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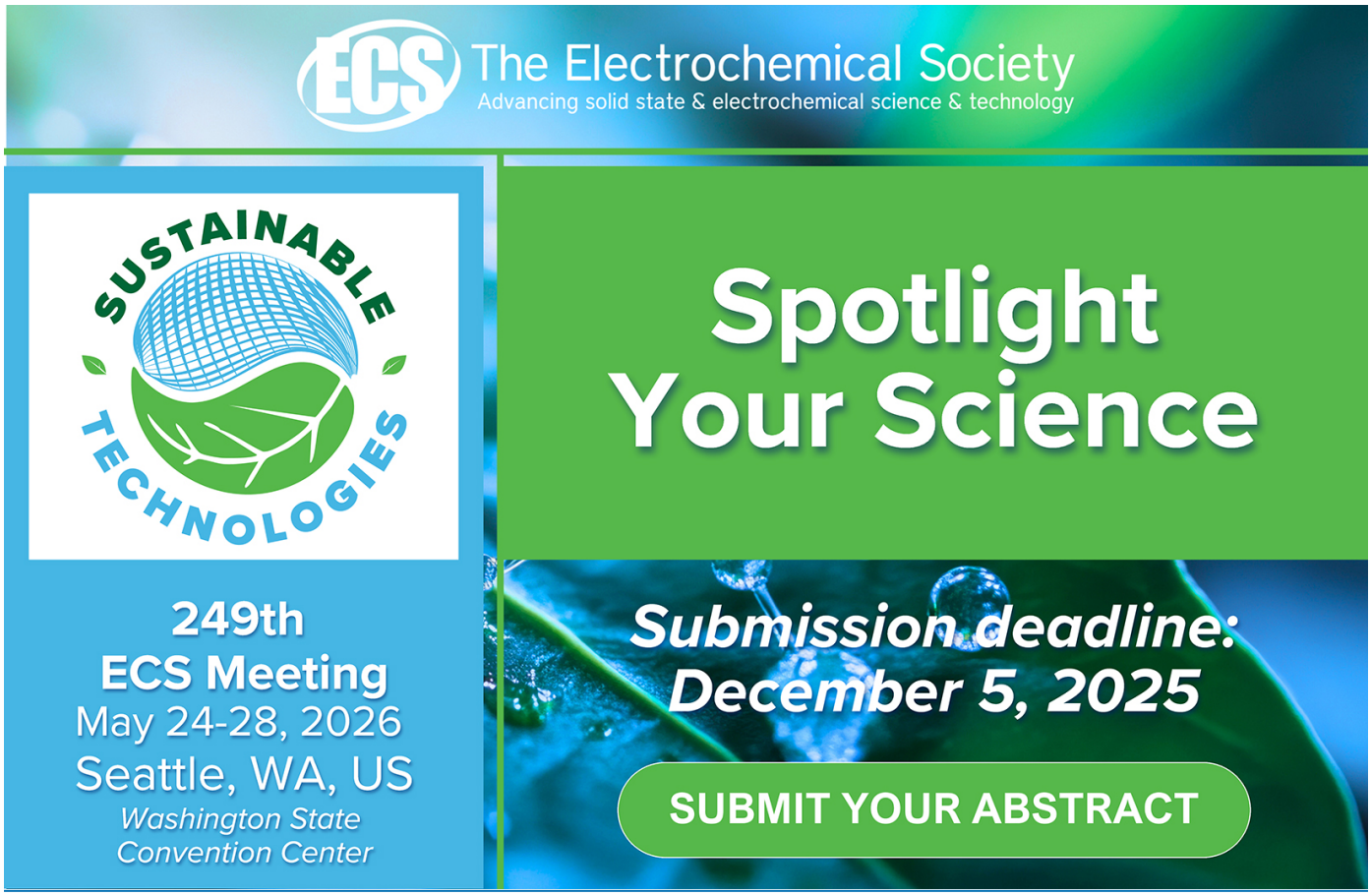
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Analysis of the time variable in on-site concrete production

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Abstract. Time is one of the most important magnitudes of physics; it is considered a variable that determines movements, positions, and speeds. Consequently, its adequate study, in the context of construction activities, allows for the dimensioning of its incidence and the correct way in which this variable should be analyzed. The objective of this research was to establish how the time variable determines productivity in the production of concrete on site. In this way, it was possible to find that this variable, when analyzed in construction activities, should not be analyzed with a unique definition, but rather it should be analyzed from 3 points of view, as productive time, contributory time, and non-contributory time. The final results indicated that the time variable measured in concrete production activity on site corresponds to productive time by 46%, to contributory time by 30%, and to non-contributory time by 24%. These results allow concluding that, for the case of activities related to the construction sector, time cannot be conceived with an absolute definition, but it should be analyzed in a discriminated way, according to the time measured for an activity, contributing or not to the improvement of productivity in a construction work. It was found that these times are not within the optimal times proposed in the literature to decrease losses in the work performed, which are around 60% for contributory time, 25% for productive time, and 15% for non-contributory time. The above indicates that the measurement of the time variable and its adequate analysis is essential to implement processes of productivity improvement in the construction sector, particularly in the way time is distributed for the production of concrete on site.

1. Introduction

The analysis of productivity times in different construction activities during the last years has been the object of study in different projects. The few studies carried out in this area lead us to uncertainty in the planning, execution, monitoring, and control of construction activities. Many tasks related to production times in concrete production in the Municipality of Ocaña, Colombia, add to this problem, being a representative activity in different work projects. This leads to a poor management in different production processes [1]. Every project is organized and managed as a value-generating process. Three categories of interest associated with productive times must be taken into account in order to conceive these values of productivity. Firstly, productive time (TP) is the time that the worker contributes directly to the production of executed activities. Secondly, contributory time (TC) is the time that the worker carries out tasks that generate added value to the activity. Thirdly, non-contributory time (TNC) is the time that is not framed within the previous times and that represents time lost or wasted by the worker in the development of the activity. It is essential to optimize the productive and contributory times since these generate value to the activity and develop improvement actions to the non-contributory times

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through plans that contribute to the continuous improvement of such activity. These times have been analyzed in different studies in order to find solutions that allow the optimization of them [2]. The analysis of thirty different types of works was carried out by the Productivity and Management Service of the Engineering and Construction Management Department of Universidad Católica de Chile, Chile; the results showed the following averages within the study time: TP 38%, TC 36%, and TNC 26%.

Similarly [3], a study of fifty works was carried out in Peru, with the following results: TP 28%, TC 36% and TNC 36%. Likewise [4], a study carried out in the city of Medellín, Colombia, on an average of 12,000 m2 of construction yielded the following results: TP 37.0%, TC 36.0%, and TNC 27.0%. Also, studies have been made in particular to different construction activities [5], where the following results were found: TP 50.2%, TC 27.6%, and TNC 22.2%. The productivity and management service of Universidad Católica de Chile, Chile, proposed optimal times for different construction works in 1995. The study was carried out on 370,000 m2 of construction [6], where these times oscillate between TP 60.0%, TC 25.0%, and TNC 15.0%. The analysis of these times seeks to maximize productivity and bring it to those optimal times to decrease construction losses, have greater competitiveness, and customer satisfaction [7]. For this reason, the lean construction philosophy [8] provides this approach to lossless construction management [9]. Considering these optimal times, we can conclude that a worker works 8 hours [10]. Of these, 4.8 hours are productive for the activity, 2 hours are for tasks that contribute to the activity, and 1.2 hours are unproductive or time that the worker does not do anything to add value to the activity.

In Colombia, normal times have been reached in different construction works [11], TP 55.0%, TC 25.0%, and TNC 20.0%. This affects optimum efficiency in the development of these works. This work presents the analysis of the productivity times in the production of concrete in different construction works in the Municipality of Ocaña, Colombia, through the five-minute test to identify the different times: TP, TC, and TNC. Within this process, priority is given to tasks that add value to the TC and do not add value to the TNC of the activity under study. The aim is to propose improvement actions that contribute to increase productivity in the production of concrete in the different works studied to optimize time for the production of this important material [12,13].

2. Methodology

The study of productivity in the elaboration of concrete in different works has a quantitative-qualitative descriptive type approach, with a probabilistic sample where the type is simple random sampling [14]. The concrete to which the time analysis was made was: 17.5 MPa, 21.1 MPa, and 24.5 Mpa concrete, respectively. According to the above, a plan was elaborated for the data collection as for the analyzed times of the different samples in the selected works, using the five-minute test. Then, these measurements are tabulated to identify the different times: TP, TC, and TNC. Within this process, priority is given to tasks that add value to the TC and do not add value to the TNC of the activity under study, in order to propose improvement actions that contribute to increasing productivity in the production of concrete on site in the different works studied. This plan is shown below (see Figure 1).

3. Results

3.1. Indirect measurement of on-site concrete productivity through the five-minute test

The first step and according to the methodology employed is to perform a test format called Lossless Measurement or five-minute test according to the Lean construction philosophy. This test consisted of establishing a random sample of the activity and analyze the crews developing the different tasks related to the TP, TC, and TNC times and consider the losses of the activity through this format where the information is collected, this can be seen in Table 1. The previous format describes the times measured in a quantitative way within these five minutes. Likewise, the tasks that generate and do not generate added value to the activity under study are identified. Also, for these tasks, the frequency of TC and TNC causes was observed [15]. A total of 2600 observations were made according to the study sample distributed in ten work sites in the Municipality of Ocaña, Colombia.

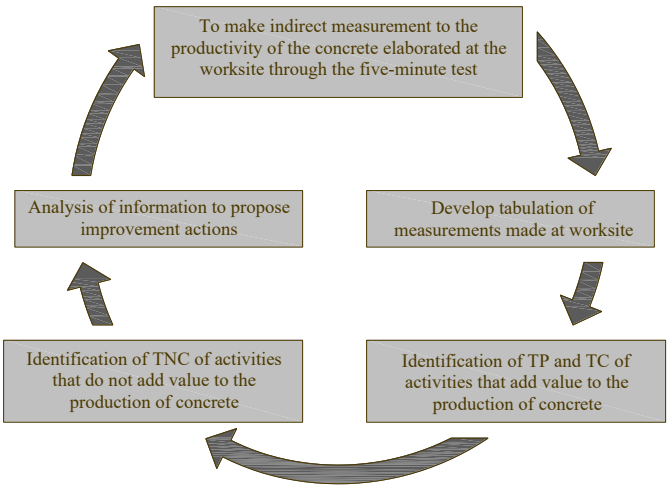


Figure 1. Plan for sampling in the different works under study.

Table 1. Loss measurement format.

Work 1: Construction of the Montelago building Transversal 2b Mz. 8		
Date: March 27, 17	Start time: 7:40 a.m.	End time: 7:45 a.m.
Activity: Production of concrete 21.1 MPa	Crew: 1 Official:4 Workers	
Measured times	Time (s)	Observation
TP	157	Production of mixture
TC	102	Transportation of materials and minor tools, discharge of materials into mixer
TNC	41	Physiological needs, travel

Comments: When measuring, the sky was partly cloudy.

3.2. Tabulation of measurements made on site

With the information collected in Table 1 and developing a descriptive statistical analysis, the different times in each worksite were analyzed, distributed in 260 samples for each one of them according to the study sample. This analysis consisted in taking minimum times, maximum times, average times, and deviations. Figure 2 shows the information tabulated for all the samples of measured times, expressed in percentages, corresponding to TP, TC, and TNC of the projects or works under study [16].

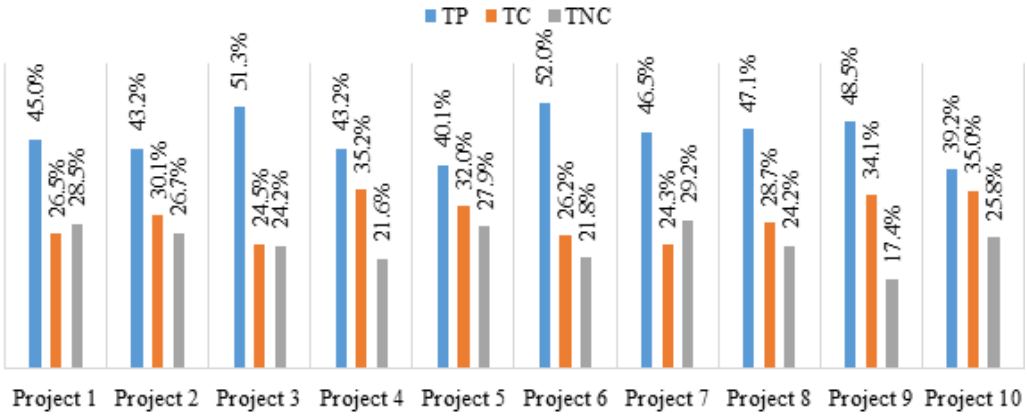


Figure 2. Report of TP, TC, and TNC of the projects or works covered in the study.

3.2.1. Percentage estimation of losses in expected times. Figure 3 shows the general percentage value of the analysis of the time measurements made in the different works according to Figure 2. Taking as a reference the values mentioned above, they can be seen below.



Figure 3. Percentage analysis of the expected TP, TC, and TNC times of the works under study.

3.2.2. Pareto diagram for the causes of contributory time activities. After developing the statistical description of the different times according to Figure 3, it is analyzed through the 20-80 theory [17], shown in Figure 4, the behavior of the tasks that generate added value to the activity under study.

In this, it can be concluded that 20% of these tasks that add value to the TP are: pouring materials into the mixer, filling material into buckets, transporting materials and minor tools, which are 80% of the results in terms of TC.

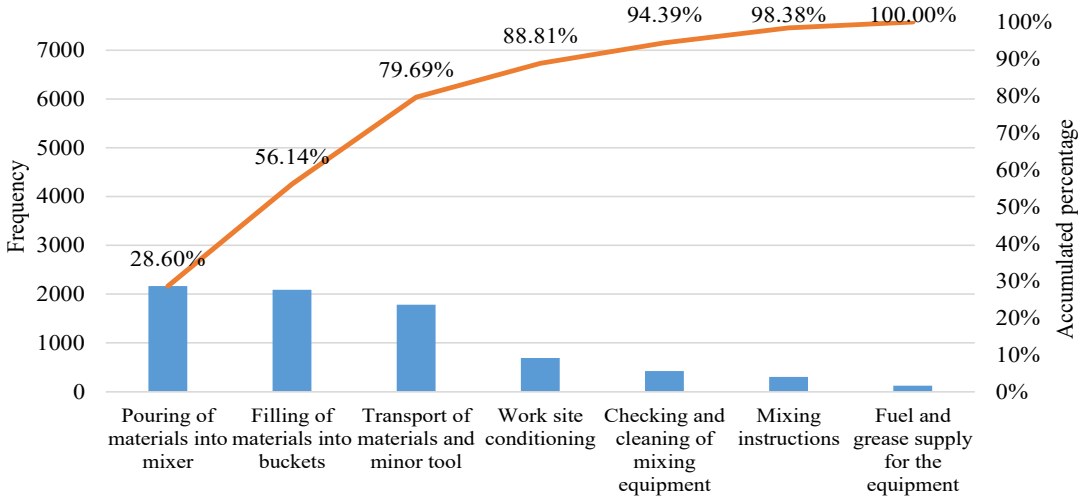


Figure 4. Pareto diagram for TC causes.

3.2.3. Pareto chart for the causes of non-contributory time activities. Similarly, the previous analysis is made to the tasks that do not add value to TP, through the 20-80 theory shown in Figure 5. We can conclude that 20% of the tasks, in which are contemplated waiting, physiological needs and travel, are 80% of the results in terms of non-contributory time, that is, they do not add value to the activity under study.

3.3. Improvement actions for activities that do not add value to the non-contributory time

When the causes that generate the problems within the TNC have been identified, according to Figure 5, an improvement plan is proposed to help mitigate, through actions, these losses within the TP [18]. See Table 2. According to Table 2 and considering the tasks of greatest impact according to the analysis elaborated in Figure 4 through the rule 20-80, these activities are detailed as the description of the causes that generate the loss of time. Then, actions are proposed to improve and recommend the optimization of this time being the most critical within the study, with 24% according to Figure 3, since the optimal is 15%.

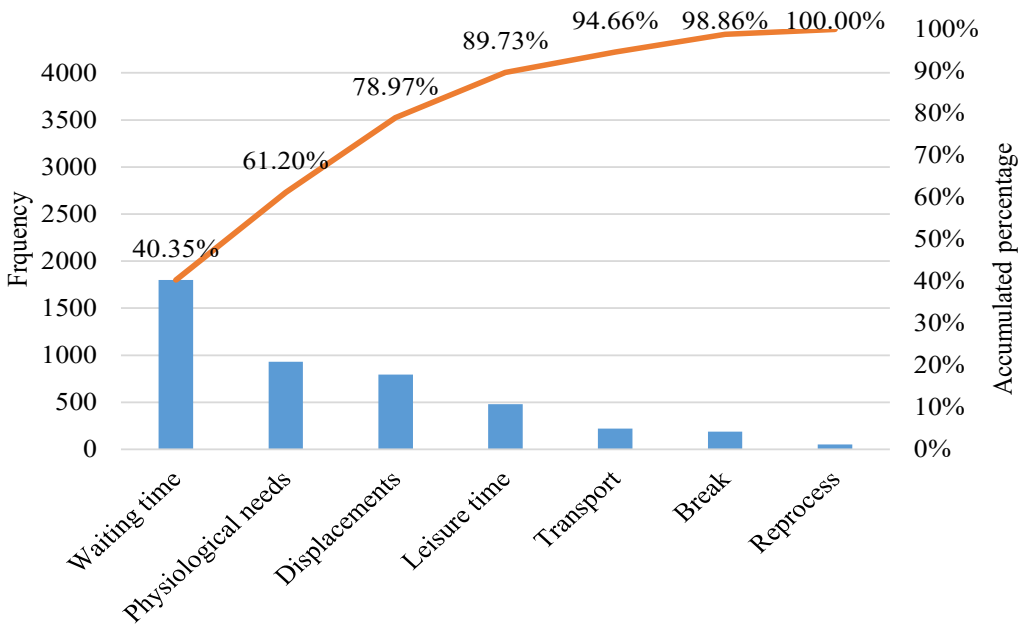


Figure 5. Pareto diagram for TNC causes.

Table 2. Improvement actions for TNC.

Causes of loss TNC	Description	Improvement action
Waiting	Over-allocation of crews	Improve the distribution of crews and work times by the site supervisor.
	Bringing equipment to the site	Optimize by the construction site manager the equipment and material available for the work, with times that do not delay the production process.
	Bringing material to the site	
	Equipment damage	Perform periodic maintenance to the equipment used for concrete mixing.
Physiological needs	Drink water during working hours	Provide hours for the workers to take a short break without affecting the production process.
	Feeding during working hours	
	Elimination of body waste	Install temporary bathrooms on site and give time to workers for this need.
Displacements	Recurring walks in the site	Control by the construction manager of unnecessary walks by workers.
	Transport of materials	Improve the transport routes of materials through the worksite.
	Equipment transportation	

4. Conclusions

Within the ten works studied, the maximum productive time corresponds to 52% and the minimum productive time corresponds to 39.2%. The maximum contributory time corresponds to 35.5% and the minimum contributory time corresponds to 24.3%. The maximum non-contributory time corresponds to 29.2% and the minimum contributory time corresponds to 17.4%.

The percentage times in this proposal are in the "expected time" range: productive time 46%, contributory time 30% and non-contributory time 24%, which are below and above the "optimum time": productive time 60.0%, contributory time 25.0% and non-contributory time 15.0%. This is due to the tasks that do not add value to the main activity in this study, such as: waits, physiological needs, and travel. These tasks are 9% higher than the optimal non-contributing time, which is why improvement actions such as those proposed here should be implemented in the different works to mitigate the non-contributory time.

Similarly, the contributory time should be improved in the different works studied since the expected time in the study was 30% which is 5% above the optimal contributory time. The actions would be more of an administrative type such as improving the type of contract and treatment of the work crews by the construction manager to improve their productivity.

References

[1] Cárdenas L, Armiñana E 2009 Un nuevo enfoque en la gestión: la construcción sin perdidas *Revista de Obras Públicas* **46(1)** 90-103
[2] Serpell A 2003 *Administración de Operaciones de Construcción* (México: Alfaomega)
[3] Guio V 2001 *Productividad en Obras de Construcción, Diagnostico, Critica y Propuesta* (Perú: Fondo Editorial de la Pontifica Universidad Católica del Perú)
[4] Botero L, Álvarez M 2006 *Identificación de Pérdidas en el Proceso Productivo de la Construcción* (Colombia: Red Universidad Eafit)
[5] Araque G, García D, Aguirre E 2017 La metodología lean Construction y el análisis de pérdidas en el sector civil colombiano: Un estudio de caso *Desarrollo e Innovación en Ingeniería* **2(1)** 378-391
[6] Botero L, Álvarez M 2004 Guía para el mejoramiento de la productividad en la construcción de proyectos de vivienda *Lean Construction Como Estrategia de Mejoramiento* **40(136)** 50-64
[7] Jorgensen B 2006 *Integrating Lean Design and Lean Construction: Processes and Methods* (Copenhage: The Technical University of Denmark)
[8] Senaratne S, Wijesiri D 2008 Lean Construction as a strategic option: testing its suitability and acceptability in Sri Lanka *Lean Construction Journal* **2008** 34-48
[9] Howell G A 1999 What is lean construction-1999 *Proceedings IGLC* **7** 1-10
[10] Botero L 2002 Análisis de rendimientos y consumos de mano de obra en actividades de construcción *Revista Universidad EAFIT* **1(128)** 10-21
[11] Botero L, Álvarez M 2004 Guía para el mejoramiento de la productividad en la construcción de proyectos de vivienda *Lean Construction Como Estrategia de Mejoramiento* **40(136)** 50-64
[12] Sarmiento A 2001 Programa integral de mejoramiento (PIM) en empresas de construcción improvement integrated program (PIM) in construction companies *Revista Ingeniería de Construcción* **16(2)** 1-15
[13] Porras H, Sánchez O G, Galvis J A 2014 Filosofía lean construction para la gestión de proyectos de construcción *Avances de Investigación en Ingeniería* **11(1)** 32-53
[14] Mateu E, Casal J 2003 Tamaño de la muestra *Rev Epidem Med Prev* **1(4)** 8-14
[15] Lugo F 2015 Aplicación de la filosofía Lean Manufacturing en un proceso de producción de concreto *Ingeniería Industrial Actualidad y Nuevas Tendencias* **4(15)** 7-24
[16] Macomber H, Howell G 2003 Linguistic action: contributing to the theory of lean construction: contributing to the theory of lean construction *Proceedings of the 11th Annual Meeting of the International Group for Lean Construction* (Virginia: International Group for Lean Construction)
[17] Ohno T 1998 *The Toyota Production System: Beyond Large-Scale Production* (USA: CRC Press)
[18] Khan M 1993 Methods of motivating for increased productivity *Journal of Management in Engineering* **9(2)** 148–156