Selective Demolition of Buildings as Sustainable Strategy

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ABSTRACT: Over the last decades the demolition process has experienced several changes, which focus mainly on how the building will be demolished more recently, the emergence of environmental concerns, brings to the surface the discussion about the damage of building demolition, which is responsible for producing a significant portion of all waste generated by construction, from the most selective processes to the most destructive. Through the selective demolition process, which is based on disassembling and collapse of the structure, harnessing as much material as possible with the aid of hand tools and mechanical equipment it is possible to recover and separate the materials obtained during demolition, which is a concern increasingly imposed by the companies that contribute to the economy of natural resources. The reuse of material is the preferred result, choosing recycling as a second option because it requires less energy, less raw material and less pollution during its process so as to continue the service life of the material. This process aims to reduce the environmental impact of the activities of the entire construction sector, decreasing the number of new products to be manufactured and the volume of waste that are usually landfilled, putting new materials on the market. This work aims to study the process of demolition and resale of recovered materials, of small demolition companies in the State of São Paulo, using two case studies. Seeking to understand the functioning of these companies and discussing sustainable strategies implemented and the aspects to be improved.

Keywords *Selective Demolition, Traditional Demolition, Demolition Waste Management, Material Reuse, Material Recycle.*

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1. INTRODUCTION

In the civil construction industry the management of waste is becoming progressively challenging. The difficulty in arranging the construction and demolition waste in sanitary landfills has gradually increased over the years, primarily because the current landfills have a capacity limit, or because it is becoming tougher to develop new sites for landfills, especially within cities, due to environmental and social concerns. Thus, there is a need for new solutions to the final disposal of waste and materials obtained from the demolition of buildings.

Conventional edifications are associated with excessive use of natural resources, a procedure recognized by the use of large amounts of materials and high consumption of energy. Consequently, traditional construction is responsible for the production of large amounts of carbon dioxide and other harmful emissions to different ecosystems. In this sense, there are already strategic orientation tools to promote better and more sustainable construction practices. However, only few makers facilitate and promote their practical application and encourage sustainable construction, for example, through financial mechanisms (CASTRO; MATEUS; BRAGANÇA, 2011).

The concept of buildings as whole objects is still the most dominant. They are conceived, designed, constructed, and used as complete entities. The materials removed are salvaged for reuse or recycling and only those that cannot be reused or recycled are discarded. Selective demolitions provide potential economic and environmental benefits compared to the conventional practice of total demolition. The economic benefits derive from the salvaged materials sale/reuse and from the avoided disposal fees. The primary environmental benefit is the reduced waste generation. However, selective demolition may take longer than the conventional demolition because of its intensive work nature. The estimated unit costs discussed below can vary according to the contractor's experience in this process and market conditions (DANTATA; TOURAN; WANG, 2005).

Demolition produces enormous amounts of debris, which in most cases are only added to the waste in landfills. Due to community concerns about the potential impacts on the environment, the availability of sites for landfills is becoming increasingly difficult. Moreover, landfills tend to be located in remote regions of developed areas, amounting in high transportation costs. An alternative to sending these materials to landfills is choosing the selective demolition instead of the usual process (COUTO; COUTO, 2010). Given the environmental concerns and public opposition, regulations are being created to set plans aiming to reduce the disposal of solid waste in landfills (DANTATA, TOURAN; WANG, 2005).

The role demolition plays in this waste production scheme is unclear, as is the role of recycling and reuse. As can be seen below, there is no comprehensive understanding of the quantities and types of demolition waste and recycling, but rather a scattering of research studies in small scale (CROWTHER, 2001). Nonetheless it is possible to observe that through a more controlled demolition, a large number of materials can be recovered, and a great homogeneity in residues can be obtained, facilitating the separation and isolation of materials containing dangerous substances, from the others that are inert.

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Demolition is the answer at the end of life of buildings or structures, when they are in a degraded state or at risk of instability if the cost of maintenance or rehabilitation is high in relation to that of a total demolition, or put the safety of the population and the surrounding buildings in risk. Demolition means the removal or destruction of any building or any part of it using pre-planned and controlled methods. Demolition methods may vary, depending on where it will be held, the time available, the building's materials, the purpose of demolition and the waste that will be accumulated. The procedures, in which the noise, dust and vibration are limited, will increase the cost of demolition.

There is a large general agreement on what constitutes demolition, it is the complete elimination of all parts of a building at a specific location and time, and typically it is the end of life for the building. Unlike the initial phases of design and construction, the end-of-life phase of buildings has received little scientific attention so far, although its quantitative and qualitative significance is considerable. Nevertheless, partial demolition actually begins during the service life of buildings, as maintenance and adaptation include the replacement of building parts, resulting in a considerable waste flow (THOMSEN; SCHULTMANN; KOHLER, 2011).

The idea of the cycle is that all stages in a system (product or service) are recognised, from inception to final disposal. A life cycle assessment is made by investigating all the environmental consequences of each stage in the life cycle of the system. Such an assessment can be represented as a two-dimensional matrix. Such a matrix offers a good model for the environmental assessment of a system. In order to do more than simply assessing the system, to truly understand how the system might be altered in order to reduce the environmental burden, it is necessary, however, to add a third dimension. This will be a dimension of strategic solutions, or of principles for sustainable activity (CROWTHER, 2001).

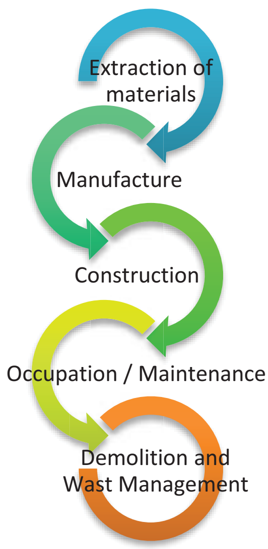

Figure 1. Building/Materials Life Cycle. Source: Author

The main objective is to ensure that in the final stage of a building it is possible to close the life cycle, enabling the recovery and reuse of materials and constructive elements, to be implemented in new buildings, continuing their life cycle. As it can be seen in Figure 1, finding solutions for the demolition and waste management, avoiding the extraction of

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new raw materials and opting for the reuse of the materials or as an alternative to recycling is essential.

2. RECOVERY MATERIALS STRATEGIES

Few buildings remain in their initial state of construction for more than a few years or, at most, a few decades. Alterations, repairs, additions, and maintenance continually work to alter the building. In the longer time frame, the building is constantly changed in response to user demands and environmental conditions. There is in fact not one single building, but a series of different buildings over time (CROWTHER, 2001).

Construction is reflected by waste production from the leftovers and construction materials, which are the debris. These characterize a major damage to the environment, because they are usually left in vacant lots, limited landfills and margins of rivers. The cost impact for companies is represented by penalties such as fines, reimbursements to third parties for damages, recovery of degraded areas and other factors, reflecting the lack of environmental protection mechanisms (PAIVA; RIBEIRO, 2011).

2.1 ALTERNATIVES TO TRADICIONAL DEMOLITION

The reason to demolish is reflected in the building's obsolescence. The components can be reused or recycled and the building may be able to be renewed, for those who make the maintenance of the building in an efficient and effective manner. The future development of sustainable, efficient and prosperous demolition guarantees the reuse of materials and components as a key aspect, requiring a considerable investment in terms of time, money, skills, tools, technologies, standards and risks taking (BOWES; GOLTON, 2001).

There are different options to the current process of undifferentiated demolition. Some of the alternatives to sending material to landfill are deconstructing or dismantling and when those are not possible, opting for a selective demolition. According to Hobbs and Hurley, demolition is the term for an intentional destruction process. The disassembly just like the name suggests, is the process of disassembling components/materials without damage, but not necessarily to be reused. The deconstruction is a similar process, but it aims to reuse the materials and components obtained (HOBBS; HURLEY, 2001).

Selective demolitions differ from traditional demolition in being less mechanized and more manual, sometimes leaving the structural part to be demolished mechanically. This process is performed in reverse to the construction process, starting with the internal or external finishes and concluding in the foundations. The advantages of a more selective demolition are the versatility of manual equipment, the performance and hand labour training of workers, the materials to be removed manually can be easily recovered and reused, and quickly set on the market, avoiding waste and thus continuing its life cycle, whenever recovery is not possible, the material is sent for recycling. In the other side, mechanized processes prove to be more destructive, making it impossible to reuse, and in some cases even recycle due to the heterogeneity of waste formed in the work site, complicating the separation of waste, forcing them to be send to landfills.

Economic deconstruction or selective demolition offers great potential because of the use and resale of materials. They also reduce landfill disposal rates, when compared to the conventional practice of total building demolition. The primary environmental benefit is the reduction of waste generation. However deconstruction and selective demolition may take longer than traditional demolition due to its intensive work nature (DANTATA; TOURAN; WANG, 2005).

The priority of this process is on reusable materials, but it also leads to the separation of hazardous materials for proper disposal, not contaminating other materials with toxic substances. As an economic matter, many demolitions include varying degrees of metals and concrete recycling, with minimal to no reuse. As the result of the demolition phase seems to be key in considering the adoption of more sustainable practices.

For this to happen, environmental regulations must be promoted, techniques of deconstruction or disassembly should be developed and implemented and there should be an improvement in knowledge and awareness of the importance of this process by the stakeholders in the construction activity, particularly designers and contractors (COUTO; COUTO; TEIXEIRA, 2006).

2.2 ALTERNATIVES TO WASTE ELIMINATION

Construction waste generates small amounts of debris during a long period of time, as a by-product. The demolition wastes, on the other hand, creates a great amount of waste over a short period of time as the main part of the process (HOBBS; HURLEY, 2001). The best way to deal with this waste is first to avoid them. If that is not possible, one should try to reuse and recycle as much as possible. When the separation of different types of waste prevents recycling, other types of reassigning value should be sough, such as composting and incineration. Sending the debris to a landfill should be the last option.

The waste incorporated into edification generates more waste over the years, through the maintenance of edification, other than the overload in the structure, which increases the cost, and consequently reduces the quality and may cause pathologies, decreasing the service life and the performance of the building (KARPINSKI ET AL., 2009).

With reference to the Resolution CONAMA n°307 of 2002, article n°2, defines that construction waste is divided into four classes: A, B, C and D. Class A corresponds to ceramic components, mortar and concrete, which in its final stage should be reused or recycled as aggregates, or sent to landfill areas, so as to permit their future use or recycling. Class B is comprised of plastics, paper and cardboard, metals, glass, wood, among others, which must be reused, recycled or sent to temporary storage areas, in order to enable their future use or recycling. Class C is for materials such as gypsum, which must be stored, transported and disposed according to specific technical requirements. Finally, D class encompasses all the toxic waste, for example, paints, solvents, oils and other contaminated waste, and as the previous class, should be stored, transported and disposed in accordance with the technical standards, but it is also possible to reuse in some cases, especially paints and solvents.

The Agenda 21 of the United Nations Conference on Environment and Development in 1992 has developed a hierarchy of waste, which establishes that the first step to be taken, regarding waste management, is the Reduction and Prevention, aiming to reduce the amount of waste, through the adoption of measures before the material or product becomes waste. After that, the best solution is to Reuse in what is known as the

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reapplication process of a residue without its transformation, avoiding energy costs and the use of raw material for the production of new material. The next option is Recycling, that is the reuse process of a residue, after being subjected to a transformation, thus allowing reuse of the material in order to extend its life cycle and reduce its problems connected waste disposal or emission of pollutants. After recycling, other ways to transform the residue to its end of life, such as Composting and Incineration follow. The last recourse is the Elimination, which is sending waste to landfill sites.

Figure 2. Different scenarios for construction waste end-of-life. Source: Author, 2016

There is a direct relationship between the physical design features of a building and what can be done with the building, or its components, when the end of its service life has been reached. It is therefore be possible, through deconstruction or selective demolition, to produce new buildings that can achieve more environmentally beneficial end-of-life scenarios (CROWTHER, 2001). Thus, the choice of demolition process influences the final disposal of waste. For that reason the most sustainable solutions should be chosen, not only from an environmentally perspective, but also socially and economically. Figure 2 illustrates for each type of demolition, the different scenarios for the final disposal of waste.

3. CASE STUDY

To understand how the final destination of demolition waste is selected, two case studies discussing the operation of two small demolition companies in the State of São Paulo in Brazil were conducted. Through the monitoring of demolition activities, talking to the responsible contractors and observing the process of demolition and waste management in the construction site, it was possible to understand the importance of the demolition method as it greatly influences the qualification of the obtained waste as examined in the literature review.

During bibliographic research, some questions about the disposal of waste and how it is performed on the construction site, emerged. With the knowledge gained during the realization of the empirical study, it became possible to answer and discuss some questions such as:

- How is the separation of materials / waste on the construction site?
- What happens to recovered materials and components?
- Does the quality and performance of workers influence the final destination of waste / materials? How?

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- What materials / components have more demand in the second hand market? Why?
- Which materials are recovered more?
- What wastes goes to landfills?
- How are these materials / components put back on the market?
- Which waste is recycled? And which is processed?

This study focuses on the waste management in worksites, and the quality and classification of final disposal of demolition waste and salvaged materials destination.

3.1 Case Study l

As mentioned above, monitoring of demolitions and conversations with the contractors of two companies of the State of São Paulo were executed. Both companies always used the process of selective demolition.

For the first company, visits were made in two demolition sites. In both visits the type of structures were habitation ground floor in masonry buildings. During follow-up of first site it was observed that the demolition process began by removing all the windows, doors and metal grates manually, only to be resold. The deposit of material is carried along the site, due to lack of space and the absence of a location for storage at the construction site, until they are transported to the store by a lorry, where the materials will be sold.

Figure 3 and Figure 4. Reuse of doors and windows. Source: Author, 2014

The next step was to remove all the coverage of the building. During this task workers must be extremely careful, because the ceramics tiles are a very fragile material, breaking very easily during the demolition process, thus causing waste of material that could be reused, and also increasing the amount of waste and creating debris in the workplace floor.

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Figure 5 and Figure 6. Reuse of ceramic tiles. Source: Author, 2014

However, it was found that during the demolition process, there was a large production of waste, which correspond to the interior and exterior walls of the building, and also debris of ceramics tiles, that was later sent to landfills or a recycling plant.

The second place of demolition was also a one ground floor building. It was started by removing the doors, windows and metal objects with value, such as plumbing and sanitation grids, to be resold. It was possible to recover the ceramics and cement tiles. After the coverage was dismantled, the external and internal walls in masonry were the only part remaining.


Figure 7 and Figure 8. Demolition of the internal and external walls. Source: Author, 2015

It is possible to visualize the accumulation of debris all over the floor during the demolition process, the disorganization of the site, due to the placement of waste over all space and the lack of a place for storage and separation of waste. It was still possible to recover many solid brick walls. The ground floor was demolished with the help of the mechanic excavator. Finally, land clearing was done, in which the debris was grouped with the help of the excavator, later to be placed in a lorry and sent to the landfill for future separation and recycling.

3.2 Case Study ll

The monitoring of the second demolition company took place in one visit of, like the previous demolitions a ground floor building in masonry. It began by removal of all furniture and installations, followed by the doors, windows and metallic objects with value. Once finalized, there was the manual removal of the coverage, which recovered the ceramics tiles and wooden slats.


Figure 9 and Figure 10. Removing the coverage of the building. Source: Author, 2015

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There was the possibility to observe the demolition of the interior and exterior walls, constituted by solid brick. Through the manual demolition it was possible to take advantage of most materials, despite the waste generated by the lack of workers caution. The demolition of the walls was carried out with the help of the sledgehammer, breaking both ends of the wall, and balanced until the wall falls. Despite the supervisor being present on site, it was noted that the demolition process is quite careless and it did not follow safety measures. Some objects, like furniture and kitchen surfaces, were removed in order to be reused. Massive brick was one of the most recovered materials, not to blend in with the debris inside the construction site were stored on the sidewalk, unprotected against theft and the risk of falling down on a pedestrian or vehicle. Wood was other material that was recovered for resale, the wooden structure was composed of Peroba Rosa, a kind of rare and good quality wood, which is very popular in Brazil. All recovered materials were resold at work, customers passing by were seeing and shopping. After the resale of the materials the demolition of the ground floor was executed with the help of the excavator. The accumulated debris was taken to a landfill, carried by a lorry.

4. CONCLUSION

Similar conclusions are reached in our analyses based on both studies. Both demolition companies used the same process of selective demolition, in all demolitions. Only the materials recovered and of value were separated and stored, while the debris accumulated over the work floor because there was no separation of waste at the site, and it was sent unsorted in a lorry to a landfill. The materials were recovered for a resale shop of construction materials, in the case of the first company. For the second company, the materials were resold at the site of demolition. In conversation with the contractors, it became evident that the most popular materials from the works of demolition are the massive bricks, ceramic tiles and wood, if it is Peroba Rosa. According to sellers, customers prefer these materials for the manufacture quality, in the case of ceramic materials, as the Peroba Rosa is rare and largely used to make furniture, it can last more than 100 years. Besides these, all metal materials are recovered, and also doors, windows, toilets, kitchens, stalls, furniture, glass and fiber cement tiles. All that becomes residue is mixed on site and goes to the landfills of the city, later to be recycled. If there are mortars and concrete these are recycled into debris for road paving, sidewalk and even park benches. It can be concluded that the choice of the type of demolition has a large influence on the quality and quantity of the recovered material, and also the amount of waste formed.

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