

# Cost Analysis of construction solid waste management through a software application in a large construction company of Londrina/Brazil

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In this work was developed and tested a software that allow construction companies to produce waste management information useful for decision makers on their efforts to identify opportunities in waste management. The software was developed in partnership with a software development company specialized in environmental software and was implemented in two construction sites of residential buildings of 30 floors of a large Brazilian construction company. A set of cost information was generated by the software and was made available to decision makers. Among all the results, the total cost of waste management was the most expressive, R\$83.551,71 for site A and R\$91.668,02 for site B. Indicators showed information previously not available to decision makers, that allowed them to realize the cost of material losses in construction sites, focusing their actions to solve the most important problems identified and profit from waste management costs reduction.

**Key words:** Construction waste management, Software, Cost indicators, Natural Resources

## Introduction

The Brazilian civil construction sector is responsible for 5,8% of the country's Gross Domestic Product and employes 2,7 million people (IBGE, 2013). However it is known to be an inefficient industry in Brazil, that causes important environmental impacts, has a high consumption of natural resources, alters significantly the landscape and produces huge amount of solid waste (HOFFMAN; MARQUES; GALVÃO, 2012, p.2).

Annually the construction industry produces 31 million ton of construction solid waste in Brazil (IPEA, 2012). It corroborates with the idea that the construction industry is not being sufficiently efficient and is wasting valuable natural resources. The causes vary from the construction technology and methods applied and not qualified labor to poor quality construction standards.

Until recently, due to the lack of specific legislation, waste was disposed unsustainably and irresponsibly. The costs related to waste were not accounted by the construction companies, while the costs and environmental impacts of disposal were paid by the whole community.

The fact that waste management does not deliver value to the construction industry, that is focused on building its product, or the real state, worsens this scenario where waste management is just not important to construction companies.

However, new legislation has been created and construction waste producers in Brazil are now responsible for their waste life cycle, from when it is produced to its recycling and landfilling. This new reality has increased substantially the waste producers responsibility and costs for waste management. Construction companies have now to find more effective ways to manage their waste and assess the economic impact of waste management on their business.

## Materials and Methods

This was a case study research in which was developed and applied a waste management software in a large construction company in the region of Londrina, Brazil. The construction company is 40 years old, has construction sites in eight Brazilian cities and in Chile.

In order to test and validate the software's information and indicators a work group of the construction company employees was formed: one regional manager, two field engineers, sustainability coordinator and four workers. The whole group was trained to use the software.

Two construction sites used the software for four months. Construction sites were similar residential buildings of approximately 35.000m<sup>2</sup>, high standard buildings in Londrina city, Paraná state, Brazil.

The software used was a Web Asp.Net application that could be accessed by any computer with login and password. Data was collected through filling out an online transportation legal document which normally is filled out on paper document. Each type of waste was registered into the software informing the cost of the waste before it was thrown away (as a resource material) cost of transportation and final destination (figure 01).

Nome do Resíduo:	Argamassa
Custo Matéria-prima:	145,00 m <sup>3</sup>
Custo Transporte:	100,00 Cacamba
Custo Destinação:	9,50 m <sup>3</sup>

Figure 1: waste cadastre. Waste name (nome do resíduo), Resource waste cost (custo matéria-prima), Transportation cost (custo transporte), Final destination cost (custo destinação)

As the transportation document was filled out, informing type of waste and volume of waste, it was possible assess the costs involved in waste management.

Indicators and reports were created using the cost data available: cost of resource waste, cost of transportation, cost of final destination, total cost of waste management, cost per volume produced (R\$/m<sup>3</sup>), cost per building area (R\$/m<sup>2</sup>).

This new information available through the software was discussed with the company's work group to assess its importance to the company.

## Results and Discussion

Two cost reports, one for each construction site, were made available to the work group through the software. It showed the cost of each type of waste, considering the resource waste, transportation and final destination. Site A (obra A) had a resource waste cost of R\$66.145,80, transportation cost of R\$8.100,00 and destination cost of R\$9.305,91. The total cost for the waste management was R\$83.551,71. (fig.2)

Análise de Custo (R\$) - Empreendimento Obra A				
Data de Início:	01/05/2013			
Data de Término:	30/08/2013			
	Matéria-prima	Transporte	Destinação	Total
Argamassa	42.531,40	5.700,00	2.786,54	51.017,94
Concreto	12.061,10	1.100,00	790,21	13.951,31
Ferro	600,00	0,00	0,00	600,00
Gesso	5.362,10	800,00	5.440,45	11.602,55
Papelão	2.310,00	0,00	0,00	2.310,00
Plástico Duro	286,00	0,00	0,00	286,00
Plástico Filme	1.980,00	0,00	0,00	1.980,00
Rejeitos de Construção	0,00	100,00	27,27	127,27
Terra/ Solo	0,00	300,00	190,00	490,00
Tijolo	1.015,20	100,00	71,44	1.186,64
<b>Total</b>	<b>66.145,80</b>	<b>8.100,00</b>	<b>9.305,91</b>	<b>83.551,71</b>

Figure 2: cost report for site A (obra A) showing costs of resource waste (matéria-prima), transport (transporte), final destination (destinação) and total cost (total), for each type of material wasted

Site B (obra B) had a resource waste cost of R\$67.356,05, transportation cost of R\$12.200,00 and destination cost of R\$12.111,97. The total cost for the waste management was R\$91.668,02 (fig.3).

Análise de Custo (R\$) - Empreendimento Obra B				
Data de Início:	01/05/2013			
Data de Término:	30/08/2013			
	Matéria-prima	Transporte	Destinação	Total
Argamassa	7.468,95	1.000,00	489,35	8.958,30
Blocos	1.875,00	200,00	142,50	2.217,50
Cascalho	0,00	400,00	207,77	607,77
Concreto	33.139,75	4.200,00	2.171,23	39.510,98
Ferro	150,00	0,00	0,00	150,00
Gesso	4.402,20	500,00	4.470,55	9.372,75
Metais não Ferrosos	3.160,00	0,00	0,00	3.160,00
Papelão	3.234,00	0,00	0,00	3.234,00
Plástico Duro	42,90	0,00	0,00	42,90
Rejeitos de Construção	0,00	100,00	55,01	155,01
Revestimento Cerâmico	9.480,90	1.500,00	818,81	11.799,71
Terra/ Solo	0,00	3.800,00	3.446,98	7.246,98
Tijolo	4.402,35	500,00	309,80	5.212,15
<b>Total</b>	<b>67.356,05</b>	<b>12.200,00</b>	<b>12.111,97</b>	<b>91.668,02</b>

Figure 3: cost report for site B (obra B) showing costs of resource waste (matéria-prima), transport (transporte), final destination (destinação) and total cost (total),

The cost report made available information for each type of material wasted during construction, It was possible to realize for example that the final disposal cost for Gypsum (gesso) was the highest, but when taking into account the cost of the resource waste (matéria-prima), the cost of the concrete (concreto) and mortar (argamassa) was higher for site B and A.

This shows clearly that resource waste is responsible for most of the waste management cost, which usually isn't taken into account, and therefore is not managed. Figure 4 shows that approximately 70 to 80 percent of waste management costs were due to resource waste in both sites.

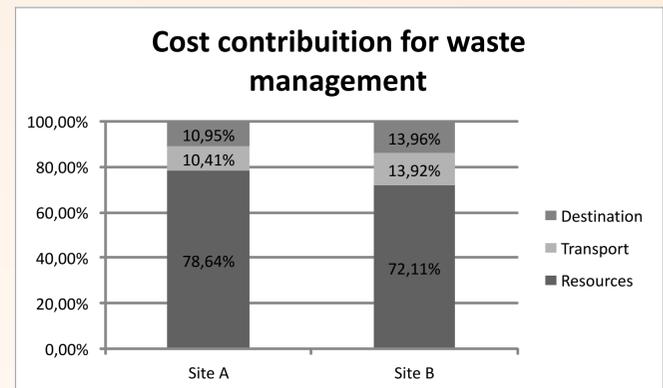


Figure 4: Cost contribution (%) for total waste management costs in site A and B

Two types of indicators were created to make it possible for the construction company to manage their waste through construction. The relation between cost (in Real) and volume of waste produced is shown in figure 5. Site B R\$/m<sup>3</sup> indicator was lower throughout the four months, mostly because it has produced a great amount of soil

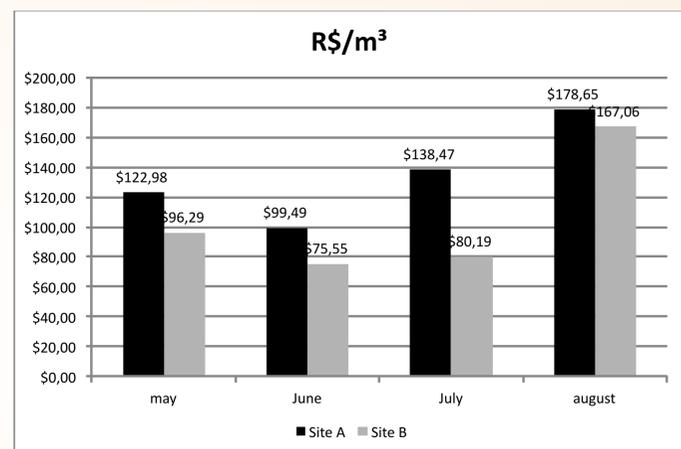


Figure 5: relation between volume of waste produced and cost of waste (R\$/m<sup>3</sup>) for site A and B throughout for months of

The indicator Waste cost/area (R\$/m<sup>2</sup>) allows the construction company to compare the cost of waste management between construction sites using a proportional parameter. Figure 6 shows the evolution of this

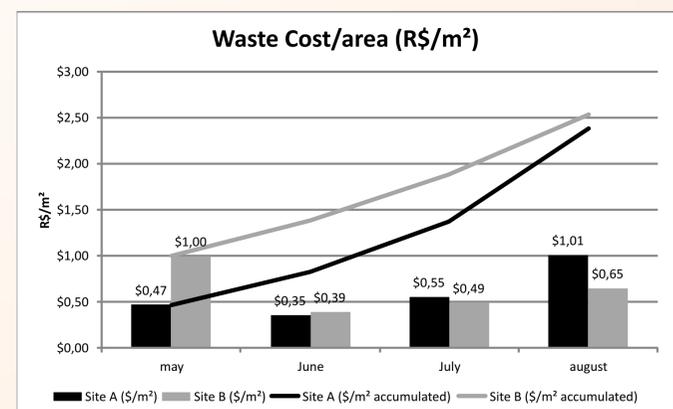


Figure 6: relation between cost of waste produced and area of the building (R\$/m<sup>2</sup>) for site A and B throughout for

## Conclusion

The research had as a result a software which was able to collect waste management data online through the use of a legal form used for transportation of waste and generate waste management cost information and indicators for construction companies as an output.

This information was not previously available to construction company's managers, who considered only transportation and destination as a waste management cost. Also, the software was able to show results on real time, as waste was produced.

These indicators tested in two construction sites showed that most of the waste management costs are due to resource waste. This was not realized by the construction company before the use of the software and it was considered to be very relevant to the construction company work group.

The set of reports and indicators showed were considered possible to be applied in all construction sites. For the indicator cost/area (R\$/m<sup>2</sup>) it is needed to set viable goals, aiming the reduction of resource waste and therefore, resource waste cost.

Implications of this tool are broad depending on the company will to actually manage its waste. It gives them the possibility to consider the economic viability to use new construction methods or new construction material as a solution for the reduction of resources waste. It implies including the waste management into the strategic decisions of the company, arising it from an operational perspective to a strategic perspective.