EMPLOYING THE PRINCIPLE OF "GOING AND SEEING" TO CONSTRUCTION

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ABSTRACT

The paper describes the team's journey from learning about the main production problems to going and seeing in the field how to improve operations and plan reliability in a large laboratory project replacement in San Diego, CA. Analyzing root causes the team realized the two categories that reduced reliability were over-committing and revising the plan. The counter measures employed improved performance in these categories, which improved reliability of meeting scheduled commitments. However, unexpectedly cycle times for concrete wall pours increased. In order to solve the problem, the team employed the principle of "going and seeing" to gather relevant information to make informed decisions. The production line was observed for several hours a day, performance was measured, and barriers to flow were documented. The result of "going and seeing" brought the team closer to managing the project as a production line. The data collected provided insight to the contributing factors to production cycle times including wait time, inventory, and rework. Tools employed to track the data included value stream maps and employee feedback to inform project planning. This provided the necessary balance to complement the implementation of Last Planner on this hard bid federal project.

KEY WORDS

Go and see, Gemba, Last Planner System™, value stream map, laboratory building

INTRODUCTION

The paper describes a general contractor team's journey from learning about the main production problems to going and seeing in the field how to improve operations and plan reliability on a large laboratory project replacement in San Diego, CA. The result of "going and seeing" brought the team closer to managing the project as a production line. Just as Ohno walked the shop floor and discovered new ways to eliminate waste, the team now walks the field to find the waste and seek improvements. The data collected from "going and seeing" provided valuable insight to the contributing factors to production cycle times including, wait time, inventory, and rework. Without this study the team would not know where to improve.

The paper is organized into three main parts: a literature review on going and seeing and continuous improvement; the description of the case and the methods used to investigate production; and conclusions.

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GOING AND SEEING AND CONTINUOUS IMPROVEMENT

An integral part of the Toyota Production System (TPS) is the practice of going and seeing how the work happens at the shop floor level or in the field where operations are carried out (Ohno 1988). Ohno and Shingo constantly referred to instances when they were observing production or sent others to observe operations where they happened. The simple act of observing production tasks as they happen grants multiple insights that data collection and complex analysis cannot show. Shingo (1988) often dives into details when explaining how he and his teams went about studying a product or process and proposing new ways of doing tasks, all without losing sight of the production process as a whole.

Paying attention to minimal details and analysing (scientifically) how they impacted production were practices used by Frederick Taylor, Frank and Lillian Gilbreth, and Henry Ford. However, TPS engineers became famous for putting that into practice and making their organization extremely successful.

Gemba is the Japanese word for "actual place" (LEI 2008, p.25. The practice of going and seeing work practices on the shop floor gave origin to the term "*Gemba* walks" to represent the walks managers do to see production tasks where they happen. Managers who are familiar with Lean concepts often call their team members to go to the *Gemba* and see work practices for themselves.

The term going and seeing is recognized in the Lean Production literature as *Genchi Genbutsu*, which relates to the action of verifying data at the source through personal observation (LEI 2008). It is common to see in value stream maps (VSMs), the "go and see" symbol, illustrated by a pair of glasses, indicating that data has to be confirmed in the field through direct observation. VSMs are maps that show the sequence of tasks in a value stream using symbols that have been standardized and popularized by the Lean Enterprise Institute, based on the work developed at Toyota. VSMs depict data related to each activity (value-added, non-value added and supporting), while simultaneously illustrating the flows of material and information to deliver a product or service to the client (Rother and Shook 2003)

USING PLAN-DO-CHECK-ACT (PDCA) TO IMPROVE PRODUCTION

Going and seeing is one step toward the improvement of production processes. Other steps are related to how people organize and make sense of the data they collect, and how they implement and verify how the suggested changes affect production. Along these lines, the simple method illustrated by the PDCA cycle (Deming/Shewhart Cycle) provides a structured way to improve production through a series of structured observations, test, and documentations.

The Last Planner System of Production Control™ (LPS™) is an example of a system that uses the basic tenets of the PDCA cycle and the going and seeing principle to shield construction operations against uncertainty. The LPS™ relies on information provided by those close to production (the last planners) to define weekly work packages based on information coming directly from the field (Ballard and Howell 1998). The LPS™ follows the logic outlined by the PDCA cycle in that they promote continuous improvement cycles of planning, implementing, checking the solutions implemented, and acting to correct deviations (Figure 1). Another way to look at the PDCA cycle is to use the words employed by Toyota to represent a similar cycle namely plan, try, reflect, and standardize (LEI 2008). Defining the last step as “standardize” means that uniform ground rules are set based on the way operations are currently executed. The use of a standard allows results to be compared and deviations from plans to be quickly detected. Standardization also allows small continuous improvement activities (*kaizen*) to depart from a common ground (standard) which is used as a step to the next level (Figure 1).

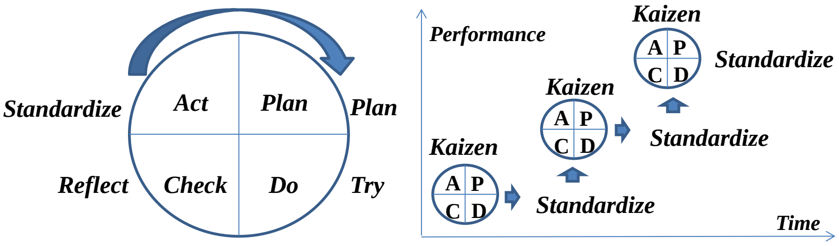


Figure 1 – PDCA cycle, standardization and *kaizen* (after LEI 2008)

THE PROJECT AND THE WORK METHODS

This section describes the project that provided the examples discussed and the work methods employed to carry out the studies presented in this paper.

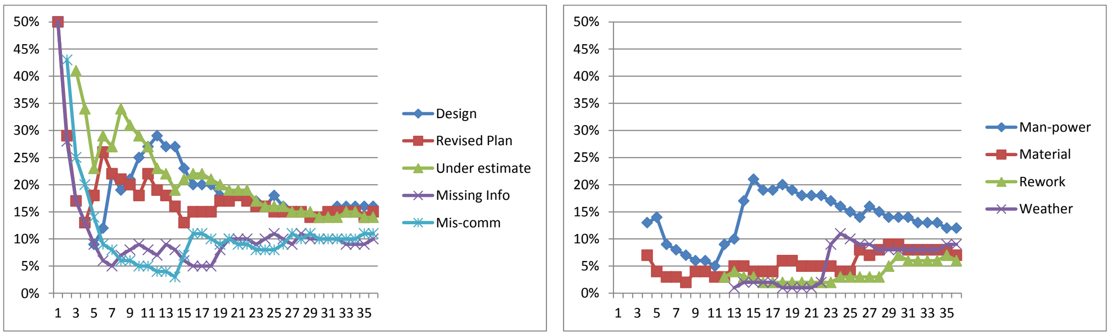
The new $60 million 287,000 square feet facility includes new parking, offices and laboratory areas. The project will include an extensive aquaria area, necropsy lab, biology labs, chemistry labs, Class 100 clean room and a new 1-million-liter seawater ocean technology development tank. The project is funded by the American Recovery and Reinvestment Act and is seeking LEED Gold certification. Although the procurement of the project included a best-value component that considered qualifications, the contract structure is a firm-fixed price based solely upon project solicitation instructions, plans and specifications.

WORK METHOD – GOING AND SEEING

The use of LPS™ was employed from the start of the project and was familiar to a good percentage of the project team management staff. However, LPS™ was a new process to the self-performed concrete personnel assigned to the project. Early on in the process two major factors were contributing to reducing reliability of the weekly work plans: over-committing and design changes. In order to address these factors the team employed two countermeasures to help address the causes of these problems, i.e., pre-planning meetings and constraint analysis.

To address the overcommitting, early on the team initiated a weekly concrete production pre-planning meeting to discuss activities for the week related to self-performed concrete. The intent of this meeting was to thoroughly analyze the plan for self-performed work and confirm the commitments that would be shared in the weekly subcontractor foremen planning meeting. This effort helped to increase reliability and affirm realistic commitments for the week. Collected data (Figure 2) suggest that this meeting helped to reduce the incidence of overcommitting as a problem that contributed to unreliable plans.

It was anticipated from the outset of the project that a contributing factor to reducing plan reliability would be the impact of design and constructability issues. Being a traditional design-bid-build project, there was no cross-functional team during the development of the design documents. As a result, a thorough constraint analysis effort was developed and employed as an integral part of the agenda during the Owner Architect Contractor (OAC) coordination meeting. Essentially, the constraint log functioned as a work plan for the Owner and the Design team outlining issues that required resolution in order to meet the scheduled dates. The constraint log was updated weekly and summarized a variety of constraint types in a concise one-page report. Moreover, the list was prioritized by importance and employed visual categorization to improve communication. Since this report was a "work plan" for the Design team and Owner, reliability was measured to track performance. Over a 16-week period the effectiveness of these countermeasures was demonstrated in downward trends in these two contributing factors and others related to miscommunication and misinformation (Figure 2a).



(a) (b)

Figure 2 – Root cause history tracking: (a) Causes showing a downward trend; (b) Other causes including manpower

Although improvement in planning reduced overcommitting, a counter trend reduced reliability: lack of manpower to meet planned commitments (Figure 2b). Initially, the manpower constraints were solely associated with the rebar subcontractor not meeting committed schedule dates. However, after getting down to the root cause that contributed to this situation it was determined that this was caused by concrete work not being completed as planned. Thus, the conclusion was that the self-performed concrete crew was not adequately staffed to meet production demand. Tracking the causes of problems allowed the team to observe how the changes implemented impacted production and how other problems surfaced and had to be addressed.

The process just described is along the lines of what Goldratt and Cox (1992) illustrate in the Theory of Constraints. Once a constraint (in this case a problem) has been identified and actions are taken to address it, a different constraint will surface elsewhere in the system and limit its ability to reach the goal. Accordingly, the team decided to investigate in more detail the new problem, which was related to field conditions and not to external causes (e.g., designer and owner tasks). A discussion of the team's efforts to address field related issues is presented in the following item.

EXAMPLES OF GOING AND SEEING

This section describes different instances in which the principle of going and seeing was used to actively manage production by the project's team.

Value Stream Mapping – Concrete Activity

The hesitancy to increase manpower levels was based upon the fact that original projections were being exceeded. This observation from the data being collected initiated the development of a new process and opportunity to integrate Lean principles to the construction practice: the team employed the practice of “genchi genbutsu” or going and seeing for themselves. Concurrently, the team also discussed the need to track concrete production at a greater level of detail. The concern over meeting production units and the contributing cause of lack of manpower created the “burning platform” that initiated the process to collect data for assessment. A collaborative meeting amongst the team generated the idea of value stream mapping the concrete activity (“go and see” production and record the results) (Figure 3).

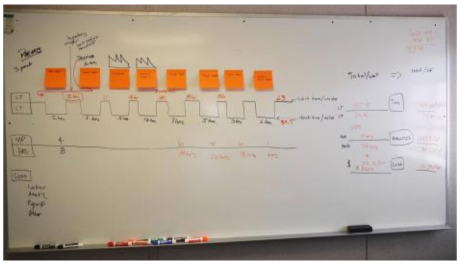


Figure 3 – Value stream map - concrete

The results of production were recorded on a VSM that measured the overall cycle time for the activity and the hours spent on the activity compared with the project estimate. The cycle time for the concrete activity was measured similarly to what is shown on a VSM and differentiated the “value” or touch time on the activity versus the “waste” or wait time incurred to complete the step. Moreover, the consistent performance observation (Figure 4) provided valuable feedback from field personnel to foster a continuous improvement environment on the project.

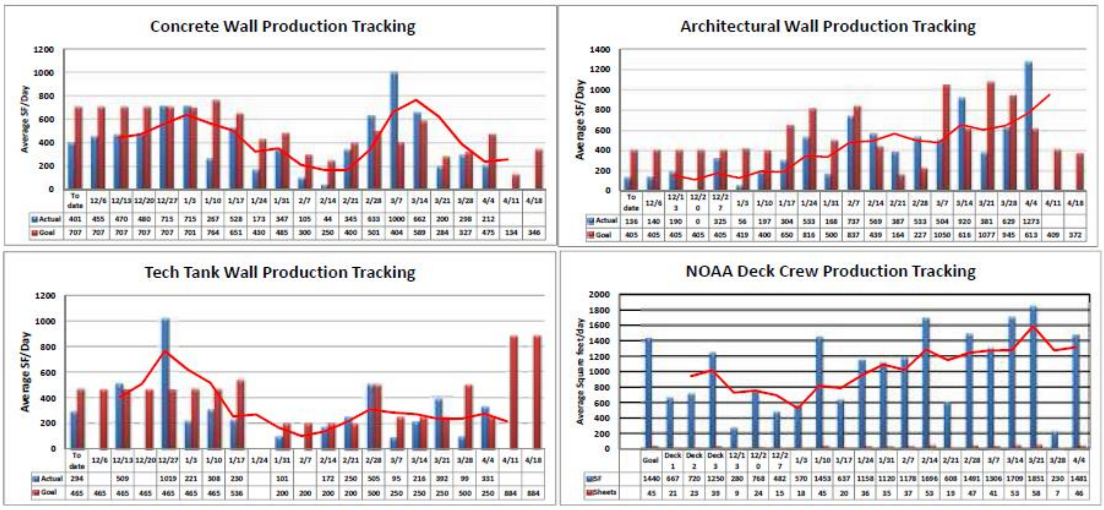


Figure 4 – Production tracking (Avg SF/day: actual|left bars vs. goal|right bars)

The graphs shown in Figure 4 illustrate the evolution of the production indicator in average SF/day since December 2010. The production goal is indicated by the right bars versus the actual production. The analysis of the indicators for the “concrete wall production” and the “tank wall production” still indicate much variation in actual vs. goal. The indicators for “wall production” and “deck crew production” revealed a trend of improvement (increase in average of SF/day delivered); however, most of the time they still lag behind the desired output.

The process was not employed during the first two deck pours. The team discovered that for the wall crews the demand fluctuates on a weekly basis based upon the available work. Over time the team began to get closer to (or exceed) the production goals and were able to forecast the future demand and better assess manpower assignments between the crews. The performance observation was conducted multiple times throughout the day to provide thorough knowledge of events occurring on the project and resulted in some benefits. First there was an acute awareness of the impacts of constraints on productivity. This facilitated a more accurate understanding of the priority of outstanding constraints and a more intimate knowledge of the details to communicate the importance of resolution to the team. Second, the time in the field afforded the ability to perform daily validation of the weekly plan. Moreover, it helped to temper frustration that often is felt by field personnel when changes occur by having the perspective and purpose that generated the changes articulated. The communication of this information helped to deter discouragement and maintain morale in the field. Workers are honest when asked about the process and are willing to actively participate in the definition of the plans and the improvement of the processes. Talking to workers enhances one's ability to manage the project as they like to make a difference by giving inputs.

SEEKING TO DEFINE TAKT TIME

After observing production for several weeks it was evident that additional manpower was needed for the self-performed concrete crew. The team struggled to develop an objective way to determine adequate manpower levels for the various crews on the project. The concept of *takt* time was considered, however the way to apply this principle to self-performed concrete had to be developed. Leading indicators on production rates were assessed based on the collected data. The production quantities were evaluated for current state *takt* time, which analyzed contact square feet of wall installed/per man/per day. Although there remained some variation in this metric based on the skills of individual craftsman, it provided a starting place for adequately planning proper manpower for form crews.

The metric was then applied to future demand based upon the weekly work plan and helped to plan concrete production needs throughout the week. The formwork demand for the deck crews stayed relatively constant on a weekly basis, so a weekly square footage goal was established and measured (Figure 5).

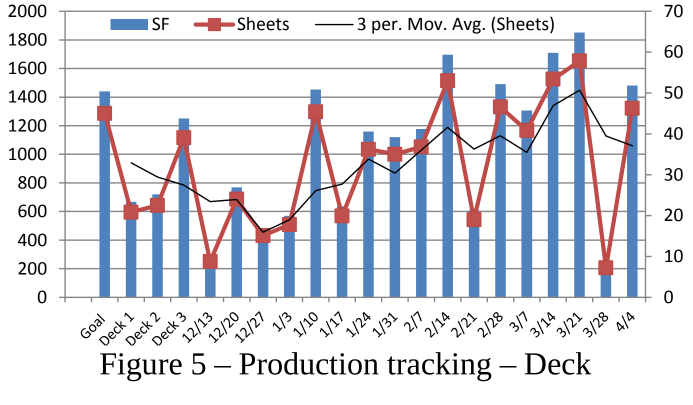


Figure 5 – Production tracking – Deck

This square footage goal was then converted to sheets of plywood needed on average per day, which allowed a tangible metric to help the crew determine whether they had a good day or not. As shown in figure 5, the process of communicating expectations coupled with implementation of LPS demonstrated a production improvement.

Due to the building geometry and differing beam depths between levels, each deck pour had its own unique characteristics. Thus, it would not be appropriate to attribute the improvements solely to the learning curve. Moreover, the Level 3 suspended deck included the setting of anchor bolt templates to receive structural steel columns for the upper levels. The construction of these decks were tracked from 2/28 – 3/21, which incidentally were the best performing weeks. The dips in production (1/17, 2/21, 3/28) were caused by lack of available work to meet demand. Essentially, these weeks followed large deck pours where available work had to be made ready before proceeding with full production. During these weeks the crews would be assigned to other tasks such as stripping or concrete columns. During the week of 3/7 a challenge related to design changes impacted production and is discussed later in this paper.

The application of *takt* time to the wall form work crews proved to be a bit more challenging. The metric of average contact square feet set per day on a weekly basis was the same, however shortly after implementing this metric it was recognized that the demand fluctuated on a weekly basis due to available work and work completed the previous week. As a result the process had to be adapted to account for this fluctuation, which required complementing the lookahead planning process by adding a demand component. This allowed the concrete foreman to manage and plan crew levels more accurately. Moreover, it facilitated a more informed commitment to weekly work plan activities.

At the outset of implementing *takt* time to manage the concrete production process, the team assumed that it would provide a necessary balance to the implementation of LPS™. The metric motivated foremen who truly wanted to understand their expectations and plan manpower levels more effectively. It also challenged the foreman to seek ways to achieve production goals in light of the inherent challenges on the project. The most notable challenges were demand for crane time, site logistics due to limited laydown area, and continuous revisions to the design. The visual tool helped the management team to measure and document progress on the site. During daily production observation walks, quantity of formwork set was documented. These walks also presented opportunities for interaction with field personnel to discuss opportunities to increase weekly production and identify constraints hampering production.

BALANCING THE LINE AND SETTING REAL EXPECTATIONS TO THE CREW

The development of a more structured process to track productivity in the field alleviated the emphasis of cycle time as a driving metric and led to a more balanced approach to determining success. Essentially, the team realized that in certain instances a prolonged cycle time could improve reliability of workflow on the project and still allow production goals to be met. This is illustrated in e figure 6.

Although cycle time for the individual wall pour was increased by proceeding with the architectural starter walls prior to the deck pour, it allowed gang panels to be set the day of the deck pour reducing the overall combined cycle time for these activities by 4 days. A similar condition took place with the level 3 elevator 1 wall pour as summarized in the following two options.

1. Window sills formed and placed prior to deck. Handset forms used to reduce demand on crane.
2. Wall panels set to help production goals and create workable backlog for rebar subcontractor. (Elevator 1)
3. Since window sills were poured prior to the deck, wall panels were set the same day as the deck pour.
4. Forms ready to be closed and pour the next day after deck pour. (Elevator 1)

Figure 6: Field operations – Understanding formwork cycle times

Option 1: It was more cost effective to place walls after the deck below was placed. This would avoid the need for an added block for the close up panel to account for the slab thickness. Thus, to reduce cycle times on the process the initial setting of one side panels would be deferred until the deck was poured.

Option 2: There were some benefits, however, to setting the one side panels in this situation. The need for a deck edge form was eliminated, which saved time and additional labor. Moreover, it provided additional available backlog for the rebar subcontractor to complete if other planned activities were unavailable. It also provided additional contact square footage during the week to improve production units.

In this scenario, the latter option (2) was implemented and the work associated with the level 3 elevator 1 wall pour was completed as fill in work for the rebar and electrical subcontractor. It then opened up additional opportunities for portions of the wall to be closed with forms that were not dependent on the deck pour. This improved production units for the week and helped to reduce the combined cycle time between the wall and deck pours. The deck was placed and the walls were able to be placed 2 days after the deck pour, which was a reduction of about 5-7 days if the former option were to be employed. Another benefit was the improved workflow on a congested site, where down time waiting on the crane was a major impediment.

The events described were made possible by the implementation of "going and seeing" and were the result of several conversations with the general foreman and foremen from the deck and wall crew. The general foreman also advocated an integral aspect that improved the balancing of work flow in a production setting. Although the various crews specialized on certain aspects of the concrete scope of work, they were not treated as competing silos on the project. Based on the production demand during the week, crews were mixed or supplemented with personnel from other crews to ensure achievement of goals. This assisted in improving collaboration amongst the various crews and reduced the tendency of counterproductive rivalries.

This practice was also an example of balancing the production line between work stations based on *takt* time. The expectations were discussed during weekly production meetings and commitments were made based upon available resources and available work. The foremen then organized the crew levels in order to meet commitments and demand for the week. This collaborative process was continuously refined by the "go and see" procedure and produced a fairly high weekly average PPC (reliability) of 77% that has improved over time (Figure 7).

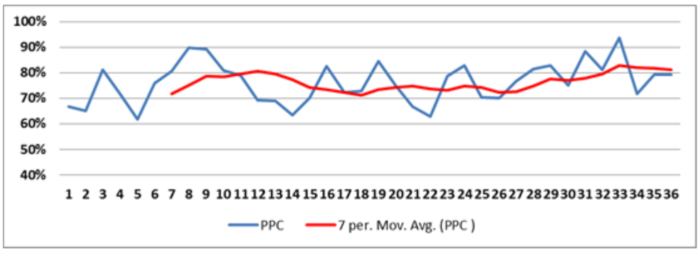


Figure 7: Percent Plan Complete (PPC) evolution

Figure 8 – Reviewing RFI with structural engineer

THE STRUCTURAL DESIGN AND THE REALITY IN THE FIELD

The completion of Level 3 cast-in-place concrete was a major milestone for the project, which paved the way for the setting of structure steel for upper levels. In the midst of this challenge a significant design change impacted progress by approximately two weeks. It had to do with the coordination of concrete beam depths and widths at steel anchor bolt locations. Due to the complex geometry of the project, it was difficult to ascertain these conflicts on two-dimensional plans. As a result, the team built in some schedule contingency to review these potential conditions.

In order to allow production to continue the team decided to form beam sides wider and deeper to provide flexibility to coordinate anchor bolt template embedments that occurred on angled gridlines. In the event that dimensions needed to be adjusted the forms could be "padded" or filled in accordingly. This allowed time for layout of actual anchor bolt templates to occur, conflicts to be discovered, and resolutions to be proposed without schedule impact. An RFI was written approximately two weeks prior to this action; however the final response took some time to be provided due to the complexity of the issue. Ultimately, in order to resolve the issue the structural engineer's local office was sent out to review conditions and provide a response to the Kansas City office (figure 8).

After reviewing the conditions in the field, the response was received as anticipated in all aspects except for one issue. The unexpected item included the lowering of an intermediate structural beam which had already been built per the original plans. The implementation of this direction would have had a severe impact on the project, so the engineer was contacted. After getting to the reason for this change it was discovered that it came from a reviewer in the Kansas City office who was only trying to help make construction of the beam easier by making it level with an intersecting girder. The team clarified that both the beam and the girder had been constructed and that the question was only regarding concrete coverage of steel anchor bolt template. Since there was no other structural value for the change, the beam elevation in question was restored to the original contract documents.

OBSERVING THE PROCESSES AND STOPPING THE LINE

The "go and see" process also assisted a manager in identifying undisclosed problems that impacted production in the field, in many instances these problems would go unnoticed. Take for instance, a problem that was discovered during the "go and see" process where the installation of rebar manifested a problem that would have been unknown. In reviewing job progress it was noted that a critical wall pour (1-line), had been set 5 days prior and rebar installation was still incomplete. Nonetheless, rebar installation had proceeded in other non-critical areas that were designated as workable backlog (Elevator 2 and L3Q1 wall pour 5 at Y.3 line). After discovering the problem the foreman for the rebar subcontractor was sought out for additional information. He indicated to the team that a mistake by detailing had occurred and they had missed the corbel in the wall. The steel would ultimately arrive four days after the expected date.

This information helped to adjust manpower levels to accommodate the critical missed commitment. The crews were then reassigned to complete wall panels in future areas to reduce overall cycle time for upcoming wall pours. A limited crew remained to complete the 1-line wall close up panels. This adjustment afforded the crew to complete other critical wall pours a week ahead of anticipated completion. This allowed the extra week to be used for breakdown of rented panel material in much needed laydown area prior to the installation of structural steel.

CONCLUSIONS

This paper presented examples from a project that used the principle of going and seeing to continuously improve production and increase the reliability of weekly work plans. The team managed production using real time data collected directly from field observations and feedback from workers, and used it make adjustments every week. Metrics collected by the project team indicate that the team's efforts have in fact improved their performance and that the use of the LPS™ and continuous cycles of timely data collection, analysis, and the implementation of improvement actions have helped the team to focus on processes (e.g., constraint removal) and tasks (e.g., design/configuration of concrete operations) that needed to be improved.

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