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The new trend to Project Management: Lean construction. A methodology to mitigate waste and risk within the project.

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Abstract - *Lean is a business philosophy, not just a tool set or method for improvement. This business philosophy was derived from Toyota experiences and from its Toyota Production System (TPS). It focusses is on reducing waste in all business processes, reducing cost and lead-time as well as an increasing the quality.*

This paper explores the principles of Lean Philosophy as applied to project management processes. This will be an introduction to the advantages of applying Lean tools and techniques to Projects. It is time for the world of projects to reap the same kind of benefits that Lean has achieved for manufacturing, - maximizing the value and minimizing waste. Proper use of Lean techniques resulted in cutting waste in the projects, producing greater customer satisfaction and improved profit margin. The goal of this paper is to provide participants with an understanding of how using Lean principles can help ensure project success. The objective is to explore how Lean principles can be applied to project management and to determine the conditions within can be successfully implemented.

Key Words: **Lean Management, Construction, Project Management**

1.INTRODUCTION

1.1 Lean Philosophy and Construction Industry

Its common at Construction Industry [1] projects have significant delays and budget overruns. Lean construction methodology is efficient in eliminating the types of waste in a construction project such as defects, overproduction of goods, inventory, motion, transportation, waiting, over processing and not out utilizing talent. *Over processing* includes over engineering, apply similar document, duplicate forms and getting double supply estimation. Any step in a process that is not adding any value the project can be considered as overprocessing. *Not utilizing talent* includes bad quality training assigning wrong people to significant roles, not effective admin tasks, poor ways of communication, poor management, lack of effective teamwork and in general issues causes inefficient management of human resources. Eliminating above issues get away the relevant waste leading to more and efficient productivity.

A lack of trust [2] within the construction sector has created systems of checks, double-checks and over specification to cover legal ramifications both real and perceived, problems that Lean construction seeks to solve. Evidence from three LCI-funded research sources show that projects that implement Lean building tools and techniques have much better outcomes across a variety of benchmarks. Lean methods of maximizing stakeholder value while reducing waste by emphasizing collaboration between teams on a project. The goal of Lean construction is to increase productivity, profits, and innovation in the industry. Lean Construction is a project delivery process that uses Lean methods of maximizing stakeholder value while reducing waste by emphasizing collaboration between teams on a project. The goal of Lean construction is to increase productivity, profits, and innovation in the industry, while minimizing waste. It focuses on increasing workflow efficiency and maximizing profit without exerting more effort or requiring additional resources.

Lean construction uses the principles such as Value, Value Stream, Flow, Pull and Perfection and applies them to construction industry to eliminate waste [10]. Lean philosophy applied to construction focus on waste elimination, improving quality, creating a pull system with continues flow without bottlenecks that meet the customer's requirements, involve employees at each level, suppliers, and client within the project process, investing inbuilding in quality and continuous improvement. Activities taking place in construction can be divided into following two categories: conversion activities that lead tangible outcome and flows activities which fasten such conversion activities within the delivery. Research has discovered that significant waste lies in that flow processes [3]

1.2 Methodology

By its nature, this paper is an integrative literature review. This is a form of research that reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated [4]. Integrative literature reviews can be structured using a set of competing models and information. No data were generated or analysed during the study. At the first part of this paper the lean concept and their principles is presented while follows the connection among lean philosophy and construction projects and the implementation of Lean principle to them. The paper highlights the barriers to this and the connection between

lean construction and sustainability. The paper is complete with conclusion and recommendations.

2. LEAN APPROACH

2.1 Lean History

Following the 1973 energy crisis, Toyota [5] was the only Japanese firm resisting by working efficiently and effectively. The company managed to overcome this crisis by deploying a culture of empowerment. Toyota employees were embarked in a continuous improvement journey and were working to drive inefficiencies out of work processes. Results are reduction of manufacturing lead-time and costs as well as improving quality and customer satisfaction.

This is a study of the automobile industry [6] that introduced this business philosophy lean production for the first time to the western world. The Toyota success story base waste elimination has since kept all industries enthusiast about the lean approach. It was also a breakthrough step from mass production to lean production, from a push system to a pull system. "Lean manufacturing uses less of everything compared with mass production - half the human effort in the factory, half the manufacturing floor space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also, it requires keeping far less than half the needed inventory on site and results in fewer defects." [6]

Over the years, Womack and Jones refined their strategy and published in 1996 *Lean Thinking: Banish Waste and Create Wealth in Your Corporation.* [7] They proposed in this book a set of management principles, tools, and best practices designed to highlight and reduce waste in work processes and increase efficiency. The aim was to help organizations get the operational excellence. To be Lean means to provide what is needed, when it is needed, with the minimum number of materials, equipment, labour, and space. The book Lean Thinking, presented in 1996, proposed the following core principles:

The first lean principle is to specify value in the eyes of the customer. Value of a product or service is defined as "a capability provided to a customer at the right time at an appropriate price, as defined in each case by the customer." [7] Value is stated in the customer's word. The challenge here is to focus on what the customer is willing to pay.

The next principle was to identify the value stream of each product. The value stream includes "all the actions, both values added, and non-value added, currently required to bring a product from raw material to the arms of the customer or through the design flow from concept to launch." [8] First thing is needed to create a value stream map that shows the process being treated and that at the next step was analyzed for waste and value creation, and a future-state map is created, which represents how the process could and should operate, generating then an improvement plan, which will enable to design the transformation from the current state to the next/ improved state. Rother & Shook [9] in their Learning to See have developed a powerful technique to map value stream which facilitate the identification of wastes and allow process improvement.

The third step was to make value flow by eliminating waste. Once the value is defined and the value stream is identified, the following step is to create continuous flow by eliminating backflows, scrap, rework, and interruptions. Within the analysis of value streams, work processes will be categorized into one of three following types:

- Value-Added Work (works are essential changes to product/service) maximizing this category provide customer value (Form, Fit, Function).
- Value-Enabling Work: the category that has potential for elimination in the future (with identified improvements) but can't be eliminated immediately.
- Non-Value-Added Work be eliminated quickly and is not dependent on improvement of other areas. This is the work nobody needs, and it is pure waste.

The last two steps are letting the customer pull the flow and the continuous improvement. The challenge here is to avoid delivering value before the customer request it and no more than the agreed initial scope. The customer pulling the flow providing a Kanban system that allows the implementation of a just-in-time approach. The final step is pursuing perfection that would lead the transformation to a lean culture creating an endless process improvement.

2.2 Lean Mindset in Construction Industry

Lean construction uses tools like A3 thinking, Choosing by Advantage and Value Stream Mapping helps decision-making It proposes mind maps like Poka-yoke to prevent errors and eliminate defects and 5s methodology to achieve a reduction and elimination of the wastes. Lean construction make use of Just in time principles considering the right quantity, at the right place and time and visualize the process using the Kanban, controlling the process of production and highlight potential bottle necks.

Last Planner helps in making trustworthy schedule and work plan for any project rather than conventional forecasting that may lead to project delays. Finally, it presents Integrated project delivery (IPD), a delivery model for construction projects using a single contract for design and construction with a shared risk/reward approach that integrates teams, structures, and business [1] . Above tools, mindsets, and philosophies are presented in the following paragraphs and their contribution to the outcome of Lean Construction is highlighted.

2.3 Implementing Lean Principles in Construction

A3 thinking is a collaborative management process and improvement method. The specific methodology can be used for problem solving, decision making, planning, or reporting of a specific issue. The flexibility of the concept makes it easy to be used within many issues. It can be developed using a pencil and paper or commonly used programs (Excel, Word, PowerPoint). Image 1.1 shows the step should be followed to preparing an A3 Report. Brainstorming, Affinity diagrams and Multivoting are tools that encourage teams to investigate their creativity and add methods for decision making Brainstorming produces many ideas of solution in a short time stimulating the creating thinking process and make sure that all group member's ideas are considered. Affinity diagrams organize facts, opinions, and issues into natural groups to help in diagnosing complex situations and exploring issues. They help identify central themes in a set of ideas, organising information well, breaking through beyond traditional thinking. Multivoting is a quick technique for identifying priorities and narrowing down the option from a list of ideas. This tool assume that you have a list of ideas, eliminates duplicates and combines related ideas before continuing [1].

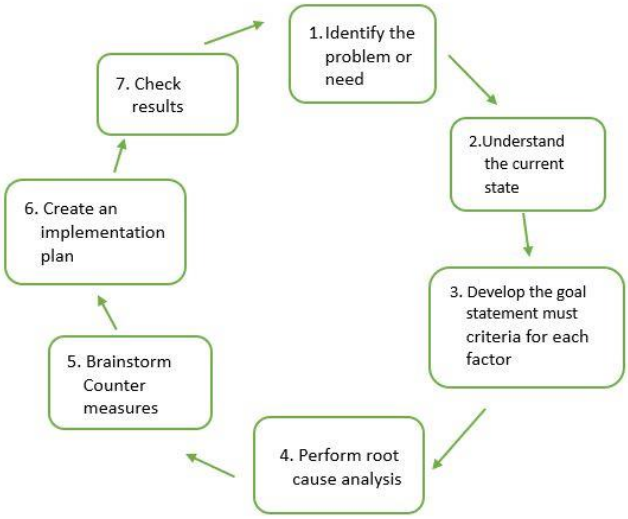

Fig -1: Steps to apply A3 thinking

A Value Stream Map (VSM) is a tool that helps visually see and understand a given process rather. This is vital because understanding the specific process can be identified any waste within the process A VSM enables people to see the flow of (Business Value-Customer Value-Added) as well as the percentages of each in the process. By understanding the process, team can easier design a solution that develops functionality and improving the outcome. Application of the methodology create improvements in the process by eliminating errors, required times, and the non-value adding activities, increasing overall performance of the process. It helps communicate inside and outside the organisation.

SIPOC is a simple diagram for identifying the basic elements of a process (boundaries, inputs, processes, teams, outputs). Creating a SIPOC [1] and top down or swing-lane flowcharts as appropriate to identify scope, key metrics, and basic process steps. The first step is the determination of individual products, services, or family of products, following from the drawing of the process flaw. The next steps are the adding of material flow, information flow, and the collection of the process data and the connection of this to Boxes on the chart. The last two steps to complete the map are the addition of process and lead time data to the chart and the verification of the map.

Choosing By Advantage (CBA) is often used when multiple variables need to be considered to decide. This tool can be used for making decision when there is number of alternative choices available, but the team can't determine the best outcome. Fig. 2 shows the step should be followed to apply CBA.

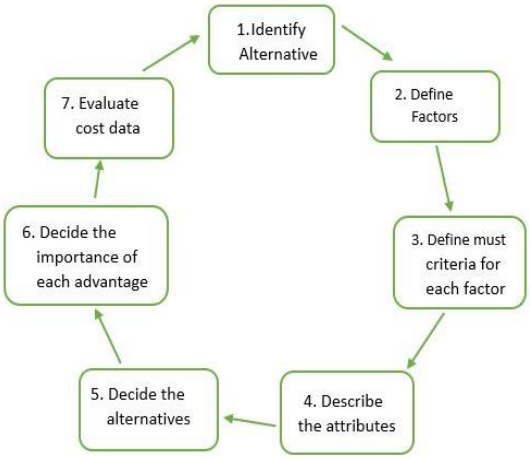

Fig -2: Steps to apply CBA

Poka-yoke [11] means "error proofing". It is a mistake proofing method applied to prevent any errors or defects. It can be implemented in design and construction phase to prevent rework and wastage of material. For example, in the design phase, if the plan of the building is made clearly with different color codes for the similar components but with different specification it would help in better understanding and prevent rework.

5 S helps [12] to the reduce and eliminate of the wastes within a process It develops people's participation, collaboration, teamwork, and at the same time reduces costs, variability and uncertainty and it helps to the develop of Lean mindset within the company, based in t following steps:

- *Sorting* - Clarify the necessary issues from the unnecessary
- *Simplifying* - Place everything which is necessary in a designated place and highlight it so it can easily be found.
- *Sweeping* - Clear cleaning up the work area- deliberately collect all parts and materials that are out of place and leave each to its assigned place.
- *Standardizing* - Create - standard ways to keep the work areas organized, clean and in order, and standard ways to succeed the 5S approach.
- *Self-Discipline* - Following the 5S's agreements and ensure it is maintained in a proper way.

JIT (Just in time) philosophy [13] proposes having the required quantity of goods, at the right place and time. Organize buffers mean piles of stuff: Materials, tools, equipment, manpower. It's a method to eliminate physical buffers. *Kanban* methodology highlights "a signal to replace or refill." Kanban is a communication tool used to tell workers to deliver more material or to refill material containers to a specified level. It is a visual tool for monitor a process. Kanban uses the pull method which secures that everything is under control and produced, in right quantity at the right time. It ensures that everything is according to the schedule. One of initial conditions setting up a Kanban system is to level the process, which leads to limit inventory of each activity within it. (Patel & Solanki, 2020) [14]

Last Planner helps in making trustworthy schedule and work plan for any project rather than conventional forecasting that may lead to project delays [15]. The "last planner" refers to the people responsible for making the final assignment. The Last Planner planning cycle (shown in figure 3) comprises:

- "the master schedule" covering the whole project,
- the detailed "phase schedule" emerging from collaborative planning,
- the "look-ahead plan" with constraints analysis and
- the "weekly work plan" with measured percent plan complete.

Front end planning begins with the master schedule which initiates strategic planning, identifies major milestone. (Planner PSW, 2007) [15]. Production/ Service planning begins with the magnification of detailed activities on the phase schedule into the lookahead plan. The lookahead plan [17] is a list of activities that need to be worked on over the upcoming six weeks. The plan is updated weekly where constraints that threaten reliable workflow are studied. Identifying responsibilities and making assignments ready follows by analyzing resource management information. The Weekly Work Plan [18] is the most detailed plan in the system.

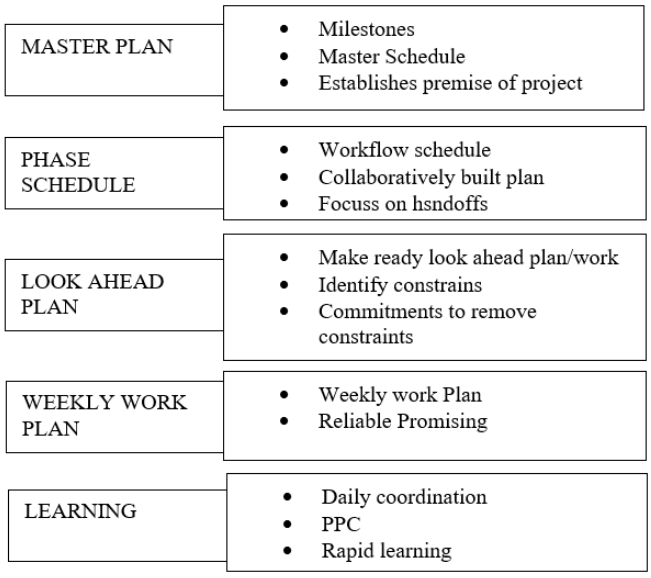

Fig -3: Last Planner

Integrated project delivery (IPD) is a delivery method for delivering construction projects using a single contract for design and construction, assigning responsibility between staff, and presenting an operating system based on lean principles, and introducing collaborative culture. IPD is a project delivery approach that integrates people, practices, and business. [16]

Integrated Project Delivery (IPD) is an important pillar of the Lean Construction. The construction industry has seen a sharp decline in productivity and project outcomes since the late 1960s. A for this decline is that a lot of projects were delivered late and over-budget. The aim of IPD is to create a better system of collaboration and communication between the parties involved in a project, from the owner to the designer to the construction team, any trades and suppliers involved. This approach contrasts with the traditional design-bid-build project delivery approach in which the owner/developer of the project has separate contracts with each party and acts as a connection between for the design and build teams. By aligning the various parties involved in the project and ensuring they stay in continuous communication throughout, IPD its ensured increased efficiency and is eliminated waste in projects. The term "waste" is referred to both literal material waste and intangible waste such as wait times, poorly assigned human resources, and overproduction. If any issue is highlighted during the design stage, it will be easier to remove the waste of time and associated costs in fixing that kind of a problem and increase your project's efficiency in your effort to deliver it on time. The IPD method is often consummated through a

single physical contract between the involved parties of the construction project. The contract outlines expectations for each group and clearly states the shared goals for the project.

Below its explored steps to adopt IPD according the LCI (Lean Construction Institute) [19]:

First step is the definition the project owner's business case and goals and the determine of the budget and work to eliminate unknowns and variables as much as possible. The fewer unknown costs are faced, the better equipped you will be to handle any curveballs thrown at the team. The second step is the successful Building of the team using the best value selection process to contract key stakeholders prior to or during concept design to validate targets and unify the team, ensuring the team is on board with using an IPD model and is prepared to take the necessary steps to implement it.

The next step is to secure ongoing training and coaching for the team to increase adoption of Lean methods. A major facet of the IPD method is a willingness to innovate and to let the expertise of the team members shine providing space for those people to emerge as leaders in your project. The fourth step is providing contracts should support a good team culture and adoption of Lean methods. A rising tide lifts all boats, so encourage all members and teams within the project to be unafraid to seek help and to constantly communicate. A last proposal for any lean project is to look for help and training and education resources.

IPD might not be the right method for every project. Project size and project status are factors to consider when utilizing IPD. Similarly, a team with fewer resources may not have the ability to educate those who have not built using IPD in the past. The following are some important requirements for a successful IPD implementation: an owner willing to remain engaged and collaborative, trust for all parties, complete buy-in from all involved in, desire to innovate, value-driven mentality, resources continuously educated team members on IPD processes [15]

2.4 Lean Applications in Construction Projects

Recent research and discussion have been carried out using lean construction applications in many(developed and developing) countries all over the world such as Nigeria by Adamu and Hamid [20], Ecuador by Fiallo and Revelo [21], Chile by Alarcon et al. [22] and Malaysia by Marhani et al. [23] .In addition, attempts have been made to apply lean principles and techniques to all project management processes, including the project delivery system, production control, work scheduling, design, supply chain, project controls, and overall construction project management.

Ballard et al. [24] presented an overview of the entire intervention, which confirms the applicability of lean concepts and techniques to the management of fabrication processes. Also, they illustrated the benefits achievable in improved management of demand, reduced cycle time, greater productivity, heightened work force involvement, and increased revenue and profitability. The results achieved illustrate the power of lean concepts and techniques and their applicability to the operations of fabricators supplying engineered-to-order products to construction projects. Tsao et al. [25] illustrated how lean thinking and work structuring helped to improve the design and installation of metal door frames for a prison construction project.

Koskela et al. [26] examined a fast-track office building project and showed how the building process could be made leaner and speedier. In the field of simulation and software, Marzouk et al. [27] used computer simulation as a tool for assessing the impact of applying lean principles to design processes in construction consultancy firms to aid in decision-making at early stages of construction projects. Sacks et al. [28] have been specified a pull flow construction management software system, and a set of functional mock-ups of a proposed system that has been implemented and evaluated. Alinaitwe [29] provided a graphical aid to enable decision-makers to concentrate their efforts to overcome barriers by investigating the influence of many barriers on the success of lean construction initiatives.

2.5 Risk Management and Risk Response Schedule

Risk management can be defined "as the process of taking calculated risks, reduces the likelihood that a loss will occur and minimizes the scale of the loss should it occur". The main objective of risk management process is to reduce the risk effect on the project objectives and thus improve decision-making. It includes both the impending of potential problems and the early discovery of problems when they occur [30].

The Project Management Body of Knowledge defined the risk management planning as the process of deciding how to approach and plan the risk management activities for a project [31]. It is important to plan for the risk management processes that follow to ensure that the level, type, and visibility of risk management are commensurate with both the risk and importance of the project. The significance of the risk management task varies with the size of the project, and its importance.

Schwalbe [32] presented risk management as a set of principles, whereby the project manager continually assesses risks and their consequences and takes appropriate preventive actions. Risk management is a critical factor for successful project management, as projects tend to be more complex and competition increasingly tougher.

There is a direct relationship between effective risk management and project success since risks are assessed by their potential effect on the objectives of the project. Contractors have traditionally used high markups to cover risk, but as their margins have become smaller, this approach is no longer effective. In addition, the construction industry

has witnessed significant changes particularly in procurement methods with clients allocating greater risks to contractors. The risk response planning phase exists to develop responses to identified risks that are appropriate, achievable, and affordable. Owners are also allocated to each risk response, to be responsible for its implementation and for monitoring its effectiveness. Risk responses are usually grouped according to their intended effect on the risk being treated. It is common to use the following four risk strategies [33]

Avoid (seeking to eliminate the uncertainty by making it impossible for the risk to occur), *Transfer* (identifying another person better able to manage the risk), *Mitigate* (reducing the size of the risk), or *Accept:* recognizing that residual risks must be taken.

2.5 Lean Manufacturing and Sustainability

Lean construction (LC) promises outstanding results in managing the construction process and achieving the project's goals by eliminating waste. Lean construction and Sustainable construction policies are two separate and independent strategies, where Lean's process goal is to improve economic standards, while sustainability aims to improve the environmental objectives. However, through enormous research and industry practices, it is found recently that the two practices are interdependent and shares the exact basics of waste elimination [33]. Components related to SC can be integrated into the concept of LC to enhance and preserve the natural resources, economic growth, and environment without compromising the future. This is possible because the integration of concepts will enhance the performance and the impact of building construction by realizing hidden cost reductions towards the environment [35]. The global construction industry will significantly benefit from adopting both Sustainable and Lean Construction concepts.

Table -1: The links between Lean construction and sustainability (adapted from Shepherd Construction)

Lean waste	Description	Manifestation of waste	Three pillars
Transport	Communication failure in between processes, multiple & complex sources	Double handling Material unavailability	Environment
Inventory	Excessive information, inadequate configuration management, complex retrieval system, work in progress	Excess materials Insufficient materials	
Motion	Searching for information, required manual intervention, lack of direct access, no collocation	Increased accidents Low productivity	Economic
Overproduction	Signoffs, too many details, unnecessary information, redundant activities, over-dissemination, pushing rather than pulling information	Overspecification coordination problems	
Overprocessing	Scope creep, overtime unplanned, excessive approvals, resources overloaded, excessive reviews, hand-offs, producing intermediate deliverables, too many iterations, unnecessary data conversions, excessive verification	Personal frustration Efficiency of output delivery	Social
Defects	Rework, poor estimation, conversion errors, inaccurate information, inappropriate design verification, unclear acceptance criteria	Defective materials/work	

2.6 Barriers in Implementation Lean Principle in Construction

Youssef Larteb et al., (2015) [35] identified that success factors of lean implementation, The study highlights factors such as: strong management's leadership, engagement, commitment, providing time and resources for improvement projects, and organising employee's development program.

Managers and supervisors should motivate, supervise, and train their employees. They must encourage them and actively participate with them in the process of improving projects for managers and production supervisors, quality should go ahead in productivity and efficiency. Managers and production supervisors actively communicate effectively and led their staff.

Nordin Norani et al., (2010) [37] identified the main reason for failure of implementation of Lean manufacturing is difficulties in managing the change process during the transformation within the organisation. Lack of adequate lean understanding and financial issues follow.

3. CONCLUSIONS

Summing up adopting the Lean construction mindset will provide an integrated road map to manage the construction and preconstruction phase of any new buildings. Lean construction will help in better decision-making, in preventing errors and defect and achieving a reduction and elimination of the wastes. Taking advantage of Just in time mind-set considering the right quantity of goods, at the right place the right time and visualizing the process using the Kanban, the control of the process will be achieved, and the

potential bottle necks will be avoided. Last Planner will help in making trustworthy schedule and work plan for the project rather than conventional forecasting that may lead to project delays.

Finally, it proposes Integrated project delivery (IPD), a delivery model for delivering construction projects using a single contract for design and construction. The main factor of lean implementation and successful outcome are the top management support. Considering Lean construction as change to traditional way of acting in the industry requires the support of the Leaders. Managers and supervisors must motivate, supervise, and rain the staff in the new way of thinking and acting.

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