ARCHITECTURE: THE ART OF INTEGRATION

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ABSTRACT

Bioclimatic Technologies and sustainable design approach can be applied in the transformation of the natural and built environment at any operational scale.

The application of bioclimatic technologies must complete with the conditions of the environment, in relation to the prevalent objectives to be achieved, such reduction of energy consumption, improving both winter and summer comfort, improving visual comfort and natural lighting, indoor comfort and indoor air quality, as well the sustainable use of water resources and the integration of Renewable Energies in buildings.

Appropriate building envelope remains the main strategy for sustainable design, but in the mild temperate/mesothermal climates, the rapid changing of outdoor conditions push toward a dynamic response of envelope parameters to allow the maintenance of interior good adaptive comfort.

To achieve the reduction of energy consumption both in new and existing buildings, we need the integration among mechanical, architectural and structural approach for a sustainable design approach.

Sustainable architecture in Mediterranean area meets its roots in traditional culture and the education of architects and engineers in this part of the world should be aimed to develop a sustainable approach to design, through the understanding of the evolution of the architectural technology and local cultural influences with new models (systems approach, holistic view of the project).

Key words: Sustainability, Technology, Energy, Retrofitting, Integration

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1. INTRODUCTION

Building components, construction tools and know how did not change a lot during many centuries while architects and craftsmen shared similar knowledge how to rise buildings and the local society identified itself in the same architectural culture.
With the beginning of last century the rapid growing of new materials, competencies and energy sources, brought industrial revolution, markets globalization and the rapid spreading and contamination of different cultures through the world.
The new scenario deeply modified traditional design approach and local building technology and now architects and engineers have at their disposal a large number of construction systems, building materials and energy choices that allow them to overcome nearly any problems, with the dangerous feeling that only economical issue and aesthetic inspiration are the criteria to achieve success.
But in the last two decade, a new general concern developed and soon has became a great ethic approach in every field, up to be recognized as the international global paradigm that will mark our century: the need to pursue a sustainable future as strategy that can be applied in every activity aimed to modifies and transform our world.
The growing of construction market, the rapid transformation of our cities and villages, need new rules and limits, benchmarks and certification to evaluate the results, guide lines to address planning and design activities.
The holistic approach in architecture means the art of integration different competencies, technologies and materials, to meet project requirements with a sustainable strategy.

2. "BIOCLIMATIC TECHNOLOGIES"

They are the set of strategies of design and construction, through which it seeks to achieve the realization of a sustainable architecture, an architecture that using its formal configuration, technologies, components, materials and equipment, try to establish an optimal relationship with the surrounding environment so as to reduce energy consumption and provide the best comfort to the occupants, using as far as possible natural systems and reducing the use of mechanical systems of the building.

This design approach can applied in the transformation of the natural and built environment at different operational scales: from the size of regional and urban planning to town and district design, architectural concept, building detailed design, mechanical plant, up to the choice of building component and to sustainable building materials and even applied to rules setting and post realization management.

Definition of "bioclimatic technologies" can be misleading because it does not constitute an independent category of technologies applied to construction, but are the result of a more comprehensive, holistic approach that involves all issues related to sustainability, and in this meaning includes both the reduction of impacts on the

environment, the amount of energy contained in the components (embodied energy), the evaluation of their active role in the life of the building, until the final disposal (life cycle analysis).
However, there is a tendency to define "bioclimatic technologies" some applications where the aims to pursue bioclimatic architecture is more relevant, and these technologies are mainly related to the building envelope, such as ventilated roof or façade, winter garden, solar shading systems, light chimneys, ventilation towers, and so on, but the concept of "bioclimatic technology" must always be compared and validated by the analysis of its appropriateness with respect to the local context in which it is used, ie the climatic context and the specific environmental design intervention and not as a model or a fashion design.
For this reason, a bioclimatic technology that is properly applied in Berlin is certainly not very appropriate when applied in Dubai and vice versa.
The choice of appropriate technology may rise from the needs of the specific building under the current climatic condition.
A possible articulation of bioclimatic technologies in line with the conditions of the environment, could be made in relation to the prevalent objectives to be achieved.

2.1 Improving winter comfort and the reduction of energy consumption

1. use of solar energy and other renewable energy sources that may be available through use of the greenhouse effect: form of buildings, optimal orientation of the building, atriums, conservatories, windows to gain direct, skylights, solar panels,
2. reduction of heat loss through the thermal insulation of the building, dynamic insulation, controlled ventilation, heat recovery, thermal mass, phase change materials
3. optimization of heating systems through the selection of heat source (boiler, heat pump) and the supply network, choice and optimization of heat transfer to the environment (radiation systems, mixed with air) monitoring systems and optimized management of all systems (BEMS Building Energy Management System)

2.2 Improving summer comfort and the reduction of energy consumption

1. shielding of solar radiation, shading the building through the form, shading with vegetation, exterior screening fixed and mobile, pergolas, marquees, green roof
2. natural ventilation and internal exploitation of the prevailing winds, shape and arrangement of buildings, cross ventilation, chimneys and towers of ventilation, ventilation openings, design of fixtures, underground pipes, night ventilation (night cooling), mechanical ventilation inside
3. evaporative cooling: the use of vegetation, evaporative systems internal and external, capillary evaporation, fountains, ponds,
4. choice, color and exterior finish materials, reflective surfaces and non-absorbent wall panels and flooring
5. thermal mass and phase shift of the thermal wave, position of the thermal insulation, roof pond, ventilated roof, green roof

2.3 Improving visual comfort and natural lighting

1. shape and size of the windows, characteristics of the glasses, special glasses,

skylights in the roof, chimneys, light reflection systems, heliostats,
2. mobile screens, inner and outer reflective screens, shape of the ceilings and screens included in the IG,
3. choice, color and external finishing of materials, reflective surfaces and non-absorbent materials for internal and external
4. rational use of artificial lighting systems with the use of high output lamps, sensors and controls, use of LEDs, integration of artificial and natural light.

2.4 Improve indoor comfort and indoor air quality
1. natural ventilation and internal exploitation of the prevailing winds, shape and arrangement of buildings, cross ventilation, chimneys and towers of ventilation, ventilation openings, design of fixtures, internal mechanical ventilation, automatic controls for the management of various ventilation devices.

2.5 Improving the sustainable use of water resources
1. collect and use of rainwater for non-drinking use, indoor and outdoor
2. local management and treatment of wastewater with possible reuse, constructed wetlands, environmental accommodations neighborhood, controlled flow of water, rolling the surplus rainfall, use of vegetation to reduce the flow velocity.

Many of the technologies and strategies that can be applied to the building are potentially contradictory with each other, especially in temperate climates where we have opposite demands in winter and summer conditions, which may be overcame with compromise or compensatory strategies or better with the introduction of dynamic components able to modifies the performance of the building in relation to external conditions, with manual controls or equipped with sensors and automatic controls like BEMS (Building Energy Management System).

2.6 Integrating Renewable Energies in buildings
This aspect cannot be as additional strategy to apply in the building, but is an important issue to be considered from the very starting of the design process, not only for the relevant visual aspect that can badly impact with architecture, but also for the constrain and limit of integrating such technologies in the building.
Elements like thermal solar panels, photovoltaic elements (crystalline or amorphous) integrated into glazing, thin photostatic cladding integrated into building components, small wind mills, geothermal wheel, heat pumps, biomass boilers, fuel cells, and also the rationalization of combined energy use such cogeneration and trigeneration, which can make a contribution significant energy needs of a building, up to more recent effort to introduce small hydrogen fuel cells at building scale.

3. DYNAMIC BUILDING ENVELOPE

Appropriate building envelope remains the main strategy for sustainable design, but in the mild temperate/mesothermal climates, the rapid changing of outdoor conditions push toward a dynamic response of envelope parameters to allow the maintenance of interior good adaptive comfort.
Dynamic envelope of buildings, such "kinetic" facades that respond to outside conditions according to the needs of the people inside or the use of mechanical louvers is an ancient technology (IE. all the systems to control the window performances) has been applied in modern iconic architecture with the Arab Institute in Paris by Jean Nouvel where the southern façade is realized with hundreds of light-sensitive diaphragms that automatically regulated the amount of light entering the building and since that project in many other buildings, until the recent realization through the world such as:
Al Bahr Towers in Abu Dhabi
http://www.youtube.com/watch?v=RU7kXOR94qg
Design Hub, Melbourne
http://www.smh.com.au/entertainment/art-and-design/hub-has-designs-on-rmits-creative-types-20120921-26ceo.html
Center for Architecture, Science and Ecology, New York
http://www.case.rpi.edu/index.php

The traditional response of the windows components that characterizes the Mediterranean architecture has recently developed by the ABITA Centre to a new range of innovative facade modules and new materials able to play different roles and dynamic response to climate.

Building components refers to more familiar elements such as operable windows, controllable blinds, flexible furniture layout and spatial freedom. Due to the variation in personal requirements, it is easier to satisfy occupants in cellular buildings than open-plan office, but it is also found that people are much more tolerant of variation in environmental conditions (for example temperature), if they are close to a window. There is also growing evidence that the provision of good outdoor views affects the overall well-being of occupants which in turn influences their response to internal conditions in a positive way: this are the basic principles of "adaptive comfort" , that produced the "green building" fashion in UK and around the world. These issues are more familiar territory for the architect and can effect the design of the building from its first planning, to the detailed specification of elements and components.

A crucial point when integrating dynamic component systems in buildings is to define a control strategy that allows the use of solar gains during the heating period and provides acceptable thermal comfort conditions during the whole year. The risk of overheating the offices during the summer months is high when the design is not coupled properly with the strategy of the HVAC system.

Efficient control system needs to be applied to manage rapidly changing outside conditions. A successful application can only be achieved when the contributions of all the devices can be synchronized by an integral control system.

The control system of the "Passive climate system" of the building should be done according to the following principles:

The dynamic building components must be controlled by automatic systems, but the occupants must be able to influence everything, even if their intervention spoils energy, and in order to save energy, the control system must take the maximum advantage from the outside conditions before switches over to the air conditioning system. (A.H.C. van Paassen, 1995).

All the control system must be focused on the realization of the comfort with the lowest energy consumption and during the unoccupied period the control system is focused only on the energy saving, while during the occupied period must be focused on the comfort as well.

The control system has three tasks to fulfill with the use of the passive and active components: keep the right level of the temperature inside the building, supply sufficient amount of the ventilation air to the building and ensure the right amount of light inside the building.

The ABITA Research Centre of University of Florence has a long experience in the field and presents here a series of prototypes and new component able to modify their performances according occupants needs and outdoor conditions, but trying to integrate them into the contemporary architecture.The design approach focuses the goals of:
-Controls solar radiation (redirect, diffuse or reflect direct radiation)
-Controls air changes (natural and forced ventilation, heat exchangers)
-Reduces energy losses and recover the heat in ventilation
-Increases security and control in windows frame
-Integrates RE in facade components
-Increases the thermal mass of industrialized building envelope (PCM)
-Increases the overall prefabrication in buildings.
The development of new facade system has been developed under current project research ABITARE MEDITERRANEO and will be soon tested under a Test Cell realized in Engineering Campus of University of Florence.
The system guarantees a considerable energy saving in office building and high standardization. With the cooperation of local window assembler company has been

possible the realization of prototypes, and a real building integration with direct monitoring of the performances.
In the attach schemes, we present three innovative facade systems: a double skin dynamic facade; a facade whit heat exchanger and a facade with integration of TIM material and internal lighting shed.
http://www.centroabita.unifi.it/mdswitch.html
http://www.msaassociati.it/

integration of TIM materials (left) and heat exchanger (right).

Dynamic building envelope in the building of Technological Park in Lucca, 2013

PV integration in the south facade (above)

4. INTEGRATION OF MECHANICAL AND ARCHITECTURAL DESIGN

When two different interacting technologies are not homogeneous for scientific content, level of innovation and industrialization, generally the more evolved one tends to prevail in interaction and the decision-making.

But this does not apply in the building sector, in the relationship between the construction technology that is traditionally "conservative", and and the mechanical technology, that has developed to high level of innovation and industialization.
This diversity of technological level, led to a strict separation of competence and professional roles, which in fact has limited the interaction and reduced the area of dialogue between engineers and architects.
Often the architectural designer is only interested in the shape of the building and believes that its proper functioning from the point of view of comfort is delegated in full to the mechanical engineer, except for dicussing about the size of space where allocate the machinery.

If this picture of relations was certainly the prevailing until recently, today we are facing a renewed interest in looking for the better integration between architectural inputs and comfort of occupants that always existed in the history of architecture until the beginning the last century.
Interest in environmental issues, the spread of ecological awareness, and the need to achieve real energy savings, are bringing more and more architects to focus thir interest also in heating and cooling mechanical systems and several engineers to look for a better interaction with the architect to optimize the mechanical choices.

From a theoretical point of view, we can say that the building, if properly constructed, should play a primary role to achieve internal conditions of well-being (at least in the temperate climatic zones) and that the mechanical equipment should be designed to achieve its goals with the minimum energy consumption.
If we consider the different durability of the two technologies, we notice that traditional masonry construction system, and the culture of conservation and maintenance (most common in Europe) compared to the logic of the demolition and rebuilding (mainly in US), leads to a remarkable durability of building envelope compared to the rapid obsolescence of the mechanical components.

This different durability should make reflect that wrong decisions in design phase of the building affect a much longer period, while appropriate design solutions and investments in higher quality of construction are lasting in a longer period, allowing to spread the higher costs in more annuity.

In heating and cooling technology, the rapid growing of new components and materials brings more dynamism and innovation, while the lower durability of components leads to more frequent replacement during the life time of the building, with lower payback time.

The integration that today we are seeking between architectural and mechanical approach, is enhanced by "bioclimatic" architecture, the holistic concept where all components of the project are seen in relation to each other and in relation to the external environment including of course the mechanical components.
Better performance can be achieved in new buildings, where the integration between building components and mechanical systems brings maximum benefits, both in terms of cost and environmental comfort, but even in refurbishment and retrofitting of existing building there are interesting opportunity.

Retrofitting the existing building stock is a crucial challenge in Europe, where this sector is responsible for the highest energy consumption, and this market is rapidly increasing and stands at about 40% of the all construction work of European Union (source: DAEI Euroconstruct), while in Italy and France exceeded the new building market.
Residential construction absorb the largest part of retrofitting and if ten years ago, the building recovery weighed to 30% on demand for materials and construction products, today the figure stands at 50% and the trend is mainly represented by the urban construction realized from '50s and' 70s, (post war reconstruction).

The theme of the recovery of "modern architecture" in suburban areas is therefore one of the most topical issues at European level, also from economical point of view, since demolition and reconstruction of new buildings is a much more costly strategy than retrofitting.and restoring the quality of buildings according to the logic of environmentally friendly .
Rehabilitating energetically a building involves considerations, evaluations and different choices depending on many variables that characterize the specificity of the building: the age, the degree of conservation, the structural characteristics, the typology, the internal distribution, the different activities carried out in the building.
The analysis of the artifact in all its characteristics is thus the basis of any type of intervention; the designer will be faced with the constraints of various kinds (structural, regulatory, distributive, cultural) that limit the ability to change and adapt to the changing needs of the building both from the architectural point of view and from the mechanical one.
The maintenance operations are dues to normal deterioration of the different parts of the building, its technological systems in addition to the general aging process of the construction. There are also circumstances that pushe to intervent, such changes in the needs of users, progress and technological innovations that offer increasingly high standards of quality of life and work, and pushing for a continuous update.

In most cases, the intervention of renoval of existing buildings, is not directly related to the energy sector and any maintenance, rehabilitation or renovation of the building, offers a significant opportunity to operate also for the energy rehabilitation.

Intervents for energy retrofitting or improving energy efficiency, as part of a wider project of renewal or maintenance of the building, is a way to reduce the cost of individual measures and the time of return of the investment is lower, both for the normal maintenance operations and for those related to the energy efficiency, with increase in the convenience of the interventions.

In conclusion, the reduction of energy consumption, sustainable socio-economic development and the improvement of facilities in existing buildings, is strongly linked to the general process of urban renoval and maintenance of buildings and that these policies must be realized with the integration among mechanical, architectural and structural approach: the art of integration for a sustainable development of our cities and villages.

5. SUSTAINABLE ARCHITECTURE IN MEDITERRANEAN REGION

The Mediterranean area is today a central focus from the strategic viewpoint as union rather than competition bridge between Europe, Africa and Middle East, and needs a commun thinking about existing constructions and new construction policies in the different countries facing this sea. The reflection about present trends focus on the need of a cultural consciousness about the importance of safeguarding the built as well as the natural heritage, by means of sustainable development strategies.

There is a number of common architectural lines and engineering techniques in settlement organisation, established in the roots of Mediterranean traditional culture, and a number of similar principles in line with the sustainable development and ecological concern. Now we have the opportunity to deeply investigate so as to define a common strategy for the future of cities and villages.

As it is very well known, the amount of resources on our planet are going to be depleted very soon, and a large number of conferences, worldly summit and meetings in the high areas of government and management have been held during the last two decades around the themes of sustainable development, pointing out the need of moving our society towards a different economy and a different way of reflecting on the possible transformation of land and city. Such terms as “green economy”, “smart cities”, “emerging technologies” and others have been created so as to clarify the various opinions and movements which can help during the establishment of this new society.

Abitare Mediterraneo is an applied research project, sponsored by the Tuscany Region EU program FESR 2007-2013, developed by the University of Florence in synergy with some construction companies.

Project aim’s to realize an “Open System” to promote technological innovation and architectural quality in the construction process in order to encourage the development of building initiatives focused on high energy efficacy; the catalog of the “Open System” is a flexible tool dedicated to enterprises to promote innovative products in the Mediterranean Areas.

The research propose a formula to create a synergy between the research and production in the building sector and also involves a «construction model» to adopt for architecture in these kind of climates and it is dedicated to draftsmen and enterprises as a promotion tools supporting design and planning in the Mediterranean climate.

The purpose is to transform Tuscany into an International Laboratory for Research of high quality living in the Mediterranean area; develop analysis of Case Studies in order to promote the future of Environmental Sustainable Buildings, designed in the context of history, culture and Mediterranean climate. Key objective fosters the creation of a “Centre for Technological Competence” as a benchmark point for research, innovation and implementation of environmental sustainability, eco-efficiency, quality of life. Innovative results from Abitare Mediterraneo up to now has been the realization of:

• Test Cell - outdoor Laboratory for Thermal Dynamic behavior of façade components realized in Florence University , Engineering Department.

Prototypes of building components such:

• MIA - Temporary Living Module specific for Mediterranean climate

• Domino - Façade System that guarantees significant energy savings

• AIW - Facade System with an integrated heat exchanger

• Shading Screen -Innovative Ventilated Wall

6. CONCLUSION

6.1 University education and ABITA Master course

The education of the architect and the engineer should aim to develop a sustainable approach to design, through the understanding of the evolution of the architectural technology and cultural influences that new models (systems approach, holistic view of the project) resulted in the design synthesis. Energy issues and the concept of sustainability applied to the design changes at different scales require new tools for understanding and analysis that will be integrated with the traditional skills of the architect. In the universities the curricula of students should be aimed to achieve the means of ensuring the effective coherence between the cognitive phase and the project, to develop a sustainable design that manages to integrate the needs of the environment and the fulfillment of the objectives of the client.

The post graduate Master ABITA has been developed twelve years ago in University of Florence as a second level of training and as a response to the high interest expressed by administration and private developers for experts in management of natural resources and sustainable design.

As part of the general transformation process as implementation of the Kyoto Protocol, and the new legislation such as the European Directive on energy conservation in buildings, ministerial decrees on green certificates and licenses to energy saving, skills of the Master Bio-ecological Architecture and Technology Innovation for the Environment refer to the objective urgency to solve the energy problem in the field of architecture, in order to define a new professional with more specialized training and in all aspects of the building process, which integrates knowledge and the basic skills of planning and design acquired in university college courses.

The need for greater environmental sustainability and proper energy management requires a high quality of the planning process and land management and execution of the works on the basis of eco-friendly environment. The Master responds to the increasing need for new professionals with specific expertise in the field of innovative strategies for the deployment of renewable energy sources and their integration into the urban space.

The goal is to provide a high-level training than would generally be offered in the current context of teaching faculty of architecture and engineering, and to provide new inputs to stimulate the creativity of the designers of the City of Tomorrow: methods and operational tools for design of the built environment in a sustainable perspective. The training objective is therefore to define a cultural base capable of formulating and managing eco-design criteria through the identification of procedures and tools to determine methods of intervention and economic viability for both the new building and for the retrofit of existing stock, in terms of quality, environmental and energy performances.

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