How to Design Buildings, Housing Estates and Towns So That Their Impact On the Environment Will Be Acceptable?

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Abstract. Currently, there is a tendency in architecture to search for solutions implementing the assumptions of the sustainable development paradigm. A number of them are components of architecture, which in the future will certainly affect urban planning and architecture to a much greater extent. On the one hand, an issue of great significance is the need to integrate sustainable system elements with the spatial structure of environmentally friendly architectural facilities and complexes and to determine their influence on design solutions as well as the implementation, operation and recycling, while on the other hand, it is very important to solve the problem of how to design buildings, housing estates and towns so that their impact on the environment will be acceptable, i.e. will not exceed the possibilities of natural environment regeneration and, how to cooperate in interdisciplinary design teams to reach an agreement and acceptance so as to achieve harmony between the built and natural environment, which is a basis of sustainable development. In this broad interdisciplinary context an increasing importance is being attached to design strategies, systems of evaluating designs and buildings as well as tools to support integrated activities in the field of architectural design. The above topics are the subject of research presented in this paper. The basic research aim of the paper is: to look for a current method of solving design tasks within the framework of Integrated Design Process (IDP) using modern design tools and technical possibilities, in the context of sustainable development imperative, including, the optimisation of IDP design strategies regarding the assumptions of conscious creation of sustainable built environment, adjusted to Polish conditions. As a case study used examples of Scandinavian housing settlements, sustainable in a broad context.

1. Introduction
The multi-aspect character of architecture in the context of sustainable development determines discussions on searching the ways to strike a balance between creative, aesthetic values, the recipient (man) and environment (urbanised and natural). The problem of shaping the built environment in equilibrium with nature, which would allow enjoying the achieved level of economic and social development as well as the comfort of living while maintaining the creative values has become one of the most difficult and complex tasks faced by the 21st-century architecture.

The questions are: What kind of contribution will architecture have in future life? Will it be a return to the roots combined with an attempt to reproduce the natural order or a continuation of the dynamic development while striving to achieve a balance between modern technologies and the quality of natural environment? If architecture fulfils the requirements of the sustainable development paradigm, will it develop in an evolutionary way, or quite the opposite?
Nowadays, despite increased ecological awareness and considerable progress in the field of sustainable development that is observed on nearly all the planes (social, economic, political), architecture is in most cases characterized by waste of natural resources (raw materials, areas, materials, energy). Progress of civilization and technology, striving for more and higher quality of life affected the content and form of the architecture of the 20th and 21th century. The situation in which the construction sector would be neutral in relation to the natural environment is unreachable. Alarming reports of environmental degradation by the construction industry gives a view of the scale of the threat environment and acknowledges the need to take all measures to minimize the level of interactions.

The scientific aim of the described researches is an attempt to determine the type and the scope of the impacts of the built environment on the natural environment. There is need to answer the questions: How to develop a design method that allows to determine the cause, type and extent of the impacts? Can we develop strategies to reduce the effects of interference?

As a research method, a systematic approach based on research and case studies, was adopted, extended of the literature studies and owns experiences (designing and teaching).

The result of the research is attempt to indicate the basic strategies for achieving environmental sustainability, which in the future could lead to the clarification of the sustainable strategies and short- and long-term actions.

2. The multi aspects of architecture

The paradigm of sustainable development concerns social life in general and realization of the importance of environment value, of which man is an essential element. In the architectural context this simply means creating a good space for living in a way that meets the expectations and gives a chance for the fulfilment of needs of both the current and future generations over a longer period of time.

The need to ensure an accessible and user-friendly environment, the infrastructure of which fits into the surroundings, is related to the wording contained in the preamble to the conference Environment and Development, reading as follows: “Human beings are in the centre of attention in the process of a lasting and sustainable development. They have a right to live in a healthy and creative way, in harmony with nature”[1]. With reference to urbanised space, two dimensions of implementing the sustainable development theory are worth highlighting – these are „natural ecology”, accentuating the quality of natural environment and public health, and “social ecology”, with an emphasis on the quality of the environment built by man, which allows creating a good space for people and human relations [2]. While taking into consideration the extremely important issues of architecture aesthetic aspect and importance in the culture and art of “new millennium”, we should perceive it holistically, through the prism of society (in the context of the development) and nature (in the context of the environmental effect), culture (in the context of the place and regional identity), science (in the context of the experience and knowledge) and economy (in the context of the effectiveness) [3]. It is showed on the figure 1.

When attempting to present multifaceted of sustainable architecture, in the context of the objectives of Agenda 21 "Sustainable buildings"1, it is necessary to notice that building should be designed, constructed, operated and utilized on the basis of a holistic approach, in the activities of construction works in accordance with the principle of triple responsibility, covering three aspects: environmental/ecological, economical and social - figure 2.

- **Environmental aspect**, taking into account forecasts of influence exerted by the designed investments (spatial economy, planning, architecture, building) on natural environment. Attention should be focused on consumption reduction, erection of structures corresponding to users’ needs, the use of local materials, recyclable raw materials, waste processing and reduction of environment pollution. In Poland one of the basic tools of environment protection management in development processes is *Evaluation of Environmental Impact*, which consists in checking
whether an investment has been designed in an optimal way and whether the benefits resulting from its implementation offset the losses in natural and social environment; compare with the concepts of providing a basis for lasting development [4].

- **Economical aspect** taking into account an evaluation and optimisation of the building life cycle, which has an impact on economic development. An assessment should include manufacturing costs, the costs of erection, utilisation and demolishing or adaptation of buildings, the income generated in the process of using the buildings and their stable value throughout the cycle of life as well as building an environment in accordance with the principle of sustainability, counteracting the climatic changes and negative influences on public health. In Poland the economic model assumes that the highest economic effectiveness occurs when the value of integrated building life cycle is minimal [4].

- **Social aspect**, which involves creating a built environment, including public spaces, buildings and complexes of buildings, and in the process of decision making takes into account the participation of communities and an effective utilisation of the area, adaptability, elimination of architectural barriers and other criteria aimed at improving the quality of living.

![Figure 1. Important fields of architecture influence in the context of sustainable development [3].](image-url)
In the era of globalization and Internet, architecture is becoming more dynamic than before. This forces such qualities as: openness, changeability and flexibility, which is a reference to the ideas of ancient Buddhist philosophy of Far East, similarly to the repeatable cycles in nature and constant flow of energy. A return to the roots certainly brings architecture closer to nature. There are five principles of sustainable architecture with reference to environment [3,5]:

- **Healthy internal environment.** Ensuring clean, fresh air inside buildings thanks to the use of good construction, building and finishing materials that have been tested for toxicity. Utilisation of an appropriate technology and natural green areas to create an interior microclimate.

- **Energy efficiency.** Maximum reduction of energy consumption in buildings by applying effective lighting, heating, cooling and ventilation systems.

- **Natural building materials.** Use of high quality local building and construction materials, the exploitation, manufacturing, application and disposal of which do not require high energy expenditure and do not produce harmful waste or emissions.

- **Context of place – environmental, cultural, climatic, biological.** Taking into consideration the broadly understood relationships between users, buildings and environment and modelling nature in ecologically oriented urban context [6].

- **Good design.** Obtaining a harmonious relationship between the built environment and natural environment, between the solution of a form, function, space, technology and the manner of using. Reference to the tradition of a place and achieving the goal in the form of lasting, useful and beautiful buildings.

To better understand the role played by architecture in sustainable development and to enable a multi-faceted, holistic approach to the process of creating a built environment, it is necessary to support a dynamic development of sustainable design concepts, which give a chance for long-term, multi-disciplinary activities, including visualisation of the results, serving as documentation of the intended changes in both environments (built and natural). Such activities lead to the development of an innovative attitude to the design process itself and to its support tools, the task of which is to ensure fast contact between the process participants and access to information in order to optimize design solutions and shorten the design process duration.
More often, design strategies strive for simplicity and universal availability of used technologies. Design integration is required in early concept, which brings significant benefits in the form of high efficiency input solutions, allows integration of land use, architecture and technology. At the same time, repeating after Christian Schittich (in the context of solar design), it is important holistic approach to the design excludes reduce architecture to the extracted elements as solar or PV installations on the roof. Rather the building must be understood as a complex configuration – total energy concept – providing the best opportunities to use local, natural sources of energy, like solar, wind, geothermal for various requirements. Passive and active indicators complement each other, the orientation and the zoning building for integration technical systems that generate hot water or energy. Variable, the active outer shell (exterior facade) of the building, adjustable by intelligent control systems responsive to the variant weather conditions, time gives the increasingly important contribution [7].

3. 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 of the influence exerted by the built environment on natural environment and man. It should be characterised by a holistic approach, expressed in the integration of environmental, socio-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 [8]. According to A. Baranowski, ecological criteria, which consist in eliminating the negative influence exerted on 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, it should be noted that the 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 [9] and, what is most important, 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, which has been presented by Samuel Mockbee: understanding the place, as a basis for sustainable design; understanding the 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 [10].

New procedures enabling the principles of sustainable development to be implemented in a built environment in the first place require re-evaluation of needs, making their scope more realistic as well as adjustment 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.

With such a wide range of activities and co-dependences 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, in consequence, a built environment characterised by an effective use of energy as well as an optimal internal comfort and minimal influence on man and natural environment. Worth emphasising at this point is 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” [8].

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. 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, 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 [9].

A broad, holistic approach, being a part of IDP, requires crossing certain boundaries and going beyond certain habits. It necessitates co-operation of inter-disciplinary designer teams, which 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 dependences 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.

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 and the construction design 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.

4. Co-operation strategies and Integrated Design Team (IDT)

The process of designing invariably involves co-operation of a specialist team, the composition of which 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 classic design team is extended with a number of 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 experts and specialists in the area of monitoring and system integration, interior microclimate and natural lighting; experts in the field of energy, environment (ecologists, biologists) and costs; service staff as well as equipment fitters and suppliers [9,11]. 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 fulfil the goals set by IDT?

The basic pre-condition of an 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.

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:

- **data collection** – selection, sorting and comparison of data which determines boundary conditions, concerns 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 it is the architect who takes final decisions.

An issue gaining considerable importance in IDP is collection of information regarding the building’s behaviour when it is utilized, transfer of collected information to conceptual models for all design levels, its analysis and re-use as an experience gained on the basis of effects of the previously adopted solutions. 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, a „guidebook” for subsequent design tasks. In this case, an important issue is wide distribution of materials for didactic and informative purposes.

5. **New design tools**

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

The designed buildings are more and more frequently treated as a set of data which defines their particular constituents – construction, materials, functional-spatial solutions, equipment etc. For this reason, computer technologies which enable storage of a large amount of data and fast information exchange are a useful design tool. It is 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 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, electricians, achieving highest efficiency and sustainability.
6. Good practices
In the Scandinavian countries, strategies for sustainable development in the area of architecture and urban planning have been developed, within the limits of the urban agglomeration, that in a successful way, affect the integration of the sustainable development paradigm with the context of the economic, social and natural sciences. An essential component of these strategies is the context of issues relating to housing because they directly affect the quality of life and implementation of the needs of present and future generations.

Analyzed research area in the context of the search for sustainability in design strategies create new environmental concepts of housing on post-industrial port and industrial areas, but also new areas that are the result of transformations in a new round set, undeveloped previously areas of cities. In both cases, the strategies are an example of creating a new, environmentally conscious image of cities and high-quality space and concern for environmental protection and highlighting values. Examples of such strategies are the districts of Hammen Vasta quarter B01 "City of Tomorrow" Swedish Housing Expo in Malmö, Fjord City Tjuvholmen and Sørenga in Oslo and Ørestad, Sluseholmen and Teglvaerkshavnen in Copenhagen.

![Fig. 3. Ørestad district in Copenhagen - Green atrium in 8 House and Senior House. (Photo by B. Majerska-Palubicka)](image)

What characterizes them is differentiated evolution of the urban landscape from open space observation axes up to the intimate green "islands" around which residential buildings that make up the quarters were designed. In many cases water plays an important element of the landscape, so the houses are standing directly over the canals, and bridges and wharves in the form of hiking routes that allow you the direct contact with the water.

7. Conclusions
Sustainable architectural design is a conglomerate of the pragmatic and ideological approaches, in which all the aspects of contemporary life resulting from the implementation of the sustainable development paradigm are equally important. As a field having a very wide spectrum of influence (society, culture, science, economy/economics, environment, nature), it should be perceived holistically, in an interdisciplinary way. Being an area which has an impact on usefulness, durability and beauty, it should strive to integrate many artefacts. It should respect the context of a place, natural values, cultural heritage and tradition, draw from the experiences of previous cultures as well as contemporary knowledge and available technologies and employ the potential of nature and society. Sustainable architecture ought to influence the creativity of artists undertaking studies on innovative
design solutions, technologies and strategies that reduce the negative impact on natural environment, and should lower the investment and operating costs.

In the summary of considerations and an attempt to answer the questions asked at the beginning, it has to be stated that sustainable design can co-create economic, social and environmental sustainability in the future. This should occur by searching for possibilities to provide dwellings and an accessible, attractive and safe public space as a foundation for social relationships’ development, while properly using and managing the resources and applying the functional-spatial, building and technological solutions adjusted to the needs and situation. The more diverse and flexible the created space will be, the better it will adapt to the environment. The answer to the question asked will most probably be efforts focused on:
- individual preferences and needs of users (humanity – humanity co-dependence),
- cultural context (intra- and inter-generational relationships),
- natural environment context (humanity-biosphere dependence),
- economic preferences (need to adjust to the economic situation),
- possibility of realizing creative visions.

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