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CAPPLICATION OF SHORT-TERM PLANNING: CASE STUDY IN A CONSTRUCTION SITE

APLICAÇÃO DO PLANEJAMENTO DE CURTO PRAZO: ESTUDO DE CASO EM UM CANTEIRO DE OBRAS

APLICACIÓN DE LA PLANIFICACIÓN A CORTO PLAZO: ESTUDIO DE CASO DE UNA OBRA

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ABSTRACT

According to IBGE statistics from 2021, civil construction represents an important fraction of the Brazilian economy. Despite growth, the sector remains stagnant in terms of resource management, such as labor and materials, resulting in high rates of waste, schedule deviations and project costs. Focusing on this issue, this research was carried out at a construction site in 2022, with the general objective of determining the relationship between short-term planning indicators and improvements in performance and productivity at the construction site. To obtain data, a construction site in the city of Curitiba was selected, which applies Last Planner tools, which encompass short-term planning. In the analyzed work, a weekly diagnosis of the physical progress in relation to the planned was made, through the application and evaluation of indicators. Through the indicators, it was possible to verify that the project was delayed in completing planned activities, which was caused by the lack of commitment of the workforce. Thus, it was concluded that the application of short-term planning contributes to obtaining information that helps to improve the construction schedule.

RESUMO

De acordo com estatísticas do IBGE de 2021, a construção civil representa uma fração importante da economia brasileira. Apesar do crescimento, o setor permanece estagnado em termos de gestão de recursos, como mão de obra e materiais, resultando em elevados índices de desperdícios, desvios de cronograma e custo dos empreendimentos. Com foco nessa questão, esta pesquisa foi realizada em um canteiro de obras no ano de 2022, tendo como objetivo geral determinar a relação existente entre os indicadores do planejamento de curto prazo e as melhorias do desempenho e produtividade no canteiro de obras. Para a obtenção de dados, foi selecionado um canteiro de obras na cidade de Curitiba, o qual aplica ferramentas do *Last Planner*, que engloba o planejamento de curto prazo. Na obra analisada foi feito um diagnóstico semanal do andamento físico em relação ao planejado, por meio da aplicação e avaliação de indicadores. Através dos indicadores foi possível constatar que o empreendimento apresentava atraso na finalização das atividades planejadas, que tinha como causa a falta de comprometimento da mão de obra. Assim pôde-se concluir que a aplicação do planejamento de curto prazo contribui para a obtenção de informações que auxiliam no ganho do cronograma de obras.

RESUMEN

Según las estadísticas del IBGE de 2021, la construcción civil representa una fracción importante de la economía brasileña. A pesar del crecimiento, el sector permanece estancado en términos de gestión de recursos, como mano de obra y materiales, lo que genera altos índices de desperdicio, desviaciones de cronogramas y costos de proyecto. Centrándose en este tema, esta investigación se realizó en una obra de construcción en el año 2022, con el objetivo general de determinar la relación entre los indicadores de planificación de corto plazo y las mejoras en el desempeño y la productividad en la obra. Para la obtención de datos se seleccionó un sitio de construcción en la ciudad de Curitiba, que aplica las herramientas Last Planner, que abarcan la planificación a corto plazo. En el trabajo analizado se realizó un diagnóstico semanal del avance físico con relación a lo planificado, mediante la aplicación y evaluación de indicadores. A través de los indicadores se pudo constatar que el proyecto tuvo retraso en el cumplimiento de las actividades planificadas, lo cual fue provocado por la falta de compromiso de la mano de obra. Así, se concluyó que la aplicación de la planificación de corto plazo contribuye a la obtención de información que ayuda a mejorar el cronograma de construcción.

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1. INTRODUCTION

The civil construction industry is often cited as an example of a backward sector, with regard to meeting deadlines and costs, with low productivity rates and high waste of resources. The need to reduce the duration of the work in many situations makes the planning and control of production to be left aside. Due to this, there are delays and problems that can be avoided with the production planning and control. Many works are carried out without execution planning and without guaranteeing the previously established deadline, a frequent problem that ends up compromising the final quality of services at the construction site (Formoso & Saurin, 2006).

Planning plays a fundamental role in the management of enterprises, and may vary according to the philosophy and needs of each organization, but it is essential for the managerial function, that is, it is a set of processes, missions, guidelines and actions that will be elaborated, implemented, developed, implemented and managed in favor of the established objective (Mattos, 2010).

Thus, the production planning and control process is a system whose objective is: to minimize shortages and idleness of equipment and human resources; to control the use of materials, equipment and production tools, transport and storage; and to obtain levels of specified quality (Lustosa et al., 2008).

This article presents the importance of the Last Planner System, focusing on short-term planning, to analyze the impacts that it causes throughout the execution, to assist in the project's productivity. Initially, a bibliographic survey was carried out regarding the Last Planner and its planning levels. The techniques used to carry out the case study are presented below. Finally, a comparative diagnosis of the planning of the project under study is carried out before and after the implementation of short-term indicators, aiming to prove that the implementation of the mentioned planning contributes to the improvement of the works schedule.

2. PLANNING AND CONTROL SYSTEMS

The planning, control and management of works allows the engineer the ability to previously know the site of the work, in a way that allows him to verify the critical points that he must be concerned with, as well as to point out variations between the real cost of the work and cost budgeted, promoting greater agility in decision-making (Pires, 2014).

The Production Planning and Control (PPC) is essential to the enterprise to ensure the continuous development of the work. The PPC aims to determine in advance which objectives related to production are to be achieved and what must be done to accomplish them effectively, meet pre-established deadlines, measure performance and compare it with what was planned, enabling the identification of errors or deviations and its correction. In view of the importance of planning, it is possible to implement tools such as the Last Planner, which make it possible to carry out and control short term planning.

Planning should define four issues: what to do (activities), how to do it (method), who will do it (resources) and when to do it (schedule) (Laufer & Tucker, 1987).

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2.1 Last Planner System (LPS)

The Last Planner System emerged as a tool to deal with the uncertainties that exist in traditionally adopted planning systems (Ballard, 1994). The tool can be defined as a production control system (LPS) that started to bring reliability to the workflow in planning, since it can be understood as transforming what must be done into what can be done, thus forming a stock of activities ready to be carried out, from which the weekly work packages will be formed (Ballard, 2000).

A production system is stable when it is possible to produce according to what was planned; stability being essential so that processes are not frequently interrupted (Liker, 2005).

In the LPS, there is a hierarchy of the planning process to avoid detailing the planning in the initial stages of the project (Laufer & Tucker, 1987). Therefore, it is possible to divide the flow of activities into 3 main planning levels: long-, medium-, and short-term planning. Through these, it is possible to obtain indicators that help to identify the main problems that affect productivity within a construction site (Ballard & Howell, 1997).

2.1.1 Long Term Planning

Placing all the activities that the project has is not practical, as it makes the schedule complex and difficult to understand for those who do not have knowledge of it, thus, aiming for continuous improvement disseminated by the Lean philosophy, developed by (Koskela, 1992), Activities are divided into work packages in order to optimize the execution of the long-term schedule and assist in the unification of services by evaluating the interdependence between them.

Long-term planning has a generic level of detail and allows identifying activities, defining durations, rhythms, sequences and interdependence between the services that will be performed, enabling the assembly of the project schedule (Mattos, 2010).

In this step, the main production rhythms are defined through diagrams and tools. This phase is also essential for establishing overall objectives and constraints for the enterprise as a whole (Pires, 2014).

2.1.2 Medium Term Planning

Its purpose is to assist short-term planning, preventing activities from being released without all restrictions having been eliminated, as well as situations involving quality, labor, inputs, etc. This form of planning also assists with long-term schedule adjustments that initially may have been poorly planned (Ballard, 2000).

After defining the sequencing, duration and rhythm of activities planned in the long term, the tasks that must be performed appear. In this interval there are several restrictions that must be overcome to guarantee the flow of activities. Such restrictions are eliminated in the medium term, which has the objective of: adapting the workflow and production, dividing the long term into work packages and detailing the executive methods for the work, preventing interruptions from occurring or that it is carried out in inadequate conditions (Koskela, 2004).

With this, a great improvement in the production system can be expected, reducing the costs and deadlines of the enterprise (Ballard & Howell, 1998).

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2.1.3 SHORT TERM PLANNING

Short-term planning is about the work agenda, where the executive team (engineers, interns, and foreman) defines the continuity of the tasks that must be developed (Mattos, 2010).

The main activities involved in this level of planning are: gathering information, preparing the short-term plan, disseminating the plan to all those involved in the project, scheduling resources, and defining the schedule of activities. Short-term planning is carried out based on restrictions established in the medium term, dividing established activities (Ballard & Howell, 1998).

Production protection takes place with the preparation of short-term weekly planning, seeking to ensure that only unrestricted activities are included and evaluating the completion of preceding activities. In addition, the activities included in the weekly planning must be well defined and present a correct sequencing with appropriately sized teams (Ballard & Howell, 1998).

Its main objective is to guide the execution of the work and detail the activities that will be carried out together with those responsible for the teams, normally carried out in weekly cycles. In short-term planning, it is common to use the PPC performance indicator (Percentage of Planned Complete), which is the ratio between the total number of tasks completed in the week, in relation to the total number of scheduled tasks. This indicator aims to calculate the progress of the work by evaluating the commitment of the teams in its execution (Rocha, 2004).

At the end of each period, the planned activities should be reviewed in order to assess whether or not they were completed, thus measuring the reliability of the planning. For unfulfilled or incomplete activities, it is necessary to analyze the causes and act on these reasons, aiming at the continuous improvement of the project (Ballard, 2000).

3. RESEARCH STRATEGY

3.1 RESEARCH PROCEDURES

For this study, a construction site in the city of Curitiba was initially selected, which applies the Last Planner System tools. The company that owns the project had several works in the city and when choosing the researched work, the one that presented more proximity, in the schedule, to the critical stage of work was chosen. After choosing the case study location, an analysis of bibliographic references was carried out so that it was possible to contextualize the main objectives of this article, carrying out exploratory readings on the themes of the line of research.

Subsequently, a case study was carried out at the construction site, evaluating the conditions of the work in order to investigate the impactful problems related to planning, considering the critical point of the project schedule. After analyzing the site, tools related to short-term planning were implemented, which made it possible to detect which problems posed a risk to the delivery time of the work.

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After the problem was identified, interviews were carried out with employees and new Last Planner tools were implemented, especially short-term planning tools that allowed data and indicators to be obtained, aiming to correct the problems before they reoccur. With the interview data, it was possible to seek adjustments so that it was possible to maintain the progress of the work according to planning.

After collecting the information, an analysis of the indicators and data obtained was carried out with the purpose of evaluating the importance and improvements after applying short-term planning.

3.2 Data Collection

For data collection, the delivery time of the project was evaluated considering the critical point of the work. From this, the existence of delayed activities was observed, as well as the reason for non-compliance with planned services. For this analysis, it was necessary to implement tools that made it possible to identify the main reasons for non-compliance with activities.

After applying the tools and subsequently detecting the problems, an interview was carried out with the operational team, including 11 employees who were contractors for the construction site operation, 2 construction interns in higher education, 1 operational construction foreman and 1 warehouseman, the in order to understand the reasons for delays, so that each person responsible could contribute to continuous improvement. The construction team was also interviewed so that they could present the point of view of those who are on top of the schedule in general.

Through interviews carried out with the aforementioned employees and data analysis, it was possible to identify the main problems related to the delay in the construction schedule. In order to solve the problems identified, an action plan was implemented seeking to eliminate all the problems mentioned, with the aim of recovering the delay presented through the short-term planning indicators.

4. RESULTS AND DISCUSSION

4.1 Initial diagnosis of the planning of the work under study

The project under study is a medium-standard vertical residential project, located in the city of Curitiba/PR. The development consists of a ground floor, 6 standard and attic floors. It has 72 units and corresponds to a built area of 4,461.24m².

The work began in July 2021 and is expected to be completed in March 2023. This information was passed on by the real estate development department, which informed the aforementioned date as the target for obtaining a profit from the project.

Aiming to guarantee financial return to the developer, this study was carried out, as continuous adherence to the construction schedule is essential to comply with the metrics established by the company.

Initially, construction included long, medium and short-term planning, already used in a basic way by the construction company. From this, different mechanisms of the Lean Construction philosophy were implemented, focusing on the Last Planner System in order to analyze whether the practice is effective in obtaining results.

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The long-term schedule presented the project's activities divided into work packages, distributed through the concept of balance lines, which allows visualizing the gaps and rhythm between activities and sequencing what must be done with their respective deadline. The aforementioned schedule was only available digitally for members of the engineering team, making analysis by production impossible.

Through the analysis of the long-term schedule, it was possible to observe that the critical point of the project was between the months of April 2022 and June 2022 (39th to 48th weeks). The period could be seen as critical since the facade of the project was about to, as well as the simultaneous execution of between 10 and 15 activities. The activities are interdependent on each other, so any activity that is delayed would harm subsequent ones, impacting the delivery schedule as a whole.

The company's medium-term planning only stipulated the activities, establishing a person responsible and their respective execution deadline, without bringing together the work team for analysis and discussions about what would be accomplished. The monitoring of restrictions was only evaluated in the following month during the execution of new planning at this level.

Short-term meetings were held weekly, held collaboratively between the construction team, engineering and those in charge of the activities that would be carried out. In these meetings, it was assessed whether the restrictions for previous week had been completed, as well as listing the restrictions for the following week, which were also sent to the contractors so that they were aware of the weekly targets. Although activities were checked and checked out, the team did not evaluate the reasons that prevented the execution of uncompleted activities.

4.2 IMPLEMENTATION OF NEW WORK PLANNING INDICATORS

Initially, the long-term plan was updated, redistributing and dividing some work packages and then made visually available to everyone on the construction site, as shown in Figure 1, enabling gains and delays to become evident, and for each responsible team to for a work package knew the completion goals for each activity. It is extremely important to make problems visible, this step is essential for continuous improvement, as it allows future problems to be minimized, in addition to helping productivity (Schultz, 2016).

Figure 1. Long term schedule displayed visually on the construction site.

Source: Authors (2022).

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According to (Prado, 2002) it is extremely important to consider the experience of those involved in the project, therefore the planning update was carried out collaboratively with the operation contractors and construction foreman.

After updating the long-term schedule, medium-term meetings began collaboratively, where in the last week of each month the subsequent 12 weeks were analyzed considering the macro planning of the work, evaluating various topics, including: projects, logistics, inputs, labor, equipment, execution, environment, quality and safety of work, with those responsible for each stage of execution, as well as those involved in the company. The assessment of restrictions began to be analyzed weekly with the aim of eliminating all problems before they impacted the general construction schedule.

During short-term meetings, the causes of unfinished activities began to be assessed. This assessment is essential so that an action plan can be established for the following week, preventing non-terminal activities from accumulating. It is important to highlight that monitoring of short-term planning activities was done day after day, without waiting for failures to be analyzed only at the end of the period, thus losing time to resolve problems, allowing for an impact on the schedule.

To evaluate unfinished activities, a spreadsheet of reasons for non-compliance was implemented. For each cause, a standard number was assigned as shown in Table 1, therefore, after checking out the activities of the past week, this number began to be assigned to the service that did not present terminality, thus facilitating the cause to be easily identified. . For short-term planning to be effective, it is necessary to carry out a careful diagnosis of the reasons that impacted the reduction in PPC.

Table 1. Numbering assigned to reasons for non-compliance with actives.

ITEM	PROBLEM DESCRIPTION
1	Lack of material due to the builder
2	Lack of material due to the supplier
3	Lack of equipment due to the construction company
4	Lack of contractor cooperation
5	Lack of manpower
6	Quality criteria
7	Low productivity of the construction workforce
8	Overestimation of labor
9	Programming change on behalf of the builder
10	Bad weather
11	Programming error
12	Lack of projects
13	Problems in managing the service on behalf of the customer
14	Problems in managing the service on behalf of the construction company
15	Delay in antecedent task
16	Work accident
17	Health criteria

Source: Authors (2022).

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Another indicator adopted was the minimum acceptable target for the PPC percentage. The metric initially established was 85%, seeking to establish an acceptable control, which would facilitate the engineering team's weekly analysis. This goal was linked to the spreadsheet of reasons for non-compliance, seeking to create a single “panel” for viewing all data, in which there is a link between all indicators, facilitating the interpretation of the data by the entire team involved. Whenever the percentage of 85% is not achieved, it is important to evaluate the reasons more precisely, avoiding impactful delays in the schedule.

The target of 85% was implemented in order to allow the team a period of adaptation, but it was advised that the ideal PPC metric would be 100%, in order to ensure that no deviations occur, given that in the medium-term meeting already restrictions are listed in advance to avoid risks and unforeseen events. However, it is known that external factors often occur (illnesses, bad weather, accidents, etc.) that prevent the execution of some activities.

A PPC of 85% was established since after analyzing the critical phase of the work, between 10 and 15 activities would be carried out weekly, using the highest data (15 activities), on average 3 activities should be completed daily. Therefore, if 3 of these activities were not carried out over the course of a working week, it would correspond to 1 day of work wasted at this stage, compromising subsequent activities. Therefore, it was evaluated and agreed with the operations and engineering team that out of 15 activities, at least 13 should be completed, thus corresponding to approximately 87%. In order to maintain easily assimilated data, 85% was adopted. Remembering that this is just an average used to obtain an indicator after evaluating the average number of activities assigned weekly.

During the meeting, the spreadsheet used for short-term planning had the implementation of the “problem” column, which listed the numbers of reasons for non-compliance with activities not carried out, as can be seen in Table 2.

Table 2. Short-term worksheet applied on site.

Team	Set of actives	Active	Start	End	d	28	29	30	31	01	02	03	Executed (%)	Problem
						m	t	w	t	f	s	s		
A4	HSW	Complete secondary trayremovel	28/03/22	28/03/22	1	x							100	
C8	Quality	Concrete the 4th and 5th floor shafts and roofs	28/03/22	01/04/22	5	x	x	x	x	x			80	7
B4	Drywall	Carryout drywall walls on the 2nd floor	29/03/22	01/04/22	4		x	x	x	x			30	7
A5	Installations 1	Drilling hole for barbecue electrical installations	29/03/22	01/04/22	4		x	x	x	x			100	
A7	Grill	Carryout the installation of the barbecues on the 2nd floor	29/03/22	31/03/22	3		x	x	x				100	
B1	Subfloor	Complete 4th floor subfloor	28/03/22	30/03/22	3	x	x	x	x				100	

Source: Authors (2022).

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Equation 1 was also applied, capable of calculating the aforementioned PPC, which corresponds to the average percentage of activities performed according to the column presented in the spreadsheet.

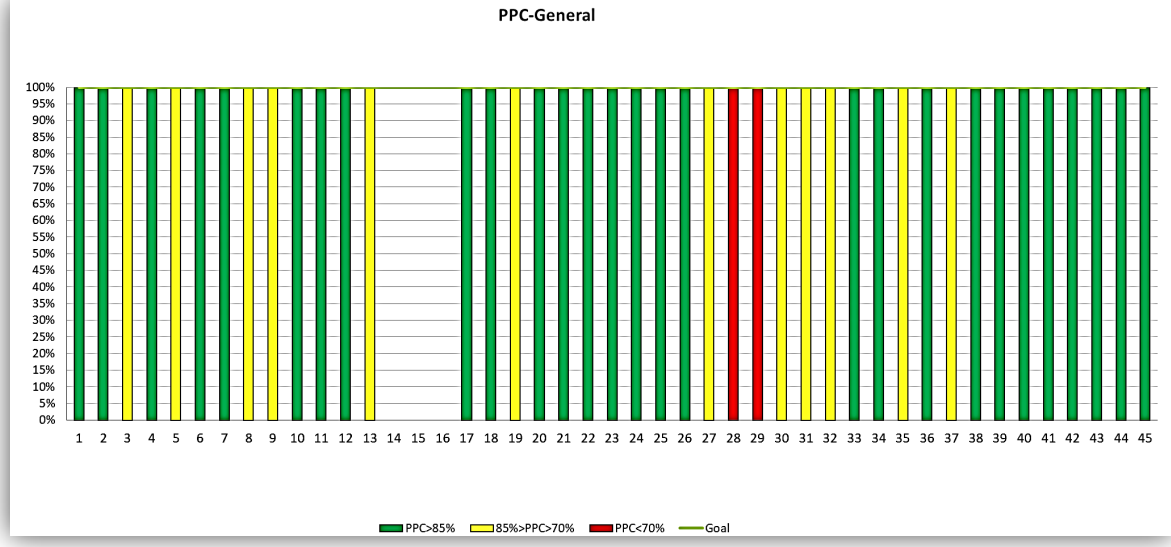
Equation 1. PPC Calculation (Planned Percent Complete)

$$\text{PPC} = \frac{\text{number of tasks 100\% completed}}{number\ of\ planned\ tasks} * 100\%$$

Source: Authors (2022).

Using this equation, a graph was created, as shown in Figure 2, which automatically updates each time the spreadsheet is completed and saved, enabling everyone to quickly understand when the established goal was not met, thus being able to directly analyze the causes that made it impossible the execution of the activity, thus applying an action plan. The columns in green represent that the target of 85% was achieved, in yellow it represents that the PPC was between 70% and less than 85% and in red it shows that it did not reach the percentage of 70%.

Figure 2. Weekly PPC of the enterprise under study.



Source: Authors (2022).

4.3 Results analysis and action plan

After the implementation of the mentioned indicators, it was possible to observe that from the 27th week of work, the minimum target of the PPC was not being reached, that is, the PPC was below 85%, being therefore necessary to evaluate in detail the problems that impacted on productivity.

With the implementation of the reason for non-compliance data, it was possible to observe that the problem 4, which is the contractor's lack of cooperation, was recurrent. So, an indicator capable of evaluating which service providers were not reaching the goals was implemented, and from this indicator a graph was generated as shown in Figure 3.

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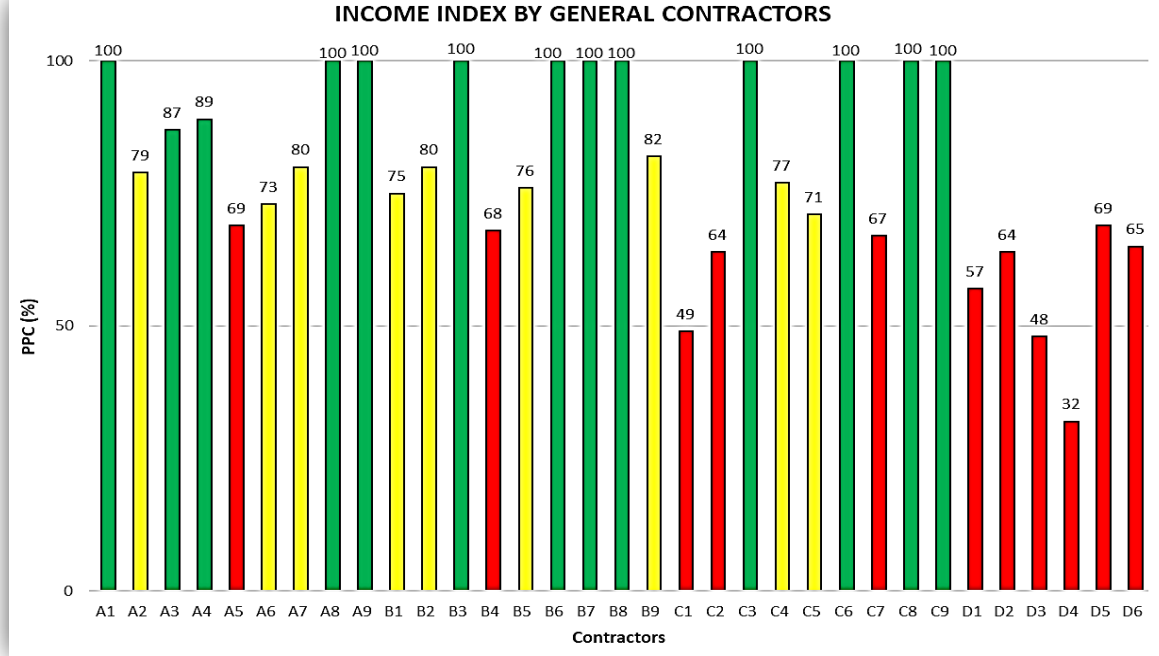
This graph also updates automatically with each filling, making it easier for the engineering team to analyze it. It was suggested that it be visually displayed at the construction site, so that each team could analyze its progress on a weekly basis, in order to draw the attention of contractors, showing the importance that each company/provider has in the general schedule of works. This visual management method helps in the transparency and integration of service providers with the engineering team.

Figure 3. Contractor's Weekly PPC.



Source: Authors (2022).

Thus, according to the Figure 3, it was possible to observe that of the 33 service providers, 11 were delivering below the target, that is, 33% being necessary to execute an action plan with each one in order to solve the problems that were encountered.

Initially, the person in charge of the work chose to understand with the service providers that showed a drop-in performance which were the biggest problems faced by them so that there was an impact on productivity. Then it was conducted an interview with those responsible for the 11 teams, the storekeeper, the foreman and two interns from the construction site, totaling 15 interviewees.

Conducting an interview with construction site workers is a challenging task as most employees are not receptive or are afraid when mentioning areas for improvement in the workplace. Furthermore, they earn from their daily production, thus presenting obstacles when pausing their work productivity, which could harm their financial gains. In order to obtain assertive communication, avoiding breaks during the service period, it was decided to talk to employees when they started work, everyone arrived before starting operational activities and spent a period of time talking, making it possible to use this moment to talk to them.

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With the company's employees, as well as: warehouseman, construction foreman and interns, it was possible to interview throughout the working day, as the research under study would be helping to develop the team and recover the delivery deadline for the project under development.

The interview took an average of 15 minutes with each interviewee and covered issues such as: (i) personal identification (name, nationality, age and sex); (ii) what is your activity within the site; (iii) what is the deadline for delivering your activities; (iv) how important is your participation in meetings together with the engineering team; (v) how open it is to ask questions to the engineering team and construction foreman; (vi) which factor or situation hinders your performance at work; (vii) what are the difficulties with inputs within the construction site; (viii) what are the difficulties involving the layout of the site for your work; (ix) what other factors caused difficulties in your work and; (x) what are the suggestions for improvement.

Evaluating the interviewees' justifications about what they believe had an impact on productivity, 4 interviewees, corresponding to 27%, mentioned that the problem lies in the delivery of inputs, which arrived at the construction site after the required deadline. In order to resolve the problem, it was agreed with the supply department that inputs would be requested in advance and that there would be a margin of emergency orders in order to resolve the delay due to the lack of supplies at the site. It is important to highlight that medium-term meetings help in requesting inputs with an appropriate deadline, as restrictions are established 12 weeks in advance. It is possible that some situation is out of plan, and therefore it is possible to request supplies urgently, taking common sense into account.

Around 20% of those interviewed, that is, 3 people, mentioned the difficulty in finding qualified labor. Therefore, the only solution was to assign a deadline for the teams to replace employees with low productivity and apply salary bonuses with the help of the developer in case of meeting targets, aiming to encourage improved performance on the part of employees.

Among those interviewed, 2 providers, corresponding to 13%, mentioned difficulties with the turnover of their own team. When analyzing the company's situation, it was found that the person responsible did not make payments adequately to its employees, meaning that they did not remain with the contractor.

In the evaluation, 1 interviewee, corresponding to 6%, presented reports that previous activities had an impact on their activities. When carrying out an evaluation of the indicators, it became clear that some activities were not terminal, thus impacting their service, therefore, several adjustments were made with regard to productivity were being achieved, it was decided to wait for the other problems to be resolved so that this provider could evolve in production.

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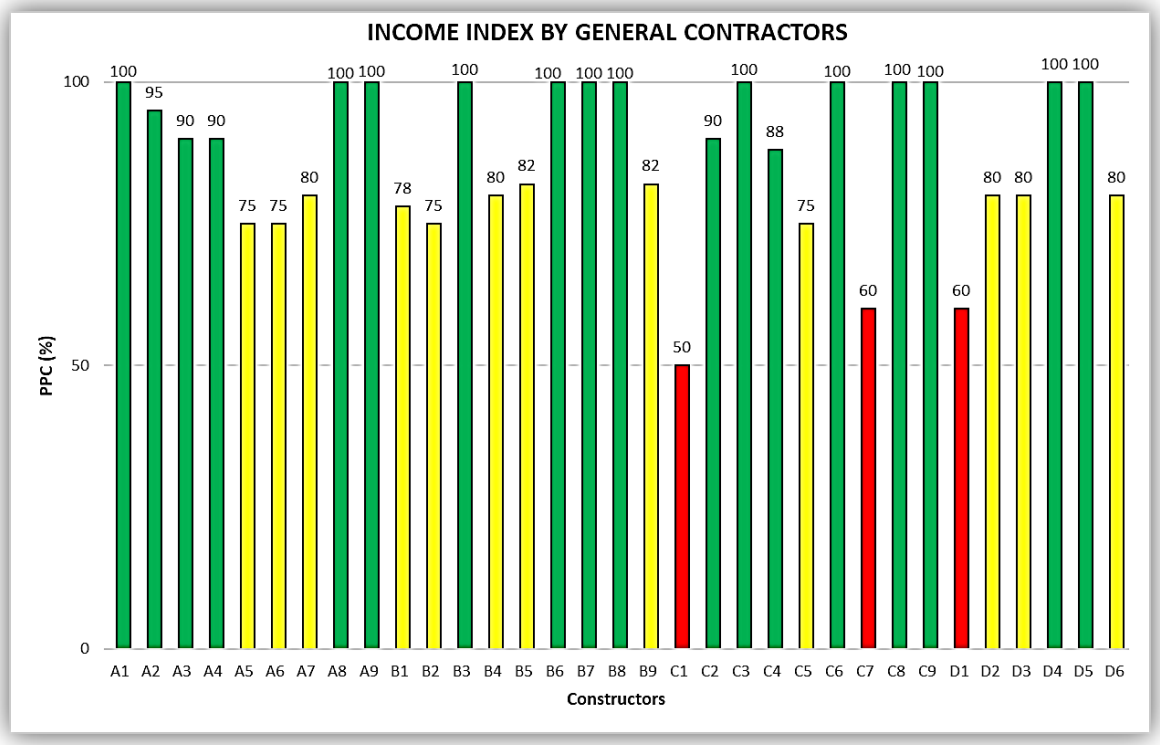
Of those interviewed, 3 of them, corresponding to (20%), mentioned difficulties in integration or disagreements with other providers. In this manner, the engineering team agreed to be more heedful of these workers to pass on more reliability and to ensure that they understand their needs on the jobsite.

The engineering team was asked to start monitoring activities daily and not just at the end of the week, as was previously done. By evaluating activities daily, it becomes faster to identify at which point productivity deviations may occur, making it possible to propose countermeasures and guarantee the success of the project. After applying the new indicators from short-term planning, it was possible to evaluate through Figure 4 that the contractors' performance improved significantly, including those of providers who were not critical in production.

Figure 4. Contractor's weekly PPC updated after application of the action plan.



Source: Authors (2022).

Another improvement implemented related to short-term planning was the visual application of weekly planning, allowing all workers to have easy access to what each one was responsible for executing.

The engineering team was asked to start monitoring activities on a daily basis and not only at the end of the week, as was previously done. By evaluating activities on a daily basis, it becomes faster to identify at what point there is a possibility of productivity deviations occurring, making it possible to propose countermeasures and guarantee the success of the project. After applying the new indicators from short-term planning, it was possible to assess through Figure 4 that the performance of contractors improved significantly, including those providers that did not present criticality in production.

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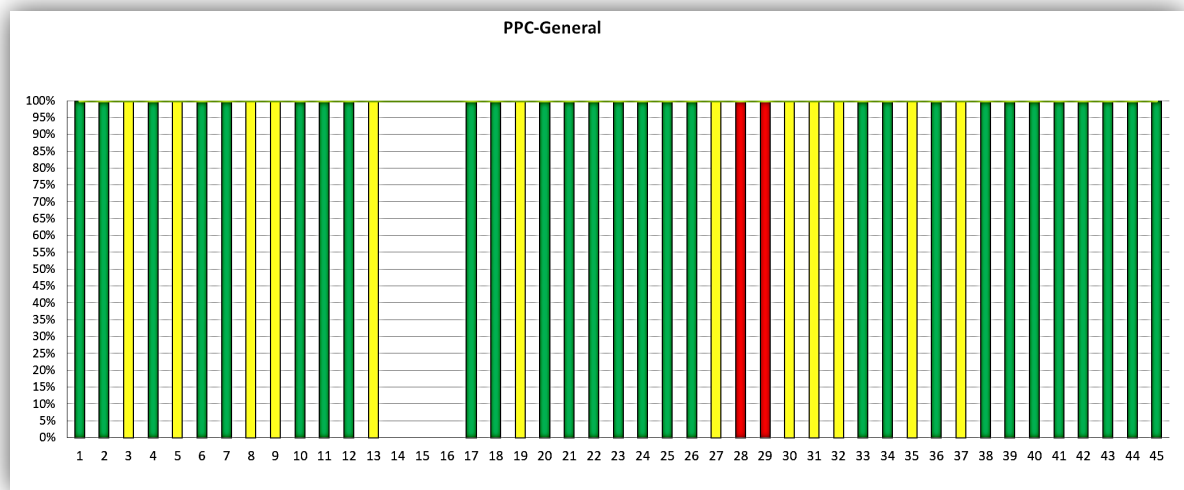
It can also be mentioned that the increase in productivity on the construction site had a direct impact on the quality of the services performed, as the percentage of reworks reduced, as well as employee turnover, thus preventing activities from being temporarily paralyzed and poorly executed after resumption.

Such measures also help to reduce the project's costs, as there is no waste of materials and work does not need to be paid for twice. Furthermore, with the reduction of the construction period, there is a reduction in the payment period for the project's permanent employees, thus resulting in savings in the project's indirect costs.

As shown in Figure 5, the PPC showed improvement and stability after the 33rd week, shortly before the critical period of the work began. After identifying that the goals were being met, it took 6 weeks for the implementations to reach everyone on the team. No improvement occurs in a short period of time, so it is essential to have the indicators in a practical and detailed way so that they can be achieved. are under constant evaluation, preventing problems from remaining hidden, causing significant and impactful delays in the project's long-term schedule.

Figure 5. Contractor's Weekly PPC updated after application of the action plan.



Source: Authors (2022).

It can be assessed that although the PPC averages are higher and with a higher percentage of targets achieved, it was necessary to evaluate some service providers who remained well below the established target even after several changes at the researched construction site.

The problems highlighted during the interview, as well as: delays in the delivery of supplies, difficulties with labor, integration, etc., were resolved, but two of the contractors were unable to adapt even after the changes. One of them did not regularize the situation of payment of employees and another was unable to meet the established demands as it was not terminal in its activities as it was unable to maintain a specialized team on the site. Therefore, it was necessary to replace both teams.

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The practices applied boosted the productivity of the work, thus stabilizing the weekly schedule before the critical point of the project. It can then be analyzed that without the provision of indicators obtained through short-term planning and careful evaluation of them, the delay could last for longer, irreversibly damaging the work schedule. In this way, it is possible to conclude that short-term planning, although it requires work and convincing on the part of the operation team, but its adequate implementation helps in the control of works, avoiding waste on the construction site and allowing the rapid assessment of the main problems that impact the control of construction.

5. FINAL CONSIDERATIONS

The present work consists of implementing the Last Planner methodology on a building construction site, in the city of Curitiba-PR. The theme was chosen due to the researcher's desire to implement practices that enable the reduction of delays frequently found on construction sites, in order to verify whether the methodology for controlling works through short-term planning is functional in civil construction.

Starting from the principles of Lean Construction, the Last Planner methodology emerged, which proposes that planning be collaborative between all teams from different hierarchies during the progress of a project, from this it was possible to implement assistance tools for planning the work under study.

At the construction site, the target of the research, it was possible to verify that the long, medium and short-term plans were implemented, but incompletely, with little inclusion of everyone involved in the construction site. Therefore, it was necessary to make changes in their application, especially in short-term planning, which presented flaws in its methodology, as the indicators were not interpreted quickly and clearly, making it necessary to implement tools that enabled improvements in control and works planning.

An indicator from short-term planning was implemented, which makes it possible to assess the biggest problem impacting production, called “Reasons for non-compliance”, through which it became clear that it was a lack of collaboration from contractors. With this result, it was possible to apply another indicator that presented the productivity of each contractor in order to identify which service providers had an impact on the work schedule, aiming to establish an action plan in order to recover the delay in the work.

To make it possible to extract data and implement new models from the Last Planner methodology, it was extremely important to interview the service providers with the most production criticality in order to understand the reasons for non-compliance with activities. It was found that in most cases these were internal difficulties that could be optimized with the implementation of new tools, especially short-term ones. In most cases, transparency helped to reduce problems.

In some cases, it was not possible to resolve productivity problems with the operation, making it necessary to change labor, but in any case, it was possible to observe an increase in PPC within a few weeks after the problem was identified. Without the indicators extracted from

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the methodology, it would not be possible to assess the lack of collaboration in the operation, and it would be risky to keep it on site, as the schedule would be compromised.

It is concluded that, in relation to the application of short-term planning tools, they help and optimize the management of works on site. By applying the short-term plan, it is possible to control the execution of activities, evaluating future risks through the creation of visual indicators that can be analyzed by any team member.

In this way, it is possible to conclude that the results obtained through the application of new indicators, help in the management of activities and organization of the construction site, making it more productive, with a great reduction in waste that impacts the cost, deadline and quality of the project, thus obtaining the continuous improvement at the construction site. Therefore, short-term planning is essential for the success of the enterprise, with regarding its schedule.

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