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EXTENDED ABSTRACT

Usage of Lean and Just in Time Techniques in the Management of Construction Projects

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1. Introduction

The construction sector plays an important role in the economy of a country, both for its weight on the nation's GDP and for the positive effects in the generation of employment. Despite this, this sector is characterized by the lack of qualified labor, waste, and high degree of complexity. Thus the opportunity to implement Lean philosophy in a large Portuguese construction company arose, and the choice was made to implement a tool that would focus not only on the improvement of individual points in the process, but rather on the whole, with its flows of materials and information, and which would allow to easily identify waste along its development. The selected tool, Value Stream Mapping, allows for a greater apprehension of the Lean concepts, due to the possibility of integrating other complementary tools and techniques to be used in the resolution of the problems that are encountered.

The principal objectives outlined for this work were:

- Setting the framework for the concepts of Lean Construction and Just in Time, as well as for the Value Stream Mapping tool;
- Surveying and characterizing the procedures used in the company;
- Creating the Current State Value Stream Map of an important element in the construction project;
- Identifying and analyzing the processes that do not add value to the final product along the production flow;
- Elaborating an Ideal State Value Stream Map model via the application of principles of the Lean philosophy;
- Applying the model to the project and conducting a comparative analysis of the results obtained by the new model and those obtained by what is conventionally used.

2. Theoretical background

Lean Thinking is a management philosophy developed by the Toyota Production System (TPS) which promotes ways of specifying value to the customer, improves the sequence of process flows, makes performance more efficient and eliminates waste in production. This philosophy counts on the Just in Time concept as one of its pillars of sustainability, by defending the elimination of stock and the problems associated with it.

Due to its enormous success in the manufacturing industry, denominated Lean Manufacturing, a great deal of research has been made towards its adaptation to other sectors, such as construction, where it has been termed Lean Construction.

Lean vs Muda

The elimination of waste (Muda in its original designation in Japanese) being the principal objective of this management philosophy, waste is constantly studied in the context of each of the respective sectors. According to Taichii Ohno, precursor of the Lean philosophy, Koskela (2004) and Womack and Jones (2003), the types of waste responsible for about 95% of the costs of the non-lean environments are the following: overproduction, waiting, transportation, extra processing, inventory, motion, defects, making-do (initiating activities without all the necessary inputs), underutilized people, unadjusted product/service.

Lean principles

The five principles underlying the Lean Thinking philosophy were described by Womack and Jones (2003) for any industrial sector as being: specify value, identify the value stream, create flow, allow the customer to pull, pursue perfection.

A great difference between Lean in construction and Lean in manufacturing, from where it originates, lies in the way how work is handed out to the team: in manufacturing, it is released and heads to an assembly line based on the factory's specifications, while in construction it is released by an administrative act: planning. The planning system is the first logical goal, but logistics must also be considered [Howell, 1999].

The Lean principles, concepts and tools developed for manufacturing were successively adapted to construction over time, starting with the work of Koskela (1992) which enumerated the following eleven principles for the Lean Construction system:

1. Increase output value through systematic consideration of customer requirements
2. Reduce the cycle time
3. Reduce the share of non value-adding activities.
4. Simplify by minimizing the number of steps, parts and linkages
5. Focus control on the complete process
6. Balance flow improvement with conversion improvement
7. Reduce variability

8. Increase process transparency
9. Increase output flexibility
10. Build continuous improvement into the process
11. Benchmark

Lean application

The application of the Lean Construction system may be made for diverse flows identified by Picchi (2003), such as the business, project, construction site, supply, usage, and maintenance flows.

The main obstacles identified by Alarcón et al. (2005, referred to by Marques, 2007) following the study of hundreds of lean implementation projects were lack of time, of training, of personal review and of elements necessary for a correct implementation.

For that implementation in construction or in any other sector, there are diverse tools and application methodologies for the diverse objectives in sight, the most relevant for this work being:

Value Stream Mapping – it is a very common application of Lean Construction, which deals with one of the fundamental principles of Lean Thinking, the elimination of tasks that don't add value to the process. In this mapping, information and materials flows for a given product or family of products are considered, the main objective being the identification and elimination of waste along the chain [Rother and Shook, 1999, referred to by Abdulmalek and Rajgopal, 2007]. While a considerable share of the existing tools concerns the individual improvement of activities, Mapping permits the improvement of the connections between them as well, aiming to creating value and making it flow from the suppliers to the final customers.

Last Planner System – one of the most common applications in the Lean Construction system, it is directed at the production planning and control, and allows for the short and long term planning, closer to the ground, where uncertainty is lesser;

Visual Management – a system of placards installed visibly, for the management of diverse information related to production, such as procurement control, the performance of programmed activities and the respective persons responsible, and the causes of non-compliance;

Just in Time – it is one of the sustaining pillars of the Toyota Production System (TPS), now being an integrant part of the Lean Construction System. It is based on a system of pull

production, producing only that which is necessary, in the moment is it necessary, and in the necessary amounts.

3. Case studies

The objective of conducting case studies in this work was to obtain a perception of the management techniques currently used in construction, in comparison to the ideals of the Lean Construction philosophy.

To this effect, research was conducted in partnership with a company of the Portuguese construction sector. Data from six of its running projects was gathered and analyzed, the projects having been selected using diversity in their characteristics and in the management styles of their directors as criteria. Table 1 lists them:

Table 1. Case studies

Case Study	Type of construction
Novo Pier Norte	Airport buildings and respective platform
Igreja Boa Nova Estoril	Parish
Sana Torres Vasco da Gama	Hotel
Parque temático Kidzania	Children's theme park
Condomínio Jardim São Lourenço	Luxury condominium housing
Edifício PT Afonso Costa	Office building

The data collection methodology involved direct visualization, analysis of documents and conduction of surveys to the individuals directly related to the management in each work site.

After the analysis of the type of management of each project, and their comparison with the Lean principles and good practices, it was possible to categorize the following items on a scale of 0 to 4: Construction site organization, Planning and strategy, Communication and employee involvement. The grades for the set of the case studies were 2.5, 2.7, and 2.8, respectively.

In this research it was noted that seldom is planning complied with on each control date, despite 73% of respondents indicating that they perform daily or weekly planning. And the accompaniment and observation of performance, while considered very important, is generally only done with access to the top of the command hierarchy.

Only 19% of respondents have any knowledge of the Lean philosophy, and even though they indicate they are confident as to its benefits, no effective implementation of it was observed – only of some isolated ideas.

The research led to noticing several opportunities for the betterment of the management system with the application of Lean tools and concepts.

4. Proposed model

The model proposed in this work intends to be in line with the application of the Value Stream Mapping tool, since it is easy to apply, and of low cost for the company.

The goals set for this implementation model were as follow: to help visualizing all the operations of a process, to identify waste's origins and reduce it, to lower processing times, to provide a common language, to show a connection between information and materials flow, to create a greater interaction between suppliers and customers, to implement diverse Lean concepts and principles. The proposed model involves the phases presented in Figure 1.

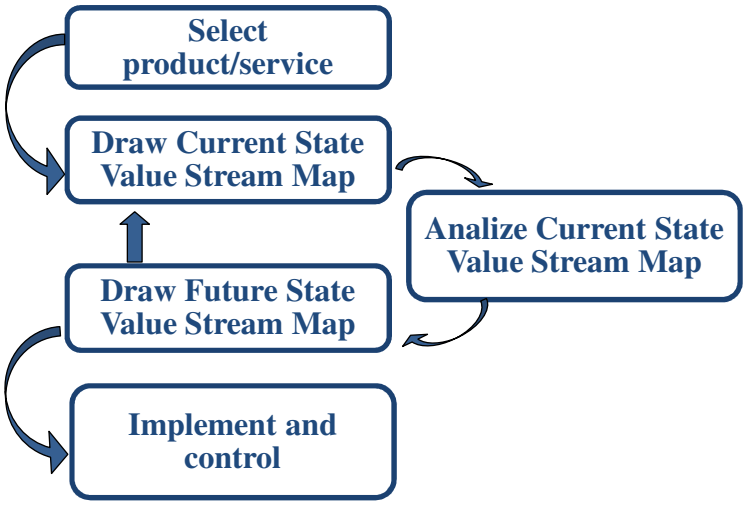

Figure 1. Proposed Model

Having established the model, the service/product selected for study was the assembly of the external window frames in the buildings of the "Novo Pier Norte" construction project. For this intent all the actors in the process, from the main supplier (Edimetal), to the main customer (Edifer), were identified.

The Current State Value Stream Map was prepared via two work sessions with both parties, preceded by a small workshop on Lean philosophy and the Value Stream Mapping tool.

The analysis of the Current State Value Stream Map indicated the following problems: communication excessively centered in the foreman, additional costs with the transportation of the frames' glass due to lack of coordination between supply and assembly, differences in productivity between various places of frame assembly, variation of daily work output and poor storage conditions on site.

For the Future State Value Stream Map the implementation of three measures and the respective tools and methodologies necessary for its success were proposed: stabilize (safety inventories and Last Planner System), standardize (Cell Design and Pull System) and simplify (Visual Management, Address System, Continual Improvement). For each of the problems identified previously, a solution based on the tools and methodologies presented in the model, together with the benefits of its implementation, were presented to the top level management of the executing company (Edimetal) – their participation was considered important due to their decision-making power and the need of their involvement in the principles of the philosophy.

5. Analysis of the results of the model's implementation

After analysis of the proposals, the Visual Management and Last Planner System tools were selected for implementation, as they offer a control of the overall production, and better comprise the whole process.

Last Planner System – this tool entails, aside from the weekly planning, the preparation of medium term planning, with the definition of the activities to take place, their obstacles, and action plan for unforeseen factors that must in turn be pondered, in order to keep the flow constant.

In this work, the application of the Last Planner System tool involved only holding weekly meetings on site with the objective to analyze the process's status, the introduction of the prioritary "next tasks", verification of the conditions provided by the customer (Edifer) and the limitations for conducting the activities, analysis of the causes for non conclusion of activities planned for the previous week, and the calculation of the production performance control

indicator, PCP, Percentage of Concluded Planning. In the end of the tool's sixth implementation week, an average of 12 programmed activities per week was arrived at, and a PCP of 59%. The PCP's low scores were, 50% of the times, due to delays on site attributable to the customer and 33% of the times due to lack of materials for assembly on the part of the executing company's factory itself.

Visual Management – for this tool's implementation, the tracking of which was conducted in 4 weeks, it was opted to put a board up on site for Edimetal's team, with drawings of the façades of the buildings where work was to be conducted. Via a simple drawing affixation system, of pushpins of different colors, according to the process's different stages, it was possible to obtain daily updates of the work's status. In this logic, different colors were selected to identify four stages: measurements survey, placing of pre-rims, assembly of the fixed frame, assembly of the glass. For the engineer in charge and the foreman, this tool allows for the calculation and better adjustment of the week's planning, as well as of the productivity of the teams in each stage of the work.

As an analysis of the results obtained, the main contributions of the implementation of the proposed model, acknowledged as advantages by the intervenients in the process, were:

- Introduction of Lean philosophy ideas and concepts with cost reduction and production flows' stability increase in sight;
- Possibility of visualizing the whole process from the beginning to the end, with the identification of waste and improvement opportunities;
- Preparation of planning more faithful to the real situation, allowing for the identification of problems on site and real time corrective actions;
- Analysis and annotation of the causes for non conclusion of activities, and the respective responsibilities;
- Expedite means for monitoring the work and determining daily output, allowing for the adjustment of resources whenever necessary.

6. Final remarks

All of the objectives initially outlined were met throughout the process of developing this work, via adjustments to the available resources. The evolution of the research was as presented in Figure 2.

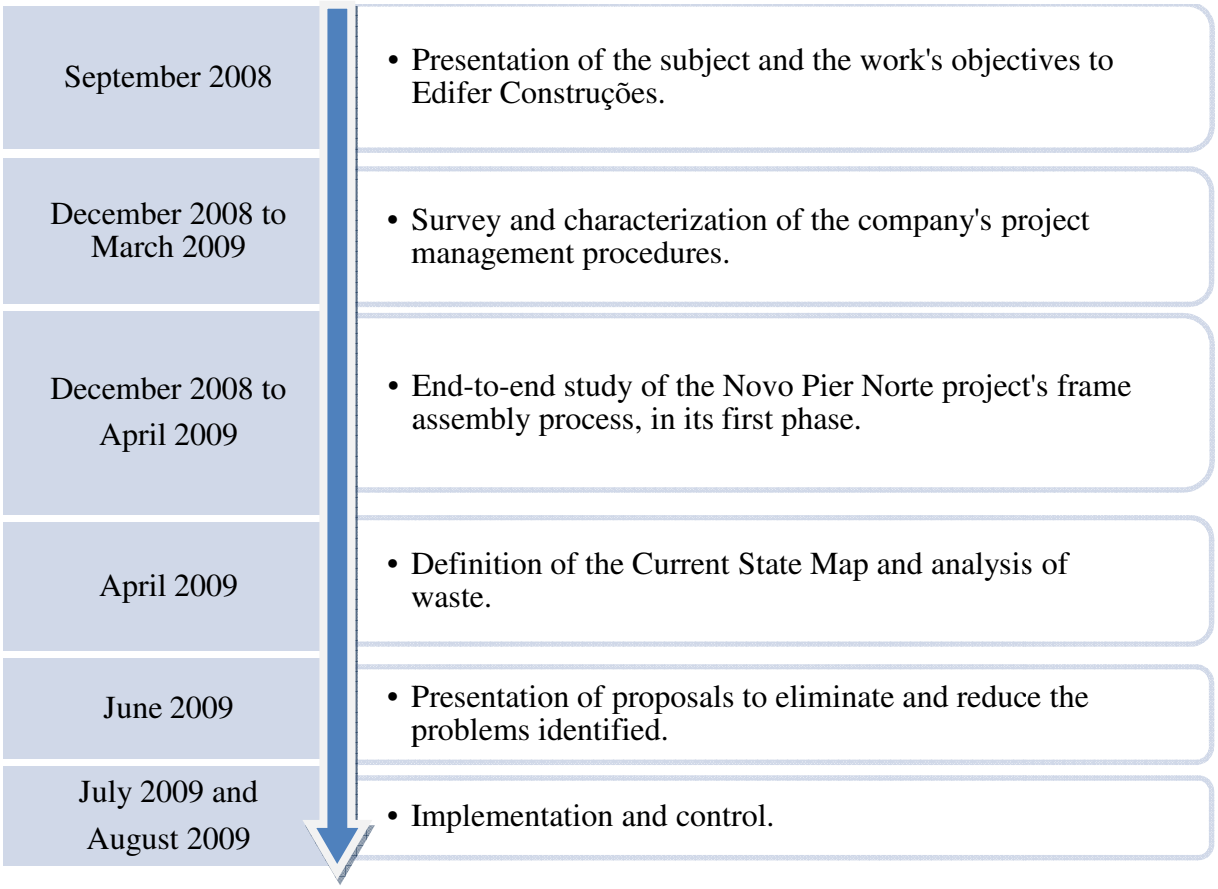

Figure 2. Research evolution

The model proposed based on the Value Stream Mapping tool allowed for the detection of the constructive process's deficiencies and the evaluation of improvement opportunities. The fact that this tool does not in itself offer solutions demands for the application of other tools, as was the case of the Last Planner System and Visual Management. The first strengthens the ability to predict occurrences with greater reliability and resource management, making what is planned and what is effectively executed compatible with one another, and real time problem resolution. The second has as its purpose production control in a simpler and faster way, and can be used for diverse types of desired information.

Just as the model initiates with the companies' top management, with power of decision-making and execution, these tools enable it to have greater control over the process's state, for they

provide data of easy accessibility, which may be obtained daily or weekly, via charts, tables, diagrams, images or indicators, updated regularly.

This work contributed for the knowledge and understanding of some of the problems and the waste related to the construction sector in Portugal, and for the introduction of concepts and tools which focus on the increased efficiency of the processes, through the idea of "producing more with less", as opposed to large investments in high-end technology.

It is hoped that this work will serve as motivation for and encourage further studies of the application of the Lean concepts to the diverse flows existent in construction, making use of the simplicity of application of its tools over the complexity of this industrial sector.

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