

RELATION BETWEEN THE SUSTAINABLE MATURITY OF CONSTRUCTION COMPANIES AND THE PHILOSOPHY OF LEAN CONSTRUCTION

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ABSTRACT

In the current economic context, the influence of globalization on business requires the entrepreneur to adopt competitive posture in market. Thus, in the civil construction industry, it is known that companies seek new processes, products and tools to maximize efficiency. The Lean philosophy and the environmental management are considered strategic practices and seek to reduce waste due to the organizational efficiency. The application of these philosophies requires investments by companies, making substantial to measure it continuously. This study aims to analyze the relationship between Lean Construction (LC) concepts and sustainable construction, by the use of assessment tools that show maturity indicators of the companies involving both approaches. About the methodological procedures, this is a qualitative research with an exploratory approach. The multiple case study was used as research strategy in two construction companies located in Fortaleza, Brazil. As results, was observed that application of Lean and Green have similarities and complementarities. Therefore, the main contribution of this research is the fact that companies could achieve their process more efficient and with more quality when they implement Lean and sustainable principles simultaneously.

KEYWORDS

Sustainability, Lean Construction, Construction Industry, Indicators.

INTRODUCTION

The relationship between the Lean Construction (LC) principles and the sustainability are the study objects in this paper. Horvath (2004) consider that the civil construction industry is one of the most polluting, because of the waste generated during the building life cycle. Several business organizations seek to avoid waste and pollution,

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considered forms of inefficiency (Rao and Holt 2005). It can be stated that the implementation of LC can ensure competitive advantage for construction firms (Lewis 2000), as well as the search for sustainability.

The LC emerged from the work of Lauri Koskela (1992), with the adaptation of Lean Production principles to civil construction. These principles seek to optimize the flows of production, considering the activities of conversion, inspection, moving and waiting, reducing the waste of time and resources (Koskela 2000). The concept of value with focus on customer needs and the continuous search for quality are prioritized.

Kibert (2007) determines the principles required in green buildings: reduce, reuse and use recyclable resources, protect nature, eliminate toxic elements, apply life-cycle costing and focus on quality. Asiedu et al. (2009) consider the sustainability in construction as a process that reaches harmony between natural and built environments in four attributes: social, economic, biophysical and technical.

The theory of LC and sustainability practices in construction shows that they are able to reduce waste for organizational efficiency, been adopted as strategic practices (Yang et al 2010). The adoption of such practices depends on the manager of each organization. There are companies that adopt the exclusively the LC, while others focus on sustainable practices. There are also companies that do not intend to adopt any of the two practices, while others seek to adopt both the LC and the principles of sustainability in construction projects, generating positive effects on AEC industry (Yang et al. 2010; Mao and Zhang 2008; Gutiérrez 2007; Kohler and Lützkendorf 2002).

Some authors believe that the LC has a positive impact on the sustainability of buildings (Horman et al. 2004; Huovila and Koskela, 1998; Lapinski et al. 2006; Luo et al. 2005; Riley et al. 2005). On the other hand, other authors state that not always lean practices generate positive impacts, because the adding value by the customer's needs does not always result in reduction of environmental impacts (Cusumano, 1994; Rothenberg et al. 2001). Bae and Kim (2007) claim that LC interferes in sustainability considering the following prospects: economic, due to the economy of resources, social, by allowing health, safety, communication and loyalty between the employees and environmental, by eliminating waste and resource conservation.

To understand the level of LC and sustainability application in companies and their possible interactions, it is important to use models that are able to quantify concretely the degree of Lean and sustainability implementation. However, some authors highlight the difficulty of measuring the implementation of these philosophies (Oliveira et al 2010; Bellen 2006). It is important to state that during the development of this work, weren't found models that measure both the LC and the level of sustainability.

This paper analyses the relationship between Lean and Green by the application of two tools and consider the assumption that the methodology proposed by Hofacker et al. (2008) is able to assess the degree of LC implementation in construction companies and that the measurement model of corporate sustainability proposed by Farias Filho et al. (2009) is sufficient to quantify the sustainable maturity of the organization researched. Other factors may influence the evaluation of performance on companies, but they will not be considered.

Thus, this study aims to analyze the relationship between the concepts of LC and sustainability through the application of assessment tools that show indicators of maturity on companies regarding the two approaches. It is intended to test the following hypothesis: the application of LC on itself contributes to sustainable maturity of the company, as well as application of sustainable procedures would make the building production more Lean.

LEAN CONSTRUCTION EVALUATION TOOL

The LC implementation by itself doesn't guarantee the quality of building. It's necessary to evaluate its progress. Considering the difficulty of measuring and evaluating and the advantages of LC concepts in construction companies, many methodologies have been created, such as the Rapid Plant Assessment, developed by Goodson (2002) the model for assessing the level of lean manufacturing firms, created by Soriano-Meier and Forrester (2001), and The Lean Construction-Quality Rating Model (LCR), proposed by Hofacker et al. (2008). The last one is the tool adopted in this work.

The LCR proposes a model to evaluate the quality and application degree of LC in building companies. The development of this tool involved a brainstorm phase, which were defined its categories and assessment points.

The evaluation of LCR was based in a questionnaire with thirty questions to be answered by the researchers. This model was developed considering the five principles of Lean Thinking established by Womack and Jones and the eleven principles of LC from Koskela's theory. The questionnaire has six categories: (1) Client Focus, (2) Waste, (3) Quality, (4) Material Flow, (5) Organization, planning and information flow, (6) Continuous improvement.

The evaluation of buildings indicates scores from zero to six for each issue. The final score provides the obtaining of an average which indicates the company classification according to the application degree of the lean construction. The buildings can reach twelve levels on a classification scale which goes from level D (the lowest one, the least Lean) to level AAA (the most elevated, the most Lean), according to Figure 1.

SUSTAINABILITY EVALUATION TOOL

Considering the sustainable development that involves the balance between the socially desirable, economically viable and environmentally friendly, it is perceived that the implementation of its principles provides advantages to the corporate environment. There are some tools for measuring sustainability in companies, such as Global Reporting Initiative, the IChemE Sustainable Development Progress Metrics; DowJones Sustainability Index World, Guide to the Multinational Organization for Economic Cooperation and Development (OECD) and Ethos Social Responsibility business (Delai and Takahashi 2008).

The application of these tools requires investments by the companies, making necessary its continuous mensuration. Given this, Farias Filho et al. (2009) developed a self-assessment tool to perform the sustainable measurement, focusing on companies of the construction industry that adopted sustainable strategies, but have few resources to invest in other instruments.

The tool is a matrix with three dimensions, 3x4x4 order. Each axis has one of three dimensions of evaluation, described below. In the contents, are 48 elements, with sustainable features that should be achieved by companies, coming from relationship of these dimensions, namely:

- The sustainability tripod: consider the economic, environmental and social dimensions.
- Strategic themes of Balanced Scorecard: addresses the most important performance indicators of organizations, considering the “financial” aspects, to observe the generation of impacts and economic values; “customers”, which assesses the sustainable practices considering the public of the organization; “internal processes”, whose goal is to analyze the companies' actions considering the optimization of processes and “learning and knowledge”, which evaluates the training and learning of stakeholders.
- Corporate Sustainable Index (ISE): characterize the organization through the “perspective of policy and planning”, analyzing if corporate policies are able to consider the three dimensions of sustainability tripod, “perspective of management”, which evaluates the interference of strategic planning in sustainability, the “perspective of performance”, involving performance and the “perspective of legal compliance”, which intends to verify the agreement between the company and the law.

The general manager of the company should evaluate all the elements from matrix, assigning a value in each sentence that varies between zero to four. Higher values indicate more sustainability. It is important to state that each element interferes differently in organizational sustainability, requiring the determination of relative weights which must be multiplied to results of self-assessment. Thus, a final score is generated, allowing to rank the company in a level of sustainable maturity as defined in Figure 2:

RESEARCH METHOD

This present work is a qualitative research which presents as strategy research the multiple case study with an exploratory approach. According to Yin (2005), qualitative studies are used when researchers use sentences like "how" and "because", when they have weak control of the events and when the research focuses in a contemporary phenomenon inserted in a real context.

About the research goals, Gil (2009) states that exploratory approach have the main intention to make the problem more explicit. Therefore, procedures are used, as literature survey, interviews with people who had practical experience with the problem, and the analysis of examples that will support the scope of the problem. Therefore, it makes possible the consideration of several aspects related to the fact studied.

In accordance to the goals of the research, the following steps have been taken to the work development: (1) Literature review involving the principles of LC based on the work carried out by Koskela (1992), and the study of insertion the environmental management in companies. (2) Selection of evaluation methodologies used in the research: Rapid Lean Construction-Quality Rating Model (LCR) from Hofacker et al. (2008), to evaluate how much the LC philosophy has been applied in construction;

and the tool for evaluation of the sustainability maturity level in civil construction corporations, developed by Farias Filho (2009). (3) Application of the methodologies in two case studies (4) Analysis and discussion about the relationship between the LC concepts and the sustainable maturity of companies.

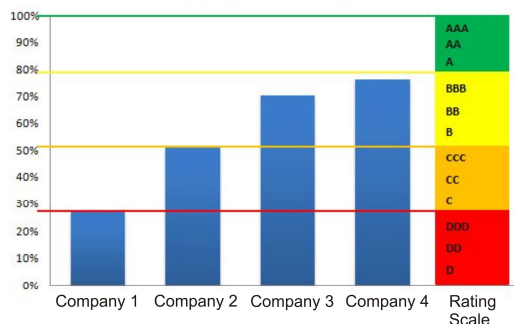


Figure 1: Comparison between the classification of the works of companies (Figure 6 in Oliveira et al. 2010).

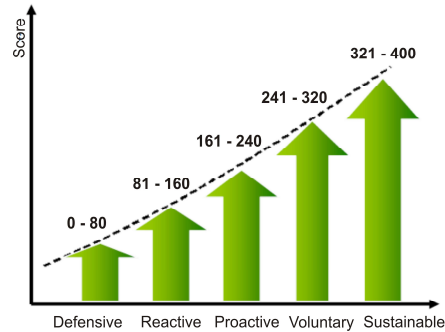


Figure 2: Levels of maturity sustainable of companies (Figure 3 in Farias Filho et al. 2009).

The assessment tool proposed by Farias Filho et al. (2009) does not propose to examine the ways of sustainability implementation in the company, but the sustainable strategy already implemented in a place. Therefore, the use of this tool is justified because it allows companies of all sizes to evaluate in an easy and complete manner their sustainability performance, providing improvements for them.

Hofacker et al (2008) developed a model for assessing the quality and degree of LC implementation in building companies, offering a categorized assessment with easy viewing and interpretation of results. Oliveira et al (2010) applied the LCR in four construction sites: two in Curitiba (Brazil) - where did not apply the philosophy, one in Porto Alegre (Brazil) and one in Sindelfingen (Germany)- both implemented the LC philosophy on site. The use of LCR is justified due to its characteristics, namely: application in a short time, in less than one hour; items organized by categories; simple and complete interface. It is necessary to researchers only the direct observation of the building and a conduction of an interview with the engineer responsible for building.

Besides the advantages mentioned above, these instruments were selected because of their specific use in civil construction sector.

SAMPLE CHARACTERIZATION

This research was carried out through two case studies that took place in construction companies which had one of their works each analyzed. The Company A, which is classified as medium sized company, started its activities in 1989. It has 20 completed buildings, among them commercial and residential constructions and their clients are from A and B social classes. This company's philosophy aims to meet their clients' needs with efficient products at a very fair price. The considered building is in a certification process, aiming the Leed Silver level.

The case study from Company A is a commercial building, which is located on a very wealthy area of Fortaleza-Brazil. It is made of four underground levels with

nineteen flooring types. This construction was at a structural stage, having its last underground level being concreted.

The company B, which is also a medium sized company, initiated its activities in 1988. It also has 20 concluded buildings, among them commercial and residential constructions for the A and B social classes. Its work philosophy is based on the good quality of services provided. This company aims to please clients, associates, and employees through innovation, continuous improvement, a more closely relationship regarding honesty and mutual trust. This company applies the LC philosophy concepts to its entire works.

The building of the company B is also a commercial construction located in the city of Fortaleza, Brazil. It is made of two underground levels with eighteen floors types. The construction was at a structural stage, with ten flooring types already concreted and with its masonry under execution.

RESULTS

RESULTS OF COMPANIES FOR THE IMPLEMENTATION OF LEAN CONSTRUCTION

The companies A and B presented distinct scores during the application of LCR. The six characteristics presented by both companies are analyzed, briefly explained and displayed in Table 1.

In the analysis of category “Client Focus”, the company B had an advantage by using a program of construction site cleaning (5S). The company A should implement a 5S program for LEED certification requirement, but had not been contemplated until the end of the study. Other requisites under the consideration of clients’ wishes in terms of sales, marketing, strategic focus, and flexibility did not make the two companies score, for considering as client the developer rather than final user. Thus, both companies showed their worst performance in the client focus category.

As for the waste, the company B presented excellent scores, making it far ahead of company A. It is wise to say that both companies have Waste Management Plan, which is required by Brazilian law by resolution 307/2002 of CONAMA. However, the company B goes beyond in this matter for the application of LC principles, and this reflects specially on its effective and organized use of construction site layout.

As for the “Quality”, the company A overcame the company B. In this category the company A presented the highest score for its high degree of mechanization through the use of crane and rack lift, and the elaboration of reports that would show the cause of possible mistakes. This last action was not present in company B. The two analyzed companies have quality management systems, the company A was certificated by PBQP-H and ISO9000, whereas the company B has ISO9000 certification and has also developed its own quality system, called PS37. At last, the visual management as guarantee of quality exists in the two companies, but it happens by deficient way.

By considering the “Material Flow and Pull” category, both companies presented an average performance, being the company B a bit better than company A. This last one reached scores due to the use of ready-mix concrete, a system to organize the material weekly orders, support and standardization of transports, use of cranes and pallets. About company B, besides meeting the same requisites as company A, it

implemented the Just-in-Time concepts, with daily measurements of the amount of storage and use of Kanban cards in a preliminary way.

Table 1: Characteristics evaluated by the LCR (The authors)

COMPANIES		A	B
Client Focus	Detecting what is value for the client, in terms of sales, marketing, strategy focus, project flexibility and cleanliness of the construction site.	8,3%	25,0%
Waste Consciousness	The process to reduce the wastes and losses in theirs construction site, stimulating waste management, space organization and reduction of wasted time	50,0%	93,3%
Quality	Search the quality through the certifications, good performance of services, safety on the construction site, prevention of rework, standardization of processes, visual management systems and mechanization	85,4%	70,8%
Material flow & pull	Evaluate the implementation of LC tools, such as: Kanban, Just in Time, ready-mix concrete, system application with replacement time of the materials, mechanization and transport standardization	50,0%	63,3%
Organization, planning, info flow	Knowledge of the top management about Lean Construction, motivation and self-responsibility of the employees and the Last Planner System applied with daily hurdle meetings.	19,4%	52,8%
Kaizen	Striving for perfection and for continuous education for the employees	50,0%	66,7%

With respect to “Organization, Planning, info flow” category, company A presented a non-satisfactory performance, while company B presented an average performance. The scores achieved by company B were granted due to the application of LC principles, by using versatile employees, vertical and horizontal information systems, and payment through work packages. Company A seems to be unaware Lean tools by taking conventional actions, using employees with specific tasks and a deficient communication system. Although the two companies seek the kaizen, company B reached the best scores, for it promoted improvements in a more adequate manner with incentive to the education of its employees through training courses.

Based on this evaluation, Company A reached a CC level, with 43.6% of the requisites fulfilled. Company B reached a B level with 62% of the requisites fulfilled as it can be observed in Figure 3:

Even that the company A was unaware of the Lean principles, it was still able to reach average results, because the search for LEED certification involves the consideration of LC strategies, such as: waste management, search for quality, and employee training. Company B reached scores expected of a company that really applies the LC principles. However, improvements still can be made, especially in terms of meeting the clients’ needs, improved signal, rework analysis, and higher level of mechanization.

RESULTS OF COMPANIES FOR THE SUSTAINABLE MATURITY

By analyzing the level of sustainable maturity of the two companies, it was observed that company A had a better performance than company B, by reaching a result almost the double score. This can be observed in Figure 4:

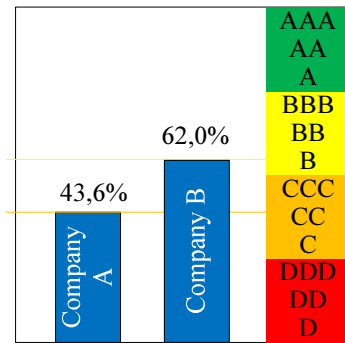


Figure 3: Levels of LEAN construction application of A and B companies (The authors).

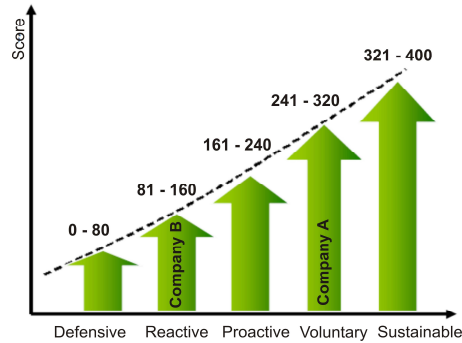


Figure 4: Levels of sustainable maturity of A and B companies (Adapted to Farias Filho et al. 2009).

Company A reached 242.1 scores and was classified as "Voluntary", explained by the intention in certifying the construction according to the LEED Silver, encouraging managers and employees to have a proactive attitude. In order to reach the LEED certification, it is necessary to fulfill a series of criteria and requisites that demand integrated learning and taking advantage of existent sustainable opportunities.

Company B presented a maturity level classified as "Reactive", reaching 123.3 scores because that company doesn't have a sustainable approach in their strategies. However, the implementation of LC principles and requirements of urban laws makes sustainable measures to be adopted, such as: optimization of production processes, waste management measures, work organization, and waste reduction.

It is important to highlight that out of the three sustainability pillars considered by the tool, the economic pillar presented the best performance for both companies if compared to the environmental and social pillars. This reinforces theories that state that the economic sphere should be of top priority in developing nations.

CONCLUSIONS

Considering the goal of this research, it can be observed that both methodologies have points in common, like the reach of quality, the reduction of waste, the information flow between employees and managers and the search of continuous improvements.

Some civil construction companies use the LC and sustainability as a competitive advantage. However, to achieve results, is necessary the awareness and commitment of all employees involved, even as the processes must be transparent.

During the development of this research, it was found that Company B reached reactive level in sustainable tool, even without the focus on environmental issues. This company presented good results in sustainability because it seeks to reduce waste, to optimize production processes and to raise the level of interaction among employees.

About Company A, it reached a median level on LCR tool. This is a reasonable score, considering that the top management and employees ignored the importance of applying the LC principles. This company presented a good rating in Lean evaluation because implemented sustainability guidelines in pursuit of LEED certification.

Given the above, this research hypothesis was confirmed: the LC application contributes to sustainable maturity of the company, as well as the implementation of sustainable procedures can make the building more lean.

Therefore, through the evidence provided by this study, it was observed that both concepts have similarities and complementarities. The application of sustainability in a building does not guarantee the full range of Lean benefits, but reinforces a good performance on the issues that the two philosophies have in common. The same goes for Lean Construction in relation to sustainability. However, the companies may present more efficient process and higher quality if the LC and sustainable principles were applied at the same time.

This paper presents the following limitations:

- The research conducted two case studies in construction companies, analyzing one work of each. A larger amount of companies evaluated could presents more detailed results about the relation between Lean and Green.
- One of the buildings uses Lean principles, while the other seeks environmental certification. The inclusion of a company that did not use any of these strategies on research could be a reference, contributing to the comparison of case studies.
- The measurement model proposed by Farias Filho et al. (2009) consists on a self-assessment tool developed based on sustainability indicators. It was applied directly to the company directors of companies. For this reason, there is an upward trend of the ranking, differently if the evaluation was performed with other people.

Thus, it is suggested future works to overcome these limitations. Besides these, it is suggested the proposition of a theoretical study joining the two assessment tools, resulting in a unique methodology of analysis. The case studies considered only commercial buildings. It would be interesting contemplate residential buildings in a future research, where there more focus on customer needs.

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