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Waste Minimization in Construction Sites Based On Lean Construction Principles – Case Study

[1] C.Bhaskar, [2] P.Naveen Kumar M.Tech, AMIE

[1] *M.Tech Student, Dept of CIVIL Engineering, SSSS Engineering College, Affiliated to JNTUA, AP, India.*
[2]*Assistant Professor, Dept of CIVIL Engineering, SSSS Engineering College, Affiliated to JNTUA, AP, India.*

Abstract: The adoption of lean construction principles within construction industries has led to notable improvement has improved time-to-market, reduced production cost, improved quality of the work. Construction site waste contributes to the large quantities of construction waste that are generated by the construction industry every year. Increased economic growth and urbanization in developing countries has led to extensive construction activities that generate large amounts of wastes. This work aimed at identifying the main sources and causes of materials waste on construction sites arising from storage and handling of high waste generating building materials and employing the Lean Construction approach to reduce such waste and to identify the barriers for adopting the lean concept. Minimizing material wastage would not only improve project performance and enhance value for individual customers, but also have a positive impact on the national economy. This work will be further intended to verify and re-evaluated the status of existing productivity and performances on construction activities and processes for local construction industries. This is meant to have a clearer picture on how "lean" in local construction industry performed currently under the compilation of new measurement parameters particularly on waste and cycle time pertaining to the concepts and principles of Lean Construction. This study mainly focuses on implementation of the tool like Relative Importance Index has been done for finding the cause and the effect of the various wastages at the construction industry. By way of choosing some major construction activities and careful observation of them for the extraction of the causes of the wastage generation has been done in this report.

Key Words: Construction Project, Lean, Wastage, Relative Importance Index, Barriers

Lean construction is the term used to define the application of lean thinking principles to the construction environment.
What is lean construction?
Lean construction is a "way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value".
Designing a production system to achieve the stated ends is only possible through the collaboration of all project participants (Owner, A/E, contractors, Facility Managers, End-user) at early stages of the project. This goes beyond the contractual arrangement of design/build or constructability reviews where contractors, and sometime facility managers, merely react to designs instead of informing and influencing the design.

Lean construction recognizes that desired ends affect the means to achieve these ends, and that available means will affect realized ends. Essentially, lean construction aims to embody the benefits of the Master Builder concept.

Lean construction supplements traditional construction management approaches with (1) two critical and necessary dimensions for successful capital project delivery by requiring the deliberate consideration of material and information flow and value generation in a production system; and (2) different project and production management (planning-execution-control) paradigms.

Getting work to flow reliably and predictably on a construction site requires the impeccable alignment of the entire supply chain responsible for constructed facilities such that value is maximized and waste is minimized. With such a broad scope, it is fair to say that tools found in Lean Manufacturing and Lean Production, as practiced by Toyota and others, have been adapted to be used in

the fulfilment of Lean construction principles. TQM, SPC, six-sigma, have all found their way into lean construction. Similarly, tools and methods found in other areas, such as in social science and business, are used where they are applicable. The tools and methods in construction management, such as CPM and work breakdown structure, etc., are also utilized in lean construction implementations. The three unique tools and methods that were specifically conceived for lean construction are the Last Planner System, Target Value Design, and the Lean Project Delivery System.
Adopting lean thinking results in a highly flexible, profitable company but the process to achieve it requires radical change and takes a number of years.

LITERATURE REVIEW

A review of literature available on lean construction principles, lean construction tools and techniques, concept of waste in construction, waste identification and categorisation, waste classification, waste measurement, waste reduction, implementation of lean construction, process improvement etc. was carried out in order to fulfill the following purposes:
1. To identify and categorise critical waste and waste cause variables.
2. To develop a framework for quantifying waste types in terms of cost.
3. To suggest improvement measures for minimising waste in construction sites

Some Fundamental Principles Of Lean Are:

- Define value from the customer's perspective
- Understand the value stream of all steps in the process used to create the end product
- Reduce waste
- Ensure a smooth flow of value added activities
- Prefabricate and modularize building systems
- Utilize collaborative pull scheduling to provide each internal and external customer what they want, when they request it
- Seek perfection by committing to continual improvement in all areas of the process.

There Are Principles To Guide The Change Work:

- Identifying value from the point of view of the customer.
- Understanding the value streams by which value is delivered.
- Achieving flow within work processes as waste is removed.
- Achieving pull so that nothing is made/delivered until it is needed.

- Perfection recognizing that improvement needs to be constantly sought.

These Principles Can Be Applied At A Number Of Levels:

- By an individual design company who recognizes its clients to be both the owner of the buildings and those downstream in the design and construction process.

- By an individual component supplier who delivers value through their component products eg. bricks, concrete etc.

- By a PFI organizations that provide value to different clients through the provision and operation of a building product e.g. a hospital or a prison.

- By a group of companies who provide value to various clients through the provision of a building product e.g. city office space.

The Benefits Of Adopting Lean Thinking Are:

- Making good profit margins whilst contributing to improving the social infrastructure by protecting the environment and respecting the people who work for you.

- Creating a construction industry for the future that attracts young people who view it as a vibrant, satisfying, healthy environment in which to employ their talents.

OBJECTIVE OF STUDY

- To review the Lean construction technique.

- To study in detail Lean construction and its benefits.

- To identification of barriers to successful implementation of lean construction.

- To investigate construction wastage.

- To reduce construction wastage using Lean Construction technique.

3-METHODOLOGY

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1 Methodology adopted for this study is shown in flow chart:

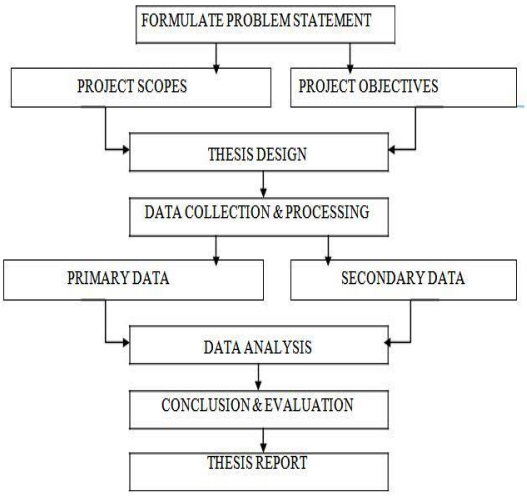

Fig-1: flow Chart

First Phase - Formulation Problem Statement Second Phase - Project Design
Third Phase - Data Collection & Processing Fourth Phase - Data Analysis
Fifth Phase - Conclusion & Evaluation Sixth Phase - Project thesis Report

To apply lean technology in the construction sector, in this project a questionnaire was used as a tool or material to find out the main factor which causes maximum wastages of different materials. Method adopted is simple and classified into following steps Study of literature review and conversation with senior engineers from various sites for the preparation of questionnaire. After preparation of questionnaire, this tool were distributed to various sites to collect the information related with wastages of materials After collection of all the questionnaire, it's analysis was carried out with the help of Relative Importance Index method to find out the ranking of various factors And lastly giving remedial measures for those factors which causes more than 70% wastages.

[1] BARRIERS TO ADOPATION OF LEAN CONSTRUCTION CONCEPTS

The barriers to implementation of Lean Construction identified from literature and confirmed by construction site practitioners that the five strongest barriers to implementation of LC in construction site are "fragmented nature of the industry", "extensive use of subcontractors", "lack of long term relationship with suppliers", "delays in decision making" and "waste accepted as inevitable", in that order. The weakest barriers include "inefficient use of quality standards", "lack of supply chain integration" and "poor project definition" among others.

Component 1: Lack of proper planning and control

This component identified delays in materials delivery, inefficient use of quality standards, long implementation period, waste accepted as inevitable, inconsistency in government policies, high dependency of design specifications on in-situ components and materials, extensive use of subcontractors, lack of long term commitment to change and innovation, lack of long term relationship with suppliers, delays in decision making and materials scarcity as major barriers to the

implementation of lean construction. Despite the significant economic contribution made by the construction sector in various countries, it faces numerous problems relating to improper planning and control.

Component 2: Lack of teamwork

This component identified the fragmented nature of the industry, lack of interest from clients, poorly defined individual responsibilities and less involvement of contractors and specialists in design process. Teamwork can be defined "cooperative effort by the members of a group or team to achieve a common goal"

Component 3: Poor project management

This component identified poor project definition, lack of equipment, lack of agreed implementation methodology and unsuitable organizational structures as barriers to implementation of LC.

Component 4: Lack of technical capabilities

This component identified lack of buildable designs, incomplete designs and lack of standardization as the major barriers to the implementation of lean construction. These barriers are considered technical because they have a direct impact on the success of application of lean construction principles and tools such as reliability, simplicity, flexibility and benchmarking might offer more cost-effective solutions.

Component 5: Lack of professional motivation

This component identified poor professional wages materials and poor workmanship and corruption as the major barriers to implementation of LC. Corruption which includes bribery, extortion and fraud may damage the implementation of LC by resulting in the cutting of corners, overpricing of projects, using of inferior Lean construction principles. materials and poor workmanship

Component 6: Poor communication between parties

This component identified lack of communication and difficulty in understanding lean concepts as the major barriers to implementation of LC. Since LC evolved from the manufacturing industry, it is vital that the parties involved in the construction industry have a full knowledge of the lean manufacturing concept before its implementation. In the process of implementing lean principles, poor communication between respective parties will lead to disruption and ineffective delivery and co-ordination process.

INTRODUCTION TO RELATIVE IMPORTANCE INDEX Relative Importance Index

Relative Importance Index method helps to determine the Relative importance of the each factors affecting to occupational health risk. Then five-point scale consist of,

1 – Never
2 – Very rare
3 - Seldom

4 - Frequent
5 - Very Frequent

Ranking of waste materials

No	Waste variables	Frequency		Impact		Weighted	
		Index	rank	index	rank	index	Rank
A	**Repair**	**.425**		**.464**		**.203**	
1	Repair on finishing works	.513	6	.560	5	.287	6
2	Repair on structural works	.467	8	.487	7	.227	11
3	Repair on formwork	.447	10	.440	11	.197	15
4	Repair on foundation works	.237	17	.367	15	.100	22
B	**Waiting**	**.467**		**.531**		**.251**	
1	Waiting for materials	.593	3	.640	3	.380	3
2	Waiting for equipment repair	.513	6	.567	4	.291	5
3	Waiting for equipment to arrive	.453	9	.560	5	.254	8
4	Waiting for prerequisite work	.413	13	.440	9	.182	17
5	Waiting for same crew members	.427	11	.473	8	.202	14
6	Waiting for instructions	.420	12	.507	7	.213	13
7	Waiting for inspection	.447	10	.533	6	.238	10
C	**Material**						
1	Waste of raw materials on site	.533	4	.533	6	.284	7

2	Loss of materials on site	.2	I8	.2	17	.04	25
3	Damaged materials on site	.267	16	.267	16	.071	24
4	Too much material inventory on	.4	14	.333	15	.133	21
5	Material overproduction in site	.333	15	.267	16	.089	23

D	Human resource						
1	Lack of supervision/poor quality	.333	15	.4	9	.133	20
2	Workers resting during construction	.4	14	.533	6	.213	13
3	Tradesman slow /ineffective	.533	5	.533	6	.284	7
4	Idle tradesman	.467	7	.333	13	.155	19
5	Travelling empty handed	.467	7	.467	8	.218	12
6	Unnecessary movement	.4	14	.4	12	.16	18
7	Transporting materials	.6	4	.533	6	.32	4
8	Travelling for tools and information	.467	7	.533	6	.249	9
E	Operations						
1	Accidents on site	.533	5	.6	4	.320	4
2	Schedule delays	.667	2	.867	1	.578	2
3	Equipment frequently breakdown	.467	7	.4	12	.187	15
4	Equipment idle	.733	1	.8	2	.586	1

No	Waste cause variables	INDEX	RANK
A	Material management		
1	Poor quality of materials	.4	5
2	Poor storage of materials	.533	2
3	Poor material handling on site	.411	4
4	Delay of material delivery to site	.6	1
5	Inappropriate/misuse of material	.533	2
B	Design and documentation		
1	Design changes	.467	3
2	Unclear site drawings supplied	.6	1
3	Uncompleted design	.6	1

4	Poor quality site documentation	.533	2
5	Slow drawing revision and distribution	.333	2
6	Poor design	.533	2
7	Unclear specification	.467	3
C	Execution		
1	Inappropriate construction methods	.467	3
2	Equipment shortage	.467	3
3	Poor site layout	.467	3
4	Outdated equipment	.267	6
5	Poor equipment choice or ineffective equipment	.467	3
D	Project management		
1	Poor planning and scheduling	.533	2
2	Lack of adequate training	.533	2
3	Slow in decision making	.6	1
4	Poor co-ordination among project participants	.6	1
E	People		
1	Lack of skilled labour	.467	3
2	Too few supervisors/foremen	.6	1
3	Late information	.533	2
4	Poor distribution of labours	.533	2
5	Inexperienced inspectors	.533	2
F	External		
1	Site condition	.533	2
2	Weather	.467	3

Conclusion:

In this thesis, we had analyzed the general perceptions of construction industry and how the lean construction tools can be used to improve the implementation of these activities particularly in managing construction wastes. As mentioned in this thesis,we developed a process improvement tool using lean construction and we had executed it in two sites.

The following are the advantages that we found by using our Lean technology reduces all forms of non-value added activities and improves its performance.

Lean technology helps to waste elimination method which provides a significant competitive advantage for the participants.

This study yields a methodology for waste detection and improvement of construction process.

This will help to saving in the project cost as saving in the materials.

Each member of the construction supply chain will

be aware of its influence on the overall project.
6. Materials and components can be selected to meet the best needs of supply chain discipline
7. It focus on delivering the value desired by the owner, which primarily leads to the principle "Customer is the King"

8. It is a continual improvement/pursuit of perfection involving everyone in the system
9. Inefficiency and waste in the use of labour and materials will be eliminated .

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