Systematic Literature review on Lean framework for implementation in Small real estate projects

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Abstract

Rapid developments are happening with vast construction activities across the world. Globally Lean Construction (LC) has gained attention for its benefits in reducing wastage, increasing the value to customers, effective use of resources and increasing the profit to the organizations. For more than two decades construction industry also adopted the principles of lean construction and the same yielded good results. But lean construction in adoption and implementation have not penetrated small and medium construction companies. Only by few large companies for big projects have adopted and availed the benefits of lean construction. This raises the question of whether lean principles work well only for large projects and big construction companies? For small construction companies and projects implementing lean, there is a need for a framework. This study reviews the literature in a systematic research method of approach about the framework for implementation of lean construction in real estate projects. The study identifies the need for a framework for the implementation of lean construction for small projects and construction companies as the gap in the literature. Very less work has been carried out by the researchers in the lean adoption and implementation for cast in situ construction projects which is to be addressed by the researcher for future scope of research. The study concludes that there is no proper literature available that guides organizations to handhold, train and implement lean techniques. This research study will help the researchers to explore in implementation and development of project-based training modules of lean construction tools and techniques for better adoption in small real estate construction projects.

Key Words: Lean Construction, Lean Framework, Real Estate Projects, Lean Construction implementation, Systematic Literature Review

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Introduction

A Finnish scholar was the one who originally coined the phrase "lean construction" (Koskela,1992). There are a number of interconnected principles in lean construction that must be used together: (1) the elimination of all activities that do not add value; (2) the systematic adoption of client requirements to increase the final value of the product; (3) the reduction of variability; (4) the reduction of cycle time; (5) the simplification and minimization of steps and parts; (6) the increase in product flexibility; (7) the increase in transparency; (8) the concentration of control on the totality of processes; (9) the establishment of continuous improvement in processes; and (10) flux improvement balance (Koskela, 1992).

Literature have many definitions for Lean Construction have provided varying definitions of LC (Howell, 1999, Salem et al., 2006, Tommelein, 2015). Howell and Ballard have contributed extensively through research, application and development of tools and techniques in construction industry. The word 'lean' describes a form of production that originated from the study of Toyota (Krafcik 1988) which subsequently led to global efforts to analyze the success of Toyota and replicate it in

other sectors including construction. In the lean approach, production systems are designed to maximize value and minimize waste and a temporary production system should be designed, controlled, and improved for delivering the products to customers (Ballard et al. 2001, Sabale et al. 2023). The consolidation of lean construction theory demands the application of its concepts and principles in practical situations (Koskela, 2000), but until now most of the implementations have been very fragmented (Picchi & Granja, 2004).

Lean construction is the only feasible solution to all problems faced by the Small and Medium construction companies. For better outcomes lean should be implemented holistically (Ankomah et al., 2018). Construction companies can perceive significant benefits of lean construction management although cannot clearly identify the extent of obtained benefits. Large companies have availed the advantage of lean construction in India with the few big players adopting and implementing the lean tools and techniques across the horizon of projects like infrastructure, real estate, industrial etc., But for the adoption and implementation there is no specific framework to train the construction workers. The studies reveal that the awareness of lean construction is very poor among the Indian construction professions. The review says that framework can prove very useful in the implementation of lean construction (Hatzigeorgiou & Manoliadis, 2017). Unlike the developed countries, where the construction is done with precast construction which is similar to the manufacturing setup, in Cast in-situ construction the challenges are different. Most of the construction labor in India are semi-skilled or unskilled which poses other challenges to the construction industry. To address this problem the best tool is lean construction adoption in small real estate projects as well. The hurdle for this is awareness and know-how of lean implementation. A framework and the training module would help the small construction companies in India to consider lean tools for real estate project construction.

Research Methodology

Systematic literature review (SLR) is a technique for hypothesis testing, for summarising the results of existing studies, or for assessing consistency among previous studies (Petticrew 2001). SLRs entail the use of a transparent and rigorous approach for the entire research process, so as to reduce bias and enable future replication (Mallet et al., 2012). A SLR usually relies on the utilization of databases that contain a large set of research publications as well as effective search mechanisms. Typically, the design process for a SLR consists of the following steps: (1) Search method; (2) Inclusion and Exclusion Criteria (3) Search Outcome.

Literature review methodology normally deals with the systematic analysis of previous attempts made according to the objectives. Several journals and articles will be reviewed from different publications. All the data obtained from the review are related to the objective where the results will be analyzed and conclude the solution. An article which deals with the review of lean tools and techniques had enlisted 93 papers and drafted a common idea about the lean concepts. (Singh and Kumar 2019).

Some journals proposes a prototype of framework which are ready to utilize on site. Basically the input is from the literature survey and the data are formalized and created a prototype or a model which will be used analyze a sample and put forth the capacity of that model.(Kasiramkumar and Indhu 2016). Papers which follow case study had a review of literature and compare those ideology with the case studies based on incidents, model or based on other paper works. With the overview of the analyzed data the results will be derived according to the data.(Bena et al. 2009; Ryan et al. 2019; Tabassi et al. 2011).

Collection of research papers related to ‘implementation of lean concepts in construction industry’ from reliable sources. Databases which are preferred are IGLC, Scopus, Web of Science (Wos). The Social Sciences Citation Index, the Humanities and Humanities Citation Index databases, and the Conference Proceedings Citation Index are all part of WoS's core collection. This varied collection was thought to conceal enough high-quality and quantity publications to allow for a systematic review (Huang et al., 2019). Scopus since it's thought to be the database with the most citations and abstracts.While the online Science database does not include IGLC conference papers, Scopus covers 750 different types of conference proceedings, such as conference papers from the

IGLC, the leading worldwide authority on LC. We picked the conference papers that were accessible on the official IGLC website (http://iglc.net/Papers) as a supplement because certain IGLC conference papers are missing from the Scopus database. The IGLC is a reputable international group made up of LC experts and scholars. The most recent research discoveries at the yearly LC conference are reflected in IGLC articles. All publications published between 1996 and 2021 are covered by conference papers starting with the fourth session on the official IGLC website.

Keywords used for the search are "lean construction", "lean construction framework", "lean construction implementation", "lean construction implementation framework". As a result, 262 literatures are obtained from the search. The papers are published in the year 1992 – 2022 range. Analyzing the relevance of papers to filter the papers which suit the objectives of the research are done accordingly. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework for shortlisting papers for study are shown in fig.1

From the research papers an entire analysis about the lean principles and concepts which are suitable for the construction industry are identified through a literature review and a check process is made to know the frequency of usage of that particular lean principles, tools and techniques for the similar scope of labor. The analysis results are displayed during a tabular and graphical format for better understanding. By performing the previous steps the subsequent information are obtained they are and those will confirmed for the next approach. Total list of journals/ conference listed in table 1 and publisher's details are shown in table 2. Across globe various researchers have added to the knowledge on lean construction and therefore the shortlisted from different counties for the specified key words are mentioned in table 3.

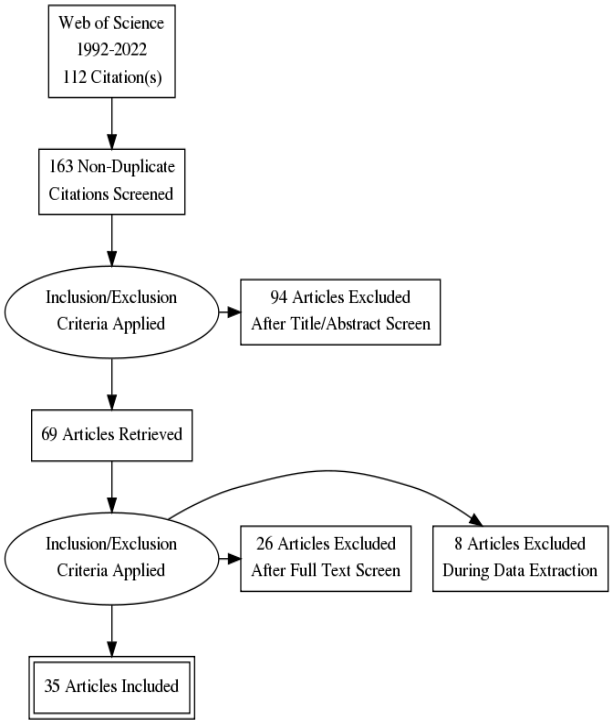

Fig.1: PRISMA framework for journal selection for review

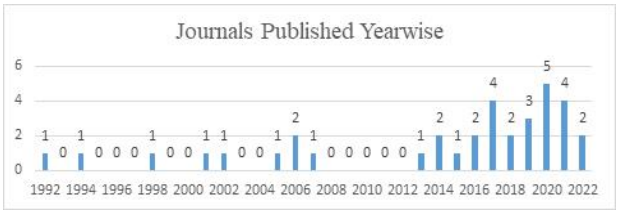

Fig.2: List of Journals published in lean implementation

Table-1: Detailed list of papers by year and publication type

S.No	Journal/ Conference Name	No. of Publications
1	IGLC Conference	6
2	Lean construction journal	3
3	Journal of Engineering, Design and Technology.	2
4	Buildings	2
5	Design and construction: Building in value	1
6	Journal of Management in Engineering	1
7	KSCE journal of Civil Engineering	1

8	Alexandria Engineering Journal	1
9	Journal of Technology Management in China.	1
10	Renewable and Sustainable Energy Reviews	1
11	Journal of Modern Project Management	1
12	International Journal of Project Management	1
13	Construction Economics and Building	1
14	Journal of Modelling in Management.	1
15	Construction Project management and Innovation	1
16	International Journal of Quality & Reliability Management.	1
17	Engineering, Construction and Architectural Management	1
18	Smart and Sustainable Built Environment	1
19	Journal of Construction Engineering and Management	1
20	Engineering Management Journal	1
21	Brazilian Journal of Operations & Production Management	1
22	Journal of cleaner production	1
23	Journal of Construction Engineering, Management & Innovation	1
24	Built Environment Project and Asset Management	1
25	Journal of the South African Institution of Civil Engineering	1
26	Book	1
	Total Publications	**35**

Table-2: Number of publications by the country of origin of the first author's institution

S.No	Country	No. of Publications
1	USA	7
2	Australia	4
3	Brazil	3
4	China	3
5	India	3
6	Turkey	2
7	Singapore	1
8	Egypt	1
9	Colombia	1
10	UK	1
11	Tanzania	1
12	Morocco	1
13	Bangladesh	1
14	Iran	1
15	Srilanka	1
16	Jordan	1
17	South Africa	1
18	South Korea	1
19	Ghana	1
	Total	**35**

Table 3: Gist of Literature

Year	First Author	Findings
1992	Koskela	Initially proposed Lean concepts in construction
1994	Ballard	Proposed LC implementation in complex construction proejct.detailed explanation on Will-Should - Can
1998	Howell G	Explained the implications of the goals and key production principles, and how when taken together they result in a different

		way to manage construction
2001	Dulaimi	It is found that only certain features of lean construction have been implemented in Singapore. Major hurdle is Cultural resistance
2002	Koskela	Implementing Lean Construction requires the progressive application of a new way to design project-based production systems. The change required is both conceptual and practical
2005	Salem	Effectiveness of the lean construction tools was evaluated through the lean implementation measurement standard and performance criteria. Most of the lean construction tools selected for the project are either ready to use
2006	Salem	Propsed a new "lean assessment tool" is proposed to quantify the results of lean implementations
2006	Kim	Introdiced exploratory study in USA reported lean planning systems, organization structure, attitudes of project participants and company strategy that played major influences on successful lean implementation
2007	Barros	Emphasiszed on proper engagement between Lean and strategic issues in construction companies
2013	Issa	Reported on minimizing and mitigating the effect of most of the risk factors in this project due to implementing lean construction techniques
2014	Shang	Chinese building professionals, include "their lack of a long-term philosophy", "the absence of a lean culture in their organizations", "the use of multi-layer subcontracting" and others. This study also reports the findings using a factor analysis that shows the six underlying factors hindering the implementation of lean practices in the Chinese construction industry, namely, people and partner issues, managerial and organizational issues, lack of support issues, culture and philosophy issues, government issues and procurement issues.
2014	Raghavan	In India, Implementation of Lean influenced by many soft aspects, such as the culture of the site and the organisation, planning and engineering expertise available, commitment and support from top management and site management
2015	Sandra Cano	110 barriers and 51 Critical Success Factors based on experiences of Lean Construction impleamtnation across the world. Six groups are made "Master Factors": people, organizational structure, supply chain, external value chain, internal value chain and externalities in Colambian Construction Industry
2016	Li S	1) different firms have different implementation levels of lean construction, and 2) the key determinates of lean construction

		implementation in China are the knowledge of lean construction, organizational structure and culture, and market factors.
2016	Pretti	identifies the emergence of an institutional level of understanding of projects
2017	Algan Tezel	Lean Construction (LC) is being implemented (current condition) and how LC can be further promoted (future direction) from a Small-Medium Sized Enterprises (SMEs) perspective. Although SMEs constitute the largest group in construction supply chains, LC, as an emerging phenomenon in civil construction project management, has been rarely investigated from an SMEs perspective
2017	Sarhan	concludes that the level of implementation of lean construction in the KSA construction industry is increasing
2017	Khaba	Cultural differences are found to be the most important barrier to LC, whereas employees' resistance to change and lack of performance measurement systems are the least significant barriers.
2017	Sospeter	indicate that the lean concept adopted in the Tanzanian construction industry is teamwork. It was consistently found that the main barriers to adoption of lean construction in the Tanzanian construction industry are a lack of technical skills and inadequate design and client information. Generally, there is a low rate of adoption of lean construction in Tanzania, as most of the listed concepts are not yet sufficiently recognised
2018	Bajjou	In Morrocco, lean construction approach adds a positive impact, specifically on quality, safety and environmental level. In addition, the main barriers hindering a successful lean construction deployment in Morocco are lack of knowledge about lean construction philosophy, unskilled human resources and insufficient financial resources.
2018	Khaba	There is a certain degree of lean awareness although the level of lean implementation is still at a nascent stage in the Indian coal mining sector
2019	Sarhan	Matrix of cross-impact multiplications (MICMAC) was applied to analyse the questionnaire data to develop an ISM model which may be adopted as a framework for lean construction implementation based on the data collected from Saudi Arabian construction companies and experts
2019	Ahmed	Reported 41 challenges for lean implemenration in Bangladesh
2019	Innella	Presented implementation of lean techniques in the modular building construction

2020	Koohestani	Qualitative research on lean impleamntation in Iran finds by thematic analysis of the results indicated that lack of awareness and knowledge of lean construction is the main obstacle for the lean Constrcution Implementation
2020	Dimirkesen	Success criteria of 7 categories were listed and related them with Analytical Network Process of Multi criteria decision making . The model was tested succfully for implementation if Lean construction in USA
2020	Ankomah	low-level application of LC principles among SMBCs. There was no indication that lean concepts were used on a company-wide basis in the Ghanaian construction industry
2020	Rodegheri	case study results were analysed and guide to the suitable MM for this scenario. Improvements to the MM and complementary tools for companies starting on LC implementation are discussed. It was verified that the elected MM has many advantages and can be used in different Brazilian SME of construction
2020	Li S	concludes that lean construction is in a stage of rapid development and addresses some issues that have not been reviewed clearly in the past, such as the factors that influence lean construction in Mainland China and the effect of lean construction in Mainland China
2021	Ugurlu	Developed a lean implantation framework for Turkish construction industry and validated with experts and also claims that this can be a guide for lean practioners in construction in Turkey.
2021	Ranadewa	Team working skills, critical thinking, leadership, communication skills, work ethics, knowledge and positive attitudes were identified as lean enabling human capacities for SMCs. The framework developed in this study provides individual, organisational and environmental level strategies that can be used to build human capacities necessary for enabling lean in construction Small and medium construction companies in Srilanka
2021	Bhawani	Six key planning steps i.e., project delivery method, organizing the project team, conducting a formal Lean kick-off, strategically selecting Lean methods for implementation, developing the project-specific Lean plan, and tracking alignment to improve continuously were found to enable systematic project level Lean implementation
2021	Al Balkhy	absence of support from the top management, low awareness toward LC, lack of training, and the absence of transparency are amongst the most serious factors that hinder the adoption of LC

2022	Marsh	describes how the Capability, Opportunity, Motivation-Behaviour (COM-B) model and Theoretical Domains Framework (TDF) were used to identify the barriers to and drivers of sustainable construction practices by construction industry stakeholders. barriers and drivers are mapped to five TDF domains (knowledge, skills, social influences, beliefs about capabilities, and beliefs about consequences), which can be targeted for behaviour change amongst construction industry stakeholders in future interventions
2022	Habibi Rad	On the foundations of Transformation Flow Value, proposed a conceptual framework to implement lean practices for the enhancement of organizational resilience

LEAN IMPLEMENTATION IN CONSTRUCTION INDUSTRY:

Lean concepts and techniques are not derived for construction industry. Introducing concepts for construction made the concepts suitable for construction industry. Based on the uncertainty in this industry implementation also facing hindrances. Several authors from construction industry background are working to derive a set of procedures or controls which regularize the work of construction projects and obtain good results. Attempts which are made from year 2009 – 2019 are reviewed and observed any data or methods.

Lean construction implementation is the solution for avoiding all kinds of wastes in construction projects. Implementing lean in construction is not a procedural type whereas it deals with the continuous improvement in every projects**.** Implementation will be successful when the workflow is stabilized where the errors during the project execution should be avoided.(Ballard and Howell 1994)**.**

Articles from conferences and journals are obtained which all deal with the implementation of lean in the construction industry. There are various methods adopted that links lean concepts and construction (Chothe and Agrawal 2022). Some of the concepts which are all relevant and support the objectives are reviewed and utilized for this research. Topics covered related to the objectives of the current research are listed in table 4.

The construction industry involves numerous operations and each project is unique. With such diverse factors, lean concept implementation is not facilitated. A core concept of lean is to eliminate waste which is caused during any operation. In construction, as the operations are not automated eliminating waste is not entirely possible. Forecasting the wastes creating activities in a construction project will help in regularize the flow and reduces the wastes. This is the first attempt to implement the lean concepts in construction. Identifying the construction wastes in terms of time, cost and materials are explained and a genuine attempt is made. The attempt comprises of data collection through a questionnaire and ranking it.(Formoso et al. 2015).

Lean and SME's are not related properly through which can bring remarkable changes to construction. The previous statement is the state during the implementation efforts of scholars. The articles collected in this review shows the conceptual links between a lean concept and operations in a construction project (Bajjou et al. 2019). A conceptual framework links all the lean principles and application of it to the various phases of it (Chougule and Chothe 2021). A framework will increase the productivity of project. An attempt of this is driven to study the problem and derived a framework. This framework is derived based on case study and field study. It shows the required tools and techniques of lean which will be apt on a construction site to improve the project productivity.(Vimal Kumar and Ramasamy 2016)**.** Exploring the concepts there is a new attempt which tries to incorporate manufacturing Toyota way model into a framework which helps analyzing the capacity of

a SME to implement lean concepts. It can be reverse flowed to self-evaluate the organization's lean adaptability. (Ankomah et al. 2018). A similar concept is attempted to create a conceptual framework which helps in analysing the capability of a contractor. This framework leads to a set of checklist which enables the user to assess the result.(Ghosh and Heidenreich 2014). Generally a conceptual attempt will include an extensive study about the relevant concept and integrate with the objective of the research.

A conceptual analysis article shows that the lean technique LPS can be linked to planning process and induced in the simulation process.(Abdelmegid et al. 2019). Implementing lean concepts in construction is the aim of the articles where this study includes the revision of all the subjects related to lean construction and anticipating a key point to drive to the solution.(Harsha et al. 2013).

BASICS model as show in table.4 for lean implementation is a conceptual model in the book and published is limited to very few sectors in a generic way **(Charles, 2019).**

Table.4: The BASICS six-step model for Lean implementation—short version. (Source: BIG Training Materials.)

Baseline	Analyze	Suggest Solutions	Implement	Check	Sustain
Prepare for Company rollout Determine and scope the inital project	Involve the staff to analyse the process	Update the process Block Diagram	Implement the new process use pilots and test it out using scrum	Do you know how to check?	Develop the case study
Change Equation Charter the team Create the vision	Process Flow Analysis (PFA)- become the customer or product	Create the optimal layout for the process	Starting up the new line	Check using the visual management systems	Creating the Lean Culture
Define the traget condition	Point to point diagram of how the product flows	Ten step process for creating master layouts	Update standard work	Heijunka & Scheduling	Create a Sustain Plan
Train the leadership Charter the team Train the Team	Create process block diagram	Design the work stations	Determine capacity and staffing (PPCS)	Mixed Model Production	upgrade the organization
Define the traget condition Train the leadership Charter the team	Group Tech analysis (if Required)	Create standard work	Implement line balancing Implement line metrics		Ongoing Leadership Coaching
Train the Team Select the pilot and team	Workflow Analysis (WFA) become the operator. This includes a	Determine the capacity and labor requirements	Visual management- Incorporate 5S, Visual displays		

members	s[aghettichart of how the operator works		and controls
Baseline Metrics Health Check Build a Chrono File Map the value	Setup/changeover analysis (SMED)	Make and approve recommendations	Implement Lean Materails Systems
Stream current, ideal, future state		Train staff in thr new process	Implement mistake proofing
Determine the customer demand and takttime (TT)			Implement Total Productive Maintenanace (TPM)

Gaps in Research:

During the first phase of implementation attempt the researches are based upon conceptual discussion. Articles based on this type of research will include an extensive study of the topic and familiarize with the concept. The study leads to the problem analysis and relating the concepts to problem case and derive a solution. In this case most of the problem statements are to implement the lean concepts in construction industry.

Future Research Directions

There is limited literature available in the framework for lean implementation and training and almost no information available on small real estate projects especially for cast in situ building construction projects across the world. The future scope on the lean implemantion framework and

Conclusions

Many literature reviews were carried out for lean implementation in large projects and by large construction companies. Lean implementation among small construction companies has not been extensively researched A detailed systematic literature review on lean construction theory to implementation is carried out from the papers published across the journals. Papers are selected from Scopus, Web of science and IGLC for the study.

Lean construction techniques, tools and methodologies were studied across various researchers. There is limited study done by researchers on lean implementation and lean training methods. This raises an opportunity for the researchers to take up this limited explored area for future studies specific the custom requirements of their own country and the construction methodology. Finally, the small real estate projects are unexplored area, especially for Indian projects, where the major activities are cast in-situ for research and development of framework and training methods.

The review suggests to improve the capabilities and capacities of Small and Medium Enterprise to adopt lean construction.

References

Bena, A., Berchialla, P., Coffano, M.E., Debernardi, M.L. and Icardi, L.G., 2009. Effectiveness of the training program for workers at construction sites of the high-speed railway line between Torino and Novara: Impact on injury rates. American journal of industrial medicine, 52(12), pp.965-972.

Ahmed, S. and Sobuz, M.H.R., 2019. Challenges of implementing lean construction in the

construction industry in Bangladesh. *Smart and Sustainable Built Environment*.

Al Balkhy, W., Sweis, R. and Lafhaj, Z., 2021. Barriers to adopting lean construction in the construction industry—The case of Jordan. *Buildings*, *11*(6), p.222.

Alexandros, H. and Odysseas, M., 2017. Assessment of performance measurement frameworks supporting the implementation of lean construction.

Ankomah, E.N., Ayarkwa, J. and Agyekum, K., 2020. Status of lean construction implementation among small and medium building contractors (SMBCs) in Ghana. *Journal of Engineering, Design and Technology*.

Bajjou, M.S. and Chafi, A., 2018. Lean construction implementation in the Moroccan construction industry: Awareness, benefits and barriers. *Journal of Engineering, Design and Technology*.

Ballard, G. and Howell, G., 1994. Implementing lean construction: stabilizing work flow. *Lean construction*, *2*, pp.105-114.

Barros Neto, J.D.P. and Alves, T.D.C.L., 2007. Strategic issues in lean construction implementation. Annual Conference of the International Group for Lean Construction.

Bhawani, S., Messner, J. and Leicht, R., 2021. Key Planning Steps Enabling Systematic Lean Implementation on Construction Projects. *Lean Construction Journal*.

Cano, S., Delgado, J., Botero, L. and Rubiano, O., 2015, July. Barriers and success factors in lean construction implementation: survey in pilot context. In *Annual Conference of the International Group for Lean Construction, Perth, Australia* (Vol. 23, pp. 631-641).

Demirkesen, S. and Bayhan, H.G., 2020. A lean implementation success model for the construction industry. *Engineering Management Journal*, *32*(3), pp.219-239.

Dulaimi, M.F. and Tanamas, C., 2001. The principles and applications of lean construction in Singapore. *9th International Group for Lean Construction*.

Formoso, C., Bølviken, T., Rooke, J. and Koskela, L., 2015. A conceptual framework for the prescriptive causal analysis of construction waste. IGLC. net.

Ghosh, S. and Heidenreich, L.T., 2014. Conceptual Framework for a Lean Construction Capability Model.

Habibi Rad, M., Mojtahedi, M., Ostwald, M.J. and Wilkinson, S., 2022. A Conceptual Framework for Implementing Lean Construction in Infrastructure Recovery Projects. *Buildings*, *12*(3), p.272.

Harsha, N., Suresh, A., & Nagaraj, N. 2013. Implementation of lean concepts in the construction engineering project. International Journal of Engineering Research & Technology, 2(5), 1078–1085.

Howell, G. and Ballard, G., 1998, August. Implementing lean construction: understanding and action. In *Proc. 6 th Ann. Conf. Intl. Group for Lean Constr*.

Innella, F., Arashpour, M., & Bai, Y. (2019). Lean methodologies and techniques for modular construction: chronological and critical review. *Journal of Construction Engineering and Management*, *145*(12), 04019076.

Issa, U.H., 2013. Implementation of lean construction techniques for minimizing the risks effect on project construction time. *Alexandria Engineering Journal*, *52*(4), pp.697-704.

Kasiramkumar, T. and Indhu, B., 2016. An implementation framework for integrated lean construction system for Indian Scenario. ARPN Journal of Engineering and Applied Sciences, 11(15), pp.9388-9394.

Khaba, S. and Bhar, C., 2017. Modeling the key barriers to lean construction using interpretive structural modeling. *Journal of Modelling in Management*.

Khaba, S. and Bhar, C., 2018. Lean awareness and potential for lean implementation in the Indian coal mining industry: An empirical study. *International Journal of Quality & Reliability Management*.

Kim, D. and Park, H.S., 2006. Innovative construction management method: Assessment of lean construction implementation. *KSCE journal of Civil Engineering*, *10*(6), pp.381-388.

Koohestani, K., Poshdar, M. and Gonzalez, V., 2020, August. Finding the Way to Success in Implementing Lean Construction in an Unfavourable Context. In *28th Annual Conference of the International. Group for Lean Construction (IGLC28)*. International Group for Lean Construction (IGLC).

Koskela, L., 1992. *Application of the new production philosophy to construction* (Vol. 72). Stanford: Stanford university.

Koskela, L., Howell, G., Ballard, G. and Tommelein, I., 2002. The foundations of lean construction. *Design and construction: Building in value*, *291*, pp.211-226.

Kumar, U.V. and Ramasamy, G., 2013. A critical study of various lean techniques in practice and developing a framework for different construction building projects. Alexandria Engineering Journal, 52, pp.679-695.

Li, S., Fang, Y. and Wu, X., 2020. A systematic review of lean construction in Mainland China. *Journal of cleaner production*, *257*, p.120581.

Li, S., Wu, X., Zhou, Y. and Liu, X., 2017. A study on the evaluation of implementation level of lean construction in two Chinese firms. *Renewable and Sustainable Energy Reviews*, *71*, pp.846-851.

Marsh, R.J., Brent, A.C. and De Kock, I.H., 2021. Understanding the barriers and drivers of sustainable construction adoption and implementation in South Africa: A quantitative study using the Theoretical Domains Framework and COM-B model. *Journal of the South African Institution of Civil Engineering*, *63*(4), pp.11-23.

MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. PLOS Medicine 2021; 18(3): e 1003583. doi: 10.1371/journal.pmed.1003583

Pretti, S.M. and Vieira, D.R., 2016. Implementation of a BIM solution in a small construction company. *The Journal of Modern Project Management*, *3*(3).

Raghavan, N., Kalidindi, S., Mahalingam, A., Varghese, K. and Ayesha, A., 2014, June. Implementing lean concepts on Indian construction Sites: Organisational aspects and lessons learned. In *22nd Annu. Conf. Int. Gr. Lean Constr. June* (pp. 25-27).

Ranadewa, K.A.T.O., Sandanayake, Y.S.Y. and Siriwardena, M., 2021. Enabling lean through human capacity building: an investigation of small and medium contractors. *Built Environment Project and Asset Management*.

Rodegheri, P.M. and Serra, S.M.B., 2020. Maturity models to evaluate lean construction in Brazilian projects. *Brazilian Journal of Operations & Production Management*, *17*(2), pp.1-21.

Ryan, M., Murphy, C., & Casey, J. 2019. Case study in the application of the Last planner® system.

Salem .O, M.ASCE; J. Solomon; A. Genaidy and I. Minkarah, M.ASCE. 2006. Lean Construction: From Theory to Implementation.

Salem, O., Solomon, J., Genaidy, A. and Luegring, M., 2005. Site implementation and assessment of lean construction techniques. *Lean construction journal*, *2*(2), pp.1-21.

Sarhan, J.G., Xia, B., Fawzia, S. and Karim, A., 2017. Lean construction implementation in the Saudi Arabian construction industry. *Construction Economics and Building*, *17*(1), pp.46-69.

Sarhan, J.G., Xia, B., Fawzia, S., Karim, A., Olanipekun, A.O. and Coffey, V., 2019. Framework for the implementation of lean construction strategies using the interpretive structural modelling (ISM) technique: A case of the Saudi construction industry. *Engineering, Construction and Architectural Management*.

Shang, G. and Pheng, L.S., 2014. Barriers to lean implementation in the construction industry in China. *Journal of technology Management in China*.

Singh, S. and Kumar, K., 2020. Review of literature of lean construction and lean tools using systematic literature review technique (2008–2018). Ain Shams Engineering Journal, 11(2), pp.465-471.

Sospeter, N.G. and Kikwasi, G.J., 2017. The state of adoption of lean construction in the

Tanzanian construction industry. *Journal of Construction Project management and Innovation*, *7*(1), pp.1689-1711.

Tabassi, A.A., Ramli, M. and Bakar, A.H.A., 2011. Training and development of workforces in construction industry. Ángel F. Tenorio, Prof. Dr., p.150.

Tezel, A., Koskela, L. and Aziz, Z., 2018. Current condition and future directions for lean construction in highways projects: A small and medium-sized enterprises (SMEs) perspective. *International Journal of project management*, *36*(2), pp.267-286.

The Lean Practitioner's Field Book (Productivity Press, 2016)

Ugurlu, D., Harris, N. and Demirkesen, S., 2021. A framework for implementing lean in the Turkish construction industry. *Journal of Construction Engineering*, *4*(3), pp.117-133.

Sabale, R., Karande, U., Kolhe, A., Kulkarni, A., and Tapase, A. (2023). "Recycling of Used Foundry Sand and Fly Ash in Concrete as a Partial Replacement for Conventional Ingredients." 2, 169–181.

Chothe, O. K., and Agrawal, V. M. (2022). "An Experimental Investigation on Applications of Fiber-Reinforced Composites for Rehabilitation of Concrete Beams." Lecture Notes in Civil Engineering, 202, 415–425.

Chougule, A. B., and Chothe, O. (n.d.). "Review of Time & Cost Analysis for Prefabricated Prefinished Volumetric Construction (PPVC) Student , National Institute of Construction Management and Research , Farmagudi (Ponda), Assistant Professor , National Institute of Construction Management and Research , Introduction : PPVC Technology Types and Process :"