

Analysis of the construction process of masonry in ceramic blocks from the perspective of lean construction

Análise do processo de execução de alvenaria em blocos cerâmicos sob a ótica da construção enxuta

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Abstract

The construction industry has historically been seen as a sector permeated by numerous deficiencies within its production process. In order to mitigate this problem, we have the philosophy of Lean Construction (LC), where the progress of the construction sector can only be achieved through the continuous identification and elimination of activities that do not add value. The present study analyzes the influence of one of LC concepts, the principle of increasing transparency, on the performance of the constructive step of executing seals on ceramic blocks. A case study was carried out in a residential building, where the degree of knowledge of the employees regarding the activities they perform and the executive methodology used for the execution of masonry in ceramic blocks was analyzed, highlighting the impacts caused by the existence or the lack of techniques for increasing transparency. Through the case study, it was concluded that the low level of transparency of the case-unit promoted a work environment with scarce information flow, causing a production process without standardization, with a high level of uncertainties and with countless wastes.

Keywords: Civil construction. Production management. Lean Construction. Transparency. Ceramic blocks masonry.

Resumo

A indústria da construção civil é historicamente vista como um setor permeado por inúmeras deficiências dentro de seu processo produtivo. Para mitigar esse problema tem-se a filosofia da Construção Enxuta (CE), onde determina-se que o progresso do setor da construção somente pode ser alcançado através da contínua identificação e eliminação de atividades que não agregam valor. O presente trabalho analisou a influência de um dos princípios da CE, que é o aumento da transparência, no desempenho da etapa construtiva de execução de vedações em blocos cerâmicos. Realizou-se um estudo de caso em um edifício residencial, onde foi analisado o grau de conhecimento dos funcionários quanto às atividades que exercem e a metodologia executiva utilizada para a execução de alvenaria em blocos cerâmicos, salientando os impactos ocasionados pela existência ou pela falta de técnicas de aumento da transparência. Através do estudo de caso, concluiu-se que o baixo nível de transparência da unidade-caso promoveu um ambiente de trabalho com fluxo de informações escasso, ocasionando em um processo produtivo sem padronização, com alto nível de incertezas e com inúmeros desperdícios.

Palavras-chave: Construção civil. Gestão da produção. Construção enxuta. Transparência. Alvenaria em blocos cerâmicos.

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Introduction

For a long time, civil construction has been constantly criticized for its poor performance compared to other industries. As reported by Tezel, Koskela and Aziz (2017), many of these criticisms can be justified by the current characteristics of the sector itself, which, in general, has a fragmented supply chain (SEGERSTEDT; OLOFSSON, 2010), lack of strategic vision (GREEN; FERNIE; WELLER, 2005), high sensitivity to market conditions (REGAN; SMITH; LOVE, 2010) and temporary or short-term organizational configurations, designed and assembled only for a particular project (CARBONARI, 1991; PAUGET; WALD, 2013).

However, in the last two decades, a trend in the construction sector has been developing. According to which, in order to promote process improvement, it is much more effective to identify and eliminate activities that do not add value to the production chain as a whole, than the isolated technological improvement of a production stage (TOMMELEIN, 2015).

This new construction paradigm, called Lean Construction (LC), argues that for the real development of the civil construction sector there must be a paradigm shift, that is, a new way of seeing the construction process and, consequently, a new way of designing, managing construction projects and focusing on identifying and eliminating activities that do not add value (HIROTA *et al.*, 2000; HOWELL; BALLARD; TOMMELEIN, 2011; TOMMELEIN, 2015).

In this context, lean thinking assumptions can be highlighted: necessity to increase production control; creation of a reliable flow of information and processes; as well as reduction, as much as possible, in the number of uncertainties present in production (LIKER, 2005).

To achieve these goals, an important principle to be applied is increased transparency. This principle is fundamental for the success of the lean philosophy, since it promotes increased process control, making its flow visible and understandable to everyone, from beginning to end. This, therefore, facilitates the identification of waste occurring within production, which highlights opportunities for improvement in quality and process performance (FORMOSO; SANTOS; POWELL, 2002; KOSKELA, 2000; MONDEN, 2011).

Therefore, as elucidated by Santos (1999), one of the ways to recognize the excellence of transparency in an organization occurs when all process employees, even those with relatively low technical knowledge, are able

to understand the entire process without the need to ask about it.

Many subsystems of a building can be improved and optimized with the principle of increased transparency. Franco (1998) emphasizes that the execution step of vertical sealing in masonry constitutes one of the activities with the highest levels of waste within civil construction, largely due to the large number of interfaces that this step has with the other subsystems. Therefore, the present study focuses on analyzing the application of lean thinking principles to increase transparency in the execution of seals in ceramic blocks masonry.

Method

The steps for the preparation of the case study occurred in the following sequence: literature review, definition of the approach, delimitation of the case-unit, data collection process, data analysis process. These steps will be further detailed below.

The means of investigation of this work is a case study. As for the purposes of the research, it was decided to carry out applied research which, according to Vergara (2011), can be defined as research whose purpose is to solve concrete problems. In other words, the applied research to be carried out will not only be situated at the level of theoretical study, but also have a practical purpose, proposing to the case-unit mechanisms that will improve its performance.

There are the following characteristics of a qualitative approach, described by Godoy (1995), which will be followed as guidelines for the investigation to be carried out:

1. The research will have the construction site as a direct source of data, having the conviction that a phenomenon can be better observed and understood in the context in which it occurs;
2. Researcher will be a fundamental instrument for the research, being he the instrument of observation, selection, analysis and interpretation of the collected data;
3. The participants' point of view will be an important aspect to be considered, so that the internal dynamism existing in the case-unit will be taken into account;
4. The interest of the investigation will be in determining the way in which a certain phenomenon, such as the lack or presence of transparency, manifests itself in activities, procedures and daily interactions.

Another important point is regarding the selection criteria for the selection of the case-unit. Aiming at making the element of analysis recognizable to the reality of construction companies in the area, the present study will have the following aspects as criteria for delimiting the case-unit:

1. Small business¹;
2. Company with at least five years of market experience;
3. Company interested in participating in the survey;
4. development being a residential or commercial building;
5. Project with standard floors;
6. Enterprise carrying out the masonry execution stage;
7. Enterprise using ceramic block masonry.

As for data collection, the following techniques were used:

1. Questionnaire: This study identified the transparency tools and techniques used in the construction process through the questionnaire by Camargo Filho (2017), applied to the construction engineer;
2. Interview: The interview was conducted with the engineer responsible for the work; employee responsible for the planning sector; architect responsible for the evaluation of the architectural project in charge of the masonry sector; all full and multipurpose officers involved in the masonry execution process; and all construction assistants directly involved in the masonry execution process.

Furthermore, the purpose of the interview was to identify three main points:

1. The level of assertiveness of employees regarding knowledge of the executive sequence of the masonry execution process;
2. List the employees' opinion about the most difficult activity to be carried out within the process of executing masonry in ceramic blocks;
3. List the employees' opinion as to which activity can cause the greatest number of problems or unforeseen events within the masonry construction process;

¹ According to SEBRAE (2013), a small business in the industry sector has up to 99 people employed

4. Documents and records: various documents and records of the work were analyzed, such as projects, masonry execution procedure, daily work report, schedule, histogram, site layout, among others;
5. Direct observation: direct observation was an important method of data collection, analyzing the process of execution of the masonry walls of ceramic blocks and the tools and mechanisms adopted that promote transparency.

After describing all the study data and obtaining a complete overview of the case-unit, the data obtained is analyzed.

The identification of the level of transparency will be carried out by joining the data collected through the questionnaire, the interview and direct observation.

As for the questionnaire, it will be analyzed in a similar way to that recommended by Camargo Filho (2017). In possession of the numerical score of each practice (ITP), the index of application of transparency in each of the four categories covered will be described (Quality Management, Supply Chain Management, Production Planning and Control, Project Management), as well as a global note, involving practices as a whole.

In order to determine the transparency application index for each category (ILCt), in addition to the scores for each practice, the importance of each one of them will be taken into account, to be determined according to the researchers' assessment. Thus, the ILCt will be determined by the weighted average of the grades of each practice (ITP) of the category in question, as observed in equation (1), given by

$$ILCt(Ct_i) = \sum_{j=1}^n \frac{ITP(P_j) \cdot \rho(P_j)}{\rho(P_j)}, \quad (1)$$

where $ILCt(Ct_i)$ corresponds to the transparency application index of the i -th category, $ITP(P_j)$ corresponds to the grade of the j -th practice of the category, $\rho(P_j)$ the importance factor given to the j -th practice and the number of practices in the category in question.

The global score of the level of application of the process transparency, in turn, will be obtained through the arithmetic mean of the $ILCt$'s found. Based on the procedure used by Camargo Filho (2017), a correspondence will be made between the degree of implementation of transparency and its overall score.

Results and Discussion

The construction of a mid-range residential building, located one block from the sea, in the municipality of Vila Velha, ES, Brazil, was chosen as the case-unit. The development has three basement floors and ten standard floors, each with ten apartments measuring approximately 63 m². In addition, it has three stores on the ground floor, each with approximately 100 m².

According to Greif (1991), in a traditional work environment, such as the work under study, control and knowledge tend to be centralized, since management is expected to have greater knowledge about the process than workers.

However, Greif (1991) states that what makes a process transparent is the existence of an information network independent from the hierarchical structure of a given order. Therefore, the knowledge of employees involved in the masonry building process, from senior management to the construction assistant, about the steps necessary to perform the service was analyzed. This analysis was carried out by comparing the number of errors obtained for each group of employees, that is, between the number of executive steps that the respondent failed to mention. The results of this analysis are described in Figure 1.

It is possible to verify that only a small percentage of employees with management positions knew how to cite all the steps to perform the masonry lifting service. The misalignment between managerial positions, regarding the knowledge of the executive stages, demonstrates a critical failure in the level of existing information, since, according to Formoso, Santos and Powell (2002), even in traditional work environments, supervisors are expected to have in-depth knowledge of the process.

At the other extreme, it was noticed that most assistants showed little interest in the knowledge of the process, with several cases in which they justified that it was not important, or that it was not consistent with their position, to know such information. Finally, the full officers, despite demonstrating that they understand the stages of service, did not clearly know the stages that mark the beginning or end of the process.

Subsequently, a comparison was made between the different positions so that it could be observed whether the difficulties in the process seen by the officers and those who are actively participating in the executive processes are in line with the management's ideas. This analysis is shown in Figure 2.

After analysis, it is clear that the difficulties mentioned by the officers and assistants had a certain degree of similarity. Taking the finishing and cutting step as an example, the results were 29% for assistants and 22% for officers. On the other hand, management did not point out the difficulties that were most mentioned by both officers and assistants.

However, some employees, auxiliaries and officers showed initial resistance to answering the questions, either because they wanted to hide their difficulties or because of insecurity about their own answer. Such insecurity, in turn, is further highlighted by the respondents' questions, who asked at the end of the interview if they had answered everything correctly, despite being informed multiple times that the answers were subjective.

According to Galsworth (2017), the scarcer the information, the less the employees trust themselves, which can make them insecure and become concerned about making a mistake.

Finally, Igarashi (1991) emphasizes the importance of transparency for production when mentioning that, when implemented, most problems, anomalies and waste that exist in the process can be easily recognized so that the appropriate measures can be taken.

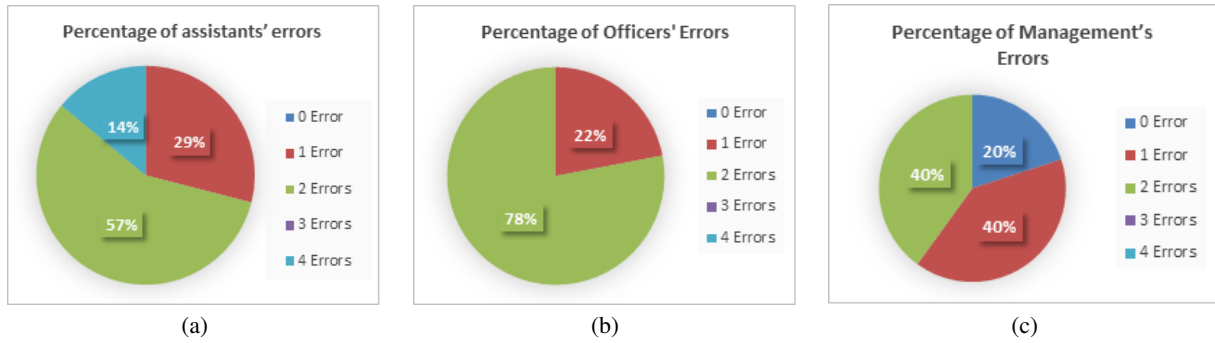
Therefore, the question was asked about the activity that generates the greatest number of problems within the process in order to analyze whether officers, assistants and managers are able to identify the factors that negatively affect production and whether the activities in question are obvious to those involved. Thus, the results shown in Figure 3 were extracted.

Undoubtedly, the management presented answers that are in line with those pointed out by the officials, who denounced, for the most part, marking as the biggest generator of problems during the production process. However, the assistants did not know how to answer the question well due to the lack of information they contained about the process as a whole, resulting in some more generic and blurred answers in the stage under analysis.

It is noteworthy, at this point, that the case unit does not use a standardized system to assess the quality of services, nor does it use any methodology to identify the root cause of the error committed. Quality inspection, in general, takes place only through the visual inspection carried out daily by the person in charge at the end of the day.

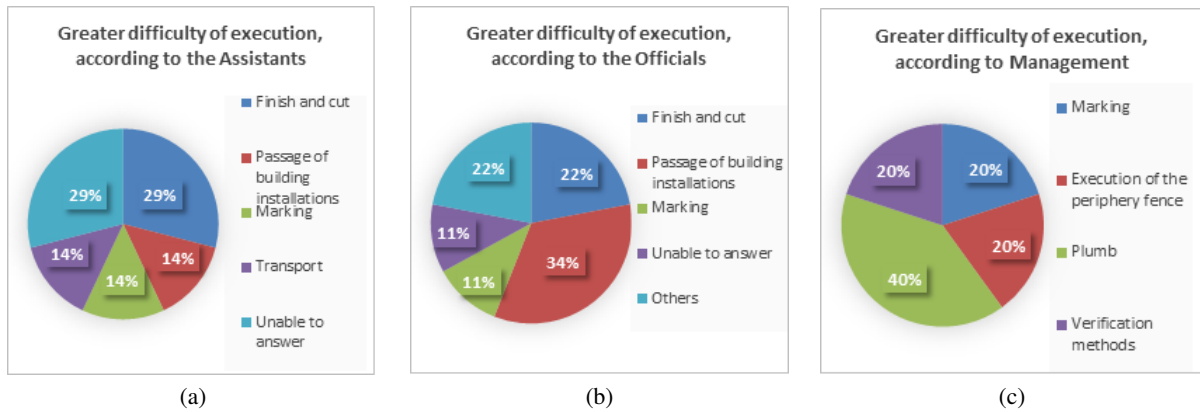
In addition, there is no record quantifying the occurrence of services whose quality was below that required.

Figure 1 – Results obtained with the first interview question – (a) Assistant; (b) Officer and (c) Management.



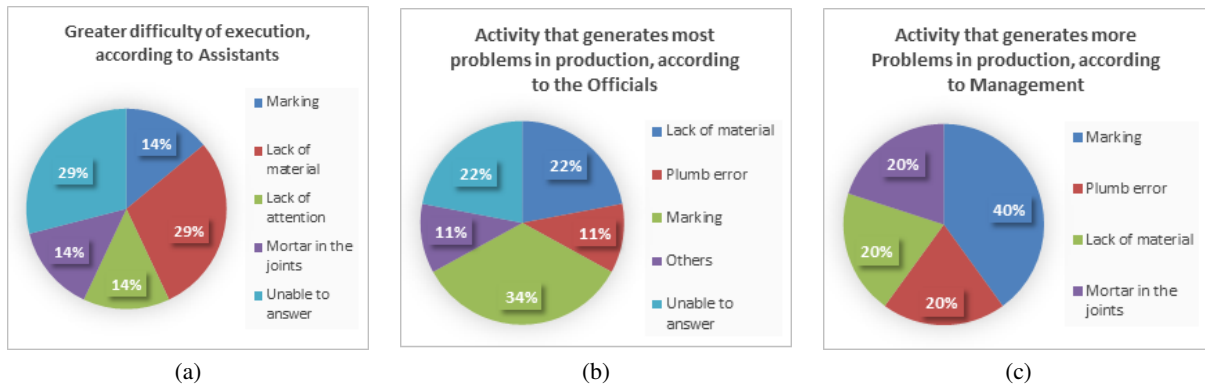
Source: The authors.

Figure 2 – Results obtained with the second interview question – (a) Assistant; (b) Officer and (c) Management.



Source: The authors.

Figure 3 – Results obtained with the third interview question – (a) Assistant; (b) Officer and (c) Management.



Source: The authors.

In view of the identification of an error, the standard procedure is to approach the employee who performed the activity so that the repair can be carried out and, in the event of a recurrence of the same error on many service fronts, a meeting is held with the teams that perform a particular activity.

After analyzing the results, it is clear that there was no congruence among employees regarding knowledge of the executive process, the most difficult activities to be performed and the activities that generate most bottlenecks to the process.

According to Galsworth (2017), this is evidence of the lack of transparency that exists within the work environment. This is because Galsworth (2017) argues that, while a non-transparent work environment has employees with dispersed opinions and approaches, an environment with a high level of transparency means that employees have clear understanding of their productivity and contribution of their work to the production process as a whole. As a result, employees have an aligned understanding of the process, making everyone seek the same common goal within the company.

This lack of transparency, in turn, can be attributed both to the lack of training and visual instructions for carrying out the work, as well as the lack of group meetings to discuss difficulties and areas for improvement.

Currently, the employees assigned to the service start production without specific training for the service to be performed, receiving only general instructions on how to carry out the task through the person in charge of the sector, who is available to any questions that may arise during the executive process.

From there, the first production of the new team is closely monitored, which may consist of the construction of an apartment, to clarify any doubts and determine whether the employee will be kept on the team or transferred to another function.

According to Barreto and Heineck (2012), employee training is a very important activity for the work environment, as workers come to understand what must be done, to propose new productive methods and, in more successful cases, even to suggest improvements in the arrangement of the architecture. Therefore, managers need to be able to teach production methods and quality parameters, in addition to being willing to embrace new opinions.

Therefore, after analyzing the current level of knowledge about the existing process among employees, the use of training is suggested so that employees understand their role and expected performance.

In addition, it is important to emphasize that, during data collection, the teams' lack of knowledge about the problems that arose during the executive stage of each service front was observed. When an employee identifies an anomaly in a service previously performed in the production chain, he transmits this information only to the person in charge, who, in turn, corrects it by bringing an officer from the anomalous stage in question.

This method, in turn, confines the information. According to Koskela (2000), the confinement of this type of information, that is, of the errors made within the process - makes employees ignorant about the problem, which causes the anomaly not to be identified in other processes and the error to be repeated. This then prevents corrective or preventive measures from being taken.

Thus, it is suggested that a way to increase the identification of errors within the process would be the practice of regular meetings, with all teams involved in the execution of the masonry, so that all contributors can share their experiences, problems and difficulties found during the process, as well as clarifying points of doubt.

According to Barreto and Heineck (2012), this learning process promotes numerous benefits, such as promoting employee engagement and group work, as well as standardizing work and encouraging continuous improvement.

Subsequently, it is verified that in the construction work, the performance of employees is evaluated in terms of productivity through daily notes in the form of a record, which report the services performed. However, instead of making the information available to the public, it is kept restricted to management.

On the other hand, there is no method for evaluating performance in relation to the quality of services performed by the teams. Therefore, there is an opportunity to program a means of quality assessment, since the defective product disturbs the production flow (SHINGO, 1996). Having knowledge of an existing method for evaluating productivity, it is suggested to carry out daily inspections in the form of a record to ensure the quality of the finished product.

Finally, after evaluating the productivity and quality of the services, it is suggested that an assessment framework be drawn up for both construction workers and subcontractors. According to Barbosa *et al.* (2013), making team performance transparent in a friendly way encourages those involved in the executive process, as well as encouraging continuous improvement.

Description and analysis of the construction process

The work analyzed divides the execution of the masonry into four service fronts: roughcast interface with concrete elements, marking, elevation and wedging.

The strategy adopted by the company is to group together pairs of bricklayers and assistants on teams that work only in one of the established service fronts. Thus, the work separates a pair responsible for the roughcast, a pair responsible for marking, four pairs responsible for lifting the blocks and two masons for the execution of the wedging of the walls.

The distribution of services is done verbally at the beginning of the week (Monday) by the masonry foreman for the teams. Although the work has a schedule in the management room, it is clear that it does not have it available to everyone involved in the process and does not show what is being carried out in a visible way. As explained by the masonry foreman, this is not done, due to the excess of information that is transmitted to the employee, which can lead to confusion and interfere in their production.

This situation is similar to that reported by Formoso, Santos and Powell (2002), in which an organizational environment is reported, whose management does not trust employees and presents a traditional work environment, as defined by Greif (1991).

In addition, due to the lack of details about the services contained in the schedule, on several occasions there is a need for adaptation during execution. For example, the diagram does not contain the wedging service nor the roughcast prior to markings carried out on site.

However, it is advisable that the schedule be displayed in an environment visible to everyone involved in the process, because the employee having more information about the production gains more motivation and reinforces his autonomy, as it makes it possible for the employee to control the production when comparing the present condition of service with the objectives provided (FORMOSO; SANTOS; POWELL, 2002).

The roughcast is only applied to the structure in contact with the periphery blocks and around the pillars. The service comprises three stages: surface cleaning, water washing and roughcast application.

Cleaning is performed by the assistant using a sander to remove the release agent and traces of the form. At this moment, the holes of the locking screws in the columns with grout are also filled.

Subsequently, the materials that can affect the adhesion of the roughcast to the concrete are removed with the use of water jets directly on the structure.

The roughcast application, in turn, is performed with a notched trowel, always paying attention to the direction of the grooves, which must be parallel to the direction of the walls that meet it.

Before starting the service, large quantities of blocks are moved to the work area and the execution begins only after the slab has been properly cleaned and the marking project transported to the pavement. Row position references are given in relation to centerlines, so the first activity to be performed is tying the rows. In sequence, the level is marked on the pillars using a level hose so that the first row of the entire floor remains level.

After completion of the preparations, the laying of the blocks begins. At this stage, the mason uses a long square, plumb, measuring tape, aluminum ruler, hand level, trowel, hand circular saw, bucket with water and suede to ensure the quality of laying the row, as shown in Figure 4. Throughout the process, the professional has access to the project to read the measurements, as indicated in Figure 5.

Figure 4 – Laying the first block of the course.



Source: The authors.

Figure 5 – Marking project laid out on the pavement.



Source: The authors.

In the project, the material and thickness of the blocks are differentiated through a color system to facilitate the recognition of the type of block that must be laid, with the blue color representing the concrete block and the orange color representing the ceramic block. However, the project does not differentiate blocks of different dimensions through colors and, to complement this lack of visual information, the work adopted the use of hatches and colored pens drawn on the physical project.

In this case, the occurrence of incomplete and unreliable information within the project is evident. It is noteworthy that, according to Koskela (2000), the existence of inaccurate information is one of the main causes of rework within production.

The settlement starts with the peripheral blocks, entirely made of concrete, followed by the internal pavement blocks composed of ceramic blocks. First, blocks are positioned so that the plumb line, level and measurement in relation to the axis are adequate, then the ruler is aligned with the blocks to then lay the course.

At this time, the mason follows the measures provided in the project, with the exception of the doors between dolls, a small protruding section of masonry intended for housing pipes or for fixing door and window frames (THOMAZ *et al.*, 2009), having the order of keeping the dolls always the same size despite the project's varying measurements.

The masons are instructed to lay the ceramic blocks of ten holes with the holes vertically at every end of the wall, so that the consumption of mortar will be reduced. It is noteworthy that, according to Yazigi (2009) and Thomaz *et al.* (2009), the ideal is to use the holes always horizontally.

During the marking, the front works assistant is responsible for transporting blocks and carts containing mortar, as well as keeping the environment clean. In addition to the direct service with the mason, he is also in contact with the operator of the winch and rack, making the request for demand for materials.

When marking rows, the mason performs the subsequent rows, paying attention to basic details of masonry, such as: mooring between blocks; fixing screens at the meeting of masonry with pillars and at the meeting of ceramic blocks with concrete blocks; position lintels over spans; keep a distance of a few centimeters between the end of the masonry and the slab; present mortar of approximately one centimeter in the vertical and horizontal joints between blocks and pay attention to the plumb line and alignment of the masonry.

The service starts with the positioning of templates using a plumb bob at the ends of the first row and a ruler supported in contact with the blocks. Then, it goes on to lay the blocks of the next row in mooring by using mortar in the horizontal and vertical joints. It is noteworthy that the mortar of the horizontal joint is regulated at one centimeter in height with the aid of a "gauge", as shown in Figure 6.

A point to be noted in the production is the excessive use of block cuts to fill gaps and widening of horizontal and vertical joints to overcome dimensional problems, which for Barreto and Heineck (2012) is an intolerable waste.

A solution for this is to optimize the arrangement of the first and second rows, as the posterior moorings are defined based on them, through a carefully designed detail that aims to reduce or eliminate these problems. Therefore, the identification of waste and errors in the product both in execution and finished becomes more visible.

Figure 6 – Laying mortar after using the gutter.



Source: The authors.

Another point to be commented upon comes from the fact that the work attributes to the masons the activity of passing the conduits inside the blocks while laying the lines. In addition, a strategy adopted to improve the service is the use of pieces of paper fixed to the blocks, containing information on the type of box (4x4 or 4x2), line on which it is located, number of conduits and conduit path, as illustrated in Figure 7.

Figure 7 – Block stock beside the anchoring center.



Source: The authors.

The boxes are previously anchored to the blocks and these are stored, reducing the interdependence between services, as suggested by Koskela (1992), so that they can be transported via winch to the demand floor, Figure 7.

Therefore, when the mason sees the paper, he immediately assimilates that a block with a box must be placed in that position and makes use of the holes existing in the blocks to carry out the path of the conduit according to the information received. There is, therefore, a system for incorporating information into the process, as mentioned by Tezel, Koskela and Tzortzopoulos (2010).

Another detail to be observed on the walls is the use of concrete blocks filled with mortar when the project foresees a counter or sink that is fixed and supported on the masonry. For this execution, the only way to commu-

nicate the instructions is through spoken language, carried out by the person in charge of the sector to the employees. It is noted that this method is susceptible to error, since the transmission of information to the employee is only verbal, at some point the employee may end up forgetting some peculiarity of the product to be executed.

Therefore, the use of a visual indicator can be beneficial to reduce procedural errors within the production and a suggestion is to incorporate information into the process by signaling the sections containing concrete blocks already in the wall marking, when coloring the blocks of the first spun using, for example, spray paint.

In this way, in addition to the use of colors being important for transparency in general (GALSWORTH, 2017), the employee would be able to recognize products with peculiarities visually and the signage being on the product would constantly remind him of the information, thus reducing the possibility of failure and increasing error visibility through simplified control (KOSKELA, 1992).

Regarding the lintels, the use of joists and concrete channel blocks for their execution was noted, as shown in Figure 8. First, the work only adopted the use of concrete channel blocks for the construction of the lintels, however a problem with the supplier made the use of beams produced on site viable. Finally, no form of synchrony between the hydraulic system and the masonry was observed, having on several occasions the presence of small cuts and even wall segmentation for the passage of vertical piping and plumbings, as shown in Figure 9.

Figure 8 – Bend in concrete gutter blocks.



Source: The authors.

The procedure chosen by the work when there is the presence of pipes from the hydraulic installation with a diameter greater than or similar to the thickness of the blocks is “casing”. The service is performed individually by professionals, without a helper, with the help of the following tools: ruler, plumb line and trowel.

Figure 9 – Segmentation of the wall for passage of the plumb line.



Source: The authors.

In the beginning, a thin steel screen is placed on both sides of the unfinished wall, extending twenty centimeters to each side of the installation, and then the mortar is applied over the screen covering the pipe. However, according to Thomaz *et al.* (2009), the recommended practice for this situation is the embedding of the pipe in shafts or in double walls.

Through the project, the presence of shafts is observed in the area of the bathrooms where the vertical piping and plumbings are concentrated, but there is no detail that informs the execution. The method used in the work is the execution of a double wall in the stretch where possible and wrap the pipe with pieces of ceramic block and, when necessary, perform the shelling. This procedure is illustrated in Figure 10.

Figure 10 – Shaft for bathroom vertical piping and plumbings.



Source: The authors.

It is noteworthy that, during data collection, a resounding failure in performing a service similar to the one evidenced in the process was observed. This failure occurred due to the employees not being able to correctly assimilate the instructions given by the project manager. At the time, the construction manager carried out the instruction of the service with the help of a sketch.

Tezel *et al.* (2015) report that an efficient method that facilitates the understanding of the expected product is the use of prototypes, such as models or 3D models. With this, it brings visibility on how the procedure should be performed, reducing the possibility of errors and the need for rework (TEZEL; KOSKELA; TZORTZOPOULOS, 2010).

As for the wedging process, this is carried out by masons without helpers. The activity, in which the professional uses only a trowel, consists of filling the space between the wall and the lower surface of the slab with mortar and pieces of ceramic blocks, as shown in Figure 11. In addition, wetting is also performed, with water in the area where the mortar is fixed.

Figure 11 – Execution of wedging.



Source: The authors.

It was observed that, for reasons of schedule, the work decided to carry out the fixing right after the elevation of the walls. However, as Thomaz *et al.* (2009) explain, the ideal is to carry out the fixation seven days after the elevation is completed, starting in the upper floors and ending in the first type.

The material transport logistics is simple. The method of transport is a trolley containing mortar moved via a rack to the pavement in service. During the activity, the mason exercises the practice of cleaning the workplace, depositing the debris in a cart that will return to the ground floor to forward the bucket.

Case-unit transparency level

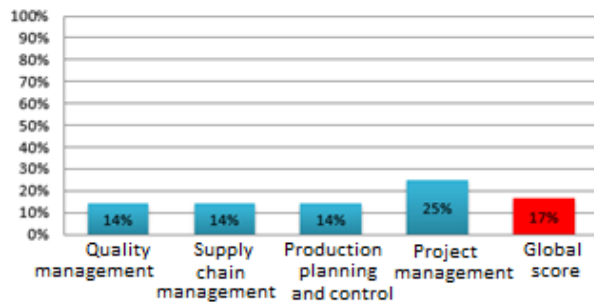
From the presentation and analysis of the results, it could be observed that the case-unit has a very low level of transparency for carrying out the necessary steps for the execution of masonry of ceramic blocks.

We seek, then, to reiterate this statement in a quantitative way, through the use of a methodology that measures the degree of transparency of a case-unit. For this, the questionnaire was used.

The questionnaire, in turn, reports which transparency tools and techniques are used in the case-unit. As already explained, it will follow the guidelines and criteria stipulated by Camargo Filho (2017), being, therefore, able to provide a percentage value for the level of transparency tools used in the work and, consequently, indicate the level of transparency of the unit case against the principle of lean philosophy.

After data collection, the construction company presented 14% application in the Quality Management, Supply Chain Management and Production Planning and Control criteria, and 25% in the Project Management criterion, obtaining a global score for the application level of process transparency equal to 17%. This result is shown in Figure 12.

Figure 12 – Questionnaire result.



Source: The authors.

Therefore, by using a correspondence between the degree of transparency implementation and its overall score, it can be concluded that, as the 17% score is less than 20%, the degree of implementation is considered very little.

It is noteworthy that, to obtain the values of the grades of each category, an importance factor $\rho(P_j)$ is considered equal to one. This is because Camargo and Filho (2017) clarifies that its value must correspond to the importance of the item according to an expert. Thus, in order for the results not to show the researchers' biases, $\rho(P_j) = 1$ was considered to keep all items at the same level of relevance.

Conclusions

Alluding to the philosophy of Lean Construction, this case study, when analyzing the process of execution of masonry in ceramic blocks, identified that the work studied presented a low level of efficiency in its production flow, not presenting effective control systems of its production or mechanisms for identification and mitigation of its waste.

Although the work studied presents some positive points that, according to Tezel, Koskela and Tzortzopoulos (2010), facilitate the process flow, such as the incorporation of information within the process through the marking of passage boxes, as well as the reduction of interdependence between the units of production through the previous anchoring of the passage boxes on the ceramic blocks, these improvements are isolated and little affect the general performance of the process. Furthermore, these improvements are still at a very embryonic stage.

Furthermore, a very low level of transparency within the process was found, which made the flow of information scarce and unreliable. Thus, it was reported that employees have dispersed opinions and approaches about the production process, reflecting the lack of understanding both about their work and their contribution to the process as a whole.

Thus, as stated by Koskela (2000), by neglecting the importance of infusing information into the process, the case-unit generated several uncertainties within its production chain, which culminated in a high amount of waste, which was not taken into account by the work management, making them invisible within the production process.

As highlighted by Formoso, Santos and Powell (2002), the real benefit of increased transparency in a process can only be fully extracted if production, at the same time, implements some basic improvements in the process, such as reducing inventory levels and tightening their production plans.

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Received: July 30, 2021
Accepted: Oct. 19, 2021
Published: Nov. 02, 2021