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Development of Lean Construction Tool for Waste Minimization

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Abstract—*India is witnessing tremendous growth in infrastructure and construction development. Construction in India is considered to be one of the largest economic activities contributing to 10% of GDP. It has been seen that the cost of construction is increased faster due to inflation over last few years. 30% of construction cost is caused due to delays, rework, poor management skills and unawareness of new tools and innovations that can help for reducing cost. Growing pressure to achieve better outcome, to reduce losses and to improve output, suggests the use of lean construction techniques which helps reduce supply chain losses, construction costs and shorten project delivery schedules. Lean thinking is a systematic approach to identify and eliminate waste through continuous improvement; it is also a comprehensive set of methodologies based on system of beliefs and principles which lead to maximizing value and minimizing waste.*
Existing literature focuses mainly on defining the lean construction techniques and complexity in implementation of lean techniques in construction field. Study aims at developing the tool which helps identify and measure the wastage and guide in order to reduce waste and to gain the potential benefits which can be obtained in terms of material, time and resources by implementation of lean construction techniques. It mainly focuses on the theory, interviews, time studies and observations to get insight into activities and processes in construction to identify and classify the waste (i.e. Value adding , Non value-adding activities, and Necessary waste) and to prioritize the activities where waste reduction is most important.

Keywords: *Lean thinking, value adding, Non value-adding, Necessary waste*

1. INTRODUCTION

Nowadays, increasing foreign competition, the scarcity of skilled labour and the need to improve construction quality are the key challenges faced by the construction industry. Responding to those challenges imposes an urgent demand to raise productivity, quality and to incorporate new technologies to the industry. A lack of responsiveness can hold back growth, and to development of the needed infrastructure for the construction industry.

Pertaining to the challenges faced by the construction industry, numerous researches and studies had been carried out for the past decades to identify the causes to the construction problems and some of them had suggested and recommend solutions to rectify those identified problems. With the lean construction paradigm, construction industry had started to be reviewed and evaluated in the possibilities of implementing these new lean perspectives of production concepts in the construction processes to optimize the overall construction performance on construction stage as well as design stage. According to the scholars and researchers in Lean Construction, the new construction production philosophy is laid on the concepts of conversion and flow process. Therefore, performance improvement opportunities in construction can then be addressed by adopting waste identification/ reduction strategies. Unfortunately, these new lean construction concepts especially those on wastes and values most of the times are not well understood by construction personnel. Particularly, waste is generally associated with waste of materials in the construction processes while non-value adding activities such as inspection, delays, transportation of materials and others are not recognized as waste. As the result of that, the productivity of construction industry cannot be fully optimized due to the narrow interpretation on the concept of waste which is currently adopted.

By using lean thinking and lean tools and adapting them to the construction industry. Purpose of research study is to develop a tool to identify and measure waste, guide in which order waste should be reduced and by this enabling estimations of potential consequences that might occur by implementing a lean approach at a construction site. This is of interest in order to bridge the research gap between conceptual lean construction and research based on empirical studies. Following are the objectives of research:

1. Identification of types of wastes in construction operations
2. Measurement of identified wastes.
3. To decide in what order the identified waste can be eliminated to get optimum results.
4. Conclude the potential effects of lean approach on a construction site (Economical, Environmental, Work environment).

2. METHODOLOGY DATA COLLECTION

2.1 Research Process

- Literature review
- Interviews
- Observations
- Development of tool
- Validation

Sets of interviews were conducted with different stakeholders participating. These stakeholders are actors within the construction business and people who possess knowledge and expertise in the lean or construction field. Since observations are seen as a source of relatively objective information I performed several field trips to construction sites. These observations have complemented the collected data from the interviews and the literature review. Finding from the literature review, interviews and observations were combined and a tool was developed in how to identify and measure waste, guide in how to prioritize eventual eight waste reduction activities and by this enabling estimation of potential consequences that might occur if lean is implemented.

2.2 Following is the summery of Interviews

Table 1: Types of wastes

Construction	Lean Experts	Construction
Industry		Academics
Practitioner		
Unnecessary	Too much	Unnecessary
Transports	material	Transports
Searching for	Damages losses	Searching for
tools and	defects and theft	tools and
materials		materials
		(downtime due to
		changing tools)
Too much	Waiting on	Too much
material	material	material
Damages, losses	Material waste	Damages, losses
and defects	(redo work due	and defects
	to incorrect	
	processing)	
Waiting on	Unnecessary	Material waste
material	handling of	
	material due to	
	coordination	
	problems	
		Unnecessary
		handling of
		material due to
		coordination
		problems

Table 2: Tools and methods to identify wastes

Construction	Lean Experts	Construction
Industry		Academics
Practitioner		
Process mapping	Process	Process mapping
	mapping	(VSM, frequency
	(VSM, material	analysis-work
	flow mapping)	sampling)
Planning methods	Look at past	Planning methods
(visual planning,	experience and	(visual planning,
last planner etc.)	especially past	last planner ,
	failures	linear planning)
Meetings (team	Total cost	Meetings (team
meetings,	analysis, looks	meetings,
Education and	at direct cost	Education and
teaching)	and overhead	teaching)
	costs	
Regular clean up		
the construction		
site		
Continue visiting		
the site (visual		
inspection)		

Table 3: Different ways in how to measure waste

Construction	Lean Experts	Construction	
Industry		Academics	
Practitioner			
Measure time	Measure time	Measure time	
(measure			
delivery rate)			
Key	Key	Key performance	
performance	performance	indicator(measure	
indicator	indicator	economic,	
(delivery	(delivery	environmental	or
accuracy)	precision,	waste metrics)	
	quality etc.)		
	Measuring cost	Measuring	cost
	(total cost	(compare	costs
	analysis)	between	different
		alternatives)	
Measure	Measure	Measure	
coordination	coordination	coordination	and
and flow (keep	and flow (do an	flow	
count on	situation		
unnecessary	analysis and		
transports and	compare this to		
express	the new		
deliveries)	situation after		
	changes have		
	been		
	implemented)		
	Technical tools		
	(lean navigator,		

		RFID)				
				Percentage		of
				planned	activities	
				completed		

Table 4: Tools and methods in how to prioritize waste

Construction			Lean Experts			Construction				
Industry						Academics				
Practitioner										
Prioritize	what	is	Identified		the	Prioritize	what	is		
most critical at the			root		cause	most critical at the				
moment	(types	of	(ishikawa			moment	(time,			
material)			diagram)			money)				
Discuss	in small		Take	on	easy	Discuss	(listen	to		
mixed groups how			problems		first	construction				
to	prioritize		to		show	workers, they have				
according		to	success stories			a	lot	of		
situation						experience)				
			Look	at	the	Identified the root				
			total cost			cause				

	Start	with	Look at	the total
	processes		cost	
	where	one		
	have the	most		
	control	and		
	power over			
			Larger	problems
			are	analyzed
			whereas	small
			problems are not	

Table 5: Effects of lean approach on construction sites

Construction		**Lean Experts**		**Construction**	
Industry				Academics	
Practitioner					
Improved	work	Improved	work	Improved	work
environment		environment		situation	
(decreased		(safer			
psychological		construction site)			
and	physical				
stress)					
Improved		Improved		Improved	
efficiency	and	efficiency	and	efficiency	and
effectiveness		effectiveness		effectiveness	
(increased		(increased			
production rate,		production	rate,		
more	money to	better	flow,		
the	construction	coordination,			
workers)		handling	of		
		material)			
Increased		Increased		Economical	
commitment		commitment		savings (cheaper	
(positive	attitude			product	or
and				increased profit)	
understanding					
for	change				
projects)					
		Economical		Environmental	
		savings		savings	
				(decreased	
				emission,	less
				material	waste
				and	energy
				consumption)	
		Environmental		Improved quality	
		savings			
		Processes			
		stability			
		(reduction of risk			
		and uncertainties			
		which leads to			
		improved			
		forecasts)			

3. VALUE STREAM MAPPING STUDIES

Value is specified from the perspective of the customer: It's about listening to the Voice of the Customer in order to meet customer requirements. The analysis of time and cost is most effective in defining value. Specifying value and enhancing value for the client needs the understanding of who are the direct clients and the final clients. Value stream is the set of all specific actions required to bring a specific product through the critical management tasks of any business.

The most effective process is achieved by performing the maximum number of value added steps and no non -value added steps. The method to maximize value-added steps in lean practice is through value stream mapping. So, the value stream is "specific activities required to design, order and provide a

specific product from concept to launch, order to delivery, raw material into the hands of the customer. Value Stream Mapping is a Lean technique used to analyze the flow of materials and information currently required to bring a product or service to a consumer.

3.1 Details of site

Company : Omkar Developers **Project** : Splendora

Location : Thane

Name of work : Construction of 13 Residential Towers of G + 10 Floors, and 1 Club House of G + 1 Floor at " Splendora" in Thane, Maharashtra

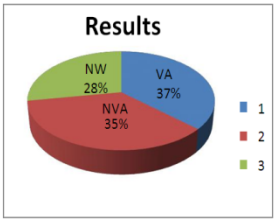
Total Area Sqft : 13.28 L

Current Stage : Under Construction

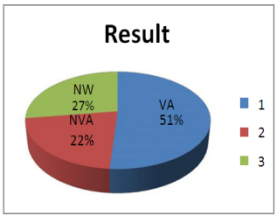
Table 6: Half day VSM study and result

Activity	Description	Classification	Start	End	Duration
walk	walking to site	NVA	9:10:12	9:15:55	0:05:43
material	Handling material and tools	NW	9:15:55	9:19:30	0:03:35
walk	walking to new place	NVA	9:19:30	9:22:10	0:02:40
material	Handling material and tools	NW	9:22:10	9:25:34	0:03:24
discussion	small talk	NVA	9:25:34	9:28:30	0:02:56
walk	walking with tools	NVA	9:28:30	9:35:50	0:07:20
material	Handling material and tools	NW	9:35:50	9:37:05	0:01:15
walk	walking with tools	NVA	9:37:05	9:40:10	0:03:05
material	Handling material and tools	NVA	9:40:10	9:47:25	0:07:15
preparation	processing pipes	VA	9:47:25	9:51:15	0:03:50
discussion	problem solving	NW	9:51:15	9:56:27	0:05:12
walk	picking up tools	NVA	9:56:27	9:59:37	0:03:10
preparation	processing pipes	VA	9:59:37	10:03:50	0:04:13
material	material planning	NW	10:03:50	10:12:11	0:08:21
preparation	processing pipes	VA	10:12:11	10:15:57	0:03:46
waiting	waiting on colleague	NVA	10:15:57	10:18:37	0:02:40
preparation	processing pipes	VA	10:18:37	10:22:53	0:04:16
material	Handling tools	NW	10:22:53	10:28:21	0:05:28
discussion	small talk	NVA	10:28:21	10:30:10	0:01:49
walk	walking away with tools	NVA	10:30:10	10:34:47	0:04:37
material	looking for material	NVA	10:34:47	10:39:17	0:04:30
discussion	problem solving	NW	10:39:17	10:43:28	0:04:11
waiting	waiting on colleague	NVA	10:43:28	10:46:50	0:03:22
construct	assembling pipes	VA	10:46:50	10:49:55	0:03:05
discussion	problem solving	NW	10:49:55	10:50:04	0:00:09
walk	going for tools	NVA	10:50:04	10:53:12	0:03:08
material	picking up tools and materials	NW	10:53:12	10:54:45	0:01:33
walk	going back with materials and tools	NVA	10:54:45	10:58:27	0:03:42
discussion	problem solving	NW	10:58:27	11:04:52	0:06:25
preparation	processing pipes	VA	11:04:52	11:09:41	0:04:49
discussion	small talk	NVA	11:09:41	11:12:22	0:02:41
construct	fitting	VA	11:12:22	11:16:14	0:03:52
material	Handling material	NW	11:16:14	11:17:27	0:01:13
discussion	problem solving	NW	11:17:27	11:19:10	0:01:43
construct	drilling and processing pipes	VA	11:19:10	11:22:47	0:03:37
walk	going after material	NVA	11:22:47	11:25:06	0:02:19
material	picking up suitable pipes	NW	11:25:06	11:28:13	0:03:07

walk	going back	NVA	11:28:13	11:36:53	0:08:40
material	material handling and	NW	11:36:53	11:39:36	0:02:43
	measuring				
discussion	problem solving	NW	11:39:36	11:42:18	0:02:42
material	Handling material and tools	NW	11:42:18	11:43:05	0:00:47
preparation	cutting pipes	VA	11:43:05	11:48:00	0:04:55
material	looking for tools	NVA	11:48:00	11:48:50	0:00:50
preparation	processing pipes	VA	11:48:50	11:50:04	0:01:14
break	taking a break	NVA	11:50:04	12:08:13	0:18:09
walk	going up to on loft	NVA	12:08:13	12:18:40	0:10:27
discussion	problem solving	NW	12:18:40	12:20:30	0:01:50
walk	searching for colleague	NVA	12:20:30	12:25:12	0:04:42
discussion	small talk	NVA	12:25:12	12:28:39	0:03:27
material	looking for tools and material	NVA	12:28:39	12:29:13	0:00:34
walk	going back with materials and	NVA	12:29:13	12:30:38	0:01:25
	tools				
preparation	processing pipes	VA	12:30:38	12:45:20	0:14:42
discussion	small talk	NVA	12:45:20	12:46:30	0:01:10
preparation	processing pipes	VA	12:46:30	12:47:50	0:01:20
material	handling material	NW	12:47:50	12:48:30	0:00:40
				Total :-	3:38:18
				VA :-	00:53:39
				NVA :-	1:50:21
				NW :-	00:54:18
			`		



Result before application of tool (full day)



Result after application of tool (full day)

4. CONCLUSION

The industry struggles with insufficient processes leaving much to be desired. In order to meet this challenge the construction industry must become more efficient by using fewer resources. Small changes in the operational costs by reducing waste, which improves the efficiency, can make substantially changes in profit. The lean construction tool explains how to identify wastes and measure the wastes through the use of value stream mapping, interviews and observations. Furthermore, the lean construction tool aims to guide in what order waste should be reduced by suggesting the use of pareto analysis.

A part of the lean construction tool is to conduct VSM studies which is done in this study is to be a simple and powerful tool to use in the construction industry. These VSMs showed the inefficiency in the industry where value added work was approximately 37% of the workers time. This has financial implication not only the each individual project but also construction industry as a whole and entire national economy. Increasing the value adding work from 37% to 50% will save 1.5% of project cost, this is small amount for individual project but it is very huge when considered for whole construction industry and share of construction industry in India's GDP.

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