

ANALYSIS OF LEAN CONSTRUCTION CASES IN IRELAND

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ABSTRACT

The purpose of this paper is to identify what lean tools and techniques construction companies are using in Ireland and what common challenges and benefits exist for their implementation. Currently, research on lean construction (LC) implementation in Ireland is weak and fragmented, and this paper will help address this gap in literature and provide an overview of this activity.

Through analysis of the 17 cases gathered through the Lean Construction Ireland (LCi) “Book of Cases 2022,” this paper identifies that most case studies originated from large, privately owned, general contracting companies and a wide array of lean tools are being used. All cases indicated benefits from LC, the most common being an improvement in quality, then cost, followed by time and safety. Covid-19 was found to be a catalyst for lean initiatives. Leadership support, staff training, piloting lean initiatives, developing a collaborative culture and continuous improvement were identified as important factors for implementing and sustaining LC. Although the sample size is limited, this paper does provide a useful indicator of overall LC activity in Ireland that will be of interest for academics and practitioners to consider and build upon.

KEYWORDS

Case study analysis, Lean tools, culture, leadership

INTRODUCTION

Ebbs et al. (2015) suggest that LC field research and case studies are very limited in Ireland. Over the last five years, a book of cases has been published annually by Lean Construction Ireland (LCi), each containing a collection of case studies from the Irish construction industry that demonstrate the challenges and outcomes of implementing LC. However, most of these case studies have not been incorporated into formal research papers. The first author of this paper is a director with LCi and was the editor for the LCi Book of Cases in 2022. The aim of this paper is to utilise the Book of Cases 2022, to identify what lean tools and techniques companies are using in Ireland and what common challenges and benefits exist for their implementation. An overview of LCi will be provided initially to set the context, followed by a literature review. The research methodology will then be outlined, followed by an overview of the Book of Cases 2022. The results will then be presented followed by a discussion and conclusion.

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In 2018, the LCi community of learning and practice became a company limited by guarantee. Its objectives are to promote lean thinking and practices in the Irish construction sector by making available information, guidelines, and support. With directors from both industry and academia, LCi has approximately 90 corporate members as well as hundreds of individual members. LCi has facilitated over 50 LC webinars, published five Book of Cases, and is focusing on capability development by sharing best practices and helping upskill and develop the workforce through its activities. By identifying lean construction case studies in industry and compiling them into book-form for annual publication, LC practices have been shared throughout the construction sector. Through academic research, the value of these cases can be strengthened so that further insights can be gained and disseminated via various research groups such as the IGLC.

LITERATURE REVIEW

In this literature review, LC will be introduced and the importance of collaboration between industry and academia highlighted. The topic of learning will be discussed as well as the various LC tools and techniques used. Gaps in research from an Irish case study perspective will then be discussed. The benefits of LC will be outlined and key factors for LC successful adoption reviewed.

Our understanding of lean principles and LC is evolving. Lean manufacturing has been studied by academics for 30 years and the MIT International Motor Vehicle Program (IMVP) benchmarked Toyota's superior performance and coined the phrase lean to describe this system (Womack et al., 1990). The findings of this prompted the formation of lean groups by practitioners including the Lean Enterprise Institute in the USA (www.lean.org), the Lean Enterprise Academy in the UK (www.leanik.org), and 15 other non-profit institutes across the globe (Netland & Powell, 2016). Similarly, the International Group for Lean Construction (IGLC) was formed to develop new principles and methods for product development and production management, specifically tailored to the AEC industry, but akin to those defining lean production that proved to be so successful in manufacturing (IGLC.Net, 2023).

The call for change in the construction industry has been well documented in terms of how this sector operates (Egan et al., 1998; Koskela & Howell, 2008; Latham, 1994;). This paradigm change is still ongoing today. The main objective of lean production is to eliminate waste by reducing or minimizing variability related to supply, processing time, and demand (Shah & Ward, 2007). In construction, the role of Lean is to improve the processes and delivery methods of a project to better meet the needs of the owner through the elimination of waste and non-value adding activities (Ghosh & Burghart, 2021).

The collaboration between industry and academia through the IGLC and communities of practice like LCi are promoting change in the industry. With the increase in the adoption of lean tools and principles in the construction industry, it is pertinent to investigate the experience of the contractors to facilitate widespread adoption of lean for improvement of industry performances (Ghosh & Burghart, 2021). Companies that collaborate with academia have shown to prosper (Pizam et al., 2013). Research has indicated that construction management research has not made a lasting impact on the sector because of misalignment of research methods and problems targeted with developments in the industry (Koskela, 2017). Collaboration between universities and industry is not straightforward and Aouad et al. (2010) suggest a "shared pace whereby the work being undertaken by the research community has meaning in both the academic and industrial world." Case studies are a suitable method to extract data for complex situations (Taggart et al., 2019) and can facilitate a meaningful collaboration between industry and academia.

Learning is important for a lean construction team. Organisational learning and knowledge creation are interdependent as learning is a dynamic process that promotes the knowledge

creation process (Lyles, 2014). Lean teams must be aware of practices for improving knowledge generation that can improve construction processes, eliminate waste, and pursue perfection (Zhang & Chen, 2016). When LC managers implement a lean tool, they unintentionally facilitate the knowledge creation. Therefore, attention should be paid to keep new knowledge recorded and to build a more holistic and efficient knowledge management system (Zhang & Chen, 2016). Case studies are a useful way of recording knowledge created from lean tools.

A broad range of LC tools exist to reduce waste and improve efficiency. For example, Zhang and Chen (2016) considered lean techniques that have transferred from lean manufacturing including concurrent engineering, daily huddles, Kanban, value stream mapping, quality management tools including Plan Do Check Act (PDCA), Just in Time (JIT), Total Quality Management (TQM), and Human Resource (HR) management. Examples of other LC tools are 5S and First Run Studies (Noorzai, 2022). In addition, Schia et al. (2019) reviewed the topic of Artificial Intelligence (AI) for the construction industry and indicated that AI can automate several operations to increase efficiency and thus minimise waste.

LC implementation case research in Ireland is limited to a few academic papers and there is no consolidated overview. Existing literature relates to the Line of Balance production planning (Taggart et al., 2019), The Last Planner System (Power & Taylor, 2019) and the integration of Lean and BIM processes (McHugh et al., 2019). A cloud based digital LPS is also reviewed by McHugh et al. (2021a) as well as reality capture (McHugh et al., 2021b). By carrying out academic research on the Book of Cases 2022, it is hoped that the range of tools and techniques currently being used in Ireland are identified and associated benefits and challenges uncovered.

In relation to the benefits from LC, Lavikka et al. (2019) identified an improvement in build time, cost, quality and health and safety, when comparing hospital construction projects that have implemented lean construction with ones that don't. Frequently, research focuses on the success of lean processes and less on the obstacles to their deployment (Simonsen et al., 2014). By identifying and understanding the barriers to implementing change and LC, more opportunities are provided to succeed and recognise the need for organisational change (Cano et al., 2015; Perez & Ghosh, 2018). Sarhan & Fox (2013) identified the top three barriers to implementing lean as the lack of adequate lean awareness and understanding, culture issues and a lack of top management commitment. This is further supported by Sarhan et al. (2016) who identified 12 critical success factors for implementing LC, such as providing education and training for lean construction, promoting a culture of teamwork and adopting continuous improvement. Xue et al. (2014) identified the importance of collaboration and culture to support innovation also. Thus, education and training, culture, collaboration, top management commitment and continuous improvement have been identified in literature as key factors for LC adoption. By assessing LC cases in Ireland, it can be determined how applicable these factors are in this local context.

RESEARCH METHODOLOGY

The aim of this paper is to identify what lean tools and techniques companies are using in Ireland and what common challenges and benefits exist for their implementation. Figure 1 below outlines the research methodology used, which initiated with a survey used to get preliminary data and finalise the case study template. Case studies were then gathered and completed. The last stage was qualitative analysis of the cases using NVIVO software.

To utilise the LCi Book of Cases for this research, the first author, who was also the editor for the Book of Cases, arranged a short, online survey of LCi members to get some insights into the relevance and suitability of the LCi Book of Cases and identify opportunities for improvement. Survey feedback was reviewed, and various improvements identified for the book of cases format and template. During 2022, 17 LC cases were drafted by 16 companies and submitted to the editor. Following an interactive process, all complete cases received in the

revised template were then refined by the editor, proofed, categorised into themes, and then compiled into a Book of Cases 2022 publication (Lean Construction Ireland, 2022).

A qualitative analysis of the Book of Cases 2022 was then undertaken. According to Burke, Johnson & Onwuegbuzie (2004), qualitative research is useful for studying a limited number of cases in depth and for understanding people's personal experiences of phenomena in local contexts in vivid detail. For case study analysis, NVIVO software was used for coding of the cases and various qualitative analytical tools such as word frequency, word searches etc. Discussions also took place with industry-based case authors to get a deeper understanding of various cases and to address clarifications. This data and analysis helped identify LC tools and benefits. Emerging themes across the 17 cases were also identified (Braun & Clark, 2006). Building on this work, a matrix was then developed to capture the key elements of each case for ease of further analysis. This matrix will be discussed later and lists the case number and key details of each case study, including indicative benefits.



Figure 1: Research Methodology

PRELIMINARY SURVEY

The first author arranged a survey with all LCi corporate and individual members to identify if improvements could be made to the book of cases format so that a case study template could be finalised. This survey identified that 72% of respondents felt that their company was at the early to intermediate stage of lean adoption. 93% of respondents agreed/ strongly agreed that the book of cases was appropriate to their organisation and was a valuable asset. In addition, 92% of respondents said that they read at least a few, if not all the case studies.

Several recommendations were made by respondents to improve the book of cases. These recommendations included the addition of an introduction section, which would provide a summary of the cases, a dedicated section on BIM/Digital Technology, making case titles clear and breaking cases into categories. These findings from this survey were implemented and facilitated the refinement of the case study template used for the Book of Cases, 2022.

CASE STUDY COMPILATION

Based on survey feedback, a new standardised template for the cases was developed with the following headings: case study title, company overview, overview and background of lead initiative, lean initiative undertaken, lean initiative improvements and impact and lessons learned. In addition, an “Introduction Chapter” was included in the Book of Cases and appropriate chapters/ themes were formed to gather related cases and make the book easier to navigate.

In 2022, a call for abstracts was issued to the construction sector through emails and social media channels. The editor recommended that all abstracts were progressed to full cases by the company-based authors using the new case template. Cases were then reviewed, edited, and refined by the editor, following consultation with the case author. All cases received were included in the Book of Cases, categorised into themes and then the book was compiled, proofed, printed, and circulated.

CASE STUDY OVERVIEW

In this section, an overview of the 17 case studies (Lean Construction Ireland, 2022) will be presented. The cases have been categorised into the following themes: Operational Excellence, Digitisation, Modern Methods of Construction and Resource Management. See the Case Study Matrix in Table 1 at the end of the paper for a full case overview. Cases have been numbered, where C1 denotes the first case, C2 the second and so on.

OPERATIONAL EXCELLENCE CASES

The following is a summary of the operational excellence related cases:

- C1: The Coffey Pillars of Lean were presented, including 6S, 8 Wastes, Visual Management, Standard Work, DMAIC and the Last Planner.
- C2: Duggan Brothers identifies 107 tasks for improvement through the involvement of 27 senior managers across eight departments.
- C3: Hawthorn Heights mapped out processes, used the LCi Lean Audit Tool and achieved significant improvements.
- C4: Kirby's developed a framework using DMAIC for determining the cost of quality and utilised Fish Bone diagrams and 5-Why tools.
- C5: Mace improved safety, quality, productivity, and schedule compliance by using an A3, 5S and 8 waste tools.
- C6: OPW developed a Dynamic Purchasing System and decreased supervision and management costs.

DIGITISATION CASES

The following is a summary of the cases listed under the digitisation theme:

- C7: Arup provided an overview of their HIVE (Human Immersive Virtual Environments) which has helped clients gain a better appreciation of proposals.
- C8: Errigal used DMAIC and digital tools to develop a data driven framework to identify and eliminate inefficiencies in processes.
- C9: John Paul Construction demonstrated the benefits of using the Last Planner and the cloud-based Field View system for achieving project milestones.
- C10: Mannings Construction Group outline how they have utilized digital solutions such as dashboards, timelapse cameras, vehicle recognition systems and the common data environment to improve overall efficiency.
- C11: SISK demonstrated the use of Artificial Intelligence (AI) to automatically read form data. Through automation and digitization, significant time is being saved and the quality of data capture has improved.
- C12: Walls first case study outlines the significant benefits of upgrading IT infrastructure and software to provide a better controlled environment with reduced administration and energy overheads.
- C13: Walls second case demonstrates employee accessibility of BIM 3D models using Dalux BIM mobile viewer as well as a reduction in waste.

MODERN METHODS OF CONSTRUCTION AND RESOURCE MANAGEMENT CASES

Cases related to modern methods of construction and resource management are:

- C14: ACB group focus on Modern Methods of Construction (MMC) using lean principles. They utilized BIM and the PDCA tool to develop its prefabrication model further by seeking to incorporate additional building finishes.
- C15: Horizon Offsite increased productivity and reduced non-conformances through workplace and factory optimization, performance tracking and data visualization.

- C16: Ardmac used a High-Performance Team model and human behavior was improved to promote collaboration and increase productivity.
- C17: DPS Engineering developed an effective resource mobilisation process using lean thinking and the DMAIC tool.

RESULTS

This section will analyse the profiles of companies that submitted cases as well as the lean tools used. In addition, indicative benefits from LC implementation will be provided. The themes that emerged from qualitative analysis will then be presented.

COMPANY PROFILES AND LEAN TOOLS USED

Table 1 at the end of the paper shows a matrix, which summarises the key elements of the case studies. This matrix lists the case number, company name, size, type, sector case title and tools used. It also identifies the theme that the case was aligned to and the indicative benefits from a time, cost, quality, and safety perspective. In terms of company profile, six companies were small to medium sized organisations (SMEs), with less than 250 employees, while ten companies were large. Only one company was publicly owned (C6), the rest were privately owned. C6 was the only client-based company represented in these cases. A multitude of sectors were represented with the most common being general contractors.

A wide variety of tools were identified within the case studies. Tools used more than once were identified and sorted by frequency and are presented in Figure 2 below. The most common tools used were DMAIC and 8 wastes, followed by BIM/ 3D viewing, LPS, 5S, and the use of Cloud Data. Value stream mapping or process mapping, PDCA, A3, and Artificial Intelligence were other tools used in two case studies. Overall, 10 tools were referenced in at least 2 of the 17 cases.

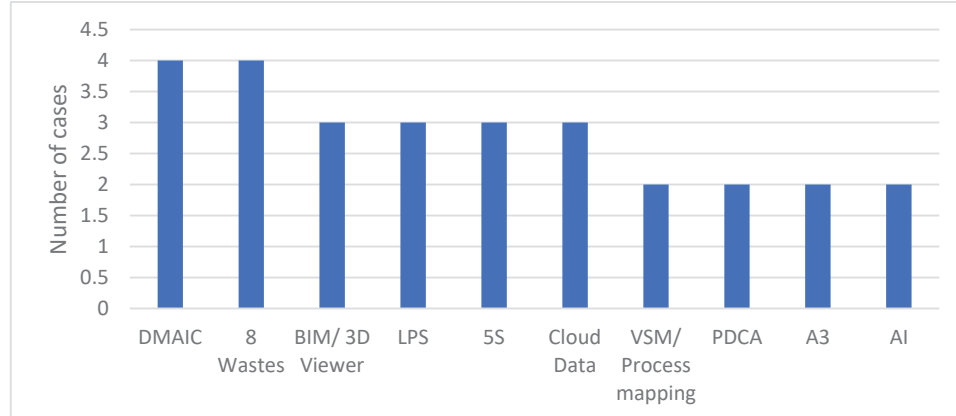


Figure 2: Lean Tools Referenced in More Than One Case Study.

BENEFITS

A range of benefits were identified in the case studies as listed in Table 1. In Figure 3 below, the main benefits are presented in terms of the percentage occurrence in the cases. 88% of cases indicated an improvement in quality, 71% of cases referenced a saving in cost, 47% indicated a saving in time and 35% had a safety related benefit. All cases except two (C4, C7) had at least two benefits indicated.

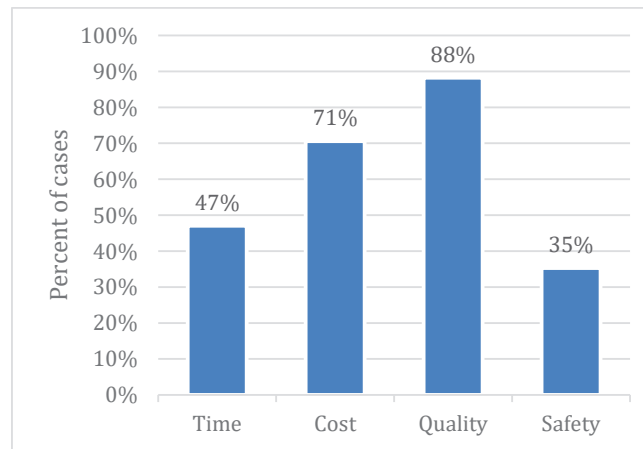


Figure 3: Benefits Identified from Lean Initiatives.

KEY THEMES IDENTIFIED

Through iterative thematic analysis throughout this study, several key themes were identified in the cases, relating to potential enablers, challenges, or barriers to lean implementation. These themes are: Covid-19, piloting initiatives, training, culture, and leadership.

Covid-19 was found to be a strong catalyst for change and an opportunity to put in place continuous improvement and lean plans (C1). It also helped drive the adoption of cloud technology to facilitate remote working (C13). Due to Covid-19 related resource constraints and rapid sudden start-up of projects, lean was applied to resource planning to improve resource mobilisation (C17).

Piloting lean initiatives on a smaller scale to prove the concept and get buy in was a regular and robust approach to rolling out change initiatives (C1, C2, C6, C11, C12). C2 used the Deming cycle (Plan, Do, Check, Act) to implement change and allow for a dynamic and flexible outcome.

Training of staff has been identified as a key enabler to lean adoption. Training has been referenced in 11 of the 16 companies (69%) as a key enabler to lean implementation and continuous improvement (C1, C2, C4, C5, C7, C8, C10, C11, C12, C15, C17). A structured approach for lean principles was sought through lean green belt training, attending LCI webinars (C1) and LPS (C1, C10). Internal training was carried out on IT systems and dashboards (C2) as well as lessons learned (C2, C10). A training programme on the cost of quality was an outcome for C4, while training on understanding waste was carried out for C5 and on virtual reality software (C7). In C8, a survey was carried out to identify what training was required by the staff. Training a machine learning model was also completed (C11). In addition, enabling staff to utilise lean and digital tools was seen to be key to improving capability (C12).

Culture was referenced in seven cases. A continuous improvement culture was referenced in C1, while a culture to improve collaboration and reduce silos was referenced in C4, C5 and C6. To sustain change and improvements, culture was seen as important (C8, C15), while generating a proactive culture was referenced in C9. Companies need to be inclusive with staff to facilitate lean adoption, so that there is buy-in to the change and staff need time to reflect on change and consider the impacts and upskill as required (C2, C8, C10). Bottom-up changes from new staff should also be facilitated (C11) and start with easy wins (C2). Tools are available and effective to specifically improve the performance of teams (C16). Overall, the case studies reveal a desire for a continuous improvement culture through collaboration, inclusion, upskilling and the use of digital and lean tools.

Leadership is also identified as an important factor in lean initiatives and was referenced in six cases. Leadership training was referenced (C1), while leadership support and buy in also featured (C1, C14, C16). Company commitment and leadership were considered in C4. Leaders fostered and maintained a creative and innovative environment (C12) and were convinced that change was needed (C15).

DISCUSSION

This study analysed 17 cases contained in the LCi Book of Cases 2022 to get an insight and overview of current tools being used in Ireland as well as associated benefits and challenges. This research also helped address the lack of case study research in Ireland. The preliminary survey results indicated that the Book of Cases is a valuable asset to construction companies. It has also connected academia and industry (Pizam et al., 2013) in a meaningful way (Aouad et al., 2010) and facilitated the investigation of experiences of contractors. Doing so has helped the adoption of LC in the construction industry as recommended by Ghosh & Burghart (2021).

A broad range of LC tools have been researched by academics (Noorzai, 2022; Schia et al., 2019; Zhang & Chen, 2016). In Ireland, LC case study research is limited to a few academic papers by Taggart et al. (2019), Power and Taylor (2019), McHugh et al. (2019), McHugh et al. (2021a) and McHugh et al. (2021b). This paper has further developed and consolidated case study literature in Ireland and has highlighted associated tools, benefits, and themes from 17 cases in 2022.

As cases were mainly from large contractors, there is scope to potentially target more diverse stakeholders in future so that a broader perspective is gained. All cases reviewed indicate multiple benefits for LC implementation, including improvements in cost, schedule, quality and health and safety. These benefits align to those of Lavikka et al. (2019). The themes that emerge from the cases include the significance of Covid-19, piloting lean initiatives, training, culture, and leadership in these case studies. These themes align to those identified in literature (Lyles, 2014; Zhang & Chen, 2016). Covid-19 has facilitated improvements in LC and piloting initiatives has helped improve buy in. Training was seen as instrumental for LC adoption. A collaborative culture with support from leadership is also seen as important for LC adoption. These findings support those from Sarhan and Fox (2013), who identified the top three LC barriers as lean awareness (training), cultural issues and lack of top management commitment.

Findings from this study resonate with those from the study of Ebbs et al. (2015), who found that short term wins are the primary focus rather than a management philosophy for LC, and that practice has not caught up with the theory. Although LPS has been used in Ireland and the potential benefits of using Line of Balance highlighted (Taggart et al., 2019) no reference to takt planning exists and there is still a lot of progress needed to enable a more mature, production management approach to LC. The Irish lean construction community will need to actively monitor trends and developments overseas so that they can be incorporated into practice and help evolve LC activity.

Although six operational excellence focused cases were developed in 2022, there was no consistent approach on how LC is adapted into companies. It appears there is a mixed approach, both from the top-down through policies and strategies and from the bottom-up through pilot projects. Ward and Caklais (2019) concur and believe that ad hoc deployment of tools and techniques is frequent, but business transformation is very rare. They examined the first use of the new international lean standard ISO 18404:2015 and suggest that it could act as a useful roadmap for those seeking to transform.

Although this study has provided an overview of multiple LC cases in Ireland and associated benefits and key factors, it is limited to a snapshot in time. Further similar research on previous and future cases will help develop a deeper understanding of LC activity in Ireland so that its

maturity can be thoroughly assessed and trended over time. In addition, the maturity of various tools was not part of this study, and the assessment of benefits of LC is indicative only. Further research on tool maturity and benefits would be helpful.

However, the Irish construction sector appears to be moving in the right direction, where culture and leadership are important elements for organisational change such as LC adoption. Published case studies are a valuable resource to both industry and academia. Further insights have been identified and shared with academia through this paper that builds upon existing literature. By continuing to carry out academic research on LC cases, further consolidation and insights can be uncovered to help improve LC adoption and maturity.

CONCLUSION

This paper has achieved its purpose of identifying what lean tools and techniques construction companies are using in Ireland and what common challenges and benefits exist for their implementation. The Book of Cases is an asset that shares insights and helps facilitate collaboration between academia and industry and help the adaption of LC. Indications are that Ireland is at an early to intermediate stage of LC maturity, as companies are deploying lean tools to reduce waste, rather than taking a wider production management approach to LC adoption. Findings relating to the lean tools, benefits and challenges support existing literature reviewed, and highlight the importance of training, culture, and top management commitment.

LC activity in Ireland is still at an early stage of adoption where the focus seems to be on short term wins, rather than on long term transformation. Opportunities to develop a lean production management approach exists, and consideration should be given to a more standardised way of business transformation.

As this paper focuses to the Book of Cases 2022, it is limited to a snapshot in time. It is recommended that further academic research on future and past book of cases should be carried out to get a deeper appreciation for LC activity in Ireland as well as to consider ways to assess tool maturity and LC benefits in a more comprehensive way.

Covid-19 has been a catalyst for digitisation of many systems and processes, which has provided new opportunities for streamlining processes and reducing administration. A more collaborative and team focused approach for LC adoption is suggested from this study, through the inclusion of all stakeholders in change initiatives, which leads to better engagement, understanding, adoption and sustainability of improvements. By developing the enablers of leadership, training, and cultivating a collaborative culture, the focus can go from individual LC initiatives to the overall creation of effective production systems.

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Table 1: Case Study Matrix

No.	Company	Size	Sector	Case Study Title	Tools Used	Time	Cost	Quality	Safety
C1	Coffey	Large	Civil Contractor	Lean and Collaborative Planning at Coffey	6S, 8 Wastes, DMAIC, LPS.			Q	S
C2	Duggan Brothers	SME	General contractor	Make the change and implement lean	8 wastes, VSM, LPS, DMAIC, 5S, FMEA, PDCA, A3, Pareto.	T	C	Q	
C3	Hawthorn Heights	SME	Civil Contractor	The use of process mapping and 5S to optimise tender success and profitability	Process mapping, 5S, LCI lean waste audit tool.		C	Q	
C4	Kirby Group	Large	M&E contractor	Framework to determine Cost of Quality on Construction Projects.	DMAIC, Prevention Appraisal Failure, SIPOC, fishbone, 5 Whys, 6M, Process Mapping, TQM.			Q	
C5	Mace Group	Large	General contractor	5S Project Improvement Programme	A3, 5S, waste walks.			Q	S
C6	Office of Public Works	Large	State Buildings	OPW Lift Replacement Programme	Two stage procurement framework, IPD.	T	C		
C7	Arup	Large	Consultancy	The Lean Approach to Immersive Technology at Arup	VR.			Q	
C8	Errigal	Large	Manufacture	Improving Productivity The Errigal Way	Big Data, AI.	T	C	Q	
C9	John Paul Construct.	Large	General contractor	The Grange Development	Last Planner, Field View, other digital tools.	T	C	Q	S
C10	Mannings Group	SME	General contractor	Mannings Construction's Digitalisation of Systems and Processes	Digitisation of systems and processes.		C	Q	S
C11	SISK	Large	General contractor	Capturing Quality Information Using Artificial Intelligence	AI form reading, Microsoft flow.	T		Q	
C12	Walls	Large	General contractor	Walls Construction Cloud Based Solutions Development	BIM 3D viewer.		C	Q	
C13	Walls	As above	As above	The Journey to Our Digital Transformation	Centralised cloud-based docs.		C	Q	
C14	ACB Group	SME	General contractor	ACB Manufacturing – Towards Modern Methods of Construction Using Lean Principles	PDCA, Prefabrication, JIT, BIM.			Q	S
C15	Horizon Offsite	SME	Steel Prefab.	Horizon Offsite – Adopting a CI mindset to their Design for Manufacturing & Assembly operations	DfMA, Visual Mgt., prefabrication.	T	C	Q	S
C16	Ardmac	SME	General contractor	Data Led Approach to Developing Lean Behaviours on Complex Projects	High Performance Teams.	T	C	Q	
C17	DPS Eng.	Large	Project mgt. and engineering	Development of an effective Resource Mobilisation Process using Lean Thinking	DMAIC for resource mobilisation process.	T	C	Q	

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