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LEAN CONSTRUCTION IN THE PLANNING AND CONTROL OF MINHA CASA MINHA VIDA PROJECTS

LEAN CONSTRUCTION NO PLANEJAMENTO E CONTROLE DE EMPREENDIMENTOS MINHA CASA MINHA VIDA

LEAN CONSTRUCTION EN LA PLANIFICACIÓN Y CONTROL DE PROYECTOS MINHA CASA MINHA VIDA

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ABSTRACT

The Brazilian construction sector has been facing a recession since 2014, peaking in 2016 with a negative growth rate of 10% and closing 2018 with a negative variation of 2.5% (CBIC, 2018). Given this scenario, coupled with high waste rates and low productivity, production management and control are essential to ensure economic competition, rapid response to opportunities and customers, cost reduction, and increased productivity (Ellis and Lange, 1994). Against this backdrop, this study aimed to identify and present Lean Construction practices in a vertical social housing condominium project financed by the Federal Government's Minha Casa Minha Vida program in Ferraz de Vasconcelos, São Paulo, Brazil. The project analysis was conducted through site visits and a questionnaire developed based on Carvalho (2008), Neves (2010), and Arantes (2008). In conjunction with field verification, the project plan was developed using the Percentage of Completed Planning (PPC), Line of Balance (LDB), and Last Planner System (LPS) tools, adopted in the lean philosophy. These tools allow for analyzing the macro flow and scheduling input purchases in advance to avoid inventory buildup and delays due to lack of materials. This reduces the project schedule by 16% and waste by 18%. This also highlights the opportunity for applying this concept due to the significant interest among professionals in the topic.

Keywords: Civil Construction. Balance Sheet. Last Planner System. Productivity. Waste.

RESUMO

O setor da construção civil brasileira enfrenta uma recessão desde 2014, atingindo seu ápice em 2016 com uma taxa de crescimento negativa de 10% e fechando 2018 com uma variação negativa de 2,5% (CBIC, 2018). Tendo em vista este cenário, somado aos altos índices de desperdícios e baixa produtividade, torna-se necessária a aplicação de um gerenciamento e controle de produção, visando a competição econômica, resposta rápida às oportunidades e aos clientes, diminuição dos custos e aumento da produtividade (Ellis e Lange, 1994). Com base neste contexto, este estudo teve como objetivo identificar e apresentar práticas de “Lean Construction”, em uma obra de um condomínio residencial vertical de interesse social financiada pelo programa Minha Casa Minha Vida do Governo Federal em Ferraz de Vasconcelos – SP, Brasil. A análise da obra deu-se por meio de visitas ao canteiro, um questionário desenvolvido com base em Carvalho (2008), Neves (2010) e Arantes (2008), e, conjuntamente à verificação em campo foi desenvolvido o planejamento de obra, através das ferramentas de Percentual de Planejamento Concluído [PPC], Linha de Balanço [LDB]

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e “Last Planner System” [LPS], adotadas na filosofia enxuta. Com estas ferramentas, pode-se analisar o macro fluxo e programar a compra dos insumos com antecedência, de forma a não produzir estoque, tampouco atraso por falta de material, reduzindo o cronograma de obra em 16% e o desperdício em 18%, além de constatar a oportunidade de aplicação deste conceito devido ao grande interesse dos profissionais sobre o tema.

Palavras-chave: Construção Civil. Linha de Balanço. “Last Planner System”. Produtividade. Desperdício.

RESUMEN

El sector de la construcción brasileño ha enfrentado una recesión desde 2014, alcanzando su pico en 2016 con una tasa de crecimiento negativa del 10% y cerrando 2018 con una variación negativa del 2,5% (CBIC, 2018). Ante este escenario, sumado a las altas tasas de desperdicio y baja productividad, la gestión y el control de la producción son esenciales para asegurar la competencia económica, la respuesta rápida a las oportunidades y clientes, la reducción de costos y el aumento de la productividad (Ellis y Lange, 1994). En este contexto, este estudio tuvo como objetivo identificar y presentar prácticas de Construcción Esbelta en un proyecto de condominios de vivienda social vertical financiado por el programa Minha Casa Minha Vida del Gobierno Federal en Ferraz de Vasconcelos, São Paulo, Brasil. El análisis del proyecto se realizó mediante visitas al sitio y un cuestionario desarrollado con base en Carvalho (2008), Neves (2010) y Arantes (2008). Junto con la verificación de campo, el plan del proyecto se desarrolló utilizando las herramientas de Porcentaje de Planificación Completada (PPC), Línea de Balance (LDB) y Sistema de Último Planificador (LPS), adoptadas en la filosofía lean. Estas herramientas permiten analizar el flujo macro y programar la compra de insumos con antelación para evitar la acumulación de inventario y retrasos por falta de materiales. Esto reduce el cronograma del proyecto en un 16% y el desperdicio en un 18%. Esto también resalta la oportunidad de aplicar este concepto debido al gran interés que despierta entre los profesionales en el tema.

Palabras clave: Construcción Civil. Balance General. Sistema de Planificación de Última Hora. Productividad. Desperdicio.

1 INTRODUCTION

The civil construction sector is inserted in a scenario of relevance to the Brazilian economy, being one of those responsible for the Gross Domestic Product [GDP] having closed the year 2018 with 1.1%, in addition to the fact that it employs a little more than 6 million people over 14 years of age (CBIC, 2018).

However, this activity is susceptible to instabilities due to changes related to technological, managerial and social advances, caused by high competitiveness and reduction in profit margins, in addition to the growth in the level of customer demand, related to the fulfillment of requirements, deadlines and quality. Therefore, the company's success is obtained by its innovation, its flexibility, the quality achieved and the reduction of its costs (Arantes, 2008).

These changes basically related to the triad of cost, deadline and quality further corroborate the criticisms obtained by this sector regarding the low production yield, linked to waste, non-compliance with deadlines, lack of planning and control and little use of new work practices (Frota et al., 2016).

Thus, it is necessary to apply ways to reduce waste, delays and cost deviation, aiming to obtain a better competitive positioning of the company, through detailed and controlled planning, in order not to obtain disappointing results (Rentes, 2000).

Despite being a necessary tool for the sector studied, the management of works in Brazil is still very little deepened, being elaborated empirically. That is, personal experiences and executed models are used, resulting in improvised management, with low productivity, low quality in processes, high costs, high waste and, above all, customer dissatisfaction (Souza and Cabette, 2014).

In order to promote such change and continuous improvement in their production processes and aiming at loss control, many organizations have directed their efforts to the implementation of the "Lean Construction" philosophy in their production systems (Neves, 2010).

This philosophy analyzes the processes in order to identify the activities that add value to the final product and to minimize those that do not, such as rework, transportation, inventory and storage, reducing costs and, consequently, increasing competitiveness (Pádua, 2014).

The objective of the work was to evaluate the impacts of the application of Lean Construction practices caused in the cost, planning and control of a civil construction work of

the government program Minha Casa Minha Vida, through the tools of Line of Balance [LDB] and "Last Planner System" [LPS], questionnaires, schedules and spreadsheets, prepared through programs such as "Microsoft MS Project" and "Excel" 2016.

2 MATERIAL AND METHODS

The present study is an experience report, qualitative in nature and based on a specific case study within a construction company, seeking to highlight the barriers to the implementation of lean construction and the impacts that this philosophy can bring to the planning and control of the work. A descriptive-comprehensive view of the data was applied, becoming essential for the analysis of the results.

Therefore, the work can be treated as a case study with a small construction company that operates in the Metropolitan Region of São Paulo in the Minha Casa Minha Vida market and can be divided into four phases: initial diagnosis of the work with characterization and data collection before the implementation of lean practices, Development of the Lean Action Plan , with reference to a stage of work, execution of the plan and data analysis after the implementation of the practices of this philosophy.

Initially, this study with the construction company seeks to identify the production process applied, the reasons for the non-application of the lean construction methodology, and, finally, to make a comparison between the results obtained by the standard production process and the lean process.

In the first part of the methodology, it was sought to analyze the implementation of the philosophy to the reality of civil construction in Brazil. To this end, a diagnosis was carried out through an informal interview, in which the interested parties answered a questionnaire based on the 11 principles of lean philosophy. In all, 27 professionals directly linked to the work of the case study were approached, ranging from the company's management body to the servant's assistant of the outsourced company.

In the second phase, the planning and control of production was formulated, having as reference the principles of the methodology studied, having produced two strategic tools of great importance for planning, being the Line of Balance and the Macro Flow of Services. In parallel with these tools, a schedule was developed with the help of the "MS Project" 2016 application with the deadlines applied to the case study work.

In the third step, the presentation, explanation and application of the planning to the interested parties were carried out. In this stage, the "Last Planner" system was used to control the execution, scheduling the services four weeks (28 days) in advance.

Finally, the results of the two processes were compared, basically using the data obtained from the schedule and the budget.

3 INITIAL DIAGNOSIS OF THE WORK

The work chosen to carry out this study was linked to the fact that it is an undertaking of the federal program Minha Casa Minha Vida with a repetitive character with a narrow construction site due to the physical limitations of the terrain, such as topography and footage, and, consequently, with little space for storing materials. In view of these barriers, the opportunity to apply lean actions was observed, in order to minimize uncertainties and waste (reduce variability), enhancing the logistics of the work (simplify processes).

This development is located in the city of Ferraz de Vasconcelos in the Metropolitan Region of São Paulo and has a tower, consisting of a ground floor and 13 floors, totaling 112 housing units with 42m² each apartment. The work began in July 2018 and is expected to be delivered in February 2020, totaling a period of 30 months.

For the work, the structure stage was used as a reference, since, as it is a structural masonry project, it is the ideal stage that will be repeated throughout the process. At the beginning of the research, the work had the third slab of the concreted pavement and the activities that were being carried out were structure, masonry and installations.

According to the initial schedule of the work, it was foreseen the execution of one floor every 12 days and, for this, initially, the purchase of inputs corresponding to 5 floors (60 days of stock) was planned, according to Table 1.

Table 1

Construction schedule before applying the concepts of "Lean Construction"

Task Name	Duration (days)	Beginning	End
Viva Vista Ferraz [PDB]	432	Wed - 01/08/18	Fri - 08/05/20
Initial Infrastructure - General	140	Wed - 01/08/18	Thu - 28/02/19
Tower	397	Thu - 20/09/18	Fri - 08/05/20
Kind	397	Thu - 20/09/18	Fri - 08/05/20
Estrut. Lost Coffin - Side B	10	Thu - 20/09/18	Wed - 03/10/18
Slab - Side B	232	Tue - 16/10/18	Wed - 25/09/19
Masonry Estrut. + Ved. - B-side	254	Thu - 04/10/18	Thu - 17/10/19

Sausages at Alv. Estrut. + Ved. - B-side	252	Mon - 08/10/18	Thu - 17/10/19
Grouting (Counterwelts and Ptos) - Side B	252	Mon - 08/10/18	Thu - 17/10/19
Estrut. Lost Coffin - Side A	10	Thu - 04/10/18	Thu - 18/10/18
Slab - Side A	213	Thu - 29/11/18	Wed - 09/10/19
Masonry Estrut. + Ved. - Side A	240	Fri - 09/11/18	Thu - 31/10/19
Embedded in the Alv. Estrut. + Ved. - Side A	238	Tue - 13/11/18	Thu - 31/10/19
Grouting (Lintels and Ptos) - Side A	238	Tue - 13/11/18	Thu - 31/10/19

Source: Original survey data

The work had a telescopic manipulator "Sky Track" to supply the tower, in addition to two racks.

Data collection prior to implementation of lean practices

The data collection began with interviews with interested parties, separately, totaling 27 professionals. The questions were related to the 11 principles of "lean construction" and to the waste of flow, transformation and value of civil construction (Arantes, 2008).

The questions can be summarized in three questions, as follows:

1) Do you know the Lean Construction philosophy?

2) Which action has the most positive impact on the cost/time/quality of the work?

3) Which waste has the most impact on the cost/time/quality of the work?

Development and implementation of the lean action plan

After diagnosing the points of improvement of the work, an action plan was prepared aimed at the application of the "lean" proposal. This plan was based on tools such as macro flow (Appendix 1), percentage of planning completed [PPC], schedule (Appendix 2), balance line [LDB] (Appendix 3) and "last planner system" [LPS], and considered four items:

- Supply of services
- Team productivity
- Quality of services
- Construction logistics

The action plan aimed to improve supply planning, mitigate waste, increase the production of the work and anticipate the delivery of the project, adding value to the product.

The actions foreseen in the plan included changing the layout of the site, changing the telescopic handler to a crane, holding weekly meetings to schedule a 28-day plan through LDB and LPS, analysis of deliverables by PPC, monitoring and updating the quarterly schedule and medium/long-term supply programming from the systemic view of the macro flow.

Macro Flow

Process mapping tool that identifies the main steps of a workflow. It facilitates the understanding of future tasks and assists in the planning of work, especially in the scheduling of supplies, since it visually clarifies the tasks and actions necessary in certain phases of the work, eliminating or simplifying the processes that need changes.

Because the macro flow allows the visualization of future services and inputs, it allows the work to be contracted through packages and not only for a certain stage. With this, this tool can generate: cost reduction in service provision, reduction in integration failures between systems and improvement of the organization's performance.

Percentage of Planning Complete [PPC]

Used in short-term planning and, through this tool, daily and weekly goals are programmed that allow analyzing the effectiveness of short-term planning and the degree of precision (Pádua, 2014).

The PPC is the percentage of completed tasks vs. scheduled tasks for that time period. From the tasks that have not been completed, it is possible to analyze the causes, check the waste and adjust the actions, together with the "last planner system" tool.

Line of Balance [LDB]

The balance line is a tool used in the planning and control of projects with repetitive activities, being ideal for application on standard pavements in a civil construction (Nascimento and Reinaldo, 2017). In it, service cycles are identified, distributing them among the floors concomitantly with other tasks, enabling better team productivity.

Basically, they are inclined orthogonal lines arranged in a schedule that indicate the pace of production of the teams. Therefore, this technique provides information on the pace of production and the duration of tasks, allowing planning with less risk, ease of comparison and analysis of the variability of the work (Pádua, 2014).

"Last Planner System"

It is a system that aims to reduce the variability of the workflow and allows the identification of the causes of delays in the stipulated goals, used in the different phases of the work, streamlining processes and minimizing variables. The planner must pay attention to the task being planned in greater detail, the sequence of work must be respected, the correct quantity must be stipulated and the work must be practicable or executable, and all these steps must be planned together with the parties involved (Nascimento and Reinaldo, 2017).

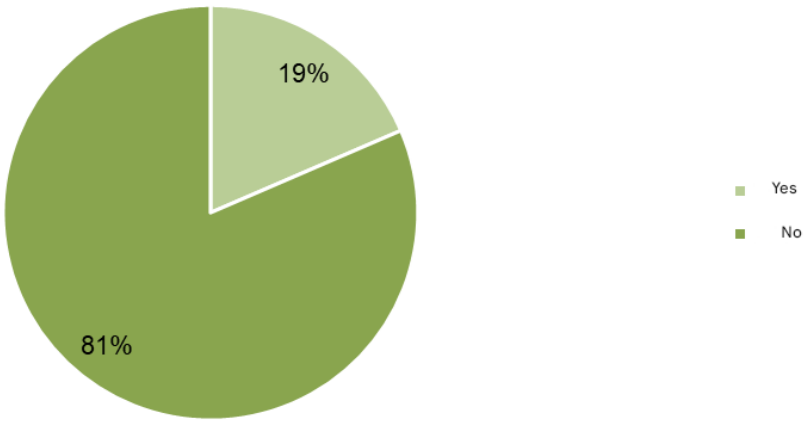
4 RESULTS AND DISCUSSION

The planning and control of works in buildings are fundamental for the application of "Lean Construction", requiring the involvement of several management levels, in order to mold them to the reality of civil construction in Brazil (Souza and Cabette, 2014). When applied correctly, it avoids waste with rationalization of materials and simplicity in planning (Nascimento and Reinaldo, 2017).

As a result of the questionnaire, it was found that the philosophy studied is still not widespread in the civil construction market, since only 19% of the interviewees know/apply the tools, and many of them know management or office positions (Figure 1).

Figure 1

Knowledge of the Lean Construction philosophy

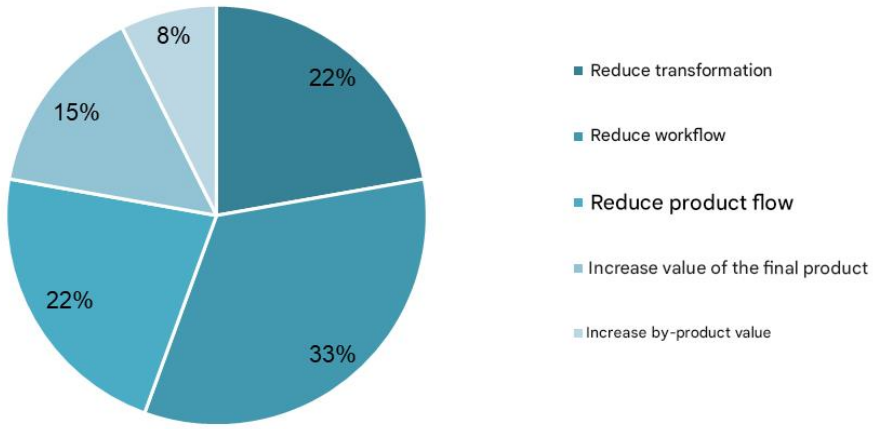


Source: Original survey results

Another piece of data produced with the survey was the identification of what most positively impacts the work was a reduction in workflow (33%), followed by a reduction in transformation (22%) and a reduction in product flow (22%), according to Figure 2.

Figure 2

Actions that positively impact Civil Construction

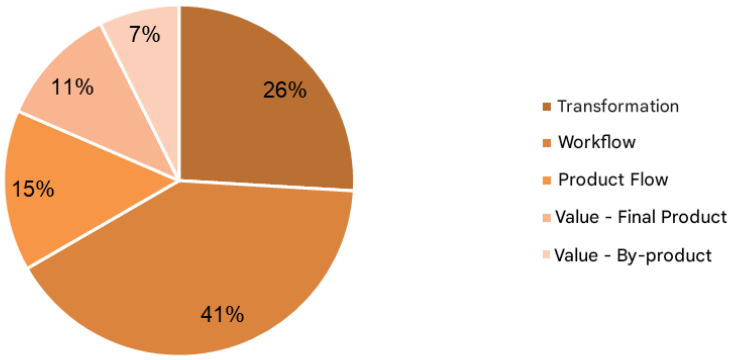


Source: Original survey results

Regarding waste, the majority of respondents reported that the waste that impacts the most was related to workflow (41%), followed by waste in transformation (26%) and product flow (15%), according to Figure 3.

Figure 3

Waste that impacts Civil Construction



Source: Original survey results

The lack of short and long-term planning of the service fronts hindered the distribution of tasks to the teams, oscillating between moments of idleness and high production. As a result, the labor that was stopped was constantly relocated, generating waste due to unnecessary movement of people, the use of improper material, inefficient work, and, consequently, loss of quality, increased rework and low productivity. Initially, the budget for

the work was prepared thinking about the use of 14 structural blocks for each square meter of masonry, totaling the cost of R$80.00 m-2. However, due to this disorganization, the consumption of blocks rose to 17 blocks per square meter of masonry and the cost to R$100.00 m-2.

This lack of planning was not exclusively in the production sector, it was also related to a lack of planning in the supply sector, that is, in the supply of materials for the work. Initially, the work was planned so that there would be five months of materials stored, so that there would be no interruption due to lack of material. However, after the first purchase was made, the weekly inventory control was not carried out and, after 50 days from the first delivery, the second purchase had not been made. This disorganization was related to the fact that the material used and the quantity needed for acquisition had not been surveyed.

Another waste linked to the management of the work was connected to the layout of the site. The site was organized in such a way that it had a warehouse in which the blocks were unloaded, a telescopic manipulator "Sky Track" and a central concrete mixer near the warehouse. This arrangement was due to the fact that there was not enough space on the land, causing a small warehouse that did not allow the separation of the structural blocks by strength or typology, a concrete mixer positioned far from the tower and a transport equipment that broke down weekly. The sum of these three factors directly impacted the construction schedule, input control, material quality and cost, increasing the production of one floor every 14 days.

Based on this information, the action plan addressed four service fronts, namely: quality, productivity, supply and work logistics.

To improve the quality of execution, training was carried out on safety, executive practices and receipt of services, through the creation of material receipt forms.

To improve the productivity of the work, a weekly plan was developed, describing the main services. On this front, the PPC was also used as a guide for planning and charging the work teams. With this tool, new production goals were defined, providing for the execution of a floor every 10 days and the use of 14 blocks per square meter of masonry, as provided for in the construction budget.

The change in the implementation of the construction site improved the storage and scheduling of the receipt of materials according to the production of the work, reducing inventory, transportation and waste. By separating the blocks by typology, it is possible to control the quantity of materials on a weekly basis and to measure the speed of consumption,

reducing the stock by a third. On the last day of the week, the PPC index and the schedule for the following week were generated, based on the services to be performed represented in the LDB, repeating this cycle for all phases of the work. These changes made it possible to improve supply and, consequently, productivity, being able to schedule the purchase of inputs every 28 days.

This study of the layout of the site facilitated the internal movement of materials and, together with the crane, improved the logistics of the work. The replacement of the "Sky Track" for a crane was necessary due to the low productivity of this equipment caused by the high maintenance rate. In the two-month period studied, the machine was stopped for 11 days, delaying the schedule by 20% at this stage.

With this action plan and together with the tools of Macro flow, Balance Line, "Last Planner System" and Percentage of Completed Planning, it is possible to attack the fronts that directly impacted the costs and schedule of the work, such as the lack of blocks and mortar, the large stock of blocks on site, the waste of material and time and the lack of supply scheduling.

When comparing the two processes, it is analyzed that there is a reduction of 16% in the construction time, 20% in costs and 18% in waste with the application of the principles of the philosophy studied, mainly linked to issues such as reducing waste and increasing rationalization. This is due to the fact that it seeks to reduce the share of activities that do not add value to the final product, increase the value of the product, reduce product variability and the cycle time of processes, simplify by reducing the number of steps, increase the flexibility of output of the final products and the transparency of the processes (Pádua, 2014).

5 CONCLUSIONS

The study aimed to analyze the improvements that the principles of "Lean Construction" can bring to a construction site. Taking into account the characteristics of the civil construction sector and the low knowledge of the principles of the philosophy studied, this application of Lean Construction must involve all stakeholders so that this change in mentality is gradual. In fact, the monitoring through the questionnaire and the visits made it possible to verify the improvements and the mitigation of customs inherent to this industry and, as planned, the points addressed brought positive results to the execution of the enterprise, and other studies are necessary for a greater depth on the subject.

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REFERENCES

Arantes, P. C. F. G. (2008). Lean construction – Filosofia e metodologias (Dissertação de mestrado, Universidade do Porto, Porto, Portugal). Recuperado em 27 de julho de 2019, de https://repositorio-aberto.up.pt/bitstream/10216/60079/1/000129800.pdf

Câmara Brasileira da Indústria da Construção. (2019). Taxa de crescimento – Setores e construção civil. Recuperado em 9 de março de 2019, de http://www.cbicdados.com.br/menu/pib-e-investimento/pib-brasil-e-construcao-civil

Carvalho, B. S. (2008). Proposta de um modelo de análise e avaliação das construtoras em relação ao uso da construção enxuta (Dissertação de mestrado, Universidade Federal do Paraná, Curitiba, Brazil).

Ellis, A., & Lange, A. (1996). Fique frio! (1ª ed.). São Paulo, Brazil: Best Seller.

Frota, F. R., Weersma, L. A., & Weersma, M. R. (2016). Método de projetos ágeis aplicado ao setor de construção civil: Caso comparativo entre construtoras de médio porte. In Anais do V Simpósio Internacional de Gestão de Projetos, Inovação e Sustentabilidade (pp. [intervalo de páginas não informado]). São Paulo, Brazil.

Koskela, L. (1992). Application of the new production philosophy to construction (Technical Report No. 72). Stanford, CA: Center for Integrated Facility Engineering, Department of Civil Engineering, Stanford University.

Nascimento, A. H., & Reinaldo, P. A. (2017). Planejamento de obra utilizando conceitos da “lean construction”: Estudo de caso (Trabalho de conclusão de curso, Universidade do Sul de Santa Catarina, Palhoça, Brazil).

Neves, A. L. H. C. S. (2010). Metodologia de planeamento e controlo da produção baseada na integração de práticas ágeis com a filosofia “lean” (Dissertação de mestrado, Universidade Técnica de Lisboa, Lisboa, Portugal).

Pádua, R. C. (2014). Implementação de práticas de “lean construction” em uma obra residencial em Goiânia – Estudo de caso (Monografia, Universidade Federal de Goiás, Goiânia, Brazil).

Pereira, M. D. C. (2012). Avaliação e análise da aplicação da filosofia lean em empresas de construção civil da região metropolitana de Belo Horizonte (Monografia, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil).

Rentes, A. F. (2000). TransMeth - Proposta de uma metodologia para a condução de processos de transformação de empresas (Tese de livre docência, Universidade de São Paulo, São Carlos, Brazil).

Santos, L. A., Perufo, L. D., Marzall, L. F., Garlet, E., & Godoy, L. P. (2015). Mapeamento de processos: Um estudo no ramo de serviços. Iberoamerican Journal of Industrial Engineering, 7(14), 108–128. https://doi.org/10.13084/2175-8018.v07n14p108-128

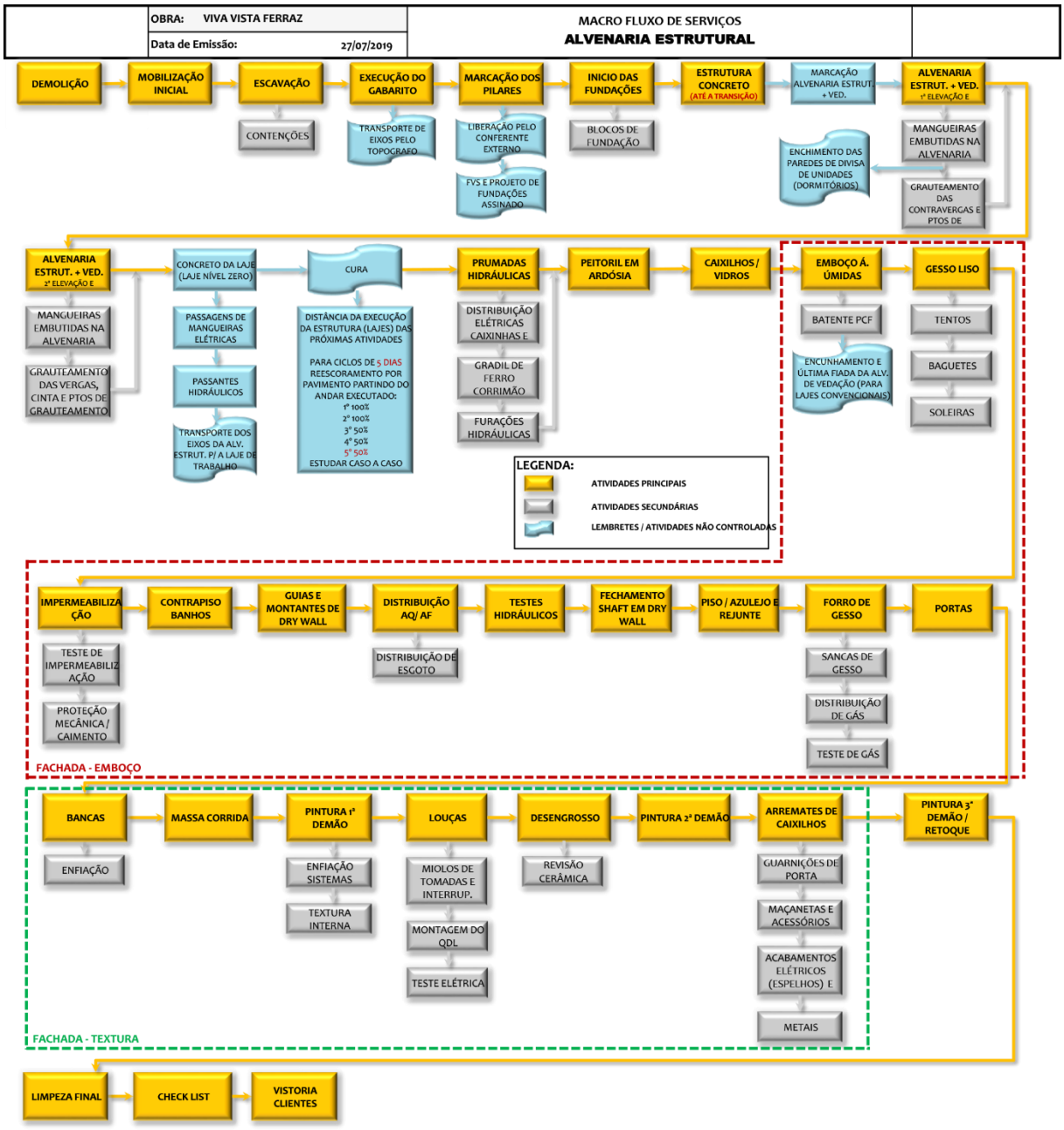
Souza, A. L. (2013). Avaliação dos princípios do “lean construction” em um canteiro de obras (Trabalho de conclusão de curso, Universidade Estadual de Maringá, Maringá, Brazil).

Souza, B. C., & Cabette, R. E. S. (2014). Gerenciamento da construção civil: Estudo da aplicação da “lean construction” no Brasil. Revista Eletrônica de Gestão e Tecnologias Ambientais, 2(2), 1–11. Recuperado em 24 de março de 2019, de http://www.revista.unisal.br/lo/index.php/reget/article/view/143

APPENDIX

Appendix 1

Macro flow of services



Source: Original survey results.

Appendix 2

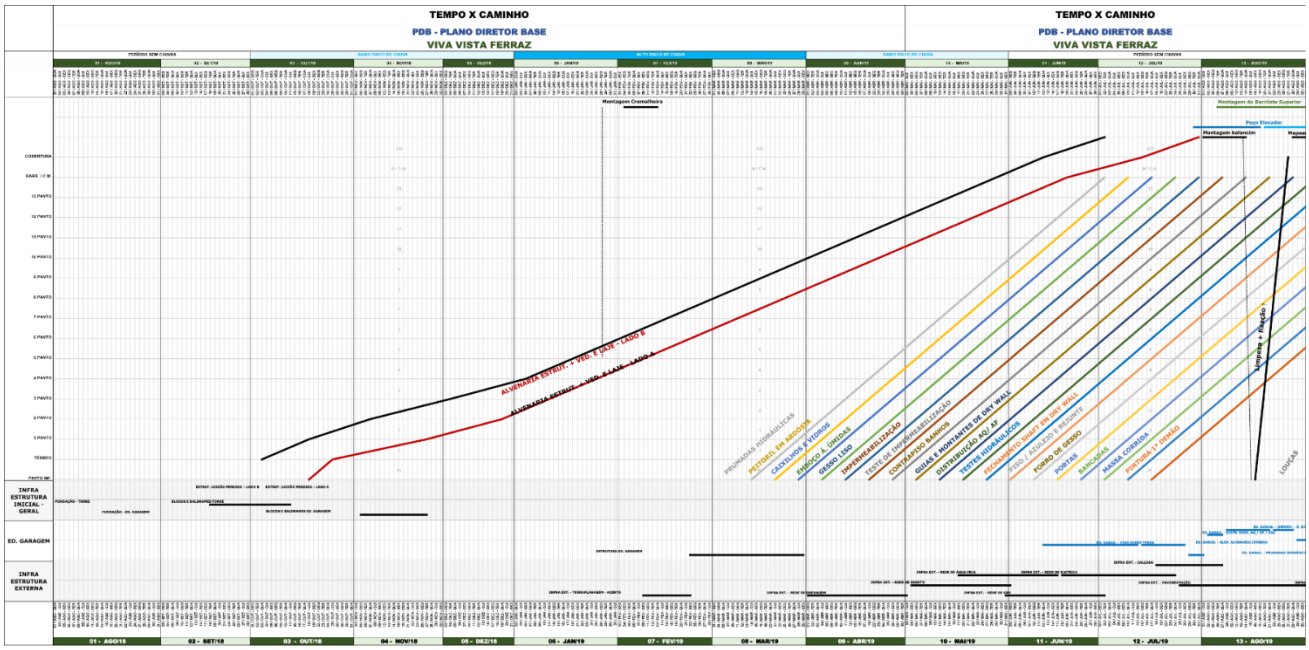
Construction schedule after applying the concepts of "Lean Construction"

Task Name	Duration (days)	Beginning	End
PDB - Viva Vista Ferraz	366	Wed - 01/08/18	Fri - 31/01/20
Initial Infrastructure - General	140	Wed - 01/08/18	Thu - 28/02/19
Tower	331	Thu - 20/09/18	Fri - 31/01/20
KIND	331	Thu - 20/09/18	Fri - 31/01/20
Estrut. Lost Coffin - Side B	10	Thu - 20/09/18	Wed - 03/10/18
Slab - Side B	173	Thu - 11/10/18	Mon - 01/07/19
Masonry Estrut. + Ved. - B-side	190	Thu - 04/10/18	Thu - 18/07/19
Embedded in the Alv. Estrut. + Ved. - B-side	190	Thu - 04/10/18	Thu - 18/07/19
Grouting (Counterwelts and Ptos) - Side B	190	Thu - 04/10/18	Thu - 18/07/19
Estrut. Lost Coffin - Side A	10	Thu - 04/10/18	Thu - 18/10/18
Slab - Side A	156	Wed - 21/11/18	Fri - 12/07/19
Masonry Estrut. + Ved. - Side A	178	Mon - 05/11/18	Tue - 30/07/19
Embedded in the Alv. Estrut. + Ved. - Side A	178	Mon - 05/11/18	Tue - 30/07/19
Grouting (Lintels and Ptos) - Side A	178	Mon - 05/11/18	Tue - 30/07/19

Source: Original survey results.

Appendix 3

Line of Balance after the application of the concepts of "Lean Construction"



Source: Original survey results.