COMPARATIVE ANALYSIS OF MASONRY PRODUCTIVITY ON A CONSTRUCTION SITE IN THE CITY OF MANAUS

Johnnathan Kennedy Lima Marques¹
Fernando de Farias Fernandes²

ABSTRACT

Objective: The main focus of this work is to conduct a comparative study on productivity by developing compositions based on the specificities of construction companies in comparison to the constants in TCPO and SINAPI, for the conventional masonry service of 9x19x19 cm ceramic brick ½ time, and to gain insights into the differences in productivity between TCPO, SINAPI, and RUP in the city of Manaus, understanding the reasons behind these variations.

Method: This study involves bibliographic research, data collection, and comparative analysis.

Results and Conclusion: The methodology used in the study allowed for on-site data collection, SINAPI data collection, and TCPO data collection. With this information, it was possible to calculate the proposed RUPs: Daily, accumulated, and potential. Using these data, the average SINAPI RUP was also calculated, and the TCPO RUP was collected. This scientific research provided a concrete study of labor productivity in the masonry work of a residential construction project. With on-site data collection, the calculation of RUPs was performed, and comparisons were made with TCPO and SINAPI references.

Research Implications: Contribution to improving productivity in civil engineering projects in the city of Manaus, reducing costs, and optimizing resource utilization.

Originality/Value: This research is novel in the region, and the comparison of data between TCPO, SINAPI, and real production is crucial to understanding their outcomes.

Keywords: Civil Construction, Productivity, TCPO, SINAPI, Comparison.

ANÁLISE COMPARATIVA DE PRODUTIVIDADE DE ALVENARIA EM OBRA NA CIDADE DE MANAUS

RESUMO

Objetivo: O foco principal deste trabalho é realizar um estudo comparativo entre produtividade com a elaboração de composições baseadas nas specificidades das empresas construtoras com as constantes no TCPO e SINAPI, para o serviço de alvenaria convencional de tijolo cerâmico 9x19x19 cm de ½ vez e obter conhecimentos acerca da diferença de produtividade entre o TCPO, SINAPI e o RUP na cidade de Manaus e entender quais os motivos que levam a essas diferenças.

Método: Neste estudo será abordada uma pesquisa utilizando-se de pesquisa bibliográfica, coleta de dados e análise comparativa.

Resultados e conclusão: A utilização da metodologia do estudo possibilitou a coleta de dados in loco, coleta de dados SINAPI e coleta de dados TCPO. De posse desses dados, foi possível realizar o cálculo dos RUP’s propostos: Diário, acumulado e potencial. Com esses dados, foi-se realizado o cálculo também do RUP médio SINAPI e coletado o RUP TCPO. Esta pesquisa científica possibilitou um estudo concreto da produtividade de

¹ Universidade do Estado do Amazonas, Manaus, Amazonas, Brazil. E-mail: jklm.eng@uea.edu.br
Orcid: https://orcid.org/0009-0001-3524-6612

² Universidade do Estado do Amazonas, Manaus, Amazonas, Brazil. E-mail: fffernandes@uea.edu.br
Orcid: https://orcid.org/0000-0002-0710-0018
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mão de obra no serviço de alvenaria de vedação em uma obra residencial. Foi possível, com a coleta de dados in loco, realizar os cálculos dos RUP’s, e compará-los com as referências TCPO e SINAPI.

**Implicações na pesquisa:** Contribuir para melhoria de produtividade em obras de engenharia civil na cidade de Manaus, na diminuição de custos e no melhor uso de recursos.

**Originalidade/valor:** É uma pesquisa nova na região, sendo importante a comparação de dados entre TCPO, SINAPI e produção real para conhecer seus resultados.

**Palavras-chave:** Construção Civil, Produtividade, TCPO, SINAPI, Comparação.

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1 INTRODUCTION

The importance of productivity planning in civil construction becomes increasingly important due to increased competition between companies, it is also believed that there are several factors influencing the productivity of civil construction, such as climate, geographical conditions and availability of skilled labor. Silva (2017) quotes that "The importance of work for human beings and society stimulates their study”. As stated by Lepore et al. (2017), "the measurement of productivity is essential for the continuous improvement of civil construction". In this sense, the use of TCPO and SINAPI as references for estimating the time required to perform specific tasks has proven to be common practice in the area. According to Alves et al. (2020), "the TCPO allows for the standardization of constructive processes and assists in the planning and control of activities, providing a basis for comparative productivity analysis". Thus, the need to review and program improvements in management principles in order to minimize losses in construction works is noticeable. Knolseisen (2003) states that: Determining costs of goods and services, seeking measures to reduce their value and analyzing the various decisions taken by companies are issues that should always be discussed by entrepreneurs and academics, not only in the field of construction, but in all, because the growth of competitiveness in the market also seeks improvement in the quality of services. It is well known that the importance of measuring and increasing the productivity of construction work is unquestionable. Productivity in construction is directly related to the best way of using the resources available in a construction site. Space must be well used as must labor, tools, inputs and transportation processes. In simpler words, productivity is about the amount of hours consumed to accomplish a task. The data obtained from the productivity survey are used in budgeting, data that generally have a lot of variation, however, if the service is standardized, the productivity indicators tend to remain close to the same number.

2 THEORETICAL FRAME

This work encompasses budgetary, productive and management themes applied in civil construction with emphasis on works in the city of Manaus, in addition, aims to compare the models of partial cost compositions with the real productivity on site. Afonso (2011) quotes that "Structuring a literature review with the aim of building knowledge and selecting journals made available on the CAPES Portal for theoretical grounding is a challenge for the researcher".
2.1 Unit Production Ratio (OR)

The Unit Production Ratio (UPR) is a concept widely used in engineering, including civil engineering, to manage projects for the purpose of expressing the amount of work or production achieved in relation to a standard unit of measurement. Baldo et al. (2018), states that the OR is "a measure that establishes the relationship between the quality produced and a standard unit of measurement, allowing the comparison and evaluation of productivity in different situations". According to the seminar on "Advances in building production management" (Sinduscon - Rs, 2019), the RUP formula is defined as the division between the production quantity and the value of the unit in measure, as shown in equation 1.

\[
RUP = \frac{Hh}{Qs} \quad (1)
\]

Where:

OR = unit production ratio;  
Hh = man-hour;  
Qs = Quantity of service.

The use of the OR allows a comparative analysis and monitoring of productivity over time, Pires et al (2020), highlights that "the OR is a valuable metric to identify variations and improvements in productive efficiency, assisting in decision making and in controlling the quantity of processes". We can use the OR to calculate productivity, which is the reverse of the OR. It is important to stress that the definition of the unit of measurement used in the outermost regions must be consistent and appropriate to the context of the project or activity in question. Ferreira et al. (2019) mentions that "the choice of unit of measurement is fundamental for the OR to be representative and applicable to the specific situation, providing precise insights on productivity". The Construction Site Project/ Production Management of the VII National Congress on Conditions and Environment of Work in the Construction Industry states that the lower the RUP, the higher the productivity: it means that less labor is being used or less time for a given service. Otherwise, the higher the OR, the lower the productivity: more men or more time are needed for the same service, as illustrated in figure 1.

![Figure 1: Variation of the RUP](Source: VII National Congress on Working Conditions and Environment in the Construction Industry (2019))

In addition to the formula variables, it is worth considering that other factors also influence productivity. They are known as context or abnormality factors. Some examples of context factors:
(a) meteorological conditions,
(b) motivation of professionals,
(c) form of payment,
(d) Type of transport equipment.
Examples of abnormality factors:
(a) lack of professionals,
(b) lack of education,
(c) lack of materials or equipment.

Three types of ORs will be proposed in this work: daily ORs, potential ORs and cumulative ORs. Figure 2 illustratively shows a chart containing the charts of the Diary, Cumulative and Potential RUP and comparing them with the RUP taken from SINAPI.

![Figure 2: Daily RUP, Potential, Accumulated, and SINAPI](source: Sampaio (2016))

3 METHOD

This study will cover research using bibliographic research, data collection and comparative analysis.

3.1 Company under investigation

The company chosen to be the subject of this study is a private company, which has been active in the construction market since 2014 and specializes in residential works. The company is headquartered in Manaus and focuses its works in this city. It is typically a contractor.

3.2 Data Collection

In this stage of the study, data were collected on site for the period from 23 August 2023 until 21 September 2023, 30 calendar days, where the productivity survey of the ceramic brick masonry service was carried out on the days of service, being the team formed by a mason and a servant. The following chart 1 shows the production of the masonry survey each day.
### 3.3 Calculation of the ORs

After the data was collected, the calculation of the Rups was performed, these being the daily, accumulated and potential Rups.

**Daily OR:** Relating to the working day. Inputs and outputs are measured on each working day of service, thus calculating the RUP, equation 1 demonstrates the RUP formula.

**Cumulative OR:** This OR is for a cumulative period. Inputs and outputs are those accumulated from the first day of the study until the final follow-up date. They serve to verify what the long-term trends are, visualizing the abnormalities of the days during the period of the execution of the service.

**Potential ORs:** It is obtained with daily OR median values below the accumulated OR value at the end of the study period. Represents a daily RUP value associated with good performance, while showing possible since it points out values already detected.

Chart 2 below demonstrates the daily, cumulative and potential RUP values together for better visualization and comparison.
3.4 Comparison of the ORs, TCPO and SINAPI

With the data collected and the calculations of daily ORs, accumulated and potential, we can now compare with the TCPO and SINAPI indices to compare the productivity of the indices and the real.

3.4.1 TCPO

TCPO is one of the most popular compositions sources nowadays, several companies use it for executing budgets in engineering. TCPO is produced by Editora PINI, where it presents TCPO Web, a construction news portal that is responsible for conducting research in the field of civil construction, the TCPO Web PINI page (2017) states: Currently, the table has more than 8500 compositions of services, reference prices calculated by the Engineering department of PINI and Company Compositions of the materials industry and construction services. Silva et al (2018) states that the TCPO are "a set of tables containing compositions of unit costs for the execution of specific activities and services in civil construction." TCPO provides a reference framework that details inputs as well as labor, equipment, charges, and other elements that make up the cost of each item. Camarotto et al (2019) cites that "the TCPO are used as a basis for the preparation of works budgets, facilitating the calculation of costs and the comparison between proposals". When the TCPO is adopted, the professionals manage to speed up the budgeting process, guaranteeing with precision and consistency the estimated values. The TCPO can also be applied as a reference for the control and monitoring of costs during the execution of the work. França et al (2020) states that "the TCPO assists in the monitoring of expenses, allowing comparison between the forecast and realized, contributing to the efficient financial management of the enterprise." It is important to note that the TCPOs are regularly updated to keep pace with market price changes and technological and regulatory changes. Silva et al (2018) states that "the update of the TCPO is necessary to maintain the accuracy of the reference values and their applicability in the reality of civil construction". Figure 3 illustrates Productivity for Punched Ceramic Brick Masonry.

![Figure 3: Type 1 Index: Punched ceramic brick masonry](source: TCPO (2010)).
The present study took into account the problems during the execution of the work and for these reasons the following productivity was chosen:

Productivity of the mason: 0,65(Hh/m²)

Servent Productivity: 0.39(Hh/m²)

Where:

Hh = man-hour;
m² = Square meters.

Thus, possessing the productivity of both, considering an average quantity of service (Qs) of 29m² during the period studied, it is possible to perform the calculation of the OR.

\[ RUP = \frac{Hh}{Qs}; RUP = \frac{(0.65+0.39) \times 8}{29}; RUP_{tcpo} \approx 0.29 \]

Where:

OR = unit production ratio;
Hh = Time Man;
Qs = Quantity of service;
RUP_{tcpo} = TCPO Unit Production Ratio.

3.4.2 SINAPI

The SINAPI (Sistema Nacional de Pesquisa de Contas e Indices da Construction Civil) is by definition a system developed by the Federal Government of Brazil and aims to carry out research, collect data and disseminate information about the costs and indices of civil construction in the country. The Caixa Econômica Federal (2021) cites that: SINAPI is the system of costs and indexes of civil construction, constituting an important instrument for the sector and is currently used as a basic reference in the evaluation of costs and the budget of services, works, projects and housing development throughout Brazil. SINAPI is widely used in the country for price standardization, comparison between different regions and as a reference tool for the execution of works, providing greater transparency and efficiency in the processes of contracting and execution of civil construction projects. Figure 4 illustratively shows coefficients taken from the SINAPI spreadsheet for masonry services.
With such compositions, it is possible to calculate the theoretical RUP for the SINAPI composition, making the ratio between the quantity Man x hour divided by the quantity of average service (Qs) that is 29m² per working day. With the average service quantity of the work, we can calculate a theoretical RUP according to the compositions of SINAPI.

$$RUP = \frac{Hh}{Qs}; \quad RUP_{sinapi} = \frac{(1.98+0.99) \times 8}{29}; \quad RUP_{sinapi} \cong 0.82$$

Where:
- OR = unit production ratio;
- Hh = Time Man;
- Qs = Quantity of service;
- RUPsinapi = SINAPI production unit ratio.

### 4 RESULTS AND DISCUSSIONS

The use of the study methodology enabled data collection on site, SINAPI data collection and TCPO data collection. With this data, it was possible to calculate the proposed ORs: Daily, accumulated and potential. With this data, the calculation was also performed of the average RUP SINAPI and collected the RUP TCPO. Thus, a comparative chart was generated among all, for analysis.
With the generation of chart 3 based on the collected data and the information obtained, the behavior of the ORs was analyzed. On days 1, 2, 4, 5, 10 - 20 the above average productivity was observed. On days 3 and 6, there were recorded high temperatures in the city of Manaus, recording 37° and 38° respectively, decreasing by 2.5 m² 2.0 m² the amount of masonry raised. Analyzing the daily Rup, on days 7, 8 and 9 there was also a fall in productivity due to the turnover that occurred in the company, where there was the change of a mason, which caused low productivity in 3 days which impacted the value obtained in the daily Rup and the other Rup's. It was observed in loco that some factors can be determinant for low productivity, such as: High temperatures due to the Amazon summer, company turnover, particularities of material and labor. For the work studied, a potential RUP of 0.5 Hh/m² was obtained. In comparison with the index researched, it showed a variation of 64% less in relation to SINAPI and 42% more in relation to TCPO. Thus, it is verified in the first case that the productivity of the work is satisfactory when compared with the SINAPI index, while in the second case, comparing with the TCPO we see that the productivity is lower than expected for the masonry sealing service, which will impact on the final cost, being favorable when the parameter adopted is the SINAPI.

5 FINAL CONSIDERATIONS

This scientific research made possible a concrete study of labor productivity in the service of masonry fence in a residential work. It was possible, with the collection of data on the spot, to carry out the calculations of the ORs, and to compare them with the references TCPO and SINAPI. In possession of this data, it was concluded that when compared with SINAPI, the work finds itself with a production above the real, however, if compared with the TCPO, it is outside the standards that he proposes. Finally, it is, through this study, a portion of contribution to civil engineering community in the state of Amazonas, specifically in the city of Manaus who want to apply the references SINAPI and TCPO in their works, emphasizing that it is important that companies develop methods of appropriation of their data so that they serve as reference in their planning and can decrease the difference between the planned and the executed.
REFERENCES


Sampaio, Jhayson Ferreira; AVALIAÇÃO DO NÍVEL DE PRODUTIVIDADE DA MÃO-DE OBRA NA EXECUÇÃO DO SERVIÇO DE LEVANTAMENTO DE ALVENARIAS EM UM EDIFÍCIO NO MUNICÍPIO DE PALMAS-TO: ESTUDO DE CASO. Palmas (2016) Trabalho de conclusão de curso. 56 p. Trabalho de conclusão de curso (Graduação em engenharia Civil) Centro Universitário Luterano de Palmas.

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