Implementation Of Lean Concepts In The Construction Engineering Project

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Abstract

The Indian construction industry is a pillar of the Indian economy, contributing to roughly 10% of the GDP. For years the cost of construction in India has increased faster than inflation making it more and more expensive to build. Presently, the construction industry and all other organisations face various problems as a result of the uncertainties of the global economic climate; including labour redundancies, delayed projects and zero margin contract bids.

Applying Lean thinking has transformed many industries and its implementation in construction has now started to show the potential benefits. The concept of lean construction is concerned with the application of lean thinking to the construction industry. It is maintained that processes such as lean construction can arguably reduce costs within the construction process. The lean approach is the only way that improvements in time cost and quality can be made simultaneously without trade off. Lean construction focuses on delivering precisely what the client and end-user want. Certain tools and methods have been conceptualized in the field of Lean Construction, which lacks research based on quantitative data. It is therefore this research paper's purpose to develop a tool in how to identify and measure waste, guide in how to prioritize eventual waste reduction activities.

An exploratory method of investigation is adopted in achieving the aim of this paper by critically reviewing, exploring, and synthesizing literature related to the subject matter. This paper reviews the basic components of lean construction, with references to the development of lean production systems by manufacturing organizations and the advances of lean construction research. It discusses the implications on the implementation of lean construction with regard to a firm's strategic planning as well as to the conditions for the industry to lesser the barriers for lean construction implementation. Adopting lean principles, this paper reports a study that identified the presence of value and waste in a construction engineering project.Finally, the paper describes the objectives and anticipated contributions of current research conducted at the construction site.

Key Words: Construction Industry, Lean Construction, Value Stream Mapping

1. INTRODUCTION

A typical Architecture/Engineering/Construction (AEC) firm often operates in a quite competitive environment and therefore there is continuous interest in the industry to develop new methods to improve organizational effectiveness. In the past few years, AEC researchers have studied key successful improving methodologies developed within the manufacturing sector and one of the most promising approaches is perhaps the adoption of lean production principles to construction projects. Through this learning process, several groups of researchers understood not only how the lean production system redefined the way a manufacturing organization manages its production operations, but also how lean production enabled firms to produce quality products at lower costs. Based on those premises, AEC research has focused on applying the key aspects of lean production that are suitable for the AEC industry's environment.

Although there are still debates about whether the productivity of the construction industry is increasing or declining, the performance of the construction industry is widely perceived as unsatisfactory when compared with many other industries. Lean construction is a production management strategy for achieving significant, continuous improvement in the performance of the total business process of a contractor through elimination of all wastes of time and other resources that do not add value to the product or service delivered to the customer. Lean concepts have resulted in dramatic performance improvements in manufacturing, and the principles behind lean have also been successfully applied to construction. Some of the lean principles that are related to the construction industry are improvements such as the construction planning process, construction supply chain, and downstream performance. Attempts have also been made to apply lean principles to all project management processes, including the project delivery system, production control,work structuring, design, supply chain, project controls, and overall construction project management. The value of lean construction has been demonstrated in many case studies. For example, Koskela et al. closely examined a fast-track office building project and showed how the building process could be made leaner and speedier, and Tsao et al. illustrated how lean thinking and work structuring helped to improve the design and installation of metal door frames for a prison construction project.

2. LEAN CONSTRUCTION

Lean Production (LP) was developed by Toyota production system in the 1950s led by Engineer Ohno who was committed to eliminating waste. The term "lean" was coined by the research team working on international auto production to contrast it with craft and mass forms of production.

The core concept behind LP is to enable the flow of value creating work steps while eliminating non - value steps i.e. waste by focusing on fast cycle times. When waste is removed from the production process, cycle times drop until physical limits are reached. Value - adding activities are however, first improved through internal continuous improvement and fine - tuning of existing machinery. Only after these improvement

potentials are realised, major involvements in new technology are considered. The primary goal of LP in Japanese is Muda, that is, to avoid waste of time, money, equipment etc. Lean construction (LC) accepts Ohno's production system design criteria as a standard of perfection. Waste is defined by the performance criteria for the production system. Failure to meet client's unique requirements is waste. The evidence of waste in Ohno's terms is overwhelming. Waste in construction and manufacturing arises from the same activity-centred thinking. Howell argues that there is a need to maintain pressure on every activity to ensure continuous improvement through the reduction of cost and duration of each activity.

Lean theory, principles and techniques, taken together, provide the foundation for a new form of project management. From roots in production management, LC has produced significant improvements particularly on complex, uncertain, and quick projects. LC is a new way to design and build capital facilities. The objective of LC is to better meet client's demands and dramatically improves the Architectural/Engineering/Construction (AEC) process as well asproduct. LC advocates the simultaneous consideration of product and process development.

Managing construction under lean is different from typical contemporary practice because it:

- Has a clear set of objectives for the delivery process
- Is aimed at maximising the performance for the customer at the project level
- Designs concurrently product and process
- Applies production control throughout the life of the project

3. LITERATURE REVIEW

Waste exists in different forms, including over-production, waiting, unnecessary movement, carrying unnecessary inventory, and rework (Womack & Jones, 2003). Time studies and different process analysis techniques have been applied to systematically identify and quantify wastes during the construction process (Lee et al., 1999). Specifically, delay and other types of wastes due to poor coordination among various project participants have been well documented in many previous studies. The highly fragmented nature of the construction industry has caused considerable low productivity, cost and time overruns, and conflicts and disputes, all potentially resulting in claims and time-consuming litigations (Latham, 1994). Higgin and Jessop (1965) argued that there is seldom a full awareness of all the steps necessary to realize an optimumoverall project outcome without loss of time and that the means of ensuring coordination are often not clear.

To improve coordination of field operations, two different types of schedules are frequently used in construction projects, namely master schedule and look-ahead or short-interval schedule. A master schedule provides a global view of the entire project and the general sequence of major work packages. A look-ahead schedule is a more detailed plan that is developed to bridge the gap between the overall master project schedule and the assignments performed at the crew level. It provides the necessary details for field personnel to operate on a day-to-day basis. The ―last planner concept proposed by Ballard (1996) is based on principles of lean production to minimize the waste in a system through assignment-level planning or detailed look-ahead scheduling. The last planner method is a very proactive

approach in that it provides forward information for control and forces problems to the surface at the planning stage, thus facilitating close project coordination. When reliable workflow is generated, simultaneous improvement in all key criteria, including time, cost, quality, and safety, can be achieved.

For master schedules, bar chart schedule and the critical path method (CPM) are predominately used because of its simplicity in communicating schedule information in the construction industry. In many cases, bar chart schedule is the only acceptable format for project reporting purposes. For look-ahead schedules, however, the industry uses a number of different formats, ranging from calendar schedules and check lists to daily planning charts, punch lists, daily work plans, and graphic schedules (Hinze, 2008).

One of the primary goals of look-ahead scheduling and the last planner concept is to improve coordination and have resources work continuously. Bar chart schedule and CPM has been attacked in lean construction for its inability to model non-value-adding activities such as waiting, inspecting, and moving (Koskela, 1992). When CPM is applied to schedule repetitive projects, the early start schedule may not be optimal because floats attached to repetitive activities represent significant amounts of unforced idleness (Harris and Ioannou, 1998). Yang and Ioannou (2001) proposed a ―pull system approach that automatically pulls activities and/or activity segments to later start times so that unforced idleness can be eliminated. The term pull system encompasses the pull concept in a Kanban system, which pulls upstream material and off-site work to match the progress on site (Tommelein, 1998). The pull scheduling algorithm has been shown to successfully eliminate idleness in repetitive linear construction projects such as pipeline construction.

4. RESEARCH METHODOLOGY

The aim of the investigation was to learn more about the subject under study and with an anticipation of generating insight within the field of lean and the construction industry. The chosen investigation design was the study of construction processes at a construction engineering project.

4.1. Research Process

The research process adopted was explorative, trying to improve the understanding of waste in construction and trying to adapt lean thinking and methods to the construction industry. In order to fulfil the aim of this project a general outline concerning how to undertake the investigation was conducted, with the investigation following six steps.

- **Problem Formulation**

A brief literature review on the construction industry and the field of lean was conducted in order to acquire basic knowledge. This was done in order to structure, shape, and define the project's problem area, purpose, and investigation questions.

- **Literature Review**

Literature assumed to be relevant for the subject under study was reviewed and connections between the field of lean and the construction industry were made. The literature review covered key concepts within the fields of lean, construction, value stream mapping, waste, and other relevant topics.

- **Interviews**

Sets of interviews were conducted with different engineers. These engineers were actors within the construction business and people who possess knowledge and expertise in the construction field.

- **Observations**

Since observations are seen as a source of relatively objective information several field trips to construction site were performed. These observations have complemented the collected data from the interviews and the literature review.

- **Development of Tool**

Findings from the literature review, interviews and observations were combined and a tool has to be developed in order to identify and measure waste reduction activities and by this enabling estimation of potential consequences that might occur if lean is implemented.

- **Validation**

The tool design has to be discussed with the construction company in order to get their perspective on it and find improvement areas. The lean construction tool would be later on tested and validated in a test case.

4.2. Data Collection

Both primary and secondary data had been collected. Primary data is information that will be gathered explicitly for the study. In that sense the main source of primary data were interviews, observations and information obtained during the execution of the study. Value stream mapping (VSM) was also performed on construction processes in order to collect primary data. It should be noted that the collection of data through value stream mapping activities had been made at one construction site only. Data that has been published or released earlier in some way is defined as secondary data and is various type of literature from the literature review.

4.3. Data Analysis

The quantifying of different waste streams, recording and detailing of it as a proportion of the total waste stream, determining its destination and recording details of waste practices was done. Finding out the true cause of a problem or performance gap was done. Impact Analysis was done to unearth the "unexpected" negative effects of a change on the organization. It

provided a structured approach for looking at a proposed change, so that we could identify as many of the negative impacts or consequences of the change as possible. Firstly, this was an important tool for evaluating whether we wanted to run the project. Secondly, and once the decision to go ahead had been made, it helped us prepare for and manage any serious issues that would arise. Percent Plan Complete (PPC) is the number of planned activities completed divided by the total number of planned activities, expressed as a percentage. PPC became the standard against which control was exercised at the crew level, being derivative from an extremely complex set of directives: project schedules, execution strategies, budget unit rates, etc.

4.4. Designing of the Tool

The lean tool has to be constructed which would be built upon many different aspects collected from the theory, interviews and observations gathered during the course of investigation.

5. CONCLUSION

The industry struggles with inefficient processes leaving much to be desired. In order to meet this challenge the construction industry must become more efficient by using fewer resources. Small changes in the operational costs by reducing waste, which improves the efficiency, can make substantially changes in profit.

Previous researchers have identified the problems of how the industry works today and pointed to possible solutions by using the lean philosophy and tools along with solutions that are part of what is known as lean construction. There has however, been relatively little research on case studies, research based on quantitative data or research making categorization of the types of waste that exist in construction. In order to help bridge this gap, this paper's academic contribution is to categorize waste in construction according to classifications more adapted to the construction industry rather than the generic waste categories originally developed from manufacturing. The new categorization of waste is called construction waste, where two new categories of waste, "Preparation" and "Breaks", were added.

The Lean Construction Tool explains how to identify and measure waste through the use of a value stream mapping tool, interviews and observations. To fully understand the reason behind the waste, the tool recommends that an Ishikawa diagram is used to study the waste. Furthermore, the Lean Construction Tool aims to guide in what order waste should be reduced by suggesting the use of a Pareto Analysis which is useful in measuring the waste as well. By performing these just mentioned activities, estimations of economical and environmental consequences can be made. This will give the construction companies the possibility to work out countermeasures for the wastes in the form of an action proposal plan that will later be implemented.

By using this Lean Construction Tool a company can gain a better understanding of the kinds of waste that exist in their construction processes. Furthermore, the tool can help companies

to decide where change needs to begin by getting to the root cause of the problem thus facilitating prioritization of problem and avoiding sub-optimization. This could lead to improved efficiency of construction activities resulting in lower operational costs, increased profit margin and reduced environmental damages.

A part of the Lean Construction Tool is to conduct VSM studies which was done and proved to be a simple and powerful tool to use in the construction industry. The Lean Construction Tool was validated in a test case and it turned out that the tool worked well. In the validation case the Lean Construction Tool guided how to perform a situation analysis, finding underlying reason behind waste, make prioritization and facilitated estimations of potential consequences of waste reductions. This indicates that tools and methods from lean production/manufacturing can be successfully applied and adopted to the construction industry.

We have filled a part of the identified gap but there are still parts that need more research in order to fully remove the gap. More quantitative data is needed as well as metrics to facilitate continuous improvements and benchmarking within the industry.

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