LEAN PROCUREMENT: THE USE OF LEAN CONSTRUCTION TECHNIQUES IN PROJECT VALUE ENHANCEMENT

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Lean construction is characterised by a set of clear objectives in project delivery involving the concurrent design of products and processes, and the application of production control throughout the project life cycle to maximise value for money to customers. The successful delivery of construction projects requires the effective use of project management techniques such as risk and value management to achieve the optimum performance of a constructed facility over time. However, it has been argued that lean construction came about as a result of the failure of traditional project management to provide an integrated project delivery process in which design, construction, operation, and maintenance are considered as a whole with an understanding of how to enhance value delivery to clients, stakeholders (including occupants), and society in general. This paper explores in depth the lean construction techniques that support environmentally sustainable benefits and value enhancement in the design and construction processes (including supply chain management). It also explains how the implementation of lean techniques in construction project delivery and procurement strategy (including partnering relationships between contractors, consultants and manufacturers) delivers a high level of benefits and value.

Keywords: construction project, lean construction, procurement, value, value management

INTRODUCTION

Lean construction is a production management-based approach to project delivery; a new way to design and build capital facilities which is based on the principles of lean thinking and production (LCI 2011). The implementation of lean within construction is a value seeking process that maximises value and continually redefines perfection. Lean construction came about as a result of the failure of traditional project management to provide an integrated project delivery process in which design, construction, operation, and maintenance are considered as a whole with an understanding of how to enhance the delivery of value to clients, stakeholders (including occupants), and society in general. This has brought a significant reform to construction process in terms of waste minimisation, value maximisation/enhancement, performance optimisation, environmental management etc. through the use of lean construction techniques that support environmentally sustainable benefits and value enhancement in the design and construction processes (including supply chain management).

This paper explores in depth the lean construction techniques that support environmentally sustainable benefits and value enhancement in the design and construction process (including supply chain management). It also explains how the implementation of lean techniques in construction project delivery and procurement strategy (including partnering relationships between contractors, consultants and manufacturers) delivers a high level of benefits and value.

A key component of lean thinking is to identify all the value adding time and reduce the non-value added activities as there is a glaring and indisputable need to improve the delivery of value to clients, stakeholders, and society in general while at the same time driving down cost and the time to deliver operational constructed facilities (Bicheno 2007).

RESEARCH METHODOLOGY

The research is a theoretical one which is based on a systematic literature review. The literature sources were accessed through web of knowledge which provides access to leading citation databases covering numerous journals and conference proceedings. Also, some textbooks were found useful in the research process. This method was chosen along side with documentary evidence (case study) as appropriate because of the issues to be explored and explained by the research study.

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LEAN PRODUCTION AND CURRENT PRACTICES

Current project management views a project as the combination of activities while lean thinking forces attention on how value is generated rather than how any one activity is managed. Production in lean construction is managed so that actions are aligned to produce unique value for the customer. Lean production is defined by Todd (2000) as "initiative, whose goal is to reduce the waste in human effort, inventory, time to market, and manufacturing space to become highly responsive to customer demand while producing world class quality products in the most efficient and economical manner". Value to the customer and throughput, the movement of information or materials to completion are the primary objectives. According to Womack and Jones (2003), lean thinking can be summarized as to correctly specify and enhance value, identify the value stream, make the product flow, let the customer pull value, and pursue perfection. Lean thinking has been considered to be one potential approach for improving organisational performance in terms of value generation (Womack et al. 2003). The research of Hines et al. (2004) which was based on the framework suggested by McGrill and Slocum (1993) reflect the relationship of value and cost and reaching the cost-value equilibrium created awareness in the managers' vision of evolving towards lean thinking.

SUPPLY CHAIN MANAGEMENT

Supply Chain Management (SCM) has been defined by Tommelein et al. (2003) as "the practice of a group of companies and individuals working collaboratively in a network of interrelated processes structured to best satisfy end customer needs while rewarding all members of the chain" SCM is characterised with achieving increased competitive advantage in the construction market. Supply chain participants such as owners, contractors, suppliers etc are still in search of a better understanding of supply chain, its dynamics and how they can increase their competitive advantage by applying it (Arbulu and Ballad 2004). SCM is closely related to lean supply (Lamming, 1996). The basic concept of SCM includes tools like Just-In-Time delivery (JIT) and logistics management. The current concept of SCM is very broad but still largely dominated by logistics.

Arbulu and Ballard (2004) proposed a strategy to improve the management of supply systems in construction using lean principles and techniques with the objective of assuring on-time delivery of information and materials to project sites at least cost and maximum value for the final customer. This strategy includes the use of lean techniques like Kanban to pull selected materials on a just-in-time basis from suppliers or logistics centres to site. Moreso, an extensive literature search has been carried out by Mollenkopf et al. (2010). It revealed the barriers, drivers, converging, and contradictory points across the three supply chain strategies namely green, lean, and global supply chain. Sharing of information among partners of a supply chain will not only reduce the operation costs of each of the partners, but the efficiency of this 'trust' based business transaction will give rise to a sense of 'customer satisfaction' along the value chain.

LEAN CONSTRUCTION TECHNIQUES FOR ENVIRONMENTALLY SUSTAINABLE BENEFITS

Vinodh et al. (2010) carried out a study on tools and techniques for enabling sustainability through lean initiatives by exploring various issues of sustainability as well as the strategies/ techniques that would enable the achievement of sustainability objectives using lean initiatives. It has been revealed through literature that lean principles are aimed at waste reduction and therefore results in capital gain, achievement of sustainable benefits as well as improving sustainability of an industry. Some of the sustainable benefits from lean principles include: reduction in material usage, energy consumption, hazardous waste, water usage etc. these benefits are presented in Table 1. According to The Environment Protection Agency (EPA) (2011), many organisations have found that implementing lean concepts and tools results in improvements in environmental performance, even when lean activities were not initiated for environmental reasons. However, since environmental savings are often not part of the "business case" for lean improvement activities, organisations implementing lean do not necessarily quantify the environmental performance gains associated with their lean initiatives case studies and best practice.

Some of the case studies and best practice examples of environmental benefits that resulted from lean initiatives are presented in Table 2. In addition to these case studies, a study was carried out on US construction companies investigating whether lean thinking principles were been adopted and if so, what results were being achieved and what were the perceived barriers in the approach.

Four company case studies were completed and results show that office construction times reduced by 25% within 18 months, schematic design reduced from 11 weeks to 2 weeks, turnover increases of 15-20%, productivity increased, satisfied clients looking to place repeat orders increased, and project costs reduced. The study showed that although there was different application of lean principles which showed some interesting initial result, all companies were partnering and a number of the suppliers were very keen to undertake lean work and were fully co-operating (Garnett et al., 1998).

LEAN CONSTRUCTION TECHNIQUES/STRATEGIES FOR VALUE ENHANCEMENT

The suitability of lean construction techniques to promote value in construction has been raised for discussion since the issue of value in construction is a complex one requiring the combination of several different value strategies within one project (Ogunbiyi et al., 2011). The main strategies for implementing a value management approach to improve on lean construction methodologies in order to contribute to sustainability implementation and performance improvement has also been explored. Egbu et al. (2004) stated that Value Management and Value Engineering are techniques for enhancing value within a project by defining what will deliver value in a specific project, engineering a best value solution to meet those defined value parameters, and then delivering a cost effective solution. Green (1999) has put forward the concept of value generation during the early stage design phase as a learning process between the client and the design professionals such that there was a joint understanding of client's value parameters and their realisation in the design.

Table 1: Environmental benefits of lean principles (Source: Vinodh et al., 2010)

LEAN PRINCIPLES/TOOLS	SUSTAINABLE BENEFITS
Pull approach	Reduction of work-in-process, elimination of potential waste from damaged products, lesser floor space utilisation
Cellular manufacturing	Reduction in set-up times and change over time hence low energy and resource usage, reduction in defects
Value Stream Mapping	Reduction in waste through fewer defects, less scraps, low energy usage, etc.
5s	Reduction in lighting requirements due to clean windows, leaks attended to immediately, reduced consumption of materials and chemicals
Total preventive maintenance	Less hazardous waste due to decreased spills and leaks, increased longevity of equipment
Six sigma	Fewer defects hence less waste, improvement in product durability and reliability hence increase in product lifespan
Pre-Production Planning	Reduction of waste at design stage, usage of right sized equipments, reducing the complexities of production processes and product design
Kaizen	Elimination of hidden wastes and unwanted activities
Visual controls	Identification and elimination of unwanted entities hence less material usage and wastes
Lean supplier networks	Introduction of lean to existing suppliers would lead to better realization of environmental benefits
Poka Yoke	Reduction in defects hence less waste, low energy usage, less scrap

Value management is one of the performance improvement tools and techniques. It is a structured method of eliminating waste from the brief and from the design before binding commitments are made. Value management is now used by up to a quarter of the construction industry to deliver more effective and better quality buildings, for example through taking unnecessary costs out of designs, and ensuring clearer understanding of the brief by all project participants and improving team working (DETR 1998) .

Table 2: Case studies of environmental benefits of lean principles (Source: http://www.epa.gov/lean/environment/studies/)

CASE COMPANY	SUSTAINABLE BENEFITS
DuBios- Johnson Diversey and Steel case	Lean practices resulted in: Energy savings of a 60 percent reduction in the BTUS required Reduction in water usage by 80 percent Waste stream was cut by 85 to 95 percent
Canyon Creek Cabinet Company	Expect savings of almost $1.5million annually from process changes Process improvements included reduction in lead time, work-in-progress, defect, overproduction, downtown, operator travel time, and material loss and damage Decreased VOCs which will reduce permitting requirements
Columbia Paint &Coating	Reduction of 15,000 lbs of paint solids from wash water saved 18,000 lbs of shrink wrap Removed 2,820 lbs of hazardous materials from the waste stream
Lockheed Martin	Reduced hazardous waste resulting in cost savings due to the elimination of RCRA permit requirements Reduced facility size by 1/3 (a reduction 550,000 square feet) Reduced chemical storage capacity to 2% of its original size

Lean Project Delivery System

A new system of delivering building projects on the basis of the principles of lean production has been proposed. This new system is termed Lean Project Delivery System (LPDS), which is seen as a project delivery method that conceptualizes design and construction projects as lean production systems (Ballard 2000). Figure 1 illustrates the Lean Project Delivery System. The five interconnecting phases of the LPDS model include: Project Definition, Lean Design, Lean Supply, Lean Assembly, and Use. Each of the phases contains three modules and is represented as a triad. Each triad overlaps the succeeding triad to include at least one common module. For example the Project Definition phase includes purposes, design criteria and design concepts and overlaps with the Lean Design phase which includes design concepts, process design and product design. Also, two modules of Production Control and Work Structuring extend throughout the lifecycle of the project. Some important features of LPDS include downstream players in the planning process, conceptualising the project delivery as a value generating process, and creating a reliable workflow amongst the project participants.

The domain of Lean Project Delivery is defined by the intersection of projects and production systems and is therefore fully applicable to the delivery of capital projects which include the formation of a temporary production system in the form of a project team that consists of owner, architects, engineers, general contractor and sub-contractors. The lean philosophy minimising waste and maximising value should be applied as early as possible in the design and construction process, i.e. at the briefing and early planning phases. In lean approaches, the desire to maximise value and reduce waste starts at the beginning (initial team composition).

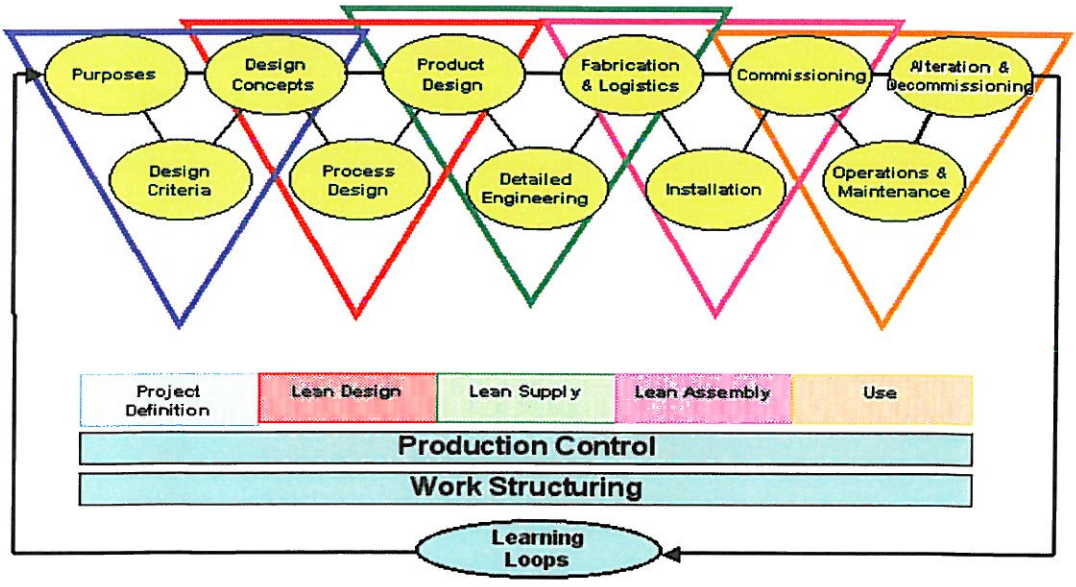

Figure 1: LPDS system (Source: Ballard 2000)

According to Garnett (1998), there are five lean principles which were described by Womack and Jones (1996) within which lean construction techniques can be successfully applied. This is represented in Figure 2 below.

In construction, specifying value comes before design and value is defined by the ultimate customer's needs through tools such as value management, quality function deployment and simulation (Ballard and Howell 1998). The key technique behind value stream is process mapping for a very specific reason: i.e. that of understanding how value is built into the building product from client's point of view. Flow is concerned with achieving a holistic route by which a product is developed. The basic units of analysis in lean construction are information and resources flow. Improvement is possible by reducing uncertainties in workflow. Redesigning the planning system at the assignment level is the key to assuring reliable workflow and this step has to be implemented early. The principle of pull makes use of just in time applications to meet the client needs and subsequently customising and delivering them more predictably when the client requires them.

Lean Construction Methodologies/Tools

Salem et al. (2005) carried out an evaluation on the Lean Construction tools such as: Last Planner, increased visualisation, daily huddle meetings, first run studies, 5s process, and fail safe for quality and safety. The effectiveness of the lean construction tools was evaluated through the lean implementation measurement standard and performance criteria. It was found that last planner, increased visualisation, daily huddle meetings, and first run studies achieved more effective outcomes than expected.

Last Planner System

The Last Planner system of production control, introduced in 1992, which emphasises the relationship between scheduling and production control, is the most completely developed lean construction tool (Ballard 2000). The Last Planner System has been described by Ballard and Howell (2000) as one method for applying lean techniques to construction.

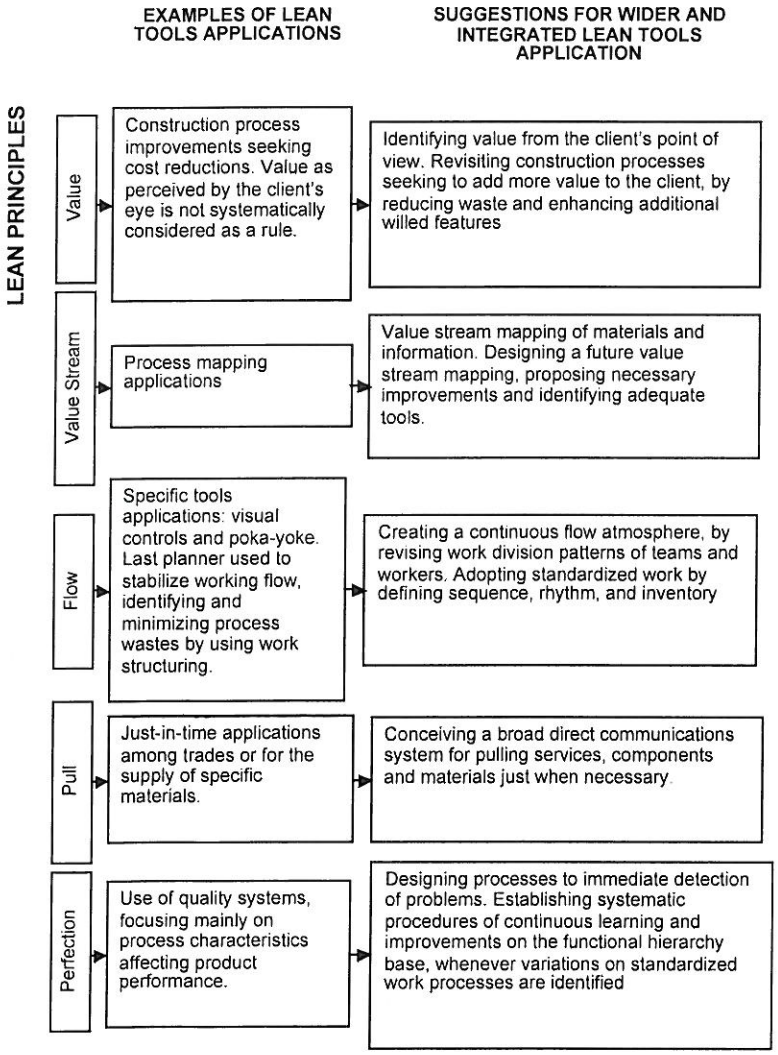

Figure 2: Examples of lean tools already reported in construction implementation and suggestion for wider and integrated application for the sector (Source: Picchi and Granja 2004)

It provides productive unit and workflow controls and facilitates quick response to correct for deviations from expected outcomes by using root cause analysis. According to them, the Last Planner is based on three levels of schedules and planning tools:

- The master pull schedule serves as the overall project schedule, as contrasted with the detailed critical path schedule that is the more traditional management tool.
- The look-ahead schedule reflects major work items that need to be completed for the milestone dates in the master pull schedule to be met. This schedule is usually based on a six to eight week time frame, and uses items "pulled" from the master pull schedule; they are carefully reviewed to ensure that they are free of constraints that cannot be removed within a given time.
- The weekly planner schedule delineates the work activities or assignments "pulled" from the look-ahead schedule that must be initiated to meet the completion dates in that schedule. Eligible activities or assignments are those that have no current constraints, and that have resources available and assigned.

Several examples of the application of lean construction techniques were presented by Forbes et al. (2002). These include a Brazilian company which collaborated on a research program with the University of Sao Paulo to improve the integration of design and production processes, Verticon Construcao e Empreendimentos Ltda who used last planner on a 90 days construction project and the application of the Last Planner Control System on a housing project in Quito, Ecuador. Some of the benefits achieved are presented respectively: Communication and motivation among the design team influenced the integration of design features with process considerations directly, the implementation of lean construction and control procedures significantly improved production efficiency, in terms of buildability and production cost control and elimination of not only material waste, but non-value adding tasks as well with a reduction in project duration from 90 days to 83 days and reduced rework etc. The last planner facilitated improved quality control and the application of lean methods, The Percent Plan Complete (PPC) and Performance Factor (PF) improved. It was proven at the construction site that look ahead planning enables one to keep current activities linked with the master pull schedule.

The main idea of the lean construction process is that the same team of suppliers, contractors and consultants work on a series of projects, continually developing the product, applying quality improvement and waste reduction techniques, and incorporating arrangements for learning and continuous improvement. The early stages of partnering are a necessary pre-requisite for improving construction but without the concept of flow production applied at a strategic level, partnering remains only a partial solution. Organising to achieve seamless flow delivery of a product gives purpose to a partnering relationship.

PARTNERING

Partnering is a long term commitment between two or more organisations for the purpose of achieving specific business objectives by maximising the effectiveness of each participant's resources. The relationship is based on trust, dedication to common goals and an understanding of each other's individual expectations and values. Expected benefits include improved efficiency and cost effectiveness, increased opportunity for innovation, and the continuous improvement of quality products and service (Packham et al., 2003). Partnering has been described by Bubshait (2001) as an innovative and effective project organisation concept and the key elements that contribute to the success of partnering to reduce cost and minimise conflict in the construction industry were discussed. The relationship between main contractors and subcontractors is mainly a transactional one where all parties try to obtain additional value at lowest cost.

This view has been supported by Miller et al. (2002) who argued that most subcontractors are small and are fundamentally different to larger main contractors but that the traditional nature of the relationship has seen main contractors attempt to take advantage. Miller et al. (2002) reflect on two case studies based on transactional and relational approaches and contrast the levels of trust and willingness to engage between the two. Suggestion was thereafter made that there is need for some form of harmonisation (such as partnering) for lean construction innovations to succeed. Partnering has been presented as a potentially important way of improving construction project performance through the benefits it brings to clients and contractors (Bresnen and Marshall 2000). Partnering the supply chain is a mechanism process by which the alliance is managed and by which it provides value to its customers. Partnering establishes a base level of trust which allows people within a system to shift their attention to improving at the system level instead of simply defending their interests. But trust is hard to maintain in the absence of reliable work flow. Complex, uncertain and quick projects are likely to fail when only traditional approaches are used with lack of a comprehensive underlying theory, efforts such as partnering are little more than patches (Howell and Ballard 1998).

CONCLUSION

The lean construction techniques that support environmentally sustainable benefits and value enhancement in the design and construction processes have been extensively explored. It has been established that supply chain management leads to improved understanding of the characteristics of construction supply chain problems and that lean principles and techniques are capable of assuring on-time delivery of information and materials to project sites and value maximisation for the final customer. The implementation of lean principles and techniques at the early stage of construction process will lead to improvement in environmental performance, waste reduction resulting to capital gain, achievement of sustainable benefit as well as improving sustainability of an industry. Also, partnering has been suggested as a potential way of improving construction project performance because of its benefits to the clients and contractors as well as being important for the success of lean construction innovations.

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