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(I) LEAN CONSTRUCTION AS AN INNOVATIVE APPROACH FOR MINIMISING RISKS IN MEGA-CONSTRUCTION PROJECTS IN DEVELOPING COUNTRIES

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The past two decades have witnessed a rapid increase in construction projects within developing countries in the Middle Eastern Gulf region. This has identified a set of the most common problems associated with construction projects in one of the Gulf Area countries - the Kingdom of Saudi Arabia (KSA) - and has led to them being categorised into three individual risk types, namely Construction Waste; Delayed Schedule; and Project Over Budget. Following a detailed identification and assessment of commonly implemented strategies and a study of the Lean Construction method as the “new” strategy introduced recently to the field, it is proposed that the Lean Construction method could lead to better results in solving these problems.

To that end, the objectives of this study are (1) to develop a Lean Construction framework; and (2) to create a Lean Construction Assessment Tool. To achieve these objectives, the research work (a) investigates the linkages between Lean and risk management; (b) reviews the concept of Lean and its application to the construction industry in Saudi Arabia (c) analyses the barriers and success factors; and (d) identifies the benefits of Lean Construction within construction organizations in Saudi Arabia.

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1. Introduction

It has been observed by the researcher in connection with various completed projects that contractors in the Middle East concentrate their interest on problems directly affecting the project's cost, despite the fact that other issues surrounding the project affect cost, including material waste, as well as project delays. Moreover, contractors do not count risk as an issue to be addressed in the planning stage; instead it is handled upon occurrence through the application of corrective actions instead of the instigation of proactive actions (Al-Kharashi & Skitmore, 2009).

First, it has been observed through years of experience in the construction industry that contractors apply traditional methods for construction project management and evaluate the performance of workers in KSA only when they see that their profit may be affected. In general, contractors do not participate in the design phase, but are more commonly involved in the construction phase; contractors adopt Value Engineering techniques to ensure that the quality of design product is met while providing a cheaper and more timely solution (Alalshikh & Male, 2010).

Second, the construction industry in the Middle East faces the problem of project delay (Al-Kharashi & Skitmore, 2009). It has been reported that 70% of all construction projects in the public sector in Middle Eastern countries are not delivered on time (Albogamy et al., 2013). At an early stage of the project, the contractor is usually requested by the consultant to submit a baseline schedule for a specific time-frame and present a bi-weekly report during the construction phase so as to guarantee that the project is on track (Albogamy et al., 2013). The big question, thus, is how contractors deal with the submitted schedule, since this will have a direct bearing on the issue of project delay.

Thirdly, the construction industry in KSA specifically, and in the region generally, faces another major problem of projects being over budget (Albogamy et al., 2013). The budget may be significantly impacted by numerous problems; therefore, the early management of associated issues may help in the control of the project's budget. Creating a reasonable cost baseline for the associated project is one of the traditional methods used to control the budget. Another way is assigning a cost control engineer to monitor and report project costs using Earned Value Analysis (EVA) (AACE International, 2008). EVA is a technique for project performance evaluation developed from industrial engineering to highlight the need for eventual corrective actions through the provision of early indications of project performance (Subramani et al., 2014). However, construction projects in KSA have not so far applied any of the commonly known risk management techniques (Alrashed et al., 2014).

2. Lean Construction framework development

2.1 Introduction

The proposed framework focuses mainly on the implementation of the Lean approach integrated with Risk Management in Mega-Construction projects in KSA. Its purpose is to allow construction organisations to evaluate and analyse their Lean implementation strengths and assess the benefits of Lean that will add value within their organisations.

In order to validate the potential improvements that Lean can achieve, the framework was applied to an Action Research project to give the company the opportunity to consider the positive and negative effects of Lean implementation on the overall business performance.

The author used the Lean Implementation Assessment (LIMA) Framework developed by Ogunbiyi (2014), the review of The Highways Agency Lean Maturity Assessment Toolkit (HALMAT) (Ogunbiyi, 2014).

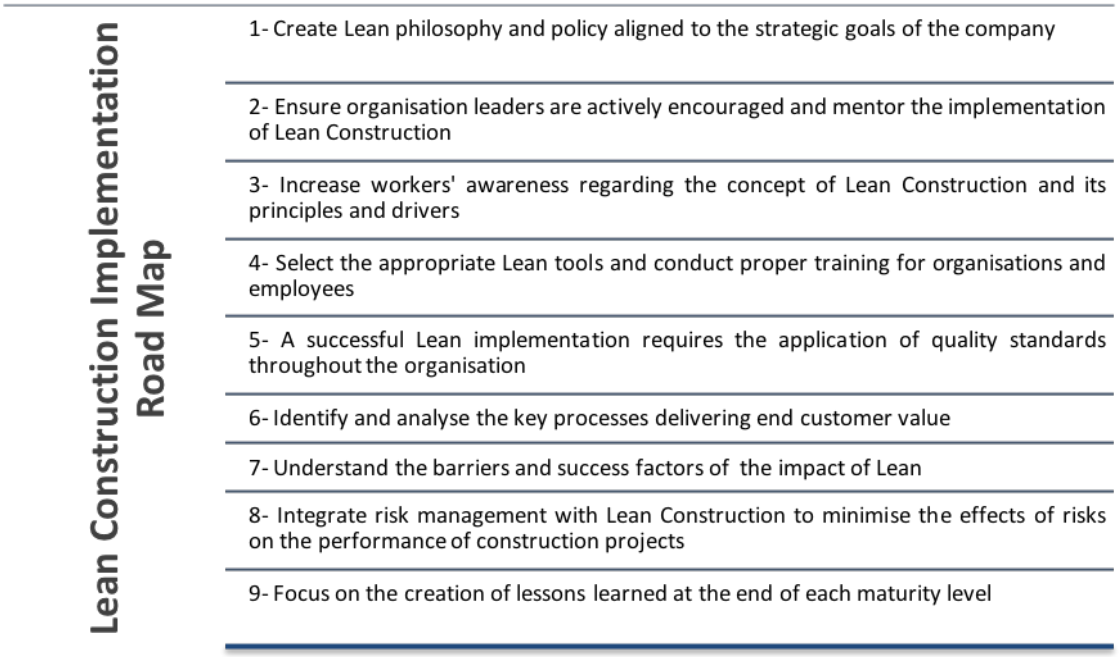
2.2 Structure of the framework

The basic structure is illustrated in Appendix 1. The proposed developed framework consists of nine Lean Construction processes congregated in the four maturity levels. The nine principles applied by the author and considered as Lean Construction implementation groups in the LCFIRM framework.

2.3 Lean Construction implementation groups

Figure 1 presents the roadmap of the developed framework to illustrate the processes and guidelines for using the developed Lean Construction framework. The following section provides more information about the adopted nine Lean Construction processes.

Figure 1: LCFIRM Roadmap



3. Implemented performance activities

Table 1 presents the proposed activities that should be implemented in each Lean Construction processes. Each process has five activities; the author put them in order of the required tasks that should be conducted in each project phase. Figure (2) illustrates the logic of the five activities in each Lean Construction process.

Figure 2: Sequence of activities in each Lean Construction process

Table 1: Presented implemented performance activities

Lean philosophy, policy and strategy	
Adopt the appropriate policy and strategy to be aligned to the organisational strategy plans and philosophy	Adopting the right policy is essential and must be suited to the culture of the organisation, as policy should be linked to organisation strategy and philosophy (Ogunbiyi, 2014). A policy can be described as a good one when there is a definite purpose for its creation and it is flexible and can be modified to change, is formed by both the employees and interested stakeholder, and is well understood by relevant parties. In addition, organisations should identify which key areas, tasks or crews they will target by implementing Lean Construction; they should also understand customer value and focus on its key processes to continuously increase it (Ogunbiyi, 2014).
Select project, team and leader to implement Lean Construction	Good management of people and processes guarantees successful implementation of Lean (Ogunbiyi, 2014). Therefore, organisations should identify the project team and assign a leader to supervise the implementation of Lean Construction. The leader should have a good knowledge and past experience of Lean Construction methods, introduce the Lean Construction process to the team, determine the planning method of implementing Lean Construction, and understand the application of the "Toyota Production System", and tailor it to fit the organisation's philosophy.
Follow policy and strategy that have been set	Ensure that the policy has a definite purpose for its creation and that it is developed through the involvement of employees and interested stakeholders. Organisation strategies and processes should be the basis for the development of a communication strategy/plan, awareness raising and training plan in order to guarantee future compliance and improvement (Ogunbiyi, 2014). Execute the work according to the Lean Construction plan.

	Moreover, implement the concepts of the two pillars of the Toyota production system, "Jidoka" and "Just-in-Time".
Ensure that the policy and strategy are aligned to the project objectives and organisational strategy goals and philosophy	Ensure that the Lean management process aligns both vertically and horizontally with the organisation's functions and activities and with its strategic objectives. Take action to control the project according to the Lean Construction plan, and analyse and evaluate the performance of the Toyota production system. Realisation of the organisational purpose is ensured by the employment of strategies. There could be some changes to the organisational structure in order to guarantee the success of implementing a new strategy within an organisation.
Make sure strategic and business plans are clear; operational and commercial targets to be realised through Lean activity in order to achieve growth and profitability and improve market position	The necessary performance improvement gains from Lean 'management' are factored into business and strategic plans. A strategic business improvement approach is deployed and demonstrates year-on-year output measure improvements linked to corporate targets (Highways England, 2012).
Lean leadership and structure	
Identify the stakeholders and their expectations regarding the implementation of Lean Construction	During the processes of decision-making and project delivery, the implementation of the Lean approach should be fully supported by top and senior management, who should be committed to the integration of Lean and risk management. Also, Lean policy should be completely comprehended by employees who are assigned to specific roles and responsibilities (Highways England, 2012).
Make sure all senior leaders and management are committed to and support the implementation of Lean Construction	All managers have completed some formal Lean training. Lean forms an element of the Personal Objectives for senior managers. Senior leaders actively communicate and demonstrate by example the organisation's expected Lean behaviours, and their benefits, to their teams (Womack and Jones, 2003).
Provide leadership, guidance and recognition of positive actions by management	All staff should receive Lean education through recorded training and education in Lean leadership principles and improvement tools from the organisation's leadership. The organisation should perform an analysis of the training needs of both its staff and relevant stakeholders on a regular basis and launch training programmes that are suitable for forcing cultural change (Smeds, 1994).
Make sure the adoption of a Lean leadership philosophy is apparent at meetings at all levels throughout the organisation	Senior leaders monitor, communicate and demonstrate the organisation's expected Lean behaviours and their benefits to their teams and lead their teams in their achievement. Senior Management should provide a continuous training programme for forcing the change and innovation of the culture and behaviour (Smeds, 1994).
Make certain that senior leaders and management mentor and foster Lean champions internally and throughout the supply chain	Ensure that all senior leaders and management within the organisation enthusiastically embrace the concept of Lean and support the transition to a Lean culture. Ensure that philosophy, policy, and strategy are developed and communicated by the involvement of organisation leaders (Highways England, 2012).
Lean principles and drivers	
Clearly define the five principles of Lean Thinking	Ensure that all employees have a good level of awareness. Define waste, identify its types and ensure it includes all non-value-adding processes. Consider other kinds of non-value-

	added work/activity which are equivalent to waste (Engineers Australia, 2012).
Create a plan of how to implement the five principles of Lean Thinking	Identify the drivers of Lean as an important aspect to be considered prior to implementing Lean in an organisation. Create a plan for managing the identified wastes among the whole project team, and create a process improvement plan.
Ensure that you are driving towards the overall organisational strategy by a constant review of your processes	Follow the identification of Lean drivers in an organisation to lead the organisation to sustain a Lean focus. Implement the principle of Lean and ensure that it aims mainly at waste elimination in processes in order to reduce the length of process cycles, improve quality, and increase efficiency. Implement Value Engineering Analysis to eliminate possible generated waste. In addition, apply the 3Rs (Reduce, Reuse and Recycle) for the waste generated after the implementation of Lean Construction (Aadal et al., 2013).
Ensure that Lean principles are constantly and consistently delivering value to the customer	Increase workers' perception of the Lean Construction method (training). Identify value from the client‘s point of view. Revisit construction processes and seek to add more value to the client by reducing waste and enhancing additional willed features. Follow continuous improvement.
Take action necessary for Lean policies and process-based orientation to be aligned across the overall organisation processes	Lean policies and process-based orientation are aligned across the overall organisation processes. Decisions should be made in full alignment with the goals of the organisation to ensure that the maximum benefit for the adaption of Lean Construction principles is achieved (Ogunbiyi, 2014).
Lean techniques and tools	
Understand Lean Construction tools and their benefits	Determine which tool is suitable for your project and required by your organisation. Integration of practices and methods guarantee the success of Lean implementation; integrated practices and methods lead to effectiveness of the Lean operating system, i.e. the tools, techniques and methods cannot work separately, as they should be implemented and tied together into a complete system (Drew et al., 2004).
Identify Lean Construction practices and methods in order to achieve successful Lean implementation	There are many Lean tools and techniques that organisations can apply, including Value Stream Mapping, Last Planner System, etc. Discuss and understand the Last Planner System and the concepts of Make Work Ready and Weekly Work Planning (Engineers Australia, 2012).
Use the Lean Construction tools suitable for your project/organisation and ensure that they will maximise project value	Lean success can not only be ensured by the application of Lean tools and techniques; other issues including people and process can affect the successful implementation of Lean in the field of construction in KSA. Make sure that selected Lean tools are effective for the organisation/project to achieve organisation/project objectives.
Measure and evaluate the performance of the project by using Lean Construction tools and compare them to the traditional methods	Evaluate the completed works according to three weeks’ look-ahead and weekly work plan by calculating Percent Plan Completed (PPC) to show what has been done (Engineers Australia, 2012). An organisation’s strategy should be based on Lean techniques, since it provides both the opportunity and the resolve to generate and sustain profitability growth.
Use professional Lean tools for planning all activities – not just design and construction.	All team members prepare and submit final project performance based on the use of Lean Construction tools and document the value added by using its tools. All team members, including subcontractors, require planning and commitments to be based on Lean tools (Engineers Australia, 2012).
Delivery of value	

Identify key value streams of major end customers and projects	Identify the key processes which deliver end customer value in order to identify waste (Highways England, 2012).
Ensure performance levels of key processes are understood and initial value stream analysis is under way to identify and deliver improvement to end customer value	Organisation process should be designed based on customer and stakeholder needs and requirements. Prioritise and deliver improvement to end customer value (Highways England, 2012).
Analyse the principle of value stream(s), allowing the identification of critical interaction	Look for opportunities to eliminate waste and create value aligned with the business objectives. Value Stream Mapping should be used effectively to deliver step changes in performance as opportunities.
Measure Value Stream performance management	Evaluate the ongoing performance of Value Streams and their interdependencies and how they are managed across the organisation (Highways England, 2012).
Undertake Standardised Work and 5S throughout the site	There should be a complete analysis for key Value Streams of major end customers and projects in addition to clear definition and effective management of handover points and interfaces (Engineers Australia, 2012).
Built-in Quality and process flow	
Determine quality processes, standards, and metrics	Determine the required processes for the project that will be used for implementing Built-in Quality. Design processes to encourage flow and balance resources. This will apply to all processes, including design, purchasing, etc., not just construction (Engineers Australia, 2012).
Create performance measurement plan	Create an implementation process of Built-in Quality by using Standardised Work and 5S. Develop a quality management plan and Total Quality Management. Create key processes within value streams to enhance flow and reduce inventory/buffer levels (Engineers Australia, 2012).
Follow processes which are adapted and integrated to complement flow	Perform quality assurance and audit to ensure that the created processes are followed and conducted properly. Review key project deliverables and processes for satisfactory quality level.
Perform quality control	Determine if deliverables are being produced to an acceptable quality level and if the project processes used to manage and create the deliverables are effective and properly applied. Assess the degree to which processes are being designed to encourage and balance resources. Ensure the stability of processes throughout the internal and external Value Stream (Engineers Australia, 2012).
Continually improve process flow throughout all value streams (internal and through the supply chain), in time with actual demand, with distance travelled and inventory/ buffer levels minimised	Make sure that processes are being designed to encourage flow and balance resources. Provide optimum value to the customer through a complete value creation process. Confirm work is done according to the required quality standards (Engineers Australia, 2012).
Lean impact (barriers and success factors)	
Create measurable objectives	Identify the drivers, benefits, and success factors in the implementation of Lean Construction to the organisation and project. In order for organisations to apply Lean, there should be a transition team, as well as a vision and guiding principles with a

	Lean impact assessment at the same time (Ogunbiyi, 2014).
Develop implementation plan and timeline	Identify tangible and intangible benefits derived from Lean Construction implementation. There should be an identification and quantification of benefits which can be assigned financial figures because they are measurable outcomes from the application of Lean principles, tools and techniques (Ogunbiyi, 2014).
Analyse resources or budget for implementing Lean	Keep focusing on the benefits and success factors of Lean Construction implementation. Success factors should be identified and their impact on Lean implementation assessed (Ogunbiyi, 2014).
Assess the degree to which processes are being designed to encourage flow and balance resources	Ensure the positive impact of Lean and its alignment to the project/organisation goals.
Ensure that cost savings, waste elimination and value maximisation are more efficient with the application of Lean Construction than with that of conventional methods	Top management commitment is necessary to integrate Lean into core business processes and decision-making. Lean implementation benefits, which could relate to either customer satisfaction or employee satisfaction and the impact on society, should be seen as the business result in terms of cost savings, waste elimination and value maximisation. In addition, prepare a comparative statement to show the value added by the implementation of the new method compared to current conventional methods (Ogunbiyi, 2014).
Risk Management	
Create risk management plan	Establish an agreed-upon approach for conducting risk management activities and risk evaluation. Identify risks; determine which risks might affect the project and document their characteristics. This process is an iterative process, since either occurring risks may trigger new risks, or the status of the identified risk may change. The risk register is the output of the risk identification process; it is a list of all identified risks with their potential impact and probability of occurrence (Project Management Institute (PMI), 2013).
Perform risk analysis and risk response plan	Analyse qualitatively the risks identified in the risk register in order to prioritise them for further action such as quantitative analysis and response plan. Assess the likelihood of occurrence of all risks as well as the potential impact on all project aspects such as cost, time and quality. Use the probability-impact matrix and the risk criteria previously defined in the Risk Management Plan to calculate the risk score. High risks shall need further quantitative analysis where the expected monetary value can be determined. For the previously analysed risks, plan risk responses to develop options and determine actions to enhance opportunities and mitigate risks. Risk responses must be appropriate to the significance of the risk, cost effective, realistic and made in a timely manner (Project Management Institute (PMI), 2013).
Perform risk reassessment and audit and update Risk Register	During the execution phase, a risk's status may change due to site conditions. Therefore, risk analysis described in the previous step should be repeated to reassess the risk's impacts and probabilities. Moreover, the risk owner may need to conduct quality audits to ensure the effectiveness of the risk responses implemented for previous and ongoing risks. In addition, the Risk Register must be updated to reflect the current status of all risks

	(Project Management Institute (PMI), 2013).
Control risks and update Risk Register	The Control Risks process applies techniques, such as variance and trend analysis, which require the use of performance data generated during project execution in order to review the implementation of risk responses while evaluating their effectiveness. The Control Risks process can involve choosing alternative strategies, executing a fall-back plan, taking corrective action and modifying the risk management plan. Fall-back plans are the Plan-B response for either identified or unidentified risks. The Risk Register must be again updated to reflect the changes implemented during the Control Risks process (Project Management Institute (PMI), 2013).
Implement and follow Risk Analysis and Management for Projects (RAMP)	Adapt the RAMP framework for analysing and managing the risks involved in projects, in order to achieve enhanced economic earnings for the customer.
Continuous improvement	
Solicit feedback from the stakeholder regarding the settled policy and strategy	Confirm work is done according to the Lean Construction plan. Create lessons learned and strengths, weaknesses, opportunities, and threats (SWOT) analysis for the implementation of TPS for future projects.
Create lesson learned	Ensure that all senior leaders and management within the organisation enthusiastically embrace the concept of Lean and support the transition to a Lean culture. Ensure that philosophy, policy, and strategy are developed and communicated by the involvement of organisation leaders (Highways England, 2012). Document the learning gained from the process of implementing the Lean Construction method. Formally conduct lessons learned sessions throughout the project's life cycle. The purpose of creating lessons learned is to share and use knowledge resulting from the implementation of the new method (Highways England, 2012).
Create user feedback	Always keep the customer/stakeholders in touch with the results of Lean Construction implementation and take necessary actions to satisfy their expectations and requirements.
Summarise lessons learned	All team members prepare and submit final project performance based on the implementation of Lean Construction integrated with risk management and document the value added by its application.
Implement new strategies collected from feedback, which can add value and improvement to the system	After successful Lean Construction implementation and archive records and documented lessons learned, maybe a new strategy can be implemented or integrated to enhance the organisation/project performance (Ogunbiyi, 2014).
Assessment gate	
Organisation requirements, plans and strategies are compiled and studied to provide a solid foundation to enable an applicable programme to be implemented and lead the organisation towards success. The researcher developed five assessment gates to measure the maturity level of the implementing organisation in order to decide the initial phase to start with and whether the organisation is eligible to move to the subsequent phase.	
Closing phase/new strategy gate	
Lessons Learned and feedback throughout the development and execution stages are created to serve as a guide to the users to further streamline the programme and continue improvement of the system through the usage of information and the users' comments.	

4. How to use the developed LCFIRM

This section presents an updated flowchart as guidance for organizations to use the developed Lean Construction framework with the proposed assessment tool. Figure 3 presents the structure of the use of the developed framework and assessment tool. It is assumed that the score range represents each level of maturity.

Level 0: Uncertain (score range: 20.0 - 30.0): your company urgently needs to improve these aspects

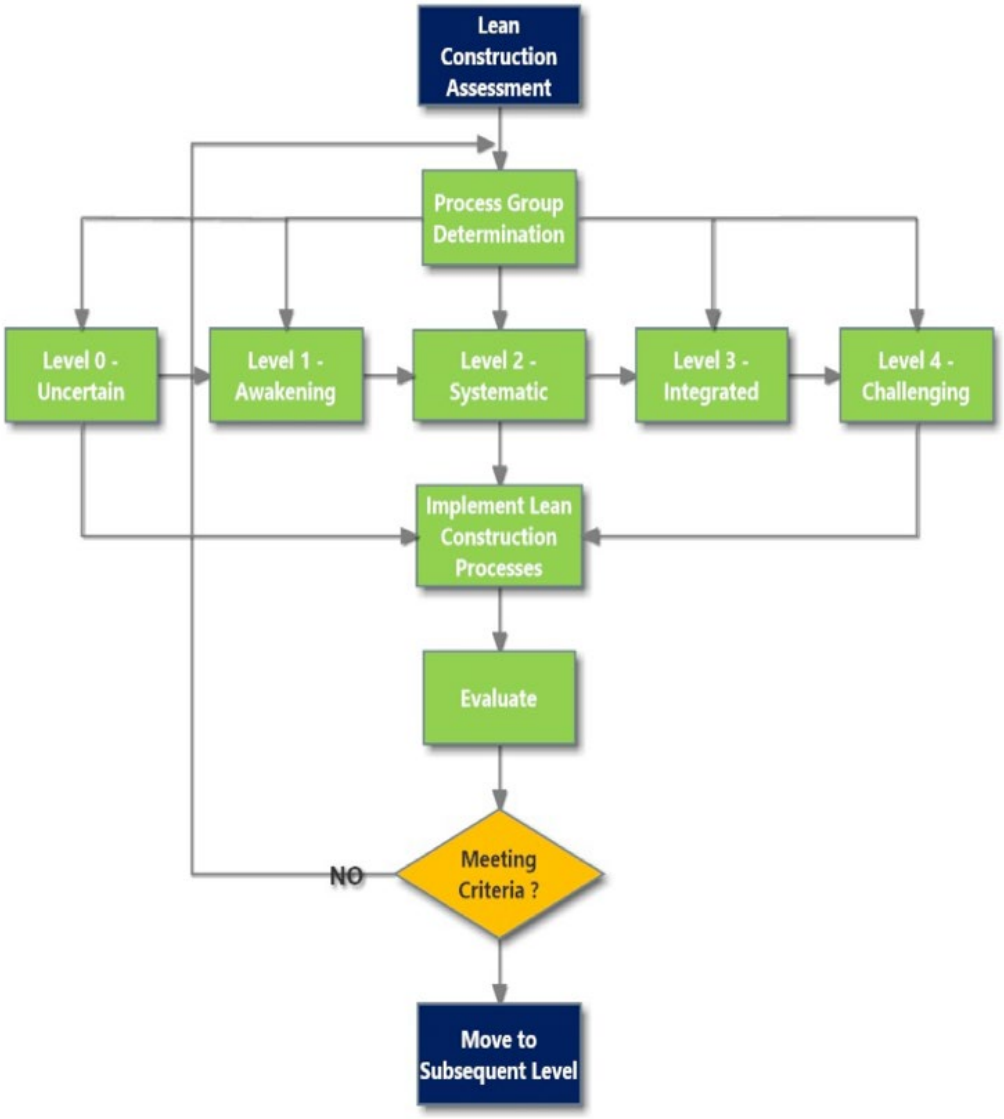
Level 1: Awakening (score range: 31.0 - 45.0): your company needs to address the gaps in its knowledge

Level 2: Systematic (score range: 46.0 - 60.0): your company has moderate capability and maturity and scope for improvement

Level 3: Integrated (score range: 61.0 - 75.0): your company has high capability and maturity

Level 4: Challenging (score range: 76.0 - 100): your company needs continuous improvement

Figure 3: Structure of the developed Lean Construction framework



5. Conclusion

The development of an innovative framework for the application of Lean principles in the construction industry was achieved and found to be a useful tool for the application of Lean by the majority of participants.

A framework for Lean Construction implementation efforts has been presented, as well as the integration of risk management, named as the developed framework. The proposed framework comprised nine main Lean Construction implementation groups addressing; (1) Lean philosophy, policy and strategy; (2) Lean leadership and structure; (3) Lean principles and drivers; (4) Lean techniques and tools; (5) Risk management; (6) Built-In Quality and process flow; (7) Delivery of value; and (8) Lean impact (barriers and success factors), (9) Continuous improvement.

The experts interviewed gave positive comments, such as “The proposed framework is comprehensive and integrates risk management with Lean construction, which, if applied, will improve performance in the construction industry, However, the main barrier that will be faced using this framework is the lack of experienced personnel in most of the organizations to implement such a framework”. In addition, it is highly recommended that there be an effective training programme to help organizations with the appropriate expertise to enable them to implement such a framework. The author received three main suggestions regarding the developed framework, presented below:

- To provide practical examples for each Lean Construction implementation process (nine processes);
- To add one more process, which is the continuous improvement aspect, to be considered for each maturity level to ensure the improvement of the implementation of the Lean Construction method within construction organizations.
- Finally, to change the project management life cycle process group (initiation, planning, execution, monitoring and controlling and closing) into maturity levels (Uncertain/level 0, Awakening/level 1, Systematic/level 2, Integrated/level 3 and Challenging/level 4).

All these suggestions have been considered, and consequently the author developed a revised framework.

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7. Appendix

Appendix 1: The proposed Lean Construction Framework Integrated with Risk Management [LCFIRM]