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Lean Technology And Waste Minimization In Construction Industry Using SPSS

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Abstract: ***Waste in construction projects indicate that waste can arise at any stage of the construction process from beginning, right through the design, construction and operation of the built facility. Waste in the construction industry has been the subject of numerous research projects around the world in recent years. It is commonly recognized that a very high level of waste subsists in construction. The following factors are considered to reduce the waste in the construction industry such as site time and cost. The objective of this study is to minimize the construction waste through lean construction principles and improve the site productivity using work sampling. Lean Construction considers construction wastes as potential wastes that hinder flow of value to the client and should be eliminated. Mapping out the activities in the manufacturing process with cycle time, downtime, in process inventory, material moves, information flow paths, helps to envision the current state of the process activities and guide towards the future desired state. The process usually includes the physically mapping of the current state while also flowing on where you get to or the future state map, which can serve as the foundation for the other lean strategies. 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.***

Keywords: Lean Technology, Waste Minimization, Construction Industry, SPSS

1. INTRODUCTION

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. It is also a holistic design and delivery philosophy with an overarching aim of maximizing value to all stakeholders through systematic, synergistic and continuous improvements in the contractual arrangements, product design and method of selection, the supply chain and the workflow reliability of site operations. The construction industry lags far more years behind the manufacturing industry because of the several reasons. The prime reason it is being split approach rather than a mixed approach. The other reason is that the construction industry is more complex than the manufacturing industry and therefore development of technical modernization is to be implemented significantly. Lean construction is a new production methodology which 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.

Lean construction much like current practice has the goal of better meeting customer needs while using less of everything. But unlike current practice, lean construction rests on production management principles, the "Physics" of construction. The result is a new project delivery system that can be applied to any kind of construction but is particularly suited for complex, uncertain, and quick projects. Waste elimination is one of the effective ways to increase the profit of any industry. Construction waste consists of unwanted and undesired materials produced directly or indirectly by various construction processes. Lean construction (LC) is technique which aims to eliminate all defects and minimize wastage of materials, time and effort in order to generate the maximum possible amount of value by using less input. Less inputs includes: less labour, less machinery, less space, less time etc...The methodology of Lean Construction is to minimize the bad and maximize the good. It include a clear setoff objectives for maximizing the benefits through concurrent design of construction facilities and processes. In Lean Construction, materials are available on site only at the time when it is required.

- Roads
- Railways
- Urban infrastructure
- Ports
- Airports

Lean construction has been introduced as a new management approach to improve the productivity in construction industry. Lot of researches is going on towards the lean concepts and principles to get results of the successful adaption of lean ideas from car manufacturing industry to the construction industry. The construction companies struggling to transform their current forms of project management into the lean management approach.

1.1 Objective of the Study

- Access lean construction from the view point of various project participants.

- Identify the benefits and barriers associated with lean implementation.
- To identify and analyze the defects in construction using Lean six sigma approach and SPSS software.
- To evaluate Lean six sigma as a process improvement method to improve the various works during construction.

1.2 Scope of the Study

- Lean Six Sigma provides structured methods of improvement to reduce waste, reduce cost, reduce lead times, promote concurrent work and to improve planning and control.
- Improve the quality, reduces rework and implementation time.
- Identification of waste in construction process
- Deliver a custom product instantly, without waste.

1.3 Construction Waste

Construction and demolition waste has been defined as wastage which are arising from construction, renovation , explosion activities ,surplus and damaged products and material arising in the course of construction work and on site work. Waste in construction is important not only from the perspective of productivity but also from the environmental considerations. Many times actual percentage of waste generation is much higher than envisaged initially causing needless utilization of resources. It means there is a plenty of scope for enhancing project productivity simply by taking waste out of construction. Construction waste once generated is difficult to recycle and reuse due to high level of contamination and heterogeneity. Researchers see waste as a non-value adding activity that always negatively affects project performance in the form of cost overruns and delays. C&D debris means the waste that gets generated in construction, renovation, or demolition processes.

1.4 Lean

Lean means to derive more value by using less of everything. Production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination.

2. METHODOLOGY

Figure 1 shows the methodology of the study

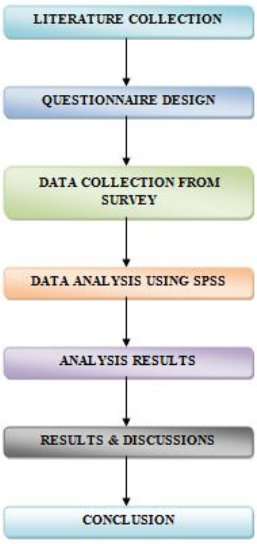

Figure 1 Methodology

3. LEAN TECHNOLOGY

3.1 Lean Principles

- Perfect first- time quality - Achieve zero defects, revealing and solving problems at the source.
- Waste minimization - Eliminating all non-value adding activities and maximizing the use of resources.
- Continuous improvement - Reduction of costs, increase quality and productivity.
- Pull processing - Products pulled from the consumer end, i.e. not pushed from the production end.
- Flexibility - The production of different mixes and/ or greater diversity of products, without compromising efficiency.
- Relationships - Building and maintaining long-term relationships with suppliers.

3.1.1 Value Stream Analysis

A value stream is all the actions, both value added and non -value added, currently required to complete a product or service from beginning to end. Value adding Activities (VA) - It generates a positive return on the investment of resources and cannot be eliminated without impairing a process. Non Value adding Activities (NVA) - It generates a zero or negative return on investment of resources and usually can be eliminated without impairing a process.

3.2 Classification of Activities

3.2.1 Construct

When a construction worker performs an activity that is value adding, e.g. pouring concrete or processing the material, the activity should be registered as construct

3.2.2 Material Handling

Whenever material needed to be transported or moved in some way at the construction site it was registered as material handling. Tools were more or less also moved

along with material thus tool handling came to be registered as material handling as well.

3.2.3 Discussion

Every time a conversation was started it was registered as discussion. However, the sort of discussion varied mainly between two types; (1) problem solving and (2) small talk. One can see the first one as necessary waste since the discussion is needed to be able to precede the construction in a correct way whereas the small talk is pure waste given that it has nothing to do with the construction work. If discussion and walk happened simultaneously the discussion is registered and appropriate time is noted in order to avoid missing out on problem solving conversations.

3.3 Lean Construction

Lean construction is defined as the continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire stream and pursuing perfection in the execution of the project work. Figure 2 shows the lean principals

Figure 2 Lean principals

Table 1 shows the Comparison of Lean and Traditional Production

Table 1 Comparison of Lean and Traditional Production

	Traditional production	Lean production
Scheduling	Forecast-product is pushed through facility	Customer order-product is pulled through facility
Production	Replenish finished goods inventory	Fill customer orders only
Product cycle times	Long-weeks/months	Short-hours/days
Batch size	Large batches moving between operations: product is sent	Small and based on one –piece flow between operations

3.3.1 Benefits of Lean Construction

- More satisfied clients,
- Productivity gains,
- Greater predictability,
- Shorter construction periods
- Improved design
- Reduced cost and less waste.

3.4 Waste Elimination

Waste elimination is very important process in the construction industries to improve the quality and profit of the project. Waste may be produced directly or indirectly during the construction in the construction industry.

3.5 Types of Waste

3.5.1 Sources of Construction Waste

3.5.1.1 Overproduction

Related to the production of a quantity greater than required or earlier than necessary. This may cause waste of materials, man-hours or equipment usage. It usually produces inventories of unfinished products or even their total loss, in the case of materials that can deteriorate. An example of this kind of waste is the overproduction of mortar that cannot be used on time.

3.5.1.2 Substitution

Related to the substitution of a material by a more expensive one (with an unnecessary better performance); the execution of simple tasks by an over-qualified worker; or the use of highly sophisticated equipment where a much simpler one would be enough.

3.5.1.3 Waiting time

Related to the idle time caused by lack of synchronization and leveling of material flows, and pace of work by different groups or equipment. One example is the idle time caused by the lack of material or by lack of work place available for a gang.

3.5.1.4 Transportation

Concerned with the internal movement of materials on site. Excessive handling, the use of inadequate equipment or bad conditions of pathways can cause this kind of waste. It is usually related to poor layout, and the lack of planning of material flows. Its main consequences are: waste of man hours, waste of energy, waste of space on site, and the possibility of material waste during transportation.

3.5.1.5 Production of defective products

It occurs when the final or intermediate product does not fit the quality of specifications. This may lead to rework or to the incorporation of unnecessary materials to the building (indirect waste), such as the excessive thickness of plastering. It can be caused by a wide range of reasons: poor design and specification, lack of planning and control, poor qualification of the team work, lack of integration between design and production, etc.

3.5.1.6 Inventories

Related to excessive or unnecessary inventories which lead to material waste (by deterioration, losses due to inadequate

stock conditions on site, robbery, vandalism), and monetary losses due to the capital that is tied up. It might be a result of lack of resource planning or uncertainty on the estimation of quantities.

3.5.1.7 Inappropriate processing

This waste is about taking unnecessary steps to process the parts. Inappropriate processing can for instance be depicted as using expensive highly advanced equipment where simple tools would be sufficient to do the work. The over complexity generally discourages ownership and encourages the employees to overproduce so that the large investment in the complex machines can be recovered.

3.6 Waste Minimization in Construction

The building industry is using a considerable amount of resources, but if the life cycle of the material on site is closely examined, it is generally known that there is a relatively large portion of the materials being wasted because of poor material control on building sites. Re-use is a form of waste reduction that: (1) extends resource supplies; (2) keeps high-quality-matter resources from being reduced to low-matter-quality waste; and (3) reduces energy and pollution even more than recycling. On the other hand, recycling waste without properly based scientific research and development can result in environmental problems greater than the waste itself. The successful research and development of new building materials or components using waste as raw material, is a complex and multidisciplinary task, including technical, environmental, financial, marketing, legal and social aspects.

3.6.1 Recycling

Recycling is commonly defined as a process of separating recyclable materials from non-recyclable materials and supplying them to a hauler or business so they can be processed to make new products. Buying building materials with recycled content helps develop a market for the waste material one recycles from the job site.

3.7 The Benefits of Minimizing Waste

- Reducing demand for landfill space;
- Saving resources and energy;
- Reducing pollution; and
- Increasing the efficiency of production.

3.7.1 Financial Benefits

Waste minimization can provide financial benefits, and in some cases can even save cost and time. The financial benefits can be appreciated over a short term or long-term period. But overall, cost benefits can be appreciated throughout the whole building process by carrying out an analysis of the life cycle costs. Financial benefits include: Reduced transportation costs for waste materials (less transportation because of less material wasted). This includes transportation to and from the site and disposal.

- Reduced disposal costs of waste materials.
- Reduced purchase quantity and price of raw materials by waste minimization.
- Reduced purchase price of new materials when considering reuse and recycling (depending on materials).
- Increased returns can be achieved by selling waste materials to be reused and recycled.

3.7.2 Environmental Benefits

Waste minimization can provide environmental benefits, which are important to be considered due to the alarming situation of materials waste on construction sites.

- Reduced quantity of waste generated.
- Efficient use of waste generated.
- Reduced environmental effects as a result of disposal, e.g. noise, pollution.

3.8 Waste Minimization Measures

- Purchasing raw materials that are just sufficient
- Using materials before expiry dates
- Use of more efficient construction equipment
- Good coordination between store and construction personnel to avoid over ordering
- Adoption of proper site management techniques
- Accurate and good specifications of materials to avoid wrong ordering
- Checking materials supplied for right quantities and volumes
- Change of attitude of workers towards the handling of materials
- Mixing, transporting and placing concrete at the appropriate time
- Waste management officer or personnel employed to handle waste issues

3.9 Identification of Waste

In this step, the wastages which produced during the project are to be identified and examined, causes are analyzed. Based on the questionnaire survey collected from the companies they are cluster together and formulated related to their usage and divided in to seven categories as follows,

- Resource Wastes
- Management Related Waste
- Design Related Waste
- Operational Related Waste
- Waste due to Labour
- Waste while Procurement
- Miscellaneous Waste

The bar and pie chart prepared by using quantitative method. The following bar and pie chart showing the percentage of waste occurred in construction industry. The questionnaire survey was carried out among 70 companies in various parts of Tamil Nadu in India. The following

result are obtained based on the questionnaire survey is shown in figure for each wastes.

3.9.1 Resource Waste

The resource waste (cement, brick, steel etc.) is the major problems in the construction sites. It's calculable that on the average construction resource waste constitutes 15-30% of the entire construction sites. It happens frequently in all sites because of carelessness of unskilled labours.

3.9.2 Operational Waste

Operational waste mainly happens due to error by trade person or laborer, equipment malfunction, Equipment frequently break down, Unreliable equipment, inclement climate, accidents, damages caused by subsequent trades, use of incorrect material requiring replacement etc.

3.9.3 Design Waste

Mostly it happens due to error in contract documents, incomplete at the commencement of project, change in design after commencement of project. Designers have to be compelled to embody rationalization of specification in every material and element that's required within the contract. Sometimes, ordered material cannot attain the location on time, forcing them to use substitute material terribly very short time. With a restricted time, designers are susceptible to opt for material that's low in quality rather than the initial demand.

3.10 Problem Identification

A problem arise when there is a distinction between what "should be" and what "is"; between the optimal and the definite situation. A problem expresses the difference between the hoped for and the actual situation. It is directly or indirectly related to an expected outcome or standard of behaviour. Identifying a very clearly characterized and exact problem is the first step to implement the problem solving process successfully. The problems identified in this research are:

- Lack of materials due to waste,
- Transport difficulties
- Improve handling on site,
- Lack of work plan
- Delays due to climate changes
- Equipment break downs
- Poor work planning
- Repeated work
- High labour turn over
- Poor communication

It was seen how the complexity of the building greatly affected the amount of work. In addition, it was observed quiet often that the workers disregard for the little things like screw, nuts and bolts. The workers need to be made aware of waste in construction and how their actions affect their work environment, cost, time and ultimately, customer satisfaction. Waiting and unnecessary movements were also identified .Waiting could be for material but for tools and colleagues as well. Unnecessary movement was a type of waste that was very visible during the observations. A great deal of time was spent searching for tools, material, colleagues or walking back and forth for different reasons.

4. ABOUT SOFTWARE

Statistical Package for Social sciences is software used for executing analysis in social sciences. It is also used by market, education and health researchers and also various organizations. The 'Data View' shows a spreadsheet using rows and columns. The following table shows the mean, Standard deviation and rank of the major seven lean wastes. These values are obtained as a result of the responses obtained from the Respondents of 25 Construction companies and the obtained data's reanalyzed and ranked using the software.

Originally it is an acronym of Statistical Package for the Social Science but now it stands for Statistical Product and Service Solutions. One of the most popular statistical packages which can perform highly complex data manipulation and analysis with simple instructions.

SPSS given the technique of specialize in design, development, and implementation of corporate analytical and data mining solution integrated with the existing data acquisition and storage of systems. It's continuously given the solution in Pharmaceutical and Medical research.

- Quality and Manufacturing.
- Compliance and Validation.
- Empower Researcher with Tools.
- Regulatory Safety Testing.
- Clinical Trails.
- Data Mining in Drug Discovery.

SPSS Statistics places constraints on internal file structure, data types, data processing, and matching files, which together considerably simplify programming. SPSS data sets have a two-dimensional table structure, where the rows typically represent cases (such as individuals or households) and the columns represent measurements (such as age, sex, or household income). Only two data types are defined: numeric and text (or "string").All data processing occurs sequentially case-by-case through the file (dataset).Files can be matched one-to-oneandone-to-many, butnotmany-to-many.Inadditiontothatcases- by-variables structure and processing, there is a separate Matrix session where one can process data as matrices using matrix and linear algebra operations. The graphical user interface has two views which can be toggled by clicking on one of the two tabs in the bottom left of the SPSS Statistics window.

The 'Data View' shows a spreadsheet view of the cases (rows) and variables (columns). Unlike spreadsheets, the data cells can only contain numbers or text, and formulas cannot be stored in these cells. The 'Variable View' displays the metadata dictionary where each row represents a variable and shows the variable name,

variable label, value label(s), print width, measurement type, and a variety of other characteristics. Cells in both views can be manually edited, defining the file structure and allowing data entry without using command syntax. This may be sufficient for small datasets. Larger datasets such as statistical surveys are more often created in data entry software, or entered during computer-assisted personal interviewing, by scanning and using optical character recognition and recognition software, or by direct capture from online questionnaires. These datasets are then read into SPSS.

5. QUESTIONNAIRE

The preliminary structure of this questionnaire is consists of around 50 questions and its categorized in 4 types such as general, Waste causes in construction, Waste generation, Lean practice. The design of questionnaire was prepared by using Multi response. Like (1 - Strongly disagree, 2-disagree,3-Neutral ,4 -agree,5- Strongly agree).The prepared questionnaires were given to the various project participants from management level to labour level (Project Manager, Design Engineers, Executive Engineers, Supervisors and Labours).

5.1 Personal Details

1. Name :
2. Age :
3. Designation :
4. Type of projects :
5. Company Turnover :

5.2 General

6. Lean construction Technique is increase productivity Compared to conventional techniques?
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

7. Waste minimization enhances the productivity in Construction activity?
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

8. Conventional system of construction is it sustainable?
- Yes
- No

9. Which is the Major problem faced by construction Industry?
- Global economic climate
- Environmental hazards
- Labor delayed projects
- Zero margin contract bids
- Others

10. Unfriendly attitudes of project team and labors errors affects the construction productivity?
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

5.3 Waste Causes in Construction

11. Complexity of detailing in the drawings
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

12. Overlapping of design and construction
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

13. Selection of low quality products also one of the reason for increasing waste?
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

14. Unfriendly attitudes of project team and labors errors
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

15. Inappropriate placement of the material
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

16. Poor technology of equipment will decrease the productivity?
- Strongly disagree
- Disagree
- Neutral

- Agree
- Strongly Agree

5.4 Waste Generation

17. Waste due to Improper Planning of Construction?
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

18. Waste due to irregular Cash Flow?
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

19. Waste produced due to over ordering & over production?
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

20. Waste due to re-work
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

21. Insufficient instructions about handling
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

22. Using excessive quantities of materials than required?
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

23. Damage to materials on site during transportation
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

24. Overproduction/ production of a quantity greater or required than necessary
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

25. Effects of political and social conditions create impact in waste Generation?
- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

5.5 Lean Practice

Table 2 shows the Scale - lean implementation in your organization

Table 2: Scale - lean implementation in your organization

S.No	Lean practice	Very poor	Poor	Fair	Good	Very good
1	Preventive maintenance					
2	JIT/continuous flow production					
3.	Cycle time reduction					
4.	Zero defects					
5.	Scrap reduction					
6.	Setup time reduction/quick changeover techniques					
7.	Inventory management					
8.	Supply chain management					
9.	Human resource management					
10.	Decrease in manufacturing cost/unit cost of manufacturing					
11.	Increase in growth rate in unit sales					
12.	Increase in sales per employee					
13.	Decrease in delivery speed /delivery lead time					
14.	Decrease in manufacturing cycle time					
15.	Decrease in defect rate/rejection rate / % rejection					
16.	Increase in labor productivity					
17.	Increase in employee satisfaction					
18.	Increase in customer satisfaction					
19.	Decrease in % of time machines are standing due to malfunction					
20.	Increase in customer return rates/customer retention					

6. SPSS RESULTS

6.1 Frequency Analysis

Table 3 shows SPSS results for comparison b/w lean & conventional

Table 3: SPSS results for comparison b/w lean & conventional

Lean construction Technique is increase productivity compared to conventional					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	16.0	16.0	16.0
	Disagree	5	20.0	20.0	36.0
	Neutral	6	24.0	24.0	60.0
	Agree	5	20.0	20.0	80.0
	Strongly Agree	5	20.0	20.0	100.0
	Total	25	100.0	100.0	

Figure 3 shows the pie chart of the comparison results.

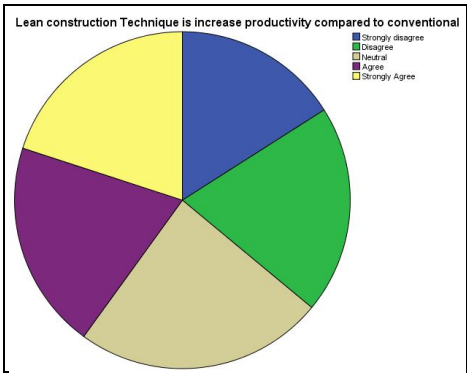

Figure 3 Pie chart shows the comparison results

Table 4 shows the SPSS Results for sustainability of conventional system

Table 4: SPSS Results for sustainability of conventional system

Conventional system of construction is it sustainable					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	16.0	16.0	16.0
	Disagree	4	16.0	16.0	32.0
	Neutral	4	16.0	16.0	48.0
	Agree	7	28.0	28.0	76.0
	Strongly Agree	6	24.0	24.0	100.0
	Total	25	100.0	100.0	

Figure 4 shows the Pie chart shows the sustainability of conventional system

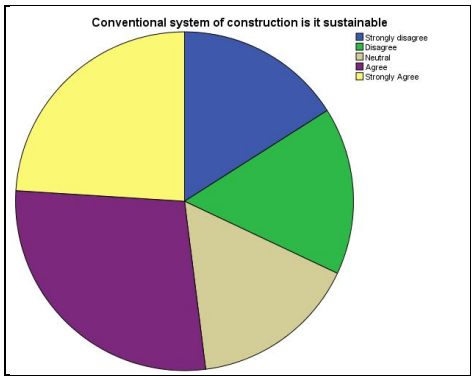

Figure 4 Pie chart shows the sustainability of conventional system

Table 5 shows the SPSS Results for Major problem in construction industry

Table 5: SPSS Results for Major problem in construction industry

Which is the Major problem faced by construction industry					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Global economic climate	6	24.0	24.0	24.0
	Environmental hazards	6	24.0	24.0	48.0
	Labor delayed projects	4	16.0	16.0	64.0
	Zero margin contract bids	3	12.0	12.0	76.0
	Others	6	24.0	24.0	100.0
	Total	25	100.0	100.0	

Figure 5 shows the Pie chart shows the Major problem in construction industry

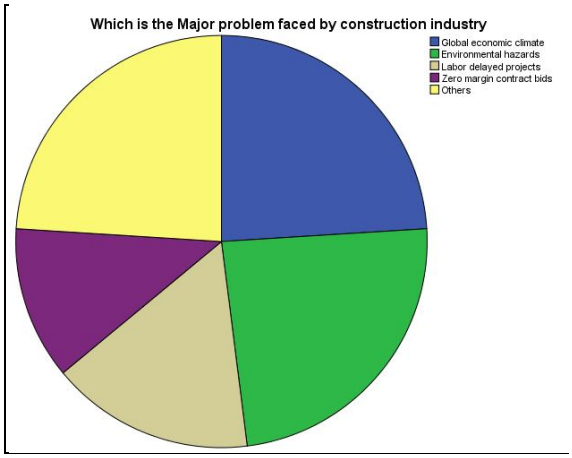

Figure 5 Pie chart shows the Major problem in construction industry

6.2 Anova Results

Table 6 shows the ANOVA results

Table 6: ANOVA Results

ANOVA								
				Sum of Squares	df	Mean Square	F	Sig.
Lean construction Technique is increase productivity compared to conventional	Between Groups	(Combined)		23.640	4	5.910	5.324	.004
		Linear Term	Unweighted	1.286	1	1.286	1.159	.295
			Weighted	1.470	1	1.470	1.324	.263
			Deviation	22.170	3	7.390	6.658	.003
	Within Groups			22.200	20	1.110		
	Total			45.840	24			
Waste minimization enhances the productivity in construction activity	Between Groups	(Combined)		7.950	4	1.988	1.323	.296
		Linear Term	Unweighted	.302	1	.302	.201	.659
			Weighted	.083	1	.083	.055	.816
			Deviation	7.867	3	2.622	1.745	.190
	Within Groups			30.050	20	1.503		
	Total			38.000	24			
Waste due to Improper Planning of Construction.?	Between Groups	(Combined)		24.423	4	6.106	4.328	.011
		Linear Term	Unweighted	1.676	1	1.676	1.188	.289
			Weighted	3.203	1	3.203	2.271	.147
			Deviation	21.220	3	7.073	5.014	.009
	Within Groups			28.217	20	1.411		
	Total			52.640	24			
	Total			44.000	24			

6.3 Descriptive Statistics

Table 7 shows the Descriptive statistics results in SPSS

Table 7: Descriptive Statistics results in SPSS

Descriptive Statistics			
	Mean	Std. Deviation	Analysis N
Lean construction Technique is increase productivity compared to conventional	3.0800	1.38203	25
Waste minimization enhances the productivity in construction activity	3.0000	1.25831	25
Waste due to Improper Planning of Construction.?	3.1200	1.48099	25
Waste due to irregular Cash Flow?	2.8400	1.49108	25
Waste produced due to over ordering & over production?	3.1200	1.39403	25
Damage to materials on site during transportation	3.2000	1.35401	25
Overproduction/ production of a quantity greater or required than necessary	2.4800	1.58430	25
Effects of political and social conditions create impact in waste Generation.?	2.6800	1.28193	25

6.4 Correlation Matrix

Table 8 shows the Correlation Matrix results in SPSS

Table 8: Correlation Matrix results in SPSS

Correlation Matrix				
		Lean construction Technique is increase productivity compared to conventional	Waste minimization enhances the productivity in construction activity	Waste due to Improper Planning of Construction.?
Correlation	Lean construction Technique is increase productivity compared to conventional	1.000	.096	.117
	Waste minimization enhances the productivity in construction activity	.096	1.000	-.224
	Waste due to Improper Planning of Construction.?	.117	-.224	1.000
	Waste due to irregular Cash Flow?	-.135	.222	-.142
	Waste produced due to over ordering & over production?	-.394	-.048	-.108
	Damage to materials on site during transportation	-.454	-.098	.071
	Overproduction/ production of a quantity greater or required than necessary	.229	-.376	-.345
	Effects of political and social conditions create impact in waste Generation.?	.086	.232	.065

Table 9 shows the Principal component analysis

Table 9: Principal component analysis

Communalities		
	Initial	Extraction
Lean construction Technique is increase productivity compared to conventional	1.000	.725
Waste minimization enhances the productivity in construction activity	1.000	.811
Waste due to Improper Planning of Construction.?	1.000	.802
Waste due to irregular Cash Flow?	1.000	.859
Waste produced due to over ordering & over production?	1.000	.836
Damage to materials on site during transportation	1.000	.684
Overproduction/ production of a quantity greater or required than necessary	1.000	.900
Effects of political and social conditions create impact in waste Generation.?	1.000	.664

7. RESULT 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. 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.

From the above results frequency analysis respondents response for both lean technology vs conventional are equal percentage (24%),from descriptive statistics analysis reason for waste is Overproduction/ production of a quantity greater or required than necessary(Std. Deviation = 1.58430, Mean = 2.4800),Waste due to irregular Cash Flow (Std. Deviation =1.49108, Mean = 2.8400)

8. CONCLUSION

Based on the work carried out it is found that 70% of companies accepted the criteria that wastes are generated in the construction industry which is accepted by the companies according to the responds of the various project participants in construction industry. 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. The most affected factors are identified by ranking using Statistical Package for Social Sciences analysis. The establishment of the incidence of non – value added activities during the process enables the construction managers to identify the best actions and paths to apply new techniques for reducing waste, leading to process improvement. 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.

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