

TOTAL QUALITY CONTROL AND SHEWART METHOD AS AUXILIARY TOOLS ON THE PRACTICE OF LEAN CONSTRUCTION PROCESS

Ana Celia Vidolin (UTFPR - PPGEC) anavidolin@utfpr.alunos.edu.br

Cezar Augusto Romano (UTFPR - PPGEC) romano.utfpr@gmail.com

Abstract

The paper aims to evaluate the improvement of the civil construction applying the total quality control, Shewart Method, in combination with the lean construction process. Total quality control is all dimensions that influence people's satisfaction and, consequently, business survival. Shewart Method or PDCA Cycle (Plan, Do, Check, and Act) is a path for the application of the processes control. Each part of the PDCA Cycle claims specific actions and metrics. By combining the philosophy of lean construction with total quality control and PDCA Cycle, there is an exciting arrangement; due to the fact, they could contribute to practice and better results of civil construction. The methodology consisted of an applied, exploratory and qualitative research, the bibliographical research made from the survey of theoretical references, combining analysis of the technical documents and interpretation of the same and the elements under study. Total Quality Control (QTC) manages the quality, cost, delivery, morale, and the safety of employees and users.

Essentially the total quality control is a management system that associates all dimensions to cover the survival of the company. Shewart Method is the method that analyses the process since the planning phase to the result is obtained in search of continuous improvement and reflects in its four stages. The basis of the philosophy of constant improvement. The characteristics of Total Quality Control and Shewart Method, when applied together, they could collaborate with lean construction and increase the management level of the company. The recommendation revealed congruent and complementary aspects when analyzed with lean construction. The reason for the company's existence is the customer, intrinsic quality, cost management, delivery on correct time and quantity, respect for the customer, as total control of quality's aspects. As having a connection between these three elements cited, they combine theoretical aspects to attain results. The contribution that this article presents is the reflection on complementarity techniques that integrate and attempt positive results for the construction industry.

Key words: Total Quality Control; Shewart Method; Control Process; Lean Construction.

1. Introduction

The technological evolution experienced in the last decades allows the improvement of productive processes in organizations, and the construction industry is not different. Contrary to the increase in the level of competitiveness in the market, the growth of companies offering similar products, the dispute for the maintenance of the customer becomes more complex day by day. In this environment of technological resources, financial resources, raw materials, and restricted labor offer, the practice of total quality and analytical structure project denotes a significant role in the life of construction companies. These combinations have the chance to reach the consumer's wishes.

The total quality control has the purpose of approaching the best product to offer to the customer, considering the complete customer satisfaction, quality in the broad sense, and cost and service conditions as influential factors of total customer satisfaction. As a complementary tool in this corporate environment, but not of minor importance, we have the significant contributions of the Shewart Method or PDCA Cycle (Plan, Do, Check, Act), which target is solving issues and stabilize a process. This tool has positive implications in the organization's financial life, in its strategic position on the market and customer service. The consolidation of the analytical design framework and the PDCA Cycle compose an encouraging combination of opportunities. The lean philosophy further supports the construction environment. Lean construction concerns the application and adaptation of the concepts and fundamental principles of the Toyota Production System (TPS) in civil construction. In both cases, the focus is on reducing waste, increasing customer value, and continuous improvement. Although many principles and tools are applicable in construction, there are some principles and tools in lean construction that are different from those applied in TPS (Sacks, et al, 2010). Thus, the main objective of this study is to analyze which contributions the principles of total quality control and Shewart method could concern the lean construction?

2 Literature Review

2.1 Total Quality and Total Quality Control

According to Carpinetti (2010), in the prior phase of the Industrial Revolution, the artisans were responsible for the whole manufacturing process, since from the choice of raw material, commercialization, and quality control. The Industrial Revolution was a milestone in the

analysis of the quality due to the artisans used to realize the production, the sale, and quality control. From the beginning of the Industrial Age to the present day, the automation index, information management, the growth of quality performance in "organizational activities can also be perceived in responsibilities which add to the area, such as environmental quality and quality of life, ethics, and values "(MARSHALL JUNIOR et al., 2003, p.18).

A new concept of quality emerged in Japan shortly after the Second World War. The change occurred as a result of the Japanese industries wanted to rebuild after the destruction, seek a differential, and the total quality favoring the industries allowing global recognition. (Lélis, 2012). Face with globalization and competition, the current approach differs from the twentieth-century quality concept, since the focus became the customer rather than the product (MARSHALL JUNIOR et al., 2003).

According to Campos (2004), the main concern of business management is to make their existence genuinely relevant to the satisfaction of customer's expectations, thus trying to ensure their survival in the market. Marshall Junior et al. (2003) assures that there is a dynamic in quality management since this interacts with factors distinct from the composition of an organization's structure. These factors "create multidisciplinary challenges and transformations in organizational management, [...] affect structuring, [...] concepts and the portfolio of skills, knowledge, skills technical tools and methodologies "(MARSHALL JUNIOR et al., 2003, p.17).

Paladini (2000, p.10) states that "quality involves many aspects simultaneously, that is, a multiplicity of items; and quality undergoes conceptual changes over time, especially, it is an evolutionary process." Deming *apud* Lélis (2012) believes that three aspects of quality evaluation should be considered since they influence the quality being: the product, the expectations of the client, and the experiences of using it this product and service. Also, Lélis (2012, p.18), affirms that quality according to Juran presents, three axes: "quality-related to product performance; quality related to the absence of defects and lack of mistakes is not a guarantee of sales".

For Werkema (1995, p. 14), **customer satisfaction** is directly linked to quality because "it refers to the specific characteristics of the final products or services of the company, which define the capacity of these goods or services to promote customer satisfaction." The evaluation of the actual quality performance and comparison with the quality goals, act on the differences, is the meaning of quality control activity (Caravantes et al., 2005). Feigenbaum

apud (Carvalho; Paladini, 2005, p.15) defines quality as "the total composition of the characteristics of marketing, design, production, and maintenance of goods and services."

Total quality management (TQM) is defined as business philosophy based on customer satisfaction, built on quality principles sustained by a set of practices and techniques, careful design for product or service, which assurance that the organization's system can produce the consistently designed product or service (DRUMOND, 1998; CARPINETTI, 2010)

According to Ballesteros-Alvarez (2001, p.173), TQC (Total Quality Control) can be understood "as a generator of sustainable competitive advantage, [...] meeting expectations and needs of customers on the desired products and services and the efficient use of the available resources to add the maximum value to the final result".

2.2 Shewart Method

Shewhart Method or PDCA cycle's quality analyzes the process from its planning phase to the result obtained in search of continuous improvement, using the statistics and graphs of easy application (Carvalho; Paladini, 2005). Already Marshall Junior et al. (2003, p.78) affirms that the PDCA cycle "is a management method for the promotion of continuous improvement and reflects in its four phases the basis of the philosophy of continuous improvement. The practicing cyclically and uninterruptedly in the organization, consolidating the standardization of practices". In this context, Vieira (2014, p.24) also admits "the PDCA cycle is a managerial method of decision making to guarantee the achievement of the goals necessary for the survival of an organization"; and is widely employed in the pursuit of continuous improvement for business success. Shewhart *apud* Garvin (1992) notes that there is always variation in the production process and that this variation could be understood using process statistics; thus, it would be possible to define the acceptable oscillations that would not cause problems to the products.

Campos (2004) corroborates that the PDCA cycle has four phases: planning, execution, verification, and corrective action. The plan defines control items, goals, and ways to achieve them; implementation is responsible for practices; possession of the data compares with the goals, and these actions make up the verification; and finally, the identified deviations are treated with corrective actions.

The continuous improvement cycle or PDCA Cycle aims to "identify and organize the activities of a problem-solving process ensure the development of a planned activity effectively" (Lobo, 2010, p.39). Moreover, Campos (2004, p.33) admits that an organization

needs to control its activities; this method is the PDCA Cycle, which represents "a method for the practice of control." According to Aguiar (2006), the organization has in its routine attention focused on the production of goods and services as agreed. Thus "managing by the PDCA of quality maintenance is to make products according to the standard operating procedures (POP) of the company" (Aguiar, 2006, p.27). Another significant contribution concerns the adaptation of terminology by some scholars, in the substitution of P (planning) for S (standard); so is the PDCA cycle for SDCA; alternation of continuous and radical improvements, sustained by moments of maintenance. (MARSHALL JUNIOR et al., 2003).

Lélis (2012) contributes to the similarity between the Method of Analysis and Problem Solving (MAPS) and PDCA. Both aim to solve problems and are formed by stages. Phase P (planning) is equivalent to the phases of identification, observation, analysis, and action plan of the MAPS. Execution (phase D) of the PDCA cycle is equal to the action plan. The check step (phase C) expresses the verification, and the phase correction (phase A) is equivalent to standardization and customization phases. The goal is that the company is always in the process of improving and reviewing its procedures, thus the constant improvement of the company's performance through the sequential stages of the cycle.

In the case of application as maintenance, the process has repetition (Campos, 2004); besides, when it comes to the application as an improvement in control's degree, the process is not repeated. The plan has a defined value goal and a method that is composed of a means to achieve the goals. When using the PDCA Cycle in the analysis of a problem, a structured methodology is applied, which avoids decision-making without justification, avoiding costs. The PDCA Cycle leads to the correct approach to problems, standardized continuous improvement, and opportunity generation. Literature brings options that fit the PDCA, such as QC Story (quality circle story) or MPAI (Method of Process Analysis and Improvement) or using the step-by-step deployment of MAPS. (MARSHALL JUNIOR, et al., 2003).

According to Campos (2004), all organizations use the PDCA Cycle in their activities, at the level of operators, or maintenance approach, since standards must be attained. However, as higher work positions within the hierarchy are reached, the PDCA Cycle is applied as improvement, so there is a combination of maintenance processes and improvements in existing processes. From this union of techniques, there are better definitions, a moment of maintenance, the search for new enhancements, and always defining new standards and contemporary controls. Management of development, senior management responsibility is to relate to the strategic level, focusing on organizational effectiveness. Management of the

routine is under the obligation of the employees. It seeks the efficiency of the organization, using "obedience to the work standards, to avoid changes or changes that can compromise the established quality levels" (MARSHALL JUNRIOR et al., 2003, p. 82).

2.3 Lean Construction

According to Liker (2004), lean can be applied efficiently in all business processes; and lean gives essential administrative support processes as buying or productive.

The TFV production (transformation, flow, and value) proposed by Koskela et al. (2002) serves as a framework for the definition of lean construction. The vision of production's conversion has two deficiencies. It does not recognize that there are phenomena in production beyond the transformations. It fails to realize that it is not the transformation itself that makes the output value, but instead, there is value in having the output conform to customer requirements. The transformation's vision is fundamental to discover what tasks are need in a production enterprise and to conclude it; however, it is not especially useful to figure out how to increase wasted resources.

Koskela et al. (2002) argue that the new industrial engineering framework introduced another view on production, namely production as flow. The flow vision in output only developed from the 1940s in Japan, and the flow vision acts to eliminate wastage of flow processes. Thus, such principles as reduction of execution time, reduction of variability, and simplification are promoted in the same way. The production has a primary objective as a value generation to arrive at the best possible value from the customer view. Oliveira, Pereira (2014) affirm that lean construction "differs from the traditional model because it attaches importance to flow and conversion activities. Conversion activities are considered events that add value to the product, while flow activities do not always add up. "

Koskela (1992), lists eleven principles to guide the achievement of expected results, elaborates an essential improvement to lean construction. These principles must be handle in an integrated way in the management of the processes:

- a) Reduce activities that do not add value;
- b) Improve product value through consideration of customer needs;
- c) Reduce variability;
- d) Reduce cycle time;
- e) Simplify by reducing the number of steps and parts;

- f) Increase the flexibility of the product;
- g) Increase the transparency of the process;
- h) Focus control in the overall process;
- i) Introduce continuous improvement to the process;
- j) Balance the developments in the flow with the upgrades of the conversions;
- k) Benchmark.

3.METHODOLOGY

To achieve the objective of this paper to identify the application principles of total quality control and Shewart method related to lean construction, and applied, exploratory and qualitative research was carried out. The qualitative approach, according to Oliveira (2010, p.60), "facilitates the presentation of reviews, a detailed description of the facts and phenomena observed," and arises when information about a particular subject can not be quantified, making interpretation necessary (TRIVIÑOS, 1987).

As for the procedures, we used bibliographical research made from the survey of theoretical references already analyzed and published in a physical and or electronic medium.

The data analysis that supported this research concerns bibliographical research, qualitative based on information that can not be quantified; then, the interpretation is applied.

For the search of the bibliographic material was defined, keywords that best represented the topic addressed. After exploratory research, the keywords chosen were "lean construction", "quality control," "Shewart Method". The choice of Google Academic was due to the high degree of accessibility and coverage of scientific journals. To carry out the research, the "CAPES Journals Portal" was consulted for access to the ISI Web of Science (Institute for Scientific Information; which was adopted to attach a high volume of periodicals of greater relevance on the topic addressed.

Hence the data inquiry was the first analysis of the technical documents. And the second, the interpretation of the same and the elements under analysis. Throughout the assessments of the themes, it was possible to elaborate on the connectivity between them and their reflexes. The cause and effect relationships in terms of the management of an organization.

4. FINDINGS

The results and discussions were elaborate from the detailed examination of the bibliographical research that conduct to a series of reflections and connectivity on the topics lean construction, total quality control and, Shewart Method.

The elements that contributed positively to the application of lean construction is suggested in two stages: analysis of the critical aspects of the total quality control; and verification of the elements of convergence of the Shewart Method.

Total Quality Control (TQC) seeks to satisfy the customer's needs. It has as dimensions of quality, cost, and delivery at the right time and the right quantity, the morale, and the safety of employees and users. With total quality control, the company guarantees its survival in the market and meets the wishes of the customers. Essentially the total quality control is a management system that starts from the recognition of people's needs and sets standards to meet these demands. Equally, a management system intends to maintain the requirements to sustain customer's demands and a management system that asks to improve the standards that support customer interest, based on the strategic vision of the business. Total quality combines all dimensions that, in one way or another, cover customer's needs and the survival of the company: quality, cost, delivery, morale, and safety.

According to Campos (2004, p. 217), the concept of TQC includes the following topics:

- a) Customer orientation;
- b) Quality in first place;
- c) Action oriented by priorities;
- d) Action driven by facts and data;
- e) Process control;
- f) Dispersion control;
- g) The next process is your customer;
- h) Upstream control;
- i) Lock action;
- j) Respect for the employee with a human being;
- k) Top management commitment.

The process control is at the heart of management; however, let's understand process meaning: set of causes, which generate one or more effects. Several methods and not only productive ones form every organization. Since each process can produce one or more results, it is essential to manage the impacts to have real control in the processes. Therefore, the control items of a process are index defined from the effects of each method to measure the total quality. If there is an unsatisfactory result on a process, then there is an issue. The process analysis, process standardization, and employee training is not a regular daily practice in several companies; and these arrangements lead to production problems.

PDCA cycle is a management method for continuous improvement, as a cyclical and uninterrupted way in the organization, consolidated the practices of standardization. Thus PDCA Cycle is a managerial method of decision-making to guarantee the achievement of the goals necessary for the organization's survival. In the context of the process, the follow-up of the measurement of control levels in a method applying the PDCA Cycle is essential. It can be practiced to maintain and improve a process, likewise used for maintenance or control of control guidelines.

Table 1: Features to improve Lean Construction

Total Quality Control	Shewart Method	Lean Construction
Customer orientation	Employee development	Improve product value through consideration of customer needs
Top management commitment	Process management: phase plan	Focus control in the overall process
Process control	Process management: phase do	Increment the transparency of the process
Action driven by facts and data	Process management: phase check	Reduce cycle time
Generator of sustainable competitive advantage	Process management: phase act	Balance the improvements in the flow of the conversions

Source: The authors (2020)

Considering the characteristics of Total Quality Control and the Shewart Method, when applied together, they could collaborate with lean construction and increase its management level. The four axes of Shewart Method (plan, do, check and act) and employee development, integrate with customer orientation, management commitment, process control and sustainable competitive advantage from total quality control, allows a better performance to lean construction. Table 1 shows some features from the Total Quality Control and Shewart Method aligned to lean construction. Lean construction seeks to improve the product value to the customer, and this goal is achieved by applying customer orientation and employee

development. The focus on the overall process is obtained from management and process management planning. An increment of transparency on the process is guaranteed practicing process control and process management – do. Another aspect is the reduction of the cycle time, which is accomplished from actions driven by fact and data and process management – check. The improvements converted on the process is guaranteed by a sustainable competitive advantage and process management phase –an act.

When the company has customer orientation, for sure, an employee development took place to improve the product value through customer consideration needs. The top management's commitment is the path, the process management of the plan is to achieve, and the focus control in the overall process. The process control is related to the second phase of process management – do - and it contributes to the transparency of the process. Action drive-by facts and data improve the process of management check. Also, Total Quality Control (TQM) is a generator of sustainable competitive advantage, raising the process management phase do, raising the transparency of the process.

CONCLUSION

This paper intended to identify which contributions Total Quality Control (TQM) and Shewart Method could assist lean construction. The theoretical reference analysis revealed the intrinsic relations and the areas of superposition between the central themes.

Total Quality Control and the Shewart Method identified the convergence elements: planning, coordination, information, organization, customer, processes, and integration.

The integration of total quality control and the Shewart Method involves the internal processes, employees orientated towards customers' wishes, to contribute to the quality and competitiveness of the organization. It also deals with company longevity, financial health, and customer service demands.

In terms of processes oriented to lean construction, it contributes to better execution of processes, reduction of waste, of time, movements over-processing; excessive production; stock; transport; unnecessary changes; defects and rework; wait, and consequently of costs. If the integration of TQC with the Shewart tool occurs, there is the enhancement of forces in the search for continuous improvement in the organization; it contributes extraordinarily to the philosophy and practice of lean construction, thus increasing the chances of success of the organization.

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