

THE STANDARDIZED WORK TOOL APPLIED TO THE WATERPROOFING PROCESS WITH ACRYLIC MEMBRANE

Nádia B. L. S. Fernandes¹, Angela B. Saggin², Caroline P. Valente³, Felipe L. Brito⁴, and Carlos Alexandre M. A. Mourão⁵

ABSTRACT

The Standardized Work is a lean tool that looks for process stability and productivity gain, by defining three main elements: precise work sequence, takt-time and standard inventory. This paper's main goal is to present the implementation of the Standardized Work tool for the waterproofing process with acrylic membrane at a construction site from a Brazilian building company to improve productivity, work conditions and precision in service's execution.

The methodology for developing this study case includes monitoring the waterproofing service, charting the collected information, analyzing data and graphics obtained, proposing a new sequence of activities and discussing it with the production and management teams. The production team supervisor has daily observed the new work routine established and the analysis has shown a 33.33% of productivity increase related to the initial stage. Furthermore, one member of the production team received a promotion, the team has better work conditions and instruments that are more adequate for the service execution, improving safety and reducing ergonomic risks to workers. Finally, the management team has improved its control and accompaniment, facilitating the knowledge management.

Therefore, the company identified the implementation of Standardized Work as an original, functional, feasible and easily replicable tool to other construction services.

KEYWORDS

Lean construction, standardization, production, waterproofing, productivity.

INTRODUCTION

According to Ohno (1997), despite the mass production system has been successfully applied in Japanese industries during the 60s and 70s, the team at Toyota Motor

¹ Civil Engineer, Fortaleza, Brazil, +55 85 98868-8094, nadiabragasaraiva@gmail.com

² Civil Engineer, Lean and Green Coordinator, C. Rolim Engenharia Ltda., Fortaleza, Brazil, +55 85 99903-0880, angela@crolim.com.br

³ Civil Engineer, M.Sc. candidate, Federal University of Rio Grande do Sul, Building Innovation Research Unit (NORIE), Porto Alegre, Brazil, +55 85 98816-3444, carolinevalente@gmail.com

⁴ Civil Engineer, Technical Manager, C. Rolim Engenharia Ltda., Fortaleza, Brazil, +55 85 3455-8000, felipe@crolim.com.br

⁵ Civil Engineer, Technical Director, C. Rolim Engenharia Ltda., Fortaleza, Brazil, +55 85 3455-8000, alexandre@crolim.com.br

Company believed that production model would not be sustainable in long-term, in view of its susceptibility to error and, therefore, excess waste generated. Thus, the company sought to develop a production system that would allow greater flexibility of models, with low costs and complete elimination of waste. The Toyota Production System (TPS) was then formulated.

From the changes of paradigms introduced by the Toyota Production System (TPS), Lean Production emerged, whose main objective is to add value to the customer through the complete elimination of waste. Thus, this production system has the following characteristics: inventory reduction, strict quality control, minimization of defects, adding value to the final product, employee's autonomy, anticipating problems and cooperation with suppliers (e.g. Womack, Jones and Roos, 1990).

Based on this, Womack and Jones (2003) expanded the concept of lean production to other areas of an organization through Lean Thinking, guided by five principles: value, value stream, continuous flow, pull production and pursuit of perfection.

In the 1940s, during World War II, the Training Within Industry Service (TWI) was started and developed to assist war production industries. Based on the philosophy 'every supervisor has five needs' (knowledge of the work and responsibility, skill in instructing, in improving methods and leading), it was developed the J-Programs, a four-step method of training: job instruction, job methods, job relations and program development (e.g. Huntzinger, 2005).

The standard work resulted from the Job Methods program, that establishes the ability to break down a process into its critical steps, and from the Job Instruction program, which allows knowledge transferring (e.g. Feng and Ballard, 2008).

According to Mariz (2012), the Standardized Work corresponds to the operational tool of the principle of continuous flow. The intent of the standardized work is to define the best methods and to reduce variation in the process steps as much as possible and not making all tasks repetitive (e.g. Feng and Ballard, 2008). Thus, this tool aims to establish the exact procedure of executing a given service through three elements:

- Standard sequence of activities: It corresponds to the sequence of activities in which a worker processes production units (e.g. Ohno, 1997);
- Takt-time: It corresponds to the production time in relation to customer demands (e.g. Dennis, 2008);
- Standard inventory: It corresponds to the minimum amount of items required for the production flow to remain continuous (e.g. Dennis, 2008).

According to Feng and Ballard (2008), standard work is a foundation of lean implementation and allows analysing the critical steps of a process. The standard work requires identifying the processes' tasks variety (low or high) and analyzability (low or high). It is also essential to determine the critical, important and low importance tasks within the process.

CASE STUDY DESCRIPTION

OBJECTIVES

This research paper has the main objective to apply the Standardized Work tool for waterproofing service with acrylic membrane in a residential project of a construction

company from Fortaleza, Brazil. Thus, there is the expectation of increased staff productivity through the proposition of a better sequence of activities and minimizing parts of the work that do not add value.

The specific objectives relate to the provision of better working conditions for employees and greater precision in the execution of the service. Despite having been chosen to present its implementation in waterproofing service with acrylic membrane, the Standardized Work is applicable for many services performed at construction sites.

THE CONSTRUCTION COMPANY

Founded in 1977 at Fortaleza, Brazil, the construction company of this case study focuses specifically to Classes A and B. It has more than 700.000m² of constructed area, distributed in various residential projects.

Since 2004 the company has been using many lean tools and practices: *kanbans*, *andon*, *poka-yokes*, supermarket concepts in the warehouses, transparency, production in small batches, new solutions formatted in the A3 tool, the standardized work tool and many others.

In 2010 the successful implementation of lean construction allowed the union of Lean System with the Quality Management System, resulting in the ISO 9001 Lean System of Quality certification, the company's current management model.

THE PROJECT

The research was conducted in a residential building (Figure 1) located in noble neighbourhood of Fortaleza, Ceará. The project consists of a single tower with 23 floors and four apartments per floor. It also has four options of floor plan and large recreation area, with completion due to January 2016. The project's gross area is 18,311m².



Figure 1: Project's façade and apartments plan (courtesy of the company)

Until early 2014, the waterproofing of wet areas occurred through the application of asphalt mantle held by a third party. In 2014, the company decided to use a new material, the acrylic membrane, which is easier and safer to apply as well as it is executed by the company's own employees.

A two-person team, consisting of an auxiliary and a professional, conducts the waterproofing service. The team had a productivity of 12 apartments per month, which corresponds to 1.75 days per apartment (or 18.06 min/m²). The takt-time was determined by the goal established by the management team, based on the upcoming services productivity such as flooring. The goal was to complete 11 apartments per month, which corresponds to a takt-time of 2 days per apartment (or 20.65 min/m²).

In addition, the company already has a work instruction for the service and the employees demonstrate familiarity with the sequence of activities, but they do not have a standard execution. So, the work team had difficulty in controlling production as well as identifying opportunities for improvement.

DEVELOPED ACTIVITIES

This case study occurred into five stages:

Characterization of the initial stage: the first methodological stage was to observe and monitor the execution of waterproofing service with acrylic membrane, in order to characterize the initial stage. Thus, the work team was accompanied for two shifts, so that all activities had their times monitored, whether inherent to the process or not. Figure 2 presents the application of the first painting with the product, as well as a sample of a sealed area.



Figure 2 – Waterproofing process with acrylic membrane (courtesy of the company)

- Tabulation of collected data: after the initial collects, qualitative and quantitative information were tabulated and compiled in spreadsheets in order to generate graphs and relevant data to the study. Figure 3 shows an example of tabulation of the observations.

Simplified Process Study Form (PSF)						
Period	Time	Interval	Activities	Comments	Room	Cycle or out of cycle
Morning	07:57:00	00:01:56	Preparation of materials	Polish machine, PPEs, extension cord, etc.	Kitchen, service area, bathroom and balcony of 1103.	Out of cycle
Morning	07:58:56	00:05:08	Thick cleaning	Removal of ceramics, bags, pallets, etc	Kitchen, service area, bathroom and balcony of 1103.	Out of cycle
Morning	08:04:04	00:03:21	Preparation of materials	Pick up a light bulb, turn on the extension cord, pick up a brush, pick up a broom.	Hall of the 11th pavement, between appartments 1102 e 1103.	Out of cycle
Morning	08:07:25	00:00:45	Thick cleaning	Sweeping	Kitchen, service area, bathroom and balcony of 1103.	Out of cycle
Morning	08:08:10	00:01:44	Stop	Identified a leak and called the responsible team.	Kitchen, service area, bathroom and balcony of 1103.	Out of cycle

Figure 3– Tabulation of collected data

- Identification of critical activities: the third stage was the proper analysis of data and graphics. Thus, it was intended to identify which were the most critical activities of the service, how the parts of the service that did not add value could be minimized, how the activities of the cycle were distributed and what could be the most appropriate intervals of time for completion of the service.
- Standardizing the waterproofing work team routine: based on the analysis of the stage three, it was suggested a new standard of work. Thus, the fourth methodological stage corresponded to the adjustments made to the sequence of activities in order to minimize the cycle time, promote greater control by employees and supervisors and increase team productivity.
- Presenting the standardized routine to management and work teams: meetings were held with senior management and the work team. The first one aimed to explain the study, present the planned improvements and seek for commitment of managers to the research in order to maintain the daily monitoring of the activities and the maintenance of new work conditions for the proper execution of the service. The second one aimed to present the proposition of the cycle of activities, as well as to confirm with the team about its feasibility of execution.

CASE STUDY IMPLEMENTATION

Because the company already had the work instruction, the waterproofing service already had the first element of the Standardized Work tool: a simple standard sequence of activities, shown in Figure 4.

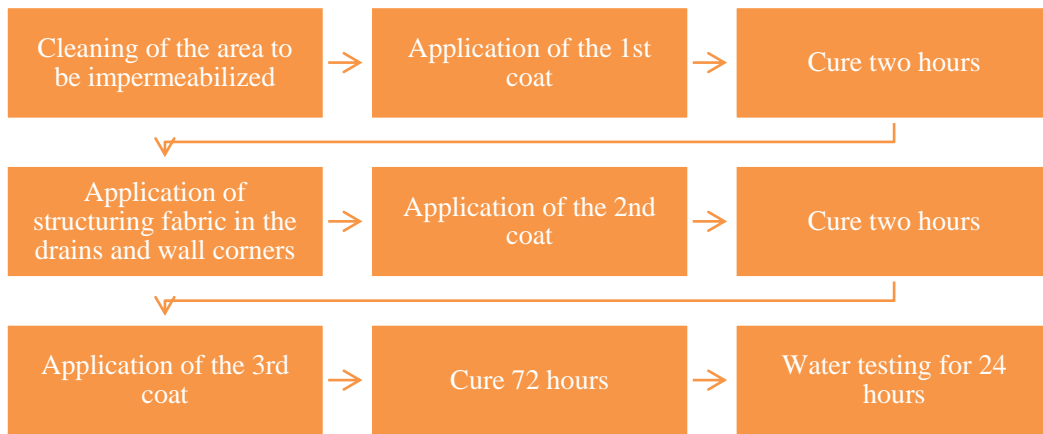


Figure 4– Flowchart of waterproofing service

As shown in the methods section, the study began from monitoring the execution of the service. Thus, it was found that 60% of employee's time was spent on activities that did not add value, such as displacements, cleaning and rework while the remaining 40% were used in the application of the acrylic membrane, in any of its coats. Figures 5 and 6 show the time distribution with activities that added and did not add value to the service.

Current Operator Balance Chart (OBC)

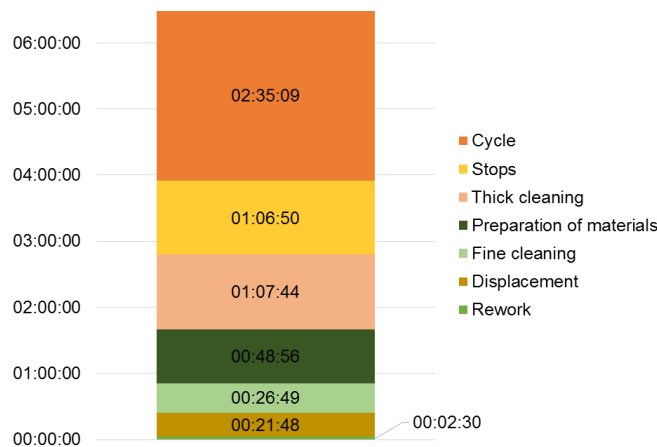


Figure 5 – Current Operator Balance Chart (OBC)

Current Operator Balance Chart (OBC) - Percentage

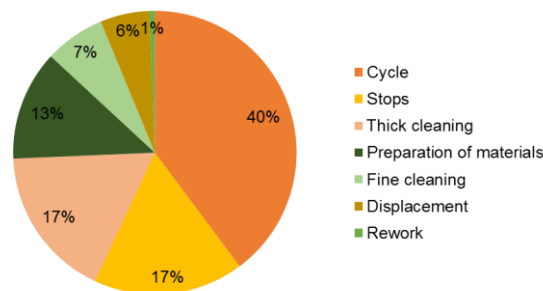


Figure 6 – Current Operator Balance Chart (OBC) - Percentage

Based on this, the first observed improvement point concerned the time spent with

stops, which corresponded to 17% of the total. These interruptions were given, in general, by the interference with other services, which sometimes made it difficult for the coat to dry and, in some cases, it was necessary to repeat the application of the membrane. In addition, other rework were also frequent, such when there was any error in installing the ceramic floor, it required the application of the acrylic membrane once again.

Another very critical issue concerned the cleaning of the area to be waterproofed, which should consist only in removing dust with broom or brush, but that, in fact, consisted of a thick cleaning by removing mortar residue and corrections of small failures due to interference with previous services. Thus, this activity consumed 17% of the total time and demanded a lot of physical effort from the employees. It was perceived that the time of thick cleaning could be very minimized if the previous service, which corresponded to the subfloor, left no imperfections in the area.

The analysis also indicated that the time of preparation of materials were considerably long, corresponding to 13% of the total time, once employees did not previously prepare the workstation, which required several displacements along the floor.

In addition, the team had no place to store their tools and equipment, so that they stayed exposed at workstations together with the materials, which sometimes caused theft. It was also observed that the working tools and the personal protective equipment could be more appropriate, as it was the case of the mask and protection glasses used.

Besides the study of distribution of time between the activities that added or did not add value, it was also analyzed the time spent with only the activities of the cycle, in order to determine the minimum time required for the execution of one square meter of the waterproofing system, if the activities that did not add value were eliminated. Thus, Figure 7 summarizes this analysis, corresponding to the future state of the service's execution and comparing the new lowest cycle time with the *takt-time*.

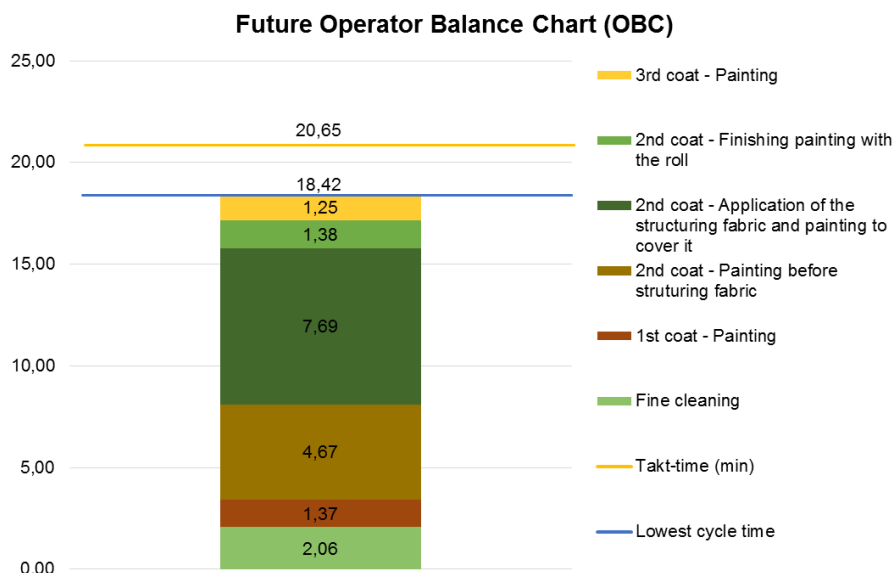


Figure 7 – Future proposed Operator Balance Chart - cycle activities

From all observations, it was defined a new standard sequence of activities that could minimize the amount of activities that do not add value, increase staff productivity

and improve the working conditions of employees. All activities were set up in a five-day cycle, enough time to perform the waterproofing of a whole floor (four apartments), as the analysis has shown.

In order to facilitate the understanding of the new sequence of activities by employees, some flash cards of the work routine were developed, which brought the day of the cycle, the shift, times, activities and workplace of each waterproofing service task. Thus, the work team now had pre-established times not only for the inherent activities of sealing itself, but also for the preparation of materials, inspection of future workplaces and resting. In addition, the use of the flash cards was also interesting for controlling the service by supervisors as well as for defining the production rate for employees. Figure 8 shows an example of the flash cards used.














Service: Waterproofing with acrylic membrane				Service: Waterproofing with acrylic membrane			
DAY 2 - TUESDAY				DAY 2 - TUESDAY			
Morning				Afternoon			
Time	Task		Place	Time	Task		Place
7h30 – 8h00	Prepare materials for cleaning		2	12h30 – 13h00	Prepare materials for 2 nd coat		1
8h00 – 9h30	Cleaning		2	13h00 – 14h30	2 nd coat		1
9h30 – 9h45	Prepare materials for 1 st coat		—	14h30 – 14h45	Rest		—
9h45 – 11h00	1 st coat		2	14h45 – 15h00	Prepare materials for 2 nd coat		2
11h00 – 11h30	Wash the brushes		2	15h30 – 17h00	2 nd coat		2
				17h00 – 17h15	Wash the painting roll		—

Figure 8 – Example of standardized work flash cards of for the waterproofing service.

RESULTS

Before the implementation of standardized work, the waterproofing team produced twelve apartments per month, so that the execution cycle of a floor was a little more than seven days. From improvements in the tools and work sequence, the execution of a whole floor has now occurred in five days, so that the monthly production increased to sixteen apartments a month, 33.33% higher than the initial stage.

At first, both workers of the waterproofing team did not seem comfortable with the presence of the research team and with many questions being asked. Nevertheless, the research team was able to identify some dissatisfaction with their tools and equipment, but mostly with frequent rework and other services interference on their activities.

With the daily contact, the waterproofing team gained trust and started to express their opinion about their routine and about the suggestions brought by the research team. After a few days, the work team was fully committed with the new work routine purposed and started to visualize its benefits.

In addition to increased productivity, some qualitative results were also perceived. The first concerns to the improvement of working conditions through the provision of

more appropriate tools and personal protective equipment to the team, such as new glasses and masks. In addition, a trunk was provided for storing their tools in order to minimize theft and facilitate transport between rooms and floors.

Another improvement corresponded to the standardized work flash cards, which served as a tool to control and monitor the production. This tool also contributed to the improvement of working conditions, as it has established times for preparation of materials and resting of employees. To ensure that the work team would use the flash cards, every day before the shift starts, the supervisor verifies with his team their daily routine.

In addition, the developed standardized work facilitated the knowledge management of the process, once it documented the standard sequence of execution of activities and allowed the daily monitoring by employees and supervisors.

It was also observed that the auxiliary of the team already had enough skills and knowledge about the execution of the service. Thus, it was requested the promotion of the employee to half-professional, in recognition of a well-done job.

The construction manager, when asked about perceived changes in the process, reported that the Standardized Work has already led to a number of service improvements. The study allowed the perception that small changes can be extremely relevant to the productivity and staff wellbeing. An example of this relates to improvements at workstations, through the provision of better personal protective equipment and most appropriate tools. In addition, the routine flash cards have been very useful for the team and their supervisors, who can monitor more adequately the tasks of each day. Finally, the construction manager considered the Standardized Work of easy replication, so that the study has been carried out with members of the management team and there is the intention to apply it in the execution of other construction services.

CONCLUSIONS

The present paper sought to apply the Standardized Work for the waterproofing service with acrylic membrane. Thus, based on these results, it is believed that the main objective has been accomplished as well as the specific objectives, since the tool was implemented properly and, from that, it was possible to promote improvements in the working conditions of employees, improving the monitoring and execution of service and increased staff productivity.

Given the above, it is believed that innovation is aligned to the current scenario of the second sector. In addition to the contributions to the company of this study case, there are contributions for the construction industry in general, due to the ease of implementation and analysis of the process, and the small demand for material and financial resources.

As Mariz (2012) reports, the application of Standardized Work in the construction industry is still incipient, because there are few studies in this area. Thus, it can be verified the originality of the study not just for the application of Standardized Work itself, but also by focusing on waterproofing service with acrylic membrane, recently implemented in the enterprise.

Another important point concerns the Standardized Work functionality, provided by the work routine flash cards, which help to keep the execution of the service according to the established time and sequence. In addition, the guidance to the

production supervision and manager of the construction site provided an assertive process control.

Finally, it is believed that the standardized work is quite affordable in terms of ease of application and financial terms. In the case of implementation, it is demanded only the availability of a professional to monitor the service and perform analysis of activities and times, so that improvements can be realized in a few weeks application. With regard to investment for deployment, it is observed that the costs are negligible, because they correspond only to shopping tools and equipment that are more appropriate and the working hours of the professional responsible for conducting the process of standardized work.

Thus, the application of Standardized Work has brought good results for the company. In addition, the work can be easily replicated for other services, given the simplicity of the analysis and the low demand for material and financial resources. Thus, there is an expectation to perform the Standardized Work with the critical services of the construction site and follow the application in other work packages listed in the line of balance, the main tool for long-term planning of the company.

ACKNOWLEDGMENTS

Authors would like to thank the construction company for allowing the results of this study to be published. Any opinions, findings, conclusions and recommendations are those of the authors and do not necessarily reflect the views of the company.

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