

BEATA MAJERSKA-PALUBICKA*

NEW METHODS AND DESIGN TOOLS AS A BASIS FOR CREATING A SUSTAINABLE BUILT ENVIRONMENT

NOWE METODY I NARZĘDZIA PROJEKTOWE JAKO PODSTAWA KREOWANIA ZRÓWNOWAŻONEGO ŚRODOWISKA ZBUDOWANEGO

Abstract

Searching for harmony between a built and natural environment requires, quoting the demand of the National AIA Convention from 2011, “an innovative approach towards planning, designing and building as well as an evolutionary or revolutionary approach towards practice, cooperation and partnership”. It is possible by the Integrated Design Process (IDP) method, which involves clear specifying of: What (in the context of sustainable development), Who (in the context of team composition and cooperation between its members) and When (in the context of process stages completion) things should be done in the design process. The aim of the paper is to present: the method, basic principles of IDP implementation, co-operation in a team and crucial differences between IDP and the traditional design process, as well as an analysis of general rules to be observed by a design team.

Keywords: sustainable built environment, Integrated Design Process, digital design tools

Streszczenie

Poszukiwanie harmonii pomiędzy środowiskiem zbudowanym a środowiskiem naturalnym, cytując postulat Narodowej Konwencji AIA z 2011, wymaga: *innowacyjnego podejścia do planowania, projektowania i budowania, wraz z ewolucyjnym lub rewolucyjnym podejściem do praktyki, współpracy, partnerstwa*. Metodą, która to umożliwia, jest Zintegrowany Proces Projektowy (ZPP), który polega na jasnym sprecyzowaniu: Co (w kontekście zrównoważonego rozwoju), Kto (w kontekście składu i współpracy zespołu) i Kiedy (w kontekście etapów realizacji procesu) ma wykonać w trakcie procesu projektowego. Celem artykułu jest przedstawienie metody, podstawowych zasad wdrażania ZPP, współpracy w zespole i różnic pomiędzy ZPP a tradycyjnym procesem projektowym.

Słowa kluczowe: zrównoważone środowisko zbudowane, zintegrowany proces projektowy, cyfrowe narzędzia projektowe

* Ph.D. Eng. Arch. Beata Majerska-Palubicka, Faculty of Architecture, Silesian University of Technology.

1. Introduction. Sustainable design

The idea of sustainable development combines ecological, environmental, social and economic issues; it is also present in architectural design where sustainable development, quoting the words of prof. Barbara Jękot: “consists in finding appropriate means of expression – an architectural concept – while reasonably exploiting the resources and reclaiming degraded areas as well as following a direction of technological and institutional development which strengthens the current and future potential based on the needs of present and future generations. It requires intellect activation. Building/architecture and technologies must change the mentality of ‘nature transformation’ into “society transformation”, in which balance means a better quality of life and better mutual relations between the urbanized and natural environment” [3].

In order to achieve the aforesaid assumptions, it is necessary to re-evaluate design goals comprising of the requirements related to economy and ecology (promotion of innovative technologies, systems of exploitation, production, construction and utilization of facilities) as well as social needs; another important issue is reference to form and beauty, the elements without which we cannot talk about in architecture. According to Thomas Herzog: “Success in sustainable design depends on consumer properties, which can be summed up and defined as sustainable. However, beauty is as important as utility. Only beautiful buildings enrich our environment and should be protected. By way of example, introduction of technology based on renewable energy consumption provides a chance for creating new forms of architectural expression, which are closely related to local conditions, such as microclimate, topography, natural resources and cultural heritage of a given region” [7].

2. The Integrated Design Process (IDP) concept

Re-evaluation of design goals within the framework of sustainable design involves submitting and analysing a large number of criteria on the influence exerted by the built environment on the natural environment and man. It should be characterised by a holistic approach, expressed in the integration of environmental, social-cultural and spatial-technical issues. It is aided by the concept of gradual selection of design solutions, proposed by prof. A. Baranowski, which is based on ecological, economic, social and spatial criteria. [1] According to A. Baranowski: **ecological criteria**, which consist in eliminating the negative influence exerted on the natural environment, should be based on the use of economic and cultural solutions that are optimal in particular conditions, **economic criteria** should take into consideration an increase of investment expenditure compared to conventional solutions and return of additionally incurred costs at a given time, the aim of **social criteria** related to knowledge dissemination and education is to encourage the use of new technologies, whereas **spatial criteria** should promote renovation, modernization, revitalization of spatial structures and technological systems. For this reason, current designing becomes a more complex process than in previous years. Classic elements included in design are now subject to new requirements. Also completely new elements are emerging. Proper optimization of buildings’ energy, which is required in accordance with sustainable development assumptions, based on an **Life Cycle Analysis (LCA)**, cannot be conducted without

a comprehensive analysis of benefits, losses, causes and effects [4], and most importantly, without understanding the reasons for their occurrence. The above mentioned assumptions have a lot in common with the principle of sustainable design, based on understanding the following points, which have been presented by Samuel Mockbee from Auburn University [6]: **understanding the place**, as a basis for sustainable design, **understanding nature**, by finding one's own place in it, **understanding the environmental influence**, in the context of search for a balance between the destructive influence exerted by the building sector's activity on the environment and the activities aimed at neutralising such effects, as well as **understanding the people**, in the context of a broadly understood cultural heritage.

With such a wide range of activities and co-dependencies included in the concept of sustainable design, the previous inter-branch co-operation is no longer sufficient and does not ensure proper integration of teams and an optimal result in the form of an effective built environment. For this reason, in the 1990s the concept of **Integrated Design Process – IDP** was born. The aim of IDP is to construct a building and consequently, a built environment characterised by an effective use of energy as well as an optimal internal comfort and minimal influence on man and the natural environment. It is worth emphasising at this point the fact postulated by prof. A. Baranowski, that “an increasing variety of criteria for taking pro-ecological design decisions and many directions of activities in this field require a system approach, based on an acceptable hierarchy of values” [1].

IDP, as opposed to previous co-operation between branches, should be characterised by continuity and dynamics. It should consist in multi-criteria optimization of solutions and cannot finish when a building has been rendered for use. Co-operation of all members in a design team, starting with the early concept stage, through multi-stage verification of the assumed parameters and finishing with the final version of the design and a possibility to check the correctness of the adopted solutions in the process of **building monitoring**, is a novelty in the principles of co-operation and in the design process.

The concept, the technical and economic assumptions, the construction design, remaining the design process elements, are subject to formal and factual changes related to the necessity of adapting them to the principles of sustainability and **systems of buildings evaluation/certification**.

New procedures enabling the principles of sustainable development to be implemented in a built environment, require in the first place reevaluation of needs making their scope more realistic as well as adjusting to an economic and social context. This entails defining real “customized” assumptions as well as strategies and methods necessary to achieve the planned solutions (urban planning, architectural, building, constructional, technological, communications, energetic, social, economic etc.), which create a sustainable built environment, such as location requirements, Area Development Plan [2], legislative requirements and branch directives.

Optimization, understood as a choice of the most favourable solution with regard to the fulfilment of the adopted assumptions from among the analysed existing admissible solutions to the problem, becomes a vital element of IDP strategy. Continuous stimulation results in adopting more favourable materials, solutions and systems, which unfortunately are often more expensive than the typical ones. This increases the costs at a given stage, which according to design assumptions, are supposed to be offset in other stages owing to the effects achieved by using such solutions [4].

A broad, holistic approach being a part of IDP, requires crossing certain boundaries and going beyond certain habits. It necessitates the co-operation of interdisciplinary designer teams and is based on theoretical simulations as well as on studies conducted in the erected facilities, where apart from theoretically predictable correlations, one can also observe dependencies that cannot be forecast in theoretical considerations, as they result from dynamic, changeable conditions of the context and co-operation of elements combined at the site.

3. Integrated Design Team (IDT) and co-operation strategies

The process of designing invariably involves the co-operation of a specialist team whose composition is currently changed in accordance with IDT requirements. IDT assumptions can be professionally implemented (in terms of knowledge, experience and competence) in an optimal way if the composition of a classical design team is extended with new members and branches. Apart from architects, urban planners, constructors, installation designers, it should also include: a co-ordinator running the design process, a building evaluation/certification expert, energy simulation experts, digital design systems experts, clients and users, facility managers, building acceptance consultants and experts as well as specialists and experts in the area of monitoring and system integration, interior microclimate and natural lighting; finally, experts in the field of energy, environment (ecologists, biologists) and costs as well as service staff, equipment fitters and suppliers should be included in the design team [4, 5].

With such a large group of people involved in the process and the necessity of close co-operation, the following question comes to mind. How should one work in an IDT team to achieve an agreement and fulfill the goals set by IDT?

The basic pre-condition of integrated design process success, is being aware of the fact that each member of the team influences sustainability aspects and environmental effectiveness as well as establishing general principles of project implementation, which regulate such issues as **what, who, how and when** things should be done in order to achieve the planned goal. For this reason, members of a design team must feel collectively responsible. They should also be aware of differences in their preferences and be convinced of the results of research and negotiation methods; they should skilfully use IDP support tools, among others such as computer technologies, parametric, generative, commutative methods as well as BIM technological design and others.

An issue gaining considerable importance in IDP, is the collection of information regarding the building's behaviour when transfer of collected information is utilized for conceptual models of all design levels and its analysis and re-use as an experience gained on the basis of the effects of the previously adopted solutions.

Apart from team work, efficient functioning of advanced systems requires communication with external databases. In this case, support provided by digital programmes and technology is very helpful. When working on a common project, they can communicate via the net, where in the digital database environment, all information about the building is correlated. Co-ordination and transfer of data take place automatically, supported by digital programmes and technologies. Information processing during design works can be divided into three stages [8]:

- **data collection** – selection, sorting and comparison of data which determines boundary conditions, concerning the real and intellectual context of creative activities,
- **collaboration, information exchange** – dialogue with co-operating specialists, visualisation of dependences, explanation of codes characteristic of the branches,
- **model construction** – supporting the construction of the main model (BIM database) containing information on the geometry, technology, processes of erection, use and simulation of states.

The IDP standard enables all team members to participate in the design process and allows achieving comprehensive technical solutions at the conceptual stage. Creativity is the basic feature which should characterise IDP participants; everybody can make remarks and come up with proposals, but according to Thom Mayne, it is the architect who takes the final decisions.

The final, comprehensive design documentation (concept, design, completion, use) and conclusions on the important process points (simulations, decisions, monitoring of the building's effectiveness in use), containing data on the course of the design process, should be prepared and stored for further use and analysis, as an experience gained in the process, feedback information and as a "guidebook" for subsequent design tasks. In this case, an important issue is wide distribution of materials for didactic and informative purposes.

4. New design tools

The effectiveness of the exchange of information from various sources is currently a basis for the co-operation of design teams. All the stages: the recording of conceptual thought, the transfer of information and in consequence, interpretation, reading and understanding of solutions, are very important. The precision and clarity of recording, speed of transfer and information exchange are the most important, as they directly influence the reading, interpretation and understanding of solutions. The design method selection, depends on architects as in the case of Frank Gehry, starting with traditional methods (handwritten conceptual sketches) and finishing with advanced digital design techniques.

The designed buildings are more and more frequently treated as a set of information (data) which defines their particular constituents: construction, materials, functional-spatial solutions, equipment etc. For this reason, computer technologies, which enable the storage of a large amount of data and fast information exchange, are a useful design tool. It is the computers that have a huge potential enabling most innovative spatial visions to be realized, like e.g., Phare Tower in La Defense designed by Morphosis Thom Mayne – the winner of the Pritzker Prize 2005.

LEED evaluation systems, 3D database – driver BIM platform, Autodesk Revit, Graphisoft's ArchiCAD, Autodesk Architectural Desktop, Bentley Systems and other systems streamline the process of designing; architects can co-operate with constructors, mechanics and electricians achieving the highest efficiency and sustainability.

BIM – Building Information Modelling is a process enabling an extensive exchange of information, which includes: building information modelling, virtual presentation of a building, intelligent simulation of architecture, platform for information storage and exchange as well as a source of data on all the construction elements which can be used according to established principles.

The pioneer of BIM implementation is Frank Gehry and his co-workers from Gehry Partners LLP and Gehry Technologies. The systems they use, like CATIA and new Digital Project, are tools which enable an automatic co-ordination of information, access to an extensive database, high effectiveness in the process of designing and conducting of simulations and results analyses, and in consequence, the erection of buildings such as: Guggenheim Museum in Bilbao, Experience Music Project in Seattle or Walt Disney Concert Hall in Los Angeles.

By the process of solving design tasks in a virtual environment (simulations and analyses) aimed at determining optimal constructional solutions, the shape of the building can be assisted by the helpful tool of **parametric modelling**, which enables optimization of construction and building elements having very complicated geometrical shapes, and allows adopting effective, economically justified solutions.

In the case of co-operation with BIM, subsequent iterations, which involve changing the shape of a building due to subsequent corrections of relations between buildings and model points resulting from an analysis of strong and weak sides of the solution, can concern the whole database – construction, materials, physics of the building and economy. Thus the advantage of BIM over traditional methods of designing and creating drawing documentation on the design process, is based on the integration of information within one database (or different, but compatible databases) and the possibility to automatically identify the changes and evaluate the benefits and drawbacks. Moreover, the use of virtual 3D models reduces the time necessary for analysis and interpretation of two-dimensional drawings. Application of **BIM + parametric design** makes it possible to take conscious decisions on the basis of the results of numerous conducted analyses, allows checking a larger number of variants and reduces the working time.

In the future, traditional design methods will most probably be combined with advanced solution modelling techniques (3D) and tools for creating documentation (2D), as for example, the Guggenheim Museum in Bilbao by F. Gehry, using BIM.

The construction of **Swiss R3 Tower** at St. Mary Axe in London, designed by Norman Foster, in which the characteristic shape of the solid with an oval line of the projection of subsequent storeys generated on the basis of simulations and aerodynamic analyses of wind flows and air whirls, was supported by a group of architects, programmers and mathematicians: The Specialist Modelling Group, SMG. The team used Bentley Systems to conduct a quick analysis of design options, which owing to the parametric approach and interface scenario writing, are fast and suitable.

The design of the Swiss Re Tower x surrounded the office spaces with a glass coating having a smooth and free form, thus creating a building with an optimal microclimate. The double curved building, based on advanced digital technology, is an extension of ideas proposed in the 1970s, in B. Fuller's designs.

Swiss Re Tower consumes 50% less energy compared to a building having a similar capacity and function which has been designed with traditional methods. Energy benefits result from the use of natural air circulation for ventilation purposes owing to triangular atria (the shape and capacity calculated on the basis of iteration processes of parametric models), located spirally around the outline of the building. Benefits related to economic effectiveness result from simple repeatable elements: facade geometric optimization based on iteration processes and analyses, repeatable panels having a rhombic form.

The Olympic Stadium in Beijing, designed by the team of Herzog & De Meuron in co-operation with constructors from Ove Arup and Gehry Technologies, was based on construction optimization: a small number of typical repeatable modules and two types of connections determined on the basis of iteration analyses, form the base of the building structure, i.e. plate girders joined at the building site into pipes having a rectangular cross-section.

The glass roofing of the **British Museum** in London, designed by Foster & Partners in co-operation with The Specialist Modeling Group (SMG), which consists of a steel and glass structure network spread over a spacious courtyard, is one of the most interesting and subtle examples of using iteration processes in parametric modelling.

5. Conclusions

Observations of architecture in the last decade, allow to conclude that it is aimed at effectiveness and creating a healthy internal environment for residential and working purposes, which is achieved by integrating the design systems and methods with environmental control systems. The basic principle in IDP is the assumption of a sustainable design objective (objectives), based on experience and knowledge gained in previous designs, simulations, research as well as on evaluation and certification systems and the principle of assessing a building after its use has begun. Introduction of proper assumptions at the early conceptual stage is characterized by the highest effectiveness. The existence of new paradigms in architectural design resulting from IDP influences, need to support design processes with IT technologies – parametric, generative, additive, BIM and other.

Despite the fact that currently only a small number of architectural studios are implementing design support computer systems (Data – Driven Design), their application is already resulting in high effectiveness of designing. New tools enable management of design data and building information, ensure quick analysis of information and data as well as good communication within design teams.

A combination of sustainability, a highly effective design strategy and BIM modelling has a potential to bring about a considerable change in the profession and contribute a higher quality to the mainstream of architectural practice. The system of building evaluation and BIM remote platform (Autodesk Revit, Grahisoft's ArchiCAD, Autodesk Architectural Desktop, Bentley Systems) can ensure a better methodology in practice.

Computer technologies themselves are not a panacea, but when combined with tested sustainable design methods, they become an important tool that can be effectively used for creating a built environment and improving the methods of co-operation in design teams.

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