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LEAN CONSTRUCTION: AN EFFECTIVE APPROACH FOR PROJECT MANAGEMENT

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ABSTRACT

Projects have been considered as temporary based production systems which need to be designed, produced and delivered within a specified time. It has been asserted by a number of researchers that fast, complex and uncertain projects cannot be managed through the conventional ways and that fast track projects with long, complicated supply chains involving many players and subject to multiple, extensive process design changes have complex flow management that have failed miserably. The conceptual models of construction management and the tools it utilizes (work breakdown structure, critical path method, and earned value management) have been criticized to be deficient in handling the present unique challenges of projects. As a result, the industry is characterized by a number of wastes including: overproduction, lead time, transportation, inappropriate processing, inventories, unnecessary movements, rework and making do wastes. There is therefore the need for practical and robust models and techniques that will help projects teams deal with the issues of wastes in projects. This can only be achieved through the adoption of lean production systems in the construction industry, thus, Lean Construction (LC). In this paper, LC approach and the importance for its implementation has been discussed as the robust approach for project management.

Keywords: conventional models, lean construction, lean principles, lean production, wastes, project management.

INTRODUCTION

Projects have been considered as temporary based production systems which need to be designed, planned, produced and delivered within a specified time. It is asserted by a number of researchers that fast, complex and uncertain projects cannot be managed through the conventional ways and that fast track projects with long, complicated supply chains involving many players and subject to multiple, extensive process design changes have complex flow management that have failed miserably (Ballard and Howell, 1994). As a result, the industry is characterized by delays and often has suffered cost and time overruns (Sorooshian, 2014).

In general, a very high level of wastes/non-value added activities is confirmed to exist in the construction industry. Several studies from various countries have confirmed that, wastes in construction industry represent a relatively large percentage of production cost. The existences of significant number of wastes in the construction have depleted overall performance and productivity of the industry, and certain serious measures have to be taken to rectify the current situation (Aziz and Hafez, 2013). It has been contended by the Lean Construction Institute (2014) that about 57% of productive time waste can be found in the construction industry. These wastes have been attributed to the inadequacies of the current projects management tools and the inabilities of the project teams to use robust and radical techniques to solve the challenges the industry faces. According to Johnston and Brennan (1996), Koskela (2000), Koskela and Howell (2001), Ballard and Howell (1994), the traditional approaches to construction or the conventional project management approaches have inadequacies in resolving the problems in the industry.

Nevertheless, lean manufacturing principles and techniques provide the foundations for minimization or total elimination of the waste faced by the industry. Lean construction has change the traditional view of labor flow and work flow reliability which were considered the most determinants of constructions works and has embraced the concept of flow and value generation. Basically, lean construction aims at reducing the wastes in workflow which the conventional methods are inadequate to eliminating them. This paper seeks to establish the fact that lean construction presents a new and robust approach to dealing with the wastes in the construction industry which the current or conventional project management models have failed to control.

THE CONVENTIONAL PROJECT MANAGEMENT METHODS

It is generally acknowledged that managements of projects must endeavor to achieve the goals of projects that were agreed upon before the start of the project. They must utilize and deploy tools, skills, techniques and available resources to facilitate projects to be able to complete projects on time. An effective and efficient project management will help meet and even exceed the expectations of the customer, they will maximize the use of available resources; be it time, money, people, space, among others, and endeavor for a successful completion of project within budget and on time; they will instill confidence in their team and also file what has been done for references in the future (Glenn, 2007). However, according to (Abdelhamid, 2004), there have been

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observations and evidence that have indicated that, the models behind construction management and project management tools like; critical path method; work break down; and earned value management; have failed to complete project within budget, on time and the quality desired for the project.

The failures of current project management help define the requirements for a new approach. This was echoed by (Koskela, 2000) who argued that, there is a mismatch between the conceptual models of project management and the reality observed. This highlight lack of robustness in the existing managements concepts and therefore calls for production theory in construction. This new approach must rest on the expanded Transformation (T), Flow (F), and Value generation (V) foundation to optimize performance in projects.

The responsibility of the project management team is to find or discover techniques for meeting and controlling schedule and budgets instead of outlining justifications or reasons for not meeting them. This tells management of a project that there are no authentic explanations for failing to meet schedule and budgets. The outcome is inability to identify and follow up on reasons why planned work is not accomplished, and inability to learn and improve. There is an assumption that all work and resources could be coordinated by schedule and those inabilities to perform to schedule are uncommon or proof of absence of responsibility (Aziz and Hafez, 2013). This was supported by (Bashford et al., 2005) who argued that the construction management systems used currently ignores the effects of the important production system variables such as cycle time, work in progress and throughput, but these variables are interdependent, related and can influence construction cycle significantly, as discovered through their study. From lean construction viewpoint, current practice of project management rests on defective model and its control.

Basically, current project management endeavors to manage activities through scheduling and to control them utilizing output measures. This fails even in the effort to manage those activities and misses completely the work process management and the creation and value delivery. In this dynamic environment with complexities, uncertainties, fast tracked and short duration projects, multiple competing, frequent changing demands from clients, technology and the market, activities are rarely connected together in just a simple consecutive chains; rather work between and within tasks is connected to work in others through shared resources and/or relies upon work in progress in others, and therefore coordinating projects in such environment cannot be guaranteed even with very detailed critical path method schedules. In such instances, the reliable release of work starting with one group then onto the next is assumed or overlooked. Project managers who depend on these schedules battle with uncertainty yet rarely see it emerging within the project from their dependence on scheduling of tasks and control of activities (Aziz and Hafez, 2013).

Also, an examination of the failures in using scheduling for projects by (Ballard and Howell, 2003) likewise demonstrated that, regularly just around 50% of the tasks on week by week work plan are finished before the end of the planned week and that most of the failures in the planning could have been moderated or controlled by contractors using an effective variability management, beginning with the project structuring (as a temporary based production system) and continuing through its operation and improvement.

There are among others three distinguishing features between LC practice and conventional project management, specifically: a) LC concentrates on waste reduction in construction processes; b) LC seeks to minimize irregularity and variability so that there will be flow of material and information in processes without any interruptions; and c) LC uses pull system: materials for construction is expected to be delivered on site just when it is required or needed (Abdul Rahman *et al*., 2012).

LEAN CONSTRUCTION

The past two decades has witnessed several performance improvements accomplishment in the manufacturing industry through the means of productivity increase. A central point in this accomplishment is the application of the concept of production philosophy, known as ‘Lean Production’, which focuses on continuous improvements in processes through the elimination of different types of wastes. In the 1940s, a newly adopted concept emerged as Lauri Koskela argued for a paradigm shift to a more robust system through the development and adoption of production philosophies and approaches in the construction industry (Koskela, 2000). However, it only became prominent in the mid-1990s and since that time, lean construction has emerged as a new concept, both in construction management and practical sphere of construction.

There are two somewhat contrasting explanations of LC. One explanation is about the adoption of the lean production methods and tools to construction. Interestingly, the other explanation sees lean production as a theoretical motivation for the theory based approach for construction, thus, LC (Koskela *et al*., 2013). Even so, (Ballard and Howel, 2004) opined that there are four roots of this LC approach: i) Accomplishment of the Toyota Production System; ii) Unsatisfactory performance of projects; iii) Efforts to establish project management on a theoretical foundation; and iv) Discovery of facts anomalous (difficult to clarify) from the perspective of conventional thinking and practice.

LC is a concept that involves the application of lean manufacturing principles or lean thinking into the construction industry. The concepts as echoed by (Koskela, 2000), (Bashford *et al*., 2005), (Sacks *et al*., 2010) will lead to an improved delivery systems and processes through the elimination of wastes in the construction industry, thus, improve project and financial performance of the industry. That is, LC is aimed at

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reducing waste, increasing productivity and health and safety in fulfilling the client's requirements. The term "Lean" basically means to make work as much as easy to understand, perform and manage and the main idea underlying this concept is about reducing waste in processes while focusing on things that add value to the customer. It is about improving the delivery systems of construction projects to satisfy client's needs.

Regardless of the fact that construction operations and supply chains are different to those applied in manufacturing, the principles of lean are equally applicable. It should however be noted that lean is as much a philosophy and culture as a set of principles or methodologies and therefore could be applied to any industry. That is, lean manufacturing techniques can be applied not only in manufacturing, but as well as service oriented and other environment. This is because every system has some levels of wastes and whether one is providing a service, processing a material or producing a product, there are some levels of components which are viewed as waste. Therefore, the methods for assessing systems, recognizing and removing wastes and concentrating on the requirements of the client are relevant in any system, as well as in any industry. LC shares same objectives as lean production; waste elimination, reduction of cycle time, continuous improvements, reduction of variability, continuous flow, pull production control, among others, (Aziz and Hafez, 2013).

The concept of lean rest on five (5) principal principles that when followed will reduce waste and maximize profit. These principles are:

(i) Value specification: Precisely specify what creates value from the client's perspective;

(ii) Value stream identification: Clearly identify all the steps in the processes (value stream) that delivers exactly what the customer values and remove everything that do not add value to the customer;

(iii) Flow: Take actions that ensure continuous flow in the value stream;

(iv) Pull: This means to produce only what the customer wants just in time; and

(v) Perfection: Always strive for perfection by delivering what the customer wants and expects through a continuous removal of waste.

The tenets of lean manufacturing have the potential to make companies to produce at a less cost through removal of waste from the value stream. As a result, several industries including the construction industry have turned on lean manufacturing production philosophies (process improvement) to deal with the challenges in their businesses, thus, LC. The potential effect of lean manufacturing philosophy on the effectiveness of construction industry is very much recorded (Abdul Rahman *et al*., 2012).

WASTES IN CONSTRUCTION

Lean has to do with designing, operating in continuous process flow or working with the right process and having it right the first time. Essentially, lean is about removal of waste. Waste is seen as activities and processes that consume resources yet do not add value, thus, any non value added activity or process is considered as waste. Waste involves anything that adds no value from the clients' perspective. The essential focus of lean is to provide a product that the client truly need through identification and removal of waste in process in a step by step approach. In other words, the focus of lean is more on value than cost, which seeks to improve value added activities whilst eliminating non-value added ones. Two kinds of activities were recognized by (Ohno, 1988): i) Value-Adding Activities; and ii) Non Value-Adding Activities. The latter are essentially wastes and ought to be removed from processes. However, (Hines and Rich, 1997) further observed three classifications of production activities and these include: a) Non-Value Adding Activities which are considered pure waste and unnecessary activities which ought to be totally eliminated; b) Necessary but Non-Value Adding Activities which involve operations that may be considered as waste yet are essential within the operating procedures. In order to eliminate them, some changes are required to enhance the standard operating procedures; and c) Value Adding Activities which include the change or transforming of raw materials or semi-finished products to finished products.

Recently, waste in construction has been a subject of interest for many researchers across the globe. Nonetheless, the focus has been on material waste, which tends to be one among the resources in construction process (Abdul Rahman *et al*., 2012). This paper however does not focus only on on-site material waste but also waste on several activities including; overproduction, lead time, transportation, inappropriate processing, inventories, unnecessary movements, rework, making do and design.

(Tersine, 2004) described waste as undesirable, money, time and other resources consuming activities which add no value to a product. For the most part, the idea of waste is specifically connected with the use of resources that add no value to the finished product. This is all that much not quite the same as the construction professionals' perspective of waste where waste is alluded to be material waste and there have not been any significant effort to separate activities of construction into value adding and non-value adding activities (Abdul Rahman *et al*., 2012).

Waste is characterized in (Ohno, 1988) seven (7) types of waste: Overproduction, Time on hand (waiting), Transportation, Additional/Inappropraite Processing, Inventories, Movement and Making Defective Products. According to (Tersine, 2004), Waste in manufacturing and construction involves excesses in inventory, time overruns, cost of quality, absence of safety, rework, unnecessary transportation, queue time, long distances,

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setup, handling, movements, inspections, expediting, poor decision or management strategies, requirements, among others. Also, according to (Koskela *et al*., 2013), waste can be differentiated between operational and process waste. Movement and waiting can be waste of machines or people which are moving unnecessarily or being idle, and these are considered to be operational wastes. The other five (overproduction, transportation, additional processing, inventories and making defective products) are process waste. The seven types of waste can be explained as follows (Abdul Rahman *et al*., 2012);

i) Overproduction is identified with producing more than required or producing earlier than should be expected. This regularly results in quantity and quality issues; an organization realizes that it will lose various units along the process of production so delivers additional to verify that the client request is fulfilled. This may result in misuse of materials, worker hours or usage of equipment. Overproduction issue can be handled by utilizing mistake proofing approach (Pokayoke) and by understanding the equipment process capacities of the production machines.

ii) Waiting is identified with idleness which is mostly caused by poor synchronization and material flow leveling, and pace of work by distinctive equipment or groups. Also, waiting occurs at whatever point products are not being processed or moving. The idleness is perhaps created during waiting for engineering, maintenance, raw materials, designing, quality assurance results, inspections, confirmation order, and so forth. Waste generated through waiting can be reduced drastically by connecting the processes together and sustaining the flow of the processes.

iii) Transportation (Material/Equipment Movement) has to do with the moving of materials or equipment within site where poor working environment layout or an absence of process flow makes numerous stops and starts in a cycle of production. The working environment of construction site can fundamentally be the major reason contributing to unnecessary transportation.

Also, extreme handling, utilization of inadequate equipment or bad states of pathways can likewise precipitate this type of waste. It is worth noting that, every movement ought to have a reason since things being moved incur some kind of cost. Work process flow interruptions can significantly add to the costs of transportation. These wastes include; waste of worker's hours, waste of space on site, waste of energy, and the likelihood of waste of material during transportation. Proper re-laying out of the machines within an industrial facility from a functional to a cellular layout has been demonstrated to not just help reduce waste generated by transportation but as well reduce Work in Progress (WIP) and Waiting. Likewise this can be applied to the construction industry where appropriate plan for site layout would be able to minimize unnecessary material movement.

iv) Processing (Excessive Processing/Over-Processing) occurs in situations where processing or conversion activity does not add value to the product or service from the client's perspective. This is constantly created by the quality issue of the work done. The most evident example of over-processing is rework relating to surface finishes or works. Tools such as Statistical Process Control (SPC), 5 whys, Pokayoke (Mistake Proofing), among others, can be used to help identify and remove the causes of this waste. This waste can likewise be avoided by changing the technology used for construction.

v) Inventory (Stock/Storage Waste) is identified with unnecessary or excessive inventories which prompt material waste (by losses because of insufficient stock conditions at site, robbery, deterioration, vandalism), and fiscal losses because of the capital being tied up. Excessive inventory is seen as waste since there is no value activity in stocking inventory. Moreover, inventory occupies space, adversely affects capital, and incurs costs, among others. Organizations often arrange more than needed to satisfy a request. The problems associated with inventory may be due to quality problems with the production processes and may likewise be as a result of inadequate resource planning or uncertainty on the quantity estimations.

vi) Movement (Motion) is identified with ergonomics and is seen in all instances involving stretching, bending, lifting, strolling and reaching. The waste generated by motion is concerned with the unproductive or unnecessary movements made by employees during work hours. This waste may be caused by poor work methods, lack of equipment, or poor work area arrangement. Also, a long distance which must be covered within a work site to perform or accomplish assignments is also considered waste of time and effort. Unnecessary movements may create or increase the level of injuries, accidents, and their related costs. Lean thinking seeks to minimize poor housekeeping, poor work area organization, poor layout of machinery, and poor or inconsistent work methods. Hence, when there is a proper work area layout, unnecessary or unproductive motion of workers would be minimized, and this would lead to costs saving. Therefore, jobs or occupations involving unnecessary movements ought to be examined and redesigned to minimize motion and its associated costs.

vii) Making Defective Products (Rejects/Unacceptable/Unnecessary Work) happen when the finished or half processed products are not up to the quality requirements. This is the common waste produced by the construction industry where segments or products made are not up to specifications. Defects may prompt rework or the use of poor or unnecessary materials to the building; for instance, extreme thickness of plastering works. The cost of product considered as defective is the same as it does to deliver a prize product.

Other than the losses, there are numerous different costs connected with rejects that make this an especially imperative classification of waste to minimize or eliminate. Defects can happen through an extensive variety of reasons, for example, poor specification and design, inadequate planning and control, inadequate qualification of the project/work team, poor integration of design and production, just to mention a few. New methods to handle defects must be used and checked. For instance, six sigma can be used for improving quality through identification and removal of defects and reduction of variability in processes. Six Sigma is able to achieve process quality of 99.99966% that are free from defects (Alireza and Sorooshian, 2014).

In addition to Ohno's seven types of wastes, various analysts have presented the eighth and other wastes. For instance, (Macomber and Howell, 2004) identified several waste which can extensively be classified as: inability to utilize individuals' abilities, skills and capacities; behavioral waste; information waste; and waste of good ideas. Also, (Womack and Jones, 2003) have included the eighth waste, which is the design of goods and services which do not satisfy the needs of the end user.

More also, (Burton and Boeder, 2003) have included waste of human potential as the eighth type of waste. Waste of human potential is identified with the failure in fully using the skills of individuals. Besides Ohno's seven types of wastes, one of the important wastes mostly observed in construction according to (Koskela *et al*., 2013), is the making-do. Making-do waste is related to a circumstance where a task is begun without all its standard inputs or a task is preceded before all preconditions or requirements or data are ready.

However, Ohno's seven wastes will be considered for this paper as other wastes classification according to (Abdul Rahman *et al*., 2012) can almost often be incorporated in one of the seven types, or they are a cause of the waste instead of a waste itself. Case in point, human potential waste is more a cause of other waste types such as waste of defects or processing waste that is generated as a result of inadequate skills of individuals.

WHY LEAN CONSTRUCTION

Since construction industry plays a major role in every national economy and many other industries depend on the industry in terms of purchasing inputs and also providing products to almost every other industry; reducing or removing waste in the industry would lead to a great cost savings for the industry as well as the society. The following among others have been highlighted to strengthen the importance of lean construction and reasons why its application is necessary for the construction industry.

It must be emphasized that value is what the client is really paying for the project to deliver and install. LC is an approach to design the system of production to reduce waste of time, materials, and effort with a specific end goal to generate the most conceivable amount of value (Koskela *et al*., 2002).

Again, designing the system of production to attain the stated ends is only achievable through the joint effort of all project participants namely client, Architect/Engineer, facility managers, end users, among others, at early phases of the project. This goes beyond the contractual agreement of design or build or constructability assessment where contractors, and at times facility managers merely respond to designs as opposed to involving and influencing the designs (Abdelhamid *et al*. 2008). LC makes this possible by integrating and engaging the effort of all the project participants. LC seeks to maximize client's satisfaction through concurrent engineering (or design) which integrate various tasks executed parallely by multi-disciplinary teams with the aim of optimizing engineering cycles of products for effeciency, quality and functionality (Aziz and Hafez, 2013).

Also, LC basically seeks to encapsulate the benefits of the concept of Master Builder. LC acknowledges the fact that desired ends influence the means to accomplish these ends, and that available means will influence realized ends (Abdelhamid *et al*., 2008).

In order to ensure reliable and predictable production system flow on project site, there should be strong alignment of the whole supply chain in such a way that waste is reduced and value maximized. With such a wide scope, lean production or manufacturing tools and techniques have been most influential and exceptionally effective in dealing with wastes in supply chain delivery systems.

CONCLUSIONS

This paper was able to establish the fact that the employed or existing project management models and strategies have not been able to deliver projects on time and as a result have created wastes in the construction industry through a comprehensive literature survey. The paper also discussed LC, its principles and wastes in the industry. The authors demonstrated that LC presents a new and robust approach to dealing with the waste in the construction industry. This was illustrated with some highlights of the importance of LC application (Why LC). Finally, the paper established that, the application of lean tools and techniques by project teams and industry's practitioners will minimize or eliminate waste, enhance performance and lead to a great cost savings for the industry as well as the society. It is expected that the fundamental knowledge provided by this paper will contribute to the knowledge and practice from delay control or waste elimination and also serve as a benchmark for continuous improvements of performance in construction industry.

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