

LEAN AND GREEN: HOW BOTH PHILOSOPHIES CAN INTERACT ON STRATEGIC, TACTICAL AND OPERATIONAL LEVELS OF A COMPANY

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ABSTRACT

The Architecture-Engineering-Construction (AEC) industry has a large impact on society, from environmental, economic, and social perspectives. Thus, concerns about sustainability are urgent. This term is evolving, and it is observed that its future on industry is correlated with other production philosophies. Some authors point to lean thinking as the first step towards a sustainable future. This paper aims to indicate, through a case study, how Lean and Green can complement and help each other in strategic, tactical and operational objectives of a company. The methodology for developing this paper includes: literature review about Lean and Green philosophies and their interaction in this industrial sector; characterization of the company (which has a nationally and internationally environmental pre-certified building), through semi-structured interviews with top managers and project managers, in order to understand strategic, tactical and operational levels; and, finally, the identification of interaction or points of complementarity of the two philosophies in these spheres. The main result of this work is the understanding that, within the strategic area, which has consistent lean management philosophy, sustainable construction is considered a way of adding value to customer. This enables lean and green philosophies to permeate tactical and operational levels as well. Moreover, it is also identified some practical approaches on how Lean and Green interact at construction sites, which some authors consider more difficult due to conceptual differences between these two philosophies.

KEYWORDS

Lean construction, green building, sustainability, environment, LEED.

INTRODUCTION

The AEC industry consumes from 40-75% of extracted natural resources worldwide and generates a quantity of waste in processes equivalent to five times the volume of raw material (Casado et al., 2009). Thus, concerns about sustainability are urgent.

Sustainability can be defined as the ability of current generations to meet their needs without compromising the ability of future generations to meet their own needs

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(United Nations, 1987). This term is evolving, and it is observed that its future interpretation in the AEC industry is correlated with other production philosophies.

A predominant and broader way of looking at sustainability is expressed by the technical term lean (Savitz, 2007). The lean thinking is the first step towards a sustainable future. Similarly, the next stage of lean philosophy is related to the environmental benefits of improved efficiency of products. This can already be seen, particularly in Japanese auto industry companies with hybrid engines and vehicles with recycled components. In application to the construction industry, buildings that include natural ventilation and lighting, energy efficiency, recycled and recyclable components and less waste will be walking into the lean and green future.

Regarding green buildings, many environmental certifications worldwide have been used to determine how sustainable construction a given project really is. The purpose of these certifications is to legitimize or seal the sustainable practices that have been employed at the building, so that a third party institution has complete knowledge of all green processes (Casado et al., 2009). There are building certifications, such as LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), HQE (Haute Qualité Environnementale) and DGNB (German Sustainable Building Council). There are also product certifications, such as FSC (Forest Stewardship Council) for wood and Green Label for carpets. According to Kibert (2007) apud Carneiro (2012), the American certification, LEED, is the predominant instrument of environmental assessment of construction projects in U.S. and perhaps worldwide.

According to Lapinski et. al (2006), the philosophy of lean construction can improve the implementation of sustainable values in existing processes, leveraging synergies between the two philosophies in the design and delivery processes. Some other authors also reinforce this idea, stating that lean construction principles increase environmental benefits (Horman et al. 2004; Huovila and Koskela 1998; Luo et al. 2005; Riley et al. 2005).

Carneiro et. al (2012) observed that due to conceptual differences, some lean construction principles do not integrate well with prerequisites and credits for LEED. Specifically, these differences may be due to the fact that LEED acts as a system of classification and measurement of sustainable performance of the building, as determined by decisions made during the conception and design of buildings, while lean construction focuses in manufacturing processes during construction.

The main objective of this research is to indicate, through a case study at Brazilian contractor C. Rolim Engenharia, how lean and green philosophies can complement and help each other in strategic, tactical and operational levels of a company. In a more specific level, it is expected to identify applications of green practices on construction sites, in view of the difficulty of operationalizing its concepts on field, according to literature review recent studies.

METHOD

CASE STUDY DESCRIPTION

C. Rolim Engenharia

Founded in 1975, the lean journey in this company started in 2004, when its top managers attended the 1st International Seminar on Lean Construction (CONENX) in

the city of Fortaleza. Lean was defined as a management philosophy, and the technical managers organized more studies on the subject, in order to increase this knowledge among all administrative team of construction sites and central office. Thus, since 2004 C. Rolim Engenharia innovates with its lean philosophy.

The first contact with the subject of sustainability was made in 2009, when top managers attended a lecture on the theme of sustainable construction in Brazil and worldwide. Then, because the green concepts converged with the lean construction philosophy already implemented, it encouraged research about sustainability and participation in the GreenBuild International Conference & Expo, also in 2009.

Now, most of the projects of the company have sustainable features. Such practices, coupled with some modifications in the project's design, culminated in the search for the main international sustainability certification, the Leadership in Energy and Environmental Design (LEED). The project chosen for this venture was Paço das Águas, who obtained the Silver Pre-Certification in category Core & Shell V3 – 2009 in 2010, consecrating it as the first residential project to receive this pre-certification in Brazil. The company also decided in 2011 to seek the National Energy Conservation Label (Procel Edifica Label) for the common areas of Paço das Águas. This label for the design phase was obtained in 2012, and it is the first Design Label for the Common Areas at the highest energy efficiency - Level A - throughout Brazil.

Activities Developed

This case study is divided into four stages. First, it was conducted a literature review about the philosophies of lean construction and green building to identify their interrelationships in industry sector and support selection of a case study.

Then, the company was characterized, so that its lean and green journey could be understood from beginning. Later, semi-structured interviews with top managers and project managers were scheduled and conducted. The interviews with top managers aimed primarily to identify the boundaries and contents of strategic, tactical and operational levels, while interviews with project managers sought, particularly, the identification of lean and sustainable practices on site. In any case, it was possible to identify these two issues (levels boundaries and lean and green practices) of the case study in both interviews.

After the identification and description of the company's perspectives and lean and green practices, it was analyzed the intersection of various practices and areas, so that it was possible to recognize if lean and green concepts permeated all spheres of business. Finally, the analysis was performed on the results, considering the purpose of the case study. It was also possible to identify some limitations of the research and some improvements to be made in further research projects.

DEVELOPMENT

BUSINESS PERSPECTIVES AND LIMITS

As mentioned, interviews with top managers of the company showed the boundaries between strategic, tactical and operational levels. The identification of these limits is important because it will enable the proper allocation of lean and green practices in each perspective. Figure 2 resumes levels on their main features for the purpose of this case study.

Strategic Perspective

The strategic level includes the construction business itself, involving land purchase, conception of the project, marketing, etc. It is worth noting that the company's management philosophy is based on lean construction philosophy. This means that, at the highest level of planning, the principles of adding value to customers, reducing waste and the quest for continuous improvement are taken into account in decision making. Among the strategic activities mentioned, the conception of the project is, in particular, the most important for this research.

Tactical Perspective

The tactical level includes the activities of design development and project management. After conceptualizing the project in strategic step, the design development of projects emerges with great importance, as it links abstract ideas and the built environment. Efficient design management promotes greater transparency between project teams, better compatibility between disciplines and less rework at the construction site due to design errors.

Operational Perspective

The operational level includes the construction site themselves and the activities related to them, such as production planning and control. These activities are of major importance to the great flow of construction, because they have direct influence on total term, inputs, resources allocated and costs with production teams.

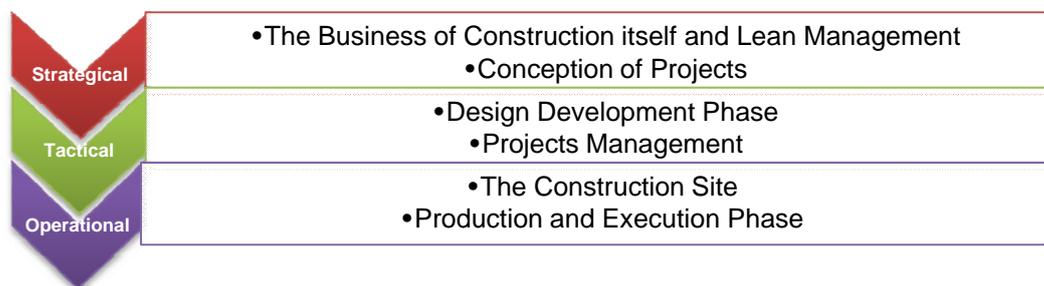


Figure 1: Business Perspectives and Limits

LEAN & GREEN PRACTICES

Next, it will be presented the company's practices based on lean or green philosophies. Due page limits, the practices will be briefly described. As mentioned, such practices were identified from interviews with the project management team and also top managers. In results, these practices will be related to each other and positioned within the company's perspectives.

Lean Practices

As the company began implementing lean in 2004, many are the company's practices that aim to consolidate this philosophy. Below, there are the main lean practices of the company, which are considered to be those with most impact on this case study.

- Last Planner System

Before internalizing the concepts and application of lean tools in 2004, the company found it necessary to stabilize production with better planning. Until that change, the planning methodology was based on the theory of PMI (Project Management Institute) and it was replaced with Last Planner System, with clear definitions about hierarchical levels of planning in the long term, medium term and short term.

The long-term planning, at the most strategic level, is based on the technic of line of balance (Schramm, 2004). The medium-term planning is tactical and performed with a two-month horizon on the line of balance, and it aims to remove all possible restrictions on progress of work to ensure production during these two months. The short-term planning is a more operational level and closer to production itself. This is done in short horizons, in the case of the company, weekly, and it is directly related to the activities that will be planned and executed, as an order of manufacturing.

- Gembas at construction site

Monthly, visits from top managers are scheduled at the construction site, to ensure the gemba. The gemba is essential to the process of construction, because it allows top managers to experience the production process and interact with employees, trying to understand the improvements that can be implemented the construction process. In addition, their critical vision complements the vision of the project team, who is constantly watching the work at site.

- Understanding value for customers through market research

A first principle of lean thinking is to add value to customer, so it is necessary to understand their needs and expectations in order to eliminate what does not confer value for them and improve value delivery. Therefore, the company periodically conducts market research with potential buyers. It has already been identified, for example, that customers value certain features of sustainability on projects, mainly because of the greater valuation of the property, the rational use of resources and the proposed savings with condominium rates over operation and maintenance of the building.

- Mansory wall design

In northeastern Brazil, ceramic bricks are still widely used for execution of external masonry in construction. Without a proper production design of walls, the loss rate of bricks can be very high. In order to optimize the process, rationalize the use of resources and reduce waste, the company draws up an entire design of mansory paging for production teams, readable to all employees. A site with low loss of bricks is a prosperous place.

- Waste management

The main purpose of the Design of Solid Construction Waste Management is to incorporate, into the operational procedures of construction site, the environmental concepts, seeking to reduce waste generation, segregate the materials for reuse, recycling and proper disposal of waste on licensed areas through accredited transportation. This design follows the guidelines of CONAMA – Brazillian National Council for the Environment - Resolution 307.

Green Practices

The green practices described below have been implemented since 2009 and especially since 2010 for Paço das Águas project. Some of these practices are required for all projects of the company, while others are directly related to national and international environmental certifications (Procel Edifica label and LEED).

- Green Commitment

This project aims to transform each m² of land acquired for the construction of buildings in trees planted. It has been implemented for all projects launched since 2009. There is a concern in offering various kinds of trees and ornamental plants, among them Jacarandas, Cedros, Painswick and even the almost extinct Pau Brazil. It is worth mentioning that this effort has led to the planting of over 20,000 seedlings.

- Use of recycled and regional materials

These two practices are credits of Materials and Resources category of LEED certification. Currently, they are being implemented only in Paço das Águas, but there is a good intent from managers to extend these practices to other projects.

To achieve the credit related to recycled materials, the project should use, preferably, materials with recycled content (in partnership with suppliers of raw materials like steel, aluminum, glass and wooden doors, certifying the use of over 50% recycling of raw materials in their manufacturing processes), reducing the impact caused by the extraction and processing of natural resources. About the credit related to regional materials, the project must also focus on the use of regional materials, i.e., materials that are extracted, processed and manufactured within a distance of 800 km from the site, reducing the impact caused by transportation, especially carbon dioxide emissions.

- Selective waste collection

This practice, although it is also a credit to the category of the LEED Materials and Resources, can be seen in all the company's projects finished since 2011.

Its goal is to promote the selective collection of waste during construction and post-occupancy. Therefore, during construction, it is fully connected to the solid waste management of construction site, supplementing their action. In fact, it requires that at least 50% of waste is diverted from landfills for reuse or to recycling plants. For the selective collection to happen after building occupancy, it is necessary for the project team to provide all the specific needs of the collection, such as bins for each type of waste, an area of sorting and separating waste, and especially adequate training to residents through the owner's manual, and those responsible for maintenance of the building, through the building manager's manual.

- Erosion and sedimentation control plan at site

Three major activities are implemented within the erosion and sedimentation control plan at site: protection of slopes with grass, to avoid erosion during rainy periods; vehicle wheels-washer system with rainwater and settling tank for reuse, to ensure that public highways access to the project are always clean and that potable water is not used; and sediment transportation covered by plastic sheets, in order to reduce pollution outside the construction site, because sediment spilled by trucks not

properly covered contribute to water and environmental issues of public roads. In addition, this plan should include washing the building sidewalks and protection against airborne dust.

- More sustainable accessories and equipment

It is worth noting the Green Building standard that has been given to all projects launched by the company since 2008. These are a number of features to maintain healthy interaction with the environment: gas water heaters, reuse of rainwater for irrigation, automated irrigation system, occupancy sensors, individual meters for water and gas, toilets and bathroom fittings of low water consumption, use of alternative energy sources, such as solar and wind, PROCEL energy efficiency tag (similar to Energy Star) for all electrical appliances installed by company. Though these measures do not satisfy all LEED requirements, they add value to the project, meet customer needs and still promote significant savings during operation and maintenance phase of condominium.

- Use of FSC Certified wood

This practice is a LEED credit and is only applied to the pre-certified building Paço das Águas. This credit requires that at least 50% of permanent wood of the building (doors, furniture, frames, etc.) has the FSC certification. Forest certification ensures that the wood used in a product is derived from a production process handled in an environmentally appropriate, socially beneficial and economically viable way, complying with all applicable laws. Currently, FSC is the best-known green seal around the globe, with a presence in over 75 countries on all continents.

- Community connectivity and promotion of public/alternative transportation

These practices are credits of LEED category Sustainable Spaces. The intent of these credits is to reduce the number of vehicles on streets and the emission of pollutants such as carbon dioxide, as displacements are encouraged to be done by walking or using public or non-motorized transportation.

In the project, there will be a bike parking space for each apartment, plus ten public spaces for the condominium maintenance team. Due to the bike rack, residents are encouraged to use an alternative transport for getting around town. Likewise, proximity to bus stops and many lines with frequent stops promote use of public transport. Since the existence of more than 15 points of services such as schools, restaurants, banks and medical clinics within a radius of 800m, residents are encouraged to walk.

- Increased energy efficiency

Energy efficiency configures an entire category of LEED, entitled Energy and Atmosphere. To meet category requirements, it is necessary to hire a commissioning agent to monitor and audit projects for lighting and HVAC (heating, ventilation, and air conditioning) building systems, seeking to reduce energy consumption.

This reduction in consumption is measured by performing an energy simulation of the project (also compulsory) following the methodology of ASHRAE 90.1 - 2007, aiming to show a minimum reduction of 10% in consumption. Fortunately, for the project Paço das Águas, the reduction in power consumption is now 18% compared to a conventional building.

RESULTS

Next, in Table 1, the relationship matrix between lean & green practices previously described. The different markers indicate in which perspective those are related. First, the interrelationships found at the strategic level of the company will be discussed. Four points were found, as shown in the table, and they are all related to the lean practice of conducting market research to understand needs and expectations of customers. Having realized that sustainable features add value to the product desired by the customer, some decisions at the level of project conception were taken and it was decided to submit the project Paço das Águas for LEED certification.

Therefore, features such as inclusion of more sustainable accessories and equipment, more attention to the surroundings of the project for meeting basic needs and providing transportation services, and the search for a more energy-efficient building were strategic, because they would demand more investments in the project.

Table 1: Relationship between lean and green practices among business levels

LEAN \ GREEN	GREEN							
	Green Commitment	Use of recycled and regional materials	Selective waste collection	Erosion and sedimentation control at site	More sustainable accessories and equipments	Use of FSC Certified wood	Community connectivity and promotion of public/alternative	Increased energy efficiency
Last Planner System		✕	✕	✕	✕	✕		
Gembas at Construction Site		✕	✕	✕	✕	✕		
Understanding value for customers through market research	✕	✕			✕	✕	✕	✕
Mansory walls design		✕	✕					
Waste management			✕	✕				

SUBTITLES: ✕ STRATEGICAL ✕ TACTICAL ✕ OPERATIONAL

A pertinent comment made by the company's top manager attests that the percentage of increase in total project costs due to LEED certification requirements is estimated at only 2%, in contrast to 7% reported by USGBC (United States Green Building Council) (Casado et al., 2009). This economy is related to two main factors: no consultancy was hired, because the company decided to invest internally in training courses for LEED certification, and also because some green features were already the company standard, so they did not represent additional costs, such as toilets and bathroom fittings with low-water consumption, automated irrigation, etc.

By contrast, as C. Rolim has this intrinsic sustainable interest, it was also thought, at the strategic level, that the Green Commitment project could mitigate the impacts caused by construction activity and strengthen the brand of the company for its stakeholders (clients, workers, community, suppliers, city hall, etc.).

At the tactical level, it is possible to understand how the practice of gemba at construction site can assist sustainable processes. The monthly gembas performed by technical staff include those responsible for LEED certification and Procel Edifica label, so the process of monitoring and documentation of requirements and credits is facilitated. It is very important to note that, without this documentation and monitoring, it is not possible to verify compliance with requirements and credits, so

the certification process as a whole may be threatened. Moreover, these gembas are essential to project management team to become familiar with the sustainable requirements of the project and for them to improve the management of the site. In summary, gembas promote greater synergy between those responsible for environmental certifications and those responsible for implementing the project.

When dealing with interrelationships between green practices and last planner system, the focus is mainly on the medium term. There, some restrictions are placed and directly related to purchase and installation of sustainable materials and equipment. This way, the construction site is well-provided of place, work teams, machinery and other specifics. Also, the medium-term makes it possible for project managers to realize how the dynamics of construction site can be modified due to its sustainable features, so that they can anticipate and prepare for such requirements, avoiding rework and waste. Finally, anchored by the strategic objective of investing in sustainability, some tactical decisions are also made regarding the choice of recycled or regional materials and FSC certified wood. These decisions are made during the development of designs, as they demand less investment (often zero in relation to investments in conventional materials) and require more design details for the appropriate choice.

Although the literature review indicates that relationships between lean and green philosophies are few at operational level, it was possible to identify six intersection points in this case study. Among them, there is a LEED prerequisite which is compulsory for LEED certification, such as erosion and sedimentation control at site.

It has been observed in previous studies that the lean practice of waste reduction and proper solid waste management is closely tied to environmental concerns and selective collection of waste. In any case, it is interesting to note its enhancement in relation to erosion and sedimentation control at site as well, because, during the activities of segregation and disposal of waste, it is essential that the practices of vehicles wheels-washer, covering the trucks with plastic sheets and protection against airborne dust are effective. If not, the company will be responsible for pollution of transport routes and disturbance to the neighborhood. Regarding masonry walls design, the use of regional materials becomes quite easy for the convenience of companies of ceramic brick and mortar located at the state. Thus, besides lean improvement, materials with a low chain of emission of pollutants are being used. At the operational level, it is still possible to identify interrelationships of green practices with the last planner system. In this case, the focus is mainly on the short-term horizon, where activities are scheduled for immediate execution, such as the selective collection of waste and erosion and sedimentation control at site.

CONCLUSIONS

It is concluded that the goals set at the beginning of the case study were achieved. First, the results obtained by the matrix of relationships between lean and green activities showed that there are many intersections among the activities described and that they permeate all business perspectives (strategic, tactical and operational). Thus, it was possible to see how lean practices can complement and assist sustainable practices (and vice-versa) within and outside the construction site, also encompassing the activities of project management, design development and conception of projects. In a more specific context, it was also possible to identify green operational practices

at the construction site, such as the selective collection of waste and the erosion and sedimentation control, which was considered unlikely to happen, because the philosophy of green buildings is more focused on the design phase (tactical level) than execution phase. Finally, and possibly the most significant result of this research, it was noticed that, within the strategic area, which had consistent lean management philosophy, sustainable construction was considered a way of adding value to customer. This enabled lean and green practices to permeate tactical and operational levels effectively. About the limitations of the research, it is important to note that this is a case study about one company only. Moreover, some of the green practices are unique to the project's LEED and Procel Edifica certification processes (Paço das Águas) and, therefore, not common to all company projects. Thus, this case study has no claim to cover other environmental certifications or even state that all green practices described above are already part of the construction standard of the company. As ideas for further work, it is suggested that the relationship matrix be elaborated between lean practices and green practices from other environmental certifications, such as BREAAAM, HQE, DGNB, etc. Likewise, it would also be interesting to relate these three environmental certifications to LEED, in order to identify the commonalities between them and, subsequently, to relate these common points of the four main environmental certifications in the world to general lean practices.

REFERENCES

- Carneiro, S.B.M., Campos, I.B., Oliveira, D.M., Neto, J.P.B. (2012). "Lean and Green: a Relationship Matrix." *Proceedings IGLC 20*. San Diego, USA.
- Casado, M; Fuhijara, M. "*Guia para sua obra mais verde.*" (in Portuguese) São Paulo: Green Building Council Brasil, 2009.
- Horman, M.J., Riley, D., Pulaski, M.H., and Leyenberger, C. (2004). "Lean and Green: Integrating Sustainability and Lean Construction." *CIB World Building Congress*, Toronto, Canada.
- Huovila, P., Koskela, L. (1998). "Contribution of the Principles of Lean Construction to Meet the Challenges of Sustainable Development." *Proceedings IGLC-6*. Guarujá, Brazil.
- Lapinski, A.R., Horman, M.J., Riley, D. (2006). "Lean Processes for Sustainable Project Delivery" *Journal of Construction Engineering and Management*, ASCE, 132(10) 1083-1091.
- Luo, Y., Riley, D., Horman, M.J. (2005). "Lean Principles for Prefabrication in Green Design-Build (GDB) Projects." *Proceedings IGLC-13*. Sydney, Australia.
- Riley, D., Sanvido, V., Horman, M.J., McLaughlin, M., and Kerr, D. (2005). "Lean and Green: The Role of Design-Build Mech.1 Competencies in The Design and Const. of Green Buildings" *Const. Res. Congress*, San Diego, CA.
- Savitz, A. W. "*A Empresa Sustentável: o Verdadeiro Sucesso é o Lucro com Responsabilidade Social e Ambiental*" (in Portuguese). Elsevier, 2007.
- Schramm, F. K. (2004). "*O projeto do sistema de produção na gestão de empreendimentos habitacionais de interesse social.*" (in Portuguese) 2004. Dissertação (Mestrado) – Universidade Federal do Rio Grande do Sul, Porto Alegre.
- United Nations. 1987. "Report of the World Commission on Environment and Development". *General Assembly Resolution 42/187*, 11 December 1987.