DISPOSAL AND REUSE OF CONSTRUCTION WASTE: TECHNICAL AND ECONOMICAL EVALUATION IN AN ACADEMIC ENVIRONMENT

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The demolition process produces great amounts of waste. Most of this waste is disposed in rubble areas or non-authorized sites, which are not adequate to receive this garbage. This cultural habit results in an increase of the amount of waste. If a careful demolition process were adopted, these materials could be better applied and reused or recycled. This paper presents a case study, in which two students of a Building Technical course have adopted the selective deconstruction approach in an academic context. The results show that it is possible to recover types of construction materials, and thus save money and natural resources. This sustainable approach should serve as a good opportunity to teach teenagers how to have sustainable habits.

Keywords: Construction Waste. Sustainability. Solid Waste Management. Sustainable Development. Environmental Education.

1 INTRODUCTION

Since the Industrial Revolution, people have moved from the countryside to the cities. This change has occurred because people would like better opportunities and better quality of life (services, health, education etc.). The increasing urban population has resulted in a change of habits. The industries have sought to increase their number of consumers every day, producing new products by advanced technological innovation (FANTINATTI; ZUFFO; ARGOLLO, 2014).

In the last century, the world population grew more than all previous centuries in the history of the mankind. The fast destruction of natural resources is astounding. The consumerism has continuously grown. It is evident that by simply replacing scarce resources with more abundant ones is not an intelligent solution (LOPES, 2006).

People do not have sustainable habits. They do not reuse or recycle their products: everything becomes waste in the modern civilization (BRAGA et al., 2005).

There are very few initiatives to send waste to recycling sites in Brazilian cities. There is an urgent need to change social habits (production, consumption and disposal). It is necessary to think of new ways of developing new technologies to reduce the environmental impact (LOPES, 2006).

In Brazil, some sectors have started to think about this problem, mostly due to law enforcement. As a consequence, they have adopted sustainable solutions to the waste they produce (ANGULO, ZORDAN, JOHN, 2001; FANTINATTI, 2011).

According to Lopes (2006), it is necessary to promote the technological, scientific and social integration in order to achieve an adequate solution. This author states that this integration must promote the cultural change, aiming at dealing with the natural resources in a sustainable manner, including both recycling and reuse.

1.1 Objectives

The main objective of this paper is to study and propose a few sustainable solutions for waste disposal, which results from constructive practices in an academic environment.

The present work also aims at helping students to develop sustainable awareness of the disposal of construction waste.

The hypothesis is that it is possible to show that the reuse of reinforced concrete materials is a feasible opportunity, which can save both natural resources and money.

2 THE CONTEXT OF SOLID WASTE IN THE CIVIL CONSTRUCTION

The construction sector generates enormous amounts of waste, most of which are disposed without any criterion. Couto, Couto & Teixeira (2006) state that a cultural change in the construction sector is imperative. The objective of this change is to reuse the construction waste. The authors assert that it is important to draw special attention to waste demolition.

The waste produced by the demolition process causes an increase in the number of public garbage sites or other non-adequate illegal sites. The culture of waste without evaluating the reuse of materials results in the

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loss of opportunities, because these materials could be better exploited provided that there was a careful demolition process. A careful process might provide the recovery of those materials, promoting their reuse and recycling (COUTO; COUTO; TEIXEIRA, 2006).

There are already several guidelines in Brazil which deal with the solid waste generated by civil construction: ABNT (2004a; 1987a; 1987b; 2004b).

The CONAMA Resolution Nº 307/2002 (CONAMA, 2002) states the guidelines, criteria and proceedings for civil construction waste management. This Resolution has been modified by the CONAMA Resolution Nº 448/2012 (CONAMA, 2012).

Due to the rapid growth of building demolition and to the evolution of environmental concerns, recent researches have been looking for ways to allow the reuse of construction materials (ANGULO, ZORDAN, JOHN, 2001).

An example of reusing materials produced by demolition was presented by Buttler (2003), which also shows means by reusing components resulted from demolition of concrete structures.

2.1 The Selective Deconstruction

Couto, Couto & Teixeira (2006) presents a more careful process, which they called selective deconstruction.

The deconstruction must be careful in order to provide better exploiting of materials. However, it is a new concept, which is not applied in large scale. Therefore, it has not benefited from wide acceptance or comprehension yet.

Thus, it is necessary to promote an environmental regulation to develop and apply deconstruction techniques aiming at increasing the awareness of its importance. In addition, it is vital to persuade politicians, construction companies, engineers and architects that this is a matter of concern (COUTO; COUTO; TEIXEIRA, 2006).

According to the authors, people will increase the amount of waste if they do not make the choice of deconstruction.

Nowadays, there is a lack of adequate methodology for construction demolition and reuse of its materials and components. It is urgent to change this situation in order to ensure the natural resources preservation and to contribute to the sustainable development.

In order to guarantee the environmental sustainability, the construction sector has to change its culture, by adopting new practices and methodologies such as the selective deconstruction.

3 Methodology

This study was carried out during the curriculum subject "Construction Practice 3", in the 3rd term of a Building Technical course, in the second semester of 2012.

Once it is necessary to teach students how to proceed with the execution of concrete structures, students were required to build concrete piles, columns and beams in a reduced scale.

Five 1-meter long columns as well as five beams were built. All of them with a section of 20 cm x 20 cm. The Figures 1, 2 and 3 show the students building the structures.

The columns were supported by fifty-centimetre long piles. The columns were supported by fifty-centimetre long concrete piles. The piles had the same shape of columns and beams: 20 cm x 20 cm. They were dug into the ground.

Figure 1 - The students building the structures – Phase 1: shaping wooden formwork for reinforced concrete

Figure 2 - The students building the structures – Phase 2: putting the steel armour for reinforced concrete

Teachers and students have decided together about the scheme of the structures. The premise was that it was necessary to build a basic structure which could be able to support a reduced scale slab. Also, the structure should be similar to a conventional building structure, that is, with piles, columns and beams. The construction process is described in the section 3.1.

3.1 The Concrete Structures Construction Process

First the students were stimulated to define the material proportion by consulting the theory studied (ABCP, 2008; ABNT, 1982; BAUER, 2000; PETUCCI, 1998a; 1998b; VAN VLACK, 2000). They also had to calculate the quantity of necessary materials. Students were then organized in five teams.

Next, each team had to plan all the execution phases, considering that they would have five days to execute their structures.

No team could begin the construction process without a feasible plan.

Then, they showed each construction stage, from the location process up to removing the wooden framework.

In general, all the teams have spent five days to execute their whole structure. First they defined the material proportion by the desired concrete strength. They also calculated the material amounts. After that, they planned the execution, indicating what they would do each day.

The execution process was the following:

Figure 3 - The students building the structures – Phase 3: throwing and modelling the concrete

- 1st. Students located the pile positions;
- 2nd. Students dug the ground to concrete the piles;
- 3rd. Each team divided their students into three groups: the first group began to shape the wooden framework, the second began to prepare the steel armour and the third group prepared the concrete for piles;
- 4th. Piles and columns were concreted together. So, the wooden framework and the steel armour for columns and beams were put in the right place before the first concreting;
- 5th. The beams were concreted;
- 6th. Last, the wooden framework was removed.

The 1st, 2nd and 3rd stages were accomplished on the two first days. The 4th stage, on the 3rd day. The 5th stage, on the 4th day. The final stage was accomplished on the last day.

3.2 The Selective Deconstruction Process

Once the entire construction should be demolished, the first step was to conduct a literature review about sustainable construction and selective demolition.

As our objective was to propose the reuse of the materials, selective demolition techniques were applied. As stated mainly by Buttler (2003), the literature has already proved that it is possible to reuse these components. As shown by Couto, Couto & Teixeira (2006), it was established that the concrete components and the steel should be suitable to be reused after the demolition process.

After the preliminary studies, it was clear that reusing the construction materials should help to lessen two fundamental problems of environmental crises: use of natural resources and waste production.

Therefore, the entire construction was demolished by means of the selective deconstruction directions in accordance to the literature (BUTTLER, 2003; COUTO; COUTO; TEIXEIRA, 2006).

As a result, almost all the materials can be recovered, either for the production of new concrete or for frames of beams and columns (PORTO; SILVA, 2003; QUEIROZ et al., 2014).

The selective deconstruction process was planned to occur on a weekend, because very noisy machines, such as the concrete breaker, would be used.

The initial idea was to do all the service on a unique day. But the process of cleaning the area could not be done on the same day (which was a Saturday), because the deconstruction process took all day long. So the area was cleaned on the following Monday. It was not a problem, because this stage did not cause much noise.

3.3 The stages of the deconstruction process

The Figures 4, 5 and 6 illustrate the main stages of the selective deconstruction process.

The Figure 4 illustrates the deconstruction process, which was carried out by two students.

Figure 4 - The students deconstructing the structures

The Figure 5 illustrates students finishing the deconstruction process, their supervisor and the deconstruction equipment used to execute the process.

Finally, the area where the research was conducted was cleaned and recovered to the original condition prior to the research, as illustrated in the the Figure 6.

While the area was being cleaned, the materials were separated in an appropriate area in the Laboratory of Construction Material.

The materials are available to be used again. The aggregate waste was separated according to their dimension: fine aggregates and coarse aggregates. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve. Coarse aggregates are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.

4 RESULTS

In order to prevent all materials from being simply disposed as garbage without being reused, this study followed the selective deconstruction approach.

The following amounts of materials were saved:

- Portland Cement: 105 kg;
- Sand: 690 liters;
- Gravel: 780 liters;
- Steel: 70 kg.

The corresponding costs[1] of producing the structures were:

- Portland Cement:
  • 105 kg x R$ 0,42/kg = R$ 44,10;
- Sand:
  • 690 l x R$ 0,08/l = R$ 55,20;
- Gravel:
  • 780 l x R$ 0,07/l = R$ 54,60;
- Steel:
  • 70 kg x R$1,17/kg = R$ 81,90.
- Total cost:
  • R$ 235,80.

1 - The corresponding costs refer to June 2013.

5 CONCLUSIONS AND FURTHER RESEARCH

It has been noticed that it is possible to apply the selective deconstruction approach in an academic environment.

Although the results are not very considerable in relation to costs, they could be a fundamental factor in long term management.

Given that aggregates plus steel represent 65.27% of all materials, it could be really important to manage educational funds in an academic institution.

It has been shown that it is necessary to adopt more effective tools to develop

Figure 5 - Students with their supervisor finishing the deconstruction process

Figure 6 - The restored area after cleaning

sustainable awareness in the construction area, also in an academic context.

Due to the selective deconstruction technique, all applied construction materials will be recovered, either the aggregates should be reused to make other concretes or the steel will be reused to form new frames of columns or beams.

Finally we believe that these research objectives have been achieved.

However, in the studied academic context, it is really necessary to improve the areas where the materials are available in the construction laboratory. As it is disorganized, people are not encouraged to reuse those materials.

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