PREPLANNING: A REWARDING EXPERIENCE

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Abstract
This paper describes the methodology and results obtained after productivity improvement work conducted on two consecutive building construction jobs. The first one was used to evaluate production rates and productivity, current construction methods, potentials and lacks of construction equipment, current construction planning methodology, and existing tools to asses productivity. These are briefly discussed in this paper. The second job was preplanned based on the experience and detailed documentation obtained in the first one. Work was conducted in order to "design" construction methods in detail, develop a detailed production planning based on the construction methods developed, select crew components and select their specific tasks, and design communication and control tools. Although the second job's schedule and budget were originally calculated using standard methods (i.e. historical production rates), new schedule and budget were calculated based on the preplanning effort. Construction performance was measured against these values.

Keywords: preplanning, construction performance, productivity

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INTRODUCTION

In the broadest sense, preplanning for on-site construction provides the thinking, arranges for the necessary elements, establishes requirements, and develops the operating rules for all that happens at the work face (Oglesby et al 1989). This paper describes an application case, in which it was decided to undertake formal preplanning to the highest extent feasible. Productivity improvement work started during the construction of 560 low income apartments in Santiago, Chile. Many significant optimization measures were taken at that moment. However, as it always happens, it was envisioned that several high impact improvement measures were tightened to the original design, and to the original planning (available equipment, crews, on-site organization, etc.). Therefore, the preplanning program was developed in order to obtain the maximum benefits from the firm's next construction job. Therefore, preplanning was conducted for a 240 low income apartments project. This project, although smaller, was very similar in many respects to the previous one. Preplanning was undertaken, covering the greatest detail possible. The second construction project is currently under construction. Preplanning has worked quite well, producing significant savings to the construction firm.

INITIAL PRODUCTIVITY IMPROVEMENT PROGRAM

Productivity measurements were performed as recommended by Serpell (1993) and Oglesby et al (1989). Besides the productivity measurements, detailed construction methods information was obtained. In this regard, each crew was categorized by: crew components; tools and equipment; clients and servers; materials; final product; detailed construction method description; productivity; general observations, and recommendations. This information was fundamental when restructuring the current construction methods in order to rationalize the work being done. Additionally, field measurements gave the field engineers a tool to argue with the foremen (who supported that there were no oversized crews) using more than their common sense (i.e. numerical results that proved their point of view). Field engineers proved the saying: "Whatever gets measured, gets improved".

CONSTRUCTABILITY

Basic constructability principles were applied during the architectural and design phases. The construction firm worked closely with the architectural and engineering firms. The experience developed in the previous project was used to optimize every single negative aspect found in job 2. In that sense, the productivity improvement effort conducted helped to collect a lesson learned file, which was used in this project. The apartments were modularized to conform to the construction technology selected for the project. All the apartment dimensions fit with the formwork, the tiles, the artifacts, etc. On the other hand, the equipment such as cranes, concrete plant, etc., were selected in order to match among each other, and the crews were designed in order to comply with the rest of the construction scheme.

CPM VS. ALL ACTIVITIES CRITICAL

Most construction projects are developed based on some sort of critical path planning method (CPM). Although there are numerous benefits associated with this method, its foundation is to find the path which is critical. The schedule is developed based on this premise. However, the fact of having a "critical path" is directly related to having several non critical ones (paths with certain degree of waste). This means that the CPM significantly diverts from lean construction philosophy, because it is founded on planning construction wastes which are willingly introduced into the project schedule and budget.

On the other hand, repetitive (rhythmic) projects allow working with rhythmic planning. In this case, in order to find the optimum use of resources, a different type of planning is typically used. Crews and equipment are designed to yield the same production rate, in terms of construction units (i.e. one floor/day, one apartment/day, etc.). If activities are planned to be built in this way, all activities could become critical. In this regard (at least in a theoretical level), no wastes are willingly planned or introduced into the schedule. This planning scheme fits much closer to the lean construction philosophy. Nevertheless, most construction projects (even simple building construction projects) are not repetitive ones. Thus, it might be thought that the “all activities critical” planning (ACP) might not be applicable. This is not true, however, for most of the construction projects. In fact, when planning is based in construction units and production velocities, fairly repetitive construction subdivisions can be developed in non-repetitive projects. In this case the schedule is developed based on the production velocity, in such a way to generate the same work rhythm for all the involved crews. The number of optimum crews is selected so that all crews will perform the same amount of construction units in the same period of time. It shall be considered when the actual volume has to be divided into more than one day, this volume shall be divided into construction elements (such as walls, beams, columns, etc.), in order to fit the actual field volumes but keeping the daily work volume fairly constant. The proposed ACP is a modified version of the line of balance scheduling. This type or approach was used in the project described in this paper.

CONSTRUCTION PROCEDURES

Detailed construction procedures were developed for every construction activity. The fact of working with a repetitive apartment building project eased the work and allowed development of a significant level of detail for the entire construction. It is worth mentioning that this high level of detail was obtained several weeks before starting the actual construction. The construction procedures included:

- Crew leader detailed functions description
- Daily construction volume
- Crew components
- Specific function of every crew component
- Required tools and equipment
- Supporting crews and activities
- Activity starting and finishing time
- Quality specifications for the specific task, and quality expected from the “server”.

SCHEDULE AND BUDGET

Schedule and budget are typically calculated (as per South American standards) using the “experience” developed in previous projects. This is the expected construction completion time being derived from a first approximation regarding the construction time that has been obtained in previous projects (and the time constraints given by the owner, of course). A similar case can be observed for generating the budget. The construction materials volume is calculated for each activity, and these numbers are multiplied by construction rates, expressed in terms of “man hours/construction unit” and “equipment hours/construction units”. The addition of the dollars obtained from this procedure results in the final direct budget. Although some input is introduced into the initial schedule regarding the construction technology to be applied as well as the management and control systems, usually no specific or accurate considerations are really introduced into initial budgets and planning. Since no formal detailed preplanning is conducted, there is quite a bit of uncertainty. This is transformed into the aforementioned construction rates in which the experience of the firm is summarized. This approach, as well as the CPM include much waste which is "willingly" introduced into the budget and schedule.

The use of an ACP approach, for repetitive or non-repetitive projects, allows a much more accurate planning and budget. During the development of the preplanning effort described in this paper, an accurate and detailed planning of daily activities was conducted from start to finish of the job. Although it was clear that internal and external problems will affect the actual accomplishment of the schedule, a construction budget was calculated from the detailed preplanning. Materials costs did not vary from those in the original budget, since the materials are independent of the planning effort. Every crew had a specific task, and therefore, it was defined for how long they would work on the job. The total man hours were calculated based on the crew optimal composition, multiplied by the time they will work on the job, multiplied by the hourly rates of every crew component. A similar approach was followed for the construction equipment costing. The budget calculated in this way was shown to be much more accurate. On the other hand, the preplanning allowed to find the potential reductions in costs due to a better man power utilization.

PREPLANNING METHODOLOGY

The methodology followed in order to generate a detailed preplanning of the construction job is discussed below.

1. Determine the construction "rhythm": Based on the time constraints given by the owner, a work rhythm was determined. In this case, it was found that approximately 200 m^2 of slab per day was a good production rate for this particular project (200 m^2 is the equivalent to half of a level).
2. List all the activities, along with their crews: A complete list of all the construction activities and their corresponding crews was generated. In the case in which a crew would perform more than one activity, this would be noted in the list.
3. Design optimum crews: It is necessary to consider the selected construction technology and methods, as well as site constraints. Considering this as well as the productivity measurements and the detailed methods information obtained during job 1, the optimum crews were designed in detail.
4. Production velocity for each crew: The optimum crews as well as their production rates were assessed during job 1. This was used in order to calculate the ACP.
5. Calculate construction volumes for each construction area: Construction volumes were calculated or each area (i.e. basement, floor 1, etc.). This is different than the usual budget volume calculations, because this one is directed towards its use for construction planning.
6. Calculate the time required to built each area: Divide the area volume by the production velocity of each crew. This will yield different time periods for each activity.
7. Adjust the number of optimum crews to generate the same production rhythm for every crew working in the same area: In order to adjust the construction time to generate equal rhythms, the number of optimum crews was adjusted. In this way, every activity would be performed in the same time. Crews shall be designed in such

way that all of them will be performing productive work continuously (refer to Table 1).

8. Develop "all activity critical planning" (ACP): With the optimum crews, the number of optimum crews, their production velocity, and the construction volume per area, it is possible to develop an adjusted and all critical activities schedule. As is can be seen in Table 2, the work was planned to reduce the waste within the schedule. Crews were designed to perform the same daily tasks on different areas of the project. Daily work was planned for 8 hours shifts. Therefore, virtually no waste was introduced into the schedule. Although zero waste is a utopia, the proposed methodology proved to significantly reduce waste during actual construction.

Table 1 Construction volumes and velocities for area 1.

Activity Area 1	Nº Labor	Construction Volume	Units	Production Velocity	Units	Duration with 1 crew (days)	Nº of crews	Duration (days) RHYTHM
Steel- walls	4	3,500	kg	980	kg/day	4	4	1
Formwork-walls	4	300	m^2	85	m^2/day	4	4	1
Concrete-walls	7	64	m^3	80	m^3/day	3	1	1

Table 2 ACP planning (B = building; Z = zone; L = level).

Activity	day 1	day 1	day 1	day 1	day 1	day 1	day 1	day 1	day 1
Steel- walls	B1Z1L1	B1Z2L1	B2Z1L1	B2Z2L1	B3Z1L1	B3Z2L1	B4Z1L1	B4Z2L1	B1Z1L2
Formwork-walls		B1Z1L1	B1Z2L1	B2Z1L1	B2Z2L1	B3Z1L1	B3Z2L1	B4Z1L1	B4Z2L1
Concrete-walls			B1Z1L1	B1Z2L1	B2Z1L1	B2Z2L1	B3Z1L1	B3Z2L1	B4Z1L1

CONTROL TOOLS

Several control tools have been applied in order to assure a thorough and timely implementation of the preplanning effort.

1. Work orders/Daily report: This is the conventional report in which the amount of work actually performed, and the starting and finishing times are filled by the crew leader. This is worked out with standard forms for every activity and crew. It also specified the exact area of work, the materials to be used, and the quality that the crew leader shall produce as well as the quality that shall be demanded from the "server" (preceding) crew.
2. Man Hour Control: The access of labour to the site is controlled by a bar code system. Every man has an ID, in which his personal code bar is printed. At 8:30am (job starting time) a form is printed in which the missing labour are highlighted. This allows for fast actions in order to modify the crews so as to avoid any construction delays.
3. Rhythm Control: The rhythmic planning is controlled daily with a visual tool. A form is printed in which the actual construction performed is printed using different colours for different buildings and floors. At the end of the day, it is quite easy to spot if there has been a not-completed activity on the field. This is a visual tool to control the percentage of planned activities completed (PPC).
4. Daily control of percentage of planned activity completed: This a form in which the actual PPC is reported daily. The problems which generated any delay are also noted and described in detail (e.g. rain, problems with the equipment, etc.). These

problems are accompanied with the solutions and the measures that should be taken to avoid future delays or activities not completed on time.

RESULTS

The optimization program conducted in Job 1, generated an increase over the budgeted profit of 80%. Additionally, a twin project which was carried out within the same equipment, and under the same general conditions, but with a poor planning and no constructability effort, was not able to finish the job. The company went bankrupt. Job 2 as compared to Job 1, showed an additional 20% increase in productivity due to the preplanning effort. The increase in the profit will be determined at the end of the job, currently under construction.

CONCLUSIONS

An important effort of preplanning has been presented in this paper. The fact of having two consecutive and similar jobs helped in order to generate a complete lesson learned first and which was used efficiently for the planning of the second job. The learning process of the construction company has grown quite fast due to the use of detailed information from previous projects. Increases of 80% in construction margin are feasible by optimizing construction productivity and procedures. An additional 60% increase in the margin is expected in Job 2 by using a detailed formal preplanning.

REFERENCES

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