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Implementing Bioclimatic Design in Sustainable Architectural Practice

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Abstract. **Today one of the topical issues in Latvia relates to the compliance of the architectural practice with the modern concept of sustainable development. Although the beginning of the first decade of the 21st century introduced positive ideas promoting energy efficient architecture in Latvia, the worldwide experience has shown that despite the importance of environmental ideas in designing, their introduction and implementation in practice often encounter problems. This article addresses a number of factors that should be taken into account introducing changes to the current practice of architectural design in line with the modern principles of sustainable development and bioclimatic design.**

Keywords: **architectural practice, bioclimatic design, sustainability.**

One of specific features of architect's profession is the necessity to combine technical areas, social sciences and arts into one inseparable unit. The change in public attitudes towards environmental values has led to reassessment of criteria for evaluating the end result of an architectural design, while computer technology has significantly altered the design process. This sets new requirements to the architect's professional qualification and training, giving to the concept of interdisciplinarity in the architect's profession a much wider perspective than before. Currently, the architectural practice in Latvia mostly focuses on energy efficiency goals in construction and evaluation methodology of the achieved results, almost disregarding the fact that certain changes need to be introduced in design process itself.

I. Relevance of Environmental Ideas in Modern Architectural Practice

Environmental issues became relevant in modern architecture around the middle of the 20th century when the public became increasingly aware of the adverse effects of technological innovations of the industrial era on the environment. In the 1960s, a new concept of bioclimatic design emerged involving the development of theoretical principles for ensuring favourable microclimatic conditions for human comfort by means of architectural and spatial elements. However, only the global energy crisis in 1973 became a crucial catalyst for introduction of changes in architectural design. Many countries introduced higher requirements to energy efficiency of buildings in their national laws and regulations. Separate attempts were made to design buildings where their internal microclimate would mainly depend on a proper spatial layout and appropriate use of building materials, not only on mechanical heating, ventilation and air conditioning systems. Since 1987 when the Brundtland Commission defined the strategy for sustainable development [1], the concept of 'sustainable architecture' has become increasingly popular representing the general inclination to integrate environmental values in architecture. However, due to a variety of interpretations of the notion, it failed to provide a sufficiently detailed picture of what exactly sustainable architecture should be. The 1990s marked a repaid increase of interest in environmental issues in various areas. In response to the change, the construction industry tried to modify production processes of building materials and some more amendments were made to the laws and regulations of many countries. In the late 1980s and early 1990s, a theoretical basis was developed for the building, whose heat loss was so minimal that the heat generated by household electrical equipment and residents, as well as the solar heat gain received through the windows provided the required comfort level [2]. The concept of the buildings was called a 'passive house', and the Passive House Institute in Darmstadt under the guidance of Dr. Wolfgang Feist still today is engaged in its development and promotion.

The amount of information available on the design of energy efficient buildings, especially passive buildings, is rapidly increasing in Latvia at the moment. The main focus, however, is on the result to be achieved in the design process that may be easily evaluated with a variety of tools, e.g., the BREEAM building assessment system, which is currently being adapted for Latvia and introduced by the agency Zaļās mājas (Green Houses) [3], or the passive house concept. Yet relatively less attention is devoted to the methodology of bioclimatic design and to the overall organisation of the architectural design process based on sustainable design principles.

II. Theory and Practice of Bioclimatic Design

The concept of bioclimatic architecture was first defined by the architect Victor Olgyay, when in 1963 he published the results of his studies in the book "Design with Climate: Bioclimatic Approach to Architectural Regionalism" [4]. The essence of bioclimatic design is to create a favourable microclimate both inside the building and outdoors through the application of architectural techniques. The studies produced comprehensive theoretical information about designing of the human-friendly spatial environment in different climatic regions and a design method, which employed a bioclimatic chart and determined comfort zones. According to Olgyay, the design process of bioclimatic architecture is linear and consists of four successive stages (Figure 1).

Later a number of other researchers undertook the further study of the bioclimatic design concept, among them B. Givoni in 1969 and S. Szokolay in 1986. The works produced by these authors shared a common feature as they all focused on the principles for determining comfort zones based on the average

Fig. 1. Bioclimatic design as a linear process (according to V. Olgyay [4, *11*])

monthly climate data (wind, humidity and temperature), using psychrometric charts as a methodological aid in designing [5, 6]. In 1971, C. Mahoney took a slightly different approach [7] proposing a design methodology that followed three stages of design elaboration (the idea-sketching phase, development of the design and detail drawings). The method was based on a successive climate analysis. There were altogether six charts, where the first four of them were intended for the input of climate data to make a comparison with the comfort zone, and the last two were used for reading the recommended design principles as regards the layout, orientation and shape of the building respecting the local climate conditions.

These studies formed an important basis for development of climate-appropriate and environmentally-balanced architectural design. Unfortunately, the methodology so thoroughly developed in the theory defied successful implementation in practice. Linearity and mathematical precision of such a design method contradict designing as a creative process. Not always the creative design can be viewed as a linear process; also the methods used in design elaboration are very different – sketching and modelling in a creative process and theoretical calculations of bioclimatic factors. Thus, as soon as personal computers were available in design industry, possible solutions to problems were sought in computer technology.

III. Bioclimatic Factors in the Computerised Design Environment

The first attempts to use computer software in the design process were based on simplified calculations of thermotechnical parameters of a building, whereas in the mid-1970s, attempts were made to imitate the actual thermophysical processes in buildings. However, the development level and availability of computer technologies at that time did not facilitate wider application of the results of theoretical research in architectural design practice. Development of studies and computer software as methodological aids for practising designers began only around the mid-1990s, though they still were used as separate tools rather than an instrument fully integrated in the existing design environment.

In the digital environment of architectural design, the transition from CAD (Computer Aided Design) to BIM (Building Information Modelling) started in the late 2010s and continues still today making it possible to apply bioclimatic design methods as part of the design process. Using the BIM concept, the design is mostly developed as a 3D model of the building where various parameters can be assigned to each element of the building, e.g., a material with specific physical characteristics can be selected. Spatial modelling, making of drawings and definition of physical parameters of the building take place simultaneously rendering unnecessary the use of different work methods for completion of different design tasks. It has allowed BIM to become a convenient platform forming an integrated environment of creative 3D designing and modelling of energy use of the building, where input and output of data take place in a format that is easy to use for architects.

All largest design software developers are gradually integrating tools required for the creation of sustainable architecture into parametric modelling software intended for architects.

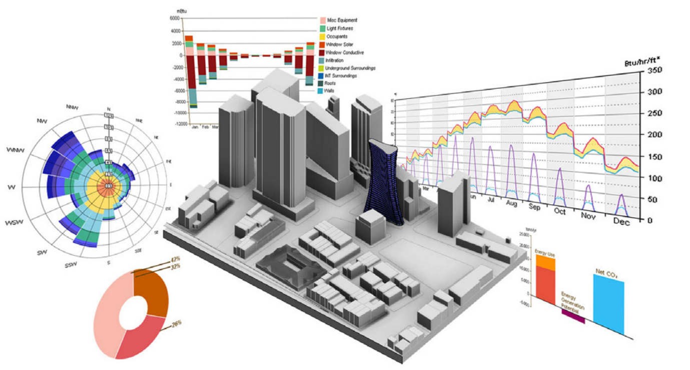

Fig. 2. Integrated environment for architectural modelling, rendering and energy analysis [8]

Options to analyse insolation, energy consumption, wind direction and other environmental factors, once offered only in a separate application Ecotect (the software for architects initially designed by architect Dr. Andrew J. Marsh) are now being integrated into the latest versions of Autodesk Revit software (Figure 2).

The company Graphisoft also follows the lead, including the function for simulation of energy and resource consumption of the building in the parametric modelling software ArchiCad that is purpose-built for architectural design. It allows architects to use the created spatial model of the building and climate data of the respective site available online to quickly determine energy consumption of the building.

Currently, one of the most popular 3D modelling tools is Sketchup; and although it does not perform BIM, being easy-to-use and freeware, it is convenient for creating 3D models of buildings. It also has the functions of free software EnergyPlus designed by the U.S. Department of Energy for architects, engineers and scientists, and available through OpenStudio plug-in. It allows performing computer simulations of energy consumption of buildings within the usual environment of digital architectural designing.

Overall, the theoretical and technical aspects of the bioclimatic design methodology have changed sufficiently to allow for wider application of the bioclimatic strategy in designing. The use of BIM software in sustainable architectural design ensures uninterrupted design process, where the software acts like an assistant in decision making at any design stage, but does not always render the understanding of theoretical principles of bioclimatic design. Integration of bioclimatic factors into the creative design process requires the architect to have a thorough knowledge in climatology, biology and thermal physics, and the ability to adequately interpret this information in different climate zones, integrate it into software-generated solutions of different levels, and also understand the interaction between climatic and natural conditions and different spatial forms. It requires changes in the existing design practice according to the national building standards and continuous improvement of architects' knowledge.

IV. Architects' Awareness of Bioclimatic Design and Principles of Sustainability

Although many architects regard saving of energy as a serious matter, only few of them apply principles of energy efficiency in design practice [9, *92*]. The reason why integration of principles of green thinking into design practice and education is so slow and inefficient [10, *12*] can be related to the fact that ideas of sustainability are disassociated from the actual design process. It is much more difficult for architects to integrate new techniques of bioclimatic design in the established “traditional” design practices, since bioclimatic design is sooner seen as a supplement to the traditional design practice than a design philosophy [11, *3763*]. Therefore, it is important to include aspects of bioclimatic design already in the early stages of architectural training. A comprehensive perception of bioclimatic and architectural 3D design should be developed as early as possible, when the young architect just starts developing his or her creative manner, style and understanding.

Over the past decade, universities worldwide have been looking for ways how to better integrate environmental issues into architectural education. Regardless of the region, the conclusion of all studies is the same: the lack of correlation between the subjects taught on bioclimatic design and the training in architectural design is the main obstacle preventing integration of bioclimatic principles into design and perception. The main problem pertains to the inability of students to understand the role of bioclimatic factors in designing if they are unable to experiment using a specific design and quickly see the impact of their decisions on the energy balance of the designed building [12]. The energy-saving issues should be integrated into the existing design-related subjects, since today environmental problems have become as essential in the design process as Vitruvius’ architectural values of *firmitas*, *utilitas*, *venustas*.

Conclusions

As regards education, significant measures are undertaken in Europe to improve training in sustainable architectural design. As regards methodology, development trends in the elaboration of methodological aspects of bioclimatic design show that the architectural 3D design based on bioclimatic principles is becoming increasingly convenient. The development of legislative framework and voluntary systems of building assessment in Latvia shows positive tendencies. Over the next years, more attention should be paid to architects’ understanding of the essence of sustainable design; also the significance of the integrity of ecological, aesthetic and technological aspects of design in architecture needs to be underlined. Surveys should be performed asking architects about the main obstacles to the promotion of sustainable design practice in Latvia in order to identify the main areas, where efforts should be concentrated to educate both professional architects and students.

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