

“Advances in Construction: Lean Construction for Productivity enhancement and waste minimization”

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Abstract- The objective of this paper is to highlight the cost and benefits of the potential contribution of lean construction to the achievement of productivity enhancement and waste minimization in construction industry. It is critical review of literature. Researcher has used exploratory method for investigating the benefits of lean construction system by exploring, and understating the available literature and some case studies. There is need for waste minimization and enhancement of productivity in construction activity. Productivity is critical determinant of cost efficiency. The conventional system of construction is not sustainable. In one of the research it is estimated that current system of construction had around 50% of non value added efforts or waste. The meaning of lean construction is that it is the application of lean thinking to the construction industry. The construction industry and other industries also are facing various problems as a result of the uncertainties of the global economic climate, environmental hazards, including labor delayed projects and zero margin contract bids, green house gas emissions etc. The construction industry is seen as one of the worst performing industry as regards to the innovation. This calls for concern about the poor state of construction innovation. The emergence of lean construction is to bring significant reform to the construction industry to achieve the objectives of value addition and waste minimization within the built environment in the critical social, economic and environmental aspects.

Index Terms—Construction Advances, Construction cost, Lean Construction, Sustainability, Waste Minimization, Indian Construction

I. INTRODUCTION

In this paper attempt has been made to understand the benefits of implementation of green and lean methods in construction L & T is one of the leading company in construction industry. They are benefiting from use of latest technologies. Is said that, productivity is a critical determinant of cost efficiency and cost optimization. Lean construction is about reducing the costs by cutting waste, innovating by engaging people and organizing the work-place to be more efficient, the concept of lean construction has been adapted from manufacturing, from Toyota Production System. Evidence from the literature reveals that innovation through lean improvement in construction processes has provided proof of productivity growth and waste minimization. Productivity- it is a measure of the efficiency of a person, machine, factory,

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system, etc., in converting inputs into useful outputs. Productivity is the measure of utilization of input by the system. What is Lean construction? It is a collective term for changes in the design and delivery process. Among the various construction processes, it is the one which can best support a focus on sustainability through “increasing value while reducing waste.”

Since the inception of Lean Manufacturing Concepts as far back as the 1900s, lean construction has been discussed and debated by many researchers worldwide. According to Abdullah et al. (2009), Lean Construction is a concept that needs to be introduced within the construction industry, specifically to increase the sector’s productivity level through the elimination of activities and actions deemed to generate waste in the construction process. Lean Construction is a combination of operational research and practical development in design and construction with an adaption of lean manufacturing principles and practices to the end-to-end design and construction process. Unlike manufacturing, construction is a project based-production process. Lean construction is concerned with the alignment and holistic pursuit of concurrent and continuous improvements in all dimensions of the built and natural environment: design, construction, activation, maintenance, salvaging, and recycling (Abdelhamid 2007, Abdelhamid et al. 2008). This approach tries to manage and improve construction processes with minimum cost and maximum value by considering customer needs (Koskela et al. 2002). In Case of L & T they prefer lean and green technologies, they use renewable energy and practice sustainability at all levels in construction.

II. METHODS

About the research methodology, in this paper is the review of relevant available literature and industry case studies relating to lean construction implementation in India. In-depth exploration and review of research publications on lean construction implementation was carried out in this paper. Case study method, it is an exploratory study. In this paper researcher’s wants to explore lean construction concept and its applicability in Indian construction industry by using Five-S model. L & T is pioneer in adopting latest technologies. The ideas of ‘lean production’ are widely associated with the Toyota manufacturing system as originally applied within the Japanese car industry (Womack et al. 1990). Lean construction is beneficial for productivity enhancement as Flanagan et al. (1998) and Saad and Jones (1998) have also recommended the use of lean thinking to construction industry.

III. WASTE IN CONSTRUCTION INDUSTRY-

Lean construction system also minimizes the wastage, which is one of the growing concerns in traditional

construction industry. What is waste? 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 (Polat and Ballard, 2004). 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 (Alwi et al., 2002; Formoso et al., 1999).

During the construction process, construction managers have to deal with different factors that can negatively affect the performance of the production process, and producing different type of wastes. Wastes can include mistakes, working out of sequence, redundant activity and movement, delayed or premature inputs and products or services that do not meet customer needs (Construction Industry Board, 1998).

In traditional construction system waste management is one of the major problem. Waste management for construction activities has been promoted with the aim of protecting the environment and the recognition that wastes from construction and demolition works contribute significantly to the polluted environment (Shen et al., 2002). The construction industry plays a vital role in meeting the needs of society and enhancing the quality of life (Tse, 2001; Shen and Tam, 2002)

IV. LEAN THINKING IN CONSTRUCTION

Why lean? Traditional thinking of construction focuses on conversion activities and ignores flow and value considerations.

Lean construction is the application of lean thinking to the design and construction process creating improved project delivery to meet client needs and improve profitability for constructors. It places ‘optimizing the total value’ instead of ‘minimizing the cost’ as the main goal. Within lean, cost cutting has to be seen in perspective of eliminating non value adding activities (Womack and Jones, 2003).

Eriksson (2010) carried out a study on how to increase the understanding of how various aspects of lean thinking can be implemented in a construction project and how they affect supply chain actors and their performance. The core elements of lean construction are investigated reflecting how the various aspects of lean construction can be grouped into six core elements: waste reduction, process focus in production planning and control, end customer focus, continuous improvements, cooperative relationships, systems perspective.

The Lean Principles

- a) Eliminate the waste.
- b) Precisely specify value from the perspective of the ultimate customer.
- c) Clearly identify the process that delivers what the customer values
- d) Eliminate all non value adding steps.
- e) Make the remaining value adding steps flow without interruption
- f) Manage the interfaces between different steps.

- g) Let the customer pull – don’t make anything until it is needed,
- h) Make it quickly.
- i) Pursue perfection by continuous improvement.
- j) Do not push your projects on customers

V. LEAN CONSTRUCTION IMPLEMENTATION

Greg Howell, a Ketchum resident and co-founder of the **Lean Construction** Institute, saw there was a better way to deliver projects and drive productivity. The LCI has developed a **Lean** project delivery system that brings the lessons found in the manufacturing process to life in the architectural and **construction** industry.

Creating a culture of collaboration, transparency and systems integration is essential to the success of any **Lean** project. The key driver is to select trade partners, designers and engineers based on value added to a team rather than overall cost. Business owners can require contractors, architects and designers to design and construct a space that meets their established values without compromise to the projected target costs. These two goals work in tandem with a **lean** team to drive innovation and by seeking out and eliminating waste, resulting in timely project delivery and profitability.

Some differences you will find in **Lean** design vs. the traditional **construction** model include the following:

Redefining control: The partners focus less on overseeing outcomes and more on creating the outcome. Driving out waste while maximizing value. Designing a facility in tandem with the production of the facility – do work only once. Each trade works closely and in tandem. Trade partners are brought on early in the design process, not last in the **construction** process. Coordinating processes and outcomes with a continuous flow pattern – a “pull” rather than the “push” of traditional **construction** methodology. Empowering partners through transparency, and eliminating a central decision authority: Arm participants with ongoing information sharing and allow them to take action.

In actual practice construction is very much different from manufacturing, in construction the tools and techniques has to be applied on job site, it is very difficult for standardization of activities in case of construction. At the same time management of human resource is also challenging. And the repetition or rework is necessary in case of construction. With these hurdles it may not be difficult to implement lean construction in India.

VI. INDIAN INDUSTRY APPLICABILITY OF LC

There is awareness of Lean to some extent in India; the actual implementation of Lean concepts in projects had not taken place in any significant manner. Anecdotal evidence from discussions with industry experts suggested the following reasons for non-adoption of Lean practices in Indian Construction Industry-

- a. Belief that Lean is more applicable for manufacturing industry
- b. Resistance for changing existing practices
- c. Tendency to avoid formal planning
- d. HR related issues
- e. Lack of trained and skilled labor force

For overcoming these hurdles, training and awareness has to be improved for proper implementation of lean construction in Indian construction industry.

In India ILCE (Indian lean construction of excellence) and IITM (Indian Institute of Technology, Madras) are pioneer organizations for proper consultancy and training required for implementation of lean construction technique in India. Lean concept is industry neutral; we can use this in any industry like construction, manufacturing, process and we can minimize the cost, the time required to complete the project.

VII. CASE OF LARSON AND TOUBRO IN INDIA

Ms. Francis, planning engineer, Larsen & Toubro, mentioned about how we can use technology innovation and Lean methodology for lean and green construction. The basic principles of Lean—resource waste elimination, increased value to the customer, the first-time right approach, pull mechanism and continuous innovation—apply to construction as well. In case of construction industry wastes could be related to waiting or idle time, motion, over-processing, over-production, transportation, inventory, and defects/rework.

Ms. Francis highlighted the findings of her study of six construction activities in four sites to establish that there is a direct correlation between the adoption of Lean methodologies and achieving a green outcome. “Lean makes construction more structured, thereby reducing the occurrence of variables. It then becomes easier to adopt technology and do micro-level planning,” Ms Francis. Her study showed that Lean helped reduce the carbon footprint during the various stages of construction. She used Value Stream Mapping to identify value-adding and waste activities by tracking cycle times, lead times, and inventory levels. Lean tools that do not involve heavy investment costs can help organizations perform better and achieve environmental sustainability.

The philosophy is simple focus on People, Planet and Profit through sustainable approach.

In L & T they have completed 43million sq ft of certified green construction projects. Company remains dedicated to sustainable development follows NAPCC (National action plan on climate change)

Some of the best practices at L & T are,

- a) Safety first for workmen-
All workers are trained on safety and precautions
- b) Skill development and productivity of workers
On job training for workers and continuous learning
- c) Emphasis on energy efficiency and energy conservation practices
Use of renewable energy and energy efficient devices
- d) Reduced water consumption
Recycled and reuse water , promote rain water harvesting
- e) Upgraded machinery for construction
Integrated management system is being implemented
- f) Environmental management
Tree plantation at construction sites

- g) Health and hygiene of employees
Periodic check up of employees and providing safe clean drinking water and sanitation to the employees
- h) Corporate social initiatives
Conducting need assessment surveys, and provide program for development of education, skill development and healthcare
- i) Innovative practices
Adapting latest technologies in construction

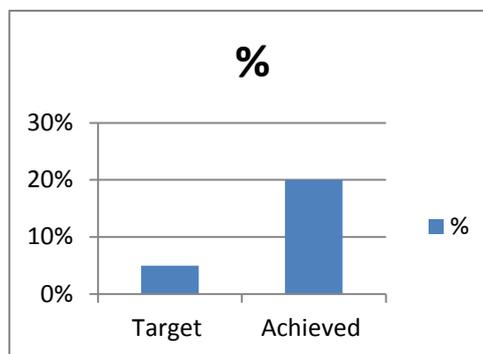


Fig: Energy conservation target achieved

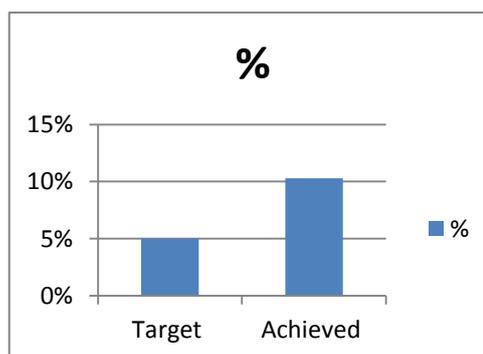


Fig: Water conservation target achieved
(Source: L & T sustainability report 2014)

They have achieved energy target of 20% and water target of 10% with implementation of lean construction techniques at sites. They have developed expertise in green buildings and reduction in the green house gases-GHG, which is responsible for climate change. Due to its best practices, it ranked 58th most innovative company in world. It is the most attractive organization to work with in infrastructure section in India. It ranked among top 10 best employers.

Analysis of L & T using five S techniques,

In Lean construction five S techniques, we are visualizing the project from start to end. According to O Salem el al., (2005) Project is a flow of activities that must generate value to the customer (Dos Santos et al. 1998). The 5s process (sometimes referred to as the Visual Work Place) is about “a place for everything and everything in its place”. It has five levels of housekeeping that can help in eliminating wasteful resources (Kobayashi 1995) At L & T they are taking care of safety and security of employees by inculcating safety culture amongst them.

Table no- 1 (five S analysis of L & T)

| Sr no | Category | Focus | Objective |
|-------|----------|-------|-----------|
| | | | |

| | | | |
|---|-------------------------|--|-----------------|
| 1 | Sort Seiri | What is needed and what is not needed | Organization |
| 2 | Set in Order Seiton | Place for everyone and everything in place | Orderliness |
| 3 | Shine Seitso | Cleaning and looking for ways for cleaning and organizing | Cleanliness |
| 4 | Standardize Seiketsu | Maintain and monitor first three categories | Adherence |
| 5 | Sustain Shitsuke | Stick to the rules and regulations for long term operation | Self Discipline |
| 6 | Safety & Security | Safety and Security at workplace | Safety of human |

L and T case-

Sort: They use to remove unnecessary items from site location

Set in order: Keeping important materials nearby for improving efficiency

Shine: cleaning is regular activity, tools and construction equipments are cleaned

Standardize: implementing standardized methods for improving efficiency

Sustain: they follow concept of reduce, recycle and recover in material handling

VIII. RESULTS AND DISCUSSION

Proper Training and Implementation of Lean concepts and practices can be successfully adopted in Indian construction projects and has increased keen interest from many organized players in the industry. It was clearly seen that the enabling factors included commitment of top management and site management, as well as the culture and systems of the organization will be main forces for the success of lean construction in India. Likewise, review of industry case studies has shown that implementation of lean construction principles facilitates company’s progress and engenders sustainable innovation practices in construction design and assembly. Even though the prevalent theory of production (or specifically, theory of construction) is seen as counterproductive, leading to added costs and reduced overall performance, the huge positive impact of lean implementation on sustainable innovation within construction have been quantified and provided proof of sustainability outcomes in terms of reduced waste, effort and time. With Lean construction, there is achievement of more for less by continuous reduction of waste in the construction process.

IX. CONCLUSION

The lean principles/concepts have been studied in depth, it was understood that Lean construction system is beneficial to industry as it minimizes the waste and increase the productivity. The concept of lean construction is studied in view of India. However, companies implementing lean construction tools and practices from an operational stand point are unable to sustain its use or derive maximum benefits from lean construction implementation since its practice is not supported by proper strategic planning. For success of lean concept everyone in the organization and on

the project must have common goal of taking benefits from lean system and accepting the new technologies in construction. Since for sustainable and green growth we have to minimize the impact of construction activities on our environment, this is possible with the proper implementation of lean construction, in case of India training and consultancy is needed for acceptance of this lean system in construction. From the case study of L & T it is understood that, lean construction is beneficial, after considering some of its hurdles, in India it is having maximum scope for implementation. The transparent positive and inclusive approach helps business work towards its objectives, while simultaneously minimizing its environmental impact. Thus quality policy of L & T emphasizes protection of environmental and minimization waste through use of lean construction techniques.

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REFERENCES

- [1] Eriksson, P. E. (2010) "Improving construction supply chain collaboration and performance: a lean construction pilot project", Supply Chain Management: An International Journal, Vol. 15 Iss: 5
- [2] Koskela, L. & Vrijhoef R. (2000). The Prevalent Theory of Construction is a Hindrance for Innovation, <http://www.leanconstruction.org/pdf/25.pdf> accessed 27/07/2011
- [3] Womack, J. and Jones, D. (2003). "Lean Thinking: Banish Waste and Create Wealth in your Corporation". Revised and updated edition. Simon & Schuster Ltd, UK.
- [4] Formoso, C., and Moura, C. (2009). "Evaluation of the Impact of the Last Planner System on the Performance of Construction Projects." Proceedings of 17th Annual Conference of the IGLC, Taiwan, 153-164.
- [5] Ballard, G., and Howell, G. (1998). "Shielding Production: An Essential Step in Production Control." Journal of Construction Engineering and Management, ASCE, 124 (1), pp. 11-17.
- [6] Flanagan, R., Marsh, L. and Ingram, I. (1998). Bridge to the Future: Profitable Construction for Tomorrow’s Industry and its Customers, Thomas Telford, London
- [7] Saad, M. and Jones, M. (1998). Unlocking Specialist Potential, Reading Constr. Forum
- [8] Womack, J.P., Jones, D.T. and Roos, D. (1990). The Machine that Changed the World, Rawson Associates, NY.
- [9] Womack, J.P. and Jones, D.T. (1996). Lean Thinking, Simon and Schuster, NY
- [10] Abdelhamid (2007). Lean Construction Principles. Graduate class offering at Michigan State University. <http://www.slideshare.net/tabeldelhamid/lean-construction-in-troduction>
- [11] Abdelhamid, T., S. (2004). "The Self-Destruction and Renewal of Lean Construction Theory: A Prediction From Boyd’s Theory". Proceedings of the 12th Annual Conference of the International Group for Lean Construction, 03-6 August 2004, Helsingør, Denmark.
- [12] Abdelhamid, T.S., El-Gafy, M., and Salem, O. (2008). "Lean Construction: Fundamentals And Principles." American Professional Constructor Journal.
- [13] Abdullah S., Abdul-Razak A., Abubakar A. and Mohammad I. S. (2009). Towards Producing Best Practice in the Malaysian Construction Industry: The Barriers in Implementing the Lean Construction Approach. In Proceedings of the International Conference on Construction Industry, Padang, Indonesia.
- [14] Tse, Y. C. Raymond (2001), "The implementation of EMS in construction firms: case study in Hong Kong", Journal of Environmental Assessment Policy and Management 3(2), 177- 194.
- [15] Shen, L. Y., Tam, W. Y. Vivian, Chan, C. W. Steven and Kong, S.

Y. Joseph (2002), "An examination on the waste Management practice in the local construction site", Hong Kong Surveyor 13(1), 39-48.

- [16] L & T , sustainability report 2014, accessed from website, <http://www.larsentoubro.com/media/31295/ltsustainabilityreport2014.pdf>
- [17] O. Salem , J. Solomon , A. Genaidy , and M. Luegring, (2005) "Site Implementation and Assessment of Lean Construction Techniques", Lean Construction Journal 2005, Vol 2 # 2.
- [18] Dos Santos, A., Powell, J., Sharp, J., Formoso, C. (1998). "Principle of transparency applied in construction", Proc. Of the Annual Conf. (IGLC-6) by C. Formoso (ed). 6th Conf. of Int. Group for Lean Construction, Guarujá, Brazil, 16-23.
- [19] Kobayashi, I. (1995). 20 Keys to workplace improvement, Productivity Press, Portland