

Ergonomic Issues in the Material Re-use Process

Maciej Skowronski and Jerzy Charytonowicz

Wroclaw University of Technology,
Faculty of Architecture,
ul. B. Prusa 53/55, 50 – 317 Wroclaw, Poland
{maciej.skowronski, jerzy.charytonowicz}@pwr.wroc.pl

Abstract. The major purposes of ergonomic design in architecture are as follows: creating comfortable space and environment around the human- body and mind, the optimization of working and living spaces, and preservation of the natural environment. One of the most important aspects of the design process is proper building materials selection. In accordance with extraction and manufacturing processes, building materials are divided into the following groups: natural materials, synthetics, and composite materials. In the second half of twentieth century, mainly due to natural resource depletion, people began to focus their attention on re-use and recycling strategies. Nowadays it seems, that thanks to material recovery and recycling, we are able to limit the destructive impact of human activity on the natural environment. However it needs to be pointed out, that today's re-use technology needs to be adjusted and improved regarding modern environmental and ergonomic issues.

Keywords: architecture, ecology, energy saving, recycling, reuse, alternative technology.

1 Background

The beginning of the twenty-first century can be characterized by a high level of urbanization, high index of energy consumption and intensified flow of various materials. Natural resources, similarly to the second half of the twentieth century, are intensively drawn out from the environment, processed into materials and used in different industrial branches. The process would not raise any controversy if it had not been for the fact that the majority of the finished products mentioned above, after their term of exploitation go to the dumping ground. The resources that were originally natural in the environment after being processed, at different stages of their life cycle, finally contribute to the pollution and degradation of the natural environment. At the beginning, those problems that undoubtedly result from Industrial Revolution were not noticed. Decades had to pass until people became convinced about the negative consequences of this revolution and about the large scale of its influence on natural environment.

The pace of change happening in the modern world is significantly connected with the rapid growth of population. In 1950 there were two-and-a-half billion people living in the world. Until 2002, the population of our planet grew to 6.2 billion, which

means the growth as big as 1.2 percent yearly. The United Nations Organization estimates that by 2050 the population may grow up to 8.9 billion [1]. A high gross world product (GWP) is a natural consequence of the population growth and the concurrent industrial expansion. During the second half of the last century the gross product value grew from 6.7 up to 48 trillion dollars [2]. A yearly increase on the level of 3.9 percent should also be understood as the fact that the world population, day by day, keeps consuming more and more goods and natural resources, which highly contributes to pollution and, consequently, rubbish growing very fast, so soon there will be no place to dump it. The pessimistic forecasts from the beginning of the twenty-first century predict the growth of energy consumption and the flow of different materials nearly three times larger only until 2050. Treating the nature as inexhaustible, never-ending source of raw materials, as well as unlimited dumping ground will inevitably and significantly influence the quality of life and this will provoke the growth of civilization diseases. Ecologists warn that at the current way of exploitation, the resources will be quickly exhausted, which will start a new era – the era of shortage or deficit. This situation demands from people that they introduce a new, rational way of exploiting raw materials.

The description of society from the turn of the twentieth and twenty-first centuries presented above, as well as the influence of man's activity on the surrounding world makes a good background for reflections on modern architecture, which – as the statistics say – has a large contribution to a high level of exploiting resources and generating a lot of waste. At the moment, in highly-developed countries the building sector swallows one-third of all energy produced. An important reason for limiting the usage of energy is the degradation of natural environment, which is progressing very fast, and the amount of fossil fuels, such as crude oil, gas, uranium and coal, drastically decreasing. With the continuous development of energetics based on traditional raw materials it is estimated that the resources will last merely for the nearest few decades, except for coal that will last a little longer. Besides, we should not forget about the problem of waste and a lack of places for a dumping ground. Currently, only within the European Union 1.3 billion tons of waste is produced, and the tendency is still growing [3]. Every year there is by 10 percent more waste, which highly exceeds the average pace of economic growth. This upsetting situation is now approached by a new direction or style in architecture, which is called the architecture of re-consumption. As the current conditions show, the proper selection and the usage of recycled materials makes it possible to achieve the designing aims assumed, with the possibility to consider a wide spectrum of ecological and ergonomic aspects. The process of using the recycled materials that are generally treated as disposable ones makes it possible to save resources which are now in short supply, and may be understood as one of basic principles of sustainable design.

2 Re-consumption in Modern Architecture

While in many technologically complicated products the race in the search for energy-saving solutions has taken place for a long time now, the application of those solutions in the building sector still seems to be quite new. The slowdown has been mainly caused by high prices of energy-saving materials and techniques as well as by

too traditional approach to the product called a „building object”. However, the last decades of the previous century brought about a rapid change in order to make the rules of natural environment protection much stricter than before. This enhanced wider considering of ecological and ergonomic aspects in designing, including architectural projects. Modern buildings ought to save energy, be ecological and planned according to the rules of ergonomic designing, i.e. they should protect a healthy environment and comfortable surrounding conditions for the people inhabiting them, and they should not be a nuisance to the natural environment at all stages of their existence. Nowadays, the main designing guidelines and assumptions of eco-architecture are the following:

- smaller scale of buildings designed
- careful selection of building materials preceded by a detailed analysis of their life cycle
- using harvested lumber in the building process
- systems of regaining and collecting rain water
- saving energy and renewable energy sources
- proper location of buildings in the area
- general accessibility to public transport
- minimal using of chemicals, which badly influence the ozone layer
- protection of green places and existing plants
- re-consumption.

The re-use and recycling architecture is subconsciously rooted in so-called Green Design. Plenty of objects of this kind were created as early as in the 60's of the last century. However, in those days the reasons for creating them were completely different, rather ideological than ecological. This does not underestimate the fact that nowadays, in the first years of twenty-first century the idea of re-consumption is one of the main foundations of eco-architecture and energy saving building industry. It gives modern engineers a variety of possibilities to use new solutions, especially when it comes to many aspects of the designing and investment process that were formerly neglected. The idea of re-consumption is quite sophisticated and can be understood in many ways. It includes such elements as: the second-use of materials without their earlier processing, recycling, use of existing building structures (renovation, adaptation, modernization), revitalization of urban areas, selection of materials, mobility of object functions, modern strategies of pulling down and engineer's designing. These are only some of the problems strongly connected with the terminology of re-consumption. All of them are equally important and only being considered together may result in the effect demanded, i.e. the state of the natural environment improved by limiting wasteful exploitation, reducing and hopefully eliminating the side effects of the industrial process and waste accumulation.

3 Influence of Recycling Process on Product Characteristics

In order to cope with the problem of the amount of waste growing, in the second half of the twentieth century a hierarchy of solutions was established, which is contained in the principle of three R's: reduction, re-use and recycling [4]. The biggest advantage for the

environment results from limiting the excessive consumption and multiplied use of product that should be categorized as waste as late as possible. Finally, the rational processing helps to solve the problems caused both by obtaining a product from original raw materials and by the accumulation of waste mentioned above. While the rightness of this strategy is beyond doubt, its practical usage is still far from being perfect. It is often a consequence of a poor selection of re-used materials for the function planned, or not always proper approach to their processing. To illustrate that fact, it would be practical to analyze some aspects of the recycling process, which is regarded as one of complex principles applied to natural environment protection. At present the repeated processing of materials that were withdrawn from exploitation is quite often limited to so-called down-cycling. It leads to reducing the quality and parameters of the initial material due to its processing, modification and finally the connection with a new, different component. As a result of joint processing of materials that have different structures and chemical compositions but belong to the same ordinal group, an apparently ecological product is created which is ready for repeated industrial use. Yet, it is usually a highly complicated structure being difficult to reduce to its elements, which additionally has its durability, quality and visual characteristics much worse than the original materials.

The phenomenon of down-cycling refers mainly to re-processing metals and often involves an irreversible loss of copper, chromium and manganese that are valuable for industry. This situation takes place for example when some steel elements taken from scrapped cars are regained and adapted for the second-use. While being processed good quality steel is connected with other components, such as copper regained from electric wires, lacquer coatings, some plastics, etc. [5]. Their joint thermal treatment and putting them together in the production process significantly lowers the quality of the new product. This consequently makes it necessary to enrich the production by using more good quality materials, minerals or chemicals that would improve the features of the final hybrid.

The recycling of paper waste— so popular recently— cannot be fully approved either. Again the right idea of processing and repeated industrial use has not been fully completed by the production engineering process applied. The strategy of maximum use of waste paper instead of wood should be promoted undoubtedly. It makes it possible to reduce the amount of energy used, helps to save water and crude oil, alleviates the problem of uncontrolled cutting down trees and ubiquitous rubbish. However, both the production method and the final product have some faults, e.g. when it comes to the ergonomic point of view. For example, the method of whitening the paper pulp by means of chemicals with chlorine results in creating a lot of sewage containing significant amounts of toxic substances that cannot be easily decomposed. The process of recycling is then accompanied by preparing the mixture of unhealthy chemicals and paper pulp as well as toxic printing- ink that was not designed for the second-use. Thus the characteristics of paper processed are much lower than expected. The surface is not smooth and the fibers are shorter than in the original material. This causes the dangerous situation when chemically toxic particles contained in the new product can penetrate the air. Then they may get into the respiratory system of man causing its vexation [5].

Similarly, in the building process some of technical solutions presently used, which include using of recycled elements, may occasionally threaten the customer's health

and lower their comfort. For instance, some of thermal insulation systems made of organic materials should be considered. The necessary adaptation of cellulose or sheep wool to fire-proof principles as well as impregnation against the activity of biologically destructive factors may frequently cause the situation in which the final product is just soaked in toxic chemicals. This consequently causes that the people staying in the room insulated in this way may suffer from allergies or respiratory system irritation. Anyway, the rightness of pro-ecological character of cellulose insulation is beyond question. It helps to reduce the amount of waste and save energy, both while exploiting the building and while the insulation material is being produced.

4 Modern Strategies of Engineer's Designing

The examples above prove that the process of recycling materials- although apparently friendly to the environment and the organisms living in it- may also cause negative side effects completely different from the assumed ones when it is used incompetently. They usually result from a wrong approach towards the process of manufacturing original materials, which were not designed for a later de-materialization, utilization or recycling. The fact of neglecting proper technical solutions at the production stage may lead to irreversible losing of those components that come from not renewable sources and are often in short supply. To solve this problem, it is necessary to improve the existing solutions so that the product in its life cycle would be used in accordance with the logic of its cycle in nature. The key factor of this strategy is the process of designing for recycling that would include the necessity of the later decomposition, utilization or de-materialization of the product withdrawn from exploitation. A solution of this kind comprises a lot of aspects neglected before, both ecological and ergonomic ones. The guidelines above should also be applied in the modern architectural designing which is understood as using properly selected materials as well as the designing for an easy decomposition afterwards. Considering the ergonomic aspects seems to be specially important because it is directly and immediately connected with ensuring comfort for the potential users.

One of such materials that were designed for the future exploitation as well as re-processing is "nylon 6". This is a synthetic polymer that in highly developed countries is now more and more frequently applied in the process of making carpets. This material makes it possible to gain good quality synthetic yarn that is resistant to abrasion. Its predominance over "nylon 6.6", which has been commonly used for many years, results from the possibility of the used product to undergo a simplified process of de-polymerization. Finally, the original monomers are regained, which can be repeatedly used in manufacturing new carpets that have the same utility features as the original product. Re-processing makes it possible to regain at least 99 percent of the original monomers [6]. Modern weaver's techniques additionally improve the material's esthetic value and resistance to unfavourable outside conditions. The variety of patterns and colors is practically unlimited.

Another example of de-polymerization applied in the recycling process is decomposition of poly(methyl methacrylate) (so called organic glass or Plexiglas) which results in regaining methyl methacrylate. Decomposition into original elements takes place in the temperature of 300 degrees of Celsius. The products of the condensation

and distillation are pure monomers that are at the same time the initial substance used for repeated polymerization in the production process [7].

Also, the method of connecting various production branches gives measurable effects helping to solve the problem of growing amount of waste. In order to make this kind of engineer's solutions more popular, in early 70's of twentieth century the Heineken company worked out the system of building walls from specially designed beer bottles. The WOBO bottles of rectangular cross-section after having performed their package function could be used as a modular building element. The modern equivalent of the solution described above can be the concept system of raising buildings by means of using specially designed plastic bottles for mineral water, which was developed in 2006. The United Bottle, as this is the name of the product designed by a Swiss project study "Instant", after having performed the original function automatically becomes a modular building element. Insulation parameters of the external wall constructed in this way give the possibility of modification through filling in the air bricks used for its construction with the material of organic origin (soil, sand, feather). The final stage will be the recycling of single elements of the system. This complementary function, i.e. the building application, in this very case should be understood as the solution for the areas affected by disasters. The neutralization of negative effects after disasters is usually connected with the necessity of providing fresh water to the area affected, which is a necessary condition of survival, as well as building of temporary shelters for people who lost their homes. Both the WOBO bottle and the Unite Bottle systems should be treated as experiments illustrating the possibility of uniting different production branches, which in this case are the production of drinks and the building industry.

5 Conclusion

The turn of twentieth and twenty-first centuries is the time when the process of natural environment degradation seems to be highly advanced. One of the consequences of industrial revolution and the western lifestyle promoted is a ubiquitous problem of waste. It results from mechanisms and ideologies that accompanied rapid industrialization in the second half of twentieth century. The approach in those days was mainly aimed at the fastest and the cheapest mass production and the sale of ready for use products. This significantly determined the way of designing, the process of creating and utilization of the given product. The obvious consequence of such approach up till now has been a wasteful excavation of raw materials and their mass processing without paying attention to a high energy consumption and the pollution of natural environment. On different stages of the materials life cycle the natural environment has been gradually contaminated. Not long ago the ecological aspects of production, exploitation and utilization were still completely neglected in any specifications and analytical studies. Such state of social awareness was deprived completely of the logic considering the natural cycle.

For the well-being of future generations this attitude to nature which is regarded as a never-ending, inexhaustible source of raw materials and a dumping ground for used materials or waste must be changed as quickly as possible. The population growth and the exploitation of natural resources progressing along makes it necessary to pay

attention to modern, ecological strategies of engineer's designing. Nowadays, both the building sector and other industrial branches ought to aim at perfecting the production techniques applied. One of the solutions available, which is intended to improve the conditions of life in modern world, is the idea of material re-consumption. The process of designing and production according to the logic of natural cycle seems to be one of major strategies to guarantee a balanced progress in twenty-first century.

References

1. Auroville Earth Institute, <http://www.earth-auroville.com>
2. Assadourian, E.: Economic Growth Inches Up. Vital Signs. Worldwatch Institute, Washington (2003)
3. Dubas, W.: Podstawy budownictwa energooszczędnego. In: Przegląd budowlany. AB Druk, Warsaw (2005)
4. Wikipedia, http://pl.wikipedia.org/wiki/Zasada_3R
5. McDonough, W., Braungart, M.: Cradle to cradle. Remaking the Way We Make Things. North Point Press, New York (2002)
6. McDonough, W., Braungart, M.: The Promise of Nylon 6. Green@Work (2002)
7. Wikipedia, <http://pl.wikipedia.org/wiki/Depolimeryzacja>