Green Design, Materials and Manufacturing Processes

Editors:

Helena Bártolo et al.

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Green Design, Materials and Manufacturing Processes

Editors

Helena Maria Bártolo, Paulo Jorge da Silva Bártolo, Nuno Manuel Fernandes Alves, Artur Jorge Mateus, Henrique Amorim Almeida, Ana Cristina Soares Lemos, Flávio Craveiro, Carina Ramos, Igor Reis, Lina Durão & Telma Ferreira

Centre for Rapid and Sustainable Product Development, Polytechnic Institute of Leiria, Marinha Grande, Portugal

José Pinto Duarte, Filipa Roseta, Eduardo Castro e Costa, Filipe Quaresma & João Paulouro Neves

Faculty of Architecture, Technical University of Lisbon, Lisbon, Portugal

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Preface

Green Design, Materials and Manufacturing Processes contains papers presented at the 2nd International Conference on Sustainable Intelligent Manufacturing (SIM 2013), conjointly organized by two Portuguese institutions, the Polytechnic Institute of Leiria through its research unit of excellence, the Centre for Rapid and Sustainable Product Development, and the Faculty of Architecture of the Technical University of Lisbon. This event was held at the facilities of the Faculty of Architecture at Lisbon, Portugal, from June 26 to June 29, 2013.

The Centre for Rapid and Sustainable Product Development of the Polytechnic Institute of Leiria (CDRSP-IPL) is a FCT Research Unit of Excellence aiming at contributing to the advancement of science and technology, leading to more suitable, efficient and sustainable products, materials and processes, helping to generate added value to the industry, and promoting the awareness of the role and importance of rapid and sustainable product development in society.

The main mission of the Faculty of Architecture of the Technical University of Lisbon (FA-UTL) is to ensure the creation, development, and transmission of scientific, artistic, and technical knowledge in a socio-culturally responsible and operative manner. The research work developed at FA-UTL promotes the production of knowledge and innovation in architecture, urbanism and design. Its Research Centre for Architecture, Urbanism and Design, called CIAUD, is a FCT research unit of Excellence.

The rise of manufacturing intelligence is fuelling innovation in processes and products considering a low environmental impact over the product's lifecycle. Sustainable intelligent manufacturing is regarded as a manufacturing paradigm for the 21st century, in the move towards the next generation of manufacturing and processing technologies. On the one hand, the manufacturing industry is at a turning point in its evolution and new business opportunities are emerging. On the other hand, sustainability has become a key concern for government policies, businesses and general public. Model cities are moving forward towards novel ecosystems, combining environmental, social and economic issues in more inclusive and integrated frameworks.

This International Conference on Sustainable Intelligent Manufacturing was designed to be a major international forum for academics, researchers and industrial partners to exchange ideas in the field of sustainable intelligent manufacturing and related topics, making a significant contribution to further development of these fields. Participants came from more than 35 countries and very distinct backgrounds, such as architecture, engineering, design and economics. Such diversity was parallel to the various multidisciplinary contributions to the conference, whose subjects cover a wide range of topics like Eco Design and Innovation, Energy Efficiency, Green and Smart Manufacturing, Green Transportation, Life-Cycle Engineering, Renewable Energy Technologies, Reuse and Recycling Techniques, Smart Design, Smart Materials, Sustainable Business Models and Sustainable Construction. All participants were strongly engaged in the development of innovative solutions to solve industry problems, contributing to a more healthy and sustainable way of life.

We are deeply grateful to authors, participants, reviewers, the International Scientific Committee, Session Chairs, student helpers and administrative assistants, for contributing to the success of this conference. The conference was endorsed by:

- The Centre for Rapid and Sustainable Product Development, Polytechnic Institute of Leiria
- The CIAUD Research Centre for Architecture, Urban Planning and Design, Faculty of Architecture, Technical University of Lisbon
- The Portuguese Foundation for Science and Technology

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Smart Technology for the passive house

S. Vattano
Department of Architecture-University of Palermo, Palermo, Italy

ABSTRACT: Planning for sustainable policies aimed at identifying Smart urban spaces is determined by the parameters of Smart Cities model that encourage the production of intelligent building for construction energy efficient. The proposed article analyzes the effectiveness of the passive house in the Mediterranean area, offered by traditional building techniques, proposing a re-reading technology for the detection of a smart design methodology that can lead to the use of technologies with high energy efficiency.

1 INTRODUCTION

The European Smart Cities and Communities initiative, proposed under the SET-Plan (Strategic Energy Technology Plan), is affecting a very broad context, not only in terms of the parameters used for the definition of the Smart City, but also refer to the type of urban realities involved (Komninos 2008). Social awareness of the environmental problem and necessity to preserve the balance of the biological system in which we live, lead to design solutions, technologies and use of materials which are sometimes different from "traditional" ones. The aim is to adopt models of production and less impact on consumption of exhaustible resources of the planet. In the complexity of the construction process is therefore required a balanced way that manages together innovative technologies and traditional knowledge in a reasonable architecture, capable of adapting different solutions depending on the needs to be met, the environmental context and the regulations to be observed. The buildings have a profound impact on the ecosystem, economy, health and productivity. The knowledge of this impact in the fields of building science, technology and operation, management and maintenance are available to designers, builders, contractors, operators, and owners who want to build green buildings and maximize both economic and environmental aspect. The solutions of sedimented architecture over the centuries, are characterized by a close relationship with the natural elements of the site and the daily and seasonal weather changes. The fact that these have persisted over time shows basically the correctness of their principles. Architectures then conditioned by the specific climate of the places in which they were built and characterized by a careful use of resources and technologies that enhance the principle of maximum efficiency with minimum expenditure of energy. The traditional architecture, in fact, was the result of all the knowledge and processes that were competing to increase man's ability to adapt to the environment and to evolve in it.

2 A SMART TECHNOLOGY FOR PASSIVE HOUSE MODEL

When we talk about super-technological cities we can consider urban planning that even before the presentation of European Smart Cities model, were built in order to reduce CO2 emissions and improve the energy performance of buildings through the implementation of innovative technologies (ICT - Information and Communications Technologies), like, for example, the city of Abu Dhabi, capital of United Arab Emirates. When talking about the model of Smart City we follow the tendency to idealize a composition of factors whose feasibility is closely linked to the rapid progress of the strategies that have new goals in the field of climate and energy (Gibson, D.V. et al. 1992). Above all, the attempt is to involve citizens and also a natural propensity towards improving the quality of life and local economies. It deals with investments in favor both of the efficient use of energy and of the reduction of CO2 emissions (considering 1990 as the base year) by

2020, necessary to support cities and regions with ambitious and pioneering measures. Another objective is to achieve a 40% reduction of greenhouse gas emissions through a sustainable use of available resources and systems approaches related to new measures on buildings, on networks of local energy and transport. The initiative allows to structure national and international proposals for programming and planning Grid Solar Energy Grid and Smart Buildings and Green Cars. Therefore the objectives of this European initiative concern the implementation of best practices related to sustainable energy especially in relation to the redevelopment of existing heritage. To move in this direction it is necessary to integrate the most appropriate technologies and policy measures best suited through the consideration of important structural intervention, in the field of existing buildings. All this is necessary to reach certain parameters on the isolation of external and internal horizontal structures and on the casing of the building, in order to avoid heat losses. In this way it will aim at identifying ambitious measures guide for the construction Smart of buildings, above all rethinking the existing buildings (Chesbrough 2003).

Specifically, we can define Smart Buildings, zero energy buildings, or zero emissions ones, taking into account the requirements on the energy performance (EPBD, Energy Performance of Buildings) through the use of innovative materials (nanomaterials, solid insulating, vacuum insulating, cold roofs, etc.), which have to respond to lower levels of energy consumption. The technologies of Smart Building implement an automation system for buildings which allows you to manage in real-time safety, energy conservation, control of the whole structure and integration with innovative monitoring systems. The logical structure of a Smart Building therefore locates the following levels: the first one is physical and includes all the sensors/actuators (humidity, temperature, fire, intruder, etc.) and systems (HVAC, elevators, etc.) that innervate the structure of the building (Tselentis et al. 2010). The second level is characterized by the so-called Building Management Systems (Fig. 1) that have the purpose of supervising the systems and implement some automation. The third one is constituted by a system able to collect events from all systems and to correlate with each other (Building Control Room). The Smart Building also includes the typology of Green Building, because it uses materials with a low environmental impact and systems for the efficient management of heat. It is an active building, which produces and distributes energy through the implementation of Renewable Energy Sources (RES), of ICT technologies and of materials that contribute to energy savings for the improvement of living comfort and safety (Komninos 2002). Smart Building can be considered as communication systems and data sources in a more integrated urban eco-system; for this reason the design approach to the entire building process has become a methodology of integrated design (Whole Building Design), founded on the principles of synergy and interconnection. But to go from design of sustainable energy building to Smart Buildings it must innovate the individual phases of the building process starting from the holistic point of view (costs, flexibility, energy efficiency and overall environmental impact, etc.) of building which will have be able to better respond to the demands of productivity, creativity, quality of life of the occupants, that is, the Whole Building Design. One of the Italian emblematic examples of Smart Building was presented by the prototype biosPHera, example of passivhaus model, designed and built by ZEPHIR (Zero Energy and Passive House Institute for Research), with the aim of showing how a passive building born and lives with an almost energy zero. The building consists of two blocks whose walls screens provide information about the inner well-being: temperature, humidity, percentage of CO2, air-conditioned environment and surface temperature of the building envelop. It was necessary the three-dimensional modeling of the house, with the study of the optimal orientation and shading optimized in three different climates: northern, central and southern Italy. The use of free solar energy, derived from the environment, together with an energy performance envelope and from an efficient plant system, have allowed to develop a near-zero energy building component. In addition, the proper arrangement of the openings ensures the house a free energy intake, which is maintained and exploited thanks to an efficient heat casing, equipped with opaque components and limited thermal transmittance. The energy obtained by free solar heat is distributed through a system of mechanical ventilation with heat recovery, high efficiency, which minimizes dispersion and waste; the limited portion of thermal power, still needed to achieve an adequate indoor comfort during the coldest days of the year, is ensured by electric radiant plates positioned inside the walls and connected to the PV system placed on the roof. The building is also equipped with an innovative plant called “aggregate compact” which incorporates, in a single machine, the production of heating air, cooling air, controlled mechanical ventilation, heat recovery, production of domestic hot water, having a high overall efficiency. Wood was the natural element used in the construction of building both limited environmental impacts, due to the production, transport and disposal, and its capacities hygrometer and of healthy indoor air: the structure of the house is made entirely of wood panels; design attention has been devoted to the study of the casing, optimizing the quality of thermal insulation of each component and assessing regularly the absence of thermal bridges at the overlaps of different components, using innovative materials (airgel panels, nano-technological superinsulating, from the aerospace industry; insulating expanded panels extruded with high insulating power; rock wool panels phono-thermal-insulation at low content of aldehydes; fiber-plaster biocompatible slabs with thermal-phono-insulation function and high absorption capacity of volatile pollutants). The design attention is then focused around windows, active element in the energy needs of the building; starting from the choice of the transparent element, a triple-glazed low emissivity is able to give at the same time a high thermal insulation and a suitable sun transmission in the winter; were studied and simulated, at dynamic level, the conformations of three types of frames: wood, wood and aluminum, aluminum. For the opaque elements of the housing, both vertical and horizontal, were composed stratigraphy consist of numerous elements, able to meet the requirements of thermal insulation, hygrometric migration of steam and air tightness. We have to questioning if already existed a precursor of the Smart Building. How you can approach the concept of contemporary intelligent building to traditional construction technologies? To associate the idea of Smart Building to a building belonging to a particular historical period and of which we can recognize a certain standard of energy performance, it means being able to read in the tradition of that building a smart technology to integrate with the contemporary innovation (Ishida 2000). It is very interesting to watch the bioclimatic aspects of traditional architecture, the immense heritage of knowledge that has led to ingenious design solutions from the functional point of view and often very significant in terms of aesthetic and symbolic. This heritage, made by culture and history of building, of symbiosis between local climate, physical environment and local building materials, is accorded to a regionalism that varies from place to place. Types, shapes and construction techniques, components and used materials, show formal solutions of an architecture that has developed without architects, as result of human intelligence and of the deep knowledge of environmental factors. The nature of the soil, exposure to sun and wind, the presence of vegetation, the moisture content are some of the factors that have influenced the settlements in every time and place. A study conducted on traditional building of popular architecture caved in the rock, leads to the identification of some of the most interesting examples for the analysis of methods of environmental control over bioclimatic architecture of the past. The most explicit examples can be seen in areas where climatic factors take on extreme values, because the first need is the protection. In Mesa Verde (Colorado), several hundred houses are carved into the rock faces south and use ingeniously the physical and environmental resources for the air conditioning (Fig. 2). Mesa Verde is located within a large cave with south exposure, away from direct high sunlight of the summer and enjoys ventilation of summer breezes coming from the valley. At the same time it is well exposed to the south to collect the lowest winter rays, so that the heat of solar radiation can be accumulated from the rocky bottom of the cavern. The heat is stored by the rock of the cave, that has a great thermal inertia, and by land bricks of the buildings in adobi, that is made of earth and sun-baked. The accumulated heat is transferred gradually during the night, to create a microclimate constantly comfortable. In southern Tunisia in the middle of the desert, at 7-12 meters deep, living for two thousand years Matmata, Berber troglodyte diggers whose agglomerations are a model in the field of bioclimatic architecture. Following only the intuition, the ancient builders realized with a small number of techniques and materials available, comfortable and functional works based on the exploitation of microclimate and local resources, for thermal comfort and shelter from the external agents. And with a wide range of solutions, because each site has its own characteristics, even at short distances. In Islamic countries you protect yourself against heat and temperature range night-day forming communities by continuous complex tissue, such as the casbah, urban systems characterized by buildings huddled together, deep porches and walls thick, sometimes culminating in the so-called wind-towers. The buildings are adjacent so as to minimize the surfaces exposed to the south and the thermal exchanges with the outside air excessively hot. The typical form of Islamic casbah is closed, with a few outdoor narrow spaces and shaded street. In coastal regions the road tissue is often oriented in order to facilitate the channeling of cool and moist breezes from the sea and to avoid dry-warm winds from the desert surroundings. In Iran and Pakistan there are, since sec. X, baud-geers (wind catcher), kind of towers or chimneys, which collect the air flow at a height and through the vacuum created by a careful study of the prevailing winds, the channels through the house. The implementation of these ducts and hoods is well known in traditional architecture of the Middle East: it is possible to obtain an internal temperature cooler than ten degrees outside. The architecture of the past decades totally ignores the natural techniques of environmental control related to the structure; the new energy technologies are introduced with difficulty, and we tend to think of them as additional elements that apply to the building without formal integration or conceal as much as possible. In many regions are hidden technological and traditional aspects and territorial morphologies that would allow a natural construction of urban settlements under bioclimatic principles: underground, houses carved into the rock, ducts, pipes, etc. To interpret bioclimatic architecture of the past through the Smart key, means to deep the functioning, the performance and technology of a building system, so that brings new benefits to existing buildings and provide the best solution to save energy. The reality of urban settlements of the Islamic tradition, for example, shows examples of spaces constructed according to the principles of passive. The design of Masdar City (Fig. 3) represents the first city in the world to be designed and conceived as Carbon Neutral (zero emissions and completely ecological) will be built in the desert about 20 kilometers from Abu Dhabi. The proposed project focusing fields such as thermal insulation of buildings, lighting, low energy consumption, the percentage of glass surface, the optimization of natural light, the installation of smart appliances, smart meters and intelligent systems for the management of buildings, through an integrated distribution grid throughout the city and an energy management system that interacts with the electrical load on the grid base or Smart Grid. The energy required it will be produced by a solar power station, as well as photovoltaic, wind, geothermal and hydrogen; the water produced by a desalination plant powered by the sun and 99% of waste will be reused, recycled, end up in composting and energy plants. In Masdar City, the form of the city is dictated by climatic criteria clearly defined: the heating of the walls of the buildings are negated by the very close distances between the facades, the spaces between buildings favored the ventilation of the roads, which also contributes the wind tower, at the center of the square. It is a conical structure which exploits the air currents above the buildings, to ventilate urban environments. The walls of residential buildings are covered with corrugated panels similar to clay with the function of solar shading (brise-soleil) and elements which facilitate ventilation. Were adopted design criteria of the typical houses Yemen, with large thickness and perimeter natural ventilation chimneys. It was possible to develop and apply a wide range of environmentally friendly materials, such as low carbon concrete; recycled aluminum; timber.

3 CONCLUSIONS

It was recognized that the greatest environmental benefits come from some of the tools more passive and less expensive: the city (and buildings), the orientation (with regard to the sun and the prevailing winds) and its shape. Respecting tradition means to observe the local culture, transpose messages, check the local availability of materials, find a form of functional and aesthetic integration into the landscape and in the existing buildings that do not break the harmony. The Smart Building today proposed must take into account the new reading of bioclimatic architecture of the past (Fig. 4); only in this way you can adapt your project to the reality of the place, trying to learn from existing local, from constructive, typological and climatic changes, and the use of the materials available on site. The rules of traditional construction are discovered and cleverly adapted to current needs, supplemented by the current opportunity to express the best results in the balance between tradition and innovation.

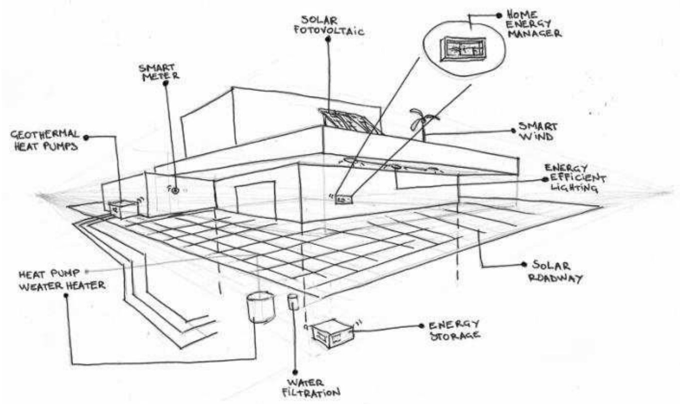

Figure 1. Example of home automation associated with the concept of Smart Building. (by Starlight Vattano)

Figure 2. Group of houses carved in the rock of Mesa Verde in Colorado.

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The rise of manufacturing intelligence is fuelling innovation in processes and products concerning a low environmental impact over the product's lifecycle. Sustainable intelligent manufacturing is regarded as a manufacturing paradigm for the 21st century, in the move towards the next generation of manufacturing and processing technologies. The manufacturing industry has reached a turning point in its evolution and new business opportunities are emerging. With sustainable development arises the immense challenge of combining innovative ideas regarding design, materials and products with non-polluting processes and technologies, conserving energy and other natural resources. On the other hand, sustainability has become a key concern for government policies, businesses and the general public. Model cities are embracing novel ecosystems, combining environmental, social and economic issues in more inclusive and integrated frameworks.

Green Design, Materials and Manufacturing Processes includes essential research in the field of sustainable intelligent manufacturing and related topics, making a significant contribution to further development of these fields. The volume contains reviewed papers presented at the 2nd International Conference on Sustainable Intelligent Manufacturing, conjointly organized by the Centre for Rapid and Sustainable Product Development, Polytechnic Institute of Leiria, and the Faculty of Architecture, Technical University of Lisbon, both in Portugal. This event was held at the facilities of the Faculty of Architecture, Lisbon, from June 26 to June 29, 2013. A wide range of topics is covered, such as Eco Design and Innovation, Energy Efficiency, Green and Smart Manufacturing, Green Transportation, Life-Cycle Engineering, Renewable Energy Technologies, Reuse and Recycling Techniques, Smart Design, Smart Materials, Sustainable Business Models and Sustainable Construction.

Green Design, Materials and Manufacturing Processes is intended for engineers, architects, designers, economists and manufacturers who are actively engaged in the advancement of science and technology regarding key sustainability issues, leading to more suitable, efficient and sustainable products, materials and processes.

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6000 Broken Sound Parkway, NW
Suite 300, Boca Raton, FL 33487
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