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IMPLEMENTING LOOKAHEAD PLANNING AND DIGITAL TOOLS TO ENABLE SCALABILITY AND SET OF INFORMATION IN A MULTI-SITE LEAN IMPLEMENTATION

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ABSTRACT

This paper seeks to demonstrate the implementation of lookahead planning in the current largest construction company and developer in Latin America and how best to consolidate and manage data from a large number of construction sites. This is demonstrated starting with the planning of the implementation pilot, defining the routine model, the participants, the methodology and tools and goes on to the part of continuous improvement within the implementation cycles. The project expansion and project support stages reached 162 sites within a year. This was split into three implementation cycles, led to training 40 multipliers in the lean philosophy and the last planner system within the company in question. The article also presents difficulties encountered in the process of implementing this high volume of sites. Using the preliminary data collected in the routines, it was identified that more than 56% of the restrictions are not removed on time and these, when delayed, cause a delay of 20 days. In addition, it was identified that material correspond to approximately 55% of the total restrictions found in the survey.

KEY-WORDS

Lookahead planning, Last Planner® System, constraint analysis, application development

INTRODUCTION

Despite Lean Construction being a production philosophy applied to construction since 1992 (Koskela, 1992) and the Last Planner System having been described for the first

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time in the following years (Ballard, 1993; Ballard, 1994), its practice is still little explored. systemically, in civil construction and, when it is implemented, it is sometimes done inappropriately, without understanding the principles and concepts behind it (Ballard, 1994). According to a survey carried out by Climb Consulting in 2020 (Climb, 2020), among the planning horizons, lookahead planning is the one in which the companies that took part in the consultation have the lowest level of implementation maturity.

Several studies have already demonstrated Last Planner system implementations in companies (Formoso et al., 1998; Kalsaas et al., 2009, Hamzeh and Bergstrom, 2010, Lindhard and Wandahl, 2013, Kassab et al., 2020). Benefits from these have included greater engagement of subcontractors in the work planning, adherence to the work planning, improvements in productivity and in the cost of sites. However, the implementation of the Last Planner System presents many difficulties. Lean requires the parties involved to collaborate, which in traditional companies is in itself a barrier, as there is a veiled unfriendly competitiveness between people, thus generating a lack of mutual trust between the parties. In addition, specifically in civil construction, the development of a stable labor supply is difficult, creating work packages with their associated productivity, resistance of those involved in the process to changes, lack of commitment to carry out the activities and routines of the new system, lack of training, and lack of support from a sponsor for the project to happen (Kalsaas et al., 2009; Fernandez-Solis et al., 2013; Ryan et al., 2019; Kassab et al., 2020).

Ballard (1997) defined the lookahead as the “missing link in production control” which, since the time of its publication, is the planning stage that has the least effective execution in the construction industry and moreover, in the Brazilian scenario, this lower adherence persists (Climb, 2020). Several articles have been published specifically addressing this planning stage (Johansen and Porter, 2003; Kemmer et al., 2007; Ballard et al., 2007, Hamzeh et al., 2008; Kalsaas et al., 2009; Samudio and Alves, 2012) and several others presenting cases in which they were implemented in small and medium-sized companies and in specific and infrastructure construction sites (Formoso et al., 1998; Kemmer et al., 2007; Hamzeh et al.., 2008; Kalsaas et al., 2009; Samudio and Alves, 2012; Kassab et al., 2020). However, the development of implementation pilots and project rollout in a company with a high volume of construction sites and units produced is not explored and in terms of the scalability of the collection and processing of information in a large number of sites within the same company, permeation of information and integration with the company’s other systems is still a gap in the literature.

Therefore, this article puts forward the process of implementing lookahead routines in a large construction company with a focus on consolidating, controlling and managing these routines, as there is a need for scale when managing the information gathered in these routines and digitization is presented as a solution. To do so, tools applied and insights already obtained using the data collected will be presented that covers from the analysis of the initial state to the stage of developing the routine.

LOOKAHEAD PLANNING

Ballard (2000) cited six functionalities of lookahead planning in his study, namely: Shape work flow sequence and rate; Match work flow and capacity; Decompose master schedule activities into work packages and operations; Develop detailed methods for executing work; Maintain a backlog of ready work; and Update and Review higher level schedules as needed. After planning 3 to 12 weeks, all activities are analyzed to identify constraints in order to generate a stock of activity packages that are ready to be placed in the week's

planning. This analysis of constraints is carried out so as to give the construction team enough time to anticipate the problems that constrain the activity being undertaken and can act towards finding a resolution in order to be able to meet the initial deadline.
Lookahead planning, in the horizons defined by the Last Planner System, serves to create a window of reliability in production, because, in those weeks that have been planned ahead, the flow, sequencing and workload have already been defined and there is a list of packages ready to be pulled to short-term planning. In other words, a step is introduced in planning that will collect information on what must be done, check what can be done and a list of activities that will be performed will be generated. (BALLARD, 1994). Ballard and Howell (1997) also point to lookahead planning as an essential step in production to shield the production and they only send activities to teams that really are able to perform them.

RESEARCH METHOD

Action research was the methodological approach adopted in this paper. Action research focus is on solving real problems (O'Brien 1998) and contributing to the organization's development, focusing on simultaneous action and research in a collaborative manner (Coghlan and Brannick 2001). The research was conducted through multiple iterative cycles of diagnosis and initial status following by three implementation cycles.

PROJECT CONTEXT AND INITIAL STATUS

Company A is currently the largest builder and developer in Latin America. It produces more than 40,000 housing units annually and has around 300 construction sites in simultaneous operation. The company focuses on constructing social housing, linked to the national program to promote housing in a country. Its product has a high similarity between different sites, even though they are at opposite ends of the country and the construction methodology is of the concrete wall type. Most of buildings have four to five storeys and there are some taller buildings ranging from 8 to 20 storeys.

The Lean implementation project was set to be run in one year and was structured as follows: three implementation cycles of three months each with a one-month break between each such cycle for a kaizen of the project in order to improve it as a whole for the next cycle. Besides the implementation, the project provided for training multipliers in lean philosophy and the last planner system on site so that they would become responsible for sustaining the project. In addition to this, these employees who were trained at each cycle were to be responsible for implementing the routines, tools and philosophy at other sites with each new cycle that would take place. In this way, as a geometric progression, the project expected to reach 19 states, 176 construction sites within 12 months and to train 40 multipliers. For this implementation, it was defined that each consultant would be responsible for up to four simultaneous sites and for training not more than two multipliers simultaneously.

The company had a type of lookahead planning, which identified some constraints. However, this routine was monthly and used only the Pert-CPM planning of the MS Project and this was done only between a person responsible for planning 5 other sites (on average) and the construction engineer. Thus, several constraints were not seen, field problems were not taken into account, there was a lack of visual management and collaboration to understand the sequencing of activities and service fronts, and the collaborative and social element of Last Planner did not exist.

IMPLEMENTING THE LOOKAHEAD IN THE SITES

After the company's initial diagnosis, a model of lookahead routines and tools were developed to be tested in the first implementation cycle. For this pilot, what were defined were how the meeting would take place, who were the participants and what visual management, materials and responsibilities there would be. The standard definition was an important deliverable considering the number of construction sites and the geographical distance in between each region (as shown in Figure 1) that could be a barrier for a complete lean implementation. For the start of the project, it was defined that the superstructure part of the buildings would be dealt with, thus leaving the external part of the condominiums aside for the time being. The summary of the implementation cycles defined in the project and some of the numbers of sites involved are presented in Figure 1.

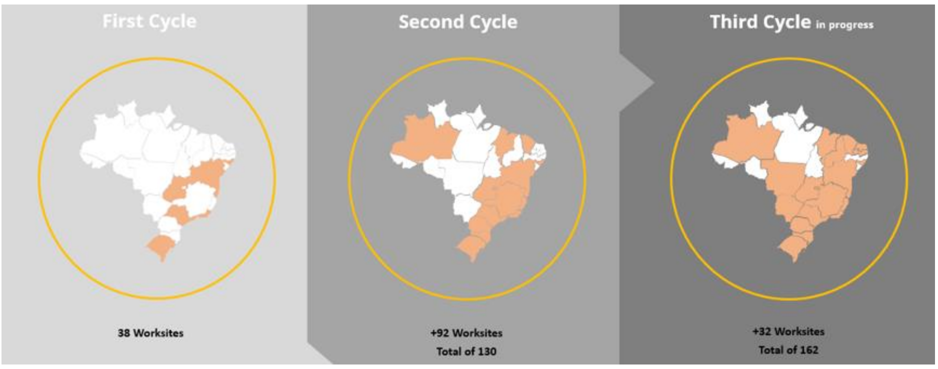

Figure 1 - Lookahead implementation cycles

Table 1 presents a summary of the main points that were generated in these meetings with regard to implementing the lookahead planning, standardizing the process and managing this information, and further on, the implementation cycles and decisions are presented in more detail.

MODEL AND FIRST IMPLEMENTATION CYCLE

The first implementation cycle was marked as a major project pilot at company A. A visual management model was defined for the Lookahead Meeting and Survey of Constraints for which wall charts and post-its were used. At this meeting, the obligation to have a construction engineer, assistants, master builder, a safety technician and a warehouseman were defined, and that, optionally, there would be a coordinator/manager of the site, a project multiplier, interns and supervisors.

As company A's product has a high level of standardization among the various sites in Brazil, work packages for all sites could be defined, in order to start the pilot of the meeting in 38 sites in 6 different Brazilian states in the most standardized way possible. For the lookahead, some tasks were grouped into packages. Thus, it is possible to be more objective when dealing with the themes. The dynamics of a lookahead meeting were initially established as follows:

- Plan the next six weeks of the sites;
- Survey constraints linked to the activity packages;
- Define an action plan for each constraint found raised with the person in charge and a deadline for its removal;
- Compile information to generate indicators of the process.

As a premise of the project, a target was set for the rhythm of production to be reached for each work package. Therefore, the concept of balancing and constructive sequence had already been incorporated into Lean Implementation. Having set the rhythm pace and standardized and sequenced packages for the six weeks, the second stage begins, which consists of detecting the constraints that may adversely impact the conduct of the planned activities. To assist in identifying and categorizing constraints, some categories of these were defined for the project, namely: (a) Manpower; (b) Material; (c) Design; (d) Accesses; (e) Equipment and Tools; (f) Safety; and (g) DAE (the acronym in Portuguese for the Department of Support to the Contractor). For this step of identifying and categorizing constraints were considered the perspective and information regarding the construction phases the following participants: engineer, interns, foreman, construction assistants, supply administrative, safety technician and planning assistant.

Table 1 - Summary of implementing lookahead planning cycles

	Cycle 01	**Cycle 02**	**Cycle 03**
Number of worksites total	38	130	162
Number of worksites using virtual Action Plan	5	49	72
Standarization of Package	Non-existent due to lack of standardizing the sequence of construction	Standardized packages for superstructure	Standardization of packages for supra and infrastructure
Constraints checklist	No	No	Yes
Access to information gathered in lookahead sessions	Local only	Remote acess to those involved in work	Remote Acess to the company
Information capture and management tool	Excel	Sharepoint List + Excel	Power Apps + Power BI
Destination of collected information	Local Only	Online Database	Enterprise Data Lake
Good feedback from the construction site's team	Greater assertiveness in the execution of work Better constraint control Good integration with the construction team and some support sectors Greater reliability in planning in generall Good visual management for the work The information digitization pilot was a success	Operational gain with new activity package split Easier and better access to information generated in the lookahead meeting	Constraints checklist brought a higher level of reliability to the lookahead process Less mature teams were able to perform the lookahead meeting with similar quality to experienced teams Reliability of the work as a whole with the inclusion of the infrastructure in the lookahead
Improvement points	Difficulty in identifying constraints	Difficulty for teams to use more digitized tools Need to include other condominium areas in the lookahead routine	Help chain structuring Draw up checklist of constraints of infrastructure activities

Once the restrictions for the period were defined, an action plan was created on a whiteboard on the wall. This generated an action for each constraint identified, with person responsible and deadline for completion. The last step was to compile this information into a spreadsheet with a dashboard on a dynamic spreadsheet, thus generating lookahead planning indicators and of the efficiency at removing constraints. The first indicators used in the project were: (a) Constraint Removal Index; (b) Constraint status per person responsible and per category; (c) Average days of delay per person responsible and per category; (d) Lists with the next constraints due to expire; and (e) List with delayed constraints. After having defined this routine and these materials and indicators, implementation began in the 38 sites of the lookahead planning and as a result, opportunities for improvement were identified:

- Lack of experience of the construction team at making a survey of constraints;
- Lack of giving support to routines when the consulting team was not present at some sites;
- Policy of not using Excel on sites to avoid sites manipulating cells and consequently, sites not being supplied with the software;
- Lack of some people’s familiarity with Excel, thus making use of it was difficult;
- Teams “forget” about the action plan from its creation until the day of the next lookahead meeting;
- Difficulty accessing the action plan when outside the Obeya room;
- Difficulty that managers and directors not on site have in sharing and monitoring indicators;
- Difficulty triggering help chain via data collected.

When these difficulties were perceived by the implementation team, it was identified, that this provided the opportunity to use an online action plan. This would enable those responsible for the constraints to be alerted, and would facilitate access to the plan outside the Obeya room and would eliminate the need for sites to use Excel or to use it to manipulate data and information. Among the tools available to the company, it was decided to use the Sharepoint List, but, still, for the time being, to keep the information dashboard in Excel. However, the data entered were automatically updated in the company's cloud and everyone connected to the sites could access the data remotely.

Despite Sharepoint being one of the platform solutions already made available by the company, the teams used only the basic functions of the app. In other words, implementing the proposed virtual tool was to be done in an environment that was scarcely digital - a typical feature of much of the civil construction industry - and for a team with little familiarity with the opportunities that has already been presented to them. Hence, the implementation and use were closely guided in a pilot format with a few sites and linked to the same consultant.

Five construction sites were chosen for the pilot. The Sharepoint list allowed engineers and managers to access the action plan even off-site without using Excel, and those responsible for the actions began to receive emails informing them when the actions were created, edited or deleted. Other alerts were created according to the need noted with the use, e.g., it was noticed that some employees postponed the deadline for resolving the action so as not to appear negative in the indicators. Therefore, an alert for the engineer had to be created whenever a date limit was changed.

As a result of this first cycle of implementation, with the tools in their most basic form and an initial standardization of routines and methodology, the multipliers reported greater assertiveness in the execution of the work, better control of constraints, good integration with the working site's team and some sectors of support, greater reliability in planning in general and good visual management for the site. In addition, the information digitalization pilot was successful, so it was then expanded to other regions. As a point of improvement, what was highlighted was the difficulty that some teams - with a very young profile in this company - have in identifying and removing constraints and in implementing integration.

SECOND CYCLE OF IMPLEMENTATION

For the second cycle, training was held for everyone involved in implementing the lookahead planning in the new digital tool that had been validated in the cycle 01 pilot. This tool had already been standardized in some categories and this permitted some further data analysis. Moreover, the use of excel as a tool to control actions could be discarded. Only the panel of indicators in it was kept, while all the filling in and manipulation of data would now be in Sharepoint.

The second cycle stood out because of the large expansion of the project. In this cycle, 92 more sites were added to it. This now totaled 130 sites in 8 different states and therefore covered 14 states in Brazil. Among the new sites, implementations carried out by multipliers trained in the previous cycle, without direct assistance from an external consultancy.

There were some changes in relation to the model of the meeting implemented in cycle 01, namely, alteration of lookahead packages covering some activities initially omitted; standard sequencing for the sites was defined. Having obtained good results by using the methodology for the activities of the supra-structure, the initiative to use the methodology and tools for infrastructure arose spontaneously on some sites. Regarding the routines, their characteristics remained unchanged. Of these 92 sites, 49 advised that they would be using the new tool to include their sites in the database. This difference can be justified because there were sites that implemented the project without the direct participation of the consultancy, sites that chose not to migrate and sites that use the tool, but did not inform the person responsible for digitizing the lookahead, which covered most cases.

After collecting the data, a base was obtained with 4,793 actions recorded by the teams of the 49 adhering sites. However, as most of the fields did not place limits on their completion, as columns could be changed to meet specific demands of the sites and due to negligence when filling in the Action Plans, it became necessary to prune the database. Thus, it was reduced to include only 1,545 actions with sufficient information and clarity for all intended categorizations. Thus, a need arose for a solution that would guide how to complete fields and prevent errors.

As a result of the second cycle, for the team responsible for implementing the project, there was an operational gain with the new division and standardization at the national level of the activities in the lookahead packages. In addition, with regard to including the action plan and indicators in the company's cloud, an improvement in access to this information was reported due to using SharePoint lists. This requires only an internet connection for checking or editing, in addition to the control facilitated by notification emails.

THIRD CYCLE

For the third cycle, as an increment to the project, the lookahead routine for the infrastructure part was standardized. This routine encompassed all construction site activities from then on. Another improvement was, based on the information collected in cycle 02 and the company's manuals for standard procedures, to create a checklist of common constraints for each of the suprastructure activities. Thus, the routine becomes less dependent on the teams' experiences and ability to identify future constraints and more dependent on the process.

Finally, an app on the Power Apps platform was developed, which replaced SharePoint. This thinks about the user’s experience, linked to a series of security devices that aimed not only at greater standardization and quality of information, but also at agility in inserting data and mitigating errors due to lack of attention or negligence. The third cycle, started in January 2022 and still in effect, was focused on sustaining the project. Hence, the lookahead routines were not implemented in as many new sites as in the previous cycle and focused on guaranteeing the project's sustainability in several sites where they have already been implemented. In this cycle, 32 more sites were added to the project, which gave a total of 162 sites in 5 more different states and thus covered 19 states in Brazil. Among the new sites, there were implementations carried out by multipliers trained in previous cycles, without direct assistance from an external consultancy. These numbers may still change during the cycle due to the company's strategic decision.

With the beginning of the cycle, the use of checklist of the constraints on activities began. This tool attracted a large and rapid adhesion from the teams and there was positive feedback regarding the increase in the agility of surveying constraints, in assertiveness and in the quality of meetings. It was identified that, even at sites with less experienced teams, the result of the meeting had a much smaller gap in quality as to more experienced teams surveying constraints, due the agility and the communication flow that derives from the lookahead meeting.

Also, with the beginning of the third cycle, implementing the lookahead planning was started for the other activities of the sites (condominium areas and infrastructure). Thus, a complete visualization could be obtained, and a protection window created for the next six weeks of the sites. Hence, this generated more action plans and larger amounts of data for the company's base, thereby enriching future decision making.

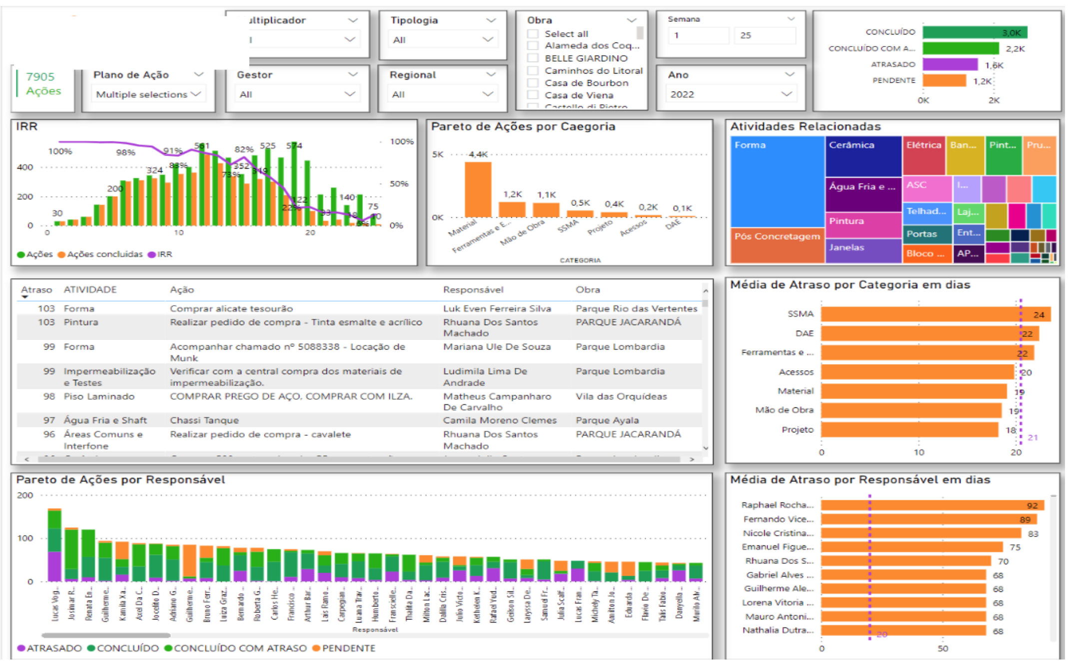

Figure 2 – 25 weeks data analysis

The use of the specially developed application was mandatory for new sites and optional for those using SharePoint lists with the option of migrating to the new solution without losing the history. This deployment format generated a large amount of data in a short time, 2363 actions raised in a month and all within the standards required for analysis. Figure 2 shows the results from the first 25 weeks of 2022.

RESULTS AND DISCUSSION

Data analysis is still preliminary, as teams are still adapting to the new tool. However, it is already possible to identify some important points for corporate analysis as shown in Figure 2:

- 56% of constraints are not removed on time. The database shows 23% of delayed actions and 42% of actions completed late with respect to the date stated in the lookahead meeting.
- 55% of the constraints refer to material, this being the main category of constraint found in sites, followed by Equipment and Tools with 15% and Manpower with 14% of the total.
- Of the related activities, 21% of the total constraints are linked to the Formwork package (the construction methodology adopted by the company) It is worth mentioning that most of the sites in which the lookahead process is being implemented using the app in this third cycle is at the beginning. However, this is a substantially higher value than those in second and third places: 8% (post-concreting) and 8% (ceramics).
- When a constriction causes a delay, the average delay is 20 days and those that cause the greatest delays are constraints related to safety at work (17 days).

NEXT STEPS

The subsequent stages to advance implementing the lookahead with a view to this being a source of data for strategic decision making, the analysis of indicators and reducing bureaucracy in the company are described below:

- Inserting data into the company's ecosystem: the capture of data from the app for the company's Data Lake was evaluated with the IT team. Thus, this will enable reports to be enriched, and to connect with any other data obtained by the various systems of the company. This process is expected to be completed by the end of the third cycle;
- Help Chain: Developing a management panel that presents the actions flagged in the appl as “help chain” and finishing structuring how this information should be passed up the other hierarchical levels of the company for quick problem resolution;
- Checklist of constraints for the other activities of the sites: The addition of the other activities of the sites in the lookahead planning and, consequently, their action plan in the apps database, will enable the checklist of constraints to be expanded. Construction teams will have access to the main constraints faced by works in progress, as well as works already completed, and thus be able to anticipate and expand the capacity to make a survey of constraints.

CONCLUSION

This article has presented the lookahead implementation project in a large construction company, and raised issues of project expansion, defining routines, a model for meetings and of tools used. The implementation in so many simultaneous sites require a great effort to standardize routines, tools and methodology on the part of those involved. The model for implementing cycles, followed by a month of reviewing standards and practices, proved to be a key point for developing the project and the continuous improvement of what was being proposed. Lessons learned in other implementations in isolated sites and in pilot format (as presented in the literature) are not enough for direct implementation in cases like this. It was possible to learn as the cycles developed and it was possible to deliver solutions that would meet the customer's needs, thereby seeking to guarantee the standardization, quality and sustainability of the project, regardless of regionalisms or peculiar characteristics of different teams.

The implementation of the lookahead generated greater integration with production support teams, production teams and administrative staff. This led to rich exchanges of information, allowing for better planning of the sites, the survey of constraints, visual management, and the engagement of employees with the established goals.

The difficulties of implementing the lookahead planning routine in a construction company and developer of such a scale were diverse. Training a large number of people is already a huge challenge and, like any change, it generated a lot of resistance. Due to the high volume of sites/consultant (up to four simultaneously), it was difficult to sustain routines, in some sites, at a time when the consultancy was not present on site. This was a reason for the lack of success at some sites, where the concepts were not fully absorbed by the field team and whenever there was no one keeping a close eye on procedures, the routines were not executed or were executed pro forma. In addition, the business environment for managing sites was not very technological and there were people who had difficulty in using online tools. The checklist developed for supra-structure activities was essential to increase the level of discussion in sites with less mature teams. However, it still greatly helped in sites with well-experienced people. This tool is always being complemented with new constraints that are pointed out weekly in feedback from sites.

Finally, it should be noted that although the solutions defined for this project were built on demand, they are not limited to use in this project. They can be used in others, even those with different characteristics that arise from some adaptations.

Regarding the data collected from the lookahead, what is demonstrated the low efficiency of the teams at removing constraints in time so as not to impact production. Altogether, 65% of constraints are not removed within the deadline and of those that are delayed, the average is 20 days. That is an important output but considering the current data we could not conclude what are the main factors that most impact on this average delay. We recommend a deeper analysis of data comparing the construction sites and the maturity of lookahead planning use to address a better understanding of the presented output.

In addition, 55% of all constraints found refer to material. In other words, more than half of the total number of constraints that impact a site refer to this category. However, there are still many restrictions that do not refer to this category of constraints (Equipment and Tolls and Manpower add up to 29% of all constraints) and they must be carefully analyzed to avoid interruptions in the flow of construction.

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