ENGLISH VERSION

Integración entre el sistema last planner y el sistema de gestión de calidad aplicados en el sector de la construcción civil

Integration between the last planner system and the quality management system applied in the civil construction sector

L. Díaz [1]*, M. de Oliveira *, P. Pucharelli *, J.Pinzón **

* Universidade Estadual de Campinas, Campinas, BRASIL
** Fénix Construcciones S.A.S, Bucaramanga, COLOMBIA

Fecha de Recepción: 28/08/2018
Fecha de Aceptación: 30/10/2018
PAG 146-158

Abstract

The high level of competitiveness in the civil construction sector, together with the high level of customer demands, has led companies to explore and implement improvements in production processes to ensure the delivery of the established deadlines and quality of the products. In this way, a large number of construction companies have adhered to improvement programs in the construction processes, some of them being the implementation and certification of the quality management system (QMS), as well as the structuring of the planning and control system. of Last Planner production (LPS). In this context, this work aims to analyze the integration of the LPS and the method of continuous improvement of the QMS in a work in Colombia that has already implemented these systems. Initially an analysis of the systems in the work was carried out, in order to know the results of the implementation of these systems. Then, engineer managers of the systems in the company were interviewed where the negative and positive points of the integration were identified. With this study it is concluded that the integration of the systems brings significant improvements in the quality, time and cost established.

Keywords: Quality management, Last Planner System, continuous improvement

Resumen

La alta competitividad existente en sector de la construcción civil junto con el alto nivel de exigencias de los clientes, han llevado a las empresas a explorar e implementar mejoras en los procesos de producción para garantizar el atendimiento de los plazos y calidad establecidos de los productos. De este modo, un gran número de empresas constructoras han adherido programas de mejoras en los procesos de construcción, siendo algunos de ellos, la implementación y certificación del sistema de gestión de calidad (SGQ), así como la estructuración del sistema de planificación y control de la producción Last Planner (LPS). En este contexto, este trabajo tiene como objetivo analizar la integración del LPS y el método de mejora continua del SGQ en una obra de Colombia que ya ha implementado estos sistemas. Inicialmente fue realizado un análisis de los sistemas en la obra, para así, conocer los resultados de la implementación de estos sistemas. Luego, fueron entrevistados ingenieros gestores de los sistemas en la empresa donde se identificaron los puntos negativos y positivos de la integración. Con este estudio se concluye que la integración de los sistemas trae mejoras significativas en la calidad, tiempo y costo establecido.

Palabras clave: Gestión de calidad, Last Planner System, mejora continua

1. Introduction

The increasing competitiveness in the market of civil construction, together with the disregard for waste and failures in the execution of processes, led companies to invest in new technologies, methods and management systems that contribute to greater control of projects. For this reason, companies were making investments in the implementation and integration of improvement systems for construction works such as the quality management system and the Last Planner System of production planning and control (Righi 2009) (Saldanha 2013), which, given the need for changes in the civil construction industry, the increase of certified companies and the importance of planning and control of construction works, show that their integration achieves operational efficiency and effectiveness in all the activities and processes of a company (Betts 1997)(Alves and Amorim 2002)(Neves et al. 2002)(Koskela et al. 2003).

The quality management system consists of a set of all those activities that are coordinated to direct and control an organization with the intention of continuously improving the effectiveness and efficiency of its performance. This system encourages companies to assess customer needs, management towards business sustainability, risk analysis, change management, etc., defining processes that satisfy them and ensuring the means to control them (NBR ISO 9001 2015). This system also helps companies in the standardization of procedures, as well as in the definition of criteria for the acceptance of services, managing to establish a quality platform for their construction works.

Moreover, in the area of civil construction, one of the most important processes is the planning and control of construction works, in which goals, pace, costs and methods to be achieved are established. This planning helps to minimize uncertainties in the execution of construction works, reducing waste and increasing the fulfillment of scheduled tasks (Formoso 2001).

For this reason, several construction companies adopted the Last Planner System as a way for continuous improvement and increased performance of the processes executed in the construction works, supported by the verification of services through the quality management system (Sukster 2005). The

[1] Corresponding author:
Universidade Estadual de Campinas, Campinas, BRASIL
E-mail: lady_alexa30@hotmail.com

objective of this study is to analyze the integration between the Last Planner System of production planning and control and the continuous improvement method of the quality management system in a Colombian construction site.

2. Integration between the Quality Management System and the Last Planner System

The Last Planner System is a system of planning and control of processes that minimizes the effects of uncertainty and variation on projects, thus creating a continuous flow between each of the activities. This system allows greater reliability in the forecast of completion dates of the activities of the construction work and in the results of the application of this system that favors the continuous improvement in the processes contributing directly to the deadlines, quality and cost of the construction work (Alves and Pio 2016).

The LPS is divided into three levels of planning: long term, medium term, and short term. These levels allow the system to contribute positively to the performance of productivity and the progress of the construction work by the managers. In long-term planning, the general objectives of the project are established, as well as the set of activities to be carried out in a given period of time, the action plans of the construction work and the length of the important activities. To do so, programming techniques such as the balance line, Gantt chart and path are used. With these techniques, it is possible to elaborate the working plans and the specification of the information about the beginning and end of the activities and the maximum length of the project (Formoso and Moura 2009).

In the medium-term planning, more detailed planning of the objectives established at the long-term level has been carried out. At this level, the construction methods and resources necessary for the execution of the project are defined (Ballard 2000) (Bernardes 2001). The main function of this level is to identify the restrictions that impede the execution of an activity (Bernardes 2001). This restriction mechanism seeks to avoid interruptions and reduce variability in activities in order to create a continuous workflow. It also helps to improve the overall performance of the project, increasing the productivity of the units, and reducing costs and deadlines (Formoso and Moura 2009).

In the short-term planning, engagements for the execution of tasks are established. At this stage, the last decisions of the workflow are made, adjusting the sequence of the teams in order to protect the production against uncertainties as well as the verification of the necessary resources for the fulfillment of the established activities. This level is monitored through the indicator called PPC (Percent Plan Complete), which is calculated as the ratio between the number of activities completed and the number of activities planned, expressed as a percentage (Equation 1) (Ballard and Howell 1998). (Figure 1) shows the sequence and function of each of the LPS levels.

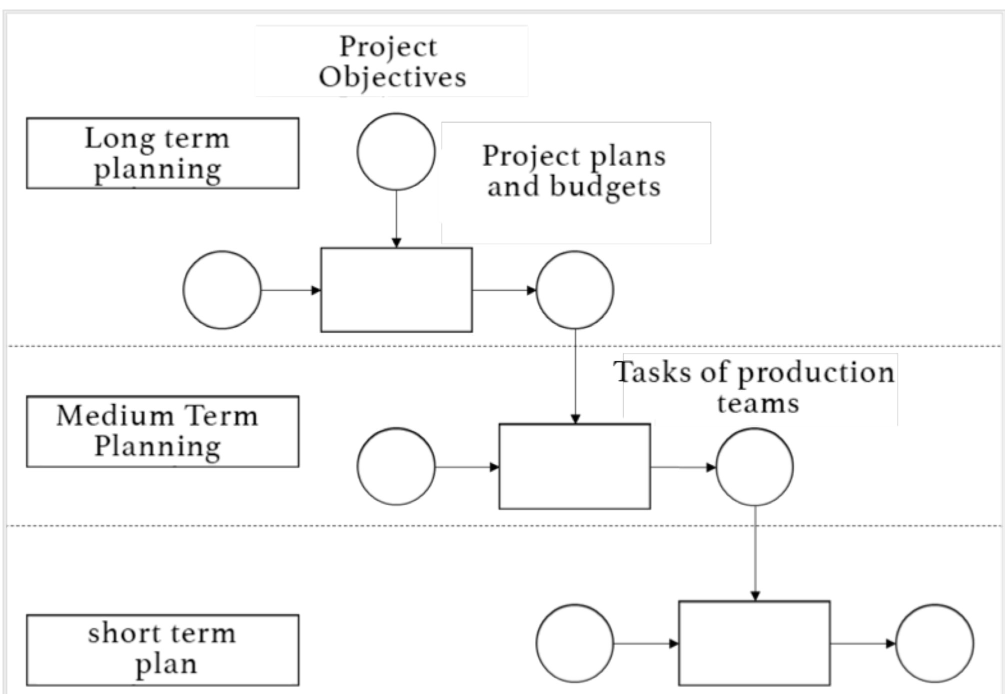


Figure 1. *Stages of the Last Planner System*
Source: (Ballard 1994)

On the other hand, civil construction has different characteristics in each of the stages of execution of the activities. Therefore, being them analyzed separately, improvements are achieved in the management and control of the construction works (Formoso et al. 1999). In addition, the planning and control of the production enable the addition of new stages in the execution of activities, which ensures the implementation and compliance with quality requirements and inspection terms during the production process (Soares 2003).

According to (Picchi 1993), the most suitable method for the implementation of quality in companies is one that adapts to the objectives and culture depending on the characteristics of each company. Therefore, the participation of all the areas of the company, external customers (suppliers, users) and internal customers leads the organization to achieve excellence. This strategy aligned with good planning allows managers greater control, better monitoring of implementation and compliance with quality requirements. In addition, by evaluating where the variation in production and product quality is located, the improvements that should be applied in the processes or activities can be identified (Koskela 1999).

If companies increase the quality (technical concepts of production and the vision of customer satisfaction) of the product offered, they increase credibility before the market making them more competitive. The process of continuous improvement in the quality management system works in a similar way to the above, where, by measuring and monitoring the activities it is possible to carry out corrective and preventive actions to guarantee the quality of the product and the operation of the quality management system. (Picchi and Agopyan 1993) confirm that the systematization through the verification of the procedures for the control of the processes and the execution of the construction work is one of the ways to measure and control quality. These control procedures describe in detail how the verification and completion of the necessary inspection documentation should be done.

3.Methodology

The methodology used for this research includes a Case Study, where according to (Gil 2009) it consists of a deep and thorough study of an object allowing its broad and detailed knowledge. The objective was to analyze the integration of the Last Planner System (LPS) of production planning and control and the method of continuous improvement of the quality management system (QMS) in order to identify positive and negative aspects of its integration. (Figure 2) shows the detail of each of the stages carried out for this research.

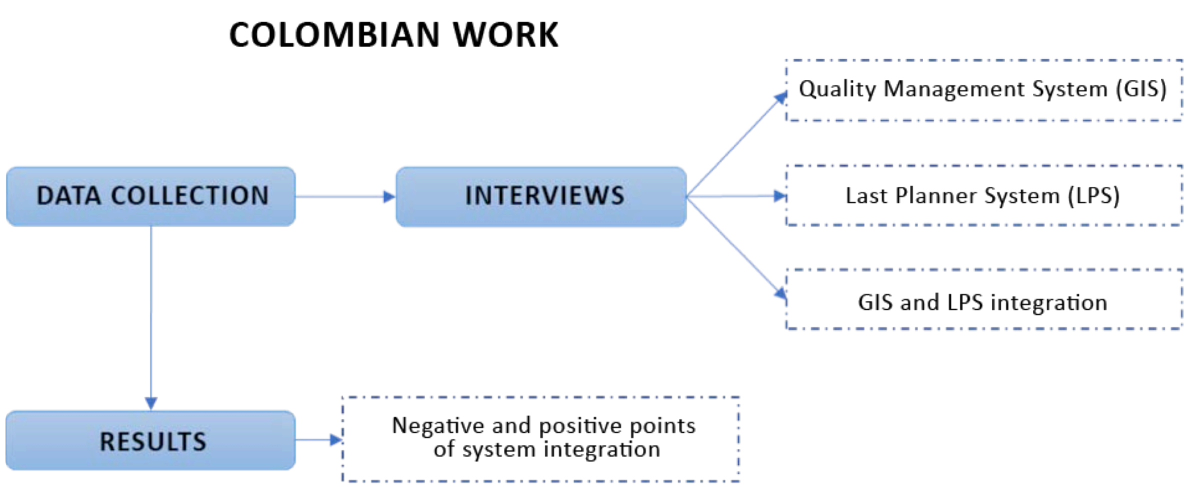


Figure 2. *Methodology Stages*

3.1. Case Study

The data of the Last Planner System and the quality management system were collected from a residential building built by a company located in the city of Bucaramanga, Colombia. The planning, control and quality systems of the company are standardized processes for all the construction works executed by them, only varying the strategies adopted by those responsible for each construction site. The buildings constructed by the company are characterized by the repetition and use of a floor type, as well as by the construction of projects using outsourced labor (contractors) which must follow the guidelines and specifications established in the construction works. This company stands out for its participation in quality and innovation programs, and it is certified by the (NBR ISO 9001 2018).

The construction site, which is the object of this study, is considered to be of a high standard and has a reinforced concrete structure with masonry walls. This project consists of a tower of 23 floors, of which 1 is a lobby and part of the social space, and floors 21 and 22 correspond to the rest of the social space. From the 2nd to the 20th floor is the apartment section where there are 5 apartments per floor with a total of 95 apartments in the building. The apartments have an area of 76 m2 for two-bedroom apartments, 99 m2 and 133 m2 for three-bedroom apartments. In addition to the apartments, in this building the social space consists of a large reception, a social lounge, a theme park for children, a swimming pool for children and a swimming pool for adults, a spa, an equipped gym, a terrace with gardens, a sauna, a whirlpool bath, a massage room and, on the roof, a terrace with a view of the city (Figure 3).

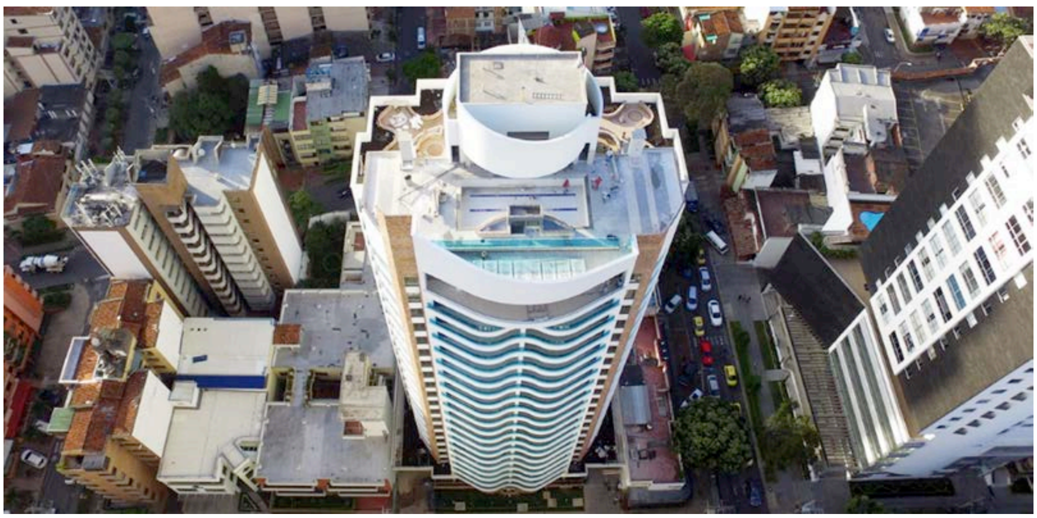


***Figure 3**. Images of the case study*
Source: www.skyscrapercity.com (2017)

3.1.1. Quality Management System

The company has a guideline management procedure aimed at controlling the production on the construction site from the requirements described in (NBR ISO 9001 2018). This guideline management procedure is detailed in the manual and the quality plan of the company. They show the corporate structure of the company and the construction work, the activities and people in charge of each activity involved in the construction work, the measurement structures that must be followed to assess each activity, the methods and resources, the requirements of the standard to be met and the documents established for the quality management system. To illustrate some parts of the manual and the quality plan, (Figure 4) shows the processes involved in the company for the development of the construction work. In addition, (Figure 5) shows in detail the structure of measurement and monitoring of the construction process which is responsible for the execution of the construction work.

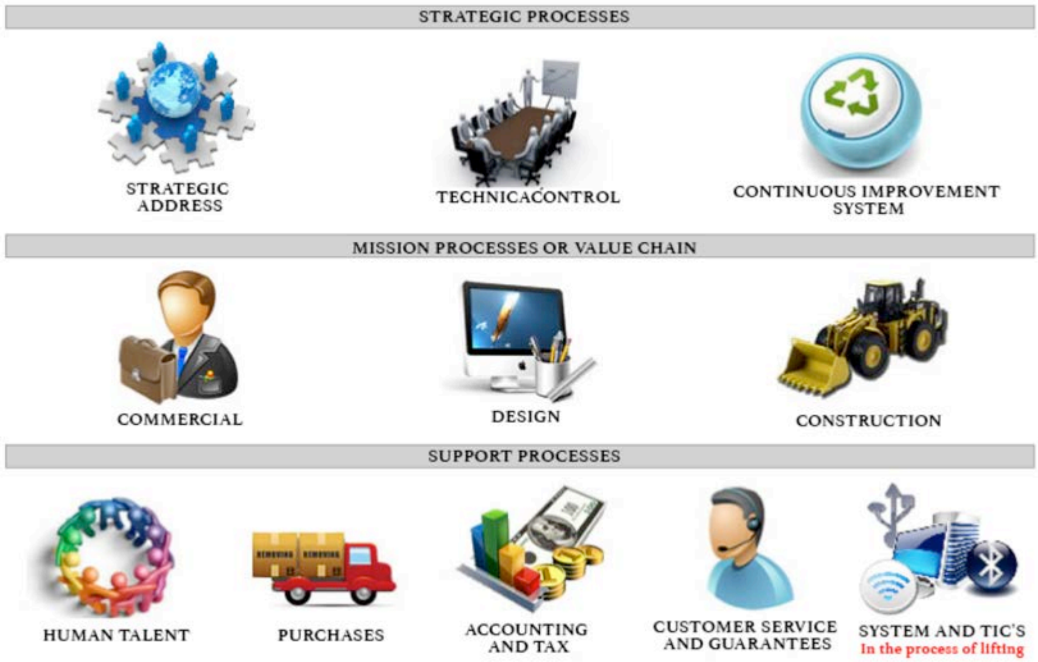


Figure 4. *Company processes*
Source: Constructora Bucaramanga – Colombia, Company archive

Process: CONSTRUCTION
Responsible: Project Director
Objective: Direct, manage and control the different stages for the execution of housing projects.

MEASUREMENT MECHANISM	GOAL	FREQUENCY
Execution Control (Executed Schedule / Schedule Scheduled) * 100	>= 95%	Monthly
Nonconforming product No. of nonconformities in the process constructive by activity	≤2 PNC by activity	Monthly
Waste Control (Consumed Material - Budgeted Material / Budgeted Material) * 100	It is established in each quality plan according to critical material	Established in each Project Quality Plan
Delivery times (Promise date - actual delivery date is days) / Total properties delivered) * 100	>= 80%	Monthly per project until the entire project is delivered
Needs and requirements met Satisfied buyers (rating ≥ 4/5) / No. Total buyers Score = arithmetic average questions 9 to 12 Client Satisfaction Survey	>= 90%	Monthly during the delivery of each project
No Delivery Conformities $\frac{No.\ Properties\ NCE \quad 1}{No.\ Delivered\ Properties} * 100$	<=15% It will be measured every 20 units delivered. This indicator does not apply to the delivery of common areas	Monthly during the delivery of each project

FOLLOW-UP MECHANISM	PARTICIPANTS (WITHIN THE PROCESS)	RESOURCES
Comités de Obra Informe mensual de indicadores Auditorías programadas	President Operations Manager - Technical Vice President Work Coordinator-Coordinator of Hiring Concrete Plant Dir Resident Professional Machinery and Equipment Director or Coordinator Quality Professional - Process and Logic Professional - Environmental Professional Facilities Coordinator-Professional Electrician networks Resident Facilities Professional Hydrosanitary and Gas Building Inspector, Storekeeper, Officers, Helpers, Advanced - Contractors	Computer Desk, chairs Telephone line Architectural, structural and public services (electrical, sanitary, hydraulic) Tools and Machinery Construction materials Intrafenix Concrete plant

REQUIREMENTS	S.G.C DOCUMENTS
ISO standards 9001: 4.1, 4.2.4, 6.4 7.1, 7.5.1, 7.5.3, 7.5.4, 7.5.5, 7.6, 8.2.1, 8.2.3, 8.2.4, 8.3, 8.4, 8.5.1, 8.5.2, 8.5.3 **OTHER DOCUMENTS** NTC ISO 9001 System Quality Management - Requirements Colombian Code of Earthquake Constructions Resistant NRS - CURRENT. RAS 2000 - Regulation Water Sector Technician Drinking and Basic Sanitation. Colombian Electric Code NTC 2050 Technical Regulation of RETIE Electrical Installations. Building permit. Planning License. Environmental Resolutions	- Quality plan. Procedures: Construction CNT – PR-06. Nonconforming product SMC – PR-10. Corrective Actions SMC – PR-07. Preventive and improvement actions SMC-PR-08 Instructions: Preparation and placement of concrete CNT - IN-01. Sampling and Concrete tests CNT-IN-02. Performing hydraulic and gas tests CNT-IN-07. CNT-IN- - CNT-IN-36 Traditional plate defrosting with donkeys, drawers and trays - CNT-IN-39 - Armed, cast, offset columns and walls CNT-IN-46 Sist Plate Construction. Industrialized CNT-IN-45 Construction of walls in Sist. Industrialized CNT-IN-44 Armed of double height plate CNT-IN-43 / -Using the tools of the latest planner (PAC) CNT- - Control of Nonconforming Product CNT-FT-24 - Control of Piles CNT-FT-27 - Measurement and Monitoring of Electrical Inst. CNT-FT-28 - Report on cylinder resistance tests taken on site CNT-FT-29 - Control input and output of machinery and equipment CNT-FT-30 - Machinery and CNT-FT-31 team - Preventive maintenance calendar CNT-FT-34 - Warehouse exits CNT-FT-38 - Materials left in Consignment CNT-FT-39 - Shipment of concrete cylinders to the CNT-FT-40 laboratory- CNT-FT-41 construction receipt - Verification of the Pie de Rey Calibrator CNT-FT-42 - Act of Court of Work CNT-FT-43 - Weekly programming of concrete CNT-FT-44 - Service Order (Fuel Supply and - Vehicle Preventive Control Form CNT-FT- 46 - Materials input CNT-FT-47 - Work Log CNT-FT-50 - Measurement and monitoring of urban planning works: CNT aqueduct - Measurement and monitoring of the installation of sewerage networks CNT-FT-52 - Internal Verification of Surveying Equipment CNT-FT-54 - Measurement and monitoring of urban works: Vehicular roads CNT-FT-55 - Test of - Register of sclerometer readings CNT-FT-62 - Measurement and monitoring of facilities - Act of Start of Work of Contractors CNT-FT-66 - Control of plans delivered on site - Control of Anchors and Bolts CNT-FT-72 - Check of flexometers, tape measures, - Machinery control CNT-FT-84 - Property Inventory CNT-FT-83 - Measurement and - Warehouse transfer CNT-FT-86 - Concrete order CNT-FT-91 - Control Sheet - Monitoring and Measurement of Structure CNT-FT-93 - Contractor Discount CNT-FT-94 - - Monitoring and Measurement of Dikes CNT-FT-100 - Water Flow Tests Sanitary networks and - Monitoring and Control for soil improvement CNT-FT-102 - CNT-FT-131 Inventory of - M & E Master Card CNT-FT-106 - Work Order for machinery maintenance - Review and delivery of terraces CNT-FT-113 - Monitoring of tightness tests CNT-FT- - Hydraulic Tests CNT-FT-121 - Work Order CNT-FT-123 - Product Registration - Form for vehicle control (Travel and Fuel) CNT-FT-127 - CNT-FT-146 -System vertical elements lead check. Traditional CNT-FT-156 -Sgto to Act. -Consolidated vertical elements resistors CNT-FT-165 - Nonconformity Format SMC-FT-32 - Preventive Actions Format SMC-FT-67 - Improvement Actions Format SMC-FT-103 - Manual of Lessons Learned in

***Figure 5**. Details of the construction process*
Source: Constructora Bucaramanga – Colombia, Company archive

Quality control is carried out during the development of the activities of the project and it is conducted by the professional and the quality coordinator. Here the compliance with the technical specifications, the technical regulations, the quality criteria proposed in the manual, the recommendations of the suppliers and the technical recommendations are verified.

3.1.2. Last Planner System

Throughout the execution of the construction work, the actions of analysis and control of the execution of the activities are implemented and they have a regular assessment for decision making and proposal of improvements. The construction work under study implemented the Last Planner System with the objective of obtaining a continuous improvement to deliver products with optimum quality for customers, as well as a measure of planning and control of the execution of activities, seeking to find and analyze the causes that hinder the performance of an activity.

The implementation of the Last Planner in the construction work begins with the long-term level where the length, sequence and pace with which the main activities of the project must be executed are planned. This planning is carried out with little detail as it only represents the objective to be achieved. At this level, the activities are illustrated in the balance line, which is a graphical representation of the activities and the objective to be met (Figure 6).

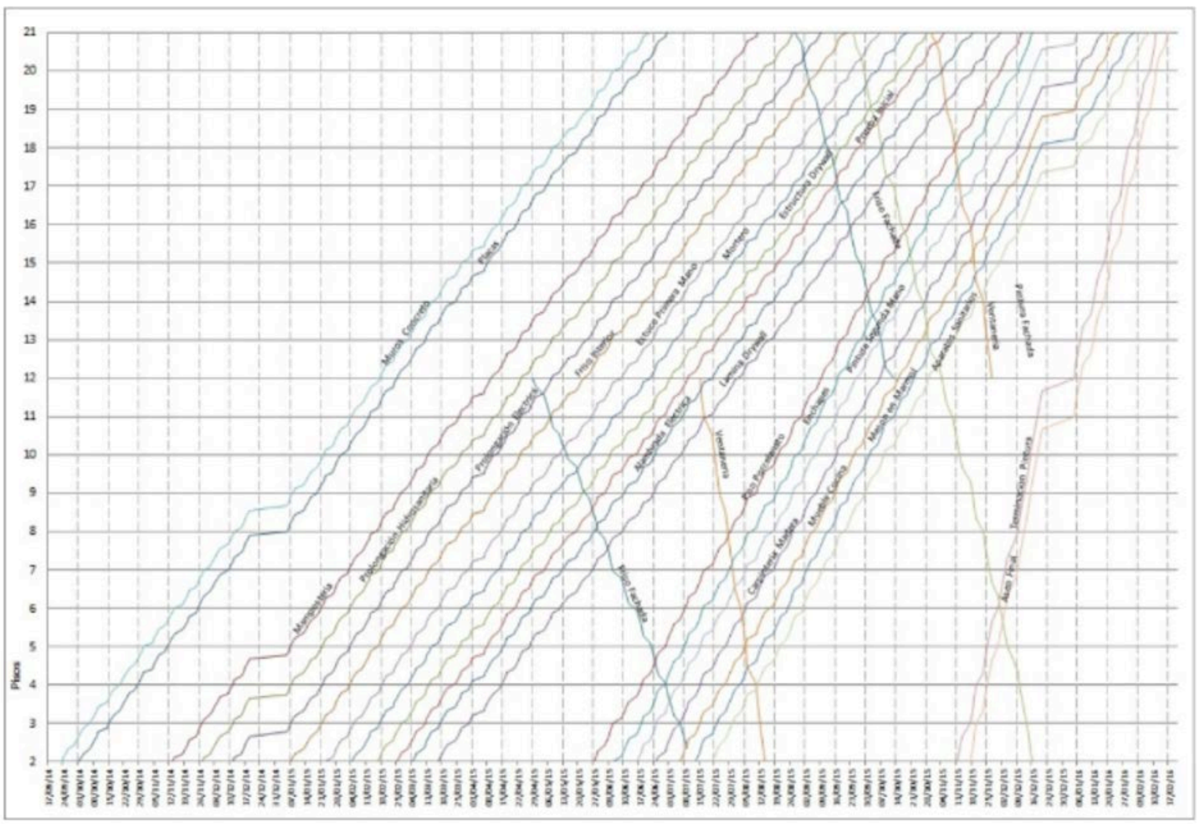


Figure 6. *Balance line of the construction work*
Source: Constructora Bucaramanga – Colombia, Company archive

Then, at the medium-term level, the activities that were defined at the long-term level to be executed are detailed and divided into stages. This planning is done on a monthly basis with a focus on activities that will begin in the next three months. Through this planning, the main resources necessary for each process of the company to execute the activity are identified, such as the processes of design, purchasing, human factor, etc. These resources are controlled with a spreadsheet made in Microsoft Excel that shows whether the process has released (cell in green) or not (cell in red) the necessary requirement for the start date of each activity. See (Figure 7). With this, the construction work aims to eliminate all those possible restrictions that will impede the execution of the planned activities. At this level, it is established as a criterion that, if an activity does not have the release of the restrictions, it will not be able to move to the next planning level (Figure 7).

ACTIVITY	STARTED DATE OF START	PURCHASES			DESIGN		
		LIMIT DATE	STATUS	OBSERVATION	LIMIT DATE	STATUS	OBSERVATION
Facade frieze	16/09/2015	17/08/2015	Received	National Material	N.A.	N.A.	N.A.
Floors and veneers	28/09/2015	29/08/2015	Received	In national purchase	OK	Received	OK
Fire fighting network	28/09/2015	30/06/2015	Without request	Design required	30/07/2015	Requested	BIM Verification
Facade masonry	28/09/2015	29/08/2015	Order	Waterproofing	OK	Received	OK
Tests after veneer	14/10/2015	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Metal carpentry	19/10/2015	N.A.	N.A.	N.A.	22/04/2015		OK

Figure 7. *Restriction spreadsheet*
Source: Constructora Bucaramanga – Colombia, Company archive

Based on the information collected at the medium-term level, the activities are detailed at the short-term level and are assigned to the people in charge in order to direct the execution of the construction work. At this last level of planning, weekly meetings are held at the construction site, where the tasks of the plan to be developed are discussed. The weekly meeting is attended by the person in charge of the execution of the activity, the engineer in charge of the planning and the person in charge of quality. As a result of this meeting, the working plans to be executed in a period of one week are established. At the end of each week, the percentage of activities completed is recorded in the PPC spreadsheet in order to assess and analyze the causes of non-compliance of activities with a percentage of less than 80% (Figure 8).

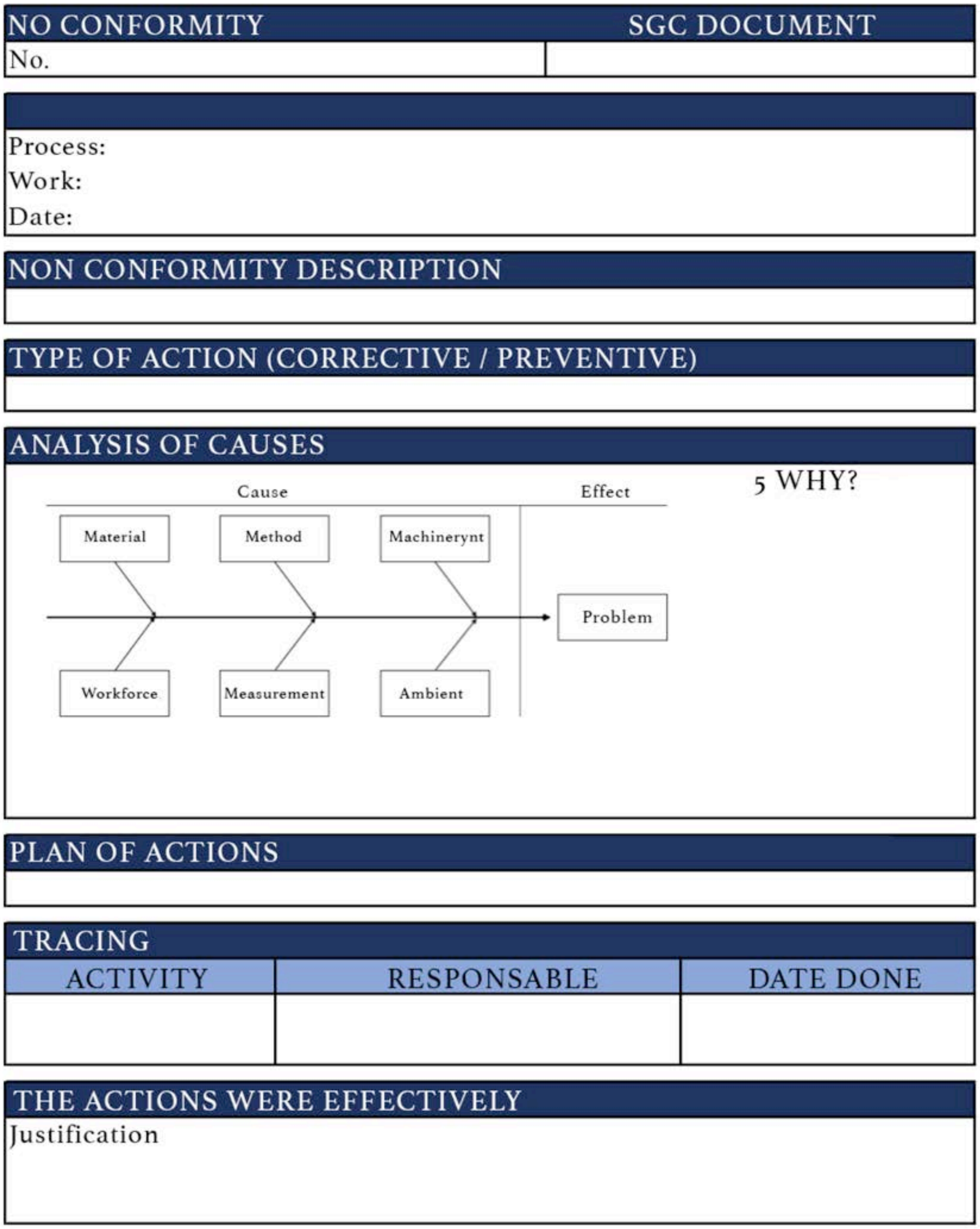
RATINGS					
1	Meet the goal with 2 more days			3	Goal to meet the next day before 2 pm
2	Goal to meet the next day before 5 pm			4	Goal to meet the next day before 10 am
		5	Meets the goal		

ACTIVITY	RESPONSABLE	GOAL		RATING	DIAGRAM OF							CAUSES OF NON COMPLIANCE					
		Committed	Reached		M	T	W	T	F	S	S	Provider	Tools	Incomplete crew	Bad weather	Prerequisite	Bad planning
Column 8 South	xxxxxx	100%	60%	3			x							x			
Column 8 North	xxxxxx	100%	65%	3			x							x			
Column 9 south	xxxxxx	100%	90%	4			x							x			x
Column 9 north	xxxxxx	100%	85%	3			x							x			
Column 23	xxxxxx	100%	72%	3			x							x			
Column 10	xxxxxx	100%	67%	3			x							x			
Column 22-2	xxxxxx	100%	90%	4				x						x			
Column 22-2	xxxxxx	100%	90%	4				x						x			
Column 11-1	xxxxxx	100%	90%	4				x						x			
Column 11-2	xxxxxx	100%	100%	5				x						x			
Column 16 south	xxxxxx	100%	0%	1				x						x			x
Column 16 north	xxxxxx	100%	0%	1				x						x			x
Column 24	xxxxxx	100%	100%	5				x						x			
Wall 5	xxxxxx	100%	80%	3				x						x			x

Figure 8. *Spreadsheet of the PPC indicator*
Source: Constructora Bucaramanga – Colombia, Company archive

3.1.3. Integration between the Quality Management Systems and theLast Planner System

The integration between these systems begins at the medium-term level of the LPS, where the quality manager assesses whether the processes met the requirements necessary to begin the planned activities. When a process fails with the removal of the restriction, non-compliance is generated for this process. As a solution to eliminating this non-compliance, corrective action is generated to avoid its repetition. In this corrective action, the treatment to be applied to the problem is chosen and the superficial causes are analyzed until the root cause is found through the quality tools Fishbone Diagram and 5-why Analysis. After that, an action plan is generated together with its follow-up for the solution of the problems. All non-compliances are recorded in the quality management system documents in the online platform of the company, which generates process indicators for internal and external audits of the company. (Figure 9) shows the quality management document used for the treatment of non-compliances.



NO CONFORMITY | SGC DOCUMENT
No.

Process:
Work:
Date:

NON CONFORMITY DESCRIPTION

TYPE OF ACTION (CORRECTIVE / PREVENTIVE)

ANALYSIS OF CAUSES

PLAN OF ACTIONS

TRACING

ACTIVITY	RESPONSABLE	DATE DONE

THE ACTIONS WERE EFFECTIVELY
Justification

Figure 9. *Analysis of non-compliances*
Source: Constructora Bucaramanga – Colombia, Company archive

On the other hand, the integration of the systems is carried out at the short-term level, where, to the extent that the planned activities are executed daily, the quality manager verifies that all the activities are in accordance with the quality established for the final product in the quality management document. Once the quality of the final product has been checked, the quality manager evaluates the quantity executed in order to make the respective payment to the contractor. In addition, with the results of the PPC spreadsheet, the causes of non-compliance are analyzed together with the possible solutions by which it is possible to have a continuous improvement in the execution of future construction work activities.

With the PPC indicator and the quality of the product, a monthly report is generated by activity which is used to assess and give a rating to the person responsible for the activity. For activities carried out by contractors, this qualification is recorded in the online system of the company and is taken into consideration at the time of contracting for other construction works. The compliance of the scheduled times in the PPC for each activity together with the good quality of the product generates monthly incentives for the *people responsible for the activities. This motivates the workers to improve every day in the development of their activities.*

From the experiences lived in the execution of the work, the lessons learned are recorded in the corresponding quality management document, which is shared with all the personnel of the construction site on a monthly basis. This is done with the purpose of making workers aware of how the low quality of a product is one of the causes of non-compliance with the times of execution of activities causing waste and delays in the construction works. (Figure 10) shows an example of an activity that was not carried out on time or in the quality of the planned activity, which was shared as a lesson learned.

Purpose
Based on the experiences acquired in previous Projects, make known to the Professionals of the Company the actions taken from the pathologies found in the different stages of the construction process, as well as improvements detected in the different projects to optimize the work activities.

Scope
Applies for all Projects undertaken by Empresa Fénix Construcciones S.A.

Developing
1. STRUCTURE

PHOTOGRAPHIC RECORD	PROBLEM	CAUSE	SOLUTION
	Bad plate leveling	1. Badly secured metal parales 2. Failure to cut the plate at the time of melting 3. Deficiencies in level controls during fades 4. Lack of anti-training of the personnel in charge of cutting the concrete	1. check the stops of the parales before starting the melt 2. Perform the verification of the plate levels with the help of the Surveying Equipment before melting and after cutting the plate 3. Perform maintenance and adjustment to the work form team 4. The form must be manufactured with modules maximum 40 x 40 cm to reduce the deformation of the cans 5. Use helicopter or vibrating metal ruler to terminate the plates 6. Levels with topographic equipment must be controlled during plate concrete melts 7. Additionally, a ruler or tube section marked with a centimeter scale must be used, so that when inserted into the concrete, it allows to know the thickness of the already cut plate, thicknesses and levels around all vertical elements must be controlled 8. Before each fade, the good condition of the sights and surveying equipment should be checked to avoid errors in the readings for damage to them. 9. Level the bottom of the plate with a free height rod to verify the leveling of the molding

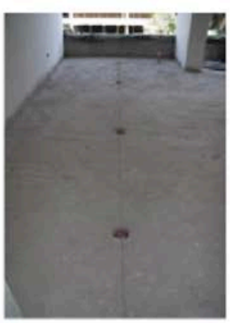
PHOTOGRAPHIC RECORD	PROBLEM	CAUSE	SOLUTION
	Cracks in concrete plates	1. Surface ducts 2. The ducts are not left embedded in asllas and they are also left installed in the center of the light of the plate area, which is where the greatest deflection of the element is presented 3. Failures in the concrete frame 4. Low thickness in the structural design in sectors where there is greater accumulation of networks in the plates 5. Bad procedure in the decoupling of concrete plates	1. Leave the pipelines (electrical, hydrosanitary and gas) embedded between meshes according to NSR Standard 2010 numeral C.6.3. 2. Change the path and location of the electrical pipe in the design so that it does not match the center of the light 3. Respect and guarantee concrete curing times 4. Increase the thickness of the plates in areas that have a high number of ducts 5. The constant retouching of the plates must be organized seven days after their placement, additionally when each of the molding modules are removed, the plate plate must be set back with stops in the center of the light of the molten element, with the in order to ensure that the plate is not free of support and decrease its deflection until it acquires adequate resistance

Figure 10. *Lesson learned example*
Source: Constructora Bucaramanga – Colombia, Company archive

Finally, as the work is executed, an informative bulletin is generated on the web page of the company, which has the purpose of showing customers the progress of the construction work. (Figure 11) shows some images of the render of the project sold to the customer, compared with the images of the completed project. These images show the quality compliance of the product sold to customers.

Figure 11. *Informative bulletin, render vs. reality*
Source: www.fenixconstrucciones.com

4.Results and Discussion

As a result of the integration between the QMS and LPS systems, it was observed that these systems involve the management of deadlines for the construction work through the exchange of information between each of the processes. With this exchange of information, there are improvements in the construction work regarding the deadlines of the project, costs and quality of the product delivered to the customers.

With the analysis carried out on the data on integration between the QMS and LPS systems, it was observed that these have a set of items that work connected since, in the execution of long, medium and short-term planning, these levels use the quality manual to verify each one of the specifications, materials, construction methods, among other aspects. In addition, all templates used for the implementation of the Last Planner System such as restrictions and PPC are part of the documents of the quality management system. In case of non-compliance, delays, etc., after performing the analysis in these spreadsheets, the solutions are controlled by the quality management system through the non-compliance format. In addition, the Last Planner System with planning and control of construction works is part of the continuous improvement through the PDCA (Plan - Do - Check - Adjust) and the lessons learned.

On the other hand, during the case study, it was detected that at the beginning of the integration the activities to be executed were planned with less time than the one actually spent for their completion. For this reason, the workers and people in charge of the construction work worked only to meet the established deadline without worrying about the final quality since the payment for the work was made only for the quantity produced. With the course of time, quality managers disapproved of completed activities because quality standards were not met, leading to delays. It was noted that the dedication of the working teams and the compliance with the established execution time together with good expected quality is important to achieve the objectives set for the project.

Through the interviews conducted, it was possible to identify the negative aspects existing at the beginning of the integration, including lack of commitment by the partners, lack of interaction between the areas of quality and planning, lack of investment in resources such as labor and materials. The positive aspects of the integration were also pointed out, such as the continuous improvement in the execution of the construction work that contributed positively in a reduction of the final deadline and the quality of the apartments delivered *to the customers, thus generating in them a high level of satisfaction. Through the use of quality tools for the analysis of the causes of non-compliance identified through the PPC, continuous improvement was carried out in the execution of the activities by the partners. Consequently, they had an increase in the learning curve. There were also incentives and awards to partners who met the goals of quality and deadline thus increasing the motivation and commitment of employees at the time of developing an activity. In this way, it was observed that good planning allows the correct execution of the activities, thus fulfilling the established goals and eliminating waste from the construction site. The separation of activities into stages also allowed for better verification by reducing rework and accumulation of activities that do not add value.*

5.Conclusions

By performing the integration between the QMS and the LPS, by implementing the Last Planner System in the construction works, the activities become repetitive (improvement of the learning curve), therefore, there is a decrease in errors because there are more specialized people performing activities and this, in turn, represents less reprocessing costs. Moreover, with the quality management system, it is possible to reduce reprocessing which leads to a reduction in costs. In addition, the QMS allows standardizing each of the processes involved in the execution of a construction work. This facilitates their planning and control.

By implementing quality, planning and control systems there is a great improvement in deadlines, costs and quality of the project which leads to customer satisfaction upon receiving their final product.

There are negative aspects to improve that hinder the full use of the benefits in terms of integration between the QMS and LPS systems. Some of them are lack of commitment by partners, lack of interaction between the areas of quality and planning, and lack of investment in resources such as labor and materials.

Although there are negative aspects to be overcome, the integration between the systems also brings to the construction works a continuous improvement in the execution that contributes positively in the reduction of the final deadline and the quality of the apartments sold to customers. Therefore, sharing lessons learned with the workers involved in the construction work allows better teamwork, better communication between them and the performance of simultaneous activities. In addition to the above, there is a better understanding of the importance of meeting deadlines and completing an activity with quality in order to avoid waste in the construction site.

6. References

Alves, A.C.N; Amorim, S.R.L (2002) A satisfação dos clientes vista pela ISO 9001:2000: O caso da construção civil. In: Congresso Nacional de Excelência em Gestão. Niterói.

Alves, T., & Pio, V. (2016). A importância do sistema Last Planner para construção civil. Congresso Técnico da Engenharia e da Agronomía (CONTECC). Foz do Iguaçu.

Associação brasileira de normas ténicas (2018). NBR ISO 9001: Sistemas de gestão de qualidade. Rio de Janeiro.

Ballard, H. G. (1994). The Last Planner. Lean Construction Institute, 1-8.

Ballard, H. G. (2000). The Last Planner System of Production Control. England: Thesis: (Doutor ENgineering) Faculty of Engineering.

Ballard, H. G., & Howell, G. (1998). Shielding Production: Essential Step in Production Control. Journal of Construction Engineering and Management, págs. 11-17.

Bernardes, M. M. (2001). Desenvolvimento de um modelo de planejamento e controle da produção para micro e pequenas empresas da construção. Porto Alegre: Tese: (Doutorado em Engenharia Civil) Curso de Pós-graduação em engenharia civil.

Betts, M. (1997). Lean Production as a purpose for computer integrated construction. Annual Conference of the International Group for Lean Construction. Golf Coast.

Formoso, C. (1998). Termo de referência para o planjamento e controle da produção em empresas construtoras. Porto Alegre: Curso de pós-graduação em engenharia civil, Universidade Federal do Rio Grande do Sul.

Formoso, C. (2001). Planejamento e controle da produção em empresas construtoras. Porto Alegre: Universidade Federal do Rio Grande do Sul.

Formoso, C., & Moura, C. (2009). Evaluation of the impact of the Last Planner system on the performance of construction projects. Annual Conference of the International Group for Lean Construction.

Gil, A.C (2002) Como elaborar projetos de pesquisa. São Paulo: Atlas.

Koskela, L. (1999). Management of Production in Construction: a theoretical view. Annual Conference of the International Group for Lean Construction. Berkeley.

Koskela, L. et al. (2003) Achieving change in contruction. In: Proceedings of 11th Annual Conference of the International Group for Lean Construction. Blacksburg, VA, 22 - 24 July 2003.

NBR ISO 9001 (2015) Sistemas de gestão da qualidade – Requisitos. Associação brasileira de normas tecnicas. Rio de Janeiro.

Neves, R., Coelho, H., Formoso, C. (2002). Aprendizagem na implantação do PCP Encontro Nacional de Engenharia de Produção. Encontro Nacional de Engenharia de Produção. Curitiba.

Picchi, F. A. (1993). Sistemas de qualidade: uso em empresas de construção. São Paulo: Tese (Doutorado em Engenharia Civil) - Escola Politécnica da USP.

Picchi, F. A., & Agopyan, V. (1993). Sistemas da Qualidade na Construção de Edifícios. São Paulo: Departamento de Engenharia de Construção Civil, BT/PCC/104: Boletim Técnico da Escola Politécnica da USP.

Righi, M. M. (2009). Sistema de controle da qualidade e planejamento de curto prazo na construção civil: integração e compartilhamento de informações. Rio Grande do Sul: Trabalho de conclusão (Engenharia Civil) – Curso de graduação da Escola de Engenharia.

Saldanha, L. C. (2013). Gestão da produção: integração entre o planejamento e controle da produção e a gestão da qualidade. Rio Grande do Sul: Trabalho de conclusão (Engenharia Civil) – Curso de graduação da Escola de Engenharia.

Soares, A. C. (2003). Diretrizes para a manutenção e o aperfeiçoamento do processo de planejamento e controle da produção em empresas construtoras. Porto Alegre: Trabalho de conclusão (Mestrado em Engenharia) - Curso de Mestrado Profissionalizante.

Sukster, R. (2005). A integração entre o sistema de gestão da qualidade e o planejamento e controle da produção em empresas construtoras. Rio Grande do Sul: Trabalho de conclusão (Mestrado em Engenharia) - Curso de Mestrado Profissionalizante.