PORTUGAL SB13

CONTRIBUTION OF SUSTAINABLE BUILDING TO MEET EU 20-20-20 TARGETS

30 Oct > 1 Nov | 2013 | Guimarães | PORTUGAL

Editors
Luís Bragança
Manuel Pinheiro
Ricardo Mateus

Universidade do Minho

TÉCNICO LISBOA

iiSBE PORTUGAL

PORTUGAL SB13

CONTRIBUTION OF SUSTAINABLE BUILDING TO MEET EU 20-20-20 TARGETS

Organized by

iiSBE PORTUGAL

Universidade do Minho

Instituto Superior Técnico

Partners

iiSBE

cib

UNEP

FIDIC

PORTUGAL SB13

CONTRIBUTION OF SUSTAINABLE BUILDING TO MEET EU 20-20-20 TARGETS

Editors

Luís Bragança

Manuel Pinheiro

Ricardo Mateus

ISBN 978-989-96543-7-2

Printed by Multicomp

1st edition, October 2013

Legal Dep. 365726/13

Foreword

The international conference Portugal SB13 is organized by the University of Minho, the Technical University of Lisbon and the Portuguese Chapter of the International Initiative for a Sustainable Built Environment in Guimarães, Portugal, from the 30th of October till the 1st of November 2013.

This conference is included in the Sustainable Building Conference Series 2013-2014 (SB13-14) that are being organized all over the world. The event is supported by high prestige partners, such as the International Council for Research and Innovation in Building and Construction (CIB), the United Nations Environment Programme (UNEP), the International Federation of Consulting Engineers (FIDIC) and the International Initiative for a Sustainable Built Environment (iiSBE).

Portugal SB13 is focused on the theme “Sustainable Building Contribution to Achieve the European Union 20-20-20 Targets”. These targets, known as the “EU 20-20-20” targets, set three key objectives for 2020:

- A 20% reduction in EU greenhouse gas emissions from 1990 levels;
- Raising the share of EU energy consumption produced from renewable resources to 20%;
- A 20% improvement in the EU's energy efficiency.

Building sector uses about 40% of global energy, 25% of global water, 40% of global resources and emit approximately 1/3 of the global greenhouse gas emissions (the largest contributor). Residential and commercial buildings consume approximately 60% of the world’s electricity. Existing buildings represent significant energy saving opportunities because their performance level is frequently far below the current efficiency potentials. Energy consumption in buildings can be reduced by 30 to 80% using proven and commercially available technologies. Investment in building energy efficiency is accompanied by significant direct and indirect savings, which help offset incremental costs, providing a short return on investment period. Therefore, buildings offer the greatest potential for achieving significant greenhouse gas emission reductions, at least cost, in developed and developing countries.

On the other hand, there are many more issues related to the sustainability of the built environment than energy. The building sector is responsible for creating, modifying and improving the living environment of the humanity. Construction and buildings have considerable environmental impacts, consuming a significant proportion of limited resources of the planet including raw material, water, land and, of course, energy. The building sector is estimated to be worth 10% of global GDP (5.5 trillion EUR) and employs 111 million people. In developing countries, new sustainable construction opens enormous opportunities because of the population growth and the increasing prosperity, which stimulate the urbanization and the construction activities representing up to 40% of GDP. Therefore, building sustainably will result in healthier and more productive environments.

The sustainability of the built environment, the construction industry and the related activities are a pressing issue facing all stakeholders in order to promote the Sustainable Development.

The Portugal SB13 conference topics cover a wide range of up-to-date issues and the contributions received from the delegates reflect critical research and the best available practices in the Sustainable Building field. The issues presented include:

- Nearly Zero Energy Buildings
- Policies for Sustainable Construction
- High Performance Sustainable Building Solutions
- Design and Technologies for Energy Efficiency

- Innovative Construction Systems
- Building Sustainability Assessment Tools
- Renovation and Retrofitting
- Eco-Efficient Materials and Technologies
- Urban Regeneration
- Design for Life Cycle and Reuse
- LCA of sustainable materials and technologies

All the articles selected for presentation at the conference and published in these Proceedings, went through a refereed review process and were evaluated by, at least, two reviewers.

The Organizers want to thank all the authors who have contributed with papers for publication in the proceedings and to all reviewers, whose efforts and hard work secured the high quality of all contributions to this conference.

A special gratitude is also addressed to Eng. José Amarílio Barbosa and to Eng. Catarina Araújo that coordinated the Secretariat of the Conference.

Finally, Portugal SB13 wants to address a special thank to CIB, UNEP, FIDIC and iiSBE for their support and wish great success for all the other SB13 events that are taking place all over the world.

The Organizers
Luis Bragança – University of Minho
Manuel Pinheiro – IST - Tecnico of Lisbon University
Ricardo Mateus – iiSBE Portugal

Scientific Committee

Contents

Chapter 6: Building Sustainability Assessment Tools

Chapter 7: Renovation and Retrofitting

Chapter 8: Eco-Efficient Materials and Technologies

Chapter 9: Urban Regeneration

Chapter 10: Design for Life Cycle and Reuse

Chapter 11: LCA of sustainable materials and technologies

Chapter 12: Thematic Session - Smart Regions: which strategies?

Bioclimatic Solutions Existing in Vernacular Architecture Rehabilitation Techniques

Débora Ferreira, Eduarda Luso, Sílvia Fernandes, Jorge Vaz, Carlos Moreno
Instituto Politécnico de Bragança, Escola Superior de Tecnologia e de Gestão
debora@ipb.pt, eduarda@ipb.pt, silvia@ipb.pt, jvf@ipb.pt, c-moreno@ipb.pt

Rafael Correia
Câmara Municipal de Bragança
rcorreia@cm-braganca.pt

ABSTRACT: The traditional architecture is founded as a defining element of the identity of a region, and its essence should be preserved and conserved by means of maintenance and recovery actions. Thus, the best solutions and proposals for intervention should be looked for but this doesn’t imply a back to back innovation and at construction progress.
This work includes the description of techniques for maintenance and conservation of bioclimatic solutions found and inventoried in the north of the Iberian Peninsula, with special focus on a unique bioclimatic solution known as Sunspace, whose main advantage is to contribute significantly to the improvement of the thermal performance of buildings. It is also important to recover the historical heritage in a sustainable manner, allowing it to become an engine of development for both urban and small rural centres that exist in the periphery of the bigger cities.

1 INTRODUCTION

Popular wisdom related to the construction is a huge legacy in the history of vernacular architecture. The culture, history and traditions of the people of each region were continuously portrayed in buildings that are today part of our beautiful landscapes, constituting a heritage that needs to be preserved and appreciated.

The vernacular architecture has instinctively developed bioclimatic concepts that are nowadays scientifically valid. Given the lack of resources, the simplicity combined to the rationality has resulted in the application of techniques and solutions which, although rudimentary, maximize the use of materials and available energy. The adaptation to local environmental conditions implied that buildings have assumed an identity that characterizes the architectural image of each region.

The use of basic materials like wood, earth and stone has evolved to more complex solutions built with huge negative impacts on the environment. In recent decades, the sustainable construction concept has been developed based on the principles of recycling and maximizing resources, protecting and stimulating the creation of healthy environment which therefore lead to the reduction of the environmental impact of the construction sector. In order to support the agents in the construction sector, research projects and knowledge transmission on sustainable development construction have been carried on.

This work is part of the BIOURB project, a cross-border project between Portugal and Spain, which intended to contribute to the change of the current constructive model toward a more sustainable bioclimatic model, both environmentally and economically, reducing the energy consumption of buildings and raising the value of bioclimatic heritage along the border. In order to achieve the study a survey has previously been conducted on the bioclimatic solutions along the boundary, more specifically between the areas covered by the municipalities of

Bragança, Miranda do Douro, Vimioso, Mogadouro, Salamanca, Zamora and, in particular, areas of the natural parks of "*Los Arribes del Duero*" and "*El Sayago*".

2 IDENTIFICATION AND DESCRIPTION OF BIOCLIMATIC SOLUTIONS FOUND IN THE REGION

In the context of the assessment of regional bioclimatic solutions, the most prevalent were identified as:

i) The inertia wall, term usually used to describe the walls of high thermal mass, in which the most common material used for its construction was for many centuries the stone shale and granite and, to a lesser extent, the adobe. The construction system of the walls was greatly influenced by the local material available and the resources of the owners themselves. These walls of large thickness, in addition to transmitting stability and protection of buildings against water, acoustic insulation capabilities, also have greatly contributed to the temperature equilibrium within their areas;

ii) Gable roof, tile roofing, with the largest dimension oriented south and the smaller to north. The non-habitable attics have the particularity of effecting climate control in a passive way. In winter the stored products (crops, grass and agricultural tools) are used as heat accumulators, helping to warm up the living spaces and, in summer, so as to avoid overheating, there is natural ventilation through openings on opposite sides. The clay tile is the most widely used coating material having excellent characteristics, adapting well to the structure of light wood stand, with emphasis on resistance to temperature variations, low weight, durability, low water permeability and high mechanical strength. In colder regions, for the sake of ease in obtaining material, slate tiles are placed in the form of irregular pieces, arranged over each other;

iii) The green wall, a living system that provides a bioclimatic solution where vegetation plays the key role, contributing significantly to the preservation of biodiversity. In addition to creating enjoyable spaces that offer pleasant comfort sensations, through the effect of regulating the climate, temperature, humidity, wind moderation, it also refreshes and purifies the environment. The use of plant species on walls of buildings, often climbing deciduous or evergreen vegetation and ornamental plants that meet all or part of the facade, is a very old habit. Some of the traditional walls incorporate a support system (corbels) on the masonry, which serves as a guide for plant growth above the roofs, making the vegetation an integrated element of the building envelope;

iv) The transition oriented spaces such as balconies, porches and terraces were designed for people to enjoy the environment without leaving home, being often leisure spaces helpful to interaction between families and friends. Regardless of the main function, all these elements are spaces of integration with the environment and climatic attenuators, contributing greatly to the regularization of the temperature differences between the outside and inside. In addition, some of these solutions allow to differentiate the buildings assuming an identity by incorporating stone or wood elements with some ornamental details;

v) The geothermal climatization is based on the utilization of the thermal characteristics of the subsoil. Superficial layers of the subsurface retains a considerable amount of energy that the sun is responsible for renewing daily, and have the particularity to present temperatures that are constant throughout the year as well as heat increases with depth. This bioclimatic solution is reflected almost everywhere in buried building, defining spaces dug in the earth or rock, sometimes very rough with no natural light, that were the most often used for preserving food and wine. In *"Los Arribes del Duero"*, Spain, a region strongly influenced by the winery activity, one can observe spaces excavated in rock at a depth of 5-6 m (*bodegas*), which are still being used as touristic sites due to its typical characteristics;

vi) Green roof, is not as frequent as other bioclimatic solutions, but have been found in some 3000 years old constructions that are currently being used by shepherds and farmers as shelter and protection from the weather and for collection or storage of tools, agricultural implements and supplies. Such constructions are integrated in the space and merge with the landscape. Paraments have irregular masonry and the roof top is composed of slabs and piled rubble. The coverage has land and vegetation, consisting of local species such as moss and small herbs;

vii) The evaporative cooling process consists of the evaporation of water leading to a cooling of the environment. This strategy allows for air cooling before entering the building, and is related to Green Walls, Green Roofs, and with air/water exchange ducts. The outer traditional paving consisting of rock and soil also have the property to improve the microclimate regulating the hygrothermal stability in comparison with current airtight and waterproof solutions. In the Spanish region of *Fermoselle* and *Sayago*, there is a system of excavated cellars interconnected by a serie of ducts allowing the drainage of water that come both from ground infiltration and from wineries washing. These ducts serve simultaneously as a ventilation system. In summer, the air that enters from the outside through openings circulates through the ducts in which water circulates in the opposite direction causing cooling by mean of water evaporation, refreshing the upper spaces (usually housing);

viii) The Sunspace is a bioclimatic solution very characteristic of the traditional houses, mainly chosen in order to improve the comfort of the interior spaces, providing spaces for true pleasure.

Figure 1. Gable roof on capture coverage in *Rio de Onor*, Portugal

Figure 2. Green wall support system (corbels) on the masonry in *Fariza* de *Sayago*, Spain

Figure 3. A transition oriented space in *Cova de Lua*, Portugal

Figure 4. The geothermal climatization (Bodegas) in *Fermoselle*, Spain

3 BIOCLIMATIC SOLUTION – SUNSPACE

3.1 *First Approach*

Based on the above described solutions, characterization (types, ages, materials, building systems and their singularities) and survey of major anomalies have been carried on. For each bioclimatic solution, intervention proposals were drawn whether in favour of preservation and conservation than of rehabilitation and construction, ensuring and maximizing the potential of bioclimatic principles which govern the solutions. These principles of bioclimatic architecture aim to adapt the building to the local climate and the adoption of a set of practices and techniques based on the use of natural and local resources, minimizing both energy consumption and environmental impact. They also have the objective of optimizing the comfort and health conditions of users. The main conclusions of the work conducted on the Sunspace, which is one of the bioclimatic solutions more widely spread in the study area, are presented below.

3.2 *Identification and singularities of the constructive system*

The sunspace is a passive solar capturing solution, constituting an attached space in the building envelope, most often with direct connection to the living spaces. It's made of glass and has the main advantage of contributing to the greenhouse effect. In traditional houses, the sunspace and the interior spaces are generally separated by walls of high thermal mass, whose main characteristic is to absorb the solar radiation during the day, releasing it slowly to the interior during the night, reducing the daily temperature range inside buildings. In summer, in order to reduce heat gains, i.e. the amount of solar energy that focuses the glass surface, shading provided by the eaves of the roof or by deciduous trees is cleverly exploited. In addition to the thermal benefits, the Sunspaces are also decorative elements of the spans, contributing to the aesthetic composition of the facades, embellishing them and giving distinctive traces to each building. From the analysis of the different types of Sunspaces, from the simplest to the most elaborated, it can be concluded that these are harmoniously integrated into the design of the elevations, mirroring the image of the whole building and also the owner's economic capacity at the time of its construction. Furthermore, valuable information about the construction period can be obtained through the range of shapes, dimensions and proportions of the Sunspace. The majority of the Sunspaces present a wood and glass window frame, with or without exterior occlusion devices such as shutters or blinds. In the majority of the buildings, the sash windows incorporated in Sunspace are very characteristic of the Portuguese region while in the Spanish region, in addition to the use of wood, quite worked wrought iron was often used defining a very particular image of these buildings and featuring different epoch of construction. The ironwork is related to recent constructions from the late nineteenth century, in which they wore floral shapes and wavy, harmoniously worked, which expresses a clear aesthetics intention. The analysed Sunspaces are often located in an intermediate floor protruding out of the plane of the façade and, in many cases, they have their own roofing.

Figure 5. Ironwork Sunspace in *Ledesma*, Spain

Figure 6. Wood Sunspace in *Gáname*, Spain

3.3 *Identified Anomalies and Proposals for Conservation and Preservation*

The most frequent pathologies that occur in observed Sunspaces are entirely due to the employed materials associated to the lack of maintenance, the action of moisture and own aging and degradation of materials. It is worth to note that these elements are particularly sensitive because of their location in the building, subjected to a direct exposure to the sun which is more intense in areas oriented to the south and west, as well as to the action of rain and wind. In the case of Sunspaces composed of wooden structure, the atmospheric and biological agents are primarily responsible for the change in strength and the appearance of pathologies in the woods, including deterioration due to insect attack, the existence of warping and excessive clearances in the mobile joints, the reduction of active section and decay due to fungal attack (rottenness), and pronounced cracking due to insufficient or deteriorated surface treatment which do not effectively protects wood against ultraviolet rays. In the case of Sunspaces composed of wrought iron structure, primarily responsible for degradation are weathering and the action of moisture causing corrosion. In the case of metals, corrosion consists generally in the oxidation that causes delamination and reduction of cross section, thereby reducing the strength of the elements. Furthermore, gaps between metal frame and glass as well as loss of alignment (warping) have been detected due to lack of maintenance and/or excessive pressure exerted on the Sunspace (metal expansion due thermal or oxidation factors). We also found some examples painted with various coating shades. The paint is a coating material responsible for the protection of thermal fluctuations throughout the year. The painting system also provides a barrier effect which is to hinder the penetration of aggressive agents into the metal or the wood. Thus, in order to prevent rapid weakening of these structures, the factors responsible for the deterioration of the painting should be quickly corrected through maintenance work. Among the unconformities of the paint attention should be given to the deterioration of painting both in the inside and on the outside with peeling of the paint owing to moisture condensation which penetrates beneath the layer of paint, cracking and wrinkling due to the existence of several layers of paint and/or incompatible paint, spraying, presence of cracks due to the existence of moisture in the wood, infiltration, poor adhesion to the last coat of paint and eventually the accumulation of corrosion products in metal/paint interface.

Finally, there are anomalies common to both types of used materials, namely: the degradation of locks and ironmonger due to the usage and existence of moisture which leads to the oxidation of metallic elements, compromising the tightness and the consequent deterioration of wood; clearances between the ironmonger and the wood due to insufficient maintenance; fracture of glass or transparent plastic films as a result of the existence of actions of different sources such as accidental shocks, structural movements of the walls, ageing of the materials and sealing glass (putty or fillers) due to the continuous action of atmospheric agents. In both cases, the analysis of the preservation state of these elements must be carried out by a proper and careful visual and functional inspection. The maintenance works required for conservation and repair naturally depend on this analysis and on the degree of deterioration. Regarding wooden Sunspace, the "minor repairs" include small repair work on damaged areas, removal of deteriorated paint and surface preparation for application of new decorative painting, with characteristics appropriated to the timber protection. This work may also include the removal and replacement of windows and ironmongery as well as disinfestation by mean of applying toxic injection, spraying or brushing.

Concerning the wrought iron Sunspaces, the "minor repairs" include small repair work on damaged areas and local replacement, including substitution of sealing profiles, glass, sealants, screws and ironmongery in general. Cleaning, stripping, preparation and repainting with an anticorrosive paint scheme can also be considered. Wherever possible, the techniques and materials used in repair of any metallic element of this type of old buildings must be the same as those used in the original construction. This aspect can bring some restrictions in terms of techniques and materials to use. In more serious damage situations it can be necessary to perform a partial replacement of parts with a new material or a total replacement, keeping the original element design.

3.4 *The Traditional Architecture: an inspiration for the future*

Nowadays, with the limited resources of fossil energy and the environmental impact of buildings both due to excessive use of materials or to the resultant waste and pollution, it becomes imperative to heed the techniques and solutions that previous generations have adopted, identifying their strengths. The idea is not to copy ancient designs and solutions, but rather to take these principles for integration in current architecture.

Incorporating a Sunspace into a building as a bioclimatic solution has benefits both in rehabilitation and in new construction. The main guidelines for the implementation of Sunspaces are presented below:

- The Sunspace should be build-up on the facade facing south in order to maximize the capture of solar radiation (orientation with variation of up to 30° to the south orientation will have 90% of the maximum heat utilization);
- Glass surfaces oriented east and west should be minimized because they receive slight thermal energy by radiation in winter (resulting in negligible thermal gains), and cause overheating in summer whenever glass surfaces have not occlusion devices such as shutters or blinds. The north-oriented glass surfaces should be avoided since a more favourable improvement of the thermal performance of the building facades can be achieved by adopting isolation and without fenestration;
- Between the Sunspace and other usable spaces, a wall with high thermal mass should be placed in order to absorb the solar radiation that can be later transmitted to the interior. The wall colour influences its storage capacity as dark colours absorb more heat energy;
- The glass surface can be designed so as to have some inclination towards greater caption of solar gains; however, this solution requires additional cares like the strength against atmospheric agents (snowfall, hail), the greater complexity in placement and operation of shading devices, and the difficulty of cleaning access;
- In cold climates such as the one in current study it is advisable to use double glazing in order to reduce heat loss as well as to contributing to sound insulation. To preserve existing window frames one should take into consideration the thickness of the frame which may constrain the use of double glazing. Rubber seals and coating, mastics and masses can be employed in order to improve performance and durability at critical points;
- The dimensions of the glass must be made compatible with its thickness, as it is a brittle material;
- Exterior occlusion devices (such as shutters) must be placed so as to minimize heat losses during the night and to prevent overheating during the summer;
- Possible shading due to neighbouring buildings or other elements must be taken into account;
- Adjustable or mobile thermal insulation of the area surrounding the Sunspace must be considered so that the different needs of heating and cooling both in winter and summer can be optimized;
- Controlled ventilation should be provided in order to avoid condensation. In case of heat transmission by convection, the openings have to be strategically placed. Warm air enters the building through openings placed at the upper parts of the walls while interior cold air is expelled to the Sunspace through openings placed at the bottom of the walls;
- Ecological footprint of employed materials should be taken into account. For instance, wood has the advantage of being a natural element available in the region, also advisable because of its low thermal conductivity (low ability to conduct heat). A wall made of stone, which is an abundant resource in the region, is a good solution due to its large mass and hence thermal inertia;
- The system idealization should take into account the dismantling and end-of-life regarding subsequent reuse of materials.

4 CONCLUSIONS

Current work, which is part of the BIOURB project study, has as its main objectives the processing of information on the biodiversity of the region as well as establishing constructive proposals intended for conservation and rehabilitation. The purpose is to assist the various stakeholders in the construction process in the decision-making related to intervention in the built environment, aiming to enhance both cultural heritage and environmental sustainability. This sort of work should be helpful in order to respond to European and international commitments regarding climate changes, and reduction of the consumption of fossil energy.

REFERENCES

Araujo, L. & Almeida, M. (2006). Thermal Inertia Walls in Portuguese Traditional Rock for Passive Solar Heating of Building, Climated Congress, Lyon, France.

Braz, R.; Lanham, A. & Gama, P. (2004). Arquitectura Bioclimática, Perspectivas de inovação e futuro, seminários de inovação, IST-Universidade Técnica de Lisboa

Gomes, A. (2009). Janelas e portadas históricas - História, desempenho, reparação e conservação, Tese de Mestrado, UTAD

Gonçalves, H. (1997). Edifícios solares passivos em Portugal, INETI

Gonçalves, H. & Graça, J. (2004). Conceitos Bioclimáticos para os Edifícios em Portugal, DGGE / IP-3E, Lisboa

Lopes, N. (2006). Reabilitação de caixilharias de madeira em edifícios do século XIX e início do século XX, Tese de Mestrado, FEUP

Mendonça, P. (2005). Habitar sob uma segunda pele - Estratégias para a redução do Impacto Ambiental de Construções Solares Passivas em Climas Temperados, tese de Doutoramento em Engenharia Civil, Universidade do Minho

Olgyay, V. (1998). Arquitectura y Clima - Manual de Diseño Bioclimático para Arquitectos, Barcelona: Editorial Gustavo Gili.

Santos, A. (2012). Sistema de inspeção e diagnóstico de caixilharias. Tese de Mestrado, IST

http://www.biourb.net/

http://www.sostenibilidad-es.org/

http://5cidade.files.wordpress.com/2008/04/reparacao-de-janelas-em-madeira.pdf

Universidade do Minho

TÉCNICO LISBOA

iiSBE PORTUGAL

ISBN 978-989-96543-7-2

design: mª fátima castro