MEDIUM-TERM PLANNING: CONTRIBUTIONS BASED ON FIELD APPLICATION

Sérgio L. Kemmer[1], Luiz F. M. Heineck[2], Marcos de V. Novaes[3], Carlos Alexandre M. A. Mourão[4], Thaís da C. L. Alves[5]

ABSTRACT

The literature on lookahead planning suggests that there are six major functions embedded on its scope, i.e., shielding production, integration between long- and short-term planning, controlling and learning, management of physical flows, cost control, and safety planning and control. Based on the literature, this paper presents a case study on the implementation of medium-term planning, a.k.a., lookahead planning, developed in a 8.758,80 m^2 multi-storey residential building in the city of Fortaleza, Northeast of Brazil. Differently from other papers on this topic, the authors present a descriptive case study, based on field experience, not a prescriptive one. Recommendations provided by the literature were used to implement concepts related to lookahead planning. This paper presents evidence on how medium-term planning was firmly established as a managerial routine six months after its initial implementation and describes how the literature recommendations were put in practice. The authors also found out opportunities for improvement, e.g., constraints identified at the medium-term level had not been defined precisely resulting on low levels of task completion at the operational level. The paper concludes with recommendations based on how the company investigated has been able to sustain and improve practices related to medium-term planning.

KEY WORDS

Planning, medium-term planning, constraints analysis.

INTRODUCTION

The construction industry has intrinsic characteristics that contribute to increased uncertainty in the production process, e.g., high number of resources and stakeholders involved in the construction process, product and local site conditions variety, the very nature of production processes in construction in which the pace of work is dictated by the worker, and long time to complete projects (Formoso et al. 1999, Koskela 2000).

Given the context in which construction tasks take place, researchers have emphasized the importance of production planning and control in construction as a means to alleviate the factors that result in high levels of uncertainty and to provide a smooth flow of work at construction sites (e.g., Ballard and Howell, 199, Formoso et al. 1999, Oliveira 2000, Bernardes 2001, Soares et al. 2002). These researchers have noticed that many construction companies carry out the planning and control process in an informal fashion. The informality of the construction planning process results in

1 Lean Initiative Coordinator, Construtora C. Rolim Engenharia Ltda., sergio@crolim.com.br
2 Assistant Professor, Department of Mechanical Production Engineering, Federal University of Ceará
3 Construction Manager, Construtora C. Rolim Engenharia Ltda., marcosnovaes@crolim.com.br
4 Procurement Manager, Construtora C. Rolim Engenharia Ltda., alexandre@crolim.com.br
5 Assistant Professor, Department of Structures and Construction Engineering, Federal University of Ceará, Fortaleza, Brazil, thaiscla@yahoo.com

low levels of consistency between plans in different hierarquic levels and low levels of efficiency of these plans.

In order to deal with different levels of uncertainty regarding the information available for the planning process, Laufer and Tucker (1987) suggest that the construction planning process should be divided in different levels (long, medium, and short term planning). The long- and short-term planning are usually carried out by construction companies. The long-term planning represented by master schedules which deal with all the activities scheduled for a project and the short-term planning which gives directives to weekly and daily work (Bernardes 2001).

However, literature on the medium-term planning (a.k.a., lookahead planning) is scarce when compared to long- and short-term planning. A review of papers published in 14 IGLC conferences and elsewhere reveal that few papers have been published specifically on this topic (e.g., Ballard 1997, Tommelein and Ballard 1997, Chua et al. 1999, Mitropoulos 2005) and others have discussed the subject as part of Ballard's (2000) Last Planner System of Production Control or indicate functions that should be performed at the lookahead planning level (Ballard and Howell 1997, Choo et al. 1998, Mendes Jr and Heineck 1999, Alves and Formoso 2000, Soares et al. 2002).

The objective of this paper is to present a case study carried out at C. Rolim Engenharia Ltda. on lookahead planning. The paper aims to contribute to improving the rate of success of the implementation of lookahead planning in construction companies and serve as a basis for researchers and practitioners working on the topic. The authors have reviewed the literature on the topic and have found that there is a need for examples that show how companies see the implementation of the lookahead planning at their sites. Differently from other papers on this topic, the authors present a descriptive case study based on field experience, not a prescriptive one. Thus, the goal is to present the implementation process, as it happened in the project analyzed, not to prescribe the best way to implement lookahead planning. We are not prescribing the best way to do things, rather we are trying what the literature on the topic suggests and reporting about the implementation process and the potential contributions for the topic.

LOOKAHEAD PLANNING

According to Shingo (1989, p.98):

> *'Toyota's master schedule is based on extensive market research (…) and yields a rough production number for sales. Unofficial monthly production numbers are given to the plant and to parts suppliers two months in advance and then firmed up a month later [intermediate schedule]. These firm numbers are used to plan detailed daily and weekly schedules and to level the production sequence. Approximately two weeks before actual production, each line is given projected daily production numbers for each model."*

Shingo's comments on Toyota's production planning highlights the dynamic characteristic of a pull system in which numbers are continuously reviewed, projections are made and adjusted to reflect reality as time passes. From an initial master schedule, based on long-term forecasts, estimates are refined and submitted to lower levels in the production system. The intermediate schedule is given to suppliers so that they can also plan to achieve the production goals defined by Toyota. Finally, the plans reach the detailed schedule level, which defines the production sequence for weeks and days to come. Shingo's comments highlight the importance of the intermediate schedule (lookahead) as a means of shaping the work flow according to actual demand and allowing suppliers to get ready to support the original plans.

Similarly, Hopp and Spearman (2000, p.432) suggest that a production planning and control framework for a pull system should have “three basic levels, corresponding to long-term (strategic), intermediate-term (tactics), and short-term (control) planning.” They point out that in the intermediate-term (lookahead) planning, customer orders indicated in the long-term planning, as well as current customer demand, are translated into “a general plan of action that will help the plant prepare for upcoming production.” Hopp and Spearman (2000) also suggest the definition of a WIP/quota-setting (production quotas) and the activities of sequencing and scheduling orders according to their actual need in order to assure that only orders that are effectively needed are scheduled for completion in the short term,

The lookahead planning, as suggested by Ballard (1997), represents the link between the project’s master planning and the operational weekly or daily plans. It allows managers to identify which tasks will be carried out in the next few weeks or months and define the needs and constraints of each task before they are released to the operational level. During the lookahead planning, assignments are defined and organized into work packages based on information related to the project’s design and resources available (Choo et al. 1998).

Ballard (1997, p.19) suggests that lookahead planning serves five purposes:

- Shape the work flow in the best sequence to achieve the project’s goals given the resources available.
- Match labour and resources to achieve what defined for the work flow.
- Group highly dependent work so that they are planned together.
- Identify tasks that should be planned jointly by multiple trades.
- Define and maintain a workable backlog of assignments already screened for inputs necessary to their execution. According to Laufer and Tucker (1987), the definition of contingency plans is one of the means to improve the performance of construction processes. At the lookahead planning level, contingency plans are developed to deal with multiple scenarios and allow crews to proceed with work that was not originally scheduled as a priority, but may become priority as changes are made in production plans.

The purposes indicated by Ballard (1997) set the foundations for other functions that derive from the lookahead planning process. Coelho and Formoso (2003) suggest that the lookahead planning has basic and secondary functions, which are analyzed in this paper.

- Basic lookahead functions include: shielding production against uncertainty, integration between planning levels, control, and learning.
- Secondary functions comprise: analysis of physical flows, cost management, and safety planning and control.

CASE STUDY

CASE DESCRIPTION

The study was carried out in a medium-sized construction company (Construtora C. Rolim Engenharia Ltda.) in the city of Fortaleza, North-eastern Brazil. During the past few years, the company has been participating in programs related to quality improvement and innovation in construction. The company is certificated according to the ISO 9000 standards.

The project analyzed is a 17-store residential building with medium to high standards for finishings. The project also included underground floors for parking, and other floors for amenities. The services carried out at the time of the case study were structural concrete, masonry, and the first layer of flooring (i.e., the service executed before granite or ceramic tiles were put in place). For this project C. Rolim Engenharia was in charge of executing the following services: masonry, flooring, wall plastering and ceramic tiles, and installation of wood doors and windows. Subcontracted services included: structural concrete, water-proofing, gypsum-related services (plastering, walls and ceiling), aluminium windows and doors, mechanical systems, and painting. The study started with meetings leaded by the company's lean project coordinator and attended by the project engineer, supervisors and interns. The goal of these meetings was to highlight the importance of the lookahead plan and the concepts related to it. After the initial meetings, others followed so that the lookahead plan could be implemented and its results tracked.

CASE DEVELOPMENT

The case study aimed at analyzing how the basic and secondary functions as defined by Coelho and Formoso (2003) were carried out at the project. The study presents a description of how the actual implementation of these functions happened on a daily basis and how managers adapted their needs and expectations to what was proposed by Coelho and Formoso (2003). What follows is a description on how each function was performed at the project. The description presented does not intend to prescribe the best way to implement and develop the lookahead plan, rather we aim to contribute for the discussion about its implementation, which is not usually found in the literature.

Shielding Production against Uncertainty

Lookahead meetings take place once every month. Based on the experience of the project's managers, and the total duration of the project (27 months), they've decided to consider a two-month window for the lookahead plan. At the first lookahead meeting, the group planned for a two-month window. The following monthly meetings are held to update the progress made on tasks scheduled for the two-month window as well as to include new tasks scheduled for the next month in the window.

The main goal of these meetings was to analyze, in an integrated fashion, the constraints identified by the subcontractors. Subcontractors used to bring a list of constraints to be discussed jointly with the other project participants at the meetings and to identify potential interferences among their work.

As time passed, it was evident that all subcontractors should develop their own lookahead schedules, which improved the discussions at the meetings as they become more dynamic. All project participants could analyze each other's constraints and cross-check all plans brought to the meeting. Finally, after plans were reviewed and changes were discussed, the lookahead plan for the next two-month period was generated. Shielding production from variations also involves the dissemination of information to production crews. In this sense, the project team elaborated a document with all the information needed to execute work packages related to masonry (e.g., list of resources needed, design and modularization of the wall).

In order to identify constraints, before tasks are executed throughout the project in a larger scale, the company builds one unit of the project (an apartment) to serve as a prototype. During the execution of the prototype, questions related to the project's design, materials used, and finishings can be answered in anticipation of potential problems that could hamper the smooth flow of work. This practice is also named as ‘first run studies’ or ‘operations design’ in the Lean Construction literature and can take place during the lookahead planning phase (for more details see Howell and Ballard 1999).

Integration between Planning Levels

Integration between long-, medium- (lookahead), and short-term planning is essential, they should all be connected. One approach to evaluate the level of integration and efficiency among the three planning levels, which was used in this case study, was the evaluation of the short-term planning.

Figure 1 presents a tool used by the company to help visualize the integration between the three planning levels. The tool reveals which work packages are considered in different planning windows (horizons) and when their actual execution happens. The tool format resembles the structure of a line-of-balance in which the horizontal axis represents time (when) and the vertical axis represents the units where tasks are scheduled to happen.

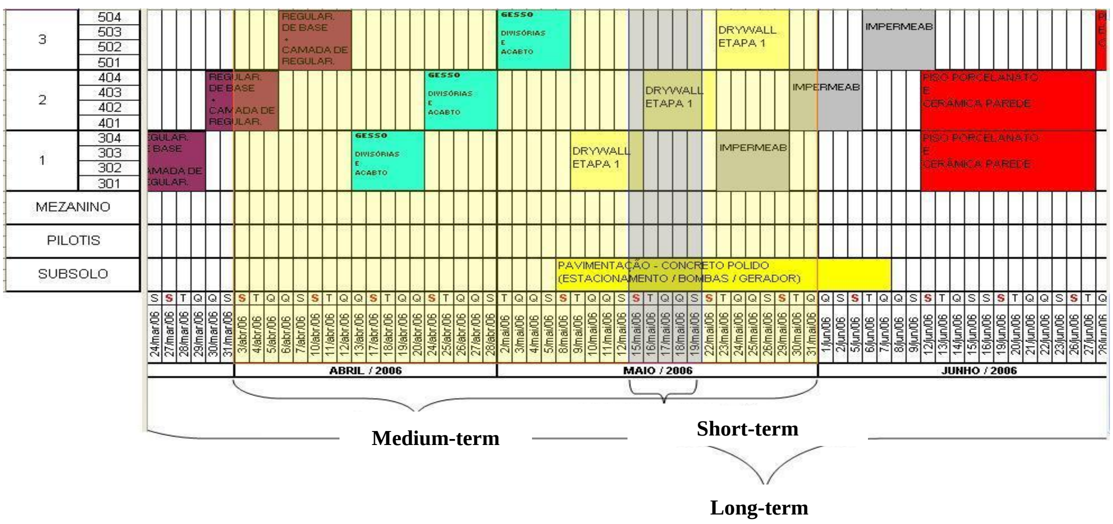

Figure 1 – Integration between planning levels

Control and Learning

During the implementation of the lookahead planning process subcontractors were encouraged to share their lookahead plans to avoid conflicts and help each other to remove constraints. This attitude resulted in an exchange of information among different project participants. Subcontractors become more and more interested in knowing better all the project’s participants needs, what contributed to improve the relationships between different trades and dramatically reduced the need to stop production due to interferences and conflicts.

For this reason, the project’s lookahead plan was geared towards a representation of the whole group of tasks, as scheduled by subcontractors (not by the company) to happen in the two-month window (Figure 2).

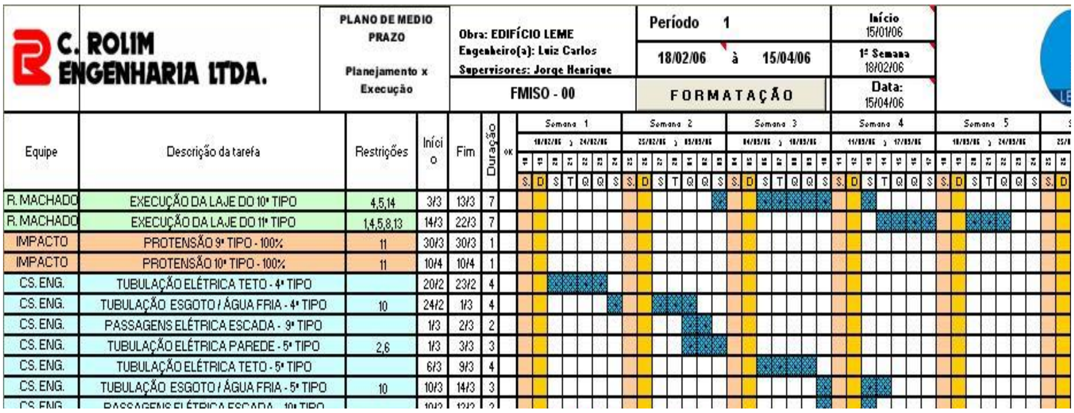

Figure 2 – Lookahead planning for all subcontractors

It's worth noting that at this planning level all subcontractors have unrestricted access to the schedules defined for all services. This allows subcontractors to have an integrated view of the project and its participants' needs, as well as encourages the participants to question, from different points of view, the means and methods used. Finally, the company documents in a data base the questions and answers provided by subcontractors and project management teams to be used as reference in other projects.

Analysis of Physical Flows

The analysis of physical flows is initiated when the site layout is elaborated in the initial phase of the project. However, due to the dynamic nature of a construction project, the site layout is reviewed during lookahead meetings throughout the project duration. The site layout was reviewed three times during the case study period. The reviews considered space needs for materials storage and the equipment needed for transporting them. Materials needs were analyzed in terms of types and quantity of materials, specifications for storage and their location. The goal of this analysis was to remove constraints related to the storage and provision of materials for different work packages. The company hired an intern to be in charge of managing the physical flows at the project site. All tasks related to receiving, storing, and distributing material to different areas and crews were part of this intern's daily tasks.

Cost Management

The project budget was developed in the same way work packages were defined to be executed on site (i.e., operational budget, which has similar compositions to the ones defined for work packages). This was made to facilitate the communication between the planning and production sectors. The initiative helped the management team to obtain quantity and cost information in a more direct fashion, avoiding rework (e.g., recombine and reorganize quantity take-offs specified on budget to obtain the actual values for work packages as executed on site). The use of an operational budget helped managers to keep track of actual vs. planned costs, increasing the transparency of the information provided by the cost control system. Owning this information, managers could use the lookahead meetings to analyze the project from a strategic standpoint, i.e., analysis of the project cash flow; renegotiation of the pace of services, dates of materials deliveries, and contracts with suppliers.

Safety Planning and Control

The planning and control of safety came as a consequence of the need to remove constraints before tasks can be part of the short-term planning. Therefore, only tasks considered safe, attending the safety criteria defined for its execution, could be included in weekly work plans. Actions necessary to guarantee safe work packages were included in the list of constraints analyzed during the lookahead meetings.

DATA ANALYSIS AND CONCLUSIONS

Based on the items discussed, it can be concluded that all lookahead functions as defined by Coelho and Formoso (2003) were part of the lookahead planning process at the project site. The consolidation of these functions on the company's daily routines was leveraged by the existence of a quality system already in place before the implementation of the routines related to the lookahead plan. According to the literature reviewed, it is at the intermediate (lookahead) planning level that plans are screened for constraints, demand is matched with capacity, and negotiations occur to allow a smooth flow of work. The case described how all these functions and others were performed at the project analyzed.

However, there is always room for improvement as it can be observed from the data presented in Figures 3 and 4, which show respectively a list of groups of constraints identified at the lookahead plan level and the causes of problems in weekly work plans (operational level).

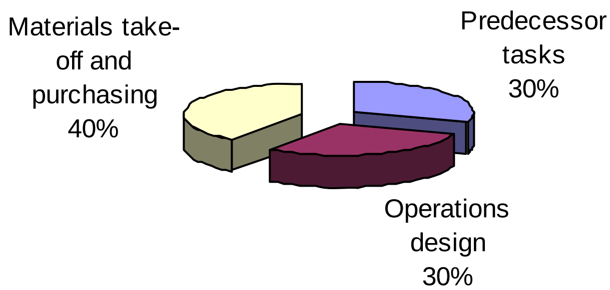

Figure 3 – Constraints listed in the lookahead plan

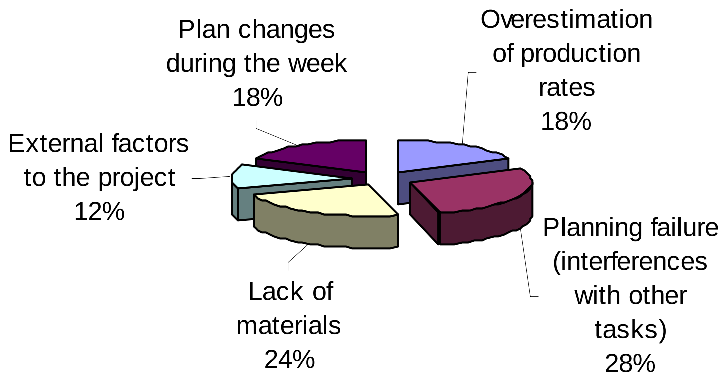

Figure 4 – Causes of problems listed in weekly work plans

The constraints listed in the lookahead plan were grouped into three main categories which relate to technical aspects of tasks (Figure 3). At the lookahead plan level, managers and subcontractors strived to remove constraints related to the means and methods to be used, to warrant that predecessors would be completed before successors were scheduled, and to search for resources needed for executing a task. The emphasis on these aspects was probably due to the use of a new technology to for covering the walls in the project.

Figure 4 indicates that some of the main problems identified at the operational level are related to interferences between tasks and overestimation of productivity. These problems are related to the knowledge about how tasks should be executed and how much workers are able to produce in a certain interval. Both aspects should be widely known by crews and their supervisors.

Other problems identified in Figure 4 are related to changes on weekly work plans and external factors to the project site, which could be deemed apparently out of the project manager's control. These problems were considered solved by managers and subcontractors, at the lookahead planning level, before tasks were included in weekly work plans. They depend on internal actions (related to the project site) and external actions (related to contracts and suppliers).

By cross-checking the data provided by both figures, it is evident that 24% of the problems (lack of materials) in the weekly work plans were related to 40% of the constraints (material take-off and purchasing) listed in the lookahead plan. Most of these problems were related to suppliers and not to the lack of actions taken by management to provide materials on site.

The lookahead plan, as implemented in this project, performs all functions suggested by the literature (e.g., Ballard 1997, Coelho and Formoso 2003). However, there is still some inconsistency in terms of making it able to pinpoint the actual problems that may hamper production. In the case study, the project managers considered more relevant the identification of constraints related to new technology used on site and less relevant the constraints related to work content, productivity, and re-planning. Perhaps, they thought that these supposedly less relevant constraints would be easily removed by the crews who supposedly knew better about how tasks are carried out. However, the new technology with all of its novelty would need more thinking before tasks could be executed. This attitude proved to be counterproductive as all tasks need to be properly screened at the lookahead plan level before being included in weekly plans, whether they are related to old methods or new technologies.

Practically speaking, identifying and removing constraints at the lookahead level should result in more reliable plans because barriers to the smooth flow of work were removed. However, this was not evident in the study as the causes of problems in weekly work plans were not identified at the lookahead level. In order to solve this problem, the company has decided to invite workers to contribute with their knowledge about how tasks are carried out and to clarify what problems stop their work. By doing so, managers aim to better understand their workers needs, design operations that are a better match to their resources, and properly identify and remove constraints that are not usually anticipated by managers but are known by crews.

ACKNOWLEDGEMENTS

Authors would like to thank Construtora C. Rolim Engenharia Ltda. for allowing the results of this case study to be published, as well as CNPq for funding part of the study. Any opinions, findings, conclusions, and recommendations are those of the authors and do not necessarily reflect the views of the company studied or the funding agency.

REFERENCES

Alarcón, L. (editor) (1997). *Lean Construction.* A.A. Balkema, Rotterdam, The Netherlands, 497 pp.

Alves, T.C.L. and Formoso, C.T. (2000) Guidelines for managing physical flows in construction sites. *Proc. 8th Annual Conference of the International Group for Lean Construction (IGLC-8),* Brighton, UK, 12pp

Ballard, G. (1997) Lookahead Planning: the missing link in production control. *Proc. 5th Annual Conference of the International Group for Lean Construction (IGLC-5),* Gold Coast, Australia, 13-25

Ballard, G. and Howell, G. (1997) Implementing Lean Construction: improving downstream performance. In: *Lean construction*, edited by Luis F. Alarcón C. A A Balkema, Rotterdam. (first published in *Proc. 2nd Annual Conference of the International Group for Lean Construction (IGLC-2), Santiago, Chile*)

Ballard, G. H. (2000*) The Last Planner System of Production Control.* Ph.D. Thesis. Faculty of Engineering. School of Civil Engineering. The University of Birmingham.

Bernardes, M. M. S. (2001) *Desenvolvimento de um Modelo de Planejamento e Controle da Produção para Micro e Pequenas Empresas de Construção.* (in portuguese) Doctoral dissertation, UFRGS, Civil Engineering Graduate Program, Porto Alegre, Brazil, 282pp.

Choo, H. J.; Tommelein, I. D.; Ballard, G.; Zabelle, T. R. (1998) WorkPlan: database for work package production scheduling. *Proc. 6th Annual Conference of the International Group for Lean Construction (IGLC-6)*, Guarujá, SP, Brazil, 11p.

Coelho, H. O. (2003) *Diretrizes e requisitos para o planejamento e controle da produção em nível de médio prazo na construção civil.* (in Portuguese) Master's thesis, UFRGS, Civil Engineering Graduate Program, Porto Alegre, Brazil, 133pp

Coelho, H. O. and Formoso, C. T. (2003) Planejamento e controle da produção em nível de médio prazo: funções básicas e diretrizes de implementação. (in Portuguese) *Simpósio Brasileiro de Gestão e Economia da Construção,* III, 2003, São Carlos, SP, Brazil, 10pp.

Formoso, C.T.; Bernardes, M. M. S.; Oliveira, L. F. M.; Oliveira, K. A. (1999) *Termo de referência para o processo de planejamento e controle da produção em empresas construtoras.* NORIE/UFRGS,. Porto Alegre, RS, Brazil, 73pp.

Hopp, W.J. and Spearman, M.L. (2000) *Factory Physics.* Second Edition. McGraw-Hill International Editions, Boston, 698 pp. (First Edition 1996)

Howell, G. and Ballard, G. (1999) Design of construction operations. *LCI White Paper #4.* 9pp Available at http://www.leanconstruction.org/pdf/WP4-OperationsDesign.pdf

Koskela, L. (2000) *An exploration towards a production theory and its application to construction.* Doctor of Philosophy, Helsinki University of Technology, VTT Technical Research Centre of Finland, Espoo, 298 pp.

Laufer, A. and Tucker, R. L. (1987) Is Construction Planning Really Doing its Job? A Critical Examination of Focus, Role and Process. *Construction Management and Economics,* 5(3), 243 - 266.

Mendes Jr, R. And Heineck, L.F.M. (1999) Towards production control on multi-story building construction sites. *Proc. 7th Annual Conference of the International Group for Lean Construction (IGLC-7)*, Berkeley, CA, 313-324.

Mitropoulos, P.T. (2005) 'Planned work ready': a proactive metric for project control. *Proc. 13th Annual Conference of the International Group for Lean Construction (IGLC-13)*, Sydney, Australia, 235-242

Oliveira, P. V. H. (2000) *Implementação de um processo de programação de obras em uma pequena empresa.* (in Portuguese) Master's thesis, UFSC, Civil Engineering Graduate Program, Florianópolis, SC, Brazil, 117pp.

Shingo, S. (1989) A Study of the Toyota Production System. Revised edition. Productivity, Portland, OR. 257 pp.

Soares, A. C.; Bernardes, M.M.S.; Formoso, C.T. (2002) Improving the production planning and control system in a building company: contributions after stabilization. *Proc. 10th Annual Conference of the International Group for Lean Construction (IGLC-10)*, Gramado, RS, Brazil, 477-487

Tommelein, I.D. and Ballard, G. (1997) Look-ahead planning: screening and pulling. *Seminário Internacional sobre Lean Construction, 2.* São Paulo, Instituto de Engenharia de São Paulo, Logical Systems.