

Lean Construction

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Abstract— Lean Construction started not from industry but from a mix of academics and consultants working to translate lean concepts to construction. Over the last 10 years, an increasing number of companies have implemented lean construction practices in an attempt to improve performance in construction projects. Most companies, and also some researchers, have reported satisfactory results from their implementation. However, there is still a need to provide more extensive analysis of the empirical evidence available to assess the impact of the implementation of lean construction. Lean construction results from the application of a new form of production management to construction. Essential features of a lean construction include a clear set of objectives for the delivery process, aimed at maximizing performance for the customer at the project level, concurrent design, construction, and the application of project control throughout the life cycle of the project from design to delivery. Strategies and support tools have also been developed for implementation.

This paper gives a great overview of lean construction techniques. It mentions specific tools and methodologies that have been developed, like look ahead planning, commitment to planning, delivery system, work flow reliability and project management. It also gives a review of benefits of the potential contribution of lean construction to the achievement of productivity enhancement and waste minimization in construction industry. It greatly facilitates the learning of lean thinking in construction and allows for quicker review.

Keywords— Lean construction, Look ahead planning, productivity, waste minimization.

I. INTRODUCTION

“Lean Construction” is simply an attempt to apply lean principles that originate from Toyota Production System (TPS) to construction, aiming at managing and improving construction processes, with minimum cost and maximum value by considering customer needs. But unlike current practice, lean construction rests on production management principles. The result is a new project delivery project that can be applied to any kind of construction but is particularly suited for complex, uncertain and quick projects.

This paper gives a summary of the origin of lean construction and what is its current state of practice. Up Till now, it was a known fact that construction is different in many ways from traditional manufacturing. But the paper gives a great summary of applicable principles, steps towards becoming lean, and likely benefits to a construction organization. This paper aims at studying the concept of Lean construction, its application in the construction industry, importance of product delivery system in construction industry and use of lean construction in productivity enhancement and waste minimization.

II. LEAN CONSTRUCTION TECHNIQUES IN CONSTRUCTION INDUSTRY

A. Last Planner System

The last Planner system (LPS) is a technique that shapes workflow and addresses project variability in construction. The last planner is the person or group of people accounted for *operational planning*, that is, the structuring of product design to facilitate improved workflow, and *production unit control*, that is, the completion of individual tasks at the operational level. In the Last Planner system, the sequences of implementation (master schedule, reverse phase schedules

(RPS), six-week look ahead, weekly work plan (WWP), percent plan complete (PPC), Constraint analysis and Variance analysis) sets up an efficient schedule planning framework through a pull technique, which shapes workflow, sequence, and rate; matches workflow and capacity, develops methods for executing work; and improves communication between trades. The important role of the Last Planner tool is to replace optimistic planning with realistic planning by evaluating the performance of workers based on their ability to reliably achieve their commitments. The goals of Last Planner are to pull activities by reverse phase scheduling through team planning and optimize resources in the long-term.

B. Reverse Phase Scheduling

Reverse Phase scheduling is used to develop a schedule that works backwards from the completion date by team planning. The purpose of the phase schedule is to produce a plan for the integration and coordination of various specialists' operations. It is done by a team consisting of all the last planners.

C. Daily Huddle Meetings

Daily huddle meetings work on the principle of a Two-way communication in order to achieve employee involvement. With awareness of the project and problem solving involvement along with some training, it aims to increase employee satisfaction. A brief daily start-up meeting is conducted where team members quickly give the status of what they had been working on since the previous day's meeting. This ensures rapid response to problems through empowerment of workers and continuous open communication. Weekly it can be divided as Monday for “weekly priority setting”, Tuesday for “New info about lean”, Wednesday for “Update on priorities”, Thursday for “Kudos to co-workers” and Friday for “Something good that happened

to the worker in that week”.

D. Weekly Work Plan

Weekly work plan meeting covers the weekly schedule, safety issues, quality issues, material needs, manpower, construction methods, backlog of ready work, and any problems that can occur in the field. It promotes two-way communication and team planning to share information on a project in an efficient and accurate way. It can improve safety, quality, the workflow, material flow, productivity and the relationship among team members. Ballard and Howell(2003) indicate that WWP should emphasize the learning process more by investing the causes of delays on the WWP instead of assigning blames and only focussing on “Percentage Plan complete” values. In this technique, analysis of the previous week is made and the PPC is calculated by dividing the quantity of works effectively completed by the total quantity of works that had been planned.

E. Fail safe for Quality and Safety

Fail safe for quality and safety introduced Poka-Yoke as new elements that prevent defective parts from flowing through the process. Fail safe for quality relies on the generation of ideas that alert for potential defects. It can be extended to safety but there are potential hazards instead of potential defects, and it is related to the safety risk assessment tool from traditional manufacturing practice.

III. LOOK AHEAD PLANNING

In a project, sometimes detailing of total project schedules accurately too far into the future is not possible because of lack of information about actual durations and deliveries. Due to which, most of the construction projects use some form of short term schedule to coordinate and direct various trades and crews working on the job. These schedules are often called “Lookahead schedules” because many look ahead several weeks into the future. Lookahead planning is the first step in production control(executing schedules) and usually covers a six week time frame. Lookahead time periods vary with the type of work being performed and the context. At this stage, activities are broken down into the level of production processes/operations, constraints are identified, operations are designed, and assignments are made ready. A look ahead schedule is simply a dropout from the higher level schedule, occasional at a greater level of detail, but with no screening of scheduled activities against soundness or other criteria. Lookahead planning is proposed as the key to improving PPC, and consequently the key to reducing project cost and duration. The functions of Lookahead planning are shape workflow sequence and rate, match workflow and capacity, maintain a backlog of ready work and detailed plans for how work is to be done. Tools and techniques include constraints analysis, the activity definition model and prototyping of products or processes, also known as first-run studies. Constraints analysis is done by examining each activity that is scheduled to start within the period chosen as the project lookahead window. The constraints that prevent the prevent the activity from being a sound assignment are identified and actions are taken to remove those constraints. The Activity

Definition model provides the primary categories of constraints: directives, prerequisite work and resources. Planning must extend beyond one week ahead in order to coordinate with internal suppliers, external suppliers, as well as with other trades. It shows a typical 5 week lookahead, so-called because it extends 5 weeks into the future, although next week is not shown. Work flow is shaped in the best achievable sequence and rate for achieving project objectives that are within the power of the organization at each point of time is improved. Labour and related resources are matched to workflow. A backlog of assignments for each frontline supervisor and crew can be produced and maintained, screened for design, and completion of prerequisite work at the CPM level can be done. Work method can be planned for the whole operation. When developing a lean ahead plan, following steps must be followed : 1) Enter the latest status and forecast information into the project master schedule. Adjust starts, completions, sequences and durations accordingly, 2) Do not allow any assignments into week one that are not ready, except by project management decision. Ask the foreman if each assignment can be completed in week one, arrange for pre work and coordinate the use of shared resources. Allow that amount of work into week one that can be completed in the week, 3) Examine the remaining weeks in the lookahead, except for the last, moving from present to future. Screen out any assignments that cannot be made ready when scheduled. Try to maintain for each crew an amount of assignments twice of that which can be completed in a week, 4) Identify those activities scheduled to start or complete in the lookahead week and screen out any activities that cannot be made ready to assign when scheduled, 5) Translate lookahead week activities into the language of assignments, grouping highly interdependent operations that should be planned as a whole, and identifying operations to be planned jointly by multiple trades, 6) Calculate the earnable man-hours. If that amount of work falls below the amount needed to maintain schedule and if you will have the labour capacity to do that amount of work, advance work from the master schedule to the extent practical. If the resultant amount of work falls below the current work force, reduce the workforce, or decide how to use the excess labour time. If that amount of work exceeds the current or projected workforce, decide whether or not to increase labour to accelerate progress, and 7) Produce a list of actions needed to make assignments ready when scheduled.

Two measurements are proposed to monitor the performance of the lookahead process: (i) *Tasks anticipated* (TA) to measure the performance of lookahead planning in anticipating tasks that need to be made ready, and (ii) *Tasks made Ready* (TMR) to measure the performance of lookahead planning in making scheduled tasks ready once they appear in the lookahead window. TA and TMR represent performance metrics at the lookahead process level. They indicate the production team’s ability to plan well ahead of execution, establishing foresight is one part of the effort. It should be followed by a proactive removal of constraints and prioritizing tasks for execution, as captured by measuring TMR.

IV. PROJECT MANAGEMENT USING LEAN CONSTRUCTION

There is an alarming number of projects which fail to be delivered on time or/ and within with a satisfactory standard that require additional work and re-work despite the substantial amount of effort in the installation of new technologies and the adoption of new strategies. Another reason for project failure is the absence of effective system in place to manage the working relationship between construction firm and its suppliers. Variability in supply and demand has an adverse effect on project management increasing cost and time delivery and decreasing project quality and safety.

Lean construction aims to identify and minimize wastes through four main elements namely Built in quality, Customer focus, Minimization of waiting by involving supplier in planning task and Creation of a continuous flow. In terms of Cost, quality and time; Lean construction aims to reduce time and cost stressing the links between project's activities. Following the principle of waste reduction, it aims to avoid re-working. This reduces the overall risk particularly in case of interrelated projects, where the delay of one project has an impact on another one. In terms of supply system, LC puts a great effort in involving suppliers in project planning and process with the aim to minimize variability. The suppliers' involvement is essential to deliver material on time at a minimum cost and minimum value for the customer. Moreover a lean local project delivery chain has clear advantages respect to a more global one. LC leads to customer involvement in order to develop a project in better way i.e. it is possible to understand the real needs and to reveal the consequences of the wishes. Training of stakeholders needs to be given in order to let them understand the lean principles and increase workers motivation. The visualization of the achieved benefits and the project progress represents a good way to persuade workers to embrace lean philosophy and overcome resistance. Visualization can be increased, for example, through the use of displays placed at construction site, organizing stand-up meetings and use of CEDAC(Cause and Effect Diagram with the Addition of Cards). More effort in planning , through the Last Planner technique, promotes a smooth workflow and decreases the variability in the process. A more accurate planning allows easier management of the project especially during small crises. Reduction of the construction time decreases, other things being equal, project costs because the necessary human resources and equipment are used for less time and because it is less likely to penalties due to delays in delivery. Improving project quality , without additional cost, increases customer value. A reduction of waste leads to decrease the project costs because no value added activities are eliminated. Reworking in lean thinking means waste. The effort spent in eliminating waste leads also to better quality. It is evident that a reduction of cost impacts directly on profitability. Even after considering the initial cost of setting up the LC implementation investment, the overall economic result is usually positive management. The most common benefits of LC are a shorter delivery time and a higher project performance, because the Productivity of the workforce increases; there is a better coordination and

communication with suppliers; there is a minimization of re-working following the lean principles "Do the right thing at the beginning"; there is a minimization of no value added activities focusing on the real customer's needs. To exploit the benefits reached with LC implementation, the following procedure can be follows; 1). Defining the indicators; 2) Planning the benefits; 3) Measuring the benefits; 4) Realizing the benefits; 5) Analyzing and reporting the benefits.

IV. LEAN CONSTRUCTION FOR PRODUCTIVITY, EFFICIENCY AND WASTE MANAGEMENT

Waste in construction has been defined in different ways by different studies. According to the new production philosophy, waste should be understood as any inefficiency that results in the use of equipment, materials, labor, or capital in larger quantities than those considered as necessary in the production of a building. Waste includes both the incidence of material losses and the execution of unnecessary work, which generates additional costs but do not add value to the product. Waste should be 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. Lean Construction aims to identify and minimize wastes through four main elements which include Built in quality , that is, reduction of rework doing the right thing the first time; Customer focus , that is, elimination of no value-added activities for the customer; Minimization of waiting , that is, involvement of supplier in planning task; and Creation of a continuous flow , that is, availability of needed resources and components, when and where they are required. Following the principle of waste reduction, it aims to avoid re-working which reduces the overall risk particularly in case of interrelated projects, where the delay of one project has an impact on another one. Improving coordination and detailing planning allows the reduction of waste in terms of waiting for information and materials, space used by inventories and unnecessary transportation. The effort spent in eliminating waste leads also to better quality. For instance the lean tools called poka-yoke devices, alerts for potential defects avoiding unnecessary reworking.

V. PROS OF LEAN CONSTRUCTION

Increase in efficiency – There are two vital elements of lean construction 1.waste elimination 2.continuous improvement. Waste is not just scrap; underutilized resources and missed timeline of project is also waste. By creating work process for project planning with management devices, productivity can be enhanced resulting enhanced efficiency.

Higher quality – It has been said that construction is primarily 'built in' and later on 'inspected in'. It is directly linked to employee empowerment. This concept is directly attributed to lean methodology, it results into significant and continuous quality improvement.

Customer satisfaction – Higher quality and increased efficiency gives client satisfaction.

Boosted profits & reduced costs – Streamlined work processes will inevitably raise profitability, but the lean approach to project management takes it a step further by

focusing on all of the ways costs can be trimmed from the minimization of defects to making sure that no unnecessary materials are purchased. Excessive movement of supplies, avoidable delays, wasted resources, and superfluous or unessential equipment are all “sins” that will be uncovered and rectified by adhering to lean principles.

More employee accountability – When a company “goes lean,” one of the major changes is the establishment of very specific performance measurements. Tracking the success or failure of initiatives is critical to monitoring operational health and gauging the impact the lean approach has had on the business. This close observation also provides insight into the contributions of individual team members and can help determine if further training or other intervention is needed.

Improved safety – By employing organization and standardization strategies like uniform tool storage and common worksite configurations as well as utilizing error-proofing and visual management devices such as directional piece marks, welding fixtures, traffic signs, and work zone assignments, lean construction companies have achieved noticeable reductions in accidents and lost-time injuries.

Closer partnerships, better communication – Lean construction compels team members and stakeholders to work closely with one another, making coordination and communication key to success. The whole operation (contractor, subcontractor, suppliers, and customers) must be involved in value engineering, production planning, organizational learning, and defect prevention.

VI. CONS OF LEAN CONSTRUCTION

Team unity, commitment, and focus required – For the lean approach to be successful, all parties must be dedicated to a common goal and prepared to stick with this methodology for the long haul. Becoming a lean construction company is an ongoing effort, not a project with a start and end date. A weak link can threaten any possible gains, and this stretches beyond just immediate team members and employees. Subcontractors and suppliers must also be committed to making the lean management style work and understand the part they have to play in the project as a whole.

Immediate results are uncommon – Similar to the potential roadblock discussed above, any partners who are searching for instant gratification from the adoption of lean principles will be severely disappointed. It takes time to see the full effects of this production management technique and although noticeable quality improvements should be quick to manifest themselves, increases to profitability will be more gradual.

Training requires significant investment of time/resources – As with implementing any major change in direction, adopting lean principles will entail much time spent instructing your workforce on new policies, procedures, and strategies. One difference with lean construction, however, is the need to educate suppliers, subcontractors, and even clients. This will take an exceptional amount of time and energy and should not be overlooked.

Some team members and partners may be resistant to change – It bears repeating that for a lean construction operation to work, everyone involved needs to be on board and focused on the same goal. If employees have not bought into the change in direction, performance will be affected and the business may suffer. This will lead to tough personnel decisions, and it may be better to cut ties with team members who could negatively impact morale rather than attempting to convince them of the merits of contributing to a collective effort.

Pressure on management – Responsibility for the success or failure of implementation will rest with management and their ability to communicate goals and guide the workforce. Senior leadership will also be forced to keep a close watch on projects as they progress while analyzing key performance indicators and assessing the status of individual teams and the entire business.

Current projects could suffer – If your company is in the middle of a project while trying to adopt a lean approach, careful coordination will be needed to ensure that the transition to a new production philosophy – and the training that will require – does not affect quality or customer relations.

Impact on employee morale – As mentioned above, it’s human nature to be wary of significant disruptions to the status quo. For this reason, as your company begins to transition to a lean environment, you may have to deal with a dip in morale from employees who struggle to handle the new approach. These declines in staff satisfaction are usually temporary.

VII. CONCLUSION

In this paper, the lean construction concept has been studied in depth, it was understood that Lean construction system is beneficial to industry as it minimizes the waste and increases the productivity. Lean construction results from the application of a new form of production management to construction. Essential features of lean construction include a clear set of objectives for the delivery process, aimed 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. The paper also discussed about the application of lean tools and techniques by project teams and how it will minimize or eliminate waste, enhance performance and lead to a great cost savings for the industry as well as the society. It also studied about look ahead planning and its various aspects and how detailed plans are developed for work which is to be done.

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