

## ARTICLE

# Lean Construction in a Real Estate Project - A Case Study

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### ARTICLE INFO

#### *Article history*

Received: 12 November 2020

Accepted: 14 December 2020

Published Online: 30 December 2020

#### *Keywords:*

Lean construction

Real estate

Waste

Continuous improvement

### ABSTRACT

Majority of all the construction projects experience cost and time overruns for reasons which are many times beyond the control of stakeholders. To overcome the same, the concept of lean integrated project delivery came into existence. Lean culture focuses on customer by empowering employees. It involves in converting waste into value by reducing waste, improving communication, and promoting teamwork integration through a common set of tools and techniques. Aim of lean construction is to achieve the affordable cost with optimum utilization of man, material and machinery. Wastes in construction industry which do not add value are supply in excess materials in inventory for raw material, work in progress, finished goods etc. Waiting for preceding activity, over processing and defects can be reduced through lean construction. This paper deals with lean construction techniques for identifying the waste in a construction project and eliminating the same. In this project estimation of a building is done to find cost of the project with respect to specifications and compared the traditional methods vis- a vis and lean construction techniques which can bring down the cost and with substantial improvement in quality aimed at satisfying the customer.

## 1. Introduction

The Construction industry has been witnessing a steady downward turn in productivity for reasons which may be attributed to prevailing internal/ external environment.

The scope of lean concepts which initially had its roots in manufacturing industry was enlarged by applying the concepts in construction industry to overcome the problem of productivity, inventory and minimization of wastage for which construction industry is notorious. Applied to construction, lean concepts have brought a revolution in the way work is executed from concept to commissioning

Resources that do not add value to the product/ser-

vice delivered to the customer requires elimination of all wastes of all types by way of achieving continuous improvement in the performance of all concerned stakeholders is the core concept of Lean Construction. Spectacular performance improvements in manufacturing has encouraged the implementation of lean concepts in construction filed also. Lean construction is associated with the following

### 1.1 Flow of Work Processes

Continuous and uninterrupted workflow is the key to ideal lean construction project if it is to be reliable and predictable. Scheduling of activities in proper sequence is key in

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construction. Unambiguous communication between all stakeholders is necessary for achieving the desired output. When an activity is executed behind / ahead of schedule, all concerned must be communicated accordingly so that the waste of waiting, motion, and excess inventory can be avoided.

## 1.2 Pull Planning and Scheduling

Based on downstream demand reliable workflow is created. This is best executed by transferring the work to subcontractors. Schedule of tasks is determined by communicating and collaborating closely with each other.

## 1.3 Continuous Improvement

Philosophy of lean lies in the fact that it is necessary to continuously keep on improving processes and to minimize/ reduce waste during production/ execution. Corrective measures for improvement are identified from executed projects and applied to future projects.

## 2. Objective of Study

To find out the wastage in various activities of a construction project through a study of a real estate construction project and to offer solutions for facilitating the implementation of lean construction concepts.

## 3. Literature Review

(1) Alinaitwe<sup>[1]</sup> highlighted that one of the main barriers under technical aspects was lack of buildable designs. Certainty in the production process and provision of benchmarks were cited as the main barriers during implementation of Lean Construction.

(2) Alarcon et al.<sup>[2]</sup> study noted that the barriers in implementation of lean construction concepts is (i) lack of time for implementing new practices in the projects, lack of Training, self criticism to learn from errors, responding to deficiencies, not understanding of the concepts, inadequate administration, weak communication and lack of transparency in construction chain.

(3) Bhargav Dave et al.<sup>[3]</sup> study on Lean Construction and information/ communication systems revealed that by process modelling, lean principles and process analysis techniques, and process standardization across the industry will highly effective and efficient.

(4) Carlos Formoso et al.<sup>[4]</sup> identified the benefits when applying lean principles in construction; (A) Reduce sharing of non-value adding activities, (B) Increased output value through systematic construction of customer requirement (C) Reduced process variability, (D) Reduced

cycle times, (E) Simplified/ minimised the number of steps parts and linkages (F) Increases output flexibility (G) Increased process transparency (H) Focus on complete process (I) Building of continuous implement into the process (J) Balance flow improvement with improvement in conversion (K) Benchmarking.

(5) Koskela<sup>[5]</sup> there were 11 basic principles to LC, which were to reduce the share of non value-adding activities, increase output value through systematic consideration of customer requirements, reduce variability, reduce cycle time, minimise the number of steps, parts and linkages, increase output flexibility, increase process transparency, focus control on the complete process, build continuous improvement into the process, balance flow improvement with conversion improvement and benchmarking.

(6) Mohd Arif Marhani et al.<sup>[6]</sup> researched on fundamental knowledge of Lean Construction and its implementation and suggested that lean construction requires holistic approaches to be adopted as health, safety, six sigma etc and need for systematic training and research with interaction and collaboration with stakeholders.

(7) Nordin Norani et al.<sup>[7]</sup> carried out a study the main reason for failure of implementation of lean manufacturing was identified to be the letdown in managing the change process whether be it lean manufacturing or organizational change. The present research studied 11 critical provided the practitioners of lean concepts with a better understanding of the lean transition and a clear guidance to minimize the resistance and conflicts for the its implementation and improving its chance of success

(8) Sindhwani et al.<sup>[8]</sup> study revealed that by meeting the latest demand of consumers, lean concept will improve its consumer relation. Parameters like overproduction, processing waste/over processing, transportation, waiting/ delays, inventory waste, motion waste and defects were used. The pull system was utilized to understand that there is need to increase the production rate. Value Stream Mapping was done to identify the constraints and one piece flow to achieve the required cycle time. Lean Construction Organization pointed out that the reliable apportioning of work between specialists in design, supply and assembly ensures value is delivered to the customer and waste is reduced.

(9) Tindiwensi<sup>[9]</sup> study revealed that most constructability elements were missing architectural designs due to the limited knowledge of construction practices and the separation of design from construction contributed to a breakdown of the production process during construction. Stakeholders should involve from the pre-construction stage and taking into consideration the viability and con-

structability of design and process. In this process, changes in designs during construction stage can be avoided that could otherwise disturb the construction schedule.

**Literature Gap**

Lean construction involves many tools and principles to optimize the resources which lead to delivery of the project according to the customer satisfaction. It also helps in eliminating waste and reducing the cost of the project without changing specifications.

**4. Methodology**

The study involved a real estate construction project with support from stakeholders. This project involved the construction of a girls hostel Agricultural University in Andhra Pradesh State of India. It consists of 6 blocks connected in H- shape having plinth area of 1001.5 square meters and 488.5 square meters in ground floor and first floor respectively. Estimation of the project was done according to the procured drawings. An estimate gives an idea regarding the quantities of various items of work, and the cost involved so that it can budgeted accordingly. Planning and execution of any work involves estimation of materials, labour, plant and time. This study dealt with cost of project and how to reduce the cost overrun by using lean construction principles. It involved mainly:

**4.1 Identification of Value as Perceived by Customer**

The traditional approach focuses on inclusion of plans and specifications as per the requirements of customer. The estimation of the project is done according to the specifications given by client

**4.2 Defining the Value Stream**

The process necessary to deliver that value can be laid out when there is a clear understanding of what the customer views as value.. This is called the value stream. Labour, equipment, and materials required for each activity are defined.. Resources that do not contribute to value are deleted.

**4.3 Eliminating Waste**

The foremost goal of Lean construction is to minimise waste. Major types of waste which are targeted by lean construction are:

**Defects:** Defects are those which is not done right the first time subsequently resulting in rework/ wastage of time/ materials.

**Overproduction:** This waste results from more services/ effort/ energy in addition to what is needed with no corresponding output. Examples of overproduction are engaging extra laborers on a project, assigning extra tools etc in the name of being overcautious.

**Waiting:** This is waiting in construction when the necessary materials needed for the work have not been delivered / the prerequisite prior activities are not completed but the workers are ready.

**Not Utilising Talent:** When the appropriate person is not given the right job, their talent, skills/ knowledge is not properly utilised.

**Transport:** This is a waste which occurs when materials/ equipment/ workers are moved to a job site before they are actually engaged.

**Inventory:** Materials that are not needed immediately block up budget, require additional storage, and often quality gets degraded when not utilised.

**Motion:** This waste occurs due to unnecessary movement between workers/ tools/ materials

**Over Processing:** This happens when features/ activities are added which adds no value to the client. This results when taking steps to eliminate the other types of waste.

**5. Case Study**

The quantities of various items obtained from case study vis-à-vis the estimated quantities are furnished in the tables below

**Earthwork Excavation**

**Table1.** Variation in Earthwork Quantity

S.no	Type quarters	Estimated Quantity Cum	Actual Quantity Cum	Difference Cum	Additional cost (Rs) Excess (%)
1	F1	95.37	98	2.63	
2	F2	111.78	112	0.22	
3	F3	92.06	94	1.94	
4	F4	297.675	299	1.32	
5	F5	83.53	85	1.47	
6	F6	73.10	76	2.90	
		753.51	764	10.49	<b>2656.27 (1.3)</b>

**Stone Dust**

**Table 2.** Variation in Stone Dust Quantity

S.no	Estimated Quantity	Actual Quantity Cum	Difference Cum	Additional cost (Rs) Excess (%)
1	754	780	26	13346.06 (3.4)

**PCC**

**Table 3.** Variation in PCC Quantity

S.no	Type	Estimated Quantity (cum)	Actual Quantity (cum)	Difference	Additional cost (Rs) Excess (%)
1	F1	9.54	10	0.46	
2	F2	11.18	11.5	0.32	
3	F3	9.21	9	-0.21	
4	F4	29.77	30.62	0.85	
5	F5	8.35	8.6	0.25	
6	F6	7.31	7.4	0.09	
		<b>75.35</b>	<b>77.12</b>	<b>1.77</b>	<b>5995.39 (2.3)</b>

**Footing Concrete**

**Table 4.** Variation in Footing Concrete Quantity

S.No	Type	Estimated Quantity (cum)	Actual Quantity (cum)	Difference Cum	Additional cost (Rs) Excess (%)
1	F1	19.71	20	0.29	
2	F2	26.59	27	0.41	
3	F3	24.79	26	1.21	
4	F4	81.00	83	2.00	
5	F5	22.88	23	0.12	
6	F6	27.23	28	0.78	
		<b>202.19</b>	<b>207.00</b>	<b>4.81</b>	<b>34212.31 (2.38)</b>

**Concrete for Columns**

**Table 5.** Variation of concrete in Columns

S.No	Type	Estimated Quantity (cum)	Actual Quantity (cum)	Difference Cum	Additional cost (Rs) Excess (%)
1	Upto GL	21.03	23	1.97	17714.63
2	Ground Floor	51.65	52.6	0.95	8542.59
3	First Floor	44.79	46	1.21	11593.51
4	TOTAL	117.47	121.6	4.13	<b>37850.73 (3.5)</b>

**Concrete in Beams**

**Table 6.** Variation of Concrete in Beams

S.No	Type	Estimated Quantity (cum)	Actual Quantity (cum)	Difference Cum	Additional cost(Rs) Excess(%)
1	Plinth	42.19	42	-0.19	-1494.45
2	Roof of Ground Floor	42.19	43	0.81	6371.0712
3	Roof OF First Floor	35.88	36	0.12	978.7656
4	Total	120.26	121	0.74	<b>5855.39(0.6)</b>

**Concrete for Slabs**

**Table 7.** Variation of Concrete in slabs

S.No	Type	Estimated Quantity (cum)	Actual Quantity (cum)	Difference	Additional cost (Rs) Excess (%)
1	Basement Slab	989.45	992	2.55	2423.11
2	Ground Floor	995.79	993	-2.79	-2651.1696
3	First Floor	707.13	709	1.87	2035.0836
4	TOTAL	2692.37	2694	1.63	<b>1807.03 (0.06)</b>

**Reason:**

- (1) Bulging of shuttering.
- (2) Method of placing.
- (3) Dimensional Errors
- (4) Labour mishandling

**Preventive Measures:**

- (1) Modern shuttering methods
- (2) Avoiding manual placing
- (3) Hiring skilled labour

**Reinforcement Steel**

**Table 8.** Variation of Steel Quantity

S.No	Type	Estimated Quantity (tonnes)	Actual Quantity (tonnes)	Difference (Tonnes)	Additional cost (Rs) Excess (%)
1	Footings	90421.65	93002	2580.35	
2	Columns	17621.71	18676	1054.29475	
3	Beams	14430.27	14440	9.73192	
4	Slab	215390.24	217450	2059.76	
		<b>247442.2133</b>	<b>250566</b>	<b>3123</b>	<b>1580587 (1.2)</b>

## Reasons:

- (1) Inadequate knowledge in preparation of BBS
- (2) Lack of Skilled Labour
- (3) Non-optimal use of cut pieces
- (4) Unavailability of rebars

## Preventive Measures:

- (1) Maximum usage of scrap steel
- (2) Usage of alternate diameters whatever are more available on site
- (3) Proper storage
- (4) Proper inventory planning

## 6. Conclusion

This study involved the application of lean construction concepts at operation and project levels and actual usage of materials vis-à-vis the estimated quantities were observed. Parameters that contributed to delay/ wastes were identified. Lack of coordination among contractors was one of the major factors contributing to project delays.

It has been observed that 6.91% of overall cost of the project can be reduced with lean construction without changing the specifications. The major variation in quantities of materials which contributed to increased cost are concrete for footings and columns, stone dust and reinforcement steel. Continuous improvement helped in delivering the project with more customer satisfaction.

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