

# PROPOSAL FOR THE STRUCTURE OF A STANDARDIZATION MANUAL FOR LEAN TOOLS AND PROCESSES IN A CONSTRUCTION SITE

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## ABSTRACT

The application of the concepts of Lean Construction appears as an important alternative to minimize waste, increase efficiency and generate more value for clients. The question that lead to this paper is whether a reduction of variability in the implementation of Lean tools and processes through a standardized manual is significantly going to improve applicability of Lean Construction. The main goal is to establish the structure of a manual to standardize Lean Construction tools and processes for further application in construction sites and to evaluate the proposed standards’ implementation through the comparison between evidence obtained from Lean Audits conducted before and after the Practical Manual of Process and Procedures. The methodology of this paper consists on the characterization of lean practices and its difficulties at a construction company from Fortaleza, Brazil, the proposition of a manual’s structure to standardize lean tools and processes and the conduction of Lean Audits in order to assess whether there was an improvement in the application of lean concepts. After compiling the results, it has been observed that the established goals were accomplished. It is believed that it will serve as guidelines for using the tools in the construction sites, thus facilitating knowledge management in the company and focusing on continuous improvements.

## KEYWORDS

Lean construction, standardization, process, practical manual, audits.

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## **INTRODUCTION**

The expansion of the construction market in the latest years already allows pointing to a number of changes in this industry. On that basis, the current scenario is composed of employees demanding better working conditions, customers becoming more critics and the other companies more prepared and competitive (ISATTO et al., 2000). Thus, it is crucial that builders seek differentials to remain at a high level. Based on this, Lean Construction emerges as an important alternative to achieve this differentiation.

Despite Lean Construction is based on clear principles, some difficulties of implementing it in a construction site are common, given that, as Ohno (1997) says, it is necessary not only to understand the concepts, but also to incorporate Lean philosophy within the organizational culture. In addition, the lack of parameters or certifications of Lean Construction combined with low qualification of employees, the lack of repeatability in the implementation of projects and the obstacles in the logistics suppliers are some of the factors that affect the implementation of lean practices (KOSKELA, 1992).

Based on this, the current paper will develop a Design Science Research in a company with 38 years in the market, in which applies lean philosophy as a management model for more than ten years. Thus, the company already has qualified employees, as well as tools and consolidated processes, built up through monthly audits proposed by Valente (2012), periodic training and its own routine.

Although the company already has maturity on lean work (Arantes, 2010), continuous improvement allows identifying that the deployment of tools based on the Lean philosophy is not enough. So, it is also necessary to establish standardized methods to ensure their correct implementation and continuity.

Thereby, this paper aims to propose the structure of a manual for standardizing processes and lean tools through analysis of previous audits, interviews with the technical management of the company, as well as tools and models adopted in the construction projects, seeking to establish the ideal procedures and providing inputs for application in construction. Thus, the established standards will be compiled for the company in manual format, which corresponds to a Policy and Standards Procedures tool.

Finally, it is believed that there will be contribution not only for academy, but also for the company, given that the standards set can serve as guidelines for using the tools in the construction sites, will facilitate knowledge management in the company, assist in stabilization of some processes to focus on incremental improvements, and can be used in other studies.

## **OBJECTIVES**

### **GENERAL OBJECTIVE**

The general objective of this paper consists on the proposition for the structure of a standardization manual for lean tools and processes used by a company in its construction sites.

## **SPECIFIC OBJECTIVES**

The specific objectives for this study are to characterize the initial stage of Lean Construction within the company; identify which standards will be established; propose the structure of a Practical Manual of Processes and Procedures based on the company's Lean Audit checklist and criteria; and verify the implementation of the tools after defining the standards.

## **LITERATURE REVIEW**

As Koskela (1992), just after the Second World War, much of the construction problems began to be understood, so that some solutions are now proposed and implemented, as investments in building technologies, total quality system, tools for control and planning, organizational methods and increase of productivity.

According to Isatto et al. (2000), construction problems come purely from managerial issues and concern to the quality of the product, to inefficiency in production processes and the dissatisfaction of internal and external customers. By inserting these obstacles in a highly competitive scenario, with the increase of demands from employees and external customers, it is necessary to search for new managerial philosophies that seek to improve production in construction.

Like other models of industrial production, the end product of construction comes from flow and conversion activities. According to Isatto et al. (2000), the flow of activities in the building industry correspond to the material flow, comprising transport, holding, processing and revisions. As Koskela (1992), despite the rework, reviews and repairs sound like insignificant when analysed on a small scale, but they have great impact when analysed the production system as a whole. Based on this, the application of the concepts of Lean philosophy has become interesting in improving the construction process.

Womack and Jones (2003) expanded the concept of Lean Production to the other areas of an organization and defined the concept of lean thinking, which is guided by five principles: define value, map value stream, create flow, establish pull and pursuit of perfection.

Despite this, some difficulties are common on implementing Lean philosophy within a construction site, in view of the uniqueness of each project, the low supply of skilled employees, the absence of lean culture in suppliers and the provisional nature of each. Despite these difficulties, Koskela (1992) states that the change in organizational culture is the key factor to overcome these obstacles. Thus, based on the lean production system, Koskela (1992) proposed eleven principles that would guide and optimize work with flow activities.

Dennis (2008) presented the Lean House, in which is possible to identify some elements and tools related to lean production. Some of them are already well implemented in the company object of this study (jidoka, poka-yokes, kanbans, 5S, A3, etc.). However, one of them is still beginning its application: the standardized work.

According to Liker and Meier (2006), the standardized work corresponds to an applied tool in repetitive processes and is based on the movement and work of the employee in order to eliminate waste. Within in construction industry context, standardization matches

as an element capable to regulate services, reduce improvisations and wastes and optimize the development of activities (MEIRA, ARAÚJO, 1997). It is worth mentioning that the standardization process involves the reduction of variability, one of the eleven principles listed by Koskela (1992).

Standardization is one of the supporting elements of the Lean House, what highlights again the interdependency between the principles of lean philosophy and Standardization.

## **METHODOLOGY**

The first methodological step consisted on the characterization of the company object of this research, the Lean Audits and the application of concepts and lean tools, based on technical visits, literature review and interviews with managers. This characterization intended to understand the history of Lean Construction within the company, evaluate lean practices at construction sites and the difficulties of working with Lean tools.

After that, it was analysed the results of Lean Audits of construction sites that were continuously evaluated by the checklist proposed by Valente (2012). The checklist was developed specifically for the company of this case study and it is divided into seven issues that contain general questions and specific company's features. The seven issues are Planning and Production Management, Kanbans, Jidoka, Flows, Production, Transparency, and Cleaning, Organizing and Safety and the goal is to obtain a 90% grade. The Lean Audit criteria are evaluated from zero to 3, being zero "None at Work" and 3 "Excellent". Each construction site is evaluated monthly and a report containing the audit final result and its analysis and observations is sent to the manager of the construction site. The complete version of the lean checklist is online (<http://www.crolim.com.br/leanchecklist.htm>) on company's website.

From the results of Lean Audits, it was fleshed out a comparative analysis of the grades and the applicability of each criterion evaluated for all of the construction sites and months of audits, in order to establish a standard for the most suitable month for the beginning and end of each parameter evaluated.

The third step was to define the standards of each tool for each criterion, based on what was discussed with the Work Managers, Lean & Green Coordinator and Technical Manager. Thereby, it was established the responsible for the preparation and monitoring of each tool, when and where each of them should be implemented, what would be the frequency of monitoring and how they should be put in practice.

Then, it was defined the models of tools and practices, which were compiled and then provided for each construction site. Thus, there was the standardization of documents and tools and, therefore, the most appropriate use of each, so that the comparison and benchmarking between construction sites were allowed.

The fifth step consisted on the analysis of the previous' audits results and, based on that, to develop a Practical Manual of Processes and Procedures for internal use in the company, which provides standards for the application of lean tools in the construction's development.

Finally, after the dissemination of the Practical Manual of Processes and Procedures in the company, it was presented the results of the Lean Audits in three construction sites.

Thus, it was analysed quantitatively the performance of the construction sites before and after the use of the Manual, in order to assess whether there was an improvement in the application of lean concepts.



Figure 1: Methodology's flow chart

## **CASE DESCRIPTION**

This study was conducted at a construction company from Fortaleza, Brazil, founded in 1975. The company has over 800 employees of its own (construction workers and administrative staff) and its expertise is exclusively property incorporation, specifically looking forward to Upper Class and Upper-Middle Class. The lean journey in this company started in 2004 and nowadays lean is the core of its management model.

It was analysed the results of Lean Audits from 3 construction sites in different construction phases. The Construction Site A is a residential project with 88 units and about 1.5 year under construction. The Construction Site B with 176 units and about 1 year under construction. Finally, the Construction Site C is a residential project with 23 units and about 6 months of under construction.

## **RESULTS**

The standards for the application of lean tools and processes were organized in a Practical Manual structure, deployed internally in the company. Then, there were three Lean Audits in three construction sites, in order to verify if there was an improvement in the performance of the sites after the implementation of the Manual.

### **PRACTICAL MANUAL OF PROCESSES AND PROCEDURES**

The Practical Manual of Processes and Procedures was drawn from the established standards and applied internally in the company. Thus, this document is structured into chapters (Table 1) and subdivided into tools. The Manual also presents the most appropriate periods for implementation of each criterion in Lean Audits, who is responsible for each tool, where and when they should be implemented and what should be the frequency of their accompaniment.

#### **Chapters**

The Practical Manual of Processes and Procedures was based on the criteria evaluated by Lean Audit proposed by Valente (2012), in view of the relationship between these criteria and the principles enumerated by Koskela (1992). Thus, the document was structured into seven chapters, named as the seven issues addressed by the Lean Audit checklist, as detailed in Table 1:

Table 1: Chapter’s structure of the Practical Manual of Processes and Procedures

Chapter	Lean Audit criterions (Valente, 2012)	Lean principles (KOSKELA, 1992)
Chapter 1	Planning and Control of the Production (PCP)	Reduce the share of non value-adding activities; Reduce the cycle time; Increase process transparency; Focus control on the complete process; Continuous improvement.
Chapter 2	Kanbans	Reduce the share of non value-adding activities; Increase process transparency; Balance flow improvement with conversion improvement.
Chapter 3	Jidoka / Autonomation	Build continuous improvement into the process.
Chapter 4	Flows	Reduce the share of non value-adding activities; Reduce variability; Balance flow improvement with conversion improvement.
Chapter 5	Production	Reduce variability
Chapter 6	Transparency	Increase output value through systematic consideration of customer requirements; Increase output flexibility; Increase process transparency; Benchmarking.
Chapter 7	Cleanness, organization and safety	Increase output value through systematic consideration of customer requirements.

**Periods to apply Lean Audits and definition of the responsible for each criterion**

Based on historical analysis of grades and applicability of Lean’s Audits criterions, it was determined the most appropriate periods to implement Lean Audits for each of them, as shown in Figure 2.

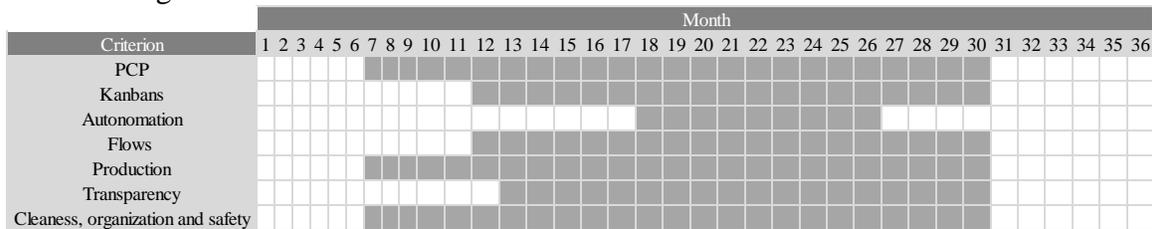


Figure 2: Ideal periods to begin and finish Lean Audits for each criterion

Based on observations of construction sites and after collecting information with Managers and Lean & Green Coordinator, it was possible to define who should be responsible for implementing and monitoring each of Lean’s Audits criterions, as can be seen in Table 2. It is also important to notice that some of them have more than one responsible, what can be explained by the existence of different people as responsible for different tools in the same criterion.

Table 2: Responsibilities of each criterion

Criterion	Responsible for implementing	Responsible for monitoring
Planning and Control of the Production (PCP)	Project manager	Project manager
Kanbans	Project manager	Storekeeper and mixer operator
Autonomation	Project manager and Technician of safety at work	Project manager and Technician of safety at work
Flows	Project manager and Technician of safety at work	Project manager, Technician of safety at work and storekeeper
Production	Project manager and Production supervisor	Project manager and Production supervisor
Transparency	Project manager, Technician of safety at work and storekeeper	Project manager, Technician of safety at work and storekeeper
Cleanness, organization and safety	Technician of safety at work	Technician of safety at work

### Definition of the places and moments to implement each criterion and the ideal frequency for the accompaniment

The moment suggested to implement each lean tool was defined with basis on the periods defined to start and finish Lean's Audits (Figure 2). However, these definitions have been adapted based on the demands of work and technical standards guidelines, so that established deployment times were very varied.

As well as the definition of moment, the places suggested for the implementation of lean tools were very diversified, based on observation in construction sites and in information obtained with Managers and Lean & Green Coordinator.

Despite this, the periodicity of accompaniment could be well represented in Table 3 and was also based on observations in the construction sites and in information obtained with Managers and Lean & Green Coordinator. As can be observed, some criterions had more than one periodicity, because of the variety of lean tools in each criterion.

Table 3: Periodicity of accompaniment of each criterion

Criterion	Periodicity
Planning and Control of the Production (PCP)	Weekly, Fortnightly and Monthly
Kanbans	Daily
Autonomation	Daily
Flows	Daily and Monthly
Production	Daily and Monthly
Transparency	Daily, Weekly, Monthly and Quarterly
Cleanness, organization and safety	Daily and Weekly

## Evaluation of performance

The figure below presents the general grades of the three construction sites for one year. It is noteworthy that August represents the month immediately before the implementation of the Practical Manual of Process and Procedures, while September to December correspond to the period after the implementation of the standards. It is important to notice that in January, June and December the Lean Audits were not conducted because interferences such as vacations or strikes and the first Lean Audit at Construction Site C was conducted in August.

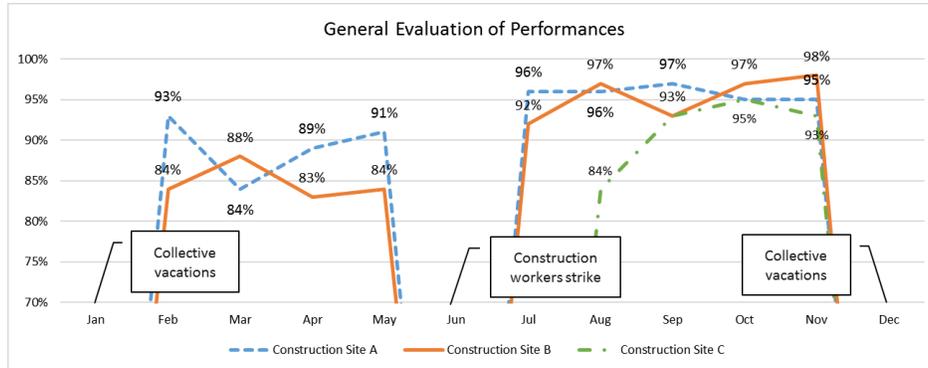


Figure 3: General Evaluation of Performances

The performance of Construction Sites A and B prior the Practical Manual of Process and Procedures had an average of 92% and 88%, respectively. After August, the average rose to 96% for both construction sites their performance did not change much during the period, so that, in general, the results were quite satisfactory. Because of the uniformity of the grades and because they are raised in the later stages of construction, it has become difficult to ascertain whether these performances were influenced by the Manual of Processes and Procedures.

However, it is also noteworthy that Construction Site C grades increased throughout the period, obtaining a 94% average. In this case, it is believed that the Manual have influenced these results, thus the Lean Audits were initiated in the first months of work, many of the processes were not yet well established, so it was possible to apply the suggested standards.

Anyhow, there are many qualitative results that should be taken into account. Before the Practical Manual of Process and Procedures, each manager of the construction site had its own pattern of documents and ways apply the lean tools. During the writing and developing process of the manual, all the good practices and tools used in each construction site were considered and adapted to fit each manager needs by unifying the controls. Thus, a set of documents were created and standardized for all construction sites.

Beside these documents, the processes and procedures described on the manual are an important source of research for current and new employees. The writing is very simple and it has many pictures showing how to use each tool, thus it may be understood by different management levels, from interns unexperienced to senior engineers. Also, the manual chapters and topics have been used as training method for new interns and

employees and as refresher training for current production supervisor and other staff from the construction sites.

However, after a few months accompanying the Lean Audits, it was possible to observe that the team commitment had increased and the criteria's exigencies could be put in a higher level, thus Lean Audit checklist needs to be reformulated. The new checklist will define different weight for each criteria in order to require better performance in the practices, tools and controls believed to be most critical to the construction site management.

## **CONCLUSION AND SUGGESTIONS FOR FUTURES STUDIES**

The current paper aimed to propose the structure of a manual for standardization of lean tools and processes and, after the implementation of these standards, audits were performed at construction sites in order to determine whether there was improvement or not in the applicability of the concepts and Lean tools.

Thus, based on the results obtained and the analysis performed, it is believed that the general objective has been reached, as well as the specific ones, in order that it was possible to characterize the Lean Construction philosophy in the company, the standards for the use of lean tools were set and the Practical Manual of Processes and Procedures was structured. It was also evaluated the application of the tools and procedures before and after the implementation of the Practical Manual, in order to verify that the document contributed to the improvement in the performance of Lean in the construction sites.

Despite the objectives have been achieved, it can not be ensured that the implementation of Practical Manual of Processes and Procedures has been the only factor that contributed to improve the application of Lean tools and processes, considering that the audit results were highly variable and difficult to analyse. Although it was expected that the building Construction Site C would be the better construction site to evaluate the implementation of the Manual, considering that its audits were initiated on the firsts months of work, the Lean Audit checklist was recently reviewed and it is not possible to compare the results. Anyhow, its Lean Audit results average is 90%.

It is also important to mention is that a long-term evaluation was hindered, because of the short time available for this study. Therefore, the "Post-Manual" period was restricted to only three months. In addition, stands out the peculiarity of the research, since it was established standards for lean tools used in a single construction company, which operates only in the residential buildings. Also, it is important to notice that further research and blending theory with practice will be conducted to improve the Manual's benefits.

Based on the presented limitations and difficulties, it is suggested the following future studies:

- Define the structure of a manual for the standardization of tools and Lean processes in a less restricted context, so it may be applicable in other industries;
- Comparing the performance of two sites for a longer period of time, so that one of them is an older location, which has not been targeted by the proposed standards, and the other is a more recent one, so that it has the deployed from the beginning of its audits;

Propose a method of dissemination for lean standards in order to achieve the various hierarchical levels of construction sites.

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