QUANTITATIVE ASSESSMENT OF WASTE MANAGEMENT IN BRAZILIAN CONSTRUCTION SITES

A. C. LORDSLEEM JÚNIOR*, S. P. FUCALE*

** Deputy Professor, Department of Civil Engineering, University of Pernambuco, Polytechnic School, Civil Engineering Post-Graduate Program, Rua Benfica, 455, Sala I-01, 50750-470 Recife, Brazil*

ABSTRACT: This paper presents a quantitative assessment of waste management from six construction sites in the city of São Paulo, from which it was possible to verify the degree of compliance with the requirements of National Council of the Environment – CONAMA Resolution N° 307. The methodology consisted of the development and implementation of a questionnaire, including the adoption of grades for the following assessment requirements: cleaning, segregation at source, final conditioning, and appropriate destination. The results demonstrated the effective application of the guidelines laid down in legislation, but also pointed to the need for action on improvements associated with each condition evaluated, as well as measures that seek to increase the involvement of subcontractors in the execution of the job, address the shortage of licensed areas for the disposal of some types of waste, implement mechanisms for control and monitoring, and encouraging the recycling of waste.

Keywords: evaluation, solid waste; civil construction; construction management.

1. IMPACTS OF CONSTRUCTION WASTE ON THE URBAN ENVIRONMENT

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.

Proceedings Sardinia 2009, Twelfth International Waste Management and Landfill Symposium
S. Margherita di Pula, Cagliari, Italy; 5 - 9 October 2009

According to Agopyan et al. (1998), Dorsthorst and 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 article, through which the worksite is verified with regard to cleaning, segregation at source, final conditioning, and appropriate destination of waste.

2. THE CITY OF SÃO PAULO AND CONSTRUCTION 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).

Saõ 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 Management of Waste. 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.

3. OBJECTIVE

This article 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.

4. 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 worksite waste management.

Table 1 presents the questionnaire developed and applied in the evaluation.

Table 1. Questionnaire for evaluation of worksite waste management

CHECK-LIST: CLEANING AND SEGREGATION

Evaluated Space	Weighting	Cleaning	Segregation at source	Paper	Plastic	Metal	Wood	Organic	Use / Obs.	Photo(s)	Not evaluated	Insufficient sweeping	Masonry and concrete waste	Wood waste	Material wrongly conditioned	Tarps, canvas spread at location	Plaster waste	Organic waste	Packaging spread	Cigarette packs, plastic bottles	Non-segregated waste	Metallic waste
AVERAGES	===	-	-																			

CHECK-LIST: FINAL CONDITIONING

Final Conditioning	Weighting	Grade 1-10	Other	Paper	Plastic	Metal	Wood	Adequate Use	Photos	Mixed Waste		Full	Not used	Used incorrectly	Not signed	Waste spread around
Utilization of Bags	30.0%															
Utilization of Bays	10.0%															
Bins	60.0%															
AVERAGE	=====															

CHECK-LIST: APPROPRIATE DESTINATION

WASTE	Destination	Quantity	Volume	Units	Cost	Grade
Concrete/Masonry/Plas						
Wood						
Metal						
Paper						
Plastic						
					AVERAGE	

FINAL GRADES	
Cleaning	0.0
Segregation at source	0.0
Final conditioning	0.0
Appropriate destination	0.0
Overall Average	0.0

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 worksite;
- final conditioning: refers to the size, quantity, location, and type of device used for the final conditioning 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 – CTR for registration of the destination, and the payment to the transporter.

The application of the check list evaluation at each worksite 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 collector used: bags, boxes, and bins.

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.

5. PRESENTATION AND ANALYSIS OF RESULTS

5.1 Characterization of the worksites and of the waste management program

The worksites 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.

Table 2. Characterization of worksites

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

Table 3. Characterization of worksites

Site	Worksite	
	Materials storage	Equipment for waste transport
A	The areas for the storage of materials were arranged on the ground floor.	1 crane and 1 lift rack, installed on opposite side of the building.
B	The areas for the storage of materials were arranged on the ground floor and in the basement.	1 lift rack.
C	The areas for the storage of materials were arranged on the ground floor.	1 crane and 1 lift rack.
D	The areas for the storage of materials were arranged beyond the projection of the building.	1 crane and 1 lift rack.
E	The areas for the storage of materials were arranged on the ground floor and in the basement levels.	1 crane.
F	The areas for the storage of materials were arranged on land outside of the construction area.	1 crane.

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.

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 CTR, 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.

5.2 Evaluation of waste management at worksites

5.2.1 Requirements and criteria for evaluation

Table 4 presents the results obtained from the evaluation of waste management at the worksites.

It can be seen from the results presented in Table 4 that the worksites 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 worksites during the visits made while performing the research.

Table 4. Results of the evaluation of worksite waste management

Evaluation requirements	Sites						Requirements average
	A	B	C	D	E	F	
Cleaning	8.3	9.1	9.6	8.7	6.2	7.7	8.3
Segregation at source	8.1	9.7	9.1	8.3	6.2	6.6	8.0
Final conditioning	9.4	8.0	6.8	6.7	5.3	5.8	7.0
Appropriate destination	7.5	10.0	10.0	10.0	10.0	8.0	9.3
Average	8.3	9.2	8.9	8.4	6.9	7.0	8.1

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 conditioning. 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.

5.2.2 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 at the worksites, because they waited for the intervention of the quality department to correct any deviations.

Figures 1, 2, and 3 show some of the main problems identified in the evaluation of waste management at the worksites participating in the study.

Table 5. Principal problems observed in the evaluation of worksite waste management

Sites	Principal problems
A	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 conditioning.
B	There was much evidence of a poor understanding of segregation at source. Bags of garbage 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 bin of concrete/block/mortar.
C	Bags were not provided at the worksite, in conformance with planning and orientation. 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.
D	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 bin of wood. There was no cleaning and isolation of the elevator pit.
E	With regard to segregation at source, a barrel was found being used for common trash. Several barrels were not found (without explanation or control). The plastic bag was not being used for final conditioning. 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.
F	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 bin was found with mixed plastic and paper waste.

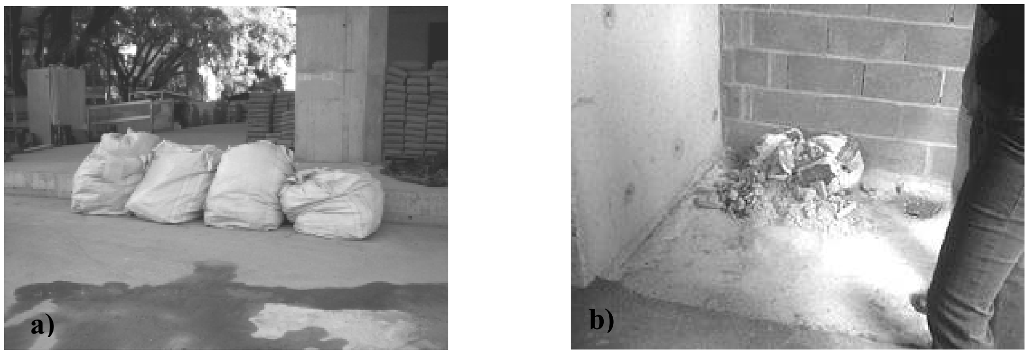

Figure 1. Problems of waste management: a) site A – plastic bags awaiting definition of collector, b) site B – residue mixed in bag

Figure 2. Problems of waste management: a) site C – mixture of waste at the source, b) site D – single bin at the site for the conditioning of wood

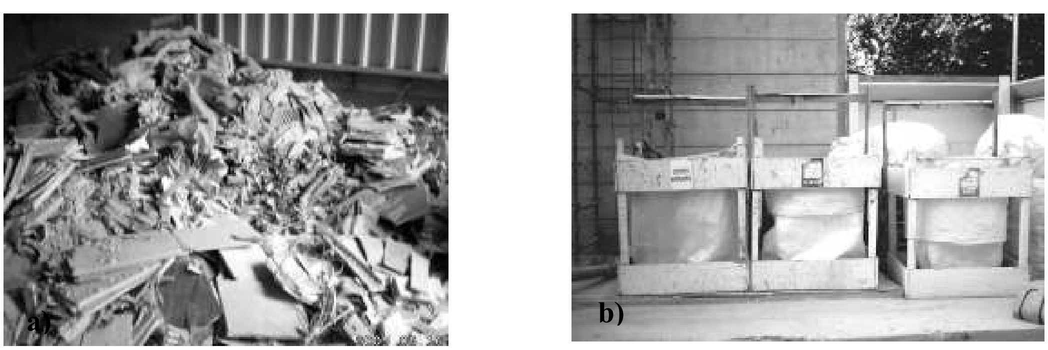

Figure 3. Problems of waste management: a) site E – stall with mixture of plaster, paper, and plastic; b) site F – bags without cover

It can be seen in Figures 1, 2, and 3 and according to Table 5 that there is a need for greater interaction between the various actors participating at the worksite, 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.

6. 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 worksite. 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 bins 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

Agopyan V. et al. (1998). *Alternativas para a redução do desperdício de materiais nos canteiros de obras: relatório final.* São Paulo.

Associação Brasileira das Empresas de Limpeza Pública e Resíduos Especiais. (2005). *São Paulo. Aterros e resíduos na cidade.* <www.abrelpe.com.br>. Accessed on: 02 de junho. 2005.

Brito Filho J. A. (1999). *Cidade versus entulho.* 2º Seminário Desenvolvimento Sustentável e a Reciclagem na Construção Civil. São Paulo, IBRACON, p. 56-67, 1999.

Conselho Nacional do Meio Ambiente. (2002). Resolução n. 307 de 5 de julho de 2002. Estabelece diretrizes, critérios e procedimentos para a gestão dos resíduos da construção. Diário Oficial da República Federativa do Brasil.

Dorsthorst B.J.H and Hendriks C. F. (2000). *Re-use of construction and demolition waste in the*

EU. In: CIB Symposium: Construction and Environment – theory into practice, São Paulo, 2000. Proceedings. São Paulo, EPUSP.

John V. M. (2000). *Reciclagem de resíduos na construção civil: contribuição à metodologia da pesquisa e desenvolvimento.* São Paulo. 102p. Tese (livre docência) – Escola Politécnica, Universidade de São Paulo.

Lordsleem Jr. A.C., Fucale S. P., Fernandes, P. C. S. and Gusmão A. D. (2007). *Solid waste management in brazilian construction sites.* In: XI International Waste Management and Landfill Symposium, 2007, Cagliari.

Pinto T. P. (2005). *Gestão ambiental de resíduos da construção civil:* a experiência do SindusCon-SP. São Paulo: Obra Limpa/I&T/SindusCon-SP.

Pinto T. P. (1999). *Metodologia para gestão diferenciada de resíduos sólidos da construção urbana.* 189p. Tese (Doutorado) – Escola Politécnica, Universidade de São Paulo.

Revista da semana. (2009). *Demografia: São Paulo terá terceira maior população do mundo em 2010.* Available at: <http://revistadasemana.abril.com.br/conteudo/brasil/conteudo_brasil_271322.shtml>. Accessed on: Jan. 20, 2009.

Schneider D. M. (2003). *Deposições irregulares de resíduos da construção civil na cidade de São Paulo.* 130p. Dissertação (Mestrado) - Programa de Pós- Graduação em Saúde Pública da Faculdade de Saúde Pública, Universidade de São Paulo.