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Innovation in Lean Thinking to Achieve Rapid Construction

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***Abstract*—**Lean thinking holds the potential for improving the construction sector, and therefore, it is a concept that should be adopted by construction sector players and academicians in the real industry. Bridging from that, a learning process for construction sector players regarding this matter should be the agenda in gaining the knowledge in preparation for their career. Lean principles offer opportunities for reducing lead times, eliminating non-value adding activities, reducing variability, and are facilitated by methods such as pull scheduling, simplified operations and buffer reduction. Thus, the drive for rapid construction, which is a systematic approach in enhancing efficiency to deliver a project using time reduction, while lean is the continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value stream and pursuing perfection in the execution of a constructed project. The methodology presented is shown to be valid through literature, interviews and questionnaire. The results show that the majority of construction sector players unfamiliar with lean thinking and they agreed that it can improve the construction process flow. With this background knowledge established and identified, best practices and recommended action are drawn.

***Keywords*—**Construction improvement, rapid construction, time reduction, lean construction.

I. Introduction

DELIVERING a successful construction project is always a dream for all construction sector players, especially the client. It will benefit the industry and parties involved because the project life cycle can be completed on time. The output, such as building, can be utilized and operation can start as early as from the handing over phase. Contemporary thinking about construction not only focuses on the project finished on time, but to achieve time reduction. Many concepts, methods and actions are being implemented to get a time reduction that will drive for rapid construction. The concepts such as modular construction, crash and fast track project, utilizing technology, outsourcing and innovative contracting, are the actions required for achieving successful project delivery. These actions can be pulled from the project lifecycle duration because it reduces the non-value added activities in construction process flow. On the other side, a systematic approach should be implemented to pull the whole cost curve as early as it can. This is the principle of rapid construction. In order to do that, the construction process flow should be stabilized and the error minimized, particularly in regards to the elimination of waste and removing the non-value added activities. The suitable approach is to integrate the management philosophy into the construction process flow. The management philosophy focuses on flow and conversion in the construction process. The perfect match is to integrate Lean Construction (LC) principles into the process. LC is being used widely in the manufacturing industry, and using this approach in the construction industry is considered as innovation. Innovation in LC or Lean Thinking can change the paradigm of conventional construction towards the improvement of the construction process flow that leads to rapid construction.

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II. Objectives

The main aim of this paper is to evaluate the correlation of LC practiced towards achieving rapid construction. It is also considering the modernizing practice that can be done with the benefits for all of the construction industry, as well as the clients. There are lots of problems that can occur during construction until hand over which can result in much of the project being unable to complete on time. Another usage of this research is to promote the LC principles that have been used in the manufacturing industry to the rapid construction process. These principles will be the variables for aiming the success of this research. This paper flows by the objective of:

1. To explore the usage of LC for time reduction; and,
2. To evaluate the non-value added using LC for rapid construction.

These two objectives will be the framework for the paper. The current conventional method needs to be evaluated and by injecting the LC into the process flow, it will make improvements on it.

III. Methodology

The research methodology will touch on the aspects of innovative construction in the implementation of this study to ensure that the findings can be operated more orderly and effectively. This matter aims to ensure all data gathered are based upon valid sources and is in accordance with objectives of the study. The procedure will be starting with understanding the construction problem and the elements of innovative construction. The principles of lean will be based in the case study to determine the suitability in approaching the rapid construction from earthwork until handing over of the building projects. The concept of rapid construction, as an innovative method in construction, will be the main element in analyzing the non- efficient techniques of traditional construction implementation. Data gathered through the perception from construction industry players in their opinion

of the construction process either conventional or contemporary.

IV. Literature Review

The construction industry is relatively slow in developing and adopting new technologies and usually prefers conservative, well-known practices over innovative construction methods. Historically, it is evident that the drive for innovation in construction often stems from demand pull [1]. Demand for the new concept was stimulated by changing lifestyles and urbanization. For example, the demand for fast communication gave rise to intelligent buildings [2]. The construction operations are a complicated activity involving abstraction of construction activities from the drawings, the choosing of suitable plants and false works, allocation of resources on site, the planning of safe working place for workers, and the scheduling of activity sequence. The increasing competition among construction players demands them to implement innovative construction methods and materials, which have not been used or tested previously [3]. The lack of tools for the construction planner to evaluate and validate the planning can result in incorrect construction plans, which can result in a lot of rework in the construction phase. Significant costs are imposed on the public during construction, including delay and disruption to local businesses. While the pressure to expedite construction increased, the public also reasonably expects high quality output. Probabilistic techniques have developed in recent years into an effective means of assessing output during construction projects. It has been shown that the innovative construction methods being used are the most effective means of construction and are within the current technical capabilities of the construction industry. Previous attempts at the construction industry have resulted in insignificant returns in productivity, safety and quality. The construction industry needs to think “out of the box” and seek alternatives to existing the fabrication and assembly process.

Traditionally, the word construction usually refers to construction activities and only involves construction parties such as contractors, architects, engineers, quantity surveyors and developers [4]; however, it is also definitely involving the client. This superficial understanding of the term is insufficient to depict and sometimes may give rise to misconceptions of the construction industry. Construction activities are vast and are not confined to the building and contract, but also the methods of implementation and the process flow. The construction industry has its own characteristics and qualities that make it distinct from other industries. Hence, it is only right that emphasis is given to the construction characteristics that differentiate this industry from other industries. From that statement, it is possible to see the complexity and the barriers that occur in the organization and definitely the construction flow will be unstable because of the various parties involved, while the project has its own limitation of time delivery. Construction industries worldwide have become notorious for underperforming in many aspects including quality, safety, productivity and product delivery to planned budgets, programmed and client satisfaction [5]. Previous research being conducted to indicate the order of magnitude of non-value adding activities, called waste on various partial studies. From the data compilation, it has shown that construction processes are characterized by a high content of waste in its activities and it is leading to additional duration of the project, as shown in Table I.

TABLE I
Compilation of Waste in Construction Process [6]

Item	Waste	Cost	Country
1	Quality costs (non-conformance)	12% of total project costs	USA
2	External quality cost (during facility use)	4% of total project costs	Sweden
3	Lack of constructability	6-10% of total project cost	USA
4	Poor materials management	10-12% of labour cost	USA
5	Excess consumption of materials on site	10% on average	Sweden
6	Working time used for non-value adding activities	Appr. 2/3 of total time	USA
7	Lack of safety	6% of total project costs	USA

There are many undesirable characteristics of current construction including difficulty in defining or measuring values, poor integration, inability to design, to set a budget and missed opportunity for adding and capitalizing on the value. The traditional construction method was understood as the common practice inherited from the long established custom of delivering the construction project. The word 'traditional' is often associated with the common practices in construction such as procurement, work process or project organization.

A. Lean for Rapid Construction

The characteristics of congested construction sites and simultaneous multi-contractor working environments require contractors or construction managers to coordinate and manage many trades to accomplish a project safely, and on time with the desired quality and within budget. The benefit of using this concept of production flow to manage construction includes providing alternatives to a sequential model of project realization, improved construction quality and better coordination among trade contractors. Construction is a process that is fed by a number of flows, out of which, one is critical for deciding the speed with which the process takes place. The construction process therefore differs from manufacturing, not only in terms of size and immobility of the product, but also through the nature of the process [7]. Shingo’s approach to identify the value stream, identifying non-value adding operations and to minimize or even eliminate them, before trying to improve the operations themselves, is of importance for the construction process [8]. Traditionally, the construction industry has been very focused on the operations flow. Operations are what is purchased through the prevailing contracting practice and what is in the focus of the project management. Project management focuses on operations, which means through contracting practice and by trade contractors, because providing operations is their

rationale for doing business, along with the efforts of the suppliers of equipment and materials, leads to improvement on value adding activities. However, this approach often generates huge amounts of waste as non-value adding activities as well, involving large quantities of resources [9].

LC as defined by the Lean Construction Institute is "a production management-based project delivery system emphasizing the reliable and speedy delivery of value". The ultimate goal is to carry on the project while maximizing value, minimizing waste and pursuing perfection. Many researchers agree with this definition and add that LC challenges the general concept of trade-off between time, cost and quality employed in traditional construction. It can be claimed that managing construction under the Lean philosophy is different from conventional construction contemporary practice in the following [10]:

- Delivery process: Clear objectives and goals;
- Performance: maximizing performance for the user at the project level; and
- Production: Control throughout the life cycle of the project.

LC practices include [11]:

- Establishing integrated teams;
- Combining project design with the process and simultaneously designing the facility of the production process;
- Hold production rather than releasing a fault into the construction process flow;
- Transparent, so that any team member can see the progress status of the project; and,
- Direct handoff between tasks in the work to eliminate clogs between project phases.

In Lean thinking, the focus is on how one activity affects the next activity, as all activities are part of the whole system. The goal in LC is to improve the performance of the whole system. They put forward that where the current project management manages projects as more or less independent activities, Lean philosophy works first to assure the reliable flow of work between the tasks. In that perspective, it depicts construction as a continuous flow of materials and/or information instead of just conversion activities (from input to output) [12]. Few common elements between lean manufacturing and LC are [13]:

- Focus on the elimination and reduction of waste;
- End customer focus in order to determine what value is and what waste is;
- Pull approach from a customer perspective;
- Focus on processes and flow; and,
- A system perspective.

Another aspect of process focus is empowerment; contractors perform self-control on their work, making project participants feel more involved in their work. Customer focus is a large part of Lean. Understanding what the customers want helps to determine what adds value. The other cluster is continuous improvement. Then, the issue of cooperative relationships and the main aspect of this core element is the harmonization between contractors and subcontractors, as well as the need for all parties involved to benefit from the improved performance.

LC has a basic improvement on rationale to compress lead time by eliminating waste. The time refers to the time required for a particular piece of material to traverse the flow. Inspection, move and wait times are factors that contribute to delays. Experience shows that non-value adding activities dominate most processes; usually 3% to 20% of steps add value and the impact of waste elimination in the construction process flow, as shown in Fig. 1 [14].

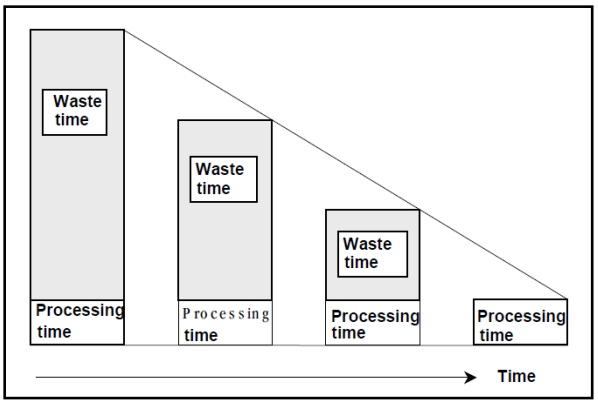

Fig. 1 Time reduction through elimination of non-value adding activities and variability reduction [14]

Elimination of waiting requires several things [15]. This, in association with the pull principle in Lean, offers the concept in rapid construction. Elimination of moving requires a process based layout (production cell), so that transport distances are practically eliminated. Push systems schedule the release of work, while pull systems authorize the release of work on the basis of system status.

The principle of time reduction also has other interesting implications, toward establishing the rapid construction concept. From the perspective of control, it is important that the cycles of deviation detection and correction are speedy. In design and planning, there are many open ended tasks that benefit from an iterative search for successively better solutions. The shorter the cycle construction process flow, the more cycles are affordable. From the point of improvement, the cycle time from becoming conscious of a problem or an opportunity for the implementation of a solution is crucial.

V. Data and Analysis

From the literature, there is the need to improve the traditional construction process. An exploratory survey was done as a first attempt. Because of these problems faced by conventional construction, the time reduction concept should be practiced as a modernizing construction in the industry. To increase the speed of tasks, understanding and managing the construction process as a flow has been a key issue. A fundamental issue in construction physic is to understand the underlying causes of time and flow variability mainly caused by the non-transformation stages of production (e.g. waiting,

moving and inspection) and to characterize the effects of this variability in the overall production process. The idea for rapid construction is similar to the production of a product, focusing not only on the main flow, but also verifying the process that there might be more than one flow of determining the performance. This is because any construction work package has conditions to be fulfilled without any delay, which is an important issue. Four main clusters of the problems occur in the traditional construction process, as shown in Table II.

TABLE II
PROBLEMS IN TRADITIONAL CONSTRUCTION METHODS

LOW SITE PRODUCTION -Higher reliance on workers rather than technology - In-situ methods creates complexity - Problems in materials supply chain - Storage or poor materials inventory - Site congestion	TIME OVERRUN - Difficulty in controlling delivery time - Difficulty in overlapping activities - Low performance due to efficiency - Less time reduction effort
POOR MANAGEMENT - Fragmentation in project life cycle - Poor coordination of workers - Difficulty in transferring information - Less experienced personnel to manage activities	POOR OUTPUT - Poor quality - Low client satisfaction - Buildability issue - Variation order - Defect and rectification

The second objective is to derive the integration of LC in order to achieve rapid construction. As mentioned, LC offers the item of time reduction. Based on the content analysis, the benefits of LC in the building construction process flow offers benefits to:

i. Decrease waiting time for the clarification and confirmation by client and consultant;
ii. Decrease unnecessary procedures and working protocols;
iii. Less rework and defects;
iv. Avoid mishandling or error in construction;
v. Controlling material deterioration or damage during the construction period;
vi. Decrease waiting time for the equipment to be delivered or mobilised on site;
vii. Decrease waiting time for materials to be delivered on site;
viii. Avoid material loss or higher security during construction;
ix. Avoid over allocation or unnecessary materials on site;
x. Avoid over allocation or unnecessary equipment on site;
xi. Avoid over allocation or unnecessary workers on site;
xii. Decrease dependencies of waiting time for each construction activity; and,
xiii. Minimising time in supervising and inspecting on construction sites.

VI. CONCLUSION

This paper shows an attempt to answer the question of adopting LC to achieve rapid construction. The general approach within LC is to make the construction process stable and leaner by reducing non-value generating activities. The reason why the LC is used in rapid construction is to solve the chronicled and congested activities within the time frame of the rapid construction projects. In many applications of the construction process flow, the use of rapid construction method components significantly decreased the construction time required for the project. From this paper, the LC signified that it can be adopted in rapid construction projects. The most significant benefit has been seen in areas where systems have been using it repeatedly. The sharing benefits from LC into rapid construction are the shortening of order fulfilment leading times, less project downtime, more innovation and true reduce the chronicle predecessor.

REFERENCES

[1] Koskela, L. (1999), Management of Production in Construction; A Theoretical View, Proceeding: Seventh Annual Conference of the International Group for Lean Construction (IGLC-7), Berkeley.
[2] Tan W. L. (2004), The Application of Lean Construction to Reduce Wastes in Construction Process Flow, Master Thesis of Project Management, University Science of Malaysia, Malaysia.
[3] Kulatunga, K. J., Amaratunga, R.D.G. & Haigh, R. (2006), Role of the Construction Client in Innovation: A Literature Review, Construction and Building Research Conference of the Royal Institution of Charted Surveyors, University College London, London.
[4] Li, H., Ma, Z., Shen, Q. & Kong, S. (2003), Virtual Experiment of Innovative Construction Operations, Automation in Construction, Vol 12, Issue 5, pp561-575.
[5] Ismail, A (2005), Persepsi Responden Terhadap Pemilihan Kontraktor di dalam Tender Kerja, Master Thesis, School of Housing, Building and Planning, USM, Malaysia.
[6] Koskela, L., Laurikka, P. and Lautanala, M. (1995), Rapid Construction as a Change Driver in Construction Companies, Proceeding on the 3rd Workshop on Lean Construction, Albuquerque, pp: 223-235
[7] Goodrum P.M. (2005), Innovative Rapid Construction/Reconstruction Methods, University of Kentucky, U.S.
[8] Shingo, S. (1992), Non-Stock Production, Productivity Press, Cambridge.
[9] Carter, D. and Sullivan, T. (1994), Concurrent Engineering: Best Practices for Global Success, Mentor Graphics Corporation, London.
[10] Dumler, M. P. & Skinner, S. J. (2008), A Premier for Management, Thomson, U.S.
[11] Schmenner, R. (1998), The Merit of Making Things Fast, Sloan Management Review, pp:11-17.
[12] Schniederjans, M. J. (2009), Topic in Lean Supply Chain Management, World Scientific Publishing, Harvard.
[13] Johansen, E. and Walter, L. (2007), Lean Construction: Prospects For German Construction Industry, Lean Construction Journal, Vol 3 (1), pp: 19-32.
[14] Bartezzaghi, E., Spina, G. and Verganti, R. (1994), Lead Time Models of Business Processes, International Journal of Operations & Production Management 14 (5), pp: 5-20.
[15] Womack, J. P. and Jones D. T. (2003), Lean Thinking, New York.