

Review of Construction and Demolition Waste management in Municipalities in Brazil and Portugal

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Abstract— The intense urbanization resulting from the world populations growth makes the construction industry responsible for causing extensive environmental damage, given the vast generation of CD&waste. Considering the management of CD&waste in Brazil and Portugal, both have a deficit in preventing dynamic interactions between the factors inherent to the management. The implementation of management strategies drives the economy and social sustainability. Therefore, their order to analyze the CD&waste management methods in Brazil and Portugal, this study was based on a thorough investigation of the theme in a municipality in each country, considered as tourist areas. With the objective of filling in the gaps related to the legal and regulatory instruments created to national and word governmental control about CD&waste management. The methodology used for the development was a bibliographic review with primary and secondary data from technical and scientific sources, in addition to interviews with those responsible for the inspection, execution of works and environmental management of the municipalities from Santa Fé do Sul, Brazil and Covilhã, Portugal, followed by field research. As a result, it can be mentioned that the municipality of Santa Fé do Sul has greater control over the management of CD&waste, the reality of the country that has a more developed CD&waste reinsertion system compared to Portugal, which in the municipality of Covilhã, has no practices of CD&waste reusing management. The reinforcement of government supervision and the implementation of economic incentives are strategies for improvement and insertion in the concept of sustainable cities and circular economy.

I. INTRODUCTION

Sustainability consists in the way natural goods and resources are used. Therefore, due to the notable natural catastrophes caused by nature's inability to absorb waste generated by human activities, it has become an extremely relevant topic in government meetings [21;23].

In New York (USA), from 25 to 27 September 2015, the United Nations General Assembly consolidated a document entitled Transforming our World: 2030 Agenda for sustainable development (UN, 2015), There are 17 goals that allow us to establish concrete and measurable goals towards a sustainable world. Among the 17

objectives is that of Sustainable Cities and Communities, 11th, which includes as one of its goals “to reduce the negative environmental impact per capita of cities, including paying special attention to air quality, municipal waste management and others, until 2030” [1].

It is identified that the generation of waste CD&waste is influenced by several factors which are: population, urbanization and GDP, that is, the CD&waste per capita income increases when construction activities and population increase.

In recent years, the world population growth rate has undergone sudden changes reaching a total of 1.2% annual growth, Brazil assumes 0.80% of this value and Portugal 0.19% [7]. As a result, the development of urbanization has taken on extraordinary proportions worldwide, reaching 55%, in Brazil about 85% of its population live in urban areas and across Europe this figure reaches 75%. These fees are responsible for the excessive generation of CD&waste requiring government entities to take management measures aimed at solving environmental problems and improving the current economy [26;28].

The circular economy is a model of production and consumption that involves sharing, reusing, repairing and recycling existing materials and products, extending their life cycle. In practice, the circular economy implies reducing waste to a minimum. When a product reaches the end of its life cycle, its materials are kept within the economy whenever possible and can be reused, that is, the reintegration of this waste in new construction, reducing the use of virgin materials and negative environmental impacts. Despite being a promising strategy for the construction industry, they estimate that the global economy is only about 6% circular [13].

The construction industry is considered the most damaging to the environment, due to the high level of extraction of natural resources and for generating about 35% of landfill waste worldwide [14]. The European Union member states have an estimated 870 million tonnes of CD&waste as a global annual production, Portugal is responsible for 1.5 thousand tons [3]. In Brazil, the average generation of construction and demolition waste was approximately 84 million m³ each year [9].

CD&waste have a very heterogeneous constitution, that is, they can contain a wide variety of materials accumulated to these solid residues generated by different origins, the main ones being: new constructions, demolitions, renovations and extensions of existing constructions [24]. This type of waste has in its composition inert materials, of low risk, which cause environmental impacts due to the large volume generated and its illegal disposal in inappropriate places, causing

damage, not only to the landscape, but also to public health, compromising other sanitation areas, such as drainage, water and sewage [16].

The classification from CD&waste can be done according to their origin, chemical properties, or even recycling possibilities, among others [2]:

- Class A: Are reusable or recyclable waste as aggregates (Bricks, Blocks, Tiles, Cladding Plates.)
- Class B: These are recyclable waste for other purposes. (Plastics, Paper, Cardboard, Metals, Glass, Wood.)
- Class C: Waste for which no economically viable technologies or applications have been developed to enable recycling or recovery. (Plaster and Polyurethane Foam.)
- Class D: These are hazardous wastes from the construction process, those that are contaminated or harmful to health. (Paints, Solvents, Oils and others.)

The generation of CD&waste is related to four factors that are part of the day-to-day work: lack of management CD&waste at construction sites; unprepared labor in relation to waste management; material losses and waste due to poorly optimized designs; ineffective methods and excessive consumption of natural resources due to the oversized construction services [10]. And Increasing research efforts have been devoted to strategies and CD&waste management measures& waste, ranging from waste reduction, treatment and recycling until final disposal [26].

With the least possible impact CD&waste in the environment, must followed a hierarchical principle, optimizing its potential value as shown in Figure 1.

Leaving of this hierarchical principle it is possible to implement the Sustainable Construction in the civil construction industry, for being able to meet to the principles of sustainability disseminated worldwide, thus constituting a form of rational use of resources.

Both Brazil and Portugal are countries that, despite having a governing government policy on construction and demolition waste, have low rates of implementation of sustainable buildings. Due to the lack of social sustainability and lack of economic incentive to develop strategies for managing CD&waste [19].

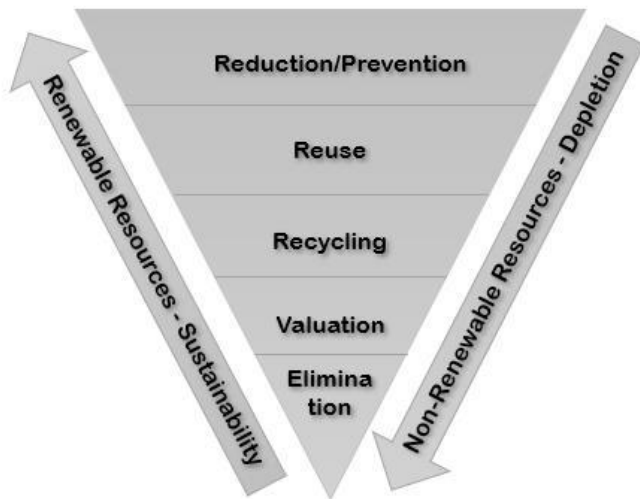


Fig.1: CDW management hierarchy [25].

The novelty of this study lies mainly in two aspects: The first is to reveal the current situation of CD&waste in Brazil and Portugal considering the strategies existing in two municipalities in the interior of both countries considered as tourist areas, a factor that causes the construction of buildings aimed at accommodating tourists in high seasons. And finally, to analyze the framing of case studies within the legislation of Agenda 30. When investigating this issue, this research can offer valuable information to allow countries like Brazil and Portugal having as reference one of their municipalities to obtain greater awareness and best practices of CD&waste.

The municipalities chosen for this study were Covilhã in Portugal and Santa Fé do Sul in Brazil were studied. Covilhã is a Portuguese city in the Castelo Branco district, with 51800 inhabitants subdivided into 21 parishes [20]. Santa Fé do Sul -SP, Brazil a Brazilian city in the interior of São Paulo with 32,563 inhabitants [13].

II. MATERIALS AND METHODS

The research / research methodology followed was divided into two parts:

- National and international bibliographic research based on data such as the level of CD&waste production, conditions for the treatment and management of this waste, using the keywords Construction and Demolition Waste, Sustainability, Sustainable Cities, Recycling and Reuse.
- Field survey to know and analyze the management of construction and demolition waste in the two municipalities, through the

application of a questionnaire to professionals in the area of Civil Construction, Environment and licensed companies for the collect and treatment of CD&waste.

Three questionnaires were developed in order to develop the research and add specific knowledge about the two municipalities. The interview (semi-structured) was carried out face-to-face with three specialists from each municipality, totaling six interviewees, including 1 Civil Engineer responsible for municipal inspection, 1 Civil Engineer from a private company and 1 Manager of licensed operators for resection of workers. CD&waste. The interviews aimed to obtain information about the situation of the management of the CD&waste of each municipality, based on a questionnaire with open and closed questions, and primary and secondary data from technical and scientific sources such as books were used; theses and dissertations; standards and manuals; periodic magazines and internet sites.

Management of CD&waste and within the construction industry, when properly executed, it has the function of promoting sustainable buildings and the creation of a circular economy. The nature of the research questions that should be investigated was a vital factor in choosing the research method, reaching the main objective of the study to understand the current strategies for managing CD&waste practiced. Questionnaire surveys are considered the most appropriate way to study, with a known level of accuracy, the work and behavior of a large population [9].

2.1 INTERVIEW

The semi-structured interview, as a research method, is defined as a method of qualitative data collection, where the researcher asks the informants a series of planned but open questions [8]. The interviews were conducted through three questionnaires. Where the first was used for interviews with the specialists representing the municipal public bodies, which was elaborated through the justification of obtaining a perspective on the current situation of the management of CD&waste, with emphasis on the existence of government directives, reinsertion and reuse programs, difficulties and municipal potential in the implementation of management strategies. The second questionnaire was submitted to specialists from private construction companies in order to clarify the inspection activities carried out by the public agency regarding the management of CD&waste in private works and the management of works in progress. Finally, the last questionnaire was prepared for companies licensed for resection and treatment of CD&waste, which focused on the processing and classification of waste received,

quantity control, municipal and national legislative requirements on accountability in the management of waste. CD&waste.

The interviewed specialists are considered suitable for the research, as they have rich information in view of the vast experience in the labor market of the construction industry. Therefore, a response rate of 100% of the questions was obtained considering the data and information provided in these studies valid and adequate. Given that the response rate in interviews within the construction industry is low or almost nil [4].

The questions submitted to the specialists during the interviews are shown in Table 1. Therefore, the survey of responses made it possible to assess the current management of CD&waste before government legislation and policy imposed at municipal and national level. Finally, check the quantity control actions CD&waste generated, recycled and reinserted back to the local economy and the inspection activities related to the implementation of the measures imposed for the management of CD&waste. In view of these questions, it is possible to obtain results that meet the objectives desired in this study.

III. RESULTS

The questionnaires were specific to investigate perceptions of construction and demolition waste management CD&waste in the construction industry. Justifying the importance of exemplifying two municipalities in order to demonstrate the way in which CD&waste before the national regulations of each country. With reference at information obtained through interviews through questionnaires, the results of the cases can be presented below.

3.1 Santa Fé do Sul, Brazil

Municipality also known as “Tourist resort of Santa Fé do Sul” has a territorial area of 206.537 km² and an index of 22.7% of urban households on public roads with adequate urbanization [14]. The municipality is located in the state of São Paulo, which is considered the most industrialized state in Brazil with more than 44 million inhabitants producing about 20 million tons of CD&waste per year [18].

To achieve sustainability and preservation of the environment, measures to regulate the disposal of construction waste have become necessary. In this way, Brazil started to count on CONAMA Resolution No. 307 of 2002, which establishes guidelines, criteria and procedures for the management of CD&waste, and also with the Brazilian Federal Law 12,305 / 2010, which

instituted the National Solid Waste Policy (PNRS). Based on this national policy, the municipality created municipal legislation to implement strategies for managing CD&waste and appreciation of the current economy. As is the case with Complementary Law 92, of December 3, 2003, which specifies the master plan for sustainable development, to reduce the generation of waste and improve the quality of life. of the population [17].

For the control of the works of private companies, the Municipality of Santa Fé do Sul imposes the follow-up of Bill no.91/2014 that establishes segregation procedures in accordance with the regulation of the master plan for sustainable development, storage, transport and final disposal of solid waste from civil construction, as well as responsibilities and penalties, with the purpose of guiding and disciplining the disposal of waste of construction in the municipality, establishing responsibilities to the generators, and, in their omission, the application of penalties. In addition to the municipality having a Plan Basic Sanitation that defines an appropriate treatment for all types of waste generated in the municipality, according to Politic National Waste Solids (PNWS) 2010, there is revision in its application and gives an appropriate destination for CD&waste.

Brazil has a recycling rate for CD&waste generated annually by 20%, which is considered a high value and which presents rates of continuous increase [18]. Of the 5,564 Brazilian municipalities, 4,031 municipalities (72.44%) have management services for CD&waste, and only 392 municipalities (9.7%) have some form of processing CD&waste [14]. The municipality of Santa Fé do Sul fits the statistics, as it has its own landfill for recession, management and reinsertion of CD&waste. The city hall municipal is responsible for CD&waste public works, while private ones are left to the owner, who hires private companies to collect through containers. An average of 800 cont are collected sprains of 3m³ / month, or be, 2,400m³ / month which is equivalent to 28800 m³ / year.

The materials collected in the buckets are very heterogeneous, requiring pre-sorting before processing to separate waste such as concrete, tiles and ceramic floors from other products not used in the process, such as wood, paper and plastic, which have other destinations. Due to this characteristic, it is not possible to use 100% of the collected rubble and, currently, up to 60% of this garbage can be used the equivalent of 17280 m³ / year, depending on how the CD&waste is segregated at the source.

Instead of discarding the CD&waste in landfills, it has been considered a recycling material to replace natural aggregates, such as crushed rocks, reducing potential

environmental impacts and improving the potential economic value of recycling [6]. The CD&waste generated in the municipality are destined to the civil construction waste landfill located on the Santa Fé to Rubinéia highway, as shown in Figures 2 and 3, the waste being crushed and transformed into coarse, medium and small aggregates, which are reused on the sub-bases, urban roads and municipal highways, an activity that generates jobs and increases the circular economy of the municipality.



Fig.2: CD&waste crushed at the landfill in Santa Fé do Sul [Own Authorship2020].



Fig.3: Crusher at CD&waste landfill in Santa Fé do Sul [Own Authorship2020].

The CD&waste that arrive at the landfill and are packed, shown in the figure above, go through proper sorting first and are separated by their class; Class A: Are separated and follow the crushing phase. Are the focus of the current management strategy, which can be recycled almost in its entirety; Class B: As soon as it separates these residues are sent to another landfill specialized in treating this type of waste; Class C: The only purpose Currently, this type of waste can be given to a landfill, to be disposed of.; Class D: They suffer the same destination as class c waste.

The crushers work to reduce the granulometry of the residues present in the rubble of buildings and demolitions. In other words, they are capable of crushing concrete

blocks, ceramics, bricks, remains of piles, rocks, etc., transforming them into smaller and homogeneous particles and making them reusable [6].

3.2 Covilhã, Portugal

Named "Snow City", the municipality of Covilhã belonging to Cova da Beira has a territorial area of 555.6 km², including its 21 parishes. Located on the slope of Serra da Estrela, the municipality has an area for urban use of 2.19 ha / km², its region is responsible for producing about 78000 tons of solid waste per year [15].

Regarding policy national governmental body in Portugal on the management of CD&waste, it is extremely important to clarify that in Portugal there are no municipal laws or decrees, only national ones that are valid equally throughout the country, and measures defined by the European Union are also adopted. In Portugal the first Decree regarding the management of construction waste is Decree-Law 488/85 of 25 November. In 2008 it is established in Portugal, by Decree-Law 46/2008, of 12 March. Based on these Decree-Laws in force throughout Portugal, the Municipal Regulation of Urbanization and Edification of Covilhã was created, in Article 77 Construction and Demolition Waste, which determines that the deposition of construction and demolition waste in containers intended for use is not permitted. deposition of solid urban waste, on roads or other public spaces [20;22].

In Covilhã, Public and Private Works Contracts have their execution projects monitored by the CD&waste Prevention and Management Plan, during the execution of the contract, the amount of waste produced is monitored by the Executing Entity (contracted),. The Public Contracts Code requires, for public works, the elaboration of a plan for the prevention and management of construction and demolition residues. The procedure for the preparation of the CD&waste Prevention and Management Plan and monitoring in the execution phase of the works until their conclusion, is implemented in all public works contracts in progress in the municipality of Covilhã.

CD&waste they are collected by licensed operators who provide containers for the deposit of the CD&waste and who subsequently collect and transport them, the collected waste is sent to licensed landfills according to the type of waste produced. Part of the CD&waste from contamination is reinstated in the works when that possibility exists. The reintegration of these residues back at works can contribute to the growth of the local economy through the practical implementation of the concepts and procedures of circular economy.

It is important stand out the municipality of Covilhã does not have its own landfill for receiving CD&waste,

however there are companies from other municipalities responsible for collecting and managing this waste, such as the private company Biscarroça located in the municipality of Fundão. Being operation for three years, responsible for collecting an average of 17 containers of 6m³ of CD&waste month in the municipality of Covilhã, which is equivalent to 102 m³ / month equivalent to 1224 m³ / year, with only 5% of this value recycled. Value equivalent to 61 m³ / year. The CD&waste collected were mostly reused in the company itself. Through use as a basis for the construction of a landfill in order to increase the resection capacity of CD&waste, as illustrated in the Figures 4 and 5. Waste that cannot be used with this function, such as cardboard, plasterboard, wood and others, receives another purpose.



Fig.4: Landfill of CD & waste company Biscarroça Fundão [Own Authorship 2020]

Above, the existing landfill for resection of CD&waste and class A waste is shown. The rest, such as classes B, C and D after sorting, are duly forwarded to other companies specialized in each class.



Fig.5: Landfill of CD&waste company Biscarroça Fundão [Own Authorship 2020]

Construction of the new landfill, being used only CD&waste class A for base composition. In cases of reinforced concrete, the materials are separated and the Class B service receives another purpose.

The company's future projects are based on finalizing the landfill using CD&waste and after that start recycling them, so that they enter as waste and leave as reusable materials. The recycled aggregate from construction and demolition waste has been used successfully as a granular pavement material, particularly in structural layers, such as pavement bases and sub-bases [6].

IV. DATA ANALYSIS AND DISCUSSION

The information revealed in this review would be valuable for understand current management practices for CD&waste both in Brazil and in Portugal, the above results are justified through the demonstration of two municipalities in potential urbanization as a portrait of the current situation of the management of CD&waste in each country.

The CD&wate requires effective government regulations, strategies, objectives, adequate recycling and disposal systems and compliance for its controls and minimization efforts [5]. Portugal has a regulatory policy for the control and management of CD&waste valid throughout the national territory that presents a better efficiency when compared with Brazil. That it also has national and regional legislation regarding CD&waste however, they do not exercise the function of controlling the CD&waste that are carried out in their municipalities. The lack of enforcement on compliance with legislation in both countries is extremely detrimental to a further improvement in construction and demolition waste management techniques.

As presented in the results of this case study in the case of Portugal, private companies must account for the amount of C&waste generated and their final disposition. However, inspection by the municipality to assess whether these companies are correctly carrying out what is required by law, without omissions or illegal activities. The same is true in the studied municipality of Brazil, where this lack of inspection becomes even more serious in view of the fact that there is no national control platform for the management of CD&waste as in Portugal. Because some contractors can illegally evict the CD&waste in unauthorized areas, in order to reduce your waste disposal costs, which seriously pollutes the environment [27].

It is identified that the generation of waste CD&waste is influenced by several factors, including population, urbanization and GDP. In the municipality of Santa Fé

there is a high rate of RCD production, but the existence of strategies for the management and reuse of this waste is satisfactorily effective, being able to recycle more than half of the waste. CD&waste arriving at the landfill. Boosting the creation of a circular economy within the municipality, serving as a mirror for Brazil's current situation, which is considerably good for recycling 20% of CD&waste generated per year across the national territory. The municipality of Covilhã also reflects the reality of the management of CD&waste in the country, considering the recycling rate extremely low at both municipal and national level. The simultaneous adoption of combined management strategies and measures can lead to better results in relation to the economic benefit and reduction of CD&waste [11].

A lesson learned from analyzing different economies is that the proper use of recycled materials can generate financial income and strong economic and environmental advantages with specialized recycling facilities. Otherwise, most waste CD&waste would go to disposal areas. In view of the concern with the environmental impact caused by the construction industry in today's society, there are some methods that can be implemented and applied so that CD&waste become a source of consolidation of sustainable cities, such as:

- Base and sub-base layers for paving;
- Manufacture of laying and coating mortars;
- Manufacturing of precast (blocks, curbs, among others);
- Drainage layers.
- Permeable floor.

Some studies were carried out with the objective of evaluating the technical, as well as economic, feasibility of using CD&waste in the production of construction materials such as concrete, mortars, concrete blocks, precast and paving elements [6].

The two Municipalities studied in this research have economic viability for the implementation of some of these projects mentioned as a way of reusing the CD&waste generated in the works. That if implemented in a national and rigorous way can contribute to the improvement of national data regarding construction and demolition waste.

V. CONCLUSION

It can be confirmed that the irregular disposal of these CD&waste causes serious damage to the environment, and to public health. Both municipalities studied have waste management plans that include

construction and demolition waste. According to the data collected, it is possible to conclude that in the municipality of Covilhã there is a lack of adequate actions to control the collection and reverse flow of CD&waste, as they face great difficulties in giving an adequate destination to this waste. What contributes to this reality is the lack of infrastructure that creates minimum conditions for the correct management of the CD&waste.

The Municipality of Santa Fé do Sul has a control of the generated CD&waste and makes a good management of them having a plant treatment installed in the city that recycles this waste and consequently leverages their reinsertion in the necessary activities in the municipality.

Given the data presented in this study, it is possible to conclude initially that none of the Municipalities studied can be considered how "Sustainable Cities. It is necessary to seek better urban planning, implementation of inspection strategies and implementation of CD&waste. Just like its municipalities, each country has a management system for CD&waste extremely different, based on this study it is possible to define that even in the face of the difficulty in controlling the execution of management strategies throughout the national territory. Brazil is a country that produces a large amount of CD&waste which is supplied by the considerable percentage of reuse and reinsertion of this waste back into the labor market. Portugal is considerably smaller than Brazil, has methods of controlling the generation of CD&waste throughout the national territory, but has a low recycling rate for these residues. Improving legislation and public awareness on both sides can fill current gaps and make an additional contribution to improving management current of CD&waste.

However, in view of the case studies, it is concluded that it is of fundamental importance that governmental entities take more rigid measures in order to improve the management of CD&waste and encourage their recycling. The capacity of government entities to control the management of CD&waste in a municipality reflects the final result of the issue at the national level.

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