

Application of Lean Construction Principle and Techniques to Minimize Construction Waste of Residential Project

Pradnya Awate¹, Bhagyashree Apte²

¹U.G., Student, Dr. D. Y. Patil College of Architecture, Akurdi, Pune, India

²Asst.Professor, Dr. D. Y. Patil College of Architecture, Akurdi, Pune, India

Abstract - Lean construction is new technology used in many countries for reduction of construction waste and increase the probability of project success. This research paper mainly aims to study the application of lean construction for minimization of construction waste in residential project focusing on multi-storeyed residential building in the Pune region. Findings from the study show the waste generation causes and volume of material waste. Also, the managerial framework from lean construction is suggested to overcome the problem. This framework is developed by considering literature review, survey, and sample study. Construction waste is divided into four categories for each category appropriate lean construction methods and techniques are suggested.

Index Terms - Lean construction, waste generation, lean construction framework

INTRODUCTION

The construction industry is the second largest contributor to India's economy. It not only accompanies huge economic potential but is also among the biggest employment providers. According to government reports, the sector was valued over 126 billion dollars in 2016 and it continues on a steady growth path. It is expected that the value of construction market and the real estate will increase 7 folds by 2028. While all of this seems encouraging, there are various challenges for construction industry in India that have been limiting the growth prospects of it. The other reason is that the construction industry is more complex than the manufacturing industry and therefore the development of technical modernization is to be implemented significantly.

Lean construction is a new production methodology that will bring a radical change in the construction industry. Construction companies have improved their

work effectiveness and quality of work, and reduced waste and costs and increased their profits to ensure their survival in today's competitive market. In current practices Lean construction has the target of better meeting customer needs while using less of everything (source). Lean construction rests on production management principles as its first used in production industry. Waste removal is one of the effective ways to increase the profit of any industry. Construction waste includes undesired and unwanted materials produced directly or indirectly in various construction processes. Lean construction (LC) is a technique that aims to eliminate all deformity and minimize wastage of construction materials, time, and effort in order to generate the value in maximum possible amount by using less input. Few of the inputs (source) include less labour, less machinery, less space, less time, etc. Lean Construction procedure focuses on minimization of the bad and maximization of the good. Lean construction includes clear set off objectives for maximizing the benefits through the contemporary design of construction processes and facilities.

The role of control in lean is to persuade reliable workflow in contrast to the traditional method which takes corrective actions after detecting differences. Lean approach is mainly targeting on the maximization of value by improving the whole process but in the traditional method, optimization is done separately for each activity.

1. RESEARCH QUESTIONS

1. How will application of lean construction principals and techniques minimize construction waste in residential project?
2. What type of waste is produced during and after the construction phase of a residential project?

2.AIM

To study the application of lean construction principals and techniques to minimize the construction waste in residential project.

3. OBJECTIVE

- To study and analyze lean construction principles and techniques for the reduction of construction waste of residential project.
- Identify which types of waste generate during and after the construction phase.
- To study application of lean construction principles and techniques on residential project.
- Examine the result of project performance in the form of waste reduction, cost overruns, and delay of the project by comparing it with traditional method.

4.SCOPE AND NEED OF THE PROJECT

Scope of the project is identification of waste by its generation causes from construction process and according to it differentiates this construction waste and development of framework to control the waste generation by using lean construction principle and techniques.

Need of the project to improve the product quality and control waste management as construction process are streamlined business can better responds to fluctuations in demand by this resulting in fewer delay and better lead time. Less waste and better adaptability for a business makes better equipped to thrive well into the future.

This study is limited to minimization of construction waste in Residential project by applying lean principals and techniques. The samples taken for the study are restricted only in Pune region.

II. METHODOLOGY

In research methodology following step are carried out
Background study and introduction

In background study few articles and books on lean construction are studied. Also, some new paper articles on construction waste generation in Pune region are reviewed. From this background study baseline for this research is decided and introduction about it is given.

LITERATURE REVIEW

In literature review three research paper published in national or international journal are studied. These papers are based on lean construction. From this study various aspects about lean construction, its benefits, effectiveness and utilization is found.

Interview with project participants and questionnaire survey

In this step interview with different project participants such as project engineer, architect, civil engineer, project manager and site engineer is done. This interview is based on the questionnaire prepared.

Data collection from sample study

Necessary data for research is collected from sample study and literature review. Sample study is focused on only residential buildings which are 11th to 14th storeyed high (Low rise building) However, this limitation in Sample size impacted the Results of the questionnaire. Optimistic values about the respondent's awareness and appreciation of lean construction is found from collected data.

Data Analysis (Comparative & Quantitative Assessment)

Data collected from sample study is shown in table form. This shows particular causes of waste generation causes and its percentage. Quantitative assessment is done for getting the actual amount.

Findings & proposals

Based on all this study, some facts and findings are defined. A framework for managing wastage in site through Lean Principles and Techniques is proposed such as Last planner systems, 5s, Gemba walk and lean principles.

Conclusion & Recommendation

Conclusion is formed on the basis of this research study. New technology like lean construction and its specific techniques and principles are proposed and recommended for the construction industry.

III. LITERATURE REVIEW

This literature review shows that 4 techniques are used for identification of waste reduction. Based on this study, the following recommendations are offered to

support the effort of implementation of lean management in construction industry, Orientation programs need to be developed for subcontractors. Because lean concepts and principles may be complex for to understand, the companies may provide adequate training for management level employees. Weekly meeting may held to the skilled and unskilled labours. Consider a maximum use of local available materials. Establish good relationship between manufacturers and management [2]. Findings from this paper study is-Advantages of lean technique, last planner system and lean construction concept are studied. This research focuses on the minimization of waste generation. Upon comparing several methods, the proposed method supported lean design ends up in better performance, where the increased values prove that this proposed strategy is productive and therefore the trade-off between time and value has been enhanced by increasing the work flow variability [3]. This paper was able to establish the actual fact that existing project management models and methods haven't been able to deliver projects on time and as a result have created wastes within the housing industry. The paper also discussed LC, its principles and wastes within the industry. The authors demonstrated that LC presents a replacement and robust approach to coping with the waste within the housing industry. This was illustrated with some highlights of the importance of LC application (Why LC). Finally establishment of the paper is that the appliance of lean tools and techniques by project teams and industry's practitioners will minimize or eliminate waste, enhance performance and cause a decent cost savings for the industry moreover because the society. It is predicted that the fundamental knowledge provided by this paper will contribute to the knowledge and practice from delay control or waste elimination and also function a benchmark for continuous improvements of performance in construction industry [4].

IV. DATA COLLECTION

Sample study is focused only on residential buildings which are 11 to 14th storeyed high located in Pune region. The sample taken for the study is located in Banner, Pashan and Bavdhan area. All these projects are residential and have different amenities such as swimming pool, gym, club house etc. This entire sample has 2BHK and 3BHK flats.

Sample No- 01 is Aloha Towers located at Banner, project area is 1.95 Acre and project size is 2 buildings - 128 units.

Sample No- 02 is Bhalerao Savannah Hills located at Bavdhan, project area is 1.09 acres and project size is 1 building - 66 units

Sample No- 03 is Parklane Urbanjoy located at Pashan project area-0.22-acre project size-1 building - 87 units. Bookcase study of Construction Lean Improvement Program (Clip) – Practical Experience of Applying Lean Thinking to Construction Projects is also done. Bookcase study findings are in order to ensure the success of any changes within an organization, particularly regarding the implementation of Lean principles, this case study shows following are the important factors should always be remember

- Lead by example
- Communicate
- Involve relevant staff
- Be realistic in your expectations

V. DATA ANALYSIS

Table no 01: Data analysis chart shows the material waste generation causes and its percentage

Sr. No	Material	Material Waste in Percentage			Material Waste Causes
1	Cement	10% -12%			Poor supervisory system Improper handling Bad storage Frequent transportation of materials on site Lack of on-site materials management
2	Concrete	10% -15%			Poorly constructed formwork Poor supervisory system Improper handling Lack of management team and labor awareness lack of quality management system
3	Ready mix plaster	5% - 8%			Poor technology and poor construction techniques
4	Sand	10% - 15%			Over-sized building components during construction Bad storage
5	Bricks	5% - 10%			Improper handling Poor supervisory system
6	Blocks	8% Siporex	10% AAC	12 % Ecolite	Unsuitable cutting Lack of skilled workers and subcontractors Damage during to transportation
7	Steel	4% - 8%			Cutting and bending waste unsuitable cutting Lack of proper supervision team Poor construction techniques
8	Tiles, Granite	5% - 6%			Unsuitable cutting Lack of skilled workers and subcontractors Manufacturing defects Forced cutting to match required dimensions Selection of low-quality materials
9	Wood	5% - 7 %			Cutting waste Decay woods
10	Gypsum	30% - 40%			Poor technology Improper handling
11	Paint	5% - 8%			Lack of labor awareness Rework required because of workers' errors Selection of low-quality materials
12	Electrical wires	2% - 4%			Cutting waste
13	Plumbing fittings	7% - 8%			Cutting waste Poor handling unsuitable cutting
14	Packaging	30% - 40%			Packaging waste of tiles, plumbing fittings, electrical fittings etc.

VI. FRAMEWORK DEVELOPMENT

A Framework was developed to show the effectiveness of implementing Lean concepts to the conventional management approach in the construction industry.

While developing the framework how lean thinking can be implementing on any project and various aspects of implementation are studied. The proposed framework showed application of lean construction, its practical guide and appropriate methods for application of it on construction industry. Data collected from the different method is considered for the development of framework. Methods are given below –

- Literature review
- Data collected from sample study
- Book case study

Literature review: For framework development some references taken from the literature review is as follows –

- Reference for preparing the questionnaire by using Likart scale.
- There are many factors which contribute to construction waste generation on site and it can be categorized into different types as per reasons behind its generation.
- This paper study shows that the waste can be classified into different type for example – operational related waste, management related waste, design related waste etc.
- Literature review also gives the idea about weekly meetings and training programme are held on site for smooth execution of work this type of weekly meetings and training programme are part of last planner system.
- Benefits and advantages of lean technique and lean construction principle are given in these papers the benefits such as improvement in project performance and increase in the value.
- Overall study of the literature review gives the clear idea about benefits of LC, classification of waste and Last planner system.

Data collected from sample study: To collect the data from survey and sample study the questionnaire is prepared and circulated among different project participants. The data is collected from the responses of the participants gives the idea about actual site

condition and is prove useful while developing the framework. Findings from this data are as follow-

- Some construction companies are aware about Lean construction techniques, few of them are actually used the lean construction techniques.
- The techniques used commonly in organization or industries are six sigma, 5s, just in time, poka-yoke, last planner system, kaizen and pull planning.
- The knowledge of this technique is quite common in organization; hence it can be easily apply to actual construction site.

Bookcase study: Book case study gives the idea about how lean principles can be successfully implemented. The procedure and benefits of implementation of lean is also given in this.

- Approach and process for lean application is given
- Value creation for customers satisfaction and sorting of the waste is studied.
- Visual controlling by using the Gemba walk method is done.
- 5s technique is used to sort out the material present on site and the material present in storage area.
- Focus on adding value and satisfying customer’s need which is mostly seen in lean principles is also studied from this case study.
- The study gives the good idea about 5s for sorting out, gemba walk for visual control of site and lean principle implementation.

From the analysis of this four data collection method the framework is developed. In this framework the waste is divided into four different types according to the causes of waste generation. For each category of waste appropriate and suitable technique from the lean construction is suggested. The developed framework is shown.

Table no 02: Lean construction framework

Waste generation causes	Specification	Framework (Lean construction)
1.Management related waste	Improper planning, selection of low-quality material, Over ordering, inaccurate estimate, miscommunication	Last planner system
2.Organization related waste	Wrong storage of material, lack of storage area, lack of supervision	5s
3.Operational waste	Improper handling, unskilled labour, waste due to rework, insufficient instruction	Gemba walk
4. Design related waste	Changes in design, overlapping of design and construction	Lean construction principles

VII. CONCLUSION AND RECOMMENDATION

CONCLUSION

Based on literature review and data study it is found that there is one new technology which is Lean construction for minimizing the waste in construction and its application on construction project gives the better outcome as compared to traditional project management practices.

Now days in India many companies are applying lean construction principles and techniques for reduction of construction waste and better project delivery. Through this study, a better understanding of construction waste generation in Pune region was achieved. The important causes of construction waste generation in residential projects were determined. The results obtained from investigation of construction waste generation shall be helpful to improve current waste management practices in Pune region by providing useful information and to suggest solution from Lean construction.

Application of lean construction principle and techniques can be done by studying the various causes of waste generation. Differentiation of construction waste will prove helpful for suggesting the appropriate method from lean construction. After studying these entire factors LC framework is developed. This framework will be advantageous and profitable for new construction as it gives solution from design stage to execution stage. If the construction project applies these LC principle and technique project will complete within time and budget with minimum construction waste.

RECOMMENDATION

The research comes to the following recommendations-

- The research study shows that to control the major challenges faced by Indian construction industry, therefore, to overcome this challenges Lean construction is one of the better management methods.
- Lean construction is mainly focuses on elimination of the waste from design phase to execution phase of the project and it will be beneficial in terms of cost saving and value addition.

- The knowledge of techniques like six sigmas, 5's, poka-yoke, kaizen, just in time and last planner system are common between engineering organizations. Therefore, application of these techniques will be easy to apply on project.
- Improvement of the application of lean construction principle and techniques is necessary for increasing the efficiency of the project, reduce project schedule time and increase higher quality construction of project.
- Application of Lean construction technique is beneficial for time and cost reduction of overall project also gives greater productivity and greater customer satisfaction.
- Recommending LC principle and techniques by seeing all its benefits and this can be easily apply as per the complexity of problem in the construction project.

VIII. FUTURE SCOPE OF STUDY

The present research aims at minimizing construction waste by application of lean construction techniques and principles. While similar study can also be conducted in the future for Indian construction industry. Lean techniques have been adopted by a range of industries around the world, including construction but in India the use of this new technology (LC) is not much. The different industries around the world are adopted lean construction to enhance the project efficiency and productivity of its operations from top level management to on site construction. Barriers for implementing lean construction is studied in India, from this research it is found that there are so many challenges and barriers for implementing LC. The future scope of the study is to downplay these barriers. this downplays will give the benefits such as increasing efficiency of the project. Further study in the field of the LC will be beneficial for the India in terms to increase in GDP.

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