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Planning and control of civil works: multiple case study in Rio de Janeiro construction companies

Planejamento e controle de obras civis: estudo de caso múltiplo em construtoras no Rio de Janeiro

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Abstract: This work aims to analyze the evolution of patterns and planning, and control techniques used in civil construction of vertical buildings in Rio de Janeiro state. Therefore, we performed a literature review on the main techniques of planning and control. Then, we developed a comparative multiple case study in four civil construction companies to verify how they manage their planning and construction processes. All companies are certified by PBQPH as level A. The results show that these processes have operational and conceptual failures, which vary according to specific issues related to crucial competitive factors, besides, they are not completely established.

Keywords: Planning and control; Civil construction; Construction management.

Resumo: *Este artigo tem como objetivo analisar a evolução dos modelos e técnicas de planejamento e controle de obras civis e identificar o atual estado de sua aplicação na construção de edificações verticais no Estado do Rio de Janeiro. Dessa forma, apresenta-se uma revisão das principais metodologias e técnicas de planejamento e controle de obras de edificações. Em seguida, desenvolveu-se um estudo comparativo de casos múltiplos com a finalidade de identificar como as empresas construtoras, no Estado do Rio de Janeiro, têm gerido seus processos de planejamento e controle de obras. Foram analisadas quatro empresas privadas de grande porte certificadas pelo Programa Brasileiro de Qualidade e Produtividade no Hábitat (PBQP-H) Nível A. Os resultados mostram que os processos de planejamento e controle praticados pelas empresas analisadas apresentam falhas, tanto operacionais quanto conceituais, variando de acordo com as particularidades específicas relacionadas aos fatores determinantes de competitividade, além de não estarem plenamente implantados.*

Palavras-chave: *Planejamento e controle; Construção civil; Gerenciamento da construção.*

1 Introduction

Construction is an activity that involves many variables, being developed in a particularly dynamic and changing environment, making their management a complex work (Mattos, 2010). However, there is much improvisation in construction sites around the world. In Brazil, many housing works are still performed without a formal planning and without compliance with the deadline of the guarantee and previously established budget (Limmer, 1997).

To Formoso (2001), deficiencies in planning and control are among the main causes of the low productivity in the sector, its high losses and low products quality. In fact, a good planning is essential to improve productivity, reduce delays, provide the best production sequence, balancing the need for labor to work to be produced and coordinate multiple interdependent activities (Ballard, 1994; Ballard & Howell, 2003; Hamzeh et al., 2012). However, improved planning requires that several construction industry obstacles are overcome, such as: management focuses on control of faults, rather than focusing on breakthroughs; planning not designed as a system; planning considered only as a schedule; Measuring absence of performance analysis and correction of faults planning (Ballard, 1994).

Ballard & Howell (2003) recommend that planning without considering the definition of production methods, resource estimates, job productivity indicators and calculation of production capacity create unworkable plans. In turn, Ballard (1994) points

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out that not adopting methods that are designed to protect the production can lead to discontinuity in the production process and, consequently, the failure to meet deadlines. In this context, a qualitative research developed by adopting the multiple case study as research strategy, in order to verify the statements of Ballard & Howell (2003) and Ballard (1994), and identify the tools and techniques adopted by construction companies located in Rio de Janeiro in developing their plans and methods used to prepare the activities planning and control.

This paper describes the development of models and techniques for planning and control of civil works. Initially, it was done a major review in the existing literature about the subject. Then the technical and planning and more relevant control tools are presented. After reviewing the literature, the methodological procedures are explained and it is done a case study in four large private construction companies certified by the Brazilian Program of Quality and Productivity in Habitat (PBQP-H) Level A, based in the state of Rio de Janeiro. Finally, a diagnosis of the current state of the planning process and production control in these companies is done in order to understand why the deadlines set by the planning are not met.

2 Systems planning and construction control

Formoso (2001, p. 5) defines planning as

> [...] a management process that involves setting goals and determining the procedures necessary to meet them, being effective when performed in conjunction with the control.

Coelho (2003) considers the process control as a monitoring of the production process, which compares the held to plan, taking the necessary actions to maintain production as expected. In addition to these functions, the control helps to increase work efficiency, accelerate schedule and reduce costs (Mubarak, 2010).

Ballard (1994) emphasizes the importance of planning and control to improve productivity, reduce delays, provide the best production sequence, balancing the amount of work force to produce the work and coordinate multiple interdependent activities. In the context of construction, there are several systems and planning and production control techniques. Such systems and techniques are presented below.

2.1 The traditional system

According Coelho (2003), the dominant model in the conceptual construction defines a set of production and conversion activities that transforms inputs into intermediate or final products. This model has pushed production predominance, being based on the critical path method (CPM) and PERT technique (Moura, 2008). However, when analyzing this model, Koskela (1992) listed the following deficiencies.

- Physical flows between the activities, although most of the costs to be derived these flows are not considered;
- Control of production tends to be concentrated on the individual sub-processes in detriment of the overall process, and a relatively limited impact on the overall efficiency;
- The non-consideration of customer requirements may result in improper products on the market since, through the conversion model, it is assumed that the value of a product can be improved by using only the best quality raw materials.

2.2 System proposed by Laufer and Tucker 1987

According to Laufer & Tucker (1987), planning should define four questions: what to do (activities), how to (method), who will perform (resources) and when running (schedule). This process should be performed in two dimensions: vertical and horizontal (Moura, 2008). The horizontal dimension refers to the stages through which the process of planning and control is carried out (planning of the planning process, gathering information, preparation of plans, information dissemination, evaluation of the planning process), while the vertical dimension refers to these steps linkage mentioned to the different management levels of an organization (Gutheil, 2004).

Laufer & Tucker (1987) add that plans should not be prepared without the definition of the methods of production and, planning methods should precede decision making on resources and deadlines. According to these authors, the plan will only be effective if integrated into control system. This integration has as its basic goals: to assist management in the direction of the company; coordinate the various entities involved in the construction of the project; enable control of production; allow comparison of alternatives, thus facilitating decision-making (Moura, 2008).

2.3 Lean Construction

Lean Construction is the philosophy of construction based on the Toyota Production System (TPS), presented in 1992 by Koskela. Ballard & Howell (2004) that point out that Lean Construction has the following guideline: deliver the product, maximizing value and minimizing waste.

Koskela's philosophy states that the construction should be considered as a stream, being comprised of two main processes: design and construction. The construction process consists of the material flow and workflow. The processes are characterized by cost, duration and value to the customer (performance and compliance with the specification) (Koskela, 1992).

To Formoso (2001), Lean Construction is applicable not only to production processes, but also to management proceedings. The author points out that in addition to the material flow, the workflow should be managed. This flow refers to the set of operations carried out by each team at the construction site. According to Formoso (2001), it is necessary to synchronize the teams in order to maintain a continuous workflow. In short, the process of planning and production control should consider the need to manage the mounting flow, materials and / or information and work, focusing on the elimination of activities that do not add value.

2.4 System proposed by Ballard and Howell 1997 - Last Planner

The Last Planner term refers to the planning chain (long, medium and short term), where the last plane acts in the execution interface. Thus, this method focuses on detailed planning just before the execution, instead of the entire planning process (Koskela & Howell, 2002). Moura (2008) states that the LPS is responsible for introducing some production techniques in both medium level and short-term, although it is rarely seen the full implementation of Just In Time.

The master planning (long-term) sets out the overall objectives and constraints that govern the project as a whole (Ballard, 2000). These plans should not be too detailed but should set the pace of the main production processes. At this stage, according to Formoso (2001), should be scheduled deliveries of features that require a long-term acquisition.

Planning lookahead starts from the detailed master planning. In it are the activities that must be performed in the medium term set. It then gives greater emphasis on programming resource, especially those with medium-term acquisition (Moreira & Bernardes, 2001). The practice in many construction projects shows misapplied lookahead planning, resulting in a large gap between the long-term planning and short-term, reducing the reliability of the planning system and ability to forecast (Hamzeh et al., 2012). According to Ballard (2000), planning lookahead performs multiple functions, such as:

- The training sequence and workflow rhythm;
- Harmonisation between workflow and production capacity;
- Breakdown of the activities of the master program in work packages and operations;
- Development of detailed methods for the performance of work;
- Maintaining possible execution services stocks.

Moreira & Bernardes (2001) point out other functions of the lookahead planning: enable interdependent work can be grouped so that the working method is planned jointly; and assist in identifying operations that can be performed jointly between the different production teams.

According to Machado (2003), planning of medium-term production capacity involves the reconciliation of the amount of man / hours available in each production unit (U.P.) and the respondent burden on scheduled operations to run on each U.P. in the time window of Lookahead programming. To Formoso (2001), one of the main functions of this level is the removal of restrictions on the production system.

The planning of weekly work, also known as planning commitment, is the most detailed plan system, shows the interdependence between activities and directly triggers the production process. Ballard (2000) proposed four criteria to ensure quality in the preparation of plans for the weekly planning: well-defined work packages, correct sequence of work, a certain amount of work and ability to perform the tasks (removing restrictions).

The work assignment is a measurable commitment to comprehensive conclusion. At the end of each period, the assignments are reviewed to assess whether they are complete or not, measuring thus the reliability of planning. For incomplete assignments, the causes are analyzed and act on these reasons, and it is the basis of learning and continuous improvement (Ballard, 2000).

Studies by Hamzeh et al. (2012) point out that normally are tracked only plan failure categories (eg, lack of materials), but analysis is not carried out to find out the causes and take preventive actions that inhibit the recurrence of such failures.

The planning process effectiveness is evaluated by the percentage indicator of completed packages, calculated by dividing the amount of work packages completed and the amount of planned work packages (Moura, 2008).

The control system Last Planner is divided into two main components: the control of the production unit and control workflow. The function of the first component is to generate progressively better plans through continuous learning and corrective actions. The role of the second is to generate pro-actively the flow of work through the production units, the best result possible and cost (Coelho, 2003).

In general, when proposing LPS, Ballard breaks the paradigm of conventional planning process, which can not see a distinction between what should be performed at the construction site (depending on the project objectives) and what can effectively be performed, based on the analysis of the restrictions imposed on the design, workload and production capacity available. Ballard's proposed sistem then involves an improvement in the planning process (and hence the operating results) by generating more reliable plans (Machado, 2003).

3 Planning and control techniques

According to Formoso (2001), there are several development plans techniques such as Gantt chart, precedence network and balance line. With the advancement of information technology, new tools have emerged, such as the case of 4D models.

3.1 Diagram Gantt - bar chart

The bar chart or diagram Gantt, developed by Henry L. Gantt in 1917, becoming popular due to the graphical representation of the activities in a time scale (Mubarak, 2010). To plot the graph, the project should be subdivided into a number of activities that can be easily measured and controlled without being overly detailed. With the duration of each activity, the bars are drawn representing their duration, start and end dates. In this chart, they are not usually represented the links between activities (Mubarak, 2010).

3.2 Network techniques, the critical path method (CPM) and Program Evaluation Review Technique (PERT)

Schedules networks or simply planning networks are degenerate graphs, which resulted from graph theory. Arrows or nodes represent networks. For the development of a network by arrows are currently used two techniques of different origin: PERT and CPM. The CPM technique (Critical Path Method), developed in 1957 by E. I. Dupont Neymours, has deterministic character. Also in 1957, the United States Department of Defense developed the technique PERT (Program Evaluation and Review Technique - Technical Assessment and Program Review), with probabilistic. With time, both techniques were united, passing the use PERT / CPM denomination for this type of network where the activities are represented by arrows (Limmer, 1997).

According Mubarak (2010), there are four steps to the preparation method: determination of activities; determining the activities duration; determination of logic between activities; network design and calculation. The calculations offer the project to date, the critical path and clearances non-critical activities. According Koskela (1992), these tools are not appropriate because rarely explain the activities that do not add value, besides the difficulty of explaining flow activities.

3.3 Balance line

The balance line technique is recommended for works with repetitive activities. The technique consists in tracing, referred to a Cartesian axis lines representing an activity and its respective time. On the horizontal axis mark is the time and the ordinate, the cumulative progress of the planned values for each unit assembly (Limmer, 1997).

For technical application, it is necessary to know the amount of services to be performed and the productivity of teams. This information is necessary to scale the enforcement teams. The simulation of the production lines of the process allows for the analysis of interference between its activities and balancing in order to perform all activities continuously. (Mendes, 1999).

3.4 Location-based Management System

As Seppänen et al. (2010), Location-based Management System (LBMS) is the result of a long research on the Line of Balance technique (Lumsden, 1968) and Flowline method. This is a planning and control of production System, viewed, most often as a flow line. The LBMS production plans in detail, considering the quantities, productivity data and location breakdown structure. Production data are collected from field observations to compare actual against planned projections. Project amounts (scope), productivity and defined locations (hierarchically within the building) form the calculation of variable durations and resources. Activity durations are calculated based on the amount of planned work, productivity and team size (Seppänen & Kenley, 2005).

In LBMS, productivity data are monitored weekly, including: actual start date of the task; real end date of task; update completed percentage or amount of progress to date; number of resources per task by location; days not worked per job by location (Kala et al., 2012).

Seppänen et al. (2010) conclude that LPS and LBMS have harmonization. LPS focuses on the social process of planning and commitment, while LBMS is a technical system used to structure information to improve the planning process and calculate the progress metrics and projections. Thus, the weekly planning reports and planning Lookahead can use LBMS progress and forecast data as an anticipation system to assess the effects of output gaps in the project.

According to the authors, the LBMS part of the CPM including an enlarged CPM algorithm that allows the planning of continuous workflow. The method allows the manipulation of buffers and lags. The overall objective of LBMS is the optimization of workflow, avoiding idleness of workers (Seppänen et al., 2010).

3.5 Modeling 4D – BIM

Building Information Modeling (BIM) conceptualizes integration and modeling of project information in a virtual three-dimensional model of the building. One of the development vectors in BIM tools is the introduction of the time dimension in their models. In terms of production in construction, this dimension can be seen in the context of an activity planning. By integrating this type of functionality in a three-dimensional model BIM, 4D BIM arises (Souza & Monteiro, 2011).

For Garbini (2012), the virtual model together with the schedule, proposes display of the sequence and progress of the work, allowing interaction with the site at all stages of construction. The BIM technology allows the coordination of construction sites, materials, and especially the exchange of information between the agents involved.

The development of planning activities in a 4D model has the following dynamics: identifies a list of the elements in BIM models; are added quantity information (taken directly from the BIM models) and production rates, giving rise to durations. The functionality of BIM models identifies elements, properties and spatial definition, to perform various types of measurements, including area, perimeter, and volume, among others (Souza & Monteiro 2011).

Garbini (2012) points out that the entire information exchange process for the preparation of projects in 4D modeling is done through various design software. Only by adopting a neutral data platform it is that it is possible to do all this exchange of information without data loss, making thus the really efficient and reliable BIM technology. The author points out that it must resolve how project areas (drawings, memorials, etc.), planning, budgeting and construction that currently relate sequentially, and that with the use of technology, will have a relationship simultaneously.

4 Methodological procedures

This research has a qualitative approach, and adopted the case study as its research strategy. Its scope is to bring the evolution, over time, the main planning and control methods and techniques and verify their applications in civil construction companies in Rio de Janeiro.

Initially, it was performed a critical analysis of the current state of knowledge in planning and control works from the literature review on the topic. To check the current status of the use of methodologies and techniques adopted by construction companies, it was decided, as a research strategy, the case study because, according to Yin (2001), this strategy is applicable to questions like "how" and "why" on a set of contemporary events in which the researcher has little or no control, which is the situation of this research. It was chosen the comparative study of multiple cases because this technique allows confront and compare, by juxtaposition, a phenomenon in different contexts (Benbasat et al., 1987).

The research universe considered constructions of buildings with multiple floors, residential or commercial. The sample consists of four large private companies certified by the Brazilian Quality and Productivity Program at Habitat (PBQP-H) Level A, operating in Rio de Janeiro. The size of the company was determined according to the research methodology employed by the National Industry Confederation (CNI) in the Construction Industry Survey Report (CNI, 2013). According to the method, the sizes are defined as the following criteria: small, 10-49 employees; medium, 50-249 employees; large, 250 or more employees. The sample size was set intentionally, according to the criteria cited by Eisenhardt (1997 apud by Alves & Ferreira, 2006), which explains that in the case study methodology with multiple cases, the sample must be between four to ten components.

Data collection took place between June and August 2014 in the city of Rio de Janeiro, being held through direct observations. Data were collected in construction of commercial and residential vertical buildings. The study is limited to investigate time management from the analysis of the planning and control of the production process.

For the development of research, structured interviews were employed, carried out with planning management, production and supplies, document study of the analyzed organizations and analysis of the processes used. From these surveys, it was developed a case study protocol, consisting of 20 questions. The instrument was presented to two civil engineers with deep understanding of planning and control systems and to an academic scholar. These assessed the understanding and relevance of the issues, ensuring face validity and content. Then the interviews, lasting an average of two hours, occurred in organizations.

The main sources of data were structured interviews, recorded and transcribed by the researchers. The content analysis technique was used to analyze the information obtained through interviews, comparing them to the existing literature on the subject. In addition to the interviews, documentary evidence, such as company websites and articles on the Industry were adopted. According to Yin (2001), documentary research helps to highlight information that has been obtained through other sources. As well as documentary

research, direct observation in business also helps in complementing the information collected in a case study (Triviños, 1987). These observations were made during interviews and visits to organizations. Finally, the triangulation of data helps to make the robust case study and to increase the construct validity. Using a case study protocol and database development also contributed to increase the reliability of the research (Yin, 2001).

5 Case study

In this section, it is contextualized the construction market, more specifically in the building sector. Finally, the results of the study are analyzed.

5.1 The civil construction market

The construction industry is composed of a complex supply chain that spans many industries, that has as its main characteristics: heterogeneity (Mello & Amorim, 2009) and the intensive use of labor, especially unskilled (Torres et al., 2010).

According to the Inter-Union Department of Statistics and Socioeconomic Studies (DIEESE, 2013), the construction activity is comprised of three segments: Construction of buildings - formed by the construction of buildings or residential, and incorporation of construction of real estate projects; Heavy construction or infrastructure projects; and specialized services. According to the National Classification of Economic Activities (NCEA), the Brazilian Institute of Geography and Statistics (IBGE), building construction activity includes: the construction of residential buildings, the construction of commercial buildings and the construction of industrial buildings (Federation of State Industries of Rio de Janeiro, FIRJAN, 2013), representing an annual turnover of R$ 180 million (Departamento Intersindical de Estatística e Estudos Socioeconômicos- DIEESE, 2013). The segments of the construction industry have specific characteristics as the determinants of competitiveness (Torres et al., 2010). They are:

- Heavy construction: the contract management capacity and integration of subcontractors chosen products, and the relationship with technology holders;
- Residential Buildings: The main factor is cost, given that the final product has a high value. The price and financing are other important factors in the consumer's decision;
- Commercial Buildings, especially hospitals, hotels and shopping centers: the critical factor is the delivery that term, warranty and work delivery speed are crucial.

The construction market in the state of Rio de Janeiro, where the units analyzed in this study operate, passes, in recent years, for a warm-up period, due to the great works for the World Cup 2014 and the 2016 Olympics, in addition to public measures and projects for the port area of Rio's capital, with investments of up to 5 billion reais in the region. According to Rohan & França (2013), the construction sector in 2009 accounted for approximately 5% share of the state of Rio de Janeiro in the national GDP. The authors emphasize that the Rio de Janeiro state has attracted record amounts of investment, which includes the civil engineering sector. The value of acquisitions, works and services carried out by the construction industry in 2012 increased by 10.2% compared to 2011, but, currently, this growth is more reduced (Lisboa, 2014).

5.2 Results of case studies

This section describes the main characteristics of the companies analyzed in the development of qualitative research, followed by comparative analysis of the results.

5.2.1 Company A

Company A was founded in the 1950s, working in major national capitals. Its portfolio includes condominiums of residential houses and buildings, corporate buildings, shopping, shopping centers, hospitals, universities and factories. Throughout its history, it constructed more than eight million square meters, and currently has 64 projects running.

Planning and control process in Company A is done as a partnership between the producion management and the Consulting team.The planning objective is to prepare a schedule that atends the finish date accorded between Company A and the final client, even that this mean that impossible targets are set. This schedule contains a very detailed long term planning wich stablishes global objectives and production processes speed.

In general, Company A planning is adhered to the traditional system of planning and control, as it has a sole plan formalized in a long-term planning very detailed. This planning is based heavily on the critical path method and PERT. The physical flows between the activities are not considered, as well as the concept of value creation, the production environment and the learning generation opportunity. The control of the production is concentrated in individual sub-processes in detriment of the overall process, and a relatively limited impact on overall efficiency.

5.2.2 Company B

The B Company was founded in the 1980s, working in the metropolitan area of the city of Rio de Janeiro. Its portfolio includes condominiums of residential houses and buildings, corporate and commercial buildings. Throughout its history, they were executed 25 projects, accounting for 2,372 units delivered and more than three hundred thousand square meters. Currently has two projects running five future releases.

In general, planning Company B is partially adhered to the traditional system of planning and control, as it has sole plan formalized a long very detailed term planning, based heavily on the critical path method and valuation technique and program review. However, concepts like physical flows between the activities, continuous workflow, influence the production environment and the learning generation opportunity are incorporated, albeit in embryonic form. The control of the production is concentrated in individual sub-processes, without losing focus on the overall process. The concept of value creation is neglected.

Planning is partially designed as a system and no measurement of performance systems. Setting goals is based on the experience of those personell involved, considering partial data on productivity, construction processes, disregarding production capacity.

5.2.3 Company C

Company C was founded in the 1960s, operating in the metropolitan areas of São Paulo and Rio de Janeiro. Its portfolio includes condominiums homes, residential and commercial buildings. In 2007, the company was associated with one of the leading construction companies in the real estate market through a joint venture.

According to the planning manager of Company C, the process of planning and control begins when it is announced that a new project will be built. At this time, the deadline is the one set during the feasibility study. With project ownership, the work location and typology, a meeting between the planning team and the production team is made to define a plan of attack to work. At this stage, the project is analyzed as a whole, from the architectural design, through the earth moving issues, construction sequence, flow of activities, weather conditions in that critical steps are performed, site logistics, workflows and materials, resources, concurrency services and other restrictions that govern the project as a whole.

In the next step, proceeds the preparation of plans with the aid of a computer program based PERT / CPM. The estimated duration is based on the experience of the professionals involved in the planning process. Once the plan is done, the baseline is saved. The end date will not necessarily match the delivery date established, and may be delays However, there is no freedom to change the production method.

The schedule is updated monthly, and the progress of work monitored through comparisons with the schedule and the budget. This step sets the goals to be achieved in the next period, through analysis of constraints. Monthly targets are broken down into weekly goals, which are accompanied by the production team. However, the weekly meetings only communicate compliance with the set targets and goals for the next period. There are not performance measurement systems.

5.2.4 Company D

A Company D is part of a business group composed of eight companies. It has over 60 years of experience. Its portfolio includes strategic projects for the country, such as the construction of Brasilia, the design of the project Nova Luz, the management interfaces in the Power Plant Jirau (Rondônia) and the shipyard Promar (Pernambuco), among others.

According to the management and production planning, process planning and control Company D begins with the contract signing, which contains the schedule to be followed and the appropriate penalties. As soon as the contractual conditions are kown, a meeting is held with various experts, including the production team, planning and management, to prepare the work plan of attack. In the plan, are analyzed: the overall objectives and constraints that govern the execution of the work as a whole; the work strategy of attack; indicators that govern planning; the physical arrangement of the work; the pace of the main activities; production methods; matching between the workflow and the production capacity and timing of activities, in order to maintain a continuous workflow.

In the next step, proceed to the preparation of the plans with the aid of a computer program based PERT / CPM. The company is initiating the use of BIM platform. The estimated duration is based on the production methods and the production flow. Planning is thoroughly studied until the end date stated in the contract is reached.

Every day, the schedule is updated and indicators are monitored. The work progress is monitored through comparisons with the initial schedule. The possible causes of delays are analyzed and corrective actions are taken to ensure that the goals set for the week are met.

5.2.5 Comparative analysis of results

Evidence collected in each company were compared analyzed and compared with the assumptions presented in the literature review. The authors summarized

in Chart 1 the results obtained for each unit of analysis in relation to the main assertions found in the literature review.

Anyway, it appears that the recommendations by Ballard & Howell (2003) and Ballard (1994) are not being followed. At the planning stage of the plan preparation process, it was observed that, except for Company A, construction companies adopt the formulation of a strategic plan, albeit informally or embryonic. However, in all the surveyed companies, the collection of information is poor. In general, only it involves the data of budget execution time and the start and end dates of the project. The definitions relating to the deadlines for implementation and start and end dates are set by developers or contractors. Thus, it was realized that decisions on overall deadlines are taken without the definition of production methods, the necessary resources and the completion of the planning, not observing what is recommended by Laufer & Tucker (1987).

Except Company D, it was observed that the estimated deadlines for the services implementation is defined by the level of participants' experience in the planning process. This criterion ignores items such as limitation of resources, harmonization between the amount of work force with the amount of work to be

Chart 1. Comparing multiple results with the main statements of the literature review.

Author	Assumption	Company A	Company B	Company C	Ccompany D
Ballard (1994)	Shortcomings in the planning process: - Planning is not designed as a system, being considered only as a schedule; - Absences measurement and performance analysis and correction of failures of planning.	Planning is charge only as a schedule. Measurements comparing planned and carried out activities. There is a deep analysis of the causes, nor remedy faults.	Seeks the development of a systematic planning, but is not effectively implemented. Measurements comparing planned and carried out activities. There is a deep analysis of the causes, nor remedy faults.	Planning is considered only as a schedule. Measurements comparing planned and carried out activities. There is a deep analysis of the causes, nor remedy faults.	Planning is understood as an important management tool. Measurements comparing planned and carried out activities. There is a deep analysis of the causes, nor remedy faults.
Ballard (1994)	Good planning home the amount of work to be done with the manpower available.	The sub-contractor contract for execution of the services is the management of Labor.	The sub-contractor contract for execution of the services is the management of Labor.	The sub-contractor contract for execution of the services is the management of Labor.	The sub-contractor contract for execution of the services is the management of Labor.
Ballard & Howell (2003)	Interference, such as sharing work and resources, should be considered in planning.	Such interference is not considered in the planning.	Such interference is not considered in the planning.	Such interference is not considered in the planning.	Such interference is not considered in the planning.
Ballard & Howell (2004)	Setting achievable goals is accomplished through a program based on production and on budget, considering the processes through which deliveries of scopes of work (contracts) should be performed.	The targets are drawn from the experience of planners without the analysis of the available resources.	The targets are drawn from the experience of planners in some incomplete productivity data, without analysis of the available resources.	The targets are drawn from the experience of planners without the analysis of the available resources.	Data on productivity and budget are considered in setting the deadlines.

Source: Prepared by the authors (2015).

Chart 1. Continued...

Author	Assumption	Company A	Company B	Company C	Ccompany D
Coelho (2003)	In traditional planning, long-term plans, very detailed, if are the only formalized plans.	Conceives a single detailed plan that includes the work from the initial services to delivery.	Conceives a single detailed plan that includes the work from the initial services to delivery.	Conceives a single detailed plan that includes the work from the initial services to delivery.	Conceives a single detailed plan that includes the work from the initial services to delivery.
Moura (2008)	Traditional planning is strongly based on the critical path method and valuation technique and program review,	Draws up the plans for a basic computer program PERT / CPM.	Draws up the plans for a basic computer program PERT / CPM.	Draws up the plans for a basic computer program PERT / CPM	Draws up the plans for a basic computer program PERT / CPM
Laufer & Tucker (1987)	Plans should not be prepared without the definition of the methods of production and planning methods should precede decision making on resources and deadlines.	The information that guide the planning of the work are: lead time, delivery date, both defined by the developer, and budget, which contains all the resources to be adopted, including how technology construtiva.	The information that guide the planning of the work are: lead time, delivery date, both defined by the developer, and budget, which contains all the resources to be adopted, including how technology construtiva.	The information that guide the planning of the work are: lead time, delivery date, both defined by the developer, and budget, which contains all the resources to be adopted, including how technology construtiva.	The information that guide the initial planning of the work are contained in the contract with the customer. From this contract the risks and taken the decisions regarding the technologies employed and resource management are analyzed.
Formoso (2001)	You must synchronize the teams in order to maintain a continuous workflow	It was noted that to prepare the planning of the work there was a concern with the timing of the teams, but this has been lost along the run.	It was noted that to prepare the planning of the work there was a concern with the timing of the teams, but this has been lost along the run.	It was noted that to prepare the planning of the work there was a concern with the timing of the teams, but this has been lost along the run.	Could not be verified.

Source: Prepared by the authors (2015).

produced, the coordination of multiple interdependent activities, the production environment and the history of previous similar works (learning).

All companies adopt as a planning technique PERT / CPM, although they are considered concepts like activity streams.

The information dissemination stage is well established in all visited sites, usually being used reports and meetings between those responsible for the planning and control of jobs and responsible for production.

The evaluation of the planning process is carried out through a weekly control, except Company D, which adopts a daily control. This control is done by comparing the activities foreseen in relation to implemented, including the updating of schedule. None of the companies has planning reliability indicators. This update normally determines a new delivery date of the work and how many days late are accounted for in the initial planning. In general, the control is not considered as a management tool that feeds decision-making sources.

The design flaws identification is done informally through the attentiveness of the staff responsible for production. Only the failure categories are presented, proving the studies by Hamzeh et al. (2012). Actions are taken without the generation of learning and, in general, do not have the characteristic of maintaining the course of action.

Surveys and interviews showed that construction companies are at different degrees of maturity in relation to the planning and control of jobs. Generalizing, the Works planning in the studied companies is to establish a schedule where the activities for the execution of the

work are described. Planning control is limited to the monitoring of the established schedule. In common, companies adopt a single initial planning, covering the entire implementation period of the project, which reduces the degree of precision of the plan, according to Nahmias (2009 apud in Hamzeh et al., 2012).

In short, it is observed that the process of planning and control in the analyzed companies have the following characteristics:

- Goal setting without programming is based on production and on budget, disregarding the processes through which deliveries of scopes of work (contract) should be carried out;
- Preparation plans without defining the production methods;
- Decision on resources and time preceding the planning methods;
- No conception of planning as a system, being considered only as a schedule;
- Management focused on the monitoring of planned activities;
- Absence of performance measurement analysis and planning error correction.

6 Final considerations

Throughout the literature review, several authors have considered the importance of the process of planning and control work. Companies researched understand this importance and adopt planning and control processes in their works.

Although the literature to present the evolution of the main methodologies and planning and control of work tools, the results of studies conducted in the surveyed companies shows that the planning and control of works is still an isolated sector within companies, without proper integration other departments, such as budget, procurement and design. For the analyzed organizations, the control is not a decision-making tool, which restricted the comparison between planned and executed without corrective actions are taken in order to keep the schedule on schedule and without analysis of the causes to prevent these failures happen again.

The survey results show that despite the evolution of planning techniques, plans are usually drawn only based on PERT / CPM algorithms. In general, the definition of the cycles does not consider productivity data, human resources and interference to share the work and equipment.

Finally, it is concluded that there is a gap between the current state of planning and control found in the studied companies and the bibliographical survey, which shows the main methodologies and identified works control tools. Thus, it becomes evident the need for better integration between academia and the construction industry for the elimination of gaps found.

It should be noted that the survey was restricted to construction on developments in the state of Rio de Janeiro. It is recommended that the study be replicated in other locations in order to verify, at the national level, to validate or invalidate the conclusions.

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