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A Contribution of Methodologies of PMI Project Management and Lean Construction Applied as Entries of Building Projects

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Abstract- With the constant development of the civil construction market, there was a need to innovate and seek alternatives to be always improving their efficiency, whether in quality, deadlines or costs, have led companies to develop new methods and technology to optimize results in all stages of construction. PMI is increasingly established as an excellent path in project management, aiming to optimize results at all stages of construction. At the same time, leveraging the planning and control of works, reducing waste and increasing the added value produced, as well as faster and more flexible planning, make the Lean Construction philosophy essential for achieving better results. Companies are looking for an in-depth study of the project before executing it, which could find or predict problems that were previously only solved in the course of the project, which generated unnecessary waste and expense for the company. When you begin to plan and design the "step by step" of the work, in the stage of project entries, control of project and construction risks, cost forecasting and budgeting, control of the finishing to the contact with the supplier and control of production in execution, it was noticed reduction of time, cost, increase in productivity and quality. With this, companies have been seeking continuous improvements in these methodologies aiming to achieve excellence in the production of the construction industry. The objective of this work is to present the two methodologies and their advantages, through tools, bibliographic review techniques, identifying the methods and processes in each stage of initiation and planning of a project. Showing in the end how it could be applied in a project.

Keywords- *Civil Construction, PMI, Management, Planning, Project Inputs, Lean Construction*

I. INTRODUCTION

Due to economic development, there has been a marked growth in the construction industry, the building sub-sector accounts for 90% of construction companies and 82% of the number of jobs generated in construction. Despite the remarkable importance of this subsector, the reality that is found in the construction sites is an archaic production, which causes low productivity of labor, waste of materials, rework, and a great resistance to the planning of the enterprise (VIEIRA, 2006).

Based on this scenario, the need arose to optimize production, promote improvements in the construction processes and the quality of the final product, creating new rules and / or project management lines with the objective of reducing production costs or shortening the production time execution making the enterprise somewhat more profitable for both the executor and the client.

Through this, the methodologies of planning and management of works are: PMI's project management methodology, which proposes ten principles of knowledge that must be analyzed and executed for the proper management of a project; and Lean Construction's lean construction philosophy that has expanded greatly in the global construction market. Visa develops information technologies in the construction and quality management through tactical and operational actions seeking the reduction of waste and the reduction of cycle times, thus increasing the value of the product, productivity and promoting the continuous improvement of the process.

The construction market has been adopting and adapting more and more to Lean Construction and PMI, taking their techniques to all stages of the building. The goal of such is the need for continuous improvement in the industry and the breakdown of paradigms in the management of construction process in the world.

II. METHODOLOGY

This research will be carried out based on a literature review on PMI and Lean Construction methodologies applied to the entry phase of the project. Initially, it will be necessary to study the theoretical basis of the theme, made from specialized books, theses, websites and articles. The contribution of the work makes an analysis of the possibilities of the synergy or combination of the processes of these methodologies in the initiation and planning phase of residential buildings, as well as the benefits acquired in the following phases of the project.

III. CONTEXTUALIZATION

A. Management in housing projects

According to UN-HABITAT (2007) in 1950, one-third of the population lived in cities, and fifty years later the proportion grew to half the population and continues to grow to two thirds or six billion people by 2050. In many cities, especially in developing countries, more than 50% of the population does not have access to housing, water, sewage, education or health services. As a result, there was an increase in the housing deficit resulting in precarious housing, family cohabitation and excessive rent burden.

According to Vittrup (2005), in 2030, approximately 40% of the world population or three billion people will need the construction of housing and basic infrastructure services, that is, to meet this growing demand, it will be necessary to build 96,150 units per day or 4,000 per hour.

Civil construction stands out as one of the sectors of the economy that most employs labor and approximately 6% of the national GDP are composed exclusively of this branch (VIEIRA, 2006).

The construction segment is characterized by the large consumption of construction material (48% of the consumption of firms with more than 30 employees in 2002) and the high intensity of labor (63% of formal employment in construction in 2004). In this segment, housing construction predominates (with 53% of the works in 2002), followed by other non-commercial buildings such as schools, hospitals, hotels and garages (19%), industrial buildings (15%) and commercial establishments (8 %), according to the IBGE Annual Survey of Construction Industry (PAIC), which collects a series of economic data on construction companies (ABIKO et al., 2005).

Despite the remarkable importance of this subsector, the reality that exists in the construction sites is an archaic production, which causes low labor productivity, wastage of materials, rework, among others (VIEIRA, 2006).

In order to identify the origin of the problems that occur in the execution of the housing project, some of the deficiencies that occur in the projects refer to the content of the project information, such as the lack of justification for the solutions adopted; the lack of descriptive memo, technical discriminations and material specifications; references to standards without specifying their content, the lack of integration between projects, budget, discriminations and places of application of materials, lack of standardization, excessive quantity of materials types, dimensions and suppliers (Mayr, 2000).

This lack of standardization of procedures certainly contributes to difficult reading of the project and to extract from it the information necessary for the execution of the work. Project deficiencies, when referring to decisions in the course of the work, can have as a consequence the loss of productivity, the compromised performance of the built system and the lack of conformity of the work in relation to the project.

Any interruptions in the progress of the project, due to problems related to the project, can be reflected in lost productivity, the need to decide on the project and the project's own deficiencies can compromise the performance of the building and be responsible for various pathologies. In addition, the lack of compatibility between the project and the constructed work, adaptations and changes made during the execution, the professional responsibility when the work is executed in disagreement with the original project, can lead to damages in the performance of the building (Mayr, 2000).

According to ENCOL (1990), improvisation, when addressing its relationship with project professionals, is accompanied by serious damages caused by cost increases, quality compromise and delay in delivery.

The lack of rigor in detailing, decisions made, and the occurrence of wrong decisions, results in cost increases, quality compromise and delay in scheduling, and the possibility of "unpleasant surprises" (Brentano, 1997).

Based on this scenario, significant changes have occurred in recent years in the civil construction sector, with the emergence of new competitors and new materials, as well as the training of managers in tune with the reality of a more demanding market in terms of quality, as the end consumer himself became more aware of his rights (FIGUEIREDO, 2006).

Soon the need arose to optimize the production of housing projects, besides the need to reduce costs and deadlines and the improvement of the construction processes, with reflections on the quality and sustainability of the activity.

The market has demanded from the construction companies a mature management, in many cases causing the systems focus to shift from financial management to rationalization of production. The path usually chosen has been the implementation of quality management systems (ALBUQUERQUE; CARDOSO, 1998).

As a result, Pereira (2008) points out that the construction industry is acquiring new knowledge and technologies, adopting high quality standards, establishing parameters between products, consumers and specialists with the purpose of correcting product incompatibilities and customer dissatisfaction.

However, housing projects still have serious managerial problems; complex projects require a lot of decisions, details, and various interdependencies between project partners. In addition, decisions must be made quickly and often without complete information. Large numbers of people are involved in this process, such as architects, production managers, structural designers and electrical and hydraulic systems, as well as marketing consultants.

Therefore, housing projects need to be planned and controlled efficiently to minimize flaws in the course of the project. The lack of planning in the project results in poor coordination and communication between disciplines, insufficient information to complete the tasks, because of the inconsistency between the projected and the executed, among other problems (PEREIRA, 2008).

According to Netto (1988), we need to improve the stages of the project cycle, that is, the phases of design, design, execution and commissioning, where specifically in the execution phase we are being challenged with regard to integration and development with effective / efficiency of the project, supply, application of financial resources and construction / assembly, as well as the participation of several parties in the process as designers, contractors, suppliers, public agencies, among others the purpose of planning, scheduling, executing and controlling the progress of the works and troubleshoot interfaces that occur.

Therefore, it is up to the management to overcome all these difficulties and a challenge, solving what is necessary, in terms of activities, interferences and interdependencies, in the course of the work, in addition to overcoming the internal resistance of organizations.

For Netto (1988), adopting a Management System has as main objectives to ensure that all the goals are fulfilled during the execution, the optimization of the technical and production performances and the compatibility of the costs in function of the enterprise.

In this context, the objective is to seek to rationalize the productive and business processes, in order to obtain cost reduction, internal and external customer satisfaction, as well as increased competitiveness.

In order to be competitive in the market, companies are looking for management methodologies to improve logistics and process control at construction sites, project entry management and the introduction of simultaneous engineering principles (PEREIRA, 2008).

In view of this, the difficulty in introducing methodologies and / or management philosophies in construction projects is notorious due to their differentiated characteristics. Yet in a world where today everything is being updated with impressive speed, there is no more room to stick to outdated thoughts and methodologies that limit the growth and advancement of a crucial sector in human, economic, and urban development. Consequently, there is a need to introduce new techniques such as the implementation of PMI's Lean Construction philosophy and Project Management.

B. Lean Contruction

Lean Construction arose from the adaptation of Lean Production to the construction industry, and for that, the origin of the Lean Thinking philosophy in the industry will be analyzed initially.

For this to be possible, the Toyota Production System (TPS) came up with the idea of reducing costs and increasing production efficiency by eliminating waste completely. This philosophy of eradicating waste in production is the foundation of Lean Production.

According to Womack et al. (1990), the sets of techniques developed by Toyota allow any company to become more competitive in the market, and thus increase its productive efficiency, manufacturing a greater variety of products, with more quality and speed, even if the market is highly varied and restrictive.This scenario is very similar to the construction market and, for this reason, Koskela (1992) proposed Lean Construction.

The Finnish researcher Lauri Koskela (1992) published "Application of the new production philosophy in the construction industry" in 1992 by the CIFE (Integrated Facility Engineering) linked to Stanford University (USA)).

Koskela (1992) proposes the eleven fundamental principles of the Lean Construction philosophy which are:

- Reduce the share of activities that do not add value
- Increase the value of the product by considering the needs of customers
- Reducing variability
- Reduce cycle time
- Simplify by reducing the number of steps or parts
- Increase output flexibility
- Increase the transparency of the process
- Focus control on the overall process
- Introduce continuous improvement in the process
- Maintaining a balance between improvements in flows and conversions
- Benchmarking

C. Project Management

PMI (Project Management Institute) is a nonprofit international professional organization that brings together project management professionals. It was created by the need of professionals in any productive sector. With the objective of formulating methods for project management; bring together professionals from the field to exchange experiences and knowledge, identify and gather good project management practices, establish an ethics in the profession and certify professionals in the field.

Founded in 1969, based in Philadelphia, Pennsylvania, this important organization is present in more than 185 countries with more than 600,000 affiliated members. Therefore, it is currently considered the world's largest institution in the area of project management, planning and control (LIMA, 2016).

In order for the best development of the project to occur, a professional project manager is responsible and accountable for the establishment of real and achievable for the project and its achievement within the approved baselines. It must manage all the areas and people involved in the project, so that there is harmony between all the components, avoiding friction and interference during the progress of the project, some characteristics of these leading professional, negotiation skills, communication, conflict resolution and problems and strategy (PMI, 2013).

According to the PMI (2013), project management is the application of tools, skills, techniques and knowledge to the project activities required to meet the requirements, it is

imperative for the professional responsibilities to develop and control the project, product requirements, schedule, evaluate risk factors, manage resources, set deadlines, costs and prioritize.

Project management has several processes and is divided into five classes that must be executed efficiently, being:

- Initiation: The processes executed to define a new project or a new phase of an existing project by obtaining authorization to start the project or phase.
- Planning: The processes needed to define the scope of the project, refine the objectives and define the line of action necessary to achieve the objectives for which the project was created.
- Execution: The processes performed to perform the work defined in the project management plan to meet the project specifications.
- Monitoring and control: The processes required to monitor, analyze and control project progress and performance, identify any areas in which changes to the plan will be required and initiate corresponding changes.
- Closing: The processes executed to finalize all activities of all groups of processes, aiming to formally close the project or phase.

The methodology processes, presented in Figure 1, are divided into groups, including "plan", "execute" and "monitor and control", "start" and "close".

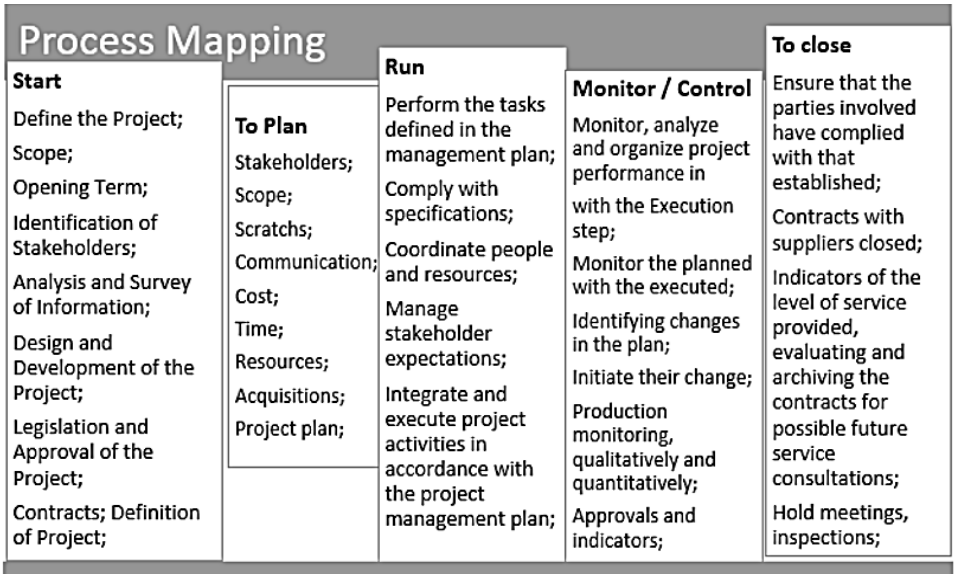

Figure 1. Map of methodology processes.(Source: Author)

D. Practices of the PMBOK

Each of these classes above encompasses disciplines related to different areas of a project, responsible for the operation. These disciplines are divided into ten:

- Integration Management
- Scope Management
- Time management
- Cost Management
- Quality Management
- Human Resource Management
- Communications Management
- Risk management
- Acquisition Management
- Stakeholder Management

IV. RESULTS AND DISCUSSION

According to the analysis and objective of this work, we can notice that the problems existing during the evolution of the project and work are numerous the synchronization between projects and the compatibility between the project and the deadlines established by the contractor. In order to enable the identification of the problems encountered during the design and construction initiation phase, which continue during the execution of the work, as well as the quality of the final delivery. It was considered: the most significant and their interference between disciplines.

Initiation in the life cycle of a project is the time to identify the needs, define the objective, carry out feasibility studies, look for alternatives, recognize the risks, premises and constraints, as well as authorize and define project management.

According to the premise of Lean Construction, it is necessary "to increase the value of the product by considering the needs of the customers". When conducting the feasibility study of the project, in the design phase, it is necessary to develop market research on the preferences of its final customers, with the purpose of adding value to the enterprise.

Based on the PMI and Lean Construction premise, "Focus on the overall process" the next step is to define the project manager, responsible for organizing meetings with the board to show them the viability and importance of the project, and thereby as well as coordinate, monitor and control all steps during the time of the project.

According to Heldman (2006), the project manager must be an expert in various skills and techniques, especially communication, negotiation, conflict management, risk and influence.

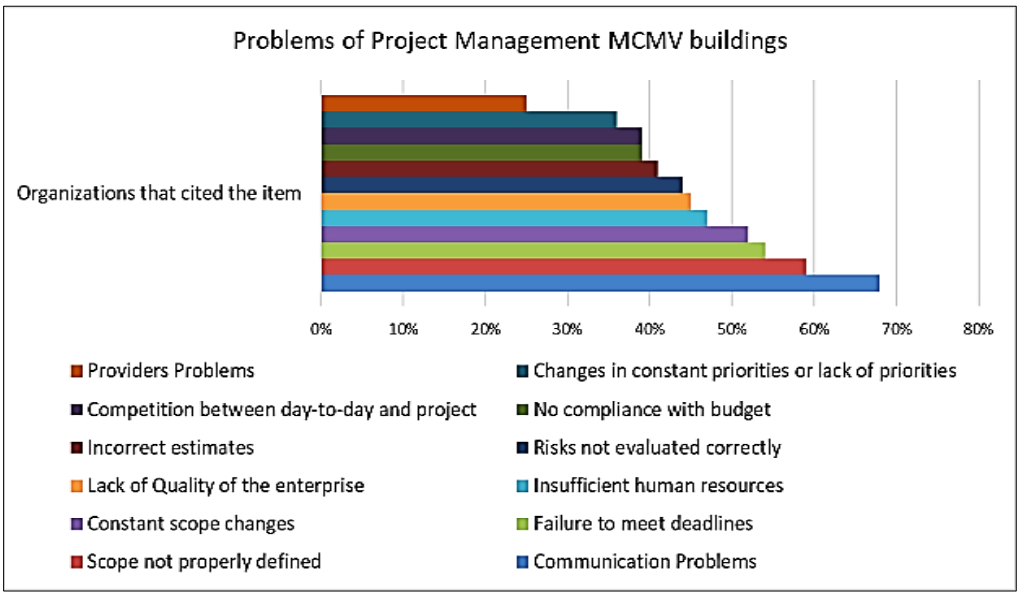

Figure 2. Problems that frequently occur in housing. Source: Benchmarking Study on Project Management 2013 (adapted).

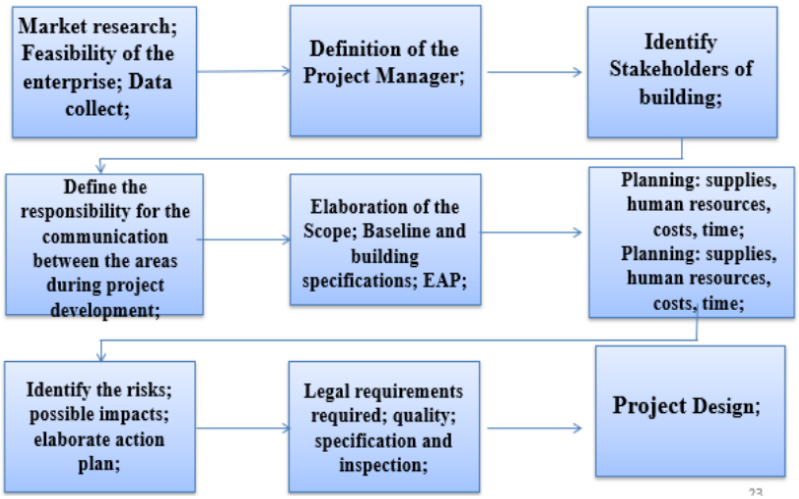

Figure 3. Flowchart of the sequence of activities in the initiation and planning phase of the building. Source: Author.

During the first phase of the project, stakeholders are also identified. It means listing all possible people, groups or organizations that have some type of interest in the project, evaluating the degree of interest, in order to classify who the manager should give more to become or remain a supporter of the project, or remain in that position. After this identification, the manager collects the specifications and expectations of the Stakeholders throughout the work life cycle and develops a strategic management plan that defines the baseline of all work throughout the enterprise.

Communications management is responsible for organizing the weekly meetings that must take place, bringing together all those stakeholders who discuss issues related to building, executive processes and service approvals. Provides detailed planning of all areas of management of a building project.

According to the Lean Construction philosophy, "Increase the transfer of processes" decisions should be recorded, which are usually not explicit, so that the same subject is discussed more than once, or the decision is changed at the time of execution, in the absence of a communications plan, often ends, causing losses in the production, since the absence or deficiency in the strategy causes interruptions in the execution, impediment of the beginning of certain activities and rework in others.

From this, the parties most relevant to the project should participate in the development of the scope, indicating their interests and desires through meetings.

The definition of the Project Scope in a building must be done properly so that there is no margin for doubt or misinterpretation, thus avoiding problems with stakeholders and customers, as it will prevent the occurrence of something that is not specified in the contract. The Scope is divided into four processes: Scope Management Planning; Requirements Collection; Definition of Scope; and Creating the CAS. And it is the management of the scope that defines how it will be executed, monitored, measured and finalized, one of the sub activities that is contained in the project management plan.

According to Ohya (2004), the scope is the way to describe the rights and obligations between the entrepreneur and the contractor. To do this, you need to collect the project requirements, identify the scope objective, and define the customer's expectations.

Scope management clearly defines what should be done during the project and how it will be done. This definition will be made on the basis of project studies and constraints such as feasibility studies, neighborhood impact study, local legislation, economic feasibility study, topographic analysis and needs study.

Scope divisions should be created so that you have a detailed level of information, including a checklist that will tell you what the expected results of the project are.

The EAP or analytical framework serves as a summary of the work, and a guide to contract management. And according to project progression, the plan can and should be reviewed and updated with the latest information gained (HELDMAN, 2006).

The elaboration of the CAS will disaggregate each scope goal into activity packages, making them closed for execution. The criteria, constraints and assumptions established in the scope are used.

Project planning should be performed on a preliminary basis to estimate the timing, cost, procurement needs, HR, quality, and analyze project risks.

To begin planning the analytical structure of the product, the definition of the product should contain in a clear and objective way what is contemplated in the project. The scope definition is a detailed list of the products that will be provided or contemplated in the project.

Planning initially defines what resources are needed to carry out the project. A list of activities - people, materials, facilities, suppliers, etc. - is made at that time. (SABINO, 2016)

Usually the resources needed to carry out the activities are labor, permanent material, equipment, facilities, consumables and services such as travel, transportation, lodging, specialized technical services. The effective Human Resources management aims at motivating the team by clarifying the role of each one during the work, leaving explicit the importance of teamwork and individual dedication, responsibilities with information on the degree of involvement and assignment of employees on determined and individual and team skills (PMI, 2013).

The main objective of the Procurement Management process is to avoid contractual fraud, to reduce risks, to describe necessary products and services, to determine evaluation criteria and to monitor costs and performance, to define standardized documents and to identify prequalified suppliers.

The supply sector, which is responsible for the procurement and contracting of all works, quotes, and after acceptance of the work, the material, equipment or contractor, is hired. The entire process is time-consuming, requiring that your request be planned in advance that is not always guaranteed due to the particularity of the work with its sponsorships and scope releases (SABINO, 2016).

Therefore, according to the premise of Lean Construction, "Reduce cycle time", and the sector aims to purchase purchases previously, with available resources the schedule can be followed according to their forecast since, the materials are available within long, medium and short term.

After scoping planning and finalized resource forecasting, the manager will have all the necessary information of the design steps and time. It is these decisions that establish when activities take place. The main processes of this management are: Definitions, Sequencing, Estimate of Resource, Estimation of Duration of Activities, Development and Control of the Schedule of these Activities.

According to the Lean Construction principle, seeking improvement in processes, "reducing the share of activities that do not add value", "simplifying by reducing the number of steps or parts," by eliminating and improving activities. Proper

planning of the sequence of activities aimed at efficiency at the construction site, when sequencing the activities the manager can control the order of execution and the need for labor and their quantity at each stage.

Therefore, it is critical to "reduce downtime" and simplify processes by working out a workable schedule, without unnecessary mooring, which will increase the duration of the project as a whole. To better visualize the project regarding the administration and management of the time, there are techniques of programming and graphical representation to define the time of each activity and how they relate (Sabino, 2016).

In the timeline is a technique through micro tasks that must be identified with codes, and sequenced, so as to allow a clear perception of what activities depend on others and the duration of each of them. Often companies use the GANTT schedule, which by means of their "predicted" and "accomplished" bar graph and arrows indicating relationships II (Start-Start), TT (Term-Term); IT (Start-End), and IT (End-Start), illustrate the path the work should take to achieve its goals (RODRIGUES, 2013).

The timeline also specifies the resources used in each task among them: human, materials, and equipment. The manager is responsible for putting this information down by dosing these resources in a way that achieves their goals with respect to time and cost. Soon the project schedule is a component of the project management plan, for evaluation and monitoring of the progress of the enterprise.

Cost and budget management are often handled during the development of the work as a whole. With each new stakeholder interest, a spreadsheet contemplating part of the overall scope is formulated. The manager is responsible for carrying out the costing of each activity, evaluating materials, equipment, procurement of subcontractors, and maintenance of labor administration.

Therefore, it is used to quotations, and experiences of other works for the elaboration of the budget. Once the cost has been defined, a profit margin is calculated on the execution of these activities, reaching a sales value, which must be within the total amount of the sponsorship and then presented for approval (SABINO, 2016).

The budget should contain a schedule, costs for the development of the project being direct expenses, as well as profits, taxes, overhead. The budget is a project summary or financial schedule, which tells you how and when resources will be spent and what sources they will come from.

From the budget the manager will define those involved in the project as the suppliers. The budget should be done with the highest level of detail possible, as it is the cost planning that will define whether the project will be feasible or not from a financial and economic point of view.

The next step is to perform previously internal or external events that are uncertain, and that if they happen in the course of the process will have positive or negative effect on the project. Usually, these risks can influence the progress of the work causing losses and damages. Thus, an evaluation is made of everything that was previously planned, in which uncertainty factors present in a given context are systematically identified, analyzed, estimated, categorized and treated.

According to the premise of Lean Construction, "Benchmarking" that aims to increase the competitiveness of the company and, as a consequence, implement the concept of "continuous improvement in the process", is directly linked to the risk planning phase. So the manager must analyze the risks qualitatively in order to define priorities, since the lack of time and resources prevents them from being treated with the same attention.

The impact analysis is carried out that each risk will cause if it occurs, generating a ranking of attention to the most dangerous threats or the most advantageous opportunities for the work, as well as in the elaboration of strategies and practical actions that can eliminate, mitigate the threats so that the work cannot be surprised by problems that can cause delays, costs, accidents or fines (Sabino, 2016).

For a well-executed planning, attention must be paid to the final quality of the work, quality management is responsible for the acceptance criteria of the products and services produced in a work, and it must be present in each service to meet the minimum requirements of evaluation criteria, as will be verified in the field, margin of tolerance for inspection and release of services, preventive and corrective actions, and performance improvement goals, so as to avoid problems with productivity, changes of scope increase cost or rejection stakeholders. (Pereira, 2012)

According to the principles of Lean Construction, "reducing the variability" in which the building will become more uniform generally brings more satisfaction, since the quality of the product corresponds exactly to the previously established specifications, as well as "focusing on the overall process" of the work makes possible the identification and correction of possible problems that could interfere in the term or its quality.

After planning the scope, schedule, budget, resources, risk and quality plan, the project manager must make an analysis of the client's specified "checklist" requirements, as well as consider legal and regulatory obligations and requirements such as service technical standards, requirement for approval in the fire department, in the city hall, regional council (CREA) and analysis of the risks related to the impact on the environment, to proceed to the design phase of projects.

Lean Construction principles emphasize that projects should be developed to reduce variability and cycle time, increase flexibility, and rationalize the stages, functionality, sustainability and quality of projects. In determining the type of project, consideration should be given to the location and size of the land available for the development to be developed, and to the appropriate infrastructure, urban, community and service facilities.

According to the PMI, the development of the projects should be carried out in order to integrate the different areas involved (geometric, drainage, architecture, structure, installations, paving, geotechnics, etc.) in order to avoid

incompatibility of projects, rework, time and unnecessary expenses, in order to meet the requirements specified in the scope. In addition, use of spaces, contemplating a feasibility study of materials and technologies that provide better performance at a lower cost, standardizing whenever possible and detailing more efficiently, in order to minimize possible doubts during the execution.

The projects designed in an integrated and streamlined way allow a greater standardization by systematic repetition of the activities, ensuring a faster execution speed, reducing material waste, contributing to higher productivity and reducing the final cost of the work.

V. FINAL CONSIDERATIONS

The present work intends to highlight problems related to management in the entrance of projects of works of popular housing, it was noticed resistance in the civil construction sector that still prevents many techniques being applied effectively, as well as, the misuse of the tools , the lack of clarity, training and understanding of the systems.

However, the sector is in a moment where companies need to stand out in order to stay in the market, aiming at efficiency in production, reducing waste and meeting the deadline and quality established in the baseline.

Based on this perception, the main objective was to study and present two of the main project management methodologies applied to housing projects, we can verify that PMI and Lean Construction do not overlap but complement each other during the development of an enterprise. PMI has a focus on the project management part of the project start-up phase and Lean Construction with an emphasis on planning and execution, using techniques to reduce expenses, meet schedule and increase productivity.

The work showed, in a simplified way, through a survey of specific bibliography, how these management methodologies would be applied to the design of a building and the ease of adaptation of the method put into practice, which only requires more time, greater financial resources and a specific training to the employees of the company who will participate in this process.

The process of applying management and planning tools was an effective way to improve organizational performance, reduce project time, eliminate waste, reduce operating costs, eliminate activities that do not add value without losing quality of service , avoid incompatibilization of projects, lack of communication, insufficient resources, lack of specifications and customer and stakeholder dissatisfaction.

The construction market has increasingly demanded efficiency and quality at an increasingly lower cost. With this change of paradigm implanted in the works, the results obtained, both with respect to the quality and the one that refers to the productivity, certainly were significant. It is clear that the concept becomes more effective when applied at the project entry stage, serving as a balancing tool between planned and executed activity flows at the construction site.

Thus, it is expected that the work has clarified doubts regarding the application and stages of this process, identifying the advantages of these methods and describing the step-by-step stages of project entry to project design and legalization.

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