Lean construction - Philosophy, principles, and implementation strategies

Lean construction – Filosofia, princípios e estratégias de implementação

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1 INTRODUCTION

The traditional problems of civil construction range from waste of inputs to low productivity, generating high costs of the final product. Constantly, construction companies are seeking alternatives to break the paradigms of the construction sites, seeking improvements in the management of production processes, driven by the competitiveness among companies due to the growth of customer demands.

The interruption of the work due to lack of equipment or materials is more common than one might think. If the construction site does not have enough equipment and supplies to supply the work teams, productivity tends to decrease and, almost always, without the perception of the site manager, because the pace of the employees adjusts according to the availability of materials. This results in a longer flow time and increased waste due to unnecessary movement of workers.

Studies indicate that, due to several adverse factors, it is estimated that the waste rate in construction is around 8% in material losses, in addition to rework that can represent 30% of the initially estimated cost. It is believed that this waste is the result of the lack of competition in terms of quality by construction companies, ranging from disorganization in purchases and deliveries to inaccuracy in the amount of materials needed (MATIAS; NUNES; CRUZ, 2018). This waste is present in several stages of the production process, involving defective products, overproduction, transportation, waiting time and even idle labor.

In the search for satisfactory results, the success of any project lies in good management and planning. A construction site with an organized flow reduces the total time of the work, allowing the units to be delivered more quickly to customers, increasing

the trust between client and company due to meeting the established deadlines. This is a competitive factor in the market, because most customers need the product in the shortest time possible.

2 OBJECTIVE

This work has the general objective of presenting an alternative constructive approach to the traditional one, seeking to improve planning and production processes, reducing idle labor and optimizing resources, prioritizing efficient managerial strategies instead of mere technological solutions.

3 METHODOLOGY

This is a literature review, prepared based on articles published between 1992 and 2021 in the electronic bases: Portal Capes, *Scientific Electronic Library Online* - Scielo and Google Academic, using the descriptors: *Just-in-time*, *Kanban*, *Kaizen*, *Lean Construction*, production system, performance, among others. Only articles that addressed the topic and were available *online were* considered. Articles outside the specified period, not discussing the theme, not available online, and duplicate articles found in different databases were excluded.

4 DEVELOPMENT

The ideology of *Lean Construction* emerged in Japan in the 1950s during Toyota's automobile manufacturing. Taiichi Ohno (1997) created a system that eliminated inventories and aimed at the quality of the products delivered. Comprising principles such as *Just-In-Time* (JIT) and *Total Quality Control (*TQC), it produced according to demand in partnership with suppliers, providing inputs to the process in a synchronized manner and better managing performance, thus avoiding excessive waste.

The concept of *Lean Construction*, based on the article by Koskela (1992), discusses the application of the production philosophy in civil construction. Allied to management and planning, the practice of this concept results in a more efficient production, coordinating the distribution of activities and materials. The motivation for applying this ideology is to improve competitiveness among companies by reducing production costs and increasing the quality of buildings.

Based on the principles presented, lean construction was established aiming at excellence and quality production in civil construction, reducing costs and resource waste

to the minimum possible, ensuring customer satisfaction, increasing profitability, and meeting construction delivery deadlines.

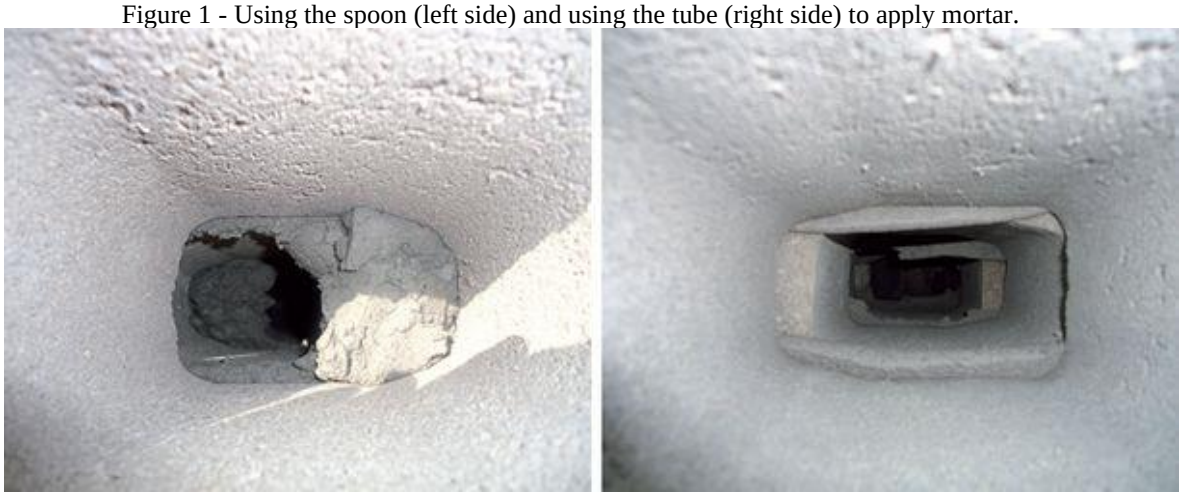
Albalkhy and Sweis (2021) discussed the main barriers to *Lean Construction* adoption in the construction industry, classifying them into three categories. The first is related to the internal environment, as the transformation from traditional practices to Lean practices requires a mutual understanding of needs and continuous cooperation among all stakeholders. In addition, it requires a change in management mindset, the adoption of a long-term strategy, and modifications in organizational structure and culture. A high level of commitment from top management is required.

The second type of barrier refers to entry factors, indicating that not only is top management relevant, but also the significant role played by workers. Finally, the third type of barriers are the exogenous ones, showing that *Lean Construction* is influenced by external issues, such as the fragmented nature of the construction industry, the different types of procurement, the contracting process, and the lack of government support (ALBALKHY; SWEIS, 2021).

Complex production systems are less efficient and reliable than simplified systems. By simplifying processes, reducing the number of steps and components or even reconfiguring them in a more appropriate way, greater operational efficiency is guaranteed. To achieve the goal of reducing activities that do not add value to the product, it is necessary to identify the flow activities that, once clarified, can be monitored and even eliminated.

The construction company Rôgga, from Santa Catarina, adopted the use of mortar in tubes in a construction site built in structural masonry, aiming to reduce the waste and the amount of mortar used, because by using the spoon, the employee used to spend more than twice the required mortar. The construction company estimates that the mortar reduction on site is approximately 60% or more. The excess mortar used when laying blocks made it difficult to install plumbing and electrical pipes. With the use of the tube, this installation process became faster and easier (FERREIRA, 2013). In Figure 1 below, it is possible to observe the difference in production processes.

Figure 1 - Using the spoon (left side) and using the tube (right side) to apply mortar.



Source: Construção Mercado magazine. Ed. 140. São Paulo, PINI, 2013.

Construtora Alavanca, of Sorocaba (SP), sought an alternative for the execution of internal services, replacing scaffolding by mechanical legs. The objective was to reach greater heights and simplify the process, increasing productivity by eliminating the need to assemble scaffolding in apartments for hydraulic installations, plastering, painting, plastering, *drywall* and finishing work. The employees were trained to keep their balance on the mechanical legs, whose support base is at a height of 60 cm, where the foot is attached (Figure 2). Above the foot, the equipment is fixed to the worker's leg to provide safety and comfort (MARTINS, 2013).

Figure 2 - Mechanical legs.

Source: Available at: <http://equipedeobra.pini.com.br/construcao-reforma/56/artigo276975-2.aspx>.

C. Rolim Engenharia implemented a cement bag chute in its construction sites (Figure 3), which allowed to reduce the team from six to two workers, and reduce the unloading time from two hours to one hour, facilitating the transport of inputs to the stock. It is estimated that this solution provides a monthly saving equivalent to the salary of an assistant, considering a work lasting two years (FARIA, 2011).

Figure 3 - Slide for cement bags.

Source: Available at: < http://equipedeobra.pini.com.br/construcao-reforma/42/escorregador-de-cimento-construtora-cria-rampa-para-sacos-de-242129-1.aspx>.

Another example of service simplification is found in the use of precast lintels and counter lintels. The use of *cast-in-place* structures demands several service fronts and intense circulation of inputs. By opting for prefabricated structures, efficiency, agility, and speed are increased, thus reducing the number of processes to perform a certain service.

In a work environment where there is overlapping of service fronts, there is an increase in the number of improvisations and adaptations, generating a disorganized flow of inputs and labor, which can result in the loss of management control. One solution to avoid such disorganization is the division of work into cells or production units, facilitating a better circulation and unobstructed flow. Through these procedures in cells, companies can start each work package by identifying the average amount of materials used for each task, the duration and standardization of services, the frequency of material requests, and the place where inputs are stored.

By establishing a construction standard, it is made explicit how the service should be executed, reducing the likelihood of errors. By providing cells of bricks already cut, the employee can perform the plastering in an aligned manner, reducing the loss of materials and the execution time of the service, increasing productivity and simplifying planning. An example of talisking cells can be seen in Figure 4 below.

Figure 4 - Splitting bricks.

Source: Fabio Almeida Có. Available at: < https://pt.scribd.com/document/310381434/Construcao-Enxuta>.

According to Rocha (2009), once the workplace is clean, safe and organized, the employee can fully dedicate himself to his function. On construction sites, it is common for workers to spend time looking for tools or waiting for materials and directions, instead of dedicating themselves to production, adding this time to the product. Accumulations of unnecessary materials and equipment are often found on construction sites, impairing the flow.

The concept of *Just-In-Time* (JIT) arose from the need to produce only on customer demand, thus orienting production to a continuous flow. For the applicability of JIT, the *Kanban* method was developed with the objective of indicating when and how much to produce. Therefore, it results in a process that has no idle stocks waiting to be processed, as well as no idle employees, nor equipment waiting for the arrival of inputs to be processed.

Total Quality Control, or TQC, is a quality management methodology that seeks to go beyond the concept of quality applied to the product. One of the first concepts

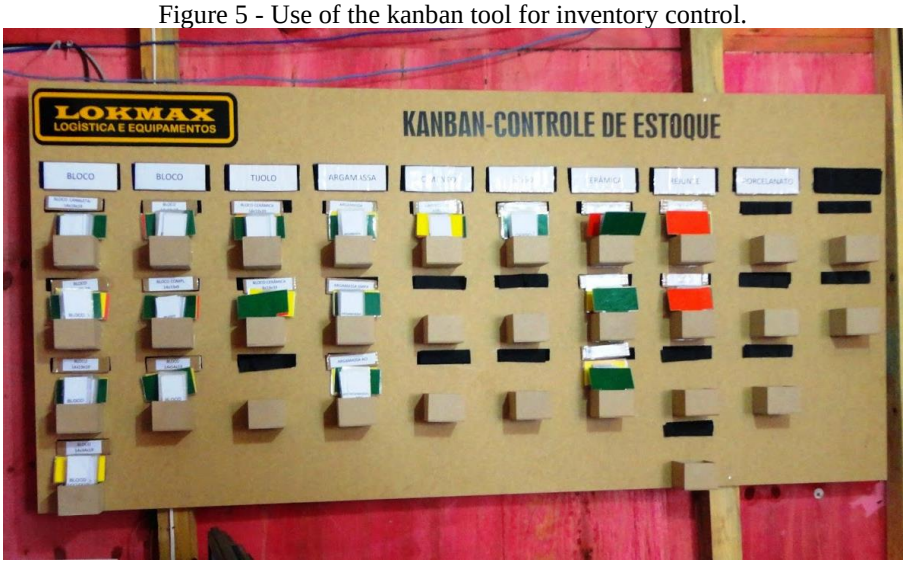
related to quality was the absence of defects in the final product. Later, the concept was extended to the process, also encompassing the product's production conditions. Currently, the focus has shifted from inspection orientation to the continuous improvement process, incorporating quality in both product and process.

One of the tools that operationalizes the Lean philosophy is *Kanban*. Lubben (1989) cited by Filho and Có (2004), describes that it can be understood as a "visual record" for the management of materials and production, which identifies, through visual cards, lights, and electronic systems, the need for each input, allowing inventory control, registered by employees.

From this definition, it is possible to associate *Kanban* with JIT, because through the control of inputs required for each stage of construction, using simultaneous engineering, it is possible to obtain strict budgetary control, drastically reducing inventory and the number of defects, by improving the supplier-consumer relationship. With this strict control of materials, errors are identified more readily and corrected more quickly.

The request *kanban* indicates the quantity of inputs that the process needs to withdraw from the supply sectors, while the production order *kanban* indicates the quantity that the previous process should produce. It is a way to request products to the production line, facilitating and speeding up the whole process (Figure 5).

Figure 5 - Use of the kanban tool for inventory control.



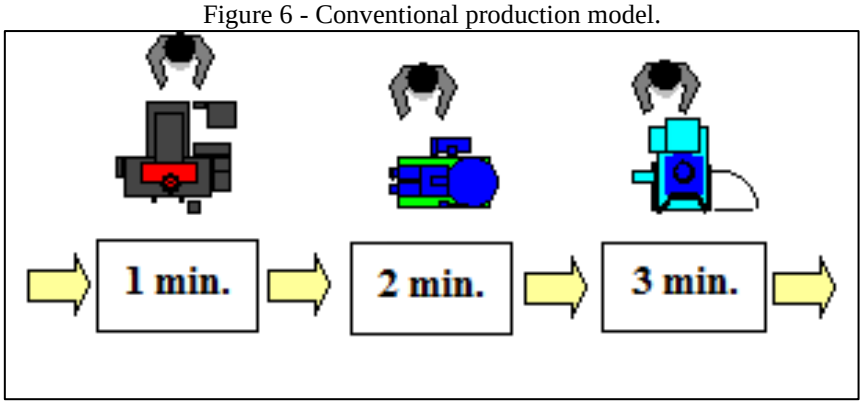
Available at< http://lkxlokmax.blogspot.com.br/2015/02/kanban-e-uma-palavra-japonesa-que.html>.

Derived from the Toyota Production System, the *Kaizen* methodology means "continuous improvement. It is an action plan that provides favorable changes in an environment of learning and continuous improvement, and is one of the tools of *Lean*

Construction. To preserve the improvement methodology, leadership support and commitment is required, so that employees are valued for their relevance and dedication at work. *Kaizen* is a way to encourage teamwork, aiming at the definitive solution of problems. Generally, one of the great challenges for companies is to understand if they are applying *Kaizen* correctly and if they are making the improvements appropriately (HUNTZINGER, 2005).

In Figure 6, you can see the traditional production system used in factories and buildings. In this model, resources and people move around, generating a high flow of transportation. Thus, if a product passed through these three production benches, it would take 6 minutes to be ready, with an efficiency of only 66.67% in the operation.

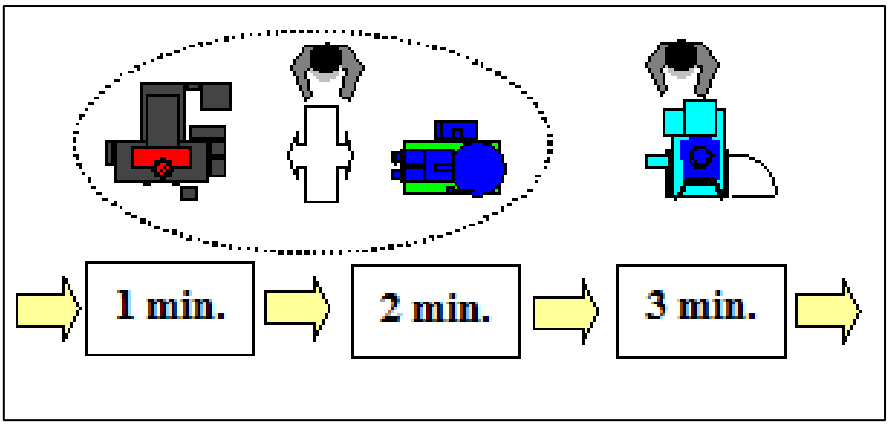
Figure 6 - Conventional production model.



Source: Fabio Almeida Có. Available at: < https://pt.scribd.com/document/310381434/Construcao-Enxuta>.

By repositioning machines and workers, efficiency can be increased, as seen in Figure 7. Transporting this concept to the construction industry, one changes the layout of the construction site to streamline the flow and minimize distances traveled. In this model, it is the inputs that move, generating large movements of materials and improving the efficiency of the process to 100%.

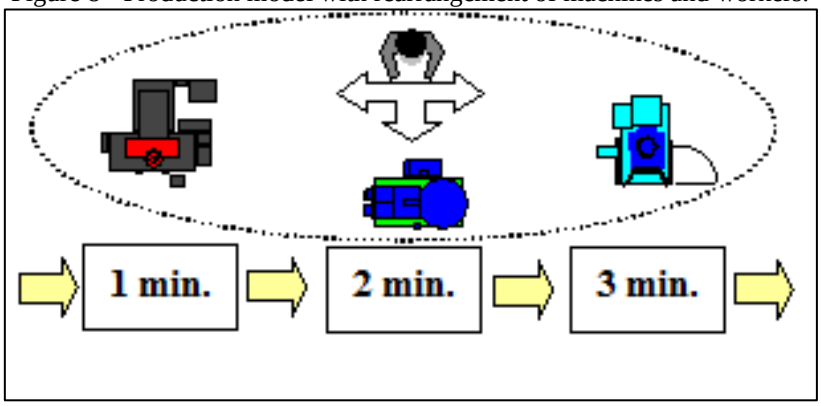
Figure 7 - Production model with rearrangement of machines and workers.



Source: Fabio Almeida Có. Available at: < https://pt.scribd.com/document/310381434/Construcao-Enxuta>.

In Figure 8, it can be seen that travel distances are reduced and the employee can perform his or her function in a more efficient manner. This concept makes the most of low intermediate stocks, reduces the movement of materials, facilitates the cleaning of the environment, and improves supervision and quality control, resulting in 100% operational efficiency.

Figure 8 - Production model with rearrangement of machines and workers.



Source: Fabio Almeida Có. Available at: < https://pt.scribd.com/document/310381434/Construcao-Enxuta>.

According to Koskela (1992), the importance of flow activities is often underestimated in the building production process. Usually, these activities are not adequately considered in planning and budgeting tasks. The effort to implement continuous improvement in construction requires the consideration of any possible waste and the minimization of losses from any resources that do not add value to the final product, whether related to conversion or flow activities.

5 CONCLUDING REMARKS

At the beginning of the process of adopting the *Lean Construction* philosophy, there may be resistance due to the necessary changes. However, it is essential to raise the awareness of suppliers and workers about the relevance of the concept of zero inventory for the effective implementation of Lean, which involves more frequent deliveries and smaller lots, according to the demand of the project.

Through the application of the *Kanban* system in synchrony with *Just-In-Time* (JIT), one can see the reduction of waiting time for materials and idle time of workers. This tool enables the control of inputs that are indispensable to most processes in a construction site, such as sand, brick, cement, and mortar, essential factors to avoid downtime. The engagement of employees is a fundamental component in this process, since it provides greater reliability and facilitates problem solving.

With the application of the *Lean Construction* concept in civil construction, one notices a time saving in the execution of services, a reduction in the number of employees needed for production, smaller inventories, shorter distances traveled, a decrease in the flow time and in the quantity of inputs to be processed. As a result, there is a reduction in waste and an improvement in the quality of the final product.

Without the proper importance given to efficient planning and a well-structured project with clear and necessary specifications, and without the proper attention to hygiene, safety, and workers' health, we live with losses. Therefore, we conclude that the use of this production philosophy, when correctly applied, has as its objective the total elimination of waste, providing economic benefits and improving production efficiency.

REFERENCES

ALBALKHY, Wassim; SWEIS, Rateb. *Barriers to adopting lean construction in the construction industry: a literature review.* International Journal of Lean Six Sigma. Vol. 12 No. 2, 2021. pp. 210-236. DOI 10.1108/IJLSS-12-2018-0144

ALMEIDA, Eduardo Lavocat Galvão de; PICCHI, Flávio Augusto. Relação entre construção enxuta e sustentabilidade. Gestão e Economia da Construção e Tecnologia de Informação e Comunicação. Ambiente construção 18, 2018. DOI https://doi.org/10.1590/s1678-86212018000100211

FARIA, Renato. Escorregador de cimento - Construtora cria rampa para sacos de cimento e consegue reduzir mão de obra necessária para descarregar o material. Revista Equipe de Obra. Ed. 42. São Paulo: PINI, 2011.

FERREIRA, Romário. Alvenaria racional - Construtora implanta tecnologias simples no canteiro e obtém economia de cerca de 60% na quantidade de argamassa e de até 10% no custo total da obra. Revista Construção Mercado. Ed. 140. São Paulo: PINI, 2013.

FILHO, José Rodrigues de Almeida; CÓ, Fábio Almeida. A integração da *Lean Construction* com a *Green Building* no desenvolvimento de um modelo de construção civil enxuto e sustentável: o modelo *Lean + Green*. XI SIMPEP - Bauru, SP, Brasil, 08 a 10 de novembro de 2004.

HUNTZINGER, Jim. As raízes do *Lean*. Traduzido por Odier Tadashi. 2005.

KOSKELA, L. *Application of the New Production Philosophy to Construction*. Technical Report, Filand, CIFE, 1992.

MARTINS, Juliana. Inovações em obra - Soluções alternativas para questões recorrentes nas construções visam à diminuição dos custos e ao aumento da segurança e da produtividade. Revista Equipe de Obra. Ed. 56. São Paulo: PINI, 2013.

MATIAS, Leandro; NUNES, Alane Fernandes; CRUZ, Rita de Cássia Alves Leal. Desperdícios na construção civil. Revista Campo do Saber, v. 4, n. 3, 2018.

OHNO, T. O Sistema Toyota de Produção: além da produção em larga escala. Porto Alegre: Artes Médicas Sul, 1997.

ROCHA, Francisco Eugênio Montenegro Da. Planejamento *Lean*. Revista Téchne. Ed. 151. São Paulo: PINI, 2009. Entrevista concedida a Renato Faria.