APPLICATION OF THE PRINCIPLES OF LEAN THINKING IN THE POST WORK CONSTRUCTION DEPARTMENT

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ABSTRACT

The increase on the competitiveness, the search on the customer satisfaction, the search by reducing waste in civil construction were facts that helped entrepreneurs and companies to seek new ways of working, being lean construction one of the ways to get that. Studies report that the application of the *Lean* tools in construction was carried out in an isolated way. This type of application was pointed as a major fact limiting the extent of achievement in implementing *Lean* principles. The aim of this studies is to identify opportunities to implement the principles of *Lean Production* in the service department of a construction company in Goiás, proposing routines that try to implement the continuous improvement of its processes, eliminating waste, reducing the *Lead Time*, allowing it to perform the mapping processes, improving the way records of requests for technical assistance, among others. For data collection it was carried out a semi-structured interview in four construction companies. Through the analysis of the responses, some Lean tools were developed like flowchart mapping of activities, an action plan for preventive maintenance and an application form for technical assistance, focusing on helping small and medium construction building companies to structure a Post Work Construction Department ruled on the Lean principles (pull, perfection, value stream). It was concluded pointing out some difficulties in the implementation of lean principles in the department and emphasizing the Lean concepts that can be presented within the activities of the Post Work Construction Department.

KEY WORDS: *Lean Production. Lean Thinking*. Technical Assistance. Post Work Construction.

1 INTRODUCTION

Civil construction is extending and it is changing the thinking of many entrepreneurs. From 1990, the growing competition between companies, the increasing on the costumer's requirements and the reduction of financial resources were important facts for changing the company's way of thinking, encouraging companies to seek the highest levels of performance through investments in management and production technology (Lorenzon; Martins 2006, Costa; Azevedo; Barros Neto 2010).

Many companies believed that one way to gain competitive advantages are summarized in the adoption of some initiatives that generates increasing productivity and quality in their products. Some managers in an attempt to combat the

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competitiveness, tried to acquire new ways of management in an impulsively way, without planning or knowledge. Within this scenario, the use of Lean practices, from the Toyota Production System (TPS), presented as an alternative capable of providing greater productivity and competitiveness for organizations (Macedo 2010). It happens due to the fact that Lean Construction is based on the success of all processes and it is directly related to their management (Koskela, Bertelsen, Bosch 2004).

Due to the gain on productivity and the reduced rates of waste on construction sites, several civil construction companies found out many ways to improve its process, implementing the Lean principles into the companies (Picchi; Granja 2004).

Barros Neto, Alves e Abreu (2007) emphasize in their studies that the literature still debates a little about the strategic issues involved in implementing the concepts of *Lean* Construction.

The civil construction activities are complex and present some specific characteristics. Picchi (2003) points out some opportunities for the application of these concepts in some areas of the civil engineering field that have not been explored yet, such as the Post Work Construction Department, or the ones that were implemented in an isolated way. These are the reasons that provided some limitations into the extension of the results obtained and new opportunities for the integration of concepts (Picchi; Farm 2004).

2 LITERATURE REVIEW

This paperwork is structured into five Lean principles: flow, value stream, value, pull, perfection. It was proposed by Womack and Jones (1998), due to its broader scope and due to the fact that it is more widely used in the industry (Picchi 2003).

Continuous improvement on production, the highest customer's satisfaction, the use of less resources and elimination of waste on the process are some of the goals that the *Lean* principles try to achieve within the organizations (Costa; Azevedo, Barros Neto 2010). Authors like Nahmens and Ikuma (2009) also cites the importance of the application on *Lean* tools to provide a safer working environment for employees, reaching incidence rates of occupational accidents about 58% lower than those companies that did not use the *Lean* tools. The concepts of the principles can be contextualized as follows:

Understanding what *Value* is for specific products from the point of view of the final customer, it is the first major challenge for the implementation of *Lean* Construction (BATTAGLIA 2007). It is a process that identifies what value is for customers by offering products with greater value aggregates, without waste and with values that customers are willing to pay. It is necessary that the decision of building companies to produce certain types of products must be based on the needs and desires of its target customers and not only the productive capacity of the organizations (Lean Institute Brazil 2011; Almeida 2009; Hicks 2007, Salerno 2005; Picchi 2003).

Identifying the *Value Stream* consists on separating actions of the production process into three types: actions that add value to the end customer, actions that do not add value but are important for maintaining the quality of the products and processes, and actions that do not add value and should be eliminated immediately (Lean Institute Brazil 20112011). The objective of the value stream mapping is to understand the process' flow, materials, people and equipment. It helps to reduce the variability of products, waste and enhance transparency procedures (Almeida 2009; Hicks 2007; Picchi; Farm 2004; Picchi 2003).

Getting a *Continuous Flow* processes it is intrinsically linked to the transparency and knowledge of the execution steps of the product. Obtaining the continuous flow

involves several departments, in which interruptions cannot occur; therefore changing the mindset of the organization and getting the support of the top management are important facts in order to achieve this goal. Benefits such as reduced *Lead Time*, which represents the time of product design, order processing and inventory, eliminating waste and adding value to the final customer are consequences of the implementation of a continuous flow production (Lean Institute Brazil 2011, ALMEIDA 2009 ; Santana 2009; Hicks 2007; Picchi; Farm 2004).

The ***Pull Production*** allows the company to produce their products from the final customer demand (Takt Time), in the right amount at the right time (Just-In-Time). Smaller amounts of stocks, elimination of waste or unproductive time, and an increase on productivity are some benefits achieved by the building companies (Lean Institute Brazil 2011, Santana 2009; Hicks 2007; Picchi; Farm 2004).

Perfection matches the pursuit for continuous improvement, to the search for improvement, continuous learning, transparency and standardization of processes, fast fault detection and problem's solution for waste disposal. These are some of the ways to raise the performance of products in order to seek improvements (Lean Institute Brazil 2011, Almeida 2009; Santana 2009; Hicks 2007; Picchi; Farm 2004; Picchi 2003).

Among the opportunities for implementing *Lean Thinking* in construction, Picchi (2003) cites some tools that can assist the integration of concepts until their implementation. Table 1 is a proposal of adapted tools from Picchi (2003) for better visualization of *Lean* principles in Post Work Construction Department.

Table 1 - Relationship between the objectives, principles and proposals for the application of *Lean* tools

Objectives	Five principles of *Lean* Construction	Proposals for the application of Lean tools at the Post Work Construction Department in Construction Companies
- Creating working routine	Value	Rationalization of the stages on customer service;
		Reduction of service time - Lead time;
		Work performed in parallel;
		Perform quality services on time;
		Identify customer requirements through evaluations of customer's satisfaction with services provided at the end of the process.
-Flowchart Mapping	Value Stream	Mapping the value stream and routines that eliminates steps that add no value to the customer;
		Creating a map of the flowchart steps that causes the most problems in the process;
		To carry out preliminary inspections to verify the actual severity and the causes of the requests to assist in the dimension of the staff and equipment needed;
		Forming partnerships with suppliers, so the delivery of materials could be done quicker;
-Reducing waste	Flow	Creating work cell with multifunctional professionals ;
		To turn a workforce available to do the job without the interference of other departments, like other construction fields;
		Creating the work instruction (WI's) to the Post Work Construction Department;
		Creating some indicators of productivity and time for assistence on solicitations.
-To increase the transparence in the process	Pull	Takt time – Rhythm demand – It is necessary a solicitation by the client;
		Propose a plan of periodic inspections within the guarantee period of 5 years after the release of the building or construction, in order to verify if the maintenance is being done, avoiding future solicitations or pathological manifestations.
		Enabling the workforce to develop several tasks;
-Eliminating some stages that do not increase value to the client	Perfection	The responsible for the management of the department will be an engineer or an architect;
		Creating a self-manageable and Post Work Construction Department structured;
		Training the workforce on the *Lean* practice;
		Effective communication;
		Propose a more didactic manual's property and make speeches about the importance of building's maintenance in its lifetime;
		Create a database that enables to include helpful information into the productive system, in order to avoid future failures;
-Reducing time on assistence		Make periodical training with the building manager;
		Make meetings with several facilities of the company, looking forward to exchange knowledge to seek continuous improvement on the processes;
		Strategic commitment from the top management in application of *Lean* tools.

3 OBJECTIVES

The objective of this paperwork is to identify the opportunities on the application of the five *Lean Thinking* principles: (*flow, value stream, value, pull, perfection)* at the Post Work Construction Department from Construction Companies (Womack and Jones, 1998).

4 METHODOLOGY

According to the proposed objectives, this research paper is exploratory, because it seeks a better understanding and improvement on methods of application of *Lean* tools in the Post Work Construction Departments of building companies. The methodology used to write this paperwork fits in action-research, considering that some researchers are involved in some of the companies that were part of the collected data.

On the first step of the paperwork, it was done a literature review on the five principles of Lean Thinking (Value Stream, Value, Flow, Pull and Perfection). Later, it was made a connection between the research objectives, the five principles of Lean Thinking and Lean tools that could be used within the Post Work Construction Department of building companies.

On the second step, it was thought to conduct a study of several cases to acquire knowledge on how the Post Work Construction Department of the state's construction companies is developed in relation to *Lean* practices. In order to get that, it was developed semi-structured questions for interviews with the responsible for the Post Work Construction Department of each company. Five consolidated building companies in the state's market were chosen, working on civil construction industry for vertical multifamily housing developments.

Among the participating companies, the company D is the only one that does not have a Post Work Construction Department formed, but due to the volume of works that have been delivered and are being implemented, the top management department noted the need to implement a Post Work Construction Department in a near future. The top management support and the participation of a member from the technical group of employees were decisive steps for the building companies to develop the guidelines for the department, which will support its implementation.

Some specific goals may also be listed, such as: align routine actions with strategic goals and map the process flow related to the use and maintenance of buildings, which may be a difference on the search for strength and profitability of the companies (Costa; Rola; Azevedo 2009).

As a way of supporting the objectives of this paperwork, using the literature, some of the tools were selected within each principle of *Lean Construtction* presented in Table 1, developing *Lean* tools adapted to the Post Work Construction Department of a building company like: analysis of the flowchart mapping and *Lead Time* activities, Planned Inspections and Technical Support Form.

5 DATA COLLECTION

Semi-structured interviews were performed in each company, trying to understand the organization of the Post Work Construction Department, its activities and its principles. The questions are presented below:

- Is there a Post Construction Department which carries out the technical assistance?
- How is the procedure for technical assistance since the customer's request until the delivery of the service conducted by the company? Can the company describe it?
- How is the assessment or refusing requests for customer service?

- Are there flow charts or work instructions that the company has adopted to standardize the technical assistance?
- Are staffs trained to perform these services? Is a qualified professional who performs the first inspection? Is this professional registered on CREA?
- How long does the building company usually take to meet the maintenance demands of customers (for example, first contact with the client, and schedule for completion of the service)? How is the delivering evaluation of the services performed?
- How are requests registered and monitored (tabulate and store)? Is there any way of tabulating these data to feed back into the production system for the next projects?
- How many projects have the company built over the last five years?
- Does the company welcome the idea to develop a Post Work Construction Department as a preventive measure to meet future requests of its customers in a faster and better way?
- Is there an indicator developed in the Post Construction Department as a way to produce and control the services performed, and an indicator for customer's satisfaction?

6 DATA ANALYSIS

The business' identification will be protected, each being assigned a company identification by means of letters, starting with the company A, following by company B and so on. All the companies contacted were receptive to answering all the questions raised on the interviews. The heads of companies A, C and D participated into the semi-structured interview to answer the questions, but the responsible for company B answered the questions electronically.

Regarding the existence of a Post Work Construction Department, companies A, B and C stated that there is such department, with some variation between them due to the volume of works to be met, since the company D sees the need to create such a department in a near future for its customers.

Regarding to the procedures of the companies A, B and C, they have some operating procedures called "Operating Procedures - OP", by others "Execution Procedure and Service Inspection - EPSI" or even "Work Instructions - WI". Company D is trying to develop its procedures. The company B and C mentioned that the disclosure of their documents is not a practice carried out by the company and therefore they could not turn their operating procedures available.

It is a common practice in all the studied building companies, all the requests made in by the customers must be made in hand writing or by telephone to the Technical Assistance Department of the company. All the requests are usually received and the Department contacts the costumer in order to schedule the date of the inspection, conducted along with an engineer or technician responsible for the Department. The occurrence will be registered and proceed with the execution of the service, material's mobilization, equipment and labor work requirement.

According to the interviews, in some cases, the first inspection in Company C is not performed by the engineer responsible for the Post Construction Department, but by someone encharged which is not recommended, due to the fact that the recording and analysis of the causes are not made by someone with a formal technical knowledge . Companies A and B confirmed that the first inspection of the customer's request is made by the engineer responsible for the Department.

At the end of each Technical Assistance Service, the department conducts a quest with the client regarding to its services. In order to manage the Technical Assistance Services in common areas, the engineer adopts the same procedure used for the units,

but the building manager is responsible for requesting and tracking the services. All the building companies, except Company D, there is a Summary of Requests for Technical Assistance which is presented in a technical meeting at the end of the month in order to discuss with all the stakeholders, trying to take corrective and preventive actions whenever it is necessary.

In the evaluation related to the time required to meet the request, it was found that there are different times of attendance. The average time that building companies usually ask to make the first contact with the customer to provide a feedback to a request for technical assistance and to schedule a technical visit is 24 hours to 48 hours. Regarding to an implementation of a service, there is no accurate time required for completing the service, considering that there are variations due to the type of problem to be solved, ranging from one day to one week.

6.1 FLOWCHART MAPPING AND *LEAD TIME* OF ACTIVITIES

In Table 1 it can be observed that the flow mapping and elaboration of the mapping activities of the Post Work Construction Department can be fitted in search for the attendance on the *Lean* principle. Relating to the Value Stream and the attempt for reducing the *Lead Time* activities it can be seen as a service to the *Lean* principle related to the **Value**. Figure 1 shows how the activities of the Post Work Construction Department were identified and their respective estimated *Lead Time*. Figure 2 represents the proposed activities for the Post Construction Department and the respective reduced L*ead Time*.

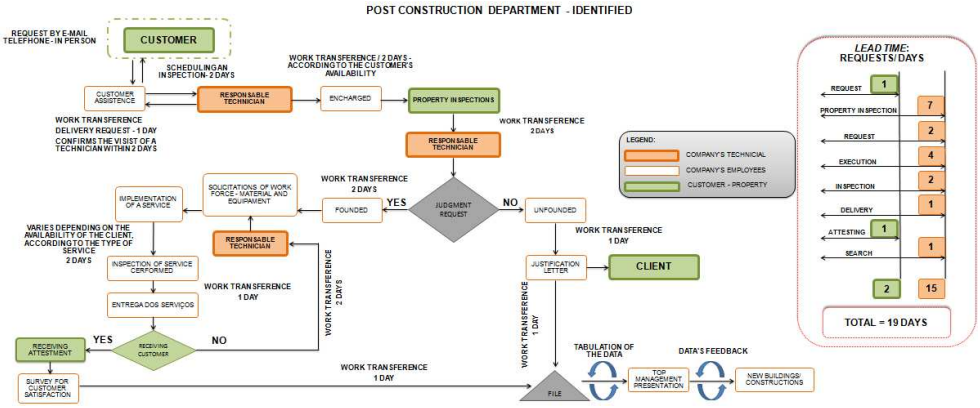


Figure 1: Identified activities in the Post Const. Department and estimated Lead Time.

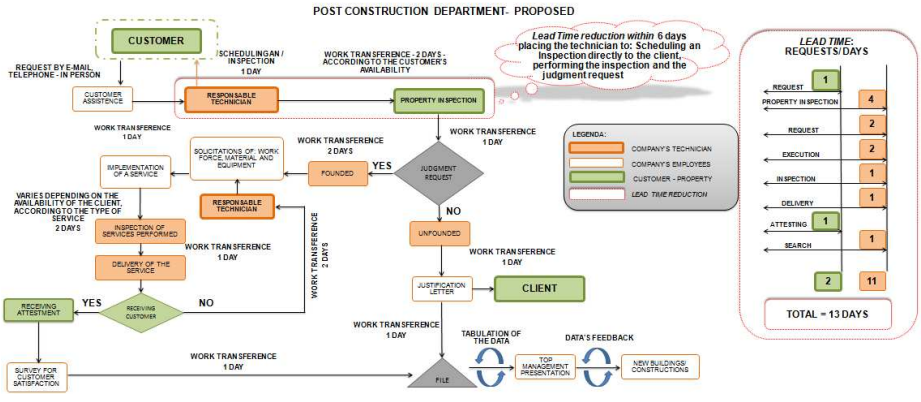


Figure 2: Proposed activities for the Post const. Department and the reduced L*ead Time*.

Reducing *Lead Time* at a Post Work Construction Department was only possible with the implementation of a technical assistance (Architect or Engineer) which is in direct contact with the client, setting up an inspection directly to the Technical/ Customer. The preceding judgment by the Technician is important, due to the fact that sometimes, this previous judgment could be done at the inspection. Beforehand, due to the fact that it was someone encharged to do the inspection, he or she did not have that authority and sometimes, he or she did not even have the appropriate knowledge.

After the solicitation judgment, the technician used to do the quantification of the technical staff, materials and schedule of the activities. The technician used to follow the inspection with the client and he or she used to release the service to the client. This monitoring and final inspection before releasing the service to the customer, it was possible to detect problems within the implementation and future measures by the receiving client. It was found that the presence of a technician at all the stages helps to reduce the variability and a reduction for errors and delays in delivering services to the customer.

6.2 Planned periodical inspections

In order to propose a tool based on the *Lean* principle referring to the **Pull** concept, it is presented a way of planned intervention, based on preventive maintenance of buildings, in order to increase the useful life of buildings thus restoring a satisfactory level of performance for buildings. The implementation of these maintenance services may be offered by their own construction companies to the customers, via contract, so that the construction company can perform the services required, guaranteeing the final product. In Figure 3, it is proposed an action plan with the frequency of preventive maintenance and inspections for building construction system that must occur from time to time in advance, from the release of the project.

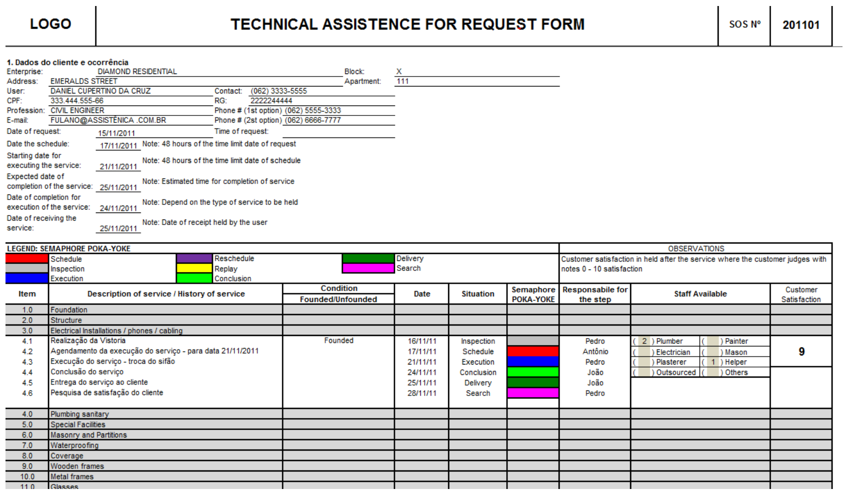
PERIODICITY OF PREVENTIVE MAINTENANCE AND INSPECTIONS												
ITEM	TIME / CONSTRUCTIVE SYSTEM	6 MONTHS	1 YEAR	1 YEAR AND A HALF	2 YEARS	2 YEARS AND A HALF	3 YEARS	3 YEARS AND A HALF	4 YEARS	4 YEARS AND A HALF	5 YEARS	FREQUENCY OF SERVICING
1	Structural Masonry		•		•		•		•		•	Every 4 years.
2	Frames and Hardware		•		•		•		•		•	Every 2 years.
3	Concrete structure		•		•		•		•		•	Every year.
4	Metallic structure						•					Every 3 years.
5	Waterproofing	•	•	•	•	•	•	•	•	•	•	Every 2 years.
6	Hydraulic installation		•		•		•		•		•	Every year.
7	Sanitary wares and sanitary metals	•	•	•	•		•		•		•	Every 2 years.
8	Electrical Installation		•		•		•		•		•	Every 2 years.
9	Wall coverings	•	•	•	•	•	•	•	•	•	•	Every 2 years.
10	Inside and Outside painting				•				•			Every 2 years.
11	Covering system	•	•	•	•	•	•	•	•	•	•	Every 6 Months.
12	Glasses		•		•		•		•		•	Every 2 years.

Figure 3: Periodicity of preventive maintenance and inspections

6.3 Technical Assistance Request Form

The objective of proposing a form for Technical Assistance Request is to help small and medium construction companies in structuring a Technical Service Department and therefore meet the *Lean* principle referring to *Perfection*, seeking to standardize the records, increasing transparency and services' control. The form will enable the company to register all the customer's requests, monitoring all the stages of the

services' execution, record costs from each request, the amount of staffs required for each type of activity, the engineer responsible for implementing each step and the search for customer's satisfaction. For the preparation of a Technical Assistance Request Form, it was used the Microsoft Office Excel 2007 program, along with concepts of a Semaphore Poka-Yoke (Zarate et al. 2011), which is a tool for foolproof, in order to facilitate the visualization of the steps performed. In order to illustrate the use of technical assistance request form, Figure 4 illustrates a filled form for hydro sanitary technical assistance instalation.


LOGO | TECHNICAL ASSISTENCE FOR REQUEST FORM | SOS Nº 201101

1. Dados do cliente e ocorrência
Enterprise: DIAMOND RESIDENTIAL | Block: X
Address: EMERALDS STREET | Apartment: 111
User: DANIEL CUPERTINO DA CRUZ | Contact: (062) 3333-5555
CPF: 333.444.555-66 | RG: 2222244444
Profession: CIVIL ENGINEER | Phone # (1st option) (062) 5555-3333
E-mail: FULANO@ASSISTÊNICA .COM.BR | Phone # (2st option) (062) 6666-7777
Date of request: 15/11/2011 | Time of request:
Date the schedule: 17/11/2011 Note: 48 hours of the time limit date of request
Starting date for executing the service: 21/11/2011 Note: 48 hours of the time limit date of schedule
Expected date of completion of the service: 25/11/2011 Note: Estimated time for completion of service
Date of completion for execution of the service: 24/11/2011 Note: Depend on the type of service to be held
Date of receiving the service: 25/11/2011 Note: Date of receipt held by the user

LEGEND: SEMAPHORE POKA-YOKE
Schedule, Inspection, Execution, Reschedule, Replay, Conclusion, Delivery, Search

OBSERVATIONS
Customer satisfaction in held after the service where the customer judges with notes 0 - 10 satisfaction

Item	Description of service / History of service	Condition Founded/Unfounded	Date	Situation	Semaphore POKA-YOKE	Responsabile for the step	Staff Available	Customer Satisfaction
1.0	Foundation							
2.0	Structure							
3.0	Electrical Installations / phones / cabling							
4.1	Realização da Vistoria	Founded	16/11/11	Inspection		Pedro	(2) Plumber ( ) Painter	9
4.2	Agendamento da execução do serviço - para data 21/11/2011		17/11/11	Schedule		Antônio	( ) Electrician ( ) Mason	
4.3	Execução do serviço - troca do sifão		21/11/11	Execution		Pedro	( ) Plasterer (1) Helper	
4.4	Conclusão do serviço		24/11/11	Conclusion		João	( ) Outsourced ( ) Others	
4.5	Entrega do serviço ao cliente		25/11/11	Delivery		João		
4.6	Pesquisa de satisfação do cliente		28/11/11	Search		Pedro		
4.0	Plumbing sanitary							
5.0	Special Facilities							
6.0	Masonry and Partitions							
7.0	Waterproofing							
8.0	Coverage							
9.0	Wooden frames							
10.0	Metal frames							
11.0	Glasses							

Figure 4: Filled form of technical assistance for hydro sanitary installation.

Figure 5 presents some results that can be obtained by the tabulation of some data's request.

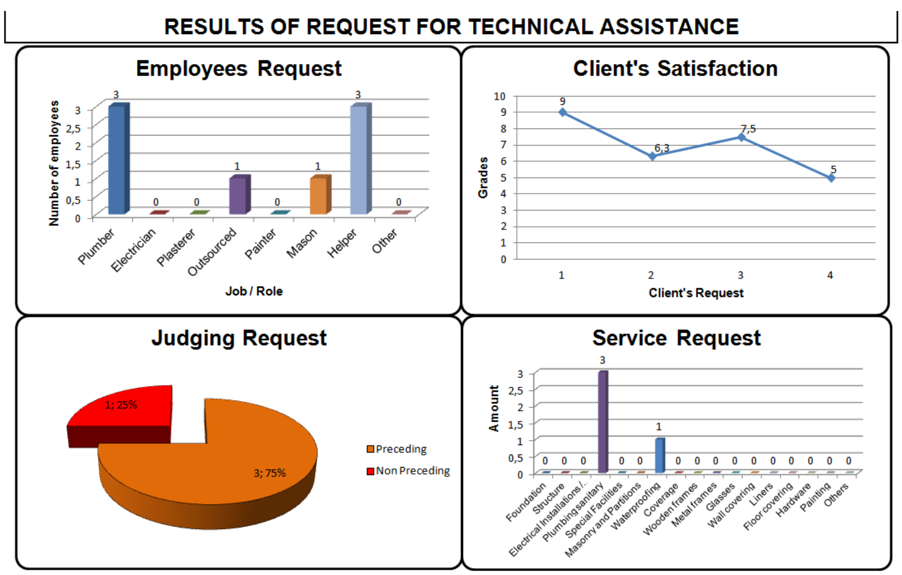


Figure 5: Presentation of some tabulated results from technical solicitations

7 CONCLUSION AND FINAL CONSIDERATIONS

The contacted companies proved to be aware and understand the importance of a Post Work Construction Department and its activities with the customers, considering that the technical assistence is part of the life cycle of a building.

Among the difficulties found, it is possible to mention the measurement of the average time for service's requests, considering that the *Lead Time* will have a considerable variation related to the type of activity that must be developed to meet the clients' request.

The demand is another important key point for the analysis, because some companies do not pursue enough demand to keep a specific staff to the Post Work Construction Department, so the employees are required to go to another type of services and when it is necessary, they are called, and then they leave the service that they were performing to meet the request for technical assistance.

Breaking the production flow when removing an employee from a working site, to run another service is a fact that occurs, and therefore it must be taken into consideration on the planning activities of these employees, since according to the *Lean* principles, breaking a continuous flow of activities must be met. One way to compensate for this break flow would be analyzing the requests monthly, verifying the services with higher demands and promoting the appropriate training to employees so that they become multi-functional employees, specializing the work force.

It was observed that there are many points that can be improved in the Post Work Construction Department with the Lean tools, and the proposed Operating Procedures, Technical Request Forms, Flowchart Mapping of activities, planning in the inspections in advance were some used tools on this paperwork to demonstrate that it is possible to meet the Lean principles: Value, Value Stream, Flow, Pull, Perfection, searching for continuous improvement, transparency and processes' control.

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