

Management Plan for Solid Waste in Construction Sites

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Abstract— *The fast urbanization and densification processes in the cities have been causing serious environmental problems, like the disposal and management of solid waste generated during the construction, demolition and renovation of buildings. The present work develops a study on the Management of Solid Waste in Construction Site. This study investigates the method and procedures of waste planning at construction sites and the disposal of these same residues, with the objective to create conditions for the proper economy, standardization and increased safety in the construction sites and facilitation of waste disposal. A theoretical framework was created regarding the provisions of construction waste at construction sites. Based on the results, management actions are being proposed for greater sustainability, with benefits like the better use of the construction site with improvements in its operation and cleaning, as a direct consequence of good solid wastes management.*

Keywords — *Solid Waste, Civil Construction, Construction Site, Disposal.*

I. INTRODUCTION DEVELOPMENT

In this article, we approach the study, classification and appropriate treatment of solid waste in the Civil Construction Industry through a Management Plan. This issue is not much discussed and is vital for the preservation of the environment, where it is primarily intended to prevent solid wastes generated in construction sites through initial construction, demolition, renovation and expansion, to be deposited in the nature, avoiding degradation.

The focus is to bring awareness to the readers for the importance of each type of waste, taking in consideration its classification and final treatment, as well as pointing

cheaper and practical ways to mitigate the waste of materials, diminishing the volume of the generated wastes.

The author Marques Neto (2005) states that it is estimated in Brazil that, for each ton of urban waste collected, two tons of rubble are collected from the civil construction area. According to the citation, it is possible to minimize the volume of waste generated by each construction company, so that they can reuse it in the construction sites when is possible, as well as reducing the waste of materials. Construction and demolition waste constitute a large proportion of solid waste. In Brazil, 59% of landfills are composed of materials from the construction industry (CARNEIRO, 2005, apud VIANA, 2009 p.16).

Taking as a reference basis the technology applied in the civil construction in Brazil, it is clear the lack of efficiency in the execution of the construction works. When comparing the volume of waste generated in new building constructions in Brazil to developed countries, it is evident that Brazil generates three times the number of wastes in comparison to the quantities generated in developed countries, 300 kg/m² built (MONTEIRO, 2001).

Finally, our purpose is to present in this study management actions with the intention to reach the economy, sustainability and correct destination of the (RSCD) Demolition and Construction Solid Wastes, significantly contributing with the environment.

One of the reasons for the decreasing in natural resources is the waste and misuse of raw materials. The exploration and inappropriate disposal are matters of concern and the reason to bring awareness for good daily practices in civil construction.

The construction waste has the property of its final volume being very large, so if the generation of waste is accelerated, it causes the fast filling of reserved spaces in sanitary landfills. Thus, in order to minimize the potential for generating economic, social and environmental impacts, we will use simple management and reuse tools at the construction site.

II. DEVELOPMENT

The solid wastes of construction and demolition (RSCD) are those generated in construction sites, coming from constructions, reforms and demolitions, like bricks, ceramic blocs and concrete in general, etc. The RSCDs are the leftovers of the construction process (BLUMENSCHNIG, 2007).

According to Zordan (1997), all the activities performed in the civil construction area have huge potential to generate waste. As for the production, the main responsible for the RCD are the volumes of material lost. In the constructions, the demolition process does not relate the applied processes or quality of the area, but instead the permanent and invariable existence of each product of the process.

Among the negative impacts to the environment, we have the (RSCD), Demolition and Civil Construction Solid Wastes, originated through construction processes and also known as Civil Construction Wastes (RCC), being a strong polluting source inserted in the construction sites if not properly treated. In Brazil, the amount of losses in corporative construction materials (residential construction in buildings) has a variable between 20% and 30%, an index considered higher than the ones found in Developed countries (SCHNEIDER, 2003 apud PINTO, 2003)

“According to Law 12.305/10, the management of solid waste can be defined as a conjunct of direct and indirect actions during the steps of collect, transportation, transshipment, treatment and the environmental-friendly final destination of solid waste and rejects, according to the municipal plan of integrated management of solid waste or with the management plan of solid waste, demanded in the Law.” (BRASIL, 2010).

Due to the large volume of Solid Waste generated in the civil construction business, it was approved the Resolution nº 307, from 07/05/2002, by the National Environmental Council – CONAMA, which defined the responsibilities and duties and made mandatory in all the municipalities of the country and in the Federal District the implementation by the local government of Integrated Plans of Civil Construction Waste Management, to eliminate the environmental impact resulting from the activities related to the generation, transportation and destination of these materials. It also determines the

adoption, if possible, of measures capable of minimizing the generation of waste and its reuse or recycling, or, when inviable, that they are allocated in a segregated manner for posterior use.

On chapter VI, Art. 225, regarding the environment, the Constitution establishes that: “Everyone has the right to an eco-balanced environment, which is a right of common use of the people and essential to a healthy life quality, imposing to the government and the collectivity the duty to defend it and preserve it for the present and future generations.” (CONAMA, 2002).

The following chart (01) shows the responsible parties (agents) and the main responsibilities in the management of RSCD.

Chart 1 - Main responsibilities in the management of the RSCD.

Agent	Responsibilities
State	Introduction of means for direct and economic regulation to regulate the management of the collection process. Stablishing of monitoring standards and use of debris for grounding; Consolidation of recycling activities Stablishing of goals for the reduction of the use of sparse natural resources Incentives for the use of waste from construction and demolition Prohibition of sand and gravel extraction; Consolidation of the production of recycled aggregates Stablishing of legal areas for solid waste disposal.
Generators	Reduction of losses and waste generation through the adoption of constructive and rational methods. Management of solid waste during the construction process; Awareness of the necessity to use recycled materials, to consolidate recycling activities and to reassure the quality of the segregated waste. Investments in Research and Development.
Entrepreneur Clients, architects, engineers and consultants	Stablishing of specification criteria for the use of recycled materials and the adoption of sustainability principles; Demanding the adoption of a waste management system in construction sites; Definition of rationalization and standardization criteria in the definition of construction methods to produce flexible buildings of simple demolition

	capacities.
Transport Companies	Demanding the exercise of the transporting activity in a conscious and responsible manner, taking the waste to the areas designated by the city; Warning the drivers about the impacts caused by the illegally disposed waste; Contribution to the program of control and monitoring of the volume and characteristics of the produced waste.
Wastes Processors	Reassuring the quality of the recycling aggregates
Universities and Research Institutes	Implementation of labs, development of applied research, parliamentary consultancy, courses, consultation, integration of agents, among others.

Source: Adapted from Blumenschein, R., 2004. Extracted from: Technical Manual - Management of Solid Waste in Construction Sites (Blumenschein, 2007, p.8).

2.1. RSCD Generation

A civil construction site involves many different organizations, such as entrepreneurs, builders, planners, financiers, engineers, architects, labor, suppliers, among others. The lack of planning, coordination, monitoring, inefficient or incomplete information of technical documents and lack of communication between these areas results in delays, high costs and wastes that increase losses and generation of waste (BLUMENSCHIEIN, 2007, p. 9).

In figure (1) below we see characteristics of a linear, traditional, schematic production process. The phases work in a disintegrated fashion from each other, which does not allow the exchange of information to make compatible the technical information and the necessary corrections before beginning the construction, avoiding errors and reworking.

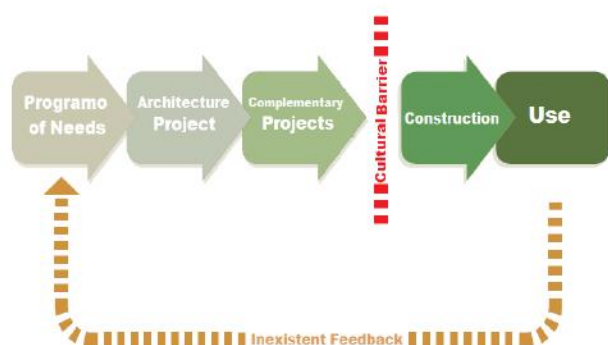


Fig.1: Traditional Construction Process

Source: Blumenschein, R., 2004. Extracted from: Technical Manual - Management of Solid Waste in Construction Sites (Blumenschein, 2007, p.9).

According to the Federal University of Bahia Publisher (EDUFBA, 2001, p.66, apud VIANA, 2009,

p.25), among the several factors that contribute to the generation of the rubble, it is worth mentioning:

- insufficient definition and detailing, in architectural projects, structure, forms, facilities, among others;
- lower quality of construction materials and components available on the market;
- unskilled labor;
- lack of operational procedures and enforcement and inspection control mechanisms.

Chart 2 shows the sources and causes of the occurrence of construction waste.

Chart 2 - Sources and Causes of Occurrence of Construction Waste.

SOURCE	CAUSE
Project	Errors in the contracts; Incomplete contracts; Project Modifications.
Intervention	Wrong orders, absence or excess of orders; Supply errors.
Material Handling	Damage during transport; Inappropriate stock.
Operation	Errors of the workers; Equipment malfunction; Inappropriate environment; Damage caused by previous and subsequent work; Uses of incorrect materials in substitution; Cutting remains; Waste from the application process.
Others	Vandalism and theft; Lack of material control and waste management.

Source: Pontes (2008, p.25). Excerpted from VIANA, (2009, P.26)

2.2. Management of RSCD In Construction Sites

For Kartam et al (2004) apud Tavaves (2007), the term management can be defined as the prudent use of means to achieve an end. Therefore, this term "management" has not been used correctly when applied in civil construction activities relating to solid waste generating activities, whose actions are reckless as a rule, and in most of the activities the ends are not achieved to the fullest.

The work of RCD management must begin well before the execution of the work, appearing already in the first planning stages, since the definition of the constructive technology to be used is crucial so that there is no waste at the construction site (SANTOS, 2012)

The resolution of CONAMA No. 307/02 calls attention to an aspect of high importance, which is the solution found for the abolition of the well-known "disposals" practices of the rubble of the civil construction. If there is no viability in establishing waste recycling from urban construction, the continuation of this highly polluting practice should be abolished (COSTA, 2005).

We cannot have in short-term high rates of RCD return to the productive cycle, but we can adopt practices that respect these materials as nonrenewable natural resources (PINTO, 2004).

In general, solid waste is one of the main determinants of environmental degradation, due to the volume of its treatment and its inadequate disposal. The main problems of its management must be solved by the government and municipal authorities (COSTA, 2003).

It is important to emphasize that no society can achieve sustainable development without the civil construction that supports it, undergoing through profound changes (FILHO, 2005 apud POLILLO, 2001).

2.3. Composition of Solid Waste

According to Silva and Fernandes (2012), the civil construction industry is one of the largest generators of solid waste today, and the waste originated during construction or demolition processes is of extreme importance in the total amount produced in urban centers.

According to Law No. 12.305/10, which establishes the National Solid Waste Policy, the objective is the prevention and reduction of solid waste generation, aiming at sustainable consumption, increased recycling and reuse of solid waste generated and its correct destination (BRAZIL, 2010).

Classification of Solid Wastes

ABNT NBR 10004/2004 classifies for standardization effects the waste in:

- a) Class I waste - Hazardous;
- b) Class II waste - Non-hazardous;
 - class II A waste - Not inert.
 - class II B waste - Inert.
- Class I waste - Hazardous:

Waste that present dangerousness and risk to public health, causing mortality, incidence of diseases or accentuation of their rates and risks to the environment when the waste is improperly managed. It may also present: flammability, corrosivity, reactivity, toxicity or pathogenicity.

- Class II Residues - Non-Hazardous:

Waste that do not fit into Class I.

- Class II A waste - Not inert.:

Waste that do not fit into the classifications of class I-Hazardous or class II B - Inert. Class II A - Non-inert

waste may have properties such as: biodegradability, combustibility or solubility in water.

- Class II B waste - Inert:

Any wastes that, when sampled in a representative manner, according to ABNT NBR 10007, and subjected to a dynamic and static contact with distilled or deionized water, at ambient temperature, according to ABNT NBR 10006, do not have any of their constituents solubilized at higher concentrations to water potability standards, except for appearance, color, turbidity, hardness and taste.

The classification of wastes as to their origin, chemical composition, presence of moisture and toxicity is presented by (LINS et al 2008, apud VIANA, 2009, p.21) as follows:

Regarding the origin:

- Residential – waste originated from the daily life of the residences.
- Commercial - waste coming from several commercial establishments and services
- Public - originated from the services of urban public cleaning (cleaning of public roads, beaches, galleries, streams and lands, remnants of pruning of trees, etc.), and cleaning of fairground areas.
- Of health services – they constitute the septic waste.
- From ports, airports, road and rail terminals – they constitute the septic wastes, which contain or may potentially contain pathogenic germs, brought to ports, airports, road and rail terminals.
- Industrial - those originated in the activities of the several branches of the metallurgical industry, chemical, petrochemical, paper, food, among others.
- Agricultural - solid waste from agricultural activities and livestock.
- Rubble - construction waste, such as demolitions and debris from works, excavation grounds, among others.

Regarding their Chemical Composition:

- Organic - paper, newspapers, magazines, plastics, packaging, rubber, tires, gloves, medicines, food scraps, crop residues, among others.
- Inorganic - metals, glass, ceramics, sand and stones.

Regarding the Presence of Humidity::

- Dry - apparently without humidity.
- Wet - visibly wet.

Regarding their Toxicity

- Class I - hazardous, which may be flammable, corrosive, reactive, toxic and pathogenic.
- Class II - non-hazardous, subdivided into:
 - Class II A- not inert. They pose no risk to public health or the environment and may be biodegradable, such as untreated and paintless wood, plaster, paper and others.
 - Class II B- inert. For instance, hardened concrete and mortars, masonry, ceramic and concrete components, tile, aluminum, glass, copper and plastic, among others.

According to the norm NBR 10004 (ABNT, 2004), the classification of class II b-inert, of civil construction, are defined as follows:

"Any wastes that, when sampled in a representative manner, subjected to a static or dynamic contact with distilled or deionized water at room temperature, according to the solubilization test, do not have any of their constituents solubilized in concentrations higher than water potability standards, except for the patterns of appearance, color, turbidity, and taste. As an example of these materials, we have rocks, bricks, glasses and certain plastics and rubbers which are not readily decomposed. " NBR 10004 (ABNT, 2004).]

Conama Resolution No. 307 defines classes according to their recyclable potential:

- Class A - reusable or recyclable wastes as aggregates, such as:
 - a) construction, demolition, alteration and repair of paving and other infrastructure works, including land from earthworks;
 - b) construction, demolition, renovation 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, bundles, etc.) produced at construction sites;
- Class B - recyclable wastes for other destinations, such as: plastics, paper/cardboard, metals, glass, wood and others;
- Class C - wastes for which no economically viable technologies or applications have been developed to enable their recycling/recovery, such as products made of plaster;
- Class D - hazardous wastes from the construction process, such as paints, solvents, oils and others, or those contaminated from demolition, remodeling and repair of radiological clinics, industrial installations and others (BRASIL, 2002).

2.4. Environmental Impacts and Final Destination of RCD

One of the main sources of RCD generation considers the high loss rate of the construction process in the industry. Most of the researchers say that the causes of RCD generation are related to the losses. However, not every loss within the construction sites necessarily represents the generation of waste effectively. as the rubble responds to 50% of all wasted material (PINTO, 1989).

In most Brazilian cities, the RCDs adopted as a management model are of the corrective type. This type of model has been shown to be unsuccessful, marked by not including preventive, costly and periodic activities, where there are no expected positive effects. This makes it a practice without sustainability to the RCD. (EDUFBA, 2001 apud TAVARES, 2007).

For the employees who work in the field, the treatment, collection and improper disposition of solid wastes have high social and economic impacts. Therefore, the negative impacts generated are of wide knowledge, and the issue of wastes has been neglected for many times, reflecting these damages on future generations and potentiating the destructive occurrences (MENEZES and MENEZES, 1999).

A considerable number of professionals working in construction do not recognize the amount of RCD they generate, and by understanding the environmental pollution they are producing, they are usually not being guided by the conditions necessary to perform the correct dumping of the volumes generated, like making use of the reusable selection and being referred to external recycling process. These practices have a high contribution to the environment, where the reduction of environmental impacts caused by the sector is directly linked (MARINHO and SILVA, 2012).

Also, according to CONAMA's resolution, Article 10, construction waste should be disposed as described in Chart 3.

Chart 3 - Destination of the RCD according to the CONAMA resolution n° 307/2002.

Class	Destination
Class A	They must be reused or recycled in the form of aggregates, or sent to landfill sites of construction wastes, being arranged to allow their use or future recycling.
Class B	They must be reused, recycled or transported to temporary storage areas and disposed of in a way that allows them to be used or recycled in the future.
Class C	They must be stored, transported and destined in accordance with the specific technical standards.
Class D	They must be stored, transported, reused and destined in accordance with the specific technical standards.

Source: CONAMA Resolution No. 307/2002.

It is well known that the irregular dumping of the RCD culminates in larger issues faced by the

municipalities, with high costs for the environment and the community. This practice of illegal dumping results in the degradation of urban quality of life, with consequences like floods, visual pollution, transportation, proliferation of vectors of diseases, pollution of water beds and sedimentation, among other environmental issues (TAVARES, 2007).

It is necessary to reduce the generation of RCD in order to minimize the impacts into the environment. The civil construction industry has been working for implement this condition, but facing difficulties to do so, as stated by (CARELI, 2008).

III. CONCLUSION

For a project to be considered sustainable, the work of the management of the RCD begins well before the execution of the work. It must point the impacts that will be generated and propose solutions that eradicate the waste in the construction sites. At the main stages of planning, it is important to create alternatives for the proper use of existing resources, such as the use of water resources and energy, as the definition of the constructive technology to be used is crucial to make a sustainable environment and minimize the potential of impact generators.

It is inevitable to generate wastes, as practically all the activities developed in the civil construction sector generate debris. The construction activities, mainly the urban ones, generate a significant volume of inert wastes, where they contribute to a low environmental quality, even more so in the occurrence of inadequate disposal.

The implementation is sustainable and economical in the construction sites, adopting programs and actions capable of reducing as much as possible the unsustainability that can be achieved through construction works. Solutions to treat inert waste, using appropriate techniques in accordance with current legislation.

Preventive and remedial actions must be introduced at the moment of the project, in order to successfully reach the proposed solutions. Prevention to minimize the generation of wastes, prioritizing non-generation, and secondarily, reduction, reuse, recycling and appropriate final disposal.

In view of this probable solution, it is necessary, in addition to raising awareness of the responsibilities of all participants in the construction processes, to implement a more efficient inspection system, not only ensuring an efficient reuse of solid wastes coming from civil construction, but also to supervise the disposal of the wastes that had its useful life expired.

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