

## Expansion of a Cohesive Appliance for a Cost Effective Road Construction Process using Lean Constructions

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### ABSTRACT

The interconnection of activities required for the design and construction of building and infrastructure involves the interplay between people, technology, situations, and decisions. It requires the astute coordination of labor, materials, and plant to realize the planned progress of work. Minimizing waste and maximizing value while continuous improvement is the concept of lean. Lean construction has proven to be an alternative for such improvements so as the satisfy client by creating customer value. Through its origins in the Toyota Production System, lean is now applied as an innovative way to manage the design and construction of projects with the use of tools which address project constraints, such as complexities and uncertainties, among others. This research is an effort to implement lean construction concept to the Sri Lankan road construction industry.

Research approach involved the use of primary data, collected from Questionnaire survey and semi-structured interviews with qualitative and quantitative mixed type research. The foremost objective was to optimize the cost, quality and time in road construction with the application of lean construction concept and identify most important lean tool among 5S, Construction process analysis, just in time, Value stream mapping, Kanban and last planner and adapted to road construction industry. Finally, the aim is to identify the most important lean construction tool for road construction improvement.

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### Introduction

The construction sector is tainted with a bad image and has a significant impact on the economic situation of a country. Claims for better and optimized processes are existent. The special properties of construction projects, especially their uniqueness, require a holistic understanding and make an adoption of the project team regarding the concerned context essential. A new way of thinking develops to cope with the complex and dynamic features. Lean has its roots in the manufacturing processes of the car industry [1].

The concept of lean was initially governed in the manufacturing field in 1950 based on the Toyota Motor manufacturing system in Japan. In the 1980s, Lean manufacturing came full circle, as struggling in U.S. automakers took the announcement of Toyota's rapid efficiency imported and increases its ideas back to the U.S., although with inconsistent commitment [2].

Lean construction is one of the most important reasonably new fashions in the construction industry. In recent years, innovations and several tools became a huge part of the lean construction, until now overshadowed the lean construction principle [3]. Lean is minimizing waste and maximizing value while continuous

improvement. In the construction field, there are so many wastages rather than other industries. Lean thinking is a novel technique to manage construction activities. Several people object on initial experience since lean concept seems to be applying for a manufacturing industry to the construction industry. Sole reply to the advice and argument that "construction is different" is to improve and make construction similar to the manufacturing over and done with superior standardizations [4].

Optimize the cost, quality and time in road construction with the application of lean construction concept is the problem statement which is identified for this research. The lean concept is a method of project delivery and it is to reduce wastage and gain more profit. The goal of this concept is to provide customer satisfaction as a final result of the cost optimization. In road construction, projects are disbursed high cost and those are highly technically planned projects. Identify most important lean construction tool for the construction industry among 5S, construction process analysis, Value stream mapping, Kanban, last planner and just in time is the main objective of this research.

### Literature Review

Lean Construction concept is an extended concept of a Lean manufacturing system that minimizes waste and maximizes value to specific methods in project delivery procedure [5]. Waste is known as a non-value adding activity according to

lean construction. The main purpose is to calculate the waste associated with the construction projects and give solutions for optimizing the cost, quality and time. In construction projects, this lean construction must be implemented inaugurated within the appraisal stage according to the Royal Institute of British Architects (RIBA) Outline Plan of Work.

The terms ‘value’ and ‘waste’ usually have economic connotations. For instance, the value is the price of client payments for a mandatory product or service, and waste is a redundant cost, that the client can decline payment for [6]. The cost of waste can take the form of ‘direct cost’, where production resources are wasted, and ‘indirect cost’, such as low return on investment, as a result of excessive inventory and low output [7]. It is also noting value that activity that does not enhance value but it is essential under an operative complaint constitutes an indirect waste. By contrast, a clear instance of unwanted thing is an activity that does not add value and it is not necessary, and wherever clients’ willingness to reimbursement for such activity is indeterminate. This explanation, therefore, suggests that value-adding activities should be enhanced, hidden wastes should be made visible and diminished as far as possible, and clear instances of waste should be eliminated in the construction process [6].

The journal Aakanksha Ingle mentioned that lean construction advances the productivity and enhances the waste minimization, and they discuss how the lean concept integrated with the waste minimization. According to Abdelrazig in 2015 they specialized into one area and afford what are the techniques interrelated to this construction building information modeling link with lean production management [8]. This research is limited to six number of lean construction tool [9].

There are a number of researchers, reporters, and authors allure to introduce the lean concept into the whole world. They derive this concept with the beginning of the manufacturing industry to all industry. This is a small step to Integrate lean construction concept to the Sri Lankan road construction projects.

### Methodology

The methodology is the foremost laborious and most complicated part of the research. Basically, the methodology helps to distinguish the broad philosophical approach behind strategies of research what we selected to use for study. This implies that the methodology chapter ought to clearly state whether or not selected to use quantitative or qualitative information assortment techniques or a mix of both qualitative approach and quantitative approach. Needed to supply justifications on why most a chosen method or explicit technique over the others. If making an attempt to work out specifically how to write methodology or the way to structure methodology of analysis or treatise then this text can purpose within the correct direction.

In this research used two types of data collection method. Those are conducting interviews and Questionnaires. In questioner mainly focus about what are the strategies used to integrate lean concept in Sri Lanka, to observe the strategies used to integrate lean concept in Sri Lankan road construction to optimize cost quality and time and Identify lean construction concept and how it implemented the road construction. When conducting interviews mainly focus to them to investigate the advantages and disadvantages of road construction with the integration of lean construction concept, what is the lean construction concept and how it involves the road construction, what are the most burning problems related to wastage in road construction?, and what are the pros and cons

of road construction with the integration of lean manufacturing concept?.

In sixteen question got an opinion about what are the most important lean tools used in road construction project. Basically, it is based on 5S, Construction Process Analysis, Value stream mapping, Kanban (Pull System), Last planner and Just in time. To prove this, insert all the data for RII. Then we can collect data through the respondents in the detailed questionnaire as the sequenced order. It selects the most important tool used for implementing lean construction concept in road construction projects. Then it gives a clear consideration to determine the most effective lean tool in the road project. Formula is,

$$RII = \frac{\sum w}{A * N}$$

W = weighting given to each factor by the respondents (ranging from 1 to 5)

A = Highest weight (i.e. 5 in this case)

N = Total number of respondents

The importance factor categorized as very unimportant, unimportant, neutral, important and very important for 1, 2, 3, 4 and 5.

### Analysis

Under methodology chapter has been divided all methods, surveys and approaches used to implement the novel concept to the Sri Lankan road construction industry. This chapter demonstrate all the information gathering procedures, validation of the collected information and interpret how this lean concept is implemented in Sri Lankan road construction industry and finally discuss the obtained results. This analysis chapter explains utilization of the lean construction concept and presents the results of this thesis. To evaluate the pair-wise comparison questions judged by the construction industry professionals’ experience, first the most dominant preference has to be determined for every pair-wise in each level. For this research I collected 86 numbers of responses from the construction industry professionals. The validation of the questionnaire progressed through three number of research objectives. Identify lean construction concept and how it is implemented the road construction, to investigate the advantages and disadvantages of road construction with the integration of lean construction concept and to observe the strategies used to integrate lean concept in Sri Lankan road construction to optimize cost, quality and time are the main objectives that this research is based on. According to this research, first I got the overall sample of the knowledge and awareness of the lean construction concept which are in Sri Lankan construction industry.

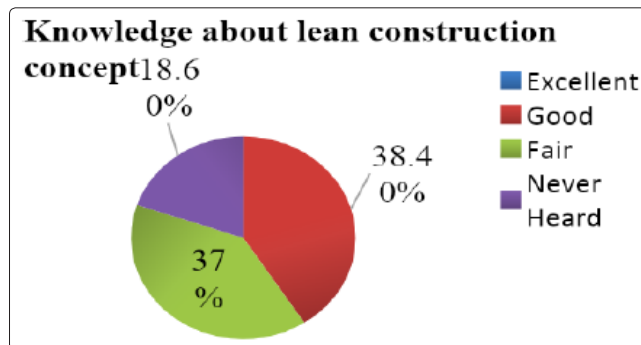


Figure 1: Knowledge about lean construction concept

Out of 86 experts 38.4% good and 37% fair, which means most of the experts in construction field, are not aware about the lean construction concept.

In order with the below table, considering lean construction tools, selected foremost tool for RII is Construction Process Analysis. It has achieved the highest score of the RII as 0.7302. It is the most evident answer. As breaking down all activities in to small work package contractors can manage time, cost and quality of the work easily. Then they can identify where the waste is or delays occurred and can reduce those things in the preliminary

stage. Second highest one is just in time. Resources planning is the most valuable thing in road construction. Material ordering, hiring, transporting each and every activity must be on time. As an example when there is a late transportation of cement to the site, there will be waste of waiting time of labour. Sometimes late transportation of the Asphalt, the fixing temperature is exceeded. Then they have to hire another one. With using this lean tool, optimizing the unnecessary expenses in the road projects is easy. Other tools are also important for the road construction but construction process analysis and just in time has got powerful tools for the road construction sector.

**Table 1: Relative important index test result for lean construction tools**

| No | Lean construction tool        | Number of responses |           |         |             |                  | RII    | Ranking |
|----|-------------------------------|---------------------|-----------|---------|-------------|------------------|--------|---------|
|    |                               | Very Important      | Important | Neutral | Unimportant | Very Unimportant |        |         |
| 01 | 5S                            | 18                  | 21        | 17      | 22          | 08               | 0.6442 | 05      |
| 02 | Construction Process Analysis | 20                  | 34        | 19      | 08          | 05               | 0.7302 | 01      |
| 03 | Value stream mapping          | 15                  | 26        | 15      | 30          | 0                | 0.6605 | 04      |
| 04 | Kanban (Pull System)          | 15                  | 30        | 20      | 11          | 10               | 0.6674 | 03      |
| 05 | Last planner                  | 12                  | 15        | 29      | 14          | 16               | 0.5837 | 06      |
| 06 | Just in time                  | 17                  | 30        | 15      | 15          | 09               | 0.6721 | 02      |

When implementing a lean construction concept to the road construction industry this research is based on six lean tools. Those are 5S, Construction process analysis, value stream mapping, Kanban, last planner and just in time.

According to all these interview and questionnaire surveys, we can identify we can implement lean construction concept into the road construction industry. For it, we must begin from the organization and then spared into the whole road projects. We have to put some effort in the beginning stage but after a few months we can achieve direct and indirect benefits and huge satisfaction with implementing this lean construction concept and we can produce high quality, more valuable output for the future.

**Conclusion**

Waste reduction, maximizing value while continuous improvement is the concept behind the lean thinking. The aim of this research is embedded in optimizing the cost, quality and time in road construction with the application of lean construction concept. Acquiring a powerful, profitable and successful project in road construction need to achieve the increase productivity and quality of the process, decrease waste, reduce invention time and manipulation time and minimize costs is required. Lean thinking is well governed in the Sri Lankan manufacturing industry and this research targets to implement this concept in to road construction industry; as well.

Main aim of the conducting experts’ interviews was to investigate the advantages and disadvantages of road construction with the integration of lean construction concept. With knowing the barriers and strengthens in this field, it is most useful to achieve target.

With distributing questionnaire the main aim is to get a majority of knowing about the existing situation about knowledge about lean concept and stages of road construction. Among the aim was to observe the strategies used to integrate lean concept in Sri Lankan road construction to optimize cost quality and time This research is mainly based on six number of lean construction tools. Such as 5S, Construction Process Analysis, Value stream

mapping, Kanban (Pull System), Just in time and Last Planner. In according to the RII value, foremost important tool Construction process analysis. With adopting this tools we can put one step to implementation lean concept. With practicing these tools, in road construction field fully focus to minimize waste and reduce cost. I found the huge amount is allocated for road construction delays and wastage from the total project sum as research findings. When use this concept we can optimize those unnecessary cost and we can convert it as a project profit. In order to my findings we can easily go to lean construction implementation. But in the beginning step we have to put more effort.

**Recommendations**

In order to conduct interview and questionnaire survey, most of the Sri Lankan construction experts were not aware about this newly govern concept. Firstly, it must be taken into account the benefits associated with lean construction concept. Some of the principal improvements gained through lean construction are reduced cost, maximum profit, high quality construction, greater customer satisfaction, sustain performance, improve performance, improve safety, increase reliability, improvement in design, improved sustainability, better risk it, management and reduce construction time. Therefore by being aware about the clear understanding of the road construction wastages, and delays thus acquiring to overcome them using lean construction concept, can be understood.

Most of the contractor’s and client’s idea “value” is cost reduction. It is wrong, value is high quality, optimize cost and on time work. As knowledge about the benefits of this concept is gained, focus should be on overcoming barriers for implementing this concept. Changing of mine set is the foremost problem in Sri Lankan context. They are focused on practicing the traditional way and not the new and easy ways. They are lazy to put small effort to implement it. But when considering the Sri Lankan manufacturing field they are well reputed in lean manufacturing concept. In this field the top management discusses and express views with regard to overcome the mindset. Then step by step the lean concept is influenced. Therefore, to implement lean construction concept

in road construction, the top management has to be persuaded, which will then result in subordinates to follow. It has to be come in mind that implementing lean concept in projects would not be accurate; it has to be implemented in the company.

The best solution to this problem would be hiring an expert in lean construction, but it is a difficult task in Sri Lankan context as it will incur a huge cost. He must be able to manage change, to change process, methods, program for each and every step in road construction. Therefore he must have more power and leadership qualities. For implementing we can commence the lean training programme in the company for permanent staff and newly appointed people for the organization. Most of the road construction projects are handled by the government. Since for implementation this lean concept we must have government support also.

### Research Limitations

Origin of the lean concept is in Japan and then it expanded into all countries and now there is a great demand for the lean concept. But still, it is not that popular in Sri Lanka. So this research is limited to Sri Lankan context and this is an effort to implement it in Sri Lanka. Because other countries perforate benefits with practicing this concept but still it is a new concept in Sri Lanka. There are a number of construction projects in Sri Lanka but this research narrows only in to road construction projects in Sri Lanka. As same as in the construction industry, there is a huge number of projects type and this research is narrow into road construction projects in Sri Lanka [8]. As per the Yasir's "using lean techniques to reduce waste and improve performance in municipal construction project delivery" research limited to the six number of lean tool and they succeed with implementing 5S, construction process analysis, value stream mapping, Kanban, last planner and just in time. Since this research also limited to this lean tools [10-13].

### Future Research Directions

After implemented to the road construction industry, further direction I invite future researchers to add new tool for carry on this lean concept. As same as invited researchers to implement this concept for other industries also.

### References

1. Friedrich C (2014) The presence of Lean Construction principles in Norway's transport infrastructure projects. Department of Civil and Transport Engineering.
2. Anon (2013) Quality magazine. [Online] Available at: <https://www.qualitymag.com> [Accessed 19 July 2019].
3. Mehany MSHM (2015) Lean Construction Principles Past and Present – A Business Model Consistency. [Online] Available at: <https://www.researchgate.net> [Accessed 19 April 2019].
4. Ballard GHAG (1998) Implementing Lean Construction: Understanding And Action. Brazil: IGLC 98.
5. Anon (2006) Lean construction defined. [Online] Available at: <https://www.leanconstruction.org/wp-content/uploads/2016/02/TDC-CH04.pdf> [Accessed 22 February 2019].
6. Han LS (2007) Modelling and representation of non-value adding activities due to errors and changes in design and construction projects. In: Washington 2082-2089.
7. Bolviken T (2014) The waste of production in construction. Norway.
8. Abdelrazig YE (2015) Using Lean Techniques To Reduce Waste And Improve Performance In Municipal Construction Project Delivery, s.l.: The University of Texas at Arlington.

9. Rafael Sacks B (2010) Requirements for building information modeling based lean production management systems for construction. *Automation in Construction* 641-655.
10. Hatcher L (1994) A Step-by-Step Approach to Using the SAS(R) System for Factor Analysis and Structural Equation Modeling. North Carolina: SAS Institute.
11. Kaliba MMKM (2009) Cost escalation and schedule delays in road projects in Zambia. *Project Management*.
12. Nunnaly J (1978) *Psychometric Theory*, New York: McGraw-Hill.
13. Salem O (2006) Lean Construction: From Theory to Implementation, *Journal Of Management In Engineering*.

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