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TOP DOWN VS. BOTTOM UP APPROACHES REGARDING THE IMPLEMENTATION OF LEAN CONSTRUCTION THROUGH A FRENCH CASE STUDY

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ABSTRACT

In order to sustainably reduce wastes on construction sites, companies need to know where they should start their Lean journey and how the different Lean tools can practically be used together. Based on a two years research project in Paris involving 15 construction sites of a major French company, this paper compares a top down and a bottom up implementation approach. During the first part of the project, Lean actions were decided by top managers using company-wide indicators. The focus was put on 5S programs in order to bring stability, to introduce Lean thinking on sites and because it is traditionally described as a part of the foundation of the "Lean House". In contrast, during the second part of the project, each use of Lean tool (5S, quality control, Last Planner System) was decided with sites crews according to local measures. Implementation methods, performances, commitment of the crews and sustainability of both approaches are discussed using case studies in order to provide practical recommendations on the use of Lean tools. Ultimately the paper shows how digital technologies can support field implementation by improving data collection and decision making.

KEYWORDS

Lean construction, 5S, Last planner system, Field implementation.

INTRODUCTION

Lean Construction is getting increasing attention from companies since it appears to be one of the most prominent improvement approaches within the construction industry. Consequently a subsidiary of one of the world's leading construction groups in France decided to implement Lean on its construction sites. Although Lean tools have shown their efficiency on construction sites as described in the literature and as demonstrated in previous Lean projects in this company, the change remains hard to achieve and above all is hard to sustain.

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According to Picchi and Grandja (2004), Lean in construction in 2004 could be described as a fragmented set of tools: The focus was on applying Lean tools in specific situations to address specific issues (such as flow, wastes, variability). This situation was confirmed by other researchers (e.g, Höök and Stehn, 2008) and describes well the situation encountered by the research team at the beginning of this project. Shifting to a global Lean application is crucial as Liker stated in *The Toyota Way* in 2004: Lean is not just a set of tools but a global improvement system. Therefore, a global implementation strategy is necessary. According to Höök and Stehn (2008), Lean implementation can be described as a top down (project performance goals set by top management) or a bottom up approach (person focused). The work described in this paper developed a bottom up approach in the context of a major French construction company, compared it with the top down way, and showed how some of the main Lean tools can practically match together.

PROJECT CONTEXT AND METHODOLOGY

The project was launched in 2012 and was carried out by a research team external to the company. It aimed to develop and test a sustainable Lean approach in the context of a major French company's subsidiary, where the construction sites are highly independent. It focused on the structural building phase since it is considered to be the core of the activities of the company.

During the first year, the lean actions were decided by top managers using companywide indicators. The implementation strategy and the company's standards were reviewed according to the impact and to the sustainability of these actions. 10 building sites were involved in this part of the project. This Top down approach was chosen following the wish of the company leaders and because this is the way most consultants currently deploy Lean in construction sites in France.

During the second year, a bottom up approach was developed with the sites crews: based on local measures (measures of Value Added/Non Value Added activities, flow measures) the tools were implemented step-by-step so that people could learn from limits and mistakes. The implementation strategy was reviewed accordingly. 5 building sites were involved in this part of the project. Figure 1 describes the top down and the bottom up process of implementation used during the project:

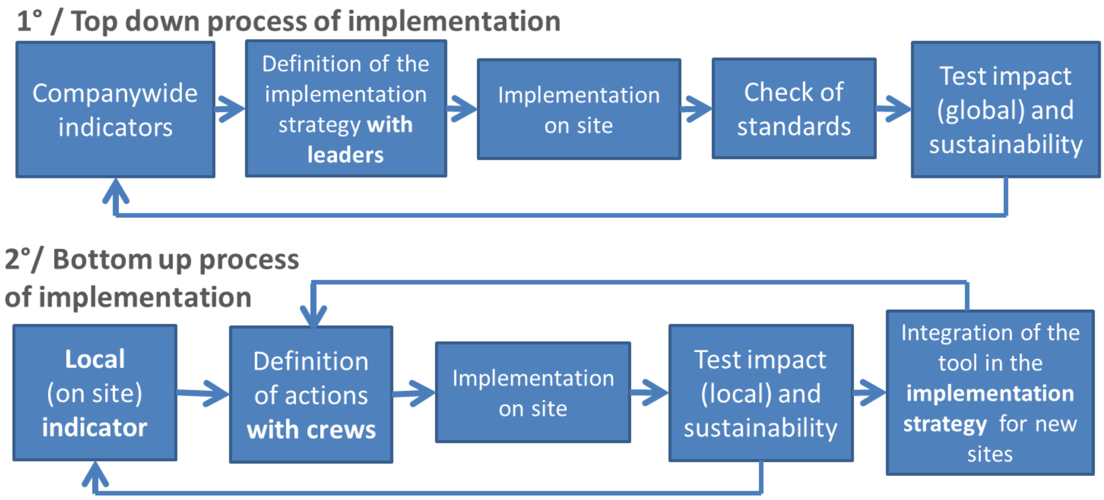

Figure 1: Top down and bottom up approaches during this project

THE «TOP DOWN» WAY

INITIAL STATE OF LEAN PRACTICES IN THE COMPANY

The representation from Höök and Stehn (2008) is a view of the classical model of the Lean House adapted to the context of construction sites (figure 2). It was used to define the weak points in the company's practices regarding Lean Construction:

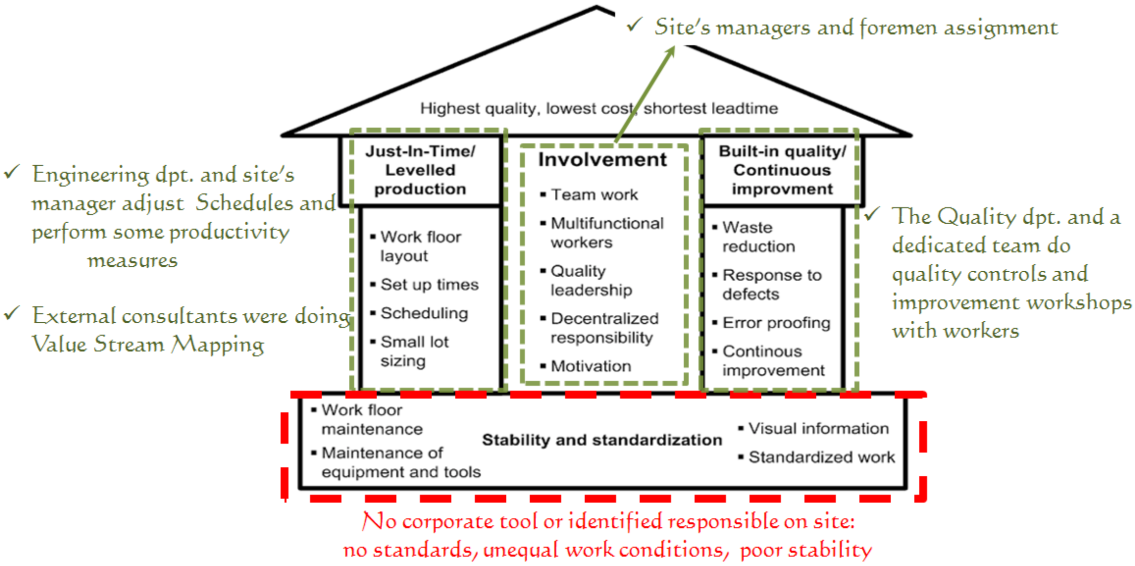

Figure 2: As-is of the company's practices regarding the Lean House based on a representation from Höök and Stehn (2008)

People (internal or external) were responsible to handle and improve Just-in-time aspects, quality aspects and involvement aspects, but no one was actually in charge of stability and standardisation (at the site and in the company). Thus, the foundation part of the Lean house appeared to be the weak point of the company's practices. It had an impact on sites performances, e.g., in a building site in Val-de-Marne, 2 months before the end of structural works, 70% of the available storage space was taken by structural steel. 50% of this steel was unnecessary material (mainly because of change orders after material delivery) stored throughout the project because of the poor work floor maintenance (figure 3) and got finally removed at the end of the project. Consequently, materials were stored on overloaded workplaces and deteriorating productivity. For example, laying beam reinforcement lasted 10 to 15 minutes but required up to 2 hours of searching time.

Figure 3: Overloaded storage and workplaces due to a lack of organization

5S TO BRING STABILITY AND STANDARDS

In this context, according to the (result-based) indicators available in the company, the company leaders decided to use the 5S tool in order to bring stability and standards on sites. 5S is a basic method of the Toyota Production System for clean-up and organisation of the workplace explained namely by Liker (2004). 5S programs can be successfully applied in construction, even at a wide company scale. For example, Leino, Heinonen and Kiurua (2014) describe a 5S program where 5S workshops involved 2,770 employees at 190 jobsites during 1 week in Finland. After this program, weekly inspection indices rose by 3.4 percent points and the number of accidents related with slips and trips were reduced. (Whether this case is really top-down or not is discussed later).

An impact on productivity thanks to the use of 5S is also expected since it directly deals with wastes such as waiting, searching and moving.

The 5S tool heavily focuses on the field and, as workers do the Lean transformation of their own workplace, it is often described as a bottom up tool. However, the 5S actions were actually decided by the company leaders and not by the sites' crews themselves; therefore it was in reality a top-down approach. In this context, the implementation protocol was:

1. Gemba Walk with site managers.
2. 5S Training of all the sites workers, managers and main sub-contractors.
3. 5S Actions in the storage zones with foremen and project manager ("Sort", "set in order"): A weekly review of the storage zone was done subsequently with project managers and foremen to manage internal logistic and supply.
4. 5S Actions on the workplaces with foremen and workers ("Sort", "set in order", "shine")
5. Spread good practices to all sites, define new standards and apply standards.
6. Follow up inspections and measures.

Was it efficient and sustainable?

In order to evaluate the integration of the 5S methods in the sites practices and in order to continuously define key actions, sites managers (or foremen) and researchers inspected the site and calculated separately a "5S rating" (in percentage) according to a standard reference table. This measure was considered as reliable because the mean gap between the rating given by the site's crew and the external assessor rarely exceeded 5%. This score was communicated to the directors and used as a non-financial companywide process indicator. Measuring and reporting progresses aimed to bring out motivated people in order to accelerate and maintain the improvement dynamic. Moreover, bad ratings (under 50%) or important decrease aimed to enable a quick hierarchical reaction and newer 5S actions. This measure was also used to evaluate the results of the 5S tool itself and of its implementation strategy by comparing it to the other indicators available in the company. The study of this 5S rating showed that:

- At the end of the first year, all sites were above a 50% rating. Whenever a site was under this warning level, site's managers reacted quickly (either because they were conscious of the risk of further deterioration or simply because of hierarchical orders). Such a 5S program was thus efficient to prevent dangerous situations (such as fig.3) and to set up standards.

- Most sites improved their 5S rating, (the mean rating grew from 52% to 67% in one year). But the sustainability remained questionable since, after a few weeks in autonomy the 5S rating tended to decrease.
- Few construction sites managed to reach the 80% rating or more. Whereas workers and managers considered that being over a 50-60% rating was relevant, getting over 80% didn't seem worth it to them.

Although it achieved to bring companywide standards (which was actually the initial objective), the top-down implemented 5S was not really sustainable. Incentive bonus regarding the respect of 5S and safety standards, non-numerical scales or rating done by workers themselves were tested and gave very similar results. The same observation applied to other improvement actions separately implemented on sites with a top-down approach (e.g. Value Stream Mapping or quality control): Actions were mostly done because of hierarchical pressure and not because of a true continuous improvement culture. Three limitations of this top-down approach have been emphasized by this case study.

Fragmented tools application is not Lean:

In *The Toyota way*, Liker (2004) already warned against a widespread misconception of Lean. He explained that many companies confused 5S with Lean and he told the story of shinning workshops thanks to 5S where quality, productivity or cost actually didn't improve. Same misconception is likely to exist in construction because of some current consultancy practices. The 5S tool when used alone did not enable to manage what was needed to fulfil the tasks on time: Most 5S actions consisted of handling materials that should actually not have been on the site.

No person centred approach:

According to the *Toyota way* (Liker, 2004), the improvement strategy must be able to bring a real cultural change. Whereas conventional organizations focus on getting things from the employee, Mann (2005) advocates for a different approach focused on people: "Focus on the people and the results will follow. Focus on the results, and you'll have the same troubles as everyone else—poor follow-up, lack of interest, no ownership of improvements, diminishing productivity". It is typically what happened here with the dogmatic use of Lean tools. Also in the case described by Leino, Heinonen and Kiurua (2014), the authors insisted on the importance of involving workers in a bottom-up way.

Insufficient performance indicators:

Sarhan and Fox (2013) explained that the kind of indicators the practioners and managers choose will directly and heavily influence the implementation results of Lean applications. In the context of the project, the decisions were taken and their efficiency was evaluated using the following companywide indicators:

- Financial result: This is the traditional (result-based) performance indicator of the site managers. The actual numbers were never communicated to researchers (or even directors) at the time of the implementation. Moreover financial indicators were not effective in identifying the wastes and their root causes as stated by Sarhan and Fox (2013). In this context, the financial KPI didn't enable to define and justify Lean actions at an operational level.

- Safety indicators (Accidents rates and safety visits): A correlation with 5S rating was done (showing a positive influence of 5S) but the statistical sample was too small to give robust results.
- Process performance indicators and productivity: Lean Construction relies heavily on such indicators. In the company, some measures were done by internal services but only used at a company level to define top down actions. The measures and their meaning were never communicated to workers.

Given this lack of indicators, the first step of the bottom up approach developed during the second part of the project was to use operational indicators that are relevant for workers and middle managers.

AN INCREMENTAL BOTTOM UP APPROACH

LEAN ACTION DECIDED WITH THE CREWS USING LOCAL INDICATORS

Considering the limits of the top down approach, the second part of the project focused on local performance indicators in order to define the Lean actions with the crews instead of applying dogmatically the decisions of top managers. As well as in the case described by Tillmann, Ballard and Tommelein (2014), the idea was to "implement only techniques that will truly add value to the field."

Therefore, the Value and Non-Value Added analysis can be successfully applied in construction (e.g. Eswaramurthi, 2013). It brings usable data from the field in order to identify, show and reduce wastes. A VA-NVA analysis was done on another site in Val-de-Marne to show wastes in the assembly process of steel beam reinforcement. The measures showed that 48% of the time spent by the workers was waste (typically unnecessary searching and handling of material due to overloaded storage area as shown on figure 4). The results were analysed with the crew and site's managers.

Figure 4 : Initial state of the assembly of steel beam reinforcement

Before the measures, the site's crew considered that the organisation of the storage and of the delivery was only a subcontractor's task. Showing an improvement area for the whole site's performances, the measure triggered more communication between both stakeholders. They decided to apply 5S in the inventory, Just-In-Time delivery, new pre-wrapping of the steel bars and Kanban to launch beams in production (figure 5). This actions increased productivity, quality and reliability (table 1).

Figure 5: State after the Lean actions

Table 1: Impact of the VA/NVA on steelwork

	Before	After
Mean cumulative time per beam	8h	5h
Quality	50% of the produced beams reworked	10% of the produced beams reworked
Work finished when planned?	NO	YES

This case is an example of the person centred approach asked by Mann (2005). Workers in Maison-Alfort were involved in the analysis of the results, and proposed new solutions. Thus they decided to apply the 5S on the worksite. The storage zone was cleaned once a week and the good results in the storage area motivated the site's crew to take more 5S action on their own. This bottom up application of 5S was sustainable as 5S rating on the site stayed above 75% during the last 3 month.

MEASURES OF FLOWS TO DEFINE THE ACTUAL CONSTRAINT

The previous example worked not only because workers felt more involved but also because the right measure was done on the actual constraint of the site. On the contrary, another VA-NVA analysis in a site in Haut-de-Seine did not achieve such results: the chosen team for the measures was the one that, according to the foreman, had the lowest efficiency and a bigger need for improvement. Value Stream Mapping showed subsequently that it was not the actual bottleneck of the site at that moment. Referring to the TFV principles (Bertelsen and Koskela, 2002), it can be argued that the foreman's view was a "transformation view" focused on the activities, whereas a flow view at the scale of the whole site was necessary to define improvement actions.

Pérez, Costa and Gonçalves (2013) summarize three different methods to measure flows and identify the associated wastes: Value Stream Mapping, Overall Equipment Efficiency (OEE) and Process and Flow Diagram. The three methods were tested. Because of the context of structural work (where the use of a crane is predominant) a focus was done on OEE measures on the crane. The impact remained however quite limited or impossible to measure. Although all three methods provide a simple understanding of flows and showed a lot of wastes, it took usually 2 to 3 weeks to measure, analyse and define actions. It was then too long to efficiently improve non repetitive activity.

Another limitation was the variability that affected the sites. For example, waiting times measured on the crane varied from 5% to 35% on the same crane in the same week. Moreover, most of the wastes measured by OEE were due to the lack of planning reliability that could arguably be addressed using Last Planner System.

INTEGRATION OF LEAN IN THE DAILY ACTIVITIES USING LPS

In the previous cases, Lean practices were still not integrated in the activities of the site's crews. In order to focus on variability and to control production of the whole site, LPS was added incrementally.

First of all, the capacity of each crew was measured in order to balance the different teams: some areas were finished in 3 to 5 days by some teams, whereas the others needed only 2 to 3 day. The decomposition of the zone to build and the capacity of each team were adjusted so that each task could be done in 2 days. Every week, Weekly Work Planning meetings were held; it enabled the team to keep the balance within the tasks and to define the new actions to focus using a PPC indicator. The objectives were adjusted by team leader and foremen according to their actual capacity every week during the collaborative meeting. The actual time per floor measured decreased from 25 day per floor to 12 days and got more reliable (figure 6):

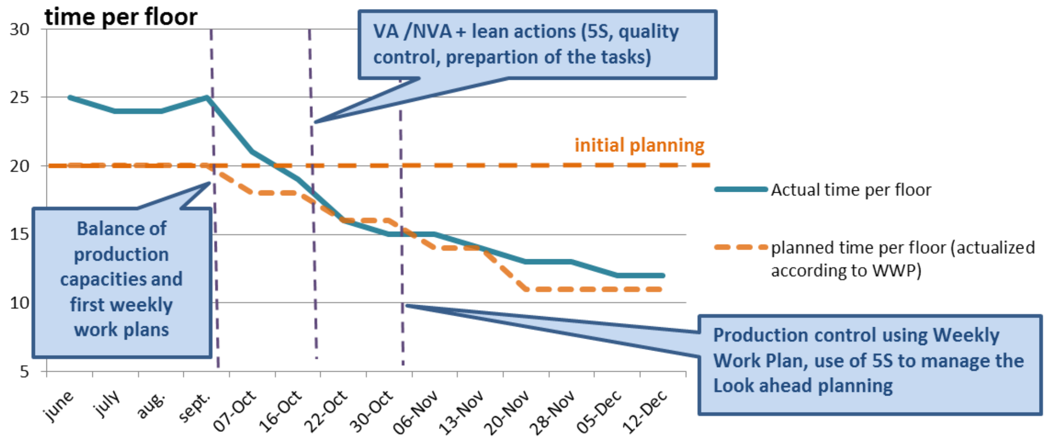

Figure 6: Actual and planned time per floor

In order to reduce variability, VA/NVA measures focused on the tasks with low PPC. Lean actions were set up by the crews accordingly. For example, using 5S and a better preparation, the maximum time to lay one column got divided by 3 (figure 7).

Mendes (1999) introduced a bottom up approach of LPS. Very similarly, LPS tools were added step-by-step during the project. In the first month, PPC measures showed tasks that were not finished on time because of missing pre-requisites. Consequently, the site's crew decided to incorporate make ready process and look ahead planning to manage the prerequisites. Instead of being an additional process for the site's managers, 5S and quality control (inspection during delivery) were thus integrated in the management of the whole site's prerequisites.

More than 1 month delay was estimated by the site's crew for the end of the structural work. Ultimately, it finished one week ahead of the delivery date with a PPC that grew from 70% in June to 90% in November.

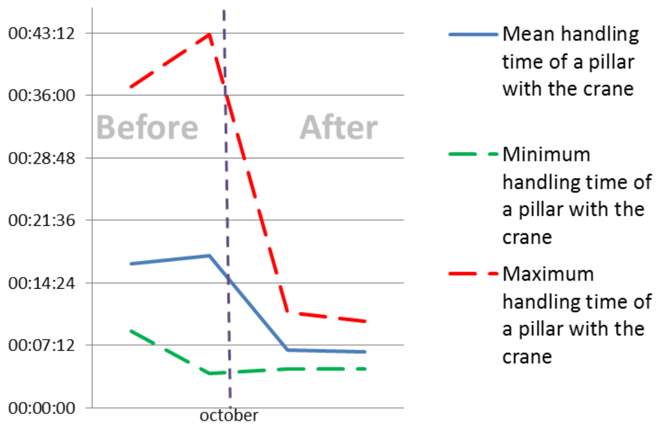

Figure 7: Reduction of the variability of the pillar laying task

LIMITS AND FUTURE RESEARCH

Because of the higher need for measures on site, the number of sites involved in the project was smaller in the bottom up phase (5) than in the top down phase (10). To facilitate learning, the new tools were integrated step-by-step in order to enable crews and managers to identify the actual improvements, instead of bringing them a "turnkey" solution. Consequently, the authors advocate for further tests on a wider scale and for a longer duration, in order to give more data on site's performances and to confirm the better sustainability of the bottom up approach.

Focusing on local performance indicators was the key point of the bottom up Lean implementation during this project. However it was also one of its weaknesses because qualified assessors and time spent by the crews were necessary in order to measure and to analyse sites practices. Choosing the best indicators and define how to measure them efficiently is thus a crucial field of research. New Technologies (e.g. RFID, BIM) bring it new perspectives of data collection and monitoring on sites. The local data it would bring can enable a more accurate management of the prerequisites and of 5S on sites.

CONCLUSIONS

This paper presented cases studies from two years of Lean implementation in a French major company. More than a set of separate tools, each one answering to a given problem, Lean is a philosophy and its implementation requires a well-suited strategy. Therefore two approaches have been practically tested on sites and discussed on a total number of 15 building projects in France. The top down implementation is based on the conviction of company leaders who rely on global indicators. With tools such as 5S, it enabled to bring more standards in the company but ended in a fragmented and dogmatic tools application. Moreover, most actions were not actually sustained and their economic efficiency was still debatable because of a lack of indicators.

A bottom up implementation was developed with the sites' managers and crews based on local process indicators. Lean tools were integrated incrementally to facilitate learning and answer to the actual needs of each site. VA/NVA analysis enabled a real awareness of the potential of improvement on workplaces. Thanks to flow indicators, the actual constraint of the site could be identified. Ultimately, Last Planner System's tool of production control enabled to monitor improvement actions and to integrate them in the site's daily practices. Variability, wastes and overall delay were thus actually reduced. To start their Lean journey, many companies can be interested in a Top down implementation such as tested during the first part of the project. This work shows the limits of this approach and provides an alternative way adapted to sites' practices.

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