QUANTITATIVE ASSESSMENT OF WASTE MANAGEMENT IN BRAZILIAN CONSTRUCTION SITES
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ABSTRACT

Resolution 307 of the National Environment Council (CONAMA, 2002) is the Brazilian regulation that has been progressively urging the consciousness of construction companies with regard to environmental management and destination of construction and demolition waste.

The purpose of this paper was to describe the quantitative assessment of construction site waste management according to Resolution 307 at six sites in the city of São Paulo. The methodology adopted for the case study research was divided into two stages: the first consisted of designing the questionnaire for assessment requirements; and the second consisted of assessing the actions taken in construction sites.

The assessment requirements were considered as follows: cleanliness, segregation at source, final packing and pre-established destination; while the assessment criteria were considered as grading from 1 (the worst assessment, no application of the waste management requirements) to 10 (the best assessment, full compliance).

The positive aspects noted included the knowledge of standard requirements and actions relating to their effective compliance, as can be confirmed by the best assessment of the pre-established destination. The main negative aspect concerned the need for those in charge of the construction sites to pay attention to changes, alterations and difficulties to take more efficient measures.

Keywords: solid waste, management, assessment, construction.

1. INTRODUCTION

The circumstances of economic transformation and the need to streamline construction have required greater concern over the entire production environment with respect to reducing costs, improving product quality, and increasing efficiency of the production processes.

However, many deficiencies can be found in all stages of the building construction process. Included in these deficiencies is the management of waste generated by the construction sites, which causes serious urban problems of public sanitation and environmental contamination arising from the scarcity of disposal areas.
According to Pinto (1999), the waste generated by construction represents about 61% of the total waste produced in urban areas, accounting for various negative environmental, economic and social impacts.

According to Agopyan et al. (1998), Dorsthorst; Hendriks (2000), John (2000), and Schneider (2003), the organizational and productive methods of construction require changes to promote the rationing of resources, reducing the waste of time and materials and their impacts on cost as well as the need for waste disposal land located within urban areas.

In this context, Resolution 307 of the National Council of the Environment – CONAMA (2002), in force since 2003, establishes guidelines, criteria, and procedures for construction waste management, creating responsibilities for waste generators, transporters, and receivers, as well as city governments, pressuring construction companies and public officials to develop actions in order to meet legal requirements and ensure environmental sustainability.

According to Lordsleem, Jr. et al. (2007), a transformation in the reality of Brazilian urban centers is beginning to be seen from initiatives on the part of construction companies to implement waste management, with the requirements of CONAMA Resolution 307 as a reference.

The Worksite Environmental Waste Management Program of the Civil Construction Industry Syndicate of the State of São Paulo – SINDUSCON-SP has been the principal reference for waste management at Brazilian construction companies (Pinto, 2005).

This program consists of the implementation of actions to meet the requirements of worksite waste management, which includes the following stages: planning, implementation, evaluation, and taking corrective action.

The evaluation stage is the subject of this paper, through which the worksite is verified with regard to cleaning, segregation at source, final conditioning, and appropriate destination of waste.

Currently, 84.2% of the population of Brazil lives in urban areas, with the city of São Paulo being the largest metropolitan agglomeration in Brazil and the fifth largest in the world, with 18.8 million inhabitants, behind only Tokyo (35.7 million), New York, Mexico City, and Mumbai, each with 19 million (Revista, 2009).

São Paulo is the principal financial, corporate, and trade center of Latin America, taking over the role of the business and service center of the country.

The construction waste management policy adopted by the São Paulo City Hall is implemented by the Municipal Plan for Sustainable Waste Management. The plan meets the guidelines established by CONAMA Resolution 307 and seeks to increase the supply of areas for the regular deposit of construction and demolition waste from small to large generators, as well as facilitate and encourage the recycling of these materials.

According to the Brazilian Association of Public Sanitation and Waste Collection Companies – ABRELPE (2005), civil construction produces 17.24 thousand tons of waste per day in the city of São Paulo, which is about 55% of the total.
The average composition of construction waste generated in São Paulo is, according to Brito Filho (1999), made up of 33% concrete and mortar, 32% soil, 30% ceramics, and 5% other materials.

2. OBJECTIVE
This paper aims to describe the evaluation of environmental waste management at six construction sites in the city of São Paulo, from which it will be possible to verify the principal problems associated with each evaluated condition.

3. METHODOLOGY
The research methodology was divided into two stages: 1) development of a questionnaire to define the requirements for evaluation and the criteria for allocation of grades; 2) on-site evaluation of actions implemented in waste management on construction sites.

Table 1 presents the questionnaire developed and applied in the evaluation of waste management on construction sites.

The following requirements for evaluation were:
- cleaning: refers to the implementation of collecting and sorting and the sweeping of environments;
- segregation at source: refers to the occurrence of activity as close as possible to the place where waste is being generated, making it available in a compatible size and preserving the organization of space in the various sectors of the construction sites;
- final packing: refers to the size, quantity, location, and type of device used for the final packing of waste;
- appropriate destination: refers to the formalization of the waste destination through the identification and registration of transporters and recipients, the issue of a Waste Transportation Control – WTC for registration of the destination, and the payment to the transporter.

The application of the check list evaluation on construction sites lasted 8 hours and was performed on a monthly frequency throughout the execution of the work.

The following evaluation criteria were considered:
- grades from 1 to 10: the values were assigned by evaluating the fulfillment of the requirements in each environment. A grade of 1 is the worst evaluation (without any implementation of waste management) and a grade of 10 is the Best (no problems, full compliance with the waste management program);
- weighting factors: are associated with the volume of each waste collection device used: bags, boxes, and container.

The areas delimited for the evaluation of cleaning and segregation at source were formed by the division of environments represented in the planning of the waste management program implementation at each site.
4. PRESENTATION AND ANALYSIS OF RESULTS

4.1. Characterization of the construction sites and of the waste management program

The construction sites are identified here by the letters A, B, C, D, E, and F in order to preserve their identities, and are characterized in Tables 2 and 3.

A and B had a greater height than the rest of the buildings; the buildings at sites C and D were for educational use, with D being executed inside a functioning campus; enterprises E and F were shopping centers, with E being an expansion of an existing structure, executed while the shopping center was open and functioning.

Table 1. Questionnaire for evaluation of construction sites waste management
### Table 2. Characterization of construction sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Type</th>
<th>Area</th>
<th>Description</th>
<th>Phase of construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Commercial high-rise building</td>
<td>29,701 m²</td>
<td>18 floors, doctors’ offices and clinics.</td>
<td>Structure, masonry, façade, and waterproofing.</td>
</tr>
<tr>
<td>B</td>
<td>Residential high-rise building</td>
<td>17,302 m²</td>
<td>27 floors, 1 triplex, 2 apartments per floor.</td>
<td>Plaster, installations, waterproofing, external façade.</td>
</tr>
<tr>
<td>C</td>
<td>University high-rise building</td>
<td>20,377 m²</td>
<td>6 floors, 27 rooms, library and auditorium.</td>
<td>Structure, external masonry, internal plaster and façade.</td>
</tr>
<tr>
<td>D</td>
<td>University high-rise building</td>
<td>12,214 m²</td>
<td>9 floors, classrooms, library.</td>
<td>Structure and masonry.</td>
</tr>
<tr>
<td>E</td>
<td>Shopping center.</td>
<td>76,175 m²</td>
<td>Fashion center.</td>
<td>Finishing and installations.</td>
</tr>
<tr>
<td>F</td>
<td>Shopping center – expansion.</td>
<td>9,000 m²</td>
<td>Cinema and mall.</td>
<td>Plaster and installations.</td>
</tr>
</tbody>
</table>

### Table 3. Characterization of construction sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Worksite</th>
<th>Equipment for waste transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>The areas for the storage of materials were arranged on the ground floor.</td>
<td>1 crane and 1 lift, each installed on opposite side of the building.</td>
</tr>
<tr>
<td>B</td>
<td>The areas for the storage of materials were arranged on the ground floor and in the basement.</td>
<td>1 lift.</td>
</tr>
<tr>
<td>C</td>
<td>The areas for the storage of materials were arranged on the ground floor.</td>
<td>1 crane and 1 lift.</td>
</tr>
<tr>
<td>D</td>
<td>The areas for the storage of materials were arranged beyond the projection of the building.</td>
<td>1 crane and 1 lift.</td>
</tr>
<tr>
<td>E</td>
<td>The areas for the storage of materials were arranged on the ground floor and in the basement levels.</td>
<td>1 crane.</td>
</tr>
<tr>
<td>F</td>
<td>The areas for the storage of materials were arranged on land outside of the construction area.</td>
<td>1 crane.</td>
</tr>
</tbody>
</table>
The following steps were completed in the implementation of the waste management program: diagnosis and planning of site management, proposal of mechanisms and physical arrangement, purchase of equipment, training of staff, orientation of the application of WTC, periodic inspections with check-list of monitoring and corrective actions.

It was the responsibility of the quality department along with the management team and engineering team at each site to implement the above mentioned steps.

4.2. Evaluation of waste management on construction sites

4.2.1. Requirements and criteria for evaluation

Table 4 presents the results obtained from the evaluation of waste management on construction sites.

<table>
<thead>
<tr>
<th>Evaluation requirements</th>
<th>Sites</th>
<th>Requirements average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Cleaning</td>
<td>8.3</td>
<td>9.1</td>
</tr>
<tr>
<td>Segregation at source</td>
<td>8.1</td>
<td>9.7</td>
</tr>
<tr>
<td>Final packing/conditioning</td>
<td>9.4</td>
<td>8.0</td>
</tr>
<tr>
<td>Appropriate destination</td>
<td>7.5</td>
<td>10.0</td>
</tr>
<tr>
<td>Average</td>
<td>8.3</td>
<td>9.2</td>
</tr>
</tbody>
</table>

It can be seen from the results presented in Table 4 that the construction sites evaluated better with regard to waste management were (in decreasing order) B, C, D, A, F, and E. The lowest grades refer to the commercial building sites.

The quantitative evaluation attributed to each of the requirements reflects as well a qualitative (subjective) evaluation performed by simple observation of the construction sites during the visits made while performing the research.

It also can be seen that the requirement which received the best evaluation was that of appropriate destination followed by, in descending order: cleaning, segregation at source, and final packing. This requirement receiving the best evaluation is in the interests of worksites in addressing compliance with the requirements of CONAMA Resolution 307 through the control of documentary evidence of the appropriate destination.

It is important to emphasize that the responsibility to comply with the other requirements of the evaluation involves comparatively more agents, thereby increasing the difficulty of meeting the requirements.

4.2.2. Principal problems identified

The principal problems identified in waste management are described in Table 5.

Some of the problems verified were found to be common among the various sites, for
example those related to segregation at source. It was also observed that the problems identified reflected the level of knowledge of those responsible for waste management on construction sites, because they waited for the intervention of the quality department to correct any deviations.

Table 5. Principal problems observed in the evaluation of waste management on construction sites

<table>
<thead>
<tr>
<th>Sites</th>
<th>Principal problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>The destinations of the following types of waste were not completely defined: wood (incinerated off-site) and plastic (bags accumulated at the site, awaiting collector). The method of cleaning at the source had not been assimilated, because waste remained mixed on the floor and only separated during final packing.</td>
</tr>
<tr>
<td>B</td>
<td>There was much evidence of a poor understanding of segregation at source. Bags of waste were seen with mixed waste (masonry, metal, plastic). There was an unidentified metal barrel on the 23rd floor. A few materials (plastic and paper) were mixed in a container of concrete/block/mortar.</td>
</tr>
<tr>
<td>C</td>
<td>Bags were not provided at the construction sites, in conformance with planning. There was much evidence of a poor understanding of segregation at source. Batteries were found mixed with waste (concrete, metal, and plastic). A legible certificate for the landfill which was the destination for concrete and masonry was not presented.</td>
</tr>
<tr>
<td>D</td>
<td>There was much evidence of a poor understanding of segregation at source. Cleaning carts were seen with mixed waste (concrete, paper, plastic). There was no place at the site for the final conditioning of concrete waste. There was only one container of wood. There was no cleaning and isolation of the elevator pit.</td>
</tr>
<tr>
<td>E</td>
<td>With regard to segregation at source, a barrel was found being used for common waste. Several barrels were not found (without explanation or control). The plastic bag was not being used for final packing. The subcontracted stalls were not being used correctly (stall for plaster with plastic and metal mixed in). The waste management system was not widespread at the site. The company contracted for cleaning did not understand segregation.</td>
</tr>
<tr>
<td>F</td>
<td>There was much evidence of a poor understanding of segregation at source. Bags were seen with mixed waste (paper, plastic, wood, plaster). The bags were prepared without a protective cover (rain). The concrete/masonry container was found with mixed plastic and paper waste.</td>
</tr>
</tbody>
</table>

Photos 1, 2, and 3 show some of the main problems identified in the evaluation of waste management at the worksites participating in the study.
It can be seen in Photos 1, 2, and 3 and according to Table 5 that there is a need for greater interaction between the various actors participating at the construction sites, in light of the various wastes observed at each site.

Furthermore, another relevant aspect identified was related to the improved planning of the necessary devices, making them compatible with the existing space as well as with the frequency of collection for transport to the final destination.
5. CONCLUSION

The management of waste at worksites is a relatively recent Brazilian concern, having been stimulated by the institution of CONAMA Resolution 307 (2002). The requirements of legislation, the environmental call of society, and the concern regarding the indiscriminate use and continuous depletion of non-renewable resources have served as a stimulus for the adoption of actions focused on waste management at construction companies.

In analyzing the research results presented in this article, it can be seen that the actions implemented by the construction companies have contributed to the promotion of environmentally committed waste management.

The evaluation of waste management attributed an overall average grade of 8.3 and identified 15 problems, these being (average and number of problems, respectively): site A (8.3 and 2), site B (9.2 and 2), site C (8.9 and 2), site D (8.4 and 3), site E (6.9 and 3), and site F (7.0 and 3).

It is important to note, however, that a number of the problems can be found at more than one construction site. As positive aspects observed in the evaluation, knowledge about the regulatory requirements and the actions relevant to their effective enforcement was noted, as can be verified by the higher grades for the appropriate destination of waste at the majority of sites.

The principal negative aspect identified in the evaluation was related to the need that those responsible for the site must have with regard to changes, alterations, and difficulties in taking more effective measures. The disappearance and/or distinct use of the waste collection container was another critical and negative aspect observed at the work sites, especially those of greater horizontal extension.

In general, it was also possible to conclude that in order to improve the management of waste, it is necessary to have a greater awareness and effective control of both maintenance and distribution of devices, as well as the segregation of waste at source, which is required for the implementation of new training courses for the teams responsible for cleaning.

REFERENCES


