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The Implementation of Lean Construction Tools: Findings from a Qualitative Study

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Lean construction (LC) is a continuous improvement mechanism that is proficient in reducing construction waste. This LC mechanism is suggested in resolving the issue of construction waste to the industry. LC is proficient in increasing the contractor's project performance. LC can help an organisation in sustaining its growth and profit. This survey was conducted to identify the LC tools that can reduce the construction waste and its implications towards a contractor's project performance. A qualitative study was undertaken using semi-structured interviews with four key personnel from the selected G7 contractors in Malaysia. The contractors, which are registered with the Construction Industry Development Board Malaysia (CIDB), were identified from the CIDB directory. It was found that repair work, equipment breakdown, and damaged material were the most types of construction waste being created on the construction site. Clarification needs and work interruptions were among the wastes generated on the site too. The findings revealed that daily hurdles meetings, teamwork, and 5S are the LC tools being applied the most by the contractor in reducing the construction waste. Most of the projects that implemented these LC tools had produced a higher quality project and maintained the safety and health environment throughout the construction processes. An organisation had also achieved zero accidents and gained 12 % of cost reduction for their project. The findings outlined in this paper could be essential for the future framework of LC tools that can handle construction waste in an environmentally sustainable way. The framework could also increase the contractor's project performance towards a greener environment.

1. Introduction

Malaysian construction industry needs to change from its traditional method of construction towards a greener and sustainable approach. Every single project aimed to adopt a more environmentally friendly construction process, energy efficient and reduction of waste generation approaches (Ahmad Bari et al., 2012). According to Sahamir et al. (2017), the implementation of sustainability has become an important initiative to be discussed and undertaken by the practitioners. This is in-line with the Government Transformation Programme (Construction Industry Development Board Malaysia, 2007) and the National Transformation 2050 (TN50, 2017). Both plans urge the industry to produce smart buildings by using more innovative construction methods with the help of appropriate building information modelling system during the construction processes.

LC is a potential mechanism that can be introduced to the industry in resolving the issue of construction waste. LC is a planning mechanism that can be implemented by an organisation during the construction processes. This mechanism is a continuous improvement approach that aimed to reduce the construction waste (Marhani et al., 2013). LC is also adequate of reducing cost and duration of a project while promising the enhancement of contractor's project performance. LC mechanism is accomplished to make sure that the organisation itself can sustain its growth and profitability in the industry too.

This survey is intended to identify the LC tools that are capable of reducing construction waste and its implications towards contractor's project performance in Malaysia. This study recommends a future framework for LC tools that is suitable for the Malaysian construction industry. Through this proposed framework, it will reduce construction waste in an environmentally sustainable way and increase the contractor's project performance towards a greener environment.

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2. Lean construction

Construction waste is not a new issue in the construction industry. This issue affected the environment solely due to the rapid worldwide development (Nagapan et al., 2012). This problem also occurred in the Malaysian construction industry. 28.34 % of produced waste is generated from the industrial and construction waste to satisfy the infrastructure projects' demands in the country (Begum et al., 2010). According to Poon et al. (2004), construction wastes refer to waste resulting from defective materials, extra materials and wastage. Typical construction wastes in the lean mechanism are the correction, over-processing, delay, inventory, conveyance, over-production and motion (Al-Aomar, 2012) (as shown in Table 1). Construction waste can also be produced during the designing of goods and services as well as the vandalism, inclement weather and accidents activities (Abdul Rahman et al., 2012). According to Burton and Boeder (2003), the construction wastes can be generated by human potential throughout the construction processes.

Table 1: Construction waste characteristics

Construction waste characteristics	Coding	Authors
Correction - Repair work, Equipment breakdown, Work defects, Rework/ Re-run, Design errors, Execution errors, Retest work & Uncompleted work	W1	Al-Aomar (2012)
Over-processing - The long approval process, Clarification needs, Excessive safety, Excessive training time, Excessive supervision, Excessive use of equipment & Overqualified resources	W2	Al-Aomar (2012)
Delay - Late work delivery, Activity start delays, Work interruptions & Ineffective work	W3	Al-Aomar (2012)
Inventory - Damaged material, Excess materials & Pilferage	W4	Al-Aomar (2012)
Conveyance - Transport time & Material handling	W5	Al-Aomar (2012)
Over-production - Idle periods & Excessive space	W6	Al-Aomar (2012)
Motion - Labour movement	W7	Al-Aomar (2012)
Design of goods and services - Failure to meet end user's needs	W8	Abdul Rahman et al. (2012)
Human potential - Failure in utilising the skills	W9	Burton and Boeder (2003)
Others - Vandalism, inclement weather, accidents, etc.	W10	Abdul Rahman et al. (2012)

LC is being advised and implemented to a construction project in overcoming the issue of construction wastes. Table 2 illustrates the available LC frameworks or guidelines that can be referred by the contractors. Most of the frameworks or guidelines provided extensive recommended practices of LC. These established frameworks or guidelines applied to an organisation in developed countries. All these frameworks or guidelines elaborated the principles of LC and recommended practices of it. It was also given examples of how to implement the LC as well as the checklist and case studies. Johansen and Walter (2007) suggested incorporating all eight focus areas of LC tools, which are procurement, management, planning or control, collaboration, behaviour, design, supply and installation in their daily activities. This is to enhance the lean culture in an organisation. Nevertheless, most of the frameworks or guidelines focused on planning or control, management and installation areas. Thus, the proposed framework is designed to furnish all focus areas in the Malaysian construction industry compared to the other established guidelines or frameworks.

According to Marhani et al. (2012), many developed countries have adopted LC and gained the benefits from its implementation. The LC implementation will enhance the contractor's project performance. Table 3 explains the project performance characteristics in an organisation. According to Bashir (2013), an organisation will strengthen the quality and client satisfaction of the product. LC will provide and capable of boosting safety environment and cooperation of team members (Bashir et al., 2013) that will benefit the practitioners. Literature also specified that by implementing LC, a project would have an impact on time

(Amaitik and Elsagzli, 2014). According to Caldera et al. (2017), the implementation of LC will reduce the construction cost and improve environmental performance as well. This LC mechanism, however, requires the organisation to adopt appropriate or suitable LC tools to reap these benefits.

LC tools are the crucial instruments in realising the LC mechanism in the construction industry. According to Blakey (2008), an organisation should apply these LC tools to the delivery processes of any project. By using appropriate and suitable LC tools, it will deliver more significant improvements to the organisation and have a constructive influence on the project performance (Suresh et al., 2011). Thus, it is up to the organisation itself in determining the most appropriate and suitable tools for their project to gain the benefits of LC mechanism.

Table 2: LC frameworks or guidelines

Authors	Frameworks or guidelines	Focus areas of LC tools							
		Procurement	Management	Planning / control	Collaboration	Behaviour	Design	Supply	Installation
Koskela (1992)	Production theory in construction		√	√					√
Santos (1999)	Application of flow model in construction industry			√					
Koskela (2000)	Transformation-flow-value theory								
Ballard (2000)	Last planner system			√					
Diekmann et al. (2004)	Lean construction wheel								
Paez et al. (2005)	LC as socio-technical design		√	√		√			
Green and May (2005)	-								
Salem et al. (2006)	Lean assessment tool		√	√					√
Johansen and Walter (2007)	-	√	√	√	√		√	√	√
Suresh et al. (2011)	A protocol for LC in developing countries		√	√					√
Engineers Australia (2012)	Application of LC methods to building new Australian LNG capacity		√	√			√		√
Construction Industry Research and Information Association (2013)	CIRIA's guides								√
Building Research Establishment Ltd (2013)	The construction lean improvement programme (CLIP)		√	√					

Table 3: Project performance characteristics

Project performance characteristics	Coding	Authors
Quality of product	P1	Bashir (2013)
Safety	P2	Bashir et al. (2013)
Client satisfaction of product	P3	Bashir (2013)
Team members attribute	P4	Bashir et al. (2013)
Time	P5	Amaitik and Elsagzli (2014)
Cost	P6	Caldera et al. (2017)
Environmental attributes	P7	Caldera et al. (2017)

3. Methodology

This survey focused on the LC tools that can reduce construction waste and its implications towards a contractor's project performance. A semi-structured interview was conducted from April to June 2017 with LC practitioners to collect qualitative data. A set of question has already emailed to them earlier to give the interviewees overall view of the research. This research method, which included seven questions is designed to get in-depth information regarding LC mechanism and to detect any flaws in the questions.

All the interviewees were shortlisted and mainly participated in the earlier survey before this. Those interviewees were willing to take part as per their questionnaire feedback. They are registered G7 contractor (projects greater than Ringgit Malaysia 10 million) with the CIDB and were identified from the CIDB directory.

To build confidence and trust during the process of collecting data, all the interviewees were fully informed regarding the aim and objectives of this survey. Confidentiality and integrity of the interviewees were strictly respected, and codes were assigned to each of them. The interviewees include the Contract officer (R1 and R2), Project manager (R3) and Senior quantity surveyor (R4). They are highly involved in the whole LC implementation of their organisations. All the answers of R1 and R3 were based on a housing project, R2 was based on a shophouse project, and R4 was based on a high-rise project. All the projects have implemented LC tools throughout the construction processes.
The interviews were recorded and transcribed verbatim to classify and formulate the data for analysis. The transcribed copy was reread to get a better understanding of the ideas and linked it to the aim and objectives of the survey.

4. Result and discussion

This section discusses findings from the interview regarding the implementation of LC tools in an organisation. A semi-structured interview was conducted to gather qualitative data amongst the LC practitioners. The frequent construction wastes had been identified, the LC tools applied to overcome it and its implications towards project performance, have been discovered through the interview sessions. The findings will then be used in evolving the LC tools framework.

4.1 Demographic study

Table 4 below indicates the level of working experience that differs among the interviewees. Most of the interviewees have more than 10 years of working experience and are in the middle to top management ranks in their organisations. Most of them are involved in housing project apart from R2, who participated in commercial building. Most of them also are had a project size more than MYR 50 million unless R2, which are had a project between MYR 5 – 10 million. All the interviewees are the LC experts within their organisations. They are considered as the right practitioners to discuss the LC mechanism, application of LC tools and its implication towards contractor's project performance.

Table 4: Sample characteristics

	Designation	Working experience (y)	Project type	Project size (MYR)
R1	Contract officer	More than 10	Housing	More than 50 million
R2	Contract officer	More than 10	Commercial building	More than 50 million
R3	Project manager	More than 10	Housing	More than 50 million
R4	Senior quantity surveyor	More than 10	Housing	5 - 10 million

4.2 Construction waste, LC tools applied and its implication towards contractor's project performance

There were a lots of construction wastes produced during the construction phase of construction projects. As per Table 5, R1, R2, R3, and R4 identified the construction wastes that are generated in their projects. R1 and R3's project had the most construction waste, which is 6 numbers. R2's project had a 5 numbers of construction wastes, while R4's project is the least with 4 numbers of construction wastes. Based on the findings, correction, delay and inventory are the most generated construction wastes on the site. Based on the interview sessions, examples of correction are repair work and equipment breakdown. Work interruption is the example of delay, while the damaged material is the example of inventory. Most of these wastes occurred at the site due to the mistakes by the workers and improper maintenance work. Nevertheless, all the interviewees also agreed these construction wastes can be caused by the consultant teams that late to respond if any issue occurs.
The interviews identified 10 LC tools across the organisations that have been established in the literature review. Daily hurdles meetings, teamwork, and 5S were the LC tools being implemented the most to overcome the construction wastes within the organisations. Most of the interviewees applied the LC tools as what has usually been practised in their organisations. R3 and R4 mentioned some of the LC tools were suitable tools for their organisations to achieve the project performance to overcome the issue of construction wastes. These are the factors that drove them into engaging the LC tools in their projects.
All the interviewees agreed that implementing LC mechanism would provide them with a higher quality project. As stated by R1, R2, R3 and R4, this could be achieved through the achievement of ISO9001 requirements in their project. R1's and R3's projects also achieved the QLASSIC score, while R2's project made the CONQUAS score. These achievements might help the organisation in accelerating the quality of its project. In term of cost performance in the project, R2's project enjoyed a cost reduction of 12 %. It gave the client an increase in its revenues and profits through the implementation of LC tools. R1's, R2's and R3's projects drew

safety and health benefits as well over the achievement of OHSAS18001 requirements. These results indirectly increase the level of satisfaction of the respective clients of their project

Table 5: Construction waste generated, LC tools applied and its implication towards contractor's project performance

	Construction waste generated	LC tools applied	Implication on project performance
R1	W1, W2, W3, W4, W5, W6	Value-based Management, Increased Visualisation, Last Planner System, Daily Huddle Meetings, Teamwork, Supply Chain Management, 5S	P1, P2, P6
R2	W1, W2, W3, W4, W5	Value-based Management, Increased Visualisation, Last Planner System, Daily Huddle Meetings, Teamwork, Supply Chain Management, 5S	P1, P2, P6
R3	W1, W2, W3, W4, W5, W7	Value-based Management, Increased Visualisation, Last Planner System, Teamwork, Supply Chain Management, 5S	P1, P2
R4	W1, W3, W4, W7	Last Planner System, Daily Huddle Meetings, First Run Studies, Teamwork, Computer-aided Tools, 5S	P1

5. Conclusions

Based on the findings, it is discovered that all the interviewees are the LC experts within their organisations. They are knowledgeable and have more extensive experience regarding the application of LC mechanism. All of them are manageable in dealing with the construction waste and the LC tools.

A construction project will generate waste of correction, inventory, over processing and delay throughout the construction processes. Repair work, equipment breakdown, damaged material, clarification needs, and work interruptions are the wastes generated at the site. These construction waste will influence the contractor's project performance. A contractor should perform more monitoring work on the workers and have a proper maintenance schedule for each of their equipment. The contractor should maintain an excellent environment to communicate well with their consultant teams to prevent the occurrence of waste.

Daily hurdles meetings, teamwork, and 5S are the most practised LC tools in overcoming the construction wastes in the Malaysian construction industry. Most of the interviewees believed that these LC tools are the most appropriate and suitable tools to be implemented in achieving their organisation's project performance.

Most of the organisations enjoy the higher quality of the project by the implementation of LC tools. Thru a few assessments on the project, an organisation enables to benchmark the quality of workmanship of their projects. Some of the organisations also can maintain the safety and health environment throughout the construction processes and achieved zero accidents. By implementing the LC tools, the organisation can identify, manage and decrease all the risks associated with health and safety. Thru the implementation of LC tools, reduction of cost is possible in a construction project. An organisation is gaining 12 % of cost reduction, and this is giving the revenues and profit to the client.

These findings could assist contractors intending to adopt lean construction (LC) in selecting the appropriate tools to address their needs. The results reported in this paper could be essential for a future LC tools framework in the Malaysian construction industry that can handle construction waste in an environmentally sustainable way. The framework could also increase the contractor's project performance towards a greener environment.

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