USING PRODUCTION SYSTEM DESIGN AND TAKT TIME TO IMPROVE PROJECT PERFORMANCE

Mario Fiallo C[1], Greg Howell[2]

ABSTRACT

The heart of the Toyota Production System is increasing flow through waste elimination. Takt time is the tool that establishes how much work has to flow through a production system in a fixed time. Takt time is a straight link between customer and production system that sets the rhythm of a production system.

The aim of this paper is to show how an Ecuadorian contractor tested the impact of production system using Takt time to improve performance on an infrastructure project. The site manager used Takt to design the production system and to communicate the system's goals to production units (crews).

The paper reports on the implementation process, key decision points and results. Lessons learned on this project have implications for the application of lean construction on projects in emerging economies.

KEYWORDS

Takt time, Flow, Production System Design, Visual Management.

INTRODUCTION

The heart of the Toyota Production System is increasing flow through waste elimination.

The Toyota Production System (TPS) incorporates tools to help managers and employees to introduce Lean into their organisation (Brady, Tzortopoulos, & Rooke 2011), also Liker in his book "The Toyota Way" (Liker 2006) says that "this is a system designed to provide the tools for people to continually improve their work".

He summarize the Toyota Production System into 14 principles arranged in four categories as follows: 1) Long-Term Philospy, 2) The Right Process Will Produce the Right Results, 3) Add Value to the Organization by Developing Your People, and 4) Continuously Solving Root Problems Drives Organizational Learning.

Category 2 is subdivided on 7 principles which main focus is to eliminate wastes. Principles two and seven of the Toyota Way are: create continuous process flow to bring problems to the surface; use visual control so no problems are hidden.

[1] Civil Engineer, Msc. Professor at Central University of Ecuador. Lean Construction Coordinator at Ripconciv Constructora. Av. Protugal y Eloy Alfaro. Edif. Milenium Plaza Piso 5 Of. 501. +593-333-2050 x 209, Mobile +593-996-94255; mfiallo@ripconciv.com.ec, mfiallo@sitiodeobra.com.

[2] President, Lean Construction Institue, Box 1003, Ketchum, Id 83340. +1-208/726-9989; ghowell@leanconstruction.org

Liker suggests that a good way to start with Lean is creating continuous flow where it is applicable, because flow tends to force an implementation of several Lean tools.

FLOW AND TAKT TIME.

Koskela (Koskela, 1992) suggest that taking flows as the unit of analysis in construction leads to deep changes of concepts and emphasis.

In construction process there are two different types of flows: material process consisting of the flows of material to the site, including processing and assembling on site, and work process of construction teams (the temporal and spatial flows of construction teams on site) which are associated with the material process.

Flow is present at the heart of the message of Lean which holds that shortening the time from raw material to finished goods ensures the best quality at the lowest price and delivery times shorter (Liker 2006).

When flow is used it is necessary to know: How fast we have to produce? What should be the crews capacity?, How many people do we need?, the answer is takt time.

Takt time is the tool that establishes how much work has to flow through a production system in a fixed time. Takt time is a straight link between customer and production system that sets the rhythm of a production system (Liker 2006).

Those are the main concepts that have been used to introduce Lean Construction on an Ecuadorian construction company in one of its construction projects.

CASE STUDY

CASE DESCRIPTION

Scope of Work

The project is in construction on Guayaquil city and its scope of work is to build 1,200 m of a concrete duct with two different sections. The first section with a length of 800 m has two chambers (1.40x1.63 m), and the second section with a length of 400 m and a cross section of (1.20x2.00 m). This duct will be buried under an existing highway with six tracks (three for each direction).

Re-construct of 2,460 m of highways, and a construction of a track for bicycles in a length of 2,345 m and 2.60 m of width.

The contract term is 10 months and the traffic never should be stopped. This highway is very busy and it is an artery of the city.

Client

The client is the municipality of Guayaquil.

ACTIONS TAKEN

The first step was carried out with superintendent, controller, administrator, and resident engineers (project team); reviewing the project information (contract, drawings, contractual plan, contractual schedule, current overhead costs structure, among others) and starting to develop the production system.

To develop the production system, the project team started with the idea in mind of "Deliver products that enable customers to better accomplish their purposes" (Ballard, Lauri, & Zabelle 2001). To accomplish that, the team held a brainstorming meeting where defined that its client is not the municipality (contractor) but the current road user and the community near to the project production site.

By that, the project was structured for value generation taken into account stakeholders interests. Two main interest were identified a) never stop traffic flow, b) always keep at least 2 tracks availables on each direction.

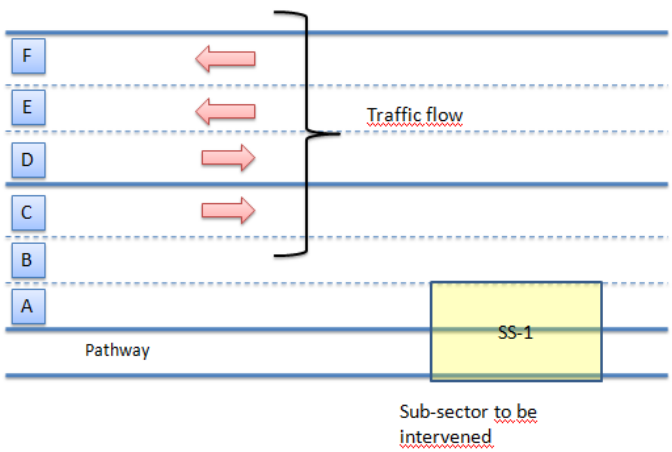
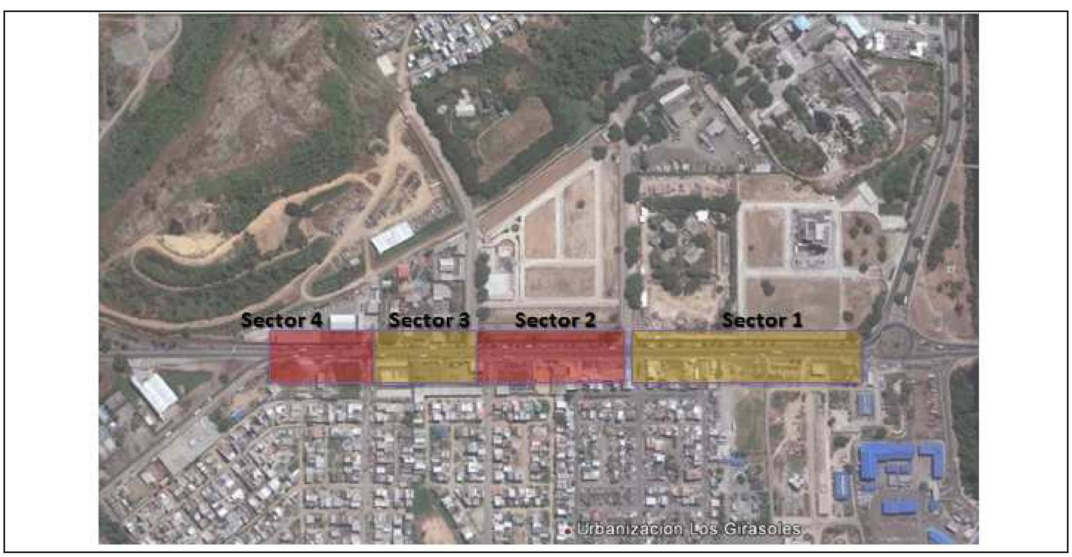
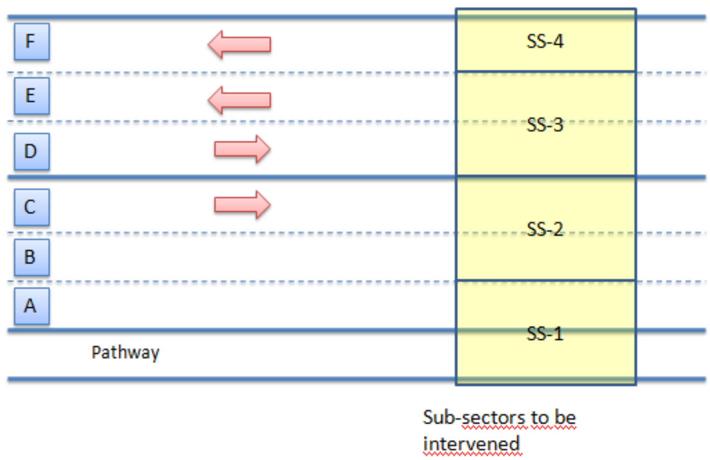


Figure 1: Value Generation. Identification of stake holders interests.

By that, the project was broken in 4 sectors along the route and 4 sub-sectors on section (fig. 2.).



(a)



(b)

Figure 2: Project Sectorization. a) Sectors, b) Sub-sectors.

Other topic taken into account on the production system design was to minimize waste. To accomplish with this goal the work was structured for flow, by that the approach used by the team was:

a. Identify the project demand rate.

b. Identify tasks to be done.

c. Estimate production rates for each task.

d. Identify bottlenecks (lowest production rate).

e. Make throughput = demand rate.

f. Structure work in continuous flow processes.

Identify the project demand rate.

Taken into account contractual schedule (our promise to client) the team defined spam times and milestones to be reached by each sector. Based on these milestones a demand rate was established on 115 m/week.

Identify tasks to be done.

Once the project was studied, six major tasks were identified as necessary for accomplish with the project: 1) pavement remove, 2) excavation for structure, 3) concrete duct, 4) refill with outside material, 5) refill with base, 6) pavement.

Estimate production rates for each task.

Reviewing previous works, production rates were identified and translated from units/hour to m/week. These production rates are shown in figure 3. It is necessary clarify that this production rate is for each process separately.

To obtain the production rate as a system it is necessary add the production rate of each sector that is working at same time.

Identify bottle necks.

Once the production rates were identified the lowest production rate was highlighted. This production rate is considered a bottle neck, see figure 3. For this case the bottle neck has a production rate equal to 36 m/week, corresponding to concrete duct.

Now the team has a big goal, improve the bottleneck production rate to improve the production system rate as a whole.

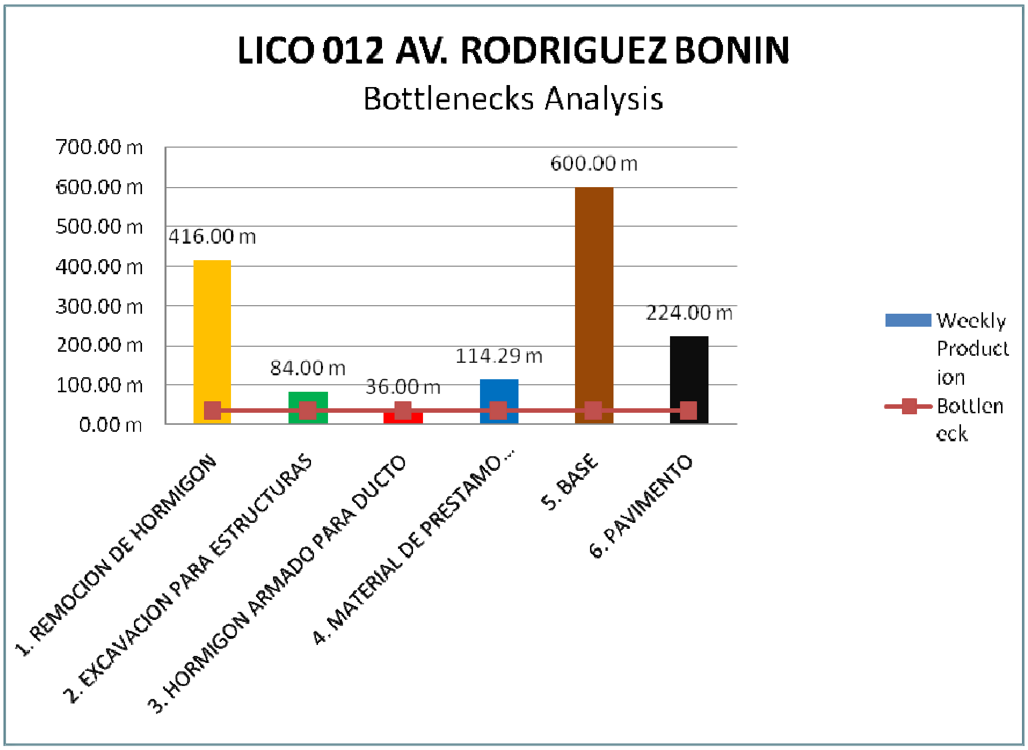


Figure 3: Production Rates

Throughput vs. demand rate.

So far, the demand rate is 115 m/week and throughput is 36 m/week. To achieve the demand rate required it was identified as needed 3 sectors working together. That would be the simplest solution.

The team was challenged to analyze a paradigm used in previous works for build the concrete duct and try to improve the flow process.

This analysis was based on eliminate wastes between different operations, waiting and overproduction. This analysis let them improve the throughput from 36 m/week to 49.5 m/week, a 37.5% of improvement (fig. 4).

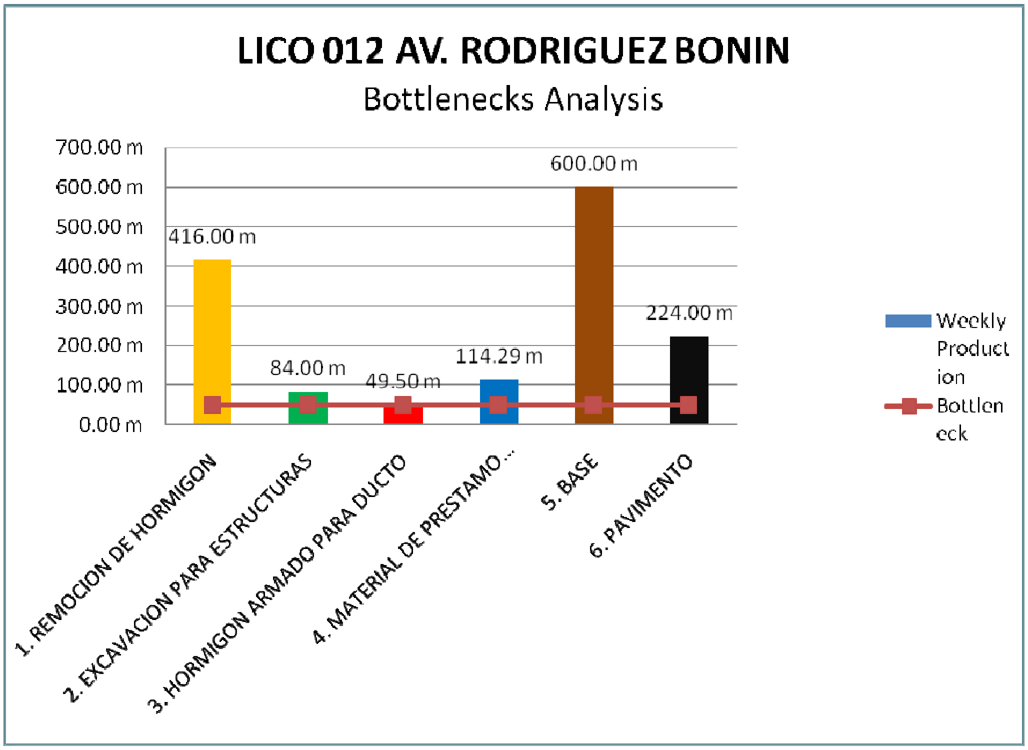


Figure 4: Production Rates after VSM analysis.

Structure work in continuous flow processes.

As it was explained above, an analysis was carried out to improve the throughput of the system.

A value stream mapping for current state was draw and then analyzed and improved (establishing a future state or required state), see figures 5 and 6.

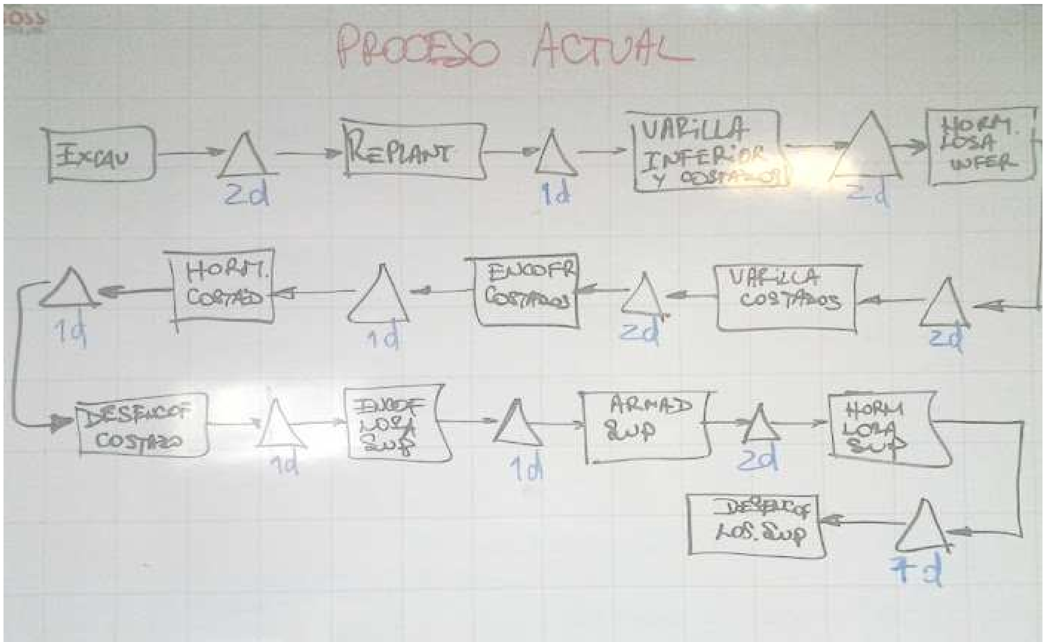


Figure 5: Current Value Stream Map.

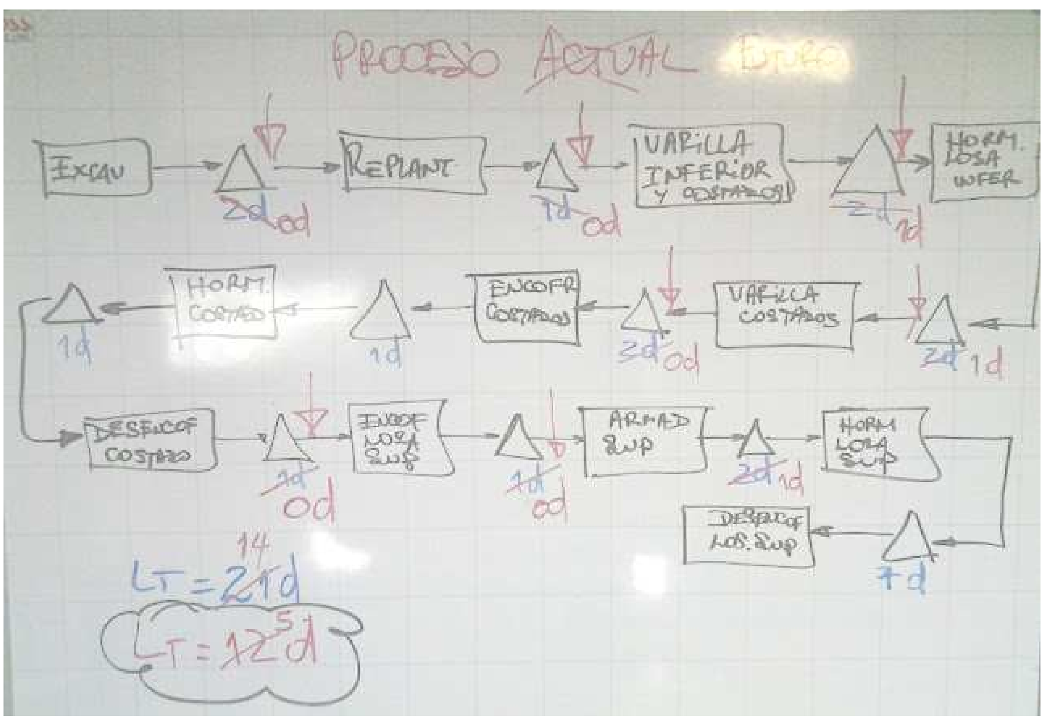


Figure 6: Future Value Stream Map

PRODUCTION CONTROL

The construction site established as a production control a series of charts to follow up the production of each task identified previously.

These charts are based on reach the goal of 49.5 m/week, this value was divided by 5.5 days worked per week and obtained a value of 9 m/day. This value represents the rhythm required for their production system (takt time).

This takt time was used by the superintendent for:

a) Design the production system, generating flow between different crews.
b) Give a daily goal for each crew, providing visual aids on site for show crews where they will be at the end of each day.

The figure 8 shows the follow up of the finalization of concrete duct on a daily based. In this chart is possible to see how the crews have to "fight" with the production to reach the goal.

At site construction office a planning and control panel was posted on a wall (see fig. 9). This control panel were used by crews, superintendent, and residents to draw their ideas and plan together the production activities. At the bottom of the control panel the current status is posted so everybody can see how well project is dealing with the production. Even more a button representing an andon system was placed at the upper zone of control panel and it would be placed, if required, over the sub-sector with troubles.

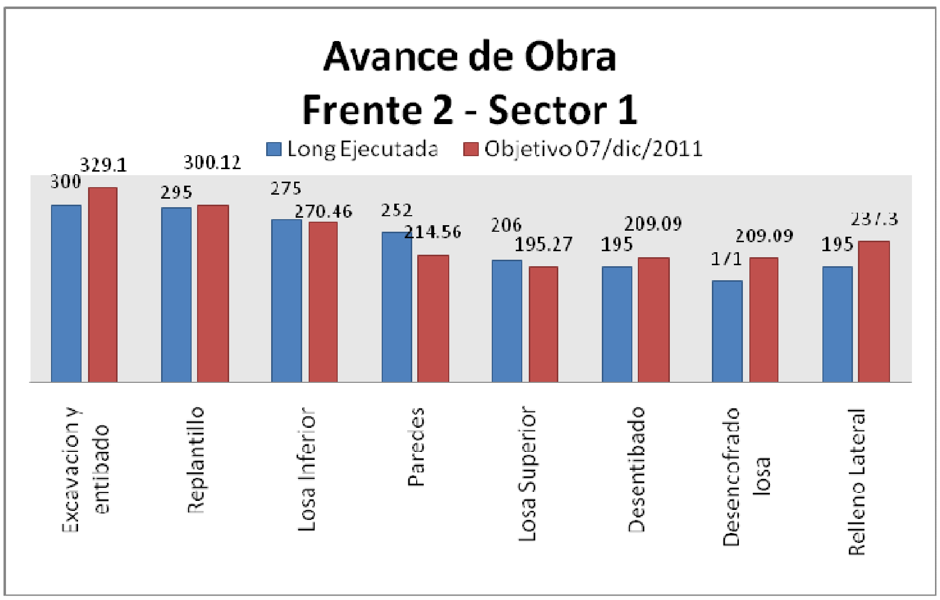


Figure 7: Status of project at 7th December 2011.

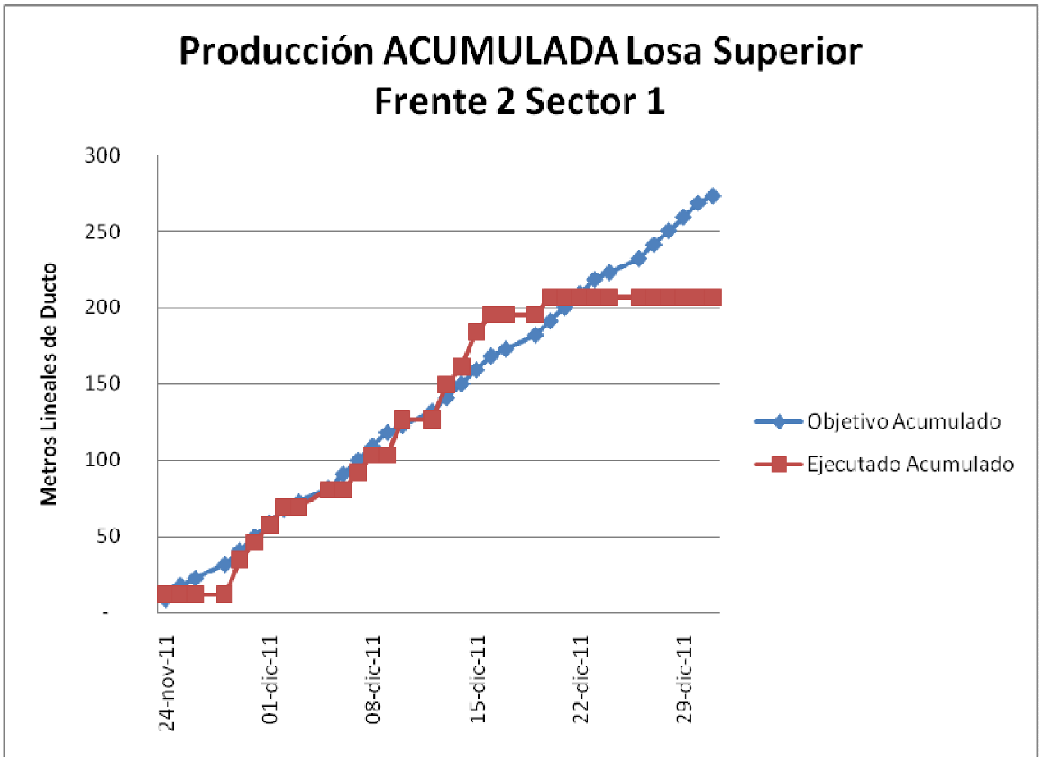


Figure 8: Control chart for concrete duct - top slab.

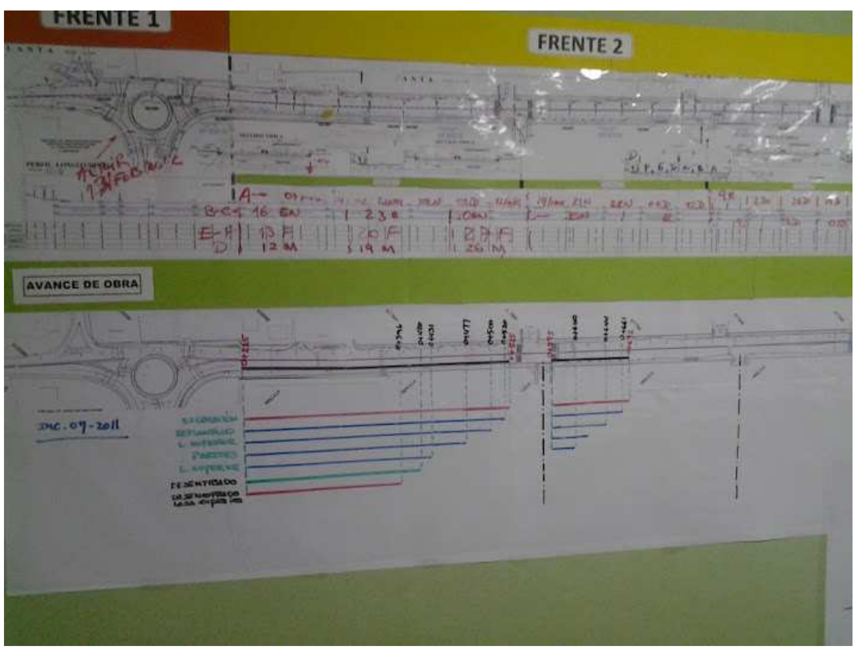


Figure 9: Plan and control panel.

CONCLUSIONS

It has been shown an alternative to find the takt time for a production system based on production rates and value stream maps.

Use takt time as a communication tool for translate project goals to production daily goals has shown be effective, because productions trends to be near to production plans (see figures 7 and 8).

Wastes like overproduction and wait, are much more evident when a production system is designed to achieve flow. Even more, buffers between tasks were designed and controlled on site.

Posted project drawings used as a plan and control panel is effective because people understand on a daily basis how the work is contributing to the main project goal.

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