ISSN 2286-4822
www.euacademic.org

EUROPEAN ACADEMIC RESEARCH
Vol. X, Issue 3/ June 2022

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

Analysis of Civil Construction Waste Generation in Social Interest Housing Works

LUCIANA CÁSSIA LIMA DA SILVA
Master's student at the
Polytechnic School of the University of Pernambuco (UPE/POLI)
Email adress:lcls@poli.br
KALINNY PATRICIA VAZ LAFAYETTE
PhD and Associate Professor at the
Polytechnic School of the University of Pernambuco (UPE/POLI)
Email adress: klafayette@poli.br

Abstract

The civil construction sector is of great importance to the society quality of life, mainly through the Minha Casa, Minha Vida Program, with the construction of housing of social interest. However, the management system is still inefficient, considering the lack of effective municipal legislation. This article aims to describe the generation of waste in social housing works, analyzing the quantity and the steps that most cause waste. The results varied according to the constructive characteristics, such as the area, the amount of pavement, the adaptation of the lean construction methodology, and the type of foundation. Regarding the foundation stage, the constructions that adopted piled rafts generated more waste when compared to the raft-only foundation. All construction works had a higher generation of waste in the structure stage due to the absence of separation of these materials. The exception was in works 5 and 6, which generated more waste in the finishing stage, facing difficulty moving and storing the materials. The largest generation of waste was in construction 1 (299,591 kg), which was the pioneer for the implementation of the lean construction methodology, observing significant reductions from construction 2 onwards. In this way, the generation of waste is determined by several factors, with great importance to the control and inspection in this type of construction.

Keywords: Civil construction waste, social housing works, construction management.

INTRODUCTION

The construction sector contributes laboriously to the world economy. However, it harms the environment, Lins (2020). The evolution and change in the population's lifestyle are the main contributors to the high generation of waste and, consequently, the increase in environmental degradation (Awoyera and Adesina, 2020).

Irregular waste disposal is the worst impact caused by these materials, mainly due to the absence of adequate facilities for collection, disposal, and treatment. That puts many areas at risk, promoting flooding, visual pollution, and the spread of diseases (Srivastava, 2020; Bakchan, Faust and Leite, 2019; Abdel-Shafy and Mansour, 2018). In this way, to minimize the damage caused by the negative impacts of waste generation, sustainable measures are adopted to conserve natural resources, providing necessary conditions for current and future generations survival (Li *et al.,* 2020). One of the sustainable ways that have become common is, according to Silva *et al.* (2019), that waste incineration, making it possible to reduce the volume by up to 90% and the mass by up to 70%, in addition to the production of energy and ash (Tang *et al.*, 2020).

However, even with the problems that involve this sector, housing construction remains relevant. According to Silva (2020), it is evident that there was an increase in population concentration in urban areas, which, with the growth in cities and services (health, transport, and education), demanded improvements in infrastructure and basic sanitation.

Nevertheless, this population concentration was not followed by the development of the public service. The latter occurred without adequate planning, contributing to social inequality and consequently greater waste generation.

In this sense, the Federal Government in 2009 created the *Minha Casa, Minha Vida* program (PMCMV) that facilitated financing, providing the most deprived population with access to housing. Realizing this, large companies in the civil construction sector have partnered with the Federal Government to receive the investments and, thus, have access to this target population.

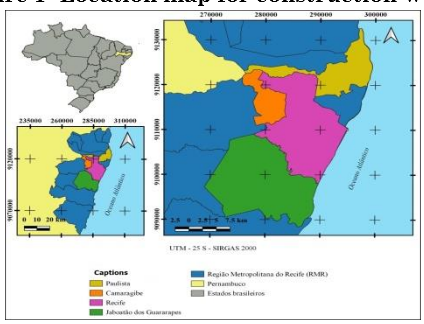
In addition to this program, between 2004 and 2010, C class population increased, followed by the 2014 economic crisis that damage real estate sales and forced construction companies to seek new construction methodologies with low executive costs to stay in the market. These companies adapted to the *Minha Casa, Minha Vida* Program (PMCMV) which, according to Law No. 12,424 (Brazil, 2011), creates incentive mechanisms for the production and acquisition of housing units.

Therefore, realizing that the PMCMV is in evidence and that there are several works carried out by the program, this paper analyzes the generation of waste in this program and the impacts of good management with new tools such as the Lean Construction management methodology, (Silva *et al.,* 2020).

CHARACTERIZATION OF THE CONSTRUCTION WORKS

The works studied are located in the Metropolitan Region of Recife (RMR), in the municipalities of Camaragibe, Paulista, Jaboatão dos Guararapes and Recife (figure 1). The company providing the data has several certifications, such as ISO 9001. SiAC/ PBQP-H (Brazilian Habitat Quality and Productivity Program) Level A.

Figure 1 -Location map for construction works



Source: Authors

Constructions 1 and 7 are in the Alberto Maia neighborhood in the Municipality of Camaragibe, with 158,899 inhabitants. According to the IBGE (2020), the average monthly income of the population in 2018 was 1.9 minimum wages. The population of this region represents the E class, up to BRL2090.00, being an area widely used for the construction of Social Interest Housing.

Constructions 2 and 5 are in the neighborhoods of Guabiraba and Tejipió, respectively. The two neighborhoods are part of the city of Recife, which has a total of 1,653,461 inhabitants and an area of 218,843 km². The neighborhood of Guabiraba has a total housing population of 6,330 inhabitants and 46.17 km². It is considered a low-income population that fits into the social housing program. The neighborhood of Tejipió has an area of 940,000 m² and 8,918 inhabitants, 2,682 houses, and an average monthly income of BRL2,118.10, which falls into class D - income between BRL2,090.01 and BRL4,180.00.

Constructions 3 and 6 are in the neighborhood of Maranguape I, Paulista, with an area of 93.52 km² and an estimated population of 316,719 inhabitants.

Finally, constructions 4 and 8 are in Jaboatão dos Guararapes, in the districts of Abrolhos and Bulhões, respectively, with a total of 258.7 km², divided into 23.6 km² of urban area and 233.7 km² of rural area. The region has a total population of 697,636 inhabitants. The municipality has 197,047 households and an average monthly-household income between 1 and 2 minimum wages.

METHODOLOGY

The method used was of the explanatory type, with descriptive elements of a qualitative/quantitative approach. The qualitative approach was based on a survey of information made available by those responsible for the constructions, in which evidence was examined more broadly. Therefore, the results arise from data collected and analysed in a systematic and specific way. The quantitative approach was carried out by obtaining values of waste generation in different construction stages.

Information for waste generation was collected in 8 construction works with the same typology (Table 1); the structure and finishing steps were performed simultaneously.

Table 1 - Quantities for the constructions

Construction	Construction site	Built-upe area	Foundation	Construction Structure	Completion of the work	Waste collection time	Number of towers	Floor per tower	Number of apart.
1	Alberto Maia	13770,06	Raft	concrete wall	10 meses	6 meses	16	4/4	256
2	Guabiraba	13666,08	Raft and Raft piled	concrete wall	11 meses	8 meses	16	4/4	256
3	Maranguape I	13374,40	Raft	concrete wall	12 meses	7 meses	20	4/4	320
4	Abrolhos	19891,91	Raft and Raft piled	concrete wall	9 meses	6 meses	11	4/4	176
5	Tejipió	17.162,82	Raft and Raft piled	concrete wall	11 meses	6 meses	18	5/4	360
6	Maranguape I	12.381,18	Raft	concrete wall	10 meses	6 meses	20	4/4	320
7	Alberto Maia	9786,81	Raft and Raft piled	concrete wall	8 meses	5 meses	12	4/4	192
8	Bulhões	20.439,16	Raft and Raft piled	concrete wall	11 meses	7 meses	20	4/4	320

Source: Authors

For the implementation of the lean construction methodology, work 1 was chosen as a pilot, to seek to reduce waste, material, time, and costs as well as increase productivity. For the other works, all followed the same pattern of methodology.

All waste generated was collected in buckets and was not separated, as the company had not yet implemented the selective collection policy. According to the characteristics, all works have a raft or piled raft type foundations. The structure is made of concreted aluminium forms and the ceramic finish is only in two rooms.

A statistical analysis of linear regression of the relationship of the generation of residues in each constructive step was carried out. This evaluation describes whether the function correctly explains the data, or whether new functions should be added. The determining factor to assess whether the function is sufficient or not is obtained by the value of R^2, which can vary between 0 and 1.

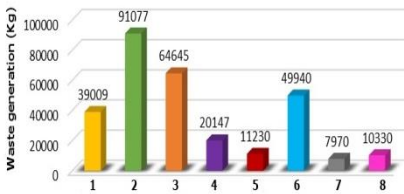
RESULTS

In the analysis of waste generation, pilot work (1), which has 16 towers, generated less waste compared to construction 2. However, despite having the same number of towers as construction 1, the latter was the one that generated the most waste in the stage foundation, among the others. That was due to the typology of the foundations, which was of the raft type with continuous helix piles, generating soil and spare concrete as residue.

Despite only having a raft foundation, construction 3 was the second-largest generator of waste, which was caused by the number of foundations executed. That was also evidenced in construction 6, which follows the same pattern as 3. The reduction in the amount of waste reflected the good adaptation of the lean construction methodology in the company.

Construction 7 was the smallest waste generator as it was the second work with the lowest number of foundations executed (figure 2).

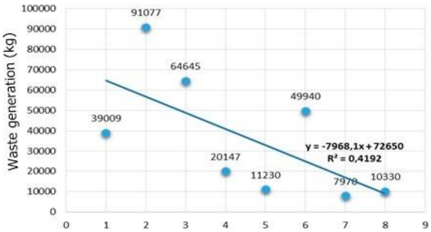
Figure 2- Comparison of waste generation in the foundation stage



Source: Authors

Figure 3 shows the relationship between the generation of waste in the foundation stage for the eight works analyzed. The closer to 0, the R² shows a low relationship between the data. Thus, for an R² of 0.42, it is possible to conclude that there was not a good relationship between the data for this linear function.

Figure 3- Relation of waste generation in the foundation stage

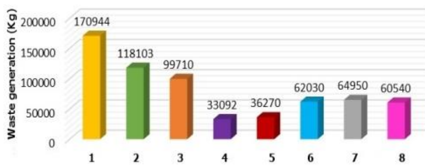


Source: Authors

As for the structure stage, the largest generation of waste was construction 1 (figure 4) since it was the pioneer in the implementation of the lean construction methodology. Consequently, it still does not have an effective adherence of the team in the reduction of waste. The smallest waste generator was construction 4 since the team had already adapted to this methodology.

To reduce costs and increase productivity (construction 6), the team was reduced and services were redistributed. Consequently, the team had to adapt to the new work format, causing an increase in waste generation.

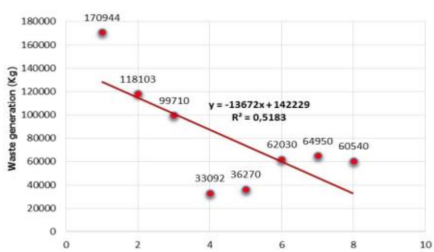
Figure 4- Comparison of waste generation in the structure stage



Source: Authors

The relationship between the variation of waste generation in the structure stage of the works is in Figure 5. With an R^2 of approximately 0.52, the linear function describes half of the analyzed data.

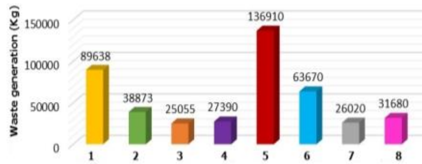
Figure 5- Relation of waste generation in the structure stage



Source: Authors

In the finishing stage, the largest waste generator was construction 5, as shown in Figure 6. The main factor for this high value was the impact of the team reduction, with readaptation and new divisions and training, as well as excessive workload.

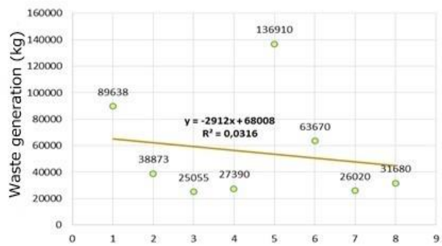
Figure 6- Comparison of waste generation in the finishing stage



Source: Authors

At this stage, the points are dispersed; R^2 is far below 50%, describing that the model does not suit the analyzed data well (figure 7).

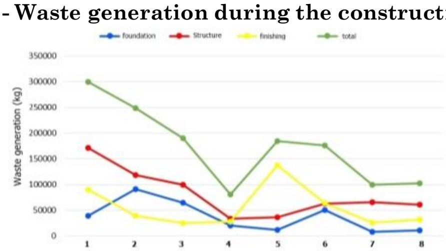
Figure 7- Relation of waste generation in the finishing stage



Source: Authors

Checking all the constructions in the three stages, the structure phase was the biggest waste generator due to the impossibility of separating these materials, thus being counted as a result in this stage. The exception was construction 5, which had difficulty storing and transporting materials during the execution of the work, causing large waste in the finishing stage, as shown in figure 8. The minimum waste generator was the foundation stage, corroborating with the data obtained by Soares (2015).

Figure 8 - Waste generation during the construction phase

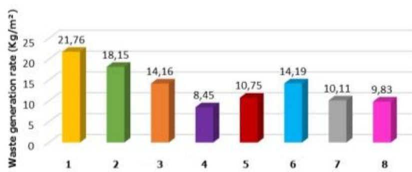


Source: Authors

In all the conditions evaluated, construction 1 remained the largest generator of waste, which is related to the fact that it was the pioneering work in the implementation of the lean construction methodology. Therefore, it was expected that the following constructions would reduce waste generation. However, constructions 5 (7 more towers), 6, and 7 (5 more towers) had an increase in the amount of waste against 4. Construction 8, which has the same construction standard as construction 4, shows a visible reduction in the amount of waste proving that the adaptation of the team to the type of methodology and the type of construction standard have a direct influence in the adoption of this system.

The waste generation rate was also calculated and varied between 8.45 and 21.76 kg/m² (figure 9), showing that the difference in the typology of the work is an important factor in obtaining these values since it is not possible to consider a single value for all types of construction.

Figure 9- Waste generation rate per m²



Source: Authors

CONCLUSION

The analysis verified that social housing works are also major waste generators and related to the methodology applied, the number of towers, floors, and services performed.

In works with the same number of towers and a raider foundation, the structure team generated more waste due to difficulties adapting the methodology and the variations in the projects developed.

In the foundation stage, for works with rafts, the variation given by the generation of waste was due to the number of foundations built.

The adherence to the lean construction methodology and the standardization in the execution of services has impacted waste reduction. Constructions 5 and 6 were the greatest waste generators due to storage difficulties and, consequently, loss of materials.

Therefore, the amount of waste generated is determined by several factors: concerning the foundation stage, the generation of waste varies according to the type of foundation and/or the number of foundations built; in the structure stage, it varies according to the number of floors executed and the adaptation of the team with the waste reduction methodology; in the finishing stage, it follows the same pattern of the structure stage with an additional waste from the difficulty of storage and material movement. On the other hand, some factors are important for the constant reduction of waste generation, such as standardization of services execution, good storage area, and adaptation of the team.

The structure stage was its biggest generator. Moreover, it is important to note that the works of the PMCMV typology are potential generators and that they need to be as supervised as the conventional works. Besides, it is necessary to understand the process and the stages of execution of each work, mainly the materials used, to determine the variation in waste generation.

REFERENCES

1. ABDEL-SHAFY, H. I.; MANSOUR, M. S. M. Solid waste issue: Sources, composition, disposal, recycling, and valorization. **Egyptian journal of petroleum**, v. 27, n. 4, p. 1275-1290, 2018.
2. AWOYERA, P. O.; ADESINA, A. Plastic wastes to construction products: Status, limitations and future perspective**. Case Studies in Construction Materials**, v. 12, 2020.
3. BAKCHAN, A.; FAUST, K.M.; LEITE, F. Seven-dimensional automated construction waste quantification and management framework: integration with project and site planning. **Resources, conservation and recycling**, v. 146, p. 462-474, 2019.
4. BRASIL. Lei nº 12.424, de 16 de junho de 2011.Altera a Lei nº 11.977, de 7 de julho de 2009.**Diário Oficial da República Federativa do Brasil,** 2011.
5. IBGE – Instituto Brasileiro de Geografia e Estatística. **Pernambuco**. 2020. Disponível em: < https://cidades.ibge.gov.br/brasil/pe/historico>. Acesso em: 29 maio 2022.
6. LI, J.; YAO, Y.; ZUO, J.; LI., J. Key policies to the development of construction and demolition waste recycling industry in China. **Waste Management,** v. 108, p. 137-143, 2020.
7. LINS, E. J. M. **Banco de dados de dados de indicadores de resíduos de construção e demolição (RCD) procedentes de edificações na cidade do recife**. 2020. Dissertação (Mestrado) – Escola Politécnica de Pernambuco, Universidade de Pernambuco, Recife, 2020.
8. SILVA, R. V.; DE BRITO, J.; LYNN, C. J.; DHIR, R. K. Environmental impacts of the use of bottom ashes from municipal solid waste incineration: a review. **Resources Conservation and Recycling,** v. 140, p. 23–35, 2019.
9. SILVA, L. C. L.; BATISTA, J. M.; SANTOS, C. R. B.; LAFAYETTE, K. P.V.; SILVA, T. A. Geração dos resíduos da construção civil em habitações de interesse social. IM: SILVA, T. S.; MARQUES, M. M. N.; EL-DEIR, S. G. (Org.). **Desmaterialização dos resíduos sólidos:** estratégias para a sustentabilidade. Recife: EDUFRPE, 2020. p. 482-491.
10. SILVA, T. E. F. **Análise da estabilidade da encosta do Miradouro de São Pedro de Alcântara, Lisboa**. 2020. 81 p. Tese (Doutorado) – Faculdade de Ciências e Tecnologia, Universidade de Coimbra, Coimbra, 2020.
11. SOARES, D. H. **Estudo da geração dos resíduos da construção civil (RCC) em empreendimento habitacional de interesse social no município de Taquaritinga-SP.** 2015. Dissertação (Mestrado) – Centro de ciências exatas e tecnologia, Universidade Federal de São Carlos, São Carlos, 2015.
12. SRIVASTAVA, R. Solid Waste Management and Its Impact on the Environment. In: **Environmental and Human Health impacts of Plastic Pollution**. IGI Global, 2020. p. 389-400.
13. TANG, Z.; LI, W.; TAM, V. W. Y.; XUE, C. Advanced progress in recycling municipal and construction solid wastes for manufacturing sustainable construction materials. **Resources, Conservation & Recycling: X**, v. 6, p. 100036, 2020.