Systems & Management 13 (2018), pp 118-129

SYSTEMS & MANAGEMENT
Electronic magazine

ENVIRONMENTAL MANAGEMENT IN SOLID WASTE: SUSTAINABLE CONSTRUCTION AND ECO-EFFICIENCY

Cristina Maria Dacach Fernandez Marchi
cristina.marchi@pro.ucsal.br
Catholic University of Salvador, Salvador, Bahia, Brazil

Mirela Carvalho Ribeiro Bohana
mirela.bohana@gmail.com
Catholic University of Salvador, Salvador, Bahia, Brazil

José Luiz Borja Fernandez
jose.fernandez@pro.ucsal.br
Catholic University of Salvador, Salvador, Bahia, Brazil

ABSTRACT

The activities of the construction industry generate great negative impacts on the environment. In order to highlight and point out new trends in the processes and materials used, this article aims to identify aspects related to sustainable construction in small and medium-sized constructions. It analyzes concepts and new trends for the construction sector as tools for meeting the requirements of the National Solid Waste Policy, regarding the observation of sustainability principles aimed at the continuous application of preventive environmental strategies. It is an exploratory, bibliographic study, whose purpose was to expand knowledge in terms of sustainable constructions, in order to guarantee familiarity with the theme and to disseminate information that can collaborate with environmental preservation. It presents and discusses the results obtained during technical visits carried out together with works considered sustainable. It concludes that there is a constructive tendency to use techniques and materials for the reduction of waste generation, reuse of water and use of alternative energy and natural vegetation. Although actions aimed at eco-efficiency in Brazilian civil construction have valuable potential in the area of prevention, they are still insufficient to solve the serious environmental problems generated by the sector.

Keywords: Sustainable Construction; National Policy on Solid Waste; Eco-efficiency.

PROPPI / LATEC
DOI: 10.20985/1980-5160.2018.v13n1.1319

Electronic Journal of Management & System
Volume 12, Number 1, 2018, pp. 118-129
DOI: 10.20985/1980-5160.2018.v13n1.1319

1. INTRODUCTION

The construction sector is responsible for moving much of the Brazilian economy. Even with the slowdown in economic growth, the sector continues as a profitable activity and permeates the imaginary of the various layers of society with the ideal "home".

If, on the one hand, the development of this sector brings economic and social benefits, such as the generation of employment and income, it is also responsible for much of the consumption of natural resources and the large generation of urban solid waste.

The current pattern of development, which aims to increase production and profit, with emphasis on consumption rather than the preservation of natural resources, begins to be questioned. There is growing concern in Brazil in terms of caring for the environment and a new awareness of preservation emerges from society, modifying (also) the scenario of civil construction, impelling a development considered more just and sustainable.

Planning, processes and materials in tune with sustainability must be part of the daily life of civil construction projects in Brazil. In this sector, the search for products and processes that do not negatively impact the environment becomes urgent. In this sense, practices related to eco-efficiency emerge, that is, preventive techniques that avoid or minimize negative environmental impacts.

Integrating preventive techniques into organizational activities permeates the strategies that make up sustainable development. In this sense, Araújo *et al.* (2015) corroborate the idea of the adoption and constant development of new products and processes, when they point out that, since the 1980s, companies have been driven by social and legal pressures to act in an environmentally responsible manner and, therefore, incorporate practices of social responsibility in their business. They cite some factors as survival requirements of organizations, such as: better use of natural resources, correct disposal of operational waste and application of environmentally correct materials and technologies.

In order to highlight and point out new directions in the processes and materials used in small and medium-sized civil construction works, the present article seeks to identify aspects related to sustainable construction in small and medium-sized constructions in the *Região Metropolitana de Salvador* (RMS – Metropolitan Region of Salvador), Bahia, Brazil.

This study adopted as premises the principle of eco-efficiency, inserted in the *Política Nacional de Resíduos Sólidos* (PNRS - National Solid Waste Policy), Law no. 12305/2010 and the concept of sustainable construction recommended by Kats (2014), which establishes it as buildings that seek to minimize the negative environmental impacts in its construction and operation, aiming to make the environment as healthy and productive as possible for its occupants.

2. THE LAW NO. 12305/2010 IMPULSIONING ECO-EFFICIENCY IN CIVIL CONSTRUCTION

Currently, despite going through changes, with a fall in profitability, the construction industry is still considered as the great driving force of the country, as it is one of the most important sectors of our economy. According to the *Câmara Brasileira da Indústria da Construção Civil* (CBIC – Brazilian Chamber of the Construction Industry, 2012), this sector had a 15.5% share in the Brazilian Gross Domestic Product (GDP), generating 8 million direct and indirect jobs, increasing the collection taxes and heating the services and sectors directly and/or indirectly related to the segment.

However, this development can have harmful consequences for the environment, caused mainly by the large production of solid waste, use of materials that attack the environment, both in production and in use, high consumption of water, energy and nonrenewable natural resources.

It should be noted that civil construction is responsible for generating 50 to 70% of urban solid waste and consumes 75% of the natural resources extracted on the planet, generating a great environmental impact, mainly in urban centers, where 85% of the Brazilian population lives (Marques Neto, 2005).

Aware of this and other environmental issues, in February 2011 in Nairobi, the United Nations Environment Program (UNEP) launched a report that encourages the world to invest 2% of GDP in ten strategic areas. One of these areas is solid waste. It is intended to disassociate GDP growth with the generation of solid waste. Instead of increasing solid waste, investing in recovery and recycling.

The PNRS, Law no. 12,305/2010, follows the vision of the United Nations Environment Program (UNEP) and determines deadlines for Brazilian states and municipalities to draw up their management plans to comply with their determinations. The PNRS establishes principles and objectives for the reduction of the volume of waste generated, in order of priority, the non-generation, reduction, reuse, recycling and treatment of solid wastes, as well as the environmentally appropriate final disposal.

These stages require public facilities and equipment that provide support for the correct delivery of recyclable and reusable waste by the population and by companies,

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DOI: 10.20985/1980-5160.2018.v13n1.1319

such as: containers and physical infrastructure of voluntary delivery points; waste sorting and recycling plants; waste treatment facilities for health services or organic waste; sanitary and construction waste and inert landfills, among others, that allow differentiated management and integrated of the waste generated.

However, Brazilian municipalities, especially those in the North and Northeast, have encountered numerous challenges that lead them to delay the provision of adequate solid waste services. Among them, it is possible to cite the complexity and interconnections of the environmental variable with social, economic, spatial and cultural problems. In addition to others, such as financial dependence to invest in infrastructure works, political discontinuity and lack of qualified technical manpower for the elaboration, monitoring and evaluation of the programs that originate in the plans of waste management (Fernandes et al, 2012). These problems interfere with and discourage the application of sustainable construction techniques in the construction sector. Rocheta et Farinha (2007) point out that sustainable construction requires care with the management of construction waste, seeking the reuse and minimization of waste. This management is based on the Eco-efficiency Principle, inserted in the PNRS.

Chapter II, V Principle, establishes Eco-efficiency as

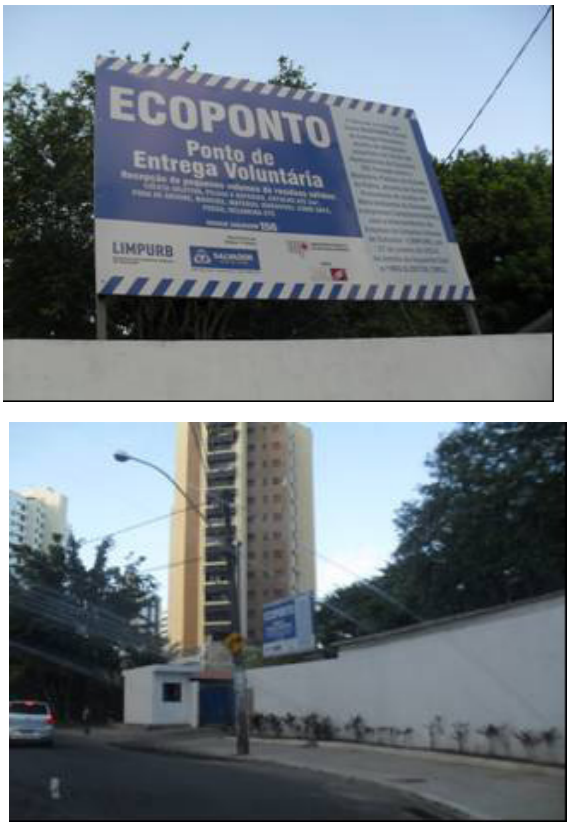
> (...)compatibility of the supply of qualified goods and services at competitive prices that meet human needs and bring quality of life and reduce the environmental impact and consumption of natural resources at a level equivalent to the planet's estimated carrying capacity (Brasil, 2010).

Practices of conduct that violate this principle will be considered illegal and fall under another principle of the PNRS, the "Polluter-Payer" principle, which consists in obliging the polluter to bear the costs of repairing the damage caused by the polluter to the environment.

In this way, the correct practices are clearly determined by the regulatory framework, which brings in its scope important definitions, such as integrated management and shared responsibility for the product life cycle, leaving waste management actions deliberate for Government, companies and citizens, and enforcement actions for competent municipal, state and federal government agencies, as well as the Public Prosecutor's Office.

The environmental oversight system in Brazil is complex and involves several agencies that find restrictions to act jointly and effectively. Several problems impede the work of oversight, among others: insufficient staffing and lack of resources to pay servers or qualify them. The absence of sanctions for companies involved in improper practices, especially those related to the Polluter-Payer Principle, as well as the lack of demand of environmental and social impact reports in small and medium-sized works, discourages the development of sustainable engineering works.

Gradually, the guidelines of the PNRS have been assuring proposals to frame the activities of the civil construction sector in the guidelines of the Law. Almeida et Marchi (2016) report on the construction of an Eco Ponto in the district of Itaigara, a municipality of Salvador, Bahia. This public equipment for the collection of recyclable and reusable materials was originated by the Terms for the Adjustment of Conduct (TAC), applied by the Public Ministry of Bahia to three contractors in the construction industry, who deposited rubble in an inappropriate place (Figures 1.0 and 2.0).



Figures 1.0 e 2.0. *Ecoponto* installed in the Itaigara Neighborhood - Salvador, from the Term of Adjustment of Conduct - TAC
Source: Almeida et Marchi (2016)

Reducing misconduct of contractors is no easy task. The incorrect disposal is still a common practice perceived by citizens when they observe squares, gardens, streets and residential avenues, vacant lots, banks of streams, among others. Much progress has to be made in implementing the eco-efficiency process in small and medium-sized civil works.

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Rincón et Wellens (2011) describe the origins of the instrument entitled "eco-efficiency". The authors show that eco-efficiency derived from the concept of sustainable development, presented in 1987 by the World Commission on the Environment, during the United Nations Assembly. Subsequently, a concept that guided the business objectives was sought, aiming at sustainable development. The result was the publication of a book, called *Cambiando el Curso* (Changing the Course), written by Stephan Schmidheiny, for the World Business Council for Sustainable Development - WBCSD. The authors state that the text of this book

> (...)sought to develop a concept that, uniting environmental and economic improvements, will show companies the challenge of sustainability. This concept was eco-efficiency (Rincón et Wellens, 2011, p.335).

Sissino et Moreira also point out the importance of creating a business council for sustainability. They narrate the creation in 1999 of the *Rede Brasileira de Produção mais Limpa* (RBPL - Brazilian Cleaner Production Network), coordinated by the *Conselho Empresarial Brasileiro para o Desenvolvimento Sustentável* (CEBDS - Brazilian Business Council for Sustainable Development). This network has been promoting and disseminating eco-efficiency and the Cleaner Production (CP) methodology as tools to increase competitiveness, innovation and environmental responsibility in the Brazilian productive sector.

For the authors, it is important to permanently monitor the production process during the implementation of the eco-efficiency program,

> (...) when all sources of water, energy and materials use are identified, where hidden waste may or may not occur, with a consequent increase in water and energy costs and an increase in the generation of solid waste, liquid effluents and atmospheric emissions. These wastes are related to factors such as operational problems, material quality and the lack of adequate training and procedures of the teams (Sissino et Moreira, 2005, page 1,896).

In order to effectively reduce the negative environmental impacts generated by the construction industry, it is essential to develop new processes. With regard to the management and technology of new processes, Cleaner Production (CP) has to be one of the main tools for the sustainable development of the construction industry, which aims to increase efficiency in the use of raw materials and inputs, in addition to reducing negative impacts on the environment.

According to the United Nations Environment Program (UNEP), Cleaner Production (CP) is the continuous application of an economic, environmental and technological strategy integrated with processes and products. Such an application avoids the generation, minimization or recycling of wastes generated by the production processes, in order to increase the efficiency in the use of raw materials, water and energy and to reduce risks to people and to the environment (Pimentel, 2009).

Stimulated by Law no. 12,305/2010, the Brazilian civil construction industry has sought to adapt to this model, especially during the construction process of large enterprises, aiming, among other things, to minimize the problem of losses in the sector. These losses are worrying:

> (...) the majority of the RCD generation in the construction phase of a work is related to the losses in its construction processes (mainly due to mismanagement, disqualified labor and little technology involved) (Fernandez et al., 2015, page 7).

The adoption of sustainable construction techniques is still seen with some resistance from some builders due to the concern with the initial costs of implementation. Although this type of construction has a higher initial cost than traditional ones, around 2%, some projects have a 0% increase in their costs (Kats, 2014). Moreover, additional deployment costs could be offset in the future with the savings achieved from the sustainability solutions adopted.

According to a survey conducted by Gomes (2010) with consumers from different countries, 18% of respondents would pay more to get sustainable products. The same author observes that, in Brazil, the scenario is different, the higher cost makes it difficult to acquire sustainable technologies, but complements that if these consumers are sensitized and informed about the benefits, they will be more susceptible to change. In this sense, the professionals involved in the construction processes have an important role in informing and raising awareness of the end customers about the advantages of eco-efficiency.

Sustainability solutions in the industry seek energy efficiency, reduction of consumption of drinking water, planning maximization in order to avoid waste, use of technology and materials with low environmental impact, conscientious and planned occupation of the physical space, mitigation of climate change, non-generation of waste and, where this is not possible, the recycling and reuse of waste generated.

The high rate of energy consumption in the sector is a problem of great relevance. Macedo et al. (2011) state that construction is responsible for the consumption of 40% of

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energy worldwide. In Brazil, the largest source of electricity is hydroelectricity, which, despite being a source of clean and renewable energy, also causes impacts on nature, since it requires large extensions, causing the flooding of spaces, changes in fauna and flora, deviation of the course of the rivers and decrease of their volume. In addition to the environmental issues involved, social issues arise, such as the expropriation of real estate and serious consequences on the livelihoods of riverine communities, among others.

The adoption of efficient systems, including the system of own power generation, solar water heating and the use of low-consumption household appliances and electro-electronics can help to reduce consumption. Kats (2014) points out some elements that support these systems:

> (...) efficient systems including heat pump, use of sunlight, insulation envelope, heating and cooling zoning and photovoltaic solar panels. This building is expected to produce more energy than it consumes in a year (page 16).

Often the occupants of these properties can even get an extra income, sending the surplus to the public network and receiving credits or discounts in the energy bill. This practice is called carbon neutral construction.

The cost of installing photovoltaic solar panels is still high and its financial return is long term. However, such equipment, if well cared for, has an average life of 25 years.

As for the optimization of natural lighting, Rocheta et Farinha (2007) cite elements that promote "the entrance of light through the coverage made not only through lanterns and skylights (...)" (Rocheta et Farinha, 2007, p.7), expanding the elements that contribute to minimize energy expenditures.

For governments it is more advantageous to encourage the implementation of improvements in energy efficiency than to invest in expanding traditional sources, as these systems are more expensive. With this, the reduction of the traditional energy demand generates great savings for the public coffers and may even cause a decrease in the final energy price.

For Kats (2014), in sustainable buildings, several factors make up the framework for improving energy performance, such as,

> (...) energy-efficient project, construction and operation, including proper construction orientation; the correct dimensioning and control of electromechanical systems for lighting, heating, cooling and efficient water heating systems; thermal insulation and high performance windows (page 28).

Water saving is another key factor in sustainable construction. In Brazil there was a 10% increase in per capita water consumption from 2008 to 2013, from 151.20 l/inhabitant in 2008 to 166,30 l/inhabitant in 2013 (Folha de São Paulo, 2015).

According to Kats (2014), sustainable buildings manage to reduce, on average, 39% of their water consumption when compared to conventional ones. This savings can be given in the form of more efficient systems, flow reduction devices, use of rainwater, reuse of wastewater and more efficient landscape projects, using local flora species more resistant to climatic conditions, reducing the volume of water used for irrigation.

The project of an efficient system for the rational use of drinking water for a building, besides the reduction of consumption, has a significant impact on the minimization of costs throughout the life of the project. The indirect benefits are related to the reduction of costs with infrastructure, water treatment and pumping system, as well as relief in the system of public drainage of rainwater.

In view of the above, Law No. 12,305, established in 2010, has also been presented in Brazil with the prerogative to promote constructive alternatives that meet human needs and bring quality of life and reduce the environmental impact and consumption of natural resources.

3. METHODOLOGY

This is an exploratory study aimed at increasing knowledge on sustainable constructions in order to ensure familiarity with the theme, associate it with the principles of the PNRS and disseminate information that may contribute to environmental preservation.

The design used was the bibliographical research, which used secondary sources, articles, scientific texts and books related to the theme. In order to demonstrate and illustrate the relation of environmental aspects, techniques and practices of sustainable works, technical visits were carried out in two buildings considered as sustainable in the Metropolitan Region of Salvador, Bahia. The photographic survey was only allowed in the case study 1. As it was not allowed to capture images during the technical visit of the construction related to the case study 2, we chose to use the images of this construction that are available in the site https: //www.flickr.com/. This site authorizes the free and open reproduction of the images of registered users, as long as they are referenced.

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As for the systematic procedures for describing and explaining the events reported, the study was developed in an environment that advocated a qualitative approach, since the meanings of these events were analyzed in a critical way, as part of the occurrences does not provide appropriate variables and indicators, nor the support of statistical information. Yet, they point to trends when evaluated together.

4. RESULT AND DISCUSSIONS

In this section, we sought to present and discuss the results obtained during technical visits, carried out by the authors, whose purpose was to verify the procedures and treatments developed with the buildings, considered as sustainable.

In view of the lack of control in the small construction sites, where material reuse and the adoption of processes aiming at environmental preservation and the reuse of natural resources do not prevail, it is possible to find some cases in the Metropolitan Region of Salvador, Bahia, which use alternatives linked to eco-efficiency. As stated before, but worth noting, the National Policy on Solid Waste defines in Article 3, item XIII, sustainable production and consumption patterns, such as production and consumption of goods and services in order to meet the needs of the current generations and to allow better condition of life, without compromising environmental quality and meeting the needs of future generations. (Brasil, 2010).

Sustainable constructions follow this objective when they seek interventions programmed in the surroundings, preserving the natural environment, reducing water and energy consumption and minimizing the generation of waste.

For this to occur, the survey of evaluation criteria is required. The principles included in the environmental management systems indicated by the Brazilian Association of Technical Standards, NBR ISO 14004, recommend that criteria and methods be developed for the evaluation of which environmental aspects will be considered significant within an organization. In order to highlight the contribution of sustainable constructions to environmental protection, these systems consider as significant aspects those related to certain constructive details, such as the minimization and reuse of construction waste, water and energy saving (ABNT, 2015).

Broadening the scenario, CBIC (2012) proposes the use of the innovative and entrepreneurial potential of construction professionals to solve socio-environmental issues related to their activities. In this case, we refer to social responsibility, corporate governance, transparency, global pact, ISO 14000, ISO 26000, cleaner production, worker health and safety, eco-efficiency, generation of wealth at the base of the pyramid, social entrepreneurship, environmental innovations, local development, among other approaches and strategies that can make companies more sustainable (CBIC, 2012, page 19).

The influence of environmental management on the operational and environmental performance of companies in the construction sector can result in an important beneficial effect for the preservation of natural resources, expanding the possibilities of applying the concepts, approaches and/or strategies related to sustainable construction and eco-efficiency in any stage of the work. The present study, through the exhibition of examples, built from technical visits to sustainable works, describes some applications of these concepts in practice.

The first example to be presented and discussed refers to the final stage, that is, the finishing of a medium-sized house, located in the municipality of Salvador. Its main feature is the unusual design of the architectural project, which prioritizes the environment, adapting the project to the local flora, preserving native trees, and minimizing environmental impacts (Figures 3 and 4).

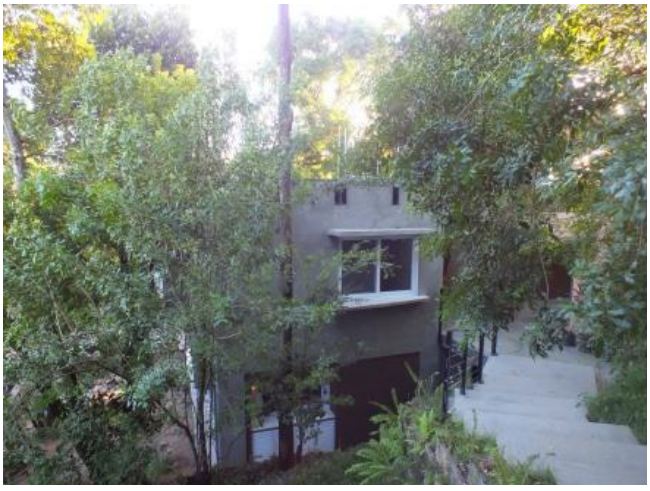

Figure 3. Photographic perspective of construction integrated to the environment
Source: Authors (2016)

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Figure 4. Photographic perspective of the construction integrated to the flora
Source: Authors (2016)

The house has high ceilings and large windows, giving priority to natural lighting and ventilation, avoiding the consumption of electricity during the day. The use of wide aluminum and glass frames allow greater ventilation and brightness to the environment. Rocheta et Farinha (2007) point out that ventilation can also be achieved through the study of partitioning and the location of openings in façades. Focusing on better ventilation, another element used was the glass and aluminum frames, due to their durability and because they are made of recyclable material and low maintenance, which avoids energy costs during the extraction of raw material (Figure 5).

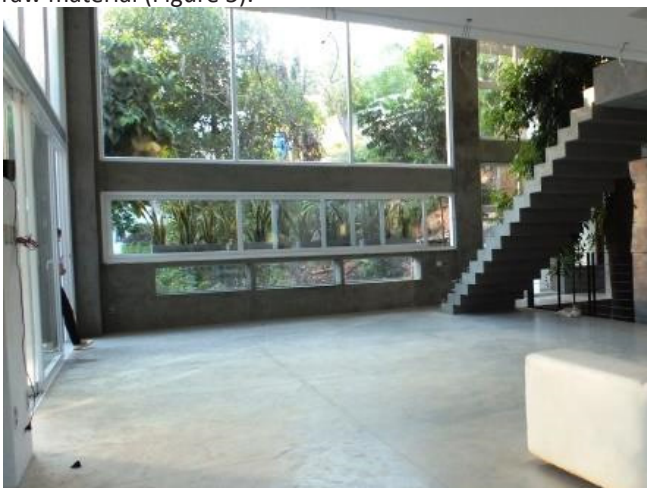

Figure 5. Natural light detail photographic perspective
Source: Authors (2016)

Ventilation can also be provided by sustainable building coverage, which even on days with extreme external air temperatures, both for the cold and the heat, the green roofs contribute to the thermal regulation in buildings (Lopes, 2007).

This type of roof provides better environmental comfort for the home and reduces the visual impact of construction on the environment, as well as the possibility of becoming a future leisure area.

Gomes (2010) draws attention to the adoption of sustainable coverage for numerous improvements in socio-environmental conditions and support to urban infrastructure. For the author, this type of construction provides the fight against urban heat islands, improving air quality in urban centers, becoming habitat for birds and butterflies, as well as reducing part of the rainwater that could flood drains.

The roof still serves to capture rainwater, as the building has a system for reuse of gray water and use of rainwater, providing savings in terms of water use. Rocheta et Farinha (2007) clarify the importance of "(...) adoption of treatment systems that allow the reuse of rainwater and gray water in sustainable buildings" (Rocheta et Farinha, 2007, page 8).

This approach was used in the study building, which has a filtration system and reconditioning of these waters, after being collected and filtered, treated and pumped to reservoirs located at the top of the building, and then distributed and reused for irrigation of the areas and toilets (Figure 6).

Figure 6. Green Roof Photo Perspective
Source: Authors (2016)

Regarding energy production, the construction foresees self-sufficiency, since solar panels were installed in order to produce energy to meet the demand of the residence, releasing the surplus in the network of the concessionaire, generating energy credits for the owners.

The second case analyzed was a house, already built and inhabited, located in the municipality of Lauro de Freitas, which belongs to RMS. This is a one-story house and its main characteristic is the use of alternative materials and techniques. The project was designed so that the construc-

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tion occupied the space in which there were no native trees (Figure 7).

Figure 7. Image of the front view of the house
Source: Gurgel, 2016

Earth-based materials and building elements are more sustainable. Murta et al. (2010) clarify this statement when explaining that,

> "(...) on the one hand, because the earth is natural, recyclable and abundant in any place, and on the other hand because the techniques used for the manufacture of these materials and constructive elements are normally simple, require little amount of energy and emit an inexpressive amount of gases harmful to the atmosphere " (Murta et al., 2010, page 8).

Kats (2014) points out the great amount of energy consumed in the extraction, manufacture and transportation of building materials, such as conventional slabs and bricks. Although built with infrastructure and usual slabs, without concern for sustainability, the house has ecological bricks in the constitution of its walls. This brick receives this denomination by using a small percentage of cement, about 10%, in its constitution, being made from a mixture of soil, water and cement, then pressed without the need of burning, as with ceramic blocks. In addition, it has a structural function, avoiding the need for pillars, reducing the consumption of concrete, wood, gravel, sand and steel, and, consequently, generating less waste (Figure 8).

Figure 8. Image of the ecological brick used in construction
Source: Gurgel, 2016

Ecological mineral paint was used on the inner walls of the rooms. This ink is composed of raw soil, with antibacterial characteristic, not posing a risk to human health, since it does not contain volatile organic compound (VOC). As the first case presented for sustainable construction, the analyzed property has a system of water reuse, both gray and rainwater. However, the system is different from the first case analyzed, because the gray water goes through the process of biological filters, where the impurities are retained, such as solid particles and soap. The waters are redirected to the reservoir which also stores rainwater captured by the green roof. Subsequently, it is pumped into an upper reservoir, which supplies the toilets (Figure 9).

Figure 9. Image of the water reservoir
Source: Gurgel, 2016

Another alternative technique used is the evapotranspiration basin, adopted in replacement of the septic tank. It consists of a system that receives the black water from the house and performs the process of retention and decomposition of the solid parts by anaerobic bacteria. While water

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percolates through layers of gravel, sand and soil, the roots of the plants absorb the water and then remove it to the atmosphere from evapotranspiration (Figure 10).

Figure 10. Image of the ecological fossa of banana tree
Source: Gurgel, 2016

The house also has green roof, with plants of the region, and a space where, in the future, the solar panels will be placed. It is important to note that the initial architectural design already pointed to aspects of sustainable construction regarding the adoption of solar panels. Thus, over the years, renovations and new installations have been added, preserving the existing infrastructure, avoiding the removal of masonry and rework of walls and roofs (Figure 11).

Figure 11. Image of green roof
Source: Gurgel, 2016

The house has a high ceiling and a skylight, which allows the use of natural lighting in all rooms (Figure 12). During the night, LED lamps are used because they have low energy consumption and longer life than traditional ones.

Figure 12. Image of the building containing details about natural lighting
Source: Gurgel, 2016

Considering the above, the case studies made it possible to visualize, in practice, the application of eco-efficiency and sustainable construction, signaled by the concern with the environment in these works, considered small and medium-sized. Next, the main elements related to eco-efficiency found during the technical visits and the references in the bibliographic study are shown in Table 1.0.

In the construction studies, it was observed that changes were employed from the simplest ones, such as rainwater collection, to the most elaborate ones, such as alterations in the construction process, which can serve as an example for other works, bringing in gradual and constant changes in current procedures, considered harmful and impacting to the point of generating up to 70% of urban solid waste and consuming 75% of the natural resources extracted on the planet, as previously reported.

5. CONCLUSIONS

The objective of this article was to identify aspects related to sustainable construction in small and medium - sized buildings in the Metropolitan Region of Salvador, Bahia, Brazil, using assumptions contained and encouraged by the principles of the Brazilian National Solid Waste Policy.

It is important to highlight that most of the inputs used by the construction industry come from exhaustible sources and some, especially those of better quality, are scarce in certain regions of Brazil. In the middle of the civil construction scenario linked to medium and small works, we can see that there are innovative and creative techniques, materials and processes that bring hope for future transformations in the constructive pattern of this type of construction.

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Table 1. Comparative table between main elements found in constructions and reference frame used

REFERENTIAL	SUSTAINABLE ITEMS FOUND ON TECHNICAL VISITS
Elements that promote sustainable energy generation	
"...efficient systems, including heat pump, use of sunlight, insulation envelope, heating and cooling zoning and photovoltaic solar panels, this building is expected to produce more energy than it consumes in a year" (Kats, 2014, page 16).	Both projects adopt the solar energy system, which is responsible for supplying the building and injecting surplus into the utility's grid. In addition, they use mechanisms that avoid the use of electricity during the day.
As for the optimization of natural lighting, Rocheta et Farinha (2007, page 7) cite the importance of promoting the "(...) entrance of light through the roof made not only through lanterns and skylights (...)".	The second case presented in the project considered the use of skylight for the intelligent use of solar lighting.
Natural ventilation system	
Rocheta et Farinha (2007, page 5) point out that ventilation can also be achieved "(...) through the study of the compartmentalization and location of openings in façades (...)".	The large frames used in the two case studies are recyclable and made of aluminum and glass, which allow greater ventilation and luminosity to the environment.
Even on days with extreme external air temperatures, both for the cold and for the heat, the green roofs contribute to the thermal regulation in buildings (Lopes, 2007).	The two buildings have a green roof, a technique that provides better thermal insulation, allowing a decrease in the temperature of the place, an important aspect, since the houses are located in a region of equatorial climate.
Water reuse	
Regarding the reuse of gray water and rainwater, Rocheta et Farinha (2007, page 8) argue that "The adoption of building treatment systems allows reusing both rainwater and domestic wastewater (from bathtubs, showers, bidets, washbasins, etc.) on site.	Although they adopt different systems, the houses have a system of collection, filtering and reuse of the water, allowing for financial savings and natural resources.
Use of green coverage	
This type of construction provides the fight against urban heat islands, absorbing greenhouse gases emitted by vehicles and improving air quality in urban centers; it decreases some of the rainwater that could flood manholes; and it becomes habitat for birds and butterflies (Gomes, 2010).	The two buildings have a green roof, a system that allows drainage of rainwater, minimizing the possibility of flooding of sewers. In addition, this space integrates the construction with the local fauna, serving as the home of birds and butterflies.
Use of sustainable materials	
"Land-based building materials and elements are more sustainable on the one hand because the land is natural, recyclable and abundant everywhere, and on the other hand, because the techniques used to manufacture these materials and building elements are normally simple, require little amount of energy and emit an inexpressive amount of gases harmful to the atmosphere" (Murta et al., 2010, page 8)	In this sense, it is observed that the second case presented better responds to this requirement, since it uses sustainable building materials, such as ecological bricks and ecological mineral paint, made with soil, while the former uses conventional techniques.
Proper management of construction waste	
"A significant amount of energy is consumed in the extraction, manufacture and transportation of building materials" (Kats, 2014, page 22).	In the second case study, the walls are composed of ecological bricks, which, in their composition, use a reduced amount of cement, besides also serving as a structural element, reducing the consumption of cement, natural aggregates and steel.
Rocheta et Farinha (2007) point out that it is necessary to take care with the management of construction waste in sustainable constructions, seeking the reuse and minimization of residues.	In the first case study, it was sought to use, where possible, waste at the site itself.

Source: Prepared by the authors.

Electronic Journal of Management & System
Volume 12, Number 1, 2018, pp. 118-129
DOI: 10.20985/1980-5160.2018.v13n1.1319

It is undeniable that the industry still needs many investments to minimize the environmental problems in its activities. In Brazil, there are still insufficient legal and organizational actions in view of the magnitude of the challenges brought about by the tailings generated. However, the National Policy on Solid Waste has been promoting, through legal instruments, some changes in the way companies, public authorities and society operate. An example to be highlighted is the condition that the public authority can use to guarantee what is required in the principle of the Polluter-Payer. Article 8, which deals with the instruments of the National Policy on Solid Waste, provides, among other things, sectoral agreements and review of effective or potentially polluting activities.

The terms of conduct adjustment are good examples. The 5th District Attorney for the Environment Department of the Bahia Public Ministry has been adopting the practice of conduct adjustments. The joint action of various sectors of society reveals the possibility of adopting new positions, new procedures and new paradigms, such as eco-efficiency and sustainable construction.

It is concluded that there is an increasing constructive trend that aims to use techniques for the reduction of waste generation, reuse of water and use of alternative energy and natural vegetation. Although the actions of CP in construction have valuable potential in the area of prevention, they are still insufficient to solve the serious environmental problems promoted by the sector, requiring joint actions of society, government and organizations, as well as greater investment in research and technological innovation.

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Received: May 16, 2017

Approved: Jan 15, 2018

DOI: 10.20985/1980-5160.2018.v13n1.1319

How to cite: Fernandez Marchi, C. M. D. F, Bohana, M. C. R., Fernandez, J. L. B (2018), "Environmental management in solid waste: sustainable construction and eco-efficiency", Sistemas & Gestão, Vol. 13, No. 1, pp. 118-129, available from: http://www.revistasg.uff.br/index.php/sg/article/view/1319 (access day month year).