APPLICATION OF THE RAPID LEAN CONSTRUCTION-QUALITY RATING MODEL TO ENGINEERING COMPANIES

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ABSTRACT

The philosophy of Lean Construction, widely circulated in construction sites as a means towards greater product and process flexibility without major technological outlays, has caught the imagination of managers, as the construction market is becoming increasingly heated up. It is imperative that engineering firms wishing to implement the Lean Construction philosophy get an update on its current state, so that they can set achievable goals and objectives with the help of this philosophy. This study proposes the application of the Rapid Lean Construction-Quality Rating Model (LCR) by means of a questionnaire to two companies in the State of Goiás. As a result, the performance level of these companies in relation to the use of Lean Construction was obtained, to check how it was understood and how its principles were applied. After this step, the results were evaluated and suggestions were made to the companies to help them implement Lean Thinking. The model used was effective, because it was possible to obtain results in terms of the implementation of lean thinking in the two companies analyzed.

KEYWORDS

Lean Construction. Performance level. Rating model.

INTRODUCTION

The construction market is at a peak. In 2010 there were growth rates of more than 11% in its Gross Domestic Product (GDP), the best result in the last 24 years (CBI, 2010). This is one of the most significant reasons for companies investing in techniques and new management practices to reduce costs and increase productivity through new production philosophies (Oyam, 2010; Mota, 2010). These authors also state that the Lean system was developed at the end of the 80s to obtain a more efficient, flexible, agile and innovative production system capable of keeping pace with a constantly changing market.

OBJECTIVES

This study set out to use the Rapid Lean Construction-Quality Rating Model to evaluate the application of the principles of Lean Construction to two construction companies in Goiás.

METHODOLOGY

The model originated from the work of Hofacker et al. (2010), in which they proposed a model for evaluating the application of Lean Construction to building

companies. They first conducted a brainstorming exercise in which the model categories and its points of assessment were defined.

Assuming that the model proposed by Hofacker et al. (2010) was efficient, but had certain flaws, some changes were made by the present authors in the model proposed. The model was reformulated and structured on the basis of eight categories, presented in Table 1:

Table 1: Categories adopted in the model

1-Reduce waste	5-Increase the value of the product/service by means of a systematic consideration of consumer requirements
2-Reduce variability	6-Material flow and pull production
3- Increase process transparency	7-Organization, planning and information flow
4-Simplify by reducing the number of steps and parts and interdependencies	8-Continuous improvement

Source: Adaptation of Hofacker et al. (2010), drawn up by the authors

These categories were defined based on the five principles of Lean Thinking (Womack, Jones, Roos, 1990) and the 11 principles of Koskela (1992) on Lean Construction. For each category 5 evaluation points were chosen, with levels varying from 0 to 3, as shown in Table 1. For each level a percentage value ranging from 0% to 100% was set. A total of 40 questions were evaluated as shown in Table 2.

Table 2: Levels adopted in the model

Level 0	The principle is not present and there are no know tools to implement it
Level 1	The principle is not present, but tools for implementing it are known and the manager is interested in implanting it.
Level 2	The principle is fully and effectively implemented
Level 3	The principle is fully present, effectively implemented bringing improvements

Source: Adapted from Carvalho (2008).

The questionnaire was applied to two projects of each company chosen for the study in order to arrive at a characterization of the company itself, and not just of the project or of the engineer in charge, which would have happened if it had been applied to only one of the company's projects. Table 3 presents the questionnaire used for evaluation.

The questionnaires were answered by the managers and overseers in each project and their answers were verified by the researchers whenever possible by checking records, through face to face contact and in dialogue with other company employees.

From the results, an arithmetic mean was calculated. The results are presented in performance percentages and classified according to Table 4, which shows the classification of the company in terms of the application of Lean Construction concepts in its projects.

Table 3: Questionnaire to assess the current state of the construction companies in relation to the use of Lean Construction

Questionnaire to assess the current state of construction companies in relation to the use of Lean Construction			
Principles	Actions		Level
1-Waste	1	Is the project concerned about reducing activities which do not add value?	
	2	Are employees on the construction site made aware of material waste? Do employees get incentives to eliminate waste?	
	3	Is there a concern to map activities at the worksite and conduct future planning of the workflow?	
	4	How are materials distributed within the construction site? Does distribution consider the distance to the point where the materials will be used?	
	5	Is there a pre-determined for materials within the construction site, from their place of deposit to the job?	
2 – Reduce variability	1	Are there documented procedures for carrying out key activities at the construction site?	
	2	Is there formal planning of the job (long, medium and short term plans)?	
	3	Are auxiliary mechanisms used to increase productivity and reduce variability?	
	4	Are there performance indicators in the services undertaken on site?	
	5	Has a standardized organizational culture been set up which can be identified in any of the company's construction sites?	
3 – Increase transparency of the process	1	Is there space for dialogue with engineers and company directors?	
	2	Is there any visual management system, such as clear signs, or systems of quality control?	
	3	Are clear relationship policies put in practice with employees, by using panels, boards and radios?	
	4	Have appropriate communication channels with consumers been established?	
	5	Is the constructive system made available and posted in the workplace?	
4 - Simplification through reduction of steps and parts and interdependencies	1	Are kits and prefabricated material used in the job?	
	2	Are production cells used?	
	3	Is planning carried out to avoid clashes between work teams?	
	4	Does the job try to use fixtures or equipment to reduce the number of steps and parts in any one task?	

	5	Is the information about the tasks to be performed during the week clear and available to all employees on the site?	
5 - Increase the value of the product/ service through systematic consideration of customer requirements	1	Does the company define what the consumer considers value in terms of sales, marketing and strategic planning by using consumer satisfaction surveys?	
	2	After doing satisfaction surveys, does the company try to make improvements in areas deemed deficient by consumers?	
	3	Is there technical assistance for inspection and maintenance throughout the life of the project?	
	4	Is there regular communication with the consumer and flexibility in adapting to their requests?	
	5	Are indicators created to control and set goals for continuous improvement in relation to consumer satisfaction?	
6- Material flow and pull production	1	Does the company use the *Kanban* card system (does it exist and is it used)?	
	2	Does the company apply Just-In-Time?	
	3	Is ready-mixed concrete used?	
	4	Is there is a system of ordering and a time to get materials (concrete, steel and bricks) from suppliers?	
	5	Are transport support systems (cranes) and transport standardization (pallets) used?	
7- Organization, planning and information flow	1	Are workers trained to be a multi-purpose labor force? (Training flexible workers for different services)	
	2	Are the goals, results and expectations of the company clearly communicated to all employees?	
	3	Do the construction sites have signed, clean, wide, unobstructed internal access roads?	
	4	What is the level of awareness, conviction and support of the top management in terms of applying the concepts of Lean Construction?	
	5	Is there planning to reduce interference between projects during the implementation phase?	
8- Ongoing improvement	1	Does the company strive for perfection through the process of applying the learning acquired from one project to another?	
	2	With regard to conversion of activities, is there concern for and actions taken to introduce improvements?	
	3	Does the company have a program which encourages employees to submit ideas for continuous improvement?	
	4	Is there a continuous education program for employees? (for example, quality, specialization courses, Lean ...)	
	5	Does the company maintain a relationship with educational institutions, such as universities and centers of specialization and technical formation, translated into partnership projects?	

Source: Adapted from Silva (2011).

CASE STUDY

To undertake the case studies two medium-sized companies in Goiás were selected one in the town of Anápolis and the other in Goiânia. Both say they do not have the principles of Lean Construction as a philosophy of managing their business.

Table 4: Levels adopted in the model

Level	Sublevel	Percentage	Characteristics
A	AAA	80% a 84%	Search for continuous improvement in promoting the quality and application of the concepts of Lean Construction.
	AA	90% a 94%	
	A	85% a 89%	
B	BBB	80% a 84%	Awareness of the processes of Lean Thinking
	BB	75% a 79%	
	B	70% a 74%	
C	CCC	65% a 69%	Focus on improvement and knowledge of Lean Construction, but not implemented
	CC	60% a 64%	
	C	55% a 59%	
D	DDD	50% a 54%	No focus on improvements or waste and no knowledge of Lean Construction
	DD	45% a 49%	
	D	0% a 44%	

Source: Adapted from HOFACKER et al. (2008)

COMPANY 1

The first company, founded in 1988, operates in the construction and electrical sector. Its services include the construction of industrial plants, residential and commercial buildings, and land and mobile telephone exchanges. The company has been certified by ISO 9001 (ABNT, 2008) and H-PBQP level “A” quality standards.

It is undertaking four projects in the town of Anápolis, one commercial, one residential involving the building of popular housing, and two high-rise residential buildings. As the popular housing project at the moment of data collection was already at the stage of handing over of keys to residents, and one of the high-rise residential projects was at the beginning of its foundation stage, the construction of the commercial building and the other residential building which had already completed its foundation phase were chosen.

The Commercial Project

This commercial project will house the offices of an isothermal panels firm, located in the Anapolis Agroindustrial District (DAIA). As the construction site was located within the industry yard, the work had to be clean and short term. Therefore a series of constructive measures were adopted, such as root pile foundation, steel structure, and insulation with isothermal panels.

Because the project needed to be delivered quickly, that is, within a period of only six months, Company 1 was required to present a general schedule of the services to be performed as well as its commercial proposal.

Some of the strengths shown by the project were the quality of its implementation and of its products, organization and cleanliness on the work site, and recycling of

materials. Figure 1 shows a radar chart, where the gray shows the percentages found in this study, and the crowns of color represent the levels established, so that the eight principles adopted in the survey can be visualized.

From the results presented it is clear that the greatest shortcomings of the project were related to the material flow whose only positive action was the use of ready-mixed concrete. There was a low focus on continuous improvement as no program to encourage new ideas for application to the project were provided for the employees, but the employees were encouraged to continue their studies. It was reported during the interview that this year, a group of foremen was trained within the company, and are working in this capacity.

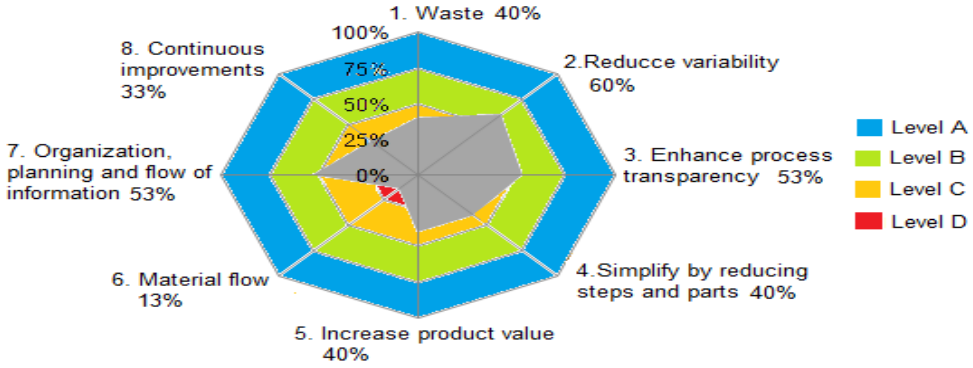

Figure 1: Level of Lean principles in Company 1's commercial project

Residential building project

Company 1's second project was a high-rise residential building, in Jardim Alexandrina in Anápolis. When the technical visit took place, the company was at the stage of initiating the building of the structure. From the results obtained in this research, three of the project's greatest shortcomings can be seen. They are related to organization, planning and information flow, material flow and reduction of the number of steps and parts, as shown in Figure 2.

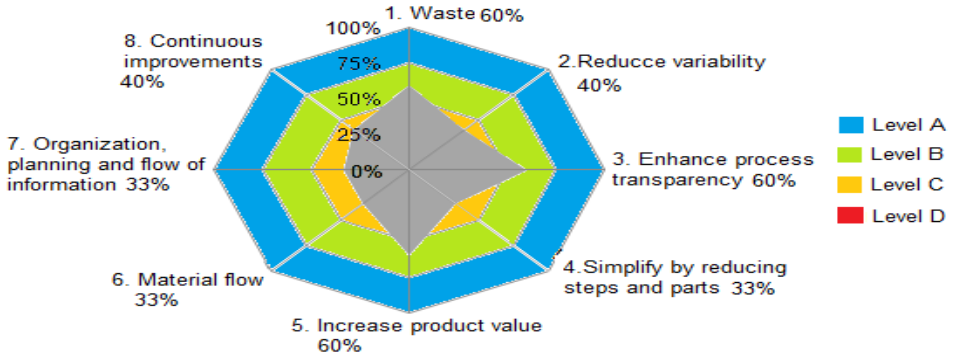

Figure 2: Level of Lean Principles of Company 1's residential project

COMPANY 2

This company, founded in 2004, involved in the building of quality high-rise residential buildings in Goiânia, has currently two projects on hand, one at the finishing and the other at the foundation phase. Presently, it has a staff of 175 contracted and subcontracted employees. It obtained ISO 9001:2008 and PBQP-H level A certification in July 2011. Both projects were part of this case study.

RESIDENTIAL BUILDING PROJECT 1

The first project chosen as an object of study for Company 2, a 33-storey building, is nearing completion. A special feature of the project is the outsourcing of most of the services.

From the questionnaire applied to Company 2's residential project, it was possible to tabulate the eight principles related to Lean Construction, proposed by the researchers. Figure 3 shows the levels obtained from the survey.

From data obtained from the research it could be seen that the major shortcoming found in project 1 had to do with the reduction of the steps and parts and its greatest performance is related to an increase in product value.

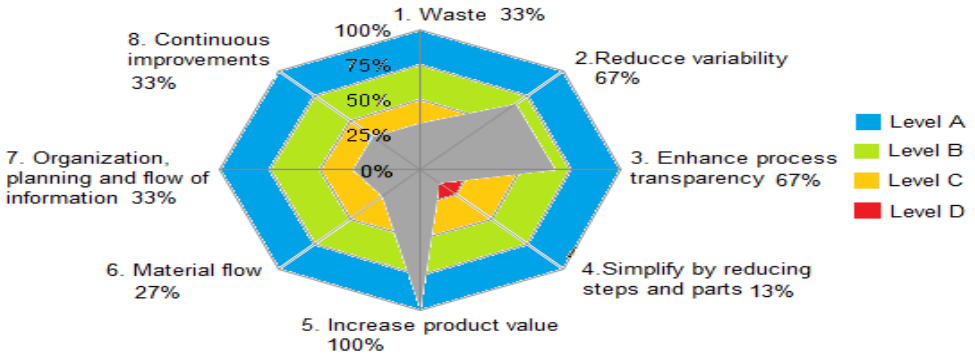

Figure 3: Level of lean principles in Company 2's first residential project

Residential building project 2

The second project, analyzed at its foundation phase, was a 30-storey building. Special features of this project were the reduction of the number of outsourced services due to experience gained from the first project, and the allocation of very little space for its construction site.

From the data obtained it could be seen that the greatest shortcoming of project 2 was related to the reduction of the steps and parts. There were also flaws in terms of material flow, but it performed best in terms of product transparency. This perception can be seen in Figure 4.

CONSIDERATIONS

Certain actions, identified as being based on the principles of Lean Construction, such as procedures for carrying out activities, consumer satisfaction surveys and company feedback with the data obtained from research, are related to the requirements of NBB ISO 9001 (ABNT, 2008), a certification obtained by the enterprises. The

aligning of Lean Thinking to the Quality Management System is to be recommended, as it can produce highly satisfactory results. Table 6 classifies Company 1 at level D and sublevel D.

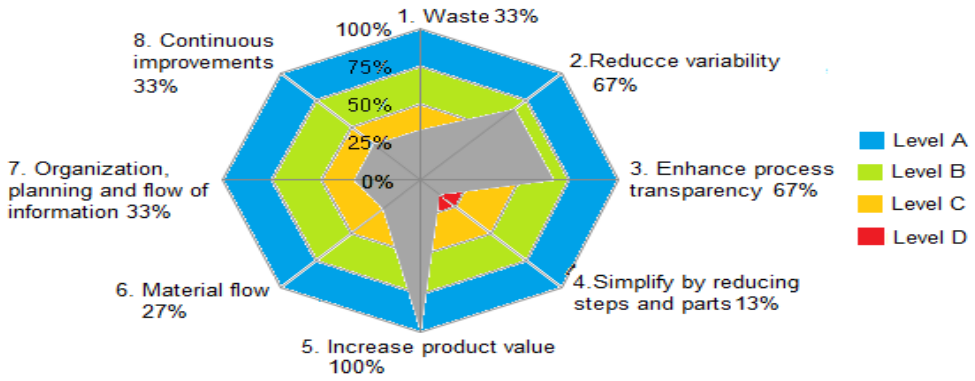

Figure 4: Level of Lean principles of Company 2's residential project

Table 6: Performance of Company 1

Principles	Action 1	Action 2	Action 3	Action 4	Action 5	Average	Level	Sub level
1	67%	50%	17%	67%	33%	47%	D	DD
2	100%	17%	0%	50%	83%	50%	D	DDD
3	83%	67%	67%	50%	17%	57%	C	C
4	100%	67%	0%	17%	0%	37%	D	D
5	33%	33%	83%	67%	33%	50%	D	DDD
6	0%	0%	83%	17%	17%	23%	D	D
7	33%	50%	67%	0%	67%	43%	D	D
8	17%	67%	17%	67%	17%	37%	D	D
FINAL AVERAGE								43%
Classification level of the company								D
Classification sublevel of the company								D

As Company 1 presented the lowest results at all levels (only level 3 was classified as C), its greatest shortcoming lies in visualizing the production process as a whole, seeing the existing flow between activities.

The main suggestion for improvement would be to adopt short, medium and long term planning crucial to the flow of any project, since this flow is only guaranteed when management redefines the construction planning paradigm, considering the interrelationships between the various stages of implementation.

The training of master-builders and foremen in the philosophy and tools of Lean Construction has been shown to be efficient, as one of the major problems in setting up short, medium and long term planning lies in the prediction or anticipation of the activities to be carried out, and for the staff of the construction site this task is easier as a result of their past experiences.

Encouraging employees to submit new ideas to the company has wrought results because it creates a sense of commitment to the project and the organization, showing that everyone can have an active voice in the company. Other suggestions for Company 1 include establishing partnerships with local universities for the implementation of new projects, using equipment and fixtures to reduce the number of steps and parts, forming multi-purpose teams and providing workers on the site with a schedule of the tasks to be performed during the week. In addition, listening to consumers and using this information for new ventures, creates a differential in the company and makes it more competitive in the market. These are simple actions but when implemented by a company make a difference to the final consumer.

In an interview to present the results of the case study, the directors of Company 1 showed an interest in the application of Lean Thinking to their company. The study was considered valid as the director showed that although he already theoretically knew the philosophy, he did not know any practical tools for applying it.

Table 7 shows the classification of Company 2 in relation to two items of Lean Construction which led to its performance being rated as level D, which means no focus on improvements or waste and no knowledge about Lean Construction.

Although the Company reached level D in terms of overall evaluation, it showed a better classification in the principle of reducing variability and reached higher levels in relation to enhanced product value which shows the main focus of the Company.

On applying the questionnaire in Company 2's two projects it could also be seen that the performance of both was similar. This result can be justified by the fact that the engineer and foreman were the same in both projects. Table 7 illustrates the performance of Company 2.

Table 7: Performance of Company 2

Principles	Action 1	Action 2	Action 3	Action 4	Action 5	Average	Level	Sub level
1	0%	50%	33%	33%	67%	37%	D	DD
2	100%	100%	0%	33%	100%	67%	C	CCC
3	100%	100%	67%	100%	0%	73%	B	B
4	50%	0%	33%	0%	0%	17%	D	D
5	100%	100%	100%	100%	100%	100%	A	AAA
6	0%	0%	100%	33%	0%	27%	D	D
7	33%	50%	33%	0%	67%	37%	D	D
8	100%	33%	33%	0%	0%	33%	D	D
FINAL AVERAGE							49%	
Classification level of the company							D	
Classification sublevel of the company							DD	

It was also seen that the company achieved 100% in the principle of enhancing product value, which shows that greater attention is paid to systematic consumer requirements. If Company 2 is to implant and implement Lean Thinking, certain steps should be taken beginning with the use of production cells and fixtures or equipment which would speed up and reduce the number of stages in each activity. The use of equipment for transporting material is highlighted (cranes, mini-cranes, pallets) as is

a concern about reducing activities which do not add value. In order to improve the transparency of the process, the Company could use an Andon signboard which shows on a luminous panel that there is a problem in production. But what is most important for the implementation of Lean Thinking is the awareness and support of top management. A reduction in the amount of outsourcing could also be emphasized. The company considers this type of contract beneficial, but it should choose the most qualified suppliers who are willing to work in conformity with company standards, which would contribute towards developing Lean Construction within the organization.

From these results, it can be seen that the model used as a parameter in the classification of the companies, is consistent with the reality found, as Companies 1 and 2 said that they did not use Lean Thinking and were classified as D (There is no emphasis on improvements, or waste reduction and no knowledge of Lean Construction), thus demonstrating the validation of the model proposed.

Application of the proposed model is more accurate when applied to all of a company's projects, so that a more profound analysis can be made to classify the company as a whole. It is also suggested that the model be applied to other companies in Goiás which would show to what extent construction companies would accept and apply Lean Thinking.

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