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Critical Review of Time Studies in Lean Construction

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Abstract: Lean study is aimed to maximize value. Lean tools and techniques are used for achieving higher productivity in construction projects. Time studies plays important role in measuring productivity. This paper aims to review the efforts of previous researchers about the time studies in Lean construction projects. From the literature overview, it is observed that time studies are effective techniques to identify value and non-value-adding activities. Even though Time study is not considered as a direct tool to improve processes but it can be considered as useful indicator, which helps identifying waste. Even it is useful to select best strategies on sites. The main focus of this study is to highlight the important role of time studies in identifying waste and increasing productivity. This study will help researchers understanding Lean practices with reference to time studies in their projects.

Index Terms **- Lean Construction, Time and Motion Study, Productivity, Waste**

I. INTRODUCTION

Time and motion studies are most effective Lean techniques for measuring and tracking productivity on construction site. Several studies have highlighted the other benefits of these studies in performance improvement, cost savings, reduced rework, safety measures, waste reduction, selection of equipment, smoothening of work flow and determination of number of workers. In the study of construction processes of installation of a floor slab, cutting tile, installation of an aerated concrete block, installation of a bracket, and painting of a wall were investigated with a case study in Kazakhstan using time study [1]. Time and motion study is proved useful for reinforced concrete construction, brickwork and plastering processes in a residential construction site [2]. Investigation also carried for identification of Non value-adding activities, identification of their root causes and necessary improvements for processes and production layout through time and motion studies on different construction sites [3]. Some researchers have investigated and quantify labor productivity for brick laying process using time and motion studies [4]. Very few studies mentioned time studies as a Lean construction technique. On the other hand, there are some studies that utilized the time study to collect data from the construction sites and investigate wasteful activities in the construction processes. Improvements cannot be achieved without measuring and keeping track of data.

II. LITERATURE REVIEW

Hossain et al. (2019) explored wasteful activities to improve productivity using lean in Astana, Kazakhstan. Observations were taken for selected construction processes to categorize VA, NVA, and ENVA activities within a construction process. Time spent on various activities such as waiting, motion, transportation, inventory, over-processing, etc. are found to be pure waste. Qualitative assessment is done through a survey to understand the opinion of construction professionals about Lean methods in Astana. Waiting and motion types of waste found more frequent. As per the authors, further investigations can be carried out to quantify the time and cost savings in case of Lean method for improving construction productivity. [1]

Balar et al. (2018) concluded that work process can be improved in combination with time measurement and changes in production layout. This study concluded that project goals and objectives achieved with the improvements in the processes, production layout and economy in human effort and the reduction of unnecessary fatigue. [2]

Karthik et al. (2018) found that Material shortage and tools delay are the most influencing Labor Productivity (LP) factors in the project site. LP can be measured with worker's task motions on site. This study has observed eight-groups of essential factors responsible for the loss of LP in construction projects in India which include: work delay; work characteristics; work schedule; organizational characteristics; assured and safety work; work conditions; workers income; workers management. [3]

Ansah et al. (2017) proposed a novel framework for evaluating lean tools in the external environment of construction projects using AHP. From the findings of the framework, Concurrent Engineering, Last Planner System (LPS) and Daily Huddle Meetings are the most effective lean tools for the delay sources mitigation. Meanwhile, Total Productive Maintenance (TPM), Preventive Maintenance and SMART Goals are the least influenced lean tools. [4]

Chien-Ho Ko et al. (2012) adapted lean manufacturing practices to establish a lean formwork construction model to reduce waste while increasing customer value. This study shows that the proposed lean formwork construction model can reduce waste in the process of assembling, machining, and transporting molds. It helped in increasing customer value. Extensive education and training is required for implementing the lean formwork construction model. This proposed model can be applied to other construction activities such as steel erection, rebar installation, and concrete pouring. [5]

Long Li et al (2018) provided a new scientific analysis and visualization to explore Lean Construction (LC) topics, research trends and the collaboration status of scholars in the LC field based on 370 articles published in peer-reviewed journals between 1997 and 2016. This paper gives a general review of the above-mentioned literature, including the number of LC-related articles published in each year, as well as the major journals and main contributors to the field of LC. [6]

Solaimani et al. (2019) addressed that the economic side of Lean construction has received the most attention so far. Future studies are encouraged to take proportional notice of environmental and social aspects of Lean construction. Also, further research on potential conflicts and trade-offs between economic, environmental and social dimensions of sustainability can contribute to the current understanding of holistic approach. [7]

Demirkesen et al. (2020) investigated the effectiveness of time studies in a construction project. Wasteful activities were investigated to assess the level of productivity in construction processes. This study revealed that waiting is the most significant non-value-adding activity for the decking process. The use of time studies were investigated in detail and a framework was proposed to enhance performance in the processes. The strategies provided might be applied to any standardized and repeatable process of a construction project. Time studies supported with motion studies can be effective to productivity and performance improvement. [8]

Issa (2013) discussed the results for applying the lean construction principles and suggested a new tool to reduce the effect of risk factors on time of an industrial project in Egypt. The risk factors were identified and the time-overrun was quantified based on the probabilities of occurrences and the impacts of many risk factors on the project time using a time-overrun quantification model. Identifications for the risk factors every three weeks were introduced based on the observations and the suggested solutions for the reasons of delayed works. [9]

Bamana et al. (2019) showed, through the use of a 3D simulation modeling framework, how concepts from the manufacturing industry such as JIT deliveries, Lean methods, and prefabrication can improve productivity in the construction industry. The results of the simulation showed that a well-organized construction site as well as easily accessible materials on site could have a significant impact on reducing construction duration. Moreover, determining the right amount of materials to order for the construction site and the ordering frequency appeared as important factors to avoid idleness or excessive deliveries on the construction site. [10]

Lajevardi et al. (2011) discussed that the process time is not a large portion of the total task time. Absolute process time, which is the only value-adding activity in a lean system, only takes up to 25.3% of the whole task duration at most. That means the rest of the time spent on the task is all wasted time rising from the activities that do not create any value to the final project delivery. Therefore the management should put all the effort to employ methods that minimize these non-value-adding activities. The study shows that the most significant non value-adding activity in concreting task is waiting time which ranges from 30% to 57% of the whole task duration. Educating management team in lean methods of purchasing and delivery such as JIT purchasing can actually reduce the task duration. Inspection time can be totally eliminated through a better relationship among the supply chain. [11]

Dallasega et al. (2018) suggested that scheduling and controlling of the physical locations (CAs) of the building, a real-time measurement of the construction progress and a reliable demand forecast is possible with the help of pitching approach from lean management. Responsible person (foreman) should be involved in the planning process to reach reliable and detailed schedules (the level of detail of tasks). The pitching concept can be used for reliable short-term scheduling and real-time monitoring. The pitching concept uses information about the right number of workers needed to perform a task and how many CUs should be completed in a specific time interval for not overrunning budget specifications. The supply chain should be triggered according to the construction progress to avoid budget overruns due to missing material on-site. Moreover, transportation processes from manufacturing to the site will be considered, to handle logistic disturbances appropriately in the approach and the IT support. [12]

Asim et al. (2017) suggested Toyota way philosophy and process sub-model for eliminating waste. The lean construction principles are used in achieving total quality management in construction activities by train staff and managing employees to minimize occurrence of delays. Time impact method of delay analysis can be used in delay liability calculation and to solve delay related issues. [13]

Maske et al. (2020) applied lean construction methodologies. The lean concept is applied systematically for eliminating waste from RCC Slab Cycle process. Value stream mapping (VSM) is designed to improve the delay time of the project. Study reveals that 5's along with VSM is a handy combination to fetch maximum value out of any process. VSM proved to be very effective approach in eliminating the waste from the process. Pareto analysis is found to be most effective tool for identifying vital few defects which has maximum impact on time and cost of the project. This study contributes in learning theory behind VSM, 5'S and Pareto analysis, understanding the key implementation factors, barriers to its full implementation and renowned benefits of Lean Construction [14]

Yahya et al. (2015) have given emphasis on lean concept such as the importance of flow, continuous improvement and waste reduction. Lean construction can be accomplished by considering constructability in the design and construction phase in order to improve flow of the job site. Standardization of design elements, modularity and pre-assembly are all methods that can improve

flow on the construction job site. In addition to consideration of constructability concepts, design teams must be expanded to include contractors, subcontractors and materials suppliers. Communication among all parties will be difficult. However, advances in information technology are making it easier to communicate. Through universal access, all key players can work cooperatively on a design instead of isolated from each other. With increased cooperation and collaboration, it is not difficult to incorporate lean principles into construction practices. [15].

III. CONCLUSIONS

Identifying the non-value adding activities can help to improve productivity. Work process can be improved in combination with time measurement and changes in production layout. Material shortage and tools delay are the most influencing LP factors in the project site. Concurrent Engineering, Last Planner System (LPS) and Daily Huddle Meetings are the most effective lean tools for the delay sources mitigation. Meanwhile, Total Productive Maintenance (TPM), Preventive Maintenance and SMART Goals are the least influenced lean tools. Lean Construction model using KANBAN and ANDAN methods can be applied to construction activities such as formwork construction, steel erection, rebar installation, and concrete pouring. As far as the lean sustainability concern, the environmental and social aspects of Lean construction should be considered. The strategies provided might be applied to any standardized and repeatable process of a construction project. Time studies supported with motion studies can be effective to productivity and performance improvement. Impacts of the risk factors on the project time can be evaluated effectively using a time-overrun quantification model. A well-organized construction site as well as easily accessible materials on site could have a significant impact on reducing construction duration. Educating management team in lean methods of purchasing and delivery such as JIT purchasing can actually reduce the task duration. Inspection time can be totally eliminated through a better relationship among the supply chain. The pitching concept can be used for reliable short-term scheduling and real-time monitoring. Time impact method of delay analysis can be used in delay liability calculation and to solve delay related issues. 5's methodology along with VSM is a handy combination to fetch maximum value out of any process.

Abbreviations and Acronyms

VA = Value Adding
NVA = Non-Value Adding
ENVA = Essential Non-Value Adding
LP = Labor Productivity
AHP = Analytic Hierarchy Process
LPS = Last Planner System
LC = Lean Construction
TPM = Total Productive Maintenance
SMART = Specific, Measurable, Achievable, Relevant, Time - bound
3D = Three dimensional
JIT = Just in Time
CAs = Controlling Areas
CUs = Controlling Units
VSM = Value Stream Mapping
RCC = Reinforced Cement Concrete
IT = Information Technology.

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