Enhancing Malaysia Construction Performance: Application of Lean Technique in Eliminating Construction Process Waste

Lim ILY (Irene Lim YenWui)[1], Projects and Facilities Management Group, Faculty of the Built Environment, University of Malaya
irene_lyw@yahoo.com

Abdul-Rahman H (Hamzah Abdul-Rahman)[2]
Dean of Faculty of the Built Environment, University of Malaya
arhamzah@gmail.com

Abdul-Samad Z (Zulkiflee Abdul-Samad)[3]Department of Quantity Surveying, Faculty of the Built Environment, University of Malaya
Zulkiflee1969@yahoo.com

***Abstract* – Poor project performance in Malaysian construction industry is not an uncommon scenario as the construction industry involves numerous parties, lengthy processes and different stages. The construction industry has unfortunate reputations in delivering projects that are unpredictable in terms of on time delivery, within budget and to the pre-specified quality, whilst concurrently attempting to ensure a zero accident rate. The Malaysian construction industry had carried out several mega projects in the past two decades but most of these projects were not cost, time and quality effective. There are a lot of non-value adding activities or wastes in construction processes and many among those were left unnoticed or unattended. Waste has been considered a major problem in the construction industry. Waste does not only have an impact on the efficiency of the construction industry but also on the overall state of the economy of the country. Previous studies have shown that tremendous productivity improvements can be achieved by simply targeting at reducing or eliminating those wastes and/or improve the process flow. Waste is defined as any losses produced by activities that generate direct or indirect costs, but do not add any value to the product from the point of view of the client. Accordingly, higher productivity could be achieved by minimizing wastes. In order to achieve that, there are dire needs for immediate changes in the industry. One of the major hindrances to waste minimization is the difficulty in establishing a proper methodology which can be used to benchmark future construction projects. Wastes that are mentioned earlier are identified by Taiichi Ohno as the seven wastes that are part of the Toyota Production System (TPS), which is also known as lean manufacturing or lean production. Lean manufacturing is a systemic approach to meeting customer expectations, whatever they value, by reducing waste. Lean production aims to optimize performance of the production system against a standard of perfection to meet unique customer requirements. Lean construction results from the application of this new form of production management to construction. Lean construction is much like the current practice, which has the goal of meeting the customer's needs while using the least of everything. This study is part of an on-going research project aiming to enhance Malaysia construction productivity performance by eliminating non value-adding activities using lean construction techniques. This is meant to have a clearer picture on how "lean" is local construction performed pertaining to the concepts and principles of lean construction. In this paper, wastes in construction processes will be identified and potential application of value stream**

mapping tools to identify and eliminate construction process will be discussed.

Keywords – Lean construction, Lean principle, Waste in construction process, Construction performance, Value stream mapping.

I. INTRODUCTION

Poor project performance in Malaysia construction industry is not an uncommon scenario as the construction industry involves numerous parties, lengthy process and different stages. The Malaysian construction industry had carried out several mega projects in the past two decades but most of these projects were not cost, time and quality effective (Pratt, 2000; Abdul-Rahman and Berawi, 2002; Hussein, 2003; Chong, 2005). Productivity levels within the construction industry have consistently lagged behind other sectors of the economy, especially manufacturing industry (Low and Choong, 2001).

According to Baccarini (1999), the distinction between good and poor project performance was defined by the project team's meeting time, cost and quality objectives. However, in reality, the construction industry has an unfortunate reputation of delivering projects that are unpredictable in terms of delivery on time, within budget and to the pre-specified quality, whilst concurrently attempting to ensure a zero accident rate (Smith, Jones and Vickridge, 1999).

Choo (2005) has claimed that there are many factors which will affect the project performance as the process is getting complicated with the combination of various parties' endeavors, many stages of work and carrying a long period till the completion. Leong and Tilley (2008) believed that construction industry poor performance was due to a gateway waste of not measuring and/or using wrong, inappropriate or insufficient measures for performance appraisal. Furthermore, other main reasons for construction industry low performance were due to the temporary organizational structure of construction team and inefficient construction process (Poon, Potts, and Cooper, 2000).

Serpell and Alarcon (1998) have stated that there are an increasing number of construction companies applying actions to improve their projects' performance by reducing all kinds of waste during the construction process. As most construction executives know, the industry can be susceptible to wasteful spending, delays and project inefficiency. Many criticisms have been directed to the construction industry, generally on poor workmanship. It not only the final product that is subjected to criticisms but the processes, the people, the materials and etc that are under tremendous pressure for better quality in construction (Wan-Mahmood, Mohammed, Misnan, Mohd-Yusof, and Bakri, 2006).

Since construction has a major and direct influence on many other industries by means of both purchasing the inputs from other industries and providing the products to almost all other industries; eliminating or reducing waste could yield great cost savings to society (Arditi, Akan, and Gurdamar, 1985). Many project management approaches have emerged to improve performance such as value-engineering, partnering, design-build and etc.

In the past two decades, great performance improvements have been achieved in the manufacturing industry in the means of increasing productivity. A major factor in this achievement is the implementation of the new production philosophy, often known as 'lean production', which provides a continuous improvement in the production process by removing various types of waste (Lee, Diekmann, Songer, and Brown, 1999). One of the fundamental principles of 'Lean Thinking' and therefore 'Lean Construction' is continuous improvement through elimination of waste. In the 1940s, lean construction methodology evolved as Lauri Koskela made the transition from the development of new production management from manufacturing to construction industry.

The potential impact of lean production philosophy on construction effectiveness is well documented (Alarcon 1997, Koskela 1992). Lean techniques are applicable not only in manufacturing, but also in service-oriented industry and service environment. According to Kotelnikov (2006), every system contains waste. Whether you are producing a product, processing a material, or providing a service, there are elements which are considered 'waste'. The techniques for analyzing systems, identifying and reducing waste, and focusing on the customer are applicable in any system, and in any industry

Essentially, lean construction aims to reduce the waste caused by unpredictable workflow, which waste is defined in Ohno seven categories: defects, overproduction, waiting, transporting, movement, inappropriate processing and inventory. Imtiaz and Ibrahim (2007) have found that implementation of lean principles to the Malaysian construction industry does improved operational performance. Besides that, their study also reveals that there is a correlation between lean principles and operational performance.

Lean concept has been introduced into the construction industry with varying levels of success for different projects. However, currently there are no practical guidelines for the application of the lean concept in the Malaysian construction industry. Numerous researches and case studies using lean construction theories and principles have been carried out to formulate models and frameworks by the means to evaluate the performance and productivity in various aspects of the construction industry. However, both the flow improvement and waste reduction/elimination concepts remained the major areas of study among the researchers as they viewed them as the value enhancement to the whole construction production processes.

II. LEAN PRINCIPLES

The concept of lean production was developed based on the original Toyota Production System, which aimed to produce what the customer wanted at the time when they needed it with minimized waste (Womack et al. 1991). Lean is about designing and operating the right process and having it right the first time. Essential to this is the elimination of waste – activities and processes that absorb resources but create no value. The primary focus is on moving closer and closer to providing a product that customers really want, by understanding the process, identifying the waste within it, and eliminating it step by step (Constructing Excellence, 2004). In short, lean is focused more on value instead of cost, which it seeks the removal of non-value adding activities whilst improving those that add value.

Lean adopters such as Ballard (1994), Womack and Jones (Womack and Jones, 1996), Picchi (2000), Koskela (2000) and others have refined and expanded the lean concept for construction. In addition, few researchers (Womack and Jones, 1996; Howell, 1999; Diekmann, Balonick, Krewedl, and Troendle, 2003; Constructing Excellence, 2004) have outlined the basic lean thinking principles. The followings are the summarized five topmost principles of lean thinking:

a. *Value* – Precisely specify *value* from the perspective of the ultimate customer

b. *Value Stream* – Clearly identify the process that delivers what the customer values (the value stream) and eliminate all non value-adding steps

c. *Flow* – make the product flow or organize the production in a continuous flow.

d. *Customer Pull* –customer pull means do not make anything until it is needed, then make it quickly.

e. *Perfection* – manage towards perfection by continuous improvement and deliver on order a product meeting customer requirements with nothing in inventory.

III. LEAN CONSTRUCTION

The emerging concept of lean construction is concerned with the application of lean thinking to the construction industry. Since the past ten years, there have been growing interests among the international academicians in lean construction (Koskela, 1992; Alarcon, 1997; Howell and Ballard, 1998). Such researchers seek to investigate the extent to which the Japanese model of lean production can be applied to the construction industry. From the study of lean construction background, lean construction is result from the adaptation and implementation of the Japanese manufacturing principles within the construction practices, which lean construction assumes construction to be like a production process – a special one (Berteslen, 2004). The concept of lean production is introduced to the construction industry following its success in the manufacturing industry. Consequently, the terminology of lean construction is formed (Mao and Zhang, 2008).

Lean construction is a concept which is still new to many construction industries in the world. Essential features of lean construction include a clear set of objectives for the delivery process, aim at maximizing performance for the customer at the project level, concurrent design of product and process, and the application of production control throughout the life of the product from design to delivery (Howell, 1999).

Lean construction aims to maximize the customer's satisfaction through concurrent design of both the constructed facilities and the construction process that delivers these facilities, and through the consequent control of each stage in the construction process (Mao and Zhang, 2008). Furthermore, lean construction is the continuous process of eliminating waste, focusing on the entire value stream, and pursuing perfection in the execution of a constructed project (Diekmann, Krewedl, Balonick, Stewart, and Won, 2004). Lean also focuses on how one activity affects the next (Pinch, 2005). In a nutshell, lean construction features include many fundamental aspects of a lean philosophy. It is a philosophy that requires a continuous improvement effort that is focused on a value stream defined in terms of the needs of the customer. Improvement is, in part, accomplished by eliminating waste in the process.

Having applied the lean production principles in the construction industry, many positive results have been achieved worldwide in many areas of the construction industry, such as enhanced value, reduced costs, and increased customer satisfaction. For example, Ballard and Howell (1994) achieved a 30% productivity increase by matching labors with the workflow of backlog and by shielding direct production from upstream variation and uncertainty. Moreover, lean principles were also deployed to improve the productivity in installing metal wall frames and in building ganged forms for digester tanks (Halpin and Kueckmann, 2002).

According to Howell (1999), there are three features to distinguish the lean construction practice from a conventional construction management:

1. Lean construction focuses on reducing wastes that may exist in any format in the construction process, such as inspection, transportation, waiting, and motion.
2. Lean construction aims to reduce variability and irregularity so that material and information can flow in the system without interruptions.
3. Construction material is expected to be on site only when it is needed.

Lean construction is about managing and improving the construction processes to deliver profitably what the customer needs. Because it is a philosophy, lean construction can be pursued through a few different approaches. However, the lean principles can only be applied fully and effectively in construction by focusing on the improvement of the whole process. This means all parties have to be committed, involved, and worked to overcome obstacles that may arise from the traditional contractual arrangements (Constructing Excellence, 2004).

Many project management approaches have emerged to improve performance such as value-engineering, partnering, design-build and etc. Lean combines concepts from these approaches with principles that are drawn to form a production management that creates a new way to manage projects (Pinch, 2005). In addition, by focusing on the workflow, lean construction is able to unplug the clogs in the project stream. Thus, construction processes like planning, engineering, designing, constructing, producing and delivering of materials are all better coordinated to deliver maximum value for the project owner.

IV. OBSTACLES TO THE ADOPTION OF LEAN CONSTRUCTION METHODS

The lean thinking system was born in the manufacturing industry, while its principles are being applied to different sectors at different levels. However, adoption of these principles of lean is not very simple as the natures of other industries differ from that of the manufacturing environment. Hence, there are difficulties in applying certain lean concepts to construction, due to the nature differences between lean manufacturing and construction (Salem and Zimmer, 2005).

In the construction industry, lean principles were taken from the lean thinking system and amended after years of research to suit the construction environment. The concept of lean explains about eliminating waste and continuous improvement in the system which indicates achieving perfection. In the manufacturing industry, as the elimination of waste from your processes is done and the flow of products is continuous according to the demands of the customers, it leads to a never ending reduction of time, cost, space, mistakes, and effort. Besides that, projects are distinct from operations due to their unique natures. Operations are repetitive; projects are one-off endeavours (Greene, 2000).

According to Koskela (1992), the incapability to improve the productivity level of construction projects is mainly perceived by people in the industry as due to its peculiarities and special features: one-of-a-kind nature of projects, site production and temporary multi-organization. In addition, one of the main differences between the construction and other industries is that the various site conditions that have a significant varying effect in the production rates of most standard construction items (Herbsman and Ellis, 1990). Mao and Zhang (2008) further state that the difficulty of application of the management method of manufacturing industry to construction industry is due largely to the unique nature of the construction process and the many risks and uncertainties involved in this process.

V. WASTE IN CONSTRUCTION

Lean is about designing and operating the right process and having the right first time. Essential to this is the elimination of waste – activities and processes that absorb resources but create no value (Constructing Excellence, 2004). While working at Toyota, Taiichi Ohno identified two kinds of activities: value-adding activities and non value-adding activities. Activities that do not add value is simply a waste and should be eliminated (Ohno, 1988). Hines & Rich (1997) further break down the production activities into three categories: value adding, non-value adding and non-value adding but required. Hines & Rich (1997) define these activities as follow:

- Non-value adding activities are pure wastes and involve unnecessary actions which should be eliminated completely
- Necessary but non-value adding activities are operations that may be wasteful but are necessary under the current operating procedures. In order to eliminate them, partial changes are needed to improve the standard operating procedures
- Value-adding activities involve the conversion or processing of raw materials or semi-finished products to the final product

Waste in the construction industry has been the subject of several research projects around the world in recent years. However, most studies tend to focus on the waste of materials, which is only one of the resources involved in the construction process. In spite of this, waste in construction is not only focused on the quantity of waste materials on-site, but also related to several activities such as overproduction, waiting time, inventories, defects, movement, processing, transportation and substitution (Formoso, Isatto and Hirota, 1999).

Serpell & Alarcon (1998) have defined waste as any construction process/activities that incur cost but do not directly or indirectly add value to the construction projects. Meanwhile, Tersine (2004) defines waste as undesirable, time, money and/or resources consuming, and non value-adding to the product. Waste also includes anything that does not add value from the perspective of the customers. Generally, the concept of waste is directly associated with the use of resources that do not add value to the final product. This is very much different from the construction practitioners' view of waste where waste is referred to material waste and there are no significant attempts to separate the construction activities into value-adding or non value-adding activities.

In the context of lean production, seven common types of wastes have been identified (Ohno, 1988; Ikovenko, 2004): overproduction, producing defective products, inventories, motion with no value to the product, waiting, extra process, and transportation. Waste in construction and manufacturing includes delay times, quality costs, excess inventory, lack of safety, rework, unnecessary transportation trips, long distances, setup, moving, handling, inspecting, expediting, prioritizing, queue time, improper choice or management methods or requirement and poor constructability (Koskela, 1992; Alarcon, 1993; Serpell 1995; Tersine, 2004).

Waste elimination will be one of the most effective ways to increase the profitability of any business. Tersine (2004) claims that profit can be increased while costs can be reduced simultaneously with a positive compounding effect on the performance by eliminating unwanted waste. To eliminate waste, it is important to understand exactly what waste is and where it exists. While construction production significantly differs with factories production, the typical wastes found in production environments are quite similar. For each waste, there is a strategy to reduce or eliminate its effect on a company, thereby improving overall performance and quality. Constructions processes can be divided into either add value or waste to the production of goods or services. The primary step in the lean thinking process is the identification of which steps in the process add value and which do not. Once the classification of these two categories is done, it is then possible to implement the action by improving the former and eliminating the latter (McBride, 2003).

The following are the seven deadly wastes originated in Japan, where waste is known as "muda." "The seven wastes" is a tool to further categorize "muda" and has been originally developed by Toyota's Chief Engineer Taiichi Ohno as the core of the Toyota Production System, also known as Lean Manufacturing (Ohno, 1988; McBride, 2003). The first five wastes refer to the flow of material; meanwhile the two last ones refer to the work of men: overproduction, defect, material movement, processing, inventory, waiting, and motion (Ohno, 1988).

1. *Waste of Overproduction (Unnecessary work)* related to the production of a quantity greater than required or making it earlier than necessary (Formoso, Isatto and Hirota, 1999). This often caused by quality problems, which a company knows that it will lose a number of units along the production process so produces extra to make sure that the customer order is satisfied (McBride, 2003). An example of this kind of waste is the overproduction of mortar that cannot be used on time. This may cause waste of materials, man-hours or equipment usage (Formoso, Isatto and Hirota, 1999). Overproduction issue can be tackled by using mistake proofing methods (Pokayoke) and by understanding the machine process capabilities of the production equipment (McBride, 2003).

2. *Waste of Rejects (Defect/Unsatisfactory work)* occurs when the final or intermediate product does not fit the quality specifications (Formoso, Isatto and Hirota, 1999). This is the simplest form of waste that construction industry produces, where components or products made do not meet the specification (Henderson, 2004). Defects may lead to rework or the incorporation of unnecessary materials to the building (indirect waste); for example, excessive thickness of plastering (Formoso, Isatto and Hirota, 1999). Defective product costs the same as it does to produce a prize product. Besides the obvious losses, there are many other costs associated with rejects that make this a particularly important category of waste to eliminate. Defects can occur through a wide range of reasons such as poor design and specification, lack of planning and control, poor qualification of the team work, lack of integration between design and production, etc. (Formoso, Isatto and Hirota, 1999). New procedures to handle defects have to be implemented and verified. According to McBride (2003), new waste management processes must be added in an effort to reclaim some value for the otherwise scrap product. He further state that it is not to be surprised to find out that 99% of all activities carried out are non-value adding if there are documentation of all the non-value added activities carried out in a typical manufacturing company.

3. *Waste in Transportation (Material movement/Conveyance)* is concerned with the internal movement of materials on site (Formoso, Isatto and Hirota, 1999) where poor workplace layout or a lack of process flow creates many stops and starts in a production cycle. Construction site layouts can often be the fundamental cause of excess transportation (McBride, 2003). Excessive handling, the use of inadequate equipment or bad conditions of pathways can also cause this kind of waste (Formoso, Isatto and Hirota, 1999). Every movement should have a purpose since items being moved incur a cost (Henderson, 2004). Interruptions to work flow can substantially add to your transportation costs. This defects main consequence are: waste of man hours, waste of energy, waste of space on site, and the possibility of material waste during transportation (Formoso, Isatto and Hirota, 1999). McBride (2003) suggested that appropriate re-laying out the machines within a factory from a functional to a cellular layout has been proven that help not just reduce transportation waste but also reduce Work in Progress (WIP) and waiting. This also can apply to the construction industry where proper site layout plan would able to reduce the excessive material movement.

4. *Waste of Processing (Overprocessing)* is related to the nature of the processing (conversion) activity (Formoso, Isatto and Hirota, 1999), in which the material movement waste that kinks in construction process flows and does not add value to the product or service from the customers' point of views. This is always caused by the quality problem of the work done (McBride, 2003). The most obvious example of overprocessing is rework relating to surface finishes (Henderson, 2004). McBride (2003) suggests that techniques such as 5 whys, Statistical Process Control (SPC) and mistake proofing (Pokayoke) are available to help identify and eliminate causes of quality defects. This waste can also be avoided by changing the construction technology (Formoso, Isatto and Hirota, 1999).

5. *Waste of Inventory* is related to excessive or unnecessary inventories which lead to material waste (by deterioration, losses due to inadequate stock conditions on site, robbery, vandalism), and monetary losses due to the capital that is tied up (Formoso, Isatto and Hirota, 1999). Excess inventory is regarded as waste since there are no value is added by stocking inventory. In addition, inventory takes up space, ties down capital, incurs storage (and security and insurance) costs and raises the risk of damage during storage as well as the risk of obsolescence (Low and Choong, 2001).

According to McBride (2003), companies always order more than required to fulfill an order. He further stressed that this might be due to the quality problems along the production process or the often mistaken belief that it saves money by ordering larger quantities. It might also be a result of lack of resource planning or uncertainty on the estimation of quantities (Formoso, Isatto and Hirota, 1999).

6. *Waste of Waiting (Delays)* is related to the idle time caused by lack of synchronisation and leveling of material flows, and pace of work by different groups or equipments (Formoso, Isatto and Hirota, 1999). McBride (2003) states that whenever goods are not moving or being processed, the waste of waiting occurs. Idle time maybe created during the waiting for raw materials, quality assurance results, engineering, maintenance, scheduling of equipment and etc in which all these are forms of waste. McBride (2003) suggests that waiting waste can be dramatically reduced by linking up the processes together to one which feeds directly into the next.

7. *Waste if Movement (Motion)* is related to ergonomics and is seen in all instances of bending, stretching, walking, lifting, and reaching (McBride, 2003). Formoso, Isatto and Hirota (1999) further states that motion of this waste is concerned with the unnecessary or inefficient movements made by workers during their jobs, which might be caused by inadequate equipment, ineffective work methods, or poor arrangement of the working place. Traveling too far within a work site to accomplish assigned tasks is a waste of time and effort and also creates increased opportunities for accidents, injuries, and their associated costs. Lean Thinking looks to eliminate poor housekeeping, lack of organization, inefficient layout of machinery, and inconsistent or ineffective work methods. Thus, with a proper layout of a work area, the unnecessary motion of employees can be minimized, creating an opportunity for saving on costs. McBride (2003) suggests that jobs with excessive motions should be analyzed and redesigned for improvement with the involvement of plant personnel.

Subsequent to the introduction of Ohno's seven wastes, numerous researchers have introduced the eighth waste category. One of them is Koskela (2004) whom have identified making-do as one of the wastes in construction process. Making-do is referred to a situation where a task is started without all its standard inputs or the execution of a task is continued although the availability of at least one standard input has ceased. In making-do waste, the inputs are negative, yet the processing is started before the input has arrived.

Womack and Jones (2003) have also added the eighth waste, which is the design of goods and services that do not meet the end users' needs. Formoso, Isatto and Hirota (1999) have also pointed out substitution as another waste that triggers monetary waste, which might be caused by the substitution of a material with a more expensive one (with an unnecessary better performance); the execution of simple tasks by an over-qualified worker; or the use of highly sophisticated equipment where a much simpler one would be enough. In addition, Burton and Boeder (2003) have added waste of human potential as the eighth category of waste. Human potential waste is related to the failure in fully utilizing the skills of people. Burton and Boeder (2003) believe that once people are trained to identify the waste, they are able to eliminate it. Other wastes include burglary, vandalism, inclement weather, accidents, etc. (Formoso, Isatto and Hirota, 1999).

However, this research will only study the Ohno's seven wastes as other types of waste can almost always be included in one of the seven types, or they are a cause of the waste rather than a waste itself. For example "waste in human potential", this is more a cause of other types of waste such as processing waste or the waste of defects that result from the lacking skill of the people. Besides that, the seven wastes introduced by Taiichi Ohno are link between the root causes (human behaviors) and the loss of profit.

VI. WASTE ELIMINATION

As stated by Tersine (2004), waste must be removed from the process, which if not removed, it will thrives and multiples, and eventually crowding out operational effectiveness since the waste tends to proliferate and generate ancillary or secondary support wastes. Alwi, Hampson and Mohamed (2002) indicate that the identification of the incidence of non value-adding activities during the process enable the construction managers to easily identify the best solutions and ways to apply any new technique for reducing the amount of waste, leading to increased project productivity.

Waste reduction can only take place after wastes have been identified (Tersine, 2004) and waste reduction efforts also typically focus on the value stream processes, which it goal is to eliminate the waste and maximize value to the customer base by striving for elevated or ultimate standards of performance (Burton & Boeder, 2003; Tersine, 2004). However, systematic identification and quantification of waste is often one of the most challenging aspects in lean construction advocates (Lee, Diekmann, Songer, and Brown, 1999). Lee, Diekmann, Songer, and Brown (1999) further claim that construction management often fails to identify or address waste in the construction waste due to it poor recognition of waste and the absence of appropriate tools for measuring waste or value. Tersine (2004) state that local efficiencies do not necessarily result in process efficiencies, so, emphasis should be primarily on the process that creates output. A value stream is all the actions (value and non value-added) required to bring a product through the main flows essential to every product (Browning, 1998). Diekmann, Balonick, Krewedl, and Troendle (2003) claimed that value stream studies able to help to understand and characterize waste in construction production process.

Burton & Boeder (2003) have identified one of the most important lean tools that most useful in improving performance is value steam mapping (VSM). VSM is developed by Toyota in the 1950s, which serve as one of the key principles for creating lean (Womack, 2006). In recent years, VSM has emerged as the preferred way to implement lean. VSM serves as a starting point to help management, engineers, suppliers, and customers to recognize waste and its source (Seth, Seth and Goel, 2007). VSM is a mapping tool that is used to describe supply chain networks (Lian & Van Landeghem, 2002). It is a process of mapping the material and information flows of all components and subassemblies in a value stream (Khaswala and Irani, n.d.). VSM is originally called “material and information flow maps”, which is a one-page diagram depicting the process used to make a product (Womack and Jones, 1996; Rother and Shook 1999; Womack, 2006). VSM focuses on the interdependence of the twin flows of material and information (Shook, n.d.). This visual representation facilitates the process of lean implementation by helping to identify the value-added steps in a value stream, and eliminating the non-value added steps/waste (Khaswala and Irani, n.d.).

VSM identifies ways to get material and information flow without interruption (Womack and Jones, 1996), improves productivity and competitiveness, helps people see waste that exists in process implement system rather than isolated process improvements (Emiliani and Stec, 2004). Besides, VSM has proven it’s effective in identifying and eliminating waste (Khaswala and Irani, n.d.). Besides that, VSM helps operation managers understand how their flows are currently operated and guiding them through the process of analysis to improve the existing flows and design better ones in the future (Shook, n.d.). VSM objectives are to enhance the value stream by identifying a future state and creating an implementation road map that can be executed to achieve the future state. VSM is a tool that is utilized to graphically represent the current state of a value stream. Creating value stream mapping is the first step required in any lean improvement initiative. It is critical that the current value stream is documented so that the waste can be correctly identified in the value stream and a future state can be determined to eliminate non value-adding wastes (Burton & Boeder, 2003).

Some of the benefits of VSM are to identify sources of waste in the value stream, provide common language for talking about the processes, form the basis of an implementation plan to identify and eliminate wastes, and allow identification of non-value-added steps, lead time, distances traveled, and amount of inventory for a process (Khaswala and Irani, n.d.; Burton & Boeder, 2003; Lasa, Laburu & Vila, 2008). However, it has to bear in mind that developing a VSM is not enough to minimize waste. It must be combined with other lean principles and lean tools to truly achieve improvement in the performance.

VII. CONCLUSION

This paper intends to expose and recommend the potential application of lean principles to enhance the Malaysian construction performance. The successfulness of lean principles in enhancing performance was due to its concept of optimizing and eliminating wastes, rather than minimizing them (Badurdeen, 2007). Wastes that are mentioned in this paper are identified by Taiichi Ohno as the seven deadly wastes in production: overproduction, defect, material movement, processing, inventory, waiting, and motion.

Lean construction includes many fundamental aspects of a lean philosophy. It is a philosophy that requires a continuous improvement effort that is focused on a value stream defined in terms of the needs of the customer. Improvement is, in part, accomplished by eliminating waste in the process.

Toyota uses few decades to fully implement the lean principle to their manufacturing industry. They start the application in a few stages. Thus, there is a dire need for the Malaysian construction industry to take their first step in implementing lean construction. As a beginner, there is no necessity to start off a project with total implementation of lean management method. It is recommendable to embark with the basic principle, which is identifying and eliminating the wastes in construction process rather than just focuses on the reduction of construction material waste. Summing up, VSM is introduced as the early introductory lean tool for those practitioners who wish to start their lean journeys.

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Author Biography

1. Irene Lim Yen Wui, female, University of Malaya, Bachelor in Quantity Surveying, University of Malaya, Candidate of MSc. (Building), lean construction, Projects and Facilities Management Group, Faculty of the Built Environment, University of Malaya, 50603 Kuala Lumpur, Malaysia.

2. Hamzah Abdul Rahman, male, Dean of Faculty of the Built Environment, University of Malaya

3. Zulkiflee Abdul Samad, male, Lecturer in Department of Quantity Surveying, Faculty of the Built Environment, University of Malaya.