The Unsustainability of Sustainable Architecture

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Abstract

Current sustainable buildings in reality are not sustainable. The sustainability concept has been transformed in a stereotype language about a theme which is more than designing bioclimatic architecture and saving energy. The aim of this work is to identify, in a critical way, the aspects related with the unsustainability of the architecture developed nowadays. Many architects have a focus only on energy efficiency in the operation phase of the building's lifecycle and forget the other issues related to the sustainable architecture. In this way, the necessary energy for the electrical devices used every day comes from the non-renewable sources. These buildings are reducing the natural resources and continuously contaminating the environment. All the buildings consume around 40% of total raw material available and produce large amounts of waste during extraction, transformation, construction and demolition. The energy savings achieved in these buildings are admirable, mostly in skyscrapers. Nevertheless, this does not mean anything in terms of architecture that respects the environment because most of the energy supply comes from non-renewable sources. Furthermore, the building materials used on these buildings are often extracted in a destructive manner and a small quantity of it is reused or recycled. The buildings are design to be built, but not designed to be deconstructed. These and other factors contribute to reduce the energy and natural resources and to increase the amount of waste. From the development of this paper it can be noticed that the actual architecture can not be characterized as sustainable, because there are many issues that must be solved until it becomes a truly sustainable architecture.

Keywords: sustainability, waste, building, resources

1. Introduction

Currently, it is widely know that non-renewable resources are limited. There are many by-products that are treated as waste and that cause environmental pollution. The climate change implies an ecological, political and social awareness. In addition, it calls for a change in how to think the new buildings and how the architects should design it. The sustainable architecture must take into account the close-loop life cycle of materials, that is, reduce, reuse and recycle the available resources. The utilization of virgin materials which are resources with low entropy should be avoided in order to preserve these resources because waste is not limited in the building material itself, but in all the production chain of a material or a component. Natural resources are inside the earth, that is, no one can see them. However, waste is a surface phenomenon; it is produced at all phases of a material's life cycle and no one can ignore it. In this sense, the efficiency in the construction material's processes must be increased, in order to produce more construction materials with minimum resources and search alternatives that are truly sustainable.

Recently, many “sustainable” buildings, mainly skyscrapers, were presented in an event called World Architecture Festival, held in Barcelona in 2008. All skyscrapers had a focus on the building's energy efficiency during their utilisation phase. The buildings presented at least use renewable energy to supply their operation phase. All skyscraper projects use double glazed skin façade with aluminium structure but no one demonstrated that these structures were made with recycled metal. Hardly any architect demonstrated interest in the close-loop of building materials. The criticism is not about energy efficiency concerns on the operation phase of a building, but rather, is the concept of sustainability applied in the architecture. A building only can be sustainable if, for instance, uses rainwater, treats organic waste generated by people in the building, there is a close loop of materials, uses renewable energy and materials are reused or recycled among other factors. In the following sections it will be explained on the critical way the points that why the architecture produced nowadays is not be considered as sustainable.

The Bruntland report (1987) defines sustainable development as “development that meets the needs of the present without compromising the ability of the future generations to meet their own needs” pp 43. The ecological footprint is a “tool that enables us to estimate the resources consumption and waste assimilation requirements of a defined human population or economy in terms of a corresponding productive land area (pp 9)” (Wackernagel and Rees (1996). The ecological footprint is estimated in hectares and is related to the amount of productive land to meet the necessities of a defined population in a sustainable way, like the water consumption, forests, and agricultural land. In 1900, the ecological footprint for developed countries was 1 hectare per capita and in 1995 was between 3 to 5 hectares per person, (Wackernagel y Rees, 1996). These definitions have the aim to prevent large amounts of waste, pollution, lack of equity and the destruction of nature. In other words, a sustainable concept must focus on a fractal with ecology, economy and equity on the vertices of the triangle (Braungart and McDonough, 2008). The following sections will discuss the aspects related with the unsustainability of the architecture developed nowadays.

2. Characteristics of building unsustainability

2.1 Complex societies

Unsustainability is an old phenomenon. The resources shortage can lead to a collapse of a society. It was happened with the population of Eastern Island due to some factors like superpopulation and deforestation. Rees (2002) argues that colonization of Eastern Island started in the 5th century. After one thousand years of growth, the population of the island was estimated between 7,000 to 10,000 people and then the collapse started. Intensive deforestation, loss of pollinating birds and the increase of rat population were some of the causes to the decline of this society. In this sense, people did not have wood to make canoes and to maintain their needs of fish. Rats eaten the seeds, and shellfishes and chickens did not provide minimum conditions of calories for people island. In this manner, the population starts to decrease. The first European that arrived at the island in 1722, encountered people living in terrible conditions in shelters or in caves and the land was totally devastated. Malthus (1798) states in his book that population grows at geometric scale and food grows at arithmetic scale. As humans need food to live, the two sides of the equation have to be equal. Human population does not grow indefinitely, but there are growth limits that must be respectes, like food growth. Saura (2003) argues that grow of any species begin by a exponential curve and then drops when some limits, for instance, food, space or other type of resources, appear. Afterwards, this reduction stabilizes by the growth limits.

Rees (2002) still argues that technology is not the only way to solve society problems. In fact, Tainter (1995) states that there are more expenditure of resources in more complex societies to maintain them. Furthermore, the author argues that industrial societies are an anomaly. This is because human species has been living for 99% of their existence in small villages. The reasons for this are the high costs involved in large and complex societies. It is more difficult to solve problems when the complexity increases and significant results require more resources. Tainter (1995, p. 401) says that “there are, reasons to suspect that science is becoming less productive overall (…) because it has become increasingly specialized and expensive”. The reason is that for every advance in science much more resources are needed and the evolution of problem solving is smaller. One example is the US health care system in which the productivity of the system declined 60% between 1930 and 1982. First studies about diseases lead to penicillin which did not cost more than 20,000 dollars. From this point the costs necessary to cure other diseases rise too much. Furthermore, when complexity of diseases increases, costs rises too, nevertheless, the increment in life expectancy is smaller, Tainter (1995).

2.2 Problems of the economic system

The current economic system is based on pendulum like motion (cycles). If there is any decrease on demand or a crack, the economic process always returns to the previous condition, that is, in economy everything is reversible. According to this principle, the basic sequence is always a constant flow among production and consumption without taking into an account external factors (Georgescu-Roegen, 1976). If this economic model degrades the nature by itself, the globalization has permitted the acceleration of degradation. Jimenez (2008) emphasizes that globalization "looks for increase productivity and competitive advantages which give better mass consumption conditions, but does not focus precisely in meeting the real needs (…) and does not insure integrity of the natural system and its autoregeneration" (p 48). These competitive advantages are a result of a complex transport and fabrication logistics.

The capitalism makes the nature have a market value. In other words, nature can be purchased and the owner can do what he wants with the natural goods available on his territory. As people persecute profit, in theory, higher money quantity would represents higher satisfaction of individual needs. For instance, United States has a quarter of the world's cars and today there are more particular cars then driving licenses (World Watch Institute, 2004). Wealth generates more consumption, which leads to higher materials production to supply the "needs" of people and it is necessary to extract natural goods from nature. Now, we are consuming high quantities of natural capital and nature is not capable to regenerate these natural goods to keep step with our current consumption and superpopulation. Marketing contributes to high consumption and says to consumers to satisfy their needs with new products which they often do not need. All this consumption increases the ecological footprint, which according to Latouche (2008 p. 41) "the planet already does not enough to all of us, it would be necessary to have 3 to 6 more planets to sustain our occidental way of life".

2.3 Exploitation and material resources shortage

Construction industry is the sector which consumes more energy and material resources and the demand for these types of resources increases more and more (figure 1). The quantity of raw materials consumed in the United States only decreases when some crisis occurs. One of the 20th century crises was the First World War. Next, there was an increasing period of use of construction materials and then other crisis. At this time it was the America's Great Depression in 1929. After this crisis, the consumption starts to increase and is decreased by the Second World War. Long time will pass until the oil crisis and recession in the United States come back to drop the consumption. What can be seen is that economy always operates in cycles with moments of high and low consumption. Nevertheless, after the Second World War, the materials consumption increased at rate of 3-4 times in 25 years, before the oil crisis.

The effects of globalization help to accelerate resources depletion. The global market has expanded 3 times in the last 20 years, while population has increased 30% at the same period. The carbon dioxide levels rise up to 30% during the industrial era and these are the highest levels in the last 160,000 years (IPCC, 2005). The economic activity nowadays does not help sustainability, because the market model promotes individualism opposite to collective values and equitable distribution. Globalization is a product of countries that have deficit in their ecological footprint, and need more cultivated earth from other countries to meet their necessities. These resources are extracted, manufactured and transported most of the time by multinationals and transformed in many parts of the planet with the aim of cost saving. For this reason developed countries adopt the neoliberal economy (Ress, 2002).

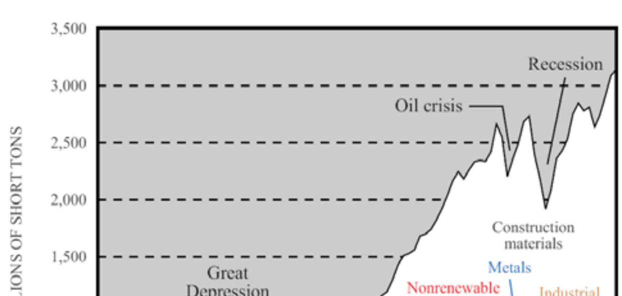

Figure 1: Raw materials consumed in United States (Sznopek and Brown, 1998)

The scarcity of some metals reflects the high rates of extraction which leads to higher mining costs. So it is necessary to explore new mining sites but the mining operation can cause serious damage in the local environment, such as deforestation and contamination with toxic elements. Metal prices reflect well the mineral resources available nowadays. The availability of iron ore is high and therefore its sale price by tonnage is low. However, the less a material is available in concentrated rates, the higher is its price due to more investments necessary to extract a determined material. It occurs in a progressive scale with alumina, aluminium, copper, nickel and cobalt. As the mineral ore become rarer, its price tends to rise as well as the building costs. The closed-loop of materials will help to decrease the extraction levels of mineral ores, as well as to decrease the environmental impact of forests which are devastated by extraction.

As well as ferrous and non ferrous metals, cement and gypsum extractions are large too. Cement industry produces around 1.6 million metric tons of material, according to Cement Sustainable Initiative data (2008), which belongs to World Business Council for Sustainable Development. In the last year, almost 200 million metric tons of cement was produced only by Holcim (2008). Torgal and Jalali (2007), argue that Europe uses more raw materials in the construction industry than whatever other economic activity. The authors also state that more durable materials have higher useful life and consequently have lower environmental impact. Other issue is to treat the waste produced in some industrial activity as raw material for another type of industry. Cork is an example and, according to Eires et al (2007), it is a waste that is converted into raw material to produce wallboards with no structural applications.

2.4 Production of residues

Building construction generates a large quantity of waste. Larson (200?) argues that "pollution is a function of design". This is because all contamination made by humanity is a result of much planning e.g. nuclear and other toxic wastes which can cause serious health problems. People need to be re-educated to avoid consumerism and the industries must change their products production processes. Wastes are produced constantly and with higher rates due to the increase of industrial era production and especially after the Second World War. The U.S. Environmental protection Agency (EPA) estimates that of all waste produced by construction industry, 92% is related to demolitions and refurbishments (Franklin Associates, 1998). However, waste production in buildings begins in the design process in which architects use mistaken concepts.

Mistaken concepts in the design of buildings can lead to utilize materials that are not necessary, such as use a low emissivity coating made of metallic oxides on the glass curtain wall “to protect” the interior of the building from infrared energy. Using transparent glass in smaller windows with appropriated orientation can provide light and the same time reducing the heat gain or loss. Many building materials are actually compound materials bounded together with resins or adhesives. This compound materials are very difficult to separate and this do not help in the close-loop circle. Braungart and McDonough (2008) state that these materials are manufactured following cradle-to-grave principle where materials are discarded to landfills after complete their life-cycle. Moreover, the authors argue that materials should be designed with cradle-to-cradle principle, i.e. treated as technical nutrients for other building materials or biological nutrients for nature. The change is in designing products thinking that products have some life expectancy and they will not exist forever. Nature is the example of recycling. Architects must know that the artificial products must be recycled anyway. It is a programmed mortality with conscious and maximum utilization of reclaimed or recycled materials.

Many sustainable buildings use materials containing toxic elements, such as PVC, paints or components with lead or cadmium. Mineral ore extraction and transformation into metal elements release large quantity of hazardous substances into the air, water and land (Sarkar, 2002). These elements can create poor indoor air quality into the building and can be potentially toxic for human health (Calkins, 2009). Transport of building materials consists in another waste, i. e. carbon dioxide. This residue results from the combustion of non-renewable energy resources and oxygen. Carbon dioxide is one of the responsible for green-house effect that began in 1850 with the Industrial Revolution and it has increased in the last years.

Other issue that contributes to the unsustainability in architecture is the demolition of a part or even the entire building (Shaurette, 2006). Building demolition requires less time and less labour cost than deconstruction. On the other hand, valuable materials are lost in the demolition process because materials are all mixed. Deconstruction process can salve large quantity of materials and energy due to carefully work in separating and salvaging the products. Designing buildings to incorporate reclaimed components is the best way to reduce dramatically the environmental impact, but reclaimed products have disadvantages too, such as: they are more labour intensive in identifying the source; no equivalent market exists and design detailing can only commence after the purchase of the reclaimed components (Addis, 2006). In this sense, the Design for disassembly (DfD) gives a way to anticipate possible residues and to decrease then.

2.5 Energy saving

Reuse and recycling of materials permit to save energy. Building materials have already passed though transformation processes requiring a lot of energy. Reuse and recycling materials contribute to decrease embodied energy of materials with subsequent utilizations. In fact, the energy that is necessary to reuse some material is very low, because a product does not need any additional transformation, but only a suitable work before its reuse on site. Recycling has more complex procedures, depending on recycling methods utilized. Nevertheless, the energy quantity necessary to produce recycling materials is lower, respect to produce the same products with virgin materials. Same as energy, reuse and recycling permit to reduce carbon dioxide emissions if compared to manufacture processes with virgin materials.

Metals are a family of materials which have one of the highest recycling potentials. These materials require much energy for its transformation since mineral ore to metal. But, when recycling factor is included, the embodied energy of metal and carbon dioxide emissions are small comparing to a conventional fabrication process (Berge, 2009). Another material, like glass follows similar recycling rules, too. The difference is with laminated glasses, because there is a thin film of Polyvinyl butyral (PVB) which is a resin used to join two panes of glass. PVB has to be taken from glass and than glass can be melted again. Drywall panels are recyclable too, but paper must be taken out previously from drywall (CIWMB, 2001). However, concrete can be downcycled into aggregates for new concretes. Many studies have focused on concrete recycling because more than a half part of the building mass is made of concrete (Hansen, 1992). Bricks can be reused (Martin, 2007). The brick separation methods for reuse are manual and very laborious. Recycled bricks are used mainly as aggregate for new concrete mixture. All of these and more options are alternatives to save energy and reduce carbon dioxide emissions, furthermore, to contribute to the preservation of virgin materials.

2.6 Limited reuse and recycling standards

A difficulty that impedes the increase in reuse and recycling rates is the lack of politics and standards favouring reutilization and recycling of building materials which continuously go to the landfills. The European Union has a general standard related to residues since 1975. From then on, each European Union Member State defines its own standards, as it can be seen in the first considerations of the last approved standard related to residues 2006/12/EC. In the United States, some States are more advanced than others, in relation to standards about reuse and recycling of construction and demolition materials (Martin 2007).

Spain has a directive about residues of construction and demolition since the year 2008. One of the characteristics of this directive is to difficult the disposal of construction and demolition wastes into the landfill without previous treatment by increasing the landfill taxes. The directive establishes producer responsibility obligations of the construction and demolition wastes which is intended as the building client. The holder of mentioned wastes is the agent who generates and controls these residues. The producer of the waste is responsible for "the inclusion of a management study of construction and demolition waste that will be produced on site" (pp7724). This directive establishes general conditions for waste managers and the correct sorting and assessment of waste. It also shows the minimum amounts of waste which are necessary to sorting - 80 mt for concrete, 40 mt for masonry, and ceramic tiles, 2 mt for metals, 1 mt for wood products, 1 mt for glass, 0.5 mt for plastics and another 0.5 mt for cardboard. The sorting applications of this directive are valid from 2010.

Europe and United States have standards that provide guidance rather than specific criteria of how to recycle these materials. It does not make much sense sorting a specific type of waste if there is no facility to treat such residue. For instance, the plastic recycling facilities in Catalonia, Spain do not accept any building construction and demolition post-consumer waste. The reason pointed out by the recyclers is that the post-consumer waste comes with a lot of contaminants and with many different formulas. The International Organization for Standardization (ISO) has standards related to the environmental labelling, but there are few products that already have such label in comparison with the total number of building materials available in the marketplace. The ISO 14020 standards are limited related to the reuse and recycling contents because many products can have the eco-label without having any recycling content in the product itself.

2.7 The problem of new housing

Housing has the main function to serve as a shelter, to protect from the environment and to meet the basic family needs. Housing can be seen as an income alternative and investment. However, housing must respond to demographic demand and economic value has influence in the number of housing units built. Earth's population is growing constantly. Up to the year 2000, almost 116 million houses in United States were built (U.S. Census Bureau, 2000). Figure 2 shows the evolution of houses built in The United States between 1968 and 2007. Only to have an idea of houses built, almost 2 million houses were completed in the year 2006.

It is interesting to note that the cycles of rise and fall of number of built houses coincide with the crises periods. These crises periods are shown in figure 1 which are related to the raw materials consumed in The United States. In de 1970's there is a drop proportioned by the oil crisis, which affected a lot the construction industry. The 1980's and at the beginning of the 1990's coincide with the recession in The United States. At this point the number of houses built increases each year, with a significant drop in 2007 possible due to the financial crisis. It can be seen too that single family houses dominates the total numbers of built area.

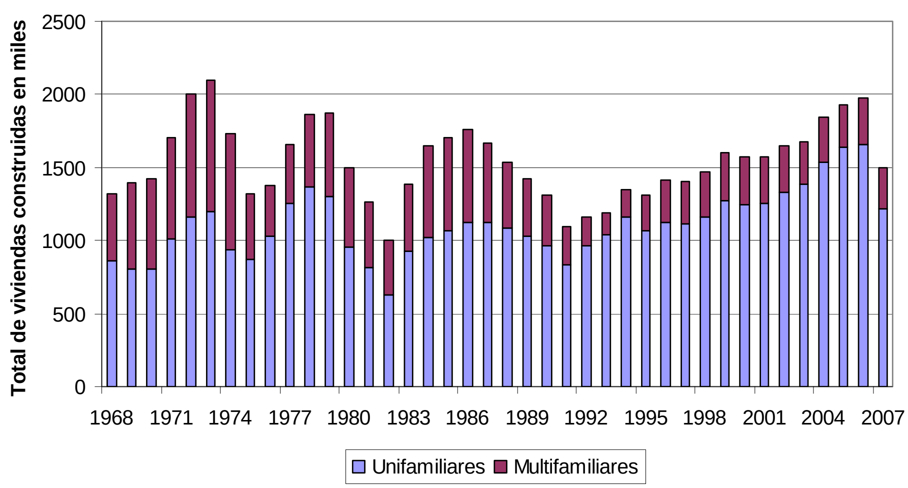

Figure2 – Relation of total houses built and total of single family and multifamily houses completed in The United States among 1968-2007. (U.S. Census Bureau, 2008).

Even though the number of built buildings dropped in the last years; the number of apartments per building has increased as well as the apartment area. For instance, in 2007, 284,000 multifamily buildings were built. The average number of apartments was 32 and the average area was 109 m^2 (U.S. HUD, 2008), which results in 993 million square meters of housing for multifamily buildings. On the other hand, the great number of single family houses multiplied by average area of each house corresponds to 267 millions square meters, which represents 27% of total built area. The total area of houses built in 2007 was 1,260 million square meters. It can be imagine the environmental impact that will be produced by the consumption of energy and materials resources and the production of large amounts of residues for new housing construction.

Other aspect is the housing deficit and the worst levels are in developing countries. According to the Ministry of Cities of Brazil, it was necessary about 8 million of new houses to supply the demand until 2008. This value does not count with the future population. According to Brazilian Institute of Statistics, IBGE (2008), Brazil has more than 56 million houses built. The sum of Brazilian houses among 2001 to 2007 is 11.5 million houses. The sum of United States houses in the same period was 12.1 million units. In other words, Brazil builds almost the same amounts of houses as United States.

According to the Ministry of Housing of Spain, this country has 24.5 million houses built until 2007 and reaches the maximum amount of houses built in 2006 with 650 thousand units. The average area of these houses in Spain is 76 to 90 square meters (INE, 2002). The total area built passed from 59 million square meters in 2001 to more than 84 million square meters in 2005 (The Second National Plan of Construction and Demolition Wastes of Spain - PNRCD, 2006). This represents an increase of 50% of total area built in Spain only by houses. Nevertheless, there was no significant increase respect to the average area of homes. In fact, there was a decrease of area of multifamily houses.

The Federal Ministry of Transport, Building and Urban Affair of Germany (BMVBS) estimates that Russia will have to build 25 million houses until 2025 to supply the demand of that country. The amounts of houses built in United States, Brazil y Spain annually summed can be estimated as been 3.9 million per year. All this quantity of new construction houses in only 3 countries. All houses that will be built will create a large amount of residues. Furthermore, the population growth will increase the demand for new houses and consequently for energy and materials resources.

3. Final considerations

From the previously exposed it can be observed that energy and material resources are currently exploited at higher rate. Aggregates are material resource of major use in building construction and are easily encountered; however, metals are more concentrated. Extraction and manufacture of these products produce waste, as well as the transport which releases carbon dioxide and can contaminate the air, water and soil. The Earth is a finite system, in turn, the economic system is based on continuous growth within a finite system. More standards and policies are necessary to diminish the environmental impact of construction industry. A few of them has been made until now in standard issue that effectively help to decrease the energy and material resources consumption. Apart from this, the existent standards are conservative.

Materials reuse and recycling is a way of preserving material resources and decreasing the amount of waste. The best option is to reuse old materials, because of energy that is saved and because it prolongs the materials' life-cycle. Recycling requires much more energy than reuse, since recycling utilizes industrial processes to transform old materials into new ones. However, materials like concrete or masonry do not have recycles but rather have downcycles, because these products can not be remanufactured in the again like metals. This same principle is valid for compound materials due to the difficulty to maintain the high quality in the separated layers. These materials neither serve as industrial nutrients nor as biological nutrients.

Populations will growth in the coming years and the demand for housing, energy and materials will increase too. So, the demand for resources will rise if the today's parameters are maintained. The majority of the so called sustainable buildings use virgin materials and almost the same materials as a conventional building. Therefore, the architecture made today is far from being considered sustainable. The enormous resources used and waste created are witnesses of unsustainability.

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