KNOWLEDGE SHARING STRATEGIES TO IMPROVE BUILDABILITY OF CONSTRUCTION PROJECTS IN SRI LANKA

WIMALARATNE. PLI[1]* & KULATUNGA. U[2]
[1,2]University of Moratuwa, Moratuwa, Sri Lanka
[1]indraniw@uom.lk, [2]ukulatunga@uom.lk

Abstract: Sri Lankan construction industry faces persistent challenges related to buildability, impacting project efficiency, cost, and quality. These issues also hinder the industry's ability to achieve sustainable solutions and practices. Buildability involves integrating knowledge and expertise at the right time through the most appropriate source. Enhancing buildability within construction projects requires effective knowledge sharing among project team members who possess multifaceted construction knowledge and experience in various disciplines. However, the current poor knowledge-sharing practices hinder the potential benefits of this valuable resource. Therefore, it is important to establish the best knowledge-sharing strategies to improve buildability in construction projects. By examining current practices, identifying the best strategies, and analysing the lived experiences of construction professionals, this paper aims to provide actionable insights for leveraging knowledge sharing to overcome buildability issues and achieve more successful and sustainable project outcomes. This research explores the lived experiences of industry practitioners to identify context-specific knowledge-sharing strategies that can enhance buildability in construction projects in Sri Lanka. 12 number of in-depth interviews are employed following thematic analysis to derive the 'knowledge sharing strategies'. The study reveals 36 knowledge-sharing strategies that can improve buildability within construction projects in Sri Lanka.

Keywords: *Knowledge Sharing, Buildability, Constructability, Construction, Strategies*

1. Introduction

The concept of 'buildability,' interchangeably referred to as 'constructability,' involves integrating knowledge and expertise at the right time and through the most appropriate sources to improve construction project performance (Wimalaratne et al., 2023). Lack of buildability is a key factor that results in poor performance in construction projects (Samimpey & Saghatforoush, 2020; Zolfagharian et al., 2012). Therefore, improving buildability is crucial in reducing project delays, cost overruns, and quality issues, and achieving sustainable project solutions (Osuizugbo et al., 2022). Hence, discussions surrounding buildability and its incorporation into construction projects became increasingly important. As a result, various studies were carried out on buildability integration into construction projects to improve construction project performance. For example, adopting an assessment tool such as the Singapore Buildable Design Appraisal System (BDAS) published by the Building Construction Authority (BCA) in Singapore, which covers the three areas of structural works, Architectural, Mechanical, Electrical and Plumbing (AMEP) works, and good industry practices (BCA, 2022) has been widely followed in the industry. In addition, incorporating buildability with modern technologies such as Building Information Model (BIM) (Govender et al., 2018), Augmented Reality (AR) (Lee et al., 2017) 3D Drawings (Liau & Lin, 2017), Off-Site Manufacturing (OSM) technology, or by adopting different procurement strategies such as Early Contractor Involvement (ECI) (Farrell & Sunindijo, 2020; Finnie et al., 2018; Wondimu et al., 2018), Integrated Project Delivery (IPD) (Leoto & Lizarralde, 2019), or in connection with another concept such as Lean Construction Triangle (LCT) (Ballard & Tommelein, 2021; Martinez et al., 2019), sustainability (Singhaputtangkul et al., 2014) can be highlighted. However, these methods either focus on specific elements/ aspects of the building or a particular phase of the project rather than achieving sustainable solutions throughout the project delivery process. According to Kifokeris and Xenidis (2017), past studies have promoted buildability integration only at a theoretical level.

According to Jadidoleslami et al. (2019), the lack of knowledge-sharing within the framework of design and construction is the origin of poor buildability in the construction industry. Agreeing with this, Osuizugbo et al. (2022) stated that the key driver of buildability is 'knowledge-sharing'. Moreover, although past studies prove that the above methods positively impact construction performance, they fail to fully identify, integrate, and apply available knowledge at the right time in the project delivery process. Therefore, investigating knowledge-sharing strategies and practices focusing on buildability improvement is crucial to achieving sustainable project outcomes. Knowledge sharing involves disseminating and exchanging information, expertise, and experience among project team members (Castaneda & Cuellar, 2020). Knowledge sharing in association with R&D projects (Wang & Hu, 2020), carbon reduction (Satola et al., 2022), IT projects (Imam & Zaheer, 2021), and innovation (Castaneda & Cuellar, 2020) have been discussed in the existing knowledge domain.

*Corresponding author: Tel: +94705823798 Email Address: indraniw@uom.lk
DOI: https://doi.org/10.31705/FARU.2024.32

However,knowledge sharing remains underexplored in the construction industry (Hwang, 2020). In construction, it is crucial to address complex challenges and improve overall project buildability through proper knowledge sharing (Assaad & El-adaway, 2020). Therefore, there is a gap in the existing literature on improving buildability through enhancing knowledge sharing among the construction project delivery teams. Furthermore, Sri Lankan construction industry faces persistent challenges related to buildability, impacting project efficiency, cost, and quality (Karunarathna et al., 2024; Lebunu Hewage et al., 2024; Manoharan et al., 2022; Pararajasingam et al., 2024). However, no studies have been conducted on the Sri Lankan construction industry regarding improving buildability. Therefore, this study aims to identify knowledge sharing strategies to improve buildability in construction projects in Sri Lanka.

2. Scope and Limitations

This study focuses on Sri Lankan construction industry. Limitations include the variability of practices across different regions and project types. Some strategies are futuristic predictions because the sector is not mature enough to implement.

3. Literature Review

3.1. BUILDABILITY DEFINITION

Buildability is a concept that deals with the optimal integration of construction knowledge and experience at various project stages to achieve the overall project goals (Naoum & Egbu, 2016). The concept of buildability has emerged as a direct result of research and practical applications aimed at improving the efficiency, cost-effectiveness, and quality of construction projects (Griffith & Sidwell, 1997). Professional fragmentation in construction was another significant aspect that triggered the emergence of the buildability concept (Wong et al., 2011). Several definitions of buildability have been introduced in the literature since the 1980s. The CIRIA has published the most widely recognised definition of buildability in the UK as, “the extent to which the design of a building facilitates ease of construction, subject to the overall requirements for the completed building” (CIRIA, 1983). This definition was criticised for its narrow scope as it confines to the design process only (Wong et al., 2007) as buildability impacts throughout the various work stages of a construction project aiming to accomplish the ultimate project goals (CIIUS, 2006). Since then, numerous studies have been conducted to strive for better project performance through improving buildability. Accordingly, numerous researchers have also identified the traits of ‘buildability’ and interpreted them based on their conceptual assumptions. For example, Illingworth (1984) stated that buildability is “Design and detailing which recognise the assembly process in achieving the desired result safely and at least cost to the client”. Later, another researcher described buildability as “integrating construction knowledge, resources, technology and experience into the engineering and design of a project” Mohammed (2014). BCA code of practice who have given deeper thoughts on buildability influence on productivity and defined buildability as, “the extent to which the design of a building facilitates ease of construction as well as the extent to which the adoption of construction techniques and processes affects the productivity level of building works” (BCA, 2011, 2022). Therefore, the common themes of buildability involves integrating construction knowledge and experience across project stages to enhance efficiency and quality. Originally focused on design, the concept has expanded to emphasize the importance of incorporating construction knowledge throughout the entire project to improve construction project performance.

3.2. BUILDABILITY STUDIES

Since the first emergence of the buildability concept, numerous studies have been conducted to investigate further how it could be integrated to minimise the issues affecting construction projects’ time, cost and quality. As a result, various researchers have concluded rules, principles, concepts and guidelines to incorporate buildability into construction projects to enhance the construction project performance. For example, various industry research institutes have contributed largely to the buildability context. Among them, the Construction Industry Research and Information Association (CIRIA) and the Construction Industry Institute in the United States (CII) have provided guidelines for improving the buildability of building designs through several studies (Adams, 1989; CII, 1998; CIRIA, 1983). Similarly, the Construction Industry Institute Australia (CIIA) has introduced concepts that can improve buildability during design (CIIA, 1996). Another study by Nima et al. (2010) suggested 23 buildability concepts that were popular at the time and referred to by many succeeding researchers. Adding to this Kifokeris and Xenidis (2017) introduced a concise mode of practice for the buildability concept, dividing the 23 concepts into three phases: initiation phase, execution phase, and delivery phase.

3.3. KNOWLEDGE AS THE KEY DRIVER OF BUILDABILITY

As per Wimalaratne et al. (2021) construction knowledge sharing is the key driver within the buildability concept. Knowledge sharing is one of the most critical processes of knowledge management (Du et al., 2007). Knowledge is an exclusive concept. Tsoukas and Vladimirou (2002) described knowledge as “the individual capability to draw distinctions, within a domain of action, based on an appreciation of context or theory, or both”. There are two main types of knowledge: tacit and explicit (Nonaka & Konno, 1998). Explicit knowledge can be expressed in words and numbers and shared through data, scientific formulae, specifications, manuals, and the like (Hoe, 2006). Tacit knowledge, on the other hand, is not easily visible. Tacit knowledge is highly personal and hard to formalize, making it difficult to share with others (Hoe, 2006). Most tacit knowledge would reside with people rather than other physical media (Crossan et al., 1999) and can only be acquired through direct experience, reflection, and internalization shared through highly interactive conversation and storytelling

(Haldin-Herrgard, 2000). Researchers agree that most knowledge in the construction sector is tacit rather than explicit (Zhao et al., 2021). Most tacit knowledge resides with people (Dang et al., 2024). Hence, knowledge sharing between stakeholders is vital to incorporating innovative solutions and buildability into construction projects (Rahmani, 2020).

Within the construction sector, projects represent an organisational structure, typically involving teams from diverse organisations and disciplines, including clients, designers, contractors, sub-contractors, etc. (Duva et al., 2024; Garcia & Mollaoglu, 2020; Guofeng et al., 2020). Theory of managing knowledge within an organisation revealed that three components of knowledge management are people, processes, and technology (Basten & Haamann, 2018; Dalkir & Liebowitz, 2011; Maqsood & Finegan, 2009). However, knowledge management in the construction industry is mostly limited by conventional methods ranging from impromptu telephone calls to formally scheduled annual meetings to facilitate knowledge sharing among employees (Hwang, 2020). Thus, it is important to identify knowledge sharing strategies to improve buildability in a construction project.

The following theoretical framework is derived from the findings of the literature review.

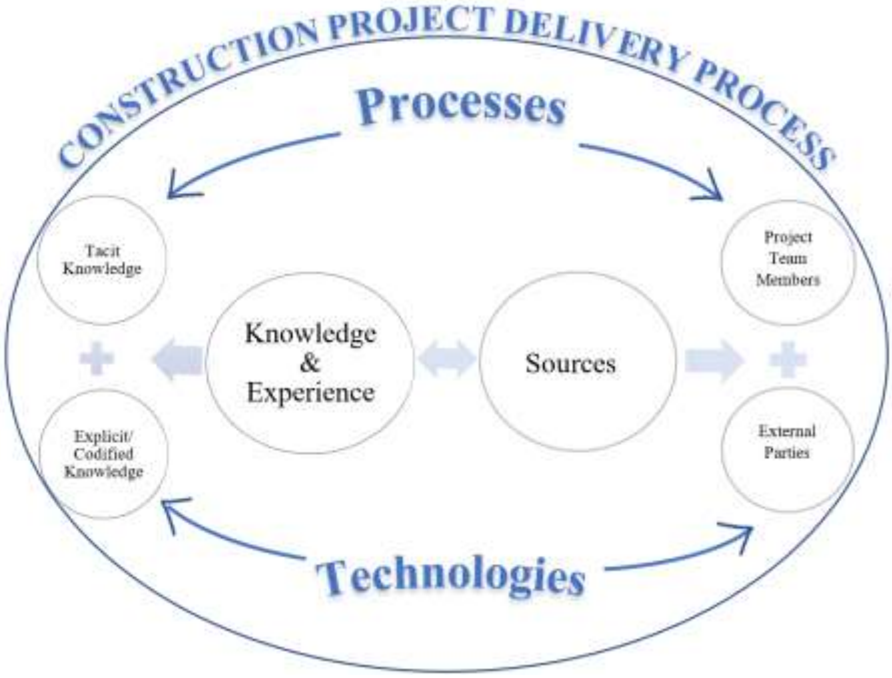

Figure 1: Theoretical framework of knowledge sharing to enhance buildability

In summary, although prior literature has highlighted the importance of knowledge-sharing and buildability for improving construction project performance, much less attention has been focused on exploring knowledge-sharing strategies to improve the buildability of construction projects. Therefore, this study aims to identify the best strategies and practices for knowledge sharing that enhance buildability of construction projects.

4. Methodology

The research method was designed to address the research aim of exploring knowledge-sharing strategies to improve buildability of construction projects in Sri Lanka. Therefore, this research takes qualitative research approach. Data collection should represent the construction professionals practising in the Sri Lankan construction industry and facilitate gathering their experiential records concerning knowledge sharing within the Sri Lankan construction project teams. Accordingly, research techniques adopted in this portion of the study include literature review, in-depth interviews and thematic analysis. Participants were selected based on the convenience sampling method. Semi-structured in-depth interviews were carried out to ensure that only the relevant data was collected and that expected outcomes aligned with the research aim. Participants who had significant experience in the construction industry and could contribute to understanding the concept being explored were recruited in this study. Targeted participants were involved in the Sri Lankan construction industry and had significant years of experience in various construction projects and playing different roles from both contractor and consultant perspectives. The interview guideline was prepared following the findings from the literature review, which were summarised into a theoretical framework as presented in Figure 1 above. The following questions were included in the interview guide.

1. How important is knowledge sharing in improving buildability according to your industry experience?

2. What are the various types/ aspects of knowledge we require in a construction project?
3. How does the requirement or nature of knowledge change during each construction stage? Why?
4. Other than knowledge written in books/codes, do people carry knowledge in construction projects?
5. Where else is the knowledge stored in construction projects other than with key stakeholders? (External people?)
6. How do the processes in a construction project improve knowledge sharing in a construction project?
7. How do you feel about modern technologies in improving knowledge sharing?
8. How can knowledge sharing be improved in the absence of modern technology?
9. Do you think technology or other means can fill that gap?
10. Other than the resources within the project, do we need external sources of Knowledge as well? What are they?
11. What else you would recommend for improving Buildability overall?

Data collection was carried out via a web interface (Zoom). The following Table 1 represents the profile of the participants who participated in the data collection.

Table 1: Respondents' Profile for Data Collection.

Ref	Discipline of Services	Years of Experience
R1	Project Manager/ Consultant	30
R2	Project Manager/ Consultant	30
R3	Construction Manager/ Contractor	28
R4	Construction Manager/ Contractor	30
R5	Estimation Manager/ Contractor	16
R6	Commercial Manager (Post-Contract)/ Contractor	16
R7	Commercial Manager (Pre-Contract)/ Consultant	28
R8	Programme Manager/ Consultant	34
R9	Engineer - Employer/ Consultant	20
R10	Engineer/ Contractor	17
R11	Architect	34
R12	Commercial Manager (Post-Contract)/ Consultant	17

5. Data Analysis

Within the scope of this paper, the qualitative data collected through in-depth interviews were analysed using thematic analysis. It began by identifying meanings and patterns in the data in the form of themes. The thematic analysis technique provides a theoretically flexible and accessible methodology towards analysing and dealing with the complexity of qualitative data (Braun & Clarke, 2019). The following Figure 2 explains the steps ensued in reaching the conclusions for this study.

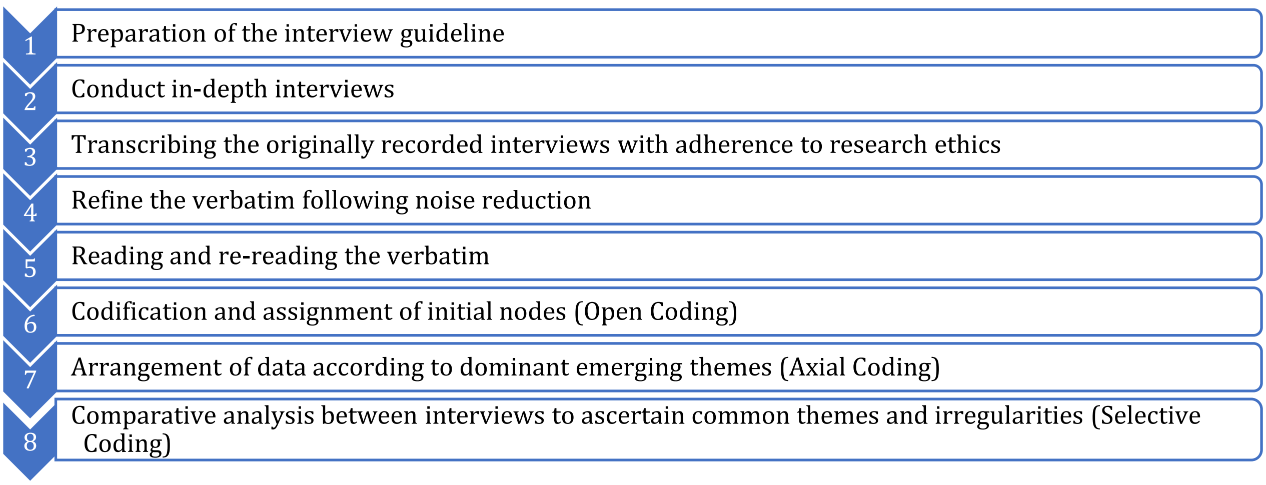

Figure 2: Data analysis process

Given the large amounts of qualitative data gathered for this study, a data management tool was utilised to deal with the complexities of the data and aid in conducting the thematic analysis. Accordingly, NVivo 14 was used to analyse data and extract meaningful conclusions. NVivo helped identify themes in the data using queries and the manual coding process to link, annotate, and create relationships in the data.

6. Findings

6.1. KNOWLEDGE SHARING AS THE KEY DRIVER OF BUILDABILITY

All the respondents asserted that knowledge sharing is the most vital construct of buildability. For example, R6 stated, "Knowledge sharing is the number one criterion for buildability", although R10 emphasised that the importance of knowledge sharing in improving buildability is poorly recognised in the industry. R1's opinion was slightly opposing when considering the scale and complexity of the project. R1 stated, "Knowledge sharing helps more in complex and large-scale projects to improve buildability than for lesser complex and small-scale projects". Contrary to this, R2 stated that knowledge sharing improves people's awareness, directly and indirectly positively impacting buildability, irrespective of the project's nature. Agreeing with R2, "Knowledge sharing can improve the performance of young generation, which then improves buildability overall in the industry", stated R3.

Further, in this regard, R4 divided knowledge sharing into 'sharing of experience' and 'sharing of knowledge' and stated, "Sharing the experience with knowledge can improve buildability!". R4 was referring to tacit knowledge while saying "experience". R9 stated that knowledge sharing can promote innovation and thereby improve buildability. Directing the focus to another angle, R8 highlighted the importance of merging the knowledge gap by stating, "Continuous knowledge sharing is not only for professionals but also should happen in the skill group". Generalising the impact of knowledge sharing, R9 stated, "To achieve cost savings, fast construction and better quality, knowledge sharing is very important".

6.2. KNOWLEDGE SHARING STRATEGIES TO IMPROVE BUILDABILITY

Thirty-six knowledge-sharing strategies and practices (sub-themes) were derived from the analysis. The open-coding process originated the knowledge-sharing strategies, leading to derive the themes (axial-coding). Following are the three themes (axial coding) that emerged.

1. People-centric knowledge sharing strategies
2. Processes-centric knowledge sharing strategies
3. Technology-centric knowledge sharing strategies

Refer to Figure 3 below for the coding structure.

Name	Files	References
Knowledge sharing and Buildability	12	495
Knowledge Sharing Strategies	11	170
Techno centric - Knowledge sharing strategies	9	105
Process centric - Knowledge sharing strategies	9	54
People centric- Knowledge sharing strategies	7	11

Figure 3: Coding structure

36 open codes (sub-themes) that lead to the above themes (axial coding) are shown in below Figure 4. Although the themes have their own demarcations, these subthemes are interconnected to one another. The below figure vividly shows the three themes and the sub-themes (knowledge-sharing strategies).

People centric strategies included 'engaging an experienced contractor for professional consultation' (may or may not be the specific builder of the project), having a competent and experienced team, facilitating knowledge sharing in the absence of key personnel (even though only a smaller part of the design is related to their speciality), and invite field staff to management meetings. The codebook is shown in the below table.

Process-centric strategies included proposals as well as existing processes. For example, having a regulatory body/authority for buildability is a proposal. Embedding knowledge-sharing processes into qualification criteria of the project, having processes to ensure no discrepancies in drawings and specifications, pre-bid meetings, tendering process, tender evaluation process, allowing flexibility for changes (change control process), project team hearings, buildability adjudications (similar to technological adjudications), brainstorming sessions, processes for disseminating knowledge (ex: seminar, CPD), processes of bringing specialists for shorter period for sharing knowledge, having reflections at the end of each stage, record keeping processes, round table discussions, detailed discussions on specific issues, conducting post completion audits, post-completion workshops, adopt processes to get end-user knowledge in, demonstrations and training were some of the areas that lead to developing strategies. The complete code book for process-centric strategies is shown below.

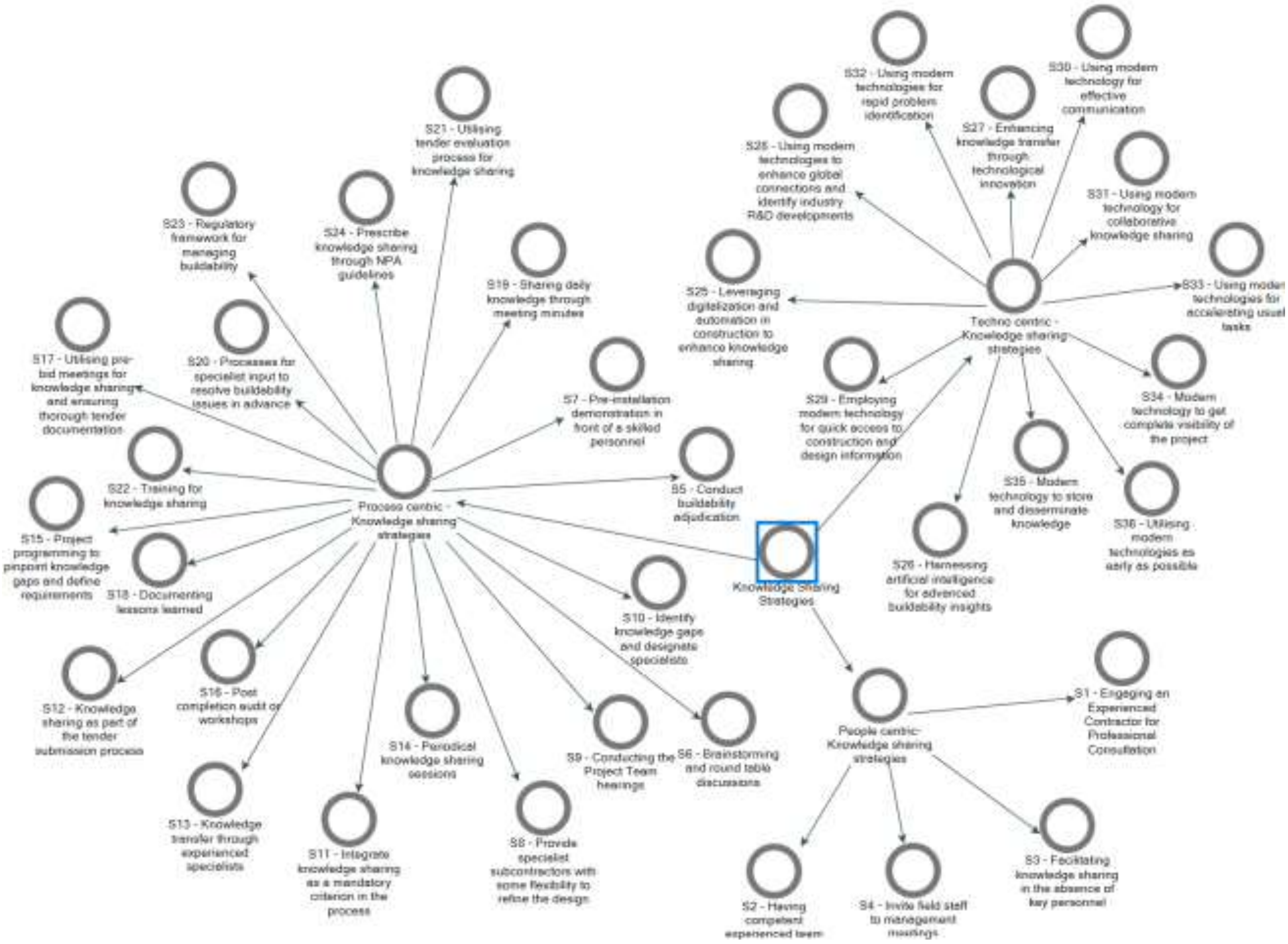

Figure 4: Themes and knowledge-sharing strategies

Table 2: Code Book for People-Centric Knowledge-Sharing Strategies

Theme	Ref	Sub-themes	Respondents
People-centric knowledge sharing strategies	S1	Engaging an experienced contractor for professional consultation	R2, R3, R10
	S2	Having a competent and experienced team	R9
	S3	Facilitating knowledge sharing in the absence of key personnel	R8, R9
	S4	Invite field staff to management meetings	R1, R12

Table 3: Code Book for Process-Centric Knowledge-Sharing Strategies

Theme	Ref	Sub-themes	Respondents
Process-centric knowledge sharing strategies	S5	Conduct buildability adjudication	R1
	S6	Brainstorming and round table discussions	R6, R4, R3, R2, R8
	S7	Pre-installation demonstration in front of a skilled personnel	R8
	S8	Provide specialist subcontractors with some flexibility to refine the design	R10
	S9	Conducting the Project Team hearings	R1
	S10	Identify knowledge gaps and designate specialists	R1, R3, R10
	S11	Integrate knowledge sharing as a mandatory criterion in the process	R6

Theme	Ref	Sub-themes	Respondents
	S12	Knowledge sharing as part of the tender submission process	R8
	S13	Knowledge transfer through experienced specialists	R1, R2
	S14	Periodical knowledge sharing sessions	R2, R4
	S15	Project programming to pinpoint knowledge gaps and define requirements	R1
	S16	Post completion audits/ workshops	R5
	S17	Utilising pre-bid meetings for knowledge sharing and ensuring thorough tender documentation	R4, R8, R10
	S18	Documenting lessons learned	R4, R3
	S19	Sharing daily knowledge through meeting minutes	R4
	S20	Processes for getting specialist input to resolve buildability issues in advance	R3
	S21	Utilising tender evaluation process for knowledge sharing	R3, R8
	S22	Training for knowledge sharing	R8
	S23	Regulatory framework for managing buildability	R10
	S24	Prescribing knowledge sharing through NPA guidelines	R2, R6

Technology-centric knowledge-sharing strategies were derived from the discussions raised around using 3D computer models such as BIM, using technology to disseminate knowledge (e-journals, databases, social media, Vlog, recoding in video form), using modern technology to store knowledge for environment-friendly and easy access (archiving, record keeping in soft forms, various software such as Aconex, and lessons learnt (databases).

The complete code book relevant to techno-centric knowledge-sharing strategies is shown below.

Table 4: Code Book for Technology-Centric Knowledge-Sharing Strategies

Theme	Ref	Sub-themes	Respondents
Technology centric knowledge sharing strategies	S25	Leveraging digitalization and automation in construction to enhance knowledge sharing	R1, R6, R3, R8
	S26	Harnessing artificial intelligence for advanced buildability insights	R5
	S27	Enhancing knowledge transfer through technological innovation	R2
	S28	Using modern technologies to enhance global connections and identify industry R&D developments	R1, R5
	S29	Employing modern technology for quick access to construction and design information	R2, R1, R5, R6, R3, R4, R7, R8, R10
	S30	Modern technology for effective communication	R1, R5, R3, R7
	S31	Modern technology for collaborative knowledge sharing	R5
	S32	Modern technologies for rapid problem identification	R1
	S33	Modern technologies for accelerating usual tasks	R3, R7
	S34	Modern technology to get complete visibility of the project	R5, R3, R8, R10
	S35	Modern technology to store and disseminate knowledge	R2, R5, R3, R3
	S36	Utilising modern technologies as early as possible	R8

Highlighting people over processes, R9 stated, “There is no process or technology that can fix buildability issues when the right person is not present in the team”. While R9 explained an intense experience related to a severe buildability issue in one of the projects they contributed, they stated, “No technology or record keep could have avoided such issues as the missing person’s input is the reason”. R9 continued stating, “Previous records and technology can help but cannot replace a missing person”. Further explaining, R8 acknowledged that having ‘the right person’ means someone with the required skills, tacit knowledge, and codified knowledge. R9 stated that even with the best processes and technologies, people can only perform ‘trial and error’ by learning from books when the ‘right person’ is absent. However, R9 continued, “Having competent architects, engineers and the experienced team alone will not add buildability. Their knowledge has to be gathered and shared to bring buildability into projects", giving more importance to 'process' over 'people' and 'technology'.

7. Discussion

Buildability deals with integrating knowledge and expertise at the right time through the most appropriate source. The literature suggests that knowledge sharing is the key driver of buildability (Wimalaratne et al., 2021; Wong et al., 2007; Zolfagharian et al., 2012). The findings confirm that knowledge sharing is the key to improving buildability. Further, the findings confirmed that successful projects often use a combination of formal and informal mechanisms to facilitate knowledge exchange.

Literature suggested looking at construction project teams through an organisational lens (Sergeeva & Roehrich, 2018). As per Basten and Haamann (2018), people, technology, and well-designed processes are essential to manage knowledge within an organisation. Agreeing with this, the main themes that emerged from the empirical investigation revealed that the knowledge-sharing strategies could be summarised into three categories people, processes and technological centric. However, it has to be noted that every strategy had at least two of the themes combined, demonstrating that people, processes, and technologies were essential to improve buildability. However, strategies are themes following their primary contribution to enhance buildability of the project.

Researchers agree that most knowledge in the construction sector is tacit rather than explicit (Zhao et al., 2021). Most tacit knowledge resides with people (Crossan et al., 1999). Therefore, in construction projects, team members are the key source of knowledge. Hence, knowledge sharing between stakeholders is vital to incorporating innovative solutions and buildability into construction projects (Farshid, 2020). The findings emphasise that successful construction projects rely heavily on integrating practical construction knowledge, continuous learning, broad stakeholder involvement, and collaboration across all team members. Following Figure 4 highlights the integration of the emerged three themes.

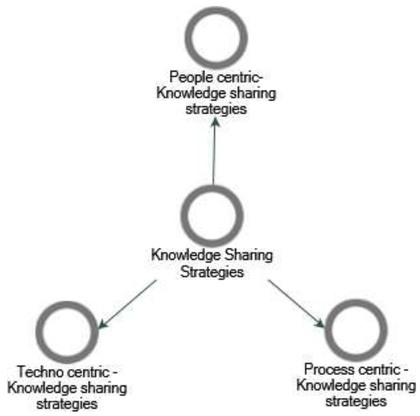

Figure 5 – Integration of people, processes and technologies to enhance buildability

In construction, achieving real integration of people, processes, and technology in one system is indeed challenging as the contribution of the team members throughout the process is influenced by the overall framework of the construction process (Kifokeris & Xenidis, 2017; Rahmani et al., 2016). Agreeing with this, the respondents collectively underscored the significance of following knowledge-sharing strategies in addressing buildability issues in construction.

8. Conclusion

Knowledge sharing plays a critical role in improving buildability in construction projects. Given the persistent challenges in the construction industry, exploring methods, tools, and practices that deliver sustainable and efficient solutions is crucial. This study identifies and emphasises effective practices and strategies for leveraging knowledge sharing to address buildability challenges, specifically in Sri Lankan construction projects. The study concludes that as the construction industry continues to evolve, embracing knowledge sharing will be essential for overcoming buildability challenges and achieving project success.

The study identified 36 strategies for improving buildability, categorised into three main themes: people-centric, process-centric, and technology-centric. These themes highlight the diverse avenues through which knowledge sharing can be harnessed to improve construction outcomes. The findings are helpful for project managers and construction managers in improving buildability throughout construction projects to deliver sustainable project outcomes. Further research could delve deeper into the impact of specific knowledge-sharing technologies on buildability. Additionally, it would be valuable to examine the role of organisational culture in facilitating or hindering effective knowledge sharing within the construction industry.

9. References

Adams, S. (1989). *Practical buildability (CIRIA building design report)* (L. Butterworths-Heinemann, Ed.).

Assaad, R., & El-adaway, I. H. (2020). Enhancing the Knowledge of Construction Business Failure: A Social Network Analysis Approach. *Journal of Construction Engineering and Management*, *146*(6). https://doi.org/10.1061/(asce)co.1943-7862.0001831

Ballard, G., & Tommelein, I. (2021). 2020 Current Process Benchmark for the Last Planner(R) System of Project Planning and Control. Berkeley, California, USA.

Basten, D., & Haamann, T. (2018). Approaches for Organizational Learning: A Literature Review. *Sage Open*, *8*(3). https://doi.org/10.1177/2158244018794224

BCA. (2011). *The code of practice on buildability*. B. a. C. Authority. https://www1.bca.gov.sg/docs/default-source/docs-corp-news-and-publications/publications/for-industry/buildability-series/copbdapr2011.pdf

BCA. (2022). *The code of practice on buildability*. B. a. C. Authority. https://www1.bca.gov.sg/about-us/news-and-publications/publications-reports/codes-acts-and-regulations

Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health*, *11*(4), 589-597. https://doi.org/10.1080/2159676x.2019.1628806

Castaneda, D. I., & Cuellar, S. (2020). Knowledge sharing and innovation: A systematic review. *Knowledge and Process Management*, *27*(3), 159-173. https://doi.org/10.1002/kpm.1637

CII. (1998). *Implementing project constructability - Instructor's guide*. C. I. I. U. S. (CII).

CIIA. (1996). *Research report 1 - The development of constructability principles for the Australian construction industry* (1876189010).

CIIUS. (2006). *Constructability Implementation Guide*. C. I. I. U. S. (CII).

CIRIA. (1983). *Buildability : an assessment*. C. I. R. A. I. Association.

Crossan, M. M., Lane, H. W., & White, R. E. (1999). An Organizational Learning Framework: From Intuition to Institution. *The Academy of Management Review*, *24*(3), 522-537. https://doi.org/10.2307/259140

Dalkir, K., & Liebowitz, J. (2011). Knowledge Management in Theory and Practice. In (2 ed., pp. 502). The MIT Press.

Dang, C. N., Wipulanusat, W., Nuaklong, P., & Witchayangkoon, B. (2024). Exploring the relationships between knowledge management enablers, employee innovativeness and market development performance in A/E/C firms: a developing country perspective. *Construction Innovation*. https://doi.org/10.1108/ci-02-2023-0022

Du, R., Ai, S., & Ren, Y. (2007). Relationship between knowledge sharing and performance: A survey in Xi'an, China. *Expert Systems with Applications*, *32*(1), 38-46. https://doi.org/10.1016/j.eswa.2005.11.001

Duva, M., Zhao, D., Frank, K. A., & Mollaoglu, S. (2024). Interaction between Project- and Group-Level Knowledge Transfer in Project Team Networks: A Social Influence Analysis. *Journal of Management in Engineering*, *40*(2). https://doi.org/10.1061/jmenea.Meeng-5718

Farrell, A., & Sunindijo, R. Y. (2020). Overcoming challenges of early contractor involvement in local government projects. *International Journal of Construction Management*, *22*(10), 1902-1909. https://doi.org/10.1080/15623599.2020.1744216

Finnie, D., Ali, N. A., & Park, K. (2018). Enhancing off-site manufacturing through early contractor involvement (ECI) in New Zealand. Proceedings of Institution of Civil Engineers: Management, Procurement and Law,

Garcia, A. J., & Mollaoglu, S. (2020). Measuring Key Knowledge-Related Factors for Individuals in AEC Project Teams. *Journal of Construction Engineering and Management*, *146*(7). https://doi.org/10.1061/(asce)co.1943-7862.0001850

Govender, K., Nyagwachi, J., Smallwood, J. J., & Allen, C. J. (2018). The awareness of integrated project delivery and building information modelling - facilitating construction projects. *International Journal of Sustainable Development and Planning*, *13*(01), 121-129. https://doi.org/10.2495/sdp-v13-n1-121-129

Guofeng, M., Jianyao, J., Shan, J., & Zhijiang, W. (2020). Incentives and contract design for knowledge sharing in construction joint ventures. *Automation in Construction*, *119*. https://doi.org/10.1016/j.autcon.2020.103343

Haldin-Herrgard, T. (2000). Difficulties in diffusion of tacit knowledge in organizations. *Journal of Intellectual Capital*, *1*(4), 357-365. https://doi.org/10.1108/14691930010359252

Hoe, S. L. (2006). Tacit knowledge, nonaka and takeuchi seci model and informal knowledge processes. *International Journal of Organization Theory & Behavior*, *9*(4), 490-502. https://doi.org/10.1108/ijotb-09-04-2006-b002

Hwang, S. (2020). Sharing tacit knowledge in small-medium regional construction companies in the U.S.: the current status and the impact of organizational ecology. *International Journal of Construction Management*, *22*(9), 1746-1755. https://doi.org/10.1080/15623599.2020.1742628

Illingworth, J. R. (1984). *Buildability – tomorrow's need*.

Imam, H., & Zaheer, M. K. (2021). Shared leadership and project success: The roles of knowledge sharing, cohesion and trust in the team. *International Journal of Project Management*, *39*(5), 463-473. https://doi.org/10.1016/j.ijproman.2021.02.006

Jadidoleslami, S., Saghatforoush, E., Heravi, A., & Preece, C. (2019). A practical framework to facilitate constructability implementation using the integrated project delivery approach: a case study. *International Journal of Construction Management*, *22*(7), 1225-1239. https://doi.org/10.1080/15623599.2019.1686834

Karunarathna, D. C., Perera, H. A. H. P., Perera, B. A. K. S., & Disaratna, P. A. P. V. D. S. (2024). Influence of delay in utility shifting for extension of time claims in road construction projects in Sri Lanka. *Smart and Sustainable Built Environment*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/sasbe-07-2023-0179

Kifokeris, D., & Xenidis, Y. (2017). Constructability: Outline of Past, Present, and Future Research. *Journal of Construction Engineering and Management*, *143*(8), 04017035. https://doi.org/10.1061/(asce)co.1943-7862.0001331

Lebunu Hewage, U. W. A., Wadu Mesthrige, J., & Too, E. G. (2024). Barriers to risk management in small construction projects in Sri Lanka. *Built Environment Project and Asset Management*, *14*(2), 296-311. https://doi.org/10.1108/bepam-06-2023-0104

Lee, S. Y., Kwon, S. W., & Ko, T. K. (2017). AR(augmented reality) based 3D workspace modeling for quality assessment using as-built on-site condition in remodeling construction project. ISARC 2017 - Proceedings of the 34th International Symposium on Automation and Robotics in Construction,

Leoto, R., & Lizarralde, G. (2019). Challenges for integrated design (ID) in sustainable buildings. *Construction Management and Economics*, *37*(11), 625-642. https://doi.org/10.1080/01446193.2019.1569249

Liau, Y. H., & Lin, Y. C. (2017). Application of civil information modeling for constructability review for highway projects. ISARC 2017 - Proceedings of the 34th International Symposium on Automation and Robotics in Construction,

Manoharan, K., Dissanayake, P., Pathirana, C., Deegahawature, D., & Silva, R. (2022). Assessing the performance and productivity of labour in building construction projects through the application of work-based training practices. *Construction Innovation*, *24*(2), 558-583. https://doi.org/10.1108/ci-05-2022-0126

Maqsood, T., & Finegan, A. D. (2009). A knowledge management approach to innovation and learning in the construction industry. *International Journal of Managing Projects in Business*, *2*(2), 297-307. https://doi.org/10.1108/17538370910949310

Martinez, E., Reid, C. K., & Tommelein, I. D. (2019). Lean construction for affordable housing: a case study in Latin America. In *Construction Innovation* (Vol. 19, pp. 570-593): Emerald Publishing Limited.

Mohammed, A. G. A. (2014). Buildability Concept Influencing Quality of Building during Design Process in UNRWA Projects. Palestine.

Nima, M. A., Abdul-Kadir, M. R., Jaafar, M. S., & Alghulami, R. G. (2010). Constructability implementation: a survey in the Malaysian construction industry. *Construction Management and Economics*, *19*(8), 819-829. https://doi.org/10.1080/01446190110089709

Nonaka, I., & Konno, N. (1998). The Concept of "Ba": Building a Foundation for Knowledge Creation. *California Management Review*, *40*, 40-54.

Osuizugbo, I. C., Okolie, K. C., Oshodi, O. S., & Oyeyipo, O. O. (2022). Buildability in the construction industry: a systematic review. *Construction Innovation*, *23*(5), 1300-1322. https://doi.org/10.1108/ci-05-2022-0112

Pararajasingam, R., Waidyasekara, A. S., & Victar, H. C. (2024). Exploring causes of ineffective material management and impact on successful project deliverables in civil engineering construction projects in Sri Lanka. *Construction Innovation*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/ci-11-2023-0281

Rahmani, F. (2020). Challenges and opportunities in adopting early contractor involvement (ECI): client's perception. *Architectural Engineering and Design Management*, *17*(1-2), 67-76. https://doi.org/10.1080/17452007.2020.1811079

Rahmani, F., Khalfan, M. M. A., & Maqsood, T. (2016). Analysing the drivers for early contractor involvement adoption by construction clients. *International Journal of Procurement Management*, *9*(4), 373-397. https://doi.org/10.1504/ijpm.2016.077701

Samimpey, R., & Saghatforoush, E. (2020). A Systematic Review of Prerequisites for Constructability Implementation in Infrastructure Projects. *Civil Engineering Journal*, *6*(3), 576-590. https://doi.org/10.28991/cej-2020-03091493

Satola, D., Wiberg, A. H., Singh, M., Babu, S., James, B., Dixit, M., Sharston, R., Grynberg, Y., & Gustavsen, A. (2022). Comparative review of international approaches to net-zero buildings: Knowledge-sharing initiative to develop design strategies for greenhouse gas emissions reduction. *Energy for Sustainable Development*, *71*, 291-306. https://doi.org/10.1016/j.esd.2022.10.005

Singhaputtangkul, N., Low, S. P., Teo, A. L., & Hwang, B.-G. (2014). Criteria for Architects and Engineers to Achieve Sustainability and Buildability in Building Envelope Designs. In *Journal of Management in Engineering* (Vol. 30, pp. 236-245): American Society of Civil Engineers.

Tsoukas, H., & Vladimirou, E. (2002). What is Organizational Knowledge? *Journal of Management Studies*, *38*(7), 973-993. https://doi.org/10.1111/1467-6486.00268

Wang, C., & Hu, Q. (2020). Knowledge sharing in supply chain networks: Effects of collaborative innovation activities and capability on innovation performance. *Technovation*, *94-95*. https://doi.org/10.1016/j.technovation.2017.12.002

Wimalaratne, P. L. I., Kulathunga, U., & Gajendran, T. (2021). *Comparison between the terms constructability and buildability: A systematic literature review* World Construction Symposium, http://dl.lib.uom.lk/bitstream/handle/123/16631/Comparison%20between%20the%20terms%20constructability%20and.pdf?sequence=1

Wimalaratne, P. L. I., Kulatunga, U., & Gajendran, T. (2023). 'Buildability' in the Digital Age: A Phenomenological Discourse of Industry Practitioners' Perceptions. *Buildings*, *13*(11). https://doi.org/10.3390/buildings13112870

Wondimu, P. A., Hosseini, A., Lohne, J., & Laedre, O. (2018). Early contractor involvement approaches in public project procurement. *Journal of Public Procurement*, *18*(4), 355-378. https://doi.org/10.1108/jopp-11-2018-021

Wong, F. W. H., De Saram, D. D., Lam, P. T. I., & Chan, D. W. M. (2011). A Compendium of Buildability Issues from the Viewpoints of Construction Practitioners. *Architectural Science Review*, *49*(1), 81-90. https://doi.org/10.3763/asre.2006.4910

Wong, F. W. H., Lam, P. T. I., Chan, E. H. W., & Shen, L. Y. (2007). A study of measures to improve constructability. *International Journal of Quality & Reliability Management*, *24*(6), 586-601. https://doi.org/10.1108/02656710710757781

Zhao, N., Ying, F. J., & Tookey, J. (2021). Knowledge visualisation for construction procurement decision-making: a process innovation. *Management Decision*, *60*(4), 1039-1055. https://doi.org/10.1108/md-01-2021-0051

Zolfagharian, S., Nourbakhsh, M., Hussein Mydin, S., Mohamad Zin, R., & Irizarry, J. (2012). A Conceptual Method of Constructability Improvement. *International Journal of Engineering and Technology*, *4*(4), 456-459. https://doi.org/10.7763/ijet.2012.V4.409