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Lean Design Management as a Solution for Delays in Design Phase

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Abstract

The results of this study reveal that traditional project management has a negative impact on the performance of construction projects and addresses its weaknesses in the design stage. Poor quality documentation from poorly managed design projects leads to budget overspending, delay, rework, and disputes. This paper emphasizes the importance of technical cooperation and highlights the lack of focus on value and waste in design development. Lean Design Management (LDM) is suggested as a remedy, emphasizing its unique focus on important components. Through an examination of useful tools and techniques created in the last ten years, the study hopes to add to the continuing discussion on lean design. It aims to talk about how these tools can help with lean design management by improving planning and control during the design process. This study fills in a significant knowledge vacuum and implementing lean principles in design development, offering valuable insights for practitioners and scholars.

Keywords: Lean Design, Lean techniques/tools, Design Management, Design delays

INTRODUCTION

The design phase of any project needs a lot of input and collaboration from a diverse group of experts to identify, and determine customer and end-user needs, visualizing and developing construction solutions that meet those needs. The traditional project management approach is unable to provide an effective solution to the difficulties of managing the design process.

Documents are developed and produced at increasing levels of complexity as the project moves forward, until they are ready for budgeting, estimating, planning, and eventually building. It has been determined that low-quality design and documentation significantly lowers the overall performance and efficiency of construction projects [1]. As a result, it is directly to blame for the numerous projects that go over budget, take longer than expected, require rework, variations, and disputes.

A lot of the quality and efficiency problems experienced during the design process are due to inadequate design management and poor quality of the end product [1]. Additionally, delay in obtaining information often occur by failing to plan the information flows in relation to the various tasks and these design management issues don't show up until much later in the construction process, thus leading to delay or rework in both design and construction [2] [3].

The application of lean thinking in design development is distinctive in the industry since it puts the emphasis on what is valuable and what is waste. Previous researches have explored to solved the above issue with the theory of Lean Design Management (LDM) and transform customer needs into engineering specifications and

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outputs [4]. Although there are a certain number of studies that approach lean design related themes, it is still under debate in terms of what it is, and how to best implement it.

For this reason, the purpose of this study is to highlight the effective lean production tools and techniques that have been developed over the past decade, to discuss how these might assist with planning and controlling the actual design process for lean design management.

METHODOLOGY

In order to achieve the final objective of this work, it was imperative to study the causes of delay in design phase of a construction project. Following which, a literature review of lean design management tools and techniques was carried out first to understand how each one of them contributes to solving different issues at different stages of the design phase. Second, an analysis of how these tools were helpful in real-life scenarios and their research gaps based on case studies in the literature was drawn. Third, understanding of the lean practice flow associated with project planning, controlling, problem solving and decision-making. Finally, based on all the above, inferences were drawn that lead to the theory on framework for lean design management.

CAUSES OF DELAY IN DESIGN PHASE

The intensity of influence on project cost is by far greatest during design phase while actual expenditures at that stage are relatively small [2]. Every project phase has its own specific elements that cause delays and no root cause can be generalized for delay factors specific to various countries, project sizes and project types. Only very few studies discuss about the delay factors occurring in design phase.

According to research on construction projects, delays that start in the design phase include inadequate schedule control by architects, the inability of owners to review designs in a timely manner, the late incorporation of emerging technologies into a design and ineffective coordination and inclusion of project user groups.

Based on a study in 2010 which listed down and analyzed the delay factors in design phase of a project by using Importance-Frequency matrix and Severity Index, it mentions about 20 different delay factors in design factors of which some are changes in clients' requirements, inadequate integration on project interfaces, change orders by deficient design, unrealistic design duration imposed, slow decision making by designers, poor communication and slow information delivery [5].

As per a study in 2014, delay factors were classified into four first level factors and totally contained 17 sub-factors under them. The four first level factors mentioned were: (1) User needs and specification requirements, (2) Organization's decision making and budget constraints, (3) Project control and review management, and (4) Design execution and interface management.

The following table summarizes the delay factors for design phase of a project based on the studies.

A construction project's overall cost and schedule are greatly influenced by its planning and design. Planning phase delays typically result in a compressed timetable for the design or construction phase when the project's completion date is set.

LEAN MANAGEMENT TOOLS

Lean production management and techniques provide the foundations for waste minimization or its total elimination from construction projects. It can be seen through vast number of studies of how other industries are benefiting from lean tools and contrastingly, how construction industry is suffering from issues of high delays and low productivity and the only feasible method to cope with this situation is to adopt the lean methodology [6] Lean tools will lead to better delivery processes and

value-added systems through the removal of wastes; transportation, overproduction, inappropriate processing, lead time, inventories, rework and unnecessary movements in construction processes, hence, improve project and financial performance of the industry [7]. In short, these tools not only help in responding to the wastes but also help in detection and processing of the wastes.

In order to resolve the problems associated with waste in construction projects, several lean tools have been recommended by a few researchers [8]. Based on research in 2012, construction practitioners with an overview of lean implementation through a list of 27 tools. A study in 2009 summed up the lean practices suggested by various researchers for large and small organizations [9]. [6] In a paper in 2017, different companies listed a combination of tools and methods for testing in case study projects [1]. [1]. The paper lists these tools under three attributes of LDM, namely Social Process (5 tools), Methods (6 tools) and Tools/Techniques (5 tools). Even though these works are worthwhile, however, they lack evidence in their analysis and how effectively these tools are implemented in a project along with other tools for effective project management.

In order to simplify ensure effective implementation of Lean its fundamental concepts must be clear. Lean relies on several fundamental concepts:

- Customer focus–value is determined by the customer values.
- Eliminate waste–if anything does not add value then it is waste and must be eliminated.
- Smooth flow–level out any variations in process steps to achieve consistent flow of processes.
- Continuous improvement–continually find ways to make any type of improvements.

A study in 2016 brought together a collection of good practices that detailed ways for applying some lean product development principles in building projects. The paper described ten principles for good practices for lean design implementation, along with the tools and techniques that were used for each based on case studies. In this aspect, application of fire and life safety principles during the design also plays an important role [10] (Roy, et al., 2023). The following is a list of different tools along with its definition or explanation from a variety of literature papers.

Transformation Flow and Value (TFV)– It is model that represents the relation between operations, processes and value creation. It ensures that the construction process is more efficient; eliminates and reduces all non-value adding activities and the best functional alternative is selected to reduce/eliminate value loss.

Plan-Do-Check-Act–PDCA cycle is a lean principle used to represent a four-step iterative model for improving processes and end product. It is useful for testing small-scale improvement initiatives, resolving issues and controlling transformation. It stands for

- *Plan:* Establish process goals and the necessary adjustments to reach them.
- *Do:* Put the modifications into action.
- *Check:* Analyse the outcomes in terms of performance.
- *Act:* Either standardize and stabilize the modification or relaunch the cycle.

Last Planner System: The Last Planner System is a project production method that encourages the development of a consistent workflow amongst different stakeholders in order to produce dependable outcomes. Potential obstacles can be identified and resolved with the LPS before they impede the flow. As a measure of productivity, *Percent Plan Complete* (PPC) helps in measuring how well the planning on a job is working.

5s-Stands for Sort, Straighten, Shine, Standardize, and Sustain. 5S Eliminates waste that results from a poorly organizer work area. Sort–eliminate that which is not needed. Straighten–put the remaining items in sensible locations and mark them. Sweep and shine–clean and inspect the work

area. Schedule–create standards for above. Sustain–maintain the above system and arrangement [11].

Target Value Design: A methodical approach to project management that will be employed to guarantee that the building satisfies the users' operational requirements and values, is completed within the allocated budget, and fosters innovation at every stage to maximize value and minimize waste (of time, money, and labor). TVD consists of three main components: a feasibility study to ascertain the client's values and constraints early in the project; setting the target cost at a level the client is willing or able to pay; designing and building to that target cost.

Set-Based Design: A system of practice that keeps the design options flexible throughout the process by considering a large number of alternatives, establishing feasibility before making decisions and gradually narrowing down possible solutions until a final solution is reached.

Value Stream Mapping: Method where the things that are valued by the customer is identified throughout a process and waste can be reduced. It can be used to visually analyze, record, and enhance a process's flow in a way that makes improvement opportunities stand out. A team maps out each step of the working process physically during the VSM process. To identify which steps in the process can be moved, improved upon, or eliminated entirely, the team must next carefully examine each one. To identify which processes are most important for producing the final good, service, or result, VSM employs a holistic strategy.

Integrated Project Delivery (IPD): Key players in the design, fabrication, and construction phases of a project are brought together under one agreement through the use of integrated project delivery (IPD). This makes it possible to collaborate and communicate continuously throughout the project's phases, which reduces waste and increases efficiency, team member respect, and project outcomes, including revenues.

Six Sigma: Sets of instruments and methods for enhancing quality by locating and eliminating flaws and lowering process variability. Six Sigma is able to attain a defect-free process quality by considering six standard deviations before it results in a defect.

Kaizen: Kaizen seeks ideas for improvements from people on the job, using their experience, knowledge, common sense and intuition to understand the process, identify the value-add and identify wastes. This strategy seeks to improve quality and efficiency through the elimination of waste from the value stream.

5 Whys: It is a quality management tool that looks for an issue’s underlying cause. It involves asking the question "Why?" up to five times. The process aims to correct a system by removing the underlying cause in order to prevent a recurrence.

Just in Time: This method’s main objective is to reduce production flow times as well as response time from suppliers and end users. It is strongly associated with pull systems, thereby reducing work-in-progress and inventory and coordination processes.

Kanban: It is a communication tool used in Just in Time production systems. Pull systems are used in information control processes to manage resource movements and releases, ensuring that supplies and parts are ordered and made available when needed. Through the use of a board to visualize the workflow, team members can work together more efficiently.

Daily Huddle Meetings: This is a method that the project team uses for communication and daily meetings to achieve employee involvement. Project awareness and problem-solving skills, along with some training provided by various tools, will boost job satisfaction.

Poka-Yoke: A mechanism to find and prevent errors in such a way that mistakes are impossible to

happen.

Virtual Design and Construction: A more advanced version of BIM called virtual design and construction is the main technological component of lean design management. One of the aspects of VDC is coordination of the mechanical, electrical and plumbing systems. The entire structure, including its technical systems, is parametrically modeled in a three-dimensional setting. This allows the model to be applied to various analysis and production planning requirements; four-dimensional scheduling is one such application.

Work Structuring: In order to improve work process reliability and speed while maintaining client quality, this is used to develop process design and operation in accordance with supply chain structure, resource allocation, product design, and assembly design efforts. It is a process of iterating loops that assigns task of work structuring to design, supply and assembly teams.

Additionally, research in 2011 provides some customized tools to manage building project design. The paper proposes a way to choose the best design concept that aligns with their primary purposes and uses a flowchart in order to formalize the tasks and to engage design team as shown (Figure 1):

The above-mentioned paper also uses a matrix of responsibilities between the various design tasks and the stakeholders with the aim to differentiate responsibilities and improve time estimation. For this a design task classification is also proposed: creative internal task, operational internal task and external task. Shown below is the mentioned matrix (Figure 2).

Based on the above discussed tools, a systematic view (Figure 3) of lean management principle, systems, techniques and metrices was developed. The principle and philosophy for the implementation of these tools can be derived from Transformation, Flow and Value (TFV) and Plan-Do-Check-Act (PDCA). Based on these principles tools, lean design management can be implemented by certain systems in place namely Last Planner System (LPS), Target Value Design (TVD), Set Based Design, Work Structuring, Kaizen and 5s.

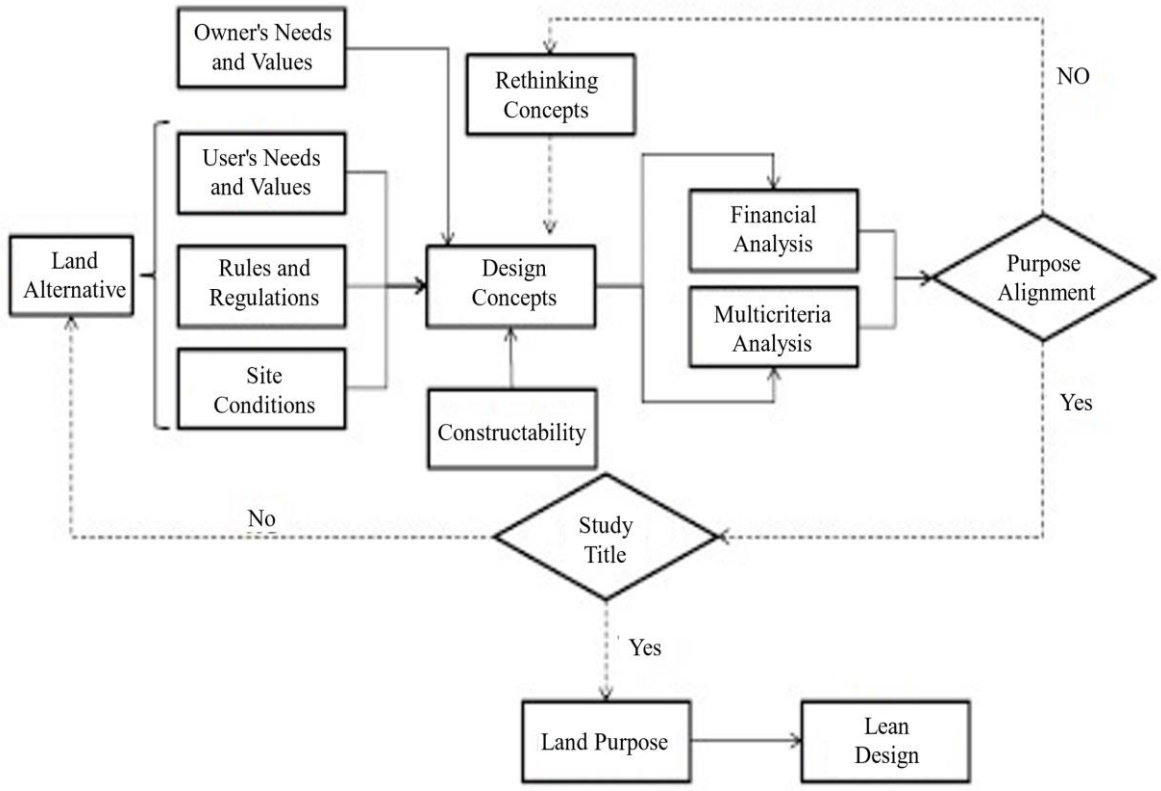

Figure 1. Structuring design tasks (Orihuela and Ulloa, 2011).

Design Task	Type of Task	Design Team								
		Project Manager	Owner	Local goverment	Architec	Surveyor	Structural enginee	Electrical engineer	Supplier of elevato	Sanitary engineer
Feseability of electric power	EX							R		
Checking of the boundaries	INO					E				
Design of pre project	INC				E					
Pre project approbal by owner	INO	C	R							
Pre project approbal by municipality	EX			E						
Selecting the type of elevators	INO	C	C		R				C	
Sizing of cistern	INO				C					E
Type of pumping	INO	C								R
Type of roof slab	INO	C					R			

EX = External Tasks
INO = Internal Operational Tasks
INC = Internal Creative Tasks
R = Reponsible
E = Ejecuting
C = Co-operating

Figure 2. Matrix of Responsibilities (Orihuela and Ulloa, 2011).

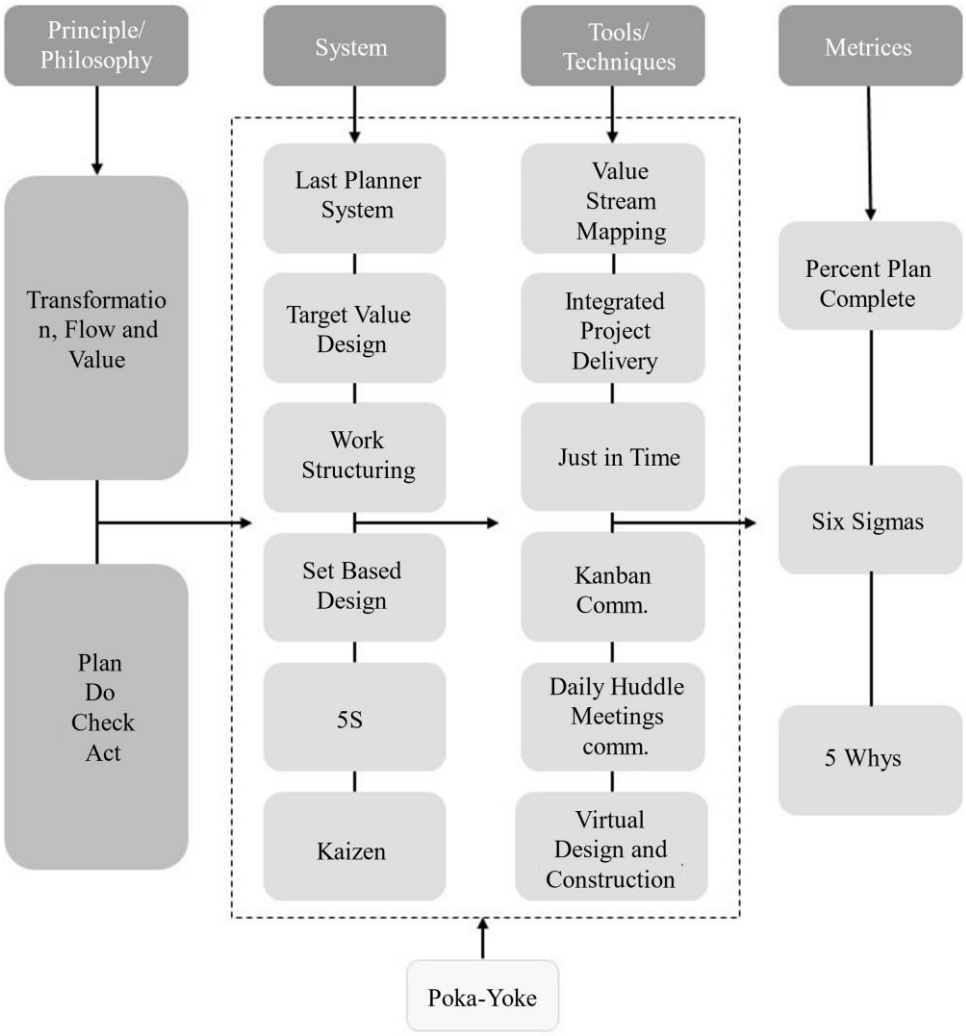

Figure 3. Systematic view of Lean Management.

These mentioned systems work better in relation with tools/techniques to use namely Value Stream Mapping, Integrated Project Delivery (IPD), Just in Time, Kanban, Virtual Design and Construction and Daily Huddle Meetings. For the improvement in future and to make design delivery more efficient with experience, there is a need for metric systems in place namely Percent Plan Complete (PPC), Six Sigma and 5 Whys.

Additionally, a mistake proofing system that can be implemented at every stage of implementation of the systems and techniques can be Poka-Yoke. It can be noticed that Kanban and Daily Huddle Meeting are also used to connect all these as a form of communication system to make the work flow better and efficient.

SOLUTION FOR CAUSES OF DELAY IN DESIGN PHASE – LEAN APPROACH

Lean design uses customer's voice to define value, focuses on process and flow when approaching design management, it focuses on process and flow when approaching design management [6]. A system is used to create value and reduce waste in building design by comprehending design activities through the concepts of change, flow and value generation.

Some building projects have already begun implementing lean design management. According to a comparative study based on Cathedral Hill Hospital, it was concluded that while most of the principles have been implemented to some degree, a few still require attention.

In addition to this, the importance of design briefing was highlighted by other authors as well. Briefs are essential for conveying client requirements to design and construction teams. A paper in 2004 proposed a process known as Dynamic Brief Development, where the brief is specifically managed to evolve over time, as more and better information comes to hand, in order to maximize the project value and to reduce the impact of changes to the project brief. The success of this depends not only on the level of involvement of client, but also on the whole project team throughout the entire design process.

Based on the study done, the following table recommends a list of good practices and lean management tools that can be used to address the delay factors for design phase of a project mentioned in Table 1.

Table 1. Factors that affect design delays

No.	Factors	Description
1.	Uncertainty of user needs	User needs are not certain, not clearly defined/difficult to meet.
2.	Limitations imposed by regulations	Governmental regulations that prevent user needs.
3.	Disagreement on design specifications	Technical specifications do not suffice to meet user needs.
4.	Inadequate integration on project interfaces	Coordination of all elements of a project including tasks, resources, stakeholders and deliverables.
5.	Change orders by deficient design	Continuous design changes due to user needs not met. Inadequate experience of designers.
6.	Improper cost estimation	Variation from initial cost estimation to final due to continuous changes or A/E's lack of experience.
7.	Slow information delivery and unclear authority among designers, contractors and stakeholders.	Slow integration of changes into design due to lack of communication or understanding among A/E, contractors and stakeholders due to lack of management.
8.	Slow decision making	Decisions taken by decision makers are not timely.
9	Resource allocation	Ineffective allocation of resources for design jobs. Insufficient budget allocation by client/by PM for each project phase.
10.	Unrealistic duration imposed	Design phase given very little importance and less time allocated for the phase, leading to incomplete drawings and specifications.
11.	PM's management method	Inefficient project control methods, lack of communication and/or

		experience of PM.
12.	PM's reviews	Review of design deliverables are insufficient.

Table 2. Lean tools for causes of delay

No.	Factors	Good Practices	Lean Tools and Techniques
1	Uncertainty of user needs	Identify value and client requirements	Target Value Design, Value Stream Mapping
		Establish a target cost and metrics system	
2	Limitations imposed by regulations	Work with specialists on briefing definition	Work Structuring, Integrated Project Delivery, Kaizen
		Form multidisciplinary teams to contribute in technical discussions	
3	Disagreement on design specifications	Develop more than one design option for client's approval	Set-Based Design, Work Structuring, 5s, Target Value Design
		Seek early involvement of consultants, suppliers and builders	
		Form a work structure for stakeholder responsibility	
4	Inadequate integration on project interfaces	Build mock-ups to help the design development process	Integrated Project Delivery, Virtual Design and Construction, Poka-Yoke
		Promote design-build and IPD contracts	
		Simulate design through software to test the design functionality	
5	Change orders by deficient design	Keep design indicators and have a design database	Set-Based Design, Value Stream Mapping, Six Sigma, 5s
6	Improper cost estimation	Using 4D BIM technology for rapid prototyping and quantities extraction to get close to accurate cost estimation	Target Value Design, Virtual Design and Construction, Kaizen
7	Slow information delivery and unclear authority among designers, contractors and stakeholders	To set up everyday meetings and clear mode of communication	Daily Huddle Meetings, Kanban
8	Slow decision making	Planning pulled by client's demands.	Last Planner System, Just in Time, Kanban
9	Resource allocation	Share human resources with other units and departments	Work Structuring, Matrix of Responsibilities
		Challenge suppliers on developing solutions to achieve a target cost	
10	Unrealistic duration imposed	Mark up duration based on realistic project briefing	Target Value Design, Just in Time
		Consult experienced professionals and look up similar projects to set a suitable timeline	
11	PM's management method	Adopt value generating management methods to handle projects efficiently and reduce waste	Last Planner System, Target Value Design, 5s, 5 Whys
12	PM's review	Form multidisciplinary teams to contribute in technical discussions	Poka-Yoke, 5 Whys, Six Sigma

The table does an effective job of highlighting the many lean tools that can help reduce delays brought on by things like imprecise requirements, poor communication, and poor project management. Target Value Design (TVD) and Last Planner System (LPS) are two examples of tools that address the planning and execution phases, encouraging cooperation and cutting down on waste. The significance of dismantling divisions and promoting collaboration is a recurrent theme. Work Structuring and Integrated Project Delivery (IPD) are two strategies that support interdisciplinary teams and guarantee that all members contribute to the successful completion of projects. The process

is further streamlined by early stakeholder involvement via Set-Based Design and transparent communication techniques like daily huddle meetings. Technology has a vital role. Accurate cost estimation is made easier by 4D BIM, and rework is decreased by Virtual Design and Construction (VDC), which enables simulation of designs prior to actual construction. Furthermore, data-driven tools that aid in the visualization and optimization of project workflows include Value Stream Mapping (VSM).

Even though the table provides insightful information, there are some areas that would benefit from more research. Certain lean tools may be more or less effective depending on the industry and complexity of the project. Furthermore, the table does not discuss the difficulties in implementing these tools. Subsequent investigations may examine prosperous case studies to comprehend the ways in which these instruments were modified and incorporated into current procedures. Through the implementation of lean principles and associated tools, project managers can effectively mitigate delays. Nonetheless, meticulous evaluation of the project's particulars and a dedication to ongoing improvement are necessary for successful implementation.

CONCLUSION

The exploratory studies brought a collection of good practices and lean tools that can be used in the industry for lean design management. Only a portion of the lean management tools could be described by the study's variables because they depended on some conceptual tools that had already been studied in the past. There might be additional lean construction techniques that, while not covered in this study, could significantly reduce waste in the planning and execution of building projects.

This work studies the causes of delay in the design phase of a construction project and also establishes a systematic view of lean management with the help of studies on various tools. This paper thus explains which of these tools help in planning and controlling which delays factor in the design process.

With each one of the projects being unique with different set of requirements, it is difficult to achieve the ideal balance between people, process and technology as the results may vary when different experts are used. Therefore, future research should concentrate on mini-cases, interviews, and testing out indicated models in combination to determine how they impact design management outcomes and project teams.

REFERENCES

1. S. Das, A. Rastogi and K. Kumar, "Applicability of Risk Assessment Tools and Techniques for a Construction Project," Journal of Research in Infrastructure Designing, vol. 4, no. 3, pp. 1–18, 2021.
2. K. Kumar, C. Basu and V. K. Paul, "Utilization of Floats in Project Schedule Recovery-A Pilot Schedule Demonstration," INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS, pp. 3496–3502, 2020.
3. V. Saif, A. Rastogi and V. Paul, "Debt Restructuring of Distressed Indian Construction Projects," International Journal of Creative Research Thoughts, vol. 8, no. 6, pp. 2802–2810, 2020.
4. R. Roy, K. Kumar and V. K. Paul, "Role of Facility Management in Fire and Life Safety in Hospitals," International Journal ofArchitectural Design and Planning, vol. 1, no. 1, pp. 8–11, 2023.
5. Mohammed, Elzafaran, N. A. Mohamed, Elhefnawy, Helmy, M. Osman and Fatma, "Using smart glazing for reducing energy consumption on existing office building in hot dry climate," HBRC, 2020.
6. K. Kumar, D. C. Basu, A. Rastogi and V. K. Paul, "Retrofitting the existing requirements for an institutional building Framework for Enhancing the Functionality," IJSDR, vol. 5, no. 3, pp. 362–368, 2020.

7. K. Kumar and D. Nayal, "Critical Review of use of Glass Fiber Reinforced Gypsum (GFRG) Panels in Housing in India," International Journal of Engineering Research & Technology (IJERT); ISSN: 2278-0181, vol. 9, no. 2, pp. 763–766, 2020.
8. S. D. Rezaei, "A review of conventional, advanced, and smart glazing technologies," Solar Energy Materials & Solar Cells, pp. 26–51, 2017.
9. Pragya and K. Kumar, "A Review of Performance of Green Roofs for Retrofitting Existing Structures," Journal of Research in Infrastructure Designing, pp. 1–7, 2021.
10. K. Kumar and V. K. Paul, "A Critical Review of Risk Factors and Reliability Assessment Issues of Fire and Life Safety in Buildings," NICMAR JOURNAL OF CONSTRUCTION MANAGEMENT, vol. XXXVII, no. III, pp. 23–33, 2022.
11. D. Pranckevicius, D. M. Diaz and H. Gitlow, "A lean six sigma case study: an application of the “5s” techniques," Journal of Advances in Management Research, vol. 5, no. 1, pp. 63–79, 2008.

