Indexes of Production of Civil Construction Waste (CCW) for Residential and Non-Residential Sites in Londrina (Paraná)

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Abstract

Given the importance of the development of urban infrastructure and environmental impacts produced by the civil construction waste (CCW), it is important to correct the handling of CCW with objective solutions that are more environmentally friendly. In that sense the present study aimed to determine indicators that make it possible to estimate the amount of CCW generated from construction sites in the city of Londrina, Parana State, Brazil. The generation of CCW was estimated in a general way, regarding the composition of its mixture, correlated to the gross areas of the buildings studied and their generated volumes of RCC. This generating rate was evaluated in a general way and specifies two types of sites: the new residential and new non-residential constructions. The data required for the development of these indicators was obtained through extensive survey and interviews carried out at the environment secretariat of the City Hall. The generating rate of CCW obtained for non-residential buildings was 0.2052m^3/m^2 or 170.44kg/m^2, for new residential sites was 0.2054m^3/m^2 or 170.60kg/m^2 and for new commercial or non-residential construction sites, it was 0.20453 m^3/m^2 or 169.85kg/m^2. It was also possible to estimate the amount generated annually per inhabitant in the municipality, which is 0.60m^3/inhabit.year or 498.55kg/inhabit.year.

Keywords: waste management, civil construction waste, sustainability.

1. Introduction

Civil construction is one of the main sectors of the economy to generate employment, in Brazil it employed more than 3 million formal workers in 2012, generating a significant contribution to the value added to the gross domestic product (GDP), in the order of R$213 million. But the development of the industry implicates in resource extraction for the manufacture of materials, the execution of construction sites and waste generation after each activity in the civil works [1–6].

Civil construction waste (CCW), usually have remains of concrete, mortar, ceramic material, steel, which currently do not have a pre-established treatment, generating impacts on the environment due to the accumulation thereof, and with the development of the urban infrastructure its production increases in a representative way, therefore it has been a current problem with the environment [7–9].

CCW constitutes 35% of municipal solid waste (MSW) in the world [4,5,10], having as final destination sanitary landfills where they are stored without a real final treatment or disposal.

World recognition of the paradigm represented by the relationship between generation and recycling is also evident with the influence of logistics in CCW management [3,11]. In the United States, for example, approximately 136 million tons of CCW per year are generated. The data also show that there are in this country approximately 3500 units for the recycling of this waste, which account for 25% of the total. On the other hand, in the Netherlands, 90% of CCW generated is recycled. In the European Union in 2010, in the middle of an economic recession, an amount of 200kg of CCW was generated [12].

In South America, countries like Brazil produce approximately 35 million tons per year of CCW. This amount is supported mainly by research carried out in the state of Sao Paulo, specifically in the cities of Sao Paulo, Guarulhos, Diadema, Campinas, Piracicaba, Sao Jose dos Campos, Ribeirão Preto, Jundiai, Sao Jose do Rio Preto and Santo Andre, where the numbers of the part of CCW in relation to the total weight of MSW generated were calculated. In most studied cities, CCW was approximately equal to 50% of the MSW [2,10,13].

The issue of the generation of MSW and consequently, the CCW, is being seen as an important part of sanitation in urban environments, given its direct influence on the quality of life of people. Specifically, in the 1990s, CCW began to be the object of scientific research and technological development in different areas of engineering, resulting in the publication of work references in the subject. All this effort resulted, in 2002, in the Resolution n. 307 of CONAMA (National Council of the Environment), which complements Resolution n. 237 of CONAMA [5,14]. The classification of the CONAMA resolution is explained below:

I - Class A - waste is reusable or recyclable as aggregates, such as: (a) construction, demolition, alteration and repair of paving and other infrastructure works, including land from earthmoving; (b) construction, demolition, refurbishment and repair of buildings: ceramic components (bricks, blocks, tiles, flooring boards, etc.), mortar and concrete; (c) process of manufacture and / or demolition of precast concrete parts (blocks, tubes, concrete edges, etc.) produced at construction sites; II - Class B - are the recyclable waste for other destinations, such as: plastics, paper/cardboard, metals, glass, wood and others; III - Class C - are the wastes for which there are no economically feasible applications for recycling / recovery IV - Class D: are hazardous wastes from the construction process, such as paints, solvents, oils and other materials contaminated or harmful to health from demolitions, renovations and repairs of radiological clinics, industrial installations and others, as well as tiles and other objects and materials containing asbestos or other products harmful to health.

There resolutions normalize the main issues regarding CCW, defining and classifying as CCW all waste from construction, renovations, repairs and demolition from construction sites, in addition to establishing guidelines and responsibilities in generation, packaging, transport, treatment and final disposal of this waste.

The Brazilian Association of Technical Standards [15], published five standards related to CCW: NBR-15112: guidelines for design, deployment and operation of screening and transshipment areas; NBR-15113: guidelines for design, deployment and operation of landfills; NBR-15114: guidelines for design, deployment and operation of recycling areas; NBR-15115: procedures for implementation of layers of pavement using recycled aggregates from construction waste; NBR-15116: requirements for the use on floors and preparation of concrete without structural function with recycled aggregates from construction waste.

The city of Londrina (Parana State) where this research is focused, enacted a Plan for Integrated Management of Waste from Construction, through decree 768 of September 23, 2009. Therefore, in accordance with the City's laws, Federal Law 10,207 /2001 and in compliance with the determination from Resolution no. 307 of CONAMA, it regulates the main procedures for municipal management of CCW, thus providing the official database for the development of this study.

Most of these laws promote reuse, reduction and recycling, facilitating the management of CCW. However, actually it can be noted the difficulty in complying with the current legislation. The main factor that contributes to this is the lack of effective tools to estimate and quantify the volume of CCW. The first step for the correct management of this type of waste will only be taken after the determination of its actual amount [10,16].

Facing a complete absence of studies pointing out the amount of CCW that is generated, transported, and with a legally supported final destination in the municipality being studied, the need to promote not only this quantification, but also an analysis of the behavior of some parameters and indexes from this subject is evident, aiming to contribute to the improvement in the management of this waste in particular [17].

The main objective of this research is to establish the Waste Generation Rate (WGR) in Civil Construction, for new buildings, residential and non-residential. Taking as a basis the official data collected at the Environmental Secretariat (SEMA) of the Londrina City Hall (LCH). As specific objectives, the indicators and parameters are laid out, from this relationship, which may assist in developing a more accurate quantification model for these residues, thus providing better planning for generators and consequently, a more effective municipal RCC management.

2. Materials and methods

2.1 Area of study

The coverage area of this research was restricted to the metropolitan area in the city of Londrina, Paraná State, Brazil. This municipality, according to the data from IBGE (2018), is responsible for the generation of a GDP of R$ 9.9 billion, it has 1,653,075km^2 of territorial extension, with a population of 506,701 people in 2010 projected to reaching 563,943 inhabitants in 2018, where 97.39% of the population lives in the urban area. In official data, submitted by the Municipal Works and Paving department of the Municipal Government of Londrina, the municipality had in 2011, some 4,156 projects approved for new residential and non-residential buildings, totaling 1,510,769.61m^2 of area to be built.

2.2 Data Collection

The data were collected in the period between the months of September, October and November 2013. This inquiry was carried out by means of careful research in the archives of the Secretariat of the Environment of the City of Londrina, where interviews were also carried out with technicians involved with the specific waste from civil construction. The data are basically composed by the characterization of the purpose and type of construction, the period of development and execution of the project, total built area, estimation of generated volumes and actually generated waste volumes, being that these volumes are separated in accordance with the classification by Resolution n. 307 from CONAMA.

The work was divided in two stages, the first was a collection of data in the Management Plan for Civil Construction Wastes (PGRCC) at the Department of Construction in the City Hall of Londrina. The second was a case study, in which 10 construction sites were monitored, as well as their built area and the amount and type of waste produced during their execution.

In order to reach the objective of the second stage, 10 construction sites that most represented the volume and typology of residential and non-residential buildings in the municipality of Londrina in the period from 2010 to 2014 were selected, as shown in Figure 1.

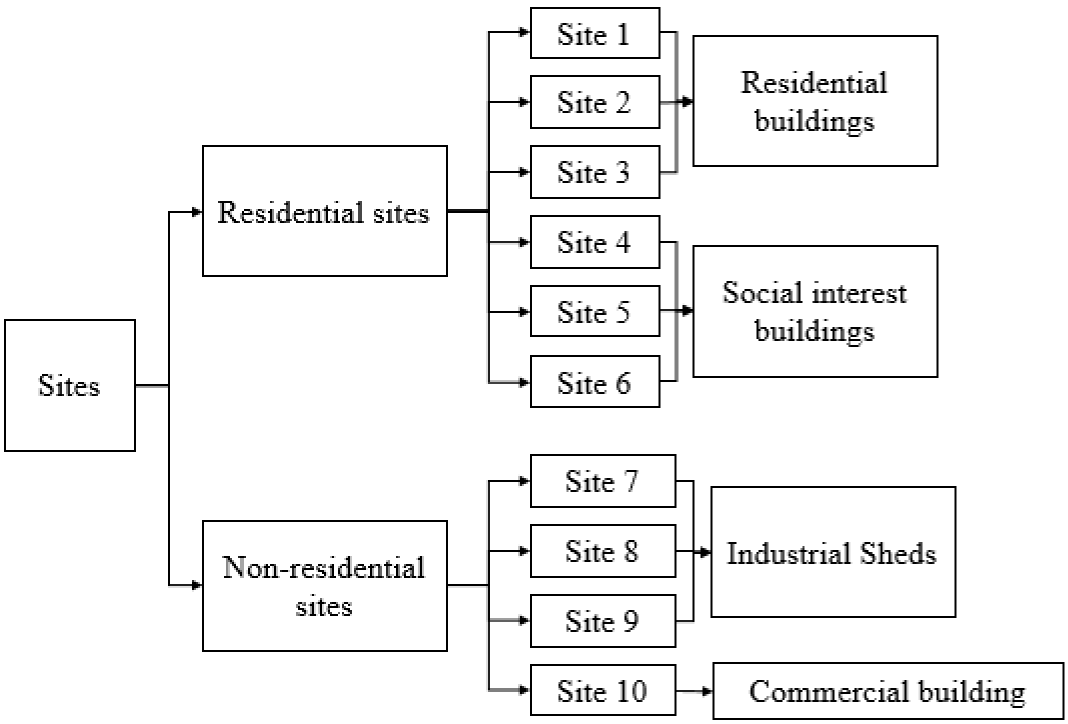

Figure 1 - Sites selected to develop the field study

Site 1 is represented by a multi-family residential building, that is a building executed in the conventional construction system, with reinforced concrete structure and brick masonry closure, composed of two apartment towers and with a total constructed area of 30,389.31m^2, of which 26,602.34m^2 are covered area and 3,786.97m^2 of uncovered built area. Site 2 is also a multi-family residential building built in the conventional system, similar to Site 1, this development also consists of two apartment towers, with a total constructed area of 29,230.45m^2, of which 25,784.35m^2 are covered area and 3,446.10m^2 of uncovered built area. Site 3 is built in the conventional system, and differently from Sites 1 and 2, is composed of only one apartment tower, with a standard of finishing higher than that shown in the other residential sites. It has a total constructed area of 17,389.69m^2, 16,280.83m^2 of covered area and 1,108.86m^2 of uncovered area.

As representative works of this segment, six twinned residences were selected, that is, three sets with two residences each, which were executed simultaneously and were denominated in this study Site 4, Site 5 and Site 6. All the residences followed the same project and were submitted to the same constructive technology (conventional system). Another important characteristic is the fact that these works are built on land that presented the same topographic and geological conditions.

In order to complete the list of sites studied, three industrial warehouses, characterized as Sites 7, 8 (conventional system) and 9 (prefabricated) respectively, were chosen and a commercial office building, identified as Site 10 (internal closure in drywall).

3. Results and discussions

The main indicators are the waste generation rates (WGR), which are obtained by direct relationship between the volumes of waste generated, in m^3 and the corresponding total built areas, in m^2. These indicators were calculated separately for each group of sites, according to its purpose and also on a general basis, without taking into account this characteristic. Thus resulting in an index expressed in units of volume per area, which for the purpose of comparison with previous studies are converted later in units of weight per area built, using the density of the mixture as 830.60kg/m^2 (16).

Table 1 presents the statistical summary of general data collected (civil construction waste management plan CCWMP). It was observed that despite the variables being presented with minimum and maximum quite incongruous values, when compared to the average, they turn out to be representative if analyzed under the aspect of the set variation coefficient.

Table 1 - Summary statistical data collected ES/LCH(Environmental Secretariat of Londrina City Hall)

Results	Built area (m^2)	Waste Volume (m^3)
Average	97.15	18.82
SD	68.65	18.56
CV	70.66	98.62
Mínvalue	21.89	2.64
Máxvalue	492.73	189.00
N°. Sites (n)	761.00	761.00

The high CV presented both for built area and for Waste Volume is explained by the number of works analyzed, and because they do not belong to the same group as such.

In a global and generic fashion, i.e., without considering the type and final purpose of the site studied, according to previously established criteria, one can interpret the generating rate of residue by global values of 0.2052 m^3/m^2, at confidence intervals of 95%, as shown in Table 2, or simply by value of 170.44kg/m^2.

3.1 General approach

Table 2 shows the average built area, waste volume, and finally waste generation rate (WGR) for general sites.

Table 2 - Waste generation rates for general works

General Works	Confidence Intervals 95%			
	n	IL	Average	SL
Built area (m^2)		92.26	97.17	102.03
Waste Volume (m^3)	761	17.49	18.82	20.14
WGR (m^3/m^2)		0.19	0.21	0.22

As shown in Table 2, the average of WGR was 0.21 and this value is very close to its extremes (inferior and superior limits), therefore it has a very low variability.

3.2 Residential Constructions

For new residential building, with built area within the interval of 0 to 500m^2, 609 elements were investigated, corresponding to 80.02% of the total of 761 sites (CCWMP).

Table 3 expresses the average built areas, the volume of waste generated and the waste generation rates, with significance level of 95%, for residential constructions. The value of WGR for this type of site, according to the criteria established, is 0.2054m^3/m^2, i.e. 170.60kg/m^2.

Table 3 - Waste generation rate for residential sites

Residential Works	Confidence Intervals 95%			
	n	IL	Average	SL
Built area (m^2)	609	94.20	96.89	99.58
Waste Volume (m^3)		18.17	18.93	19.69
WGR (m^3/m^2)		0.19	0.21	0.22

3.3 Non- residential or commercial work sites

Similarly, for new non-residential or commercial work sites 152 elements have been objects of study, with representativeness of 19.88% of the total works sites. The value for the waste generating rate, for this category, is 0.2045m^3/m^2, or 169.85kg/m^2, as shown in Table 4. Although data collection has been developed in an impartial and completely random manner, a great deal less elements for this group are identified. Almost 1/4 of the elements collected in the former category.

Analyzing the summary statistics in Table 4, it is noted that for commercial or non-residential work sites, there is greater dispersion in the elements, with a high number of outliers for a reduced amount of elements, compared to the sampling of residential constructions.

Table 4 - Waste generation rate for Non-residential works

Non-Residential Construction	Confidence Intervals of 95%			
	n	IL	Average	SL
Built area (m^2)	152	91.91	98.15	104.38
Waste Volume (m^3)		16.91	18.33	19.74
WGR (m^3/m^2)		0.18	0.20	0.23

3.4 Stage 2

Below are described and the results obtained in the studies performed in a group of cases of six residential and four non-residential constructions.

3.4.1 Residential sites

A follow-up to the execution of 3 residential sites was carried out, taking into consideration the built-up area and the volume of waste produced. Figure 2 shows the distribution of the waste produced in each of the sites according to the resolution of CONAMA.

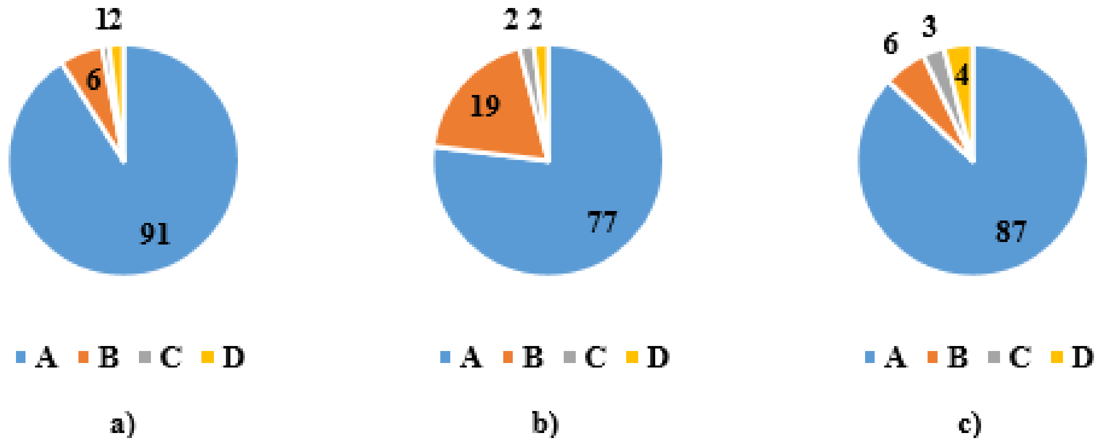

Figure 2 - Distribution of CCW in residential building Sites a) 1 ; b) 2 and c) 3

As shown in Figure 2 in the residential sites the variation of generation of the residue class A was in the range of 77 to 91%, being generally the most produced in sites of this type. Site 1 generated 5,277.00m^3 of CCW in its totality, being 4,797.00m^3 of class A, 348,00m^3 of class B, 40,00m^3 of class C and 92,00m^3 of class D. Observing the generated volumes, the ones generated by classes A and B (97% of all RCC generated by the site) are much higher than those of classes C and D, as occurred in the first stage of this investigation.

Site 2, similarly to Site 1, shows that the volume generated by classes A and B (96% of all RCC generated) are also much higher than those of classes C and D, as occurred in the first stage of this investigation. In order to calculate the overall WGR of the site, the volumes of the four classes will be computed. In this case, class A, represented by inert residues of concrete, ceramic materials, mortars and also including soils, participate with 77% of the total volume of CCW generated which amounts to 5,071.00m^3.

In the Site 3, the collected volumes of waste classes A and B are also representatively superior to those of classes C and D, representing 93% of the total of 3,728.00m^3 of CCW generated in the course of the works. Class A, represented by inert residues of concrete, ceramic materials, mortars and also including soils, participate in 87% of this volume.

Based on the results found, the WGR of Sites 1, 2 and 3 were 0.126$m^3.m^{-2}$, 0.215$m^3.m^{-2}$, and 0.160$m^3.m^{-2}$ respectively.

3.4.2 Social interest works

A follow-up to the execution of 3 social interest works was carried out, taking into consideration the built-up area and the volume of waste produced. Figure 3 shows the distribution of the waste produced in each of the works according to the resolution of CONAMA.

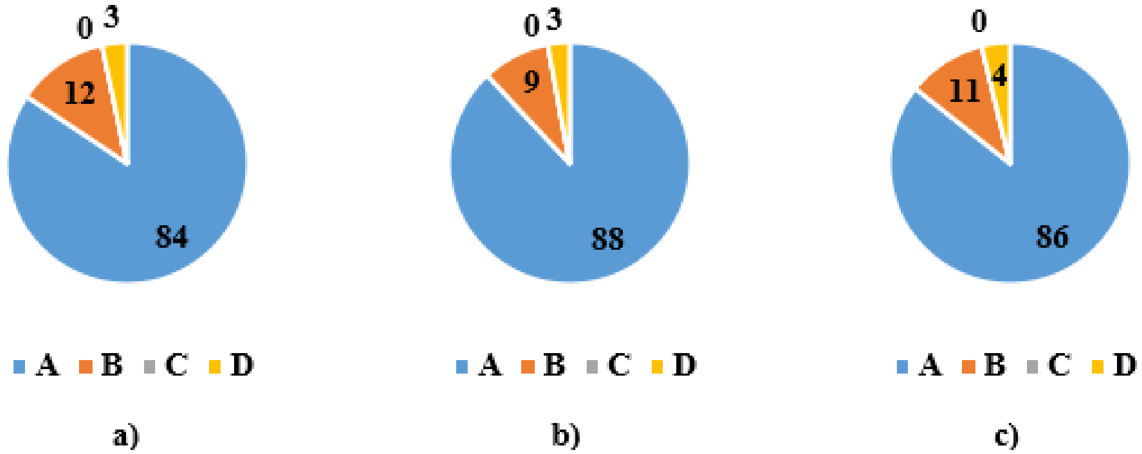

Figure 3 - Distribution of CCW for social interest buildings works: a) 4; b) 5; c) 6

As shown in Figure 3 classes A and B represent, on average, 96.66% of all waste collected in the three sites, and the share of class A waste is even more significant (86.07%), which justifies the adoption of only the first two classes in the calculation of the WGRs of the works of residences of social interest, similarly to the one occurring with the works of residential buildings.

Class D waste, represented here by the remains of painting materials, waterproofing materials and contaminated packaging, participated in a reverse logistics policy, being returned in its entirety to the manufacturer.

The WGR values are 0.1405m^3.m^{-2}, 0.1539m^3.m^{-2} and 0.1481m^3.m^{-2}, respectively for the sites 4, 5 and 6.

3.4.3 Non-residential sites

The results of the case studies of non-residential sites, represented by three industrial warehouses and a commercial office building, are presented and discussed in Figure 4.

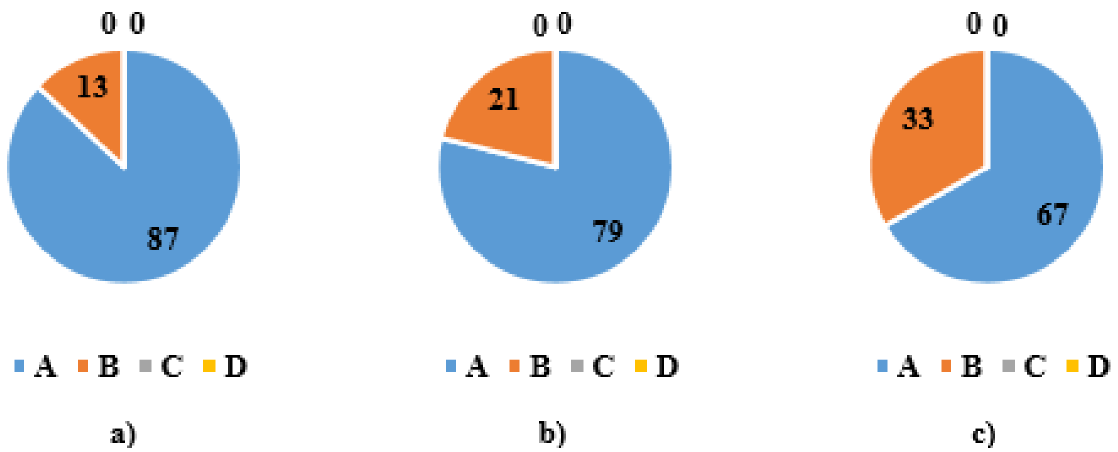

Figure 4 - Distribution of CCW for industrial sheds sites: a) 7; b) 8; c) 9

As shown in Figure 4 as in the other sites studied, it is possible to observe a significant difference between the values of the waste volumes collected in classes A and B, compared to classes C and D; these values represent on average 98.06% of all collected residues. Therefore, for the same reasons mentioned above, the calculations of WGR for the sites 7 and 8 will be made taking into account only the volumes of classes A and B.

The WGR values are $0.02396 m^3.m^{-2}$, $0.01979 m^3.m^{-2}$ and $0.00078 m^3.m^{-2}$ for works 7, 8 and 9 respectively.

3.4.4 Commercial site

Figure 5 shows the results of production of construction waste in the site 10 based on the CONAMA 307 Resolution.

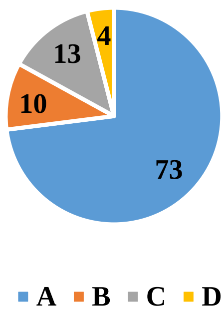

Figure 5 - Distribution of CCW for a commercial site

As shown in Figure 5, the volumes collected from classes A and B wastes do not represent the majority of waste collected at site 10. In this case, the contribution share of the class C waste is very representative, even surpassing that of class B. For this particular site it makes sense to compute in the calculation of the global WGR, in addition to class D waste, the volumes of classes A, B and C, which in this case represent 96% of the total of 2,850.43 m^3 of CCW generated in all the course of the work. WGR of site 10 is $0,0823 m^3.m^{-2}$.

3.5 Summary

In the first stage of the research, the indexes of waste generation showed very close values for new residential and non-residential buildings, including for general sites (Residential + Non Residential). This is evidenced when comparing the averages obtained for the respective types of sites. Therefore, the value of 0.20 cubic meters of waste generated for each square meter of construction is representative for residential and non-residential sites, according to the results obtained in this stage of the research as shown in Table 5.

Table 5 - Summary results for stages 1 and 2, values in $m^3.m^{-2}$

		Study Sites	WGR (A)	WGR (B)	WGR (C)	WGR (D)	Total WGR	WGR
Stage 1		General Sites	0,15745	0,04166	0,00121	0,00488	0,2052	0,2052
		Residential Sites	0,1576	0,0417	0,00121	0,00489	0,2054	0,2054
		Non-residential sites	0,15691	0,04151	0,00121	0,00487	0,2045	0,2045
Stage 2	Residential Sites	Residential buildings						
		Site 1	0,16086	0,01167	0,00134	0,00309	0,17696	0,13611
		Site 2	0,11964	0,0337	0,00318	0,00409	0,16061	0,12518
		Site 3	0,18727	0,0126	0,00642	0,00919	0,21548	0,15999
		Social interest buildings						

	Site 4	0,11856	0,01727	0	0,00471	0,14054	0,14053
	Site 5	0,13549	0,01396	0	0,00446	0,15391	0,15391
	Site 6	0,12682	0,01561	0	0,00562	0,14805	0,14805
Non-residential sites	Industrial sheds						
	Site 7	0,02083	0,00313	0	0	0,02396	0,02396
	Site 8	0,01563	0,00417	0	0	0,0198	0,01979
	Site 9	0,00052	0,00026	0	0	0,00078	0,00078
	Commercial building						
	Site 10	0,05913	0,00876	0,01136	0,00309	0,08234	0,08234

In the second stage, comparing the values obtained in the residential sites, it is possible to notice that between the WGR calculated for the multifamily residential buildings (Sites 1, 2 and 3) there are no significant differences between the first two sites, obtaining the value of 0.169m^3.m^{-2} as the average of the waste generation rate. In the case of site 3, there is a 28% increase compared to the average of the WGR that has the contribution of the soil movement, but if this portion is suppressed, the indexes are practically the same. This fact can be justified by the existence of two basements in site 3, generating a considerable volume of class A waste in the months corresponding to this activity.

In sites of social interest residences (Sites 4, 5 and 6) it is possible to establish an average of 0.148m^3.m^{-2} for the indexes of waste generation, since analyzing the individual values does not show differences between them. If this comparison is extended to the six residential works studied, excluding the plot of soil movement in Site 3, the difference between the generation averages is only 5%. This difference makes it possible to state that even with the limitations of the study, the average index of 0.16m^3.m^{-2} is representative and reflects the generation of residues of the residential works surveyed at this stage.

In the commercial building project (Site10), the option for the internal closure in drywall, with acoustic insulation executed with glass wool, considerably increased the rate of generation of class C waste in the months corresponding to the execution of these activities. In this situation, a sequence of factors related to design decisions, materials choice and technology employed, which together, altered the evolution of the specific waste volumes generated in this site.

4. CONCLUSIONS

- The WGR obtained in the first stage of this research, using the data archived in ES/LCH, presented a unique value of 0.20m^3.m^{-2} for residential and non-residential sites. That has identified the need to carry out an investigation closer to the construction site, where the waste is actually generated, with the follow-up of the *in loco* waste generation process; quantifying and characterizing this residue in a more careful way and mainly identifying the evidences that contribute to answer the proposed research question.
- The volumes of the waste generation prediction obtained in the first stage of this research, using the data reported in the PGRCCs filed in ES/LCH, were three times higher than the volumes actually generated.
- The waste generation indexes obtained by the case studies developed in the second stage of the research were: 0.17m^3.m^{-2} for multi-floor residential buildings; 0.15m^3.m^{-2} for residences of social interest (conventional); 0.08m^3.m^{-2} for multi-floor commercial buildings (drywall); 0,022m^3.m^{-2} for works of industrial sheds in masonry and pretty much insignificant (0.0008m^3.m^{-2}) for prefabricated industrial sheds.

- In the residential building sites, among the total volume of waste classified as "Class A", according to Resolution 307 of CONAMA, the soil represented a significant portion. The uncontaminated soil should have another focus on the classification of the RCC, since it can be reused directly in other construction sites or deposited in duly licensed temporary transshipment areas.

5. REFERENCES

[1] F. Gonçalves, C.H.U. de Souza, F.S. Tahira, F. Fernandes, R.S. Teixeira, Incremento de lodo de ETA em barreiras ipermeabilizantes de aterro sanit?rio, Rev. DAE. 65 (2017) 5–14. doi:10.4322/dae.2016.018.

[2] R.E. Córdoba, J. da C. Marques Neto, C.D. Santiago, E. Pugliesi, V. Schalch, Alternative construction and demolition (C&D) waste characterization method proposal, Eng. Sanit. e Ambient. 24 (2019) 199–212. doi:10.1590/s1413-41522019179720.

[3] P.J. Silva, M.J. De Brito, Práticas de gesião de resíduos da construç ão civil: Uma análise da inclusão social de carroceiros e cidadáos desempregados, Gest. e Prod. 13 (2006) 545–556. doi:10.1590/s0104-530x2006000300015.

[4] C.L.V. e Freita, V.M.L. dos Santos, J.E. dos Santos Júnior, T.C.C. da Silva, Reciclagem de resíduos de construção e demolição (RCD): Um estudo de caso na usina de beneficiamento de resíduos de Petrolina-PE, Rev. Gest. Soc. e Ambient. 10 (2016) 93–109. doi:10.5773/rgsa.v10i1.1121.

[5] L.B. Scremin, A.B. de Castilhos Junior, J.C. Rocha, Sistema de apoio ao gerenciamento de resíduos de construção e demolição para municípios de pequeno porte, Eng. Sanit. e Ambient. 19 (2014) 203–206. doi:10.1590/S1413-41522014000200011.

[6] C. Arantes Da Silva, G. Refulia, D. Santos, Gestão De Resíduos Da Construção Civil E Demolição-Responsabilidade Pública, Privada E Social Na Cidade De São Paulo Management of Civil Construction and Demolition Waste-Public, Private and Social Responsibility, (1988).

[7] T.E. Ribeiro Alves, M.S. Ferreira dos Santos, A GESTÃO DE RESÍDUOS DA CONSTRUÇÃO CIVIL EM TERESINA – PIAUÍ [The management of waste of civil construction in Teresina – Piauí], REEC - Rev. Eletrônica Eng. Civ. 15 (2018) 112–124. doi:10.5216/reec.v15i1.50156.

[8] A. Paola, V. Saez, A.D.G. Baez, J.G. Navarro, R. Merino, Redefining construction and demolition waste management systems : best practices on civil engineering works / Naujas poziuris i statybiniu ir griovimo atlieku tvarkymo sistemas : geroji praktika civilines inzinerijos srityje / Gruvesu un buvgruzu vadibas , (2014).

[9] A.P. Kern, L.V. Amor, S.C. Angulo, A. Montelongo, Factors influencing temporary wood waste generation in high-rise building construction, Waste Manag. 78 (2018) 446–455. doi:10.1016/j.wasman.2018.05.057.

[10] D.H.F. da Paz, K.P.V. Lafayette, M.J. de O. Holanda, M. do C.M. Sobral, L.A.R. de C. Costa, Assessment of environmental impact risks arising from the illegal dumping of construction waste in Brazil, Environ. Dev. Sustain. (2018). doi:10.1007/s10668-018-0289-6.

[11] K.R.A. Nunes, C.F. Mahler, R.A. Valle, Reverse logistics in the Brazilian construction industry, J. Environ. Manage. 90 (2009) 3717–3720. doi:10.1016/j.jenvman.2008.05.026.

[12] C.D. Zanna, F. Fernandes, J.C. Gasparine, Gerenciamento de resíduos de construção civil em empresas construtoras de grande porte por meio de software específico-estudo de caso, Acta Sci. - Technol. 39 (2017) 169–176. doi:10.4025/actascitechnol.v39i2.30098.

[13] K.P.V. Lafayette, D.H.F. da Paz, M.J. de O. Holanda, L.A.R. de C. Costa, Analysis of generation and characterization of construction and demolition waste on construction sites in the city of Recife, Brazil, Rev. Mater. 23 (2018). doi:10.1590/S1517-707620180003.0503.

[14] CONAMA, RESOLUÇÃO nº 307, de 5 de julho de 2002. Publicada no DOU n.136, de 17 de

julho de 2002, (2002) 95–96.
[15] D.E. Normas, Abnt nbr, (2006).
[16] J.V. BAPTISTA JUNIOR, C. ROMANEL, Sustentabilidade na indústria da construção: uma logística para reciclagem dos resíduos de pequenas obras, URBE - Rev. Bras. Gestão Urbana. 5 (2013) 27. doi:10.7213/urbe.05.002.se02.
[17] M. Akash, Bath Kumar, P. Rana, International Journal of Advance Engineering and Research, Int. J. Adv. Eng. Res. Dev. 5 (2018) 434–439. doi:2348-4470.

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