# LAST PLANNER, LOOK AHEAD, PPC: A DRIVER TO THE SITE OPERATIONS

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## ABSTRACT

The paper describes the experience of a civil engineering company of a small town in São Paulo State of introducing a model of production management in sites based on the concepts of Lean Construction. It presents the concept outlining of the model and reviews the practical results obtained in the construction of a library in the city of Campinas during the period of 18 months.

## KEY WORDS

Production management; civil engineering; information flow

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## INTRODUCTION

The problems faced by the sector of civil engineering are already known. There have been efforts in searching for new techniques and tools that can guarantee organizational competitiveness in the long run, through the systematic decrease of losses and wastefulness, improvement of the product quality and improvement of the environmental and safety conditions (Koskela 1992).

In this context, the competitive differentiation among the companies that act in the sector of civil engineering can be characterized not only by the simple application of these new techniques and tools, but also through the way they define the process of decision taking, based on the qualification and compromising of the working teams and in the agility and exactness of the information systems. The ability to manage uncertainty and the resulting conflicts during the production processes management generally guarantee the optimization of the results for each enterprise.

Kahkonen (1994) defines three different approaches of production management:

- the traditional model of production management, in which each activity must be individually analyzed and is based on the conversion of input into end product;
- the model based on quality improvement, aiming the decrease of Non-Quality costs and improvement of the Perceived Quality by the client;
- the model based on Lean Production, in which the objective is to decrease those activities that do not aggregate value to the product and that improve the efficiency of the process;

The traditional approach fails because it does not act over the difficulties related to input flowing and also over the management of activities that normally do not aggregate value to the product, such as: transportation, waiting and inspection.

The higher the aggressiveness in the control of the individual cost for each activity, the lower the focus on the impact of this activity over the global result. Moreover, the specialization inherent to the hierarchic organizational model increases the number of activities that do not aggregate value. If we consider that the implementation of new technologies normally demands more specialists, the company runs higher risks of loosing the control or of swelling rather than growing.

The adoption of a new model of production management in the sector of civil engineering based on Lean Production, and named Lean Construction, searches the analysis of all conversion processes associated to activities of logistics characterizing each execution step. The approach based on value analysis guarantees not only the decrease of the cost of Non-Quality and the improvement of the efficiency of the processes, but also aims the decrease or elimination of all activities that do not aggregate value to the product.

An important difference between the traditional and the new model based on Lean Production must be observed: the adoption of Lean Construction implies a new organizational outlining, in which decision making is brought to the operational levels of the company. Agility is gained to guarantee the quality and efficacy of each service and, on the other hand, the whole organization must adapt itself to a new reality in which the

learning process occurs day by day, through the study and analysis of errors performed in all hierarchic levels involved.

Maybe this is the great difficulty that civil engineering companies face when adopting a new model of management:

> "It is easy to contract the purchase of something, and it is more difficult to contract behavior standards. In civil engineering, the focus is on the contract, and the enterprises fail due to the lack of team work—a behavior component."
> (Howell and Ballard 1994)

The objective of this paper is to report the process of implementing a model of production management based on the concepts of Lean Construction, applied to a civil engineering company that acts both in the area of general building and also of industrial building.

## CONSTRUTORA REYNOLD AND ITS PILOT PROJECT: THE CONSTRUCTION OF A LIBRARY IN CAMPINAS

Construtora Reynold is located in Piracicaba, 160 km from São Paulo, and has been acting in the market of civil engineering for the last 30 years. Systematically, Construtora Reynold seeks to optimize its operational performance by improving the quality of its products in relation to market requirements and also by reducing its production costs, resulting in lower prices for sale and stabilization of the profit margin.

Its organization comprises the functional areas of Projects, Budget and Planning, Supply and Execution of Building, integrating its fixed team of professionals, a fact that constitutes a powerful competition weapon because, due to the structure adopted, the company has conditions of administering most uncertainties related to each enterprise within its domain.

In April 1997, a project aiming the implementation of a system to follow up and control constructions based on the concepts related to Lean Construction was launched. To do so, the construction of a library in the city of Campinas, foreseen to be ready within 18 months (scheduled to August/98) was adopted as the pilot project.

This choice was due to the special characteristics of the project and construction presented, as well an opportunity of implementing new routines together with a lean and compromised administrative team (an engineer, a foreman, a trainee and a quantity surveyor).

## CONCEPTUAL BASIS AND PRACTICAL APPLICATION

A good construction project is one that is executed according to the plans! And a good plan is the one that:

- foresees the correct sequence of activities;
- foresees the correct quantity of services;
- guarantees that the planned job can be effectively accomplished.

Considering the uncertainty that is inherent to the productive process, a strong characteristic of the productive sector of civil engineering, more important than to plan a construction is to have agility and competence to re-plan and re-program the sequence of jobs.

The sentences above represent a great difficulty, or even an utopia, to those companies that currently have as basic operational characteristics:

- not discussing the operational characteristics of the construction BEFORE the beginning, without analyzing errors of the project, such as interference, etc.;
- not discussing the technical specifications of each input per service related to the construction without analyzing occasional improvements of the process, or even new engineering solutions;
- budgeting made by third parties, in which the figures are based on unit price compositions that do not correspond to the culture of the company, not even to the operational characteristics of the construction;
- not performing a reliable survey of quantities, becoming liable to errors that can even make the construction unfeasible;
- not planning the strategies for contracting services and products, preventing that in practice effective partnerships between the company and main suppliers occur.

The successful implementation of a model of management based on Lean Construction occurs with the stabilization of the operational environment of the enterprise, which is reached through the decrease of variability of input and improvement of the performance of subsequent activities (Howell and Ballard 1994-a, 1994-b, 1994-c)

The decreased variability of input is a function of the quality of the recourses used and of the agility in the processes of re-planning and re-programming services. On the other hand, the improvement of the performance of subsequent activities becomes viable as the working team accomplishes potential gains during the execution of the services, decreasing the global term of the enterprise without implying increased costs or decreased quality of the end product.

Thus, a new model of production management must be defined as from the simultaneous execution of two jobs. The first is related to the projects of the specific construction, considering the integration of Project, Planning and Execution teams, aiming the clear and objective definition on:

- executive processes to be used in each front;
- materials to be applied in each step of the job;
- studies of occasional interference between design or alternative solutions;
- definition of the strategies for negotiating with service or materials suppliers (elevators, air conditioning, painting, etc.)

The second job is the execution of the Executive Planning of the Enterprise, exactly defining:

- each composition of unit prices, including a discussion on consumption rates to be used for each input;
- quantity survey for each service to be executed;
- assessment of the inputs and policies for contracting labor and services;

- physical arrangement of the site in every step of the construction;
- budget spreadsheets;
- programming of the services in the site.

Although all functional areas related to an enterprise (Project, Budgeting, Planning and Execution, Supply and Execution) actively participate in this process, the responsible engineer must control the sequence of jobs and the quality of the final results. His participation must engage the foreman in charge of the enterprise, considering his important participation in the development of the services, as will be demonstrated later.

After the first phase is finished, the control of the development begins, which is characterized by the following functions:

- weekly preparation of a medium-term schedule (Lookahead), with the objective of allowing that the future activities can be seen, anticipating occasional needs and reducing the chances of surprises or changing of direction without previous plans. In general, the Lookahead covers the two following weeks with daily details, and the six subsequent weeks without details, because uncertainty is increased when the plans are detailed for this term;
- elaboration of a weekly working plan (Daily Plan), based on Lookahead, which foresees each service front to be executed during the following week, precisely defining recourse needs (labor, equipment, tools, operational pre-requisites, etc.) so that each one can be executed without problems;
- appointment of the data, aiming the survey of consumption and use of inputs in the site, per activity, during the period of analysis;
- generation of position reports of the site, that allow to visualize current situation of the site and its strong and weak points.

The engineer must assume the responsibility for discussing the Lookahead and Daily Plan with the foreman.

Each week, based on the results of the effectively executed jobs, it is possible to estimate the PPC (Percentage between Planned and really Concluded), which is a performance indicative of the rate between the number of effectively executed activities and the number of activities programmed for the period.

Decreased uncertainty during the execution of the construction occurs with the stabilization of the operational environment. The first step for the occurrence of this fact is the decreased variability of entrance and so, the construction must always aim PPC equal to 1.00, which means that what had been programmed was effectively executed.

The new function of the foreman is clearly perceived here: he becomes responsible for allocating the recourses (machinery and personnel) to the jobs, to guarantee the execution of all services foreseen in the Daily Plan. The engineer must assume the responsibility of administering the enterprise as a whole, guaranteeing the necessary logistic support, so that the foreman is able to succeed in his mission.

The frequency of the control of development is determined for each case, but it is recommended that it not exceed a fortnight for each result analysis. The main reports must show current physical position of the construction and also in terms of costs, with the objective of allowing the analysis of the possible reasons of observed operational

deviations and the correction of these deviations and their respective impact, within the shorter period of time.

The step dedicated to follow up the development presents a cyclic behavior, and must be continuously repeated until the end of the services. Whenever it is necessary, observed results must feedback the routines of budgeting and planning of the construction in order to consolidate the culture acquired by the company, represented by the calculation of the real consumption rates for each activity executed in the site.

## PRACTICAL APPLICATION IN THE SITE

The main focuses of the strategy adopted in this enterprise were:

- to drastically decrease the uncertainty related to projects and technical specifications;
- to drastically decrease the uncertainty related to the executive planning of the construction;
- to guarantee the complete control of the information related to the construction to the site engineer;
- to create conditions for the persons involved (both in the central office and in the site) to be compromised with the goals;
- to create conditions for the agile and simple management of the construction, giving immediate subsidies for a repositioning in each period of control;
- to allow that the actions of repositioning are planned and executed by the personnel of the construction.

Thus, the decision of creating an activity dedicated to the logistic support of the activities of the site, responsible for guaranteeing the feed of all front of services in the site and for cleaning and organizing the physical facilities was taken on Phase I – Executive Planning of the Construction.

The team associated to this function was formed by all laborers normally allocated together with the craftsman in the unit price compositions for each activity. That is, as from the beginning of the construction, unit price compositions do not have the laborers that are normally associated to the tradesman responsible by the execution of each service. The laborers in the site (in this case, 12 helpers per month) were allocated to the foreman, who had the task of coordinating the activities of the team, aiming to keep the working flow continuous and the operational areas clean and organized.

It must be noted that the amount destined to laborers represented approximately 6% of the global price of the enterprise.

The survey of the quantities was developed considering the quality of the generated information, being that all calculation memories were available to the site through printed reports and Excel spreadsheets (MS Office). Therefore, the site would not have to execute new surveys during the execution of the services, a fact that would liberate time for the engineer and his team to effectively execute their jobs.

A detailed CPM net was elaborated, dividing the site into sectors, with the objective of glancing the scheduled date for ending the work. The most important part of this work was not the estimate dates, based on the extent of the activities calculated according to productivity rates that were simply estimated by the technical team, but the detailed

definition of the attack plan for each step of services. At this moment, the construction engineer, together with the team, identified several difficulties in the execution that in general are considered to be secondary but that sensitively compromise the normal development of the work.

The site received four documents that summarize its Executive Planning:

- projects, descriptive memorials and technical specifications;
- register of calculation memories and survey of quantities;
- budget spreadsheets and compositions of unit prices;
- schedule of activities.

The construction schedule is composed by a table with the dates foreseen for beginning and ending each front of service, being that this strategy defined that every week, after physically measuring the services, CPM net would be reviewed, both in terms of the physical progression and of occasional corrections of precedence relations. Thus, every week, the construction engineer and the foreman counted with precise information on the next activities to be executed, considerably improving the quality of Lookahead and Daily Plans.

It was never necessary to place enormous graphics in the walls of the office of the site, being that the spreadsheet that resulted from the previous week was the basis for executing the physical measurement of the current week. Routine became really simple and agile.

The physical arrangement of the site was developed aiming flexibility for receiving materials and agility for transporting and handling these materials. Considering the low volume of stock in the site, resulting from a systematic update of the Lookahead and Daily Plan, the areas destined to store materials were not big.

The appointment of materials was defined as a responsibility of the quantity surveyor in the site, making daily consolidations of all requisitions of materials separated according to the activity. In the case of disperse materials, such as sand, specific forms were developed to control the consumption as a function of other activities, such as, control of mass production. In the case of ceramic bricks, considering the quality of the survey of quantities and the memories of calculation, the foreman already had the approximate consumption per front of service, unloading the trucks into piles near to the areas in which they would be consumed.

Appointment of labor became a responsibility of the foreman, with the support of an experienced storekeeper. As the activities do not have laborers to be appointed, the appointment of each service is restricted to the tradesman who permit a good quality of the generated data because their service do not change. All results of labor appointment is calculated on a daily basis and inserted into a computer located in the site.

Appointment of contractors followed the conventional model of measuring calculations, and whenever it was necessary, the team executed a survey on their productivity considering the comparison with the rates of their own teams or those previously adopted for other budgets. Considering the fact that the laborers of the company gave the logistic support, a strategy for negotiating with some contractors was defined, in which the laborers were supplied by the company. The result, besides of a subsequent decrease in the number of persons in the site, was a decrease of the cost

negotiated with the contractors because they would not have to contract laborers and could maintain their profit margin.

With the variability of entrance under control, it is possible today that the construction engineer and the foreman search for better solutions for the processes of the subsequent activities, a fact that did not occur in a systematic way in other constructions in the past.

Thus, every Thursday, a physical measurement of the construction is made, updating the CPM net (precedence and executed percentage), obtaining a new date for finishing. Based on this new net, PPC is calculated on Friday, when the Lookahead and Daily Plan for the following week are defined.

Every Monday, the appointment reports are consolidated and the reports of position are generated and discussed together with the team (engineer, foreman, trainee and storekeeper) and sent to the head-office for analysis and information.

The flow is continuous and the learning process is encouraged at every moment. In this site, initiative and vision become to have similar weight in the search for better operational results for the company and better quality of living for the collaborating teams.

## CONCLUSIONS

The project finished at the beginning of August and it can be clearly perceived that the company has changed its management model and advances to the stabilization and consolidation of this new culture in current constructions.

The most difficult steps were those related to the implementation of the new information system, linking the areas of supply, execution and integrated financial control.

Coordination meetings evolving the Design, Planning and Execution, Supply and Commercial areas are frequent (weekly, in general), when specific procedures are defined in each meeting, for instance: recently, the commercial area included in the sales strategy the need of time to adequately develop the design and to plan the construction well in advance before the services begin.

The changes were well accepted by the team at the site, and it is possible to hear from the construction engineering and foreman expressions that demonstrate this acceptance, such as: “Today we could see the construction beforehand!”, “Fire has decreased!”, “I’m worried about being calm!”

During the job, a work related to the Japanese model Novos 5S, introduced in Brazil in 1994 by Prof. Kenji Nakata, Japanese Consultant, was introduced in the site. Currently, at the end of each service the tradesman cleans his area, and at the end of each day, the laborers perform a procedure for cleaning and organizing the site.

The construction engineer and his team attend courses to improve the knowledge of computing tools available in their computer. The foreman participates of seminars outside the company. A meeting of the technical teams of all sites are being used to discuss advancements and disseminate knowledge. Speeches on Work Safety and Hygiene are part of the routine and the use of safety equipment is common in the site.

According to the operational point of view, we could perceive the following advancements:

- the date scheduled for finishing the construction (initially August 12$^{th}$ 1998) was achieved, although the various changes in designs, due to client decisions;

- as from the beginning, the average number of laborers in the activity of logistic support is stabilized in seven, increasing to 11 at the end of the project. If we consider the fact that calculations were 12 laborers per month, a great rationalization of the work was achieved, besides approximately 42% of cost decrease in relation to the plan;
- evolution of PPC shows rates close to 1.00, being that most problems observed for the non-execution of the activities of the Daily Plan were design changes made by the client, and some projects of third parties that were delayed. In the practice, this construction had not the execution of services interrupted because of lack of materials or equipment;
- purchase of materials and service contracting presented a better performance because of the consistency of terms and technical specifications, resulting in lower prices. In the case of the bricklayer, a decrease of 23% per square meter was obtained. The adoption of strategies for the development of suppliers aiming future partnerships is under study;
- the project didn't presented budget overruns, being under control during all the site operations;
- the client is satisfied with the development of the work, being that with the liberation of the time of the technical team of the construction, the level of service associated to the quality of the service allows the execution of extra-contractual services within a short period of time, which will not impair the development of the work as a whole.
- the strategic next stage is to reach the real productivity indicators for each task at the site, providing a strong competitive weapon, due to better cost estimates;

The production teams and the board of directors of the company are confident in the improvements projected for the near future, a fact that supports the continuity of the several works that will be executed.