IMPLEMENTATION OF LEAN CONSTRUCTION PRINCIPLES IN PORTUGAL:
“Adaptation of good practices from a Danish Case Study”

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During the post-war, the construction industry has tried to change for the better through the adoption of practices or technologies successfully applied in other sectors. Born with the Toyota Production System, the lean approach has spread to other industries. The Danish implementation of the concepts is recognised as one of the most thorough applications of lean in the sector.

To the construction in Portugal it is a good opportunity to invest in the dynamism of civil engineering segment. By implementing lean principles through the Last Planner System, the project management experienced in the Portuguese construction can now be optimised.

After having analysed the characteristics of each country’s construction, the paper reports the outcomes of two case studies and compares both approaches. Factors such as costs, working environment and safety are analysed as well as today’s construction critical necessities: the significance of the client’s value in the construction.

The paper analyses the possibility of implementing lean concepts based in the Danish adaptation of the lean concept to construction, within the Portuguese construction sector.

KEYWORDS: lean construction, last planner, Danish construction, Portuguese construction.

INTRODUCTION
The construction sector has always had a major influence in a country’s development. Representing up to 16% of the Portuguese GDP (Santander Totta, 2008), this industry is of main interest in the development of the nation’s prosperity. Also presenting most of the times a poor performance in significant parameters, this sector should be given more attention.

The Portuguese construction sector has demonstrated to be able to make large scale projects. Now, after recovering from a crisis and with large infrastructures to construct in a near future, it should bet on the implementation of project management principles that can facilitate construction processes and improve important aspects in construction.
After WWII, a series of initiatives arose with the intention of stimulating change and development in construction. Based in the manufacturing industry and now spread in some countries around the world, the lean construction was created. Based in the value adding to the client and waste reduction, this construction philosophy has spread through various countries around the world with positive outcomes: duration and costs’ reduction, safety communication between the different parties among others (Ansell et al., 2007).

If the correct principles are transferred, more countries can benefit from this approach to project management. One of the successful implementations of lean construction stands out in Denmark. Having in mind the possibility of improving in various factors, the Portuguese construction sector is a potential follower of the lean construction philosophy implemented in the Danish construction.

The main focus of this paper is to analyse the possibility of implementing lean concepts, based in the Danish implementation, within the Portuguese construction sector. Also, future research to the topic development is suggested.

**Research Methodology**

To address the main topic, some questions emerge that act as a directive for the work research development:

- *What is Lean Construction?*
- *How is Lean Implemented in the Danish Construction Sector?*
- *Can Lean be Relevant to the Portuguese Construction Industry?*

In order to answer these questions, several research documents were analysed, interviews to experts were made and implementation cases were explored. After having responded to these and considered the varied collected information, it is much simpler to have a conclusion about the main topic.

**LEAN CONSTRUCTION**

Lean construction is based in management principles adopted in the manufacturing industry (specifically in the Toyota Production System) during the post-war period (Krafcik, 1988). Labelled as lean production after presenting productive results in terms of productivity, quality and product development, these principles used drew attention in other industries. The lean thinking became globally famous by changing the way work is done throughout the delivery process (Edgington et al., 2002).

Contrasting with the traditional slow progression in the sector, lean construction brings a faster approach to important goals such as financial, time and quality results. In order to reach these, the lean approach focuses in maximising the workflow through the implementation of process transparency and minimisation of performance variation and the elimination of systemic waste sources. (Lean Construction Institute)

Critics concerning the lean concept in construction also exist such as the almost inexistent approach to HR aspects Green (1999, 2002), its point of focus (Thomasse et al., 2003) and the oversimplified perception of value, topics that should have a further research development.
TFV

During the 1900s, Koskela (1992) proposed a new theory of Project Management, the Transformation/Flow/Value (TFV) understanding of construction. He asserted that there was an overemphasis given to transformation and that the flow and value aspect should be more taken into consideration in construction management. Koskela then stated that it is necessary to look to construction from a production point of view, focusing:

- Production as a transformation of inputs to outputs
- Production as a flow
- Production as a generation of value

He also introduced the seven preconditions necessary in order to carry out a construction work package, known as the seven flows:

- Information (construction design)
- Materials (and components)
- Workers
- Equipment
- Space
- Previous work
- External conditions

Last Planner System

Later, in the beginning of the 1990s, Ballard (1993) introduced a new method for applying lean in construction: the Last Planner System (LPS). This model is based in a short term planning and control of operations approach and has been one of the most used models around constructions following lean. In order to assure that the production in continuously flowing, the model assures that the necessary pre-requisites are verified before starting an activity. The LPS addresses and resolves important issues such as obstacles and coordination of subcontractors which are analysed in weekly work plan meetings; these become a fundamental key to the successful implementation of the model.

Having as a basis three main plans, the planning of schedule occurs with a satisfactory work flow control:

*The Master schedule:* Selects the sequence of activities and identifies all the work packages on which obstacles should be removed and is elaborated by all the parties involved in the construction; it defines what *should* be done;

*Lookahead Plan:* By having an outlook up to four weeks ahead, this plan controls workflow ensuring the workable backlog is sufficient for an activity to be completed; it defines what *can* be done;

*Weekly Work Plan (WWP):* Looks at short-term perspective and selects sequences and sizes of the work of the following week, detailing flows’ verification, activities’ executions and respective responsible; it then defines what *will* be done.
The control of the workflow is then made through some approaches such as the PPC (percent planned completed), an activities’ weekly plan measure used in the implementation of the model which provides information related to the production productivity and planning effectiveness (Howell et al., 1998).

**LEAN CONSTRUCTION IN DENMARK**

The Danish cases of the lean principles adapted to construction are known to represent some of the most thorough lean application that can be found worldwide. This fact would not be achievable if the country did not have the current background in the sector such as the existence of highly skilled workers in the sector and the funded programmes focused in developing the construction projects (Bonke et al., 1996).

By recognising some similar approaches in the sector such as the Just-in-Time logistics, in the turn of the century a new label for lean appeared in the country: TrimByg (Trimmed Building) is the name given to the adjustment of the lean concept within the Danish construction industry (Bertelsen, 2002). The adaptation of the Lean Construction Institute (LCI) models of lean thinking stand out from the usual application by focusing on the value (to the client) parameter and the cooperation between the trades in construction. The process moderator is also an innovation in the implementation of lean philosophy in Denmark. This new individual is the facilitator of the lean approach in construction, acting as the coach of the building site; he implements lean by concentrating in ensuring a good collaboration with and between subcontractors.

**Danish Case Study**

In order to analyse the practical implementation of the Danish lean principles in a construction site, this paper examines an ongoing construction where the principles are applied. The construction of an office building located in Hellerup, near Copenhagen, has been a challenge as it is attached to an existent and currently working area facility. The contractor is a large Danish contracting firm, NCC, who is applying lean principles in their projects for several years already. Through inquires, interviews elaborated to some construction intervenients about the planning and lean elements in the construction, and the attendance to a WWP meeting, some conclusions were achieved.

The Last Planner System implementation is done through a one hour weekly work plan meeting, where all the parties currently involved in the construction are present. These meetings are led by the process manager who addressed the following topics:

- **Overview of the previous weekly work plan** – checking the activities progress – PPC;
- **Obstacles list** – verifies the existent obstacles that hinder the ability to execute the activities;
- **View of the Lookahead plan** – assures that the pre-requisites of activities yet to come in the following weeks are made ready;
- **Overview of the master plan** – verifies if any activity in another part of the project needs to be paid attention and if everything is going according to plan;
- **New weekly work plan** – elaboration of each subcontractor’s following week work plan;
With these complete and effective meetings, the project manager affirms that fewer obstacles exist in the activities are starting soon and the small problems existing on site are usually resolved between the site managers (due to their new communication skills taught by the process moderator).

All of the enquirees understood the relevance of planning within the production process and affirmed that the main cause of non conclusion of activities (which affects the PPC) was mostly due to information flaws (one of the seven flows). Although half of the enquirees had previously worked with lean principles before, the expectations relating to the improvement lean can give for the improvement of the construction management system varied between ‘confident’ and ‘indifferent’.

The main differences the enquirees perceived between using lean principles and the traditional way of construction were the introduction of men on site in the production planning, the increase of information available to workers and the better process flow.

Positive results concerning communication, costs and quality in the construction are also verified by the project manager, who states that the project delivery team operates in an atmosphere where relationships are equitable and members are respected, which contributes to the process transparency and positive outcomes. He is also sure that the lean principles applied already in the beginning of the planning definitely helped them winning the project concourse.

It was also observed that there was focus in optimising value for the client and users is present in the majority of processes, as well as the strategy for building continuous improvement into the process.

PORTUGUESE CONSTRUCTION INDUSTRY

In Portugal, new construction philosophies are practically non-existent. After now being slowly emerging from the recession under which it has been labouring over the last ten years, it is now time to start investing in new principles that promote and offer substantial improvement (Baganha et al., 2002).

Although generally the sector does not have many highly skilled workers as in Denmark, some large construction companies use to train their workers in order to achieve better results. Also, although there is not much collaboration between design and planning, problems with errors and omissions in the projects executed by these large companies are considered low.

People within the sector acknowledge that communication, bringing people working on site into the process and that design and production combination are very relevant, but these are still not well integrated in the Portuguese construction projects.

Portuguese Case Study

The case analysed to study the Portuguese approach in construction was an already completed project. Located in Lisbon, Parque das Nações, the contractor of CUF Descobertas Hospital project was Profabril S.A.. The workers at the construction site were hired by a time contract which was renovated when it expired. The costs and activities’ planning control was made monthly, but meetings with site managers took place every week (ECG, 2008).
The planning of the following weeks and also checking the seven flows was usually made during the meetings between the project manager and site managers, which lasted sometimes up to four hours. The completed planning percentage at each control was in average lower than 30% and the main causes for having a two months delay in the construction deadline and also cost deviation were caused by project changes solicited by the Client and the rough indefinities existing on the project.

Waste causes experienced in the construction were mostly due to planning errors, project changes, failure in communication and also pre-work requisites of the activities yet to start. The activities’ feedback was considered insufficient, which is also significant for the production productivity control.

When interviewed, the inspector of works was not aware of lean construction techniques, the Last Planner System implementation model and its benefits. After being clarified about it, he affirmed that it would have been possible to integrate this philosophy in the project and within the general Portuguese construction site management, resulting in positive achievements.

**FINAL OUTCOMES**

The Weekly Work Plan meetings are considered one of the basis for a methodical application of the lean principles through the Last Planner System. Also, the process moderator is a keystone for all the process as he is in control of the workflow and responsible for the transference of the lean principles in the meeting, on site and within the entire organisation.

The application of the lean construction principles in the Danish case revealed an accomplishment in the production of better results through the construction. The involvement of the site workers in the planning also evidences their interest in contributing for better PPC results (Arbulu *et al.*, 2006). It is as well important to keep the meetings short in order to make them effective: only the relevant issues are brought up and discussed. The focus on the client value is imperative for a well adaption of the processes in the construction which is, among others, experienced through the elimination of non value-adding activities on site.

All of this description contrasts with the general Portuguese construction, where the communication between site managers is poor, the weekly meetings are too extent, the stimulation at work is low and the site workers are not that involved in the planning. On the other hand, factors such as training of workers in large firms, the verification of the flows at the weekly meetings and the understanding of how communication is vital are some of the similarities found which influence the integration of lean principles in a positive way.

Nonetheless, some conceptual changes still need to take place in the sector for the implementation of lean through the Danish principles; for instance, the insertion of an experienced process moderator with a leadership character and an effective client involvement in the process design and production phase is vital for the implementation success.

More site workers should benefit from trainings in their speciality and also a workshop in lean principles in construction must be performed for all the parties involved in the process (designers, site workers, etc).
IMPLEMENTATION BARRIERS

As the major part of Portuguese workers has never heard about lean construction, the training in this new philosophy would be necessary. Workshops made by experts on the subject and also the intervention of the process moderator during the construction can be a resolution for the problem. The company implementing lean principles should also have certain internal organisational skills led by top management, as they are a key figure during the important stages of the model’s implementation.

Human and cultural aspects such as worker’s lack of self-criticism (Alarcón et al., 2008) do not facilitate the successful implementation of the lean principles, but again, training can be the solution. It is also necessary to have a controlled notion of time (to execute the activities, to control the meetings, etc) and that is achieved through the experience gained throughout the implementation.

CONCLUSIONS AND REFLECTIONS

After having profoundly studied the lean construction concept, the research questions can now be answered

- What is lean construction?

A simplified version of lean production, a management approach based in the value adding to the client and waste reduction, the lean thinking is nowadays applied in construction. The adaptation of the concept to the sector is a new approach to the management of construction processes that have revolutionised the industry: positive outcomes such as cost reduction and safety improvement in construction. By reducing non value-adding activities and improving the communication between all the parties, the lean thinking adds value to the client through the construction. Taking different manifestations around the world when applied in practice, this philosophy has demonstrated satisfactory results.

- How is lean implemented in the Danish construction sector?

Based in the LCI principles of lean, the Danish implementation of lean construction has shaped itself to a more adapted version in the country. They have focused in adding value to the client through the enhancement of cooperation between trades on the project. They also implemented a key figure in the sector, the process moderator, who ensures a feasible workflow in the projects.

- Can lean be relevant to the Portuguese construction industry?

The opportunities the sector has at the present date to invest in new management philosophies, the will to change expressed by the sector and by having planned the construction of large projects in the near future, the construction sector can benefit from the application of philosophies. These are able to modify the acknowledged features of construction: projects with extended duration, high costs and a discontinuous workflow. After implementing some conceptual adjustments in the sector, the application of lean principles in the Portuguese construction can improve these and other poor results presented in the industry.

After having gone through an ordered exploration of the main subject, it is possible to analyse the main issue at this time. Characterised as having competitive, uncertain and complex projects in hand, the Portuguese construction sector can now experience diverse benefits by
implementing lean principles within the organisations. The application of the lean principles through the Last Planner System model can be a triumph in the country if having as a basis one of the most successful implementation of lean the principles, the Danish model.

**FUTURE DEVELOPMENT**

Further research should be made to the implementation of lean construction principles in Portugal by actually applying it in projects. The feasibility of integrating design in the production has not been studied in the paper but some reports (Jørgensen, 2006) confirm that it leads to more interesting and positive results. Also, the quality and safety in lean construction is said to be improved, but actual studies addressing specifically this topic should be performed. Lastly, the reinforcement of the value perspective can lead to interesting outcomes, such as the analysis of sustainable solutions in the implementation of lean construction.

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