

LEAN DIAGNOSIS FOR CHILEAN CONSTRUCTION INDUSTRY: TOWARDS MORE SUSTAINABLE LEAN PRACTICES AND TOOLS

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ABSTRACT

Construction companies face important challenges to implement and sustain Lean methods, and they need to periodically assess the state of their implementation efforts. This paper presents the results of a collaborative initiative from seven Chilean construction companies to diagnose the implementation state of some aspects of Lean organizations: Philosophy, Culture and Technology. The diagnosis was carried out using data from four different tools: interviews with managers, workshops with Last Planner implementers, visits to projects and planning meetings, and an organizational survey to validate previous results. Despite 90% of managers believe that Lean is central to enhancing their businesses, important barriers to sustain practices were detected such as Last Planner (LP), which was identified as a common tool among those companies. Thus, the most important aspects observed could be summarized as lack of certainty, lack of training, and very limited use of other tools; moreover, important differences were identified with regards to the level of LP implementations. The diagnosis is expected to constitute a base to generate improved company strategies to implement and sustain Lean construction practices, with emphasis in the development of people as a core of Lean organizations.

KEYWORDS

Continuous improvement, Last Planner System, Lean construction, Lookahead.

INTRODUCTION

Continuous improvement is promoted as a permanent practice for organizations working under a Lean approach. Hence, identifying the current problems in order to

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look for the best practices and sustaining them over time have become essential activities to achieve better results.

Different studies have been presented at the International Group for Lean Construction – IGLC -, which intended to evaluate the implementation states of Lean tools such as Last Planner System (LPS) and/or to identify cultural aspects to assess the maturity state of Lean organizations. Up to now, various barriers have been identified, helping both researchers and industry people to recognize the critical aspects to focus their efforts on solving these problems more proactively Viana et al., 2010; Hamzeh, 2011). One possible reason for the identified barriers is that the companies implement Lean tools only from an operational point of view, disregarding essential aspects such as a solid support base, a clear view of the future vision aligned with the companies' strategic objectives, and a more holistic approach (Barros and Alves, 2007). This is further combined with other common problems related to lack of knowledge (Viana et al., 2010.), lack of training (Brady, et al., 2009; Porwal, et al., 2010; Cerveró-Romero et al., 2013), education (Brady et al., 2009; Jara et al., 2009; Mossman, 2009) and lack of maturity in the organizations (Chesworth, London and Gajendran, 2010).

Changing traditions and culture seem to be prerequisites for implementing Lean in the Construction sector. That is why the development of implementation strategies and training at both organizational and project levels with strong leadership and commitments could be the most important steps for a successful, sustainable implementation over time.

Chile has been a pioneer country in the application of Lean Construction practices, which has given rise to the Building Excellence group of companies, which work collaboratively under the guidance of the Production Management Centre of the Catholic University of Chile (GEPUC) in various investigations in order to improve this field's performance. This paper presents a research called "Lean Tools Sustainable over Time," whose main objective was tackling the great concern among companies about making LPS a successful tool over time, avoiding the difficulties that ineffectiveness commonly causes as work develops. For this purpose, the first phase of the research consisted of a diagnosis attempting to identify the current state of the implementations and other aspects that may be related to Lean Construction (LC), whether belonging to these organizations' cultures or philosophies. It should be noted that the 10 companies participating in the research have LP as a common tool; therefore, the diagnosis activities are mostly focused on assessing this planning system.

LEAN CONSTRUCTION TRIANGLE ACCORDING TO GEPUC

Womack and Jones (2003) summarize Lean thinking in 5 key principles: Specifying value (according to the customer's perspective), Identifying the Value Chain (Value v/s No Value, Losses), Creating Continuous Flow, Pulling Production by the Customer, and Searching Perfection. In order to visualize the key aspects of Lean in the construction sector, GEPUC has suggested a triangle that graphically represents in its vertices three fundamental aspects for a global understanding: Philosophy, Culture and Technology and/or Tools (Figure 1). Thus, for diagnosis development these aspects were regarded as the starting point for viewing different aspects related to the sustainability of successful Lean Construction practices.

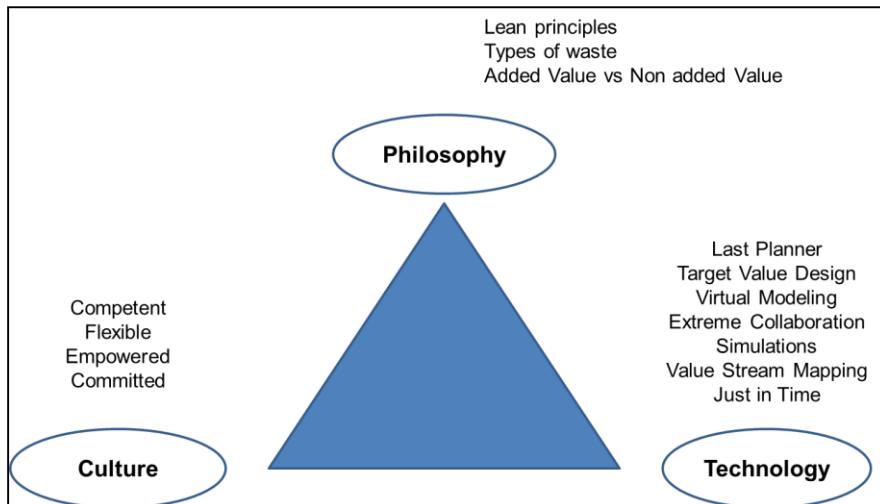


Figure 1: GEPUC's Lean Triangle (own elaboration).

METHODOLOGY

In order to define the current state of Lean implementation, considering that Last Planner is a common tool for the 10 participating companies, a diagnosis from August 2014 to January 2015 was carried out. In summary, data collection process includes four main steps summarized in Table 1.

Table 1: Data collection process

Stage	Objective	Participants	Description
Stage 1 (August, 2014): Management Interview.	Identifying involvement state from management on Lean operational issues.	31 participants: General Manager, Operations/Project/Technical Manager, Human Resources Manager, Implementers.	Ten structured interviews with the managers of organizations with an average duration of 2 hours were carried out. Open questions intended to learn about aspects such as reasons to implement Lean methods and resistance to change within organizations, whether the Lean perspective was a part of the training or induction processes of their workers, their workers' skills facilitating the development of their organizations, among others were asked.
Stage 2 (September, 2014): Last Planner Implementers Workshop.	Identifying experience in LPS implementation on-site.	25 LP implementers with 1 to 10 years experiences.	Two workshops were carried out with activities aimed at collecting information regarding issues related to the support from the organization, implemented strategies for success, leadership, barriers, among others.
Stage 3	Viewing the	On-site teams (Last	Eleven projects were visited,

(October to November 2014): On-site Visits	implementation, use of tools, and cultural aspects realities. Validating the information obtained from management interviews and the implementers workshops.	planners	specifically their planning meetings. For data collection, the following three instruments were used: Survey to all participants in the planning meeting. This tool was structured based on closed questions. Its aim was to collect information regarding: experience, culture, planning, standardization, transparency and continuous improvement. Planning practices checklist: This instrument was designed based on literature study, and it seeks to detect whether key issues are being addressed (e.g., Lookahead). Additionally, general aspects of culture, such as respect, leadership, and others were identified. On-site inspection checklist: With the objective of detecting Lean-related practices on-site, the use of tools was identified.
Stage 4 (December 2014 to January 2015): Massive, on-line surveys.	Contrasting obtained information from the earlier stages (based on the company's general view)	533 participants, including managers, administrators and foremen.	Seven on-line surveys consisting of 53 statements, with a Likert scale, which addressed the following dimensions: Teamwork, Capacity Development, Management Practices, Continuous Improvement, 5S, Communication, Understanding of Lean, Standardization, Value, Planning and Technology.

DIAGNOSIS RESULTS

The information obtained in steps 1, 2 and 3 allows us to identify organizational elements or aspects that are considered barriers or that have contributed to support Lean practices within organizations. It should be noted that in step two the assessments made by experts are also considered.

Stage 1- According to the interviewed managers' opinions, the main factors are the following:

- Factors identified as barriers to support Lean Practices:
 - Resistance to change: Lack of certainty about the usefulness of Lean tools persists on an organizational level, which is even greater on senior professionals whose previous experiences are not based on this new approach. Moreover, loss of motivation is considered a factor influencing the change of approach at the level of organizations
 - Lack of Training: Poor preparation of people is recognized. Accordingly, seven of the ten companies have not added any kinds of

- skills to their staff selection under a Lean focus, and only 50% of the 31 interviewed managers have participated in inductions or trainings related to this.
- Leadership: According to the managers interviewed, in order to find key characters influencing the companies' transformation, it is difficult to have people with adequate leadership skills.
 - Industry features: Aspects related to the industry's distinctive features such as high staff turnover, lack of continuous monitoring of new practices (return to traditional procedure to face emergencies) and coordination difficult due to a large number of subcontractors working simultaneously are recognized.
 - Success to maintain Lean Practices:
 - Certainty: According to those interviewed, in order to sustain the success of Lean tools over time there must be organizational certainty, and senior managers must promote their use. Significantly, 90% of the interviewed agrees that Lean methods are crucial to the growth of the company, and they should not be seen as complementary.

Stage 2 – According to the Last Planner Implementers, the following aspects can be identified:

- Barriers to maintain Lean Practices:
 - Lack of alignment: Within organizations there is no unanimous perception of Lean philosophy, but an increased understanding of the tool as an instrument, e.g., "Lean Philosophy is the same as Last Planner." Additionally, it is noted that if the company's areas are not aligned based on a common philosophy or goal, there will always be conflicts affecting the sustainability of the practices.
 - Resistance to change: People's ages and the organization's ineffective internal communication channels.
- Success to maintain Lean Practices:
 - Certainty: According to the opinions of workshops participants, the key success factor of the tools is internal certainty about their existence regarding their usefulness. In most cases it is recognized that LP has been the only tool used; in this sense, few organizations have promoted the use of other tools such as 5S and VSM.

Stage 3 - Site Visits allow identifying the following key elements:

- Barriers to maintain Lean Practices:
 - Lack of social skills: According to experts' assessment, Commitment and Motivation exhibit the lowest rates (Figure 2). These results come from the assessment carried out at the LP meeting, in which not only aspects related to the tool itself were evaluated, but also those related to the skills of those people conducting these meetings.
 - Lack of key elements of LPS: Table 2 shows that indicators such as Percent Constraint Removed (PCR) and Executable Work Inventory (EWI) are observed only in 2 and 3 projects respectively. Therefore, the potential benefit of Weekly Work Planning and Short Term Planning in uncertainty management is being wasted. It is important to

note that despite the Causes of Non-Completion (CNC) management in 7 of the 11 projects visited (64%), planning meetings do not lead to find the root causes of the problems. Additionally, it is possible to identify that only 36% of Last Planners analyse their own causes of noncompliance.

- Visual management: According to experts' criteria, some elements that may be affecting the sustained success of Lean practices is the limited use of visual management tools. Thus, they have been incorporated in less than half of the projects, and the way it has been observed is through panels, dynamic displays, and graphics to present production results, among others.
- Lack of tools: Tools related to continuous improvement such as Ishikawa Diagram, among others, were not identified. On the other hand, the use of management support tools, such as A3, BIM, VSM and Kitting, as well as 6S's approach on-site is observed in a small number of projects (Figure 3).
- Success to maintain Lean Practices:
 - Social skills: According to the experts' criteria, Leadership and Respect have the highest rates evaluated⁵ (Figure 2). Both are considered key factors for the sustained success of the LC-associated practices.. Regarding the on-site survey, all aspects are largely well evaluated by the participants of the meeting, reaching approvals of over 90% (Figure 4).

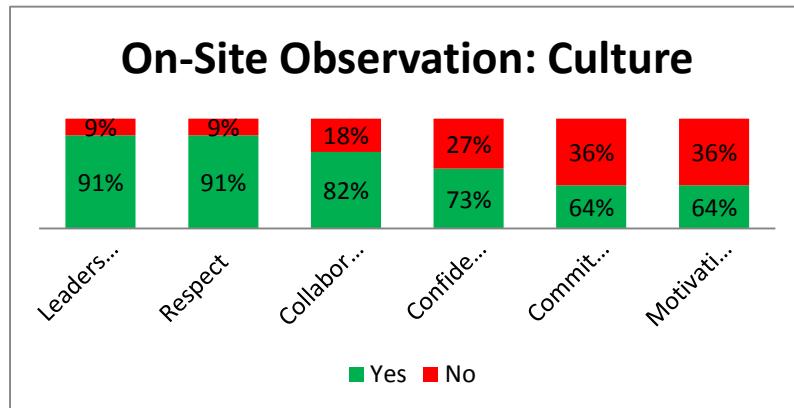


Figure 2: Culture: on-site observation (own elaboration).

⁵ Note that these aspects were evaluated based on the perceptions of consulting engineers and psychologists with training and experience in Lean Construction

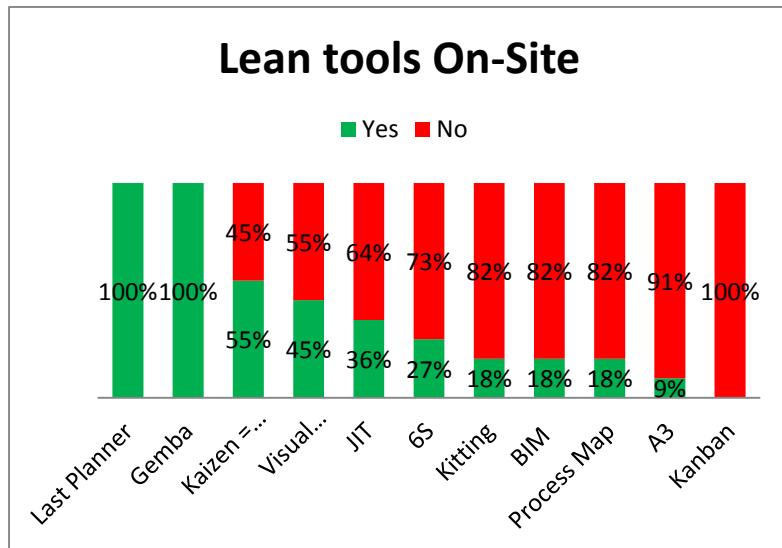


Figure 3: Lean Tools On-Site (own elaboration).

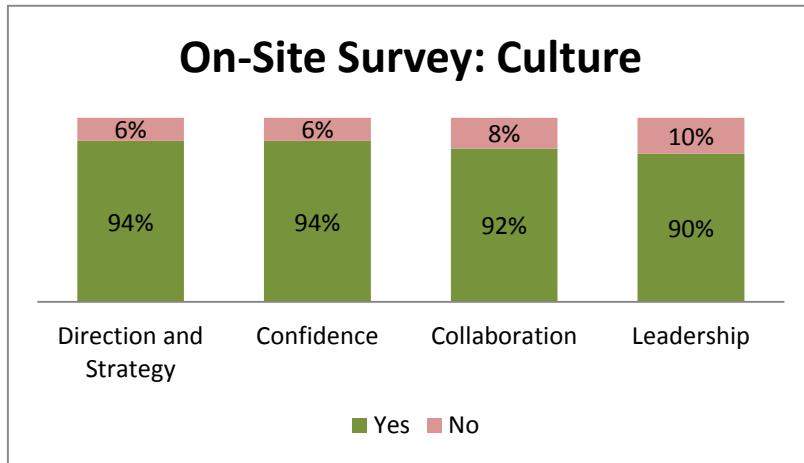


Figure 4: Culture: on-site survey (own elaboration)

The final stage includes the organization's global view, represented by opinions from the management departments to those of the on-site technical offices.

Stage 4 - Organizational surveys: The lowest dimensions correspond to Skills Development, Lean Understanding and Planning. Note that these dimensions involve the following aspects.

- Skills Development: Selection, Induction and Training.
- Lean Understanding: Lean Concepts and tools, advantages of this approach, and aspects of the philosophy.
- Planning: Involving, compromise, transparency and continuous improvement of planning processes.

On the contrary, the highest measured dimensions according to the organization's global view correspond to:

- Teamwork: Incentives, common objectives, awareness of colleagues' skills, internal client.

- Culture: Encompassing aspects such as continuous improvement, respect, motivation and leadership.

General results are shown on Figure 5.

Table 2: LPS Implementation Level

Phase	Practice	Average
Master Plan	Master Plan – Phases	100%
	Interactive Planning	27%
Intermediate Plan	Intermediate-Lookahead Plan	91%
	Percent Constraint Removed (PCR)	27%
Weekly Plan	Executable Work Inventory (EWI)	36%
	Weekly Plan	100%
General	Percentage of Plans Completed (PPC)	82%
	Causes of Non-Completion (CNC)	64%
	CNC Solution	36%
	Weekly Meeting	100%
	Standardization of Processes	9%
	Visual Information	36%
	Average Lookahead (weeks)	3.7



Figure 5: Organizational Survey: General Results (own elaboration).

CONCLUSIONS

The results of the diagnosis presented in this study have identified aspects related to sustainability practices related to Lean in a group of 10 Chilean construction companies belonging to the "Building Excellence" Collaborative Group of GEPUC.

The results show that although most managers considered Lean philosophy as central to the development of their companies, the skills of their employees have not been adjusted to this new thinking up to date; also, there is no continuous training. Both aspects are considered important elements to create culture inside organizations. At present, there are no standardized HR management practices in organizations, with no continuous training models or programs to transversally integrate the philosophy. This highlights the lack of alignment of the efforts in implementations with the strategy of these organizations. Important aspects related to change resistance within organizations were identified. Some of them are related to the industry's characteristics, such as high staff turnover and coordination difficulties due to the large number of parties involved in the same project. Others are related to the difficulty of teaching new approaches to seniors.

With regards to the use of technologies and/or tools,, the employment of other commonly used tools by organizations, apart from Last Planner, both on-site and at headquarters, cannot be broadly identified, which can also be considered an important aspect when assuring success of Lean practices over time.

Regarding the particular case of LP, it is confirmed that despite the efforts made to date, some fundamental aspects such as analysis of reasons for incomplete assignments, constraint management, among others are still on a basic level. Accordingly, when analysing projects of the same company, significant variations were observed. It is also concluded that it is impossible to view a clear alignment of the companies with LC approach. Note that in the organizational survey the planning dimension was one of the most poorly evaluated.. An important aspect to note is that leadership, which is recognized as a key factor for the success of Last Planner, proves to be a well-assessed aspect by the expert evaluators of the planning meetings. On the other hand, the organizational survey showed that aspects related to teamwork are well perceived within organizations.

. It is worth noticing that the most relevant aspect is certainty when considering Lean Construction as a valid approach for organizations. Hence, there is agreement that the strategy should be aimed at demonstrating the utility with tangible results, effective training, and empowerment with the equipment.

Finally, note that the second stage of this research will be aimed at developing a development model for people. Thus, it will be necessary to study competence and role gaps for a "lean profile" which supports people management departments. The idea is that these profiles consider key aspects to be included in induction programs, which will be considered in the organizations' performance evaluations.

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REFERENCES

- Alves, T. 2009. Incentives and innovation to sustain Lean Construction Implementation. In: *Proc. 17th Ann. Conf. of the Int'l Group for Lean Construction*, Taipei, Taiwan, July 15-17.

- Alves, T. and Fauchier, D. 2013. Last Planner System is the gateway to Lean behaviour. In: *Proc. 21st Ann. Conf. of the Int'l Group for Lean Construction*, Fortaleza, Brazil, July 31- August 2.
- Al-Aomar, R. 2012. Analysis of Lean Construction practices at Abu Dhabi Construction Industry. In: *Proc. 20th Ann. Conf. of the Int'l Group for Lean Construction*, San Diego, USA, July 18-20.
- Arbulu, R. and Ballard, G. 2003. Kanban in Construction. In: *Proc. 11th Ann. Conf. of the Int'l Group for Lean Construction*. Virginia, USA, July 22-24.
- Barros, N.J. and Alves, T. 2007. Strategic Issues in Lean Construction implementation. . In: *Proc. 15th Ann. Conf. of the Int'l Group for Lean Construction*. Michigan, USA, July 18-20.
- Cervero-Romero, F. and Napolitano, P. 2013. Last Planner System and Lean Approach process: Experience from implementation in México. In: *Proc. 21st Ann. Conf. of the Int'l Group for Lean Construction*. Fortaleza, Brazil, Jul 31- Aug 2.
- Chesworth, B., London, K. and Gajendran, T. 2010. Diffusing lean implementation & organisation cultural maturity. In: *Proc. 18th Ann. Conf. of the Int'l Group for Lean Construction*. Haifa, Israel, July 14-16.
- Fullalove, L. 2013. Examples of Lean Techniques and Methodology applied to UK Road Schemes. In: *Proc. 21st Ann. Conf. of the Int'l Group for Lean Construction*. Fortaleza, Brazil, July 31- August 2.
- Hamzeh, F. 2012. The Lean Journey: Implementing the Last Planner System in Construction. In: *Proc. 20th Ann. Conf. of the Int'l Group for Lean Construction*. San Diego, USA, July 18-20.
- Kemmer, S. and Alves, T., 2013. Using the Line of Balance for Production System Design. In: *Proc. 21st Ann. Conf. of the Int'l Group for Lean Construction*. Fortaleza, Brazil, July 31- August 2.
- Koskela, L. 1992. *Application of the New Production Philosophy to Construction. Technical Report #72.CA*: Department of Civil Engineering, Stanford University.
- Liker, J. and Meier, D. 2006. *The toyota way fieldbook*, New York: The McGraw-Hill Companies, 2006.
- Morrey, N. and Pasquire, C. 2011. Developing a Strategy to Enact Lean. *Journal of Engineering, Project, and Production Management* (EPPM), 3(1), pp.35-45.
- Pekuri, A. 2012. Applying Lean in Construction-Cornerstones for implementation. In: *Proc. 20th Ann. Conf. of the Int'l Group for Lean Construction* San Diego, USA, July 18-20.
- Porwal, V., Fernández-Solís, J., Lavy, S. and Rybkowski, Z.K. 2010. Last planner system implementation challenges. In: *Proc. 18th Ann. Conf. of the Int'l Group for Lean Construction*. Haifa, Israel, July 14-16.
- Salem, O. and Salomon, J. 2006. *Lean Construction: From Theory to Implementation. ASCE, Journal of Management in Engineering*, 22(4), pp.168-175.
- Viana, D. and Mota, B. 2010. A survey on the Last Planner System: Impacts and difficulties for implementation in Brazilian Companies. In: *Proc. 18th Ann. Conf. of the Int'l Group for Lean Construction*. Haifa, Israel, July 14-16.
- Wandahl, S. 2014. Lean Construction with or without Lean – Challenges of Implementing Lean Construction. In: *Proc. 22nd Ann. Conf. of the Int'l Group for Lean Construction*. Oslo, Norway, June 23-27.
- Womack, J.P. and Jones, D.T. 2003. *Lean Thinking*. New York: Free Press.