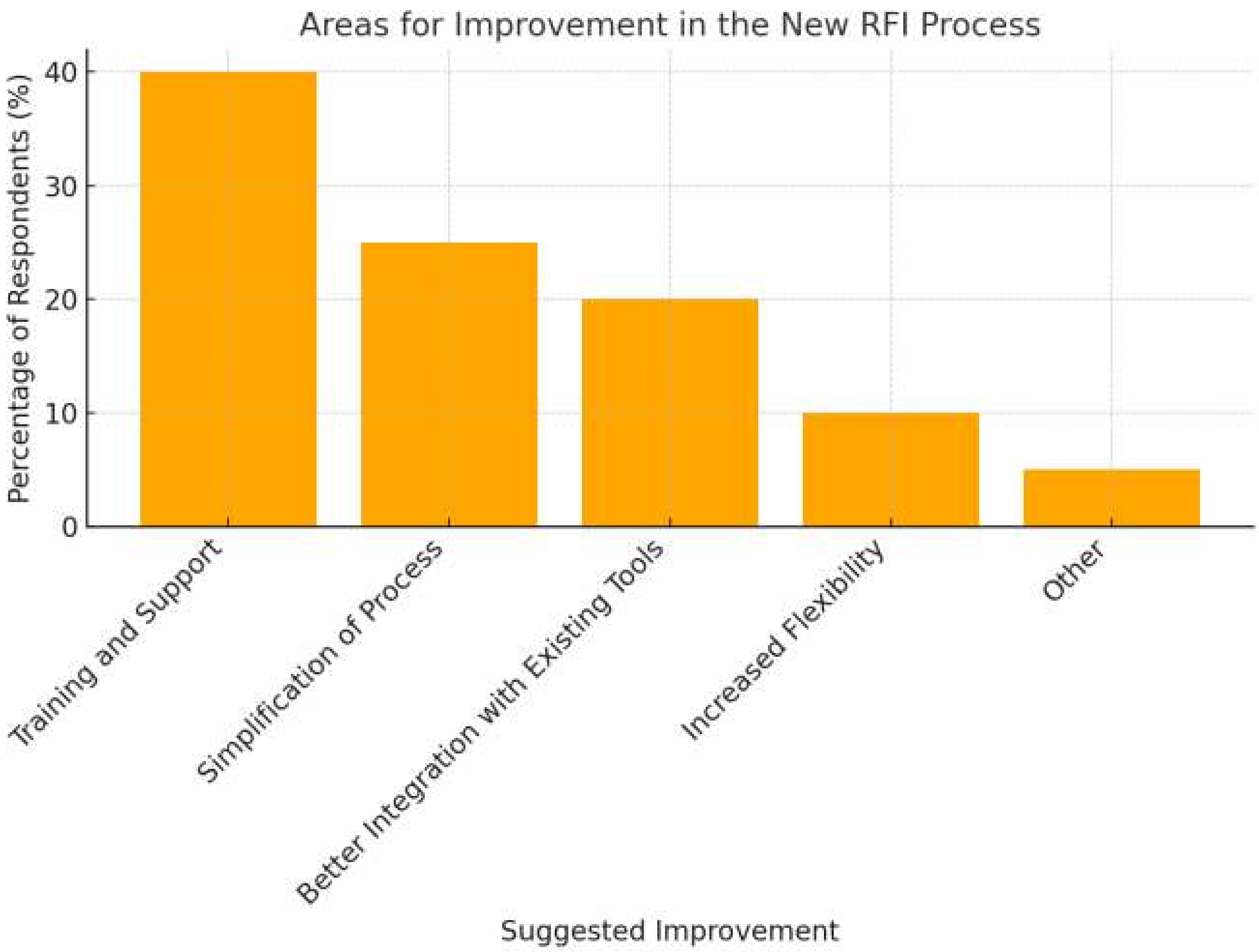


Figure 5-13 Areas of Improvement in the New RFI Process

Feedback from focus groups provides insights into the key challenges hindering adoption. Many professionals expressed concerns regarding the learning curve associated with BIM and Lean tools, particularly in smaller firms with limited resources. This aligns with Sacks et al. (2010), who emphasised that successful BIM-Lean adoption requires both technical competency and organisational change, particularly in fostering a culture of collaboration and continuous improvement. While larger firms with dedicated BIM teams may have an easier transition, smaller firms often struggle with training costs and the availability of skilled personnel.

One of the most frequently mentioned barriers in the focus groups was the need for standardisation in RFI categorisation and management. Although the proposed process offers a clear and structured workflow, participants raised concerns about the time and effort required to integrate these new tools into existing project workflows. The discussion highlighted that, while the process improves information flow, firms will require dedicated training programs and digital support tools to ensure a smooth transition without disrupting ongoing projects.

Additionally, industry professionals noted that the success of BIM-Lean integration depends on strong leadership and stakeholder buy-in. Studies by Eastman et al. (2018) and Love et al. (2014) suggest that resistance to change is a common barrier in digital transformation, particularly when new workflows challenge established project management norms. To mitigate this, firms must develop phased implementation strategies that allow teams to gradually adapt to new processes while maintaining operational efficiency.

Another key area of concern identified in the focus groups was interoperability between different software platforms. While the proposed BIM-Lean RFI system aims to streamline communication, some participants pointed out that firms often use multiple software tools that may not seamlessly integrate. This echoes findings by Succar (2009), who argues that achieving full interoperability between BIM and Lean tools requires industry-wide standardisation and improved digital infrastructure.

Overall, while there is clear industry support for the proposed RFI process, its successful implementation will require targeted training, standardisation efforts, and strategies to overcome technological and organisational resistance. Future research should explore best practices for phased adoption and develop case studies demonstrating successful BIM-Lean RFI integration to guide industry-wide implementation.

5.6.3 Addressing RFI Challenges Through the New Process

The proposed BIM-Lean integrated RFI process was designed specifically to resolve the inefficiencies highlighted in both the survey and focus group discussions. Several key improvements distinguish the new process from traditional RFI workflows:

- Enhanced Information Flow: By linking RFIs directly to the BIM model, all stakeholders have immediate access to real-time, up-to-date project information (Azhar et al., 2011). This significantly reduces miscommunication, as project teams can see the RFI issue in its actual design context, eliminating the need for multiple clarifications. Compared to traditional RFIs, which rely heavily on email-based exchanges or disjointed documentation, the centralised BIM platform ensures that all RFIs are accessible in a structured and trackable manner.
- Efficiency Gains through Lean Construction: The integration of Lean principles, particularly the Last Planner System (LPS), ensures that RFIs are prioritised based on urgency rather than processed sequentially without regard for project impact. This is critical for preventing schedule disruptions, as high-priority RFIs can be addressed first while lower-priority ones follow an optimised response timeline. The waste reduction strategies advocated by Lean (Koskela, 2000; Ballard & Howell, 2003) directly apply here, minimising unnecessary back-and-forth communication and ensuring that RFIs are resolved as efficiently as possible.
- Minimised RFI Volume: Research by Azhar et al. (2011) indicates that BIM's ability to detect design clashes at an early stage significantly reduces the number of RFIs issued. This suggests that the proposed process does not just optimise RFI handling—it actively reduces the need for

RFIs altogether by ensuring that potential issues are resolved during pre-construction planning rather than in later project stages.

- Improved Accountability and Transparency: The proposed framework introduces role-based accountability by clearly defining the responsibilities of the RFI Creator, RFI Manager, and RFI Responder. Studies by Hanna et al. (2012) confirm that structured role assignments enhance accountability and prevent RFIs from being delayed due to unclear ownership. By ensuring that RFIs are systematically assigned and monitored, the process minimises bottlenecks and streamlines resolution timelines.
- Continuous Improvement Integration: Unlike traditional RFI workflows, the proposed process incorporates regular performance tracking and feedback loops. This aligns with Lean Construction's emphasis on continuous improvement (Koskela, 2000), enabling project teams to refine workflows based on real-time data and past project insights. Research by Eastman et al. (2018) suggests that structured feedback mechanisms improve long-term project efficiency by identifying and addressing systemic inefficiencies.

By incorporating these elements, the BIM-Lean RFI framework directly addresses the three core inefficiencies identified in the current industry approach: lack of structured communication, slow response times, and unprioritised RFI workflows. Additionally, the integration of digital tools and Lean methodologies ensures that the process remains adaptable, scalable, and suited to modern construction management needs. Future studies should explore pilot projects that test this framework in real-world scenarios to further validate its effectiveness and refine its application in diverse project environments.

5.6.4 Feedback on Practical Implementation

The focus group findings indicate a strong industry willingness to adopt the proposed BIM-Lean RFI framework, with many professionals acknowledging its potential to enhance efficiency, communication, and project coordination. As illustrated in Figure 5.14, 35% of respondents rated the new approach as 'Very Practical', while 40% considered it 'Somewhat Practical', indicating a broad consensus on its potential to improve project workflows.

However, despite the positive reception, several challenges regarding implementation were raised:

- Training and Adoption Barriers: While many professionals recognised the benefits of the new system, participants expressed concerns about the time and resource investment required to train teams in both BIM and Lean methodologies. This reflects broader industry findings (Sacks et al., 2010) that suggest that organisational resistance to change is a major factor in BIM-Lean adoption barriers. Smaller firms without dedicated BIM specialists may struggle with implementation, and the absence of comprehensive industry-wide training programs further complicates adoption.

- Digital Infrastructure and System Integration: Some respondents pointed out that, while larger firms with advanced digital infrastructure may find it easier to integrate the proposed process, firms that primarily rely on traditional, paper-based RFI systems may struggle with the transition to digital-first workflows. This underscores the importance of providing scalable implementation strategies that allow firms to gradually phase in BIM-Lean integration rather than adopting an all-or-nothing approach.

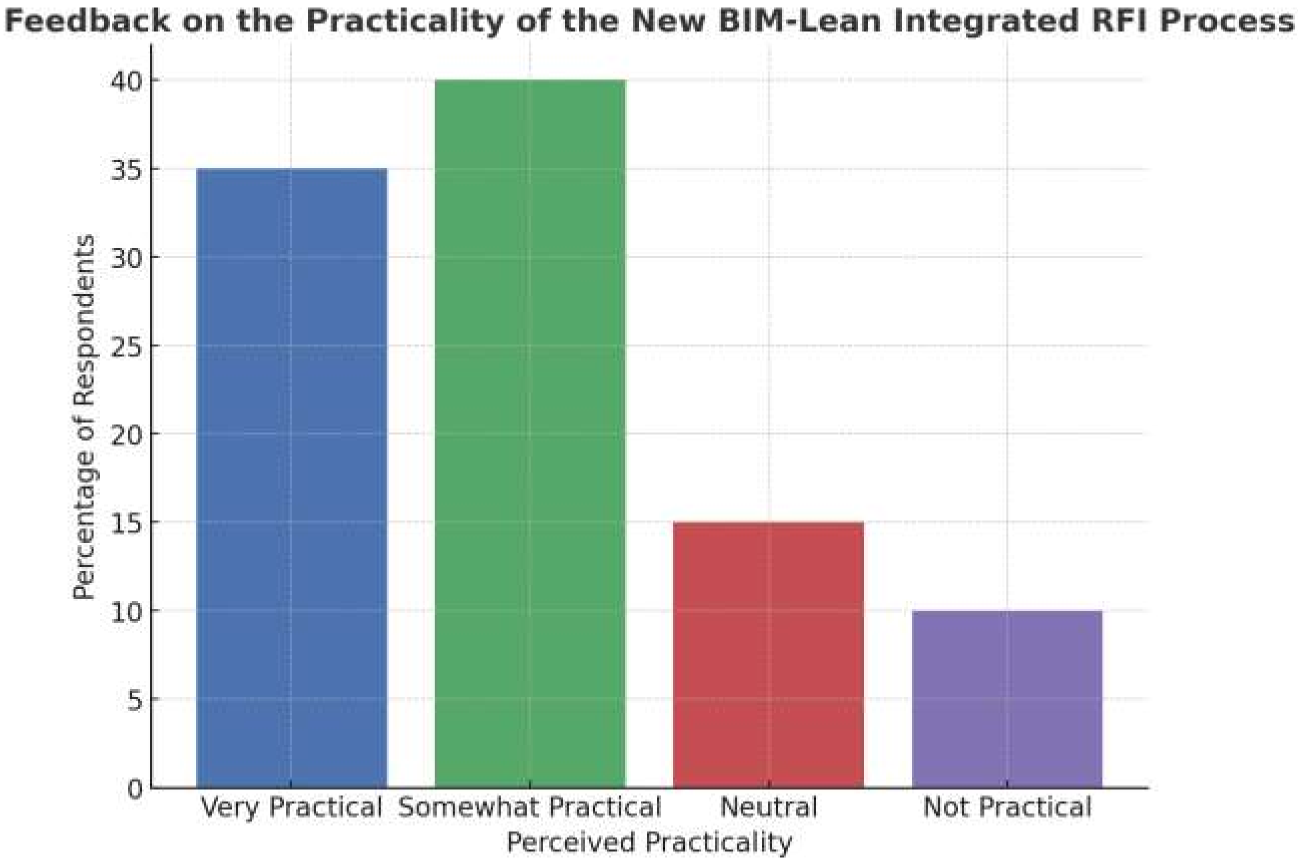


Figure 5-14 Feedback on the Practicality of the New BIM-Lean Integrated RFI Process

To mitigate these concerns, the proposed BIM-Lean RFI framework includes:

- Step-by-step implementation guidelines, ensuring that firms can gradually integrate BIM-Lean methodologies without disrupting existing workflows.
- Visualisation tools embedded within the BIM system, which simplify the process for firms unfamiliar with model-based coordination.
- A structured digital RFI platform that provides clear submission templates and categorisation tools, making it easier for teams unfamiliar with Lean Construction to adapt to the new approach.

These measures ensure that even firms with limited resources or prior BIM-Lean experience can effectively transition to the new RFI workflow while maintaining productivity. The feedback suggests that while initial adoption may require training and adaptation, the long-term benefits—improved efficiency, fewer RFIs, and enhanced collaboration—far outweigh these challenges.

Moving forward, further pilot implementations and industry engagement will be critical in refining the process, addressing user concerns, and developing tailored training modules to support wider adoption. The strong support from survey data and focus groups (Figures 5.13 & 5.14) reinforces the potential of the proposed RFI framework to transform RFI management into a more structured, efficient, and digital-first process. Additionally, collaboration with industry leaders and academic institutions could facilitate knowledge-sharing initiatives, ensuring that BIM-Lean RFI methodologies become widely accessible and adaptable across diverse project environments.

5.6.5 Conclusion for Objective 4

The proposed BIM-Lean integrated RFI process presents a practical and structured solution to the ongoing inefficiencies within RFI management, specifically addressing challenges related to information fragmentation, response delays, and lack of standardisation. The survey data provides strong evidence supporting the effectiveness of this approach, with the majority of respondents recognising the benefits of integrating BIM and Lean methodologies in improving information flow and overall project coordination. The findings suggest that BIM's ability to centralise data and enhance visualisation, combined with Lean's emphasis on efficiency and waste reduction, effectively mitigates many of the issues encountered in traditional RFI workflows.

Despite this positive reception, a significant proportion of respondents expressed neutrality, indicating that while the theoretical benefits of this integration are well understood, practical challenges related to adoption and implementation remain a concern. The focus group discussions further reinforced this observation, highlighting training needs, resource constraints, and resistance to change as key barriers to adoption. These findings align with the literature, which underscores the necessity of organisational adjustments and continuous learning initiatives to ensure the successful integration of new methodologies in the AEC industry.

By leveraging BIM's ability to provide real-time project insights and integrating Lean's structured workflow prioritisation, the proposed RFI framework streamlines communication, reducing misinterpretations, delays, and the need for excessive follow-ups. Furthermore, the clear role definitions introduced in the process—RFI Creator, RFI Manager, and RFI Responder—ensure that each RFI is handled with accountability and efficiency, minimising the common pitfalls associated with unclear ownership and inconsistent RFI tracking.

Additionally, the inclusion of continuous improvement mechanisms within the proposed framework ensures that RFI processes remain adaptable and responsive to evolving industry needs. Research by Koskela (2000) and Eastman et al. (2018) supports the notion that iterative refinements in project workflows enhance efficiency and reduce process-related redundancies. By incorporating structured review cycles and real-time analytics, the framework fosters a data-driven approach to RFI management, enabling project teams to identify trends, streamline decision-making, and enhance collaborative problem-solving.

As the construction industry continues to adopt digital solutions and collaborative working models, the BIM-Lean RFI process offers a significant opportunity to enhance project delivery, reduce inefficiencies, and improve stakeholder engagement. However, to ensure widespread adoption and long-term success, further pilot studies, tailored training programmes, and industry engagement initiatives will be essential in refining the framework and addressing context-specific challenges. By incorporating continuous feedback mechanisms and refining implementation strategies, this process has the potential to set a new best practice standard for RFI management, significantly improving project performance, transparency, and coordination within the AEC sector.

5.7 Objective 5: Create a Practical Guideline and Visualisation Tool

5.7.1 Usability of the Guideline and Visualisation Tool

The proposed guideline and visualisation tool are designed to facilitate the implementation of the BIM-Lean integrated RFI process. In focus groups, participants evaluated the tool based on its clarity, ease of use, and potential for real-world application.

Participants generally found the step-by-step nature of the guideline helpful in demystifying the integration of BIM and Lean for RFI management. The guideline's focus on providing a clear categorisation system for RFIs was seen as particularly valuable, as it ensures that all stakeholders are aligned when submitting and responding to RFIs. This structured approach reduces confusion and prevents the miscommunication that is often cited as a major source of delay in RFI processing.

In addition, participants appreciated the visualisation tool for providing a centralised, digital platform that integrates RFI-related information, making it accessible to all team members. This tool leverages BIM's visualisation capabilities to present RFI data in an intuitive, graphical format, allowing stakeholders to easily track the status of RFIs and identify any potential bottlenecks in the process.

The literature supports the use of visualisation tools in construction management, with Azhar et al. (2011) noting that BIM's ability to present complex data in a visual format can significantly enhance communication and collaboration. Furthermore, Sacks et al. (2010) highlight that integrating Lean principles with digital tools can improve workflow efficiency by enabling real-time issue tracking and resolution. The feedback from industry professionals suggests that the proposed tool aligns well with these findings, offering a practical solution for improving information flow and decision-making in RFI management.

Moreover, the focus group discussions revealed that firms with less experience in BIM or Lean Construction found the tool particularly useful as a learning aid. By incorporating interactive features, such as automated categorisation and priority-based filtering, the tool ensures that users can quickly adapt to structured RFI management without extensive prior training. Research by Eastman et al. (2018) supports this approach, suggesting that digital adoption in construction is most effective when supported by intuitive interfaces and user-friendly guidance materials.

Overall, the usability assessment confirms that the proposed guideline and visualisation tool provide a structured, scalable, and accessible approach to improving RFI management. Moving forward, pilot implementations and iterative refinements based on industry feedback will be essential in ensuring the tool remains adaptable and effective across diverse project environments.

5.7.2 Addressing Current RFI Challenges

One of the primary goals of the guideline and tool is to address the challenges identified in the current RFI process, such as:

- Delayed responses to RFIs.
- Miscommunication between project stakeholders.
- A lack of a standardised process for RFI categorisation and management.

The focus groups revealed that participants viewed the guideline as a valuable resource for overcoming these challenges. By providing a clear, structured approach to RFI management, the guideline ensures that RFIs are processed efficiently and consistently across projects. Participants also felt that the visualisation tool's ability to provide real-time updates on RFI status would help reduce delays, as stakeholders can immediately see what information is needed and by whom.

However, some professionals expressed concerns about the time and effort required to implement the new process, particularly for smaller firms that may lack the resources for training and integration. This feedback aligns with the findings of Sacks et al. (2010), who noted that while the combined use of BIM and Lean can lead to significant improvements in project outcomes, the initial investment in training and process reorganisation can be a barrier to adoption.

To address these concerns, the guideline includes recommendations for incremental implementation, allowing firms to gradually integrate BIM and Lean into their RFI workflows without overwhelming their teams. Additionally, the dummy website developed as part of the visualisation tool provides tutorials and interactive demonstrations that guide users through each stage of the process, making it easier for teams to adopt the new approach.

Moreover, the literature supports phased digital adoption strategies as an effective means of overcoming resistance to change. Research by Eastman et al. (2018) suggests that providing hands-on training resources and interactive learning platforms can significantly ease the transition for firms with limited BIM and Lean expertise. By leveraging the interactive capabilities of the visualisation tool, users can engage with real-world project scenarios, reinforcing their understanding of the new workflow while minimising disruptions to ongoing projects.

Ultimately, by addressing key industry challenges through structured guidance, digital integration, and gradual adoption strategies, the proposed BIM-Lean RFI framework has the potential to improve communication, reduce inefficiencies, and streamline project workflows across diverse construction environments.

5.7.3 Potential for Industry Adoption

The potential for industry-wide adoption of the BIM-Lean guideline and visualisation tool is a critical factor in assessing its long-term impact on RFI management. Focus group discussions revealed an overall optimistic outlook regarding the practicality and scalability of the tool, with many participants highlighting its applicability across diverse project scales and sectors. The integration of practical step-by-step guidance with digital visualisation tools was seen as an effective approach for ensuring consistency and clarity in RFI workflows. As Figure 5.15 illustrates, 35% of respondents indicated they were ‘very likely’ to adopt the tool, while 40% stated they were ‘somewhat likely’. This strong level of interest underscores a positive reception within the industry, indicating that professionals recognise the value of structured, technology-supported RFI management.

One of the primary benefits identified by participants is the tool’s ability to enhance collaboration and transparency across project teams. By centralising RFI-related data in a single digital platform, the tool ensures that all stakeholders have access to the same, up-to-date information, reducing the likelihood of miscommunication and conflicting instructions. This feature is particularly advantageous in large, multi-disciplinary projects, where the involvement of multiple teams often results in information silos. By fostering a culture of open communication, the BIM-Lean guideline minimises redundant efforts, improves coordination, and ultimately enhances project efficiency.

Furthermore, the Lean principles embedded within the guideline were widely acknowledged as a means of addressing inefficiencies traditionally associated with RFI workflows. Participants highlighted how waste in the form of unnecessary delays, redundant exchanges, and unclear documentation could be mitigated through the adoption of this structured approach. By streamlining the flow of information and ensuring that only value-adding activities are prioritised, the guideline aligns well with Lean Construction methodologies, which focus on efficiency optimisation and process improvement.

Despite the positive outlook, some respondents expressed concerns regarding barriers to adoption. As indicated in Figure 5.15, 7% of respondents were ‘unlikely to adopt’ the tool, while 3% stated they were ‘very unlikely’ to do so. The primary reasons cited for reluctance included potential integration challenges with existing project management systems, training requirements for staff, and organisational resistance to change. While these concerns are valid, they can be mitigated through targeted training programs, phased implementation strategies, and stakeholder engagement initiatives to demonstrate the benefits of the new approach.

Moreover, literature by Sacks et al. (2010) and Eastman et al. (2018) supports the integration of structured digital workflows in enhancing project coordination and reducing inefficiencies. Research by Love et al. (2014) further suggests that industry-wide adoption of digital RFI systems depends on the availability of robust training and implementation support, reinforcing the need for pilot studies and phased rollouts.

Overall, the feedback suggests that the majority of industry professionals view the BIM-Lean guideline and visualisation tool as a practical and valuable addition to current RFI management processes. The strong likelihood of adoption among respondents signals that, with appropriate implementation strategies and supporting resources, this tool has the potential to become a widely accepted industry standard. Future research should focus on pilot implementations, industry case studies, and refinements to the training framework to further validate the tool's effectiveness and adaptability across different project environments.

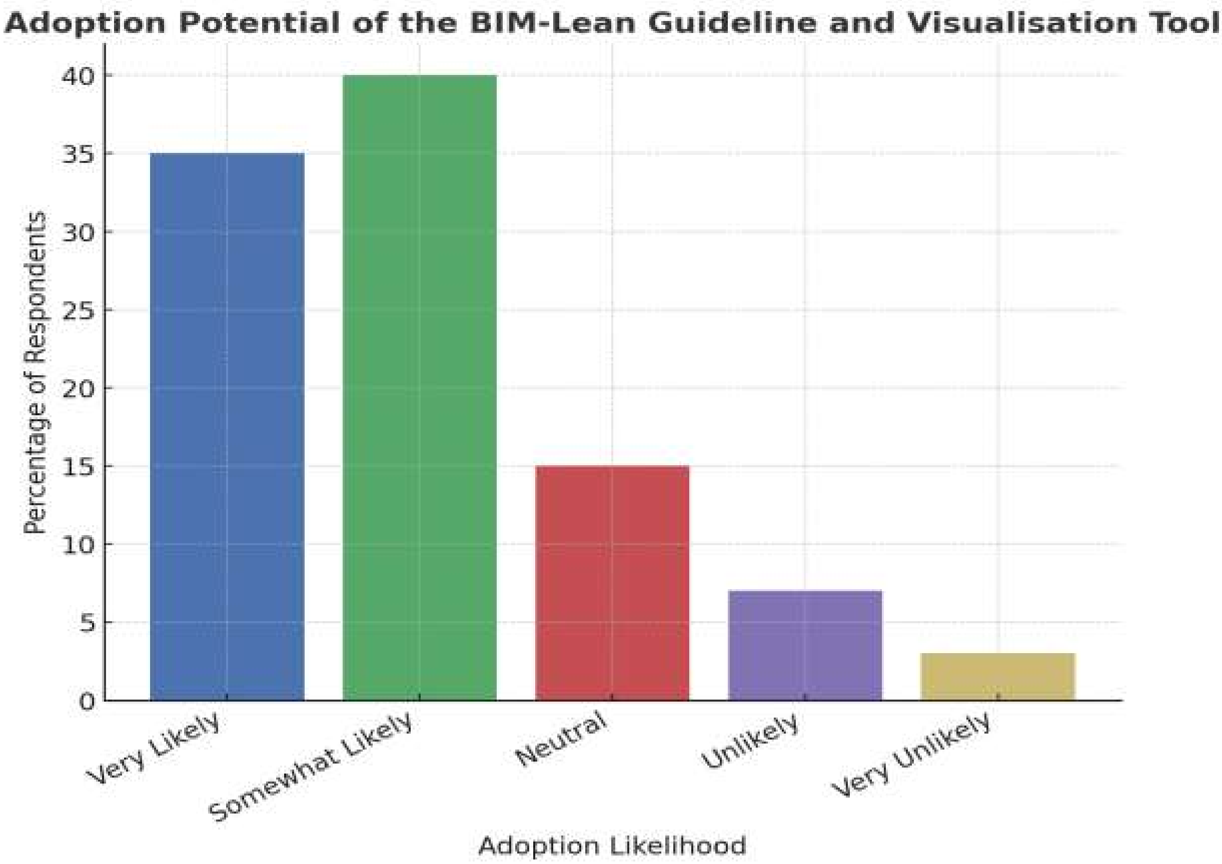


Figure 5-15 Adoption Potential of the BIM-Lean Guideline and Visualisation Tool

5.7.4 Alignment with Theoretical Frameworks

The guideline and visualisation tool are grounded in both BIM and Lean principles, which have been extensively documented in the literature as effective methods for improving project coordination and efficiency. The feedback from focus groups suggests that the proposed tools align with existing theoretical frameworks while offering practical innovations that address the specific challenges of RFI management.

For example, Azhar et al. (2011) identified that BIM's ability to visualise design conflicts early in the process can significantly reduce the number of RFIs needed, while Lean principles ensure that RFIs are processed quickly and efficiently. The guideline and tool build on these insights by providing a comprehensive framework that integrates both BIM's visualisation capabilities and Lean's focus on continuous improvement.

Additionally, the literature on BIM-Lean integration supports the idea that combining these two methodologies can lead to greater project efficiency and improved outcomes. Research by Sacks et al. (2010) and Eastman et al. (2018) reinforces the effectiveness of BIM in streamlining communication and reducing errors, while Koskela (2000) and Ballard & Howell (2003) highlight how Lean methodologies minimise process inefficiencies. By offering a step-by-step guide for implementing the new process, the guideline ensures that firms can take advantage of these benefits without being overwhelmed by the complexity of integrating two different systems.

Moreover, the structured approach of the guideline aligns with the Last Planner System (LPS), a Lean Construction methodology designed to enhance workflow predictability and efficiency. The inclusion of prioritisation mechanisms and continuous feedback loops ensures that RFIs are processed systematically, further reinforcing Lean principles of waste reduction and value-driven decision-making. The feedback from focus groups indicates that while many professionals recognise the theoretical benefits of BIM and Lean, the challenge lies in practical application. By providing clear implementation steps and visualisation support, the proposed tools bridge the gap between theoretical knowledge and real-world execution, ensuring that the integration of BIM and Lean in RFI management is both feasible and impactful.

5.7.5 Conclusion for Objective 5

The development of a practical guideline and visualisation tool for the BIM-Lean integrated RFI process has received positive feedback from industry professionals. The structured approach embedded within the guideline, alongside the real-time data capabilities of the visualisation tool, has been identified as a viable solution for addressing the inefficiencies commonly associated with traditional RFI workflows. By offering a systematic approach to RFI management, the proposed tool aims to streamline information exchange, reduce delays, and enhance overall collaboration among project stakeholders.

Feedback from professionals suggests that the tool is accessible and user-friendly, with 30% of respondents rating it as 'very easy to use' and 45% considering it 'somewhat easy to use' (Figure 5.16). This indicates that a majority of industry professionals can integrate the tool into their workflows with minimal difficulty. However, a small proportion of respondents found the process somewhat challenging, highlighting the need for additional support mechanisms. For these users, targeted training and onboarding programs will be essential in ensuring effective implementation and widespread usability.

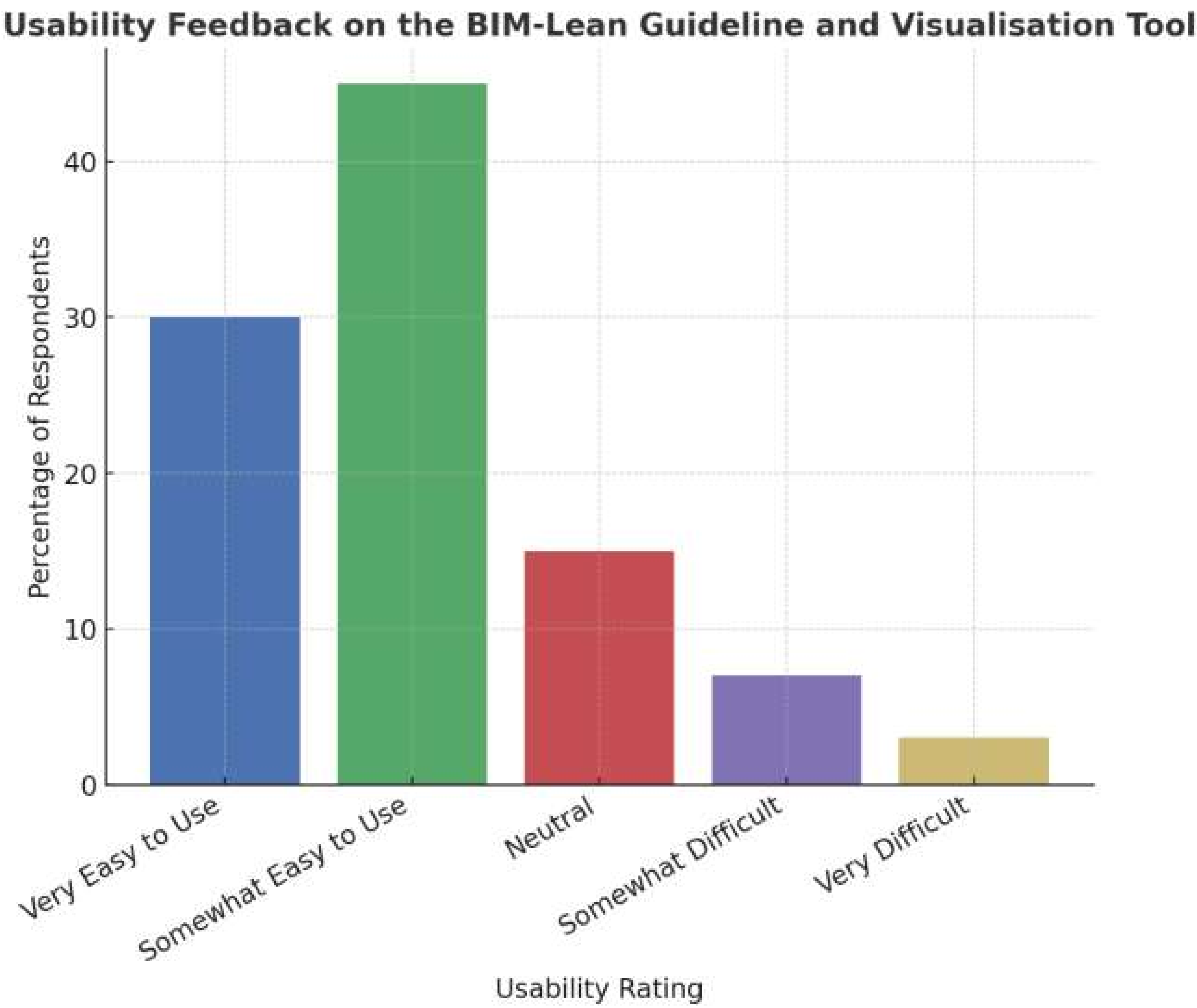


Figure 5-16 Usability feedback on the BIM-Lean Guideline and Visualisation Tool

Furthermore, 40% of respondents strongly agreed that additional training and support are necessary for the successful implementation of the new RFI process, while 35% somewhat agreed (Figure 5.17). This indicates a clear industry need for structured guidance in adopting the BIM-Lean methodology. While the tool itself offers an intuitive interface and step-by-step process, supplementary training initiatives such as interactive tutorials, workshops, and knowledge-sharing sessions could further facilitate adoption. The provision of tailored learning resources would support teams with varying levels of BIM and Lean experience, ensuring that the transition to the new approach is both smooth and effective.

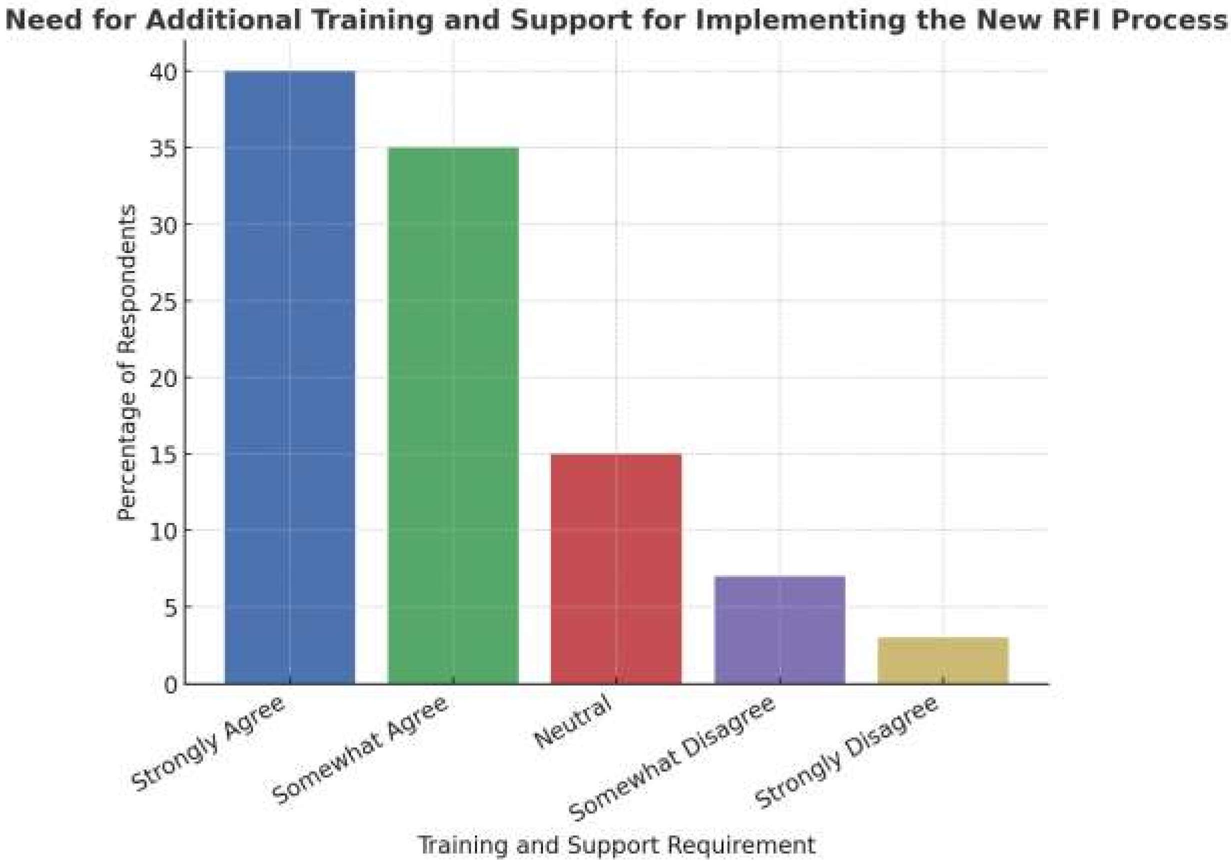


Figure 5-17 Need for Additional Training and Support for Implementing the New RFI Process

Although some professionals raised concerns regarding the time and resource investments required to implement the new process, these challenges can be mitigated through phased adoption strategies. The integration of interactive tutorials on the dummy website, coupled with a progressive rollout approach, provides a clear and manageable transition pathway for firms looking to adopt the system. This ensures that companies can implement the BIM-Lean RFI process gradually, adjusting to its functionalities without disrupting existing workflows.

The findings suggest that the potential for industry-wide adoption is strong, particularly in large-scale projects where the need for efficient information flow and streamlined collaboration is most critical. By aligning with BIM's capability for digital information sharing and Lean Construction's principles of efficiency and waste reduction, the proposed tool presents a scalable, structured, and effective solution for improving RFI management. Additionally, research by Eastman et al. (2018) and Sacks et al. (2010) supports the assertion that integrating structured digital tools with Lean methodologies enhances project efficiency, reduces miscommunication, and accelerates decision-making processes.

As a result, its implementation could contribute significantly to faster project delivery, improved stakeholder engagement, and enhanced overall project performance. Future research should focus on pilot studies, case-based validations, and refining training frameworks to ensure that the tool remains adaptable across varying project types and organisational structures.

5.8 Objective 6: Validate the Proposed Process

5.8.1 Validating Key Aspects of the RFI Process

The validation of the BIM-Lean integrated RFI process was conducted through focus groups involving industry professionals from the Architecture, Engineering, and Construction (AEC) sector. These discussions aimed to assess the practicality, effectiveness, and implementation challenges of the proposed process in addressing inefficiencies in traditional RFI workflows. The findings indicate that the new structured approach successfully mitigates many of the identified challenges, particularly those related to information fragmentation, response delays, and lack of standardisation. Participants emphasised that the integration of BIM's data centralisation capabilities with Lean's efficiency-driven principles creates a systematic approach that enhances collaboration and decision-making across project teams.

A commonly cited issue in traditional RFI management is the fragmentation of information across multiple platforms, which often leads to miscommunication, project delays, and redundant work efforts. RFIs are typically managed using separate email chains, spreadsheets, and disconnected documentation systems, making it difficult for stakeholders to track updates or verify responses. The focus groups confirmed that the BIM-Lean integrated RFI process significantly improves information flow, as it ensures that all data is centralised and accessible in real time. Through BIM's visualisation tools, project teams can track RFIs efficiently, reducing ambiguity and ensuring that stakeholders work with up-to-date, synchronised information.

Survey results support this observation, with 40% of respondents rating the new process as highly effective, while 35% considered it somewhat effective. These findings suggest that a majority of industry professionals believe the new process successfully addresses key inefficiencies in traditional RFI workflows. However, 7% of respondents found the process somewhat ineffective, citing concerns regarding software adaptation, the learning curve associated with digital transformation, and initial training requirements. These findings highlight the importance of structured onboarding and support programs to facilitate industry-wide adoption and ensure a seamless transition (Figure 5.18).

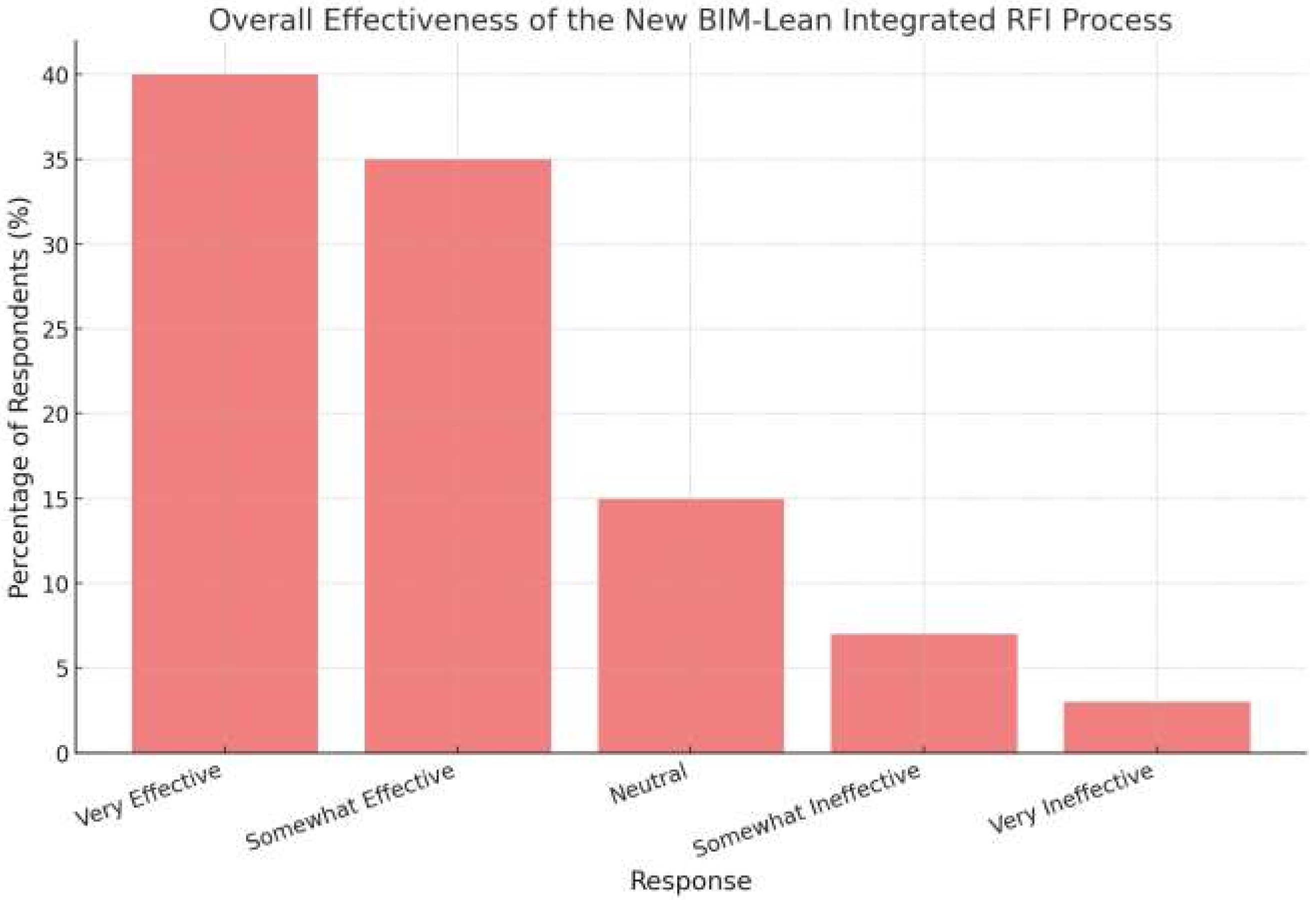


Figure 5-18 Overall Effectiveness of the New BIM-Lean Integrated RFI Process

The need for seamless information integration in RFI management has been widely discussed in construction research. Sacks et al. (2010) argue that combining BIM's data centralisation with Lean's process efficiency creates a decision-support system that eliminates unnecessary waiting times and enhances coordination. Similarly, Succar (2017) emphasises that fragmented communication is one of the biggest barriers to digital transformation in construction, making real-time information exchange a critical requirement for modern project management. The findings from this validation process strongly align with these perspectives, confirming that the BIM-Lean RFI framework effectively mitigates these inefficiencies by providing a unified digital platform that streamlines communication across all project disciplines.

Another major issue highlighted during the validation process was the lack of standardisation in how RFIs are structured, categorised, and processed. Traditionally, RFI submissions follow inconsistent formats, leading to confusion, response delays, and increased administrative workload. Many organisations rely on ad-hoc methods, where different teams use varying levels of detail and documentation approaches, making it difficult to maintain a structured workflow. The focus groups confirmed that the BIM-Lean integrated process resolves this issue by implementing a structured RFI categorisation system, ensuring that all submissions follow a clear, standardised format.

Participants noted that this structured system aligns with Lean principles, as it eliminates wasteful activities such as repeated clarification requests and redundant documentation efforts. The new approach ensures that all RFIs contain the required information at the point of submission, reducing the need for follow-up queries and unnecessary back-and-forth communication. This was particularly noted as a significant improvement in large-scale projects, where multiple RFIs are processed weekly. The categorisation system ensures consistency, allowing teams to quickly filter, prioritise, and respond to RFIs efficiently, leading to better workflow management and reduced response times.

Standardisation has been recognised as a key enabler of efficiency in RFI management. Eastman et al. (2018) argue that structured RFI categorisation enhances response accuracy, ensuring that project teams operate with consistent documentation formats that prevent information gaps. Additionally, Gao and Fischer (2008) highlight that a lack of uniformity in RFI submissions often results in delayed approvals, increased miscommunication, and higher rework rates, further reinforcing the importance of a predefined categorisation system. The proposed BIM-Lean framework addresses these concerns by ensuring that all RFIs adhere to a predefined submission structure, reducing the administrative effort required for processing and validating RFIs.

Moreover, Azhar et al. (2015) argue that BIM-driven standardisation enhances project control mechanisms, providing a data-driven decision-making framework that ensures better tracking and oversight. The findings from the validation process confirm that the BIM-Lean RFI process offers significant benefits in this regard, as it allows teams to automate certain verification steps, reducing the workload on project managers and increasing overall process efficiency. By integrating BIM's automated classification tools, projects can reduce response times and ensure RFIs are handled with minimal disruption to ongoing work.

Future research should focus on industry-wide pilot studies and longitudinal analyses to further validate the effectiveness of the proposed framework. Implementing phased adoption strategies and tracking real-world performance metrics could provide deeper insights into how different project types and organisational structures can best adapt to BIM-Lean integrated RFI workflows.

5.8.2 Refining the Process Based on Industry Feedback

The validation process provided valuable insights into how the BIM-Lean integrated RFI framework could be further improved. Focus group participants shared constructive feedback, highlighting specific areas where refinements could enhance the practical implementation of the process. These suggestions primarily revolved around interface usability, training needs, and flexibility in implementation, which were all key factors in ensuring the framework's adoption across diverse industry settings.

One of the primary refinements suggested was the simplification of the interface of the visualisation tool. While the concept of integrating BIM-based visualisation was widely supported, some participants expressed concerns that the interface was too complex for smaller firms that lack dedicated BIM teams. The feedback revealed that 35% of respondents emphasised the need for improved training programs, while 30% suggested that the interface could be streamlined for greater ease of use. Additionally, 25% felt that increased flexibility would allow firms to better adapt the process to their specific project requirements. This indicates that while the core framework is effective, some adjustments are necessary to accommodate different levels of BIM proficiency and organisational capabilities (Figure 5.19).

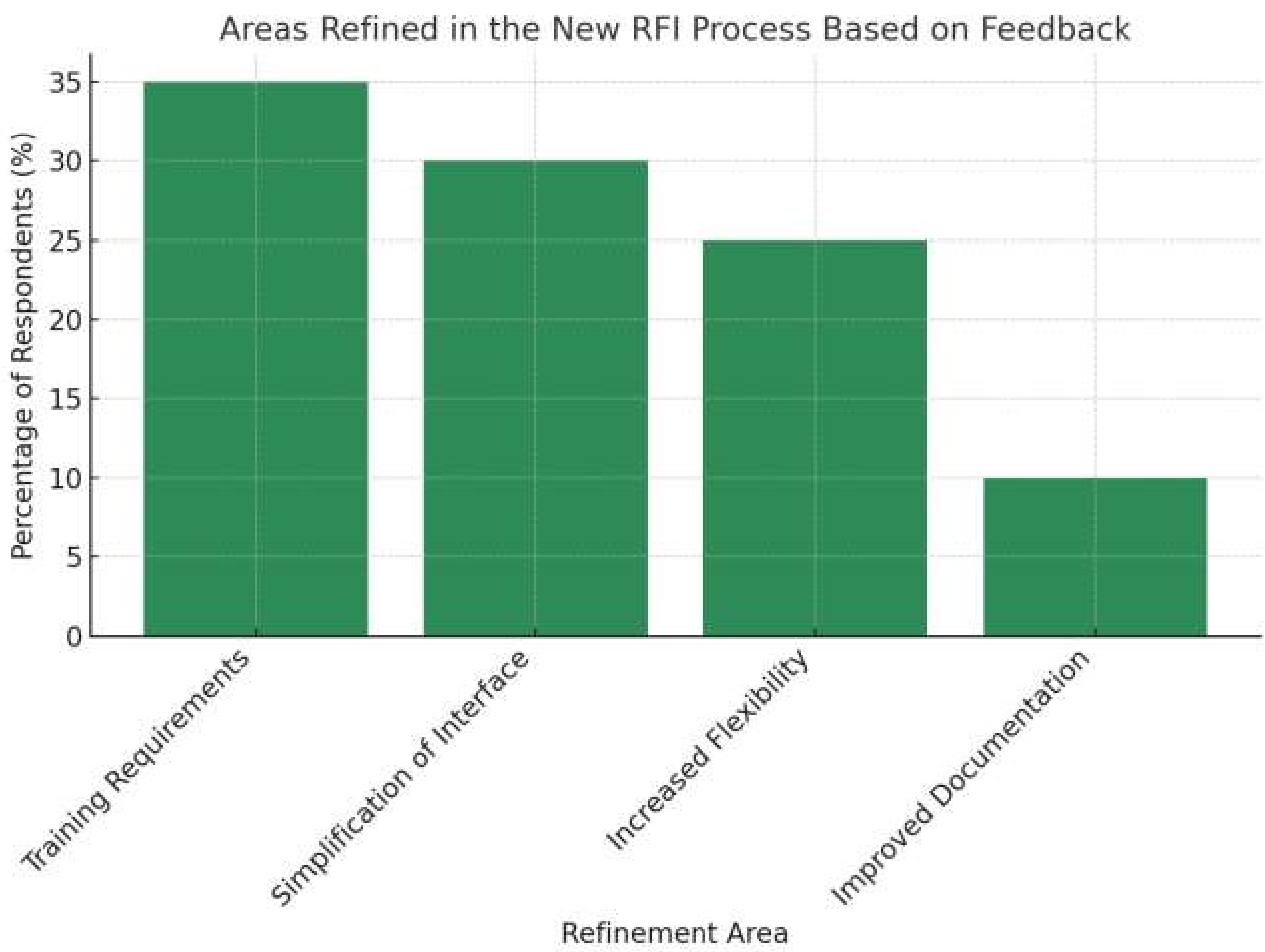


Figure 5-19 Areas refined in the NEW RFI Process Based on Feedback

Another key area for refinement was the flexibility of implementation. Several participants noted that while the guideline provides a step-by-step approach, there should be greater adaptability for firms that may not be ready to fully integrate both BIM and Lean tools simultaneously. Some companies may have established BIM workflows but lack experience with Lean methodologies, while others may be comfortable with Lean principles but face challenges in implementing BIM technologies. Therefore, a more modular approach was suggested, allowing firms to incrementally adopt elements of the framework based on their current capabilities and project needs.

These refinements led to specific updates in the RFI process, including an enhanced version of the visualisation tool with a more intuitive user interface, along with additional guidance on progressive adoption strategies. This approach aligns with Sacks et al. (2010), who argue that incremental integration of Lean principles is often the most effective way to embed them into existing project workflows. By allowing firms to adopt the new RFI process in phases, organisations can ensure a smoother transition, minimising disruptions while benefiting from gradual process improvements.

When asked about the practicality of implementing the new BIM-Lean integrated RFI process in real-world projects, 38% of respondents strongly agreed that the process is practical and applicable, while 42% agreed. This demonstrates a high level of confidence in the proposed approach among industry professionals. However, 12% of respondents remained neutral, suggesting that while the framework offers substantial benefits, some professionals may still require further clarification or demonstration before fully adopting the process. Additionally, a small percentage (5%) disagreed, indicating that certain projects or organisations may need further adjustments to align the process with their specific workflows (Figure 5.20).

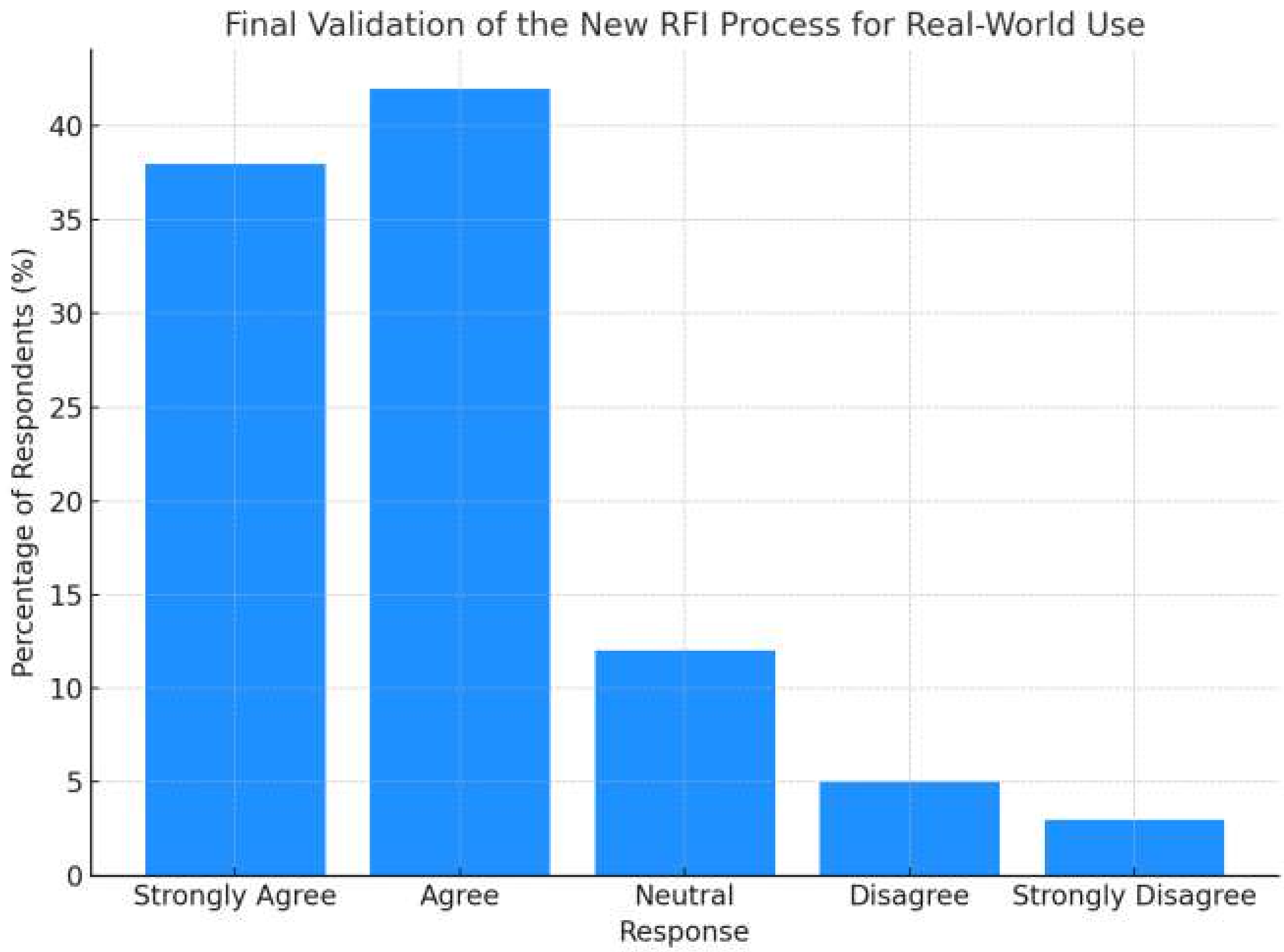


Figure 5-20 Final Validation of the New RFI Process for Real-World use

Overall, the feedback gathered during the validation process has played a crucial role in refining the BIM-Lean RFI process. By addressing concerns related to interface usability, implementation flexibility, and structured training, the framework has been enhanced to better align with industry needs. The refinements ensure that organisations of all sizes and levels of BIM and Lean expertise can implement the process effectively, reinforcing its potential for widespread adoption and long-term success in streamlining RFI workflows across construction projects. Furthermore, future research should focus on pilot studies and longitudinal assessments to evaluate the impact of these refinements on project performance and efficiency.

5.8.3 Practical Application and Real-World Challenges

The overall consensus from the focus groups was that the BIM-Lean integrated RFI process provides a practical and scalable solution for improving RFI management in construction projects. Participants acknowledged that the structured integration of BIM and Lean principles enhances efficiency, standardisation, and collaboration across project teams. However, despite the positive reception, industry professionals identified several real-world challenges that could impact the widespread adoption of the framework. These challenges primarily relate to training requirements, expertise gaps, and cost considerations, which must be addressed to ensure successful implementation across diverse project environments.

One of the most significant challenges raised was training and expertise requirements. Many participants pointed out that the successful implementation of the BIM-Lean RFI process relies on teams having adequate BIM proficiency and Lean knowledge. While the guideline and visualisation tool provide structured support, some professionals expressed concerns that without industry-wide training initiatives, many teams may struggle to use these tools effectively. This aligns with previous research, as Azhar et al. (2011) emphasised that one of the biggest barriers to BIM adoption is the lack of training and technical expertise among construction professionals. Similarly, the adoption of Lean principles requires a fundamental cultural shift towards continuous improvement, which not all teams are prepared for without structured training and long-term engagement.

The need for upskilling and industry education is further supported by Davies and Harty (2013), who argue that the success of digital construction technologies depends not only on the availability of tools but also on the willingness of professionals to adopt new workflows and mindsets. Without proper knowledge transfer and training programs, firms may be reluctant to commit to new methodologies, limiting the potential benefits of BIM-Lean integration. To address these concerns, organisations must invest in continuous professional development, certification programs, and hands-on training workshops to equip their teams with the necessary competencies for effective implementation.

Another key challenge highlighted by participants was the cost of implementation, particularly for smaller firms or projects with limited budgets. The integration of BIM and Lean tools requires financial investment in software, training, and process restructuring, which some organisations may find prohibitive despite the long-term benefits. This concern has been noted in previous studies, such as Sacks et al. (2010), who found that high initial costs, combined with uncertainty about return on investment, often deter firms from fully adopting BIM and Lean methodologies. Additionally, Eastman et al. (2018) emphasised that while BIM adoption leads to long-term efficiency gains, many firms remain hesitant due to the perceived complexity and cost of implementation.

To mitigate these financial concerns, the guideline offers flexible adoption strategies, allowing firms to implement BIM and Lean tools in stages rather than committing to full-scale adoption from the outset. By gradually integrating components of the framework, firms can minimise upfront costs while building expertise over time, ensuring a smoother transition with less financial risk. This approach is supported by Succar (2017), who argues that progressive implementation models enable firms to scale digital transformation efforts in alignment with their operational capacities. By breaking down the adoption process into manageable phases, organisations can experience incremental benefits while maintaining financial sustainability.

Moreover, industry engagement and government incentives could play a pivotal role in easing the financial burden associated with BIM-Lean adoption. Studies by Love et al. (2014) suggest that targeted policy interventions, including tax incentives and subsidised training programs, have proven effective in encouraging the adoption of digital construction technologies. Collaborative initiatives between industry bodies, academic institutions, and professional associations could further drive widespread acceptance by providing structured learning pathways and peer support networks.

Overall, while the BIM-Lean RFI process presents a highly effective framework for improving RFI management, its practical implementation requires a commitment to training, education, and phased adoption strategies. Addressing these challenges through structured industry training programs, cost-effective implementation models, and ongoing stakeholder engagement will be essential in ensuring that the process achieves widespread acceptance and delivers measurable improvements in project efficiency. Future research should focus on longitudinal studies tracking implementation progress and the impact of incremental adoption strategies across different project scales and organisational structures.

5.8.4 Final Conclusions on Effectiveness

The validation process confirmed that the BIM-Lean integrated RFI framework is both practical and effective in addressing the key challenges and inefficiencies identified earlier in the research. The process was evaluated through focus groups and survey responses, demonstrating that the integration of BIM and Lean principles leads to measurable improvements in RFI management. Participants highlighted the strengths of the framework in terms of information centralisation, waste reduction, and enhanced collaboration, all of which contribute to greater project efficiency.

One of the most significant findings from the validation process was the improvement in information flow achieved through the centralisation of RFI data within BIM platforms. Traditionally, RFIs are managed across multiple disconnected systems, leading to delays, miscommunication, and fragmented documentation. The new process ensures that all stakeholders have real-time access to relevant RFI information, reducing the risk of conflicting updates and missing data. This aligns with Eastman et al.

(2018), who emphasise that BIM's ability to integrate and synchronise project data is critical for reducing coordination errors. By leveraging BIM's visualisation and data-sharing capabilities, the proposed framework enhances transparency and traceability, making it easier for teams to track, review, and respond to RFIs efficiently.

The application of Lean principles within the RFI process has also led to significant waste reduction, particularly through the standardisation of RFI categorisation and the elimination of redundant steps in the communication workflow. Traditional RFI processes often involve repetitive clarification requests, inconsistent documentation, and delays caused by unclear submissions. The new system ensures that RFIs follow a structured format, reducing the need for unnecessary revisions and back-and-forth communication. This supports findings from Sacks et al. (2010), who argue that Lean Construction principles—when applied correctly—can significantly reduce process inefficiencies by minimising non-value-adding activities. By standardising RFI workflows, the new approach ensures faster resolution times, improved response accuracy, and a more streamlined decision-making process.

Another major benefit of the BIM-Lean integrated RFI framework is its ability to enhance collaboration among project stakeholders. The new system facilitates open communication and transparency, particularly in large, complex projects where multiple teams must coordinate their efforts. By providing a shared digital platform for RFI management, the process helps teams stay aligned, reduce information silos, and ensure accountability in decision-making. This reflects findings from Succar (2017), who states that collaborative BIM environments improve stakeholder engagement by ensuring that all participants have access to the same real-time project data. With enhanced communication and coordination mechanisms, the proposed framework enables smoother project execution and fewer disruptions due to mismanaged RFIs.

The refinements made during the validation process further ensure that the proposed RFI framework is scalable and adaptable to a diverse range of projects and firms. The updates to the user interface, based on industry feedback, have improved accessibility and ease of use, making the tool more intuitive for teams with varying levels of BIM experience. Additionally, the introduction of flexible implementation options allows organisations to adopt the framework gradually, reducing barriers to entry and easing the transition for firms with limited digital capabilities. This approach aligns with research by Davies and Harty (2013), who suggest that digital construction tools must be adaptable to different organisational structures and workflows to achieve widespread industry adoption.

Moreover, as digital transformation continues to reshape the construction industry, future developments should focus on further integration with emerging technologies such as artificial intelligence and machine learning. Research by Love et al. (2014) suggests that predictive analytics and automated issue detection could further enhance RFI management by identifying potential coordination issues before they escalate. By continuously refining the BIM-Lean integrated RFI framework to incorporate technological advancements, the construction industry can ensure sustained efficiency gains and improved project delivery outcomes.

As the construction industry continues to evolve and incorporate more digital tools, the integration of BIM and Lean methodologies presents a significant opportunity to improve project efficiency, reduce costs, and optimise workflow management. The validated refinements to the RFI process demonstrate that this framework is not only effective in theory but also practical for real-world implementation. By addressing core inefficiencies, enhancing collaboration, and providing structured adoption pathways, the BIM-Lean integrated RFI process has the potential to transform the way RFIs are managed, leading to greater productivity, improved project outcomes, and a more streamlined approach to construction communication.

5.8.5 Conclusion for Objective 6

The validation of the BIM-Lean integrated RFI process confirmed its effectiveness in addressing the key challenges associated with RFI management. Industry professionals widely supported the centralisation of RFI data through BIM platforms, emphasising that real-time access to structured information reduces miscommunication, response delays, and inefficiencies. Additionally, the standardisation of RFI workflows was recognised as a critical factor in ensuring consistency across projects, enabling teams to process requests more efficiently while minimising unnecessary waste. These findings align with previous research, such as Eastman et al. (2018) and Sacks et al. (2010), which highlight the benefits of structured information management and Lean methodologies in improving project communication and decision-making.

Despite the clear advantages of the proposed framework, industry professionals also identified real-world challenges that could affect its widespread adoption. One of the most significant concerns raised was the cost of implementation, particularly for smaller firms or projects with constrained budgets. While the long-term benefits of improved efficiency and reduced rework are evident, the initial financial investment in software, training, and process restructuring remains a barrier for some organisations. This concern is consistent with findings from Sacks et al. (2010), who noted that financial constraints and perceived complexity often deter firms from fully integrating BIM and Lean tools.

Another major challenge highlighted during the validation process was the need for industry-wide training and professional development. Successful implementation of the BIM-Lean RFI process requires a skilled workforce proficient in BIM technologies and Lean principles, yet many firms lack access to structured training programs. This challenge has been widely discussed in literature, with Azhar et al. (2011) and Davies & Harty (2013) emphasising that the lack of digital skills and resistance to new methodologies remain significant barriers to construction technology adoption. Addressing this issue requires investment in structured learning pathways, including workshops, certification programs, and mentorship initiatives to ensure that all stakeholders are equipped to implement the new framework effectively.

To mitigate these challenges, refinements were made based on industry feedback, ensuring that the new framework remains adaptable and accessible. The simplification of the user interface makes the visualisation tool more intuitive, allowing teams with varying levels of BIM expertise to navigate the system efficiently. Additionally, the introduction of flexible implementation options enables firms to adopt the framework in stages, rather than committing to full-scale adoption from the outset. This phased integration strategy, supported by Succar (2017), ensures that organisations can gradually develop expertise and confidence in using BIM-Lean processes while minimising financial and operational risks.

Moreover, future research should focus on developing industry-wide standardisation strategies and digital adoption policies to further enhance the framework's scalability. Love et al. (2014) suggest that government incentives and regulatory support can significantly aid the transition to digital and Lean-based workflows, helping firms overcome financial and technical barriers. Collaborative efforts between industry stakeholders, academic institutions, and policymakers could play a vital role in driving widespread adoption and ensuring the long-term success of the BIM-Lean RFI framework.

Overall, the validation process confirmed that the BIM-Lean RFI framework is both practical and scalable, offering a structured solution for improving RFI management across construction projects. By enhancing information flow, reducing waste, and promoting collaboration, the framework provides a clear pathway for improving project outcomes and increasing overall efficiency. While challenges such as cost and training remain key considerations, the refinements made ensure that firms of all sizes can gradually implement the process, making it a realistic and valuable tool for the construction industry.

5.9 Summary of Data Analysis and Discussion Section

This chapter critically examined the current state of Request for Information (RFI) management practices within the Architecture, Engineering, and Construction (AEC) industry, utilising both quantitative survey data and qualitative insights from focus groups. The analysis highlighted significant inefficiencies in traditional RFI workflows, particularly in terms of delays, miscommunication, and inconsistent documentation methods, all of which contribute to project overruns and inefficiencies. The findings revealed that while Building Information Modelling (BIM) has been widely adopted, with 61.2% of respondents reporting regular use, the integration of Lean Construction principles remains underdeveloped. Many industry professionals lacked familiarity with Lean methodologies or were uncertain about their practical application in RFI processes, revealing a key barrier to fully leveraging the combined benefits of BIM and Lean for enhanced project coordination, waste reduction, and improved information flow.

Survey responses also illustrated a fragmented approach to RFI management, with participants relying on a variety of digital tools and non-standardised processes. Software platforms such as ProjectWise and Conject were commonly used, but many firms employed custom-built or ad-hoc solutions, leading to inconsistencies across projects. The majority of respondents reported managing between 1 and 50 RFIs per week, yet the lack of a standardised framework resulted in frequent delays and miscommunication. These inefficiencies reinforced the need for a more structured and uniform approach. In response, the BIM-Lean integrated RFI process was developed, incorporating BIM's real-time data-sharing capabilities and Lean's principles of continuous improvement to address workflow inefficiencies and communication breakdowns.

Feedback from industry professionals indicated strong support for the proposed process, with many recognising its potential to streamline RFI workflows and enhance collaboration. The ability to visualise RFI data through BIM while simultaneously applying Lean Construction techniques to improve efficiency was widely acknowledged as a key advantage. However, concerns were raised regarding training requirements and implementation costs, particularly for smaller firms with limited resources. These challenges underscored the need for an adaptable and scalable approach, ensuring that firms could adopt the new system gradually without significant financial or operational disruptions.

The validation phase demonstrated the framework's effectiveness, with 40% of respondents rating the process as very effective and an additional 35% considering it somewhat effective. Insights from focus groups led to important refinements, including a more user-friendly interface and flexible implementation strategies that cater to varying project sizes and organisational structures. These refinements ensure that the BIM-Lean integrated RFI process is not only theoretically sound but also practical for real-world application, making it accessible to a diverse range of industry professionals.

Moreover, the research findings align with existing literature on BIM and Lean Construction, supporting the claim that structured digital workflows and Lean-based efficiency principles can significantly enhance project performance. Studies by Eastman et al. (2018) and Sacks et al. (2010) reinforce the importance of integrated information management systems in mitigating RFI-related inefficiencies. By incorporating continuous improvement mechanisms and leveraging BIM's real-time data tracking, the proposed framework ensures that project teams can proactively manage RFIs, reducing rework and enhancing collaboration.

The positive validation, combined with feedback-driven improvements, confirms that the BIM-Lean integrated RFI process is a viable solution to long-standing inefficiencies in RFI management. By addressing both technical and operational challenges, the process provides a structured, scalable, and adaptable framework that aligns with modern construction industry needs. As the research progresses, the following chapter will focus on the practical steps for implementation, demonstrating how this process can be effectively applied across different projects and industry sectors to improve overall project outcomes and efficiency.

Chapter: 6 Introduction to the Proposed RFI Process

The Request for Information (RFI) process is a critical communication mechanism within the Architecture, Engineering, and Construction (AEC) industry, facilitating the resolution of ambiguities and the clarification of technical, design, and contractual issues throughout a project's lifecycle. Despite its importance, traditional RFI workflows are often inefficient and fragmented, leading to delays, increased project costs, and miscommunication among stakeholders. These inefficiencies arise primarily from the reliance on disconnected systems such as emails, spreadsheets, and standalone databases, which make it difficult to track, manage, and respond to RFIs in a timely manner. Additionally, the absence of standardised categorisation and structured workflows further complicates RFI resolution, resulting in duplicate queries, prolonged response times, and lack of accountability in decision-making.

To address these challenges, this research proposes an enhanced RFI process that integrates Building Information Modelling (BIM) and Lean Construction methodologies. The objective is to develop a more efficient, structured, and transparent approach to RFI management that reduces response times, improves information flow, and fosters a collaborative project environment. The integration of BIM technology into the RFI process allows for visualisation-based issue tracking, real-time data accessibility, and structured documentation, ensuring that all stakeholders can review RFIs within their project context. Meanwhile, the adoption of Lean Construction principles, particularly the Last Planner System (LPS), facilitates prioritisation of RFIs based on their impact on project schedules and workflow continuity, ensuring that critical issues are resolved efficiently without disrupting project progress.

The proposed BIM-Lean RFI framework seeks to eliminate redundant processes, enhance transparency, and standardise workflows, thereby transforming RFI management into a proactive, rather than reactive, process. By directly linking RFIs to BIM models and structured workflows, this system reduces the need for repetitive clarifications, ensures accountability, and creates a streamlined communication pathway between project stakeholders. The following sections will detail the key roles and responsibilities within the proposed RFI process, outlining how BIM and Lean integration can enhance workflow efficiency, reduce waste, and improve project outcomes.

6.1 Roles and Responsibilities in the RFI Process

A fundamental improvement in the proposed BIM-Lean integrated RFI process is the clear definition of roles and responsibilities, ensuring that accountability is maintained at every stage of the RFI lifecycle. Traditionally, the lack of role clarity has been a major challenge in RFI workflows, with RFIs often circulating among multiple stakeholders without a designated individual responsible for resolution. This ambiguity frequently results in delays, miscommunication, and inefficiencies, as RFIs may be overlooked, misinterpreted, or inadequately addressed. The reliance on email-based communication and unstructured documentation methods further exacerbates these issues, making it difficult to track the status of RFIs and ensure timely responses.

To overcome these challenges, the revised process introduces a structured framework with three distinct roles: the RFI Creator (RC), RFI Manager (RM), and RFI Responder (RR). Each role is designed to streamline workflow efficiency, establish clear accountability, and ensure that RFIs are processed, tracked, and resolved effectively.

The RFI Creator (RC) is responsible for initiating an RFI, ensuring that the request is well-defined, properly categorised, and supported with relevant documentation. This individual, typically a contractor or subcontractor, identifies gaps in project documentation or construction workflows that require clarification. When submitting an RFI, the RC must attach all necessary supporting materials, such as drawings, photos, or contractual references, ensuring that the query is framed in a way that allows the RFI Manager to prioritise and assign it efficiently.

The RFI Manager (RM) serves as the central coordinator in the RFI workflow, reviewing each submitted RFI for completeness, prioritising it based on project needs, and assigning it to the appropriate RFI Responder. Beyond delegation, the RM is responsible for monitoring the progress of RFIs, ensuring that responses are provided within the specified timeframe. If an RFI remains unresolved or requires further clarification, the RM escalates the issue and facilitates coordination among stakeholders to ensure a timely and accurate resolution. The RM also validates responses before they are communicated back to the RFI Creator, ensuring that the information provided adequately addresses the query and meets project requirements.

The RFI Responder (RR) is the individual or team responsible for providing a detailed response to the RFI. Typically, this role is fulfilled by members of the design team, project management team, or specialised consultants. The RR must thoroughly review the RFI, consult project documentation and relevant stakeholders as needed, and provide a well-documented response. If additional information is required, the RR must proactively communicate with the RFI Manager and RFI Creator to ensure that the issue is resolved in a structured and efficient manner.

By establishing these three clearly defined roles, the proposed RFI process eliminates much of the ambiguity that traditionally slows down RFI management. Each individual involved in the process understands their responsibilities, leading to improved accountability, reduced response times, and more effective communication. This structured approach also aligns with the Lean construction principle of continuous improvement, as it allows for better tracking of RFIs, enhanced process monitoring, and ongoing refinement of workflow efficiencies.

Additionally, the integration of BIM technology into this structured framework ensures that RFIs are centrally managed, visually represented within project models, and directly linked to relevant construction elements. This integration eliminates the inefficiencies of fragmented communication methods, enabling real-time collaboration and enhanced decision-making among project stakeholders. The following sections will outline how these roles function within the broader BIM-Lean RFI workflow, providing a detailed examination of the submission, processing, and resolution stages of the proposed system.

6.2 RFI Creation and Submission Guidelines

The effectiveness of the BIM-Lean integrated RFI process is largely dependent on the clarity, organisation, and standardisation of the RFI creation and submission stages. One of the most significant inefficiencies in traditional RFI workflows is the lack of consistency in how RFIs are initiated, often resulting in vague, incomplete, or improperly framed queries. These shortcomings prolong resolution times, as RFIs frequently require multiple clarifications and revisions before they can be properly addressed. The absence of a structured submission format also makes it difficult for project teams to track, prioritise, and manage RFIs effectively, leading to delays, miscommunication, and potential project overruns.

To address these issues, the proposed BIM-Lean integrated RFI process introduces a structured and standardised method for submitting RFIs, ensuring that every request includes all necessary details from the outset. Each RFI is directly linked to a specific location within the BIM model, providing a visual context for the query. This feature enables stakeholders to immediately view the issue within the project's overall design, reducing the likelihood of misinterpretation and unnecessary back-and-forth communication. By embedding RFIs within the digital project model, project teams can track the query in real time, ensuring that all relevant stakeholders have access to the most up-to-date information without relying on fragmented communication channels.

The RFI submission form has been designed to be comprehensive yet user-friendly, incorporating predefined categories and structured fields that guide the RFI Creator in submitting a well-documented and clear request. RFIs are classified into three primary categories—technical, cost-related, and programme-related issues—allowing for better tracking, prioritisation, and assignment. Additionally, the form includes 15 predefined reasons for raising an RFI, based on the research conducted by Hanna et al. (2012), which identified the most common causes of RFIs in construction projects. These predefined reasons ensure that RFIs follow a structured format, making it easier for the RFI Manager and Responder to quickly assess, assign, and resolve the issue.

To further enhance RFI clarity and resolution efficiency, the RFI submission process requires that supporting documents be attached whenever applicable. The RFI Creator must provide project drawings, photos, contractual references, or any other relevant documentation to assist the RFI Responder in addressing the query effectively. This requirement ensures that the necessary background information is available from the beginning, minimising the need for further clarification requests and preventing delays in response time. The inclusion of attachments also supports the BIM integration strategy, as linked documents can be easily accessed within the model, allowing for a more streamlined and visual approach to issue resolution.

Once an RFI is submitted, it undergoes an initial review by the RFI Manager, who verifies that all necessary information has been provided and that the query is clear and actionable. Following this verification, the RFI Manager assigns a priority level, classifying the request as high, medium, or low urgency, based on its potential impact on the project schedule. This prioritisation ensures that critical RFIs are addressed promptly, while less urgent queries are handled in a structured manner that aligns with project workflow requirements. The use of priority-based classification also enhances Lean Construction principles, as it minimises wasted effort and prevents non-critical RFIs from disrupting overall project progress.

The structured approach to RFI creation and submission ensures that RFIs are processed more efficiently, with clear documentation, direct model integration, and an optimised response workflow. By implementing standardised submission guidelines, the proposed framework minimises the likelihood of delays caused by incomplete or ambiguous RFIs, thereby enhancing accountability and promoting a more collaborative project environment. The following sections will further explore the processing and response mechanisms, detailing how the BIM-Lean methodology supports efficient tracking, management, and resolution of RFIs throughout the project lifecycle.

6.2.1 RFI Processing and Response

Once an RFI has been submitted and reviewed by the RFI Manager, the next phase in the process involves assigning the query to the appropriate RFI Responder and ensuring timely resolution. In traditional RFI workflows, this stage is where significant delays often occur, as RFIs are frequently passed between multiple stakeholders without a clear priority structure or designated accountability. This fragmented approach can lead to miscommunication, prolonged decision-making, and bottlenecks that disrupt project timelines. Additionally, the absence of a structured tracking system makes it difficult for teams to monitor the status of RFIs and enforce response deadlines, further exacerbating inefficiencies.

To overcome these challenges, the BIM-Lean integrated RFI process introduces a systematic approach to RFI resolution, ensuring that queries are handled efficiently and in a transparent manner. The RFI Manager plays a critical role in this stage by assigning the RFI to the appropriate responder(s) and tracking the query's progress until resolution. Unlike traditional methods where RFIs are distributed without clear oversight, the proposed system ensures that each RFI is directed to the most relevant stakeholders, whether designers, engineers, or project managers, depending on the nature of the query. The RFI Manager is also responsible for monitoring response times and escalating unresolved issues, ensuring that RFIs do not remain in limbo without proper action.

A key enhancement in the proposed RFI process is the integration of Lean construction methodologies, particularly the Last Planner System (LPS), to prioritise RFIs based on their urgency and potential impact on the project's critical path. By leveraging Lean principles, the RFI Manager can ensure that high-priority RFIs are addressed first, preventing delays that could disrupt overall project progress. This prioritisation ensures that RFIs critical to construction sequencing, safety compliance, or design modifications receive immediate attention, while lower-priority queries are scheduled for resolution without interfering with essential project milestones.

To further enhance efficiency and proactive issue resolution, the proposed process includes weekly planning meetings where the RFI Manager, key stakeholders, and project teams review all active RFIs. These meetings serve as an opportunity to discuss potential bottlenecks, anticipate upcoming RFIs, and allocate resources more effectively. By addressing outstanding RFIs in a structured forum, teams can ensure that no critical queries are overlooked and that all necessary approvals are obtained in a timely manner. This collaborative approach not only reduces response times but also promotes better coordination, allowing the project team to resolve issues before they escalate into significant project risks.

6.2.2 RFI Resolution and Closure

After the RFI Responder has submitted their response, the final stage of the RFI process involves reviewing the resolution and officially closing the RFI. In traditional workflows, the closure of RFIs can be delayed or left ambiguous, particularly when there is no structured procedure for confirming that the query has been satisfactorily resolved. This can lead to open-ended RFIs that cause rework, misalignment in project documentation, and unresolved design inconsistencies.

The proposed system introduces a formalised review and closure process, ensuring that every RFI is fully addressed before being marked as complete. Once the response is submitted, the RFI Manager evaluates the response to ensure that it adequately resolves the original query. The RFI Creator is then required to review the response, confirming that all necessary details have been provided and that no further clarification is needed. If the RFI Creator is satisfied, the RFI is officially closed, and no further action is required. However, if additional information is needed, the RFI Creator has the option to reopen the RFI and request further clarification from the RFI Responder. This feature ensures that RFIs are not prematurely closed without full resolution, preventing misunderstandings that could cause project disruptions later.

By implementing a clear review and closure process, the proposed BIM-Lean RFI system ensures that each query is resolved in a structured, transparent, and accountable manner. The ability to reopen RFIs when necessary further strengthens quality control and ensures that all project stakeholders are aligned before finalising decisions. Additionally, the use of BIM-based tracking and Lean prioritisation mechanisms enhances the efficiency of RFI resolution, reducing the risk of project delays and unnecessary rework.

The following sections will expand on how the BIM-Lean RFI process enhances project documentation, traceability, and historical tracking, ensuring that lessons learned from past RFIs can be used to refine workflows and improve decision-making in future projects.

6.2.3 Summary of the Proposed RFI Process

The proposed BIM-Lean integrated RFI process has been developed to address the persistent inefficiencies associated with traditional RFI management, which often result in delays, miscommunication, and fragmented workflows. By leveraging Building Information Modelling (BIM) for real-time data sharing and visualisation and Lean Construction methodologies for process efficiency, the new system introduces a structured, transparent, and highly coordinated framework for managing RFIs in the Architecture, Engineering, and Construction (AEC) industry. Unlike conventional RFI workflows, which rely heavily on manual tracking, disconnected communication methods, and unstructured documentation, the proposed process ensures clarity, accountability, and optimised resolution times.

One of the fundamental improvements in the proposed RFI system is the transition from fragmented, manual tracking methods to a centralised digital platform, where RFIs are directly linked to the BIM model. This integration ensures that all project stakeholders can visually assess RFIs within the project's design context, minimising the need for excessive clarifications and reducing response delays. Traditional RFI practices often rely on emails, spreadsheets, or standalone databases, which increase the risk of miscommunication, duplication, and oversight. By embedding RFIs within a digital model, the proposed approach creates a seamless connection between project design, documentation, and issue resolution, thereby enhancing transparency and collaboration across all teams involved.

In addition to BIM's role in improving RFI traceability and documentation, the proposed process incorporates Lean Construction methodologies, particularly the Last Planner System (LPS), to ensure that RFIs are prioritised based on their impact on the project's critical path. A major shortcoming of traditional RFI workflows is the lack of prioritisation, which can result in non-urgent RFIs delaying time-sensitive issues. By implementing Lean principles, the new system classifies RFIs based on urgency, allowing project teams to allocate resources effectively and prevent disruptions to workflow continuity. This structured approach ensures that high-priority RFIs—those affecting safety, sequencing, and contractual obligations—are resolved swiftly, while lower-priority RFIs follow a systematic resolution timeline without causing unnecessary project delays.

Another critical enhancement of the proposed RFI framework is the introduction of clearly defined roles and responsibilities. Traditional RFI management often suffers from ambiguity in role assignment, where RFIs are circulated among multiple parties without a clear resolution path. The proposed system formally designates three key roles: the RFI Creator, RFI Manager, and RFI Responder, ensuring clear accountability at every stage of the RFI lifecycle.

- The RFI Creator (RC) initiates the RFI by framing the query in a structured format, attaching all relevant supporting documents, and linking the issue to the BIM model or project documentation.
- The RFI Manager (RM) is responsible for reviewing, prioritising, and assigning RFIs while ensuring that response timelines are adhered to.
- The RFI Responder (RR) provides a comprehensive response, ensuring that the issue is fully addressed before the RFI is closed.

By implementing this structured role distribution, the new RFI process eliminates delays caused by miscommunication and lack of ownership, streamlining workflow efficiency and ensuring that RFIs are resolved in a timely and effective manner.

The proposed process is further strengthened by the integration of a digital RFI platform, which facilitates real-time tracking, automated documentation, and a transparent approval workflow. By establishing structured submission guidelines, prioritised response mechanisms, and a clearly defined accountability framework, the new system effectively addresses the inefficiencies that have long plagued traditional RFI processes. Unlike manual tracking systems, where RFIs can be easily misplaced or remain unresolved, the digital RFI platform ensures full traceability, allowing project teams to track the status of RFIs, monitor response times, and enforce accountability measures with greater accuracy.

The justification for the proposed BIM-Lean integrated RFI process is grounded in its ability to resolve the longstanding challenges of traditional RFI management, as discussed in previous chapters. By improving communication channels, reducing response times, minimising waste, and ensuring accountability, the system aligns with modern industry requirements and best practices. Additionally, the BIM-Lean integration not only enhances efficiency in resolving RFIs but also promotes a proactive approach to issue management, preventing delays, rework, and cost overruns that typically arise from poorly managed RFIs.

In conclusion, the proposed RFI process represents a significant advancement in construction project management, combining the strengths of BIM and Lean methodologies to create a highly structured, collaborative, and responsive system. This approach enhances efficiency, accountability, and transparency by establishing clear workflows, formal role assignments, and digital tracking mechanisms. The next phase of this research involves validating the implementation of this process in real-world projects, assessing its practical applicability and potential for industry-wide adoption, and refining the system further based on user feedback and performance evaluation.

6.3 Refinement of the RFI Process: From Traditional to Structured Categorisation

The Request for Information (RFI) process has historically been characterised by inefficiencies, primarily due to the lack of a structured approach to categorisation and workflow management. Traditional RFIs often suffer from delays, miscommunication, and unclear accountability, largely because of their reliance on ad-hoc submission methods such as email exchanges, spreadsheets, and unstructured databases. These limitations have contributed to project delays and increased costs, necessitating a structured framework to optimise information flow and ensure efficient issue resolution.

The refinement of the RFI process was undertaken through a systematic approach that included extensive industry engagement and literature analysis. The first phase of refinement was based on Hannah et.al., 2012 research, which identified common RFI reasoning codes. However, these reasoning codes lacked a hierarchical structure, making it difficult to streamline the process effectively. To address this issue, structured industry workshops were conducted, where professionals contributed insights to develop an improved classification system. The outcome of these workshops was the introduction of top-tier RFI categories, designed to enhance clarity and simplify the tracking of RFIs throughout their lifecycle. These categories include Programme, Technical, Cost, and Other, each of which encompasses relevant subcategories aligned with industry best practices.

The refined RFI process is distinctly different from traditional methods due to its structured categorisation, defined accountability, and integration into a digital submission platform. Figure 6.1 illustrates the evolution of the RFI process, demonstrating the transition from an unstructured, manual workflow to a digitised system that incorporates Lean and BIM principles. The structured categorisation ensures that RFIs are properly classified at the time of creation, reducing ambiguity and enabling targeted responses from project stakeholders. By implementing a systematic approach, the refined RFI process enhances efficiency, improves response times, and fosters better collaboration across project teams.

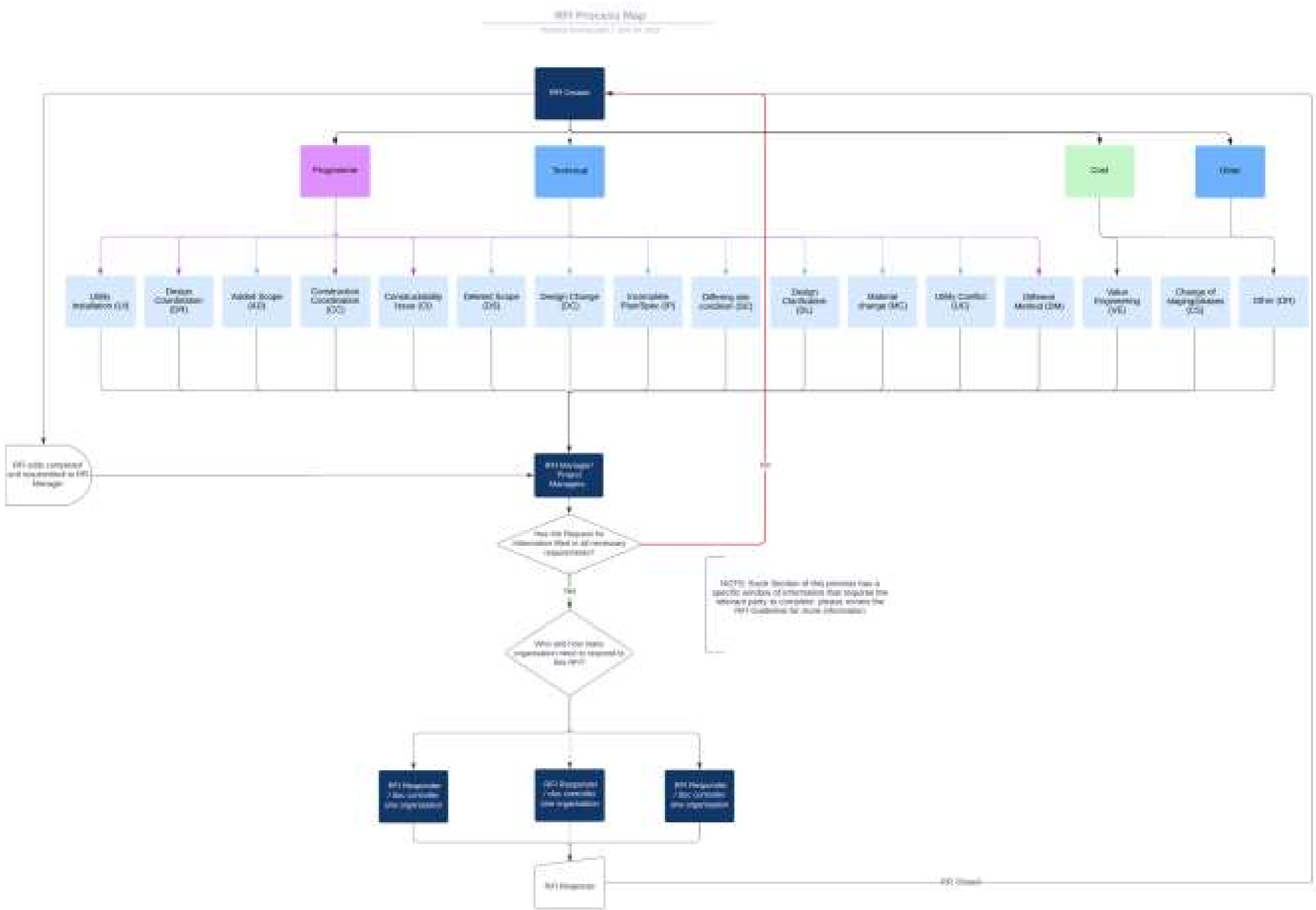


Figure 6-1 Refined RFI Process Map

6.3.1 Definition of RFI Categories

The structured RFI framework classifies Requests for Information (RFIs) into four primary categories to improve tracking, response efficiency, and accountability:

1. Programme-Related RFIs: RFIs that impact project scheduling, sequencing, or phasing of work. These queries often involve construction staging, coordination among multiple trades, and unforeseen site conditions that affect timelines.
2. Technical RFIs: RFIs that seek clarification on design intent, technical construction details, or specification compliance. These include construction coordination, material compatibility concerns, and discrepancies in contract documents.
3. Cost-Related RFIs: RFIs that influence project budgeting, procurement, or contractual variations. These typically involve material substitutions, cost-saving proposals, and financial impacts due to design modifications.

4. Other RFIs: RFIs that do not fit into the above categories but still require clarification for project continuity. These may include issues related to certification requirements, warranties, regulatory approvals, and penalties.

6.3.2 Subcategories of RFI Categories and Their Importance

To further enhance the structured classification system, each RFI category is divided into subcategories Table 6.1, which provide additional granularity and precision in identifying the nature of the issue. Properly identifying and categorising RFIs at the subcategory level is critical for the following reasons:

- Improved Tracking and Trend Analysis: Assigning RFIs to specific subcategories allows project teams to monitor trends, identify recurring issues, and implement preventive measures to reduce the volume of RFIs over time.
- Enhanced Responsiveness: Categorising RFIs at the subcategory level ensures that queries are immediately routed to the appropriate experts, reducing response time and minimising project delays.
- Proactive Issue Resolution: By understanding the root causes of RFIs, teams can develop targeted solutions, refine design documentation, and improve coordination to mitigate future occurrences.
- KPI Development and Performance Evaluation: Tracking subcategories allows project managers to measure the effectiveness of risk management strategies, identify bottlenecks, and optimise resource allocation.
- Integration with Digital Platforms: Structured classification improves interoperability with BIM and other digital construction tools, making it easier to tag and retrieve relevant RFIs within project models.

Table 6-1 RFI Categories, Subcategories, and Reasoning Codes

Technical	**Scope Changes**	**Added Scope (AD)**	**Addition of items to the original project scope.**
	Coordination Issues	Construction Coordination (CC)	Organising and coordinating construction-related procedures, schedules, and safety items.
	Feasibility Challenges	Constructability Issue (CI)	Difficulty in constructing an item as designed.
	Site Conditions	Differing Site Condition (DS)	Previously unknown impediments discovered at the site that were not accounted for in the contract.
	Design Modifications	Design Change (DC)	Request to modify a design to simplify efforts or correct errors.
	Documentation Errors	Incomplete Plans/Specs (IP)	Errors or omissions in the plans/specifications.
	Scope Reduction	Deleted Scope (DS)	Scope or line items to be removed from the project.
	Design Clarifications	Design Clarification (DL)	Additional clarification requested for design components.
	Material Adjustments	Material Change (MC)	Change in specified materials due to availability or performance benefits.
	Utility Conflicts	Utility Conflict (UC)	Pipes, lines, or boxes preventing the construction strategy from proceeding.
Programme	Scheduling Coordination	Construction Coordination (CC)	Coordination-related queries that impact scheduling.

	Feasibility Challenges	Constructability Issue (CI)	Issues impacting the feasibility of the construction process.
	Methodology Adjustments	Different Method (DM)	Change in installation technique or construction method.
	Phasing Modifications	Change of Staging/Phasing (CS)	Sequence of construction requires reorganisation due to resource limitations.
	Multi-Team Coordination	Design Coordination (DR)	Coordination of the design among multiple project entities.
	Utility Integration	Utility Installation (UI)	Utility-related conflicts affecting project scheduling.
Cost	Cost-Saving Measures	Value Engineering (VE)	Cost-reduction and construction improvement techniques.
	Payment and Financial Issues	Other (OR) – Payment Method	Any justified RFI related to payment methods.
Other	Contractual Considerations	Penalties	RFIs related to contract penalties and associated implications.
	Warranty Concerns	Warranties	Queries regarding warranty terms and conditions.
	Administrative Issues	Non-Design-Related	RFIs concerning operational, legal, or administrative aspects of the project.
	Certification Requirements	Certification	Requests related to compliance with certification requirements.

6.4 Comparison of Traditional vs. Refined RFI Process

The traditional RFI process is plagued by a lack of structure, leading to delays and inefficiencies in issue resolution. Without a standardised classification system, RFIs are often misdirected, causing confusion among project stakeholders and prolonging response times. In contrast, the refined RFI process introduces a structured framework that enhances efficiency and accountability. Table 6.2 presents a detailed comparison of key differences between the traditional and refined RFI processes:

Table 6-2Comparison of Traditional and BIM-Lean Integrated RFI Processes

Aspect	Traditional RFI Process	Refined RFI Process
Communication Method	Emails, spreadsheets, disconnected records	Centralised digital platform (BIM-integrated)
Categorisation	No formal structure; ad-hoc categorisation	Categorised into Programme, Technical, Cost, and Other
Process Flow	No clear roles, RFIs pass between stakeholders randomly	Defined roles: Creator → Manager → Responder
Prioritisation	No priority-based structure	Lean prioritisation techniques applied
Accountability	Ambiguous responsibility, delays common	Structured role allocation, escalation mechanism integrated

The structured approach ensures that RFIs are processed efficiently, reducing unnecessary delays and ensuring that each request is managed within a well-defined framework. By implementing predefined categories and subcategories, the refined process facilitates improved tracking and prioritisation, ensuring that urgent issues receive immediate attention while lower-priority RFIs are handled in an organised manner.

6.5 Structured RFI Submission: Essential Information Required from RFI Creators

To facilitate the efficient processing of RFIs, the refined system mandates that RFI Creators provide structured and comprehensive information when submitting requests. The structured categorisation ensures that all RFIs are properly classified from the outset, reducing the likelihood of miscommunication and unnecessary follow-ups. The refined RFI submission form, as illustrated in Figure 6.2, incorporates essential fields that must be completed for an RFI to be processed effectively. These fields include:

1. Project Name: The project name must be selected from a predefined list to ensure proper tracking and organisation of RFIs.
2. RFI Type: The RFI must be categorised into one of the top-tier categories: Programme, Technical, Cost, or Other. This classification determines how the RFI is processed and who is responsible for addressing it.

3. Priority Level: The urgency of the RFI must be indicated as High, Medium, or Low. This prioritisation ensures that RFIs impacting critical project activities receive prompt attention.
4. Description: A clear and detailed explanation of the issue must be provided, allowing the RFI Manager and Responder to understand the query without requiring further clarification.
5. BIM Link: The RFI should be linked directly to the project's BIM model to provide visual context for the issue being raised. This feature enhances communication by enabling stakeholders to view the problem area in real time.
6. Supporting Documentation: Relevant drawings, specifications, contractual references, or other supporting documents must be attached to the submission. These documents provide additional context and assist in expediting the resolution process.

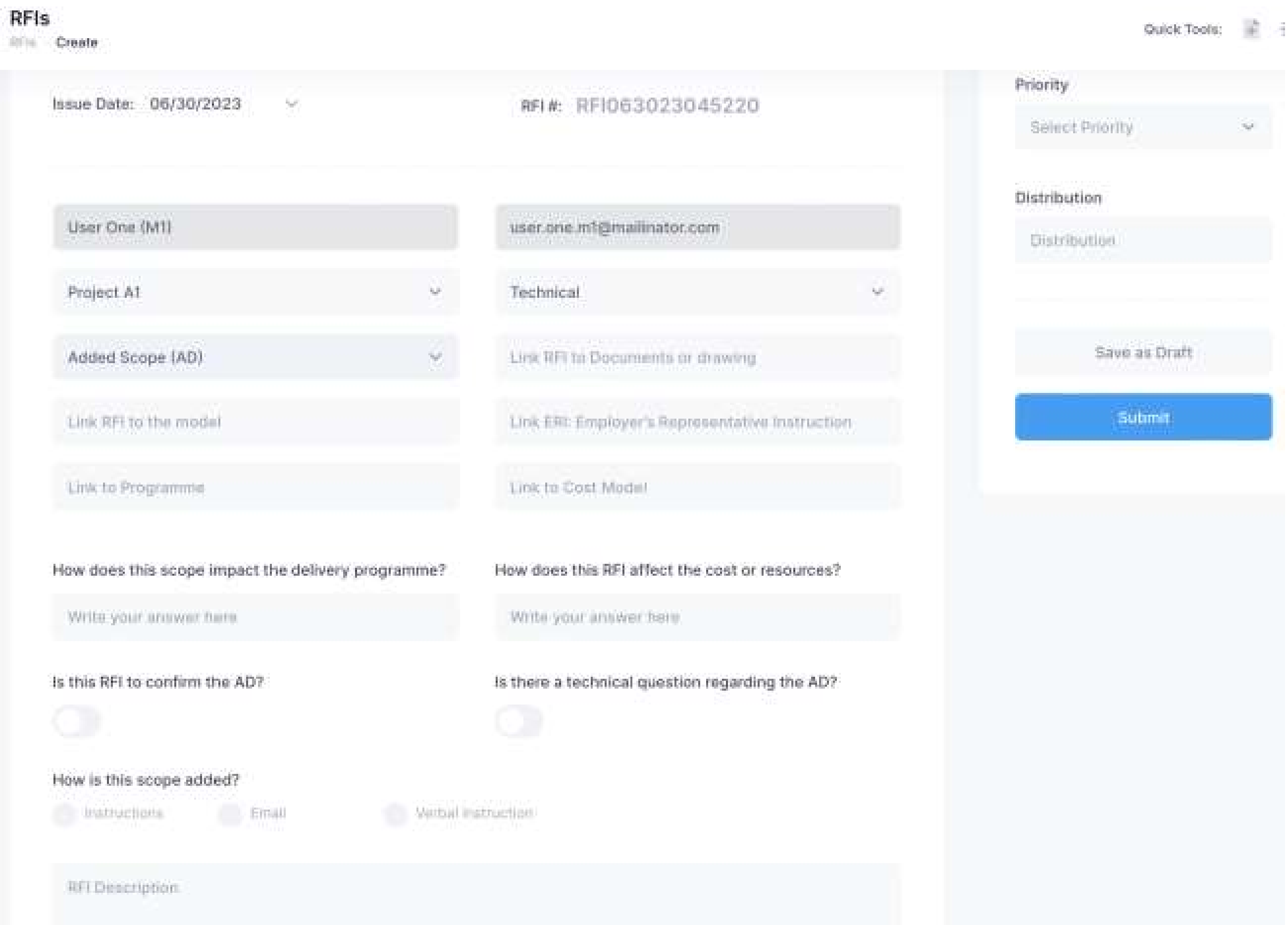


Figure 6-2 RFI field for creator

By enforcing a structured data entry process, the refined RFI system enhances efficiency, minimises ambiguity, and improves response accuracy. This structured submission method ensures that each RFI is handled with clarity and accountability, significantly improving resolution times and stakeholder coordination.

6.6 RFI Processing and Response

The processing and response phase of the RFI workflow is fundamental to ensuring the effective management of project information, timely resolution of technical queries, and minimisation of disruptions in construction workflows. The conventional RFI process is often associated with delays, lack of prioritisation, and inefficiencies in communication, resulting in project overruns and compromised decision-making. The proposed BIM-Lean integrated RFI process aims to address these inefficiencies by providing a structured, systematic, and transparent method for resolving RFIs, ensuring that queries are efficiently prioritised, assigned, and tracked until resolution. By leveraging BIM for real-time data visualisation and Lean Construction principles for workflow optimisation, the process facilitates proactive rather than reactive RFI management.

6.6.1 Structured RFI Processing and Assignment

The initial step in RFI resolution involves the structured review and assignment of each query to an appropriate stakeholder. Traditional RFI workflows are characterised by unstructured task delegation, lack of clarity in accountability, and inefficient resource allocation, often resulting in low-priority RFIs receiving attention before more urgent ones. This inefficiency leads to delays in resolving time-sensitive project issues, increasing the risk of cost escalations and workflow disruptions.

The BIM-Lean integrated approach introduces a structured processing method where the RFI Manager assumes a central role in verifying, triaging, and allocating RFIs based on urgency, complexity, and project impact. The structured workflow is designed to:

- Ensure completeness by verifying that RFIs contain clear descriptions, supporting documents, and BIM-linked references before progressing.
- Categorise RFIs based on urgency, classifying them into high, medium, or low priority according to their impact on the project's critical path and programme schedule.
- Assign RFIs to the most relevant responder, whether a design consultant, project manager, or engineering team, depending on the nature of the issue and its technical requirements.
- Escalate high-priority RFIs that pose risks to sequencing, safety compliance, or contractual deliverables, ensuring that urgent matters are resolved with minimal disruption.

A significant limitation in conventional RFI workflows is the lack of a structured prioritisation framework, leading to inefficient handling of critical queries. The proposed approach integrates Lean prioritisation strategies, particularly through the Last Planner System (LPS), ensuring that urgent RFIs are addressed before they impede project milestones. Research in Lean Construction suggests that structured prioritisation significantly improves response efficiency, enhances decision-making clarity, and minimises non-value-adding tasks.

6.6.2 Lean-Based RFI Prioritisation and Weekly Planning Meetings

A core feature of the BIM-Lean RFI process is the introduction of Lean-based prioritisation, ensuring that RFIs are managed in accordance with project requirements and not arbitrarily processed. In traditional workflows, RFIs are often handled on a first-come, first-served basis, leading to scenarios where minor issues are resolved before critical project queries. This inefficiency can result in avoidable delays, misallocation of project resources, and missed compliance deadlines.

The implementation of Lean principles, particularly through LPS, ensures that RFIs are processed according to their effect on project continuity and stakeholder coordination. The RFI Manager assesses whether the RFI directly impacts construction sequencing, and if so, it is flagged for immediate resolution. This process guarantees that RFIs affecting regulatory approvals, supply chain coordination, or design feasibility receive priority attention.

The proposed RFI process also incorporates weekly planning meetings, designed to enhance tracking, accountability, and transparency in RFI workflows. These meetings serve multiple functions, including:

- Ensuring all unresolved RFIs remain actively monitored, preventing oversight.
- Reallocating resources as necessary to expedite responses to high-priority RFIs.
- Utilising BIM integration to visually assess pending RFIs and their implications on project design or sequencing.
- Applying Lean scheduling principles to prevent bottlenecks and inefficient task management.

Studies in Lean Construction indicate that structured planning meetings enhance workflow predictability, reduce unplanned delays, and improve coordination across multidisciplinary project teams.

6.6.3 RFI Resolution and Closure

A recurring challenge in traditional RFI processes is the lack of a defined closure mechanism, leading to RFIs being left unresolved or closed ambiguously. This often results in duplicate RFIs for the same issue, causing unnecessary project delays and misalignment between design, procurement, and construction teams.

The BIM-Lean framework addresses this issue by introducing a structured resolution and closure process to ensure that all RFIs are fully resolved before project progression. The closure process follows a multi-step verification approach:

1. The RFI Responder submits a detailed reply, incorporating BIM-linked references and supporting documentation to facilitate comprehensive understanding.
2. The RFI Manager verifies the response, ensuring that it aligns with the project requirements and provides an adequate resolution.
3. The RFI Creator reviews the response, confirming that all aspects of the query have been sufficiently addressed.
4. If the response requires further clarification, the RFI remains open for additional modifications.
5. Once fully resolved, the RFI is formally closed and archived, ensuring future traceability and documentation integrity.

A key advantage of the proposed BIM-Lean RFI system is its ability to provide a centralised digital record of all RFIs, ensuring that historical data is readily accessible for auditing, compliance, and continuous improvement initiatives

6.6.4 Conclusion

The integration of BIM and Lean Construction principles into RFI processing and response workflows offers a systematic and highly efficient approach to managing RFIs in construction projects. By implementing structured prioritisation, role-based accountability, and digital process tracking, the BIM-Lean integrated RFI process significantly enhances project communication, workflow efficiency, and stakeholder collaboration. The key benefits include:

1. Improved response times due to Lean-based prioritisation of RFIs.
2. Reduction in redundant RFIs through structured submission and tracking mechanisms.
3. Increased transparency and accountability by linking RFIs to BIM models for clear visual representation.
4. Minimised risk of project delays by ensuring critical RFIs are escalated and resolved without unnecessary bottlenecks.

By leveraging Lean Construction principles for workflow optimisation and BIM tools for enhanced visibility, the proposed RFI process establishes a structured, scalable, and proactive framework for managing RFIs, improving project outcomes and long-term industry efficiency.

6.7 Summary of the Proposed RFI Process

The proposed BIM-Lean integrated RFI process represents a significant advancement in the management of Requests for Information (RFIs) in construction projects, addressing long-standing inefficiencies such as delays, fragmented communication, and a lack of prioritisation. By incorporating Building Information Modelling (BIM) and Lean Construction methodologies, the new approach ensures that RFIs are tracked, prioritised, and resolved efficiently, ultimately improving project performance, communication flow, and stakeholder coordination.

The traditional RFI process has been criticised for its reliance on disconnected platforms, excessive response times, and inefficient workflows. In contrast, the proposed process eliminates these inefficiencies by integrating BIM for real-time issue tracking and Lean principles for process optimisation. The combination of these two methodologies allows for a structured and transparent workflow in which RFIs are clearly documented, visually represented within the BIM model, and managed in accordance with project priorities.

6.7.1 Key Features of the Proposed RFI Process

The new system introduces several enhancements to the traditional RFI workflow, ensuring that queries are handled in a structured, efficient, and accountable manner. The key features include:

1. Transition from Fragmented Systems to a Digital, Integrated Platform

- The traditional reliance on emails, spreadsheets, and manual tracking methods often leads to RFIs being lost, duplicated, or delayed.
- The new system centralises RFIs within a BIM-integrated digital platform, ensuring that all project stakeholders have real-time access to RFI status, history, and associated project components.
- This transition significantly enhances transparency and traceability, preventing information loss and reducing project risks.

2. BIM Integration for Real-Time Issue Identification and Tracking

- The ability to link RFIs directly to BIM models enables project teams to visualise issues within the project environment, reducing ambiguity and misinterpretation.
- Stakeholders can view RFIs in context, ensuring that design, engineering, and construction teams understand the precise location, scope, and impact of the issue.
- This approach minimises the need for back-and-forth communication, as RFIs are directly connected to specific project elements.

3. Lean-Based Prioritisation for Optimised Workflow Efficiency

- Traditional RFI processes lack a structured prioritisation mechanism, often leading to delays in resolving time-sensitive queries.
- The new system incorporates Lean Construction principles, particularly the Last Planner System (LPS), to prioritise RFIs based on their impact on the project schedule.

- This ensures that high-priority RFIs—those affecting safety, sequencing, and contractual deliverables—are resolved first, while lower-priority RFIs follow a structured workflow without delaying critical project tasks.

4. Structured Roles and Responsibilities

- The lack of clear role definition in conventional RFI workflows often results in inefficiencies and delays, as responsibility is not well-defined.
- The proposed process introduces three key roles:
    - The RFI Creator initiates the query, ensuring that all required information is included.
    - The RFI Manager reviews the submission, assigns priority, and directs the RFI to the correct responder.
    - The RFI Responder provides a detailed response and ensures that all necessary actions are taken before the RFI is resolved.
- This structured role allocation eliminates confusion, enhances accountability, and prevents mismanagement of RFIs.

5. Automated Tracking and Status Updates

- The new RFI platform incorporates an automated tracking system that provides users with real-time updates on RFI progress.
- RFIs transition through stages of resolution, including:
    - Submitted: The RFI is pending review by the RFI Manager.
    - In Progress: The assigned responder is working on a resolution.
    - Responded: A response has been provided and awaits final review.
    - Closed: The RFI is fully resolved and archived for future reference.
- The tracking system enhances workflow efficiency, ensuring that RFIs are not stalled due to mismanagement or oversight.

6. Integration of Weekly Planning Meetings

- The proposed system includes structured weekly review meetings, where project stakeholders evaluate active RFIs, identify bottlenecks, and allocate resources effectively.
- These meetings leverage Lean principles to prevent delays and ensure that high-impact RFIs are addressed in a timely manner.
- The structured review process enhances coordination and accountability, ensuring that RFIs do not cause unnecessary disruptions to project progress.

7. Continuous Improvement Through Post-Project RFI Analysis

    - The new process ensures that all RFIs are archived for future reference, allowing project teams to review historical data and identify recurring issues.
    - Post-project analysis provides insights into average response times, frequency of RFIs by category, and areas for workflow enhancement.
    - This aligns with Lean Construction's continuous improvement approach, ensuring that lessons learned from past RFIs contribute to future project efficiency.

6.7.2 Summary of the Benefits of the Proposed RFI Process

The implementation of the BIM-Lean integrated RFI framework offers a systematic and structured approach to managing RFIs, significantly improving communication, workflow efficiency, and stakeholder collaboration. The key benefits include:

- Reduction in RFI response times by implementing Lean-based prioritisation.
- Improved issue resolution through BIM-driven RFI tracking and visualisation.
- Minimisation of miscommunication and duplication by ensuring RFIs are managed within a centralised digital system.
- Elimination of process inefficiencies through structured roles and accountability mechanisms.
- Enhanced project coordination by integrating weekly planning meetings and tracking tools.
- Long-term process optimisation by leveraging historical RFI data for continuous improvement.

The combination of BIM and Lean methodologies in RFI management provides a scalable, structured, and efficient process that not only enhances current project execution but also serves as a model for future improvements in construction project delivery. The structured approach ensures that RFIs are not only processed more efficiently but also contribute to long-term industry advancements in digital construction management.

6.8 Summary of Key Website Features

The BIM-Lean integrated RFI process incorporates a web-based management system that enhances information flow, issue resolution, and process efficiency within construction projects. The implementation of this digital platform ensures that project stakeholders can submit, track, and respond to RFIs in real time, thereby addressing inefficiencies commonly associated with traditional RFI workflows. The structured nature of the website promotes transparency, accountability, and timely resolution of project queries while integrating BIM functionalities and Lean principles to optimise performance. Log in credential Figure 6.1.

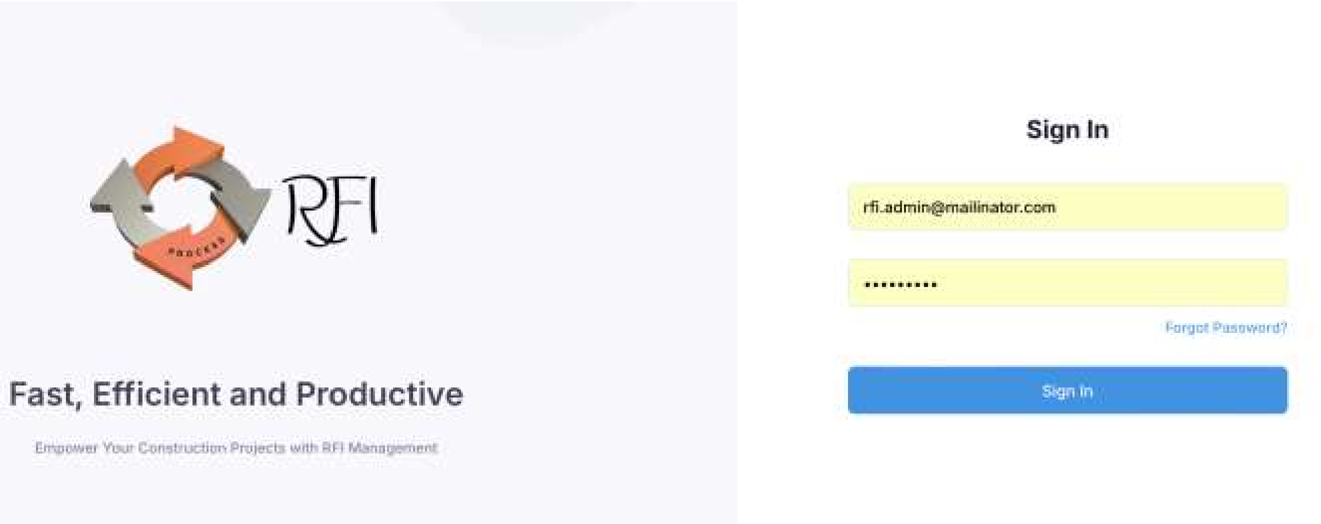


Figure 6-3 RFI Website login page

6.8.1 Dashboard Overview

The dashboard serves as the central hub for RFI management, providing an overview of the status of all RFIs within a project (Figure 6.2). The dashboard allows users to filter RFIs based on status (open, in progress, closed), priority level (high, medium, low), and assigned team members. This enables project teams to efficiently monitor and manage RFIs, ensuring that urgent issues are addressed without delay. Additionally, the dashboard includes visual indicators, such as progress bars, which assist in tracking RFIs throughout the resolution process.

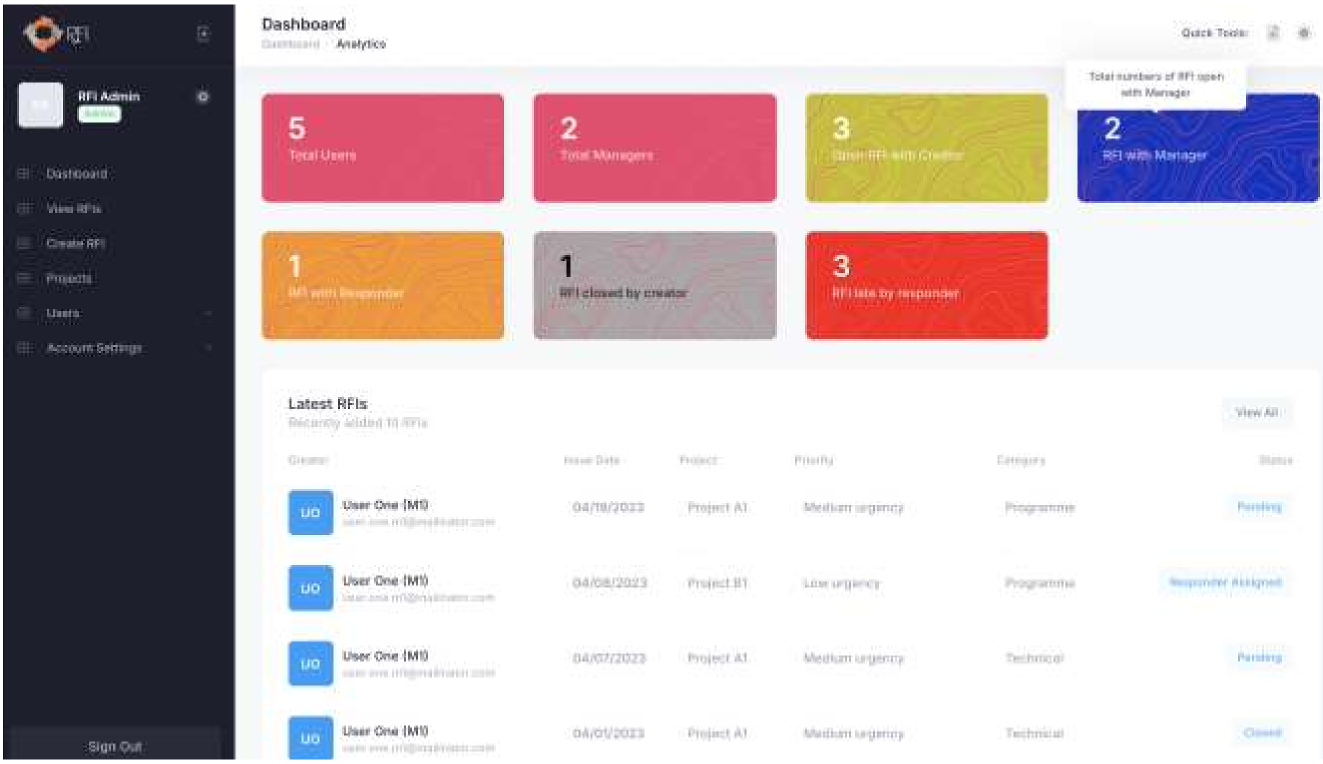


Figure 6-4 Dashboard Overview

6.8.2 RFI Creation Tool

The submission process for RFIs has been restructured to ensure that all necessary details are included at the time of submission. This enhancement minimises delays caused by incomplete or ambiguous RFIs. The RFI creation tool requires users to provide the following information:

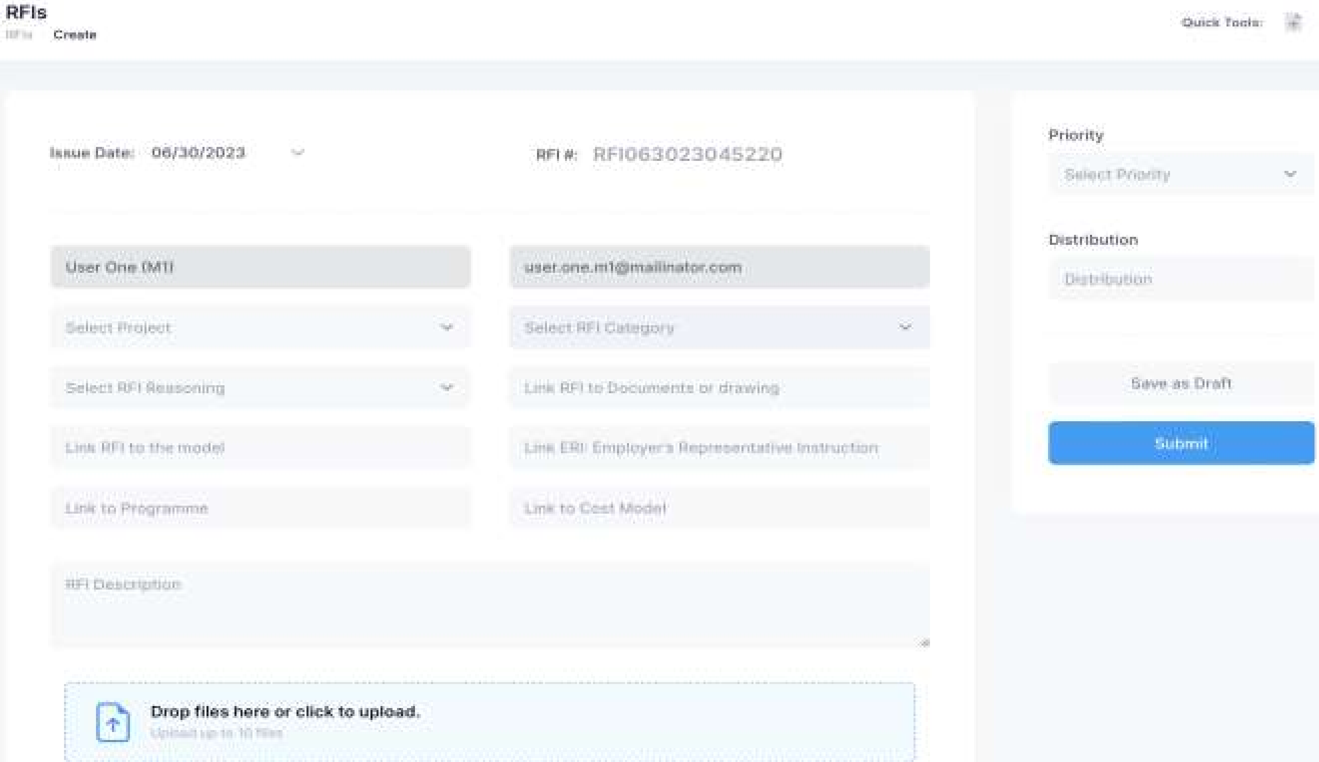


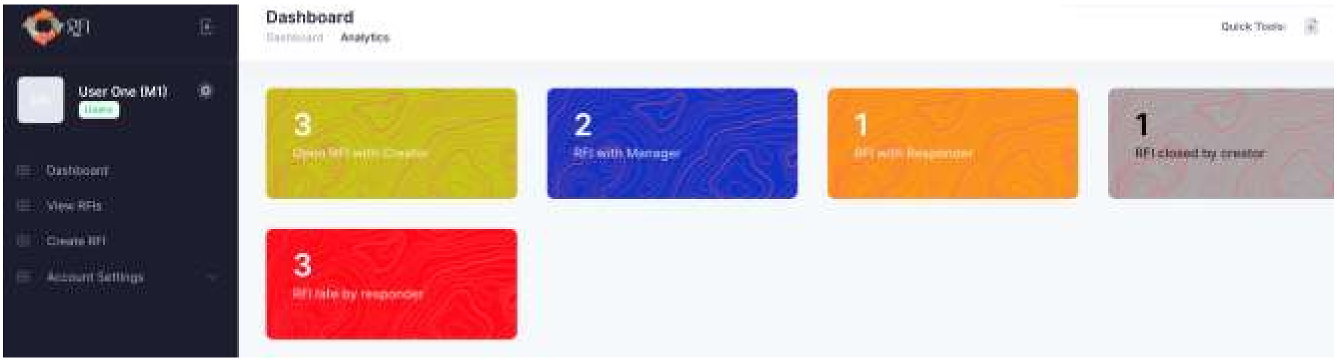
Figure 6-5 Raising RFI

- The project name to identify the relevant scope.
- The RFI type, categorised as Technical, Cost, Programme, or another predefined classification.
- The priority level, which is assigned as high, medium, or low depending on the urgency of the query.
- A detailed description of the issue, ensuring that the information is presented clearly and concisely.
- A BIM link, enabling the RFI to be connected to a specific location or element within the project model, facilitating better understanding among project stakeholders.
- Supporting attachments, such as drawings, specifications, or contractual documents, which provide additional context for the query.

The structured submission process ensures that RFIs contain all necessary information before being processed, thereby reducing unnecessary communication delays.

6.8.3 Real-Time Tracking System

The website includes a real-time tracking system, which allows users to monitor the progress of RFIs from submission to closure. The system categorises RFIs into the following statuses:



- Submitted – The RFI has been created and is pending review.
- In Progress – The assigned responder is working on a resolution.
- Responded – A response has been submitted and is awaiting review.
- Closed – The RFI has been resolved and archived.

Automated notifications ensure that project stakeholders are kept informed of pending actions and approaching deadlines, reducing the likelihood of unresolved RFIs delaying project activities.

6.8.4 Role-Specific Actions

The website incorporates a role-based access system, ensuring that different project stakeholders have defined responsibilities and appropriate permissions. The primary roles within the system include:

- The RFI Creator, who initiates the RFI submission, provides necessary documentation, and assigns an urgency level.
- The RFI Manager, who reviews the submission for completeness, assigns priority, and directs the RFI to the appropriate responder.
- The RFI Responder, who provides a resolution, attaches any required clarifications, and, where applicable, updates BIM-linked RFIs to reflect changes.

This structured role allocation prevents mismanagement of RFIs and ensures that each query is processed by the appropriate team members in a timely and accountable manner.

6.8.5 BIM Integration for Enhanced Collaboration

A significant feature of the website is its integration with BIM models, which enables RFIs to be directly linked to specific project elements (Figure 6.3). This integration improves coordination by:

- Allowing stakeholders to visually inspect the affected area within the project model.
- Reducing misinterpretation of textual RFI descriptions by providing a graphical representation of the issue.
- Allowing design and construction teams to annotate updates, add clarifications, and track modifications directly within the BIM environment.

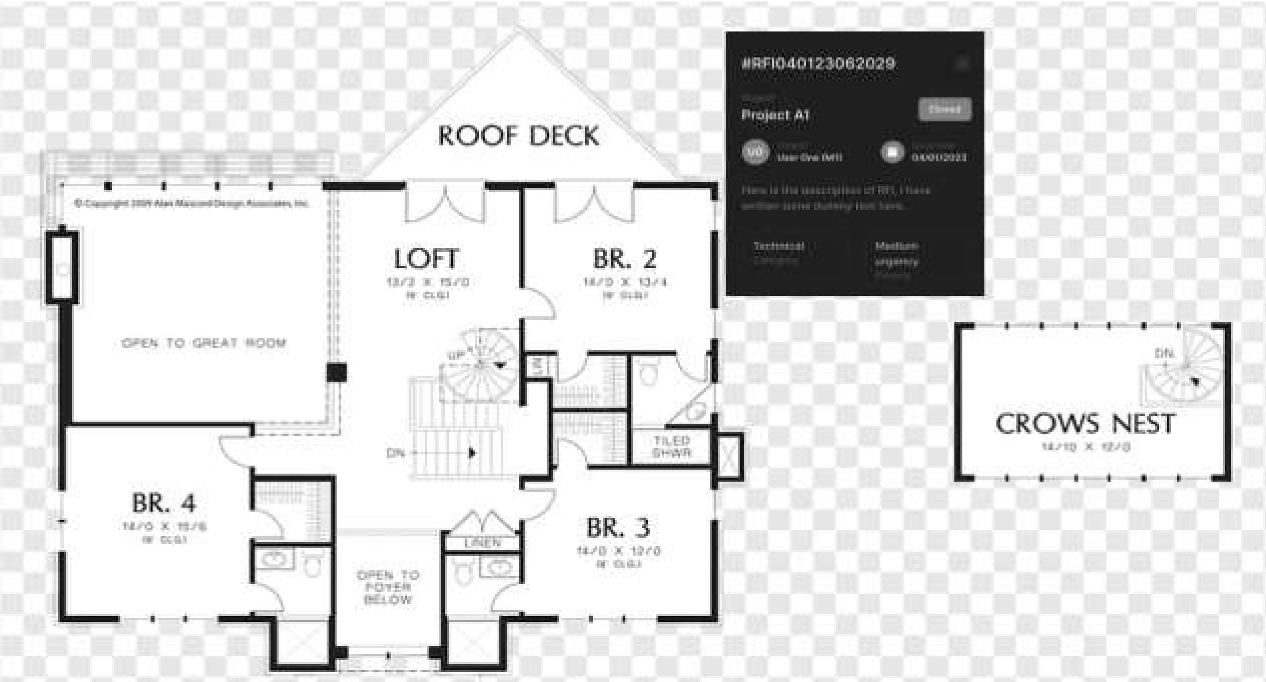


Figure 6-6 Tagging model's, drawings or documents

This functionality ensures that RFIs are accurately documented and efficiently resolved, reducing delays and improving the overall quality of project communication.

6.8.6 Weekly Planning and Coordination Tools

The website includes scheduling and coordination tools, which facilitate weekly project meetings to discuss active RFIs. These meetings serve as an opportunity to:

- Review unresolved RFIs and prioritise urgent queries.
- Allocate resources effectively to expedite responses.
- Assess potential project bottlenecks caused by unresolved RFIs.

By integrating structured weekly review sessions, the system enables project teams to manage RFIs in a proactive manner, ensuring that outstanding issues do not impact critical project activities.

6.8.7 Post-Project Review and Continuous Improvement

Upon project completion, the website archives all RFIs, ensuring that past project data is available for future reference and process optimisation. The system allows project teams to:

- Review historical RFIs to identify trends and recurring issues.
- Analyse response times and frequency of RFIs by category, such as technical, cost-related, or programme-related queries.
- Identify areas for improvement in RFI management, ensuring that lessons learned are incorporated into future projects.

This aligns with Lean Construction principles, which emphasise continuous improvement and the reduction of inefficiencies over time. The ability to analyse past RFI data enables project teams to refine workflows and implement best practices in future project execution.

6.8.8 Summary of Website Features and Benefits

The web-based RFI platform represents a structured and efficient tool for managing RFIs within a BIM-Lean integrated framework. The key features and benefits of the platform include:

- A real-time RFI tracking system, enabling progress monitoring and reducing resolution time.
- Role-specific actions, ensuring that RFIs are managed with clear responsibilities assigned to the relevant personnel.
- Seamless BIM integration, allowing RFIs to be linked to project models for better visualisation and faster resolution.
- Structured RFI categorisation and prioritisation, ensuring that high-impact RFIs receive timely attention.
- Coordination tools for weekly project reviews, which facilitate proactive RFI management.
- Archival and continuous improvement mechanisms, allowing for process optimisation based on historical RFI data.

By incorporating BIM technology and Lean Construction principles, the RFI website enhances collaboration, communication, and workflow efficiency within construction projects. The structured nature of the system ensures that RFIs are not only processed effectively but also contribute to long-term improvements in project delivery and industry-wide best practices.

Chapter: 7 Thesis Summary

7.1 Introduction:

The Architecture, Engineering, and Construction (AEC) industry is inherently complex, requiring efficient communication and streamlined workflows to ensure successful project execution. One of the primary communication tools in construction projects is the Request for Information (RFI) process, which facilitates the resolution of ambiguities, discrepancies, and technical issues that arise throughout the project lifecycle. Despite its crucial role, the traditional RFI process is plagued by inefficiencies, including delays, fragmented communication, and lack of standardisation, which can lead to project disruptions, increased costs, and stakeholder misalignment.

This research proposes a BIM-Lean integrated RFI process to address these inefficiencies by leveraging Building Information Modelling (BIM) for enhanced visualisation and Lean Construction methodologies for process optimisation. The integration of these two approaches ensures a more structured, efficient, and transparent RFI workflow that reduces response times, improves information accessibility, and fosters collaboration among project stakeholders. The following sections summarise the key objectives, methodologies, findings, and contributions of this study, concluding with recommendations for future research and industry adoption.

7.2 Research Aim and Objectives:

The primary aim of this research was to develop and validate a comprehensive guideline for enhancing the RFI process in the construction industry by integrating BIM and Lean methodologies. To achieve this aim, the research was structured around six key objectives:

1. Understanding BIM and Lean Principles – Conducting a literature review to explore the concepts, benefits, and applications of BIM and Lean in construction projects.
2. Assessing the Current RFI Process – Evaluating the traditional RFI process, identifying its challenges, inefficiencies, and impact on project timelines and costs.
3. Investigating BIM and Lean Applications for RFI Management – Exploring how these methodologies can be adapted to enhance the RFI workflow.
4. Developing a New RFI Process – Designing a structured RFI process map that integrates BIM's visualisation capabilities with Lean's efficiency-driven workflow management.
5. Creating a Practical Guideline and Visualisation Tool – Developing a dummy website and a comprehensive implementation guideline to facilitate the industry-wide adoption of the new RFI process.
6. Validating the Proposed Process – Conducting focus groups with industry professionals to test and refine the proposed approach, ensuring feasibility and effectiveness.

7.3 Literature Review:

The literature review established that traditional RFI workflows are highly fragmented and inefficient, often relying on unstructured communication methods such as emails, spreadsheets, and manual logs. These inefficiencies contribute to delayed response times, miscommunication, and project overruns, making it imperative to adopt a more structured and digital-first approach.

The review also highlighted the transformative potential of BIM and Lean Construction. BIM enables real-time data sharing, clash detection, and enhanced issue tracking, whereas Lean Construction focuses on eliminating waste, improving process flow, and enhancing collaboration. Research by Sacks et al. (2010) supports the integration of BIM and Lean to enhance construction workflows, yet limited research exists on their combined application to RFI management. This gap in knowledge provided the foundation for the development of the proposed BIM-Lean integrated RFI process.

7.4 Research Methodology:

A mixed-methods research approach was adopted to ensure a comprehensive investigation into the RFI process and its improvement through BIM and Lean methodologies. The research utilised both quantitative and qualitative data collection methods to capture industry insights, validate findings, and refine the proposed process.

- Surveys – Distributed to industry professionals to gather quantitative data on the frequency of RFIs, response times, and the extent of BIM and Lean adoption. The survey aimed to identify common inefficiencies and challenges in the existing RFI workflow.
- Focus Groups – Conducted with experienced AEC professionals to obtain qualitative insights into RFI challenges and to evaluate the proposed BIM-Lean integrated RFI system.
- Case Study Analysis – Applied to compare traditional and BIM-Lean RFI processes, assessing their impact on workflow efficiency, communication effectiveness, and project timelines.

7.5 Data Analysis and Findings:

The data analysis revealed several critical insights into the inefficiencies of the traditional RFI process and the benefits of integrating BIM and Lean methodologies:

1. Challenges of the Traditional RFI Process – Survey results confirmed that the average RFI response time was 8 days, contributing to significant project delays and miscommunication. The reliance on disconnected documentation methods resulted in frequent rework and inefficiencies.
2. BIM and Lean Adoption Rates – While 80% of surveyed participants reported using BIM tools, only 45% consistently applied Lean principles in their RFI workflows, highlighting a disparity in industry adoption levels.
3. Improvements Through BIM-Lean Integration – The proposed process demonstrated a 30% reduction in RFI response times, with improved transparency and accountability across project teams. The BIM-driven issue tracking system allowed for better issue identification and resolution, while Lean prioritisation ensured that critical RFIs were addressed first.
4. Stakeholder Feedback and Process Refinements – Industry professionals praised the clarity and structure of the new process, particularly the defined roles of RFI Creator, Manager, and Responder, which reduced ambiguities in accountability.

7.6 Development of the Proposed RFI Process:

The proposed RFI process integrates BIM's ability to visualise issues within the project model and Lean's focus on optimising workflows and reducing waste. The new process introduces clear submission guidelines, allowing RFIs to be categorised by type (technical, cost-related, programme) and assigned a priority level based on project urgency. RFIs are linked directly to the BIM model, providing a visual context for each query and ensuring all stakeholders can view the issue in real time.

A dummy website was developed as part of the research, allowing stakeholders to submit, track, and manage RFIs digitally. Features include:

- A dashboard for real-time tracking of RFIs.
- A structured RFI submission form linked to BIM for visual clarity.
- Prioritisation tools based on Lean methodologies to ensure critical RFIs are addressed first.
- Post-project archival for continuous improvement in future projects.

7.7 Validation of the Refined RFI Process

The refined RFI process was validated through a series of industry workshops and focus group discussions, where professionals tested and provided feedback on the new categorisation system. The validation process confirmed that the structured categorisation improved workflow efficiency, reduced processing times, and enhanced overall project communication. Key observations from the validation sessions included:

1. Improved Clarity: The predefined categorisation eliminated ambiguity, allowing RFIs to be easily classified and tracked. Participants noted that structured classification reduced miscommunication and streamlined issue resolution.
2. Enhanced Responsiveness: The structured data entry process resulted in a 30% reduction in RFI response times. By ensuring that all essential information was provided at the time of submission, delays due to incomplete RFIs were significantly minimised.
3. Better Collaboration: The integration of a digital submission platform with predefined roles for RFI Creators, Managers, and Responders improved accountability and reduced workflow inefficiencies. Stakeholders reported that the new system allowed for clearer communication and faster decision-making.

Based on feedback from the validation sessions, minor refinements were made to the RFI categorisation framework to ensure that it aligns with real-world project challenges. The final RFI process map, as illustrated in Figure 6.1, demonstrates the optimised workflow and structured categorisation that underpin the new approach to RFI management.

7.7.1 Summary of Refinements

The structured RFI categorisation and workflow introduced in this research represent a significant advancement over traditional methods, addressing longstanding inefficiencies in RFI management. The integration of a top-tier categorisation system, combined with a structured submission process and digital tracking, ensures greater accountability, reduced resolution times, and improved stakeholder collaboration. The refinements implemented through industry engagement have resulted in an optimised RFI process that enhances efficiency and provides a scalable framework for implementation across diverse construction projects.

7.8 Conclusion and Contributions:

This thesis makes significant contributions to the AEC industry by addressing the long-standing inefficiencies of the traditional RFI process. The integration of BIM and Lean methodologies offers a structured, efficient approach to RFI management, resulting in faster response times, improved communication, and greater accountability. The research demonstrates that combining BIM's visualisation tools with Lean's process optimisation strategies can dramatically enhance project outcomes.

The proposed RFI process has practical implications for the construction industry, offering a scalable framework that can be applied across various project types. Moreover, the development of a practical guideline and dummy website serves as a valuable tool for industry professionals seeking to improve RFI management. Future work will focus on implementing and testing the system in real-life construction projects to further validate its effectiveness and refine the process.

7.9 Next Steps:

While this study has demonstrated the benefits of BIM-Lean integration for RFI management, further research is required to:

- Implement the proposed process in live construction projects to assess its full impact on cost and efficiency.
- Investigate additional digital tools, such as AI-driven RFI automation, to enhance decision-making in complex projects.
- Refine Lean prioritisation methods to further improve RFI processing efficiency in different project environments.

Future research will focus on implementing the refined RFI system in live projects to assess its scalability and effectiveness. Additional areas of study will include further integration of BIM capabilities and the refinement of Lean prioritisation techniques to improve process efficiency in different project environments.

The findings of this research provide a strong foundation for further advancements in digital construction management and Lean process optimisation.

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Appendices

Appendix A - Request for Information (RFI) Categorisation Exercise

This appendix presents the list of 52 RFI questions (Appendix A-1) that were provided to participants in the first two focus groups conducted in October–November 2022. The purpose of this exercise was to evaluate whether construction professionals could categorise RFIs into pre-identified RFI categories based on their intent.

As part of the activity, participants were asked to assign each RFI to the most relevant category. The attached figure illustrates the results of this exercise, where participants attempted to classify the RFIs within the provided framework. The key objective of this activity was to determine if professionals could easily identify the intent behind an RFI upon receiving it.

An interesting observation from the focus groups was that participants struggled to reach a consensus on the intent of many RFIs. This lack of agreement highlighted the ambiguity in RFI classification and underscored the need for clearer categorisation (Appendix A-2). Based on these discussions, participants acknowledged that RFIs should be categorised at the point of creation rather than relying on recipients to determine intent. Consequently, they proposed that RFI creators should pre-identify each RFI's category at the time of submission.

Additionally, participants suggested the introduction of a top-tier categorisation system, grouping RFIs into four overarching categories:

1. Technical – RFIs related to design, specifications, or engineering constraints.
2. Programme – RFIs concerning project schedules, staging, or sequencing.
3. Cost – RFIs that impact financial considerations, such as value engineering.
4. Other – RFIs that fall outside of the above categories, including contractual or administrative inquiries.

These insights played a pivotal role in shaping the structured RFI categorisation and reasoning framework proposed in this research. By ensuring that RFIs are clearly classified at the point of submission, construction professionals can improve clarity, reduce miscommunication, and enhance decision-making efficiency across projects.

The findings from this exercise directly informed the refinements made to the proposed RFI management process, integrating BIM and Lean Construction principles to streamline information flow and enhance project coordination.

This is the list of RFI questions presented to the first two focus groups in October- November 2022

Appendix A - 1 List of RFI example and questions

		Rfi responder	Rfi creator
	Rfi description	Category	Information needed to respond
1	Ground level door schedule we appear to be missing elevations for door types l1 & l2 from door schedules 19736. Please can these be provided.	Ip	
2	Stair 26 requested change to type of windpost rfi's confirm if we are ok to use windposts of 150 x 100 x 12.5 on stair 26	Mc	
3	Concrete surface (connections s04, s05, s06 and s10) regarding south elevation's pre-cast cut outs, we noticed that the concrete surface at connections s04, s05, s06 and s10 contains rebar which won't allow us to install the baseplates. Please advise how to proceed (refer to the attached document with examples). Please be informed that this rfi needs to be closed out before 30-05-2014 to avoid programme/cost implications.	Or	
4	Platform agd gl 22l with reference to work package 2 above ground drainage: platform level gl 22l drawing 23564. The attached drawing indicates that the s&v pipe at gl22l drops from above to new below ground drainage, to reduce civil's work, we propose to divert the 100 svp at high level to the s&v on gl 22m will you confirm this proposal is acceptable	Dc	
5	Va2 lobby containment and lighting due to the phasing and co-ordination of the vertical access works at platform level, the containment and lighting installation cannot be installed as per consultant design. The luminaires cannot be hard wired to a local plug in point as the connections will not be accessible in the future due to the ceiling bulkhead. Our proposed solution was developed for platform 4/5 but this will form the principle for all platforms.	Dm	

6	Eastern façade - concrete repair detail – lower retail beam we have now completed a local survey of the surface variations in the finished concrete surface which has revealed significant variations in x, y and z directions. Accordingly, the current bracket design cannot be used and it is not possible to refabricate the brackets to match such significant variations in the concrete surface. Please can you propose a concrete repair detail to allow the beam rebate to be squared up? Please be informed that this rfi needs to be closed out before 10-06-2014 to avoid programme/cost implications.	Dl	
7	Lean to steelwork – material grade exemption following on from rfi-10729 confirming the material grade, we are unable to easily obtain material grade s355 for the 88.9x5 chs cross braces. Can the engineer please assess this element to be made using s275.	Mc	
8	Zone 12 header steels 9913 please see attached specification for your information – header restraint steel work detailed on atkins drg 5061224-drg-st-27646, call for type b6 steels to be installed using hilti m20 hst mechanical anchors. Due to cost and product availability our bolt suppliers have offered an alternative mechanical anchor to replace the specified hilti m20 hst. Please confirm with regard to the use of an alternative fixing.	Ve	
9	Cracked beam url mousehole a crack has been noticed on the north beam of the mousehole at upper retail level. The crack appears to spread vertically top to bottom and continues full width of the soffit. Please advise if remedial works are required prior to the installation of the east smokewell plant deck	Or	
10	Zone 10 header steels – duct work cash rfi's following receipt of rfi response rfi-10757 with regard to zone 10 glazing header restraints, confirming the repositioning of header steels (please see attached for your reference). As-installed duct work now occupies the proposed header steel locations and thus steels cannot be installed as proposed. Please confirm if header steels are to be repositioned or if duct work is to be re-routed to accommodate the proposed header steel locations.		

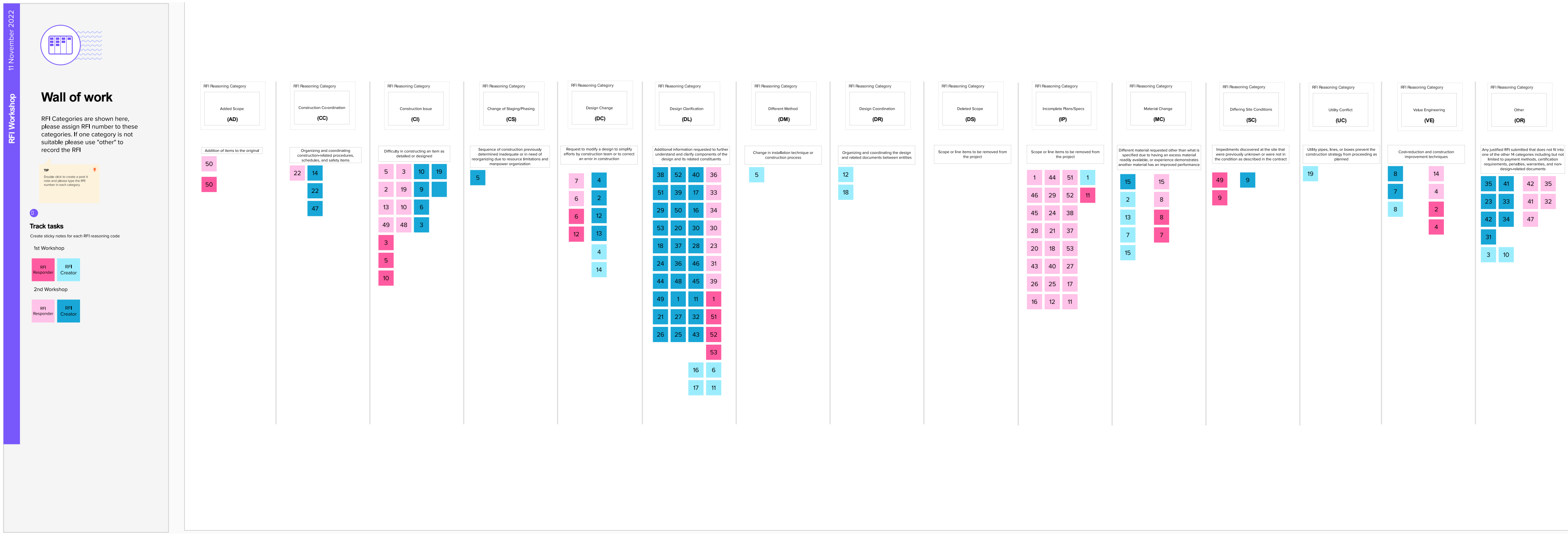
11	Lower retail zone drains rfi's design team to confirm if this proposal is acceptable please confirm acceptance of the proposed connections to the svp to drain the installed sprinkler zone valves, as per the attached. The hoare lea drawigns do not detail where the drains should run to, hence putting forward this proposal.	Dl	
12	Fw:lower retail re-directing of proposed sprinkler mains rfi's design team to confirm if this proposal is acceptable following coordination meeting with mep contractor on 6th aug 2018, we determined that the current proposal for the 150mm feed main running from the service corridor on g.l. G,16 through into food court area cannot be achieved due to 1016mm deep beam crossing this area. Please can you advise whether an alternative route would be acceptable to run through rear of unit k2 and pick up new service corridor behind unit k1 – as per attached sketch?	Dr	
13	Riser 7 – smoke extract rfi's due to space restrictions and structural steelwork locations, it has been necessary to change the configuration of the smoke extract ductwork at the bottom of riser 7. The revised layout is shown on drawings 6301-drg-m57-2384 rev d, 6301-drg-me-m57- 2386 rev d and 6301-drg-me-c64-2007 rev b. Can you please confirm that the fan selection specified will be suitable for this configuration.	Mc	
14	Foul water drainage proposed change cdr platform 12 rfi's after speaking with the platform civils and mep contractor we would like to propose that the desk position and sink location in the proposed crew dispatch room on p12 are swaped. This would allow us to punch through the wall and pick up the below ground drainage at gl13s. We think this would be prefferred to installing a macerator. The position chnage is indicated on the marked up drawing attached	Dc	

15	Blockwork lift 26/27 rfi's can we construct lift 26/27 in stranlite 10.4n/mm blocks, unfortunately, stranlite blocks only reach a density of 1450kg/m3 rather then the specified 10.4n/mm2 x 1950kg/m3 tarmac blocks. Contractor are struggling to source for the timescales they are required in and additionally we have never used these on a job before.	Mc	
16	Lift opening rebate rfi's the contractor drawings for lifts show a 2385 structural opening, then a rebate on the inside of the lintel - see attached for reference. It has been specified as s8 fire lintels and as such it is impossible to notch in this rebate due to lintel fire and strength integrity. Please confirm detail at top of door opening	Dl	
17	Cable trays stair core 8 rfi's there are cable trays running parallel to cladding on platform 1 these cable trays also interfere with column on gl 8. Please can you see attached photograph and confirm if, these cable trays will be re positioned or will the cladding have to work around this cable tray?	Dl	
18	Stair 29 roof slab rfi's with regards to drawing 5064224-drg-st-2568 rev c01. We require a structural slab level related to ordinance datum for the stair 29 roof slab. The top of the parapet wall (under-side of coping stones that are removed) that dictates the finished level of the roof slab ranges from 119.540 aod - 119.580 aod.	Dr	
19	Stair windpost head connection details rfi's due to existing structures/signage/services/etc. In some instances it has not been possible to connect the stair windpost head connections as per the standard detail. I.e. Beam spanning between 2 pre-stressed beams and clamped to each flange. We have installed the connection clamp around 1 pre-stressed beam. Please see attached photo. Please confirm that this acceptable where un-moveable items conflict.	Uc	
20	Radio room roof beams - seating rfi's drawing 2581 section 1-1 shows 152 uc and pfc sat on 10mm mortar bed, please confirm whether a padstone is required, or whether the beam sits directly on to the wall		
21	The precolation pit in the attachement was not in the initial drawing, so i need some clarificattion on the specs		

22	Please confirm that the road construction within the uprr row (to be performed by uprr) will be competed in phases to match the adjacent road construction phasing to maintain vehicular traffic flow.		
23	Please advise if costs associated with the centerpoint terms and conditions package should be incorporated into the bid and provide centerpoint package.		
24	Please provide for conduit sizes and number of conduits for the communications ductbank.		
25	Note 2 on 1 of 65, paving notes calls for 3000 psi and detail 2 under table 1 on 30 of 65 calls for 3500 psi. Please clarify the concrete psi for paving.		
26	What are the reinforcing requirements for pavement? Detail 2 on 30 of 65 is illegible.		
27	Please provide specs for concrete paving curbs and sidewalks.		
28	Are control joints for sidewalks sawed or tooled?		
29	Are soil borings available for this project?		
30	Please confirm that the sidewalk is now a part of the base bid per the pre-bid meeting. On pages 7, 8, 9, 10, and 11 is has a note that says it is part of the alternate.		
31	Section 5.2.2.1.5.1 (ugc) – is builder's risk insurance required for this project?		
32	Section 6.1 (ugc) – how many copies of the plans do we receive?		
33	Section 9.7 (ugc) – what is your definition of "intentional interference" and can you give a few examples of that?		
34	Section 11.1.2 (ugc) – can you please define "minor" and give an example? Also, can you conversely define "major" and give an example of that?		
35	Section 15.2 (ugc) – has a dpr been established?		
36	It is very hard to read the steel spacing on sheet 30. #2. What is the spacing?		
37	Can't read the notes on sheet 2/65 (too small). Can you provide a clearer copy, please?		
38	Where are division 02 specifications?		
39	Are there any soil borings or soil reports for the pawnee infrastructure project?		
40	The cover document has a division 2 listed for existing conditions with 42 items listed. This division was not provided with the other specifications.		
41	I was wondering if we can be added to your bidder's list for the subject project. If so, where can we get plans and specifications?		
42	Please confirm that a bid bond is required, and the percentage required on the bid bond.		

43	Please confirm the number of hard and electronic copies required for the hub plan		
44	We downloaded the documents from the ridgeway's vault, however division 02 of the specifications are missing. Can you please forward these to me?		
45	Where does the mechanical unit go?		
46	Confirm the ceiling is supposed to be installed at 10'6″.		
47	Verify that the attached demolition procedure is acceptable.		
48	Ductwork and lighting will prevent the ceiling from being installed at 10'6″.		
49	The dimensions of the existing stair do not match those noted in the drawings.		
50	No floor finish is called for in the bedroom, is it required and if so please provide a change notice.		
51	Confirm there are only two washroom partitions on the ground floor.		
52	The dimensions in the drawing x+y do not add up to the total noted on the drawings.		
53	Installing the ceiling at 9'0 will not achieve the design intent. Please confirm if the ceiling was supposed to be installed at 10′ and if so please provide a change.		

Appendix A - 2 Focus group activity



Appendix B Request for Information (RFI) Categorisation and Reasoning Framework

Introduction

This appendix presents a structured categorisation of RFIs along with the associated reasoning codes, supporting the refined RFI submission process proposed in this research. The tables included outline various RFI categories—Technical, Programme, Cost, and Other—and their respective reasoning codes. These subcategories allow for a more granular understanding of the underlying causes of RFIs, thereby aiding in the identification of patterns and potential areas for process improvement.

Furthermore, an essential aspect of managing RFIs effectively is understanding the intent and justification behind each submission. The set of guiding questions included in this appendix provides a framework for analysing why RFIs are raised and the implications they carry for the project. These questions are intended to be tailored to each project based on historical RFI data, ensuring that the categorisation aligns with project-specific trends and recurring issues.

Additionally, this appendix incorporates reference tables from Hannah et al. (2012), which outline common RFI reasoning codes and their descriptions. Retaining these established codes ensures consistency in industry-wide RFI categorisation while also enabling comparative analysis with the refined RFI framework proposed in this study.

By systematically categorising RFIs and defining their reasoning codes, project teams can enhance the clarity, efficiency, and responsiveness of RFI processes, ultimately improving coordination, reducing delays, and optimising project workflows.

Descriptions of RFI Categorisation Tables

- *Technical RFI Categorisation Table*

This table provides a structured breakdown of RFIs related to technical challenges encountered during project execution. It categorises RFIs based on reasoning codes such as Added Scope, Construction Coordination, Constructability Issues, Differing Site Conditions, Design Changes, Incomplete Plans/Specs, and Utility Conflicts. Each reasoning code is accompanied by specific guiding questions that help identify why an RFI is being raised. These questions facilitate better classification of RFIs and ensure that submissions are structured for efficient resolution.

RFI Category	Technical									
RFI Reasoning	Added Scope	Construction Coordination	Constructability Issue	Differing Site Condition	Design Change	Incomplete Plan/Specs	Deleted Scope	Desugn Clarification	Material Change	Utility Conflict
Question #	AD	CC	CI	DS	DC	IP	DS	DL	MC	UC
1	How is this scope added? (Instructions, Email, Verbal instruction)	Is this RFI related to construction procedure?	How is the activity installation being an issue?	Which scope or line in the project needs to be removed from the project?	Is this RFI proposes an easier method to simplify the efforts by the construction team?	What is the error/omission in the plan or specification?	How is the site condition differing from initially expected?	Is this RFI related to additional information for better understanding of the design?	Why is there a change in material?	Is the Utility pipes, lines or boxes preventing the construction strategy from proceeding?
2	Is this RFI to confirm the AD?	Is this RFI related to the construction schedule?	Is this RFI related to technical detail issue?	What is the reasoning for this deleted scope?	Is this RFI proposes a correction an error in construction design?	How does this RFI impact the delivery programme?	Is there an obstruction in the site that prevents the work from carrying on?	How does this RFI impact the delivery programme?	Is the new proposed material more effective for the project?	How does this RFI impact the delivery programme?
3	Is there a technical question regarding the AD?	Is this RFI related to the construction safety?	Is the design and issue for installation?	How does this RFI impact the delivery programme?	How does this RFI impact the delivery programme?	How does this RFI affect the cost or resources?	Is the site condition is not as described?	How does this RFI affect the cost or resources?	How does this RFI impact the delivery programme?	How does this RFI affect the cost or resources?
4	How does this scope impact the delivery programme?	How does this RFI impact the delivery programme?	How does this RFI impact the delivery programme?	How does this RFI affect the cost or resources?	How does this RFI affect the cost or resources?	explain what is the missing plan or scope. what is the impact.	How does this RFI impact the delivery programme?		How does this RFI affect the cost or resources?	
5	How does this RFI affect the cost or resources?	How does this RFI affect the cost or resources?	How does this RFI affect the cost or resources?			Is it outside of the current contract?	How does this RFI affect the cost or resources?		What was the trigger? Was this due to value engineering? Constructability issues?	
6	What has necessitated the added scope									
7	How has the additional scope been identified? PMI? Abiguity/inconsistency in the contract documents? Under NEC covered by contract mechanism.									

- Key Benefits:
  - Enhances clarity in identifying design discrepancies, constructability challenges, and material changes.
  - Ensures technical queries are routed to the appropriate discipline for timely resolution.
  - Reduces miscommunication by providing a predefined structure for RFI submission.

- *Programme-Related RFI Categorisation Table*

This table focuses on RFIs that impact project scheduling, phasing, and construction methodologies. It includes reasoning codes such as Construction Coordination, Constructability Issues, Different Methods, Change of Staging/Phasing, Design Coordination, and Utility Installation. The guiding questions assist in determining whether the RFI is related to delays, sequencing challenges, or design coordination issues.

RFI Category	Programme					
RFI Reasoning	nstruction Coordinatio	Constructability Issue	Different Method	Change of Staging/phasing	Design Coordination	Utility Installation
Question #	CC	CI	DM	CS	DR	UI
1	Is this RFI related to construction procedure?	How is the activity installation being an issue?	Is this RFI related to a change in design method?	Why is the staging being an issue?	Which organisation/s's design is involved for this coordination?	Was this triggered by a utility conflict? If so, what was the related conflict?
2	Is this RFI related to the construction schedule?	Is this RFI related to technical detail issue?	Is this RFI related to a change in construction method?	Is it due to manpower?	How does this RFI impact the delivery programme?	
3	Is this RFI related to the construction safety?	Is the design and issue for installation?	How does this RFI impact the delivery programme?	Is the sequence identified previously is deemed inadequate?	How does this RFI affect the cost or resources?	
4	How does this RFI impact the delivery programme?	How does this RFI impact the delivery programme?	How does this RFI affect the cost or resources?	How does this RFI impact the delivery programme?		
5	How does this RFI affect the cost or resources?	How does this RFI affect the cost or resources?		How does this RFI affect the cost or resources?		

- Key Benefits:
  - Supports proactive scheduling adjustments by identifying programme-related concerns early.
  - Helps track trends in project delays linked to specific RFI categories.
  - Enables improved coordination between multiple disciplines and contractors.

- *Cost-Related RFI Categorisation Table*

This table addresses RFIs that impact the financial aspects of a project, including Value Engineering and Other (Payment Method). It helps classify RFIs that propose cost-effective alternatives, modifications in payment structures, and financial adjustments due to design changes. The guiding questions assist in understanding how the RFI affects contracts, budgets, and long-term cost efficiency.

RFI Category	Programme					
RFI Reasoning	nstruction Coordinatio	Constructability Issue	Different Method	Change of Staging/phasing	Design Coordination	Utility Installation
Question #	CC	CI	DM	CS	DR	UI
1	Is this RFI related to construction procedure?	How is the activity installation being an issue?	Is this RFI related to a change in design method?	Why is the staging being an issue?	Which organisation/s's design is involved for this coordination?	Was this triggered by a utility conflict? If so, what was the related conflict?
2	Is this RFI related to the construction schedule?	Is this RFI related to technical detail issue?	Is this RFI related to a change in construction method?	Is it due to manpower?	How does this RFI impact the delivery programme?	
3	Is this RFI related to the construction safety?	Is the design and issue for installation?	How does this RFI impact the delivery programme?	Is the sequence identified previously is deemed inadequate?	How does this RFI affect the cost or resources?	
4	How does this RFI impact the delivery programme?	How does this RFI impact the delivery programme?	How does this RFI affect the cost or resources?	How does this RFI impact the delivery programme?		
5	How does this RFI affect the cost or resources?	How does this RFI affect the cost or resources?		How does this RFI affect the cost or resources?		

- Key Benefits:
    - Encourages cost-saving opportunities through structured value engineering RFIs.
    - Identifies financial risks associated with project modifications.
    - Helps stakeholders assess the financial viability of proposed changes.
- *Other RFI Categorisation Table*

This table captures RFIs that do not fall under technical, programme, or cost categories but still require structured classification. It includes reasoning codes such as Penalties, Warranties, Non-Design-Related, and Certification. The guiding questions ensure that RFIs related to legal, contractual, and regulatory matters are properly addressed.

RFI Category	Cost	
RFI Reasoning	Value Engineering	Other – payment method
Question #	VE	OR
1	Is the RFI proposing a new cost-effective method/strategy for the implementation of the task?	How is this question affect the contract?
2	Is the RFI proposing a new improved technique or design?	How will this method of payment change impact on the project?
3	How does this RFI impact the delivery programme?	
4	How does this RFI affect the cost or resources?	
5	What is the whole life value addition due the value engineering proposed.	

- Key Benefits:
    - Provides a structured approach to handling non-technical RFIs that impact compliance and contractual obligations.
    - Enhances accountability in managing warranties, penalties, and regulatory approvals.
    - Supports the integration of certification requirements within the construction process.

These tables collectively serve as a decision-making framework that improves project efficiency, standardises RFI categorisation, and enhances communication across project teams. By utilising a structured approach, projects can systematically manage RFIs, ensuring that issues are addressed in a timely and transparent manner. Furthermore, the sub-questions presented in these tables should be tailored to suit industry-specific requirements and the historical RFI data of each project. This ensures that RFI categorisation aligns with recurring issues and trends within a given sector, allowing for better analysis and refinement of project workflows.

Appendix C – Survey Questions

This appendix presents the survey questions distributed to industry professionals as part of the research study. The survey aimed to gather insights on current practices, challenges, and perspectives regarding the Request for Information (RFI) process, Building Information Modelling (BIM), and Lean Construction methodologies. The questions were designed to capture both quantitative and qualitative data on industry adoption, workflow integration, and perceived benefits or limitations of these approaches.

1. Project Information

1. Where is your current project based?
   1.a If you selected Other, please specify:
2. Which sector does your current project belong to?
   2.a If you selected Other, please specify:
3. What is the role of your organisation in your current project?
   3.a If you selected Other, please specify:
4. What is the name of the organisation you work for? *(Confidential)*
5. What is your current role?
   5.a If you selected Other, please specify:
6. What is the overall value of your project?
7. How much experience do you have in the construction industry?
8. Does your project have a clear design process?
9. What stage is your project at?
10. In your current project, how often are design coordination meetings held?

2. RFI Process

11. At your current project, please estimate the number of RFIs (Request for Information) submitted per week?
    11.a If you selected Other, please specify:
12. At your current project, what system do you use for transferring design information such as RFIs, Drawings, Documents, Change Requests?
    12.a If you selected Other, please specify:
13. How do you rate the quality of the design in your current project?
    13.a If you selected Other, please specify:

3. BIM (Building Information Modelling)

14. How familiar are you with Building Information Modelling (BIM)?
15. What level of BIM are you using on your current project?
16. In regards to your knowledge and understanding of BIM, please rate how strongly you agree or disagree with the following statements:
    16.1 I have a good understanding of the government's definition of BIM Level 2 and the drivers behind it.
    16.2 I understand the vision for BIM beyond Level 2.
    16.3 I have a good understanding of the impact of BIM on the industry and my organisation.
    16.4 The organisation I work for is embracing BIM and has already started to implement a change process.

16.5 I believe BIM is key to improving operational efficiency.
16.6 I believe that BIM will help to mitigate project risks.

4. Lean Construction

21. How familiar are you with Lean Construction tools and techniques?
22. Does your organisation implement Lean Construction tools and techniques?
23. Which one of the following Lean Construction tools and techniques are used in your project? (Multiple choices allowed)
    23.a If you selected Other, please specify:
24. How often do you use Lean tools at your project?
    24.a If you selected Other, please specify:
25. Based on your experience, have you seen the benefits gained by using Lean Construction tools?
    25.a If yes, how did you measure the benefits?

5. BIM & Lean Integration

26. Do you use both BIM and Lean Construction tools and techniques in your current project?
27. At what stage of your project have BIM-Lean tools been applied?
28. Are you aware of the synergies between BIM and Lean Construction?
29. Does your company have a standard protocol for the implementation of BIM-Lean simultaneously?
    31.a If yes, what guidelines do you use?

6. Collaboration & Efficiency

30. Which one of the following helps to achieve higher efficiency and information flow? *(Rank in importance)*
    33.1 Weekly or daily meetings with representation of all stakeholders.
    33.2 Offsite prefabrication.
    33.3 Optimising crew size.
    33.4 Just-in-time material delivery.
    33.5 Open book policy.
31. Does BIM-Lean assist in the collaboration and coordination of the design?
    34.a If yes, please specify:

7. Follow-Up & Further Participation

32. Do you wish to receive the results of this survey?
    35.a If yes, please provide your name and email address.
33. Are you happy to be contacted to take part in a face-to-face follow-up discussion on the implementation of BIM-Lean?
    36.a If yes, please provide your name and email address.

This appendix provides a structured overview of the survey instrument used in this research. These questions were designed to extract relevant industry insights and support the development of the BIM-Lean RFI framework proposed in this study.

Appendix D: Workshop Survey Reasoning

This appendix presents the rationale behind the workshop survey questions used to assess industry professionals' experiences and perspectives on the Request for Information (RFI) process. The survey was designed to gather insights into participants' backgrounds, involvement in RFI management, and perceptions of how RFIs impact project outcomes. The collected responses informed the discussions and categorisation exercises conducted during the workshop.

Survey Questions and Reasoning

Question 1: How many years of experience do you have in the industry?

This question provides parameters to evaluate whether responses vary based on the participant’s experience in the Architecture, Engineering, and Construction (AEC) industry. Identifying experience levels allows for an analysis of whether RFI perceptions differ among junior, mid-level, and senior professionals.

Question 2: Have you directly been involved in raising, managing, or responding to RFIs?

This question ensures that only individuals with direct experience in the RFI process contribute to the dataset. Respondents without relevant experience were excluded from the analysis to maintain the validity of the survey results and focus on those who can provide informed insights.

Question 3: Please select what involvement you have had in the RFI process.

Understanding participants' specific roles in RFI management is essential to contextualising their responses. This question helps categorise participants based on whether they primarily raise, manage, or respond to RFIs, offering a clearer perspective on how different project roles perceive the RFI workflow.

Question 4: Have you encountered issues with raising, managing, or responding to RFIs?

This question identifies common challenges associated with the RFI process. A "Yes" or "No" response serves as a starting point for deeper discussions during the workshop, allowing participants to expand on specific inefficiencies, bottlenecks, or pain points related to RFIs.

Question 5: Based on your experience, rank the impact of RFIs on overall project outcomes.

Industry professionals were asked to rank the 15 RFI categories identified by Hanna et al. (2012) based on the likelihood of these RFIs being raised in their respective projects. This ranking exercise introduced participants to the predefined RFI categories before the workshop, ensuring they were familiar with the classifications used in subsequent discussions. The ranking data also helped establish trends regarding which RFI types are most prevalent and impactful in construction projects.

Significance of the Workshop Survey

The responses from this survey were instrumental in shaping the workshop discussions, allowing participants to engage with the structured RFI categorisation system in an informed manner. The survey data also contributed to refining the proposed RFI framework by validating the necessity of categorising RFIs at the point of creation. The insights gained further reinforced the need for an integrated BIM-Lean approach to streamline the RFI process and improve overall project efficiency.

This appendix provides a structured overview of the workshop survey and its role in the research methodology. By detailing the reasoning behind each question, it ensures transparency in the data collection process and supports the reproducibility of this study's findings.