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Sustainable production: use of construction waste in the manufacture of anchor bars

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ABSTRACT

The construction industry is an important segment of Brazilian industry, taken with an indication of the economic and social growth. However, also an activity that generates environmental impacts, and their waste has represented a major problem to be administered, and may in many cases generate environmental impacts. In addition to the heavy consumption of natural resources, large enterprises collaborate with the change of the landscape and, like all other activities of the company, generate waste. Thus, the main objective of this work was the development of alternatives to the proper utilization of industrial waste and construction rebars CA 50 and CA 60, through its transformation into new structures. In preparing the proposed anchor bar model considered various methods described in the literature, the process of product development, the knowledge already acquired, the difficulties of creating the prototype and interdisciplinarity with other areas of knowledge of production engineering. During this study it was seen that the construction production activities cause an environmental impact proportional to its gigantism, including being the largest consumer of raw natural and higher generating the waste in the environment. The reuse of waste, such as steel, is one of many possibilities for increased sustainability construction, since the generation of waste is inevitable in this area. The study of economic feasibility was satisfactory, finalizing the analysis and giving conditions for reuse were done on a larger scale.

Keywords: Construction; waste; reuse; steel; PDP.

INTRODUCTION

The advancement of technology has created a continuous pressure on the increasing use of natural resources in the world, since the demand growth, a growing amount of raw materials, thus creating a large amount of waste. (FERRAZ & SEGANTINI, 2004; AGUILAR et al., 2008; Pinheiro et al., 2016). In Brazil, the Ministry of the environment acknowledges that the construction area has lead role in achievement of the global

objectives of sustainable development. The International Council of construction (CIB) points to the civil construction industry as being one of the most consumes raw materials from nature and uses energy resources intensively, causing numerous environmental impacts. (MINISTÉRIO DO MEIO AMBIENTE, 2015).

Sustainable Development recommends that the volume of waste should be minimized as much as possible and reused in the production chain where possible. In construction, for example, several studies have been made in the last decade in order to raise the awareness of professionals involved in the process about the problematic that the thread has been facing with the generation of waste and depletion of natural depositsSustainable Development recommends that the volume of waste should be minimized as much as possible and reused in the production chain where possible. In construction, for example, several studies have been made in the last decade in order to raise the awareness of professionals involved in the process about the problematic that the thread has been facing with the generation of waste and depletion of natural deposits (FERRAZ & SEGANTINI, 2004).

The construction is an area that consumes large amounts of water and energy, in addition to producing waste for at least 30 years. Of the various losses, either directly or indirectly, the debris generation is the one causing concern comes: the amount of waste generated construction on the planet is about a billion tons .(BUTLLER, 2005).

With regard to the productive process, there will always be waste generation, who mostly come from non-renewable raw materials of natural origin. This production model has several problems, due to the decrease in the amount of natural resources. (ANGULO et al, 2001; (FERRAZ & SEGANTINI, 2004).

From the years 80, the growth of the accumulation of waste has become a serious problem, with expensive, lack of management area for debris disposal, sanitation problems and environmental contamination. (FERRAZ & SEGANTINI, 2004).

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Large volume of waste in most cases is a result of the lack of planning and control during the construction process. Besides the waste of materials, waste generation generates numerous other expenses related to their disposal as their deposition in landfills (AGUILAR et al., 2008).

One of the proposed solutions to the destination of the waste generated by the construction are recycling, incineration and landfilling. However, other forms of action have been taken into consideration to prevent the generation of waste and maximize the potential of use of materials (AGUILAR et al., 2008).

Recycling, however, should not be the main focus of the sustainability of construction, since this technique involves processes that require high energy expenditure and still produces by-products that could cause damage to the environment. From a different point of view, assess sustainability just as a good project management does not eliminate the generation of residues (AGUILAR et al., 2008).

From this context, construction waste is being tackled with the qualification of labor, project

control and use of materials. The present work aims by reusing waste, assist in combating waste of materials and environmental preservation.

The research papers that seek to use alternative materials in construction, in the current context of maximum use of waste and environment preservation, being of great importance and contribution in engineering, including because some types of waste can be used with cost reduction and technical advantages (FERRAZ & SEGANTINI, 2004), As is the case of anchor bar, built from construction waste, such as steel, main subject study.

Steel, raw materials discussed in this paper, is commonly identified as a "friend" of the environment, due primarily to its potential for recycling and reuse. The construction using steel materials, besides being extremely versatile and durable, is in accordance with the concept of sustainability.

So, this article aims at the development of alternatives to the appropriate utilization of industrial waste from construction civil, the CA 50 and CA 60 rebars, through their transformation into new structures (anchor bar), as well as technical, cost and results of their environmental impacts.

MATERIAL AND E METHODS

The present study used a qualitative character, in order to understand the facts, through the non-numerical vision and not statistics, describing the meaning of actions and using a logical comparison between theory and practice (YIN, 2001). We can say that this research has an exploratory vision, since it seeks to know the process of developing construction product.

From the study of the process of developing a product of low complexity, the anchor bar, as a didactic experience and sustainability in construction it was possible to develop the result and discussion.

In drafting the proposed anchorage bar model was considered various methodologies described in the literature, the product development process, the knowledge already acquired during the study, the difficulties of creating the prototype and interdisciplinary with other areas of knowledge production engineering.

The model for the development of anchor bar from the reuse of steel in construction and information survey consisted in the implementation of the steps for the product development process (PDP) (FARIAS, 2007).

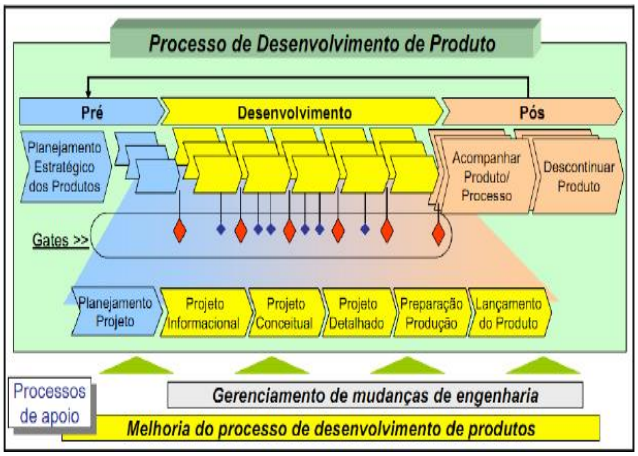
The product development process (PDP) can be defined as a range of activities through which is sought from the market demands and opportunities, considering the company's product strategies, reach the design specifications of a product and its production process to manufacture is able to produce it. The PDP still includes the monitoring of the product after launch, as well as planning the discontinuation of the product on the market, in view of all the needs of the new product developed throughout its life cycle (FARIA, A. F. *et al*, 2008).

Smith e Morrow (apud MIRON, 2002) in his work, product development as a process that translates customer needs into information so that a product can be produced. The idea to develop a product that meets the quality requirements of customers in a timely manner and at a cost

compatible with its competitors, is a function of the product development process.

Currently there are several templates that can be used as a reference for the definition of PDP, being one of the main models used, the unified model of reference (MUR), prepared by Rozenfeldet al. (2006). The MUR (Figure 2) is composed of three macrofases: pre and post development.

Figure 1 – Stages of the product development Process (Modelo Unificado de Referência)



The work followed the stages of the product development process in the order presented a seguir follow:

1) Project planning: this step has defined the scope of the project, that is, it was determined the boundaries of the project, and the proposed definition and objectives. The main activities were the development of the concept and definition. At this stage were still certain the goals, objectives and commitment of resources.

The structuring of the activities of this dimension, as a generation of ideas, concept development and market survey, is highlighted by Mahajan & Wind (1992) in work where the author studied models of product development in companies.

2) Informational project: aimed to establish, from a detailed survey information, specifications-anchor bar of type "saury", a set of measurable requirements with target values and additional qualitative information that reflect how customers ' needs will be met in an ideal way. This phase was marked by the constant care to register effectively client needs.

3) Conceptual design: conceptual design phase, was in turn the target specifications in the product design, which consisted of more tangible product features and functionality. Phase involved functional modeling of product, the development of your solution alternatives, alternatives of design models, which, at the end of the stage were evaluated until it reached the best concept
for the product. Also involved forecasting how the product will be produced.

4) Detailed design: the detailed design encompassed the final realization of the product, where are detailed its functionalities, final technical characteristics. The typical outputs of this project were detailed product specifications: product structure and list of material, product specifications and components, final drawings with tolerance, detailed process and plan a functional prototype.

RESULTS AND DISCUSSION

The first meetings of the project development aimed to analyze the possible successes and failures of the product that was being designed. Thus, were displayed that points should improve, that points should keep to the new product, which management lacked tools for the quality was better, among other issues.

After each meeting developed in the institution was made an analysis of the PDP research that was

being done. Successes, failures and possible improvements that could be implemented were discussed and evaluated by researchers.

During realization of the project were not homogeneous and not character television production when it involves reuse of construction waste for the production of the anchor bar, due to the uniqueness of the product and raw material, often custom made. It can be said that the final product, the anchor bar, has semi-artesanal character in the constructive process. (Figura 2).

Figure 2– Anchor bar being tested during the development process.

The anchor rods were tested, in loco, verifying and analyzing its resistance to taper and clamping workpiece shapes of pillars. Although they are very robust and resistant anchorage bars are designed to suffer axial effort (traction and anchor), so if they are thrown, tossed or become badly packed may suffer physical damage, and even have their flange ripped.

According to NBR 6118:2003, all reinforcement bars must be anchored so that the efforts that are submitted are fully transmitted to the concrete, either through grip or mechanical devices or combination of both. (CORREIA, 2012).

However, it is important to note that the MUR does not represent a specific model of PDP to be applied directly to projects within an enterprise. The MUR is a model that represents the ideality of the product innovation process according to the best practices in the field of knowledge, and should be adapted to the specific realities.

How to determine the economic viability of a product containing waste is still little studied. One of the conditions to make the new product on the market is that your selling price is competitive. To attract the waste generator under the strict financial point of view, reuse needs to reduce the cost of waste, including costs arising from the need for treatment of waste in order to tailor it to reuse.

The viability of a particular process of reuse is an equation of an essentially local, since commodity prices and cost of landfilling are defined locally. In this sense, the simple import of experience between different countries or regions is inadequate.

In the present study the economic viability had positive results, since the anchor bar made from recycled civil construction steel, would be at least two times less costly when compared to the traditional manufacturing. Because the bar anchoring studied in this research has several models and complexity in costs as follows in the table1.

Table 1 - material for study of economic feasibility deancoragem bar with reuse gifts (anchor nut and screw rod).

Descrição do Material	Quantidade	Valor (R$)
Barra de Ancoragem Torcisão Ø 5/8 1 Metros – **Mérito Comercial**	1	10,50
Barra de Ancoragem Torcisão Ø 5/8 1 Metros – **Barra de reuso**	1	5,0*

During this study it has been seen that the production of construction activities cause an

environmental impact proportional to its size, being the largest consumer of including raw materials and greater natural waste-generating environment.

In Brazil, the Ministry of the environment acknowledges that the construction area has lead role in achievement of the global objectives of sustainable development. The International Council of construction (CIB) points to the civil construction industry as being one of the most consumes raw materials from nature and uses energy resources intensively, causing numerous environmental impacts (MINISTÉRIO DO MEIO AMBIENTE, 2015).

The increasing growth of Brazilian cities generates demand for new homes at the same time that the construction of new industrial and infrastructure works such as roads, which shows the importance of the construction sector in the growth of the country and the devastation of the environment (CARNEIRO et al, 2001).

According to Ram et al. (2001), the construction industry represents about 14% of the national GDP. In addition to the impacts caused by the excessive consumption of natural resources, impacts caused by the generation of waste, where is that about 50% of the solid waste generated by industry and the range of human activities are from the construction industry. These environmental characteristics added to the quality of life that the built environment provides, form the link between construction and environment. Thus, due to constant quest to lessen the environmental impacts generated by the construction, the idea of sustainable construction (MINISTÉRIO DO MEIO AMBIENTE, 2015).

Sustainable construction is defined as: "a holistic process that aspires to restore and maintain the harmony between the built and natural environments, and the creation of settlements that affirm human dignity and encourage economic fairness ". In this context of sustainable development, the concept also covers economic and social sustainability (MINISTÉRIO DO MEIO AMBIENTE, 2015).

The main goals of the sector consists in reducing and optimizing the consumption of materials and energy, reduce waste, the preservation of natural resources and in improving the quality of life generated by the built environment (MINISTÉRIO DO MEIO AMBIENTE, 2015; FERREIRA et al., 2016).

The term sustainable development was first used in 1980, the International Union for ConservationofNatureand Natural Resources (International Union for conservation of nature), the named document: World ConservationStrategy (World Conservation Strategy). This document addresses the sustainable development as a situation achieved through the conservation of the living resources (IUCN, 1980).

The United Nations Conference on environment and Sustainable Development – Rio-92, headquartered in Rio de Janeiro-Brazil, in 1992, in which 170 UN member countries participated (United Nations), formalized an agreement between the participating countries, whose objective was to put into practice an extensive programme for the sustainable development of the planet. However, in a report presented by Brazil, five years later, the Rio + 5 Conference in New York, there was the recognition that advances in planning and

management of natural resources in the country have been insufficient (OLIVEIRA & ASSIS, 2001).

The damage to the environment take major proportions when one considers the total production of waste, originated by the foreseeable losses in projects added to the waste resulting from the lack of construction processes in the execution of the works. This waste is a feature of great impact in construction and can be set to what is spent for the execution of a given service adds value to the same.

Among the four most common types of waste are the waste of materials, time, those relating to manpower and financial resources (FREITAS, 1995).

The waste of materials happens from the selection of suppliers, through the elaboration of the project, which has inadequate solutions and not optimized, in the acquisition of materials, ranging from transportation, receipt and storage of these, in the execution of the work, the birth of the increased consumption of materials for correction of imperfections, and finally, on post-occupancy phase where waste of materials in repair function (NETO, 2007).

The waste according to the workmanship occurs due to low qualification of workers, and especially by the lack of human resources policies, where such errors could be combated with appropriate measures of quality management on the basis of the components of human factor (training, information, communication and motivation (NETO, 2007).

The waste of time is related to the lack of organization and planning of the time spent in each stage of execution of services at the construction site. Already the financial waste is the result of three types of waste mentioned above (NETO, 2007).

In the first decade of the 21st century emerged called buildings Green Buildings, which are buildings in which environmental problems generated during the design, construction and operation of the building are minimized without sacrificing customer service customer needs user (SILVA, 2000).

In this type of project, there is the concern with sustainability, which is present from the design phase up to the use of the building by the customers. Second Menegat (2004), the search for sustainability cannot be limited to the immediate environmental impact on the environment, but also should be analyzed other aspects: social, economic, cultural and political involved. The idea of Green Buildings consistent with the guidelines of Menegat (2004) and addresses the various aspects of sustainability (SILVA, 2000).

The waste must have appropriate management so that dropouts are avoided, and thus build up on riverbanks, vacant lots or other inappropriate places. Typically, the construction waste represent a serious problem in many Brazilian cities: the irregular layout of this waste can generate aesthetic order, environmental issues and public health. On the other hand, is a problem that presents itself to the municipalities, overloading the public cleaning systems (MINISTÉRIO DO MEIO AMBIENTE, 2012).

The issue intensifies by the large quantity and volume of waste generated by this segment of the economy, as they may represent 50 to 70% of the mass of municipal solid waste. For the most part, are materials similar to natural aggregates and soils.

In General, the waste from construction are seen as low-risk waste, and the impact caused by large

volume generated. However, these wastes there is also the presence of organic material, toxic chemicals and various packaging that can accumulate water and encourage the proliferation of insects and other disease vectors (MINISTÉRIO DO MEIO AMBIENTE, 2012).

The reuse of waste, like steel, is one of many possibilities to increase the sustainability of the economy, since the generation of waste is inevitable in this area. About 60% of the steel produced in Brazil is made by the first process, which uses about 25% to 35% recycled steel, while the production of steel in electric arc furnace that percentage rises to up to 95%. (GERVÁSIO et al, 2005).

The steel industry is quite intensive, both in terms of materials and of energy. More than half of the large amount of materials and energy that enters the process results in the production of gaseous effluents and by-products. Most relevant emissions are to the atmosphere, mainly with regard to the emission of CO2 and other greenhouse gas (GERVÁSIO et al, 2005).

In the present day, where the economy is globalized, a competitive merits of an industry or company is related to its ability to put new products and services on the market, with essential features, such as: quality, satisfactory performance when compared with competitors, low cost and a distribution that satisfies the demands of consumers (FARIA, A. F. *et al*, 2008).

The product development process (PDP) lies in the interface between the company and the market, and its function to identify the needs of both the market and propose environmental solutions through product designs that meet such needs (CHRISSIS *et al*, 2003).

In the literature there are several methodologies for the development of new products and it is up to the undertakings or persons concerned find and tailor an approach that best suits the team that will manage the process of creating, which usually involves several areas: marketing, engineering and production (FARIA, A. F. *et al*, 2008).

The importance of action to develop new products in the construction area is notorious. Such an action determines about 70% to 90% of the final cost of the product and other factors related to quality, diversification and the time of placing on the market, in addition to producing a product perfectly adapted to the purpose. Therefore, the product development is one of the most important processes responsible for adding value to the business (TAKAHASHI & TAKAHASHI, 2007).

One of the main advantages highlighted in the literature about the reuse of the waste are the preservation of natural resources, saving energy, reducing landfill volume, reducing pollution, generating jobs and reducing the cost of environmental control by the industries. The study of economic viability was satisfactory, finalizing the review and giving conditions for reuse were done on a larger scale. The present work is of great importance, since it is necessary to modify the form of use of non-renewable materials and apply sustainable construction as routine, as this isauthor's intention that this be published for knowledge of the scientific community.

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