PRODUCTIVITY IMPROVEMENT APPLYING PRODUCTION MANAGEMENT IN PROJECTS WITH REPETITIVE ACTIVITIES

George Flores[1] and Carlos Ollero[2]

ABSTRACT

This paper discusses a part of a socially complex project consisting in performing 315,000 times the same activity in 17 districts located at the southern part of the City of Lima, Peru.

The project consisted in changing the water service measurement system of the houses in those districts, where there was a lack of skilled labor, most of the workers were plumbers, and the geographical conditions of each district and social issues around the work area represented a major challenge for carrying out the project. In this context, we decided to apply the Lean Construction philosophy as a strategy to meet those challenges.

This paper presents some of the results obtained after implementing some Lean principles.

KEYWORDS

Productivity, lean construction, last planner system, flow, action learning, production management, services.

INTRODUCTION

The City of Lima had been using the same water measurement system for over 20 years. Because of this, the measurement indicators in Peru's capital were below the region average. In this scenario, SEDAPAL (the city's national potable water supplier company) bid up the SIAC Project, which consisted of the renewal of the entire water service measurement for the city.

This paper is based on the experience of 17 districts located at the southern part of the city (San Borja, Santiago de Surco, Surquillo, Miraflores, Lince, Barranco, Chorrillos, Villa Maria del Triunfo, San Juan de Miraflores, Villa El Salvador, Pachacamac, Lurin, Pucusana, San Bartolo, Punta Hermosa, and Punta Negra. Santa Maria del Mar), which had geographic and economic differences from each other.

Following the contract terms, we found a lack of qualified personnel to maintain the unit rates established in the budget (each person had to do 18 installations per day). The initiative to change all the water meters that were more than 3 years old was supported by two private companies: G y M S.A. (Peru) and AGBAR (Spain), which became strategic partners of SEDAPAL to achieve this goal.

[1] Implementer in the Project Control Management Department at "Las Bambas" Project, Civil Engineer. Paseo de la República 4675, Lima, GyM, Mobile: (511) 991244004, gfloresc@gym.com.pe

[2] Project Control Chief at "CH Cerro del Águila-Sector Presa" Project, Sanitary Engineer. Paseo de la República 4675, Lima, GyM, Mobile: (511) 993112634, collero@gym.com.pe

KEY CONCEPTS

PRODUCTIVITY

Productivity is defined as the efficient use of resources and is represented as the relationship between the units that we produce and the resources used for this (*Graña y Montero*, 2008).

PRODUCTION MANAGEMENT

For a construction project, a Production System consists in the interaction of flows (Koskela, 1992). Most of losses in a production system occur both when the flow stops and for excessive resource utilization in processes. However, losses are greater when the flow stops (Graña y Montero, 2012*)*

To maximize productivity, the Production Management seeks first to obtain an uninterrupted flow and then the process optimization (Graña y Montero, 2008).

METHODOLOGY

The methodology adopted for the company for your projects is based on the principles of production management. To do this defined a team that would perform the initial project analysis, the design of the implementation plan, the development of necessary tools and the execution of the activities considered in the plan.

These tools were implemented for all staff involved in production activities of the project and were developed based on three fundamental steps: Ensuring an uninterrupted flow, obtaining an efficient flow and efficient operations.

ENSURING A UNINTERRUPTED FLOW

To ensure an uninterrupted flow within the project, you need to establish appropriate strategies to face external factors, and keep all available resources before starting the work. This is fine provided that you avoid large inventories.

After receiving all the initial information about the project, it must be analyzed, so we can develop a simple schedule, easy to read and update. Then we have to identify our critical resources, the non-critical and the ones that have high turnover rates, so that this allows us to establish the appropriate supply strategies.

In this project, one of the critical resources were the water meters, because apart from their purchase, we needed to manage their transport, storage and testing. A meter with any measurement problems could bring serious consequences to the client, so we needed to ensure their timely arrival and that they were in the best possible condition. For this we used a tool, to keep track of what we had in the warehouses, what was in transit and the all the requirements we had for a three-month horizon.

DESCRIPTION	OCTOBER	NOVEMBER	DECEMBER	DIFFERENCE
FLOWMETER FOR WATER SINGLE-JET 15mm	11148	11148	11148	33444
FLOWMETER FOR WATER MULTI-JET 15 mm	0	0	0	0
FLOWMETER FOR WATER MULTI-JET 20mm	83	0	0	83
FLOWMETER FOR WATER MULTI-JET 25mm	30	21	0	51
FLOWMETER FOR WATER MULTI-JET 40 mm S/M	0	0	0	0
HOOP PROTECTOR DN 15mm	0	0	0	0
CUP PROTECTOR DN 15mm S/M	0	0	0	0
CUP PROTECTOR DN 25mm S/M	0	0	0	0
CUP PROTECTOR DN 40mm S/M	0	0	0	0
SAFETY DEVICE CAGE FOR MULTI-JET WATER METER 15 - 25 MM	83	0	0	83
SAFETY DEVICE CAGE FOR SINGLE-JET WATER METER 15 MM	11148	11148	11148	33444

Figure 1 - Example of table of requirements

As shown in the figure above, apart from the meters, other critical materials were the guards and devices to prevent any robbery. For the management of external factors, we established a strategy that consisted of performing preliminary inspections of the work areas. The inspectors were responsible for identifying what work has to be done and explore the surroundings to gather any necessary information, like traffic intensity in the streets, dangerous zones, clients that refuse to change their meters, etc.

In order to track the progress and work done by the inspectors, we used a control panel (Figure 2) for controlling their work day by day. In case that anything unexpected happens, that could cause the stoppage of the crew activities, we used buffers. These buffers, consisted in heading to other previously inspected and released areas, so that the impact in the daily production could be minimized until the problems were solved. To control the size of the buffers, the work was calculated based on an average, the number of workers and the rest of the remaining hours of the day.

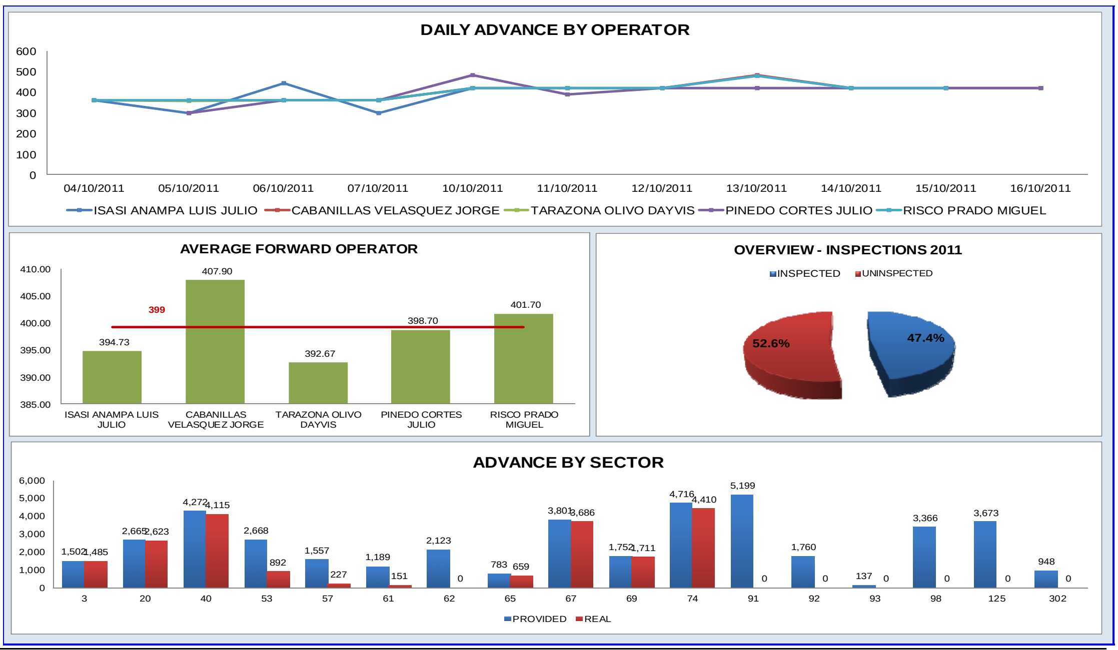

Figure 2 - Control Panel for previous inspections

In order to increase the reliability of having available resources, we used the Last Planner System that consisted in the implementation of the following tools (Yoza and Flores, 2011):

- Lookahead for production, with a three week horizon.
- Constraint Analysis.
- Weekly Plan.
- Percentage of plan completed (PPC)
- -Non Compliance Causes (CI)

We also developed a routine of meetings (Figure 3):

- **Weekly Project Meeting:** each support area responsible exposes the possible drawbacks or problems for closing the restrictions identified by construction.
- **Weekly Production Meeting:** the lookahead plan was presented so that we could analyze construction productivity, perform a feedback of the successes or failure in executing the activities in each front, review the scheduling reliability (PPC) and present the status of the most critical restrictions.
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ROUTINE MEETINGS
1693 SIAC PROJECT

TIME	MONDAY	THURSDAY	WEDNESDAY	TUESDAY	FRIDAY	SATURDAY	SUNDAY
8:00 - 9:00							
9:00 - 10:00	MANAGEMENT COMMITTEE						
10:00 - 11:00							
11:00 - 12:00					RECEIPT OF DELIVERABLES TECHNICAL OFFICE		
12:00 - 13:00							
13:00 - 14:00							
14:00 - 15:00							
15:00 - 16:00		PROJECT MEETING			PRODUCTION MEETING		
16:00 - 17:00							
17:00 - 18:00				RECEIPT OF DELIVERABLES SUPPORT AREAS			

Figure 3 – The routine of meetings

Additionally, the support areas sent some deliverables to construction, containing all the necessary information that could help them schedule their activities (Figure 4):

- Human Resources: Personnel Requirement Status.
- Construction Equipment: Program of equipment maintenance and supply (included maintenance dates and equipment arrival dates).

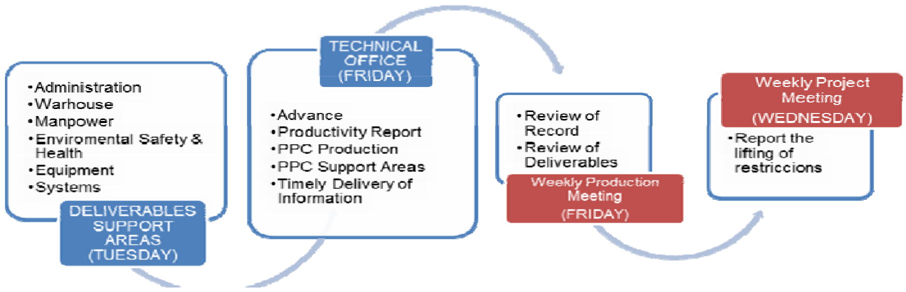


Figure 4 - Information flow for routine of meetings

EFFICIENT FLOW

Because of the high number of repetitive tasks being performed, the project focused on finding a balanced system, i.e. to identify a bottleneck and propose a continuous improvement cycle through which increases the capacity of the whole production system, so that the capacity of the critical workstations can be increased to the level of other production workstations. By doing this, some of the capacity waste could be eliminated and the system efficiency increased.

The main bottleneck detected during the initial development of the project was the warehouse. All crews gathered their materials and equipment at the same time and by a single window. Additionally, orders were different from each crew and work area, because of the different diameters for the water meters and accessories (15, 20, 25, 40, 50, 80 and 100 mm), the type of material being used, water flow rate, etc.

The following strategy was used for dealing with the bottleneck:

- Rearrange the arrival times of the crews to the warehouse: every half hour, three or four crews should go to the warehouse to withdraw the necessary equipment and materials, previously coordinated via telephone between the field engineer (that was responsible for scheduling the daily activities), the crew’s foreman or driver (who knew the materials or equipment available in their vehicle), and the warehouse responsible (who prepared all the materials and equipment that should be delivered to the crew).
- Speed up this service: we prepared standard material packages (Figure 5) that were designed after a statistical analysis of historical consumption and varied in diameter and work area. These packages were prepared by warehouse staff and allowed a quicker control of delivered materials (the final amount was the sum of the multiples of each package).

Figure 5 – Material Packages ready to be delivered to crews

EFFICIENT PROCESSES

Once you have an uninterrupted and balanced flow, we proceeded to optimize each activity in this flow. This was achieved through sampling techniques with the aim of increasing the share of productive work.

These samples consisted in observing to four crews, doing 90 to 120 observations in average for one week. The consolidated results are shown in the following figures.

First step: Perform activity sampling.

Figure 6 indicates that there are some improvement opportunities, since 67% of the time is spent in contributory and non-contributory work (Figure 6).

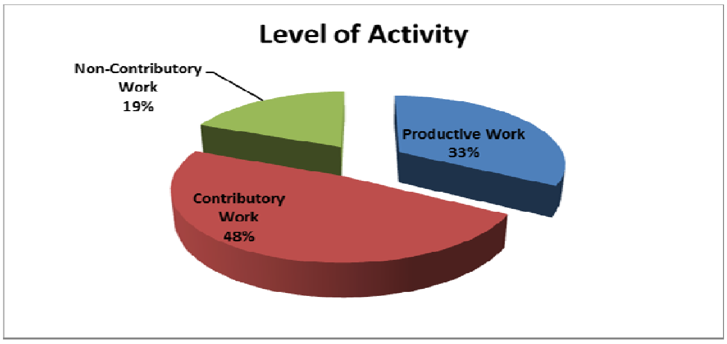
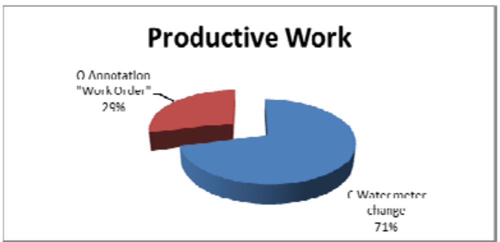


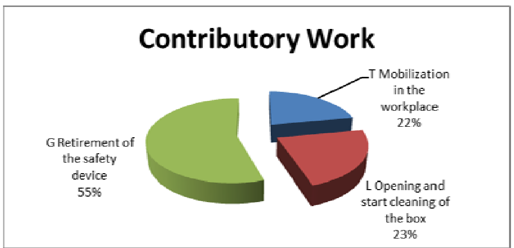
Figure 6 - Summary of one crew cycle

Figures 7, 8 and 9 presents the different types of activities for each category of time. We identified that the main improvement opportunities were the activities T, L and E.



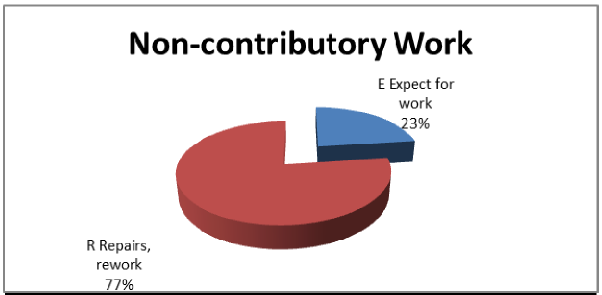
Productive Work	
C	Water meter change
O	Annotation "Work Order"

Figure 7 - Productive Works



Contributory Work	
T	Mobilization in the workplace
L	Opening and start cleaning of the box
G	Retirement of the safety device

Figure 8 – Contributory Work



Non-contributory Work	
E	Expect for work
R	Repairs, rework

Figure 9 – Non-contributory work

We developed an improvement work plan with the following actions:

- The workers had to carry many things that exceeded their capacity. This forced them to make several trips between their vehicle and their work area. That is why, we decided to use small carts where they could store all their stuff and make only one trip to the work area (Figure 10).

Figure 10 – Workers ready to start the day with their equipped carts.

Each of the work areas of the 17 districts was different. One could open the lid of a water meter box and find land, water, concrete debris, and other materials that had to be cleaned before changing the water meter. As workers spent much time on this, so we introduced a special working crew that was in charge, using the information given by the inspectors, to clean each water meter box. Each team consisted of two workers with lower productivity rates.

Figure 11 - Status of some water meter boxes

Second step: map the progress and number of people that was involved in the implementation activities and evaluate the daily production performance per person.

The daily performance at the beginning of the project was approximately 5 water meters installed per person per day, that after 1.5 months of work (with proper production management) reached about 10 water meters installed per person per day representing a 100% improvement (Figures 12 and 13).

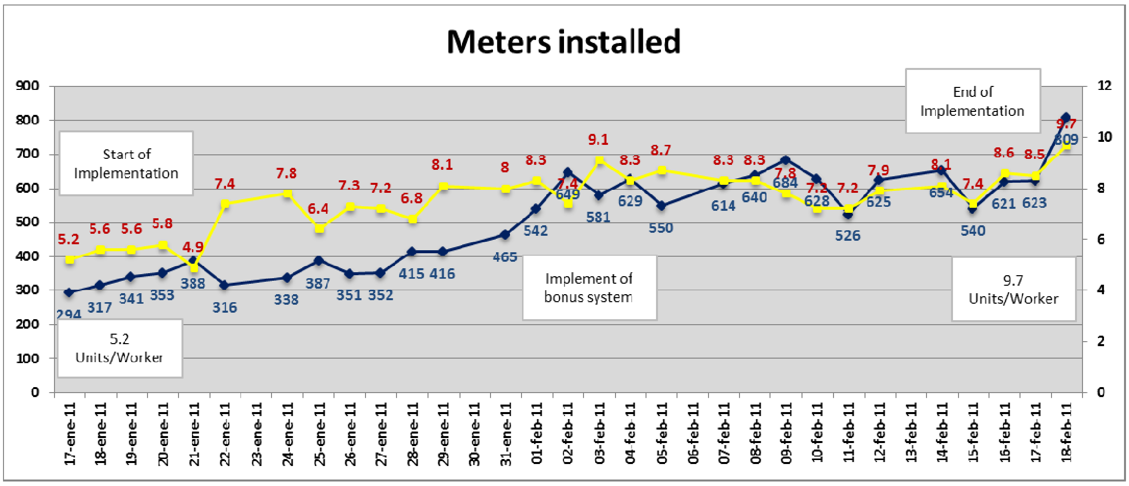
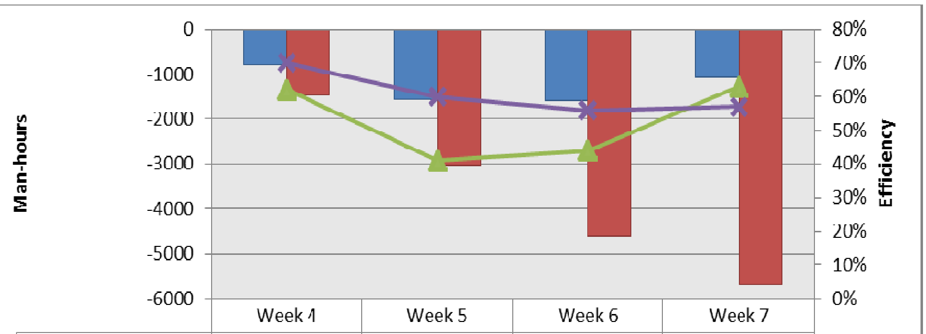


Figure 12 – Water Meters installed (Blue) and Performance per person (Yellow). First Management Milestones (At the beginning of the implementation)

Third step: Labor Productivity Report, identifying cost gaps.

The IP (Productivity Report) is a graphical tool where you can see the evolution of the work efficiency and relate it to additional cost being generated by productivity lower than the budgeted (Figure 13).



	Week 4	Week 5	Week 6	Week 7
MH Weekly	-776.12	-1556.09	-1583.68	-1074.64
MH To date	-1466.95	-3023.04	-4606.72	-5681.36
Weekly efficiency	62%	41%	44%	63%
Efficiency to date	70%	60%	56%	57%

Figure 13 - Labor Productivity Report

In order to reinforce these improvements, we decided to implement a bonus system and a training program. In other words, we rewarded the workers with the highest daily production rates and also those who helped training other crew members, this with idea to ensure the efficiency of the entire crew. The bonuses were dynamic and had not limitation. The crew foreman received bonuses for his crew performance, his own performance and the ability to train new workers.

We created a category called "skilled worker" (Certified by the company). This category consisted of workers with a daily production rate of more than 15 installed water meters over a three-month study.

Figure 14 - Recognition of workers with the highest productivity (a daily production rate average of 16 installed water meters)

CONCLUSIONS

These are the main conclusions of the study that was carried out:

- Although the budgeted performance did not considered nonproductive time (the budgeted daily rate was18 water meters installed per person), with simple and dynamic solutions, we reduced the time spent in contributory and noncontributory work, achieving an average of a daily installation rate of 10 water meters per person (an improve of 100% compared with the initial actual rates).

- The identification of new activities or problems through preliminary inspections, improved the schedule performance, ensuring an optimal resource leveling. With an adequate knowledge of the work areas, we can obtain better performance rates and to avoid problems related to the location, etc.
- The use of incentives promotes acceleration in the learning curve. Sometimes we reached daily rates of 18 installed water meters per person, similar to the original budget. Other ways to motivate workers such as recognition awards also contribute to increase productivity.

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REFERENCES

Graña y Montero (2008), Manual of Construction Project Management, Lima, Peru.

Graña y Montero. Corporate Learning Center (CCA) (2012), Course of Production Management and Operational Excellence, Lima, Peru.

Koskela, L. (1992), Application of the New Production Philosophy to Construction, Stanford University, United States.

Yoza A., Flores D. (2011), “Impact of the Last Planner System Method on Sanitation Works”, 19th Ann. Conf. International Group for Lean Construction, Lima, Peru.